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and
Seminar on

Waste Management in Built Environment

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FOREWORD

Throughout most of history, the amount of waste generated by humans was insignificant due to low population density and low societal levels of the exploitation of natural resources. Common waste produced during pre-modern times was mainly ashes and human bio-degradable waste, and these were released back into the ground locally, with minimum environmental impact. Following the onset of industrialisation and the sustained urban growth of large population centres, the buildup of waste in the cities caused a rapid deterioration in levels of sanitation and the general quality of urban life. The streets became choked with filth due to the lack of waste clearance regulations.

An important component of Municipal Waste is Waste generated during construction activities. Construction and Demolition (C&D) waste has caused serious environmental problems in many large cities. Enormous amounts of infrastructure and building work have been built, so numbers of demolished structures are also increasing in construction work. These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container. It is not uncommon to see huge piles of such waste, stacked on roads especially in large projects, resulting in traffic congestion and disruption.

All these issues have led us to think of some alternatives for disposing of the hazardous wastes and making the environment free from the detrimental impact of the said wastes. Various methods of treatment of solid and liquid waste have been successfully developed and implemented globally. However, the waste management practice is not sufficient to make the environment completely free from the detrimental impact of the wastes. With continuous improvement in the fields of science and technology, engineers have achieved new technologies by which human beings will not only enhance their knowledge for disposing of the hazardous waste but also develop some alternate products generated from the same waste, which can be highly useful to society. Examples of such achievements are many – such as generation of bio-fuel, bio-energy, biogas, bio-fertilizer and so on. The day is not far when wealth will be generated from waste.

IBC has selected "Waste Management in Built Environment" as the theme of the Seminar to be held during the Mid-Term Session and Seminar at Ghaziabad on December 12-13, 2014. In order to focus the attention of all concerned on the above mentioned vital aspects. It is hoped that seminar will generate due concern among the professionals to create an effective and practical approach for making waste management as an integral part in the process of planning and construction of the Built Environment in our country.

(Dr. SPS Bakshi)
President, IBC &
Chairman & Managing Director,
Engineering Projects (India) Ltd.

PREFACE

IBC is holding the Mid Term Session at Ghaziabad on Dec. 12-13, 2014 and very aptly along with a Seminar on the theme of “Waste Management in Built Environment” which is very much in conformity with the ‘Swachh Bharat Abhiyan’ started by the Government.

The “good old methods” in solid waste management included open burning dumps that were routinely set on fire. These dumps polluted the groundwater, provided no landfill gas control, and had unsafe working conditions resulting in numerous injuries, but all at low cost. While the public liked the low cost for garbage disposal, they were not aware of the many problems these practices caused. The engineer is responsible for transforming the industry into a professional field with best practices. Today, open dumps have been replaced by sanitary landfills with gas-control leachate-collection systems. Garbage incinerators have been closed and modern waste-to-energy plants with state-of-the-art air-pollution-control equipments have replaced them. Collection has evolved from putting the garbage into a can to a series of recycling bins, yard waste cans, and waste oil containers. Household hazardous waste is managed separately from refuse. While all of these changes have been beneficial to society and the environment, they have resulted in an increased cost to the public.

To be cost effective, the solid waste engineer must be competent in three areas: technology, regulations, and public communications. These three areas are like the three legs of a stool. Without all three, the stool will fall over. Technology in the solid waste field is constantly evolving. For example, new landfill liners are being developed for different applications. Materials recovery facilities are being re-engineered to process different types of waste streams. Regulations become more stringent and complex every year. Regulations pertaining to solid waste management are issued by central and state Govts. which have to be followed religiously. Integrated solid waste management services and supporting facilities, by their very nature, are public facilities and services. The public will use them, see them, and be affected by them. Because of the public nature of these facilities and services, the solid waste engineer cannot forget that he has to take such decisions which are technically correct and simultaneously the public in large should be satisfied with good communication.

We had fairly good response to the call for papers and 27 papers have been included in this pre-conference publication. There are papers from academicians, architects, services engineers and consultants to be presented and discussed under three sub themes viz Construction and Demolition Waste, Concept Approach and Vision and Energy Recovery From Waste.

I hope the Seminar will result in fruitful discussions and motivate more building professionals to adopt waste management fairly in their working. I am very grateful to my colleagues in the Technical Committee for their efforts and contributions in making it possible to bring out this Publication.

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TECHNICAL SESSION - I

CONSTRUCTION AND DEMOLITION WASTE

USE OF WASTE MATERIAL IN CONSTRUCTION: CONCRETE AND BITUMEN

MAHESH KUMAR*

Abstract

Natural resources are fast depleting due to large scale quarrying of all materials required by mankind. It consumes a lot of energy and carbon fuels to quarry these resources and results in enormous carbon emission. It is high time that natural resources taken out from earth are recycled repeatedly so that natural resources are protected alongwith saving in fuel and simultaneously reducing carbon emission.

Huge quantity of concrete and demolition waste (CDW) is produced throughout the world which can be easily recycled. It requires a detailed study to analyse the Construction and Demolition Waste so that same is used for production of quality concrete and various bitumen mixes.

Practical tests have been carried out by use of CDW, various mixes prepared, tested and conclusions drawn. In addition, recycling of bitumen mixes have been adopted in a large scale, appropriate items evolved and implemented in large contracts and same resulted in no contractual litigations.

INTRODUCTION

The Indian construction industry is highly labour oriented and accounts for approximately 50% of the country's capital outlay in successive Five Year Plans projected investment which continues to show a growing trend. Out of 48 million tonnes of solid waste generated in India, CDW makes up 25% annually. Rapid economic growth leading to urbanization and industrialization is generating waste, which is adversely effecting the environment. The percentage of India's population living in cities and urban areas increased from 14% at the time of independence to 28%.

Projections for building material requirement by the housing sector indicate a shortage of aggregates to the extent of about 55,000 million m3. An additional 750 million m3 of aggregates would be required to achieve the targets of the road sector. There is also a huge demand for aggregates in the road and housing sectors, but there is a significant gap in demand and supply. A huge quantity of CDW is generated during the construction stage and after demolition of existing structures which is necessitated due to various reasons like; failure of a structure: the structure has outlived its life or has become obsolete.

Most of the Indian cities are littered with demolished material and every open area has been used as a dumping ground for CDW and garbage. India is the 2nd largest producer and consumer of cement. The recycling of demolished concrete will not only save this open land from becoming a dump yard but will save enormous amount of natural resources, money and reduce carbon emissions. It is high time that the CDW is recycled to produce aggregate of suitable sizes for use in new concrete and bituminous mixes after appropriate treatment.

Estimated waste generation during construction is 40 kg per m2 to 60 kg per m2. Similarly, waste generation during renovation and repair work is estimated to be 40 kg per m2 to 50 kg per m2. The highest contribution to waste generation comes from the demolition of buildings. Demolition of pucca (permanent) and semi-pucca buildings, on average generates between 500kg per m2 and 300 kg per m2 of waste, respectively. The presence of CDW and other inert matters makes up almost one third of

**Engineer-in-Chief, Haryana PWD Chandigarh & Past President, IBC*

the total waste on an average, but so far no notable development has taken place for using this in an organized manner. At present, private contractors remove this waste to privately owned, low-lying land for a price, or more commonly, dump it in an unauthorized manner along roads or other public land.

PROBLEM

In more than 95% cases, wastes such as bricks, metal, wood, plastics and glass have some market value and there are contractors who focus solely on dealing in CDW. The use of these materials require them to be sorted and separated, and is dependent on their condition, although the majority of this material is durable and therefore has a high potential for reuse. It would, however, be desirable to have quality standards for the recycled materials.

The total quantum of waste from the construction industry is estimated to be between 12 million to 14.7 million tones per annum, out of which seven to eight million tones are concrete and brick waste. In construction and housing sectors, 70% of the consumers are "not aware of the recycling techniques" while the remaining 30% are not even aware of recycling possibilities. Furthermore, the Bureau of Indian Standards (BIS) and other codal provisions do not provide specifications for the use of recycled products in construction activities. Fig.1 shows the cost comparison between new and old cost comparison new and old building materials recycled building material. Fig. 2 gives the hierarchy which should be followed for reducing C & D waste

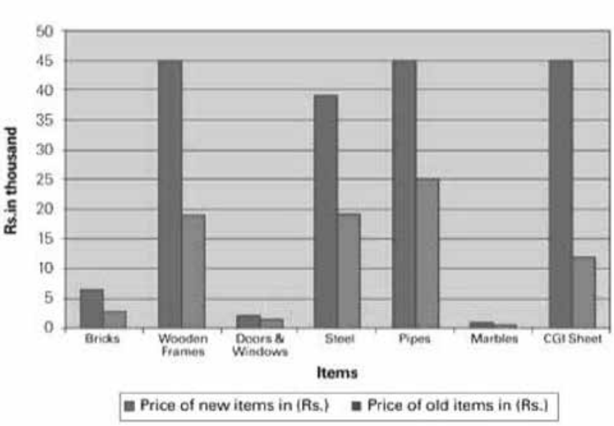

Fig. 1: Cost Comparison Between New and Old Building Materials

Fig. 2: Hierarchy of Techniques for C&D Waste Treatment

RECYCLED CONCRETE AGGREGATE (RCA)

- No special equipment for production of RCA is required. The entire process basically involves three steps i.e.

(a) Breaking the bigger concrete blocks / slabs into the size of 6 inch to 8 inch so that the same can be fed to the stone crushers (Fig. 3).

(b) The second step will involve crushing of broken blocks into RCA of required grade.

(c) The third step to produce high quality aggregate will be mechanical grinding / heating & rubbing and eccentric rubbing method.

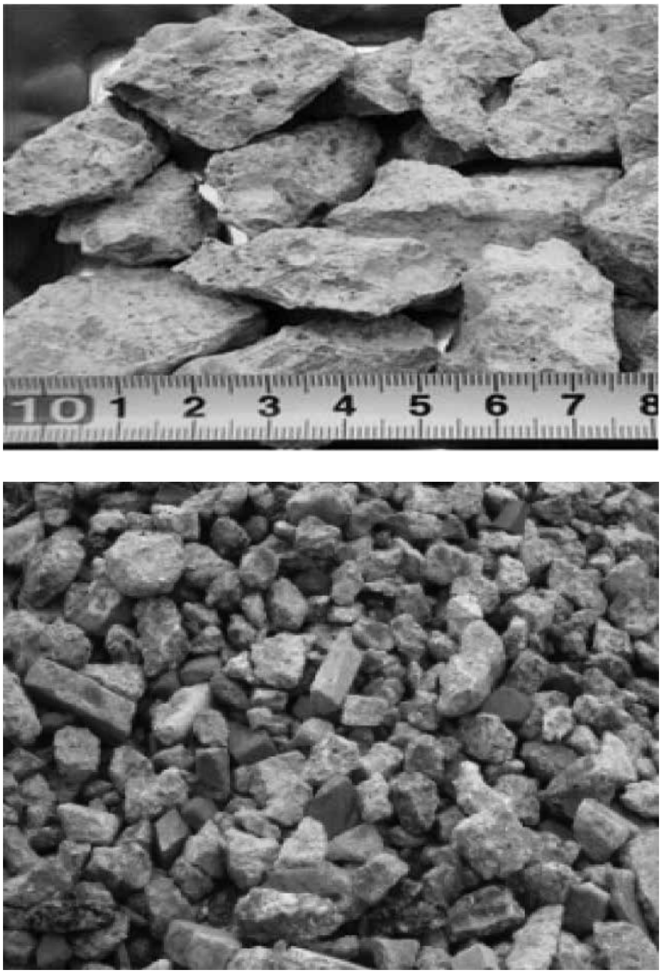

Fig.3 Steps for Producing RCA

EXPERIMENTAL STUDY

The RCA was produced manually by breaking of concrete in two steps:

- Breaking into smaller pieces 6” to 8” with the help of heavy hammer
- Breaking into required sizes of 20mm and below with the help of routine manual process as in the case of WBM material

Around 400 kg of material of (20mm, 10mm and fine aggregate was produced for laboratory investigations:-

Evaluation of RCA

The RCA so produced was put to following tests

- Water absorption test
- Impact value test
- Specific gravity test
- Flakiness / elongation index
- Sieve analysis

The comparison of the results of RCA with those of fresh aggregate is given in Fig.4, Fig. 5a &b and fig 6 a, b show the comparison of particle size distribution for fresh aggregate and RCA for fine and coarse aggregate respectively.

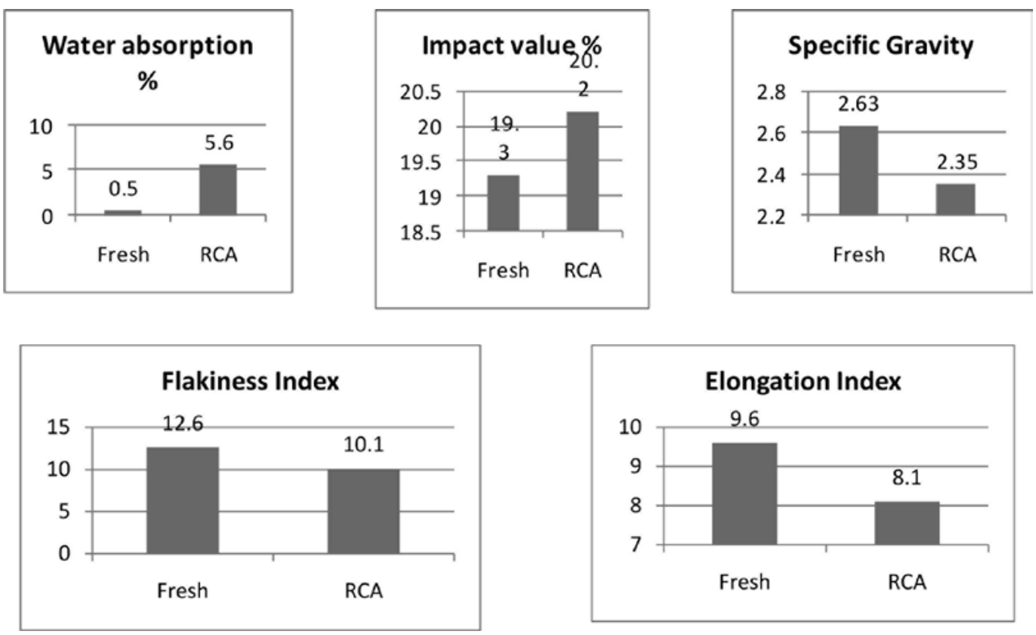

Fig. 4 Comparison of RCA with Fresh Aggregates

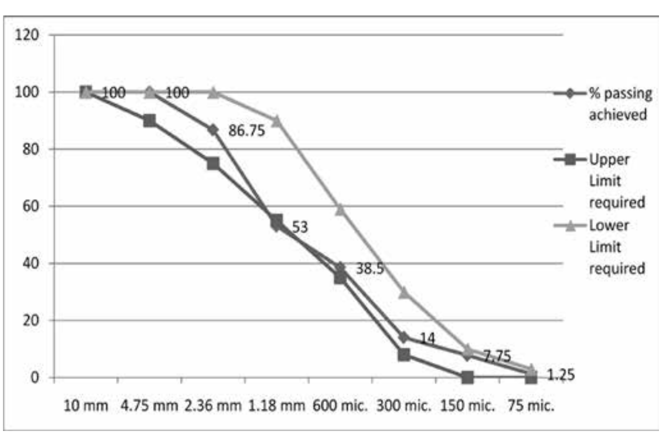

Fig. 5. Particle Size Sieve Analysis (Coarse Sand) (a) Fresh Fine Aggregate

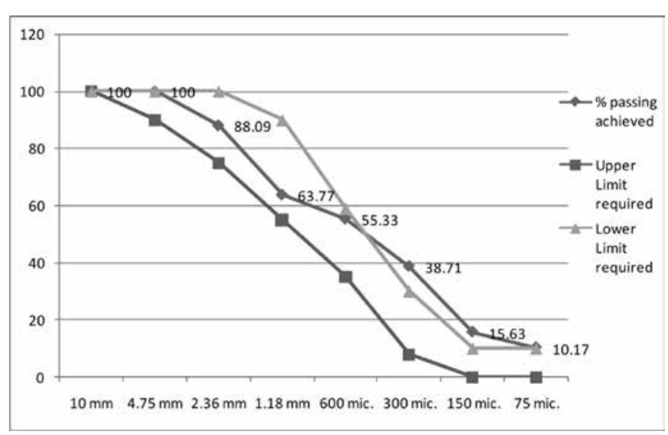

Fig. 5. Particle Size Sieve Analysis (Coarse Sand) (b) Fine Aggregate (RCA)

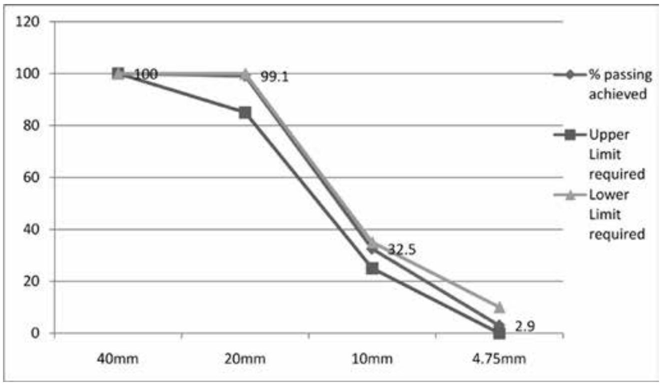

Fig. 6. Particle Size Sieve Analysis (Coarse Aggregate – 20mm nominal size) (a) Fresh Aggregate

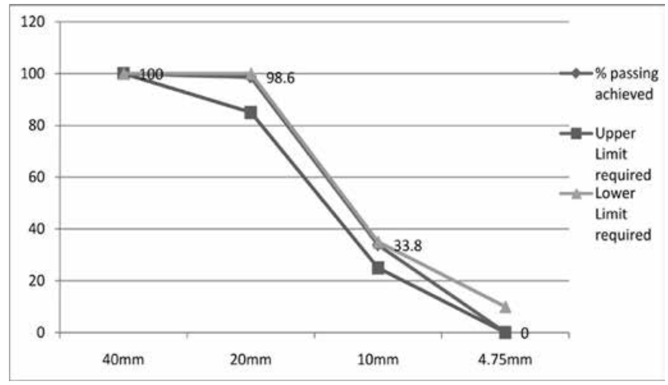

Fig. 6. Particle Size Sieve Analysis (Coarse Aggregate – 20mm nominal size) (b)Coarse Aggregate (RCA)

PRODUCTION OF CONCRETE USING RCA

The following trial mixes of M40 pavement quality concrete (PQC) were carried out using different percentages of RCA.

- 0% (All fresh aggregate)
- 30%
- 40%
- 50%
- 100% (All RCA)

Production Methodology

- The job mix design for M40 PQC was used for all the above trial mixes and same quantity of admixture was used to produce trial mixes having different percentages of RCA.
- By preparing various mixes of concrete with different %age of RCA, no recycled fine aggregate has been used keeping in view the fact that Recycled Fine Aggregate has large percentage of fines i.e. 38.71%, 15.63% and 10.17% on 300 micron, 150 micron and 75 micron respectively, (Fig.5b) whereas the fresh aggregates have a percentage of 14%, 7.75% and 1.25% respectively (Fig.5a refer Sieve analysis).
- The fine aggregate produced by recycling of old concrete has lot of fine particles passing 300 micron sieve, which is a high quality inert material having high silica and can be a substitute of filler material as well as fine aggregates in bituminous mixers. The recycled fine aggregates can also be used for preparing cement mortars but with greater control because of high %age of fine material and it is recommended that not more than 30% of fine RCA should be used in preparation of cement mortars.

The different trial mixes of M40 pavement quality concrete (PQC) were carried out using different percentages of RCA as shown in fig7.

Besides above comparison the other significant comparison between other properties of concrete using RCA and fresh / natured aggregate is as under depending upon the %age of RCA used:

- Reduction in flexural strength is between 0 to 15%.
- Reduction in tensile strength is between 0 to 17%.
- Reduction in bond strength with steel is between 0 to 15%.
- Reduction in shear strength is between 0 to 18%.

In the entire production and evaluation process the limiting factor is that:

- The RCA has been produced manually. Good to medium quality of RCA has been produced by this process.
- The manual production of RCA is similar to the process of producing aggregate by crushing with cone crusher.
- The quality of RCA when produced with jaw crusher which is most commonly used for producing aggregate may not be as good as produced manually or by cone crusher.

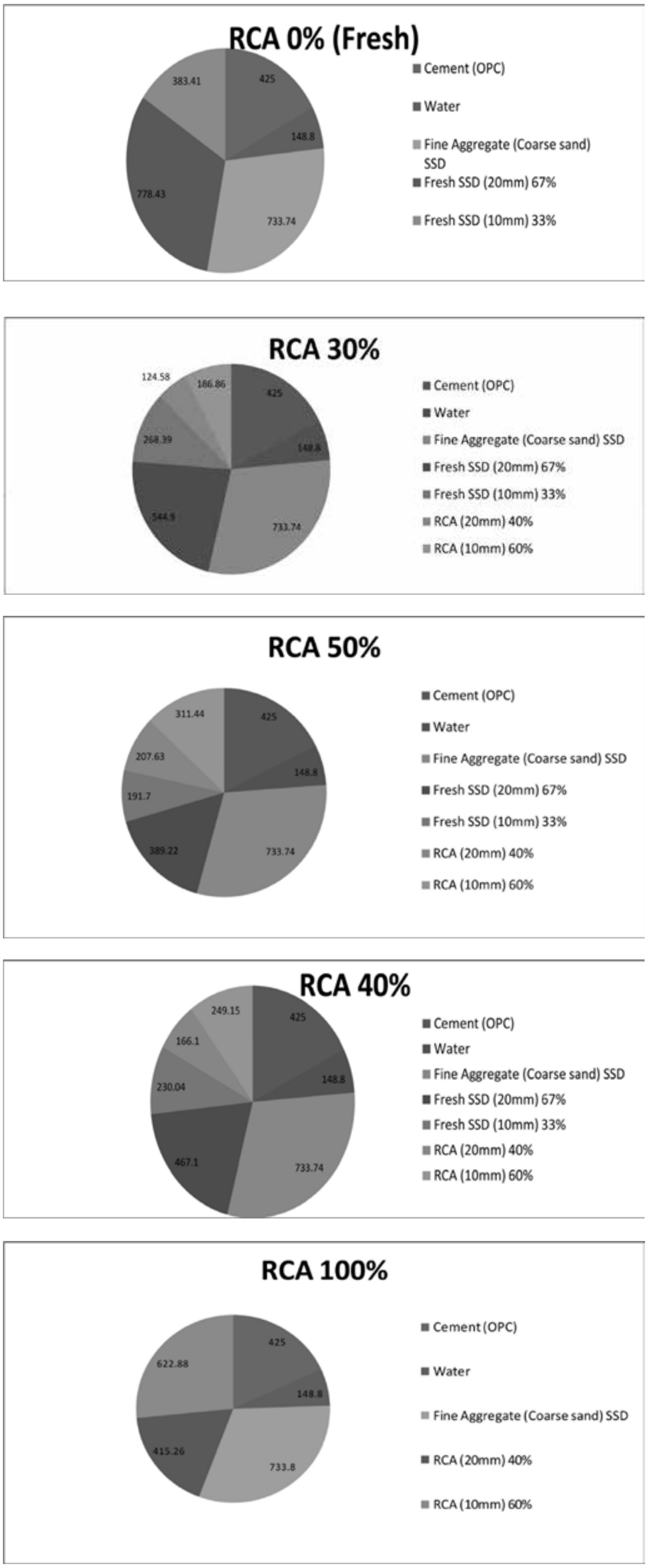

Fig. 7 Various Trial Mixes of M 40 Pavement Quality Concrete using Different Percentages of RCA (SSD : Saturated Surface Dry Condition)

COMPENSATION OF STRENGTH

From Fig.8, it can be seen that reduction in strength, if 100% RCA is used, is about 18% in M-40 concrete. This reduction in strength varies with the grade of concrete. Higher the grade of concrete, higher is the reduction in strength. This reduction in strength of concrete using recycled aggregates can be compensated by adding additional cement say; an addition of around 25kg of cement and reducing a minor quantity of water cement ratio to the tune of 0.02 to 0.03 as explained in Table 1.

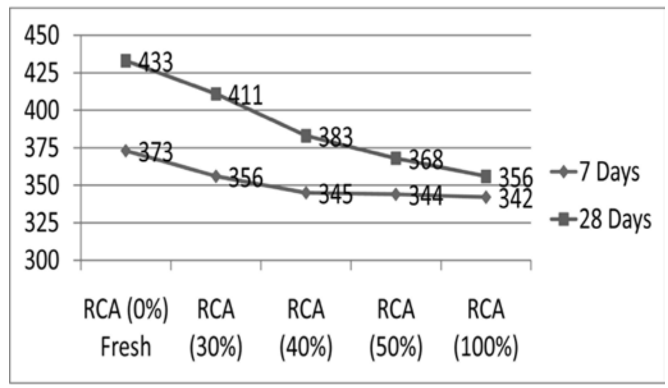

Fig.8 : Comparison of compressive strength of Cement Concrete M-40 (PQC)

Table 1: Durability Test on Different Types of Concrete

Durability Test	Conventional Concrete	Concrete with Recycled Aggregate	Percent variation.
Compressive Strength, kg/cm2 Continuously immersed in 90 days	100	100	0
Compressive Strength, kg/ cm2 Heating-Cooling, in 90 days	95.8	96.6	+ 1%
Compressive Strength, kg/ cm2 Freezing & Thawing, in 90 days	103	124.1	+ 20%

Compressive Strength, kg/ cm2 Immersion in Sulphate solution & heating in 90 days	43.1	58.6	+ 36%

ECONOMICS

Availability of Construction and Demolition Waste:

- The dismantled concrete is available free of cost in most of the places and is in fact consuming lot of open spaces apart from giving shabby look.
- Provision can also be made in the projects in which dismantling / demolition is involved that the dismantled material will be the property of the client department or the dismantled concrete will be reused after production of RCA of desired quality.
- The crushing of CDW to produce RCA consist of following steps and relative cost is as under:

— Breaking of aggregate to size 6" to 8" manually or mechanically will cost approximately	:	Rs.125/- per cum
— Carriage of broken material to crusher site (alternatively if quantity is more then crusher can be shifted at site) with an average lead of 30 kms	:	Rs.250/- per Cum
— Cost of crushing	:	Rs.150/- per cum
— Carriage of RCA to work site with an average lead of 30 kms	:	Rs.250/- per cum
— Total cost of produced RCA / Cum	:	Rs.775/- per Cum

- The material rate of fresh coarse aggregate at present in State of Haryana is Rs.1200/- per cum
- If the quantity of CDW is huge, a mobile crusher and screening unit which is easily available can be hired / purchased and installed at site which will reduce the cost to about Rs.300-400/- per cum. as the major cost involved is the transportation cost.

RECYCLING OF BITUMENOUS LAYERS

It has been put into best use on all highways without any contractual litigations.

Use of Recycled Bitumen Layers

- Recycled bitumen extracted from dismantling of old roads should be used for upgradation/ construction of roads.
- Dismantling of existing road to the extent of bituminous layers (i.e. DBM/ BM/BC/SDBC/ MSS/ PC) by cold milling to a possible depth of bitumenous layers, plaining the surface after cold milling, hauling and stockpiling the reclaimed material near the central recycling plant
- The reclaimed material can be considered minimum 80% of the theoretical quantity

Recovery Item in BOQ: Salient Features:

The following is a sample of recovery item which can be inserted in a contract

- Pdg & laying 50mm BM/80mm DBM using the reclaimed material to the extent of 30% of the required quantity, hauling and stockpiling the reclaimed material near the central recycling plant after carrying out necessary checks and evaluation, adding fresh material including rejuvenators as required, mixing in a hot mix plant, transporting and laying at site and compacting to the required grade, level and thickness, all as specified in Clause 519 of Specifications for Road and Bridge Works of MoRTH (5th Revision) of 2013 using bitumen VG-30

Precautions Required

- The unutilized quantity of reclaimed bituminous mix material received on milling should be a recovery item in BOQ
- The rates quoted against recovery items will not be included in the total amount. Rather it will be

deducted while calculating financial statement of the agency.

- Material obtained from dismantling of existing bituminous crust and reclaimed material after milling of bituminous crust have been calculated taking assumption that 80% of theoretical material will be retrieved
- The dismantled material can be used in any of the item for the work after modification (bringing it to required specifications) after approval from employer. In case it is not possible to use this material on the work, the agency can take away this material
- This balance material can be taken away by the agency at the price quoted by the agency but minimum price to be quoted is limited to reserve price as fixed and mentioned in BOQ is @ Rs.1300/- to 1600/- per. Cum
- All quantities of the dismantled materials are worked out on the basis of theoretical quantities laid on the road
- Agency can visit site before quoting rates and assess the extent of retrieved material. There shall be no measurement after actual dismantling and if material after dismantling is found on lesser side, no claim of agency on this score is entertained and full recovery on the basis of quoted rate and quantity exhibited in the BOQ are made
- The reserve rates are minimum rates to be used as base for quoting purchase rate by the agency. No rates below the reserve price will be entertained and reserve price will be considered for all purposes in case the agency quotes lesser than reserve price

CONCLUSION

From the study as above, it can be easily seen that the use of RCA not only result in precious saving of natural resources but has a significant saving. It is high time to start using RCA. A perusal of results shows that 30% RCA can be used without any change in mix designs and even 100% RCA can be used with suitable change in mix design especially carried out with the samples of RCA. Similarly for highways, recycling of bitumen material and their use have added considerable saving to total cost of project apart from preserving natural resources.

Management of C&D Wastes - Current Status

Dr. A. K. Mullick*

Abstract

Need of management of Construction and Demolition (C&D) wastes, as distinct from Municipal Solid wastes, is a relatively new subject in India. This presentation describes the needs, the present status and the tasks ahead.

To begin with, there is no precise estimate of the amount of C&D wastes generated in India. The primary reason is absence of focussed regulatory process and strict enforcement. Specific recommendations are made in the paper on this issue.

Techniques and equipment used for demolition of dilapidated buildings, and processing and recycling of wastes are described. Uses of different components of the wastes after processing are discussed. Recommendations are made for formulation of Standards by BIS on use of recycled concrete aggregates in structural concrete. Recycling and reuse of bricks, tiles, wood, timber, plastics, metals etc. recovered as waste are discussed. Confidence building measures and promotional efforts needed are mentioned in the paper.

INTRODUCTION

For the purpose of management of C&D Wastes in India, Construction and demolition waste has been defined as 'waste which arises from construction, renovation and demolition activities. Also included within the definition are surplus and damaged products and materials arising in the course of construction work or used temporarily during the course of on-site activities [1]. The various streams of wastes to be considered will include;

- Excavated materials,
- Tiles, brick, ceramics, asphalt concrete,
- Plaster,
- Glass,
- Metal and steel,
- Plastics,
- Wood, asphalt, and
- Concrete rubbles, etc.

However, C&D waste shall not include any hazardous waste as defined under 'Hazardous Waste (Management & Handling) Rules, 1989'. C&D waste shall not include any waste which may have any chance of getting contaminated with nuclear waste or exposed to nuclear radiation. Special care shall be taken before demolition of any nuclear establishment [2]. Material generated from de-silting activity is also excluded from C&D waste category as it contains decomposed organic material and may also contain heavy metals and other toxic materials.

TIME TO MAKE A BEGINNING

Management of C&D waste is a relatively new subject in India. In spite of sporadic use for filling low-lying areas and some salvage attempts, there was no systematic approach. The primary reason is absence of focussed regulatory process and strict enforcement. The applicable rule for management of municipal solid waste – 'The Municipal Solid Waste (Management & Handling) Rules, 2000' has brief mention about C&D waste, but there is no separate rule for C&D wastes. The Local Authorities (municipal bodies) are mandated with ensuring appropriate management of C&D waste. It is now (2014), that Ministry of Environment and Forests (MOEF), Govt. of India, has taken up the task of framing separate rules for the management of C&D Wastes [2].

**Consultant, Former DG, NCCBM & Chairman ICI Technical Committee on C & D Waste*

Codes of practices for constructions by Bureau of Indian Standards (BIS), Indian Roads Congress (IRC) and others do not envisage use of building materials recycled from C&D wastes, nor are there any specifications for such materials.

The tasks, therefore, include framing of necessary rules, taking stock of required processes and technologies, minimising wastes in new constructions, adoption of recycled products from processing of wastes and standardisation of quality requirements. Promotional and confidence-building measures are important.

AMOUNT AND COMPOSITION OF C&D WASTE GENERATED

Even at the beginning, let it be admitted that adequate data on C&D wastes generated in India are not available. Part of the reason of the above state of affairs is that there is no separate regulatory framework for management of C&D wastes, as a separate entity, distinct from Municipal Solid Wastes.

In different countries, the estimate of quantity of C&D wastes is linked to that of municipal solid wastes (MSW). A 2008 report of MOEF estimated the amount of MSW in India to be 0.573 million metric tonne (MMT) per day. On that basis, the amount of MSW in India will be about 210 Million tonnes per year [3, 4]. For total population of 1.2 billion, this amounts to about 175 kg per capita per year; much lower than the World Bank estimate of up to 1000 kg per capita per year for Asian countries (2000 estimate) [1]! This would be the first example of underestimate in this matter.

Two reports by Government agencies have stated that C&D wastes in India amount to nearly one-third of the total MSW (3, 4). On that basis, the amount of C&D wastes can be estimated to be nearly 70 million tonnes per year. Yet, the same Reports state the amount of C&D wastes to be 10 – 12 million tonnes (3, 4). There is, thus, a serious disconnect between the two estimates in the same reports. That, a figure of 10 – 12 million tonnes of C&D wastes per year in India is gross underestimate as is clear from comparison of data from other countries given in Table 1. The sources of information are also identified. Selected data of C&D waste generated in some Asian countries obtained from Ref. 7 are shown graphically in Fig. 1.

Table 1: Amount of C&D Wastes in various Countries

Country	Amount, MT per year	Year	Reference
Germany	223	2003	5
Australia	19	2008-09	6
China	200	2005	7
Japan	85	2000	7
	77	2012	8
S. Korea	61.7	2013	9
India	14.7	2001	7 (Quoting MOEF)
	10 – 12	2012	3, 4

One of the main reasons for paucity of authentic data has been absence of regulatory compulsions. It is hoped that, with promulgation of strict regulations and guidelines for management of C&D wastes, as has been advocated in this paper, more accurate data on the waste generated will be available with local bodies, who will issue permits for demolition as well as new constructions.

Composition - The composition of the wastes depends upon the type of construction. For example, if a concrete bridge superstructure or flyover is demolished, the wastes will be almost entirely concrete. On the other hand, demolition of old residential blocks may result in the wastes comprising soil, masonry, brickwork, tiles, wood, metal, plastics etc. in addition to concrete.

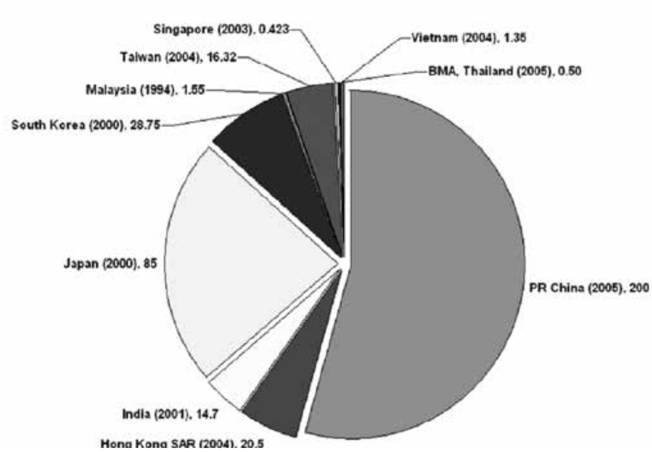

Fig. 1: Estimates of C&D Wastes in Some Asian Countries (Ref. 7)

Estimates for the composition of typical demolition wastes in India have been made by different agencies. These are shown in Table 2 [4].

Table 2: Estimates of Composition of C&D Wastes in India

Components of C&D Wastes	Typical as per TIFAC	MCD Survey, 2004	Survey 2005 by IL&FS
Soil/Sand, Gravel	36.0	43.0	31.5
Bitumen	2.0	-	-
Metals	5.0	-	0.4
Concrete	23.0	35.0	-
Wood	2.0	-	1.5
Others	1.0	7.0	7.6
Total	100.0	100.0	100.0

Based on TIFAC study, quantum of waste generated during construction is of the order of 35 kg/m^2 of construction activity, while during demolition waste generated is about 350 kg /m^2 of demolition. It is presumed that the data in Table 2 above essentially relate to building demolition wastes. The data above indicate the proportion of concrete in demolition wastes to vary from 23 to 35 percent. The proportion of soil varied between 31.5 to 43 percent. With improvement in data collection as suggested above, more precise estimates of the composition of C&D wastes will also be available.

REGULATORY FRAMEWORK

It is recommended that appropriate rules be framed covering the following;

- The relevant regulations and by-laws for civil construction would have to be changed so that the recycled C&D material can be used legitimately.
- For new constructions, permission from municipalities should include a clear waste management strategy, including use of recyclable building materials. The emphasis will be on reduction of wastes and deconstruction instead of demolition.
- Use of recycled materials meeting requirements of quality for the use should be made obligatory for new constructions, subject to prices being competitive.
- Permission for demolition will be required from municipalities, with a provision that owner of the property being demolished takes full responsibility of collection, recycling and disposal of demolition wastes and the related expenses. Detailed plans for safe demolition will be required.
- Local authorities should issue detailed deconstruction plans and detailed recycling specifications.
- Local authorities should be responsible for arranging the collection, recycling and disposal infrastructure of C&D waste, either on their own, or through other agencies. In such cases, the costs will be borne by the owners.
- There should be charges for disposal in landfills, which should be sufficiently high to encourage processing and recycling of C&D wastes.

Formulation and promulgation of separate rules for the management and handling of Construction and Demolition wastes is being considered by the Ministry of Environment and Forests [2]. According to the rules being postulated, the generator would prima-facie be responsible for appropriate storage and collection of C&D waste generated. The municipal/development authorities would make arrangements for placement of appropriate containers (skips or other containers) and their removal at regular intervals or when they are filled either through own resources or by appointing private operators. The competent authority would get the collected waste transported to appropriate site(s) for further processing and disposal either through own resources or by appointing private operators, who would be the authorized agency. It is hoped that the other points made above will also be incorporated in the rules.

Meanwhile a number of urban local bodies (ULBs) have notified tenders for management of C&D waste, especially, for setting up processing facility. In a couple of cases, the projects have been awarded and even the project site handed over to the BOT operator.

TECHNOLOGIES OF PROCESSING AND RECYCLING

The wastes originate from demolition of existing structures like old dwelling units, pavements and industrial structures, new constructions and renovation and repairs. These are required to be sorted out in following separate categories;

- Materials which can be recycled in waste recycling plants - concrete, stone, blocks, tiles etc.,
- Materials which can be disposed as scraps – metals, steel, aluminium, doors and windows, frames etc. and
- Materials which can be disposed off by other methods – paint, asbestos, glass, electrical etc.

The schematic of the recycling process, as is common in many countries is depicted in Fig. 2 [1]. The first step towards recycling is use of excavators along with task-specific attachments to methodically dismantle buildings and to process the material at the site. Jaw crushers, jack hammers, saws, debris buckets, metal shears etc are widely adopted. Precast concrete elements and concrete blocks can be reused with little or no processing, if care is taken during demolition to separate them.

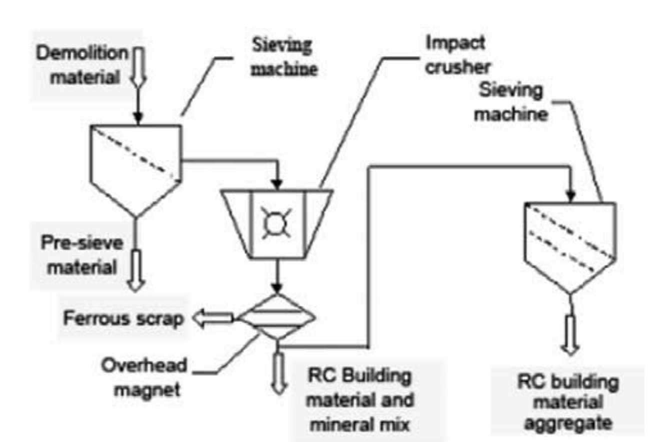

Fig. 2: General Recycling Process

On-line and in-plant sorting and processing of C&D wastes are accomplished by use of both mobile and stationary machines. These include;

- Manual sorting lines,
- Shredders,
- Crushers,
- Aggregate sifters,
- Separators – water-based density separators, magnetic separators, eddy current separators, air blower separators etc.

C & D WASTE RECYCLING PLANT, BURARI

The only working C&D waste processing facility in India is at Burari, West Delhi, which has capacity of 500 T waste materials per day. The C&D waste material after being received at the plant is first segregated. The segregated C&D waste is screened through a grizzly to remove loose soil and muck. The screened material is collected in the hand sorting section where bricks and concrete are separated. Bigger size concrete boulders are broken by help of a rock breaker. Further size reduction is done by the help of processing machines.

The central processing unit has mobile crushing units Rubble Master RM 60, with capacity of 60 T per hour. Nearly 65 to 70 percent of the C&D waste received is soil, which cannot be processed and perforce has to be used for landfill. To overcome this handicap, a wet processing system known as the "Evowash System" has been installed. This wet processing system extracts pure sand from the unprocessed soil as also, the end product will be clean soil which can be used for landscaping etc.

The process flow of C&D waste recycling at the plant is shown in Fig. 3.

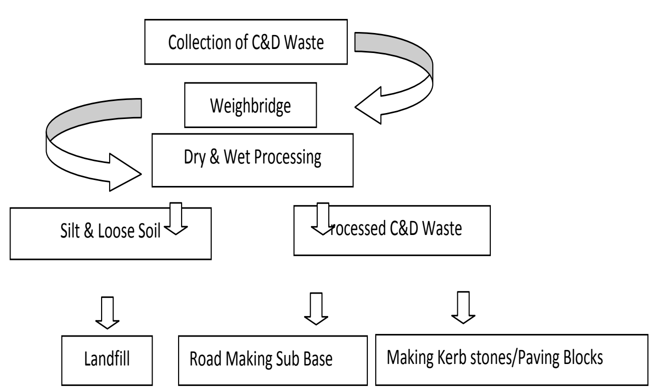

Fig. 3: Flow Chart of C&D Waste Recycling in Delhi.

Demolition - Selective demolition, which allows separation and sorting of materials is preferred.

At first, domestic wastes like furniture, appliances etc., metal components like window frames, pipes etc., timber components, and other wastes like tiles, asphaltic materials, ceramic products etc. are removed one by one. Brick walls are demolished, followed by concrete structural members. Mounted hydraulic breakers, long reach excavators and wrecking balls are used for demolition. Other equipment used include hydraulic concrete splitters, hydraulic concrete crushers and pulverisers etc.

For reconstruction of typical 50 years old, 4 – 9 storey residential blocks in metro cities, the portion to be demolished is isolated with diamond cutting, the unwanted portion is demolished and concrete elements like columns, beam and slab are crushed. Varieties of diamond sawing include wire saw, floor saw, hand saw, chain saw, wall saw etc.

Use of Recycled Materials

Uses of different components of the wastes after processing are discussed. It is necessary to highlight high-end uses, so that C&D wastes are recognised as resource material suitable for conservation of natural resources in new constructions; otherwise the subject will continue to be seen through the prism of mere disposal of debris, as have been the approach so far. Bureau of Indian Standards (BIS), MORTH, IRC and Railways should bring out specifications of construction materials obtained from recycling of C&D wastes, as appropriate to different types of constructions. The recycled products need to be tested in reputed laboratories for their mechanical properties and appropriate application.

Recycled Concrete Aggregates

After removal of contaminants through selective demolition, screening, and /or air separation and size reduction in a crusher to aggregate sizes, concrete rubble results in recycled concrete aggregate (RCA). The fine fractions can be used as replacement of sand. The most significant factor is that recycled concrete aggregate contain not only the original aggregate, but also hydrated cement paste adhered to it. This paste reduces the specific gravity and increases the porosity compared to similar virgin aggregates. The bond with the matrix in new concrete is affected, resulting in lower characteristics of concrete. Most of these effects can be overcome by proper processing (rubbing) and two-stage mixing. This has been aptly described elsewhere [10].

IS: 456 or IRC: 112 do not permit use of aggregate other than those obtained from natural sources and conforming to IS: 383. In view of international developments and experiences, as well as shortage of aggregate from natural sources in many parts of the country, it is time that recycled aggregates are permitted for use in concrete constructions. Proper use of recycled aggregate will be subject to test of its characteristics as laid down for normal aggregates. A broad framework is suggested, based on which suitable specifications can be drawn up by BIS;

Categories – The following categories are suggested;

- ✓ Category I - The recycled aggregate meets the requirements of IS: 383.
- ✓ Category II - Not fully meeting the requirements of IS: 383. The content of crushed concrete and unbound stone is greater than 85 percent, oven-dry density > 2500 g/cm3, water absorption less than 3 percent.
- ✓ Category III - If the content of crushed concrete is equal or greater than 70 percent. Content of brick or masonry not more than 30 percent.

Areas of application –

- ✓ Category I - It should be permitted for unrestricted use.
- ✓ Category II - it can be used as coarse as well as fine aggregate up to a total replacement level of 30 percent, in concrete grades up to M50. For grades up to M25, the replacement can be 100 percent.
- ✓ Category III - It can be allowed to be used in non-structural concrete (grade M20) up to 100 percent replacement of natural aggregate.

Other Materials – The other materials recovered from C&D wastes can be used as under;

- Bricks – Reused as bricks, road base, construction fill.
- Wood, timber – Recovery of reusable timber in furniture, flooring; recycling in fibreboard, particle board,

- Metals – Steel – smelting, manufacture of steel from scrap. Aluminium – Recycle and reuse.
- Plastics – Recycle.
- Tiles – Direct reuse; Crushed – gravel and crushed stone replacement.
- Excavation material – Reuse as backfill in sand and gravel pits, road fill material.

CONCLUSION

A number of 'confidence building measures' have been recommended [1]. These include policy and financial incentives to make recycling and reuse of C&D wastes viable. Increase in tax on disposal in landfills, preference for purchase of waste-derived materials in constructions, allotment of land for waste recycling plants, increase in permissible 'floor space ratio' and weightage in 'green rating' of buildings are typical examples.

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AVOIDANCE OF WASTE GENERATION FOR CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

Dr. K M Soni*

Abstract

The objective of the waste management plan, particularly of construction and demolition waste (C & D) is for sustainable development. Hierarchy of waste utilisation is avoidance or reduction of waste generation, reuse, recycle, energy recovery and in the last, safe disposal. But in India, unfortunately, last method in hierarchy is mostly followed meaning thereby C & D waste is disposed that too, in municipal landfills. Such disposal requires considerable landfill space and is environmental unfriendly.

Mostly C & D waste is in the form of bituminous material, bricks, aggregates, glass, tiles, plastic, wood, steel, sheets, aluminium, soil, hardware items etc. C & D waste is generated through demolition of civil engineering structures or due to rejected materials which cannot be used in the structures. For generation of such waste, substandard work, inappropriate methods, poor construction and maintenance management practices and policies of granting additional FSI on existing structures are largely responsible as they lead to reduction in life of structures leading to reconstruction and waste generation. In some places, the structures are just replaced for utilisation of funds.

Best way of waste management lies in prevention or avoidance of waste generation. Thus, waste avoidance needs to be implemented through quality control, appropriate construction techniques and proper construction and maintenance management.

INTRODUCTION

Construction and Demolition (C & D) waste is the waste generated from construction or demolition activities of civil engineering structures. Such waste is generated from the roads, footpaths, buildings, bridges, flyovers, dams, and other similar civil engineering structures. It consists mostly of inert and non-biodegradable materials such as bricks, stones, aggregates, concrete, aluminium, steel, tiles, wood, plastic, ceramic materials, electric wiring, glass, and many more similar materials. These waste materials are mostly heavy having high density compared to municipal waste.

Though some costly and recyclable materials such as metals, wood, and even recyclable plastic are removed in India manually while others become the part of C & D or even municipal waste. In case, C & D waste is mixed with municipal waste, municipal waste becomes heavy and cannot be used for composting or energy recovery. Therefore, C & D waste needs to be separately disposed. In case, this is disposed in any landfill, the structure cannot be constructed over the landfill due to uncertainty of the bearing pressure of the waste leading to unequal settlement and thus has to be removed for construction of buildings. Thus, best way of disposal of C & D waste is to use it as a resource material either by its reuse or recycle.

As per US, EPA-2003, US Environmental Protection Agency estimated that C & D debris totalled 170 million tonnes (mT) which included 15 mT construction waste, 71 mT renovations waste, and 84 mT demolition waste in US. Percentage breakdown in terms of residential and non residential classification is as shown in Fig 1. The waste due to construction is 9 %, due to renovation is 41 % and due to demolition is 50%. In non residential

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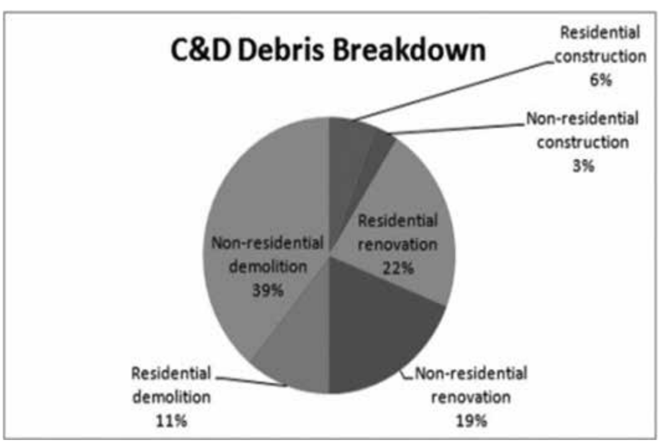
construction, waste is only 3%, and in residential 6% while in renovation of non residential buildings is 19% and residential is 22 %. In demolition, contribution to non residential structures is 39% while of residential is 11% only. If same trend is considered, above data indicates that in USA, waste due to renovation and demolition of non residential buildings is considerable. Reason of demolition due to non residential buildings may be due to cost of such properties going high and increase in permissible FSI. Once, FSI is increased, additional floors cannot be constructed over existing buildings due to inadequate foundation, hence, such buildings are demolished. Similarly, in urban areas, in case, FSI is increased, both existing residential and non residential buildings are demolished. Such additional construction also loads to services which also lead to demolition of such services. Also, there is a trend of internal renovation due to new materials coming in the market and money available with companies having offices particularly in urban areas. Therefore, it can be construed that in non residential buildings in urban sector, renovation and demolition lead to considerable waste generation.



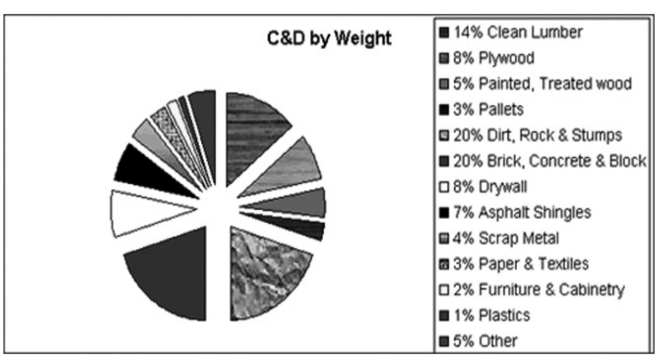


Fig. 1. Percentage of C & D Waste
(source: intechopen.com & co.orange.nc.us)

C & D WASTE GENERATION IN INDIA

In India also, C & D waste is generated from the same sources i.e. through construction waste, waste generated during renovation and demolition. But, there is a major difference in developed countries and countries like India where demolition waste is generated before the period it should have, due to some of the reasons listed below;

Unauthorised Construction

Unauthorised construction leads to C & D waste due to two reasons, one; due to demolition directly by the government and other; due to poor quality of construction resulting into short life of the structure. Such structures need to be demolished before their prescribed life.

Un-engineered Construction

Such construction is generally carried out in illegal or unauthorised colonies though regularised many times in future. Construction in such colonies is carried out hurriedly without proper design and specifications, even multi storeyed structures, generally by public as well as by builders. These structures have limited life due to poor quality and inadequate or no design, hence needs to be demolished much before the life of designed engineered structures, resulting into large C & D waste. Thus, there is a need of having a system of registration of the builders who can only construct the buildings after getting them designed. In case, the structures do not last for the designed life, builders should be held responsible for their safety and quality.

Poor Quality Construction

Poor quality of construction leads to short life of structures, large maintenance requirements, large renovations and high life cycle cost. Such construction is common in illegal and un-engineered structures and also in designed and engineered structures both being constructed in government as well private sectors. Such structures again lead to short life of structures, and large maintenance. Demolition waste is generated both in the maintenance as well in replacement of such structures before useful life of the structures. The registration of builders and contractors and making them responsible for poor quality in case of failure or defects due to construction may lead to better results.

Allowing Additional FSI

Additional FSI (Fig. 2) is allowed due to various reasons in the country by changing existing norms. When such additional FSI is made available, builders and owners demolish existing structures before they have outlived their life and create additional space which fetches them handsome profits. Thus, such policies generate waste from the demolition of structures and also from the existing services which become inadequate due to additional load required.

(source: 99acres.com)

Extra FSI for 2k redevpt projects in island city

Sandeep Ashar | TNN

Mumbai: A Bombay high court verdict has paved the way for about 2,200 redevelopment projects in the island city to avail of additional FSI.

A bench comprising Justice A M Khanwilkar and K K Tated, on March 20, struck down a condition imposed by

HC ON CESSED BLDGS

the government for grant of additional FSI in the case of ongoing redevelopment schemes for old cessed buildings.

In May 2011, while modifying development control (DC) regulations to increase FSI for such redevelopment projects from 2.5 to 3, the state had imposed a rider that in case of ongoing schemes, it can only be availed if the construction of the rehabilitation building had not progressed beyond the plinth stage.

A Mhada official informed that there were about 2,200 ongoing projects. A developer, J Gala Enterprises, had challenged the condition on grounds that the condition was "unconstitutional and ultra-vires".

The court ruled that extra FSI could be availed by ongoing incomplete redevelopment projects (where full occupation certificate has not been granted) on submission of structural stability certificate by a certified licensed engineer. Claiming that implementation of the judgment could lead to a trend where developers do not apply for full occupation certificates, Mhada has decided to seek a stay on the implementation.

(Source:mchi.net)

Fig. 2: C & D Waste Due to Additional FSI

Maintenance

Though, structures, particularly in the government sector are created but maintenance is not given sufficient weightage resulting into short life of structures. This is also true in many buildings, created by the development authorities/boards, particularly common areas. Thus, there is a need to give emphasis on proper maintenance, particularly by the governments by allotting sufficient budget by classifying repair and maintenance under plan head to avoid premature demolition of the structures and generation of large C & D waste.

