A STUDY ON MUNICIPAL SOLID WASTE AND ITS EFFECT ON METHANE EMISSIONS FOR KANCHIPURAM MUNICIPALITY, TAMIL NADU

VE NETHAJI MARIAPPAN[1]*, S PARTHIBAN[2] AND R PYNTHAMIL SELVI[3]

[1]Scientist-F, Centre for Remote Sensing and Geoinformatics, India

[2]Senior Scientific Assistant, Centre for Remote Sensing and Geoinformatics, India

[3]ME Student, Department of Chemical Engineering, Sathyabama University, Rajiv Gandhi Road, Jeppiaar Nagar, Chennai- 600119. India.

ABSTRACT

A lot of waste is generated from each household in the form of solid waste, sludge that are disposed improperly. Municipal Solid Waste (MSW) of Pallavan Nagar of Kanchipuram Municipality was taken up for field investigation on waste collection, segregation, questionnaire survey, face-to-face interviews were employed among the residents for this study. Municipal Solid Waste (MSW) of 215 houses in the ambit of Pallavan Nagar, Kanchipuram Municipality was collected, segregated and weighted with the help of Hand in Hand - A Non Government Organisation (NGO) for a period of one month starting 13th December 2010 to 11th January 2011. Household waste was classified into eight categories viz., Organic matter/food waste, Paper and Cardboard, plastics, glasses, foot wares, cloths, and metals and miscellaneous. The study concluded that total amount of waste generation arrived with the available dataset was about 1632 kg/month. Among the classes Organic matter/food waste was highest (54.18%); miscellaneous (18.81%) and metals (0.40%). Waste generated from plastics resulted to (11.71%) and from foot wares (1.01%) and Methane and N2O emission from landfill was of 1.24 Gg/yr and 760 kg/yr. Results of this study established waste disposed during weekend period was relatively higher than weekdays. Proportion of waste like glasses, clothes, Paper and Cardboard and Card Board and foot wares are higher during weekends and low during weekdays. An appropriate planning of waste management has to be inculcated among the residents of Pallavan Nagar of Kanchipuram Municipality for a sustainable solid waste management.

INTRODUCTION

The rapid urbanization experiencing in the cities of the world has accentuated for a plethora of environmental challenges within the different residential spheres. These problems include urban sprawl, decaying inner-city, inadequate housing, crime, and congestion, among others. (Oresanya, 1998). Waste is classified as solid, liquid, or toxic, has become a major consequence of modernization and economic development (Tsiboe, *et al*., 2004. Notably, the solid form of waste is fast becoming a menace in both developed and developing Nations (Contreras, *et al*., 2009; Musademba, *et al*., 2011). Usually, municipal solid wastes in developing countries share some common characteristics of high food wastes and moisture content (Visvanathan, *et al*., 2004). In the tropics, a clear distinction in rainfall pattern between dry (summer and winter) and wet (rainy) seasons also provides a unique environmental condition (Chiemchaisri, *et al*., 2007). The management of domestic solid waste is one of the huge challenges of the urban areas of all sizes. MSWM system comprises four activities, i.e., waste

---

*Corresponding authors email: nethajim@gmail.com

generation, collection, transportation, and disposal. (Bundela, *et al.*, 2010; Cai, *et al.*, 2007). Four activities of MSW in most of the semi urban municipality remain at a very nascent stage. Improper disposal of MSW by residents coupled with improper coordination in collection and non periodic removal of waste lead to accumulation of MSW especially at street corners, temples, hospitals and marriage halls. The part of waste disposal such as plastic, metals, batteries, coils etc., of the municipal waste is picked up by the rag pickers and by passers dispose for money at waste disposal shops. Unscientific disposal causes an adverse impact on all components of the environment and human health (Rathi, 2006). Unregulated dumping and open burning are still considered as the ultimate waste disposal methods. Proper coordination is required for collection of MSW and disposal at landfill site need to be updated in all metropolitan cities.

