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Management of Urban Solid Waste Pollution in Developing Countries

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ABSTRACT: Solid waste pollution, like the other environmental problems, is assuming serious dimensions in Delhi. From the last few decades, the study area has been experiencing a significant increase in the generation of solid waste that is adversely affecting its physical environment and is creating aesthetic problems. The current study reviews the data on the quantity of municipal solid waste generation, its physico-chemical characteristics, collection and disposal system. During the analysis it has been found that rapid population growth in Delhi has enhanced the rate of generation of solid wastes manifolds. Consequently, the management of waste has become Herculean work, and, piles of garbage and waste of all kinds littered everywhere have become a common site. The present analysis highlighted that the existing system of waste collection and its disposal within the municipal board is not only inadequate and insufficient but also unscientific. It has been tried to develop a strategy for mitigating and managing this problem in the sustainable urban development perspectives by involving Non-Government and Community-Based Organizations. Besides, the analysis also provides a background for the discussion of strategic issues relating to how these organizations in Delhi can assist the local government in solving the waste management crisis.

Key words: Delhi, Solid Waste, Organization, Urbanization, NGOs

INTRODUCTION

Solid waste and by-products of production and consumption are considered urban territorial phenomena and can be defined as an excess supply of waste materials resulting from a mismatch between the costs and benefits of material use in general, and generating and managing waste material in particular. It includes the heterogeneous mass of garbage from the urban community as well as more homogenous accumulations comprising of countless different materials such as food wastes, construction wastes, industrial process wastes and pathological wastes etc (Turk and Turk, 1984; Joseph and Nagendran, 2004). Since the beginning human kind has been generating waste, be it is the bones or the wood they use to make food. But the management of solid waste was hardly an issue for the old communities. The quantum and composition of wastes produced by them was such that it would easily decompose and revert to soil or be washed away by rivers without creating any serious environmental hazard. With the progress of civilization, the waste generated became of a more complex nature. It assumed serious proportion only after the human concentrations became engaged in non-agricultural forms of production (Roy, 2003). The population is projected to increase from 2.4 billion in 2007 to 5.3 billion in 2050 (World Urbanization Prospects, 2007 Revision).Recently, several studies have been oriented towards implementation of an appropriate solid waste management system in developing countries (Nwabanne *et al.*, 2009; Monazzam and Park, 2009; Omran *et al.*, 2009; Oshode *et al.*, 2008; Jalili Ghazizade and Noori, 2008; Ghiasinejad and Abduli, 2007; Abdoli, 2009; Uemura, 2010; Abduli *et al.*, 2008; Karamouz *et al.*, 2006).

Unlike the other developing countries, India, being the world's second highest populated country and one of the fastest urbanizing countries is facing the problem of solid waste management. With industrial progress, growing urban areas and resultant growth in urban solid wastes has become an emerging and engaging area of study. From the last few decades India has witnessed a significant increase in solid waste generation. It has been estimated that during mid-seventies, the per capita solid waste generation ranged from 150 - 350 gm/day for various Indian cities (CPCB, 2001); whereas presently, it ranges from 0.3 – 0.6 Kg/day (CPCB, 1999). India produces approximately 46 million tons of urban solid waste annually (Kumar *et al.*, 2004) and is expected to increase to a mammoth figure of 300 million by 2047. The estimated land requirement for disposal of such huge quantum of

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waste would be 169.6 km^2 as compared to 20.2 km^2 in 1997. The amount of waste generated per capita is estimated to increase at a rate of 1%–1.33% annually (Shekdar, 1999). Municipal Solid Waste (MSW) in Indian cities is collected by respective municipalities and transported to designated disposal sites, which are normally low lying areas on the outskirts of the city. The limited revenues earmarked for the municipalities make them ill-equipped to provide for high costs involved in the collection, storage, treatment, and proper disposal. As a result, a substantial part of the MSW generated remains unattended and grows in the heaps at poorly maintained collection centres. Typically one to two thirds of the solid waste generated is not collected. As a result, the uncollected waste, which is often also mixed with human and animal excreta, is dumped indiscriminately in the streets and in drains, so contributing to flooding, breeding of insect and rodent vectors and the spread of diseases. In addition, most of the municipal solid waste which is collected is dumped on land in a more or less uncontrolled manner. The average collection efficiency for MSW in Indian cities is about 72.5% and around 70% of the cities lack adequate waste transport capacities (Singhal and Pndey, 2001). This paper examines types, sources and physico-chemical characteristics of municipal solid waste in Delhi. An attempt has also been made to evaluate the collection and disposal management practices. Finally, we have tried to develop enforced and time-bound strategy for collection efficiency and treatment/disposal practices by involving Non-Government and Community-Based Organizations that will help in reducing the risks of health damage and will ensure better environment for a growing Delhi.

MATERIALS & MEHTODS

The present analysis is theoretical based on empirical observation and has an exploratory design. The methodological principle adopted for the present analysis is based on primary and secondary sources of data collected from field survey and official record of various govt. agencies. The data are organized, classified and analyzed with the statistical techniques as well as visual presentation in the form of graphs, diagrams and maps.