Integrated Sanctions

When sanctions are taken in parts in the government departments, agencies take up works at different times and dismantle the works even executed recently. Such split sanctions, lead to generation of C & D waste. Thus, integrated sanctions should be accorded for all the works. Also, single agency should be made responsible to take up the works on behalf of all the agencies responsible for providing various utility services at a place to avoid dismantling of recently completed structures and thus generating C & D waste.

Integrated Trenches for Services

Integrated trenches should be constructed for utility services so that all the services are taken through the trenches for easy laying as well maintenance. This will reduce the C & D waste, generated in laying and relaying of services, and during their maintenance, repair, renovation and replacement.

Thus C & D waste needs to be avoided by;

- Not allowing extra FSI on existing structures till their useful life is over.
- Not allowing unauthorised structures.
- Not allowing un-engineered structures.
- Fixing responsibility on builders for unauthorised construction and quality.
- Maintaining quality in construction.
- Maintaining structures properly.
- Planning all services in trenches and giving responsibility to one agency for all such services in one locality.

C & D WASTE MANAGEMENT PLAN

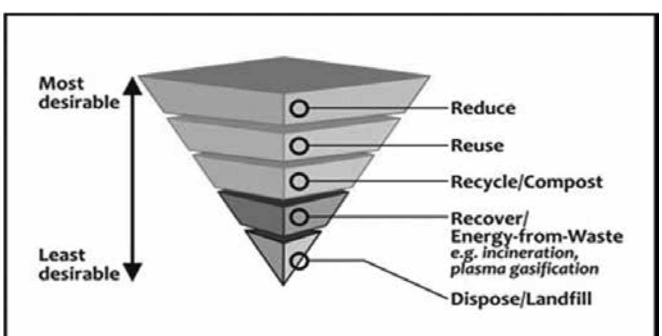
For any management plan, it is essential to have a policy so also for C & D waste management. Any management plan should include its objectives, organisation, structure, responsibilities and authorities, resources, management representatives and management review.

The objectives of the plan are waste prevention, reduction, re-use, recycling, energy recovery and disposal for sustainable development. The hierarchy (Fig.3) of the objectives can be summarised as;

- Prevention or avoidance
- Reduction or minimisation
- Reuse
- Recycling or materials recovery
- Energy recovery
- Safe disposal

The plan should include estimated quantities of waste, proposed and intended methods of its prevention, use, recycling, handling procedures, segregation methods, washing methods, guidelines, precautions and safety and pollution control requirements in various stages and disposal, quality management, incentives for its use as a resource etc. for effective implementation. Basic objective of the plan is;

- Avoid generation of C & D waste (prevention and reduction)
- To convert C & D waste into resource (reuse, recycle and energy recovery) and
- Disposal for engineering use



(Source:Ottawa.ca)

Fig. 3 : Hierarchy for Sustainable Development

Generally C & D waste management plans available in various countries revolve around waste generation during construction, renovation and demolition. It hardly provides emphasis on taking steps to prevent recurring generation of C & D waste due to unauthorised, illegal and un-engineered construction, poor quality of construction, maintenance and inappropriate techniques used in construction and maintenance which generate more C & D waste. This is because the idea of recycling of C & D waste is being imported directly from developed countries where unauthorised and illegal constructions are negligible and quality of construction is also considerably better and as such demolition waste is generated after useful life of the structures. Also, due to low rate of increase in population, vertical expansion of the buildings is not permitted frequently and as such structures are not demolished frequently for reconstruction. Therefore, an integrated approach is to be adopted during preparation of C & D waste management plans in India which should ensure that structures are not demolished before their useful life is over.

RECYCLING OF C & D WASTE

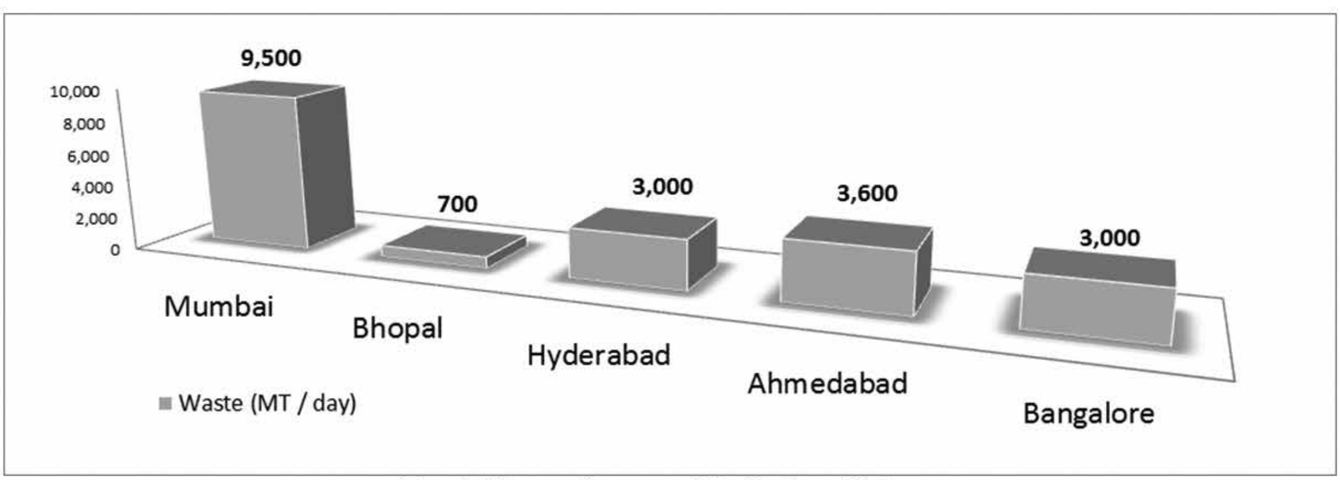
It is estimated that the construction industry in India generates about 10-12 million tons of waste annually, though some non government organisations do not agree to such a figure and claim for a very high figure. Building materials requirement of the housing sector is estimated to have a shortage of aggregates to the extent of about 55000 million cum. An additional 750 million cum aggregates is estimated for achieving the targets of the road sector. Thus, recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors. This is attracting C & D waste recycling companies to come in the market but they need favourable conditions, incentives and assured market. This would simultaneously ease the problem of the waste disposal for the governments/ local bodies. Recycling of C & D waste will become common due to large market available in the country including that of municipal solid waste in the near future.

Recycled asphaltic roads and recycled products like interlocking blocks, hollow and solid concrete blocks, bricks particularly for framed structures, tiles, wood etc. will gain popularity in future. Recycled concrete aggregates for use in concrete may find place even in concrete works, initially with lean concrete, as natural materials may become very costly and prohibitive. Recycled sand, and aggregates may get preference due to their categorisation as green materials and catchy names like manufactured sand/ aggregates. Though economic, they may not be cost effective initially compared to materials manufactured from primary materials but they would be classified under green building materials category and also government and industry may promote them, hence will become part of the construction industry soon. But one must ensure the quality of such recycled materials considering the life cycle of the structures else, recycled materials would be generating higher waste at less intervals than natural materials. In fact, today, C & D waste involves a considerable cost in its disposal but there may be a day, when C & D waste will be sold as a resource material and would not be available free of cost.

Large number of manufacturers of C & D waste machinery is available now as C & D waste recycling has become common in developed countries. The C & D waste has to be segregated first and thus segregation may be carried out at demolition site itself to avoid transportation though it is easier to have segregation near the plant. The agencies or individuals generating C & D waste would be asked to segregate C & D waste from municipal waste first and thereafter C & D waste would have to be segregated either by the agencies at the demolition site or they will be asked to pay for it. The government may impose a ban on mixing of C & D waste into municipal waste and thereafter only selected agencies may surface in the market for segregation, washing, and then recycling the waste. Recycling of each material would be done separately and marketed accordingly. Technology in production of recycled materials is based on C & D waste materials mixed with additional cement/fine materials/special additives/resins for manufacturing recycled materials like aggregate, concrete , bricks, tiles, wood etc. Crushers, mills, sand making machines, magnetic separators, washers, conveyors and other machines are available for recycling wastes. Now, even mobile recycling plants are available which can be installed at the site.

Roads can be constructed only with recycled materials in future with addition of additional quantities of bitumen and some other additives. At present this technology has not gained much popularity in India due to poor quality of roads as estimated quantity of bitumen is not available during recycling and thus recycling does not remain cost effective. Still, roads with recycled materials are being constructed in some parts of the country. But in case the quality of roads is maintained, recycling of bituminous roads would be a common feature and this would also reduce the C & D waste generated in raising the footpaths, relaying the kerb stones, separators, reconstruction of drains etc.

As already indicated, it is estimated that India generates about 10-12 mT per annumn of C & D waste. This waste may include about 4.20 to 5.14 mT of soil, sand and gravel, 3.60 to 4.40 mT of bricks and masonry, 2.40 to 3.67 mT of concrete and other miscellaneous items like metals, bitumen, wood etc.



(Source: nexusnovus.com)

Fig. 4 : Waste Generated in Indian Cities

Mumbai generates approximately 9500 MT (Fig.4) of solid waste every day, out of which 7000 MT is recyclable and bio-degradable and the remaining 2500 MT is C & D waste. The only landfill of Bhopal, the Bhanpur dumpsite, is located around 15 km away from the city limits. There are proposals of opening three more new landfills around the city expected to serve for a period of 20 years. The project cost is estimated to be around 400,000,000 INR. About 4000 tonnes C & D waste is generated daily in Delhi.

Thus, there will be excellent opportunities for international companies specialized in various waste management processes and interested in selling products, machinery and technology in India being a big and lucrative market. With a growing urgency for efficient waste management in many cities across India, there will be more and more projects which may be funded by central and state governments or even may be run on alternate funding modes. Foreign companies may also get the golden opportunities of partnerships with Indian companies to create integrated solutions in waste management and consultancy.

CONCLUSIONS

Waste management plan of C & D waste needs to consider avoidance of C & D waste by freezing FSI for the prescribed life of structures, ensuring quality, checking unauthorised and un-engineered construction and through proper maintenance. There is also a need to have registered builders who should only be authorised to take up construction even for private parties. Guidelines for the builders should be prepared considering the requirements of quality and engineered construction and fixing the responsibility in case the buildings show distress before their designed life. The hierarchy of C & D waste management plan has to be adopted through avoidance, prevention, reduction, reuse, recycle, energy recovery and safe disposal by segregating from municipal waste. Waste needs to be converted into a quality resource material by making its use in manufacturing recycled quality products. Urban services need to be planned in integrated way by way of laying them in pre-planned trenches. By adopting integrated waste management plan that includes municipal waste also; urban hygienic conditions will improve leading to better quality of life of the citizens.

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MANAGING C&D WASTE- A MCD INITIATIVE

V.R. Bansal*

Abstract

Construction and demolition (C&D) waste is the waste/debris generated during the construction, remodeling, repair or renovation, and demolition of buildings, roads, and bridges or land clearing activities. C&D materials often contain bulky, heavy materials.

The construction and demolition waste constitute about 25% of the 48 million tonnes of solid waste generated in India annually. C&D waste from individual households finds its way into nearby municipal bins and waste storage depots, making the municipal waste heavy, and degrading its quality for treatments such as composting or energy recovery.

This paper gives a Case Study

INTRODUCTION

Construction and demolition (C&D) waste is the waste/debris generated during the construction, remodeling, repair or renovation, and demolition of buildings, roads, and bridges or land clearing activities. C&D materials often contain bulky, heavy materials, such as

- Bricks, rubble or other masonry materials
- Soils, trees, or any type of vegetation;
- Rock
- Wood (included painted, treated and coated wood and wood products)
- Land clearing debris
- Wall covering, plaster, dry wall
- Plumbing fixtures
- Non-hazardous insulation
- Glass
- Roofing, waterproofing material and other roof coverings
- Asphalt pavement
- Plastics, paper, gypsum boards, electrical wiring etc.

The construction and demolition waste constitute about 25% of the 48 million tonnes of solid waste generated in India annually. C&D waste from individual households finds its way into nearby municipal bins and waste storage depots, making the municipal waste heavy, and degrading its quality for treatments such as composting or energy recovery. C&D is briefly included in the "Municipal Solid Waste (management and handling) rules, 2000" but there is no detail except a brief mention in Schedule II of the rule for its separate collection.

MCD INITIATIVE

Based on the then estimated C&D waste generation of about 2000 MT/day in Delhi, the then Municipal Corporation of Delhi signed an agreement with IL&FS Environmental Infrastructure & Services Limited for a pilot project at Jahangirpuri, Delhi (Fig.1) for Collection Transportation and Processing of 500 MT/day of C&D waste. The project is based on PPP model (Public Private Partnership) and is first of its kind in the country. Another project has been proposed for another 500 TPD capacity C&D plant in Shahdara, Delhi by East Delhi Municipal Corporation.

INNOVATIONS

Earlier the entire C&D Waste used to be sent Sanitary Land Fill (SLF) sites alongwith the Municipal

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Solid Waste (MSW), causing extra load on already over-flowing SLF Sites. With the implementation of this project, the C&D Waste is separated from MSW and re-cycled /re-used into useful building material. This, in turn, will help improve the life of such land fill sites.

This is first project of its kind in the country and selection of processing equipment as well as methodology adopted for processing had to go a number of reiteration/improvements. Due to the heterogeneous nature of incoming C&D Waste, the production process as well as the technology adopted for re-cycling had to be constantly fine-tuned and now, about 95% of incoming C&D waste is recovered.

Fig. 1: Project Site

Endeavour has been well appreciated by Ministry of Urban Development and has asked all states to look into the possibility of installing such facility in cities having population above 10 lac.

BENEFITS

Reducing and recycling C&D materials conserves landfill space, reduces the environmental impact of producing new materials, creates jobs, and can reduce overall building project expenses through avoided purchase/disposal costs.

SCOPE OF WORK

The scope of work for the project includes:

- C&D waste collection: this includes collection from designated location, on-call C&D waste collection services and operational call center/ helpline
- Transportation: This includes transportation of C&D waste from the designated collection points to the processing site, along with owning or hiring tricks for transportation.
- Processing: this includes wieghtment; segregation of C&D waste; screening through grizzly and wet processing/ dry processing.
- Selling Recycled Material: this includes use of recovered aggregates to produce variety of products including RMC (Ready Mix Concrete), brick dust and granular sub-base (which is sold as a building material), pavement block, kerb stone, concrete block, bricks etc.

C&D waste collection

A number of C&D waste collection points, atleast one in each ward, are designated by MCD, as per the concession agreement where C&D waste is collected and later transported to the plant site, either by the department or by the concessionaire. These waste collection points are identified at convenient places so that it is easier for the collection and subsequent transportation of the C&D waste. Endeavour is also made to create awareness for identifying new areas where C&D waste is available, in consultation with representatives of the concessionaire.

Transportation

The concessionaire is required to lift and transport the C&D waste from the designated sites of three zones i.e. Karol Bagh, Sadar Paharganj and City Zone. From rest of Delhi, the C&D waste has to be transported to the plant site by respective agencies. In case of transportation of C&D waste from the site to the plant by the concessionaire, the same is preferably done in the presence of representative deputed by the concerned MCD authorities/official. SLF Slip (Sanitary Landfill Slip) is generated in triplicate which is signed by JE and a copy is handed over to the Driver of the Vehicle

In addition to the collection and transportation done by IL&FS, other government agencies like DMRC are bringing the C&D waste to the processing plant for further processing.

On arrival of vehicle with C&D waste, quality of the waste is visually checked by Quality Control Supervisor. If quality is not acceptable as per

Concession agreement, vehicle is sent back with a Rejection slip

C&D waste processing

The activities of the C&D recycling plant can be classified into the following sections:

- Weighment
- Manual Segregation
- Processing of C&D waste
- Quality Testing and storage
- Sales and dispatch

Weighment

C&D waste being received at the plant site is weighed and weighment slip is generated in triplicate and one of it is handed over back to the concerned MCD official. Daily Report of C& D waste received is prepared by Weighbridge operator under the instructions of Plant Incharge and sent daily to various authorities at the plant as well as the EE incharge from MCD.

MANUAL SEGREGATION

Manual segregation of C& D waste is carried out. JCB is deployed to spread the unloaded waste in the incoming material storage area so that manual segregation is convenient. Workers segregate the bricks and stones and keep it separately for further processing. Concrete Blocks and stones are processed to recover recycled cement aggregates for RMC and then used in the Kerb stone, Tiles and Paver blocks etc. These high value concrete blocks are segregated manually and transferred to the Crusher for crushing and recovery of recycled cement aggregates.

Whole and partly broken bricks from the waste are segregated manually and stored separately. These bricks can be sent to plant to recover aggregates which can be sold to the customer. These whole bricks segregated are also used for In-plant construction works.

Manual Segregation of unwanted material like wood, plastic, cloth etc. is also done at feeding point. The collected MSW is sent to the Okhla facility for further processing.

The left over silt-soil mixture is sold to customers as filler material.

PROCESSING OF C&D WASTE

- Collected C&D waste is first screened through a 60 mm grizzly to remove loose soil and muck
- Over sized screened material is collected in the hand sorting section where bricks and concrete are separated
- Segregated Bigger size concrete boulders as well as mixed concrete are broken with the help of rock breaker
- Further size reduction is done with the help of processing machines

There are two methods of processing of C and D waste, i.e. wet processing and dry processing.

Wet Processing

The wet processing plant (Fig.2) involves the following steps:

- Feed reception: in this step the oversized materials are sized and removed. Also the undesirable materials like metals, plastics, rugs, woods are detected and removed. The mix is then fed into the hopper with an initial screen of 200mm to get the material of desired composition and size.
- Separation of Concrete and bricks: the concrete blocks of size over 200 mm are separated by hand and are stacked separately.
- Size reduction using impact crusher: the size of the concrete blocks and mixed C&D is further reduced using crushers, to size as suitable for the end use.
- Feeder Conveyor: the material is further fed into the hopper and the crushed material is then collected. The material is then feeded to prograde/ rinsing station.
- Screening: water is then added to improve the quality and to retrieve the fine particles. The material is then sent to the Log washer to separate light contaminants (i.e. Plastic and wood)
- Washing & Contamination Removal: the aggregates are sized by rinsing and using screens of different sizes. The clean and dry aggregates are sized and stockpiled into bays.

- Fines Recovery: the washed sand produced which is free from any silt is recovered. The size of the washed sand recovered is maintained at -3mm to +75 microns
- Water Treatment: the -75 microns material is passed to the Aqua cycle thickener. Specifically chosen flocculent is added to it in controlled quantities. Condensed sludge is then formed. The clean water is recycled.
- Waste Management: Filter Press squeezes water from sludge. Filter cakes of upto 80% dry solids are dropped into bay as final waste. This can be used for brick making/ pavement blocks/ CLC bricks etc.

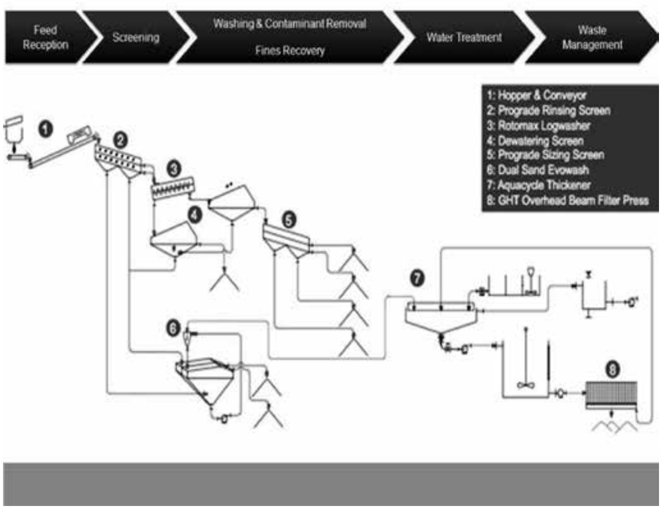


Fig. 2. Wet Processing of C&D waste

Dry Processing

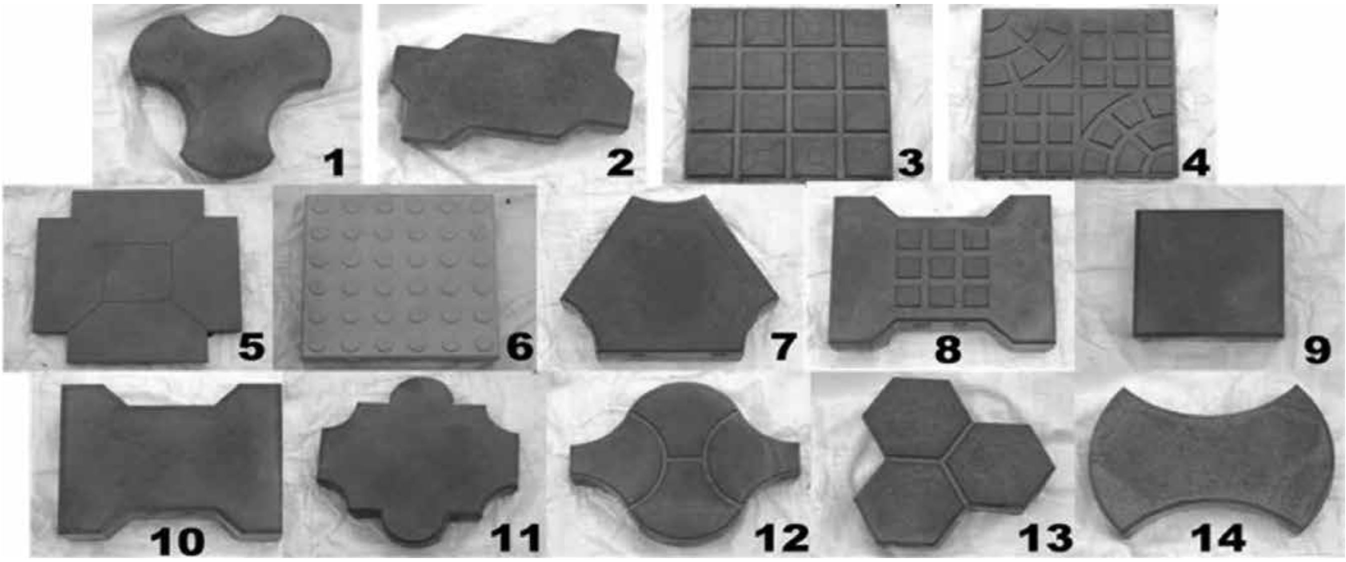
The dry processing is done by Rubble Master Compact Recyclers. The Rubble Master Compact Recyclers are the compact class for C&D Processing and produce high quality cubic value grains from construction debris.The machine is capable of processing @ 50 tonnes per hour. It is a diesel operated machine with inbuilt system for spraying water to minimize the dust generation. With the help of this machine, hand segregated concrete is crushed and graded to produce Recycled concrete Aggregates (RCA) The machine has been appreciated by the residents for its dust suppression and noise reduction cover system. It is compact processing machine and can be easily transported from one place to another and can be made operational in short span of time.

PRODUCTS

The following products (Fig. 3.) are made from the recycled C&D waste: -

- Recycled Concrete Aggregates (RCA)
- Ready mixed concrete
- Brick pozzolana
- Pavement blocks and kerb stones, drain covers, and any other non-load bearing pre-cast product
- Coarse sand and silt
- Brick sub-base.
- Mixed concrete and brick base is converted into granular sub-base which is used for making concrete blocks which meet the strength requirements of IS:2183.

Products from RCA



Fig, 3. Product from RCA

Strength specifications for the relevant products are strictly adhered to Strength Specification specified in IS 15658 is being adhered.

QUALITY MONITORING AND CONTROL PROCEDURE

Quality control of the finished products is monitored as per the relevant BIS norms. For RMC, samples are collected from the each and every batch manufactured in the batching plant and tested in the testing lab on 7th, 14th and 28th day for its hardness. The following is the acceptable level of hardness for the RMC manufactured.

- o For Kerbstones ----- →20 Kilo Newtons.
- o For Tiles & pavers --- →25 Kilo Newtons.

The aggregates are checked for contamination of other materials like bricks, plastics or any other unwanted foreign materials as also for any size variation.

ENVIRONMENTAL MANAGEMENT

Ambient Air Quality Monitoring

Ambient air quality is monitored at least every 2 months and readings recorded. Analysis of the particulate matter in the ambient air is monitored using the Gravimetric method. A PM(10) sampler is installed permanently for the purpose.

Noise Monitoring

Noise level inside the premises are measured and kept under the threshold level defined by DPCC.

For Day time -----→ 55 dB(A) Leq.

For Night time --- → 45 dB(A) Leq.

Noise level are monitored at least every 2 months and readings recorded.

Green Belts

Green belts have been developed along the periphery of the facility wall. Regular maintenance and watering of plants are being carried out.

SAFETY MANAGEMENT

Safety and physical hazards

Safe operation of plant activities is only possible with the complete cooperation of all personnel participating in the operation. A safe work place means a workplace where every attempt is made, by all involved, to recognize and minimize hazards and to train each employee in the proper procedures to manage those hazards.

C&D Recycling operations will involve certain risks because of the potential for encounters with heavy equipment used in processing, transportation during collection, foreign materials contained in raw materials, noise, dust, fire, etc. Stringent safety norms as per the industry standards are maintained at the plant site to mitigate the physical and health hazards.

Key Innovations Implemented

- Mechanical and Manual separation of concrete from mixed C&D waste.
- Processing of concrete and mixed C&D in batches,
- Size reduction of C&D by use of Impact crusher, as by use of Impact crusher better cleaning of aggregates is achieved (as compared to conventional jaw and cone crusher)
- Use of Vertical Shaft Impactor, to produce manufactured sand.
- Inter connection of process lines so that aggregates in usable sizes as per market demand can be made.
- Design mix of Ready Mix Concrete using 100% recycled concrete aggregates.
- Production of products like pavement Blocks, Pavement tiles, roof tiles
- With the implementation of the wet processing facility, recycled material upto 95% is obtained from the C&D waste, whereas, earlier only 40% was obtained.
- The 5% remaining comprises of wood and other material, which is sent for RDF generation.
- Above 500 tonnes of C&D waste is being lifted and processed at this plant

Therefore, the facility is a 0 waste plant.

CONCLUSION

Social / Environmental Impact of the Innovation are:

- Improvement in C&D debris management situation in Delhi
- C&D Waste is processed as per Compliance with MSW, 2000 Rules
- Urban areas have huge dump sites where Municipal Solid Waste for years has been dumped. C&D waste also continue to go to these dumpsite. By reuse of C&D, load on overflowing dumpsite is reduced
- City will be more cleaner
- Drain clogging is less
- C&D waste which is indiscriminately dumped throughout the city is processed and made into products, which can be again used by the building Industry
- Professional and scientifically managed project
- Improving efficiency of composting and energy Efficiency processes
- Long-term sustainable solution
- Constant endeavor for improvement through R&D
- Recycle and reuse of C&D Debris
- Gradual shift of illegal C&D debris dumping to legalized disposal system
- Phase wise transfer of C&D debris management cost to the generator / polluter.

CONSTRUCTION AND DEMOLITION WASTE: BEST MANAGEMENT PRACTICES

Dr. Shakti Prakash*

Abstract

Some of Construction and Demolition Waste (CDW) items like bricks, tiles, wood, metal are re-used and re-cycled. Concrete and masonry, constituting about 50 per cent of the CDW is not currently recycled in India. Very little effort to manage and utilize CDW has been made in India so far. Each city needs to have its own mechanism for collection and disposal of waste from bulk waste producers and construction debris. There is an urgent need for stipulating relevant standards for adopting and implementation of Best Management Practices (BMPs) and the development of the market for CDW recycled products for ensuring the environmental, social and financial sustainability. Reports of the city development plans prepared for several cities under Jawaharlal Nehru National Urban renewal Mission confirm that existing institutional capacities, mechanisms and resources are far from inadequate, resulting further in unavailability of quality data and information required for sustainable waste management.

The present paper intends to briefly overview existing situation of CDW management in India besides assessing potential business opportunities for the implementation of BMPs to overcome capacities and resources related inadequacies and deficiencies for making sustainable waste management a visible reality in building industry of India .

INTRODUCTION

Quantity of Construction and Demolition Waste (CDW) being generated in India has become a matter of vague speculation, because existing data regarding the same is more than decade old. Technology Information, Forecasting and Assessment Council (TIFAC) in 2001 in its report on C &D waste stated that the quantum of solid waste generation in India is about 48 million tones per annum of which waste from the construction industry accounts for 25 per cent or 12-14.7 million tones per annum. The Ministry of Urban Development in 2000 estimated 10-12 million tones of CDW annually which also finds mention in the Ministry of Environment and Forest report Road Map for Waste Management in India (2010). However, the Performance Audit of "Management of Waste in India" by Comptroller and Auditor General in 2008 noted, "No estimates or even guess estimates exist for construction and demolition waste" in the country. Research studies carried out indicate a continually sustained growth of construction industry in India from 2001 to 2014, except slow down in the year 2008. The Planning Commission of India has proposed an investment of around US$1 trillion in the Twelfth five-year plan (2012-2017), which is double of that in the eleventh five-year plan. The total investment in infrastructure, which also includes roads, railways, ports, airports, electricity, telecommunications, oil gas pipelines and irrigation – is estimated to have increased from 5.7% of GDP in 2007 to around 8.0% by 2012. Unofficial estimates of CDW indicate that India generated over 626 million tones of construction and demolition (C&D) waste in 2013, which is 52 times higher than decade old figure given by MOUD in 2000. Thus, management of CDW is and will be full of challenges and opportunities and poses serious risks for ensuring and achieving environmental, social and financial sustainability, pre-requisites for the sustainable development of infrastructure in the country. Causes of CDW generation have been summarized in table 1.

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Table 1; Causes of Construction and Demolition Waste

General	Specific
Lack of material management system	Wrong use of various grade of metal
Poor house keeping and storage condition	Silt content in sand
Poor Quality Control	Improper cutting of Steel
Adhoc procurement	Improper cutting of Steel
Contractors negligence	Use of dry cement
Unconcerned supervisory staff	Non –utilisation of cut piece of steel mishandling of cement bags
Untrained labour	Excess mortar/concrete preparation for cement, sand and aggregates
Non-use of left over materials	
Theft and pilferage	
Change in design and specification	
Improper handling	
Loss during transportation and application	

CDW can arise from a range of different origins, or site types, as has been summarized in Table 2:

Table 2: Origin of Construction and Demolition Waste

Demolish and clear sites	Sites with structures or infrastructure to be demolished, but on which no new construction is planned in the short term.
Demolish, clear and build' sites	Sites with structures or infrastructure to be demolished prior to the erection of new ones
Renovation' sites	Sites where the interior fittings (and possibly some Structural elements as well) are to be removed and replaced.
Greeland' building sites	Undeveloped sites on which new structures or infrastructure are to be erected
Road build' sites	Sites where a new road (or similar) is to be constructed on a green field or rubble free base
Road refurbishment' sites	Sites where an existing road (or similar) is to be resurfaced or substantially rebuilt.

As far as constituents of CDW in India are concerned, TIFAC in 2001 suggested following classification, as given in the table 3.

Table 3: Constituents of C&D Waste

Constituent	Quantity Generated in million tons p.a.
Soil, Sand, and gravel	4.20 to 5.14
Bricks & Masonry	3.60 to 4.40
Concrete	3.60 to 4.40
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

HAZARDOUSNESS IN C &D WASTES

Environmentally sustainable management of CDW has become a top priority among generators, by paying adequate attention hazardous components, as summarized in table 4:

Table 4:Hazardousness in C &D Waste

Waste Streams	Examples
Some C&DW steams are hazardous because the materials originally used contained a high proportion of materials which were themselves hazardous	asbestos, lead, tars, paint and preservative residues, adhesives, bonding agents and sealants and certain plastics
Some materials become hazardous as a direct result of the environment in which they have existed for many years	A factory where surface reactions between the originally non-hazardous building materials and chemicals carried in air (or water) pollution associated with the processes in or near the factory resulted in parts of the building's fabric
Some CDW become hazardous if hazardous materials are left in them and/or subsequently get mixed with them	Lead –based paint tins thrown onto a pile of bricks and concrete, making the whole pile hazardous waste

INADEQUATE EXISTING REGULATORY FRAMEWORK

CDW management in India is still not able to ensure environment, social and financial sustainability due to in-adequacies in existing regulatory framework and management practices. Isolated CDW management activities are visible in public domain. A brief discussion regarding some issues has been provided in following sections.

Existing Regulatory Framework:

Ministry of Environment and Forest promotes environmentally sustainable construction through environmental clearances based upon EIA Notification (2006) and subsequent amendments. Specific and General conditions ensure compliances to following legislations:

- Management and Handling of Municipal Solid Waste (2000)
- Management and Handling of Bio-Medical Waste (1998, amendment 2003)
- Management and Handling of Hazardous Waste (1989, amended in 2008),
- Recycled Plastics Manufacture and Usage Rules (2011)
- Fly Ash Utilisation Notification (2007 & 2009)
- Batteries (Management and Handling) Amendment Rules, 2010
- E-Waste (Management and Handling) Rules, 2011

Annual environment statements which are submitted to MoEF by different sectors of industry, have provisions for submission of date and information regarding all types of waste materials, however, seldom any industry report the adequate amount of data and information regarding waste generated and disposed.

However, no rules/guidelines had been enacted in India for the disposal of the following kinds of waste:

- Construction and demolition activities
- End of life vehicles
- Packing
- Waste tyres
- Agriculture/forestry
- Management of mining waste

At state level, Government of Maharashtra has notified the "Maharashtra Non-Biodegradable Solid Waste (Proper Scientific Collection, Sorting and Disposal in Areas of the Municipal Corporation) Rules, 2006" wherein reuse of CDW is included in the action plan. Municipal Corporation of Greater Mumbai notified the "Construction, Demolition and

De-silting waste (Management and Disposal) Rules". Other municipalities involved significantly in CDW management are Delhi, Hyderabad and Chennai.

Under present system of regulatory framework of MoEF, there is no mechanism to ensure:

- How the generator of CDW will ensure its disposal in environmentally sustainable manner.
- The mandatory use of recycled CDW waste
- Technical Standards and Specifications regarding waste utilization
- Research and development based database regarding any aspects of CDW including Best Management Practices and Environmentally Sustainable Technologies to be involved
- Development of an organized market for recycled CDW

The IS:323-1970, Indian standard specification related to aggregates for concrete states that these should be from natural sources. Thus only virgin materials (sand, aggregate) mined directly from nature can be used. This does not allow the use of recycled or reused components. Thus, arises legal complications in the use of recycled aggregate becomes illegal. Public voices have been raised for required amendment in this standard.

Similarly, MoEF Report "Road Map for Waste Management in India" (2010) says that "Amendment should be made to the existing MSWM Rules 2000 to include and address the CDW with guidelines for its collection, utilization and safe disposal". However, majority of stakeholders have a view that there should be a separate regulatory and management framework for CDW in India.

Existing Management Practices

Among the various approaches, the manual separation is highly labour oriented and the mechanical separation requires costly installations. The present CDW handling practices in India at different levels are:

- Discounted sale of CDWs in the market
- Inadequate attention to assess the feasibility of recycling in most cases
- Items that cannot be re-used are used for filling the land.
- No mechanism for landfill tax among municipalities
- The waste is disposed without segregation
- No penal action is taken against violators
- Inadequate awareness regarding cost savings from proper handling of CDW.

NEED FOR ECO-INNOVATIONS– DEVELOPMENT AND IMPLEMENTATION OF REQUIRED POLICY

As pointed above that a separate regulatory framework does not exist in India. Apart from this, inadequacies in financial instruments, rare cases of Public Private Partnerships (PPP) have resulted in the underdevelopment of CDW management market. Market forces or instruments like self obligation of the industry can be very successful in India also as are in other countries like USA, Germany, Canada, Austalia etc. Eco-innovations, through high level research and development, are required in all aspects and areas of CDW for bringing required support for the acceptance, possibilities of use and quality standards of the generated recycling products.

Establishment of Best Management Practices

Key essential infrastructural requirements for applications of BMPs are as follows:

- Establishment of specialized departments to deal with CDW issues
- Provision of a dense network of transfer stations, where separated fractions of CDW can be disposed of free of charge by anyone
- Introduction of CDW collection systems preferably operated by private enterprises, in order to ensure efficiency and reduce costs.
- Installation of CDW recycling plants, where CDW fractions are turned into good quality products for new constructions or other uses.
- Establishment of materials testing laboratories to check the quality of recycled products, specially risk of contamination of CDW from old industrial sites, in order to increase confidence in these products
- Development of a mapping and monitoring system of the locations and availability of waste materials

- Establishment of special CDW networks and associations of stakeholders in the CDW industry
- Formulation of a separate legislation to support CDW recycling and minimize disposal to landfills.
- Introduction and enforcement of stricter safety standards to ensure safe disposal of hazardous and toxic waste.
- Revision of building codes, standards and specifications to allow for the use of lower quality products in lower value applications.
- Introduction of the concept of producer responsibility, which requires the manufacturer or supplier of goods to take back their products at the end of their useful life.

Establishing Required Quality Controls in Recycled CDW

The main barrier to greater market acceptance appears to be potential buyers' doubts about their quality and consistency rather than a lack of formal standards for recycled materials.

The International Recycling Federation has recently compared some existing national quality systems for recycled materials and made recommendations as to the structure which such systems should follow. Their recommendations are summarized in the table 5. In general, better product management tends to lead to a better final product which can be used in a wider range of applications.

Table 5: Quality Systems for Recycled C&D Waste

Heading	Sub-Heading	Notes
Resources	• Determination of sources of input material • Avoidance of contamination/ purity	• Sources might include unbound CDW hydraulically bound C&DW, industrial by-products or incinerator bottom ash • To be attained by selective demolition and collection of mineral and other CDW
Storage	• Pre-treatment storage • Post-treatment storage	• Raw materials should be stored separately to achieve good product quality • Treated materials should be stored separately according to quality classes
Preparation	Achieving the required properties	Preparation should be carried out in such a way as to ensure that the materials (s) fit specified quality classes
Type (quality classes)	Classification according to the envisaged end use	Recycled materials should be classified according to their intended use(s)
Engineering tests	• Particle size distribution • Frost resistance • Stiffness • Compactability	These and any other tests should (for the time being) be conducted according to national standards
Composition	• Percentage of other minerals • Mixing ratio • Detrimental components • Dangerous components	• Other minerals would be those which differ from the main product (i.e. concrete in asphalt granulate) • Mixing ratio gives the variability of percentages of different mineral products in the granulate mix. • Detrimental components are materials which adversely affect the mechanical

		behavior of the material • Dangerous components are organic or inorganic contaminants which create a risk for the environment
Environmental acceptability	Leachability	For recycled materials the parameters and limit values should be defined according to the quality class
External monitoring	Determination of parameters and frequency of testing	To be conducted by a laboratory or testing organization licensed or recognized by the Government
Internal monitoring	Determination of parameters and frequency related to volume of production and quality classes	To be conducted by either an in-house laboratory or an external organization

Source : The International Recycling Federation (FIR-2010)

POTENTIAL SUSTAINABLE BUSINESS OPPORTUNITIES

There exists a huge market for CDW management in India, especially for recycled concrete aggregate, bricks, concrete and wallboard reused as clinkers, roofing granules, aggregate for paving materials, and asphalt filler. Other areas are –soil stabilization, pipe bedding, landscape Materials. Quantified estimation of business opportunities in CDW in India is still not available due to lack of data and information. However, studies carried out at global level opportunities indicate that the global market for CDW recycling services may grow form $ 158 billion in 2011 to $322 billion in 2017.

Chinese and Japanese CDW Management companies are performing better and far ahead than Indian counterparts as far as realizations of business opportunities are concerned. Isolated business activities are also visible in Indian municipalities, for example IL & FS Waste Management and Urban Services Limited and Municipal Corporation of Delhi has entered into an agreement for setting up a CDW processing plant at Burari. Collected CDW is recycled into aggregates which are converted to ready mix concrete, pavement blocks, kerb stones and concrete bricks. However, the products manufactured by the recycling plant are finding no takers due to lack of information and the absence of Indian Standards. Similar types of initiative has been by European Business and Technology Centre in Mumbai. The city has devised collection; transportation and disposal of CDW at a fee and would like to have appropriate technologies to recycle such waste back into concrete block/paver block construction. Other municipalities involved actively in the CDW business are Hyderabad, Chennai. Government of Belgium has developed collaborations with Delhi. More foreign collaborations, promoting the use of advanced technologies, are expected to grow due the increase in Foreign Direct Investment (FDI) in construction sector.

Measures to be Taken for the Strengthening of the Existing CDW Market in India

There are numerous means of promoting the use of recycled CDW:

- Countrywide data collection and identification of Hot spots for CDW reuse, especially the reuse customer base
- Increasing taxes on landfilling, tax exemptions on use of recycled products
- Organizations and associations need to be established to promote CDW activities.
- Special exchanges for salvaged and recycled goods must be established to facilitate selling and buying such products. This should be supported by entries and advertisements in professional journals and yellow pages of telephone directories.
- Good practice awards and eco-labeling also have strong effects in promoting the use of salvaged and recycled CDW
- Public buildings that have been built with salvaged

and recycled CDW are the best advertisements of the technology

CONCLUSION

- Lack of updated data and appropriate regulatory framework on construction and demolition wastes poses serious management and sustainability challenges
- India is lagging far behind not only in providing quantified estimates of CDW but also in realization of enormous business opportunities existing in the CDW sector.
- Business opportunities (customer demand) for recycled CDW are likely to grow as environmental consciousness grows, new building materials become more costly and household incomes (and therefore construction budgets) become increasingly constrained
- CDW recycling enhances natural resources conservation and ultimately bring resource efficiency, one of significant objectives of Green Economy
- There is a need for detailed technical studies of designated agencies to speed up certification especially for the standardization of alternative material/recycled CDW.
- Generations of CDW must not only, ensure quantified targets for the use of recycled concrete in both road construction and building industries, but also provide reliable data and information including sustainability performance indicators, in the public domain regarding reductions achieved in natural resource exploitation and waste going to landfill. This will bring wider level public acceptance for the use of the recycled concrete.

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NEED FOR PROPER MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE

J. BHATTACHARJEE*

Abstract

Natural resources are not unlimited and are being depleted with time. Unnecessary wastage of natural resources must be restricted and regulated for our sustainable development. Construction and demolition waste is generated whenever any construction/demolition activity takes place. It consists mostly of inert and non-biodegradable materials. These materials contain lot of re-usable materials. Recycling can turn the otherwise waste material into usable product, which can help in conserving our natural resources for our future generations and for the sustainable development of the society. This requires a proper waste management plan.

This paper deliberates on formulating and implementing proper waste management plan throughout the life cycle of the projects, which can minimize the waste. With an integrated resource management, most of the construction and demolition materials can be recycled and more natural resources can be conserved for our future generations. The success of recycling and using recycled materials in high value applications requires promotion by means of education in educational Institute, awareness through Seminars/Conferences etc, in addition to statutory rules from the concerned Govt. authorities. In the paper, it is highlighted that in most of the developed Countries, they have formulated their own strategies on management of waste at National level.

INTRODUCTION

The construction activities generate over million tones of construction and demolition (C & D) materials every year. The materials though contain a lot of reusable materials, if not properly managed they will become real waste, a burden to the society, which become extremely expensive to handle and occupy precious landfill space. This paper contains an overview of the concept on waste management and how proper waste management plan at the life cycle of construction can reduce its generation, maximize its direct reuse, increase the opportunity for recycling and reduce the need and hence the cost associated with disposal as waste. The construction activities include site formation, road works, tunneling works, demolition of buildings, bridges, flyover, subway, reconstruction work and maintenance works. Most of these materials are inert materials such as earth, rocks and concrete, which can be reused or recycled. Even timber and wooden materials can be reused or recycled, if properly handled. With the prosperity and rapid development of a society, our certain section of society in general has become more extravagant and less concerned on conservation of natural resources. A numbers of factors are contributing to this situation. The construction in India generates about 10-12 million tons of waste annually. As a result, lots of natural resources are being drained away as waste and require extra expense and resource to handle and accommodate. It is not only creating environmental and social problem, the society is consuming the remaining resources at a much faster rate than is necessary. Therefore there is an urgent need for proper waste management in our country for the sustainable development.

CHARACTERISTICS AND STORAGE OF WASTES

The category of waste is complex due to different types of materials being used but in general may comprise major and minor materials. Major components in buildings are cement, bricks, cement plaster, steel, rubble, stone and timber/wood. The minor components are conduits (iron and plastic),

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pipes (GI, iron and plastic), electrical fixtures, panels (wooden and laminated) and others items like glazed tiles, glass panes etc. The wastes are best stored at source i.e. at the point of generation. If they are scattered around or thrown (which normally is common in India), they not only cause obstruction to traffic but also add to workload of the local body. The following measures need to be followed.

- All construction/demolition waste should be stored within site itself.
- Attempts should be made to keep the waste segregated into different heaps as far as possible so that their further gradation and reuse is facilitated.
- Material, which can be reused at the same site for the purpose of construction, leveling, making road/pavement etc. should also be kept in separate heaps from those to be sold or land filled.
- The local body or a private company should arrange to provide appropriate number of skip containers/trolleys on hire.
- For large projects involving construction of bridges, flyovers, subways etc., special provision need to be made for storage of waste material. Depending on storage capacity, movement of waste has to be planned accordingly.
- In case of repair/maintenance of roads, water pipes, underground telephone and electric cables etc, normally wastes are neglected. In coordination with municipality, the debris generated should be removed by the concerned departments and contractors.

RECYCLING AND REUSE OF WASTES

The use of the demolished materials basically depends on their separation and condition of separated materials. Majority of these materials are durable and therefore, have a high potential of reuse. It is desirable to have quality standards for the recycled materials. The construction and demolition waste can be used in the following manner:-

- Reuse (at site) of bricks, stone slabs, timber, conduits, piping railings etc to the extent possible and depending on their condition.
- Sale/auction of material, which cannot be used at site due to design constraint or change in design.
- Plastics, broken glass, scrap metal etc. can be used by recycling industries.
- Rubble, brick bats, broken plaster/concrete pieces etc. can be used for building activity, such as leveling, under coat of lanes, where the traffic does not constitute of heavy moving loads.
- Larger unusable pieces can be sent for filling up low lying areas.
- Fine materials such as, sand, dust etc. can be used as cover material over sanitary landfill.

STRATEGY FOLLOWED IN VARIOUS DEVELOPED COUNTRIES

In order to minimize the adverse impact, both social and environmental, most developed countries, such as Germany, Denmark and Hong Kong etc. have formulated their own strategies in management of waste at national level. Such measures include followings:-

- Setting target on achievement on recycling by stages.
- Imposing heavy tax on waste disposal.
- Imposing aggregates tax to encourage use of recycle aggregates.
- Increasing effort in education and information on waste reduction and recycling to identify and exploit opportunities and overcome the barriers and obstacle due to conservatism.

Generally speaking, the following strategies in hierarchical orders are adopted by most countries:-

- Minimizing the generation of waste in the first instance.
- Reusing the C & D materials in its original form as far as possible.
- Recycling with minimal input of energy.
- Disposing of the waste environmentally.

LESSONS TO BE LEARNT IN INDIA

As per International experiences, there is a requirement of adopting following initiative/measures in India to deal with the situation.

- Promoting separation of C & D waste at source.
- Promoting recycling.

- Ban on land-filling of C & D waste.
- Developing market for recycled products.
- Production of concrete bricks and paving blocks etc.
- Issue of guide lines and policies for using C & D waste. Policy is required to be framed for mandating the data collection and analyzing data by national nodal agency.
- To take initiative for changing relevant regulations, BIS standards and modification of building by-laws etc.
- Developing designs, which facilitate "deconstruction" instead of outright demolition.
- Promoting building materials with longer life.
- Disseminate knowledge about C & D waste through school/college and seminars etc. The crucial factor for success of C & D waste management program is information, education and communication
- To promote proper utilization of waste through R and D initiative.

In India, mostly people are not aware about importance of waste management. Despite introducing several schemes, municipal corporations have failed miserably in most part of the country to streamline the waste management in cities/ towns. Since people are mostly unaware, so no segregation of wastes. Most schemes are unsuccessful due to poor monitoring by municipal authorities; no proper accountability and lack of proper infrastructure. Since no recycling is properly operatives, landfills are choking. These situations are existing in place like Delhi also. Delhi and other cities mostly failed, though tried to segregate waste. As per current reports, since no incentive so far provided for sorting garbage at home, problem is getting compounded. Further tonnes of recyclable waste is being dumped at land-fills every day. Waste dumps are contaminating ground water and probably reaching Yumuna River through sewers. Further, burning waste on landfill, especially plastic, can release toxic emissions that pollute the air near landfill. Major health threat is apprehended not only to just waste pickers, but also to the people living nearby.

RECOMMENDATIONS

For successful implementation of the waste management strategy, it is required to formulate, implement, monitor and review waste management plan during life cycle of the projects. In advance countries, such as Germany and Denmark etc, waste management plan is not only established in corporation level, it has been extended to state or central level also, to show the determination and commitment on waste management. In general, waste management plan should cover activities at all stages, from conceptual and planning stages to design and construction stages, and to maintenance and reconstruction stages, with life cost on waste disposal taken into consideration. In fact Govt. should issue technical circular requiring the implementation of waste management in all public works projects, which most of the advanced countries are doing. Further Govt. should also encourage the private sector to adopt the scheme. In addition, there is also a requirement to motivate by giving financial incentive on management and reduction of waste by implementation of construction disposal charging scheme. Heavy penalty for non-implementation may also be resorted to make waste management scheme a success.

In India, Govt. took the initiative of getting a manual made entitled "Manual on Municipal Solid Waste Management" (Ministry of Urban Development, 2005), in which a chapter on "Construction and Demolition Waste" has been included. C & D is also briefly included in the "Municipal Solid Waste (Management and Handling) Rules 2000, but there is no detail available. The brief mention does not appear to be sufficient in view of growing quantum and the way it affects the overall management of municipal solid waste. It is felt that greater details and more teeth are required for controlling the situation and for leading to efficient management of C & D waste. The principle of "3R" –reduction, reuse and recycle need to be implemented on priority for C & D waste. In this systematic collection is crucial for success of C & D waste management system.

In India, reliable data regarding quantum and characteristics of C & D waste is scanty and without authentic data no proper planning can be done. A nodal agency needs to be created in each state, which would receive all information gathered by Urban local bodies. The state level nodal agency should create a data base and data analyzed by expert organizations and evolve ways to use the materials in the best possible manners. The utilization potential may vary for different parts of the country, therefore involvement of the state level agencies would be essential; but overall help and supervision of the central Govt. would be useful. Based on the recommendations from different parts of the country, the relevant regulations and by-laws for civil construction should be modified, so that the recycled C & D waste can be used properly. The working sub-group on construction and demolition waste is working on guide-lines for appropriate management of C & D waste under Indian conditions. There is a need for regulation to be formulated and implemented on ground in a time bound manner.

The following points are suggested for consideration by the competent Authority in the Govt.

- The civic authority need to notify that no person should dispose of construction/ demolition waste on the streets/pavements/ storm drainage/open land belonging to the municipality or the other Govt. Agencies. Some accountability to be fixed for violating the instruction and to be monitored on ground.
- Such waste should be stored within the premises, till they are removed from the site to a place notified/permitted by the local body.
- The primary responsibility of removal of such waste would be that of the generator of such waste. The civic authority should charge suitably for helping in removal of waste.
- The generator of waste should inform the concerned civic authority in writing in advance before undertaking activity and deposit fees in advance.
- For new construction, the advance is to be deposited with the application for sanction of the building plan.

These rules should be made applicable for all types of construction by Govt./Semi-Govt./Public Sector Deptt. and private sector also. The building Control Authority has to work more closely with the industry to shift from conventional methods to sustainable construction. There is a need for adoption of proper methods for recycling various waste materials. There is a need for promotion by means of education at school/college level and also through Seminars/Conferences for recycling and using recycled materials, for saving the natural resources.

The specialized equipments which are available internationally for demolition and recycling need to be utilized/implemented on ground. This industry has got great potential of generating employment and income in India, through proper implementation of C & D wastes also. If the processing of waste is taken up in large scale in each city and towns of the country, then huge manpower will be required to collect, transport, sort out, process and market it in proper shape.

CONCLUSION

In India there is a great need of proper management of C & D wastes. As we all are aware that the natural resources are limited and are being depleted gradually with time. Since we are developing country, we have to go for lot of infrastructure development for our proper survival and thereby unnecessary wasting of natural resources has to be restricted and regulated. As brought out in the paper by formulating and implementing proper waste management plan throughout life cycle of projects can minimize waste significantly. With integrated resource management, most of the construction and demolition materials can be recycled and reused and thereby natural resources can be saved for our future development/generations. The success of recycling and using recycled materials in high value applications requires promotion by means of education and information through seminars etc, in addition to statutory rules from the concerned authorities. In fact we have to give more importance on implementation of various policies and schemes of the Govt. / authorities concerned.

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ECONOMIC ASPECTS OF CONSTRUCTION WASTE MANAGEMENT IN CONSTRUCTION INDUSTRY

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Abstract

The management of construction waste is important today. The scarcity in the availability of aggregate for the production of concrete is one of the important problems facing the construction industry. Appropriate use of the construction waste is a solution to the fast degradation of virgin raw materials in the construction industry.

The excessive wastage of materials, improper management and lack of awareness for waste reduction are common at construction sites. It is economically feasible to recycle construction waste up to 80-90% and most demolition and recycling technologies are easy to implement and control. Due to the growth in construction industry the amount of waste has increased considerably, which has a economic value.

This paper enlightens the importance of reduce, reuse and recycle (3R) concept for managing the construction waste. It also covers the economic feasibility of waste minimisation of construction waste materials.

INTRODUCTION

Construction industry involve large amount of natural resources and also generates large quantities of construction waste. The economic and environmental benefits gained from waste minimisation and recycling are enormous, since it will benefit both the savings along with conservation of natural resources. Presently, awareness of resource-efficient construction practices is lacking in India. The excessive wastage of materials, improper management on site and low awareness of the need for waste reduction are common in construction sites. Construction activities generate a large amount of waste that is becoming increasingly expensive to discard. In a study of construction firms, it is indicated that the costs for disposing of construction debris negatively affect their economic health. These costs also have negative impacts on the affordability of homes.

Various Constituents of Construction waste includes

- Soil, sand and Gravel ----------------------35%
- Bricks and Masonry -----------------------30%
- Concrete ----------------------------------25%
- Metal --------------------------------------5%
- Wood -------------------------------------2%
- Bitumen ---------------------------------2%
- Other -------------------------------------1%

(Source-TIFAC, 2009)

(Technology Information, forecasting and Assessment Council)

BENEFITS OF CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

Managing C&D Waste can achieve higher construction productivity, save in time and improvement in safety, while disposal of extra waste takes extra time and resources that may slow down the progress of construction.