Municipal Solid Waste (MSW) generation in Kanchipuram has increased from 20 tonnes to 80 tonnes per day within the last 10 years (Pynthamil and Joshua, 2011). Significant amount of waste is disposed without proper segregation leading to both economic & environmental sufferings. The most common problems associated with improper management of solid waste include disease transmission, odour nuisance, atmospheric, land & water pollution, fire hazards, aesthetical nuisance & economic losses. Therefore, it is better to segregate the waste at the household level where it is generated rather than segregating it centrally which is cumbersome & expensive (Nethaji and Pynthamil, 2015). Land filling is the one of the method used for the discarding of industrial waste in Chennai, and the majority of the landfill sites are open dumping areas, which causes severe environmental and social threats (Nethaji and Prathiba, 2012). There is currently a limited statistical data available in India. Generation and composition of waste are commonly calculated using the waste arriving at the final disposal site (Gustavsan, 2008). Therefore, this study attempts to understand the composition of MSW generation of Pallavan Nagar and dynamics of waste generation during week and weekend days. Non-Governmental Organisations (NGO) in association with corporation staff play a vital role in garbage collection, segregation, disposal of managing MSW in Kanchipuram Municipality.

RESEARCH METHODOLOGY

Study Area

Kanchipuram municipality is located in the South West direction at a distance of 76 km from Chennai.

It is situated at 12°50′ North Latitude and 79°42′ east longitude. The town has an average elevation of 83 m above Mean Sea Level (MSL). The main land lies on the northern bank of the River Vegavathi, a tributary of the River Palar. The town has more than 1000 temples. It is also a fast growing town with many Special Economic Zones around it. The town being a district head quarters and an important pilgrimage centre attracts daily floating population of about 18500 people. Total population of the city is around 1,66,300 as per 2010 census of India report. The population of the city has increased nearly 10% within last 10 years. Due to urbanisation, change in lifestyle and food habits the amount of solid waste has rapidly increased accompanied by the change in composition of solid waste.

Climate

The Kanchipuram district usually maintains a mean minimum and maximum temperature is 20°C and 37°C respectively. The highest temperature is observed to a maximum of 43°C during summer season. Rainfall is received through South West and North East monsoons. Maximum rainfall is received from northeast monsoon period. Relative humidity's are high between 58 and 84% prevail throughout the year. Higher rates of relative humidity are observed between November and January i.e., 83% to 84%. In the months of June, the humidity is lower i.e., around 58% (Fig. 1).

Vegetation

Kanchipuram district lies in Sub tropical region possessing a large number of tanks.

Major crops such as Paddy, Sugar cane, Ground nut and vegetable crops are cultivated in and around Kanchipuram district. Adequate water is available for raising crops for a minimum of two seasons in a year. In the recent past quiet a large number of Industries are well established in the ambit of Kanchipuram district. This phenomenon has led to increase in residential areas in the fringes of the Municipality. Pallavan Nagar is one such settlement where a large number resident belongs to people working Kanchipuram Collectorate office.

