Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 3, Issue 9; April-June, 2016, pp. 746-751

http://www.krishisanskriti.org/Publication.html

Solid Waste Management in Cochin, India: Practices, Challenges and Solutions

Hridya K K[1], Princy Lukose[2] and R Rajesh[3]

[1,2]M.Tech (Industrial Engg & Management) Student Department of Mechanical Engineering
Rajiv Gandhi Institute of Technology, Velloor P.O. Kottayam, Kerala – 686501
[3]Department of Mechanical Engineering Rajiv Gandhi Institute of Technology,
Velloor P.O. Kottayam, Kerala – 686501
E-mail: [1]hridyaiem14@gmail.com, [2]princylukose91@gmail.com, [3]rrajeshraghu@gmail.com

Abstract—*Increasing solid waste generation and the subsequent environmental issues are one of the major threats faced by the big cities. The waste treatment practices of a city have major impacts on human health, air quality, water quality, ecological, aesthetic and development dimensions. Cochin City is considered as the industrial and commercial capital of the state of Kerala. There is a rapid increase in the waste generation in the city due to increasing population by migration from other areas. This paper presents an overview of solid waste characterization and waste management practices followed in Cochin City. The total solid waste generation at the city is 180-250 metric tonnes per day. The waste treatment plant of the city is located at Brahmapuram. The plant treats only biodegradable waste and all the other waste is being dumped outside the plant in an unscientific manner. Open dumping of the waste is an unhygienic process and it caused majority of the residents in the neighborhood to migrate because of issues like bad odour and drinking water quality. The surrounding water bodies like the river Kadambrayar is getting polluted and water life is getting affected. A survey was conducted among the residents in a five km radius from the waste treatment plant at Brahmapuram to study major environmental problems. The number of households covered was 180. The survey was helpful in identifying the environmental issues due to the current plant, and points to the need for proposing alternate solid waste management system. Various municipal solid waste management practices such as open dumping, sanitary land filling, incineration, gasification, composting, energy recovery etc have been studied to propose a feasible integrated solution for waste management in the city. This study provides useful insights for decision makers of Cochin Corporation and academicians dealing with municipal solid waste problem of Cochin.*

1. INTRODUCTION

Municipal solid waste (MSW) management is a big problem faced by the developing countries like India. The major cities in India faces the threats of increasing municipal solid waste generation and it has become a big burden on both the local bodies as well as public. The present annual quantity of MSW generated in Indian cities has increased from 6 million tons in 1947 to 48 million tons in 1997 -annual growth rate 4.25%. (CPCB, 2004) It is expected to increase to 300 million tons by 2047. It is not an easy task to manage these wastes. There are different approaches of waste management followed in Indian cities. The most common type of waste management practice followed in Indian cities is open dumping of waste. Open dumping is generally considered as the worst method of solid waste management due to the different ill effects of it. The main problems related to open dumping includes problems related to human health parameters, drinking water contamination, soil pollution etc. More than 90% of the waste generated in Indian cities is being disposed directly to the land in an unscientific manner (Das et al., 1998). Cochin is one of the main cities of India and often considered as commercial and industrial capital of Kerala. Although many of the Indian cities are having enough land to follow the open dumping practices, the more congested and populated cities like Cochin cannot afford to lose a large area of land just for open dumping of the west. The problems related to the rapid increase of MSW generation in the city are mainly because of the rapid urbanization and population growth. The objective of this paper is to analyze the existing practices of MSW treatment in Cochin and to propose feasible solutions.

2. MSW MANAGEMENT IN COCHIN

Cochin is known as the queen of Arabian Sea. It is a major port city which is a part of Ernakulam district in the state of Kerala. It lies on the south west coast of India by the Arabian Sea. Population of Cochin is 603000 plus the floating population and metropolitan population is 2.1 million as per the census 2012.

The corporation of Cochin is responsible for the municipal solid waste management of the city. The two departments of corporation of Cochin are Health department and Engineering department. The collection, transportation, disposal of MSW is the responsibility of the Health Department while the Engineering Department assists them in planning, formulation of programs and in procurement of vehicles, equipment and developing the site. The Project Engineer is responsible for engineering components of solid waste management (SWM)

and vehicle procurement and maintenance. To treat 1 tonne of biodegradable waste, corporation is spending 550 rupees on an average. Corporation collects 3 Rupees per Kg for biodegradable waste and 5 Rupees per Kg for Chicken and plastic waste from the residents and commercial establishments (Corporation of Cochin). The existing waste treatment practice followed by the city is shown in Fig. 1.

