Challenges in Municipal Solid Waste Management in India

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Abstract: India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment and disposal. Current systems in India cannot cope with the volumes of waste generated by an increasing urban population, and these impacts on the environment and public health. The challenges and barriers are significant, but so are the opportunities. A priority is to move from reliance on waste dumps that offer no environmental protection, to waste management systems that retain useful resources within the economy. Waste segregation at source and use of specialized waste processing facilities to separate recyclable materials has a key role. Disposal of residual waste after extraction of material resources needs engineered landfill sites and/or investment in waste-to-energy facilities. The main problems of managing this solid wastes are accumulation, segregation, transportation and lack of public awareness. About 70-80% of the generated solid waste has been collected for disposal and rest is remains in the streets, institutions and different places. Accumulation of this waste in nature affects the living and non-living environment adversely. So the need of the day is to manage solid waste properly. The present study describes and evaluates the present status of municipal solid waste management in India.

Key words: Solid Waste Management (SWM), Waste collection and transport, Composting

INTRODUCTION

India is rapidly shifting from agricultural-based nation to industrial and services-oriented country. About 31.2% population is now living in urban areas. Over 377 million urban people are living in 7,935 towns/cities. India is a vast country divided into 29 States and 7 Union Territories (UTs). There are three mega cities—Greater Mumbai, Delhi, and Kolkata—having population of more than 10 million, 53 cities have more than 1 million population, and 415 cities having population 100,000 or more (Census, 2011a). The cities having population more than 10 million are basically State capitals, Union Territories, and other business/industrial-oriented centers. India has different geographic and climatic regions (tropical wet, tropical dry, subtropical humid climate, and mountain climate) and four seasons (winter, summer, rainy, and autumn) and accordingly residents living in these zones have different consumption and waste generation pattern. However, till date, no concrete steps had been taken to analyze regional and geographical-specific waste generation patterns for these urban towns and researchers have to rely on the limited data available based on the study conducted by Central Pollution Control Board (CPCB), New Delhi; National Engineering and Environmental Research Institute (NEERI), Nagpur; Central Institute of Plastics Engineering and Technology (CIPET), Chennai; and Federation of Indian Chambers of Commerce and Industry (FICCI, 2009), New Delhi.

Municipal solid waste management (MSWM), a critical element towards sustainable metropolitan development, comprises segregation, storage, collection, relocation, carry-age, processing, and disposal of solid waste to minimize its adverse impact on environment. Unmanaged MSW becomes a factor for propagation of innumerable ailments [1]. In the developed countries, solid waste management (SWM) belongs to prominent thrust areas for pursuing research [2] and economic and technological advancements have initiated responsiveness of stakeholders towards it[3]. High population growth rates, rapidly varying waste characterization and generation patterns, growing urbanization and industrialization in developing countries are the important reasons for paying attention towards MSWM as more area is required to accommodate waste [4].

Annually, about 12 million tons of inert waste are generated in India from street sweeping and C&D waste and in the landfill sites, it occupies about one-third of total MSW. In India, MSWM is governed by Municipal Solid Waste (Management and Handling) Rules, 2000 (MSWR) and implementation of MSWR is a major concern of urban local bodies (ULBs) across the country.

Composition and characteristics of Indian municipal solid waste: Following major categories of waste are generally found in MSW of India: • Biodegradable Waste: Food and kitchen waste, green waste (vegetables, flowers, leaves, fruits) and paper. • Recyclable Material: Paper, glass, bottles, cans, metals, certain plastics, etc. • Inert Waste Matter: C&D, dirt, debris. • Composite waste: Waste clothing, Tetra packs, waste plastics such as toys. • Domestic Hazardous Waste (also called "household hazardous waste") and toxic waste: Waste medicine, e-waste, paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and pesticide containers, batteries, and shoe polish. MSW in India has approximate 40–60% compostable, 30–50% inert waste and 10% to 30% recyclable. Analysis carried out by NEERI reveals that in totality Indian waste consists of Nitrogen content (0.64 ± 0.8) %, Phosphorus (0.67 ± 0.15)%, Potassium (0.68 ± 0.15)%, and C/N ration (26 ± 5) %. Waste Generation Per Capita in Indian Cities is shown in Table 1.

