Integrated Solid Waste Management for Sustainable Development; With Special Reference to Berhampur City

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Abstract

In the era of urbanization and globalization accompanied with the population explosion in developing and underdeveloped countries, the waste management is major social and environmental challenge. Hence the solid waste management is the basic issue we are concerned of among all the urban and rurban waste outputs. In the event of the visionary goal of Swatch Bharat Mission, by govt. of India, we are still under the influence of poverty, infrastructure insufficiency accompanied with rapid population growth and rapid rural urban migration. In case of developed countries, they have successfully addressed the issue, while in case of developing countries the situation is more critical. Hence India is not an exception from having the issues of solid waste management, and there are multiple reasons for this. The study aims to carry out an analysis on the waste management practices and to develop a integrated waste management model for Berhampur city and for the similar environment.

Keywords: *Environment, Globalization, Integrated waste management, Solid Waste management, Swatch Bharat Mission, Urbanization.*

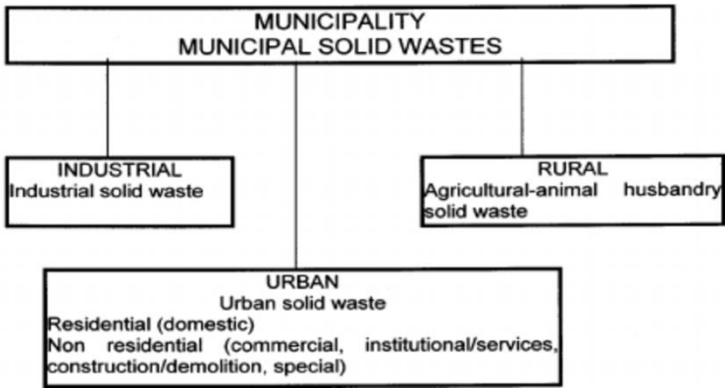
1. Introduction

The Solid Waste Management is a challenging problem for the developing countries like India where the trend of urbanization is very high. The municipal bodies offer the solid waste management services. It is an essential service, still it is not getting proper priority, which it deserves and services are poor. This has created many problems in urban environment as well as to the public health in urban Indian cities and towns.

2. Review of literature

Municipal Solid Waste could classified in to Urban, Industrial & Rural. The urban division splits into two subdivisions, as per sources: (a) residential (dwellings), and (b) non-residential (commercial, institutional/services, construction/demolition, and special). The industrial division covers all facilities formed by a single industrial class. The rural division includes all sources derived from agricultural and animal husbandry activities, and is formed by the agricultural–animal husbandry class (Buenrostro et al., 2001)

Figure: 1. Classification of solid wastes



Source: Buenrostro, O., Bocco, G., & Cram, S.

Global municipal solid waste (MSW) production reached 1.3 billion tonnes per year in 2010 and it is expected to increase to 2.2 billion tonnes per year by 2025 (Zheng, et al.2013)

Storage of MSW at the source is substantially lacking in most of the urban areas. The bins are common for both decomposable and non-decomposable waste (no segregation of waste is performed), and the waste is disposed at a communal disposal center. (Sharholy at al, 2007)

Municipal Solid Waste Management (MSWM) is a vital, ongoing and large public service system, which needs to be efficiently provided to the community to maintain aesthetic and public health standards. Municipal agencies have to plan and execute the system in keeping with increasing urban areas and population.

The quantity of MSW generated in India has increased considerably during the last three decades and that produces enormous challenges to the municipal bodies for their effective management and disposal. Like other towns and cities of the country in the state of Odisha, the problem of solid waste becomes a serious one and needs extensive research for effective management of the wastes.

The Silk city "Berhampur" is located in the Eastern part of India, in the states of Odisha. The silk city is now transforming to a garbage centre with the increasing volume of wastes and its impacts have been observed on the urban environment and public health. The present research aims to study the existing waste management mechanism and to design an Integrated Solid Waste Management (ISWM) model for sustainable management of wastes in Odisha town.