Topography and Geomorphology

The prominent geomorphic units identified in the district through interpretation of satellite imagery are i) Chingleput-Tirukkalukkunram Surface (Erosional) ii) Palar Surface (fluvial and iii) Mamallapuram (Mahabalipuram) surface (Marina) etc. The elevation of the area ranges from 100 m amsl in the west to a sea level in the east. The major
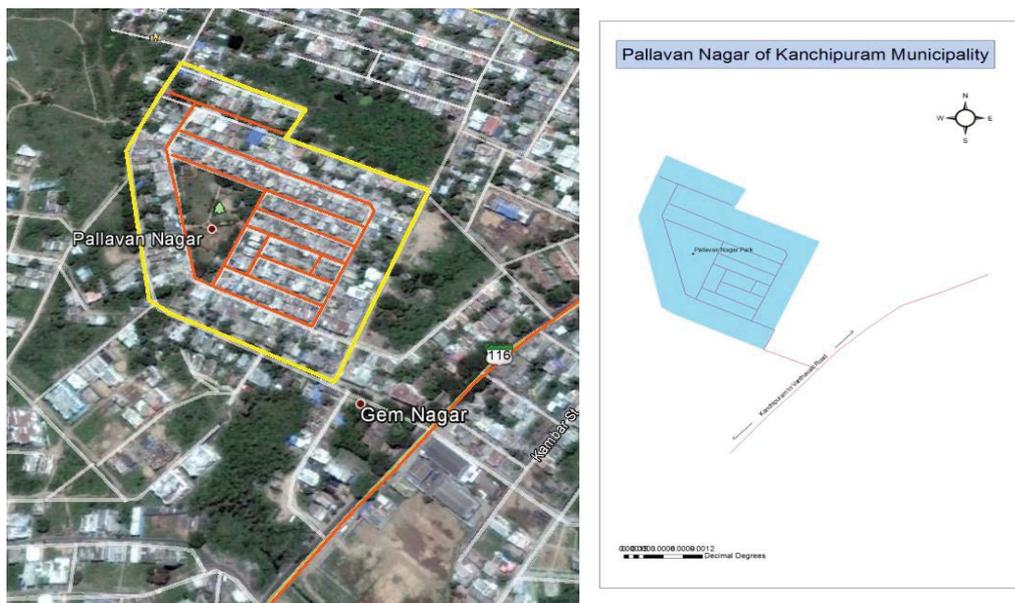
Fig. 1 a) Google earth showing Pallavan nagar of Kanchipuram **b):** Study area Pallavan nagar map.

part of the area is characterized by an undulating topography with innumerable depressions, which are used as irrigation tanks. Soils have been classified into 1) clayey soil, 2) red sandy or red loamy soil 3) Red sandy brown clayey soil and 4) Alluvial soil. Of the above soils brown clayey soil is the most predominant, covering more than 71 percent of the areal extent of Kancheepuram district. Alluvial soils are found on the banks of Palar, Cheyyar and other rivers. The river alluvium is transported and is seen in coastal area of this district. Sandy coastal alluvial (arenacious soil) occurs along the seacoast as a narrow belt (CGWB, 2007).

Role of NGOs

NGOs are the only group who have been successful in Municipal Solid Waste Management system. Their work involves in house hold waste collection, segregation, dumping at a common place with proper and adequate measures. They share a common goal of instituting a waste collection and disposal in a sustainable manner. Hand-in-Hand is one such NGO involved in waste disposal mechanism of Pallavan Nagar of Kanchipuram Municipality. Their stint to this activity has been for a long duration of time that has kept the study site in a clean environment. Approximately ten social workers are involved in collection, segregation, and dumping at common bin at each street corner. They usually come in tricycles having few bins and a garbage bag.

Data Collection

Pallavan Nagar which is situated next to the Kanchipuram Collectorate has been selected for this

study which comprises people from various socio – economic background. The study area comprises of 215 houses with 816 people. Initially public awareness has been created among the people though personal interaction at household level, through questionnaires and by conducting interviews. This survey has been conducted during the period of 13th December 2010 to 11th January 2011. Hand in Hand, a NGO has been working on the MSW management in this locality for the last two years.

Waste Classification

Data on waste collected from each household were weighed using a weighing balance. Such waste was later segregated into 8 classes namely i) Organic matter/food waste (include raw vegetables, cooked food, dry and wet leaf litter) ii) paper and cupboard (news paper, reading books, note books, magazines, compressed wood, wood chips) iii) Plastics (pet bottles, carry bags of various microns, stationary bags, school bags) iv) Glass (mirror, sanitary bottles, alcoholic bottles and miscellaneous bottles v) cloths -vi) metals vii) foot wares viii) miscellaneous.

Questionnaire Analysis

Public Awareness Questionnaire was prepared for a total of 215 houses.

comprising 816 residents. They include type of waste generated, nature of waste collection, how to group waste, handling of waste, disposing location, time of disposal and responses related to storing of waste in each house, placing of waste outside their house, etc. Ten social workers from Hand in Hand, were involved in collection the waste generated from the

houses has been segregated at a common point and has been weighed during the same duration. Upon analysis of the data the composition, per capita waste generation of MSW were worked out for Pallava Nagar of Kancheepuram municipality.