Table 1:

Waste Generation Per Capita In Indian Cities	
Population	Waste Management Rate (kg Per Capita Per Day)
Cities with a Population of < 0.1 Million	0.17-0.54

Cities with a Population of 0.1-0.5 Million	0.22-0.59
Cities with a Population of 1-2 Million	0.19-0.53
Cities with a Population of > 2 Million	n 0.22-0.62
Source: CPCB Report 2014 [8]	

Solid waste management practices and challenges in India: Unfortunately, no city in India can claim 100% segregation of waste at dwelling unit and on an average only 70% waste collection is observed, while the remaining 30% is again mixed up and lost in the urban environment. Out of total waste collected, only 12.45% waste is scientifically processed and rest is disposed in open dumps [2].

Waste People Generate- India's urban population of 429 million citizens produce a whopping 62 million tonnes of garbage every year. Out of this, 5.6 million tonnes is the plastic waste, 0.17 million tonnes is the biomedical waste, 7.90 million tonnes is hazardous waste and 15 lakh tonnes is e-waste. A staggering figure of forty-three million tonnes of Solid Waste is collected annually, out of which only 11.9 million, that is 22-28% is treated, while about 31 million tonnes of waste is left untreated and dumped at the landfill sites.

Major Metros Manage Their Trash- Major metropolitan cities like Delhi, Mumbai, Chennai, Hyderabad, Bengaluru and Kolkata generate about 10 million tonnes of garbage every day. The problem is not the enormous amount of waste generation, but how a huge chunk of garbage is remained untreated every single day. Here's a look at how the two major cities of India, Mumbai and New Delhi manage their waste.

India's Ever-growing Landfills - India's landfills are bursting at the seams and overflowing with items that shouldn't be thrown in the trash. More than 70% of collected urban waste is dumped straight into the landfills. As a result most of them are brimming and are way past their limit.

	Known Landfills	Landfills Area (Hectares)
Delhi	3	66.4
Mumbai	3	140
Chennai	2	465.5
Kolkata	1	24.7

The Problem of Untreated Waste- Imagine 3 million trucks piled high with garbage. That's how much untreated garbage Urban India generates every day. Just in case if you are wondering how much waste that is – If these 3 million trucks are laid end to end, they would cover half the distance between the earth and the moon. That's also the distance you would cover if you made 15 trips between Mumbai and Los Angeles.

Top Waste Generating Cities In India- Talking about solid waste, according to a Central Pollution Control Board (CPCB) report, Maharashtra tops in solid waste generation by generating over 26,820 tonnes of solid waste per day. In the e-waste sector, Mumbai comes first as it generates an estimated 1,20,000 tonnes of e-waste annually. Delhi and Bengaluru are ranked second and third, with 98,000 and 92,000 tonnes of e-waste generation respectively. The biggest threat to our environment comes from plastic. 60 major cities in India together churn out over 3,500 tonnes of plastic waste every day, with cities like New Delhi, Chennai, Kolkata, Mumbai, Bengaluru, Ahmedabad and Hyderabad being the biggest culprits.

Prediction -Research shows that if India continues to dump untreated garbage at its current rate, then we will need a landfill of size 66,000 hectares which is 10 metres high and can hold 20 years' worth of waste. That is almost 90% of Bengaluru's area.

Around the word – Where India Stands- Globally, there are around 2,200 waste-to-energy plants, of which the European Union has 445, China has 150 and USA has 86. Despite its burgeoning population, India just has 8.If India starts collecting and treating its waste effectively then it can be used to generate a lot of energy. Did you know that unused waste has the potential to generate 439 MW of power from 32,890 TPD of combustible waste? To put it in perspective, this much energy is enough to meet the power demand of a union territory like Pondicherry.

India's Contribution To The World's Growing Waste Miseries- Researchers say India pumps around 0.6 tonnes of plastic waste into the oceans annually. It is the 12th biggest plastic polluter in the world and ranked 10th when it comes to the generation of municipal solid waste. India also discards around 1.7 million tonnes (Mt) of electronic and electrical equipment annually and is the fifth biggest producer of e-waste in the world.

Poor Waste Management Turning India's Cities Into Pollution Bombs- All you need is a small spark from the light of a matchstick or a cigarette stub to turn any dumping waste site into an inferno of hazardous gasses.Apart from overflowing waste, India's landfills are also home to toxins, leachate and greenhouse gases. With time, toxins produced by waste leaches into the soil and groundwater, and become environmental hazards for years. Another area of concern is the imminent danger of Green House gases. When organic material like food scraps and green waste is put in the landfills, it is generally compacted down and covered. As a result, the oxygen is removed from it which causes it to break down in an anaerobic process. Eventually this releases methane, a greenhouse gas that is 21 times more potent than carbon dioxide.