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DRAW BACKS IN MANAGING C&D WASTE

Following are some of the reasons for not managing C&D Waste:-

- Lack of awareness in the industry:- There is a lack of awareness among construction industry players such as owner, builders, engineers, architects, service providers about waste management techniques and approach. Usually most of the waste that is produced during the construction process is the result of uncontrolled handling and lack of systematic approach.
- Lack of interest from owner:- Owner has least interest in imposing waste reduction and management practices into the projects, because owner is not aware of potential benefits of these activities.
- Lack of proper training and education:- There is lack of professional institutes in the industry which could significantly raise awareness among the construction industry about the possible economic benefits and its social consequences.
- Lack of skilled labour:- Construction labour in the industry is unskilled. They are not fully equipped with the knowledge of handling construction waste. There is need to train them. There are certain institutes like CIDC, IBC etc who under take this job of raising skilled labour.
- Cost benefits study:- Cost benefits study carried out in the construction industry for waste minimisation and management techniques are negligible. Whatever study done have not been popularised.
- Lack of Government regulations:- There are no regulations at present to check the disposal of construction waste in landfills, which is considered cheap and easy by the owner, builder. Though the same is not true. Whereas the disposal of waste through systematic approach is more beneficial and economical. Regulations like landfill tax or tax incentives to incorporate this approach in the project might enforce industry to explore cost savings seriously.
- Lack of waste reduction approach by Construction Players:- Usually construction players do not give preference to waste minimization approach during design, planning and construction stage. Designing as per standard minimum sizes will eliminate wastage on sites.

DIFFERENT SITES WHICH GENERATE C&D WASTE

C&D Waste can arise from a range of different origins, or site types, as defined in table1 below:

Table 1: Site Types

Type	Details
'Demolish and clear' sites	Sites with structures or infrastructure to be demolished, but on which no new construction is planned in the short term.
'Demolish, clear and build' sites	Sites with structures or infrastructure to be demolished prior to the erection of new ones.
'Renovation' sites	Sites where the interior fittings (and possibly some structural elements as well) are to be removed and replaced.
Greenfield' building sites	Undeveloped sites on which new structures or infrastructure are to be erected.
'Road build' sites'	Sites where a new road (or similar) is to be constructed on a green field or rubble free base.
Road refurbishment' sites	Sites where an existing road (or similar) is to be resurfaced or substantially rebuilt.

HUMAN ATTITUDES IN WASTE GENERATION

A number of studies have investigated the role of human behaviour in waste generation. The outcome of this research effort is recognition that, whilst construction industry participants recognise the impact(s) of their actions, there is reluctance within the industry to implement waste minimisation initiatives. Furthermore, despite recognition that human attitudes have major influence on waste generation there has been little research into the role of human attitudes in waste generation on construction projects, despite these comprising 99% of all work undertaken in the construction sector.

EXISTING C&D WASTE HANDLING MEASURES

The present waste handling measures adopted by the construction industry at various levels are

- Construction /demolition material sold at source in the market at a discounted price of new material.
- C&D Waste material not considered useable are disposed to landfill site maintained by local bodies.
- Different constituents of waste are not segregated prior to disposal except in certain areas.
- Builders/ owners bear the cost of transportation of C&D Waste to landfill sites
- Municipal authorities maintain landfill sites at their own cost.

There is no scientific approach in disposal of C&D Waste in the industry due to lack of awareness in the industry .

The C&D waste management methods are not practically implemented in most of the construction sites. This shows that the industry is not aware about the possibilities of cost savings from proper handling of C&D waste. In fact, higher construction productivity, save in time and cost can be achieved by proper implantation of C&D waste management system.

SEGREGATION OF C&D WASTE

The following type of C&D Waste need be collected separately.

- Hazardous and potentially hazardous C&D Waste ;
- Non-inert C&D Waste justifying sorting and separate collection;
- Inert C&D Waste justifying sorting and separate collection.

Hazardous and Potentially Hazardous C&D Waste

It identifies those components which are potentially hazardous, the properties that make them potentially hazardous, and some of the options most likely to be considered for their treatment and/ or disposal. Specific hazardous and potentially-hazardous items that may occur on new construction sites include:

(i) solvent-based concrete additives; (ii) damp proofing chemicals; (iii) adhesives; (iv) tar-based emulsions; (v) asbestos-based materials; (vi) mineral fibres (insulation); (vii) some paints and coatings; (viii) treated timber; (ix) resins; (x) plasterboard; (xi) empty or part empty gas bottles (from cutting, welding etc).

On demolition sites there are always likely to be some materials (such as asbestos and sodium/ mercury vapour lamps) which are hazardous in their own right. Residues of hazardous substances manufactured, used or stored at the site may remain. Where possible these should be removed from the site prior to demolition activities commencing. If they have become impregnated into the fabric of the building it may be possible to neutralise or treat them in situ prior to demolition.

Some specific hazardous and potentially hazardous items that may be encountered on demolition sites are listed below. These include some (the first three and the last) which also occur on the construction materials list provided above:

(i) asbestos-based materials; (ii) treated timber; (iii) mineral fibres (insulation); (iv) electrical equipment containing toxic components; (v) CFC-based refrigerants; (vi) CFC-based fire fighting systems; (vii) radionuclides; (viii) biohazards; (ix) empty or part empty gas bottles (from cutting, welding etc).

Refurbishment works are likely to produce a mixture of materials typical of both construction and demolition sites. Since the main fabric of the building is likely to be substantially untouched, the percentage of hazardous material is likely to be higher on refurbishment sites than on mainstream demolition or construction sites that it is unlikely to exceed 10% of the total.

Non-inert C&D Waste Justifying Sorting and Separate Collection

Some materials may be inert or relatively non-hazardous in situ, but could become hazardous depending on the disposal method. For example some treated or coated timber can give rise to toxic fumes if incinerated

Gypsum, when placed in a landfill can generate hydrogen sulphide, an acid gas.

Other non-inert materials and products justify sorting and separate collection as a result of their economic (resale) value.

Inert C&D Waste Justifying Sorting And Separate Collection

The main justification for sorting inert materials from the stream which will be crushed is economic.

USES TO WHICH C&D WASTE MAY BE PUT

Uses to which they may go once they have been collected on-site. These will include one or more of the following:

Re-use options

- re-use on-site for the original intended purpose;
- re-use off-site for the original intended purpose;

The re-use Materials be neither treated as waste nor recoded as such.

Recycling options

- on-site processing to recover high value saleable materials;
- off-site processing to recover high value saleable materials;
- recycling on-site for a low-value purpose (including non-essential land raising);
- recycling off-site for a low-value purpose (including non-essential land raising);

It is difficult in practice to draw a clear distinction between them, though they range from sending scrap steel to mini mills for processing into new steel to the breaking up (but not crushing) of concrete to produce material suitable for filling holes or creating noise bunds on the original site.

Incineration options

- off-site incineration with energy recovery;
- off-site incineration without energy recovery;

Landfilling options

- off-site landfilling of segregated waste materials;
- off-site landfilling of unsegregated waste.

The incineration and landfilling options are self explanatory, and incineration only applies to a few wastes such as uncontaminated wood waste and some plastics (including some packaging materials). In theory it may be possible to landfill C&D Waste in dedicated landfills with a view to future processing and recovery when market conditions are more favourable. In practice this option has seldom been used to date.

EFFECTS OF REDUCING AND RECYCLING C&D WASTE

Reducing and recycling C&D waste are important for their effects on both the environment and housing affordability. Environmental aspects are clear: landfill space is becoming more and more limited; faulty landfills pollute air, earth, and water; and illegal dumping of C&D Waste is increasing.

Regarding housing affordability, the builders pay twice for construction materials that could be recycled but end up in landfills: payment is made when the materials are purchased and fees are assessed when the materials are dumped. These costs are then passed on to homebuyers in the form of increased house prices.

MEASURES TO REDUCE CONSTRUCTION WASTE AT SITE

At present there are no practices adopted to reduce waste at construction site. Following measures are suggested for waste minimisation and site waste management practices:-

Government - Policy

Government to frame policy for waste reduction by

- Imposing Landfill tax to encourage the reduction of waste
- Providing a subsidy for recycled construction products,
- Providing tax benefits for the construction that use recycled products will encourage reducing, reusing and recycling of material waste in the industry.

Create awareness among Owners and Builders

Construction firms should be encouraged by setting up of various regional level federations and institutions which readily provide knowledge of economical benefits of waste minimization and management by appropriate techniques

Training and Education

Construction firms should take the responsibility to provide appropriate training to the unskilled labour about proper techniques to minimize construction waste. This is a step towards waste reduction at source.

Role of Engineers

Designers should design buildings with waste minimization into consideration. Use of standard dimensions and sizes can greatly improve waste reduction on sites. Engineers should recommend recycled materials in their specifications and should guide owners in other possible design approach to waste minimization.

RECYCLING OF C&D WASTE

Drywall Waste

Recycling of drywall waste is a best alternative. Some firms process gypsum board waste into new wallboard. But the low cost of raw gypsum makes it economically unsound. Another alternative is incineration, but air pollution concerns associated with that approach make it undesirable. A study of ocean dumping of gypsum board concluded that because the materials in gypsum board are naturally present in the ocean environment, this method of disposal would be environmentally favourable. However, public perceptions of ocean disposal of solid waste materials limit the usefulness of this option.

Another alternative for drywall waste is to use it as a soil improvement. Gypsum has a composition of 79% calcium sulphfate and 21% water; this calcium and sulphfur available from the pulverized drywall enriches the soil without the addition of heavy metals to the environment.

Further it is observed that fire resistant drywall, for example, has fiberglass in its composition; asphalt-based wax emulsions are used in moisture resistant drywall. These are not regarded as favourable soil additives. These concerns could be addressed by limiting drywall as a soil quality improver, but effective limitations would require strict controls.

In addition drywall waste from new construction sites is most commonly processed because it is free of contaminants. Equipment in place ranges from large grinding plants to mobile chippers. Gypsum is then sold as pellets or powder for agricultural and other uses.

More research is needed to investigate feasible methods that can be used at construction sites to reduce the amount of waste drywall that is being generated.

Wood Waste

Wood waste is another significant component of debris from construction sites. Viable options to land filling include recycling for use in composite wood products, mulching on site, and collection for other uses. The amount of wood waste from new construction alone is substantial.

Use of Construction & Demolition Waste in Road & Building Construction

Major conclusions drawn from the detailed fields / laboratory investigations Conducted at Central Road Research Institute (CRRI), New Delhi & Central Building Research Institute (CBRI) Roorkee leads to the following conclusions:-

- The specific gravity of C&D waste aggregates being lesser than conventional hard stone aggregates can be attributed to presence of brickbats and mortar.
- Crushed C&D waste or sieved C&D waste can be utilized for construction of embankment. The side slopes of embankments can be protected against surface erosion. C&D waste can also be utilized for construction of sub-grade.
- Mechanically stabilized C&D waste mixture with C&D waste aggregates and powdered C&D waste in the designed proportion can be used for sub-base layer. C&D waste has a marginally lower ten percent fines value and hence may be used in lower half of sub-base course for high traffic density roads.

- Powdered C&D waste or mechanically stabilized C&D waste mix (mixture of C&D waste aggregates and C&D waste powder) can be stabilized with 5 per cent of cement and used for base course construction. Cement stabilized C&D waste can be used to replace lower layers of WBM or WMM layers in road pavement.
- C&D wastes be used for construction of low traffic volume colony roads.
- C&D wastes can also be used for widening of high traffic volume roads in case necessary width for rolling operations is available.

Use of Concrete & Masonry waste in construction of roads

In India, the concrete [Reinforced or Mass Concrete] and masonry waste, quantifying almost more than 50% of the total C&D waste, is presently neither being processed nor used for pre-planned purposes like construction of road(s), cubes etc.. Whereas, the concrete and masonry waste can be used by sorting, crushing, washing and sieving to achieve well graded aggregate(s). This aggregate can be used for making concrete for road as well as for building construction, besides for mortar in building construction. The Central Building Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi is working on aggregate recycling.

Other C&D Waste

Other components of construction debris include cardboard from packaging materials, roofing shingles, asphalt impregnated felt, pressure treated wood, containers, ferrous-based and other metals, masonry and ceramic materials, plastic and paper. Many of these materials can also be diverted from a landfill.

ECONOMIC FACTORS AFFECTING RE-USE AND RECYCLING

The component of materials cost is nearly 40%–60% of the project cost.Thus material waste generation from construction industry is also huge in monetary terms. Therefore it is desirable that economical evaluation is conducted for C&D Waste for cost benefits.

Proper waste handling on construction sites can economically benefit a project and the construction industry. Generally, economic feasibility is carried out by standard measures of profitability, which is cost-benefit analysis. Waste management makes good economic sense and at the same time it can improve production efficiency, profits, good neighbour image, employee participation, product quality and environmental performance.

Although some potential users of aggregates do choose recycled materials to enhance their 'green credentials', but most choose C&D Waste -derived aggregates whenever:

Equation $Qp + Tq > Er + RCp + Tr$ ------------(1)

where: Qp = Price of newly quarried product at the quarry gate

Tq = Cost of transport from quarry to site

Er = Any extra costs created by using C&DW-derived aggregates

RCp = Price of recycled product at the recycling centre gate

Tr = Cost of transport from recycling centre to site

In the above mathematical presentation

- Qp is fixed by market forces.
- Tq and Tr will largely depend on distance, Tq will be significantly different from Tr (unless the C&D Waste -derived aggregates are re-used on their original site, in which case Tr = 0). Most urban areas are adequately served either by local landfills or by locations where a fixed C&D Waste recycling facility could be installed. The trend is for wastes to travel longer distances to disposal facilities, rather than attaining recycled material form recycling plant.
- Er- Representing the price advantage which the user demands before buying C&D Waste-derived aggregates instead of primary material.

Whoever is driving the process as the demolition manager, his decision can also be expressed as an equation. He can choose selective demolition and separate handling whenever:

Equation $Vm(Tm + Dm) > V1(T1 + R/D1 - SV1) + V2(T2 + R/D2 - SV2) \ldots Vn(Tn + R/Dn - SVn) + Es$--(2)

where: Vm = Volume of unsorted C&D Waste

Tm = Cost of transporting unsorted waste to disposal site

Dm = Cost of disposing of unsorted waste

V1 = Volume of inert waste

T1 = Cost of transporting inert waste to recycling or disposal site

R/D1 = Cost of recycling or disposing of inert waste (including quality control costs)

SV1 = Sale value of recycled product (if relevant)

2 ...n = Other sorted waste streams

Es = Additional costs of separate demolition and materials sorting

SV1 as defined above is equal to RCp from the first equation.

The link between the two equations specified so far has already been identified as the returns from recycling (SV1 or RCp). Recycling will generally occur if these returns exceed the costs of recycling. Taking the relatively simple case of the demolition contractor with his own recycling centre, this means where:

Equation SV1 (or RCp) > Dc - Df + T1 + R/D1 + LFri + Tri + recycler's profit margin----(3)

where: Dc = Full on-site demolition costs not paid direct by the site owner,

including Es (previously defined)

Df = Demolition fee (paid by site owner to demolition contractor)

T1 = Transport costs (previously defined)

R/D1 = Costs of crushing and sorting inert wastes (previously defined)

LFri = Costs of landfilling residual (post-crushing) inert materials

Tri = Costs of transporting residual inert materials to landfill

Dc will be heavily affected by the specific characteristics of the site, and the extent to which machinery can be used to demolish the structures there. Where the recycling process relies on a mobile crusher on the original site T1 will be zero. In general LFri and Tri will be small.

Fly tipping' is the practice of illegally dumping waste. This is usually done beside a road, or on open land, or in a wood. Although these are being actively closed down as waste management practices improve. Some of these still receive MSW and C&D Waste with the local authorities' tacit approval.

Economic theory suggests that 'fly tipping' is likely to be more of a problem where landfill charges are high. However, experience would suggest that once the industry has adjusted to higher charges, 'fly tipping' will revert to something like its previous level.

(Source –Report to DGXI European Commission February 1999 on Construction and Demolition Waste Management practices and Their Economic Impacts.)

CONCLUSION

Inflationary pressures, relatively low skilled and uneducated labour, government bureaucracy, and lack of infrastructure are some of the negative points that make the construction activity more challenging. There is an urgent requirement for a infrastructure plan for India to continue on its high growth path towards economic maturity. The salient points for C & D Waste Management are:

- Strategies to mitigate the problem at industry level will require government policy decisions to initiate the waste minimization and management system.
- The high costs of landfill charges and high taxes of using virgin materials can create a derived demand - supply dynamics in the construction industry.
- Benefits from cost savings will encourage more builders to adopt and compete in the market. This will initiate market competition to evolve in the industry which will soon appear at significant level.
- The exploitation of potential resources from construction and demolition (C&D) Waste is best opportunity and future profession in the construction industry in India.
- Waste minimization and waste management programs are in its infancy in India.
- It is possible to minimize the volume of C&D waste generated by identifying the potential waste early in the design.

STUDIES ON CONCRETE MADE WITH RCA UNDER LABORATORY CONDITIONS

K. SIVARAMAN* AND S. KOTHANDARAMAN**

Abstract

Although Construction and Demolition (C&D) waste is a problem of increasing magnitude, there is little consensus about its volume. In most countries these wastes are not given due consideration to reuse them in constructive manner. It is reported that in Europe alone C&D wastes represent 450 million ton per year, which constitute 35% of the total wastes. Engineers and scientists have coherently worked and significantly contributed to our knowledge on the use of C&D wastes. However, still we have to go a long way to establish certain facts to inculcate the confidence to use C&D wastes for construction purpose. One of the problem is the variations in the property and the availability of contaminants in C&D wastes.

This paper presents the findings of an experimental investigations on fresh and hardened properties of concretes made with RCA. Two grades of concrete mixtures have been considered. Natural aggregate was replaced with RCA in 0, 30, 60 and 100 percentages. Compressive, flexural and split tensile strength have been assessed. The test results show that the concretes made with RCA have higher strength than the reference concretes.

INTRODUCTION

Construction of buildings and structures is not an environmentally friendly activity. It was considered that only the manufacture of building materials, such as cement, steel, bricks etc. was responsible for the environmental degradation. But now it is realized that the wastes produced through construction and demolition (C&D) of buildings have also become another source of threat to environment. Recycling of C&D wastes is of paramount importance because it reduces environmental pressure. It prevents an increase in the area needed for waste disposal and also avoids the exploitation of non- renewable raw materials (Pacheco-Torgal et al 2013). Sonigo et al (2010) reported that in Europe alone C&D wastes accounting to be 970 million tons/year, represents an average value close to 2.0 ton/per capita. Worldwide aggregate consumption is around 20000 million tons/year and an annual growth rate of 4.7% is expected (Bleischwitz and Bahn-Walkowiak 2011). Though the use of C&D wastes as recycled aggregates in concrete has been studied nearly for the past two decades, there are still too many concrete structures made with virgin aggregates. There are social, economic, political and technical barriers embedded with the promotion of C&D wastes in construction practices. Various countries, like China, Finland, Germany, Ireland, Japan, Norway, Spain, Hong Kong, UK, and France have their own national plan and regulation for effective use/disposal of C&D wastes.

CONCRETES WITH RECYCLED CONCRETE AGGREGATES (RCA)

Concrete is widely used construction material. It consists of nearly 80% of stone aggregates. RILEM (1994) classified C&D wastes into Type-I (Recycled masonry aggregates), Type-II (Recycled concrete aggregates) and Type-III (Blend of recycled and natural aggregates). Natural aggregates (NA), RCA and mixed aggregates will absorb maximum 3%, 12%, and 20% of water respectively (Agrela et al 2013). While using RCA for concrete, superplasticiser (SP) may be added to compensate the increase in water demand. It is also suggested that RCA may be pre-saturated before preparing the concrete mixture.

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Mechanical and durability properties of concrete made using RCA have been studied (Nixon 1978; Hansen 1992; Topçu and Sengel 2004). Xiao et al. (2012) and Sánchez de Juan (2004) reported that the use of coarse recycled aggregate in concrete caused a reduction in compressive strength due to poor quality of RCA, high water demand, presence of weak zones etc. However, when limited amounts of RCA are used, the mechanical and durability properties of recycled concretes are hardly affected. In contrast, higher strengths can be obtained when RCA obtained from good concrete debris are used. When comparing the strength of recycled and conventional concretes, it is important to use the same effective w/c ratio for both (Katz 2003). If the RCA are used in dry conditions and their absorption is not compensated for in mix design, they will absorb water during the mixing process, reducing the effective w/c ratio and so improving the strength of the recycled concretes. This explains why, in some experimental studies, even greater strengths are obtained in recycled concretes than in conventional concretes (Agrela et al 2013). Sánchez de Juan and Alaejos (2004) reported that a maximum strength loss of 6% could be expected for a substitution of up to 50% in concretes with strength exceeding 40 MPa. And, there can be a significant decrease in compressive strength when 100% coarse recycled aggregate is used. The reduction level in strength is reported to increase with the increase in strength level.

Tensile strength, both splitting and flexure strengths of recycled concrete are reported to exhibit much lower reductions compared to compressive strength. Kou et al. (2011) reported that splitting strengths obtained by with 50 and 100% replacements, It was observed that although initial resistances were higher for conventional concretes (recycled concretes exhibit a tensile strength reduction of 10% at 28 days), at later stages (90 days) the values were similar for all types of concretes. This improved behaviour of recycled concrete regarding its tensile strength is attributed due to good adherence of paste- aggregate developed by the RCA. These aspects were studied by Katz (2003) and Poon et al. (2006). Xiao et al. (2012) revealed that the splitting failure in concretes manufactured with RCA initiated not only from the interfaces between the RCA and new cement paste, but also from some of the RCA itself. Concerning flexural strength, differences observed between the recycled and conventional concretes are reduced. That is a decrease of 10% was found in RCA concretes.

It is possible to produce concretes with RCA with comparable strength. However, if we aim high strength, either increase in cement content or reduction in effective water-cement ratio or both should be tried. In normal strength range, if RCA obtained from good quality concrete is used it is possible to obtain even higher strength.

EXPERIMENTAL STUDY

Materials

In the present work it has been decided to prepare recycled aggregates from the RC beam specimens used for some research work in the Department of Civil Engineering, Pondicherry Engineering College. The strength of concrete used for those specimens was in the range of 30 to 40 MPa and the specimens were more than one year old. Using jack hammer the specimens were broken and hammered manually to get the required size aggregates.

The aggregates, natural aggregates (NA), RCA, and fine aggregate (FA) (locally available river sand) were tested in accordance with IS: 2386 (1963) for gradation and other physical properties. The physical properties are presented in Table 1 and the grading of the curves for the aggregates are shown in Fig. 1.

Table 1: Physical Properties of Aggregates

Property	Test Results		
	NA	RCA	FA
Water absorption (%)	0.50	3.20	0.12
Specific gravity	2.62	2.43	2.65
Fineness modulus	9.10	7.60	2.28 (Zone- II)
Impact value (%)	19.66	32.65	---
Crushing value (%)	22.30	31.47	---

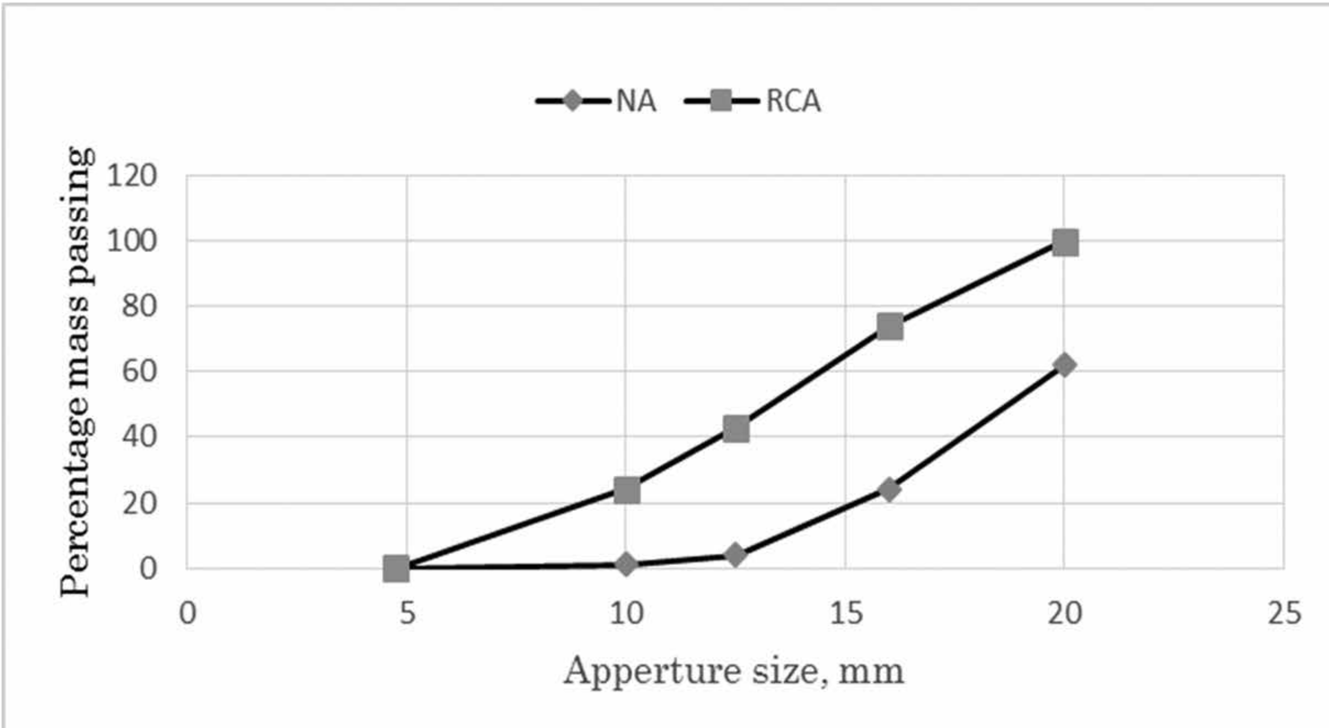

Fig. 1: Grading of Aggregate

Ordinary Portland Cement 43 grade conforming to IS: 8112 (1989) was used for the present study. The physical properties of the cement used are presented in Table 2.

Table 2: Physical Properties of Cement

Property	Test results
Normal consistency (%)	28.5
Initial setting time (Min)	185
Final setting time (Min)	240
Specific gravity	3.13
Compressive strength (MPa) of mortar at: 3-day 7-day 28-day	 28.0 36.9 46.0

Concrete Mix:

Two basic concrete mix (RM1 and RM2) have been considered in this work. The proportions of the mix are given in Table 3.

Table 3: Proportions of Reference Concrete Mix

Mix designation	Constituent Materials, kg/m^3				
	Cement	Water	FA	NA	SP
RM1	330	165 (w/c = 0.50)	730	1270	3.5 (1%)
RM2	450	175 (w/c=0.39)	650	1220	3.4 (0.75%)

On the above two reference mixes NA was replaced by RCA in the range of 30%, 60% and 100% by mass and these mixes were designated as RCA30, RCA60, and RCA100 respectively. It should be noted that in RCA mixtures the respective water-cement ratio was kept constant as indicated in Table 3. Naphthalene based superplasticiser (SP) was used. All the concrete mixes were proportioned for a slump of 75 – 100mm.

Specimen Preparation:

In order to assess compressive, splitting tension and flexural tensile strengths suitable size specimens were prepared and moist cured till the date of testing. For each category and age three specimens were tested. Pan mixer (55-110 l capacity) was used for preparing concrete and the specimens were prepared using a table vibrator.

RESULTS AND DISCUSSION

Various strength results are presented in Tables 4 – 6. It is found that compared to reference mixtures RCA mixtures have acquired compressive higher strength. As the RCA have higher water absorption capacity the effective water-cement ratio might have reduced in RCA mix and hence attained higher compressive strength. The strength has been on the increase at 30 and 60 percent replacement, however, at 100 percent replacement the increment level is reduced. While using 100 percent RCA, more water might have been observed to disrupt the hydration of cement.

The maximum rate of gain in compressive strength has been realized at the age of seven days and subsequently it gets reduced. Considering all the cases together the minimum and maximum gain in compressive strength are 5% and 54% respectively. With regard to the tensile strength, similar behavior as that of compressive strength has been noticed. However, the percentage gain is slightly smaller compared to the compressive strength.

Table 4: Compressive Strength Results

Mix designation	Compressive strength (MPa) at	
	7 days	28 days
RM1	22	28
RCA30	27 (+23%)	32 (+14%)
RCA60	30 (+36%)	34 (+21%)
RCA100	23 (+5%)	27 (-4%)
RM2	30	35
RCA30	42 (+40%)	48 (+37%)
RCA60	46 (+53%)	54 (+54%)
RCA100	35 (+17%)	38 (+9%)

Note: The bracketed values indicate the percentage increase in strength compared to the respective normal aggregate concrete strength.

Table 5: Split Tensile Strength

Mix designation	28-Day split tensile strength (MPa)
RM1	1.3
RCA30	1.6 (+23%)
RCA60	1.8 (+38%)
RCA100	1.4 (+7%)
RM2	1.6
RCA30	1.8 (+13%)
RCA60	2.2 (+38%)
RCA100	1.5 (-6%)

Table 6: Flexural Tensile Strength

Mixture designation	28-Day Flexural tensile strength (MPa)
RM1	5.5
RCA30	6.8 (+24%)
RCA60	6.8 (+24%)
RCA100	6.0 (+9%)
RM2	6.2
RCA30	6.7 (+8%)
RCA60	6.9 (+11%)
RCA100	8.4 (+35%)

Note: The bracketed values indicate the percentage increase in strength compared to the respective normal aggregate concrete strength.

CONCLUSION

Based on the experimental studies on the effect of normal and recycled aggregates the following conclusions are drawn:

- Recycled aggregates extracted from good quality concrete without impurities impart higher strength benefits to concrete compared to normal aggregates.
- Maximum strength benefit could be derived at sixty percent replacement. However, at hundred percent replacement level strength equivalent to normal aggregate concrete strength could be obtained.
- The increase in strength is more during the early age (7 days) compared to later ages.
- On identical water-cement ratio, recycled

aggregate concretes gain more strength than normal aggregate concrete due to reduction in effective water-cement ratio.

- Maximum gain in compressive strength due to the use of recycled aggregate is more than fifty percent, which is a significant benefit.

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TECHNICAL SESSION - II

CONCEPT APPROACH AND VISION

BIO-MEDICAL WASTE MANAGEMENT – ISSUES AND CHALLENGES: A CASE STUDY

P.S. Saini*, Dr. Parampreet Kaur Ahuja** and Dr. Amarjeet Singh***

Abstract

The paper focuses on the management of biomedical waste in 'Post graduate Institute of Medical Education & Research' (PGIMER), Chandigarh, India. The Biomedical waste generated in the Institute is classified into various categories as per the Bio-medical waste (Management & Handling) Rule 1998. PGIMER which has its own Biomedical Waste Management programme comprising of own incinerators, shredder and well-trained staff to handle different type of wastes.

The BMW generated is collected from OTs, wards, OPDs and research centres in different bins and then taken to garbage collection point from where the waste is sent to the incinerator for burning and the general waste is sent for land filling and the plastic waste is sent to the shredder. The approximate quantity of the various types of hospital waste generation in PGIMER has been found to be 1378 kg /day and the amount of waste incinerated is 842 Kg/day. PGIMER is an apex institute in the region, its hospital waste management system should serve as a model for other hospitals.

INTRODUCTION

It is ironical that the hospitals which provide relief from diseases to the ailing masses can also create serious health hazards. Hospitals and other health care institutions generate 'waste' day in and day out which is a potential health hazard to the health care workers, the general public and the flora and fauna of that area.

Bio-medical wastes (BMW) from hospitals, nursing homes and clinics include hypodermic needles, scalpel blades, surgical gloves, cotton, bandages, clothes, medicines, blood and body fluid, human tissues and organ, body parts, radioactive substances and chemicals etc. The present day hospitals and health care institutions including research centres use a wide variety of drugs including antibiotics, cytotoxics and corrosive chemicals and radioactive substances which ultimately become part of hospital waste. The advent of "disposable" in the hospitals has brought in its wake; attendant ills viz. inappropriate recycling, unauthorized and illegal re-use and increase in the quantum of waste. All round technological progress has lead to increased availability of health related consumer goods, which have the propensity for production of increased wastes.

The Ministry of Environment and Forests, GOI has provided a legal framework under the Biomedical Waste (Management and Handling) Rules, 1998, which are to be followed throughout the country. These rules have been framed in exercise of the powers conferred by sections 6, 8 and 25 of Environment (Protection) Act 1986 (29 of 1986); and shall apply to every hospital, nursing home, veterinary institutions, animal houses or slaughter houses, which generate bio-medical waste in a time bound manner. These rules have been further amended in 2002 and 2003. But, in the absence of strict implementation and non invoking of penal provisions by Pollution Control Boards, these rules are being flouted everywhere.

In fact, it is common place to find large heaps of "Bio-medical" wastes in the vicinity of a number of hospitals. Therefore, adequate management of waste assumes tremendous importance in a country like India whose economy forces the poverty stricken

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and ignorant "rag pickers" to sift and sort through dumped waste material, in order to eke out a living. Time and again, the audio-visual and print media has highlighted the desperation and pathetic conditions of these people, but the apathy of the people at the helm of affairs is that they have managed to give this problem less importance than what it deserves. So much so, that unscrupulous element have moved in and "recirculation" of waste has become one of the "leading" industries in the unorganized sector.

There is particular concern about infection with human immunodeficiency virus (HIV) and hepatitis viruses B and C, for which there is strong evidence of transmission via health-care waste. These viruses are generally transmitted through injuries from syringe needles contaminated by human blood. Sharps may not only cause cuts and punctures but also infect these wounds if they are contaminated with pathogens. Because of this double risk-of injury and disease transmission, sharps are considered as a very hazardous waste class.

Due consideration must be given to the impact of hospitals on environment, especially to risk of pollution of water, air and soil, besides aesthetics of the biomedical waste generated in the hospital. In order to minimise these environmental problems, action should be taken to deal with pollution at source, i.e. waste should be segregated and concentrated within health care institutions, and whenever possible it should be disposed off safely.

Hospitals also have to ensure that they practice 'NO HARM' policy i.e. human health should not be adversely affected due to impact of hospitals on local environment.

CASE STUDY – PGIMER CHANDIGARH

Against this background, the authors conducted a study with an objective to evaluate the management of biomedical waste in 'Post graduate Institute of Medical Education and Research' (PGIMER), Chandigarh, India, a referral hospital for several northern Indian states. It is one of the most prestigious medical institutes of national importance. There are presently 1959 beds and the number of annual admissions is around 71,000.

The Institute has its own Biomedical Waste Management (BMW) programme comprising of incinerators, shredder, transport vehicles and well-trained staff to handle different type of wastes. It's BMW incineration facility is also shared by other local nursing homes, hospitals and institutes of the city. The BMW generated in the institute is classified into various categories as per the BMW (Management and Handling) Rules 1998.

The color coded bins as specified by the Chandigarh Pollution Control Committee are placed in all wards (private and general) for throwing hospital waste. This biomedical waste is then collected and transported in trolleys to the Central refuse collection point by the sanitation staff of the Institute from where the different categories of waste are transported to various locations where they are subjected to different treatment methods as depicted in the fig. 1. Table 1 shows the approximate quantity of the various types of hospital waste generation per day in PGIMER and disposal strategies being adopted.

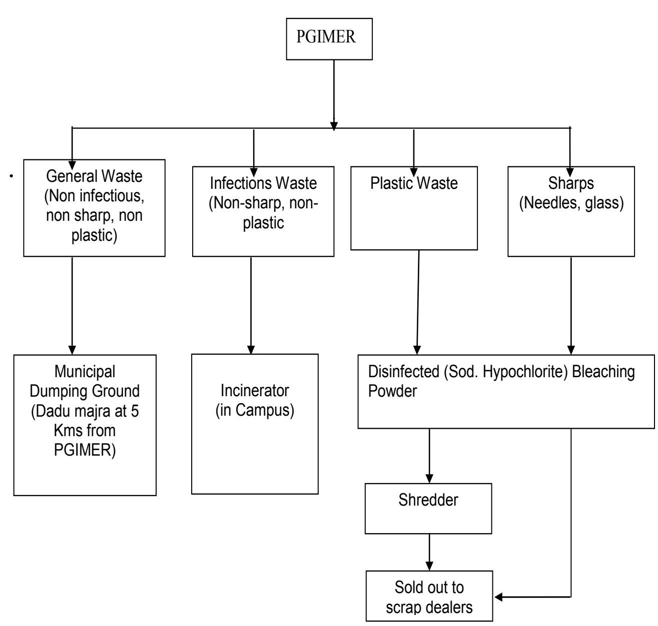

Fig. 1: Bio Medical Waste Processing in PGIMER, Chandigarh

Table.1 Quantity of the Various Types of Hospital Waste and Disposal Strategies

S. No.	Waste Category	Quantity in Kgs/ day (average)	Treatment & disposal practices as followed in PGIMER
1	Human anatomical waste	5.2	Through incineration.
2	Animal waste	1.14	Through incineration.
3	Microbiology & Biotechnology waste.	70.6	These media before being discarded are autoclaved.
4	Waste sharps	362.3	It is first disinfected chemically by treating it with sodium hypochlorite 1% solution for the minimum 30 minutes. The needles are destroyed by an electrically operated needle destroyer provided in each clinical area. Mutilated needles are then sent carefully for land filling.
5	Discarded medicine and cytotoxic drugs	------	The surplus/remaining drugs are returned to the patients who give it back to the chemist. The medicines approaching date of expiry are returned to the supplier, at least 3 months prior to the actual date of expiry.
6	Soiled Waste	747.3	Through incineration.
7	Solids Waste	173.3	After disinfection with the sodium hypochlorite 1% solution for minimum period of 30 minutes and cutting the plastic waste with scissors and sent for shredding.
8	Liquid Waste	Not assessed. STP/ETP under installation.	The vials containing the blood/sputum/ other body fluid are submersed in 1% solution of sodium hypochlorite for minimum 30 minutes.
9	Incineration ash	30	By landfilling
10	Chemical waste	Not assessed. ETP under installation.	……..

STAGES OF WASTE MANAGEMENT

The stages/activities for BMW management in PGIMER, Chandigarh include:

Generation: Various areas of the hospital and the Institute viz; OTs, wards, OPDs and research centres generate biomedical waste which is classified under different categories of the waste. The segregation of the waste is done at the sources of generation. As 70-75% waste generated in the hospital is non-hazardous or general waste, segregation reduces the quantum of waste that needs special treatment to only 25-30% of the total waste.

Collection: It is collected regularly from the areas of generation and transported to a central refuse collection point in the colour coded bags by trolleys. The team for collection is earmarked and wears a special uniform with all protective gears. Sharp waste, though already sterilized with1% Sodium Hypochlorite solution are carried in labeled bags to avoid any cut injury to the collection team while collecting and transporting it to the refuse point.

Reception: General waste and the waste other than the one which goes to incineration plant are received at the hospital refuse point. At the incineration plant there is an adequate space for receiving and storing the hospital waste to be incinerated.

Storage: At refuse point, bags with proper tags/ levels are received and stored only for a period of 2-4 hours when a refuse van (belonging to PGI only) carries this waste to dumping area earmarked by Chandigarh Administration for land filling. In the incinerator plant storage is done in the storeroom provided for the same. It is never stored for more that 24 hours as the incinerator plant is operated every day.

Transportation: The waste which is to be disposed off by land filling is carried by refuse van of the Institute to the land filling areas in the Dadu Majra at a distance of 5 kms. The plastic waste is taken to the shredder.

Treatment & Disposal : Solid (Plastic) waste is treated with 1% Sodium hypochlorite solution for minimum 30 minutes at the source of generation and then shredded in the shredder and again treated with 1% Sodium hypochlorite solution for minimum 30 minutes and sold after sterility report is obtained from Microbiology Department. Sharp waste is also treated with1% Sodium hypochlorite solution and then sold out to scrap dealers. The infectious waste is incinerated. The disposal of radioactive waste is done as per the regulations of RPPAI, BARC, Mumbai. A room has already been earmarked for storage of incinerator ash and the ash is being disposed off at M/s. Nimbua Greenfields, Punjab Ltd, Derabassi as per CPCB guidelines.

RESULTS AND DISCUSSION

Between 75% to 90% of the waste produced by health-care providers is non-risk or "general" health-care waste, comparable to domestic waste. It comes mostly from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10-25% of healthcare waste is regarded as hazardous and may create a variety of health risks.

BMW, generally consists of:

- Soiled bandages, linen and other infectious waste (30-35%)
- Plastics (7-10%)
- Disposable syringes (0.3-0.5%)
- Glass (3-5%)
- General uninfected waste including left over food (40-45%)

It has been found that in India the generation rate varies between 0.5 to 2.0 kg per bed per day and total generation is more than 0.33 million tonnes per year. The amount and composition of hospital waste normally generated in a hospital is as follows:

Hazardous/non-hazardous

Hazardous	15%
Hazardous but non-infective	5%
Hazardous and infective	10%
Non-hazardous	85%

The approximate chemical composition of general health-care waste is usually as follows:

- 50% carbon
- 20% oxygen
- 6% hydrogen
- Numerous other elements.

The biomedical waste generation rate in PGIMER, Chandigarh is between 1.5-2.5 Kg/day/bed, which is quite less than the hospital waste generated in some developed countries of the world. However, the generation rate is quite comparable with most of the hospitals of the country where roughly 1-2 kg of waste is generated per bed per day. Also, wastes generated in developing countries like India, contain much less disposable articles and plastics than waste generated in developed countries. This is because of differences in lifestyle and less use of disposables in India.

Total quantity of BMW generated in PGIMER, Chandigarh is nearly 1378Kg/day. The amount of incinerable waste is 842 Kg/day and non-incinerable waste is 536kg/day. Two incinerators of 200 Kg/day capacity have been installed for treatment of incinerable waste.

Most of the waste treatment and disposal practices in PGIMER conform to the Biomedical Waste (Management and Handling) Rules 1998. However, the process of segregation of waste needs improvement. The patients and their attendants need to be guided in a proper manner about the usage of different colored bins. Simply putting posters on walls where the bins are located does not serve complete purpose. Moreover, sharps should be collected in puncture proof bags. It was observed that the sharps were thrown along with other hospital waste even in red and yellow bags. This often resulted in injury to the sanitation workers. It was also found that, at times, the bags used for collecting biomedical waste were overflowing during transportation. The waste storage room of incinerator plant did not have racks and flooring was not covered with glazed material. However, the same has been provided now. There is no autoclave/microwave in the Institute to ensure complete sterilization of material meant for recycling.

Though the incinerators installed in the Institute during 1997 were complying to prevalent CPCB norms yet they do not fully comply with the present guidelines and during one of the inspections an year back, CPCB pointed out the following deficiencies in the installation:

- No automatic device for charging BMW to incinerator
- Tamper-proof Programmable Logic Control not attached to incinerator.
- Device for measuring air flow rate in incinerator chamber not attached with incinerator
- Stack emission monitoring not carried out regularly
- Flue gas analyzer not provided

Further, the role of incinerators in BMW disposal is being debated nowadays. All the developed countries and even some of the developing countries have banned the use of incinerators in their countries because of the toxic emissions from incinerators. Incineration has been found to be the leading source of highly toxic dioxin, furans, mercury, lead, and other dangerous air pollutants.

NEW TECHNOLOGIES BEING ACQUIRED

Efforts of Chandigarh Administration to provide Common Waste Treatment Facility for which the Institute had given an undertaking to join, has also landed into litigation. These factors have moved policy makers in the Institute to consider viable alternatives of incineration. The Institute has invited Expression of Interest from manufactures and specialized agencies for replacement of incinerators with burn/non-burn technologies so as to comply with the latest guidelines issued by Central Pollution Control Board. The process of purchase of 1000L capacity autoclave with shredder (hydroclave) has been initiated. The specifications would comply with the guidelines issued by CPCB. It would have an average cycle time of less than 75 minutes and waste reduction volume would be achieved upto 85 ±5%.

There are 5 broad medical waste treatment technologies viz; mechanical, thermal, chemical, irradiation and biological. The majority of technologies for the treatment of infectious waste employ heat to destroy disease-causing microorganisms in the waste. Non-burn technologies such as steam based systems, microwave treatment and chemical processes using disinfectants to treat waste are other options to be explored.

The latest Positive Impact waste solutions (PIWS) technology has an on-board computer interface that monitors the entire process. The operator stages and loads the waste directly into a feed hopper. The feed hopper captures the net weight of the load and the computer identifies the date and time. A measured amount of the registered dry chemical and water mist required to treat the volume of waste to be processed is then added. The automated cart lift mechanism transfers the waste into twin treatment chambers for the large unit and a single grinding chamber for the smaller unit, where the registered dry chemical is chemically bound to the waste material. The BMW is ground and mixed for approximately 10-30 minutes per load. This process balances the pH level and renders the organic material and microbiological organisms noninfectious. In addition, the processing blades of the PIWS reduce the original volume by more than 70% and render the waste unrecognizable. The treated material is then emptied into the medical facility’s general waste stream.

Another non burn technology has been brought by ECODAS, France. The patented process combines shredding, direct heated system and pressure to achieve complete sterilization of infectious materials. The final treated material which is about 20% of the original waste is absolutely harmless and safe to dispose of as land filling etc. However, the reliability and operating cost of these technologies is yet to be established in Indian context. They have been approved by Pollution Control Board only on trial basis.

Liquid wastes generated from hospitals have to conform to specified parameters and permissible limits and have to be disinfected by chemical treatment before discharge into public sewers. At present, the Institute does not have a treatment facility. However, we are at an advanced stage of planning and designing the STP/ETP's.

NO ENVIRONMENTAL CLEARANCE FOR NON-COMPLIANT HOSPITALS

The State Environment Impact Assessment Authority (SEIAA), Chandigarh has started declining environmental clearance for fresh construction to the non complying hospitals. The Institute has received environmental clearance for setting up a new 250 bedded hospital of total built up area of 25823.73 sq.m from SEIAA subject to the condition that the hospital can only be commissioned if STP/ETP's are installed to take care of liquid wastes from the hospital.

The Engineering Department of the Institute has mooted a proposal for setting up an Environmental Cell in the Institute to efficiently handle the treatment and disposal of BMW in the Institute besides taking care of other environmental issues complying with the instructions of SEIAA, Chandigarh.

NON-COMPLIANCE OF BMW MANAGEMENT RULES ATTRACTS PENAL ACTION

Bio-Medical Waste (Management and Handling) Rules, 1998 were notified under provisions of Environment Protection Act, 1986. Section 15(1) of Environment Protection Act, 1986 provides that whoever fails to comply with or contravenes any of the provisions of this act, or the Rules made or orders or directions issued thereunder, shall, in respect of each such failure or contravention, be punishable with imprisonment for a term which may extend to five years or with fine which may be extended to one lakh rupees or with both, and in case the failure or contravention continues, with additional fine which may be extended to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention. Although there are many instances of non-compliance of the Rules by many government and private hospitals in India, yet the respective Pollution Control Boards/Committees are avoiding imposition of any penalty against erring hospitals. As a result the provision of penalty has not acted as a deterrent for non-compliance of the Rules in the hospitals.

Recently, the Office of Director General of Audit (Central Expenditure), New Delhi had undertaken thematic audit on management of bio medical waste in government hospitals. Six out of eight reputed government hospitals covered in audit were generating, collecting and disposing bio-medical waste without mandatory authorization. Hospital waste management committee was not constituted in two hospitals. In three out of four government hospitals, the Effluent Treatment Plant (ETP)/Sewage Treatment Plant (STP) was not installed. Thus, overall implementation of Bio-Medical Waste (Management and Handling), Rules, 1998 in the hospitals was inadequate.

CONCLUSION

As PGIMER is an apex institute in the region, we are striving to ensure that its hospital waste management system serves as a model for other hospitals. Alternative technologies are being explored for treatment of BMW so as to minimize environmental pollution. Treatment and disposal of Biomedical waste is a regulatory requirement and the architects and engineers need to give due attention to this aspect while planning and designing health care facilities. BMW management has to be an integral part of hospital hygiene and infection control.

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USE OF RECYCLED PLASTIC AS A SUSTAINABLE BUILDING MATERIAL

Akshaya Bomanwar*

Abstract

Economic growth and changing consumption and production patterns are resulting in an increase in generation of plastic waste. The rate of consumption has increased much more than the average, owing to the rapid pace of urbanization. Considering the rate of generation of plastic waste, some reforms are to be taken. The problem persists in rural as well as urban areas. In rural areas, the menace of plastic waste is increasing due to unawareness.

Recycled plastic can be used as a building material in rural as well as urban areas. It can replace the traditional building materials being used like bricks, blocks, tiles, cement, timber, etc. Plastic which is hard to degrade can easily find architectural applications. Recycled plastic can prove to be a sustainable building material. In this paper the ways and the methods of using plastic as a building material is highlighted.

INTRODUCTION

Plastics are a very integral part of our day to day life. The demand of plastic goods has seemingly increased. This results in an increase in the production so as to meet the demand of the consumers.

About 0.1 million of tonnes of municipal solid waste is generated in India every day. Annually, tons of solid waste is generated from cities as well as rural areas. Per capita waste generation in major cities ranges from 0.2kgs to 0.6kgs. Out of total Municipal waste collected, on an average 94% is dumped on land and 5% is composted. Waste collection efficiency in India ranges from 50%-90%. After food and paper waste, plastic waste is the major constituent of municipal and industrial waste. In India, due to lack of solid waste management and throwaway culture, the plastic is neither collected properly nor disposed off, thus increasing its impact on the environment, public health and littering and choking of sewage systems. Between 2015-2025 the waste composition of Indian garbage will undergo some changes, for example plastic will rise from 4%-6%. It is the need of the hour to do something about this plastic being generated.

PLASTIC WASTE BEING GENERATED

The world's annual consumption of plastic materials has increased from around 5 million tonnes from the early 1950s to nearly 100 million tonnes, thus 20 times more plastic is being generated today than 50 years ago. This implies that on the one hand, more resources are being used to meet the increased demand of plastic; and on the other hand, more plastic waste is being generated. India generates 5.6 million metric tons of plastic waste annually. The side effects of plastic waste in India are known to all. The Mumbai floods of 2005 had devastation effects on the city. Water was not being absorbed in the soil due to plastic waste all over. People saw the disaster that plastic can cause.

In rural India, the problem of plastic waste is more as compared to the urban areas. In rural areas the people are not aware of the damage caused by the plastic. Sometimes the waste from urban areas is also dumped in large quantities in rural areas. The plastic waste from factories, industries is also dumped in rural areas. Heaps of plastic waste is found on open lands.

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ENVIRONMENTAL ISSUES ON DISPOSAL OF PLASTIC WASTE

Indiscriminate littering of unskilled recycling/ reprocessing and non-biodegradability of plastic waste raises the following environmental issues:

- During polymerization process fugitive emissions are released.
- During product manufacturing various types of gases are released.
- Indiscriminate dumping of plastic waste on land makes the land infertile due to its barrier properties.
- Burning of plastics generates toxic emissions such as carbon monoxide, chlorine, hydrochloric acid, dioxin, furans, amines, nitrides, styrene, benzene, 1, 3-butadiene, CCl_4, and acetaldehyde.
- Lead and cadmium pigments, commonly used in LDPE, HDPE and PP as additives are toxic and are known to leach out.
- Non-recyclable plastic wastes such as multilayer, metalised pouches and other thermoset plastic poses disposal problems.
- Sub-standard plastic carry bags, packaging films (<40μ) etc. pose problem in collection and recycling.
- Littered plastics give unaesthetic look in the city, choke the drain and may cause flood during monsoon .
- Garbage mixed with plastics interferes in waste processing facilities and also cause problems in landfill operations.
- Recycling industries operating in non-conforming areas are posing threat to environment to unsound recycling practices.

ADVANATGES OF USING RECYCLED PLASTIC

Traditional materials like clay, sand, stone, cement, gravels, bricks, blocks, tiles, timber are being used as major building components in building sector. All these materials have been produced from the existing natural resources and will have intrinsic distinctiveness for damaging the environment due to their continuous exploitation. During the manufacturing of these materials, especially decomposition of calcium carbonate, lime and cement manufacturing, high concentration of carbon monoxide, oxides of sulphur and nitrogen are invariably emitted into the atmosphere. Exposure to such toxic gases escaping into the environment leads to contamination of soil, air, water, land, flora, fauna, aquatic life and ultimately human beings and their living conditions.

Even the cost of construction materials is increasing incrementally. In India the cost of cement during 1995 was `1.25/kg and in 2005 the price increased three times. Similarly the price of sand had increased four times over the ten years from 1995. Also due to high transportation cost of these materials, demand and environmental restrictions, it is necessary to find functional substitutes for conventional building materials in the construction industry.

In rural India, the rural housing is vulnerable to weakness in the delivery system for housing materials and services. Most of the people live in 'Kachcha Makan' made from mud and dung. Services are to be provided to people. Their needs are to be understood. Houses made from polli bricks should be introduced. Maximum people are below poverty line, these houses will be effective as they are cost efficient.

PLASTIC

Plastics are non-biodegradable, synthetic polymers derived primarily from petro-fossil feedstock and made-up of long chain hydrocarbons with additives and can be moulded into finished products excluding compostable plastic .These polymers are broken in presence of suitable catalyst, into monomers such as ethylene, proplyene, vinyl, styrene and benzene. These monomers are then chemically polymerized into different categories of plastics.

Categories of Plastics:

The main category of plastics include ;

- Recyclable Plastics (Thermoplastics): PET, HDPE, LDPE, PP, PVC, PS, etc.
- Non-Recyclable Plastics (Thermoset and others): multilayer and laminated plastics, PUF, bakelite, polycarbonate, melamine, nylon etc.

SUSTAINABLE BUILDING MATERIAL

In view of the importance of saving energy and conservation of resources, efficient recycling of all the solid waste is now a global concern. Recycled plastic has been used as a sustainable building material earlier. One such example is the 'ECOARK' in Taiwan for Taipei International flora exposition. This 9 storey mega-structure is made up of 15 lac polli bricks made from recycled plastics (Fig.1).

Fig. 1: Ecopark Pavilion in Taiwan, made of Polli Bricks

It is estimated that this pavilion used 1.5 million recycled polyethylene terephthalate or pet bottles. It weighs 50% less than a conventional building, yet it is strong enough to withstand the forces of nature, even fire. The Architect Arthur Huang made honey comb shaped pet bottles structure and used them as bricks for the ECOARK. The ECOARK is re-constructible and the polli bricks can be removed and fixed again. The ECOARK pavilion is hailed as a new benchmark of green buildings which has converted Taiwan's trash into treasure. The ECOARK adheres to the principle of Reduce, Reuse and Recycle (Fig.2).

SUSTAINABLE BUILDING MATERIAL

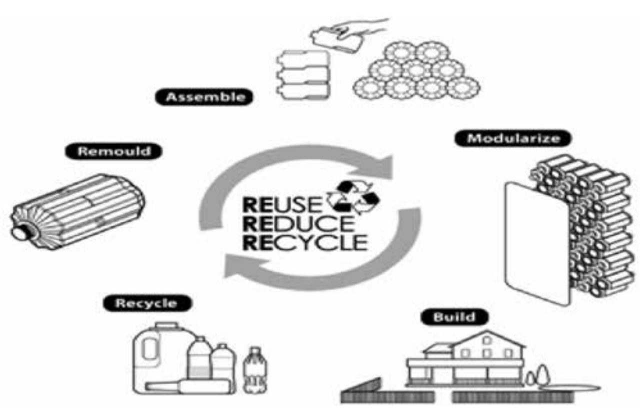

Fig. 2: Plastic as Sustainable Materials

Not only polli bricks, plastic can also be used in roofing, flooring and wall cladding. Other applications involve, skylights, vertical planters, curtain wall systems with UV protected laminates, PVC baking for fireproofing and even a raft. There are various applications of plastic in the building industry. Properties can be imparted to the pet bottles by making some chemical changes. Desired polli bricks can be obtained.