3. Methodology

To achieve the desired objectives and to design the research paper the following research methodologies are followed:

3.1. Solid Waste Survey

The first step is to measure the quantum of generated waste to design an accurate management system. Hence, a pre-sort site assessment was carried out with the aim to determining the suitability of the site and facilities for waste categorization study. Information gathered during the pre-sort site assessment helps in designing the sampling procedures for the waste characterization study. The Materials Classification categories were carried out by using the material classification format as given in Table 1.

Table 1: Material Classification details

Sl. no	Waste Types
1	Organic
2	Fine Earth
3	Demolition Debris
4	Plastic Materials, Polythene Bags, Thermo cool etc.
5	Metals
6	Glass
7	Soiled Papers, Card Boards
8	Textiles
9	Miscellaneous

Source; Author

The completion of the site assessment is followed by waste characterization assessment. The Characterization assessment study covered-

3.1.1. Collection of Waste

To study the waste characterization, waste sample were collected from 10 numbers of community bins across the town and about 100 kilograms of wastes were collected.

3.1.2. Sorting of waste

The Solid Waste samples collected from community bins were sorted, categorized, weighted and documented. A Material based categorization approaches were adopted to categorize the samples.

The Literature contains several methods for waste quantum and characterization study. The study adopted a weighting exercise method and the traditional and simpler material based classification approach was as per the guideline of the solid waste management rules, 2016, Ministry of Environment, Forest and climate change, Govt. of India.

Measurement exercise was carried out to estimate the total volume of Solid Waste generated in the town. To perform the same the number of trips performed by all categories of vehicles were recorded for seven consecutive days. This record helps to determine the average number of trips performed by each category of vehicle/day and to estimate the total volume of wastes generated daily in the study area. This method is most relevant in India as most of the

municipality authorities adopted this method to estimate the volume of daily generated waste (Kumar, 2009).

The MSWs generated by each person/day was estimated by dividing the total volume of wastes generated daily by total estimated population of the study area. Daily about 100 kg of waste samples were collected from 10 community bins located in different localities across the town and mixed thoroughly. The above were finally reduced to 12.5 kilogram by Quartering Techniques. With this technique, the total collected wastes were divided into four equal parts and waste from two diagonally opposite portion were taken and mixed, while the other two portions were discarded.
The same procedures were repeated until a waste sample of approximately 12.5 kilograms in weight. From the above sample, wastes were categorized into 9 pre designed categories – organic, silt, demolition debris, plastics, paper, metal, glass and miscellaneous wastes.

Finally, the segregated components were weighed to determine their weights as a percentage of the total weight of sample. This Weighting exercise method is considered to be the best method to know the waste characteristics as far as the Indian conditions are concerned (Kumar, 2009)

3.2. Study Region

Silk city Berhampur is an important city in the state of Odisha. The name has been recently changed to Brahmapur. This is one of the most ancient cities in the state of Odisha and is also the largest city in the state. topographically It lies in the east coast line of Odisha and coordinates at 19.32°N Latitude and 84.78°E Longitude. The elevation is at a height of 27 meters or 88 feet above the average sea level. Berhampur has an area of 86.82 square kilometers.

3.2.1. Population of Berhampur

On the basis of 2011 Census of India (provisional), the approximate population of Berhampur was about 385,823 (the actual population is much higher than this), of which 185,584 were males and 170,239 are females, this makes it the fourth most populous urban city in Odisha state and 126th in India.

3.2.2. Climate of Berhampur

As per climate, Berhampur is a city which is located in near the sea coast in the state of Odisha, famous for its incredible beaches and villas. Berhampur summers are quite hot with the winters being a bit cold due to its tropical climate. The temperature from March to June that is during the summer is maximum, which can be up to 45°C. while the monsoon season lasts from July till September. During October to January that is during the winter months there is maximum number of tourists visiting this place as this time is considered to be the best time to visit this place. Hence it is convenient to travel during this time as the tourists do not have to carry heavy gears or jackets around them.

