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Research Article

A SHORT REVIEW ON SOLID WASTE GENERATIONS, RECYCLING AND MANAGEMENT IN THE PRESENT SCENARIO OF INDIA

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ABSTRACT

In India about 980 million tons of solid waste is being generated annually as by-products, during mining, industrial, municipal, agricultural and other process. Out of this ~ 380 million tons are organic wastes from agricultural sources. Industrial and mining sector produce ~ 290 million tons in organic wastages and ~4.5 million tons are hazardous in nature. Recent development in the solid waste management gives emphasis on the use of the waste in construction materials in place of traditional materials like tiles, blocks, bricks, aggregates, cement, ceramics, lime, paints, soil etc. To protect the environment efforts are being made for recycling various wastes and utilize them value added applications. In this paper present status on generation and utilization of both hazardous and non-hazardous solid wastes in India, their recycling potential and environmental effects are reported and discussed.

INTRODUCTION

Now-a-days solid wastes may be defined as generation of valueless substances which is left after they are used once. The materials like brick, sand, stone, clay, cement gravel, tiles, paint, timber, Iron, steel, copper etc. are the major building components in construction sector. These materials are produced from existing natural resources and a pose a great threat to the environment due to their continuous exploitation. During the process of manufacturing various building materials viz. decomposition of calcium carbonate, lime and cement manufacturing, high connection of carbon monoxide, oxides of Sulphur, oxides of nitrogen and suspended particulate matter are emitted to the atmosphere. By the end of 19th century due to rapid industrialization the earth itself becomes more polluted with solid wastes particularly the non-degradable wastes. Day by day dumping materials increase to a sizeable quantity.

The price of the construction materials is increasing incrementally. In 1995 the price of one brick was Rs. 0.66 but in 2017 it is around Rs. 6 per brick. The present data of solid waste production from domestic and industrial sectors from different countries of the world is very alarming. Thus it should be more pertinent to investigate the waste products of one industry and use it in another industry to get the desired products.

Though more funds are required for research and development on solid wastes, yet it would yield safer economic environment. Hazardous waste generation in India is directly linked to quantum of development and progress of the cities and showed variation among Indian cities. The solid waste amount is expected to increase significantly in the near future as the country strives to attain Industrialized nation status by the year 2020 (Sharma & Shah, 2005 ; CPCB 2004).

Due to rapid increase in population, production and consumption, urban society rejects and generates solid materials regularly. The volume of solid wastes generated from domestic waste, commercial waste, and industrial waste increase day by day. In addition to this garbage, rubbish, construction and demolition waste, leaf litter, hazardous waste are generated by the urban society. In India the per capita waste

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generation is estimated to increase 1% - 1.33% annually (Shekdar, 1999).

For example the population of Mumbai grew from 8.2 million in 1987 to 12.3 in 1991. Municipal waste generated in the city increased from 3,200 tons to 5355 tons per day in the same period registering a growth of 67% (CPCB, 2000).

The developed countries generate larger amount of wastes but they have managed the wastes in judicious manner due to the developed adequate, facilities, competent Govt. institutions and bureaucracies. Developing countries are still facing the problems towards better management of the wastes. Generally, the solid waste is disposed of in low lying areas without taking any precaution or operational controls which adversely affects the environment. Thus the solid waste management is a major environmental problem of Indian megacities (Sharholy, *et al*., 2008).

Clear Govt. policy and efficient bureaucracies are needed for proper solid waste management. Disposal of wastes is commonly done by dumping, incineration or long term storage. All these methods have negative impacts on environment with adverse environmental and health risk (Table 1).

Table 1. Types of litter regenerated and approximate time it takes to degenerate.

1.	Organic waste	One week or two
2.	Paper	1.-30 days
3.	Cotton cloth	2-5 months
4.	Wood	10-15 years
5.	Woolen items	1 year
6.	Tin, Al & others materials	100-500 years

Types of Solid Waste and its Generation RTE in Different Indian Cities

Domestic waste or household waste or municipal waste

The municipal solid waste includes:

a) Decomposable waste from household products.

b) Waste generated from shops and hotels, offices and other commercial units.