Plastic bottles used for water can also be used in the foundations of buildings and a structure which is resistant to flood can be attained. At the foundation of a building, the groups of plastic bottles tied together are to be connected during the times of flood, the whole building will float on water thus decreasing the damage.

In India this will be totally new culture. Social acceptability will be attained with time. Awareness among people regarding plastic waste should be created. Once we make them realise the importance of reducing, reusing and recycling, the social acceptance of these polli structures will increase automatically.

POLLI BRICKS

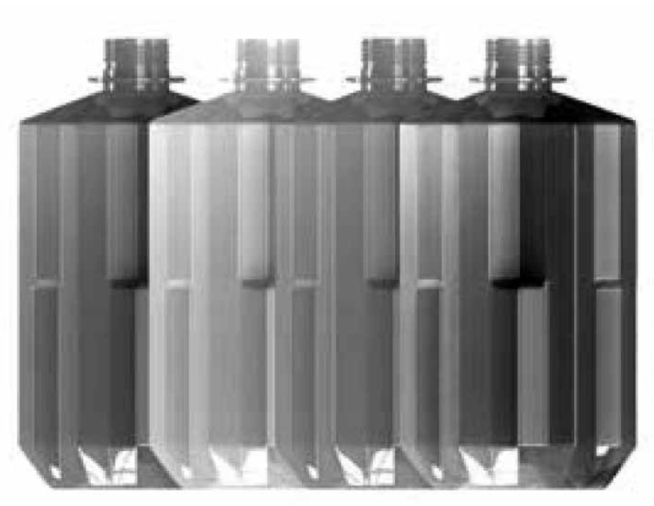

Fig. 3: Polli Bricks

Polli bricks cost 1/4th of what conventional building materials could have cost. Thus in India, these bricks have scope as they are even cost-effective and will definitely do better at markets. These bricks are arranged on a structural framewok. Honeycomb like structure is formed out of them. Solar panels can be fitted on the external façade. Polli bricks have been used in the ECOARC. These polli bricks are made out of recycled plastic. Pet-bottles are currently being used for that. Polli bricks are precisely used in the ECOARK in Taiwan.as a coin has two sides, there was problem regarding polli bricks also, the problems were in joining. So a laser cut polycarbonate sheet to create the panels, aid in the lateral loading, and eliminate imprecision in brick location was used. Thus strength was acquired in the external wall.

IMPLICATION IN INDIA

These Polli Bricks Construction can be practiced all over India. Temperature resistance of the bricks and temperature of the place where they are to be installed should be taken into consideration. Solar panels can be installed on the facade. Thus the building can be self sustainable for electricity.

Owing to the population explosion in India the demand of habitation will face an increase in the coming years. Architects and builders need to come up with a sustainable building material to meet the needs. Cost effectiveness will be a major factor as long as construction is taking place in India.

The slums can be cleared and new houses made up of polli bricks can be constructed. The problem of habitation in leading cities like Mumbai can be solved. Slums like Dharavi can be cleared.

Even employment can be provided to people in the manufacturing of polli bricks.

CONCLUSION

Owing to huge amount of solid waste generated everyday in this world, recycling is the main concern. The recycled products should be brought into use. As far as plastic is concerned if not recycled, it will be a hazard to the society. Using it as a building material is one of the best ways of putting it into use. Plastic waste can be converted into a sustainable building material.

In India owing to the population explosion that is being faced currently, the demand and consumption of plastic has increased. And it will keep increasing. The usage has to be controlled and specified. Recycled plastic can be successfully used as a building material. It will also result in low carbon construction. The use of traditional materials can be reduced. Recycled plastic is an efficient material to meet the needs of the modern world. Thus the rate of plastic pollution and its damage to the society can be decreased.

SOLID WASTE MANAGEMENT FOR CLEAN AND HYGIENIC DELHI

A.K. Jain*

Abstract

Delhi generates about 7500 metric tonnes of solid waste per day. Of this only 4500 mt is collected and 2500mt per day is treated. Other than domestic and office garbage, the waste includes biomedical waste, hazardous waste from abattoirs, markets and industries; construction debris, fly ash, etc. In Delhi most of the existing dumps have reached the limits and. there is a strong opposition to location of new landfills. These are seen as an environmental disaster, causing health risk from flies and rodents; air pollution and water pollution through leaching. It may be more practical to build several small, decentralized waste facilities rather than large one. Keeping in view the variety and composition of solid waste, different approaches and technologies should be adopted. These include Energy Recovery from Waste, Bio-methanation, Fuel-Pellets, Incineration, Pyrolysis/Gasification, Composting and Vermi-composting and Solid Waste Energy and Recycling Facilities which can reduce the need for landfills by 90 per cent, besides reducing odour and health risks.

About one-third of solid waste in Delhi comprises construction and demolition waste, which should be reused and recycled for land filling, road soling, pavement base material and production of pre-cast tiles and blocks. Garbage transportation is one of the largest overheads of local bodies. To obviate this problem, pneumatic waste collection can be adopted, which may be pre-planned in the new sub-cities with underground ducts, gravity chutes and garbage stations at every kilometer. A hygienic and sustainable solid waste management needs municipal reforms, recognizing kabaris and rag pickers who are its backbone, capacity development and a partnership approach.

"There must be a reason why some people can afford to live well. They must have worked for it. I only feel angry when I see waste. When I see people throwing away things we could use."

- Mother Teresa

INTRODUCTION

The problem of solid waste management in Delhi is assuming serious proportions due to increasing population, urbanisation, changing lifestyles and consumption patterns (Fig.1). The garbage from unauthorised developments, slums, JJ settlements, etc. is hardly collected which create hygienic, public health and environmental problems. As per Planning Commission (2014) Delhi generates 7500 metric tones (mt) per day of solid waste. Only 4500 mt is collected, of which 2500mt per day is treated. Delhi has three composting and three waste to energy (W2E) plants. There is no municipal vermi-composting, bio-methanisation or pelletisation plant for solid waste treatment in the city. According to Aseem Burman Committee (1998) the informal waste pickers are the backbone of waste management. They not only help in cleaning the neighbourhood, but also collect, reuse, recover, recycle and remanufacture an estimated 3000mt of garbage per day. The projected garbage generation in Delhi in the year 2021 @ 0.68 kg per capita per day would be 15750 tons/day.

Other than domestic and office garbage, the waste includes biomedical waste, hazardous waste from abattoirs, markets and industries, construction debris and fly ash, etc. which require specialized handling and disposal. Major part of solid waste is disposed of in sanitary landfills, which in Delhi are

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saturated. Keeping in view the fact that finding new sanitary landfill sites in Delhi is becoming extremely difficult, there is no option, but to resort to alternative and decentralised methods of waste treatment, reduction, recycle and use, which include vermiculture, fossilization and composting.

Fig. 1. Garbage, Open Defecation, Stagnant Water: A Common Urban Problem
(Source: UN Habitat)

The Ministry of Environment and Forests notified the "Municipal Solid Waste (Management & Handling) Rules, 2000" that require the following compliances:

- Development and Improvement of properly engineered and constructed sanitary landfill, from which pollutants do not escape and having an impervious bottom layer for leachate collection and treatment
- Identification of landfill sites for future use and making site(s) ready for operation.
- Setting up of waste processing and disposal facilities.
- Monitoring the performance of waste processing and disposal facilities once in six months.
- Segregation of solid waste at point of generation, which include organic, recycled, (plastic, glass, metal, paper, etc.).
- Specialised handling of construction and demolition waste, bio-medical waste, industrial/ hazardous/toxic waste, and e-waste (electrical and electronic waste).

Inert material in the municipal solid waste has been steadily increasing (30-50%), a majority of which is generated from the demolition and construction activities. This needs a specialized storage, collection and transportation. Organic food wastes can be locally recycled and composed, which would reduce transportation cost and reduce landfill site demand. Bio-medical waste is generated in relatively smaller quantity in comparison to municipal solid waste but due to its infectious and toxic nature, it needs careful handling which is regulated by a Bio-medical Waste (Management and Handling) Rules, 1998.

In Delhi most of the existing dumps have reached the limits, and. there is a strong opposition to location of new landfills, which are seen as an environmental disaster, causing health risk from flies and rodents; air pollution and water pollution through leaching. Around 1990 in the Trans-Yamuna area in Delhi leachate contamination of the underground aquifer and water sources affected over 1,00,000 people by the epidemic.

A study conducted by the World Health Organisation titled "Management of Solid Wastes in Developing Countries" concluded that to achieve the lowest cost, a policy of encouraging multiple small composting plants should be followed. Various studies conclude that recycling wastes is by far the cheapest alternative to landfills; and plants that convert garbage into other products are cheaper than those that burn garbage. As such, it may be more practical to build several small, decentralised waste facilities rather than large one.

ENERGY RECOVERY FROM WASTE

By adopting scientific methods, energy can be recovered from waste. As the organic matter decays it produces biogas, known as landfill gas (LFG), landfills have to be managed so that the LFG does not pose a threat to the surroundings. Rather than discharging it to the atmosphere, LFG can be recovered for providing a useful energy. Delhi's municipal waste has a potential to generate 150-250 cu. mtr. of biogas/ LFG per ton depending upon the quality of wastes. By employing a set of generator and transformer, bio-gas can be converted in electrical energy.

As a pilot project, the Delhi Energy Development Authority since 1986 has been extracting gas from a sanitary landfill in Timarpur. Eight wells were bored into this 80 acre dump, 20 to 35 feet deep, have been yielding 33 cubic feet of gas a minute. This can be used either for cooking or to power a 30 KVA generator, using diesel or a mixture of diesel and gas as fuel. The gas, similar to bio-gas, is 55 to 60 percent methane, with a calorific value of 550 British Thermal Units and is supplied to 20 outlets in Balak Ram Hospital twice a day for six hours. The gas has not been used to generate electricity over a length of time though the provision is there and the necessary electrical connections to the hospital have been made. The generator consumes six litres of fuel an hour but when mixed with gas a saving of 4.5 litre of the fuel is effected. To extract the gas, a four inch diameter perforated pipe is sunk. Another perforated pipe, two inches in diameter, is lowered into it and the surrounding area is filled with bricks to prevent decaying matter from clogging the pores.

BIO -METHANISATION TECHNOLOGY

In this process organic matter of solid waste is segregated and thereafter it is fed directly into a bioreactor, where in presence of methanagenic bacteria, and under an aerobic condition, the fermentation takes place and biogas is produced. In addition a high quality organic manure is also produced. Energy can be recovered by digesting certain organic wastes and recovering the methane rich bio-gas which provides heat and electricity (Fig.2).

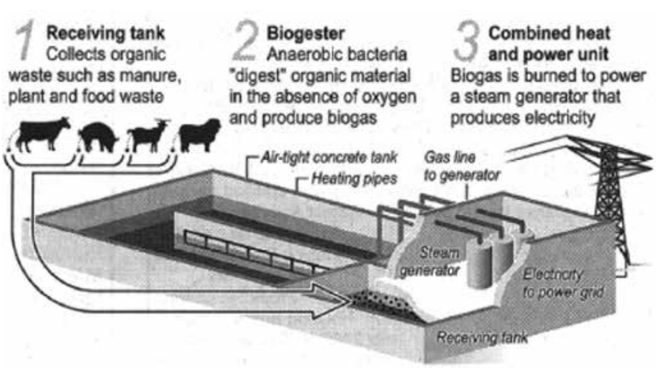

Fig. 2: Producing Electricity from Methane

FUEL-PELLETS

Municipal Solid Waste (MSW) comprises various materials such as paper, plastics, glass, metals, vegetable matter, rags, rubber, etc. It is essential to segregate the organic materials from MSW in such a way that it is free of sand, moisture and other ferrous & non-ferrous materials. The segregated organic matter can be dried, ground and pelletised. This ground organic matter can be added by biomass to enrich calorific value of fuel pellets.

A pilot project of the Department of Science and Technology had been set up at Mumbai for producing about 80 tones per day of refuse derived fuel pellets as a coal substitute. The pelletization technology has been developed as an indigenous technology with pallets having a calorific value of 3500 Kcal/Kg, as a substitute of coal.

In Gujarat, Vadodara Municipal Corporation has taken up the production of petro-coal pellets. It is produced from combustible garbage plastic, dry leaves, discarded clothes and vegetable waste supplemented by oil or petro-waste available from oil refineries. The process that turns combustible garbage into petro-coal is similar to the natural process that yields ordinary coal from the mines. After dehydrating and pulverising the garbage, it is mixed with petro-waste. Pelletisation makes the material dense and hard, ensuring that it burns slowly and uniformly. The fuel is about half the price of coal and emits lower levels of sulphur dioxide and carbon monoxide. The entrepreneurs have also taken up conversion of biomass like, paddy husk, straw, groundnut shell and other waste materials of low calorific value into briquetted fuel which is an efficient source of energy.

INCINERATION TECHNOLOGY

Incineration is a process of controlled combustion of solid wastes and residue. During combustion, moisture is vaporised whereas the combustible portion produces heat Carbon dioxide, water vapour, ash and non-combustibles are the end products. The heat generated during incineration is recovered and utilised for the production of steam, heating water, and generating electricity. Incineration technology is economical for the treatment of large quantities of solid wastes, by thermal process. This type of refuse includes not only metals and laminates but also untreated domestic wastes.

PYROLYSIS/GASIFICATION TECHNOLOGY

In this process segregated combustible matter is allowed for drying and thereafter it is shredded in a hammer mill. The combustion/pyrolysis of shredded matter takes place in a fluidised bed reactor without any fuel support. The end product includes combustible "producer" gas, which can be utilised for production of power. The heat produced in the process can also be employed for production of steam and ultimately generating power. Although not fully competitive with conventional electricity at today's energy prices, extracting energy from wastes offers environmental benefits, helping to reduce fossil fuel consumption and, amongst other things, the problem of methane emissions from landfill sites.

COMPOSTING OPTION

Incineration is an effective solution, but it is expensive for wastes having a high proportion of vegetable and putrescible matter. Economic constraints favour composting, as the city wastes contain a significant amount of nitrogen, phosphate and potash, as well as organic soil supplements.

A study by NEERI of 33 cities of India indicates that waste contains moisture varying from 10 to 40%, non-combustible materials or ash 50 to 80%, and volatile or combustible material only 10 to 25%. Modern day garbage also contains a large amount of various non-recyclables, viz. wax paper, silver printed packets, tatrapacks, foamy plastic, cigarette foil, soft squeeze tubes, sachets, cellophane paper and thermocol. Thus, incineration is not always a viable and practical process to dispose and treat the waste. Another common problem is mixing of MSW with sewerage. In absence of sanitation and sewerage facilities in many areas, especially in inner city, village, squatter settlements and slums, night soil and sludge get discharged in the river, local drains, ponds, garbage dumps or streams. In Delhi, it is assessed that the BOD load of river Yamuna is as high as 1,50,000 Kg. per day. High quantities of sludge endanger the soil and sub-soil water by percolation of the pollution. This calls for adoption of simple and economical processes, like composting.

In spite of its simplicity and relative cost advantage, composting has remained a challenge. Commercial viability has so far been elusive except occasional reports. The MSW Rules of 2000 stipulate stringent quality requirement, especially in terms of minimum concentration of eight metals—As, Cd, Cr, Cu, Pb, Hg, Ni and Zn. However, for bio-degradable matter composting is one of the most popular system of garbage disposal. Apart from saving land, valuable products like compost, biogas, heat, electrical power, recycled paper, plastics, glass, metals, etc. are obtained. Composting can be done in different ways:

- Aerobic window composting
- Anaerobic trench composting
- Vermi-composting
- In-vessel aerobic composting

Vermi-Composting

Composting of biodegradable waste including human excreta, by earthworms, is gaining popularity. Organic waste is allowed to be decomposed by micro-organisms already present in the waste. The process can be accomplished either in presence or in absence of oxygen known as aerobic or decomposition respectively. During aerobic decomposition, organic compound gets oxidized to oxides of carbon and nitrogen and temperature of the mass rises to 70 C.

The destruction of common pathogens and parasites takes place during this period. Absence of oxygen during the process generates methane in addition to other gases. The mixture of methane and carbon dioxide is known as biogas which is a useful source of energy. This process requires controlled environment and closed reactor to reduce odour problem, eliminate flies and for effective collection of gas.

Vermicomposting is the process in which earthworm species are used for the conversion of organicwaste into compost. Selection of appropriate species of earthworms for vermicomposting in India is limited to a few. The best choice for vermi-composting is two species i.e. Eudrilus eugeniae and Eisenia foetida. Eudrilus eugeniae, popularly known as African Night Crawler is found to be the best for vermi-composting. It has excellent growth and high conversion ratio.

Earthworm degrades the organic waste by both physical and chemical breakdown in their gut. The gut of an earthworm acts as a bio-reactor providing ideal conditions for temperature. PH and oxygen concentration for speedy growth of aerobic bacteria which outcompete pathogens resulting in pathogens destruction. These micro-organisms produce useful compounds like antibiotics, vitamins and plant growth hormones. Worms use about 5 to 10 per cent of the organic material for their growth and excrete the rest in the form of granular cast which is known as vermicompost. The granular loose vermicast provides oxygen rich, nutrient rich media for aerobic microbes which further promote decomposition process. About 2,000 worms are required for a volume of lx 1x0.5 m. On an average, 5 kg of waste is partially digested by 1,000 worms in a day (Fig.3).

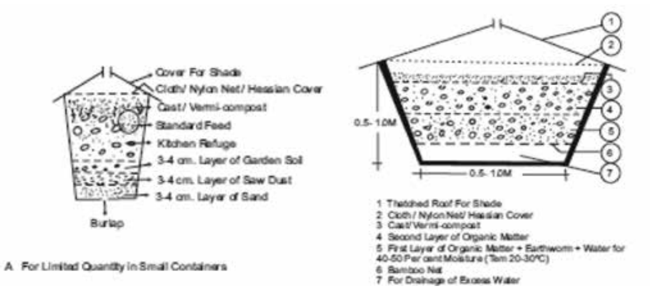

Fig. 3: Vermiculture and Vermicomposting

SOLID WASTE ENERGY AND RECYCLING FACILITIES

A sustainable and feasible solution for the management of municipal solid waste is by setting up a Solid Waste Energy and Recycling Facility (SWERF). SWERF reduces the need for future acquisition of land for landfills by 90 per cent. Odours and health risks are reduced as the SWERF is totally enclosed. There is sterilized handling of recyclables and rejects as the municipal solid waste is first processed in an autoclave. Greenhouse gases are reduced to the maximum by efficient conversion technology. The SWERF system has the following features:

- Waste Reception
- Autoclaving of waste
- Mechanical source separation of recyclables
- Organic pulp washing, drying and storage
- Gasification of organic pulp to create syngas
- Electricity generation from syngas

The existing technologies that are being used by SWERF include:

- Split bin collection for municipal wastes
- Sorting and processing technologies utilized in existing materials recovery facilities.
- Value adding process for glass, plastics, metals and paper.

RECYCLING AND REMANUFACTURING C&D WASTE

About 30 to 35% of solid waste in Delhi comprises construction and demolition waste. The SWERF provides its segregation from other wastes and encourages its recycling in accociation with the builders, PWD, MCD, etc. Construction and demolition waste is compulsorily segregated for reusable items and recycling. This can be used for land filling, road soling, pavement base material, production of pre-cast tiles and blocks and recycled concrete aggregate.

PNEUMATIC WASTE COLLECTION

Garbage transportation is the one of the largest overheads of local bodies in Delhi. To obviate this problem, at least in new areas, pneumatic waste collection can be adopted. It consists of an integrated collection station, piping system and discharge valves that are situated below vertical chutes outside the residential, commercial and other areas. Waste of one type is collected into the garbage chute, where it is stored above a garbage valve between the emptying cycles. There is a main pipe network under the valve that connects all valves and transports the waste to the collection station. These systems work best in a radius of about a kilometer. The new sub-cities like Rohini, Dwarka, Narela, Zone J, K1, L, PII and N can pre-plan pneumatic waste ducts, gravity, chutes and garbage stations at every kilometer for pneumatic waste collection (Fig.4).

Fig. 4: Pneumatic Waste Collection System

(Source: www.envoegroup.com)

The current system which uses more than 500 waste-hauling trucks is very costly compared to the operating cost of mechanized system. Disadvantage of current system include unsightly, unhygienic landfill sites, dhalos, transportation, truck maintenance cost, labour cost and the noise and pollution. Pneumatic waste collection offers a cleaner solution that can alleviate traffic congestion and encourage recycling. It also would improve the overall city hygiene, aesthetic, and landfill sites required, besides cost reduction in waste collection. The processing of garbage is mostly underground at local collection stations. Fewer garbage trucks lead to a reduction in CO_2 emission, traffic noise pollution and reduced haulage costs.

Pneumatic Solid Waste Management has been implemented at several places, including Mecca, at Holy city's Grand Mosque. Vacuum conveying technology specialist Mari-Matic has supplied a waste collection system to deal with the massive waste management challenge facing this city. Completed in 2013, Mari-Matic's Metro Taifun System in Mecca automatically conveys 900 tonnes of solid waste per day during peak season like the annual Hajj pilgrimage. Waste bags are fed into gravity chute intakes linked to a network of 30 km of pipelines running beneath the grand mosque complex. Transporting waste through airtight pipelines instead of using trucks minimizes problems of noise, smell and dust. Waste is conveyed through the pipelines to a collection terminal well away from the mosque. At the terminals the waste is compacted into containers for transportation by truck to a recycling and landfill site. The system uses much less energy than trucks or conventional automatic waste collection systems.

Managing Waste-Japanese Model

The local municipality in Japan has invoked strict laws to keep the city clean, which ensures that there is no garbage/spitting on to the roads.

Strict segregation laws: At household level, residents are required to segregate garbage into four types-combustible (kitchen waste), non-combustible (plastic), resources trash (newspapers, magazines) and large-sized trash (furniture, home appliances).

Garbage Collection: The municipal authorities have designated specific days in a week to collect different types of trash. For example, if the days specified for collecting combustible waste are Monday and Thursday, then residents would throw out only combustible waste on those days. To get rid of other trash, they would have to wait for the specified day.

Treating waste: Instead of dumping the waste directly into landfill sites, the waste is processed, treated and then dumped into a landfill.

Incineration: No fuel is used for burning the waste. Heat is generated by friction, the incineration unit has a sand bed through which air is passed. The air causes the sand to whirl like boiling water and the garbage burns in the whirling sand at 600° celsius. Toxic gases produced are treated before being released in atmosphere.

Recycling: While non-combustible waste is directly sent for recycling, in case of bulk waste, valuable resources like iron are separated (using a magnetic belt, etc) and compressed and then sent for industrial reuse.

e-waste: There are separate laws for electronic waste. In case of computers, refrigerators, washing machines and TV sets, the manufacturing company collects the appliance from the user and sends it for recycling. The customer has to shell out a recycling fee whenever he disposes of an old electronic appliance. The chlorofluorocarbon gases from refrigerators and ACs are neutralised before being disposed of.

(Source: *Hindustan Times, July 24, 2006)*

THE ROLE OF THE RAG PICKERS

The informal rag pickers and kabaris help to keep the city clean. They recycle about 3000mt of waste per day. However, they face serious problems of health and essential facilities. In Bagota, incentives like free bus ticket, food coupons and cinema tickets are given to waste pickers for collecting and depositing waste in the designated municipal waste collection centres. Learning from Colombia and Brazil where the rag pickers are officially recognized, Pune Municipal Corporation has also brought them in municipal SWM network and provides them with remuneration, uniforms, waste bins and bags, gloves, pushcarts and health insurance. In US cities, like Chicago, property tax incentives are given for reduced waste disposal.

CONCLUSION

Promoting alternative approaches in solid waste management need municipal reforms, change in attitude (particularly towards rag pickers), capacity development and a partnership approach involving the private and community sectors. Suitable mechanisms need to be evolved to overcome the barriers in promotion, development and dissemination of new approaches to waste management. This requires proper coordination and dovetailing of the resources of the government/local bodies, development authorities, NGOs, RWAs, industry, cooperatives and private sector. A clue can be taken from the British Local Authority Act, whereby the concept of 'Compulsory and Competitive Tendering' has disbanded the monopoly of local bodies in the solid waste management and other services. Delhi can learn from such success stories and incorporate suitable legal, managerial and financing reforms that will bring investments, together with state of art technology and operational efficiencies.

Integrated planning and management should include, maintenance and replacement of machinery, equipment and vehicles, manpower training and research, identification of appropriate sites for the dustbins, dalaos, transfer stations, SWERF and SLF sites, compost plants, incinerators, workshops, etc. The operational planning involves planning and development of gravity chutes, pneumatic ducts, route optimisation for transportation of waste; marketing of bye-products, and effective involvement of rag pickers, community groups and resident welfare associations, etc. Regular analysis of waste characteristics on seasonal basis both in terms of quantity and constituents may help in improved SW management. Preparation of Waste Management Plans in consultation with the inter-connected agencies would help in synergizing the efforts and improving overall performance.

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PLASTIC WASTE OPTIMIZATION FOR FLEXIBLE PAVEMENT AND OIL GENERATION

Dr. Sushma*

Abstract

Solid waste management is the thrust area. The disposal of waste plastic is a threat and become a serious problem due to its non-biodegradability and unaesthetic view. Since these are not disposed scientifically, there is possibility to create ground and water pollution.

Waste plastics, mostly used for packing are made up of polyethylene, polypropylene and polystyrene. Their softening varies between 110oC to 140oC and they do not produce any toxic gases during heating but the softened plastics have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160oC. The plastic coated aggregate is a better raw material for the construction of flexible pavement. The plastic waste modified bitumen mix show better binding property, stability, stiffness, density and extra resistant to water. The plastic waste can also be used to produce oil by using pyrolysis process and thus resolve the problem of its disposal. Both these methods are eco-friendly and economical too. In this paper, these methods have been examined to manage the plastic waste and recover the better outputs.

INTRODUCTION

Plastic is a very versatile material. Due to the industrial revolution, and its large scale production, the plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, electronics, electrical, building construction, communication sectors has been virtually revolutionized by the applications of plastics. Plastic is a non-biodegradable material and can remain on earth for 4500 years without degradation.

The improper disposal of plastic waste may cause health hazards like genital abnormalities, reproductive problems, etc. We cannot ban use of plastic but we can reuse the plastic waste effectively for coating the aggregates for construction of flexible pavement. The plastic waste can also be used to produce oil by using pyrolysis technique. These methods are environment friendly and helpful in managing the plastic waste.

GENERATION OF PLASTIC WASTE IN INDIA

India has the lowest (12-16 kg) per capita per year consumption of plastics than that of world (24-28 kg) and consequently the plastic waste generation is also very low. The total plastic consumption (or plastic waste generation) in India during last decade has been shown in fig. 1.

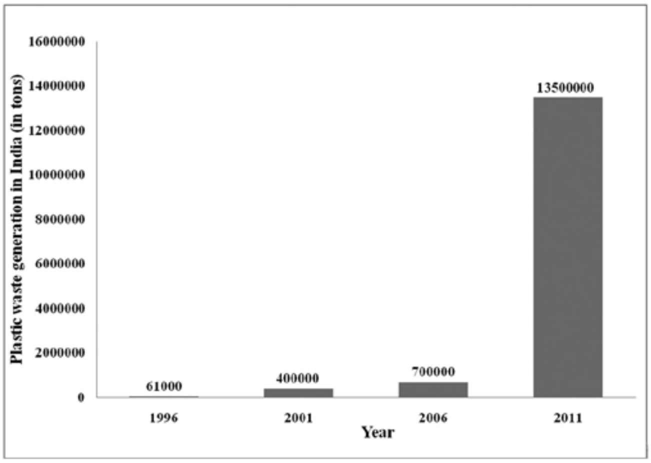

Fig. 1: Plastic Waste Generation

PLASTIC WASTE CLASSIFICATION

Plastics can be classified in many ways, but most commonly by their physical properties. Plastics may also be classified according to their chemical sources like cellulose plastics, synthetic resin plastics,

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protein plastics, natural resins, elastomers, fibers, etc. But depending on their physical properties may be classified as thermoplastic (like polystyrene, polypropylene, poly vinyl chloride, etc.) and thermosetting (like bakelite, epoxy, polyester, etc.) materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. Thermosetting materials which once shaped cannot be softened/ remolded by the application of heat.

Most of thermoplastics on heating soften at temperature between 110-140oC. The Thermo-gravimetric analysis of thermoplastics has proven that there is no gas evolution in the temperature range of 130-180oC and beyond 180oC gas evolution and thermal degradation may occur. Thus the waste plastic can easily be blended with the bitumen as the process for road construction at temperature in the range of 155-165oC. The sources of waste plastic generation are shown in table 1.

Table 1: Waste Plastic and its Source

Waste plastic	Origin/ Source
Polyethylene Terphthalate (PET)	Drinking water bottles, etc.
Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, vapors packets, microwave trays, etc.
Poly Vinyl Chloride (PVC)	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders and pens, medical disposables, etc.
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. foamed polystyrene: food trays, egg boxes, disposable cups, protective packaging, etc.
Low Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles, etc.
High Density Polyethylene (HDPE)	Carry bags, bottle caps, house hold articles, etc.

METHODS FOR MANUFACTURING MODIFIED BITUMEN MIX USING PLASTIC WASTE

There are two important methods/processes used for manufacturing the modified bitumen mix using plastic waste for construction of flexible pavement (fig. 2).

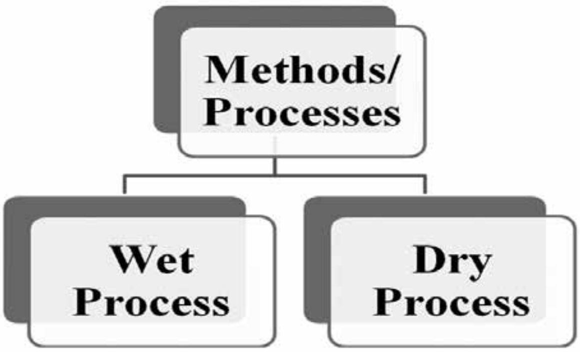

Fig. 2: Methods for Manufacturing Modified Bitumen Mix using Plastic Waste

Wet Process

Waste plastic is ground and made into powder; 6 to 8 % plastic is mixed with the bitumen. Plastic increases the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. The shredded plastic waste acts as a strong binding agent for making the bituminous mix last long. By mixing plastic with bitumen the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C. The vigorous tests at the laboratory level proved that the bituminous mixes prepared using the treated bitumen binder fulfilled all the specified Marshall Mix design criteria for surface course of flexible pavement. There was a substantial increase in Marshall Stability value of the mix, of the order of two to three times' higher value in comparison with the untreated or ordinary bitumen. Another important observation was that the bituminous mix prepared using the treated binder could withstand adverse soaking conditions under water for longer duration.

Advantages of Wet Process:

- This Process can be utilized for recycling of any type, size, and shape of waste plastics.

Disadvantages of Wet Process:

- Wet process is time consuming as more energy is required for blending.
- A powerful mechanical set up is required for this process.
- Additional cooling is required as improper addition of bitumen may cause air pockets in roads.
- Maximum 8% of waste plastic can be added in the bitumen.

Due to the limitations mentioned above the wet process has now been replaced by dry process or modified process.

Dry Process

In this process the plastic waste is shredded into 2 to 4 mm size and is mixed with heated stone aggregate (160 to 170oC) for 30 to 40 sec for uniform coating at surface of aggregate. The plastic coated aggregate then mixed with the hot bitumen at temperature (155-165oC) to produce plastic-bitumen-aggregate mix which can be used for road laying (fig. 3).

The aggregate used for dry process is chosen on the basis of its strength, porosity and moisture absorption capacity and the bitumen is chosen on the basis of its binding property, penetration value and visco-elastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to be noted here that stones with porosity less than 2% can only be allowed by the specification for this process.

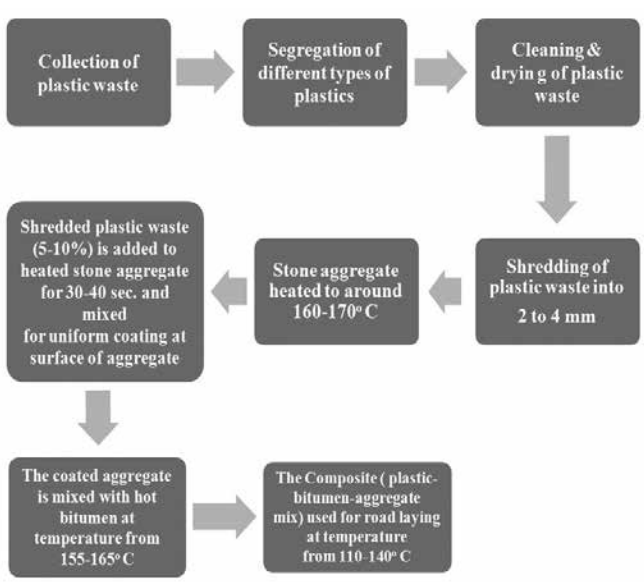

Fig. 3: Process Flow Diagram of Plastic Coated Bitumen Mix

Advantages of Dry Process

- Plastic is coated over stones and thus improve the surface property of aggregate.
- Coating is easy and temperature required is same as road laying temp.
- Use of waste plastic more than 15% is possible.
- Flexible films of all types of plastics can be used.
- Doubles the binding property of aggregate.
- No new equipment is required.
- Bitumen bonding is strong than normal.
- The coated aggregates show increased strength.
- As replacing bitumen to 15%, higher cost efficiency is possible.
- No degradation of roads even after 5-6 yrs after construction.
- Can be practiced in all type of climatic conditions.
- No evolution of any toxic gases as maximum temperature is 180ºC.
- The penetration of water is reduced due to plastic-bitumen-aggregate mix which resists stripping and hence no pothole formation takes place on roads.
- Plastic will not leach out of the bitumen layer, even after laying the road using waste plastics-bitumen-aggregate mix.
- Waste plastic-bitumen blend shows higher softening temperature. This increase will reduce the bleeding of bitumen during the summers.

There is no observable demerit either in this process or in the road characteristics. For the last several years various roads laid using waste plastics are functioning well.

USE OF PLASTIC WASTE FOR ROAD CONSTRUCTION IN HARYANA

The Central Road Research Institute has

supervised laying of test section as a part of pilot study for demonstration of plastic waste modified mix technology for implementation on roads under jurisdiction of Haryana PWD (B&R). Specifications and mix design was done and experimental section was laid at km 97 to 98 of Rothak-Bhiwani road as shown in fig. 4 and 5.

Fig. 4: Laying of Plastic Waste Modified Mix at Rohtak-Bhiwani road

Fig. 5: Finished Surface of Plastic Waste Modified Mix at Rohtak-Bhiwani Road

The Haryana PWD (B&R) has recently floated tenders amounting to nearly Rs.1000 crores under Pradhan Mantri Gram Sadak Yojana Part-II with a provision of plastic waste modified mix on the various roads in the state.

OIL GENERATION FROM PLASTIC WASTE

The pyrolysis process system can be used to crack the hydrocarbon chains within the plastics, to produce distilled fuels. The plastic waste is chipped to approx. 15mm, washed (to remove impurities) and dried (to remove moisture). The chipped plastic is fed through a melt-in feed system into the chamber. This system consists of a stock in-feed system, pyrolysis chambers, contactors, distillation, oil recovery line and syngas as shown in fig. 6.

During start up, the furnaces are supplemented with either natural gas or LPG, depending on availability. The pyrolysis chamber operates on a 24 hour cycle, during which plastic melt is continually fed and pyrolysed. The pyrolysis process is performed within a heated sealed chamber that has been purged of oxygen. The chamber is fed molten plastic by an extruder, and the plastic is stirred in the vessel by an agitator. Plastics in the chamber continue to be heated and pyrolysed in the absence of oxygen, producing hydrocarbon vapours. The plastic is pyrolysed at 370-420ºC, and the pyrolysis gases are condensed in a two-stage condenser to produce a low-sulphur distillate. The vapour is converted into various fractions, including raw diesel, in the distillation column and the distillates then pass into the recovery tanks. Non-plastic materials fall to the bottom of the chamber. The raw diesel is further refined in another distillation column, where it is distilled into the main three products, road diesel, kerosene and light oil. A synthetic gas is produced as a by-product. This is manipulated and then cleaned prior to use in the furnaces that heat the pyrolysis chambers, making the system a closed loop process, improving the efficiency of the process.

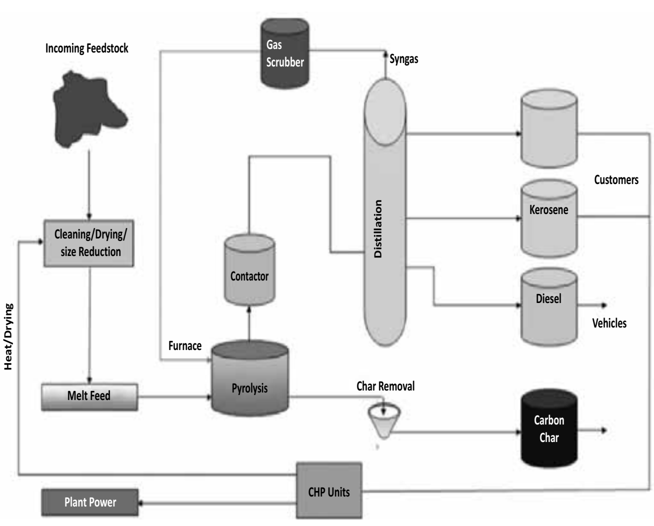

Fig. 6 Waste Plastic Pyrolysis Process System

Outputs of Pyrolysis Process

The plant converts mixed waste plastics into diesel, kerosene, light oil, kerosene and residual char as shown in fig 7. The exact recovery ratio and characteristics of the product distillate differs depending on the types of plastics received and the decomposing temperature.

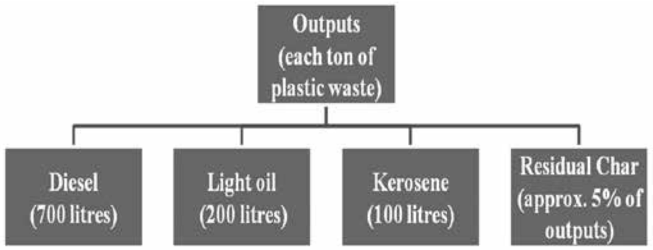

Fig. 7: Outputs of Pyrolysis Process

The diesel fuel produced can be directly used in vehicles, allowing them better control over their internal transport costs. The light oil fraction can be used as a raw material in the chemical industry, including as a raw material in the manufacture of new plastic products. The kerosene can be blended with conventional fuels or used in amended engines. The char can be used in manufacturing of tiles or as a pigment for coloring concrete.

ROLE OF LOCAL ADMINISTRATION IN MANAGING PLASTIC WASTE

The local administration should enforce the collection of bio-degradable and non bio-degradable domestic waste in green and red dust bins respectively. The bio-degradable waste can be used for making compost. The plastic, so recovered from non bio-degradable waste can be separated easily and efficiently used in hot mix plants for construction of flexible pavement and in pyrolysis plants for oil generation as shown in fig. 8.

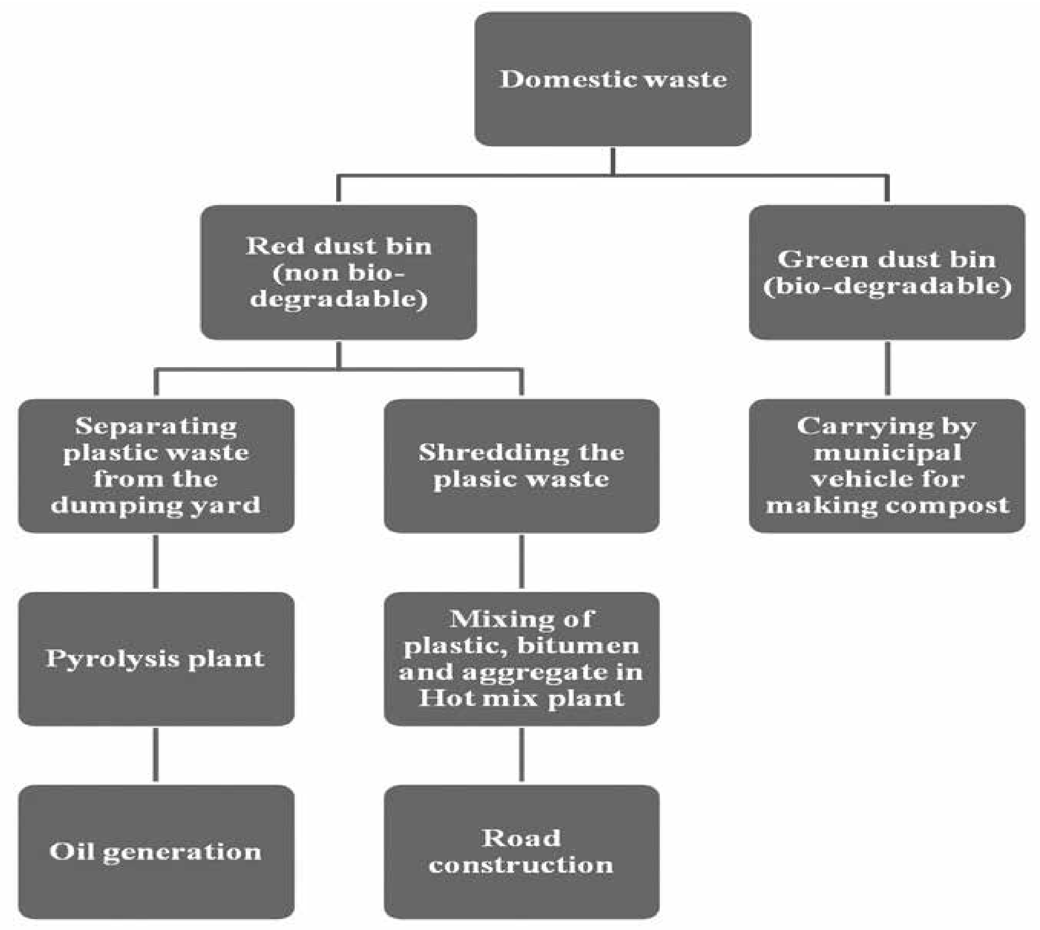

Fig. 8: Role of Local Administration in Managing Plastic Waste

CONCLUSION

The use of plastic waste in construction of flexible pavement by dry process and generation of oil by pyrolysis process is now changing the road construction industry and energy market scenario on large scale. The plastic waste is now being utilized efficiently by using these advanced processes and thus helps in resolving the problem of its disposal worldwide. The local administration should move ahead to develop a system to separate the bio-degradable and non bio-degradable waste at the door step of consumer, so as to avoid the wastage of energy/ resources in separating, cleaning and drying the plastic waste and to fulfill the concept of plastic waste optimization.

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INTEGRATED WASTE MANAGEMENT IN THE CONSTRUCTION INDUSTRY

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Abstract

Effectiveness of waste management at construction sites can be enhanced only by an integrated system approach, commencing from the initiation stage, integrating into the planning and execution stage of the projects, and continued over the entire life of the infrastructure created. The compelling need of business growth of the bottom lines of construction companies and its supporting manufacturing industries challenges waste management practices. The philosophy of waste management in the context of environmental sustenance needs to be viewed in a radically different perspective.

In an integrated approach to waste management on construction projects, the "eliminate – reduce – recycle" philosophy will go a long way in protecting the fragile and damaged environment of our planet. Environmental sensitivity and ecological balance are key factors in regulating waste generation. Creating awareness of good construction practices to eliminate and effectively reduce waste creation can be achieved by a coordinated approach encompassing policy makers, educational institutions, professional forums and practitioners from the construction industry.

INTRODUCTION

By virtue of the fact that economic prosperity of nations hinges on infrastructural support for various economic activities, construction industry has been the backbone of this journey. As a result it is also a major generator of waste, commencing from the extraction and production of the basic raw materials needed for construction, the waste generation continues even after completion of construction. The aspect of waste management in construction industry has been extensively studied since many decades. But unfortunately for the current breed of construction industry professionals these studies are only of academic interest as these studies revolve around the perceptions and need of the day when these studies were carried out. Way back in the 70s' apart from the impact of waste on future availability of materials, the increase in demand on the transportation system was a major concern.[1]

The shortage of final disposal areas was a major concern addressed by another study in the early 90s',[2] while yet another study in the late 90s' attempted to identify reliable methods to measure construction waste and thereafter to prevent it to ensure compliance with the national environmental policies.[3] With sustainability and environmental safetybeing the need of the hour, waste management has to be addressed from a different perspective, which has to be radical and also practical. Sustainability should be addressed from the larger perspective of the availability of resources over generation rather than from the industry sustainability perspective.

UNDERSTANDING "WASTE"

"Waste", traditionally referred only to the material wasted or inefficiency which has resulted in the excessive usage of material, equipment, labour or capital in excess of the need[4] or as materials which are discarded at the end of their 'intended "lifespan" [5] would be a very myopic approach. While these direct components of the wastage are well documented and practitioners are sensitized on its management, what is hidden and significant is the impact of the indirect waste that the construction activity generates - excessive consumption of fossil fuel, power usage by manufacturing plants, labour productivity losses, etc.

The correct definition and unambiguous understanding of "waste" in construction activities is

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essential to design a rational and practical approach to its management. Construction industry is a part of a large supply chain,which includes the manufacturing industry, Information Technology (IT) and IT enabled services etc., which collectively are major components of the economic system. It therefore becomes imperative that we understand the concept of waste as a system rather than as an isolated phenomenon. This broad based understanding is critical in the backdrop of the fact that there is already a crunch on the inputs to the construction industry, which in turn has increased the cost of construction, and is going to worsen in the years to come.

WASTE GENERATION IN CONSTRUCTION INDUSTRY

The generation of waste by the construction industry which commences right from the conceptualization stage, maximizes during the design stage and extends through the life of the creations of the construction activities.Just as an example, it is a known fact that housing is a major problem the nation is facing, but the question is who and where.About 18.78 million households belonging to the EWS, LIG and MIG[6] cannot afford the lakhs of houses built across the cities in the country, and as they lie unoccupied and deteriorate, valuable natural resources have been wasted permanently. While umpteen examples can be cited and goggled, the essence of this exercise is to understand the waste cycle as an integrated system. The supply chain supporting the construction industry is depicted in Fig.1.

A report by the Supreme Court appointed expert committee to study the cause of the natural disaster in Uttarakhand in June 2013 has linked uncontrolled construction activities along the Ganges and its tributaries as the main reason for the floods which devastated the state, leading to unquantifiable losses in terms of property, lives and ecological imbalance in the region.[7] The debate on whether such large scale destruction which leads to wastage of multifarious resource is attributable to construction activities or not can continue, but there is no doubt that practitioners have to be sensitized to these aspects of the eco system of the business environment. Land use change from residential to commercial which leads to large scale waste generation needs no deliberation. In many cases incorrect and unrealistic assessment of the needs of the end users, not aligned to the economic environment of the community or the value addition it brings to the community has resulted in large scale wastage of construction resources.

Some major contributors to the generation of waste whichare relevant to the practitioners for a broad based understanding of the magnitude of the problem, but not highlighted or documented in previous studies,are enumerated below:-

- **Underground Construction:** Underground construction, which costs minimum three times the construction cost for a similar structure above ground, does not offer any tangible benefits apart from circumventing the building bye laws. In these constructions the reliability of the

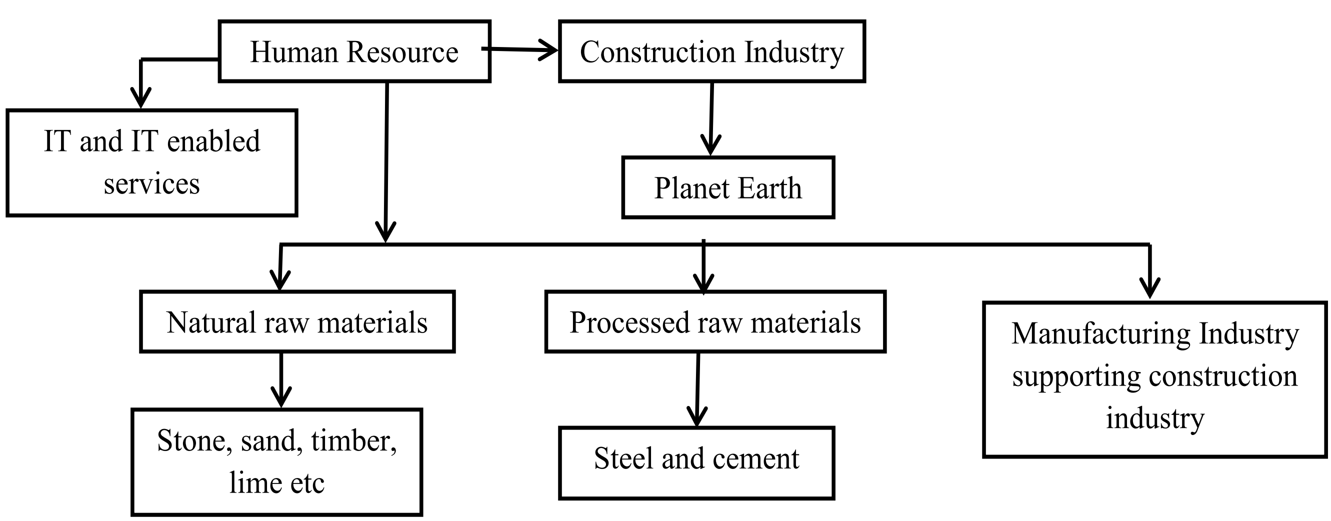

Fig. – 1 : Supply Chain Supporting Construction Industry

composition and behaviour of the soil is always an assumption during design, thereby susceptible for deviations which cannot be predicted. As a result there is always an excessive usage of material for ensuring the stability and durability of the structures in the form of retaining walls, anti-termite treatments, water proofing works etc. Such duplication of processes not only increases the cost of construction but also results in waste creation starting from unscientific disposal of the excavated soil.

- **Vastu Compliance:** Post 1990s' there has been a sudden spurt in vastu consultants and practitioners of vastu compliant architects and builders. Vastushastra, the science of construction has existed since ancient times in India, and refers explicitly to the "dwelling or house with a corresponding plot of land".[8] This science was developed and documented in a period where the common man had no understanding of the building technology, material science, metrology etc and was a ready reckoner for him to plan and construct their dwellings. According to vastushastra, the orientation of the buildings was designed to maximize the effective utilization of the natural resources like sunlight, slope of the ground, directions of the winds and optimization of resources potential based on the characteristics of the building materials used for construction. Unfortunately, today, the lucks and prosperities of individuals are linked to the vastu of the buildings. And with no documented evidence of vastu's influence in changing the fates,the large scale exploitation of the naïve people, who have no understanding of a highly scientific approach to construction,has resulted in large scale waste generation.

- **Experimenting with New Building Materials:** Creations of the construction activities are expected to last for centuries and this has been achieved by understanding the characteristics of the materials used in construction. The longevity is attained by a rational and fact based selections of materials, which had been documented, and the knowledge transformed from generations to generations. In recent times, the mushrooming of cheaper variants and untested alternatives has increased the wastage phenomenally. In the absence of any regulatory mechanism to monitor the performance of new alternatives and frequent changes in the garb of innovations, R & D, etc, there is no documented evidence on the performance of these new materials. Though the Building Material and Technology Promotion Council has made some headway in this regard, there is much more to be done for the system to be reliable.To overcome this lack of information and to ensure longevity of structures the practitioners have resorted to duplication of processes with the logic that should one system fail an alternative has already been incorporated. For example fixing of water proof membranes on the outside face of retaining walls before backfilling or applying a coat of protective membrane over an RCC roof mixed with water proof compounds is standard industry practice.

- **Green Buildings:** While the intention of advocates of the green concept and its applications in building industry is not debated, the specifications stipulated to integrate this concept is debatable in the context of waste generation. For example the specifications for earning 4 points under heading of "Heat Island Effect – Roof" as part of the Site Selection and Planning 4 (SSP4) it is recommended to use "material with high solar reflectance and thermal emittance (such as, white/ light coloured china mosaic tiles or white cement tiles or high reflective coatings or other high reflective materials/ surfaces) to cover at least 50% of the exposed roof areas".[9] This use of material with solar reflectance is in addition to the water proofing chemicals mixed with the RCC for the roof slab and the protective layer provided over it as part of standard practice. A lack of understanding of the spirit of the Green Buildings Standards, coupled with an unscientific methodology of executing the same without understanding the characteristics of the building materials, results in rework and waste of resources.

- **Non-Existence of HR Systems:** The grant of industry status to construction in 2000 has not influenced and facilitated in institutionalizing good human resource management (HRM) practices. While some organizations have focussed on skill development, lack of good HRM practices still contributes to attrition, low productivity, substandard quality of workmanship and accidents, problems that have plagued construction industry about a decade ago,[10] and contributes significantly to the waste generated by construction activities.

- **Ineffective Legislations** The lack of a comprehensive and practical legislation to tackle the problem of construction waste management has been a major impediment. As a nation we have taken over 14 years to appreciate the gravity of a mammoth problem facing us and promulgated The Municipal Solid Wastes (Management and Handling) Rules, 2000, enacted under the provisions of the Environment (Protection) Act, 1986. A very ineffective piece of legislation, it has not achieved the objectives intended. Chapter IV of the The Manual of Solid Waste Management, published by the Ministry of Urban Development, Govt of India, published in 2005, which deals with Construction and demolition waste is again advisory in nature[11] and fails to effectively regulate waste generation and management. Similarly the Demolition and Desilting Waste (Management and Disposal) Guidelines issued by the Municipal Corporation of Greater Mumbai has also been ineffective to a large extent.[12] With trivial penalties defined under other legislations like Torts or Code of Civil Procedure, if applied and successfully prosecuted, there is no deterrent to discourage bad practices of waste management.

SMALL STEPS FOR REDUCING AND MANAGING "WASTE"

Translating theoretical discussions into action is a big challenge which policy makers and practitioners will face. Ease of assimilation, adoption and integration into the existing systems holds the key to a fruitful exercise in effective waste management in the construction industry. Sustainability of further construction activities hinges on conserving the limited pool of natural resources for which an effective waste management system needs to be put in place without delays.A realistic solution should address the problem from an integrated systems perspective rather than as an isolated issue, as waste generation in any component impacts the whole system. A successful system should evolve around the philosophy of "eliminate – reduce – recycle", i.e., eliminate waste generation with effective designing, reduce by improved efficiency of operations and recycle waste into other processes.

