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Solid waste management in India

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SOLID WASTE MANAGEMENT in India is an emerging and engaging area of study. However, the picture is often confusing and solutions fuzzy as information available in public domain is either scanty or scattered. This paper attempts to put together available information and analyse macro-tissues facing the Indian Techno-managers.

Though core of the paper is built around urban solid wastes, a comparison with rural wastes is also provided. The comparison serves to highlight inherent strength of traditional knowledge systems in coping with rural wastes but also outlines the scope for modern S & T inputs. A separate section also outlines specificities of solid waste management in the Himalayan region. A series of conclusions and recommendations are reached after analysing the urban solid waste scenario.

Rural solid wastes

There are various types of wastes in rural areas namely community wastes, wastes from agricultural and agro-based industries, animal wastes and oil bearing seeds etc. Table 1 provides estimated annual generation of various types of rural wastes in India (Adapted from Report, 1990) (1).

The community wastes from rural area is estimated at 5 million tonnes of night soil and 10 million tonnes of refuse. The rural population of 629 million (Census, 1991) (2) is distributed over nearly half a million villages. This makes for a small population per rural settlement. Additionally, the population densities are also very low com-

pared to highly urbanised areas. Due to these reasons, collection and transportation of rural wastes in India is not a pressing problem. Low overall volumes also do not necessitate institutional structures for its management.

For using as fuel, animal dung is shaped into cakes and dried and stored to be used for domestic cooking. The excess is also used to make compost for farm applications. Composting is carried out by accumulating dung, domestic and other wastes in a heap or pit. Agricultural residues are largely used as animal feed; a small portion is also used as fuel and as construction material. Percent utilisation of rural wastes for various end uses is outlined in Table 2 (Adapted from Report, 1990) (1). It is found that traditional practices of using wastes by way of fuel, animal feed and farm manure accounts for nearly 90 % of all waste utilisation. Barely 1.6 % of wastes are not being utilised for any useful purpose. It is clear that traditional methods have been adequate in handling wastes generated.

Hence, rural solid wastes do not constitute a problem area like urban solid wastes. However, a case for S & T inputs does exist. Technologies such as Improved Chulhas (wood/dung stoves), Bio-gas from night soil or agro-residues, Biomass Densification, Gasification and Pyrolysis offer a way to enhance energy efficiencies and ensure efficient utilisation of available resources, in addition to improving quality of life for rural masses.

The use of certain wastes as industrial raw material is limited to only 1.5 %. However, a number of possibilities exist to ensure increased industrial utilisation of rural

Table 1. Estimated Annual Generation of Various Rural Wastes in India.

Types of Waste	Estimated Generation (million tonnes)	Percentage of total waste
Community	15	0.81
a) Night Soil	5	
b) Refuse	10	
Agricultural Residues	322	17.4
Animal dung	1365	73.74
Agro-Industrial By-products	49	2.65
Oil Seeds	100	5.4

Table 2. Percentage Utilization of Rural Wastes for Various End Uses

End use	Percent Utilisation
Fuel	14.8
Animal Feed	35.0
Farm Manure	39.3
Construction Material	2.8
Industrial Raw Material	1.5
Other Uses	4.9
Waste	1.6

wastes for making value added products. Rice husk based particle boards, Bagasse based paper, charcoal, packaging material, chemicals through bio-conversion and industrial fuel are some examples.

Urban solid waste

With industrial progress, growing urban areas and resultant growth in urban solid wastes is a relatively new phenomenon in contemporary India. During mid-seventies, the per capita solid waste generation ranged from 150 - 350 gm/day for various Indian cities (Bhide et al. 1975) (3); whereas in late eighties, it ranged from 320 - 530 gm/day. The urban population is currently about one-fourth of total population. It is projected to be nearly one third by end of the century. The total urban population in 2001 is estimated to be around 330 million from current 218 million. The class I towns alone account for nearly 60 % of all urban population (Census, 1991) (2).

The traditional knowledge systems primarily evolved for rural and dispersed populations have not coped up well with densified living conditions and associated need for basic infrastructure and its management. Relatively poor management of urban wastes is reflected in degradation of living environment of urban areas.

Table 3 (Adapted from Report, 1989) (4) presents average per capita solid waste generation and collection efficiencies data for various categories of towns in India. Whereas, the large towns show distinctly higher per capita waste generation; there is no significant difference between medium and small towns. The collection efficiencies in small and medium towns lag far behind at nearly 60% than those of large towns at > 80%. This points to weak infrastructure and poor financial status of small and medium towns.