Lack Of Awareness And Enforcement - The solid waste management rules of 2016 has made waste segregation mandatory for every waste generator be it an individual, community, society or an corporate office, but implementation remains poor. Another reason for the poor waste management in India is the lack of awareness. Waste generators don't know what they can do in order to reduce their own carbon footprint. Though composting is an important part of the Swachh Bharat Abhiyan Campaign, the lack of knowledge makes it unsuccessful.

Typical composition of municipal solid waste of Indian cities

S.N.	Components	Composition (% by weight)
1	Metal	0.2-2.5
2	Glass, Ceramics	0.5-3.5
3	Food and Kitchen waste	40-65
4	Paper	1-10
5	Plastic rubber	1-5
6	Misc. Combustibles	1-8
7	Misc incombustible	
8	Inert	20-50
Sources: Arceivala and Asolekar (2012)		

The municipal solid waste generated mainly contains organic waste in almost all cases. The highest amount of organic waste was reported in Mumbai (62%), followed by Chandigarh (57%). Other than this, moisture content was also high in all cases (except Ahmedabad) ranging between 41 and 64%. The CV is very low ranging between 742 and 2,632 kcal/kg and the C/N ratio ranging between 18 and 37.

Collection and storage of municipal solid waste: In the country most of the urban areas are lacking municipal solid waste storage at the source, significantly. There are common bins used to collect the waste (compostable and noncompostable) without any segregation, and disposed off at a community disposal centre. Movable and fixed bins are two types of storage bins commonly used. Because of the position of fixed bins cannot be changed once they have been constructed, are more durable. Due to the flexibility in transportation, the movable bins are not very much durable. Corporation/ municipalities are responsible the collection of municipal solid waste. The predominant system of collection (through the communal bins) at various points along the roads in most of the cities, and sometime this leads to the creation of unauthorized open collection points. In many megacities such as Delhi, Mumbai, Bangalore, Madras, and Hyderabad, just start the house-to-house collection with the help of NGOs. To arrange collection of municipal solid waste, some urban areas are using the welfare association, on specified monthly payment. Privet contractors for secondary transportation from the communal bins or collection points to the disposal sites, have been employed by many municipalities while other have employed NGOs and citizen's committees to supervise segregation and collection from the generation source to collection points located at intermediate points between source and dump sites. Where privet contractors and NGOs are employed for the collection and transportation of municipal solid waste, the average colletion efficiency for municipals solid waste in Indian cities and states is about 72%, which shows that the collection efficiency is high in the states. Most of the states are unable to provide waste collection services to all cities [6]. The municipal solid waste collection and disposal services are very poor in low income states. Many practices are often illegal and the people are unwilling or unable to pay for the services in these states. Citizens through away the waste near or around their house at different times, it makes the collection and transportation of waste very difficult. The central pollution control (CPCB) has found that manual collection comprises 50% while collection using trucks comprises only 49% (CPCB-2002), in a survey 299 class one cities in India.

Incineration- The incineration is a poor option as the waste consists mainly high organic material (40-60%) and high inert content (30- 50%) also low calorific value content (800-1100 kcal/kg), high moisture content (40-60%) in municipal solid waste and the high costs of setting up and running the plants . In 19187 the first large-scale municipal solid waste incineration plant was constructed at Timarpur, New Delhi, with a capacity of 300 t/day and a cost of Rs. 250 million (US$5.7 million) by Miljotecknik volunteer, Denmark. The municipal corporation of Delhi was forced to shut down the plant due to its poor performance after 6 months. In India in many cities, small incinerators, are being used for burning hospital waste however [9].

Pyrolysis and Gasification Technologies- Pyrolysis and gasification both are endothermic process. The end products are gas in both the processes termed as syngas, liquid (containing acetic acid, acetone and methanol) and char (containing carbon with inert material). To produce fuel gas from the solid waste we use gasification, which is a type of incineration under oxygen deficient condition. There are very few gasifiers in operation in India, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest waste. Gasification can also be used for municipal solid waste treatment after drying, removing the inert and shredding for size reduction. For the burning of agro-waste, sawmill dust, and forest wastes in India one gasification unit installed at Nohar, Hanungarh, Rajasthan by Narvreet Energy Research and Information (NERI) and other is installed at Gaul Pahari campus, New Delhi by Tata Energy Research Institute. Its efficiency is about 70-80% and the waste feeding rate is about 50-150 kg/h. 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 (CPCB, 2004).