3.2.3. Topography of Berhampur

Silk city Berhampur is bounded by Ganjam District in the State of Odisha. Large number of cultivable plains surrounds this region. The whole plain is bounded in the West and the North by a range of hillocks which contain Granite rocks. The Granite rock belts are a major source of employment and revenue in this region. These plains have a mild slope towards the Bay of Bengal. Berhampur is elevated at an altitude of 24 meters above the average sea level. The topographical, geo-physical features and the climate of the city offer great potential for expansion and development.

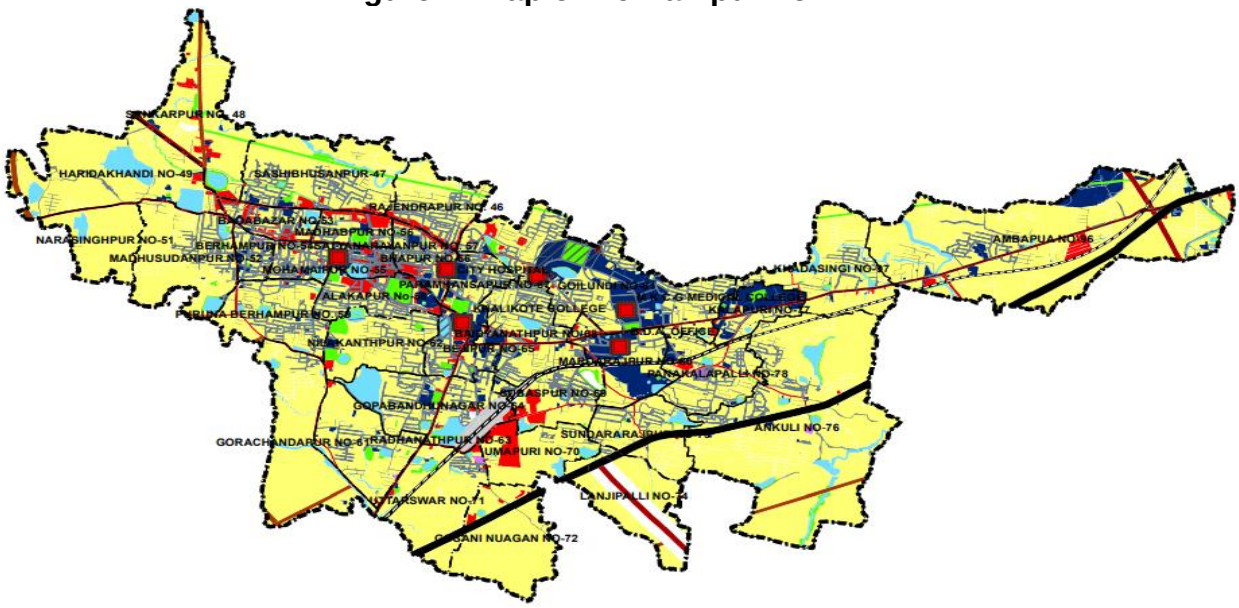
3.2.4. Soil Texture of Berhampur

Because of the tropical climate and the rainfall which last for four months in a year, the soil condition found in this region is clayey except for in some places where rocky beds and hard soil are also found. The soil here is also very fertile in nature which is an asset to the agricultural production and helps in the cultivation of crops in this region.

3.2.5. Rivers in Berhampur

The geography of Berhampur is nourished by three main rivers in Odisha. River Rushikulya flows about 30 km far from the city and drains into Bay of Bengal which is near the Gopalpur port. This is called as the Ganga of Ganjam District as it is main source of water here. Longest river of Odisha the River Mahanadi flows in the east through the dense forest. Returning River Bahuda flows along the Sonepur beach on the Odisha–Andhra Pradesh border. These three rivers have been an important part of the life of the people here as the majority of the population depends on agriculture. The people make use of the river water for the purpose of irrigation and industry. These rivers also provide livelihood for the fishermen living in this region.