Table 4 (Report, 1991) (5) presents physical characteristics of Indian urban garbage. The figures presented are on wet basis and the moisture levels can range from 40-70%. The wastes largely comprise of bio-degradable organics. High moisture and organic content coupled with high prevailing temperatures make frequent removals necessary. This places additional burden on already overstrained system.

The collection of refuse presents peculiar problems as household wastes are thrown out indiscriminately. Also due to narrow lanes, collection vehicles can reach only selected accessible points. Hence, unskilled labour is used to sweep streets and collect garbage. Though labour rates are cheap but due to large scale manpower deployment and low productivity, the costs are high. It is estimated that India spends four times as much on sweeping as on refuse collection (Pickford, 1983) (6). Poor motivation of workers, inadequacy of supervisory and management skills at local government levels are other leading causes of low productivity. The problem needs attention at appropriate levels.

The cost of collection in India tends to be a very large part of overall solid waste budget. To cite an example, the city of Ahmedabad with 3 million population and ~1260 tonnes of solid waste per day, spends 85.8 % of its budget on collection, 13.4 % on transportation and only 0.8 % on final disposal (Report, 1990) (7). The benefits from present level of expenditure can be enhanced by following better methods of collection, efficient transportation, appropriate technology induction, better management practices and motivation of workers.

The three R's of waste management namely Reduce, Recycle and Recover are oft-repeated phrases in Indian policy circles. However, what is lost sight of is that culturally there is no propensity to waste. Also, there is a thriving informal sector of recycling. This recycling is achieved through Kabaris the waste handlers, who go from door to door and collect used bottles, broken plastics, metals, waste paper etc. This material is then traded for manufacture of secondary products for which markets exit.

Scavengers foraging through wastes is an unhygienic practice. It still however, contributes to recycling effort in India. The scavengers act as the second filter after Kabaris have taken away first batch of useful materials for secondary market. The income from foraging provides much needed subsistence to poorest of the urban poor. A ban on scavenging on health grounds may seem like a solution but will only aggravate the problem of basic sustenance. However, providing facilities such as bathing at the end

Table 3. Average per Capita Urban Solid Waste Generation and Collection Efficiencies in Indian Towns.

Category of Town (Nos.)	Total Population	Waste Generated (Tonnes)	Per Capita Waste Gen. (gm/day)	Collection Efficiency (%)
Large (7)	22,312,961	11,761	527	82.8
Medium (17)	9,567,133	3,025	316	59.0
Small (9)	424,223	148	349	59.5

Table 4. Physical Characteristics of Indian Urban Garbage.

Constituents	City-wise Percentage of Physical Constituents				
	Delhi	Madras	Calcutta	Bangalore	Bombay
Paper & Card	5.88	5.90	0.14	1.50	3.20
Metals	0.59	0.70	0.66	0.10	0.13
Glass	0.31	-	0.24	0.20	0.52
Textiles	3.56	7.07	0.28	3.10	3.26
Plastics & Leather & Rubber	1.46	-	1.54	0.90	-
Wood, Hay & Straw	0.42	-	-	0.20	17.57
Bones etc.	1.14	-	0.42	0.10	0.50
Stones etc.	5.98	13.74	16.56	6.90	-
Fine earth and Ash, etc.	22.95	16.35	33.58	12.00	15.45
Fermentable	57.71	56.24	46.58	76.00	59.37

of days work to foragers will go a long way towards improving their health status.

This market driven mechanism of segregation at source is a positive feature of Indian urban waste scenario. There are no figures available to estimate the volume of waste being processed, as this sector is not documented. The secondary product market though strong is not regulated. The specifications and quality is often sacrificed e.g. a lot of mixed plastic waste is reprocessed to make containers etc. These being cheap are bought readily by the consumers. However, storage of food stuff in these containers can be harmful for human health. There is a definite need to examine secondary products and to regulate effectively to safeguard human health.

Landfilling

Like other Asian countries, in India too most of the waste is landfilled. The methods followed are not in keeping with modern practices of sanitary landfilling. The wastes are largely dumped. This dumping is normally carried out in low lying areas which are prone to flooding. During rainy season, possibility of surface water contamination increases due to flooding of these low lying areas. The ground water pollution though largely unassessed is another threat posed by dumping of wastes. The daily cover techniques are poor leading to vector problems. The birds foraging on garbage dumps are known to cause substantial problems for aircrafts operating in the urban areas. The bird strikes have resulted in a great deal of loss to aviation sector.