NCT of Delhi with 13.8 million populations (2001) is the third largest urban centre of India. It is situated between the latitude of 28º24´17”and 28Ú52”north, and of 76Ú50’26"and 77Ú20’37"east longitude at an altitude of between 700 and 1000 feet. It covers an area of 1483 sq. km. with maximum length and breath of 51900 km. and 4848 km respectively. Situated on the both side of the River Yamuna, Delhi is flanked by Uttar Pradesh in the east and Haryana in the north, south and west (Fig.1). Delhi is governed by three administrative bodies namely Municipal Corporation of Delhi (MCD), New Delhi Municipal Council (NDMC) and Delhi Cantonment Board (DCB). MCD occupies an area of

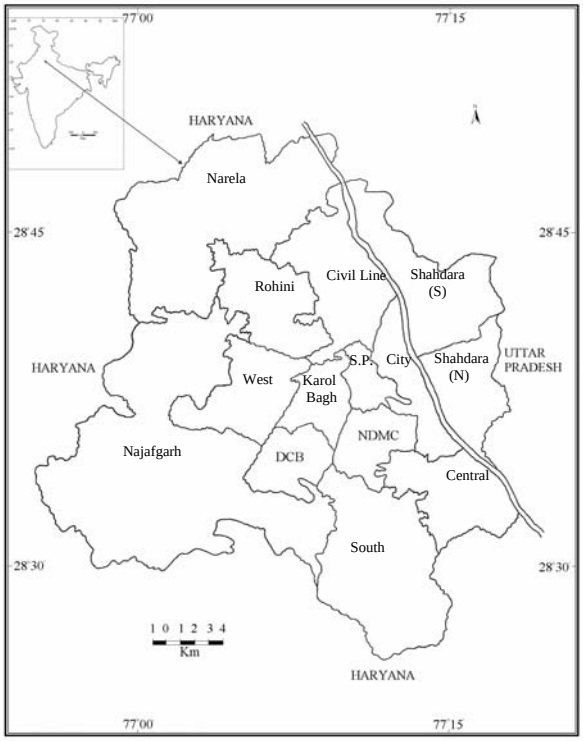

Fig. 1. Delhi: Location Map

1397.29 sq. km., containing 96.96 per cent of the total population while the rest is shared by NDMC and DCB. MCD is next only to Tokyo Municipal Corporation in terms of area. It has the dual responsibility of providing civic services to its people in both rural and urban areas.

RESULTS & DISCUSSION

The urban population increased from 52.76% (1901) to 93.01% in 2001 whereas the urban area has increased from 43.3 km^2 in 1921 to 924.68 km^2 of the total area in 2001 (Fig.2). Consequently, it has been experiencing a significant increase in the generation of municipal solid waste. In recent years not only solid waste has grown in quantity but it has increasingly acquired a hazardous dimension. The generation of solid waste has been estimated to increase from 4,500 Metric Tones/day (MT/day), 6,500 MT/day to 12,000 MT/day in the year 1981, 1991, and 2001 respectively (ADSORBS/37/ 2001-2002). It is expected that on the basis of growth assumption of 6-8 per cent, the quantity of waste will be 17,000-25,000 MT/day by 2021 (Dhamija, 2006). Even if it was possible to provide the maximum reduction of waste through composting and incineration there would still be a minimum 20 per cent residue of 4,000-5,000 tones per day that would have to be land filled by 2021[13]. Out of the total solid waste, municipal solid waste accounts for 6000 -7000 metric tones, the industrial waste weigh up to 4000 metric tones and bio-medical waste contribute 60 metric tones per day (LATS/17/2004-2005). The rest is contributed by construction debris, silt and other wastes. The average density of the solid waste in Delhi is estimated to be 500 kg /cubic meter (TERI 2001).

Due to growing prosperity and changing lifestyle of people, communities in Delhi are getting increasingly oriented toward consumerism. From the last few decades, the rate of generation of solid waste has increased so much that the civic agencies responsible for the collection and disposal of wastes are unable to deal with the total quantity produced every day. As a result, a major part of the waste remains uncollected and accumulates in the form of heaps at various locations within the inhabited areas that soon begins to rot and becomes an environmental hazard (TERI Report No. 1999 EE41). It is estimated that Delhi generates about 6000- 7,000 metric tones of MSW per day (MCD 2001). Fig.3 indicates the increasing trend of domestic solid waste generation. The quantity of domestic waste has been found to increase from 2305 MT/day, 4070 MT/day to 6188 MT/day in the year 1981, 1993 and 2001 respectively. It recoded 168.17 per cent growth rates over the period of twenty years (1981-2001).

As far as the sources of solid waste are concerned it has been observed that they are primarily arising from anthropogenic activities. Table 1 reveals that the most prominent sources of solid waste generation in Delhi are residential areas, institutions, commercial establishments, health-care facilities and slaughter houses etc. It has been estimated that there are nearly 1, 40,000 informal retail units, 24,000 wholesale establishments, 6,000 makeshift shopping spaces, 3000 residential areas, and many other sources that are generating solid wastes of varied nature. In addition, the wholesale fruits and vegetable markets, truck terminals, slaughter houses and small scale industries with their filth, squatter and unsanitary conditions also