Figure 2: Map of Berhampur Town



Source: Govt. of Odisha.

3.2.6. Berhampur at a Glance:

Country: India
State: Odisha
District: Ganjam
Altitude: 88 feet above sea level
Climate: Tropical Climate
Precipitation: 937 millimeters (36.9 in)
Avg. annual temperature : 24°C
Avg. summer temperature : 28°C
Avg. winter temperature : 16°C

3.3. Berhampur Municipality Corporation (BMC)

Berhampur city was declared as a Municipality in the year 1867. As per population this is fourth largest city of Orissa with an estimated population (2011) is about 0.39 million. Berhampur city has about 110 slums where thirty per cent of the city's populace lives. Majority of people (about 80 percent) of the city's waste is generated from residential areas. At present about 138 tons per day (TPD) waste is generated in the city. With this trend, it is expected to increase to 250 TPD in the next three decades.

Recently the city corporation decided new waste management policy in PPP mode. Hence a new entity was formed under the name 'Berhampur Waste Management Company Private Limited'. This company is a consortium of ULP Environment and Engineering, the Ram Engineering and Construction Company and BMC has been formed for implementation the project. Besides, some other adjoining towns would also be included in the project in future. The implanting agency shall collect the garbage from the nearby cities also

3.4. Estimation of Waste Quantum in Berhampur city

Below Table 2 presented the result of the exercise performed in the study area. Number of trips made by different vehicles for seven consecutive days and the approximate amount of waste carried to the disposal site is shown in the Table 2. The average daily number of trips performed by each category of vehicles and the approximate load carried by these vehicles, the total quantum of Solid Waste generated in the town was estimated. Hence, the average amount of wastes was estimated at 138 tones with an average amount of 0.345 kg/person/day.

Table 2: Quantity of Solid Waste generated and Number of trips conducted by the vehicles in Berhampur

Vehicle Type	Load Carrying capacity (Tones)	No of vehicles in operation	Average amount of load per trip	Total no of trips per day	Total quantity of waste carried daily	Total quantity of waste carried weekly

			(Tones)			
Mini Truck	6	1	4	2	8	56
Tractors	4	3	3	6	18	126
Dumper placer	2	1	1.5	2	3	21
Total	12	5	8.5	10	29	203

Average quantity of garbage generated by each person is calculated as following calculation;

Total amount of waste generated

Total population of the city

3.5. Waste Composition Analysis in Berhampur Town

Table -3 shows the percentage of components of Solid Waste collected and analyzed in the study area. Table- 3 presents the percentage of organic components in the waste stream as 72%. The Hot and very humid climatic conditions are considered as important causes behind the high percentage share of organic wastes in the waste stream. Further It was observed that, a large volume of organic wastes were generated from the residential areas in the form of kitchen waste, garden waste and fruit waste.

The Wastes sources like lawns, parks, playgrounds and institutional campuses have also contributed sizeable volume of organic wastes in the waste stream.

Last but not the least, fruits and vegetable residues from the both wholesale and retail market areas, leftover foods from the hotels, restaurants, hostels, community halls etc. have increased the percentage of organic waste to such an extent. Also the quantity of silt, clay and fine earth was found high about 9% in the total waste volume. Such types of wastes were mainly derived from covered and open drains.

In the rainy days from the un-surfaced roads a large quantum of silt and sands accumulates in the drains and contributes a sizable share to the total volume such wastes. The % of demolition debris were estimated at 3% of the total volume of Solid Waste and such types of wastes were originated from the construction and demolition sites. The development rate of urban growth has increased the percentage of such kind of waste in the waste stream.