This state of affairs results from lack of knowledge and skills on part of local authorities. Diversion of large part

of money to collection and transportation of wastes results in non availability of funds for disposal activities. This forces local authorities to curtail even known precautions and practices and use short cut approach.

Composting

Composting is a highly suitable option for urban solid wastes in India. High organic content and moisture make it particularly attractive. Conceptually, the idea of composting is appealing as it helps to recycle the nutrients back to land. The process, however, requires segregation of inert material; which is achieved easily due to recycling by Kabaris and scavengers. This option, hence, appeared ideal in mid-seventies when a number of compost plants were set up in various cities. Mechanised aerobic composting offered hope for big towns starved of landfill space. Details of these plants are provided in Table 5 (Report, 1990) (7). The plants were commissioned during 1977-80 and were operated either by State Agro-Industries Corporations or by Municipal Corporations.

These plants were expected to provide much awaited answer to growing problem of urban solid wastes but operational and other problems began to appear. Due to low skill/managerial inputs the operating efficiencies were low resulting in high cost of production. The problem was further compounded due to large distances between compost production centres and the compost utilisation centres, namely the farmlands. The resulting cost of transportation made marketing even more uneconomical. Farmers also reported problems with broken glass pieces in the compost.

Table 5. Details of Pilot Compost Plants.

S.N.	City	Capacity (tonnes/day)	Operated by
1.	Bangalore	200	Karnataka Compost Dev. Corp.
2.	Baroda	150	Baroda Municipal Corp.
3.	Bombay	300	Bombay Organic Manures Ltd.
4.	Calcutta	300	Calcutta Municipal Corp.
5.	Delhi	150	Municipal Corp. of Delhi.
6.	Jaipur	200	Rajasthan State Agro-Ind. Corp. Ltd.
7.	Kanpur	350	Kanpur Municipal Corp.

The composting, however, still remains a strong option for small and medium towns. Semi-mechanised aerobic composting is ideally suited to waste volumes in these towns. It demands less in terms of operational and management skills. The product off-take can be good due to close proximity of agricultural areas to almost all such towns in India. The problem of broken glass can be taken care of by suitable local legislation to ensure segregation at source.

Incineration

Incineration is not a total solution for solid wastes. The inert remains still have to be landfilled or used otherwise. This acts as a volume reduction step. In India, it has not found much use as the garbage tends to be low in calorific value and volumes are generally low for a central facility. The technology for incineration is not available indigenously and import options are highly capital intensive.

During 1980's an incineration plant was set up at N. Delhi at a cost of Rs. 220 million or US\$ 6.9 million (May 94). This 300 TPD plant was set up using Danish technology with assistance from Danida. It was also expected to generate power for local grid. The operational experience was not satisfactory. The desired calorific value garbage did not reach the facility as a result of prior segregation due to market mechanisms and scavengers.

Despite apparent failure of this attempt, incineration will remain an option for future and experience gained in this venture will be useful. In the meanwhile, incineration on smaller scale with or without energy recovery will continue to be a viable option in a number of location and waste specific cases such as hospital wastes.

Anaerobic digestion

For high moisture and organic content of Indian wastes, the anaerobic digestion is another suitable option. However, there are no ready technologies available for processing heterogeneous material such as urban solid wastes. The existing methods are suited to homogeneous materials. The costs of cleaning and separating mixed heterogeneous wastes are likely to be high.

A good way to avoid these problems is to intercept suitable wastes at the point of generation before it is mixed with other wastes. Kitchen and vegetable market wastes are largely suited for this purpose. These wastes can be collected and treated at source, if space permits. The resulting bio-gas can be used for captive energy use such as lighting and cooking etc.

Few Bio-gas systems are currently available to treat wastes of fruit and vegetable origin (Nagori et al. 1988) (8). Though currently unfeasible as a large scale option, Bio-gas systems can effectively handle localised and specific wastes and contribute to environment friendly disposal of wastes.

Refuse derived fuel (RDF)

This method of waste disposal primarily views waste as a resource. After separation and size reduction, the combustibles can be pelletised. Integrated Waste Management project at Bombay attempted to do just that. Due to local conditions, the product off-take and price realisation was estimated to be good. This avoided the earlier problem faced by composting plants. The large scale processing of garbage was also supposed to considerably slow down exhaustion of landfill space in the near vicinity of the city; obviating need to spend much larger amounts on transportation costs.