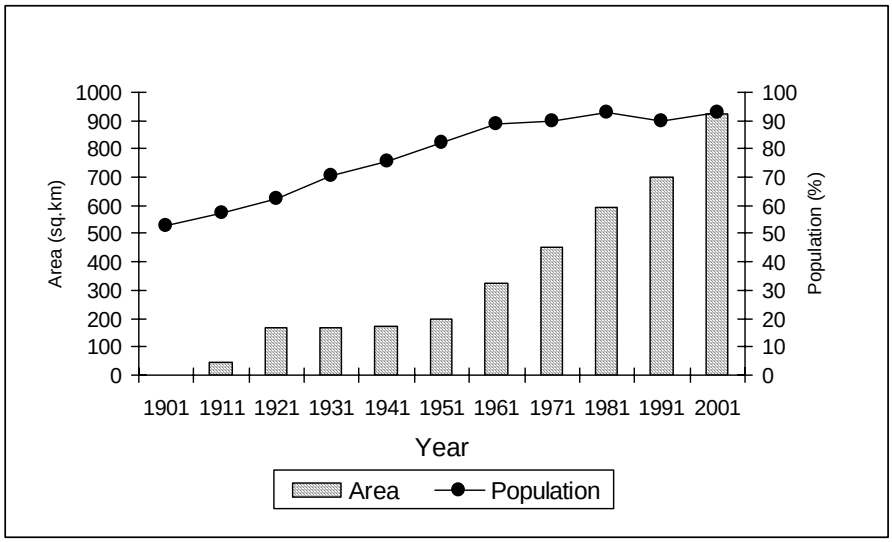

Fig. 2. Delhi: Changing Urban Area and Population

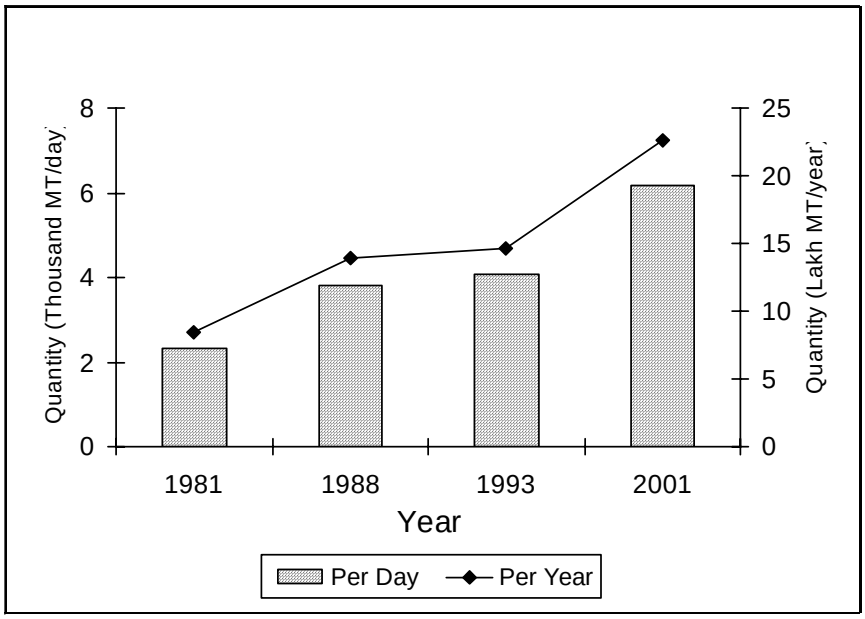

Fig. 3. Delhi: Average Domestic Waste Generated

Table 1. Delhi: Waste Generating Sources

S. No.	Sources	Number
1	Residential Areas	3,000
2	Organized Market	1,600
3	Wholesome establishments	24,600
4	Weekly Market	100
5	Makeshift Shopping Space	6,000
6	Informal Retail units	1,40,000
7	Hospitals	80
8	Nursing Homes	1,000
9	Miscellaneous	100
	Total	1,76,480

Source: MCD

contribute in waste generation and aggravate the deteriorating environment. The composition of solid wastes varies from one place to another place within the study area as the socio-economic status and socio-cultural factors of the inhabitants within an area affecting the refuse properties in different ways (Srishti, 2002). The composition of waste has changed in such a manner that, today, a major proportion of the waste is composed of non-biodegradable materials such as plastic, iron, glass and other materials. Packaging materials are becoming an increasingly important component of municipal waste. As the gross national product and urban population continue to grow, paper and packaging waste will also increase, shifting waste composition (Cointreau-Levine, 1982). Fig. 4 shows the physical characteristics of municipal solid waste. It has been observed that the biodegradable items have the largest share (38.6 per cent) followed by inert material (34.71per cent), bio-resistant (13.87 per cent), and plastic wastes (6.03 per cent). The relative amount of recyclable material is found quite small because waste collectors generally retrieve them from garbage dumping sites to a considerable extent.

Fig. 5 indicates the chemical characteristics of MSW. It has been observed that the waste is characterized by high moisture content i.e. 43.65 per cent. The organic content, nitrogen, phosphorous, potassium, C/N ratio and calorific value of MSW is recorded at 20.47 per cent, 0.85 per cent, 0.34 per cent, 0.69 per cent, 24.08 to 715 kcal/kg respectively.