Some suggestions in this direction which can be deliberated and considered are:-

- **Design and Specifications improvements:** The first major step towards waste elimination is a design which eliminates extra and frivolous works. Architects and other allied services design engineers should be educated on effective ways by which functional and structural stability can be metand waste generation totally eliminated or reduced. Specifications in standards and manuals like the DSR or the SSRs, quality manuals should lay more emphasis on single process specifications rather than duplicating work with multiple items of works.
- **Effective and Practical Legislations:** With inadequate machinery to enforce legislations, and with a track record of innovating ways to circumvent the legal provisions in the country, the need of the hour is a new thought leadership. Profits being the only factor driving players in the construction business, administering any legislation not linked to finances will be a great challenge. Some thoughts for increasing effectiveness of existing legislations or new legislations are:-
    - Embargo on underground construction. This will eliminate the problem of soil disposal,reduce consumption of resources and costs.
    - Transparent mechanism to monitor performance of new materials and wide based involvement of stakeholders for future improvement.
    - Engagement of citizens and public spirited groups as extensions of regulatory mechanisms to curb violations at the beginning by offering them incentives.
    - Incentivizing manufacturers supporting

the construction industry for improving manufacturing processes which aims at reducing waste both during construction and maintenance of infrastructure.

- Mandatory education to all individuals involved in the construction activity either through formal and structured education or as Standard Operating Procedures at work places.
- Charging waste generators at the time of approvals.

➢ **Effective Human Resource interventions:** The emphasis on trained manpower has been reiterated by many experts over the years. Good HR policies which define clear career growth paths, manage aspirations and with assured pay and perks can contribute significantly. While the manufacturing sector is proactive in engaging technical and skilled tradesmen from Industrial Training Institutes and Polytechnic institutes, the construction industry still relies on untrained tradesmen who have evolved over the years but lack an understanding of the technicalities of the task at hand.

➢ **Delegation of Responsibilities** Considering the scale of operations and the geographical spread of these operations, administering of any system is a big challenge. A system of delegating the tasks of monitoring waste management practices and reporting violations will have to be put into place. Today, with a very active and participative citizen community in the country, their involvement in such tasks can be encouraged by an awareness program highlighting the benefits to the community. Professional bodies should also become proactive in educating the practitioners on good practices of waste management, undertake audits and can link performance to future business generation of the organizations.

CONCLUSION

Waste generation by the construction industry is a live problem which everyone is aware of, but little has been done in controlling or managing it. The approach of "educate – reprimand – penalize–prosecute" which has proved effective in solving many social problems has unfortunately not been effective in waste management, just due to the sheer massive scale of operations. The need of the hour is an innovative approach to control this problem, and the first step could be redefining construction methods. Approvals of construction activities being in the hands of the authorities, installing checks and balance at the inception stage could be experimented with, and thereafter, other measures like rewards and incentives could be experimented with. The emphasis should be on voluntary submission to the mechanisms rather than an enforced submission.

"If the plan does not work, change the plan but not the goal"

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SOLID WASTE MANAGEMENT

R.G. GUPTA*

Abstract

Solid Waste Management (SWM) is one of the most expensive municipal services that a local body has to provide as its obligatory municipal function and absorbs about 1% of GNP in the urban areas. About three to six persons per 1000 population are required to cater to this important civic amenity, which is about 1% to 2% of the total National Work Force. It is, therefore, imperative to optimize this huge civic expenditure and evolve an indigenous low cost technology which is technically sound, financially viable, aesthetically beautiful and socially acceptable to public.

The paper deals in existing issues, the various proposals under the Master Plan 2021 and recommends a plan of action for appropriate phasing of solid waste management.

INTRODUCTION

Solid Waste Management (SWM) is one of the most expensive municipal services that a local body has to provide as its obligatory municipal function and absorbs about 1% of GNP in the urban areas. About three to six persons per 1000 population are required to cater to this important civic amenity, which is about 1% to 2% of the total National Work Force. It is, therefore, imperative to optimize this huge civic expenditure and evolve an indigenous low cost technology which is technically sound, financially viable, aesthetically beautiful and socially acceptable to public.

Regional Plan-2001 proposed that solid waste disposal and management should be planned for a minimum period of 20 years and at least controlled tipping should be adopted in the disposal of the solid waste. Areas should be identified in all the towns for sanitary landfill and, all the towns above one lakh population should have arrangements to properly manage the waste disposal.

In the review of Regional Plan-2001 it was observed that large quantities of solid waste (garbage) were generated daily, out of which very little was collected. NCT-Delhi, however had comparatively better collection (70% of the waste) than rest of NCR towns. Most landfill sites are brimming to the full and vacant sites for landfill are not available in Delhi. No specific sites have been identified in any Sub regions for disposal of solid wastes and landfill.

EXISTING SITUATION AND ISSUES

Studies have revealed that none of the towns in the region are disposing off solid waste in environmental friendly manner. The landfill sites are not lined to protect the ground water from leachate percolating into it. No other disposal system has been adopted by the local bodies.

As per estimates, at present 13,499 MT/day of garbage was being generated in the year 2001 in the NCR region, out of which 9,488 MT/day was being generated from the NCT Delhi sub region. Total garbage generation in the NCT Delhi sub-region is likely to be about 15,413 MT/day by the year 2021 and handling of this kind of waste will need special efforts and funds. Sub-region wise details have been in Table 1.

Table 1: Areas wise Details

Sub-region	Garbage Generation (in MT/day)	
	2001	2021
1	2	3
NCT-Delhi	9,488	15,413
Haryana	1,540	4,569
Rajasthan	201	1,116
Uttar Pradesh	2,270	6,138
Total	13,499	27,236

Source : Regional Plan 2021 National Capital Region

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Since land is a resource, the disposal methodologies for solid waste cannot remain only sanitary landfill. We have to examine other environmental friendly and financially viable options also.

Some of the major issues in this sector include:

Lack of Knowledge of the Local Bodies

Local bodies adopt casual approach for the management of solid waste. Most of the municipalities are not aware of the ways and means to dispose off solid waste that is generated in their respective towns. Even the collection and transportation system of solid waste is not up to the mark. Major chunk of the revenue generation from the city is eaten away in managing the solid waste, which is done inefficiently. Non-availability of suitable Land for Solid Waste Disposal in Environmental Friendly Manner

In most of the towns, no land is earmarked for the disposal of solid waste, neither as landfill site nor for disposal through other techniques. The Master/ Development Plans, prepared by the Town Planning Department, do not reflect this aspect. Many a times, land is earmarked for sanitation purpose, which includes the disposal of solid waste as well as a site for sewage treatment plant, which is insufficient for either use. Since location of the land plays an important role, therefore, it should be located in such a way that solid waste is disposed of in decentralized manner so that the transportation cost for the solid waste is optimized.

Lack of Public Awareness

People are not aware of the harmful effects of solid waste that litters around in towns and cities in the region. There is need for arranging awareness campaign in this regard.

Non-Availability of Funds

Local bodies do not have funds to handle this kind of waste and in future, as discussed above, the quantities are likely to increase manifolds. In case the waste is not handled and disposed of in a scientific manner, it will reach unmanageable proportions in future. In view of this, the local bodies should improve their financial condition through better management and improve their revenue generation capacity. It should also examine the alternative options for optimization of transportation costs of solid waste.

Piecemeal Approach for Handling of Solid Waste

Local bodies do not have any Waste Management Plan for their towns/cities. The state of affairs is such that when the NCR Cells contacted the local bodies for data on solid waste to create database for solid waste management, some of the local bodies were not even aware of the quantum of solid waste generated in their town. Local bodies/municipalities are adopting piecemeal approach in this regard.

Dependence on Departmental Staff causing Labour Related Problems

Most of the local bodies are dependent upon their own staff for handling of solid waste, which has resulted in labour related problems. Major chunk of revenue is eaten away by way of paying wages, upholding transportation fleet, operation and maintenance etc. There is need for the local bodies to adopt a comprehensive approach to manage solid waste in terms of collection, transportation, treatment and disposal of waste factoring in various components like labour, equipment, vehicles, institutional arrangements etc.

OTHER DEFICIENCIES

- Lack of coverage
- Poor collection system specially in the narrow and circuitous lanes, making the collection more difficult
- Mixed variety of organic and inorganic solid waste
- Non-involvement of NGOs/informal sector and private agencies.
- Unsanitary conditions in and around community bins.
- Handling of specialized wastes
- Shortage of vehicles
- Shortcomings at landfill sites
- Organizational inadequacies
- Shortage of equipment and committed supervisory staff
- Financial stringency

POLICIES AND PROPOSALS

In order to improve the overall situation in the NCT Delhi for the harmonized and balanced development for the perspective 2021, following policies and strategies are proposed :

Identification of Land for Treatment /Disposal of Waste

While preparing the Master/Development Plan for various towns/cities, Town Planning Department of respective Sub-regions should earmark the land for treatment/disposal of solid waste. The acquisition of these sites, by the development authorities and municipalities, should form a compulsory element of the development programme and properly budgeted for in their Plan documents.

In NCT-Delhi, the land is scarce and it should plan for future development considering the availability of land for various aspects because the solid waste generation in NCT-Delhi alone by the year 2021 has been projected as 15,000 MT/day, which requires about 28sq kms of land for disposal of solid waste through sanitary land filling assuming that the depths of landfill will be 10 metres (partly below ground and partly above ground), density of solid waste is 0.85 MT per cubic metre, life cycle of landfill site is 20 years and there are three landfill sites. Details of various options examined are in Annexure 4/II. Land area of about 28sq kms required for solid waste disposal through sanitary land fill, should be identified in the MPD-2021, which is under preparation. Another 85sq kms of land area should also be kept reserved for solid waste disposal in future beyond year 2021.

Sanitary landfill sites should be designed and engineered properly to collect and treat leachate and biogas should be collected and utilized in a planned manner. Constituents States of NCR should also earmark land for solid waste disposal by sanitary landfill and other means appropriately.

Waste Minimization-Recycling/Recovery of Resources

In view of the limited availability of land for use as landfill sites, there is an urgent need to find other mechanical means of minimizing waste requiring disposal. In fact, we should aim at zero waste output. Fly-ash from proposed/existing thermal power plants should be utilized in environmental friendly manner by using it in the construction industry. The prevalent system of recycling/recovery of plastic, glass, metal, paper, etc. from the domestic waste is completely informal/unorganized. This should be done in more organized, scientific, cost effective and environmental friendly manner. The segregation of biodegradable waste from non-biodegradable waste such as plastics, glass, metal, paper etc. at the source should be made compulsory in all towns/cities. Not more than 50% of the total solid waste generated should be disposed of through sanitary landfill.

Public Awareness and Training

Public awareness need to be created through mass media including T.V. and newspapers regarding the harmful effects of littering around and how the places can be kept clean. The informal training along with broad-based formal awareness through schools educational curriculum is also recommended. NGO's and Resident Welfare Association (RWA) should be actively involved in the public awareness campaign.

Institutional Improvements

Institutional capacity building measures are required to be taken in order to improve the efficiency and effectiveness of solid waste management at each stage such as waste collection, transfer/ transportation, treatment and disposal. There is a need to associate NGOs/private sector also in this regard. The combination of private sector and public sector in proportionate ratios will be the right option.

In the rural areas, there is no mechanism for collection and disposal of solid waste. This should be developed by associating local Panchayats.

Resource Mobilization

Local bodies and Panchayats should improve their financial conditions through better financial management and should also improve the revenue generation capacities.

RECOMMENDATIONS

Other suggested measures, which are required to be taken, are as follows :

- Adoption of closed bins and covered transportation vehicles

- Modification of building bye-laws to ensure provisions of refuse storage
- Safe and separate storage as well as doorstep collection of biomedical waste, hotel and yard waste etc. on full cost recovery basis.
- Community participation.

PLAN OF ACTION AND PHASING OF IMPLEMENTATION OF STRATEGIES/ POLICIES/PROPOSALS

In order to implement the policies of solid waste disposal in the region, it is imperative to have a phase wise plan of action so that the implementation of policies and proposals in the Regional Plan can be dovetailed with the five-year plans. In view of this, each recommendation has been phased plan-wise where certain activities are to be completed within first five-year of the implementation of the Region Plan whereas some activities will span over to all the four five-year plans. Some of the activities which need to be implemented in the first five years of the Regional Plan include preparation of the Solid Waste Management Plans for all the towns, creation of mass awareness, allocation of land, waste minimization through recycling of solid waste. Construction of solid waste disposal sites and treatment plants in the region, as recommended above, have been proposed to be carried out in a phased manner in all the five-year plans.

Phased programme and plan of action have been worked out to give effect to the proposal and implementation thereof, is given in Table 2.

Table 2: Plan-wise Investment Required for SWM

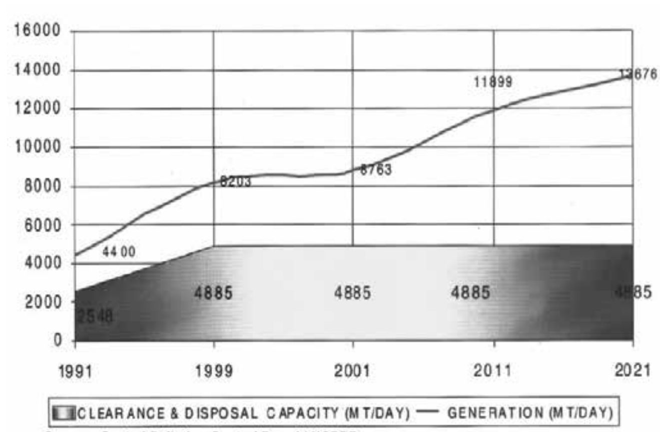
Plan Period	Percentage (%)	Amount (Rs. in Crores)
1	2	3
2002-2007	40.0	544.73
2007-2012	25.0	340.45
2012-2017	20.0	272.36
2017-2021	15.0	204.27

Source : Regional Plan 2021 AD National Capital Region

The investment for solid waste management in the 10th Plan is estimated to be Rs. 544.73 crores, for 11th Plan Rs. 340.45 crores, while for 12th Plan it is projected to be Rs. 272.36 crores and for 13th Plan the estimate is Rs. 204.27 crores.

SOLID WASTE MANAGEMENT

In most localities of Delhi garbage/solid waste dumps are over flowing and the number of open garbage dumps in the by lanes, parks, drains and roadsides are on the increase. It contributes to the pollution of entire environment - air, water and soil. During 1999, estimated quantity of waste generated was 8,203 MT based on 0.61 kg per capita per day (average of NEERI norms for NDMC area - 0.67 kg/c/d and MCD 0.60 kg/c/d) and despite High Court's intervention and regular monitoring, the clearance/disposal was limited to 4,885 MT. The civic agencies MCD, NDMC, Delhi Cantt. Board are hard pressed and have failed to provide clean and healthy environment. It is estimated that with present growth of population and changing life styles quantity of waste generation would increase to 13,676 MT by 2021AD. With the present capacity of the civic bodies limited to handling the above quantum of solid waste, the present gap is likely to increase to 64% in 2021 AD as shown in fig. 1 and the facilities required for treatment disposal of waste are indicated in Table3. while names of zone & sub-zones are shown in Table 4.



Source : Central Pollution Control Board / NCRPB

Fig. 1 Waste Generation and Capacity of Civic Bodies for Handling the Waste

Table 3: Proposed Facilities for Waste Treatment and Disposal during the Master Plan Period (2005-2024)

S. No	Facility	Proposed Location	Waste Treatment capacity (tpd)	Area Required (HA)	Area Available (ha)	Start Year of Operation	Project cost (INR)	Remarks
1.	Land fill	Jaitpur	-	10	10	2005	24,00,00,000	Project underway to be speeded up
2.	Compost (Upgrade)	Okhla, MCD	200	3.2	3.2	2006	14,02,50,000	Work to start next year
3.	Compost (Upgrade)	Okhla, NDMC	200	3.4	3.4	2006	14,02,50,000	Discussion required with NDMC
4.	Land fill	Narela Bawana Road		112	62	2007	168,00,00,000	Work to be speeded up urgently, add land requirement to be addressed.
5.	C & D	Burari Jahangirpuri	500	3.92	20.98	2007	15,00,00,000	Project to commence next year
6.	C & D	Bakarwala	500	3.92	2.1	2007	15,00,00,000	Project to commence next year
7.	Methanisation (Pilot)	Narela Bawana Road	50	2.5	2	2007	16,00,00,000	Project to commence next year
8.	RDF (Pilot)	BurariJ ahangirpuri	100	5	5	2007	15,00,00,000	Project to commence next year
9.	Land fill	Bhatti Mines	-	73	0	2008	224,00,00,000	Work to be speeded up land acquisition is priority.
10.	Compost	To be identified	600	12		2010	30,60,00,000	Land identification to being in 2004
11.	Methanisation (upgrade)	Narela Bawana Road	250			2011	72,00,00,000	Project to commence in 2009
12.	Methanisation	To be identified	250	2.5		2011	72,00,00,000	Land identification to being in 2004
13.	RDF (upgrade)	Burari Jahangirpuri	500			2011	60,00,00,000	Project to commence in 2011
14.	Compost	Bhalswa, Private	500	4.9	4.9	2013	0	Assuming 25% investment by MCD
15.	C & D	Bhatti Mines	1000	7.85	2.5	2014	15,00,00,000	Project to commence in 2013
16.	Compost	To be identified	600	12		2015	30,60,00,000	Land identification by 2010, Project to commence in 2013
17.	Methanisation	To be identified	250	2.5		2015	80,00,00,000	Land identification by 2010, Project to commence in 2013
18.	RDF	To be identified	500	5		2015	75,00,00,000	Land identification by 2010, Project to commence in 2013

19.	Methanisation	To be identified	250	2.5		2020	80,00,00,000	Land identification by 2010, Project to commence in 2018
20.	RDF	To be identified	500	5		2020	75,00,00,000	Land identification by 2010, Project to commence in 2018
	Total	6750	271.0	116.08		1071,25,00,000		

Table 4: Names of the Zones and Number of Sub-Zones

Zone	*Name of Zone*	*Area (Ha.)*	*No. of Sub Zones*
A	Old City	1159	26
B	City Extn. (Karol Bagh)	2304	7
C	Civil Line	3959	21
D	New Delhi	3959	19
E	Trans Yammuna Area	8797	21
F	South Delhi-I	11958	19
G	West Delhi-I	11865	7
H	NW-I Wazirpur, Rohini	5677	9
J	South Delhi-II Exterme South Delhi	15178	10
K-I	West Delhi-II Mundka, Baprola	5782	20
K-II	Dwarka	6408	19
L	West Delhi-III Najafgarh-Ujwa	22840	20
M	North West Delhi-II (Rohini)	5073	23
N	North West Delhi-III (Khanjwala)	13975	18
O	River Yammuna/River Front	8070	06
P-I	Narela	9866	19
P-II	North Delhi-Burari Complex	9866	13
	Total	**148300**	**277**

(Source: Delhi Master Plan 2021 AD)

DIMENSIONS OF SWM AS GIVEN IN ALL THE ZONAL PLANS OF DELHI

Data Taken from Various Zonal plans : (Table 4)

- **Zone-A**

  The projected average garbage generation up to the year 2021 is @ 0.68 kg per capita per day and total quantum for the zone would be of the order of maximum 13.31 MGD and minimum 9.96 MGD per day.

  (Walled city, Jama Masjid, New Delhi Railway station, Pahar Ganj, Jhande Wallan, Sadar bazar; Qadam Sharif; Idgah; Kasmere gate etc).

- **Zone – B**

  The solid waste, disposal requirement based on the existing norms could be disposed of outside the zone by the local body, and the sites identified for the purpose.

  (Kishan ganj, Sarai Rohilla, Anand Parvat, Rajendra Nagar, Pusa Institute, Todapur, Karol bagh; Patel nagar; Nariana)

- **Zone-C**

  A large sanitary landfill site in Timarpur along the Outer Ring Road (Road No.50) has been filled up. This zone is saturated in terms of land. It is difficult to provide additional land for physical infrastructure at Zonal Development Plan level. Thus optimum utilization of existing lands shall be done. Any additional request shall be seen by DJB/GNCTD who own land-pockets in this zone.

  (Hindu Rao Hospital, Kamla Nagar, Timarpur, Dr. Mukherji Nagar, Civil lines; Delhi University Area; Shakti nagar, Ashoka Vihar, Modal town, GTK industrial area; Kings way camp; Jahagir puri;)

- **Zone D**

  (Cannought Place, Rajpat, Rashtriya Bhavan, Budha Jayanti Park, Lodhi Colony, Sarojini Nagar, NetaJi Nagar, Dohla Kua)

- **Zone E**

  (Karaval Nagar, Soniya Vihar, Mustafabad, Gokulpuri, Bhajanpura, Bhrampuri, Seelampur, AShok Nagar, Nand Nagri, Dilshad Garden, Gandhi Nagar, Vishwas Nagar, Vivek Vihar, Anand Vihar, Krishna Nagar, Jagatpuri, Gagan Vihar, Geeta Colony, Laxmi Nagar, Pandav Nagar, Preet Vihar, Kalyan Puri, Trilok puri, Mayur Vihar, Himatpuri, Kondli)

- **Zone-F**

  This zone has large sanitary landfill sites; on Maa Anand Mai Marg (Okhla Industrial Area Phase-I). However, for disposal of garbage, modern technology and methods which are environmentally more safe, need to be adopted.

  (R.K. Puram, Mahipalpur, Masudpur, Mehrauli, Lado Sarai, Qutub Institutional Area, Munirika, Vasant Vihar, Malviya Nagar, Sheikh Sarai, Pushp Vihar, Panchshila Park, Safdarjang Enclave, Green Park, Hauz Khas, Saket, East of Kailash, Greater Kailash-1, East of Kailash, Greater Kailash-2, Dr. Ambedkar Nagar, Govindpuri, Okhla Industrial Estate, Madanpur Khadar, Maharani Bagh, New Friends Colony)

- **Zone-G**

  Keeping in view the norm of 0.68 per kg. Per capital per day, the total solid waste disposal of the entire zone works out to around 2500 Tones per day. A large part of this solid waste could be accommodated in the sanitary land-fill sites identified as per MPD-2021. No site has been proposed in the zone.

  (Kirti Nagar, Moti Nagar, Punjabi Bagh, Paschim Vihar, Pira Garhi, Nangloi, Vikaspuri, Janakpuri, Uttam Nagar, Mohan Garden, Rajouri Garden, Subhash Nagar)

- **Zone H**

  (Rohini, Prem Nagar, Sultanpur, Mangolpuri, Shakurpur, Shakurbasti, TriNagar, Krishna Nagar, Rithla)

- **Zone J**

  (Extreme South Delhi, Krishan Nagar, Aya Nagar, Gadaipur, Ansal Villa, Zaunapur, Fatehpur Beri, Chattarpur, Neb Sarai, Sainik Farm, Khanpur, Sangam Vihar)

- **Zone-K-I and K2.**

  Considering the resident and floating population of Dwarka sub-city, the daily waste works out to be about 800 MT. Zone K-II, being adjacent to the international airport and its flight path, requires a modern and sophisticated technology to handle the huge quantity of waste disposal. Identification of suitable land in and around Dwarka for treatment of solid waste into Bio-degradable and non-bio-degradable requires due consideration.

(Sagarpur, Dabri, Uttam Nagar, Bindapur, Mahadev Enclave, Sadh Nagar, Palam, Raj Nagar, Dwarka, Bamnauli, Bijwasan, Matiyla, Kakrola)

- **Zone-L**

  It is proposed to set up the mechanized plant / compost plant for solid waste which is projected to be 1360 tonnes per day. This plant shall be located based on the requirements in the green belt or at location in village Tikri Kalan, Jhuljhuli and Kanganheri.

  (Najafgarh, Shyam Enclave, Qutab Vihar, Chhawla, Kangan heri)

- Zone –M ------------------
- Zone-N ---------------------
- Zone- O -------------------
- Zone-P-I

  Total Solid Waste 840 Tonnes / day. The process of disposal is to be through sanitary landfills, composting and incineration depending upon the quality of the refuse. In future emphasis is to be laid on solid waste disposal by more scientific method, where the land requirement gets reduced to minimum, in consultation with the concerned agencies.

- Zone-P-II ---------------------

Table 5: Plan of Action and Phasing of Solid Waste Management

SOLID WASTE MANAGEMENT					
1.	All the towns in NCR should prepare detailed Solid Waste Management Plan as per directions of the Ministry of Environment & Forests and Norms & Standards given in the Manual of CPHEEO, MOUD&PA.	Should be prepared immediately compliance by the respective State Governments.	Respective State governments to ensure the implementation of the Plan.	Respective State governments to ensure the implementation of the Plan.	Respective State governments to ensure the implementation of the Plan.
2.	Land for treatment/disposal of solid waste should be earmarked while preparing the Master/ Development Plan for various towns/cities. The acquisition of these sites by the Development Authorities and Municipalities should form a compulsory element of the development programme and properly budgeted for in their Plan documents.	To be done immediately compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.
3.	The policy of waste minimization through recycling /recovery of resources should be adopted- at least 50% of the Solid Waste generated should be disposed off through other treatment technologies like composting and the balance through sanitary landfill.	To be done immediately compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.

4.	Institutional capacity building measures should be taken including involvement of NGO's/ Private Sector to improve the efficiency and effectiveness of Solid waste management at each stage such as waste collection, transfer/transportation, treatment and disposal. Local bodies and Panchayats should improve their financial conditions through better financial management and should also improve the revenue generation capacities	Capacity building is a continuous process and is required to be taken up immediately by the respective State governments. The Board should help the State governments in conducting the courses for capacity building. States should improve water tariff by the end of 11th Plan. Training courses for capacity building to continue. Tariff to be reviewed.			
5.	In the rural areas, there is no mechanism for collection and disposal of solid waste. This should be developed by associating local Panchayats.	All the urban villages to be covered in Tenth Plan.	Other villages to be covered by the end of Eleventh Plan.	To ensure the compliance by the respective State Governments.	To ensure the compliance by the respective State Governments.

RECYCLING LIQUID WASTE AND WATER BODIES

*USHA BATRA AND **DR. K M SONI

Abstract

Liquid waste includes waste water from domestic and commercial establishments and industries. Considering the growing requirements of water, waste water has to be recycled for its reuse. Recycled waste water can be used for flushing, horticulture and industrial use with primary, secondary or tertiary treatment. Though recycling in building complexes should be continued, recycling of waste water from individual buildings and of storm water can be done at municipal level by constructing water bodies as treatment at individual building is very costly compared to municipal level. Water bodies are also helpful in maintaining and even in creation of biodiversity as they help in maintaining eco-life. Water bodies also kill pathogens and bacteria in oxidation process, increase vegetation and aquatic life, promote tourism and also help in maintaining water cycle.

Funding of creating water bodies can be done through schemes like JNNURM, MNREGA and National River Conservation Plan.

INTRODUCTION

Liquid waste or waste water normally includes domestic as well as industrial waste water. Waste water from rain water can also be included as considerable amount of water is wasted during rains. Considering the growing need of water, efforts are to be made to economise the use of water, prevent wastage of water, conserve available water and recycle waste water for its reuse by treating it.

Treated water is obtained by recycled sewerage, industrial effluents, and rain water. Recycled water is normally used for horticulture, agriculture, industrial or flushing use. Such recycled water is often distributed with a dual piping network to keep it separate from potable water pipes. Treated water can be stored in water bodies which can be used for various purposes whenever required and particularly during non availability of rain water.

Water bodies have many other advantages and they also help in maintaining biodiversity, hence, treated water should be stored in water bodies rather than discharging into rivers or streams.

LIQUID WASTE AND ITS TREATMENT

Liquid waste is the liquid waste discharged from drains, homes, commercial establishments and industries. Storm water is drained in open or covered drains which contain only suspended solids, dirt etc. and thus it is easy to treat it. From homes, liquid waste is discharged into the sewerage system, normally waste water. Liquid waste from homes may contain sewage, urine, waste water from kitchens containing oils, and from bath rooms containing fats. Liquid waste from the commercial establishments like restaurants, hotels, banquet halls contains more of oils while from the industries it may contain high quantity of chemicals or excess nutrients, depending upon nature of the industries. Due to different requirements of treatment processes, discharge from industries is not mixed in municipal sewerage system. Similarly, discharge from hospitals, labs, special installations is not directly mixed with municipal sewerage system due to its contents. But such types of liquid wastes cannot be discharged into the rivers or streams without treatment required as per local bylaws.

Liquid waste cannot be discharged into the rivers or ground aquifers without treatment. Therefore,

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based on the type of liquid waste, the following type of treatments (Fig.1) may be required;

- Primary treatment
- Secondary treatment
- Tertiary treatment
- Sludge disposal

Primary treatment may include removal of solids and thus may include screens, grit chambers and sedimentation tanks. Sometimes, removal of heavy and bulky materials, grit, fat and grease is included in the pretreatment process. Secondary treatment includes BOD treatment through aeration tanks, sedimentation tanks/clarifiers and disinfection of the waste water. Tertiary treatment may include chemical/nutrient and toxin (pesticides, VOC, metal) removal. After the treatment, waste water is normally discharged into the rivers/streams. There is a need to store it and reuse it. Storage of such water can be done through water bodies.

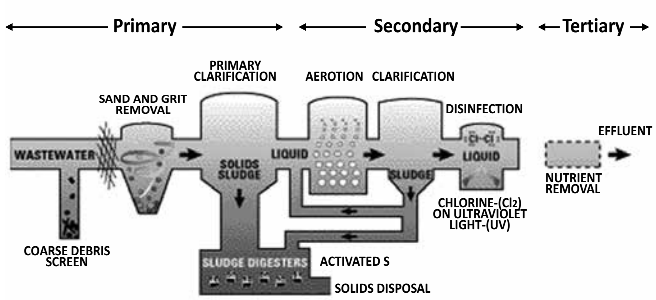

Fig. 1: Treatment of Liquid Waste

(Source: http://www.sheffy6marketing.com/index.php?page=test-child-page)

Domestic waste water is recycled after secondary treatment. Normally, grey water is recycled in India which is used for flushing in the cisterns or for horticulture purposes.

Recycling of Waste Water and its Reuse

Demand of water is increasing day by day due to population increase, and additional agricultural, industrial and horticulture requirements. On the other hand due to urbanization, hard paving, and deforestation, water retention and aquifer recharging have gone down worldwide. Therefore, there is no option but to make use of waste water in place of discharging it into the rivers by storing it so that water availability can be increased. This has necessitated recycling of waste water for various uses which may include the following;

- Horticulture and landscaping
- Industries
- Agriculture (irrigation)
- Household such as flushing
- Drinking

Recycled waste water is frequently used for horticulture and landscaping as it does not require secondary or tertiary treatment. Storm water can be used only with pretreatment process and primary treatment. Such waste water can be stored in water bodies or with simple treatment and even overflow can be discharged into ground aquifers through these water bodies. In such case, excess water can be discharged into ground aquifers before entering into water bodies. Since parks and gardens require considerable water for irrigation, water bodies can be constructed in parks and gardens, particularly in urban areas, both in cities and towns. Excess water available from these water bodies can also be used for supplying water for different uses like flushing. Excess treated waste water from large residential colonies can also be discharged into these water bodies. Recycled treated water from sewerage is used for flushing as well as for horticultural purposes.

Another use of recycled waste water is in industrial organizations. This can be used as "make up water" for air-conditioning plant though it needs to be treated at higher scale as even odour is to be removed from such water, hence tertiary treatment is normally carried out in such waste water. Treated waste water of water bodies removes odour through its natural process, hence treatment of waste water from water bodies is economic.

Another use of waste water is in irrigation which ultimately saves potable water. Irrigation requires large quantity of water hence any saving in the use of irrigation water or partial use of recycled water for irrigation saves potable water. Also, availability of waste water assures farmers and thus planning of crops can be made effectively which is required in rural as well as towns hence water bodies can play a vital role in irrigation. Recycling through water bodies of storm water and rain water will require only primary treatment.

At present, use of waste water is carried out for flushing in urban areas. Recycling of waste water is largely carried out in urban areas in individual buildings or a cluster of buildings. Such treatment is very costly and requires high O & M cost in individual buildings. From the studies done abroad and data of our country as given in Table 1 and 2, it can be seen that law of scale of economies is equally applicable here also. Therefore, it is economic to go for large scale treatment plants by constructing municipal treatment plants (STPs). Treated water of such treatment plants should not be discharged into rivers which get wasted but stored in water bodies for its use in required times.

Table 1: Comparison of Costs for Wastewater Management Systems (Relating to county Cape Cod USA –April 2010)

Capacity (gallons per day)	Unit construction cost (gallons per day)	Unit O & M cost (gallons per day)
10,000	$70	$13
100,000	$35	$5
1,000,000	$17	$2

Table 2: Cost of Installation of STPs in Bangalore

STP locations	Proposed Initial Capacity in MLD	Recommended Treatment Process	Estimated cost in Rs. Million
Raja Canal	40	Extended Aeration	448
Horamavu Agara	20	Sequencing Batch Reactor (SBR)	224
Kachohalli	3	Membrane Bio Reactor	34
Kadugodi	6	SBRs	67
Nagasandra	20	SBR	422
Kengeri	60	Activated Sludge	792
K & C Valley	60	Activated Sludge	1558
Bellandur	90	Activated Sludge	1110
Doddabele	20	SBR	224
Chetty	15	SBR	204

Source – V.C. Kumar

Therefore, measures are to be taken at individual and municipal levels both. Each municipal corporation needs to have municipal STPs while individual STPs can continue. To give a boost to individual STPs, incentives can also be worked out such as if treated waste water is discharged into a water bodies network system, owners can be given equivalent quantity of free water. Thus owners of the buildings even if do not use full quantity of treated water, will get incentives for treating and recycling waste water.

Recycled waste water from sewage is normally not used for drinking as it requires very high level of treatment and also may contain pathogens. Such water is also not used for washing the vegetables and fruits due to same reason. Even, there are apprehensions on direct use of recycled waste water from sewage for irrigation.

Quality norms need to be developed for all such water which could be allowed to be discharged into distinct waste water system connected to water bodies which would be available for reuse.

RECYCLED WATER NETWORK

Recycled water network needs to be developed at large scale in urban areas for its use for horticulture, landscaping, irrigation and household purposes. Recycled water from the waste water bodies can be connected to households who will take separate connections for their use such as flushing, horticulture. Such a network will have distinct coloured pipes to avoid its mixing with potable water. Thus, individual household owners can be asked to take two connections, one for potable use and other for flushing and horticulture purposes while societies having cluster of houses can be asked to have their own STPs who can recycle waste water and reuse it. In case, there is any excess treated water available, the same can be connected to recycled water system. For providing recycled water, municipal corporations will require treatment system, storage system, distribution system, and piping system. Water bodies will actually serve as storage system and will require less treatment as it will have advantage of natural treatment. Recycled water will be in a distinct distribution system and it will have to be ensured that there are no cross connections with potable water system.

SOURCES OF FUNDING WATER BODIES

India has about 600000 villages and 7933 towns. Budget outlay of MGNREGA scheme is 205500 crores from 2006-07 to 2012-13. Thus, average outlay of each year can be considered as 30000 to 40000 crores. Suppose, in each village and town a water body of 100m x 50m x 4m is considered and an average rate of earth excavation is Rupees 150 to 200 per cum, in one year 100000 water bodies can be constructed. Another source of funding is from National River Conservation Plan. Expenditure till 3/2011 by all the states was 4302.44 crores. Hence, it is easier to have financial resources for funding creation of water bodies from this scheme also. Financing in urban and semi urban areas can also be done through JnNURM.

ADVANTAGES FROM WATER BODIES

Recycling of waste water through water bodies has the following advantages;

- The discharge is not thrown in rivers, hence rivers are not polluted.
- Water bodies prevent floods in the rivers as the water is not discharged into the rivers and also they receive rain water from the catchment area.
- Water can be used throughout the year from the water bodies in an assured manner.
- Water is available near to the place required for irrigation.
- Mixing of fresh water can be made in the water bodies for various uses according to the requirements. Water bodies can also be planned to receive rain water from the catchment area.
- Water bodies help in promoting the tourism.
- Water bodies help in generating employment due to tourism and agricultural development near water bodies.
- Water bodies help in creation of trees and vegetation near water bodies.
- Water bodies help in recharging of ground water table.
- Water bodies help in maintaining aquatic life.
- Water bodies help in maintaining ecological balance in the area.
- Water bodies help in preventing air pollution due to evaporation process.
- Water bodies help in maintaining green environment.
- Recycling through water bodies is highly economic compared to small recycling plants used in isolated buildings.
- Large STPs and water bodies are energy efficient as they save considerable energy required in operation and maintenance.
- Monitoring of treated water from STPs is effective when discharged in water bodies away from the rivers due to local public involved in it than discharging into the rivers.

Water bodies require land which is to be made available. The land can be made available in the parks and gardens in the cities. In rural areas, land can be made available from the panchayat land.

CONCLUSION

Water has to be considered as a precious resource and thus wastage of water whether surface, recycled, rain or ground water has to be stopped for future generations and sustainable ecological life on economical basis. Old water bodies can be preserved and new created for storing waste water. Municipal STPs should be given priority compared to individual STPs and individuals should be promoted to adopt waste water recycling methods. There is a need to create a waste water network for reuse of waste water as per the requirements for various allowable purposes. Funding of creation of water bodies network system can be made from existing government schemes.

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CHARACTERIZATION OF MINE OVERBURDEN AND FLY-ASH AS A STABILIZED PAVEMENT MATERIAL

MAHASAKTI MAHAMAYA* AND DR. SARAT KUMAR DAS**

Abstract

Mine overburden removed during surface mining is considered as 'waste' or 'spoil'. It is distinct from mine tailing, the material that remains after economically valuable components have been extracted from the generally finely milled ore is typically not contaminated with toxic components and may be used to restore an exhausted mining site.High ash content (30–50%) of Indian coals is contributing 130 million tons of fly ash per year (in 2006-2007) with less than 50% of it being used. Many a places, the thermal power plants are close to the coal mines. In such places, a mixture can be prepared by using fly ash, coal mine overburden with or without cement, which can be used as a stabilized pavement material.

In the present study an attempt has been made to characterize cement stabilized mine overburden fly ash mixture as a pavement material. The mixture in different proportion with cement percentage varying from 2-10% was used. Based on the unconfined compressive strength and California Bearing ratio values of the stabilized mixture it was observed that it can be used as a stabilized pavement material.

INTRODUCTION

Thermal energy is the main source of energy in India with 90% of which is coal based. The coal mining may be open cast mine or underground mining. In India, there are 556 coalmines producing 411 million tonnes of coal .Considering geo-mining conditions, surface mining technology is most appropriate and only 164 surface mines with 33 mixed mines are responsible for major production of coal (80%). Mine overburden is the material which remains after economically valuable components have been extracted from the generally finely milled ore, it is also known as 'waste' or 'spoil'. In coal mines the mine overburden are in layers The mine overburden including top soil is approximately 2.0 times the amount of coal mined.In South Eastern Coal field Ltd. (SECL) only, 84 million m^3 (Mm^3)annual overburden removal is done per year with an accumulation of 916Mm^3 since 1990 (Jamal and Sidharth 2008). This volume of overburden is going to increase every year due to dumping of overburden, increase of depth of coal seam and coal production.

Utilization of this mine overburden will reduce environmental impact and availability of land resource in coal mining area. This will also result in reduction of mining cost, which occurs on maintenance of mine spoil as reclamation, plantation,slope stability etc. The plantation will be more effective and cheap in plain land than unstable sloppy dumps. Some efforts have been also made for manufacture of bricks using mine overburden, but the volume of utilization is limited. Hence, there is a need to utilize the mine overburden in large quantities like mine filling, construction of embankment etc. Fig. 1. shows a typical open cast coal mine.

Fig.1: Layers of Overburden of an Opencast Coalmine in Chhattisgarh.

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A soil material can be prepared by a mixture using fly ash, coal mine overburden, with or without cement which can be used as a stabilized pavement material. This mixture needs no compaction at field, very easy to deliver and place. It has best use in tight or restricted-access areas where placing and compacting fill is complicated. This mixture have another advantage, that it can be re-excavated. In the present study an attempt has been made to develop a mixture using the mine over burden, fly ash and cement. The mixture is made with trials with different proportion of the above materials. The individual materials are characterized in terms of morphology, mineralogy and other geotechnical properties. The properties of the mixture is evaluated in terms of its flow ability, unconfined compressive strength, California bearing ratio, direct shear strength and permeability.

MATERIALS

In the present study the mine over burden, fly ash and cement are constituent of the mixture material. The mine over burden consists of two part (i) top soil and (ii) shale. The mine over burden was collected from the coal mines from Raigad, Chhatishgarh. The fly ash was collected from the hopper of a thermal power plant from Raigad, Chhatishgarh. The cement used was Portland slag cement available in market. A typical picture showing the over burden of a open cast coal mine is shown in Fig 1. A brief description about the above material is presented as follows:

Shale: Shale is a fine grained, sedimentary rock composed of mud that is a mix of flakes of clay minerals and small fragments (silt-sized particles) of other minerals, especially quartz and calcite.The ratio of clay to other minerals is variable. Shale is characterized by breaks along thin parallel layering or bedding less than one centimetre in thickness, called fissility. Mudstones on the other hand, are similar in composition but do not show the fissility (Fig. 2).

Top soil: Topsoil is the upper surface of the earth's crust in the mining area.The top soil used for the purpose of preparing mixture in lab was collected from coal mine area. Fig. 3 shows the top soil used in the present study.

Fig. 2: Shale Collected from Coal Mines

Fig. 3: Top Soil Collected from Coal Mine Area of Raigad

RESULTS AND DISCUSSION

The mixture is prepared using the basic material mine over burden (shale and top soil), fly ash and cement in different trial mix. The results of laboratory experiments, performed on shale, top soil, fly ash and the mixture are presented in the following section.

Morphology: The scanning electron micrograph of shale and top soil is shown in Fig. 4 and 5, respectively. It was observed that the particles are irregular shaped. It was also observed that surface coating of finer particles. Fig. 6 shows the microphotograph of fly ash. The particles are mostly spherical in nature. The cenosphere and plerosphere particles are also observed. More amount of cenosphere shows that the fly ash contains a good amount of pozzolanic material.

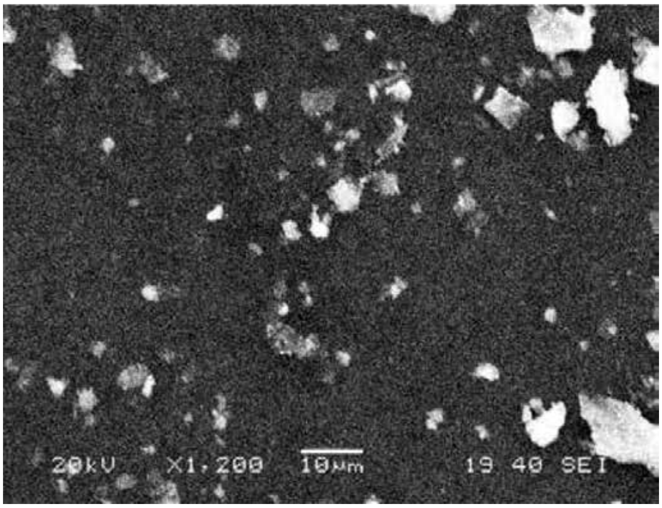


Fig. 4: Scanning Electron Micrograph of Top Soil

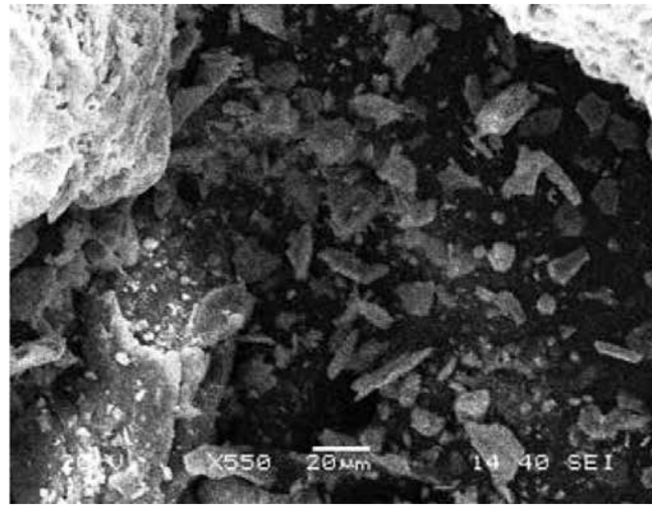


Fig. 5 Scanning Electron Micrograph of Shale

Mineralogy of Material:

By conducting XRD test it was found that shale consists of ferrous oxide, zinc, manganese oxide, titanium dioxide, zinc oxide. In local soil it was found that it consists of silicon carbide, ferrous oxide, titanium dioxide, manganese oxide, ferric oxide, zinc oxide. Similarly XRD test reveals the fly ash consists of quartzite, mullite, and hematite minerals.

Grain Size Distribution and Specific Gravity

The grain size distribution of shale, top soil and fly ash are presented in Fig. 7. It can be seen that shale and top soil are mostly coarse grained and fly ash is fine grained with more than 75% particle are fine particles (< 75 µm). The specific gravity values of the materials are found to vary from 2.186 for fly ash and 3.020 for cement as presented in Table 1.

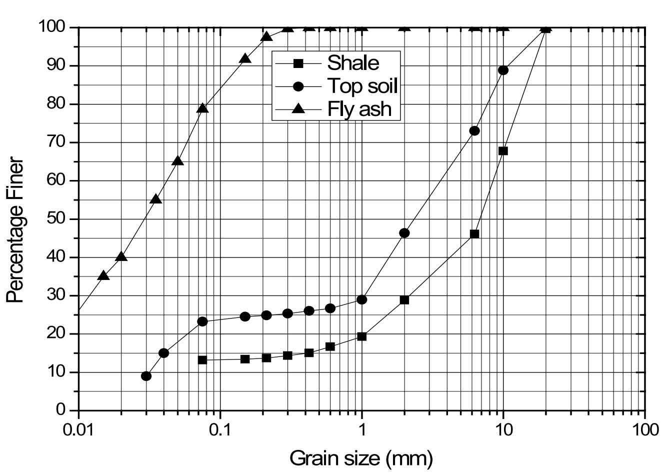


Fig. 7: Grain Size Distribution curve of Various Soil

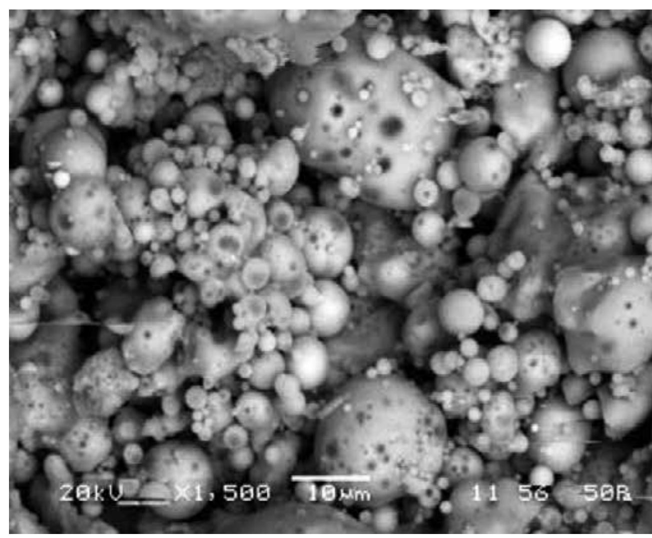


Fig. 6: Scanning Electron Micrograph of Fly-ash

Table 1: Specific Gravity Various Materials

Material	Specific gravity
Fly-ash (FA)	2.186
Local soil	2.925
Shale	2.560
Cement	3.020

Compaction Characteristics:

In this both light compaction (standard Proctor) and heavy compaction (modified Proctor) tests were conducted. For the fly ash maximum dry density achieved in light compaction test is 1.258 gm/cc at optimum moisture content (OMC) 22.95 and 1.312

gm/cc at OMC 21.15 at heavy compaction test (Fig. 8).

Similarly the compaction curve for shale and local soil are presented in Fig. 9 and Fig. 10, respectively. For shale, the maximum dry density achieved in light compaction test is 1.852 gm/cc at optimum moisture content 12.21% and 1.972 gm/cc at OMC 9.13 at heavy compaction test. For the top soil the maximum dry density achieved in light compaction test is 1.897 gm/cc at optimum moisture content 12.17 and 2.017 gm/cc at 11.86 OMC at heavy compaction test.

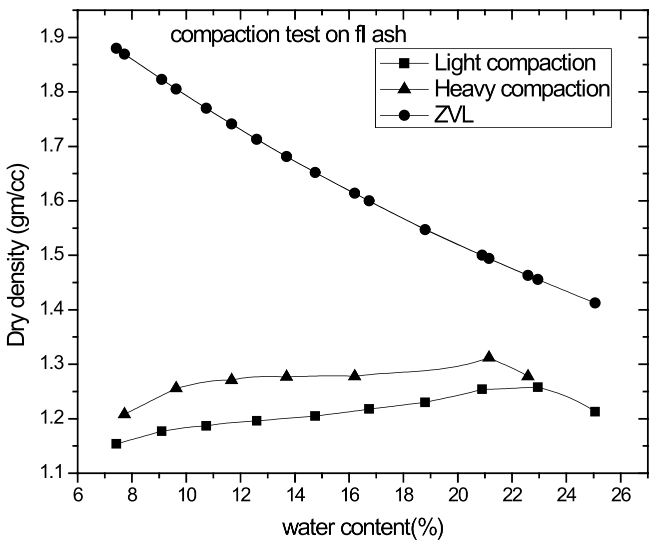


Fig. 8: Compaction Test on Fly-ash

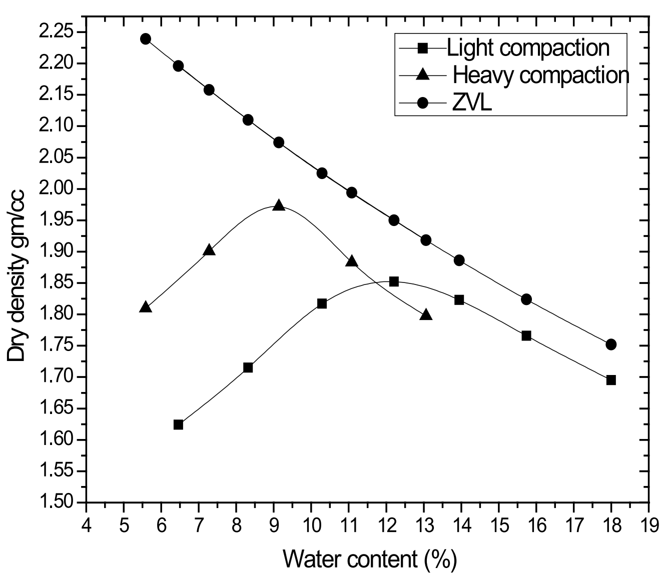


Fig. 9: Compaction Test on Shale

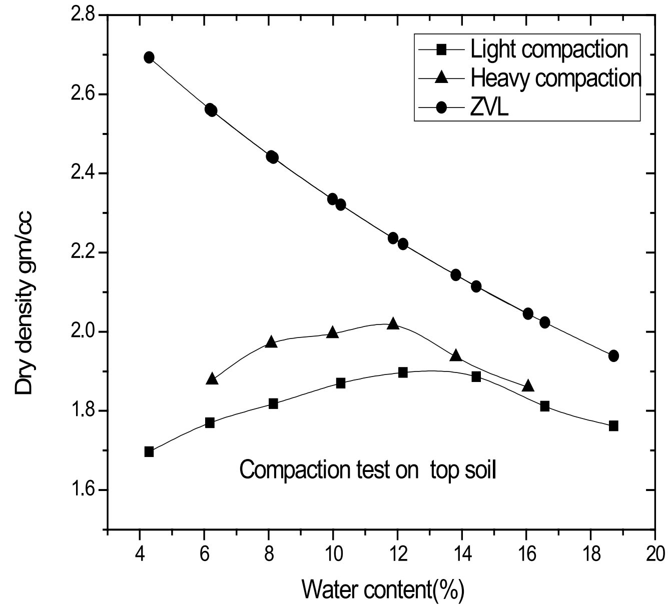


Fig. 10: Compaction Test on Top soil

After conducting above tests on different materials, the mixture is prepared using above materials in different proportions. Table 2 shows the percentage of ingredients of different mixture soil samples.

Table 2: Specification of Mixture Samples

Mixture type	Sample No	Shale (%)	Top soil (%)	Fly ash (%)	Cement (%)
Mixture 1	M1S1	46	30	20	4
	M1S2	36	40	20	4
	M1S3	26	45	25	4
	M1S4	45	30	20	5
	M1S5	35	40	20	5
	M1S6	25	45	25	5
	M1S7	44	30	20	6
	M1S8	34	40	20	6
	M1S9	24	45	25	6
	M1S10	36	27	30	7
	M1S11	38	30	25	7
	M1S12	23	40	30	7
Mixture 2	M2S13	45	-	55	-
	M2S14	50	-	50	-
	M2S15	65	-	35	-
Mixture 3	M3S16	58	-	35	4

	M3S17	30	-	63	5
	M3S18	60		35	5
	M3S19	30		65	5
	M3S20	60		34	6
	M3S21	30		64	6

Unconfined Compressive Strength Test:

Then, to know the strength of fly ash over burden mixture, unconfined compressive strength (UCS) tests were conducted on soil sample after 7days of its preparation. Fig. 11 shows a UCS value with 4% and 5% cement and found that they are comparable but it increase with 6% cement. The shear failure pattern of the sample M1S1, M1S4 and M1S7 is shown in Fig. 13. The UCS values for other mixtures are shown in Fig. 12.

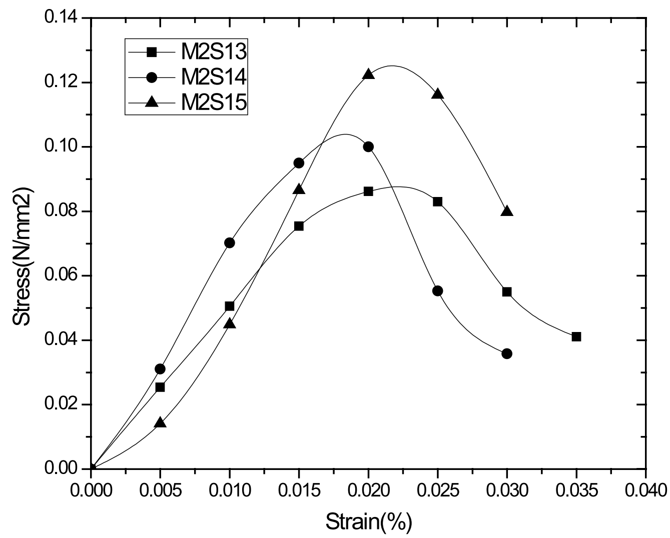


Fig. 11: Unconfined Compressive Strength Curves of Different Soil Sample with Different Percentage of Cement.