RESULTS AND DISCUSSION

Questionnaire

Residents of pallavan nagar usually collect household waste and store in disposable plastic bins or plastic bags usually referred as carry bags, paper boxes, baskets, unused buckets, or any container that are supposed to be disposed in near future. Typically they use a polythene bag usually of storing waste that is in small quantity. Some of the waste that is greater in size which could not be accommodated in the polythene bag was stored in bins.

A total of 1632 kg waste was generated for the whole duration; include 52% of organic matter waste, 30% of recyclable waste and 18% of inert waste. Generally, during the segregation of waste valuable waste, recyclables are sorted at a common facility was sold via waste selling mart. Amount generated was shared among the NGOs of that locality used towards their incidental charges. The safe disposal of solid waste by the residents and by the NGOs was the ultimate stage in solid waste management system, influenced by factors such as characteristics of waste to be disposed, cost consideration, availability of disposal site, cost of labour, and technical implication of methods of disposal. The resident's use of designated places, incidental open spaces, drains, on river banks, beside road as their places of disposal. NGOs usually collect

waste from all those places within their boundary and dispose off at common facility usually at street corners. Apart, some of the residents use to dispose waste in uncompleted building, vacant land that are beyond the reach of NGOs. Literacy of the study area also determines handling, segregation, storing and disposing of household waste at the right place and time.

Some residents those do not have patience to store waste may drop it either in the front or backyard of their house. Improper disposal of waste was more common among the aged people and the children in that locality whereas, middle aged people precariously store it in their dustbins of their residence.

Data Segregation

Municipal solid waste data pertaining to Pallavan Nagar was collected for a period of one month (i.e. 13th December, 2010 to 9th January, 2011). Daily data were then aggregated to week and weekends shown in Table 1. Week days usually represent (Monday-Friday) and weekend days (Saturday-Sunday) thus it encompasses five week's and four weekend's average for the entire study period.

Waste collected from each household was segregated by the NGOs as biodegradable and inert

waste. Plastics, metals and glasses were disposed in a separate bin. At the end of each street they further segregate into eight classes as mentioned in Table 2. Each group of waste was later weighed using weighing balance and disposed in common disposal bin. Thus all the data were averaged for week and weekend period in Table 2.

Table 1. Shows the MSW data segregation for week and weekend days

Variables	Avg	Avg	Avg	Avg	Avg	D Avg	Week Avg	End Avg	Avg
Dates	13-17 Dec	20-24 Dec	27-31 Dec	03-07 Jan 2011	10-11 Jan 2011	18-19 Dec 2010	25-26 Dec 2010	01-02 Jan 2011	08-09 Jan 2011

Table 2. Average MSW generated during week days and weekend for the study period

Nature of Waste	Average (Kg)	Average (Kg)	Average (Kg)	Average (Kg)	Average (Kg)	Average (Kg)	Average (Kg)	Average (Kg)	Average (Kg)
Organic/Food waste	105.40	92.38	104.85	84.75	100.74	88.50	108.20	88.63	110.38
Paper	15.30	16.00	15.55	19.38	170.80	18.25	18.60	17.63	26.00
Plastics	18.15	20.25	19.45	24.38	20.10	24.75	21.55	19.88	22.50
Glass	2.35	2.50	2.30	4.13	2.25	4.75	3.10	3.13	3.13
Cloth	0.00	1.75	0.00	5.13	0.30	4.10	4.70	10.63	6.50
Metals	0.30	0.63	0.15	1.38	0.30	1.00	0.40	1.38	1.00
Foot ware's	1.10	0.75	0.40	2.50	1.15	2.00	1.85	4.50	3.75
Miscellaneous	36.30	34.00	33.90	39.63	33.75	34.13	38.10	30.38	26.63
Total Weight	178.90	168.25	176.60	181.25	176.39	177.48	196.50	176.13	199.88

Proportion of waste from Organic matter/food waste was usually higher followed by miscellaneous waste. Paper and plastics were in next category approximately contributed 15% out of total waste. Waste such as glass, metal and cloth and foot wares are relatively less in proportion but significantly contribute pollution to the environment. Distribution of waste varied for week and weekend period, however quantum of waste disposed during weekend were relatively higher than week days.