Due to urbanization & change in life style and food habits, the amount of municipal solid waste has been increasing rapidly. The total quantity of solid wastes generated in urban areas of the country is about 1.6 lakh tonnes per day.

According to CPCB survey, in 1997 total municipal solid wastes generated from Class-I and II cities is 18 million tonnes. (CPCB, 2000a). It is expected to increase to 300 million tons in 2047. More than 25% of MSW is not collected at all, 70% of Indian cities don't have adequate capacity to transport it and there is no sanitary landfill to dispose of waste. So these contaminate the ground and soil water through percolation. In addition to this, animal wastes, farming wastes, horticulture wastes, domestic waste degrades the environment. These wastes increase concentration of ammonia and methane which causes acidification and global warming.

Inorganic solid waste

Inorganic solid waste is of both non-hazardous and hazardous in nature. Inorganic non-hazardous solid wastes are from mining sector and these wastes are mainly from the primary process rejects. Inorganic hazardous wastes are mainly from the secondary process of non-ferrous metal extraction like lead, zinc and copper. In addition to this household hazardous wastes include old batteries, shoe polishes, paint tins, old medicines and medicine bottles. Hospital wastes contaminated by chemicals is also considered as hazardous. In India Gujarat, Maharashtra, Tami Nadu and Andhra Pradesh are facing the problem of hazardous waste disposal than less developed states.

According to the report of Ministry of Environment and Forest there are 323 hazardous recycling units use indigenous raw materials while 20 depend on imported recyclable wastes. The major type of hazardous waste imported by the country includes battery, scrap, lead, zinc, ash, galvanized zinc. Hazardous wastes are toxic to humans, animals and plants. These are corrosive, highly inflammable, and explosive which react when exposed to certain things like gasses.

Radioactive wastes

These are generated from nuclear power plants, nuclear testing lab, and industrial establishment. The World Watch Institute provides the information that about more than 80,000 tons of irradiated fuel and hundreds of thousands tons of other radioactive waste accumulated from the commercial generation of electricity. It takes million years to decay. So, it must be kept away from the possible human contact (Fig. 1).

Solid wastes generated from mining operations

In India out of 200 MT of non-hazardous inorganic solid wastes generated in every year 80 MT are mine tailings or ores of iron, copper and zinc mines etc. In India Bihar Chhattisgarh, Madhya Pradesh, Odisha, Andhra Pradesh are rich in ferrous and non-ferrous minerals. India has a good reserve of

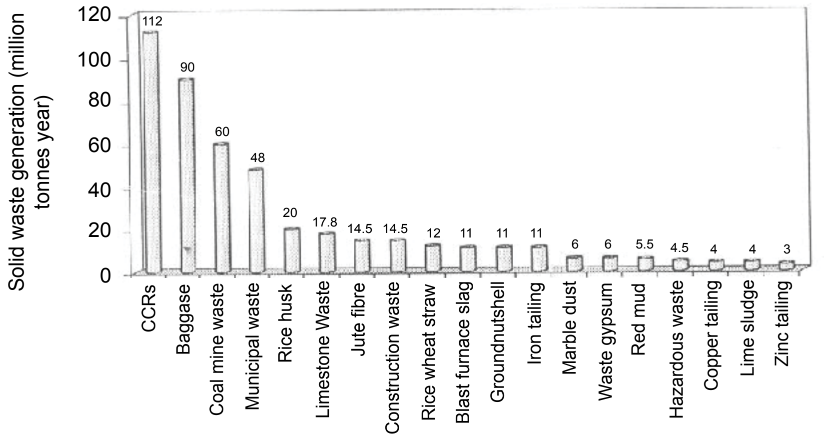

Fig. 1. Current status of solid waste generation in India.

iron ore, bauxite ore, tin ore, dolomite, chromite, manganese, limestone, coal etc. during the extraction process, tailings are produced which constitute mill as slurry i.e., 40-70% liquid and 30-60% solids. The major source of pollutants of mining operations are overburdened waste disposal, tailings, dump leaches mine water seepage and other process wastes disposed of nearby the industries.