2.1 Sources and quantities of MSW

The major source of MSW in the city include domestic waste sources, commercial establishments, marriage and community halls, hotels and restaurants, markets, institutions, schools, offices, street sweepings, hospitals(Non infectious), slaughter house, construction and demolition etc. The total daily production of MSW in city is 180- 250 metric tonnes. The percapita waste generation is 482g/day/head.

2.2 Collection and segregation of solid waste

Corporation of Cochin collects the solid waste in the city in a daily basis. The waste is being collected from the households and commercial and other type of institutions by means of Kudumba Sree units and also by corporation directly. Almost 90% of collection is done by means of Kudumba Sree units. Segregation of waste is being done at the collection point itself. There are 140 primary vehicles for collecting waste including tricycles.

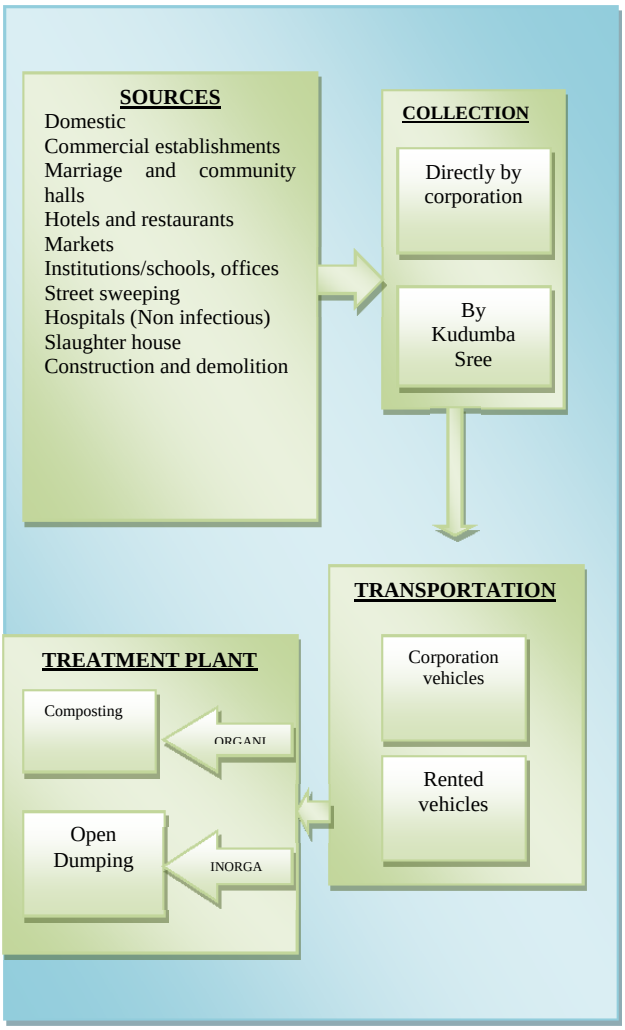

Fig. 1: MSW management practices at Cochin city

Fig. 2. Collection and segregation of MSW

Table 1: Quantity of MSW in the city (KSUDP)

MSW Generation sources	Quantity
Domestic soures	134.7
Commercial establishments	32.99
Marriage and community halls	4.75
Hotel and Restaurants	29.9
Markets	20.39
Institutions / Schools, offices	14.75
Street sweepings	31.3
Hospitals (Non infectious)	4.22
Slaughter house	5.26
Construction and Demolition	17
Total	295.26
Per capita generation(g/day/head)	482

Fig. 3. A tricycle used for MSW

Table 2: Physical composition of MSW at collection point and dumping site (KSUDP)

Type of MSW	Collection Point(%)	Dump site(%)
Paper	4.87	4.42
Plastic	4.83	4.1
Metals	0.35	1.03
Glass	1.06	2.04
Rubber and Leather	1.5	1.42
Inerts	1.74	1.81
Ash and fine earth	1.68	3.68
Compostable Organics	79.78	77.14
Domestic Hazardous	0.28	0.74

Table 3: Chemical characteristics of MSW at the dumping sites of Cochin (KSUDP)

Property	Value
Density(Kg/m3)	267.81
Moisture Content(%)	55.29
Caloric Value(K.Cal/kg)	1759
pH	7.5
C(%)	26.4
N(%)	1.25
C/N	21.1