It has been observed that due to the intervention of rag-pickers, the waste in Delhi has a distinct bio-degradable profile. Several thousands of urban poor make their living upon wastes in many small industries using plastics, tin cans, bottles, bones, hair, leather,

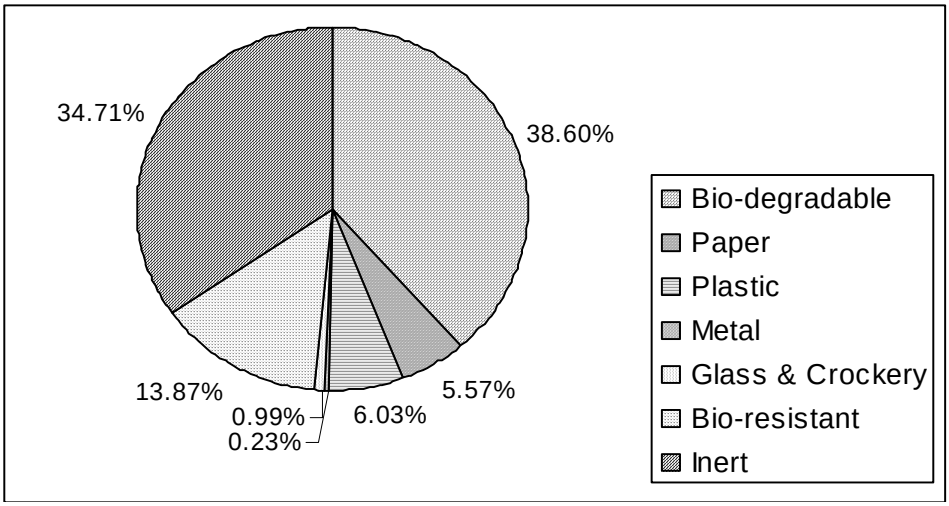

Fig. 4. Delhi: Physical Characteristics of Municipal Solid Waste

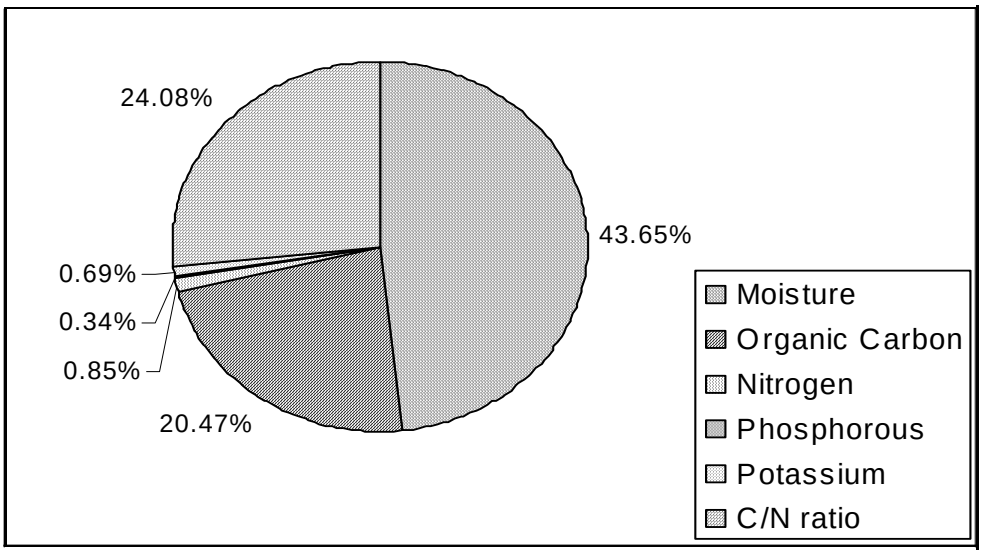

Fig. 5. Delhi: Chemical Characteristics of Municipal Solid Waste

glass, metal etc recovered from MSW. All metals, unsoiled paper, plastics, glass, cardboard etc are readily marketable and hence recycled by householders themselves or Rag-pickers. By the time waste reaches the community bins, it contains every little in the way of recyclable and consists mainly of vegetable / fruit peelings, scraps of soiled paper and plastic, used toiletries etc (Gopal, 1993).

The collection of the municipal solid waste is performed by the Conservancy and Sanitation Engineering Dept. of MCD. It is estimated that out of the 7000 metric tones of MSW, MCD collect only 5000 metric tones per day while the rest is either picked up (mostly through rag pickers) for recycling or remain uncollected (Dayal *et al.*, 1993). As a result, a substantial part of the MSW generated remains unattended and grows in heaps at poorly maintained collection centres which attracts birds, rodents, fleas, etc. to the waste that creates unhygienic condition mainly odor and release of air borne pathogens etc.

The generated waste from different sources is collected by MCD and transported to designated disposal sites or collection points that are provided by MCD. Waste generated at households is generally accumulated in small containers. Individuals deposit their waste in bins located at street corners and at specific intervals. Dalaos and dustbins are the main garbage collection points. The containers are generally

constructed of metal, concrete, or a combination of the two. There is no standard norm for the placement of these receptacles i.e. distance between receptacles or number of receptacles per unit area (ADSORBS/31/1998-2000). Commercial sector like shops, offices, hotels etc all use the community waste bins and their wastes are also collected along with the household wastes. Due to lack of municipal receptacles, open sites have also been identified in some areas as local garbage collection points. However, in those areas where community storage arrangements are not conveniently located, householders tend to throw their wastes into the roadside or into drain (DUEIIP, 2001).