Gradual increase in waste disposal was observed from 1st week of December, 2010 to 2nd week of January, 2011. Such an increase in disposal municipal solid waste coincided with Christmas vacation (last week of December) followed by beginning of Pongal vacation (second week of January) resulted in higher disposal of waste from family members and children of that locality. The tradition of disposing waste before the religious function was a common phenomena among the people of Tamil Nadu that resulted in increase in quantum of waste disposal from beginning to the end of the study period. Furthermore, children dispose papers, plastics, cardboard and PET bottles that were observed in this study.

MSW Data Analysis

A statistical analysis covering minimum waste, maximum, mean and standard deviation values of waste recorded for study period are listed in Table 3. It was observed that Organic waste was higher with a minimum value of 84.25 kg/day to maximum of 119.25 kg/day, whereas an average minimum 92.38 kg/week and average maximum of 110.4kg/week were recorded for the 2nd weekend and 5th week respectively. Waste from paper was highest 30kg/day and a minimum of 13 kg/day as against an average minimum 15.3kg/week and average maximum of 26kg/week were recorded for the 1st week and 5th week respectively. Glass, metals and footwear's contributed less than 10 kg/day. Maximum amount of cloth 18.5kg/day was disposed with an average weekend highest of 10.63kg on 4th weekend attributed to winter vacation.

On an average disposal of organic/vegetable waste seems to be higher followed by miscellaneous,

plastics and paper. Footwear, glass and metals are non bio degradable even in minor quantities pollute the environment. Residents usually dispose non recyclable waste in dustbins during weekend days. It was observed that week days viz., Monday and Friday the amount of waste disposed was high, whereas weekends were comparatively less. Such waste was collected by government refuse van that area dumped in landfill site located outside Kanchipuram Municipality. Landfill gas created from decomposition processes of solid wastes were mainly composed of methane and carbon dioxide. The produced gases, if not properly managed, could create several adverse effects, such as health risks or global warming consequences.

Dynamics of MSW

From the study, it has been found that there has been a substantial increase in the amount of plastic disposed in the MSW, which would result in environmental degradation upon not being managed properly. (Fig. 2a and 2b) depicts proportion of waste category disposed during week and weekend days. Quantum of waste disposed as organic waste, paper, plastics and miscellaneous were relatively higher during week and weekend days in (Fig. 2a). Proportion of disposal as glass, cloth, metals and footwear's were less than 12 kg/week in (Fig. 2b). Highest amount of cloth was disposed in the first week January, 2011 coinciding with bogie celebration, where people in Tamil Nadu usually dispose/burn clothes, tyres and foot wares. Despite its low disposal, its degradability was meager upon burning may cause environmental pollution to the atmosphere.

Greenhouse Gas Emissions from MSW

(IPCC, 1996), methodology was adopted to derive Greenhouse Gas Emissions from Kanchipuram Municipality by following the procedures of IPCC Good Practice Guidance, 1996 for estimating CH_4. MSW data collected from Pallavan Nagar of Kanchipuram municipality for the year 2011 has been extrapolated and employed in this study. CH_4 is calculated as follows.

$$CH_4 emissions\ Gg\ /\ yr\ = [MSW_T * MSW_F * L_0] - R]*(1 - OX)$$

(Eq. 1)