Table 4: Heavy metal content in MSW at the dumping site in Cochin(After KSUDP)

Heavy metal	Quantity
Ar Mg/Kg	5.72
Ni ppm	4.49
Cd ppm	0.38
Pb ppm	2.48
Cu ppm	47.53
Zn ppm	98.98
Hg Mg/Kg	<0.1

3. TREATMENT PLANT

The existing waste treatment plant is located at Brahmapuram. The Brahmapuram plant is of area 106 acres. The plant is treating only biodegradable waste and all the other waste, including plastic and sanitary is being dumped outside the plant. In the plant bio wastes from Ankamaly, Aluva, Kalamassery, Thrikakara, Tripunithura municipalities are also being treated. Brahmapuram plant treats 220 tonnes biodegradable waste and receiving 72 tonnes non biodegradable waste on an average on a daily basis. There are almost 60 workers at the plant. All are contract workers. (Corporation of Cochin) The organic waste is being treated at Brahmapuram using Inoculum bacteria in aerobic method (aerobic decomposition). The capacity of the palnt is 220 metric tonnes per day (Corporation of Cochin).

The existing plant at Brahmapuram is in a dilapidated condition. The treatment facility is only for organic wastes. And other wastes including hazardous wastes are open dumped outside the decomposing plant. This has led to serious environmental issues. The air quality of this area is affected. The odour nuisance from the plant is beyond control.

The main problem happens with this plant is the contamination in the surface water bodies. The plant is on the shores of river Kadambrayar. The water life is being affected by the existence of plant. The current issues including migration of people from neighbourhood shows that it is high time to check the efficiency of current open dumping practice followed in the city.

The site is near to many of Kerala's prestigious developmental projects like Smart city, Infopark, Cochin metro etc. So the odour nuisance caused by the plant in these areas will be a major setback.

Fig. 4. Open dumping of waste outside the plant

Fig. 5. Dumping site

Fig. 6. Existing treatment plant

4. QUESTIONNAIRE SURVEY

A questionnaire survey was conducted as part of the study to understand the main problems and impacts of the current waste treatment practice of Cochin City. The main objective of the survey was to identify and analyze the impacts of current waste treatment process at Brahmapuram waste treatment plant. The questionnaire consists of 26 questions, out of which 9 questions were preliminary yes or no questions. And questions 10 to 26 were having 2 parts which allow the respondent to quantify the extent of the effects.

The survey was done with the people residing in a 5 KM radius from the plant at Brahmapuram. The sampling technique used is area surveying. 2 respondents from 1Km^2 area are selected. The number of household units who participated in the survey was 180. The respondents were approached individually at their homes to get their responses. The major findings from the survey include different negative impacts to the human health, environment and water body due to the existence of the Brahmapuram waste treatment unit. Some of the important responses are shown below as tables.

Table 5: Percentage Responses

Factors	Response(%)		
	yes	neutral	no
Decreased air quality	93.9	5.6	0.6
unpleasant odour	100	0	0
Dust issues	37.8	32.2	30
Pollution in the Kadambrayar river	95.6	0.6	3.9
Ill effect on water life	98.3	0.6	1.1
Decrease in drinking water quality	92.2	0.6	7.2
Ill effect on agricultural land	53.9	8.3	37.8
Decrease in land value	96.1	1.1	2.8
Migration from the area	84.4	15	0.6
Ill effect on developmental projects	90	3.9	6.1
Effect on operational cost of buisiness	77.2	11.1	11.7
social issues because of the plant	54.4	39.4	6.1
noise pollution	33.3	20	46.7
Decrease in littering of waste	48.3	22.2	29.4
Sufficient transportation methods	19.4	21.7	58.9
Noise pollution due to the transportation	93.3	3.9	2.8
effect on religious places	34.4	31.7	33.9