It has been observed that in collection procedure waste pickers supplement the municipality's effort to collect and finally dispose of solid waste. In Delhi, 10-15 per cent of waste is taken care of by it. Delhi has approximately 90,000 to 100,000 rag pickers. The hierarchy, which at its higher level is increasingly organized, at its base, consists of waste pickers more commonly known in India as 'rag pickers' (ADSORBS/37/2001/2002). In addition, there are waste dealers or *Kabariwallas* agents and finally preprocessors or recyclers.

After collection from municipal receptacles, MSW is transported to landfill sites. The solid waste disposal mechanism in Delhi is not thoroughly systematic and it is dumped at low lying areas. The solid waste from households and industries is dumped near the roads, parks or in municipal dalaos, from where it ultimately reaches to sanitary landfills dispersed in various parts of NCT of Delhi (CPCB 1999; CPHEEO2000). Table 2 indicates that the average per day disposal of garbage and silt at three sanitary landfill sites (SLF) has been continuously increasing excluding the year 2000-01. Disposal of average daily garbage increased from 3617.90 MT (1994-95) to 5693.86 MT (1999-2000) but decreased to 5375.53 MT (2000-01) whereas average daily silt disposal enhanced from 302.06 MT (1994-95) to 2129.07 MT (1999-2000) that reduced to 649.13 MT in 2000-01. It has been observed during study that the continuous generation of solid waste has depleted several landfills area. The entire waste generated in MCD areas along with waste collected by NDMC are subjected to land filling. Presently waste is disposed at three sanitary landfill sites (SLF) viz. Ghazipur, Bhalswa, and Okhla. The Ghazipur landfill site serves the zones of Shahdara North, Shadara South, City, Sadar Pahargunj, and NDMC. Civil Line, Karol Bagh, Rohini, Narela, Najafgarh and West served by Bhalswa and the Okhla Landfill site serve the Central, South and City zones. As the existing sites have completed their operational period, there is an urgent need of proper planning for the management of solid waste to avoid health risk and environmental problem associated with it.

In the study area, the solid waste is collected by municipal agency where SWM systems and practices continue to be outdated and inefficient. It is unplanned and is operated in an unscientific way. Neither the work norms are specified nor the work of collection staff appropriately supervised. The vehicles are poorly maintained and no schedule is observed for preventive maintenance. Further, there is no co-ordination of activities between different components of the system. There is no public system of primary collection from the source of waste generation. The waste discharged here and there is later collected by municipal sanitation workers through street sweeping, drain cleaning etc (Bhoyar *et al.*, 1996). Even street sweeping is not carried out on a day-to-day basis. Only commercial roads and important streets are prioritized and rest of the streets are swept occasionally or not swept at all. Generally, no sweeping is done on Sundays and public holidays.

While allocating resources including finance, SWM is assigned with a low priority resulting in inadequate provision of funds. Though a large portion of the municipal budget is allotted for solid waste management, most of it is spent on the wages of sanitation workers. Due to shortage of financial resources, the vehicles are often used beyond their economical life resulting in inefficient operation.

The equipment and machinery presently used in the system are generally outdated. This results in

Table 2. Delhi: Disposal of Municipal Solid Waste at Sanitary Landfill Site

S. No.	Year	Average daily garbage disposal	Average daily silt disposal
1	1994-95	3617.90	302.06
2	1995-96	3654.07	467.90
3	1996-97	4500.65	529.29
5	1997-98	5120.25	2493.53
6	1998-99	5077.98	2692.00
7	1999-2000	5693.86	2129.07
8	2000-01	5375.35	649.13

Source: MCD

underutilization of existing resources and lowering of the efficiency (Jalan *et al.*, 1995).

The operational efficiency of SWM depends on the active participation of both the municipal agency and the citizens. Yet, the municipal authorities have failed to mobilize the community and educate citizens on the rudiments of handling waste and proper practices of storing it in their own premises. There is no practice of storing the waste at source in a scientifically segregated way. In the absence efficient service, citizens tend to dumping waste on the streets, open spaces, drains, and water bodies in the vicinity. Citizens assume that waste thrown on the streets would be picked up by the municipality through street sweeping. For the general public, which is quite indifferent towards garbage disposal etiquette, the onus of keeping the city clean is entirely on the MCD.

In Delhi, almost 99 % of the solid wastes collected by municipal agency are disposed off through the method of sanitary land filling. Remaining one per cent is disposed off by composting at one plant situated in the NDMC area. Incineration is not used for disposal of municipal wastes due to low calorific value of the wastes. Here, the waste comprises mainly of not easily combustible vegetables and meat wastes, since the more easily combustible substances such as cardboard, paper, cloth and plastic are already eliminated at source or by rag pickers for sale to '*Kabariwalas*'.

The main problem in adopting sanitary landfills for solid waste disposal is of land acquisition. The requirement of land to accommodate increasing solid waste has been increasing day by day. The Delhi Municipal Corporation which operates these sanitary landfill sites is dependent on Delhi Development Authority, Delhi Administration and Land and Development Office of the Government of India. In variably MCD's demand for additional land are not met.

On the contrary, even the sites shown in the Master plan for sanitary land filling are diverted to other uses and the corporation is forced to resort to unplanned dumping on any available government land. Moreover, as the time passes by and the existing sites get exhausted, new sites can be found only at increasing distance from the area which generate most of the solid waste. The value of land goes up and substantially enhanced financial resources have to be raised for land acquisition. Not only that, increasing distances means lesser number of trips per vehicle, and to cater to the same area a larger fleet of vehicles and bigger manpower and dealing with the union demands becomes an intractable problem by itself.