Table 3. Maximum, minimum and mean values of classified waste category

| S. No	Organic Waste	Paper	Plastics	Glass	Cloth	Foot wares	Miscellaneous
Per day waste Minimum (kg)	84.25	13.00	1.75	0.00	0.00	0.00	24.75
Per day waste Maximum (kg)	119.25	30.00	5.00	18.50	2.00	6.00	43.00
Per day waste mean (kg)	100.84	17.69	2.84	2.71	0.55	1.65	34.66
Standard Deviation	9.91	3.82	0.89	4.24	0.70	1.97	4.89
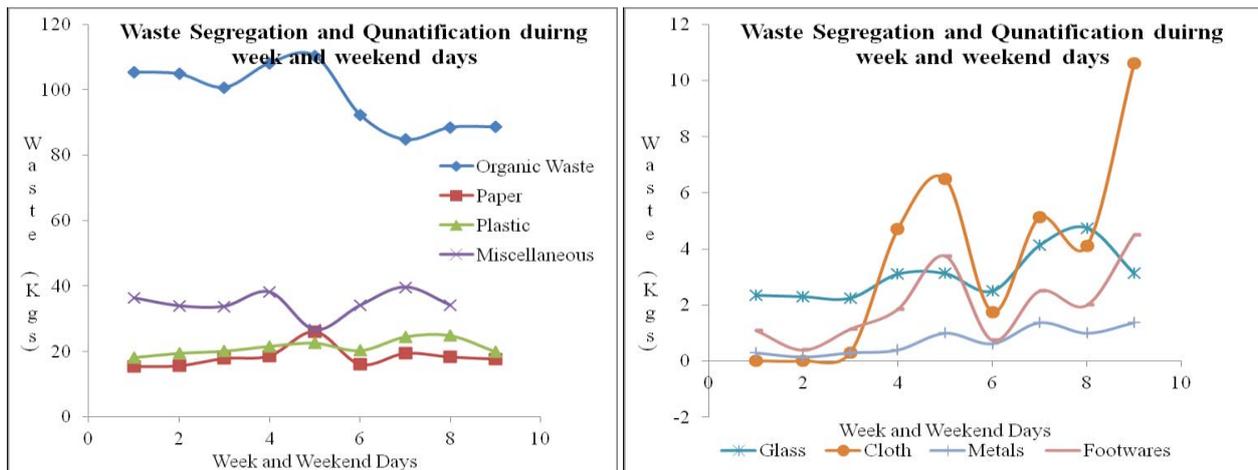
Fig. 2a and 2b Depicts proportion of waste category disposed during week and weekend days.

Thus total amount of MSW generated (Gg/year) is marked as MSW_T and Fraction of MSW disposed at Solid Waste Disposal Sites (SWDS) as MSW_F. Methane generation potential (L_0) is derived as (MCF × DOC × DOC_F × F × 16/12 (Gg CH4/Gg waste); Default values (0.4) prescribed by IPCC for Methane Emission Factor (MCF) is employed for this study. DOC_F described as fraction of DOC dissimilated was derived on a theoretical model (DOC_F=0.014 x Temp + 0.28 where the variation depends on the temperature in the anaerobic zone of the landfill as 0.62. Default values of 0 were used for recovered CH_4 (R) (Gg/year) and Oxidation factor (fraction) respectively. A value of 0.5 was used for Fraction of CH_4 in landfill gas by volume (F). DOC=Degradable organic carbon [fraction (Gg C/Gg MSW) as 37.83. The ratio of total CH4 emitted from Kanchipuram municipality for the year 2011 was of 1.49 Gg/Yr is similar to than estimates reported by (Arvind, *et al.*, 2008) for Chennai region.

Emitted methane from the landfill naturally undergoes biological treatment by aerobic decomposition in the disposal site (IPCC, 2006; Lino and. Ismail, 2013; Medina, 2000). Biologically treated methane can be estimated by a default method given hereunder.

$$CH_4 emissions\ by\ biological\ treatment\ (Gg/yr) = \sum (Mi * Efi) * 10^{-3} - R$$

(Eq. 2)

Thus, CH_4 Emissions described total CH_4 emissions in inventory year, $CH_{4,}$ (Mi) Mass of organic waste treated by biological treatment type i. (EF) emission factor for treatment i, g CH_4/kg waste treated and i as composting and (R) total amount of CH_4 recovered in inventory year. N_2O has been arrived to about 760 kg/yr is more likely nearest to value arrived by (Arvind, *et al.*, 2008) for Chennai region.

CONCLUSION

Number of dustbin in Pallava nagar need to be added in order to match the amount of waste generated for each street. Awareness programme on waste disposal, segregation of biodegradable and non biodegradable waste, also on the effect of pollution on human health needs to be promoted through NGOs. Manpower on MSW collection should be strengthened to improve done door to door approach. Organic matter waste can be composted by natural methods for composting. Alternative energy recovery from organic matter through biogas power generation could also be attempted to improve recovery efficiency. News Paper and Cardboard and Card Boards can be transferred to the printing and pulp industry. Other inert materials and miscellaneous residues can be disposed in closed landfills.