Table 6: Extent of effect

Factors	Extent of effect				
	None	Mild	Acceptable	High	very high
Decreased air quality	6.1	2.8	13.3	75	2.8
unpleasant odour	0	0	6.1	62	32.2
Dust issues	65	18.9	14.4	1.7	0
Pollution in the Kadambrayar river	4.4	3.9	3.9	74	0
Ill effect on water life	1.7	8.3	21.1	53	16.1
Decrease in drinking water quality	7.8	32.8	25	34	0.6
Ill effect on agricultural land	45	37.2	5.6	12	0
Decrease in land value	4.4	37.2	34.4	23	0.6
Migration from the area	15	45.6	22.8	16	0.6
Ill effect on developmental projects	10	52.2	26.7	11	0
Effect on operational cost of buisiness	22	71.1	3.3	3.3	0.6
social issues because of the plant	46	47.8	6.1	0	0.6
noise pollution	68	31.7	0.6	0	0
Decrease in littering of waste	52	7.2	32.8	6.1	1.7

Sufficient transportation methods	77	16.1	5	1.1	0.6
Noise pollution due to the transportation	7.2	27.2	30.6	35	0
effect on religious places	67	33.3	0	0	0

From the questionnaire survey it was found that there are several environmental issues pertaining at the area. 81.1% of respondents participated in the survey does not find the existing waste treatment practice is not sufficient for the city. 91.1% of household have health problems due to the plant. And 48.9% of them incurred significant financial problems because of the health issues.88.3% of respondents feel that their revenue is affected by the existence of the plant.

5. MSW MANAGEMENT SOLUTIONS

Numerous MSW management practices are being used worldwide. In India, open dumping is the most common practice. Newer MSW practices are being focussed upon to improve MSW management operations and to reduce environmental issues [15, 16]. Some of the commonly used MSW management practices in India are;

- Open dumping
- Land filling
- Composting (Aerobic and Anaerobic)
- Incineration
- Bio methanation
- Gasification
- Refuse-derived Fuel
- Material recovery

The existing plant has two main components, i.e., 'Aerobic composting' and 'Open dumping'. There is currently a proposal to setup a new waste treatment unit in Brahmapuram by the Government of Kerala. The main components of the proposal include 'e-waste recovery', 'Aerobic composting' and 'Open dumping'. The current waste treatment practices at the city cannot be considered as sustainable. The problems related to open dumping of inorganic waste are crucial rather than the decomposition of biological waste. Here an integrated waste management solution is suggested.

5.1 Integrated MSW Management system

The method proposed is an integrated solution which consists of 4 methods, i.e., 4R(Reduce, Recycle, Recover, Reuse), Composting, Gasification and land filling. By combining four of the above said methods it is possible to reduce the issue of waste management of the city.

4R is a method which should be adopted by every person of the city in order to attain maximum cleanliness in the city. Recycling is Using waste as material to manufacture a new product. Reducing is the process of minimizing the waste generation by adopting a philosophy to embrace resource conservation efforts. Recovering is the conversion of waste materials for the recovery of the energy values contained within the waste material (BTUs or protein). Reuse encompasses the entire spectrum of used goods. Reuse can be done by refurbishing, repairing or remanufacturing [3]. Composting is a technology which is already in practice at the plant. It refers to the decomposing of waste materials to fertilizers. In Cochin Inoculum bacteria is used to make the decomposing faster. Gasification is a process that devolatilizes solid or liquid hydrocarbons, and converts them into a low or medium BTU gas. Gasification has several advantages over traditional combustion of MSW. It takes place in a low oxygen environment that limits the formation of dioxins and of large quantities of SOx and NOx [2]. Gasification is an effective method which can be used to energy recovery. The energy recovered by this method can be used for the day to day operations of the plant and it will be economically beneficial for the corporation of Cochin. Sanitary land filling of the wastes will be adequate for the city. The wastes which cannot undergo neither composting nor gasification can be used in sanitary land filling. Sanitary landfills are the sites where waste is isolated from the environment until it is safe. It is considered when it has completely degraded biologically, chemically and physically.

The integrated waste management will be possible only through the cooperation of public. For that there should be public awareness programs which would introduce the concept of 4R to the common people.