Table 3: Percentage of components in the waste stream in Berhampur municipal area

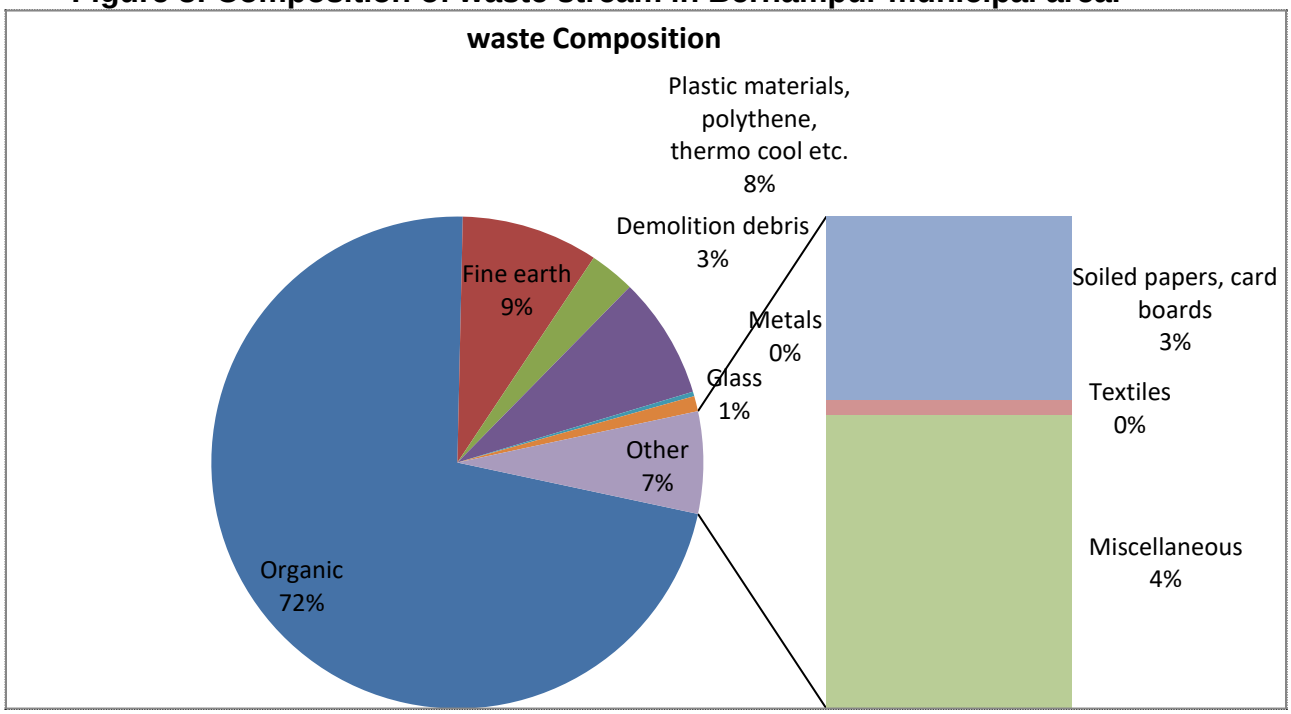
Sl. no	Waste type	Waste in percentage
1	Organic	72
2	Fine earth	9
3	Demolition debris	3
4	Plastic materials, polythene, thermo cool etc.	8
5	Metals	.30
6	Glass	1

7	Soiled papers, card boards	2.50
8	Textiles	.20
9	Miscellaneous	4
Total		100

The dense plastics, polythene bags, plastic packets were found in large quantities in the waste stream. Consumption of polythene bags not only increases their volume but is also responsible for serious environmental problems in the town. The % of soiled paper, card boards, thermo cols, used tyres and synthetic materials were also found high in the waste stream and their percentage shares were estimated at 8%.

While the quantity of metals cans, news papers were found substantially low as such wastes have either picked up from the community bins and open dumping sites or collected directly from the households by the rag–pickers for recycling purposes. In the below Fig-3 shows the percentage share of various composition found in the waste stream in Berhampur municipal area.

Figure 3: Composition of waste stream in Berhampur municipal area.