ACKNOWLEDGMENTS

REFERENCES

Arvind, K.J., Sharma, C., Nahar, S., Ramesh, P., Purjaja, R. and Prabhat, K.G. (2008). Greenhouse gas emissions from municipal solid waste management in Indian mega-cities: A case study of Chennai landfill sites. Chemosphere. 71 : 750-758.

Bundela, P.S., Gautam, S.P., Pandey, A.K., Awasthi, M.K. and Sarsaiya, S. (2010). Municipal solid waste management in Indian cities – A review.

International Journal of Environmental Sciences. 1 : 591-606.

Cai, Q., Mo, C., Wu, Q., Zeng, Q. and Katsoyiannis, A. (2007). Concentration and speciation of heavy metals in six different sewage sludgecompost. J Hazard Mater. 147 : 1063-1072.

CGWB. (2007). District Ground Water Brochure Kanchipuram District. Publ.: Central Ground Water Board, South Eastern Coastal region, Chennai, India.

Contreras, F., Ishii, S., Aramaki, T., Hanaki, K. and Connors, S. (2009). Drivers in current and future municipal solid waste management systems: cases in Yokohama and Boston. Waste Management & Research. 28 : 76-93.

Gustavsan, A. (2008). Implementation of solid waste management Kancheepuram Tamil Nadu state of India. M.Sc. Thesis. KTH Industrial Engineering and Management, Stockholm, Sweden.

Chiemchaisri, C., Chiemchaisri, W., Sunil, K, and Hettiaratchi, J.P.A. (2007). Solid waste characteristics and their relationship to gas production in tropical landfill. Environ Monit Assess. 135 : 41-48.

IPCC. (2006). Guidelines for National Green House Gas Inventories. 5 : 4.1-4.7.

Lino, F.A.M. and. Ismail, K.A.R. (2013). Contribution of Recycling of Municipal Solid Waste to the Social Inclusion in Brazil. Journal of Waste Management. 4.

Medina, M. (2000). Scavenger cooperatives in Asia and Latin America. Resources, Conservation and Recycling. 31 : 51-69.

Musademba, D., Musiyandaka, S., Muzinda, A., Nhemachena, B. and Jambwal, D. (2011). Municipal solid waste (MSW) management challenges of Chinhoyi town in Zimbabwe: opportunities of waste reduction and recycling. Journal of Sustainable Development in Africa. 13 : 2.

Nethaji, M.V.E. and Prathiba, P. (2012). Environment Assessment of Industrial Landfill Site in Tamil Nadu. International Journal of Current Research. 4 : 252-256.

Nethaji, M.V.E. and Pynthamil, S.R. (2015). GIS based municipal solid waste management solution for Kanchipuram Municipality. Journal of Advanced Research in Civil and Environmental Engineering. 1 : 17-22.

Oresanya, O. (1998). Waste control measures and responsibility of a waste manager within the framework of recent management methods and development in municipal and industrial wastes. in Proceedings of the Workshop on Effective Waste Management in Nigeria, The Nigerian Society of Engineers, Lagos, Nigeria.

Pynthamil, S.R. and Joshua, A. (2011). Study on the composition of municipal solid waste in Kanchipuram Municipality. International Journal on Applied Bioengineering. 5 : 40-43.

Rathi, S. (2006). Alternative approaches for better municipal solid waste management in Mumbai, India. Journal of Waste Management. 26 : 1192-1200.

Tsiboe, I.A. and Marbell, E. (2004). A look at urban waste disposal problem in Accra, Ghana [Masters thesis], Roskilde University, Roskilde, Denmark.

Visvanathan, C., Trankler, J., Joseph, K., Chiemchaisri, C., Basnayake, B. F.A. and Gongming, Z. (2004). Municipal solid waste management in Asia. Asian Regional Research Program on Environmental Technology. Asian Institute of Technology.