Landfilling- Landfill is a vacated land area onto or into which waste is disposed. It is an essential part of any planned municipal solid waste management system. After pertinence of all available management options, they are the final depot of any city's municipal solid waste. In most of the developing countries, open dumping is the most, lucid and economical practice is implemented. Among all available management practices, about 51% open dumping takes place in Asia (World Bank 2012) [21, 59, 60] . The aim of landfilling of municipal solid waste is to avoid any contact between the solid waste and the surrounding environment, particularly the ground water [6].

Refuse Derived Fuel (RFD) Plants- In this method municipal solid waste produces an improved solid fuel or pallets. This plant reduces the pressure on landfills. Combustion of the RFD from municipal solid waste is technically sound and generating power. Without any ill effects for generating heat, RDF may be fired along with the conventional fuels like coal. Operation of the thermal treatment system not only costly but also a relatively higher degree of expertise. In the country many plants are in operation, in Bangalore RFD plant was established and has regular production of fuel pallets since October, 1989,

compacting 50t/day of garbage, converting in to 5t of fuel pallets, which can be designed both for industrial and domestic uses. For processing garbage into fuel pallets, the RDF plant at Deonar, Mumbai was set up in the early 1990s. It is based on indigenous technology. However, at present the plant has not been in operation for the last few years and it is owned by Excel India. The Hyderabad RDF plant was commissioned in 1999 near the Golconda dumping ground with a 1000t/day capacity (but receiving only 700 t/day at present). The RDF production is about 210t/day as fluff and pellets, and it is going to be used for producing power (about 6.6 MW) [7].

Composting- Particularly in rural India composting is used traditionally for disposal of solid waste [8]. Due to presence of a lot of non-organic materials in waste, it is difficult to compost it. The quality of end product is very poor if solid waste is composted as such (mixed waste). The presence of plastic goods in solid waste is especially problematic, since these materials do not get recycled or have a secondary market. Even the best waste management system or plant will be rendered useless, in the absence of segregation. In the country the first large-scale aerobic composting plant was setup in Mumbai in 1992 to handle 500t/day of municipal solid waste by Excel Industries Ltd. However, only 300 t/day capacity is being utilized currently due to certain problems, but the plant is working very successfully and the compost produced is being sold at the rate of 2 Rs./kg. Another plant has been operated in the city of Vijaywada with 150t/day capacity, and a number of other plants have been implemented in the principal cities of the country such as Delhi, Bangalore, Ahmadabad, Hyderabad, Bhopal, Lucknow and Gwaliar over the years. To have composting facilities very soon, many other cities have either signed agreements or are in the process of doing so. Due to composting needs segregation of waste and shorting is not widely practiced, there is only 10-12% composting is used in India [9].

Vermicomposting- Vermicomposting is an eco-friendly, eco-biotechnological and bio-oxidative process which stabilizes organic solid waste into valuable bio-product, called vermicompost. In this process there is an inter-mutual action of earthworms and microorganisms. The microbial biomass present in the earthworm's gut is also responsible for the biochemical decomposition of organic matter, in addition to the feedstock. Earthworms are responsible for alteration of physical status of organic waste directly and chemical status indirectly by acting as important mediators which increase accessible surface area to microorganism, thereby improving enzymatic action [10]. Other than this to colonise surrounding microbes supporting microbial growth and action, earthworms provides suitable organic substrate by producing faecal matter. Earthworms have a major role in solid waste management plus soil management, as they are considered as the biological indicator of soil health. Earthworms decrease the stabilization time of household waste and sewage sludge by vermicomposting and turned them into valuable end product i.e. vermicompost that can be further utilized in agricultural and horticultural practices [11], thus improving the productivity and fertility of soil.

Recent initiative by Union Government

Ministry of Housing & Urban Affairs has launched '**My Home-My Neighborhood**' (Ghar Bi Saaf-Pados Bhi Saaf) campaign with the following six components:

1. Segregation of waste at source
2. Compost making from wet waste within the premises/ neighbourhood/area
3. Recycling of dry waste
4. Freeing the neighbourhood from open defecation and open urination
5. Motivating the residents of neighbourhood against throwing garbage in open spaces; and
6. Adopting a nearby park or open place for collection and waste segregation.

Successful Waste Management practices:

Rwanda and Kenya can serve as precedents for India which have introduced stiff penalties for use of flimsy plastic bags.
In the country itself, Alappuzha in Kerala and Panaji in Goa can serve as good examples because they do not have any landfills. Both these cities convert their compost or biogas and recycle plastic, glass, metals and papers.
Green protocol, which is aimed at reducing garbage generation discouraging disposables and using reusable alternatives.