Source: Author

3.6. Present scenario of waste management

Berhampur municipal area produces about 138 tons of wastes daily and to store the wastes only 35 numbers of community bins have been used. Because the numbers of community bins were few and distributed haphazardly without any planning, residents have no other alternatives rather than to deposit the wastes along the road sides and in the open drains. RCC bins and metallic containers are used by the urban local body to store the wastes and 132 numbers of workers were engaged to handle the waste management task. Sweeping crew collects the wastes from road sides and deposit in the nearby community bins by using tricycles. A Door to door waste collection system has not yet been started in the municipal area and to transfer the wastes two numbers of tractor trailers, a mini truck and a dumper placer were used.

Daily, the tractor trailers performed 3 trips each while the mini truck and the dumper placer only 2 trip each. And the collected wastes were carried in open trailers and trucks and disposed at the final disposal site located at Mohuda 12 Kilometers away from the city. The process of collection drive starts at 7 A.M and continued till 2 P.M in the afternoon under the supervision of officials of the engineering divisions of the Urban Local Authority maintaining a pre-designed schedule. The Collected wastes were finally disposed by simply dumping and land filling at Mohuda, the dumping site is located a distance of 12 kilometers from the city. The area of waste dumping site is about 33.62 acres. It's a normal Open air burning and unscientific land filling of wastes not only causes air pollution but also contamination of ground and surface water in the nearby locality.

3.7. Integrated solid waste management system

An Integrated waste management is concerned with synthesizing a range of different option to deliver an environmentally and economically sustainable system for a particular area (White et al, 1995).

That's why, it describe an approach in which decisions on waste management takes account of different waste streams, collection, treatment and disposal methods, environmental benefits, economic optimisation and social acceptability. In a vision to integrate a solid waste programme within a community, the programme should address the needs of the community as a whole. Hence the waste generated from individual houses, apartments, public places, business, and industries located within a community should be taken into consideration for efficient management. A high degree of flexibility shall be built into a programme so that it can protect the environment. Voluntary participation of the community as a whole in reducing waste is essential. Hence, apart from management practices, due consideration should be given to educating the source reduction concept coupled with proper storage, effective collection, transfer, treatment and disposal of waste.

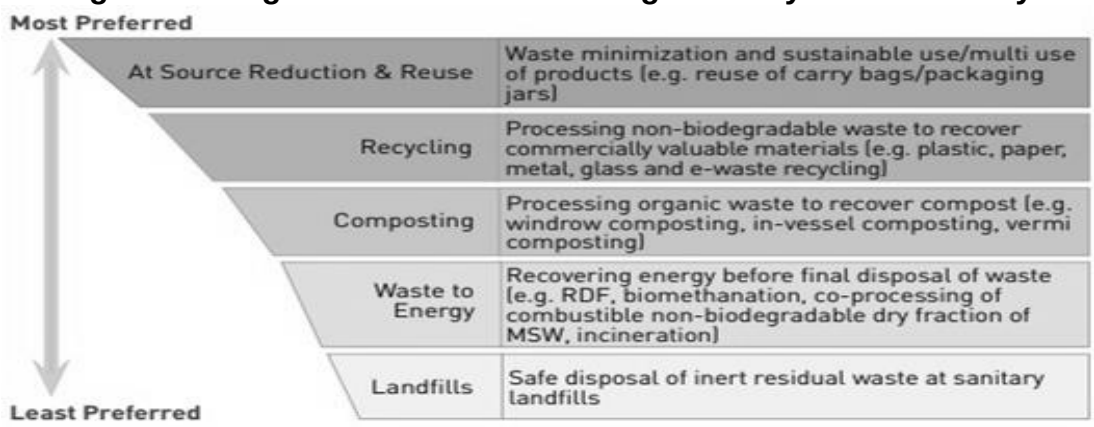
3.8. Planning integrated solid waste management through a Hierarchy

Ensuring a better human health and safety there shall be a need of effective solid waste management system for the urban areas. A system, that needs to be safe for workers and

public health. Besides these requisites, the system must be environmentally sustainable and economically feasible. An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach as per solid waste management rules 2016, Ministry of environment, forest and climate, Govt. of India.