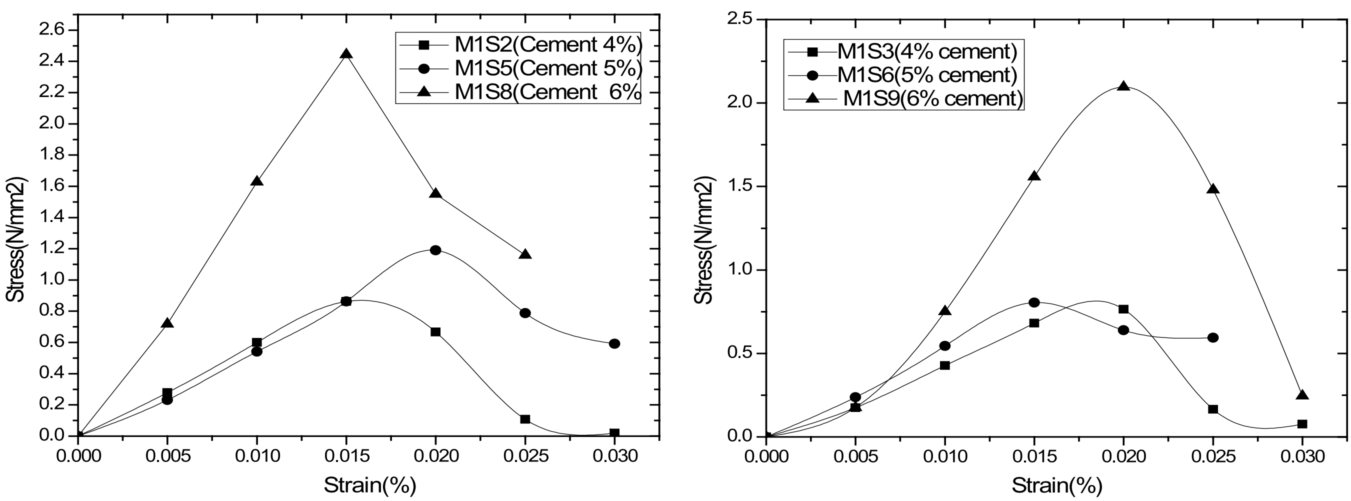
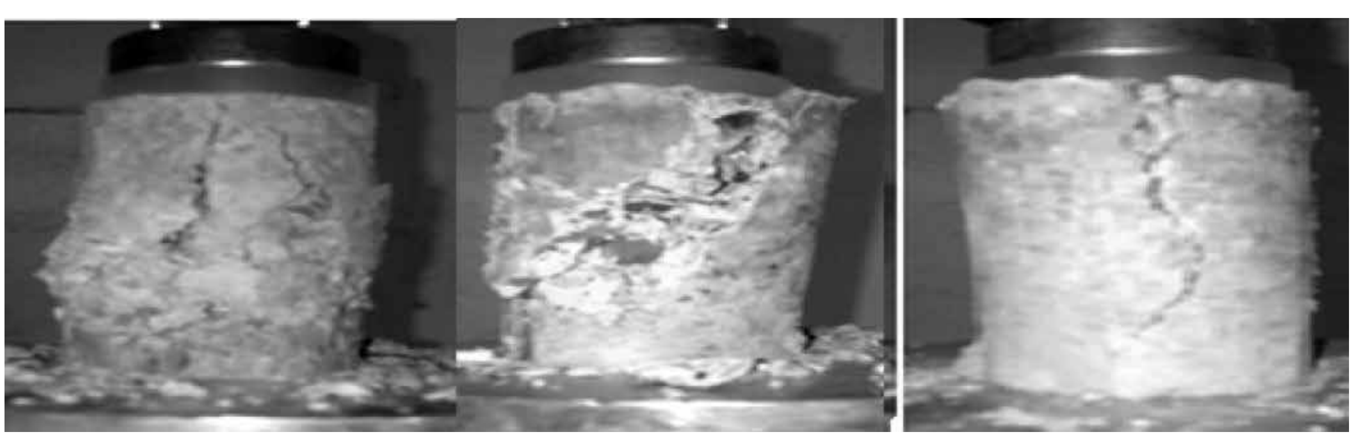


Fig. 12: Unconfined Compressive Strength Different Soil Sample with Different Percentage of Cement.



M1S1 **M1S4** **M1S7**

Fig 13: Typical Failure Pattern of Soil Samples M1S1, M1S4, M1S7 in UCS test

Similarly the UCS tests and the failure patterns for the Mixture 2 is shown in Figure 14. Here also it was observed that the UCS value increased with shale content.

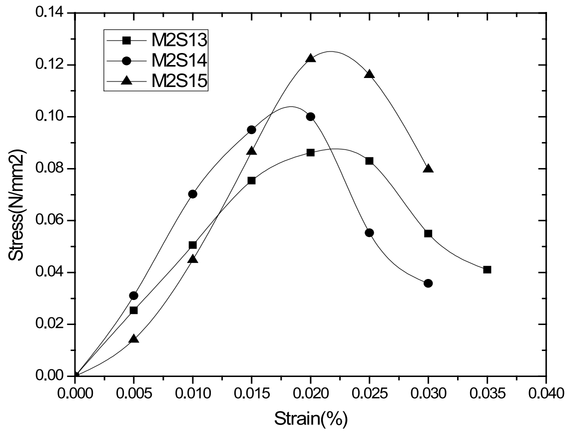


Fig. 14: Unconfined Compressive Strength Curves of different soil sample without cement

CBR Test Results

Both soaked and unsoaked CBR test were conducted on the samples with soaked condition for 7 days and for other sample it was soaked with surcharge for 96 hours of the 7 days curing.The load penetration curves for two typical mixes M1S1 and M1S2 are shown in Fig. 15 and 16, respectively. The results are presented for different mixes in Table 3.It was observed that the mix with 11 days curing has more CBR value than that of 7 days soaked as expected. For same cases the volume are comparable as expected for mixes without cement soaked CBR

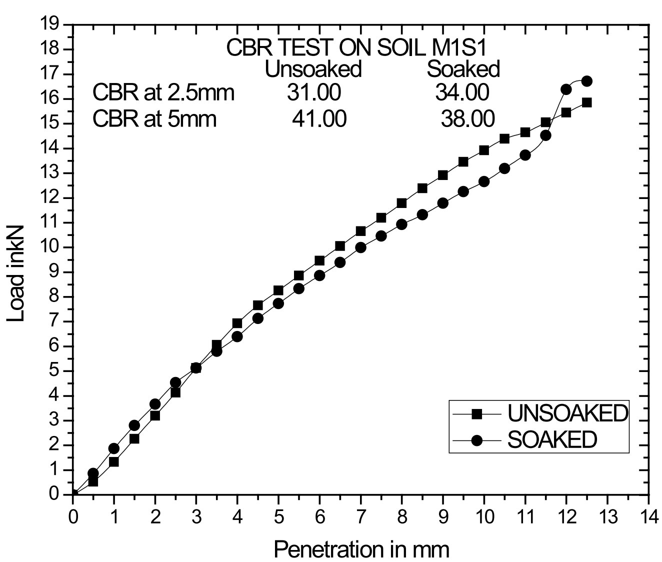


Fig 15: CBR curve of M1S1

less than unsoaked CBR.CBR value found to be vary from 22.8 to 63.0. Hence as per IRC 37 the mix with more than 4% cement can be used for sub base. The mix without cement can be used on subgrade.

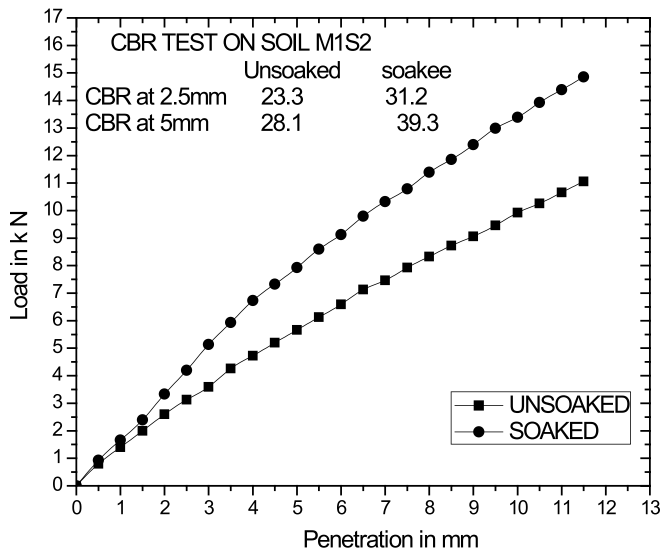


Fig 16 : CBR curve of M1S2

Table 3 CBR Test Values on Prepared Soil Samples

Mixture Type	CBR Value (Unsoaked)	CBR Value (Soaked)
M1S1	41.00	38.00
M1S2	28.1	39.3
M1S3	27.1	36.7
M1S4	49.60	46.300
M1S5	44.3	46.3
M1S6	39.0	52.5
M1S7	44.0	61.8(C)
M1S8	68.4(C)	98.1(C)
M1S9	74.0	74.7(C)
M1S10	32.7	48.2(C)
M1S11	54.90	79(C)
M1S12	56.2	82.0
M2S13	5.6	4.0
M2S14	7.3	6.6
M3S15	24.30	4.800
M3S16	92.5	87.2
M3S17	61.8	67.7

M3S18	36.7	37.7
M3S19	29.4	33.7
M3S20	61.5	61.1
M3S21	45.6	44.9

CONCLUSION

The mine overburden including top soil is approximately twice the amount of coal production. High ash content (30–50%) of Indian coals are contributing 130 million tons of fly ash per year (in 2006-2007) with less than 50% of it being used. There is need of vast utilization of these materials for sustainable development. Development of new kind of mixture material using mine overburden, fly ash and cement is an innovative methodology in this regard. Based on the limited study as described above following conclusions can be made:

- The mine over burden consists of shale and top soil are mostly granular material, whereas the fly ash used in this case contains 75% of fines. The morphological study showed that the mine overburden are angular, plate shaped but the fly ash are spherical with mostly cenosphere.
- The specific gravity of top soil is found to very high due to presence of iron content of residual soil. The fly ash contents good amount of glassy/ pozzolanic part.
- In absence of any design mix guideline, trial mixes were made with cement as the binding agent varying from 4 to 7%. Some mixes were also made without cement. Based on the flow ability test similar to that of ready mix concrete, the moisture content depend upon cement and fly ash content. The moisture content increased with cement and fly ash content.
- The unconfined confined compressive strength of the mix was found to increase with cement content with 6 to 7% cement found have UCS value upto 4 N/mm2. The values found to depend upon the mixture proportion. Hence, it can be suitably used for embankments.
- The failure surface of the UCS sample found to vary brittle to ductile failure depending the mixture type.
- The CBR values for mixture without cement found to vary from 5.5 to 24. The CBR values for soaked and unsoaked condition of the mixture cured for 7 days found to have high values for soaked than the unsoaked values due to development of strength of cement. The CBR values of the soaked CBR value found to vary from 22.8 to 63.0.
- Based on limited studies it was observed that, there is a potential for effective utilization of such material in slopes and embankments.

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SOLID WASTE MANAGEMENT IN BUILT ENVIRONMENT

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Abstract

Every settlement inhabited by the people in this world generated solid waste of every kind which needs to be disposed by one method or the other. Traditionally, the wastes generated were mainly biodegradable and hence had least problems for its disposal rather the wastes were used to produce manure. With the changing time coupled with industrialization and urban way of life styles, the human habitation started seriously facing rapid deterioration of the built environment and lately, reached the dangerous situation because of no serious attention paid towards the solid waste management plan in order to save the general quality of urban life.

The situation in major urban centres of India particularly, the metropolitan cities is serious as there is no holistic approach to tackle the problems through Municipal Solid Waste Management Plan with adequate budgetary support to equip and update the present technology that is being used by the Local Bodies. This is one of the most priority areas unlike education, health of the citizens. Pubic awareness and education through public forum, electronic media, news channels and more important the involvement of the people can create the environment for good living in modern urban India.

INTRODUCTION

Throughout the history, the amount of waste generated by humans was not significantly less due to low population density and low societal levels of the exploitation of natural resources. Common wastes produced during pre-modern times were mainly ashes and human biodegradable wastes and these were released back into the ground locally, with minimum environmental impact. Tools made out of wood or metal were generally reused or passed down through the generations. Following the onset of industrialization and the sustained urban growth of population of urban centers in India, the buildup of wastes in the cities caused a rapid deterioration in the levels of sanitation and the general quality of urban life. The dramatic increase of wastes for disposal led to creation of landfill sites for dumping of wastes or composting of waste materials which led to adverse environmental impact.

Deterioration of the built environment is the biggest dangerous situation lately ever faced by the people of the society in many developing countries because no serious attention is given to the root causes leading to such a bad environmental conditions. There are no accurate figures of huge amount of harmful solid wastes dumped into the land and water without proper treatment. In a thickly populated country like India, rapid urbanization with industrialization, without sufficient precautions for protecting the environment and controlling pollution, the environmental condition of various urban areas are getting worse day by day. India's rising population with poverty, various types of diseases and complex environmental and pollution problems are increasing and no organization may possibly be keeping track of the deteriorating conditions due to any specific environmental reason. The need for the appropriate solid waste management technologies with respect to the changing pattern of the waste generation can help the local bodies responsible for solid waste management in preparing an efficient plan. India, with a population of over 1.21 billion account for 17.5 % of the world population of which 377 million live in about 7000 urban areas of the country. India has 475 urban agglomerations including 53 metropolitan cities and three of which has population

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over 10 million namely Mumbai (18.4 million), Delhi (16.3 million) and Kolkata (14.1 million). The very high rate of urbanization coupled with improper spatial planning and poor financial condition has made municipal solid waste (MSW) management a herculean task.

CLASSIFICATION OF MUNICIPAL SOLID WASTES

The quantity of municipal solid waste generated depends on a number of factors such as food habits, standard of living, degree of commercial activities and seasons. Indian cities now generate eight times more MSW than they generated in 1947 or during pre-independence era due to increasing urbanization and changing lifestyles. A per capita MSW generated in Indian cities now varies between 0.2 to 0.5 kg/day. Studies reveal that for every Indian Rs. 1000 increase in income the solid waste generation increases by one kilogram per month. The growth rate of GDP for every decade since 1960, have gone up rapidly from 3.5 to 6.4 in 2010.

In India, municipal solid waste can be classified as a) night soil, b) wastes like garbage, paper, plastics, metal scraps, c) old domestic appliances, furniture, wastes generated from old roads, buildings and new construction waste materials and debris, d) toxic substances like paints, pesticides, used batteries, medicines and medical wastes and e) E-wastes like electronic goods, appliances, equipments etc. besides food wastes or organic wastes and street sweeping wastes including soil, ash and other materials and so on. Similarly, industrial wastes can be grouped on i) wastes for direct disposal, ii) wastes that are to be treated prior to disposal for minimizing the harmful effects, iii) wastes for in-house recycling in the industries, iv) wastes to be treated and utilized as suitable raw materials for other industries and v) those wastes from which the valuables are recovered before disposing it off.

SOME SPECIFIC WASTE

General philosophy for treating the Solid Wastes including industrial wastes is to recover as much as possible before disposing it off for treatment of the wastes or recycling the waste materials. In this regard lot of research and development have been carried out mostly in developed countries and some of the wastes treatment processes have been translated into practice. For example, metal scraps, broken glasses, refractory, waste plastics and papers are recycled in their respective industries after suitable treatment. Coal, dust, waste furnace oil, oil sludge, wood chips, saw dust, organic garbage etc. are utilized to generate energy by incineration. Similarly, some wastes are processed to use as raw materials in other industries like blast furnace slag as cement or copper plant rejects to extract nickel, selenium, gold, silver and platinum group metals. Likewise night soil, animal dumps and sewerage sludge are used for producing fuel gas through fermentation etc. Garbage from domestic and public places, office papers and textile industries contain lot of corboneous materials which by proper incineration would produce a large amount of heat to generate steam and hence the electricity.

TREATMENT AND DISPOSAL OF MUNICIPAL SOLID WASTES

Composting

Domestic solid waste management is becoming a critical problem in India. The crux of the problem however, is that disposal, picking and recycling is yet to receive full attention. The basic objective is to keep the city clean and ensure healthy environment. This requires interventions both at policy and decision making level and at the grass root level i.e. full co-operation from the households. With the industrial and technological advancement at-least the urbanites are aware of the consequences of the negligence towards not caring for clean and healthy environment.

From prehistory up to the present day, dumping has been the most widespread system for wastes disposal. Throwing it into open spaces near the points of production, generally without taking special precautions or open burning continues to be the principal method of waste disposal. Although in the definition of strategies for the management of wastes, the landfill option appears to be the least desirable, the reality is that it is still the most common system for wastes disposal world wide, both in fully industrialized countries and in developing countries. Composting has a long tradition particularly in rural India. Composting is difficult process because the waste arrives in a mixed form and contains a lot of non-organic materials. When such waste is composted, the end product is of poor quality. The presence of plastic and glass objects in the waste is more problematic. In the absence of segregation, the waste management system is rendered useless. The first large scale aerobic composting plant in the country was set up in Mumbai in 1992 to handle 500 t/day of MSW by Excel Industries Ltd. which worked very well and the compost produced sold was at the rate of Rs. 2/kg. Number of such plants, have been set up and are operational in many other cities such as Vjjaywada, Delhi, Banglore, Ahmedabad, Hyderabad, Bhopal, Lucknow, Gwalior and so on.

Incineration

In India, the incineration is a poor option as the waste consists mainly very high organic material (40-60%) and high inert content (30-50%) also low calorific content (800-1100 kcl/kg), high moisture content (40-60%) in MSW and the high cost of setting up and running the plant. The first large scale incineration plant was set up in Delhi (Timarpur) in 1987 with a capacity of 300 t/day with the help of Danish technology but had to be abandoned within 6 months due to poor performance as the solid wastes was predominantly organic based and the plant could not be continued economically besides the cost of maintenance.

Gasification Technology

Gasification is the solid waste incineration under oxygen deficient conditions, to produce fuel gas. In India, there are few gasifiers in operation, but they are mostly for burning of biomass such as agro-residues, sawmill dust and forest wastes. In India one gasification unit installed at Gaul Pahri campus in Delhi by Tata Energy Research Institute (TERI) and other is installed at Nohar, Hanumangarh, Rajasthan by Navreet Energy Research and Information (NERI) for the burning of agro-wastes, sawmill dust and forest wastes. The efficiency is about 70-80 % and about 25 % of the fuel gas produced may be recycled back into the system to support the gasification process and the remaining is recovered and used for power generation.

Land filling

A landfill is an area of land where waste is deposited. The basic aim is to avoid any contact between the waste and the surrounding environment, particularly the groundwater and the water bodies. In India, open, uncontrolled and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation. 60-90 % of MSW in cities and towns are directly disposed of on land in an unsatisfactory manner. Normally, dumping is done in low lying areas, deep ditches which are prone to flooding increasing the possibilities of surface water as well as ground water contamination during the rainy days. The pollution of ground water is not assessed but definitely it becomes a threat due to dumping of wastes. Besides this, it has been producing bad odour, generation of inflammable gases within the waste dump, pests, rodents and wind blown litter in and around the waste dump. It also becomes a place for unhygienic living for the neighboring areas. It is therefore, more important to ensure the sanitary land filling with certain improvements as many big cities are facing the problem of limited availability of land for wastes disposal as it requires very large space at different locations and obviously not considered to be economical due high cost of land. Big mounts or heaps of solid wastes disposed of on landfill sites can be seen in many metropolitan cities.

Bioreactor Landfill

Another development in landfill technology is the bioreactor landfill which is designed, constructed and operated to optimize moisture content and increase the rate of anaerobic biodegradation. The principal function that distinguishes bioreactor landfills from conventional landfills is lachate recirculation. The goal is to increase the rate of bio-degradation to achieve maximum gas generation rate and output so as to optimize recovery for energy production. This approach aims at, minimizing the landfill stabilization time and reduce the period of monitoring and liability retention.

ISSUES IN MUNICIPAL SOLID WASTE MANAGEMENT

Handling Source Segregation, Collection

In India, there is virtually no organized and scientifically planned source segregation except for individual waste where due to organized nature of sector, segregation is sometimes practiced for healthcare wastes due to regulatory requirements. Sorting is done mostly by unorganized private sector (Scavengers and rag pickers) and rarely done by waste generators. Hence, efficiency of segregation is very low as the unorganized sector tends to segregate only those waste materials which have relatively higher economic return in the recycling market. The unsafe & hazardous conditions under which segregation and sorting take place are well known. The substantial amount of wastes is left to rot on the streets or is dumped into low lying areas like canals, rivers, ponds etc. or dumped along roadsides or along the rail lines. Several factors are responsible for such low collection efficiency; lack of appropriate collection systems; lack of collection facilities such as waste disposal bins, organizing rag pickers with some incentives, collection vehicles, transport vehicles; lack of funds and enforcement of appropriate regulations etc.

Treatment and Disposal

Municipal Solid Wastes is mostly disposed without any treatment into dumping sites thus causing severe environmental and health risks. The progress in moving towards sanitary landfills and/or disposing through well designed and well operated incinerators is rather slow.

Resource Generation

Lot of materials can be recovered from wastes for recycling which can then serve as a raw material input for manufacturing. Despite the absence of organized segregation systems, quite substantial amounts of clean plastics, cellulosic, metals and glass are already recycled in India due to their increasing amount which attracts economically. A large number of people ranging from rag pickers to primary dealers and recycling industries earn their living out of wastes recycling. The organic wastes which constitute the largest proportion in the wastes stream, is often disposed of rather than segregated and converted into bio-gas, compost etc. Landfill gas is mostly unutilized unless adopted by way of a scientific method to tap the bio-gas generation.

Policy Issues

A vigorous policy framework to give a direction and thrust to environmentally sound waste management does not exist in India. Policy measures to promote wastes minimization, recycle and recovery are rather lean. No national target has been set up to deal with overall issue of waste management in line with country's economic development programme. Most of the current policies are in support of end-of-pipe approach creating huge burden on municipal authorities. There are no policies to promote segregation and reuse and conversion of wastes into useful materials/energy.

Technology Issues

Launching targeted technologies for materials and energy recovery from waste is the need of the hour in India. To build confidence and test the application of such technologies in the context of developing countries, pilot demonstration projects need to be established. Presently, most of the work is focused on augmenting wastes collection and building disposal facilities and not going for innovative technologies available internationally of which some may be suitable for Indian condition.

Financing Issues

To support wastes management, one of the most pressing issues is the availability of funds. The municipal bodies are mostly in dire financial situation and are barely able to maintain the basic jobs of wastes collection and somehow dispose it to keep the city clean. It is an utmost important issue to look into the future needs of the people in the changing environment and also their changing lifestyles in choosing an appropriate technology to deal with the solid wastes management.

FUTURE CHALLENGES IN MUNICIPAL SOLID WASTE MANAGEMENT

Effective solid wastes management systems are needed to ensure better human health and safety besides environmentally and economically sustainable. The treatment and disposal of MSW will depend upon the technology choices and disposal options based on the composition of the wastes generated in future. It would be necessary to look for innovative solutions to address the issue of solid wastes management in a more meaningful manner. The effects of population, per capita income, changing life style, consumption pattern, density, GDP of the city is going to pave way to the composition of the wastes and particularly for more and more hazardous and toxic wastes because of industrialization as well as end of life products. The negative impacts of wastes on the local environment will be more acute often resulting in public out cries and demands for the action. The impacts of inadequate wastes management is not just to the local level but are now crossing boundaries and due to gases like methane emission are even affecting global environment. More water bodies are getting contaminated. The land under and around wastes dump sites are becoming heavily polluted and will require tremendous efforts and resources for rejuvenation.

The cost of wastes management is increasing on several accounts; firstly on account of increase in quantity of wastes being generated, secondly, changing composition of wastes with increasing content of non-biodegradable and hazardous substances that will require sophistication in wastes management techniques and technologies and thirdly, increasing environmental and health awareness. As already mentioned national and local policies on wastes management are not yet comprehensive to cover all types of wastes management in India. Policy framework to support resource recovery from wastes is still inadequate in the country. This also needs priority unlike health, education, infrastructure development, job creation, poverty eradication etc.

FUTURE OPPORTUNITIES

- Solid Wastes minimization or reduction at source is increasingly being realized as a component for enhancing competitiveness. Many industrial firms are making special efforts to minimize generation of wastes so as not only to reduce their wastes treatment and disposal cost but also improve their resource efficiency.
- Due to increasing energy and material costs, recovery of materials and energy from waste is becoming more and more economically viable. A whole new range of industrial sector can be developed based on recycling wastes materials. The Government of Gujarat in India is already contemplating an idea of establishing a 'recycling industry park' which will benefit from a cheap and perennial supply of input materials.
- The current waste management cost can be reduced by designing the waste management systems, scientifically with focus on 3R. The volume of 'residual waste" after recovery / recycle of materials can be drastically reduced thus cutting down treatment and disposal costs. In case residual waste is sent to landfill, this would also mean that the life of existing landfills will be appreciably increased. Earnings from recovered materials and resources can further ease the budget requirements for wastes management.
- Recovering energy from waste can become an excellent source of renewal energy. Conversion of organic wastes into useful material and/ or energy can apart from affecting a significant reduction in wastes quantity can provide cheap and renewal energy. Other wastes components which are not easily amenable to recycling like dirty plastic and paper can also be converted into fuel, of course with due care for combustion related emissions.
- Private sector is getting involved in wastes management. In many cities the entire range of wastes management services – collection, segregation, transportation, treatment and disposal are now provided by private sector. There is a huge potential for engaging private sector not only in recycling industry but also in establishing industry based on recycled materials as input materials. The beneficial environmental aspects in terms of reduced extraction of non-renewable resources are obvious.
- Solid waste management with focus on collection, segregation and recycling can serve dual purpose of the objectives of creating employment opportunities for the poor & thus enabling them to improve the life styles. It could also be a business opportunity for the private sector too with a good potential for generation of economy through sell of maneuver, return from recycled materials being used as a raw materials by the industry, protecting land and soil from contamination by preventing pollution, producing biogas for generating energy etc.
- Medical wastes generation ranges between 0.5 to 2.0 kg per bed per day. It is estimated that about 0.33 million tons of waste is generated in India consisting bandages, linen and other infectious waste (30-35 %) , plastics (7-10 %), disposable syringes (0.3-0.5 %), glass (3-5 %) and other general waste including food (40-45 %). As per Biomedical waste (Management and Handling) Rules, 1998 Amendments dated 24th August, 2011, the biomedical waste has been divided into 8 categories namely i) Human Anatomical Waste, ii) Animal Waste, iii) Microbiology and Biotechnology Waste and other Laboratory

Waste, iv) Waste Sharps, v) Discarded Medicines and Cytotoxic Drugs, vi) Solid waste, vii) Infectious Solid Waste and viii) Chemical Waste. Efforts have to be made to minimize the healthcare waste by adopting innovative methods keeping in sight the guidelines for waste management.

CONCLUSION

The changing trends of generation of municipal solid waste as well as other urban wastes both in terms of quantity and its characteristics find its impact on the performance and capacity planning of collection/recovery, recycle, processing including incineration and landfill facilities. The changing composition of the solid wastes emphasizes the importance of segregation for successful processing of wastes management and modernizing the existing facilities by the authorities concerned. The Local Bodies should maintain the storage facilities in a proper manner so that the surrounding areas do not get affected or cause an unhygienic condition. At the same time the Local Body should maintain the periodic data with regard to the quantitative and qualitative solid wastes generation, its composition for future plans. While preparing the plans for future, the projections of the probable quantum or volume of the solid wastes should be assessed and appropriately locate the sites for processing of the solid wastes in a planned manner.

There is also a need to make the households aware of their responsibilities as good citizens by the Local Body concerned and to educate them about the solid waste management programme, its necessity in order to keep their city clean and with healthy environment. The best practices adopted by other cities' authorities on this issue should be discussed at citizen's forum and shared their experiences with the public and related agencies. Print and electronic media can play a vital role in creating awareness and educating the public for the success of the solid wastes management plans. At the Central and State Government level the priority should be given for clean and green environment of human habitats for better lifestyle and support budgetary requirements.

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DESIGNING ZERO WASTE CITIES

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Abstract

Material resources are depleting at such a rate that we are likely to soon face shortages in materials we currently dump in landfill - lead, copper, cadmium, tungsten and zinc, to name a few. We hope to embed notions of sustainable consumption with architects, designers and urban planners, who all face different challenges depending on where they are in the world. Choosing sustainable building materials and systems go beyond considering durability. We need to take life cycle analysis and supply chain into account, and specify the most appropriate materials for a project - the least polluting, most easily recyclable, most energy efficient (least embodied energy) - and from sustainable sources. We can't achieve zero waste through behavior change in the area of resource recovery and recycling alone.

The prime benefits in adopting zero waste are environmental; many cities that have enacted zero-waste plans say they have taken up the task in the name of sustainability. Architects and engineers should work towards zero waste and zero landfill in metros in the country and ensure resource recovery and protect scarce natural resources by ending waste disposal through incinerators, dumping, and landfills. The plan should encompass waste reduction, composting, recycling and reuse, changes in consumption habits and industrial redesign. In a zero waste approach, waste management is not left only to politicians and technical experts; rather, everyone is impacted from residents of wealthy neighborhoods to people living around a city's waste dumps, private, and informal sector workers who handle waste and we can live in some zero waste communities.

INTRODUCTION

Today's consumption-driven society produces an enormous amount of waste. This large amount of waste puts huge pressures on the city authority to manage waste in a more sustainable manner. From the time of the first Eve, it took human history over 3 million years to reach 1 billion people in the early 1800s. Now, we gain 1billion people every 12–14 years and the world's population grows by more than 200,000 each day. Currently, half the world's population lives in urban areas and almost all regions of the world will be predominantly urban by the middle of this century. Urbanization is higher in high-consuming counties compared to low-consuming countries.

Designing sustainable cities is very challenging. Among all key challenges, waste management is one of the most important challenges for sustainable city design. In high consumption cities in the industrialized world, large amounts of paper waste, over-packaging, food waste, and e-waste are all causing particular socio-economic and environmental problems. "Zero waste" means designing and managing products and processes systematically to avoid and eliminate the waste and materials, and to conserve and recover all resources from waste streams. Therefore, zero waste cities would recycle 100% of their waste or recover all possible resources from waste streams and produce no harmful waste for our environment. Waste is a small contributor to global greenhouse gas (GHG) emissions (<5%) with total emissions of approximately 1,300 Mt CO_2-e in 2005, mainly from landfill methane (CH4),followed by wastewater (CH_4 and N_2O); in addition, minor emissions of carbon dioxide (CO_2) result from incineration of waste containing fossil carbon (C) (plastics; synthetic textiles). The concept of "zero waste city" would tackle the issue like GHG emissions and the provision of potential specific solutions for emissions reduction

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and sustainable waste management. Therefore, "zero waste" management is a holistic view of managing waste and resources in a sustainable city. Waste management systems include socio-economic, political, environmental, and technological aspects and have many stakeholders. Therefore, waste management systems create a complex cluster of different aspects, and functions of this complex cluster are also dynamic and interdependent. The aim of this study is to analyze the challenges, threats, and opportunities to transform traditional waste management practice into a zero waste practice.

The Concept of "Zero Waste" Systems

The term "zero waste" was first used by Dr. Paul Palmer in 1973 for recovering resources from chemicals. There is no concrete definition that can singularly define "zero waste" concepts. However, a structured definition given by Zero Waste International Alliance states: zero waste is the designing and managing products and processes to systematically avoid and eliminate the waste of materials and to conserve and recover all resources. The concept of zero waste includes different concepts which have been developed for sustainable waste management systems and such concepts include reducing, reusing, redesigning, regenerating, recycling, repairing, remanufacturing, reselling, zero landfill and incineration of waste, full life cycle of cradle-to-cradle design systems. There is a growing interest from architects and urban planners in zero waste concepts and in implementing it by redesigning the urban system with "zero waste" and upgraded recycling infrastructure to achieve the "low-to-no carbon" city districts. The concept zero waste includes recovery of all resources from waste materials and, aiming for a 100% recycling rate for municipal solid waste management systems.

ZERO WASTE DEFINITION

The Planning Group of the Zero Waste International Alliance adopted the following definition of Zero Waste on November 29, 2004. This is intended to assist businesses and communities in defining their own goals for Zero Waste. "Zero Waste is a goal that is ethical, economical, and efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health."

ZERO WASTE BUSINESS PRINCIPLES

These Zero Waste Business Principles establish the commitment of companies to achieve Zero Waste and further establish the following criteria by which workers, investors, customers, suppliers, policymakers and the public in general can assess the resource efficiency of companies:-

- Commitment to the Triple Bottom Line : We ensure that social, environmental and economic performance standards are met together. We maintain clear accounting and reporting systems and operate with the highest ethical standards for our investors and our customers.
- Use Precautionary Principle : We apply the precautionary principle before introducing new products and processes, to avoid products and practices that are wasteful or toxic.
- Zero Waste to Landfill or Incineration – We divert more than 90% of the solid wastes we generate from Landfill and Incineration from all of our facilities. No more than 10% of our discards are land filled. No mixed wastes are incinerated or processed in facilities that operate above ambient biological temperatures (more than 2 00 o F.) to recover energy or materials.
- Responsibility: Take back products and packaging - We take financial and/or physical responsibility for all the products and packaging we produce and/or market under our brand(s), and require our suppliers to do so as well. We support and work with existing reuse, recycling and composting operators to productively use our products and packaging, or arrange for new systems to bring those back to our manufacturing facilities.
- Buy Reused, Recycled and Composted : We use recycled content and compost products in all aspects of our operations, including production

facilities, offices and in the construction of new facilities. We use LEED-certified architects to design new and remodeled facilities as Green Buildings.

- Prevent Pollution and Reduce Waste : We redesign our supply, production and distribution systems to reduce the use of natural resources and eliminate waste. We prevent pollution and the waste of materials by continual assessment of our systems and revising procedures, policies and payment policies.
- Highest and Best Use : We continuously evaluate our markets and direct our discarded products and packaging to recover the highest value of their embodied energy and materials according to the following hierarchy: reuse of the product for its original purpose.

GLOBAL PRINCIPLES FOR ZERO WASTE COMMUNITIES

This document outlines the principles and some of the practical steps being taken around the world in both large urban communities and small rural communities in the pursuit of Zero Waste. Zero Waste programs are the fastest and most cost effective ways that local governments can contribute to reducing climate change, protect health, create green jobs, and promote local sustainability.

There are three overarching goals needed for sustainable resource management.

- Producer responsibility at the front end of the problem: industrial production and design.
- Community responsibility at the back end of the problem: consumption, discard use and disposal.
- Political responsibility to bring both community and industrial responsibility together in a harmonious whole.

Zero Waste is a critical stepping-stone to other necessary steps in the efforts to protect health, improve equity and reach sustainability. Zero Waste can be linked to sustainable agriculture, architecture, energy, industrial, economic and community development. However, with good political leadership, everyone could be engaged in the necessary shift towards a sustainable society

THE NOTION OF THE "ZERO WASTE CITY"

Cities are over-consuming and per capita waste generation is relatively higher in high-consuming cities compare to low-consuming cities. Cities attract people because of the economic and social activities and quality of life offered to their inhabitants. Currently, many cities are designed and planned based on eco-city concepts and those cities are designed to deliver a high quality of life to their residents. Completed eco-city projects like Vauban Freiberg (Germany), Hammarby Sjöstad (Sweden) and uncompleted projects for example Masdar City (UAE), Tianjin Eco-City (China) are designed to offer a good quality of life. All those eco cities are designed by considering sustainable city design practices.

Principles and Practical steps towards Zero Waste encourage all communities to:

- Establish benchmarks and a timeline to meet goals for measuring success and monitoring accomplishments. Communities should aim to make significant strides within five years and to invest local resources and leadership in achieving tangible and visible accomplishments that demonstrate to the public this new direction as quickly as possible.
- Engage the Whole Community. It is important not to leave Zero Waste to "waste experts." Many different skills need to be deployed in the movement towards Zero Waste and sustainability. Citizens or communities need to take the leadership role in organizing meetings to engage all sectors of the community. All organizations (nongovernmental organizations, grassroots movements, business and governmental) that provide waste reduction, take back, reuse, recycling and composting services should be involved in order to achieve Zero Waste.
- Demand decision makers manage resources not waste. Existing incinerators must be closed down and no new ones built. Landfill practices must be reformed to prevent all pollution of air and water including pre-processing all residues at landfills before burial to stabilize the organic fraction and prevent methane generation and the use of residual separation and research facilities. However, facilities such as these should not be used to pre-process discarded materials before

going to incinerators or any thermal treatment technologies. Landfills are a major source of greenhouse gases (particularly methane, which warms the atmosphere 23-72 times more quickly than carbon dioxide as well as groundwater contamination. Incinerators and other burning and thermal treatment technologies such as biomass burners, gasification, pyrolysis, plasma arc, cement kilns and power plants using waste as fuel, are a direct and indirect source of greenhouse gases to the atmosphere and turn resources that should be reduced or recovered into toxic ashes that need to be disposed of safely.

More energy can be saved, and global warming impacts decreased, by reducing waste, reusing products, recycling and composting than can be produced from burning discards or recovering landfill gases. Communities should fight any effort to introduce new incinerators, in any guise, and replace existing landfills and incinerators, with Zero Waste policies and programs, including EPR, resource recovery parks, reuse, recycling and composting facilities.

- Use economic stimulus funds and fees levied on tons of waste hauled or land filled to fund programmes to educate and train resource managers to use a Zero Waste approach, to develop programs for handling community discards, and to create green jobs and to enforce environmental rules
- Educate Residents, Businesses and Visitors: Zero Waste is a strategy not a technology. As such, it aims for better organization, better education and better industrial design. To achieve the cultural change needed to get to Zero Waste, communities must establish programs to educate and train residents, school children, college students, businesses, and visitors about new rules and programs.
- Perform Zero Waste Assessments. Communities should conduct a waste audit to find out the amount and type of waste being produced in their community. These audits should be used as a baseline to identify recovery and employment opportunities, cost savings and measure the success of the reduction and recovery program.
- Build Residual Separation and Research Facilities. In the interim phase, residuals should be sent to residual separation and research facilities before the remaining inerts are allowed to be buried in a landfill designed to have no air or water emissions. These facilities should act as a way of linking community responsibility to industrial responsibility. If the community can't reuse it, recycle it or compost it, industry should take it back itself for reuse, recycling or composting, or design it out of use.
- Develop New Rules and Incentives to Move Towards Zero Waste : Communities can significantly change what is "economic" in the local marketplace with new policies, new rules and new incentives. Communities should restructure contracts and policies to make the avoided costs of collection and disposal a key engine for moving towards Zero Waste.
- Enact Extended Producer Responsibility Rules: Communities need to help and encourage local businesses to take back products and packaging at their stores and factories from consumers. As much as possible, discard management costs for products and packaging that are difficult to reuse, recycle or compost in most local programs should be shifted from local government to the producers of the product. This gives producers the financial incentive to redesign products to make them less toxic and easier to reuse and recycle. Products and packages that cannot be reused, recycled or composted locally or are toxic should be required to be taken back at the point of sale or facilities set up by producers to conveniently receive those products at no cost from the public.
- Remove Government Subsidies for Wasting: Governments, particularly in the US, have adopted many tax incentives to encourage mining and timber harvesting, which are no longer needed and subsidize the wasting of resources. Governments have also subsidized incinerators under the guise of "Energy from Waste" when in fact such facilities waste energy. Community adopted garbage rate structures have also made it cheaper to waste than recycle, rather than adopting Pay As You Throw incentives.
- Support Zero Waste Procurement: Local governments should adopt the Precautionary

Principle for municipal purchasing to eliminate toxic products and services; purchase Zero Waste products and services; avoid single use products and packaging; return to vendors any wasteful packaging; reduce packaging and buy in larger units; use reusable shipping containers; purchase reused, recycled and compost products; buy remanufactured equipment; lease, rent and share equipment; buy durables; and encourage businesses and institutions to follow these practices as well.

- Construction, Demolition, Land Clearing and Remodeling (C&D) - Adopt deconstruction, reuse and recycling policies citywide (including requiring all contractors to submit plans and deposits to meet community targets), and implement programs and facilities needed to achieve Zero Waste. Work with Green Building programs to prioritize deconstruction and reuse, and to require all new buildings to provide space for recycling containers.
- Challenge Businesses to lead the way to Zero Waste – Thousands of Zero Waste Businesses already divert over 90% of their wastes from landfill and incineration around the world. Zero Waste Businesses are reducing their costs of managing resources and discards, increasing their operating efficiency, decreasing their carbon footprint (including energy use) and decreasing their long-term liability.

CONCLUSION

To make the zero waste city concept a reality, we need to rethink the way we design, produce, maintain/operate, and recycle all products, buildings, neighborhoods, and cities. In the zero waste city strategy, existing cities need to be re-engineered to become more sustainable and resilient. From high-carbon fossil fuel use to low-carbon emission technologies, we will fundamentally change and reshape the way we design, construct, operate, and recycle buildings, neighborhoods, and cities. Consumers need to be made aware of the fact that waste is a precious resource; for instance food waste, e-waste, glass and packaging cardboard have a value. Legislation is needed to make product manufacturers and construction companies operate in a more material-efficient and less wasteful manner. The zero waste ethos's are a big call, radical in its ramifications, and it requires more than a top-down, government-imposed approach. To be successful, zero waste needs to be embraced and implemented by architects, engineers, citizens and community groups, business and industry.

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REUSE OF WASTE PLASTICS IN FLEXIBLE ROAD PAVEMENT – HIMACHAL'S INITIATIVE

D.N. HANDA*

Abstract

There is a need to actively pursue a policy of waste minimization as a part of our efforts to promote environmentally sustainable development. Waste accumulates from number of sources such as municipal, industrial, commercial, construction and demolition materials. Waste minimization relies on three 'Rs' Reduce, Reuse or Recycle.

Plastic in different forms is found in municipal solid waste to the extent of 10%. It is made from petroleum and non-renewable resource and thus is non-biodegradable and toxic. Plastic is everywhere in today's living. The use of plastics in different forms mostly as carry-bags, disposable cups and bottles cause wide spread pollution, litters streets, parks and chokes drains. These are either land-filled occupying valuable land or incinerated causing severe pollution of the atmosphere, which is taking a serious toll on our health and environment. The problem is what to do with this plastic waste. The use of this non-biodegradable waste has been a matter of great concern to scientists and engineers, who have found its reuse as modifier in bituminous mixes for road pavement works with certification now by CRRI, IRC and other Institutions. The use of plastic waste in road tarring works resulting in improved and durable pavement and a relief from choking of drainage and environmental pollution needs to be encouraged. States like Himachal Pradesh, Delhi, Karnataka and Chennai have made some efforts using plastics waste in road tarring works. Himachal Pradesh bagged PM award for 2009-10 for Plastic Waste Management.

INTRODUCTION

Waste materials are a common problem in modern living. There is a need to actively pursue a policy of waste minimization as a part of our efforts to promote environmentally sustainable development. The waste materials have to be disposed off in such ways that do not affect our environment and human health. In view of this, waste minimization and disposal are to be seen as environmentally and ecologically sustainable strategy. Most of the waste material goes into landfill, especially in urban areas where the land is very scarce and valuable. Plastic accounts for a large quantity as landfill waste. Keeping in view the goal of waste minimization and ecologically sustainable development,there is a need for an integrated approach as under:-

- Legislation:- By enactment of Waste Minimization Act that identifies and strengthens the pursuance of waste minimization. Punitive action taken for illegal disposal of waste should act as a deterrent towards waste reduction. Himachal Pradesh Government has since banned use of plastic bags and replaced them with paper bags.
- Promotion of Waste Minimization Policies:- Waste minimization relies on three 'Rs' Reduce, Reuse and Recycle i.e. avoiding unnecessary resource consumption, recovering resources by reuse and reprocessing/recycling etc. Himachal Pradesh is also using its waste plastic in road tarring work.
- Waste Reduction Funds:- Waste reduction funds includes grants to local municipalities, community groups, research organizations and individuals. The state of Himachal Pradesh has extended fiscal incentives to urban bodies, panchayats and individuals for proper collection of waste plastic in their respective areas.
- Waste purchase:- This would require all state governments to buy waste materials at reasonable rates. The state of Himachal Pradesh

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has offered a buyback scheme for the waste plastic at Rs.3.00 per Kg. from the rag pickers.

Waste Plastics

Waste accumulates from a number of sources such as municipal, industrial, commercial, construction and demolition materials. Plastic is found in municipal solid waste to the extent of 10%. Plastic is one of the most widely used product as packaging, carry bags, disposable cups and bottles. It is everywhere in today's living. It is made from petroleum and non-renewable resource and thus is non-biodegradable and toxic. The generation of waste plastic is increasing day by day due to rapid urbanization and development. It is a common sight both in urban and rural areas to find empty plastic bags and other types of waste plastic materials littering the roads, parks and drains. Due to its non-biodegradable nature, it remains in the ground for several years. Disposing plastic waste as landfill is thus unsafe since its toxic chemicals leach into soil and underground water and pollute water bodies. It chokes the drains and creates stagnation of water and associated health problems. There are three alternatives by which the problem can be handled:-

- By letting waste plastic degrade naturally but it will occupy the scarce and valuable land as plastics are not decomposed with the time.
- Burning/incineration which causes severe air pollution.
- Follow the principles of three'Rs' – Reduce, Re-use and Recycle. Recycling seems to be better way but it too has its own demerits. Re-using is preferable and better option as it uses less energy and few resources as compared to recycling.

Need to Keep Himalayas Clean

Himalayas are in danger of becoming a great rubbish dump. The heaps of plastic mineral water bottles, food wrappers and cold drink bottles left by tourists and trekkers are quite visible on hills. There was no such plastic and other garbage in hills 30 to 40 years back but we now see it on all the ways. The trekkers and campers perhaps have no idea of the adverse impact on the lush green valleys, pleasant climate and serene environment of hills. At such higher altitude and environment, plastic waste will remain there for more than 1000 years. It is difficult to clean the rubbish after the trekkers have gone. In order to make the tourism sustainable, we will have to think about managing this waste. It has to be insisted upon the tourists, trekkers and campers to bring back with them their plastic and other garbage to the nearest town for its re-processing or re-use. The trekkers and campers need to be advised to be environment conscious and not to leave any trash and also to pick up the same on their way back. Signboard have been put up by Himachal Pradesh Government on tourist spots and hiking trails suggesting the tourist and trekkers to keep the green slopes litter free and also not to leave any trash behind.

REUSE- THE MODIFIED PROCESS

The use of this non-biodegradable product is growing and the problem is what to do with this waste plastic. Its disposal has been a matter of great concern to the scientists and engineers. One promising solution to the problem has come from Professor R. Vasudevan of Thyagrajan College of Engineering, Madurai. He thought of an idea of shredding plastic waste, mixing it with bitumen or as plastic coated aggregate-bitumen mix and using the polymerised mix in flexible road pavements. The use of plastic waste in this way has proved to be useful as it increases the life of the road.Plastic melt down after being shredded into flakes. The durability of the roads laid with shredded plastic has been much more as compared to tarring with conventional mixes. By incorporating them in bitumen, the quality of available bitumen and thereby, the performance of the road is improved beside reduction of this non-biodegradable waste. Some universities, CRRI and IRC have now given their certification to this new method. The IRC has come out with a code on the basis of studies and investigations carried out in some regions of the country on the benefits of using waste plastic in laying road pavements. Attempts have been made in some states like Tamil Nadu, Karnataka, Delhi and Himachal Pradesh to use their plastic waste in bituminous road pavement works with success. The gains of the technology beside increased durability, stability and strength include the resistance to water-induced damages, saving of bitumen and gainful disposal of plastic. The seepage of rain water is minimised reducing thereby formation of potholes; consumption of bitumen is reduced and the process is eco-friendly.It is understood that CRRI and Bangalore University have taken up monitoring of some stretches of roads constructed with modified process in different parts of the country. A marginally higher cost of construction with waste plastic is well offset by saving in bitumen consumption, increased life of road pavements and reduction in maintenance cost.

Mixing Process.

The use of plastic coated aggregate however, is much better than the use of polymer modified bitumen in many ways. The waste plastic when added to hot aggregate forms a fine coat of plastic cover over the aggregate and such aggregate when mixed with bitumen is found to give higher strength and resistance to water. It has further been observed that such pavements are not subjected to stripping. The use of 10% plastic reduces the use of equivalent quantity of bitumen. Following procedure is adopted for plastic coating of aggregate at Hot Mix Plant.

- The waste plastic should be free from the dust and dirt and is required to be shredded. The shredding is the process of cutting the plastic into small sizes between 2 mm to 4 mm with the help of shredding machine.
- The aggregate is heated to temperature 165 to 1700 C and then transferred to mixing chamber. Simulatingly bitumen is heated to about 1600 C.
- The shredded plastic is added over the hot aggregate in the mixing chamber. The plastic get melted and coated uniformly.
- The plastic coated aggregate is mixed with hot bitumen.
- The mix is then used for laying road pavements at 11^0 to 120^0 C.

The above process can also be carried out using "Central Mixing Plant". The shredded plastic is added over the heated aggregate in the conveyer belt and then transferred into mixing chamber where the aggregate coated with plastic is mixed with the bitumen. The mix so prepared is then transported for laying the pavements. The Central Mixing Plant ensures better mixing and temperature control and thus helps in uniform coating.

Some special features of the process are:

- Simple, easy and in situ process.
- No new or special machinery required.
- Both mini hot mix plant and central mixing plant can be used.
- Only aggregate is plastic or polymer coated and no modification of bitumen is required.
- No evolution of toxic gases.
- Coating of plastic to aggregate gives better results as under :

➢ Improves "Aggregate Impact Value".

➢ Shows lower crushing value.

➢ Decreases abrasion value in comparison to plain aggregate

➢ Increases specific gravity as compared to plain aggregate (The higher specific gravity is an indirect measure of its higher strength).

➢ Gives almost nil values of stripping.

➢ Decreases moisture absorption.

Benefits

When compared with normal mix, the stretches of road laid using plastic coated aggregates have shown improved functional performance in terms of better surface condition. Besides increase in service life, the process has potential to minimise the waste plastic. Following benefits are claimed:

- Strength/durability of road increased 50 to 100%due to increased Marshal Stability Value and thus life of the road pavement increased substantially.
- Better resistance to rain water and water stagnation.
- The frequency of road repairs is minimized.
- No stripping of bitumen and thus minimizing the problem of potholes.
- Increased adhesion and thus better bonding of mix.
- Consumption of bitumen reduced by about 10%.
- Less voids and thus less rutting and raveling.
- Less bleeding during summer due to increase in softening point of bitumen.
- Eco-friendly process due to use of plastic waste.

- Landfill and burning of plastic could be avoided.
- There is substantial increase in scrap value of this undesirable waste. It will therefore be collected and sold by the scrap pickers instead of its getting littered or going into drains or landfill.
- The use of waste plastic for road pavement, renewals and repairs to potholes on hill roads would be especially useful in restoring extensive rain and snow damages to the pavement.

HIMACHAL'S INITIATIVE

The use of polythene has since been banned by Himachal Pradesh Government under its programme of "Polythene Hatao, Paryavaran Bachao" (Remove Polythene and Save Environment) involving Government departments, institutions, panchayats, urban bodies and even rag pickers. The plastic bag has been replaced by paper bag that breaks down easily or can be recycled. State has taken lead in litter cleaning drive on its popular tourist spots and hiking trails. The government is also using its plastic waste in road tarring work for which, it has offered a buy-back scheme for the waste plastic at Rs. 3 per Kg for collection.The state government has also extended fiscal incentives to Panchayats, Urban bodies and individuals contributing towards proper collection of waste plastic in their area.

The Central Pollution Control Board (CPCB) has advocated the re-use of waste plastic in road construction. According to the board, plastic coated bitumen flexible pavement displays increased strength due to strong polymer-bitumen bonding, better resistance to rain water and no formation of pot holes. Himachal Govt. has accordingly given a green signal to its Public Works Dept. for use of waste plastic in black topping of roads. Due to heavy rains and snow and resultant damages, the use of plastic waste in road pavement work would be a boon in hilly areas. One of the news items that appeared in different newspapers is reproduced below:

"Himachal begs PM award for plastic waste management: Himachal is one of the first states in the country to ban the use of plastic. For its sustained campaign against usage of plastic bags Himachal Pradesh was conferred with Prime Minister's Award for the year 2009-10 which has boosted the state's initiative in sustainable plastic waste management. By adopting innovative strategies for protecting fragile ecology of Himalayas, the state has been making pioneering efforts in preservation and conservation of the environment and the award is in recognition of state's efforts in this direction."

CONCLUSION

Waste minimization, in general, can be achieved by an integrated approach of legislation, waste minimization action program, waste reduction grants and by following the principles of three 'Rs' including its purchase at reasonable rates. Plastic Roads, as they are popularly known, have been found to perform better as compared to those constructed with conventional bitumen mix. It can thus be concluded that plastic coated aggregate- bitumen mix is quite useful for flexible road pavement. It is a win-win solution: better road pavement that last longer, cleaner environment and also with some income to the poor. The use of waste plastic in road pavement work, renewals and patch repair will be of special benefit on hill roads.It is proposed to make obligatory in the first instance to use it on urban roads where it is available in good quantity. This can further be extended to nearby rural roads.

There is, however, need to carry out further work on various aspects such as collection, processing and effective utilization of this waste material as under:

- Proper estimation of the useful types and quantity of waste plastic available in the municipal solid waste and from other sources.
- Methodology for collection and sorting out the useful components for use.
- Carrying out further laboratory tests, construction of some test tracks and field studies on their performance.
- Working out relative economics.

- Preparation of Specification and Standards.

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ISSUES AND STRATEGIES FOR SOLID WASTE MANAGEMENT IN JAMMU CITY

Sunil Kumar* and Ashwani Kumar**

Abstract

Indian cities are expanding at a very high rate due to high population growth, high urbanization, availability of economic activities and job opportunities, which have led to an increase in the quantity and complexity of generated solid waste. Waste is an unavoidable by - product of human activities. Inefficient management and inappropriate disposal cause degradation of the environment in most of the India cities. Often municipal corporations are not able to handle the ever-increasing quantities of waste, which results in uncollected waste on roads and in other public places and results in major environmental hazards and degraded living conditions.

Jammu- the winter capital of the state of Jammu and Kashmir and important religious town famous for its temples, is one such context where inefficient management and inappropriate disposal of solid waste effects the living condition and well being of residents and environment in and around the city. Presently, city is facing pressing problems related to collection, transportation, sorting, recycling, treatment and disposal of solid waste.

This study highlights various issues of Solid Waste Management in the specific context of Jammu city and also suggests possible strategies for improvement of Solid Waste Management Process so that better living conditions can be achieved.

INTRODUCTION

Indian cities and towns are increasing at a very fast rate and it is expected that the urban population will tremendously increase from 340 million in 2008 to 590 million in 2030, as it is highlighted in MGI report on India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth, 2010. No other country in the world (except china) have experienced such large scale of urban growth in such a small duration of 20 years. As a result of this enormous. Urban growth it is expected that urban centres of India will have manifold increase in next two decades and these over developed urban centres will face tremendous problems related to basic infrastructural provisions for residents to have quality living as the existing infrastructural facilities, which are currently inadequate are going to prove insufficient to support this high population growth. These problems of inadequate/insufficient and inappropriate provisions of infrastructural facilities are more pronounced in Tier II and Tier III cities which are presently facing problems and issues to provide basic infrastructural facilities like water supply, sewage system, transportation network and solid waste management and the condition can further be aggravated with further increase in population.

As it is specified in HPEC report on Indian infrastructure and services, a total investment of Rs. 3918670 crores is proposed to improve the condition of urban infrastructure in Indian cities and towns by 2031 to improve the living condition and standard in Indian cities and to cater the increased pressure on infrastructure due to increase in urban population. Soild waste management in one such infrastructure, which is mostly neglected in Indian cities and towns and where it is provided, different provisions associated are insufficient and/or inappropriate. As a result of which the residents are facing problems related to hygiene, foul smell, water and land contamination, spreading of diseases and degradation of quality of living in an urban area.