This pilot technology development effort also offered prospect of totally indigenous and cheap technology. The cost of 80 TPD plant was Rs 15 million or nearly half million US dollars (May 94). This compared very favourably to N. Delhi incineration plant (300 TPD, Rs 220 million). As it was first attempt of its kind, it required experimentation and modifications to zero down on specific waste handling, size reduction and separation processes along with optimisation of system parameters.

The plant was erected and extended trials were undertaken. A number of new innovation were made in garbage separation methods. The fuel pellets produced were also test marketed successfully. However, there was a need to support the technology development effort for a long enough duration which has been lacking.

Despite the promise of RDF, it will be limited in application due to need to have large industrial areas in close proximity to market the fuel to. The cost differential between cost of coal and the RDF should also be attractive to ensure sales.

Solid waste management in the Himalayan Region

The Himalayan region of India is spread across twelve states and accounts for 18 % of country's land area and 6 % of the population (Swarup et al. 1994) (9). The region is largely remote and comprises of far flung and difficult to access settlements. The population is largely rural. The urban areas comprise of small and medium towns. The region also receives a good number of tourists. Proper

management of solid wastes is of paramount importance in this region because of its increased pollution potential resulting from down stream effects.

Rural population relies on surrounding forests for its energy needs. This has been one of the causes of forest depletion. It is difficult to reach conventional urban energy sources such as bottled cooking gas, kerosene etc. to remote rural areas due to difficulties of access in mountain terrain. This makes role of non-conventional energy sources quite important. The rural wastes also assume significance due to their energy potential. The role of simple technologies to ensure efficient utilisation of energy from waste will hence be very important in this region. The Bio-gas option will have limited application due to lower prevailing temperatures in the region. It may however be feasible upto certain altitudes. Improved wood/biomass burning stoves and biomass gasification technology can play important role.

The urban waste disposal options will be considerably affected by mountain specificities. Landfilling may not be possible due to undulating terrain and paucity of flat spaces. Composting may be predominant choice but with due care to intercept run-off from composting areas and its treatment.

The seasonal flow of tourists accounts for a good deal of floating population especially during summer. Any planning for solid waste should consider this factor. The large influx of tourists has also resulted in problem of litter at high altitude scenic and tourist spots. This has created peculiar problems of waste retrievals and restoration of those areas.

General Conclusions

1. Bio-gas systems can effectively handle localised and specific wastes and contribute to environment friendly disposal of wastes.
2. The semi-mechanised aerobic composting, however, still remains a strong option for small and medium towns.
3. Mass incineration will remain a possibility for future.
4. Incineration on small scale will be indispensable for hospital waste etc.
5. RDF in specific cases is an attractive option provided that sustained indigenous technology development efforts are made.
6. All technologies attempting to process garbage are difficult to master as they are traditionally geared towards handling virgin and homogenous materials.
7. The role of simple technologies to ensure efficient utilisation of energy from waste will hence be important in the Himalayan region.

8. Waste generated by floating population of tourists is an important consideration in the Himalaya.
9. Though a number of options are suited to Indian conditions, a particular solution should take into account location and waste specific factors.
10. No single technology option will be sufficient to take care of emerging problems of urban solid wastes. A mix of options will have to be developed and applied on case to case basis.

Recommendations

The recommendations can be broken up under various categories such as:

- Manpower/Education & Training
- Regulatory & Fiscal
- R & D and Technology Development

Manpower/education & training

1. Local governments should work towards infusion of greater management and supervisory skills.
2. Data and knowledge base at the local govt. level should be strengthened.
3. The problem of over-staffing should be given serious socio-political consideration.
4. Education efforts should focus on women to highlight proper household disposal, segregation and community participation.
5. Steps should be taken to improve health status of scavengers.

Regulatory & Fiscal

1. Local bodies should awaken to the need for suitable legislation as per the prevailing local conditions.
2. Privatisation of collection and transportation of urban solid wastes is highly recommended. It will help provide a cap on expenditure, reduce inefficiency and provide better level of service.
3. Private initiatives in waste disposal or utilisation should also be encouraged by way of fiscal and other incentives.
4. A nominal garbage tax along the lines of house tax is recommended. It will generate much needed finances and also bring into focus much neglected problem of solid waste.
5. Secondary products should be regulated to protect consumers.

R & D and Technology Development

1. Standard practices for sanitary landfilling under Indian conditions should be developed.
2. Technology and training packages for semi-mechanised aerobic composting at small and medium scale should be developed.
3. R & D efforts should focus on developing improved plants for wastes from vegetable markets, kitchens and restaurants etc.
4. Recycling in the informal sector should be quantified.

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