Construction debris, marble and processing waste

Annually about 14.5 MT of solid wastes are generated from construction industries. These include wasted sand, gravel, bitumen, bricks and masonry, concrete. Some quantity of such wastes is being recycled and utilized in building materials. In India about 6 MT of waste are generated from marble industries during cutting, polishing, processing and grinding.

Rajasthan accounts for the 70% of processing wastes as there are about 4000 marble mines. In dry season marble dust dangles in air and are deposited o vegetation and crop. These have significant effect in local ecosystem and by large in the environment. The marble dust disposed in riverbed reduces the porosity and permeability of topsoil which leads to water logging. It also causes poor fertilizing of soil due to increase in alkalinity.

Coal combustion residue from thermal power plant

CCR refers to the residue such as fly ash, bottom ash, boiler slag and other solid particles produced from coal combustion & finally disposed to ash pond. In India thermal power plants release. 112 MT of CCRs as solid wastes per annum. Out of which 35% are being utilized. The remaining CCRs creates great problem for its sound management.

Health impacts

Improper management of solid waste creates health hazard and causes severe damage to the environment. In India most of the municipal solid wastes are disposed of unscientifically. Waste treatment and disposal sites can create health hazard for the neighborhood. Incineration plants cause air pollution. Improperly managed and designed landfills attract all types of vectors viz. insects and rodents that spread diseases such as dysentery, diarrhea etc. which affect the health of human beings.

Direct handling solid waste can cause various types of infectious diseases and chronic diseases to other workers. Improper disposal of solid waste also produces bad smell which destroy the beauty adjacent areas.

Solid waste management

Waste management is an acute problem in rural and urban areas of developing countries. They have adequate waste management technique, poorly controlled open dumps and illegal roadside dumping. These spoils the scenic resources, pollutes soil, water and air. This poses a potential health hazard to plants, animals and people.

Since waste management is the fundamental requirements for public health, Article-48 A of the Indian constitution establishes the responsibility to the state to manage these wastes properly. CPCB with assistance of NEERI has conducted a survey in 59 cities in 2004-2005 and reported that 39,031 tons of solid wastes per day have been produced in India. Ten major metropolitan cities in India are producing 25,364 tons of solid wastes per day as shown below in the Table 2.

Waste minimization is a technique used to reduce the waste source, recycle and reuse of waste materials.

The following aspects of waste management have to be considered properly:

I. Source reduction

II. Onsite storage

III. Collection and Transfer

IV. Processing Technique

V. Disposal

The following flow chart shows the inter relationship between functional elements in solid waste management (Fig. 2).

Waste disposal option

In India the final step of waste management is its disposal. A wide range of disposal options adopted in many developing countries are:

i) Non-engineered disposal: The most common uncontrolled disposal method is open dumping. They tend to remain for a longer time and degrade the environment with breeding of mosquito, rodents, fly which pollutes the land, water and air. More than 90% of the solid waste in cities are disposed of on land in this manner (Sharholy, *et al.,* 2008)

ii) Engineered disposal: ***Sanitary land filling***: It is a fully engineered disposal option which emphasizes

Table 2. Production of solid waste in major cities in tons per day.

Major Cities	Waste quantity in tons per day
Surat	1000
Pune	1175
Kanpur	1100
Ahmedabad	1302
Hyderabad	2187
Bangalore	1669
Chennai	3036
Kolkata	2653
Delhi	5922
Mumbai	5320

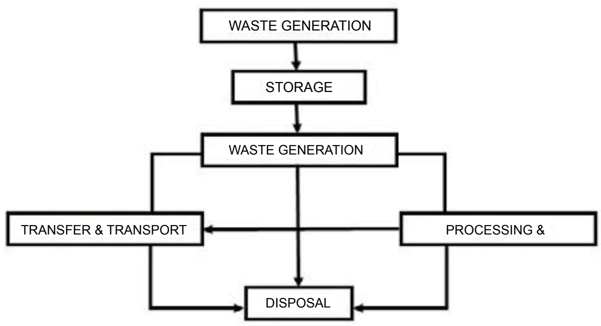

Fig. 2. Flow chart shows the inter relationship between functional elements in solid waste management.

on reduction of harmful effects and controlled dumping by spreading compacting and covering the wasteland. It is non-odorous and free of pathogens. (Ashan, 1999; Khan, 1994; Das, *et al*., 1998)

iii) Incineration: In this process combustible waste is burnt at very high temperature (9000 to 10000) to consume all the combustive materials leaving only ash and non-combustible materials to be disposed of in landfills. This process is adopted when land filling is not possible and waste constitutes highly combustible materials like plastics papers etc.