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Any discarded or used material which can be solid, liquid and semi-solid or containerized gaseous materials obtained from residential, commercial, public, institutional and recreational areas is generally termed as municipal solid waste. Solid waste is generally heterogeneous in nature and its characteristics vary from place to place, and season to season, which depend upon the use, source and life style of the people. The Solid Waste Management (SWM) system covers the full cycle from collection of waste generated from household and commercial establishments to the acceptable final disposal. This process includes solid waste generation, collection, segregation, transportation, sorting, recycling, treatment , compaction and disposal.

The scenario of solid waste management is most unsatisfactory in tier II and Tier III cities and to highlight various issues and problems of solid waste management in tier II city, Jammu is considered as study context.

JAMMU- THE STUDY

Jammu- the winter capital and second largest city in the state of Jammu and Kashmir and important religious and pilgrimage centre, is one such city which is currently have inappropriate solid waste management infrastructure and as a result facing numerous problems. The municipal area of the city is spread over an area of 112 sq km and has a population of 5,03,690 in 2011. Similarly, Jammu Planning Area (JPA) covers an area of 287 sq km and had a population of 651825 in 2011. The population of city is expected to increase at much higher rate due to high population growth and high migration from the nearby surrounding areas. Jammu is an important religious town in the country which is experiencing huge volume of religious pilgrimage, in the form of people coming to visit Shri Mata Vaishno Devi Shrine, Amarnath and different temples spread all over the town. Jammu city will act as the base gateway for pilgrimage to Shri Mata Vaishno Devi Shrine, Amarnath. In the year 2012, as per official records of Shri Mata Vaishno Devi Shrine Board 1.05 crore pilgrims have visited Shri Mata Vaishno Devi Shrine and 6.22 lakhs pilgrims have visited the holy Amarnath in the month of june and july. Jammu acts as important starting point for the domestic and international tourists to visit important tourist places in the state of Jammu and Kashmir. Jammu is also a major regional centre and connects Kashmir valley and Ladakh region to the rest of the country and huge number of people commute through this city to and from these two regions. These enormous numbers of pilgrims, tourists and regional commuters exert huge pressure of already insufficient infrastructural facilities, especially on solid waste management as the solid waste generated by these is confided to specific zones of the city and also have seasonal variation. Moreover, the solid waste generated in different parts of city is also not collected completely and as a result of these above discussed factors/issues, problems of foul smell, unhygienic conditions, health problems, pollution, contamination of air and surface and ground water, choking of drains, environmental degradation and deteriorating living conditions persist in Jammu city.

On the basis of Quantification and Characterization (Q & C private agency) survey, Solid Waste from residential area is found to be 298.675 gm/capita/day. Jammu Municipal Corporation (JMC) is managing the Solid Waste Management Operations for waste quantity of 183 MT only generating from 6, 13,091 in 66 sq. km. area. Thus there is no arrangement for remaining residential area. The Jammu Municipal Corporation has not developed proper land fill sites. Presently Solid Waste is being crudely dumped at the bank of Tawi, resulting in environmental degradation.

A primary survey was conducted in different localities of Jammu to understand different issues associated with solid waste management process and to know the resident's view about improving the solid waste management process. This study was conducted in 37 wards of old city, area of jammu and study area has a population of 2,54,513 (2011). The following observations/points related to existing solid waste management process are highlighted:

- Generation of waste: The total population for the selected survey areas is 2,54,513 and the total waste generated is 78 tonnes/day. It is worked out that the waste generation is at an average rate of 305 g/cap/day.
- Collection of waste: Average density of solid waste is taken as 500 kg/cum (as per NEERI). It is taken after considering the density of the

waste generated from residential areas of the Jammu city. Presently in the city, there are total 40 number of bins placed in different localities of city for solid waste collection which collects 64 tonnes of solid waste (fig. 1). Out of these 49 bins, 25 bins have a capacity of 4.5 cum (each) and remaining 15 bins have a capacity of 1.0 cum. There are also 75 Open Collection Points which are located at different locations of the study area .

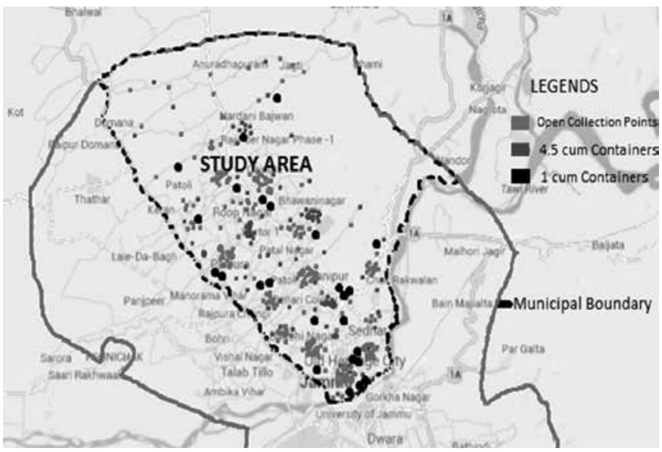

Fig. 1: Map showing Locations of Garbage Bins in Jammu City

- For the collection of waste and sweeping of the roads about 550 Sweepers are deputed in the Old City by Jammu Municipal Corporation. On an average 14 tonnes/day waste is not collected in the Containers and remains at the Open collection points, road sides, drains, etc in the study day which is collected periodically and not on regular basis.
- Transportation of waste: 63 tonnes/day of waste is carried by 17 JMC Vehicles to the Sanitary Landfill Site. 15 tonnes/day of waste is not collected and transported by the JMC Vehicles to the Landfill Site.
- Disposal of waste: The waste collected from different collection points of city is transported to the Sanitary Landfill Site near Bhagwati Nagar along the bank of Tawi River having an area of 10 acres and distance of the site is 5 km from the JMC office.

Along with this existing solid waste management process, various other problems of solid waste management are also highlighted and discussed below.

ISSUES RELATED TO SOLID WASTE MANAGEMENT IN JAMMU

The main Solid Waste generation sources in Jammu city are residential, commercial and market, slums, slaughter houses, institutional organization like hospitals, hotels and restaurants, small and big scale industries, Construction and Demolition Waste etc. Various problems related to solid waste management as observed in Jammu city are as follows:

- Solid waste in Jammu city remain uncollected at the streets, road side, open places etc. which give rise to unsanitary conditions especially in thickly populated areas (slums etc.) which results in an increase in morbidity especially due to microbial and parasitic infections.
- There is no segregation of solid waste at the source and much of solid waste generated is not collected by local municipality.
- The number of waste collection points and bins placed in the city are insufficient to collect all waste generated. Moreover, the existing collection bins are inappropriately placed which further makes the waste collection more difficult.
- The transportation facilities used for transportation of collected solid waste are insufficient in number and also existing vehicles are mostly unmaintained, which further worsen waste transportation process.
- In Jammu City, during rains the runoff carries with it the degraded, half degraded as well as plastics to the nearby water bodies causing reduction in the carrying capacity of the nallah/ river, and lakes etc. and pollute the water resources.
- Domestic waste contaminated with bio medical toxic waste and industrial hazardous waste spreads infections to the people handling this waste.
- There is no scientific treatment or processing of waste done in Jammu City before it being dumped on the site.
- Sorting is not done at household level. Rag pickers pick plastic material, polythene and recyclable material from the collection points

and rest of the waste is mixed and not segregated when it is transported to landfill sites.

- Open vehicle transportation is another issue which creates problem because the waste over flow and fall on the roads and result in choking of the drains along the side of the roads.
- Suitable landfill site is not available in Jammu generally dumping is done on the banks of the Tawi river which pollute its water.

STRATEGIES FOR SOLID WASTE MANAGEMENT IN JAMMU CITY

Different strategies which are required to improve the existing condition of solid waste management in Jammu are divided/ discussed in the following categories:

— Waste collection strategies

— Waste transportation strategies

— Waste sorting and recycling and reuse strategies

— Waste treatment strategies-compaction and disposal strategies

— Strategies for creating awareness

Waste Collection Strategies

- Door to door collection should be adopted for collecting solid waste with the help of private agency so that the efficiency of waste collection should be improved.
- Segregation of waste should be done at household level by separate bins for organic and inorganic waste.
- Initial sorting need to be done by the waste collector before putting all the waste at collection points and recyclable waste and waste/s having the economic value should be separated and processed.
- Sufficient number of community collection points and garbage bins should be placed at proper locations for collection of waste.

Waste Transportation Strategies

- Depending upon the population served and location of bin, the frequency of collecting waste from the bin should be decided and bins full of waste should be replaced by vacant bins at a collection point.
- Number of vehicles need to be increased so that the waste is transported efficiently and timely from the collection points.
- Frequency of vehicles transporting waste should be as per the waste generation.
- Sufficient equipment should be there for loading and unloading the waste as well as for the compaction of the waste in the vehicle so that more quantity of waste will be transported in a vehicle.

Waste Sorting, Recycling and Reuse Strategies

- Transfer stations should be provided at desired locations so that sorting can be done.
- Recyclable waste, organic waste and inert waste should be sorted and further sent for treatment.
- Appropriate machinery should be used for sorting of the waste and hand sorting should be avoided.

Waste Treatment, Compaction and Disposal Strategies

- Organic waste can be treated using processes of composting, vermin-composting, biomethanation, etc and composted matter should be used as the manure to reduce the load on landfill sites.
- Inorganic waste can be treated by incineration, fuel pelletisation, etc.
- Recyclable waste should be sent for recycling.
- Inert waste can directly be used for landfilling after sufficient compaction with the help of suitable machinery.
- After treatment, the remaining waste can be directly dumped at the disposal site.
- The landfill site should be properly leveled and prepared so that there should be no leakage from the landfill site, which may cause contamination of land and ground water aquifers. The gases level need to be checked and continuous monitoring of landfill sites should be undertaken.

Strategies for Creating Awareness

- Strategies regarding creating awareness among the people residing in the area need to be developed so that people should be aware of segregation of waste and have an active participation in solid waste management process.

- Different awareness camps at locality level need to be organized to make residents aware about solid waste management and a sense of belongingness should be developed in residents.
- Different cleanliness drives for different localities in the city need to be undertaken with the help of various NGOs so that the existing conditions are improved and people need to be made aware about the significance of cleanliness and hygiene.

CONCLUSION

Uncontrolled decomposition of organic constituents of the waste results in various environmental problems. Strategies developed for collection, transportation, sorting, treatment and disposal need to applied at local authority level. Various processing technologies have been developed which decompose/stabilize the waste so that the load on disposal site is reduced. These technologies need to be applied in Jammu to achieve neat and clean environment.

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GREEN CEMENT FROM INDUSTRIAL WASTE BY GEOPOLYMERISATION

L. GARANAYAK* AND DR. S.K. DAS**

Abstract

Presently environmental pollution is the biggest issue for growth of industries especially cement industry, which emits huge amount of carbon dioxide, that is leading to climatic change. To resolve the universal issue it is more significant to develop an alternative of cement as binding material from industrial waste using the technology named as geopolymerization. It is an exothermic process and heterogeneous type of chemical reaction that requires alkaline, alkalipolysilicate or combination of both of them as activator solution to activate the aluminosilicate particles present in the waste products and developed binding material named as geopolymer.

In this paper, geopolymer is studied based on fly-ash activated by sodium hydroxide with varying ratio as 0.3, 0.35, 0.4, 0.45 and 0.5. The geopolymer samples were cured in oven at 40°C temperature for 1, 3, 7, 14 days. The strength properties were compared with that of available pozzolana cement.

INTRODUCTION

After water, cement concrete is second most demanding element among all over the world that fulfill over 1.6 billion tons annually (Rashad 21014). On the otherhand, cement industry is the second most leading industry for emission of carbon dioxide gas and third in case of energy consumption (Rashad 2014). Greenhouse effect, natural disaster, climatic change, increased level of sea are specially caused due to high concentration of carbon dioxide gas. To face the biggest environmental issue, now it is a technical challenge to develop an alternative of cement as binding material from waste industrial byproducts. Geopolymer or green cement, one of the new term of binding material in construction industry has been developed from alkali activation of waste industrial products involving pozzolanic property, i.e. presence of siliceous or both aluminous and siliceous materials. Examples of common raw materials used in geopolymer are – fly ash, calcined clay, slags (Provis and Deventer 2009). Geopolymerization is the geosynthesis or heterogeneous type of chemical reaction between solid aluminosilicate oxides and alkali metal silicate solution at highly alkaline conditions and mild temperatures that based on alumino-silica chain, which consist of Si-O-Al (sialate bond) and Si-O-Si bonds (siloxo bond) (Rattanasak and Chindaprasirt 2009, Bakri et al. 2011, Weerdt 2011).

Geopolymer is named by Joseph Davidovits in 1970 that cover the class of synthetic alumino-silicate materials and used as partially or fully replacement of Portland cement, advanced high-tech composites, ceramic application, forms of cast stone, monolithic refractory, thermal protection of wooden structures, coating for fire protection, heat resistant adhesive (Motorwala et al. (2013), Provis and Deventer). In other way it is the meaning of mineral polymer obtained from geochemistry or geosynthesis (Heah et al. 2012). It is more admirable in case of mechanical properties including fire, sulfate and acid resistance (Jaarsveld et al. 2002, Rashad 2014). It has high compressive strength and stability at temperature up to 1300°C to 1400°C which can be synthesized at lower temperature as like to zeolite (Rattanasak and Chindaprasirt 2009). Fly ash based geopolymer are amorphous to semi-crystalline in structure

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(Kamhangrittirong et al. 2012) and also named as alkali activated Fly-ash, alkali bounded ceramics, soil cement, inorganic polymers (Ma, 2013). It develops three dimensional network of aluminosilicate gel that connected to three dimensional network of aluminate (AlO4) and silicate tetrahedral (SiO4) with negative charge balanced by alkali metal cations (Provis and Van Deventer 2009, Ma 2013) having general formula (Duxson et al. 2005, Weerdt 2011):

$M_n\ [-(Si\text{-}O_2)_z - Al - O]_n .\ wH_2O$

Where, n = Degree of polymerization

z = 1, 2 or 3 stands for Si/Al ratio and named as-

[(poly (sialate) - 1, poly (sialate-siloxo) - 2 and poly (sialate-disiloxo) - 3)]

M = Alkali metal cation like potassium or sodium (K^+ or Na^+)

MATERIALS AND METHODS

Different materials namely fly ash, sodium hydroxide (NaOH) and sand are used in the present study. The Fly-ash also named as flue ash is collected in electrostatic precipitators after the combustion of coal. Its composition, colour, quality is varied and depends on type of combustion process and quality of coal used (Singh 2012). But all fly ash is common in calcium oxide (CaO) and silicon dioxide (SiO2) (amorphous and crystalline type). It is spherical in shape classified as class C and class F according to presence of lime content. It consists of very fine particles having average diameter less than 10μm, either solid or hollow type, mostly glassy or amorphous, abrasive, mostly alkaline, refractory and pozzolanic in nature (Singh 2012 and Ahmaruzzaman 2010). Generally its color varies from tan to grey to black type depending on amount of unburned carbon presence in fly ash (Ahmaruzzaman 2010).

In this experiment fly ash is collected from NALCO, Angul Odisha, which is grey in colour. It has chemical composition as given in Table 1. Other physical and chemical properties of fly ash are presented in Table 2.

Table 1: Chemical Composition of Fly-ash

Chemical Compositions	Quantity
Silica (SiO_2)	75.39%
Aluminium (Al_2O_3)	22.26%
Iron Oxide (Fe_2O_3)	0.51%
Iron (Fe)	0.36%
Chromium (Cr)	4.21 mg/kg
Copper (Cu)	8.17 mg/kg
Lead (Pb)	5.73 mg/kg
Mercury (Hg)	<0.5 mg/kg
Zinc (Zn)	12.04 mg/kg
Phosphates (P_2O_5)	0.27%
Moisture	0.21%
Calcium (CaO)	0.17%
Sulphur Trioxide (SO_3)	0.11%
Magnesium (MgO)	0.07%
Total Alkalis	0.52%

Table 2: Physical and Chemical Properties of Fly-ash

Physical & Chemical Properties	Results
Bulk density	1.00gm/ml
pH	6.85
Colour	Greyish
Fineness	20%
Particle Size (45μ)	67.6%
Specific gravity	1.98

Sodium Hydroxide

Alkali hydroxides like sodium hydroxide or potassium hydroxide are most commonly used as an activator due to its easily available. Sodium hydroxide is less expensive and more viscous than potassium hydroxide and improved with reduced rheological properties in fresh mix samples. But crystalline zeolitic structures are developed by both solutions which is performed too rapidly in case of sodium hydroxide solution and results in loss of strength (Weerdt 2011). In this study, only sodium hydroxide of 2M is used as an activator having molecular weight 40g/mol to study the strength properties under different solution and fly ash ratio. Solution is prepared before the start of experiment with white pellets of ≥ 97% specifications.

Sand

Local river sand is collected from river Jhirpani near Rourkela, Odisha. It was standardized manually as Grade I, II and III by sieving through 2mm, 1mm, 500μ and 90μ and washed properly and oven dried to remove the silts. The physical properties of sand is presented in Table -3, which corresponds to Zone– II.

Table 3. Physical Properties of River Sand

Properties	Results
Specific gravity	2.6
Water absorption	0.4
Fineness modulus	3.52
Bulk density	1.45
Surface Index	1.15
% of voids	40.25

EXPERIMENTAL METHOD

Sample Preparation

NaOH solution having concentration of 2M is prepared in volumetric flask. 1 liter of solution is prepared by mixing of 80gms of sodium hydroxide pellets in distilled water. It is allowed to cool down at normal atmosphere temperature. Fly ash and standard sand (mixing equal proportions from each grade) are mixed as 1:1 proportion. Then NaOH solutions are mixed with that sample at different ratio i.e. ratio of liquid to fly ash varied as 0.3, 0.35, 0.4, 0.45 and 0.5. Mortar mixing is prepared within 5 minutes manually. Fresh samples are poured rapidly into steel molds of size 50 x 50 x 50 mm and tamped by tamping rod in two layers (each 32 strokes) following IS Code: 4031 (Part 7) - 1988. Then vibrating for 2 minutes in vibrating machine for avoiding voids. Three sets of each ratio are kept for 24hr within molds in atmosphere temperature. After that samples are demolded and kept in oven at 40°C temperature for curing. In case of 0.3 and 0.35 ratio, water is added as 10% of fly ash to avoid dryness of the mortar paste.

All mortar samples are kept in oven for curing at different ages i.e. 1, 3, 7, 14 days. Compressive strength was measured in terms of unconfined compression strength (UCS). Reported results are mean of the three samples. After the UCS test, the specimens were grounded to powdered form and used for XRD test for qualitative analysis.

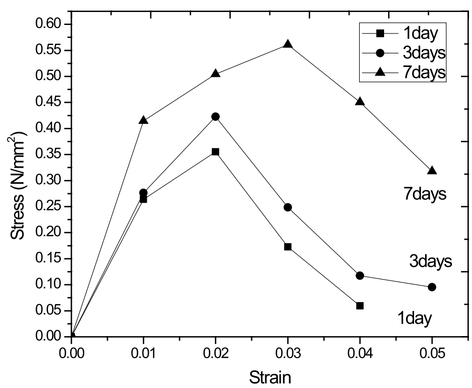
Results and Discussion

Here compressive strengths are calculated as average of three specimen from each ratios of solution and fly ash. It was observed that strengths of geopolymer based fly ash vary according to age which are represented in Fig. 1 for different concentration of NaOH.

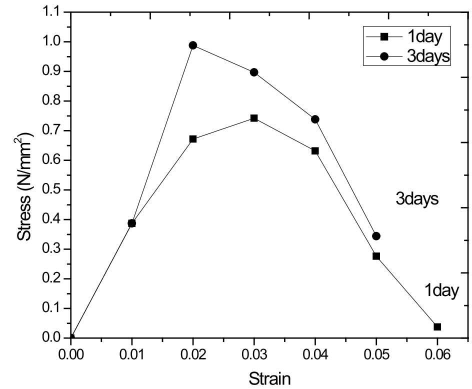
The results are also compiled and presented in Table 4. For comparison the compressive strength of the cement mortar with ordinary cement is shown in Table 5. It can be observed that the UCS values of the alkali activated fly ash is very low compared to standard cement.

Table 4. Comparison of Strengths of Different Ratios of Geopolymer (Soln: fly ash)

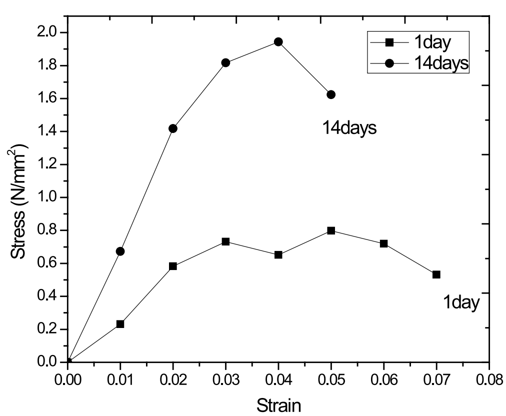
Soln:FA	Curing Age (w.r.t. max. strength)	Maximum Strength
0.3:1	7 days	0.56N/mm2
0.35:1	3 days	0.98N/mm2
0.4:1	14 days	1.94N/mm2
0.5:1	3 days	1.96N/mm2



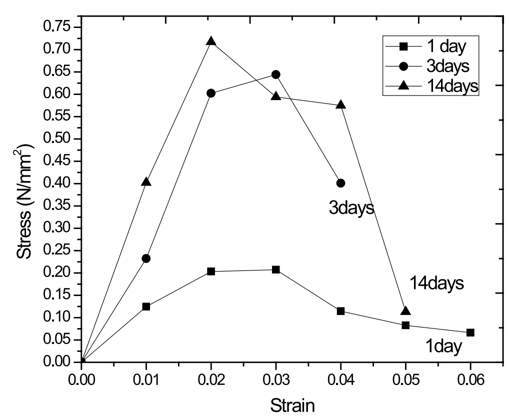
(a) Sol^n: FA = 0. 3



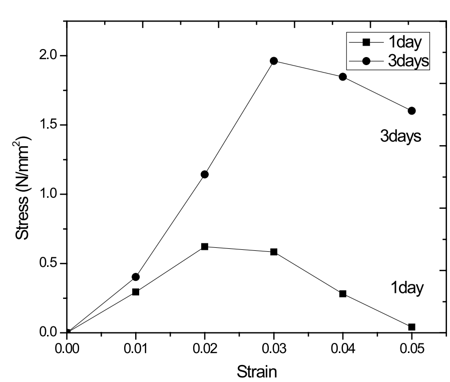
(b) Sol^n: FA = 0. 35



(c) Sol$_n$: FA = 0. 4



(d) Sol$_n$: FA = 0. 45



(e) Sol^n: FA = 0. 5

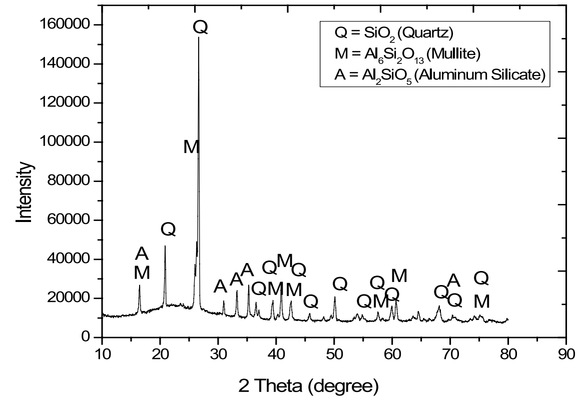
Fig. 1. Compressive Strength of Geopolymer Based Fly-ash of Different Ratios

Table 5. Comparison of strengths of different Water Cement in Cement Mortar (1:1) ratios (Reference data)

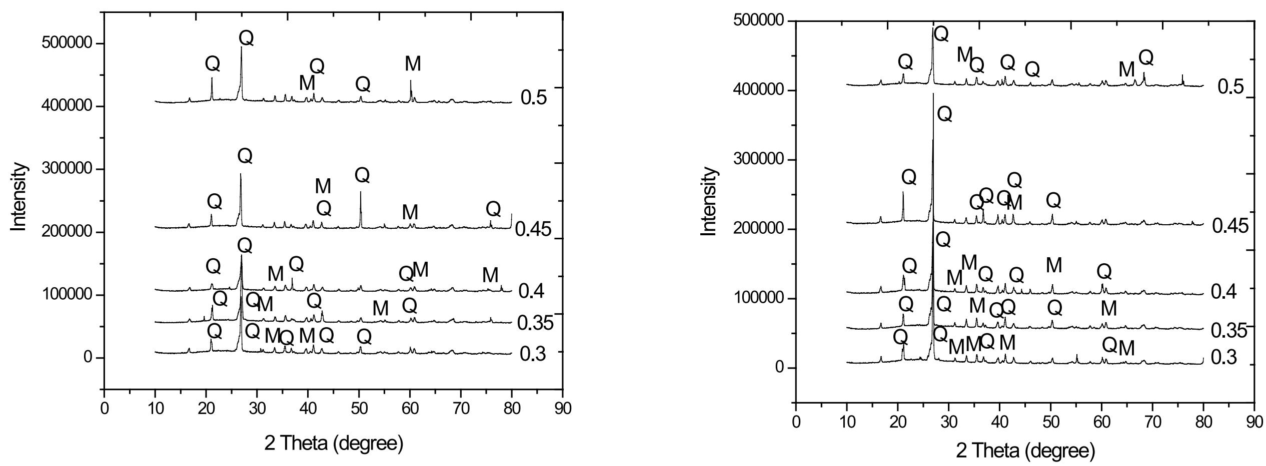
w/c ratio	Curing Age (w.r.t. max. strength)	Maximum Strength
0.3	14 days	26.15N/mm2
0.35	14 days	21.03N/mm2
0.45	14 days	23.18N/mm2
0.5	14 days	16.44N/mm2

XRD TEST

All the mortar specimens were also analyzed by XRD test. Here only 7 days and 14 days curing are selected for this test to study changes in compositions. Quartz, mullite, aluminum silicate are the common minerals present in Fly-ash, which is given in Fig. 2. The XRD analysis was done after 7 and 14 days curing of geopolymer. It was observed that quartz level is more compared to mullite element in case of 7 days and 14 days curing. This shows the changes in the chemical components are responsible for gain in straingth.



(a)



(b) (c)

Fig. 2: XRD analysis of (a) Fly-ash and Geopolymer (b) 7 days' curing (c) 14 days' curing

CONCLUSION

An efforts was made to characterize the geopolymer concrete. As part of the above, in this paper an attempt has been made to study the development in strength of alkali activated fly ash mortar with age and percentage of sodium hydroxide. Based on the above study following conclusions can be made. Although, strength values are very less in comparison to cement used but it is observed that strengths of geopolymer based Fly ash varied according to age of curing, ratio between fly ash and solution keeping constant temperature of curing (40°C) and concentration of sodium hydroxide. According to different ratios, maximum strength was observed in 0.4 at 14 days curing and 0.5 at 3 days curing, but lesser strength is observed in 0.3, 0.35 and 0.45. Hence 0.4 ratio was found better to use as an activator ratio for making it as binder material.

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TECHNICAL SESSION - III

ENERGY RECOVERY FROM WASTE

ENERGY FROM HUMAN EXCRETA

*Deepak Sundrani and *Virendra Deo Vyas

Abstract

We have heard of gobar gas made from cow dung and also cooking gas made from elephant dung in a temple in South India. Now we can think of cooking gas made from sewage. Human beings are a guaranteed perennial source of energy namely sewage. Also just like electricity can be generated from gas fired engine, it can also be generated from gas produced from sewage.

The article describes five case studies where energy is being generated from sewage namely; The Didcot Sewage Works in Oxfordshire which generates cooking gas, Chinclana de la Frontera in Spain which generates fuel for vehicles, Microbial fuel cell pit latrine by Butler which generates electricity, The Inland Empire Utilities Agency wastewater treatment plant in Ontario which creates methane gas which in turn generates electricity, and one case study of Microbial Battery developed by Stanford University which generates electricity and is successfully tested in laboratory and may be used commercially in future.

INTRODUCTION

In rural India `uplas or cowdung cakes' made from cowdung are commonly used as replacement for firewood. Biogas called Gobar gas made from dung of livestock (mainly cattle) is also very commonly used in rural India, which is produced from the anaerobic digestion of manure in small-scale digestion facilities. It is estimated that such facilities exist in over 20 lakh households in India, due to the large population of livestock. The digester is an airtight circular pit which is made of concrete with a pipe connection. The manure is directed to the pit, directly from the cattle shed. The pit is filled with a required quantity of wastewater. The gas pipe is connected to the kitchen fireplace through control valves. The combustion of this biogas has very little odour or smoke. Because of the simplicity in implementation and use of cheap raw materials in villages, it is one of the most environmentally sound energy sources for rural needs.

The Deenabandhu Model is a new biogas-production model popular in India. (Deenabandhu means "friend of the helpless.") The unit usually has a capacity of 2 to 3 cubic metres. It is constructed using bricks or by a ferrocement mixture. In India, the brick model costs slightly more than the ferrocement model; however, India's Ministry of New and Renewable Energy offers some subsidy per model constructed.

As early as in 1982, Guruvayoor temple in Kerala which then had 38 elephants started using elephant dung as source of cooking gas. Bio-gas made from elephants and other animals can also be used to generate electricity by converting gas to electricity similar to conventional gas fired engine. Electricity from elephant dung and other zoo-animals in Munich Zoo is an example of this. The zoo has built three large containers, each capable of holding about 100 cubic meters of animal waste -- that's around a week's collection of dung from all the vegetarian animals in the zoo. Once inside the containers, it's mixed with warm water and the bacteria in the dung is left to decompose in an oxygen-free environment for 30 days. The resulting biogas, mainly comprised of methane and carbon dioxide, rises naturally through vents in the ceiling to a corrugated hut on the roof where it's collected in a "big balloon,". The biogas is then fed into a gas-powered engine that's used to generate electricity. The balloon can store enough biogas to meet 5% of the zoo's energy needs.

Further, when the biogas is turned into electricity, it creates heat which can also be harnessed for heating some enclosures. Once the fermentation process that creates the methane is finished, the remaining solid matter, or "digestate" is used as an organic fertilizer for crops.

A mature elephant can eat about 100 kilograms

*****_Associate Professor, NICMAR, Pune_

of fruit, vegetables a day, producing a huge quantity of dung and all the zoo animals together create roughly 2,000 tons of the stuff every year, which is enough to power about 100 Munich households.

Disposal of sewage generated by humans is one of the most important problems of any Municipal Corporation. Many developing countries face a severe problem of shortfall of energy such as cooking gas and electricity. These two problems can be combined to get a solution, namely energy from human sewage. Thus human beings are a guaranteed source of green energy, although the energy generation cost may not be very attractive : but then same is the case with use of solar energy, wind energy and many other renewable sources and there are enough justifications for using them. Governments of many developed countries have committed themselves to generate part of their energy requirements from renewable resources and are giving incentives for the same.

Bill and Melinda Gates Foundation also takes active interest in this topic and had organised a competition `Reinvent the Toilet Challenge', one of the aims being to recover energy from human waste.

CASE STUDIES

Similar to the generation of power from the excreta of animals, the excreta of human beings can also be used for power generation, although for the same amount of weight, the amount of power generated from human excreta is less in comparison to the livestock dung. The authors have compiled five cases studies where human exceta is indeed being used for energy generation and the fifth case is of a laboratory prototype, which may be used in future.

1) Didcot sewage works, Oxfordshire, UK

Biogas Plant Adjoining Didcot Sewage Works in Oxfordshire

In October 2010, human waste power plant started functioning in the UK. It is a biomethane project that turns human waste into green gas. The project converts the treated sewage of 14 million Thames Water customers into clean, green gas and is pumping that gas into people's homes. The new biogas plant is constructed adjoining to the Didcot sewage works in Oxfordshire. Now, people can cook and heat their homes with gas generated from their own sewage.

Process : The waste goes to the Didcot sewage works to begin its treatment. The solids, or sludge, go on to be warmed up in huge vats so that bacteria can break down any biodegradable material (the process is known as anaerobic digestion.)

The end result of this process is biogas, which is further cleaned up before being fed into the gas grid. It takes around 20 days for the cycle to complete from start to finish and produces enough renewable gas to supply upto 200 homes. The average person is said to produce about 30kg (dry weight) of sludge every year. This means that if all the 9,600 waste treatment facilities in the UK similarly processed sewage from the whole population, it could meet the annual gas demand of over 2 lakh homes.

The joint venture between Thames Water, British Gas and Scotia Gas Networks is seen as an important move towards low carbon gas production in the UK. The biogas project took six months to complete at a cost of GBP2.5 million (US$3.9 million) approximately Rs. 25 crores. The project is in response to the UK Government incentives for companies that pursue renewable energy sources. The UK has committed to 15% of its energy from renewable sources by 2020

2) Town of Chiclana de la Frontera, Spain

This town on the coast of Spain has launched a plant that converts sewage into bio-fuel to be used in automobiles. The Spanish sewage-to-energy project is part of a wider initiative to meet the European Union's Renewable Energy Directive to increase transport biofuels from 2.4 to 10% by 2020.

The facility in town of Chiclana de la Frontera on the Spanish coast uses wastewater and sunlight to produce algae-based biofuel called All-Gas. During the treatment process, the contaminants are removed while anaerobic bacteria feed on some of the waste while giving off gas which can be captured and used by the plant. After that, algae is added to the pools of wastewater and exposed to the plentiful sunlight found in the region. After reaching a critical mass, the algae is extracted to be processed for oil. The remaining algae biomass left behind can be used to make bio-methane, carbon dioxide and minerals.

The goal of All-Gas is to produce 3,000 kilograms of dry algae per day with an oil content of 20% which is sufficient bio-diesel to fill up about 200 cars. It could take years before algae biofuels are commercially viable; but in the end, they may eventually be able to replace some portion of petroleum.

3) Microbial Fuel Cell Pit latrine

This research project, is being funded by a $100,000 grant from the Grand Challenges Exploration program supported by the Bill and Linda Gates Foundation. Environmental Engineering Professor Caitlyn Butler from the University of Massachusetts, Amherst, USA has designed and developed a green pit latrine, called a Microbial Fuel Cell Pit Latrine, which will produce carbon-neutral electricity to provide lighting in a village in Ghana. “This would be a centralized resource for the whole community,” explains Butler. “Its purpose is a combination of removing the harmful components of human waste and generating electricity for the villagers.”

Using this technology in place of a conventional pit latrine in a village of 100 people could power up to ten 45-Watt incandescent lights for over five hours every evening, or even longer if energy-efficient light bulbs are used. The technology can be adapted to existing latrines, which makes the cost very inexpensive. In addition, none of the materials are expensive. This latrine is a waste-treatment device that transforms biochemical energy into sustainable electricity.

Butler’s pit latrine is in essence a battery, it has an anode and a cathode, similar to all batteries. After solid wastes are first filtered in a composting chamber, dissolved waste organic matter is oxidized in an anode chamber. The oxidation of organic matter is facilitated by bacteria that reside on the anode surface and use the anode as an electron acceptor to complete their metabolic reaction. Electrons released in this biological process are conveyed through a load-bearing circuit, producing electricity, to the cathode compartment. There a different community of bacteria uses the cathode as an electron donor, capturing the energy from the electrons, to reduce harmful nitrates in the waste stream.

The primary nitrogen compound found in human waste is ammonium, which can be broken down by the oxidation of ammonium, or nitrification. In Butler’s latrine, nitrification is facilitated by bacteria living in an intermediate chamber that separates the anode and cathode chambers. The result is effluent water that is quite low in organic matter and nutrients, minimizing pathogen persistence in the environment.

4) Inland Empire Utilities Agency waste Water Treatment Plant in Ontario

The Inland Empire Utilities Agency sewage treatment plant in Ontario is using a product from wastewater to power its operation. Specifically, the solid waste flowing in from surrounding cities is used to create methane gas, which, when added with water and heated, feeds into fuel cells which power 60 percent of the plant’s energy.

Emissions are carbon neutral: The system doesn’t release harmful by-products into the atmosphere. The methane gas, heated with water, creates a positive and negative charge as hydrogen and carbonate react inside two large fuel cell units at the plant. Both generate about 2.8 megawatts of energy. That’s about 60 percent of the plant’s energy use at any given moment. The fuel cell system costs about $17 million (Rs. 100 crores). The solid waste product is dried through a centrifugal process at the plant. It’s turned into a black coal-like material called “cake.” About 150 tons of cake is transported out of the plant daily and turned into compost fertilizer.

The Inland Empire Utilities Agency Sewage Treatment Plant in Ontario

5) Microbial Battery Developed by Stanford University

Engineers at Stanford University have devised a new way to generate electricity from sewage using naturally-occurring “wired microbes” as mini power plants, producing electricity as they digest waste, which they hope will be used in places such as sewage treatment plants.

The laboratory prototype is about the size of a D-cell battery and looks like a chemistry experiment, with two electrodes, one positive, the other negative, plunged into a bottle of wastewater. Attached to the negative electrode, an unusual type of bacteria feast on particles of organic waste and produce electricity that is captured by the battery’s positive electrode, called as fishing for electrons.

Microbial Battery

In this battery, exoelectrogenic microbes (organisms that evolve in airless environment and develop the ability to react with oxide minerals rather than breathe oxygen, to convert organic nutrients into biological fuel) are used. These microbes act as bio-generators. At the battery’s negative electrode, colonies of wired microbes cling to carbon filaments that serve as efficient electrical conductors. The microbes make nano-wires to dump off their excess electrons. As these microbes ingest organic matter and convert it into biological fuel, their excess electrons flow into the carbon filaments and across to the positive electrode, which is made of silver oxide, a material that attracts electrons.

CONCLUSION

From the above case studies, we conclude that human waste can be used for generation of power. Although it may not be economical as compared to the conventional non-renewable resources today, but in the long run it may prove to be very important. We have to make all efforts to develop green energy from renewable / non perishable resources for our future generations.

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PRODUCTION OF BIODIESEL FUEL FROM WASTE: JAPAN EXPERIENCE

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Abstract

The clean fuel, alternative fuel, green fuel, safe fuel, etc are the various terminologies used to define a fuel which may cause less environmental problems related to air pollution, carbon di-oxide emission, public health hazard, etc. The production and use of such fuel is the need of the hour to prevent global warming and promote sustainable habitat.

The production of biodiesel fuel (BDF) from waste edible oil is one of the examples to recover energy from household waste. It is practiced in Kyoto City of Japan. The BDF produced at the Centre is used in waste collecting vehicles and municipal buses. Such approach contributed in reduction of carbon dioxide emissions by about 3,200 tons per year. Therefore, it is considered as production of environmental friendly low public hazard fuel. Further, the recovery of energy from waste edible oil promotes a recycling society.

INTRODUCTION

Bio-diesel is a non-petroleum diesel fuel which is typically produced in the presence of a catalyst through the reaction of a vegetable oil or animal fat with methanol. The chemical name of biodiesel is methyl esters.In many countries, biodiesel is considered as either alternative fuel or blended with petroleum diesel. In the context of alternative fuel, it is accepted as pure fuel whereas blended with petroleum diesel, it is known as 'fuel additive'. In fact, biodiesel can be blended from additive level (0%) to 100% biodiesel. The factor 'B' is used to state the amount of biodiesel in any fuel mix. 100% biodiesel is referred to as 'B100'. Similarly, 2% biodiesel and 98% petro-diesel is labeled as 'B2' whereas 20% biodiesel and 80% petro-diesel is labeled as 'B20'. 'B100' is the purest form of biodiesel which can be used with certain engine modifications to avoid maintenance and performance problems whereas up to 20 % blended (B20) does not need modifications but the most of the vehicle manufacturers do not provide warranty coverage if blended fuel is used. However, the specification for biodiesel is approved by the American Standards for Testing and Materials (ASTM) under code number 6751.

BIO-DIESEL FUEL (BDF): A SAFE FUEL

Biodiesel is considered as a 'Fuel for the Future" which is safe alternative fuel to replace petroleum diesel and for promotion of environmentally sustainable transport. It is produced from renewable sources and therefore biodegradable. It acts like petroleum diesel but reduces CO2emissions by over 78% as compared to petroleum diesel. The blended biodiesel also significantly reduces emissions. It is stated that the plants used to make biodiesel feedstock absorb more CO2 as they grow than the biodiesel produces when it is burned. The figure 1 illustrates the comparative analysis of reduction of emission under different categories between B100 and B20. The negative value shows the reduction.

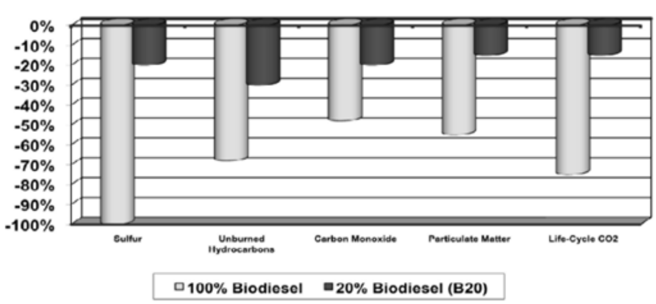

Fig. 1. Comparison of Emission between B100 and B20 Fuel

Source: US Dept. of Energy (US-EPA) and National Renewal energy Laboratory.

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At present, blended biodiesel fuel is used in many countries like Brazil, Canada, China, India, Finland, France, Korea, Sweden, etc but each country sets the targeted value as per their respective biofuels directives. However, some countries have legal system, tax incentives and provisions of subsidiaries to promote the use of biofuel.

PRODUCTION OF BIODIESEL FUEL AS ENERGY RECOVERY FROM WASTE: JAPANESE EXPERIENCE

The city of Kyoto, known as "City of Ten Thousand Shrines" is the capital city of Kyoto Prefecture in Japan. The city of Kyoto is also known globally due to Kyoto Protocol which is an international agreement linked to the United Nations Framework Convention on Climate Change. The Kyoto Municipal South Clean Centre (Fig.4) has been set up to recycle the waste edible oil discharged from the households, restaurants, cafeteria, etc and refine it to produce environmentally friendly biodiesel fuel. The basic approach to BDF production project in Kyoto City is as follows:

- Recycling edible oil (used edible oil) as an alternative fuel to diesel oil
- Recovering and refining the used edible oil discharged both from households and businesses (restaurants and hotels).

The basic aim of the project is to prevent the global warming by reduction in CO2 emission and build a recycling society.

Production Process

Step 1: Receiving Waste Edible Oil

The waste edible oil (used tempura) is recovered monthly from households, restaurants and cafeteria by placing polyethylene tanks in recovery points in each district. It is collected by the active participation of the residents, volunteers, companies and municipality (Fig.2). The same is stored in the raw material storage tanks after checking the properties.

Fig. 2: Disposal of used Edible Oil at Collection Centre by the Residents

Step 2 : Preparatory Treatment

It is necessary to remove contaminants and moisture from waste edible oil. Such impurities are removed to make it suitable for further chemical reaction. Dewatering is done to reduce moisture.

Step 3: Reaction Process

Waste edible oil is treated with Methanol in the presence of catalyst which yields methyl ester as a final product whereas glycerinis also present as by product.

Step 4 : Separation of Final Product

Gravity separation method is used to separate final product and by-product. The crude methyl ester is separated from glycerin using the specific gravity difference.

Step 5: Process of Crude Methyl Ester

The crude methyl ester is mixed with clean water and kept in refinery tank which is heated. Impurities such as free glycerin and catalyst remaining in methyl ester are removed. It gives cleaned methyl ester which is further treated to remove moisture and contaminated and injected additives. The refined methyl ester which is known as "Biodiesel Fuel" is stored and filled with nitrogen to prevent oxidation (Fig. 5).

Fig. 3: Biodiesel Fuel and Product Samples

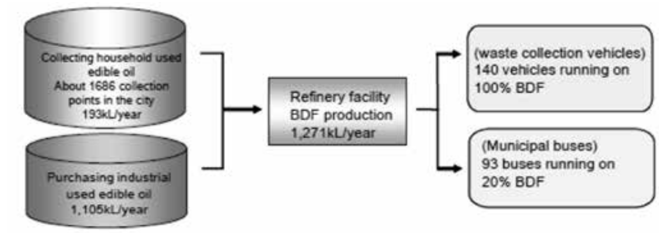
Cost of Biodiesel Fuel

The production cost of BDF is 136 yen/litre (INR 100= Yen 172)

Fig. 4: Kyoto Municipal South Clean Centre
(Biodiesel Fuel Production Facility Centre)

Use of Biodiesel Fuel

The various blended BDF such as B100, B20 and B5are produced. Initially, B5 was used for city buses\ followed by B20. However, both B100 and B20 fuel are produced at this Centre and used in vehicles such as municipal buses and waste collection vehicles. Figure 5 illustrates the BDF production and use flow.



Fig, 5: BDF Production and Uses in Kyoto City

CONCLUSION

The set up of Municipal waste edible oil fuel production facility at Kyoto is a bold step taken by the Kyoto City. Kyoto city is recovering energy from waste edible oil discharged from households, restaurant, etc. In fact, it promotes recycling society for better envoronment.

Kyoto city developed “Kyoto Standard” in order to secure high quality BDF widely used in newly commercialized vehicles . It is also known as Preliminary Standard of Kyoto 2002 which is slightly deviated from EU Standard (EN14214), 2003 and USA (ASTM-D 6751) 2002 but more suitable to Japan’s vehicles. The use of BDF reduces carbon dioxide emission significantly and therefore prevent global warming.This BDF is currently used by all waste collecting vehicles and some municipal buses. It contributes to a reduction of carbon dioxide emission by about 3,200 tons per year.

The participation of local residents, volunteers, municipality, companies, etc in collection, transportation and treatment of waste edible oil is a concept of re-vitalization of society for recycling society.The generation of energy (BDF) from waste edible oil is a promotion of environment friendly low public hazard fuel which contribute reduction of black smoke contained in automobile exhaust gas. The approach to expand the cycle of waste edible oil recovery and to reutilize it as fuel in collaboration with the local residents, citizens, companies, municipality, etc promote human exchange and vitalize local activities to create a recycling society.

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GOLD NOT GARBAGE: ENERGY RECOVERY FROM MUNICIPAL WASTE IN INDIA

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Abstract

Energy recovery from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas recovery. This process is often called waste-to-energy. Recovery of energy from municipal solid waste by combustion in Waste-to-Energy plants reduces landfilling and air/water emissions, and also lessens dependence on fossil fuels for power generation. Converting non-recyclable waste materials into electricity and heat generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil sources and reduces methane generation from landfills.

India is facing an uphill task for maintenance of cleanliness in the cities and at the same time struggling due to acute shortage of energy. It may therefore prove a boon for the country to convert this waste into most useful asset needed by the country.

INTRODUCTION

Urbanization has increased in speed and scale in recent decades, with more than half the world's population living in urban centres. By 2050, urban dwellers probably will account for 86 per cent of the population in developed countries and for 64 per cent of the population in developing countries. Rapid urban population growth has resulted in a number of land-use and infrastructural challenges, including municipal solid-waste management. National and Municipal governments often have insufficient capacity or funding to meet the growing demand for solid-waste management services.

Municipal Solid Waste (MSW) contains organic as well as inorganic matter. The latent energy present in its organic fraction can be recovered for gainful utilisation through adoption of suitable Waste Processing and Treatment technologies. The recovery of energy from wastes also offers a few additional benefits as follows:-

- The total quantity of waste gets reduced by nearly 60% to 90%, depending upon the waste composition and the adopted technology;
- Demand for land, which is already scarce in cities, for landfilling is reduced
- The cost of transportation of waste to far-away landfill sites also gets reduced proportionately; and
- Net reduction in environmental pollution. It is, therefore, only logical that, while every effort should be made in the first place to minimise generation of waste materials and to recycle and reuse them to the extent feasible, the option of Energy Recovery from Wastes be also duly examined. Wherever feasible, this option should be incorporated in the over-all scheme of Waste Management.

GOLD NOT GARBAGE

Municipal solid waste is generally composed of electrical and electronic equipment (such as discarded computers, printers, mobile phones, TVs and refrigerators), construction and demolition waste, health-care waste, and waste from households, offices, shops, schools and industries, and agricultural residues. These include food waste, garden and park waste, paper and cardboard, wood, textiles, nappies

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(disposable diapers), rubber and leather, plastics, metal, glass (pottery and china) and refuse such as ash, dirt, dust, soil and electronic waste (Fig. 1 and 2). Waste management presents an opportunity, not only to avoid the detrimental impacts associated with waste, but also to recover resources, realise environmental, economic and social benefits and to take a step on the road to a sustainable future. Decision makers, responsible for planning and policy making, need to be well informed in order to develop integrated waste-management strategies adapted to the needs of citizens. When informed decisions about waste management are made and applied to the circumstances that prevail, waste will turn into gold.

MSW management has not always been a high priority for local and national policy makers and planners, especially in developing countries. Other issues with more social and political urgency might take precedence and leave little budget for waste issues. Thus, in many cities around the world, effective, functioning policy measures have been elusive and the resources invested in the sector inadequate. National governments can make a critical contribution by making waste management a national priority. They can also ensure the availability of skills, knowledge, and capacity to implement waste management programs effectively, especially at the local level, helping turn garbage to "gold."

Fig 1: Electronic Waste

Fig 2: Garbage being Picked up by Poor Children: A common Site in India

BASIC TECHNIQUES OF ENERGY RECOVERY

Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) basically through two methods as follows:-

Thermo-Chemical Conversion

This process entails thermal de-composition of organic matter to produce either heat energy or fuel oil or gas. The thermo-chemical conversion processes are useful for wastes containing high percentage of organic non-biodegradable matter and low moisture content. The main technological options under this category include Incineration and Pyrolysis/ Gasification.

Bio-Chemical Conversion

This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol. The bio-chemical conversion processes are preferred for wastes having high percentage of organic bio-degradable (putrescible) matter and high level of moisture/ water content, which aids microbial activity. The main technological options under this category are Anaerobic Digestion, also referred to as Bio-methanation.

Parameters Affecting Energy Recovery

The main parameters which determine the potential of recovery of energy from wastes (including MSW), are:-

- Quantity of waste.

- Physical and chemical characteristics (quality) of the waste. The actual production of energy will depend upon specific treatment process employed, the selection of which is also critically dependent upon (apart from certain other factors described below) the above two parameters.

The important physical parameters requiring consideration include:-

- Size of constituents
- Density
- Moisture content

Smaller size of the constituents aids in faster decomposition of the waste. Wastes of the high density reflect a high proportion of biodegradable organic matter and moisture. Low density wastes, on the other hand, indicate a high proportion of paper, plastics and other combustibles. High moisture content causes biodegradable waste fractions to decompose more rapidly than in dry conditions. It also makes the waste rather unsuitable for thermo-chemical conversion (incineration, pyrolysis/ gasification) for energy recovery as heat must first be supplied to remove moisture. The important chemical parameters to be considered for determining the energy recovery potential and the suitability of waste treatment through bio chemical or thermo-chemical conversion technologies include: -

- Volatile Solids
- Fixed Carbon content
- Inerts
- Calorific Value
- C/N ratio (Carbon/Nitrogen ratio)
- Toxicity

In most cases the waste may need to be suitably segregated/ processed/ mixed with suitable additives at site before actual treatment to make it more compatible with the specific treatment method. In case of Anaerobic digestion, if the C/N ratio is less, high carbon content wastes (straw, paper etc.) may be added; if it is high, high nitrogen content wastes (sewage sludge, slaughter house waste etc.) may be added, to bring the C/N ratio within the desirable range.

Assessment of Energy Recovery Potential

A rough assessment of the potential of recovery of energy from MSW through different treatment methods can be made from the knowledge of its calorific value and organic fraction, as under:-

In thermo-chemical conversion all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output:

Total waste quantity: W tonnes

Net Calorific Value: NCV k-cal/kg.

Energy recovery potential (kWh) = NCV x W x 1000/860 = 1.16 x NCV x W

Power generation potential (kW) = 1.16 x NCV x W/ 24 = 0.048 x NCV x W

Conversion Efficiency = 25%

Net power generation potential (kW) = 0.012 x NCV x W

If NCV = 1200 k-cal/kg., then

Net power generation potential (kW) = 14.4 x W

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output:

Total waste quantity: W (tonnes)

Total Organic / Volatile Solids: VS = 50 %, say

Organic bio-degradable fraction: approx. 66% of VS = 0.33 x W

Typical digestion efficiency = 60 %

Typical bio-gas yield: B (M3) = 0.80 m3 / kg. of VS destroyed

= 0.80 x 0.60 x 0.33 x W x1000 = 158.4 x W

Calorific Value of bio-gas = 5000 kcal/m3 (typical)

Energy recovery potential (kWh) = B x 5000 / 860
= 921 x W

Power generation potential (kW) = 921 x W/ 24
= 38.4 x W

Typical Conversion Efficiency = 30%

Net power generation potential (kW) = 11.5 x W

In general, 100 tonnes of raw MSW with 50-60% organic matter can generate about 1-

1.5 Mega Watt power, depending upon the waste characteristics.

TECHNOLOGICAL OPTIONS

There are various technological options which can be employed for recovery of energy from MSW. While some of these have already been applied at a large scale, some others are under advanced stages of development. A brief on these technologies is given below.

Anaerobic Digestion (AD)

In this process, also referred to as bio-methanation, the organic fraction of wastes is segregated and fed to a closed container (biogas digester) where, under anaerobic conditions, the organic wastes undergo bio-degradation producing methane-rich biogas and effluent/ sludge. The biogas production ranges from 50-150 m^3/tonne of wastes, depending upon the composition of waste. The biogas can be utilised either for cooking/ heating applications, or through dual fuel or gas engines or gas/ steam turbines for generating motive power or electricity. The sludge from anaerobic digestion, after stabilisation, can be used as a soil conditioner, or even sold as manure. Fundamentally, the anaerobic digestion process can be divided into three stages with three distinct physiological groups of micro-organisms.

Stage I: It involves the fermentative bacteria, which include anaerobic and facultative micro-organisms. Complex organic materials, carbohydrates, proteins and lipids are hydrolyzed and fermented into fatty acids, alcohol, carbon dioxide, hydrogen, ammonia and sulfides.

Stage II: In this stage the acetogenic bacteria consume these primary products and produce hydrogen, carbon dioxide and acetic acid.

Stage III: It utilizes two distinct types of methanogenic bacteria. The first reduces carbon dioxide to methane, and the second decarboxylates acetic acid to methane and carbon dioxide.

Factors, which influence the Anaerobic Digestion process, are temperature, pH (Hydrogen Ion Concentration), nutrient concentration, loading rate, toxic compounds and mixing. For start-up a good innoculum such as digested sludge is required. A temperature of about 35-38°C is generally considered optimal in mesophilic zone (20-45°C) and higher gas production can be obtained under thermophillic temperature in the range of 45-60°C. Provision of appropriate heating arrangements and insulation may become necessary in some parts of the country. Anaerobic Digestion (AD) of MSW offers certain clear advantages over the option of Aerobic process, in terms of energy production/ consumption, compost quality and net environmental gains as following.

- AD process results in net production of energy.
- The quality of the digested sludge (compost) is better as Nitrogen is not lost by oxidation.
- Its totally enclosed system prevents escape of polluted air to atmosphere.
- The net environmental gains are positive.