The other problems associated with sanitary landfills are that contrary to what its name suggests, the method is actually operated in an unsanitary manner. Most landfill sites give an unhygienic look. The garbage is left to rot and becomes a breeding ground for germs. Rag pickers rummage through the mounds of garbage, picking up diseases which they pass on to others. Besides, landfilling leads to deterioration of water quality in neighbourhood areas of landfill sites due to contamination by leachates from the landfills (Jeevan and Shantram 1995). This has adverse health impacts on people living nearby, causes bad odors, and the people living nearby live in the constant fear of explosion of methane gas that can accumulate at the landfill sites. Landfill gas, which is 50%–60% methane, contributes significantly to global warming. Provisions for leachate and gas control do not exist. A soil cover is rarely provided, except at the time of closure of the site. Most of the disposal sites are unfenced and the waste picking is commonly in vogue, posing problems in the operation of the sites (Luis *et al.*, 1997; Datta 1997).

Composting as a method of garbage disposal has become obsolete due to relatively easy availability

Table 3. Delhi: Operational Sanitary Landfill Sites (SLF)

S.No.	Name of SLF	Year of operation	Landfill approx. operation up to	Average depth	Area (in acres)	Amount received per day (MT)	Service Area
1	Ghazipur	1984	2004	3m	70	2200	CL, KB, Nar, Nfg, West
2	Bhalaswa	1992	1999	4m	40	2000	Sh (S), Sh (N), City, (SP)
3	Okhla ph-1	1994	1998	3m	18	1200	NDMC, Central, South, City

Source: MCD

and handling, and price competitiveness of chemical fertilizers. The production of garbage compost has thus reduced. One plant, which was operated by MCD, has already close down and the other operated by the NDMC is working at 20 per cent of its capacity. Incineration is very expensive (Rs 3000/tonnes compare to about Rs 300/tonnes for sanitary landfill).

Solid waste management being a part of public health and sanitation is one of the important components in the process of development of Delhi. The quality of environment in near future will considerably depend on the proper management of solid waste. Presently, the systems are assuming immense importance due to rapid population growth in municipal area, legal intervention, emergence of newer technologies and rising public awareness towards cleanliness. Solid waste management is definitely not only a technical challenge (MoEF 2000). The modern concept of integrated solid waste management is very complex comprising of not only the environmental aspects of the waste hierarchy or the technical aspects of the conventional approach, but also taking into account the financial and economic calculations, social and cultural issues, and the institutional, political and legal framework, is most crucial for planning and operation of a sustainable solid waste management scheme.

The basic premise is that solid waste need not be considered merely as a menace but rather as a resource or even a livelihood. Quantity and characteristics of waste are two major factors, which are considered as the basis for the design of efficient, cost effective and environmentally compatible waste management system. Some innovative methods of dealing with solid waste can be found in technology. In order to have a satisfactory, efficient, and a sustainable system of solid waste management, the following aspects need consideration. The so-called waste hierarchy of solid waste management based on environmental maxims and upholds the fundamental principle – 'prevention is better than cure'. Prevention of waste generation is the most preferred option for solid waste management. Further down the hierarchy, reuse and recycling of waste according to its respective characteristics is preferred to disposal in landfill sites, dumping or open burning. The present system of solid waste management at source could be improved by adopting these measures; house to house collection system, segregation of dry and wet wastes at the source. The segregation system would reduce 50 per cent of the garbage going to landfills and thereby result in cost reduction. Ban on throwing wastes on streets and levy of administrative charges from those who litter the streets, doorstep collection of wastes, sweeping streets on all days of the year, work Norms for sweeping of streets, abolition of open waste storage sites and manual collection. availability of containers at an appropriate interval (100-300 meters) and locations as