Incineration of urban waste is not a better process as it leads to air pollution and production of toxic ash. Smoke-stacks from incinerators may emit oxides of nitrogen and Sulphur that leads to acid rain. In modern smokestack special devices are fitted to trap pollutants but the process is very expensive (Botkin and Keller, 2000).

iv) Pyrolysis: It is a form of incineration that chemically decomposes organic materials at high temperature in the absence of oxygen. In pyrolysis, the chemical constituents and chemical energy of some organic wastes are recovered by destructive distillation of the solid waste. It occurs under pressure and temperatures above 430°C. It is not possible to carry out pyrolysis completely in absence of oxygen. Thus a small amount of oxidation also occurs. Semi volatile or volatile substance if present undergo thermal desorption. Organic materials are converted into gases and small amount of liquid and solid residue containing carbon ash. Gases may also be treated in secondary unit. Particulate removed instrument is also required.

Various pyrolysis units are available including rotary kiln, rotary hearth furnace or fluidized bed furnace. These units operate in simpler manner as that incinerator at low temperature and less oxygen supply.

v) Vermi composting: As municipal solid waste is highly organic in nature, so vermin composting has become an alternative for safe hygienic and cost effective disposal of it. In this process, earthworms feed on the organic matter present in the solid waste and convert them into 'casting' rich in plant nutrient. In cities like Mumbai, Bangalore and Faridabad vermin composting has been used (Sharholy, *et al.*, 2008)

vi) Composting: It is a biological process to decompose the waste under controlled conditions of ventilation, temperature moisture and organism in the waste themselves into humus like materials. This process gives odour free materials which acts as soil conditioner. This process is carried out if the considerable fraction of the waste contains biodegradable materials.

Many composting plants with capacities ranging from 150-300 tons per day were set up at Bangalore, Mumbai, Kanpur, Jaipur, Delhi, Baroda during 1975-1980 (Sharholy, *et al*., 2008) After composting the final product obtained is used as fertilizer and it is non-odorous and pathogen free (Ashan, 1999; Khan 1994; Basu. *et al*., 1997; Chatterjee, *et al*., 1993).

Utilization of organic solid waste

• Decomposition of both the animal and urban organic waste can be done in aerobic and anaerobic digestion.

• There is great potential for the production of CH_4 as the huge quantity of animal and organic wastes are produced annually. This will help the reduction of greenhouse gases.

• Use of organic wastes viz. coir dust, rubber, peanut husk etc. will be done in eco-friendly manner as described in the Table 3 (Das, *et al*., 2001; Maudgal, 1995; Das, *et al*., 2000).

Recycling and utilization of inorganic solid waste

• The mine tailing is disposed of in onsite ponds. These can be recycled and minerals of economic value can be extracted. The spoils from coal industry is used as filler in road embankments.

• Studies on potential use of different mining tailings in bricks have revealed that this waste along with clay can be used for better quality fired bricks.

• Copper tailings have been used in achieving strength of 190 kg/cm^2 under firing temperature of 950°C.

Recycling of construction debris

• Marble dust can be used to produce polymer composites which will be used as substitute to wood products.

• Attempts are being made to utilize marble waste in road construction, cement production, concrete and asphalt production etc.

Recycling and utilization of other non-hazardous inorganic waste

• CCRs in India are being utilized in cement, concrete, bricks, in backfill road embankment, adhesives, agricultural soil amelioration, waste land development wood substitute etc.