Incineration of Waste (with Energy Recovery)

It is the most common thermal treatment of waste and can reduce the volume of disposed waste by up to 90 per cent. The gases from the thermal step are used to boil water to create steam. This is then fed into a steam turbine to generate electricity and/or used for heating. Incineration is expensive in terms of capital and operating costs, and requires high standards of operation and maintenance. In many developing countries, MSW generally has a low energy value because of its high moisture content and the prior removal of paper and plastic by waste pickers. Incineration of such waste will require additional fuel (usually oil) in order to keep the wastes burning.

The advanced thermal treatment of waste includes such technologies as pyrolysis and gasification. Pyrolysis leads to the chemical decomposition of organic material at elevated temperatures of 430°C in the absence of oxygen. The main product "syngas can be used as a fuel to generate electricity or steam or as a basic chemical feedstock in the petrochemical and refining industries. Gasification uses very high temperatures that convert organic materials at controlled amounts of oxygen into carbon monoxide, hydrogen, carbon dioxide and methane. Hydrogen is high in energy and an engine that burns pure hydrogen produces almost no pollution. However, the technologies are technically difficult, relatively unproven at commercial scale.

GLOBAL DEVELOPMENTS

A number of thermal-based energy recovery processes have been set up, mainly in Europe, the United States, Japan, China and South Korea. Waste to Energy Process in Europe already supplies a considerable amount of renewable energy (some 38 billion kilowatt-hours in 2006). By 2020, the amount might grow to as much as 98 billion kilowatt-hours, enough to supply 22.9 million inhabitants with electricity and 12.1 million inhabitants with heat. By 2009, USA had 88 Waste to Energy plants that combust about 26.3 million tonnes of MSW and serve a population of 30 million.

The first US incinerator was built in 1885 on Governors Island in New York, NY. By the mid-20th Century hundreds of incinerators were in operation in the United States but until the 1960s little was known about the environmental impacts of the water discharges and air emissions from these incinerators. When the Clean Air Act (CAA) was enacted in 1970, existing incineration facilities became subject to new standards that banned the uncontrolled burning of municipal solid waste (MSW) and placed restrictions on particulate emissions. Currently there are 86 facilities with capacity to produce 2720 megawatts of power per year in the United States.

INITIATIVES TAKEN BY THE GOVERNMENT

The Government of India has sanctioned the implementation of Programme on Energy Recovery from Municipal Solid Waste during the year 2012-13. The scheme provides financial assistance for setting up of five Pilot projects for power generation from MSW to be undertaken in accordance with the decision of Hon'ble Supreme Court and recommendations of the Expert Committee. The main objectives of the proposed Programme on Energy Recovery from MSW are as follows:-

- To set up five Pilot projects for recovery of energy from MSW; and
- To create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilization of MSW for recovery of energy.

Key recommendations of the Expert Committee in regard to development of MSW based waste-to-energy projects are given below:-

- The issues such as Project Development including characterization of wastes, sizing of projects, technology selection and project design, management model and operational issues including close co-ordination between Municipal Corporation and the Promoters, financial appraisal and approval of project should be adequately addressed.
- In view of the problems of treatment and disposal of municipal wastes (solid and liquid) in cities and towns, which are only likely to increase with the growth of population and urbanization, an integrated approach to waste processing and treatment will be necessary.
- The selection of technology for the solid waste management depends upon the quality of waste to be treated and the local conditions
- The Committee has also recommended that projects based on biomethanation of MSW should be taken up only on segregated/uniform waste unless it is demonstrated that in Indian conditions, the waste segregation plant/process can separate waste suitable for Biomethanation. It is expected that State Nodal Agencies, HUDCO, IREDA, IL&FS, TCOs, etc, will develop the projects with the help of consultants, as may be necessary,

The Government will provide financial support under this Programme for setting up five Pilot Projects on Energy Recovery from Municipal Solid Wastes is as follows:-

- Financial assistance at a flat rate of Rs.2.00 crore per MW, subject to ceiling of 20% of project cost and Rs. 10.00 crore per project, whichever is less.
- Financial Assistance to be provided for projects selected through a transparent competitive procedure.
- Financial assistance of 20% higher than those specified for different categories of projects will be provided for projects in North Eastern Region and Special Category States, namely, Himachal Pradesh, J&K, Sikkim and Uttarakhand.

- The financial assistance will be released by the Ministry in two installments.
- First installment of 50 percent of subsidy may be released against Bank Guarantee from Nationalized Bank for the same amount to the FI/bank lending for the project upon release of 50% of sanctioned loan amount. This may be treated as interest free loan until the release of second installment of subsidy.
- In the event of the second installment not getting released within a period of one year due to non-completion of project, this amount may be refunded by the Bank/FI with interest and paid to MNRE (Ministry of New and Renewable Energy) by revoking the Bank Guarantee. A proper agreement will be entered into with the Bank/FI concerned for recovery of released amount of subsidy if second installment not getting released.
- Second installment of 50% of subsidy may be released in three months after commissioning of the project, and achievement of an average Plant Load Factor (PLF) of 60% during the third month of operation. The quantum of second installment may be reduced by 5% per month in the event of delay in achieving the average monthly PLF of 60%.

CONCLUSION

The different technologies for recovering useful energy from Municipal Solid Wastes already exist and are being extensively utilised in different countries for their multiple benefits. It is necessary for the success of these technologies in India to evolve an Integrated Waste Management system, coupled with necessary legislative and control measures. A detailed feasibility study needs to be conducted in each case, duly taking into account the available waste quantities, characteristics and the local conditions as well as relative assessment of the different waste disposal options. Suitable safeguards and pollution control measures further need to be incorporated in the design of each facility to fully comply with the environmental regulations and safeguard public health. The Waste-to-Energy facilities, when set up with such consideration, can effectively bridge the gap between waste recycling, composting and landfilling, for tackling the increasing problems of waste disposal in the urban areas, in an environmentally benign manner, besides augmenting power generation in the country.

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FUEL GENERATION FROM TYRE WASTE: A STEP TOWARDS RENEWABLE SOURCE OF ENERGY

NARENDER SINGH*

Abstract

The quantum of tyre waste has been increasing day by day due to increase in population, urbanization, motorization and change in the life style of people. The disposal of waste tyres is a menace and become a serious problem globally due to their non-biodegradability and unaesthetic view. The traditional waste tyre recycling techniques like land filling, incineration and co-combustion are available with certain limitations have now been replaced worldwide by the most eco-friendly and advanced waste tyre recycling techniques like retreading, gasification and pyrolysis.

The continuous increasing motorization and industrialization has lead to significant rise in demand of petroleum products which are non-renewable and it is difficult to predict the availability of these resources in future, resulting in uncertainty in its supply and price, which in turn impact the growing economies like India. The pyrolysis of scrap tyres can be efficiently used to produce fuel oil and proved as the best substitute or alternate to the petroleum products, thereby resolving the problem of tyre waste disposal. In this paper, the advanced technique being used to recover fuel oil by using waste tyre recycling pyrolysis plant has been reviewed with elaboration of its positive aspects.

INTRODUCTION

The automotive vehicles are increasing rapidly due to increasing motorization and industrialization which definitely leads to generation of tyre waste globally. Billions of waste tyres are available in all over the world. We can't burn or landfill them due to pollution problems. Disposal of tyre waste is becoming an environmental challenge in many developing countries like India due to its non-biodegradability. Now a day, the developed techniques like pyrolysis process could be used to produce fuel oil from tyre waste to substitute the conventional energy resources/ fossil fuel.

PROBLEMS WITH TYRE WASTE

The main problems with tyre waste are as follows:

- Cause land and water pollution
- Cause health problems
- Can catch fire
- Non-biodegradable
- Un-aesthetic to view
- Expensive to get rid of
- Need reasonable space to stock

TYRE WASTE GENERATED IN INDIA

More than 3.4 million tons of end-of-life tyres are generated annually in European Union, 2.5 million tons in North America and 1 million tons in Japan. However, the quantity of scrap tyres produced

Fig. 1: Menace of Used Tyres

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in India is not exactly available but the increasing trend of use of road transportation will definitely create a problem of disposal in very near future (Fig.1).

As per "Road Transport Year Book 2011-12, Ministry of Road Transport & Highways", the total number of registered motor vehicles increased from about 0.3 million as on 31st March, 1951 to 159.5 million as on 31st March, 2012. The total registered vehicles in the country grew at a Compound Annual Growth Rate (CAGR) of 10.5% between 2002 and 2012. Assuming the same CAGR the total number of registered motor vehicles may increase up to 194.7 million by 2015.

In India, the total number of registered two wheelers, cars/jeeps/taxis, buses, trucks and other vehicles in 2004 were 71.4% (51.9 million), 13% (9.4 million), 1% (0.73 million), 5.2% (3.8 million) and 9.4% (6.8 million) respectively out of the total 72.7 million vehicles as shown in table 1.

Considering average life of tyre used in these vehicles as 10 years after retreading twice, total number of waste disposable tyres will be in the order of 265.8 million per year from 2014 that approx. equal to 3.2 million tons assuming average 12 kg weight of tyre (fig. 2).

CONSUMPTION OF PETROLEUM PRODUCTS IN INDIA

As per "Indian Petroleum & Natural Gas Statistics 2012-13, Ministry of Petroleum & Natural Gas", India's petroleum product consumption has increased from 111.6 million tons in 2004-05 to 156.5 million tons in 2012-13 at a CAGR of 4.1%.

Table 1: Composition of Registered Motor Vehicles in India (% of total)

Composition of registered motor vehicles in India (% of total)						
As on 31st March	Two Wheelers	Cars, Jeeps etc.	Buses	Trucks	Other Vehicles	Total (Million)
	(as % of total motor vehicle)					
1951	8.8	52.0	11.1	26.8	1.3	0.3
1971	30.9	36.6	5.0	18.4	9.1	1.9
1991	66.4	13.8	1.5	6.3	11.9	21.2
2002	70.6	12.9	1.1	5.0	10.4	58.9
2004	71.4	13.0	1.0	5.2	9.4	72.7
2006	72.2	12.9	1.1	4.9	8.8	89.6
2008	71.5	13.2	1.4	5.3	8.6	105.3
2010	71.7	13.5	1.2	5.0	8.6	127.7
2012	72.4	13.5	1.0	4.8	8.3	159.5

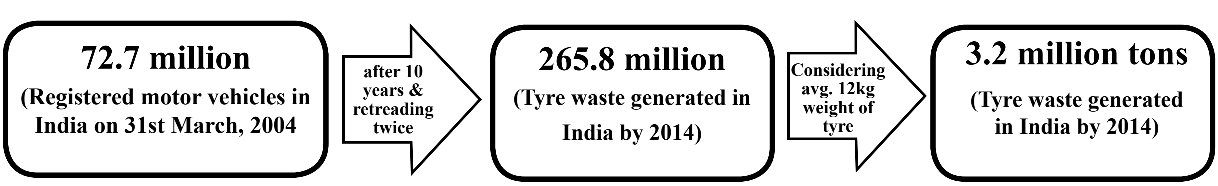

Fig. 2: Tyre Waste Generated in India by 2014

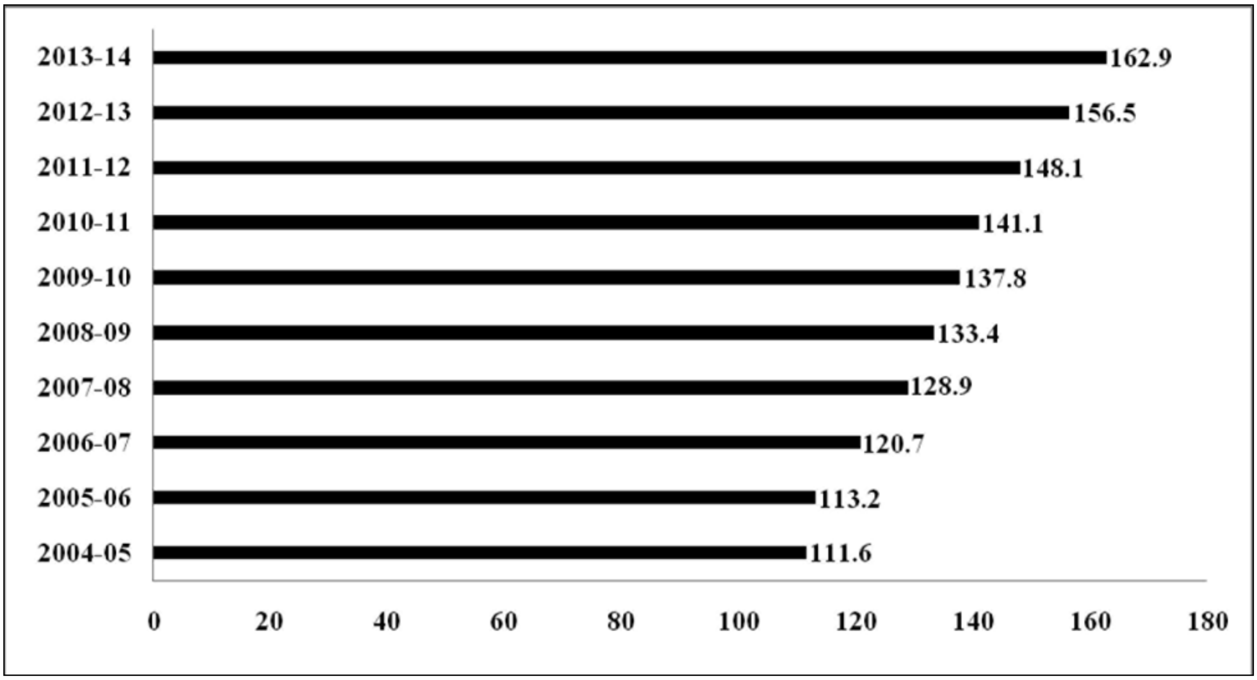

Fig. 3: Consumption of Petroleum Products in India (in million tons)

Assuming the same CAGR the petroleum product consumption may increase up to 162.9 million tons by 2013-14 as shown in fig. 3.

This increase in consumption of petroleum products will result in steep rise in their demand and make it difficult for government to subsidize petroleum products in future. Around the world, there are initiatives to replace gasoline and diesel fuel due to the impact of fossil fuel crisis and hike in oil price. Millions of dollars are being invested in the search of alternative fuels whereas the disposal of waste tyres from automotive vehicles is becoming more and more complex. Waste to energy is the recent trend in the selection of alternate fuels. So, in order to prevent automobile tyres from damaging the environment, it is highly desirable to recycle the same to generate fuel oil as a substitute to the petroleum products.

TRADITIONAL TECHNIQUES OF WASTE TYRE RECYCLING

The traditional techniques of waste tyre recycling have been described in Fig. 4:

Land Filling

Land filling is one of the most common ways to tackle the waste tyre problem. However, many countries have imposed ban on land filling of the waste tyre, especially the land filling of whole waste tyre due to its non-biodegradable nature.

Incineration

Incineration is a waste treatment technology that involves the combustion of organic materials or substances in an oxygen-rich environment. Incineration of waste materials converts the waste into

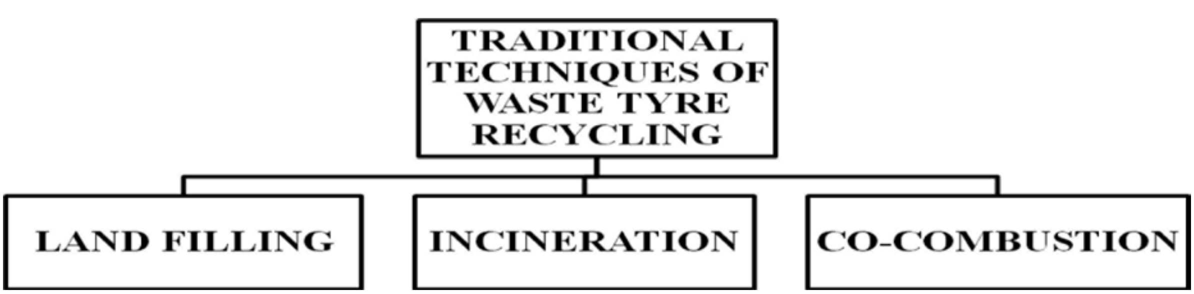

Fig. 4: Traditional Techniques of Waste Tyre Recycling Land Filling

incinerator bottom ash, flue gases and particulates in which flue gases can be used to generate electric power. Incineration reduces the volume of the original waste by 95-96%. However, incineration may involve the emission of hazardous pollutants which are extremely harmful to human health and environment.

Co-combustion

Co-combustion is the combustion of equal or more than two different types of materials at the same time. Waste tyre co-combustion can be used to improve the combustion of fuels with low energy content.

Due to the emission of hazardous pollutants from waste tyre combustion, the incineration and co-combustion of whole tyre in cement kilns has been banned in a number of countries.

ADVANCED TECHNIQUES OF WASTE TYRE RECYCLING

The advanced and most eco-friendly technique of waste tyre recycling have been described in Fig. 5:

Retread or Remould

Retread or recap or remould is a manufacturing process designed to extend the useful lifespan of a worn tyre. The old tread is buffed away and a new rubber tread is applied to the bare casing with the help of specialized machinery. Retreading is regularly undertaken on airplane tyres. Retreading is the most eco-friendly way of recycling the used tyres as manufacturing the average car retread takes 4.5 gallons less oil than manufacturing equivalent new tyre. With commercial vehicle tyres, the savings are even greater, estimated to be nearly 15 gallons per tyre.

Gasification

Gasification is the conversion of waste materials into their simplest molecules including carbon monoxide, hydrogen and methane forming a syngas (synthetic natural gas)/ synthesis gas which can be used for generating electricity or producing valuable products. The gasification process produces zero toxic emissions, making it a green energy technology and is environment friendly.

Pyrolysis

Pyrolysis is a thermo-chemical decomposition of organic material at elevated temperature in the absence of oxygen. Several research works have been carried out on the pyrolysis of waste automobile tyres. In the pyrolysis process, larger hydrocarbon chains break down at certain temperatures in the absence or limited supply of oxygen that gives end product usually containing solid, liquid and gases. The waste tyre recycling pyrolysis plant is generally used to generate fuel oil which is a substitute to diesel fuel and help in minimizing the utilization of the natural resources.

WASTE TYRE RECYCLING PYROLYSIS PLANT

The waste tyre recycling pyrolysis is a unique technology that had come up with a concept of setting new standard in renewable energy that includes using of waste tyres as a raw material and producing green fuel oil, carbon black, steel and gas. With global warming and utilization of rubber tyres, it has now become necessary to recycle the waste and convert it in fuel oil in such a way that it is environment friendly. This technology can change energy market scenario in a big way. The waste tyre recycling pyrolysis plants are available with 5 to 12 tons per day capacity. The 5 tons per day capacity recycling pyrolysis plant has been considered for studying the fuel generation process. The technical requirements of pyrolysis plant have been shown in table 2.

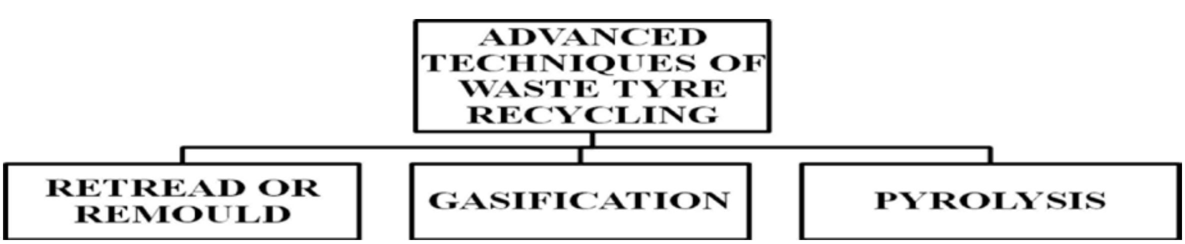

Fig. 5: Advanced Technique of Waste Tyre Recycling

Table 2: Technical Specifications of Pyrolysis Plant (5-tons per day capacity)

Sr. No	Details	Specifications
1	Land Required	Approx. 2000 sq. yard
2	Raw Materials	Waste tyres
3	Reactor Type	Horizontal Rotary
4	Reactor Size	2200x6000 mm
5	Cooling Type	Water Cooled- Cell & Tube Type Condensing System
6	Heating Type	Direct Heating
7	Heating Material	Wood, Coal, Gases, Oil, etc
8	Required Power	30 HP
9	Working Pressure	0.05 to 1 Bar
10	Control System	0.4 rpm
11	Reactor Rotation Speed	Computerized PLC / Manual
12	Reactor Weight	Approx. 8.5 tons
13	Machine Weight	Approx. 27 to 30 tons
14	Process Timings	24 hours/batch
15	Man power required	Technical-1, Manager-1, Unskilled-5
16	Water required	1000 Liters/day

Pyrolysis Plant Process

In pyrolysis plant the waste tyres are fed in to the reactor vessel and initial heat is provided with the help of wood, coal, gas or oil under controlled conditions of temperature and pressure (Fig. 6).

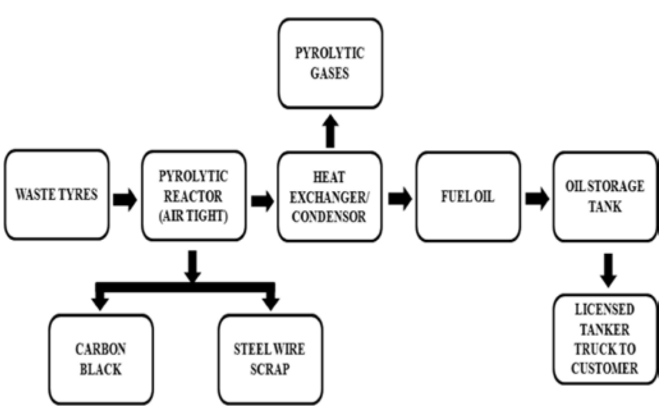

Fig. 6: Pyrolysis Plant Process

Pyrolysis typically occurs under pressure and at operating temperature of about 430oC in a batch process system. The process will bring about molecular restructuring of rubber and convert in to vapour and gases. These vapours and gases come in to separator where heavy oil fraction is separated from gases and the gases are passed through the series of heat exchangers to condense the vapour in to liquid form called tyre/fuel oil by means of re-circulated water from cooling tower and is collected in to the storage tank. Non condensable gases also called pyro gases are used for heating the reactor in place of initial heating source (wood, coal, gas or oil) as per the requirement and rest of the gases are burnt in the open air by means of gas burner. During the process carbon black and steel wires are also generated, being pulled out of reactor to be sold in to the open market.

PYROLYSIS END PRODUCTS

The pyrolysis end products have been shown in Fig. 7:

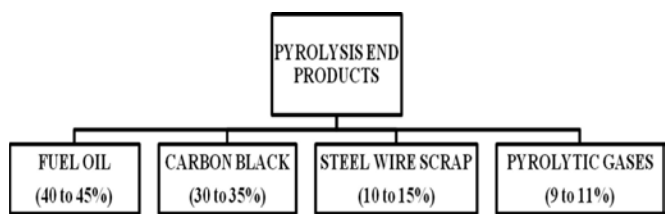

Fig. 7: Pyrolysis End Products

Fuel Oil

The main product produced by pyrolysis plant is fuel oil that is used for industrial and commercial purpose. There are two types of oil we get from the process, one is normal tyre/ fuel oil and other is heavy oil. Heavy oil is about 5 to 7% of fuel oil. The final percentage of fuel oil is about 40 to 45% depending on tyre quality. Now a day, there is a great demand of fuel oil in the market, as every industry requires fuel for heating purpose.

Applications of fuel oil:

- Steel industries
- Rolling mill industries
- Chemical industries
- Used in the boilers for the heating purpose
- Used in hot mix plants for heating bituminous mix

Carbon Black

The second product of tyre pyrolysis plant is carbon black. The quantity of carbon black is about 30 to 35% according to tyre quality. The carbon black can be used as a chemical strengthener in rubber industries and coloring agent in pigment industries. This carbon black price is very competitive compare to petroleum carbon black, so pyrolytic carbon black is good option instead of petroleum carbon black.

Applications of carbon black:

- Steel industries for burning process
- Footwear industries to make rubber souls
- Polish and ink industries
- Color industries as pigment
- Iron industries
- Electric cable jacketing
- Hose and doormat
- Black nylon bag
- Rubber additive & automotive spare parts
- Heat isolation
- Plastic pipe
- Fire fighting

Steel Wire Scrap

The third product of tyre pyrolysis plant is steel wire. The quantity of steel wire is about 10 to 15% according to tyre quality. It is easy to sell steel wire scrap in local market.

Pyrolytic Gases

The pyrolytic gases generated during process are about 10% of total tyre waste. The main component of these gases is methane (CH_4). These gases has a higher calorific value compared to natural gas and can replace natural gas and propane when stored. The pyrolytic gases can be used as energy resource in gas burners and also used in pyrolysis system.

MERITS OF PYROLYSIS PLANT

The merits of pyrolysis plant are:

- Raw material (waste tyre) is cheap and easily available.
- There is 100% recycling of waste tyres and no disposable materials are left at the end of the process.
- No chemical ingredients/ catalysts are used in the plant during process.
- During and after the process; no soil, water or air pollution is observed and thus eco- friendly.
- Creates economically valuable products out of tyre waste which are industrial raw materials and have a reasonable market value.
- Each recycled ton of tyre preserves 10 tons of CO_2 that is a major greenhouse gas.
- The system creates an alternative source of energy to replace petroleum products and natural gas.
- It is feasible technology with small amount of investment and high availability of raw materials.
- System gives the opportunity to government and local administrations to deal with the waste tyre problem to a great extent.

FUEL OIL GENERATION FROM TYRE WASTE IN INDIA

As per fig. 2, the tyre waste generated in India is nearly 3.2 million tons by 2014. Therefore, the probable fuel oil generated from this tyre waste by using pyrolysis plant will be approx. 1.44 million tons as shown in fig. 8.

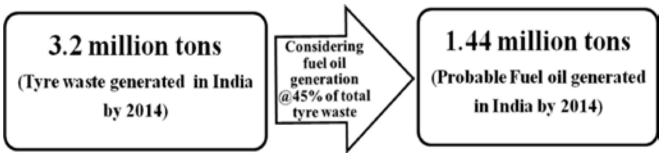

Fig. 8: Probable Fuel Oil Generation in India Using Tyre Waste

CONSUMPTION OF LIGHT DIESEL OIL AND FURNACE OIL IN INDIA

As per "Indian Petroleum & Natural Gas Statistics 2012-13, Ministry of Petroleum & Natural Gas", India's light diesel oil and furnace oil consumption has decreased from 9.78 million tons in 2005-06 to 6.46 million tons in 2013-14.

The LDO and furnace oil are being used as fuel for agricultural pump sets, industrial units, start up fuel for power generation, etc. These can be substituted with the fuel oil generated from pyrolysis process of waste tyres. The present demand (tentative consumption) of LDO and furnace oil in Indian industries is 6.46 million tons. This demand could be met out up to 22.29% (1.44 million tons) with the supply of fuel oil, presumed to be generated by pyrolysis of 3.2 million tons of tyre waste.

CONCLUSION

The fuel oil recovered from pyrolysis of scrap tyres is changing the energy market scenario in a big way, resolving the problem of tyre waste disposal and substituting the conventional energy resources to the renewable sources. The pyrolysis technique is thus helping the developing countries to become self-sufficient and improve their economies. The government authorities should move ahead to introduce pyrolysis technique on large scale in the public sectors so as to optimize this advanced technology at ground level.

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ANALYSIS OF SOLID WASTE MANAGEMENT MODEL IN DENMARK

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Abstract

Presently in India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tonnes are organic wastes from agricultural sources; 290 million tonnes are inorganic waste of industrial and mining sectors and 4.5 million tonnes are hazardous in nature. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling different wastes and utilize them in value added applications.

In recent times, the impact of wastes in any form (solid, liquid, gas) on our environment has been so much that our scientific astrologers are predicting a great threat to the environment in the near future. The increase in quantity and complexity of this solid waste has been to such an extent that there is an adverse effect on our environment. The objectives of solid waste management are to control, collect, process, utilize and disposal of solid wastes in the most economical way consistent with the protection of public health and the natural environment.

This paper presents a case study of how solid waste management is implemented in Denmark successfully by using 'hierarchy of waste management' method. The hierarchy adopted was (1) waste minimization at source, (2) recycling, (3) waste processing (4) waste transformation and (5) disposal on land. Application of these methods results in a more friendly and pollution free environment.

INTRODUCTION

Since the beginning, humankind has been generating waste, be it the bones and other parts of animals they slaughter for their food or the wood they cut to make their carts. With the progress of civilization, the waste generated became of a more complex nature. At the end of the 19th century the industrial revolution saw the rise of the world of consumers. Not only did the air get more and more polluted but the earth itself became more polluted with the generation of non biodegradable solid waste. The increase in population and urbanization was also largely responsible for the increase in solid waste.

Each household generates garbage or waste day in and day out. Items that we no longer need or do not have any further use fall in the category of waste, and we tend to throw them away. Following are different types of solid waste depending on their source.

- Household waste is generally classified as municipal solid waste (MSW)
- Industrial waste as hazardous waste
- Biomedical waste or hospital waste as infectious waste

CASE STUDY OF DENMARK

In Denmark, the treatment of household, commercial and hazardous waste is responsibility of the local authorities. The local council is responsible for ensuring that collection, transportation and management is in compliance with the regulation. When a collection scheme has been established, citizens, freeholders and enterprises are, as a rule, under an obligation to use the scheme. In large cities, compactor trucks with lifts for automatic emptying of waste bins and containers are frequently used. Large containers with four small wheels are often used for mixed domestic waste collection from large multistory

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houses. From smaller dwellings and one-family homes, waste bins as well as paper or plastic bags may be used in combination with compactor trucks or open lorries. In the case of open lorries, the bags are manually thrown and stacked. Besides, separated waste is most frequently collected in containers. Source-sorted waste is frequently collected jointly from several domestic areas in large containers. The frequency of the collection is daily, once per week, once per fortnight or once per month, depending on the different types of waste.

Awareness in Denmark

The waste sorting habits of the residents is a long process. Waste sorting means that there will be several bags for the different kinds of waste, instead of mixed collection with one bag. For example in the city of Esbjerg, Denmark, the Environmental Protection Agency organized the propaganda by distributing the leaflets to the public to promote the advantage of waste sorting. Until 1996, the detailed plan for waste sorting and recycling was developed. That means the public awareness plays an important role for waste sorting.

In Denmark, the young children attach great importance to the environmental awareness and good habits. From primary school, the students are taught the concept of environmental protection and eco-cycle, and they in turn teach their parents at home which impacts the society finally. People have more progressive perception that they should reduce consumption, promote green consumption and leave more for future generations of resources such as forests.

Waste Sorting System Implemented

There is a good waste sorting system from the waste collection to the waste treatment. In the residential area or the public area, there are many different waste bins for the different waste, such as the wood, glass, paper etc.

Danish Waste Hierarchy

The most important objective of Danish waste management policy is to reduce waste, which is in line with the integrated product policy of the Danish Ministry of Environment and Energy, aiming at limiting resource consumption and environmental impact for all products. By environmental management and cleaner technology it is possible to reduce the generation of waste. The concept of "cradle to cradle" has already been used for production in Denmark. It means the products could be reused again and again instead of using the virgin materials, which is very helpful for waste reduction. At present, there are more activities for promotion of "cradle to cradle" in Denmark.

According to the hierarchy, recycling ranks higher than incineration with energy recovery, and landfill ranks lowest. In Denmark, the different kinds of waste are treated in different ways. For instance, 20% of the domestic waste is recycled and 80% of it is incinerated. In case of Construction and Demolition waste about 90% is recycled and 8% of the waste is landfilled.

In general, in terms of the waste in Denmark, we can see from the Figure -1 that 65% of the waste is recycled and 26% is incinerated and 9% is landfilled. And incineration does not count as recycling in Denmark.

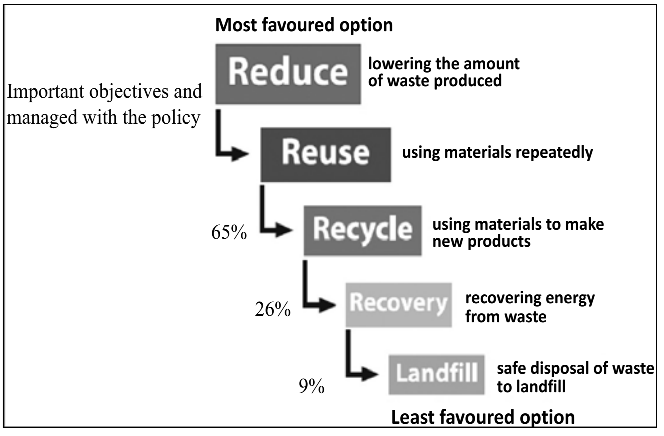

Fig. 1: Danish Waste Hierarchy

INCINERATION: CASE STUDY OF VESTFORBRÆNDING

In Denmark, the waste treatment company is working on many aspects for waste disposal. For instance, the incineration plant is only one part of the waste treatment company, which means that the incineration plant should not be separated with other processes of the waste treatment.

Vestforbrænding is an environmental company creating solutions in the waste management field, which is working to minimize waste and pollution, and treating waste as a resource. At the same time, Vestforbrænding has 6 recycling centres and the largest incineration plant of Denmark. It generates both power and district heat by incineration commercial and MSW.

Vestforbrænding handles around 900,000 tonnes of waste a year of which 33% is recycled, 62% goes to energy recovery through incineration and 5% goes to special treatment (including landfill).

The big difference of the incineration between Denmark and China, is that Danish company is a 'non-profit cost-coverage' company, which is owned by 19 municipalities around Copenhagen. Vestforbrænding does the most of the steps it can do, including collection waste, recycling, separation and management of hazardous waste, research and development in the waste management field. According the "waste hierarchy" of Vestforbrænding, incineration has the least priority.

There is a full automatic control centre working for the waste treatment and incineration. After the waste sorting and recycling, the left non-recyclable and combustible waste is transferred to the bottom layer of the incineration plant (Fig.2) and the waste is continued to be mixed and sifted. After 4 more working procedures for the waste treatment, finally the waste will go into the incineration plant. All these processes are observed and controlled by workers in the control center.

Fig. 2 : Incineration Plant

Solution of Pollution Problems

The technology is used to solve the pollution problems. Ammonia is used to reduce the emissions of nitrous gases through the flue-gas stack. They put activated carbon into their filter bags to dispose dioxins and other harmful substances. Fly-ash is also collected in the filter bags. All flue-gases such as hydrochloric acid, heavy metals, and SO_2 are washed and removed in the scrubber system. In addition, sulphur precipitate as gypsum is landfilled, which occupies around 0.3% of total waste input. Water from the flue-gas washing processes is led to the in-plant water treatment facility where it is neutralized, among others with lime, and cleaned for heavy metals and harmful substances. Then the water is led to a municipal waste water treatment plant. Sludge from waste water treatment is sent to landfill together with fly ash, which occupies 3% of total waste. Vestforbrænding also measures flue-gas flow, flue-gas temperature in different locations in the incineration plant, and also measure the oxygen rate, water rate, CO contents, Nox, dust, SO_2, and TOC (Total Organic Carbons).

Vestforbrænding operates Denmark's largest plant for incineration of waste including four incineration furnaces at the plant with a total capacity of 600,000 tonnes a year. There are two old furnaces, and each can incinerate around 12 tonnes of waste per hour, which were commissioned in 1970. The other two incineration furnaces were commissioned in 1999 and 2005, and can incinerate respectively around 26 tons and 35 tons per hour. In 2008, Vestforbrænding incinerated around 563,000 tons of waste.

After the waste has passed through the furnace it is completely burned out. Only the bottom ash is left, which makes up around 17 % of waste input measured in weight and the volume is only around 5 % of the original amount of waste. Bottom ash is reprocessed ensuring that 95 % of ash volumes are recycled. It is used as a filler material in major construction works such as motor ways, roads, and bridges.

Vestforbrænding generates the energy; around 20% becomes power and 80% to heating distribution, which substitutes fossil fuels elsewhere. In 2008, Vestforbrænding generated 245 GWh of power and 1.390 GWh of district heating, which correspond to the power consumption in 80,000 homes and the heat consumption in 75,000 homes.

District Heating

When waste is incinerated in the furnaces, the flue-gas is cooled with water, which is converted into steam under high pressure and high temperature in the modern boilers and the steam turns into power. The power is distributed in the national grid to residents and other consumers, whereas heat is distributed through Vestforbrænding's own grid and other district heating grids in the form of hot water through insulated underground pipes (one supply pipe and one return pipe). Transfer takes place in a heat exchanger transferring heat without direct contact between the water from the grid and the water in the in-house systems. When the district heating water has given off its heat, it is be returned to Vestforbrænding to be re-heated in the incineration plant. Hence the district heating grid is a closed system where water is alternately heated and cooled.

Vestforbrænding is expanding its district heating network dramatically, which not only benefits the customers, but also socially substitute for more CO2 intensive energy source such as oil and natural gas, which is also saving the energy budget at the same time. As for the consumers, the conversion from natural gas to district heating will in general give them saving of 10-20% of their heating costs.

Waste Taxation

Denmark has made a significant improvement by carrying out its waste taxation mechanism. Since 1987, considering the problems of landfill sites, especially in the greater Copenhagen area, and problems with dioxin emissions from incineration, tax was levied to support the waste management and recycling; and also to increase the proportion on waste managed by techniques towards the top of the waste management hierarchy. The waste disposal tax has been a very important instrument and has lead to a significant increase in recycling, and a significant decrease in the amount of waste landfill. Another purpose of the taxation is to promote incineration over landfill.

There is no tax on recycled waste which encourages the promotion of the technologies development on the waste recycling. All households are obliged to pay a fixed price for their waste bin. The local municipality is responsible for managing the waste collection and for paying waste tax. However, the effects of the waste tax on the industrial and construction & demolition waste are small and the importance is less.

The taxation is one of the important tool to promote the technologies for the waste disposal and to increase the proportion of the waste recycling.

CONCLUSION

Following are the salient features of Danish Model

- All the steps are strictly monitored by the local council.
- The systematic waste collection and waste sorting are the key factors which cause the high proportion of waste recycling (65%).
- Vestforbrænding is not only working on incineration, but also for the pre-treatment of the waste. During the incineration process, advanced systems for the pollution control and energy recovery are used.
- The district heating not only benefits for saving the energy consumption and heating cost, but also contribute to the CO_2 emissions reduction.
- Waste tax on household waste and industrial waste makes the people to recycle the waste to reduce the burden of tax.

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ENERGY RECOVERY FROM WASTE

Dr. Mutyala Rajagopal Prakash*

Abstract

There is a looming dearth of concepts and technology concerning energy' recovery from waste (ERW)' in productive sectors of Indian economy, no matter which economic sector one may consider. The paper attempts to conduct microscopic inquiry to unleash the laxity in (a) R & D concerning ERW and (b) reluctance of people at large in viewing the ERW seriously and realize dangers of letting out the waste to grow in India. A Cost Benefit Analysis is attempted to estimate ERW, the policy constraints and resistance from the beneficiaries to pay and use the facility. The paper brings out example and citations from other countries who have successfully implemented the ERS and limitations that is driving India into inaction.

The paper embarks on the absence of the organized agency or if at all any one is functioning, it might be run by the most outdated technologies; no matter whether such a unit is being managed by the private or public or PPP. What is required at this point of time is to innovate technologies which can deliver the successful venture of energy recovery from waste. The paper attempts to suggest and build an organizational structure to deal with this issue and pleads to sensitize the Government of India to issue the necessary policy directions or legal frame work to implement the ERW

INTRODUCTION

Amongst the most critical problems encountered by India, the Waste generation occupies worst form of eye sore to our population. The waste generation and its dumping in open spaces is almost continuous process no matter whether it is day time or night. The menace of waste dumping gets worse in monsoon time, windy days and during speeding automobiles/ trains, along the roads. The people have no fear, concern or modesty in littering the waste almost in every direction . The most ugly scene is when one observes the guy who spits tobacco in public like cosmetic spray without any regard to the civility. The rules, regulations to curtail these kinds of inhuman behaviour could not succeed in India as there are no strict regulations in place or being implemented. Ironically a habitually littering guy who visits developed nations, behaves very well and even does not mind to pocket the trash in to his deep pockets even though prohibition of littering sign board is unseen. It is fear of penalty in those countries which is around 100 Great Britain Pounds or 200 to 300 US dollars, if any one breaks the laws related to the littering.

On large scale of the same, people in India, dump the wastages of different types and the rubbles of the buildings during construction, and other forms after the construction of the buildings. It is a great task for the Municipal bodies which are more prone to face the menace of the wastage collection, transport and disposal.

TYPES OF WASTAGE GENERATED

Wastage is always generated by act of human being and much less by the nature such as wastages from the trees, dead creaturesand dust formation. The illiteracy and callous attitude invigorate such creation. Table 1 discloses awful facts that Jaipur is highly littered city followed by Baroda and Delhi. Fig. 1 shows the spread and thickness of littered quantities.

******Director , Institute of Development Planners and Researchers, Gandhinagar*

Table 1. Density of Municipal Solid Wastes in Some Cities

Sl.No.	City	Density (Kg/m3)	Rank
1.	Bangalore	390	6
2.	Baroda	457	2
3.	Delhi	422	3
4.	Hyderabad	369	7
5.	Jaipur	537	1
6.	Jabalpur	395	5
7.	Raipur	405	4

Source: Manual on Municipal Solid Waste Management, MUD, Vol. 1 & 2

Fig. 1: Wastage Heap at Jaipur

"Twenty three Indian cities will generate more than 1000 metric tonnes of municipal solid waste per day each in the next five years. Cumulatively they will generate 93,000 tonnes of municipal solid waste every day. (Credit: RanjithAnnepu)" The wastage dump site belongs to Jaipur Municipal Corporation, India.

Fig. 2: Wastage Heap Being Dumped without Sorting
Source: Energy and Wetlands Research Group, Centre For Ecological Science, I.I.S.

In India wastages are mix of several items which includes the scrap from ship breaking, automobiles, machines and others. The most dangerous out of the wastages are medical waste generated by the nursing homes, hospitals and butchers. Most important aspect is that the people working in these yards are not protected from the contamination. In Fig. 2 one may observe a guy is standing near the wastage dump unperturbed of the contamination effect. In Gujarat some measures are in place for collecting and destroying the medical waste through Public Private Partnership (PPP). Municipal Bodies are however, miles away from the implementation of concepts related to the Waste to Energy (WTE).

Table 2 : Solid Waste Categories Based on Source

Source	Typical facilities, activities, or locations where wastes are generated	Types of Solid waste
Agricultural	Field and row crops, orchards, vineyards, diaries, feedlots, farms, etc	Spoiled food wastes, agricultural wastes, rubbish, and hazardous wastes
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc.; nonindustrial waste including food waste, rubbish, ashes, demolition and construction wastes, special wastes, and hazardous waste.
Commercial and Institutional	Stores, restaurants, markets, office buildings, hotels, auto repair shops,	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes, etc.
Municipal solid waste	Includes residential, commercial and institutions	Special waste, rubbish, general waste, paper, plastics, metals, food waste, etc.

Source : (Hester, R. E and Harrison, R. M., 2002)

The wastage generation can be classified for convenience based on the sectors of the key economy. Table 2 explains the types of the wastage generated in India. Unfortunately we have not devised the system of sorting out of these wastages right from the beginning similar to the countries like U.K and U.S.A. In these countries, the green container is for non harmful waste and the grey or black coloured containers are meant for dumping harmful wastages like bottles, medicine containers, batteries, and others. In India the wastages are mixed up and they are being dumped together for long time which cause high risk of contamination and diseases.

"After the outbreak of the plague epidemic in Surat, the magnitude of the problem was realised by the government. A high powered committee was set up in 1995 which gave many recommendations for the improvement of MSWM like door to door collection, setting up of transfer stations, charging user fees, etc. The ministry of Environment and Forests and CPCB held meeting with the municipalities to evolve a strategy for MSWM. About 50 waste treatment facilities were set up after this. In 1996, the MNES initiated a pilot program to promote waste-to-energy projects in India, which may be considered as the birth of the new era of waste-to-energy programs in India." (Source : Unknown).

Similar to the sectorial classification of the waste generation, the waste generation in Municipal areas can be classified as shown in Table 3. The additional category is to be added in to table concerns, littering of cigars, tobacco , spitting, oil leakages from vehicles and sprinkle of water

Table 3: The Sources of Municipal Solid Waste

Sources	Examples
Residential	Single family homes, duplexes, town houses, apartments
Commercial	Office buildings, shopping malls, warehouses, hotels, airports, restaurants
Institutional	Schools, medical facilities, prisons
Industrial	Packaging of components, office wastes, lunchroom and restroom wastes (but not industrial process wastes)

Source :(Tchobanoglous, G and Kreith, F., 2002)

IMPORTANCE OF ENVIRONMENT AUDIT

There are several types of environment audits in vogue, however they are either dormant or ineffective in Indian conditions. In the Table 4 the types of environment audits are described. For the time being , the paper considers itself in the seat of "policy audit". In general the audit is required to be followed by the compliances and taking the audited points seriously. In our county neither compliance/ accountability exist or the Government System takes seriously the audited points, unless a major catastrophe similar to Surat epidemic surfaces and damages the population in thousands. The audit can do good even in focussing the Waste to Energy while considering the Cost Benefit Analysis. Such audit system required to be assigned to the team of professionals drawn from private and public sector organisations.

Table 4: Environmental Audit Types

Liabilities Audit	Management Audit	Activities Audit
Compliance Audit	Corporate Audit	Site Audit
Operational Risk Audit	Systems Audit	Waste Audit
Acquisition Audit	Policy Audit	Product Audit
Health and Safety Audit	Issues Audit	Cross-boundary Audit

ITEMS SUITABLE FOR THE WASTE TO ENERGY

Most of the items from the waste are suitable either for landfilling or energy generation. There has been severe criticism that the developed nations are using the developed countries spaces for land filling to burry dangerous items like nuclear waste, demolition of oil/acid tankers. Unfortunately the developing countries succumb to pressure as they seek the financial aids from the developed countries, and they get dictated with terms to accept the garbage from developed countries as quid pro quo.

It would be justified if such garbage is being used for the WTE, provided the technology is being transferred by the developed nations along with the funding towards fixed and variable cost involved for the WTE. Not all the items in India are susceptible towards WTE. In reality the WTE is a serious research field and several experiments are being held by the advanced countries. A general description of such WTE is listed above. The paper is unable to elaborate the techniques for want of place in this paper.

MODERN CONCEPTS AND TECHNIQUES OF WTE

- Converting Waste Heat to Electricity
- Costs for Thermo-photovoltaic Cells Significantly Reduced
- Water into Hydrogen Fuel with Waste Energy
- Fuel from Chicken Feathers
- Waste to Energy Continues to Gain Steam
- Converting Water and CO_2 into Fuel
- Waste Heat Could Double Battery Life on Laptops, Cell Phones
- Turning Wastewater into Ethanol
- Getting Biofuel from the World's Garbage
- Electricity and Desalination from Wastewater
- Hydrogen From Waste Materials
- Nanotube Technology Transforms CO2 Into Fuel
- Trans-America Journey Powered by Waste Vegetable Oil
- Converting waste into a renewable energy sources
- Waste as a Renewable Energy Source
- Negative Impacts of Incineration-based Waste-to-Energy Technology
- Anaerobic Digestion of Biomass
- Turning Airborne Carbon Into Fuel
- San Francisco Greasecycle Program
- Harvesting Hydrogen from Farm Waste

LIMITATIONS OF WTE IN INDIA

WTE is badly stalled in its progress for the following reasons

- R & D is at its low standards. There is no specialisation in technical courses, thinking that it is an area of punk, rag pickers and weak department in Municipal bodies.
- There are no professional private sector which can offer its services towards zero littering and spread of waste products.
- No awareness programme are communicated by any of the television channels as there are no sponsorers to boost their TRP for this kind of social work.
- The common man is not sensitized with the kind of dangers the waste and littering can cause. The story of Surat and any other place should find its place in communicating to the people with examples of human tragedy.
- The wastages particularly pvc bags, plastics, and others fetch poorest value to the rags pickers. Therefore they seldom either accept them to buy or pick them from open spaces.
- The energy generating devices are poorly structured, financed or maintained by the Government agencies or private companies. An optimal and most modern complex to WTE complex is given at Fig. 3.

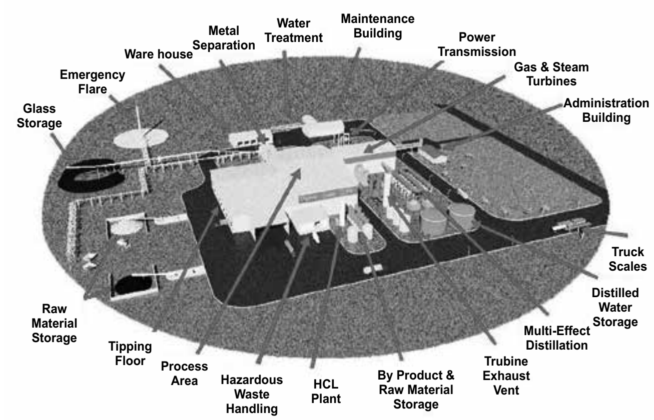

Fig. 3: The Multi Activity Waste to Energy Complex (Source: Energy Planet)

- It is high time that India should construct almost a similar WTE for the cities cited at Table 1.
- India may offer even services of waste processing under the concept of WTE to other countries in (a) construction of such complexes for developing countries and (b) may offer services to the developed countries, to ship their wastages for processing. This would not only create jobs in India but most important thing is that the complex would offer good remuneration to the people who may be interested to supply the waste from our cities.
- It is high time that Municipal bodies must keep

themselves away from the task of WTE as the same is not within their capability. It is a high technology mission and professionals required to be engaged from privates sector/NGos.

VIABILITY OF WTE COMPLEX IN INDIA

The Energy producing units from waste in India have been struggling to achieve the break even point. The waste is being recycled by some units there by the entrepreneur tend to achieve some economic gains and keep him in to the business thereby disallowing WTE. The recycling of waste was estimated to the order of 19%, and the rest is assumed to go in to the landfill. Indirectly it is energy wastage - reason being 'economic viability'. The most important aspect in WTE mission is (a) collection of waste, (b) transport to safe place and (c) to process it for generation of electricity through steam, turbines and power generating devices. (d) to provide hot water to hospitals. Such generation of electric power is dismally low as India does not have appropriate technology.

One may observe that the country has heaps of waste lying in the open areas. Some of them are being used as landfill and others form part of littering. The collection system is observed to be erratic and unsystematic. The public servants employed as sweepers hardly show dedication in collecting the waste, and tend to conduct half hearted and incomplete work.

The rag pickers try to pick up some and leave others as they do not find it economically attractive. As a result the waste clearance is no ones choice. The author attempted to formulate some sort of economic model so as to enthuse the people to pick up the waste and deposit them in to the place where no one would refuse to accept such deposit. This system is proposed as no amount of penalty or police action succeeded in arresting the tendency in people to litter the public places.

MODEL TO STRENGTHEN GARBAGE COLLECTION FOR WTE

As whole world is moving towards innovating the Waste to Energy concepts progressively, India should not remain as silent spectator. India is contributing to the largest stock of waste next to USA, Japan and Europe. The developed nations strive by all means to make the Waste to Energy economically and technologically viable as they have the system in place to collect the garbage in most systematic manner. Even the people cooperate willingly to deposit the waste in the order the Government (Council/Boroughs) require them. These countries find scope to dump such garbage in to other developing countries not mindful of serious consequences from such an act.

The author built a skeleton model which enables the entire operation of waste removal and generation of electricity. Though the activity is by all means not economically viable but it helps in bringing good health, and clean surroundings to our population. The model is termed as "Scavenger Model".

SCAVENGER MODEL SPECIFICATIONS

The power grid is the storage system which attracts the supplier to generate and deposit electricity. Such generation could be from any source, such as thermal, oil combustion, hydro driven turbine system, solar , and wind. We add the power generation component from Waste to Energy though the same is dismally low both percentage wise and continuity of supply wise. The sources of such energy to grid is shown in the relation 1.1

$$G = A + B + C, \ldots, + N \quad (1.1)$$

G is grid and the relation in alphabets are sources of energy and A is source of electricity from Waste. The incremental supply of energy is shown as ΔA at time 't'.

$$(\Delta G + G) = (\Delta A + A) \quad (1.2)$$

The supply cost of Waste to Energy is shown as

$$(\Delta A)\, \Delta C = f(\Delta P) \Delta C'. \quad (1.3)$$

Where (ΔA) is the incremental WTE generated and the grid purchases at unit cost ΔC. In economics one man expenditure is another man's income. In the equation suppose procurement P is to be increased the cost of procurement C' will have to be increased. So as to increase the procurement of waste which means clean up ; for which it is essential to pay more to the garbage suppliers. The psychometrics of the system can be better explained , where a man finds himself happy to pick up a Rupee Note on the street. Suppose the same is Rs 5,10,20,50,100,500, 1000 his happiness goes boundless in disproportionate manner. Similarly if a trash is made valuable by the WTE agency, the wastage would disappear from the open places magically. This method is better than the punitive action which has fatally failed completely in India. The supply cost of WTE to the grid could be balanced either by grants given by the Government or through the enhanced cost of PVC bags and other items. They be mercilessly loaded up with extra taxes to make them prohibitively costlier and at the same instance the funds so collected be channelled to the payment towards collection of the waste and garbage. The crux of the 'Scavenger Model' is, make earnings fun for some and sorrow for others with a view to get rid off our social and health menace.

ARCHIVES OF OUR LEGISLATION OF POLICIES

The following are the ineffective archives of our legislations and policies:

- Municipal Solid Waste (Management and Handling) Rules 2000, notified by the ministry of Environment and Forests, Government of India vide notification No. S.O.908 (E) dated 25th September 2000. The guidelines given in this law cover all the functional elements of municipal solid waste management.
- The Water (Prevention and Control of Pollution) Act, 1974. Two aspects have to be kept in mind of this law in regard to MSWM. Firstly, a consent from the state pollution control board for establishment of a sanitary landfill site and compost plant is essential and secondly, no water pollution should be caused by the leachate that is emitted by the sanitary landfill site or a compost plant.
- The Water (Prevention and Control of Pollution) Cess Act, 1977 and amendments thereon. The only aspect that should be considered in this law in regard to MSWM is provision for levying and collection of cess on water consumed for the sanitary landfilling, composting and anaerobic digesters.
- The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereon. The aspects to be considered in this law with respect to MSWM is the need for obtaining consent from the State Pollution Control Board for establishment of the processing plants and disposal site and from an environmental aspect would be the pollution caused by incineration plants, compost plants and landfill sites.
- The Environmental (Protection) Act, 1986 and its subsequent notifications. The aspect in regard to MSWM would be the EIA notification, 1944, which states that for any project to be authorized an EIA report should be submitted first.

CONCLUSION

Considering the arguments in the present paper it is recommended that Government of India should come out with the regulations concerning an appropriate Waste to Energy Policy to provide teeth to the cleaning up mission of environment. Scavenger Model being a skeleton in structure could be well developed in to a Policy Model.