Problems in municipal solid waste management

1. Source segregation, collection

Except for industrial waste where due to organized nature of sector, segregation is sometimes practiced and for healthcare waste due to regulatory requirements, there is virtually no organized and scientifically planned segregation source in India. Sorting is mostly done by unorganized sector (scavengers and rag pickers) and rarely done by waste generators. Therefore, the efficiency of segregation is quite low as the unorganized sector tends to segregate only those waste materials which have relatively higher economic return International Journal of Biology Research 131 in the recycling market. The unsafe and hazardous conditions under which the segregation and sorting takes place are well known. The waste collection efficiency even in high income cities (i.e. Delhi) is rather low. Often a substantial amount of waste is left to rot on the streets and/or dumped in to low lying areas, canals, rivers etc. Lack of appropriate collection system, lack of and/or inadequate collection facilities such as waste disposal bins, collection vehicles etc., lack of funds, lack of and enforcement of appropriate regulation etc. are the main factors are responsible for such low collection efficiency. 2- Treatment and disposal Municipal solid waste is generally disposed as such without any treatment. Most of the municipal solid waste is still disposed of in dumps causing sever environmental and health risks. The progress in moving towards sanitary landfills and/or disposing through well designed and well operated incinerators is rather slow.

2. Policy Issues In India- there is no any vigorous policy framework to give a direction and thrust to environmentally

sound waste management. Policy measures to promote waste minimization, recycle and recovery are rather lean. To deal with overall issue of waste management in line with country's economic development programme, there is no any national target has been set up. The environmental policies are 'discharge end control' based instead of shifting to 'source end control' based approach. The industrial policies continue to rely on manufacturing from virgin resources and a rational pricing mechanism and/or market based instruments to accelerates waste minimization and support greater use of recycled materials are not in place. Most of the current policies are in support of end-of-pipe approach creating huge burden on municipal authorities. At source and conversion of waste into useful materials/energy, there are no policies to promote segregation and reuse of municipal solid waste.

3. Technology Issues In India- it is need of the day to launching targeted efforts for development/acquisition of technologies for material and energy recovery from municipal solid waste. To built confidence and test the application of such technologies in the context of developing countries pilot demonstration projects need to be established. To facilitate assessment of recycling /recovery potential and design/development of technologies, this in turn will require extensive data collection on waste characterisation and quantification. In this direction almost no efforts seems to be taking place. Most of the work is focussed on augmenting waste collection and building disposal facilities.

4. Financing Issues- One of the most pressing issues is the availability of funds to support waste management. The local authorities are mostly in a dire financial situation and are barely able to maintain the basic jobs of waste collection and somehow dispose it. Municipal level waste management continues to be heavily subsidised by governments. To promote use of environmentally sound technologies, for technology development and demonstration are conspicuous by absence.

Future challenges in municipal solid waste management -A successful long term planning depends on the characteristics of the solid waste and estimation of future quantities. In future the decisions related to treatment choices and disposal options for solid waste management will get affected by the composition of solid waste. To address the issue of forecasting the quantities of municipal solid waste, researchers have been reported for innovative and forward looking solution [12] . Although both planning and design of municipal solid waste management system require accurate prediction of solid waste generation. Yet achieving the anticipated prediction accuracy with regard to the generation trends facing many fast-growing regions is quite challenging. A long time forecast will be more meaningful if it gives the most optimistic, most pessimistic values and also the most likely values. In India some of the future challenges for the management of municipal solid waste are, (1) Increasing quantities and changing composition (2) Increasing severity of adverse impacts (3) Increasing cost of waste management (4) Limited policy framework (5) Lack of political priority