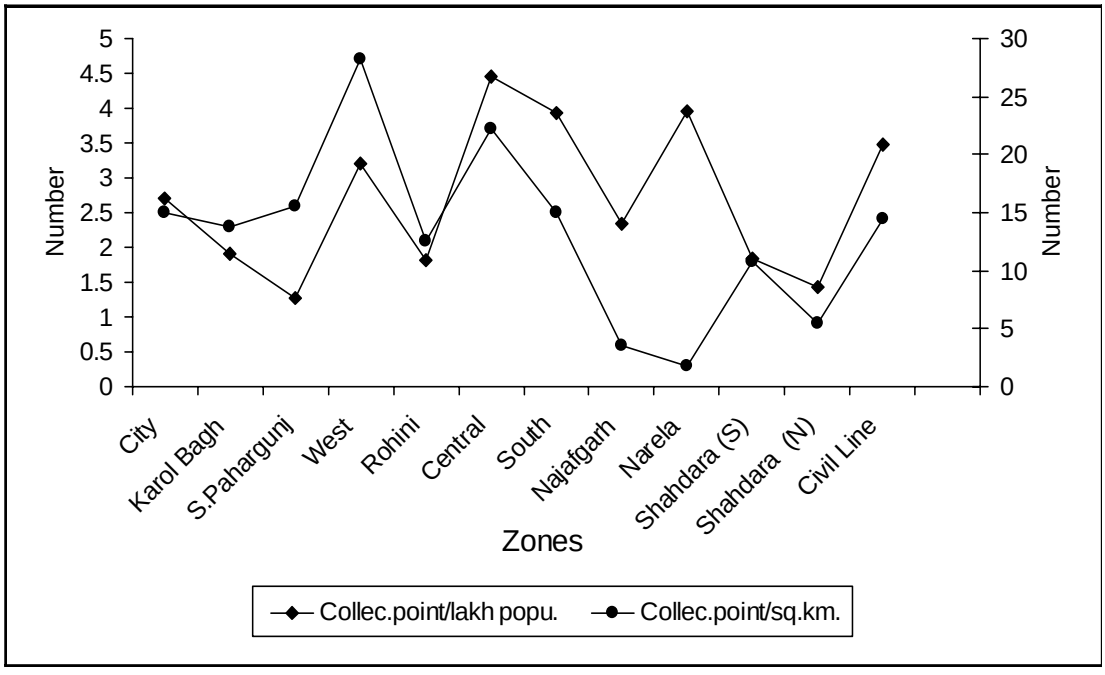

Fig. 6. Delhi: Collection Points of Municipal Solid Waste

per MSW handling rules, 2000, installation of closed container or dumper placer bins, use of separate colour code as per MSW (Management & Handling) Rules, 2000, separate collection system for slaughter house, horticulture, demolition, market and commercial wastes, removal of many open collection spots, selection of landfill sites on the basis of geological and hydrological factors of the site and the development of green belt around the landfill sites to avoid soil erosion etc. The three R's of waste management namely *Reduce*, *Recycle* and *Recover* are oft-repeated phrases in Indian policy circles. In addition, Private Sector Participation (PSP) must be used as an agent for change. There is enough evidence that PSP may achieve substantial cost saving with improved quality of service. PSP does not mean privatizing solid waste management. PSP means using "Third Sector", organization such as NGOs as well as the commercial sector. Such initiatives as exist in Chennai, Banglore and other cities may serve as models. Public Private Partnerships (PPPs) are internationally used to build and operate large downstream reduction and disposal facilities.

In general, NGOs can be involved into two categories: those with a more labour- market/socially oriented agenda, such as working with street children and women, and ones with a more environmental focus which are involved in education. They can establish the house to house collection and transport of waste to transfer points through their own employees, as well as separation of waste for their own compost production or for sale. Recycling and rag-picking of municipal solid waste is widely prevalent in Delhi through the involvement of an extensive network of informal (rag-pickers and scrap-dealers) and formal (recycling facilities) stakeholders. A wide range of materials and items are involved, such as, paper / cardboard, plastics, metals, glass, rubber, leather, textiles and clothing etc. As per a study the number of rag-pickers in Delhi is in the range of 80,000 to 100,000 (Srishti). It is estimated that about 1200-1500 TPD is removed from the municipal collection and disposal chain by these activities. However, these activities, carried out in unhygienic and unscientific manner, have unfavourable environmental, occupational health and community health implications. The *ragpicker* community is an important link in the SWM system. They can survive under Indian conditions as a result of two basic situations - the extreme poverty of large sections of urban communities, and the relatively high value of raw materials to be recycled. They are instrumental in segregating the waste and then taking away the non-biodegradable for selling to the *Kabariwalas*. This ensures an income of about one hundred rupees per day for an individual. The income not only provides employment but also recognises their important contribution to the society and prevents them from resorting to petty thefts and other anti-social activities. It is a laudable step towards "dignity of labour". Present day activities of *ragpickers* are not systematic and they scavenge around from one locality to another. Their movements in the early hours of the morning lead to suspicions and they are exploited by law enforcement agencies. All *ragpickers* in a particular locality should be brought together by the municipal authorities, assigned areas of responsibilities and introduced to the RWA. They could also be given the task of picking up segregated waste from households for which they could be paid a fixed monthly amount by residents. The *ragpickers* could also be trained to do composting and a certain amount from the proceeds of sale could be allotted to them.

By charging for the environmental and economic costs of production and disposal of waste upfront, market forces can be employed to improve the efficiency of waste management. By incorporating the cost of disposal also in the production cost, tendency to use less packaging or adoption of the recyclable/reusable packaging material would be promoted. Setting mandatory standards could make business responsible for the waste it generates.

Waste-to-Energy (WTE) technologies include incineration, pelletization, and bio-methanation. The present analysis indicates that the waste characteristics are expected to change due to rapid urban development, increased commercialization and changing standard of living. The physical and chemical characteristics of waste show that the paper and plastics content will increase while the organic content will decrease in near future. The ash and earth content is also expected to increase mainly due to an increase in the constructional activities. Although, the organic content is expected to decrease, the material will still be amenable to biodegradation and the calorific value will continue to be unsuitable for incineration. The analysis brings out the fact that a self-sustaining combustion reaction cannot be obtained and auxiliary fuel will be required to aid waste combustion. That is why; an incineration plant at Timarpur (Delhi), set up in 1987 using Danish technology, failed to operate properly because the waste fed into the plant did not have sufficient calorific value.