The ISWM hierarchy ranks waste management strategies according to their environmental benefits.

Figure 4: Integrated Solid Waste Management System Hierarchy



Source: bbmp.gov.in

3.8.1. At source reduction and reuse

This is the most preferred option for waste management in the ISWM hierarchy is to prevent the generation of waste at various stages including in the design, production, packaging, use, and reuse of products. The Waste prevention helps to reduce handling, treatment, and disposal costs and various environmental impacts such as leachate, air emissions, and generation of greenhouse gases (GHG). The Minimization of waste generation at source and reuse of products are the most preferred waste prevention strategies.

3.8.2. Waste recycling

After source reduction, the next preferred option for waste management in the ISWM hierarchy is recycling of waste to recover material resources through segregation, collection, and re-processing to create new products. Under the waste management hierarchy, composting is considered as an organic material recovery process and is often considered at the same hierarchical level as inorganic waste recycling.

3.8.3. Waste to energy

The third alternate is to convert the waste to energy, when material recovery from waste is not possible, energy recovery from waste through production of heat, electricity, or fuel is preferred. Biological methane formation (Bio-methanation), waste incineration, production of refuse derived fuel (RDF), co-processing of combustible non-biodegradable dry fraction from MSW in cement kilns and pyrolysis or gasification are some waste-to-energy technologies.

3.8.4. Waste disposal

The last step of of ISWM is the Residual inert wastes at the end of the hierarchy are to be disposed in sanitary lined landfills, which are constructed in accordance with stipulations prescribed in SWM Rules, 2016. Across the world, landfills which integrate the capture and use of methane are preferred over landfills which do not capture the landfill gas.

As per the hierarchy, the least preferred option is the disposal of waste in open dumpsites. But Indian laws and rules do not permit disposal of organic matter into sanitary landfills and mandate that only inert rejects (residual waste) from the processing facilities, inert street sweepings, etc. can be land filled. While in cases where old dumps are to be closed, there is a possibility of capturing methane gas for further use. Still a repeated burning of waste significantly decreases the potential of capturing methane. ISWM hierarchy indicates that all options of source waste minimization should be utilized before appropriate treatment technologies are selected and implemented.

The ISWM is closely follows the 3R approach (reduce, reuse, and recycle), which also preliminarily emphasizes the importance of waste reduction, reuse, and recycling over other forms of waste processing or management. Adoption of these principles helps in minimizing the amount of waste to be disposed, thus also minimizing the public health and environmental risks associated with it. The Maximizations of resource recovery at all stages of solid waste management is advocated by both approaches.

The planning of integrated solid waste management system has been explained below in a case study for Berhampur Town.

1. The Reduction of waste at source with the active participation of the community. The Wastes can be reduced by changing the consumption pattern, use of recyclable materials, practice of waste segregation and refusing the use of polythene bags etc. a gross about 20% reduction in waste generation is possible through simple housekeeping measures that require no marginal investment (Ramachandra, 2008).
2. A considerable benefits of increasing solid waste recycling and reuse. The Source separation and recycling of waste reduces the volume of the waste considerably. Promotion of recycling is an alternative to the existing forms of waste disposal may be economically gainful. Moreover, thousands of poor people are directly or indirectly participating in waste collection and recycling to support their families.
3. Another approach is Composting, this seems to be a very effective measure of waste disposal in the study area as organic waste constitutes about 72% of the wastes stream. This is a form of source reduction or waste prevention as the materials are completely diverted from the disposal facilities and require no management or transportation. The diverting such materials from the waste stream frees up dumping space or the materials that cannot be compost.

i. a regular Practice of dumping of waste along the final disposal site is found to be unscientific and highly vulnerable to environment and public health. The process of sanitary land fill not only reduces the risk to the environment and public health but also proper use of land fill site to the fullest extent. Hence , adoption of sanitary land filling will be a better option for final disposal of wastes in the study area.

ii. Another component is the Community, its participation is essential for smooth and efficient operation of solid waste management system. The Performances of such system depend on the meaningful participation of individuals, communities and institutions, producers, NGOs and government. The maajor element of the community participation is involvement of the community in the decision and implementation process. Hence, a consistent and ongoing educational programme is necessary for the success of the waste management system.