Recommendations to Improve MSW practice in India:
The community should pay to augment inadequate resources for MSWM of municipal bodies. Community participation in SWM is the key to sustain a project related to management of solid waste. Till date no such tax has been levied for SWM. (2) The people should be educated to realize the importance of source segregation at generation point as biodegradables, inert and recyclable material for proper waste management. (3) Viable decentralized composting plants should be installed to reduce the load on ULBs for collection and transportation of MSW, which subsequently culminates in reduction of the pressure exerted on the landfills.
(4) For large cities, zone-wise decentralized composting units should be setup. Through community participation, segregated biodegradable waste from individual community/units should be collected and disposed into these decentralized composting units. (5) Characterization of waste at collection and also at disposal point should be made and be available in public domain. Government should take initiative to encourage Universities, technical Institution to take up waste management in its curriculum. Assistance of academic institutions should be solicited in characterization of waste in their vicinity. Thereby most part of India would be covered and location-specific appropriate solutions for waste management can be developed. It can also help to select suitable waste-to-energy technologies for particular regions. (6) The waste should be treated as resource and formal recycling sector/industries be developed to recycle non-biodegradable recyclable component from the waste thereby providing employment to rag-pickers and absorb them in mainstream. Also a policy, fiscal intensive and development of quality standard for reuse and recycle of C&D waste be developed and notified so that producers dispose/reuse it as per guidelines, thereby reducing burden on landfill. (7) Manufacturing of non-recyclable polyethylene bags should be banned or research should be initiated to develop biodegradable polyethylene. (8) In most parts of India, sweeper and rag-pickers are still considered inferior class of citizens despite several laws in place to bring dignity to their profession. To change people's views and perspective, awareness regarding this important service to community should be initiated and manpower engaged in such activities should be named as Green brigade/Crew, and so on. (9) Though, in India, prevailing MSWR does not permit leachate/water/liquid addition in landfill, biodegradable waste gets mixed again during transportation and finally disposed in landfill. Therefore, practices of leachate/liquid recirculation in landfill should be encouraged

to enhance waste stabilization and gas recovery as practiced in developed countries. Modification and provision for it should be made in MSWR accordingly. (10) Protection of groundwater contamination from leachate percolation from open dump/landfill site should be made compulsory. Appropriate technological solution should be adopted to achieve this goal.

Summary- An attempt has been made to study the changing trends of quantity and characteristics of municipal solid waste to find its impact on the performance and capacity planning of recovery/recycle, compost, incineration and landfill facilities. For successful operation of waste management facilities, the changing pattern of waste composition emphasises the importance of segregation. Municipal authorities should maintain the storage facilities in such a manner that they do not create unhygienic unsanitary conditions. In the country, a new survey should be carried out on the generation and characterization of municipal solid waste. A large number of samples have to be collected and analyzed to obtain statistically reliable results, since the municipal solid waste is heterogeneous in nature.

REFERENCES

[1] Sunil Kumar et al. Assessment of the status of Municipal Solid Waste Management in Metro cities, State capitals, Class I cities, and Class II towns in India: An Insight, Waste Management ; vol. 29, pp.883-895, 2009.
[2] GOI, National program on "Energy recovery from Urban, Municipal and Industrial Wastes by MNES
[3] Shekdar, A.V., Municipal solid waste management – the Indian experience, 1999.
[4] Idris, A., Inane, B., Hassan, M.N.,. Overview of waste disposal and landfills/dumps in Asian countries. Material Cycles and Waste Management, vol. 16, pp.104–110. 2004.
[5] Solid Waste Management Rules , Ministry of Environment, Forest and Climate Change, New Delhi, 2015.
[6] Gupta S., Choudhary N. and Alappat B.J., "Bioreactor Landfill for MSW Disposal in Delhi" Proceedings of the International Conference on Sustainable Solid Waste Management, Chennai, India. pp. 474-481, 2007.
[7] Yelda, S., Kansal, S., Economic insight into MSWM in Mumbai: a critical analysis. International Journal of Environmental Pollution, vol. 19 (5), pp.516–527, 2003.
[8] CPCB, Status of Municipal Solid waste Generation, Collection,Treatment and Disposal in Class I Cities, Series: ADSORBS/31/1999–2000.
[9] Sharholy, M., Ahmad, K., Vaishya, R., Gupta, R., Municipal solid waste characteristics and management in allahabad, India. Waste Management, vol. 27 (4), pp. 490–496, 2007.
[10] Fornes F, Mendoza-Hernandez D, Garcıa-de-la-Fuente R, AbadM, Belda RM. Composting versus vermicomposting: a comparative study of organic matter evolution through straight and combined processes. Bioresour Technol,;vol. 118:pp.296-305, 2012.
[11] Kale RD, Bano K, Krishnamoorthy RV. Potential of Perionyx excavates for utilising organic wastes. Pedobiologia, vol. 23:pp. 419-425, 1982.
[12] Srivastava AK, Nema AK. Comparison of artificial neural network and ARIMA models for forecasting solid waste quantities, Proceedings of Indian International Conference on Artificial Intelligence IICAI-05, pp. 924-937, 2005.