• In India 35% of CCRs is being utilized and the remaining 65% of CCR is a major challenge

• Thus, to overcome difficulties a detailed long term environmental and economic analysis including life cycle assessment studies are to be carried out in the CCR base technologies to maximize the use of CCRs (Committee on environmental affairs, 1987; Central Pollution Control Board (CPCB2000), 2005).

Hazardous waste recycling and utilization

• Most of the metallurgical industries are taking care of safe disposal of pollutants generated in the form of solids, liquids or gaseous wastes. But more attention is still required to achieve objectives and comply

Table 3. Types and nature of solid wastes and their recycling utilization.

S. No	Types of Solid Waste	Source Details	Recycling and utilization in building application
1	Agro waste (organic nature)	Baggage, Rice and wheat straw and husk, Cotton stalk, Saw Mill waste, Ground nut shell, Banana stalk and jute, Sisal and vegetable residues	Particle boards, insulation boards, wall panels, printing paper and corrugating medium roofing sheets, fuel, binder, fibrous building panels, bricks, acid proof cement, coir fiber, reinforced composite, polymer composites, cement board
2	Industrial wastes (inorganic)	Coal combustion residues, steel slag, bauxite red mud, Construction debris	Cement, bricks, blocks, tiles, paint, aggregate, concrete, wood substitute products, ceramic products
3	Mining mineral waste	Coal washeries waste, mining overburden waste Tailing from iron, copper, zinc, gold, aluminum industries	Bricks, tiles, lightweight aggregates, fuel
4	Non-hazardous other process waste	Waste gypsum, lime sludge, lime stone waste, marble processing residues, broken glass and ceramic, kiln dust	Gypsum plaster, fibrous gypsum boards, bricks, blocks, cement clinker, super sulfate cement, Hydraulic binder
5	Hazardous waste	Metallurgical residues, galvanizing waste, Tannery waste	Cement, bricks, tiles, ceramics and board

with the policy of Basel conversion (Agrawal, *et al.*, 2004).

Non-ferrous metal wastes and their utilizations

• The blast furnace slag is utilized in road making, walls, embankments and landfill. SM slag is also utilized in road making, as rail ballast as aggregate and soil conditioner, cement manufacturing. Fly ash is used in making bricks, as aggregates and cement refractory products and in landscaping in agriculture as partial soil substitute (Saxena, *et al*., 2002; Gupta, 2004; Asokan, 2006; BMTPC, 2005; Ramachandra and Saira, 2004; Saxena and Joshi, 1996).

Solid waste from zinc, Pb and Cu industries and their utilization

• During the productions of zinc jarosite is produced which is a hazardous waste containing toxic substances like Zn, Pb, Cd, S, Fe etc. effects are being made to recover valuable materials and transform them to less harmful materials.

Solid waste disposal and recycling in Cu-industry

• The converters slag, anode slag, efficient treatment sludge, anode slime is utilized in secondary processes like pyro metallurgical process to produce copper.

• Copper slag as also being used in making tiles mine backfill materials, granular materials (Ministry of Environment & Forest Website, 2003; Hazardous wastes resource center website, 2004).

CONCLUSION

During various industrial, mining, agricultural and domestic activities India produces 960 MT of solid waste. Which is a major environment and ecological problem besides occupying a large area of land for their storage and disposal. To utilize such large quantity of waste secondary industries should be set up. Due to lack of awareness many lab, techniques, products and technology based on Agro Industrial wastes is removed. But environmental friendly energy efficient and cost effective, alternative materials developed from solid waste will have good market potential to meet the people's need in urban and rural area.

To effectively utilize these wastes thermal, mineralogical, physical-chemical properties to be evaluated and accurate utilization methods will be adopted. Emphasis should be made on innovative techniques, cost benefits analysis and life cycle assessment, so that the waste can be utilized in an eco-friendly manner. Curriculum of higher education should include waste based newer building materials and their environmental significance and their application in various sectors which will boost the young generation for new R & D in this context. The scientific advancement will lead to better use of waste resources as valuable products. The attempt needs to be made to encourage entrepreneurs, construction agencies to develop new products and processes using these wastes as raw materials for setting up secondary industries and contributing to reduction of greenhouse gas and global warming.

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