3.9. Proposed ISWM scheme for Berhampur Town

The ISWM scheme for Berhampur municipal area have been designed to minimize the initial generation of the wastes through source reduction, then through reusing and recycling to further reduce the volume of the material being sent to landfill sites for final disposal.

An efficient management of wastes requires collection of up- to- date information for corrective measures as well as future planning. Integration and assimilation of information from various sources and levels also have been considered important in ISWM. Hence, a strategic approach for ISWM involves integration of available data, guidelines and framework to eliminate the constraints.

The major objective here is to proper storage, effective collection, transfer, processing and disposal of wastes according to the constituents present in the waste stream in a sustainable manner with the participation of the community. Lastly to maintain a healthy environment, the ULB has to adopt this approach and set goals to reduce the amount of solid waste in a cost effective manner.

3.10. Focus of the ISWM Scheme

1. The Segregation of wastes at source especially the household wastes through active participation of community and in separate containers and regular collection of wastes by using separate fuel efficient vehicles according to nature of the wastes. The use of compactor makes the collection drive more efficient and cost effective.

2. To improve community bins, storage containers for the storage of biodegradable and wet wastes and containers should be placed scientifically using GIS and GPS.

3. An adequate training to all the levels of staff engaged in solid waste management to handle respective functional aspects like collection, generation, storage, segregation of waste etc. and medical check-ups for municipal workers and rag pickers should be mandatory at regular interval.

4. By Establishment of some transfer station for smooth operation of the SWM system at some suitable locations.

5. The Composting should be done with the help of technological experts and o handle the bulk of waste generated everyday sanitary landfill site have to be set up to dispose off the rejects after composting.

6. By Promotion of public participation in the SWM scheme and constitution of citizen forum in each municipal ward involving local people.

7. By Developing public –private partnerships leading to privatization of some aspects of garbage collection, recovery and disposal.

8. Tackle various issues such as road sweeping, open dump, open burning, garbage collection, disposal etc. regular monitoring is necessary.

9. Installing Garbage tax should be levied against large and small generators for the disposal of Wastes.

10. Introducing administrative restructuring of the ULB to discharge more efficiency and specific responsibilities. It requires structural changes within administration aimed at decentralizing authority and responsibilities. It also includes periodic meetings among the staff and between the executives and elected wing of the board.

11. By Encouraging involvement of local NGO's in working on various environmental awareness programmes and areas related to waste management including the public about the importance and necessity of better waste management.

12. By Privatize solid waste management facilities or contract for waste disposal services, including recycling

4. Conclusion

A Rapid population growth and unplanned urbanization led to the tremendous increase in the amounts of municipal solid waste in many cities and towns of the developing countries like India.

The mismanagement of wastes not only causes serious environmental problems but also risks to public health. Hence, there is a shift from the traditional solid waste management options to more integrated solid waste management approaches.

But, the lack of planning, adequate resources, administrative inefficiency is posing a serious obstacle to implement the ISWM approach. The Waste management system in Berhampur is traditional and needs up gradation in the areas of storage, collection, transfer, processing and disposal.

The financial hurdles and lack of co-ordination and co- operation between the concerned authority and the public has created bottlenecks in improving its efficiency.

Potentiality of the community participation in the waste management system has to be given more and more emphasis for smooth management of the system along with the adoption of latest spatial analytical technologies such as GPS-GIS system.

While, government initiative is always necessary to make the system successful.

The waste recycling can be promoted through consumer campaigns that will encourage citizen to co-operate in waste separation and to purchase recycled products.

At the same time ULB should encourage composting of wastes which will not only reduce the volume of waste to dispose but also maintain a healthy environment and low risks to public health.

Finally, a proper monitoring of the system in every steps is utmost important for smooth functioning of the system.

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