Biomethanation of municipal solid waste is one option. It involves bioconversion of organic matter

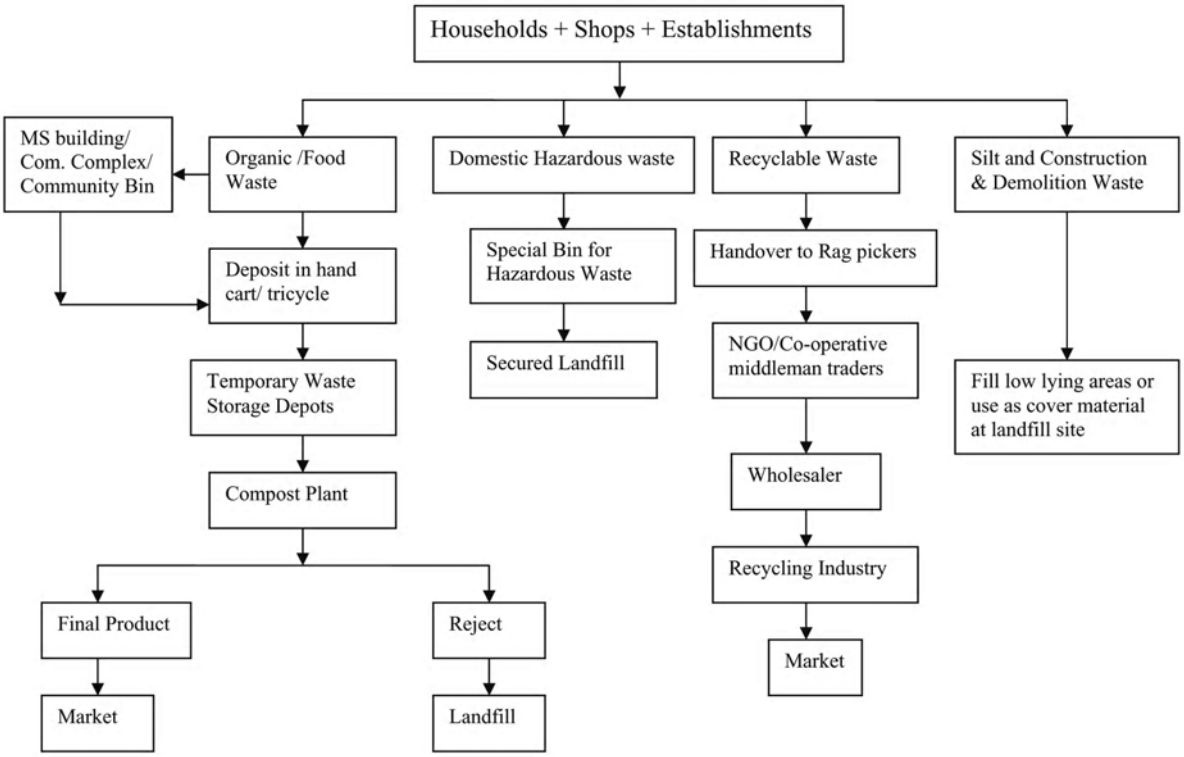

Fig. 7. Delhi: National Plan for MSWM

to biogas and humus. This methane rich biogas is then used to generate power. Delhi generates sufficient waste; typically the minimum required for such facilities is 300 TPD. *Vermiculture* is also a good option, i.e., using earthworms, for instance, to decompose and stabilize organic waste. *Pelletisation* is another alternative. Here organic material is crushed into tight pellets for use as fuels in boilers. Through another method, garbage is treated in a recycling plant so that it neither stinks nor attracts birds. It can then be used for land filling which is more hygienic as compared to sanitary landfill. *Anaerobic digestion* for high moisture and organic content is also can not be a suitable option because of heterogeneous nature of the urban solid wastes. The costs of cleaning and separating mixed heterogeneous wastes are likely to be high.

Lack of public awareness has made the situation worse. No environment programme can succeed without mass awareness and right perception at community level about various aspects of environmental pollution. By launching various action programme and a number of public awareness activities through massages and articles related with environmental pollution must be disseminated through newsletters, pamphlets, magazines, television, radio, internet and through workshops, summer courses, exhibitions, display and pollution control camps etc., we can go a long way in the protection of the environment. The individuals must be educated enough to understand the nature of pollution and its adverse effects on human health and wealth.

Last but not the least rigorous follow of national plan of municipal solid waste recommended by the Expert Committee (1999) constituted by the Honourable Supreme Court of India. The recommendation is summarized in a flow chart as depicted in Fig.7.

CONCLUSION

Delhi has been experiencing phenomenal increase in the generation of solid waste. This escalation could be accounted to rapid population growth, development in economic activities and changing consumption patterns of the people etc. The increasing solid waste quantities, changing characteristics of waste and the areas to be served strain the existing SWM system. Piles of garbage and wastes of all kinds littered everywhere have become eye sore that are polluting the environment. Risks to the public health and the environment due to solid waste in study areas become a monstrous reality. The municipality is facing the challenge of poor infrastructure and financial constraint for efficient MSW management that can ensure the scientific disposal of MSW. These

requirements have generated demand for planning, administration, finance, technical expertise, equipment, material, and legal aspects of activities associated with generation, storage, collection, transportation, processing and disposal in an environmentally compatible manner. It has been found that the waste management system cannot be successful without the involvement of all stakeholders including people, NGOs and entrepreneur etc who have a vital role to play in successful implementation of the scheme. Besides, community sensitization and public awareness should develop for the successful implementation of the legal provisions of MSWM.

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