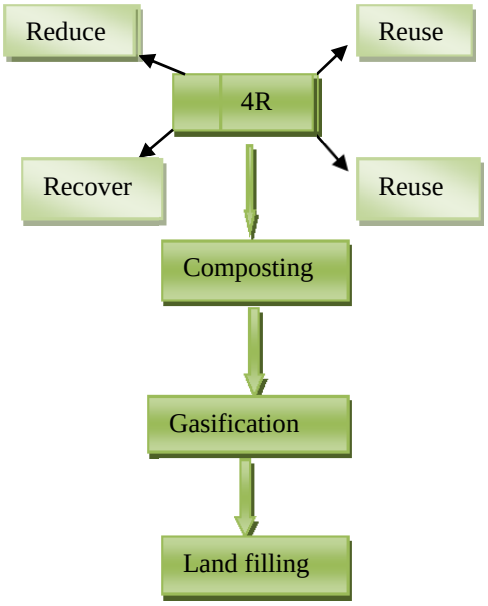

Fig. 8: Proposed integrated solid waste treatment for Cochin city

6. CONCLUSION

Data regarding the municipal solid waste management are collected. Main problems related to the waste management are identified from both the questionnaire survey, interviews and also from the direct observation. An integrated waste management solution is proposed. The municipal solid waste management practice in the city includes composting of organic wastes and open dumping of other wastes. This method is not sufficient for the city. An integrated solid waste treatment is required. This paper suggests an integrated approach to solid waste management. Further studies should be done on the feasibility of this method. Environmental Impact assessment will be a suitable method of feasibility study in this case. All the negative impacts that may cause by this project should be analyzed. Sustainability can be achieved only through impacting the environment positively.

REFERENCES

[1] Hazra, T., & Goel, S. (2009). Solid waste management in Kolkata, India: Practices and challenges. *Waste management, 29(1),*2009,p 470-478.

[2] Klein, A., Gasification: an alternative process for energy recovery and disposal of municipal solid wastes ,*Doctoral dissertation, Columbia University*, 2002

[3] First Nations of Quebec and Labrador Sustainable Development Institute. (2008). Reduce, Reuse, Recycle and Recover Waste: A 4R's guide for the First Nations communities of Quebec and Labrador.

[4] Guerrero, A.L., Maas, G., & Hogland, W."Solid waste management challenges for cities in developing countries", *Waste Management 33*, 2013, p 220–232.

[5] C. Visvanathan, J. Trankler, "Municipal Solid Waste Management in Asia: A Comparative Analysis", *Asian Institute of Technology.*

[6] Joonas Hokkanen, Pekka Salminen, "Choosing a solid waste management system using multicriteria decision analysis", *doi:10.1016/0377-2217(95)00325-8*.

[7] G. Fred Lee, R. Anne Jones, "Municipal solid waste management: long-term public health and environmental protection", *NWWA National Outdoor Action Conference Las Vegas*, Nevada ,1991.

[8] Alexander Klein, Nickolas J. Themelis, "Energy Recovery from Municipal Solid Wastes by Gasification*", North American Waste to Energy Conference (NAWTEC 11)*, 2003, p. 241-252.

[9] Christian Zurbrügg, "Urban Solid Waste Management in Low-Income Countries of Asia How to Cope with the Garbage Crisis", *Scientific Committee on Problems of the Environment (SCOPE)*, 2002.

[10] Seth Schindler, Brij Kishore ,"Why Delhi cannot plan its 'new towns': The case of solid waste management in Noida", *Geoforum* 60, 2015, p33–42.

[11] WeijianXue, Kai Cao, Wenwen Li . "Municipal solid waste collection optimization in Singapore", *Applied Geography 62*, 2015, 182-190.

[12] Giulio Cainelli, AlessioD'Amatob, Massimiliano Mazzantic. "Adoption of waste-reducing technology in manufacturing: Regional factors and policy issues*", Resource and Energy Economics 39*, 2015, 53–67.

[13] AgataMesjasz-Lech,"Municipal waste management in context of sustainable urban development", *Procedia - Social and Behavioral Sciences 151*, 2014 , 244 – 256.

[14] R Gidde,V V Todkar, K KKokate, "Municipal solid waste management in emerging cities, a case study of Pune city", *IICGC* 2008.

[15]Joshi, R., & Ahmed, S.,Status and challenges of municipal solid waste management in India: A review, *Cogent Environmental Science*, 2(1), 1139434,2016

[16] Gupta, N., Yadav, K. K., & Kumar, V. 2015). A review on current status of municipal solid waste management in India. *Journal of Environmental Sciences, 37*, 206-217, 2015

[17] Kerala State Urban Development projects(KSUDP), 2010, Municipal Solid Waste Of Major Cities

[18] Central Pollution Control Board (CPCB), 2004. Management of Municipal Solid Waste, *Ministry of Environment and Forests, New Delhi, India*.

[19] CPCB, 2000, Status of Solid Waste Generation, Collection, Treatment and Disposal in Metro cities, *Series: CUPS*/46/1999–2000.