Proceedings of the 8th Academic Sessions, University of Ruhuna 2010
Vol. 8 pgs 95 – 101

BF - 05

Efficient and effective solid waste management system for Galle Municipality

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Abstract

The current solid waste management system in the Galle municipality is full of loopholes. Source separation is hardly practiced and unsorted solid waste is dumped on a semi-controlled landfill. Hence in this study, solid waste samples collected from 14 wards were analyzed; the current solid waste management system was studied carefully, and a questionnaire survey was conducted among 100 households. The results were used to develop a solid waste management plan based on the six functional elements of the integrated solid waste management. The study revealed that the solid waste was mostly organic with the highest percentage as 93.8. There was a decrease in the organic content and an increase of the polythene, paper and plastic content when compared to those in year 2005 and 2006. The moisture content was higher than the solid content. The highest calorific value was 18 MJ/kg, while the calorific values of normal fuels are higher than 45 MJ/kg. Thus the waste cannot be directly used for fuel generation. The moisture content of the composting piles remained less than 40 % for the entire composting run of 8 weeks. This had led harmful fungus to grow. The reduction of volatile solid content in the composting piles was from 72.8% to 31.3%. The key suggestions are source separation, introduction of composting and anaerobic digestion for all the biodegradable waste, introduction of recycling options for recyclables and an engineered landfill for the inert matter.

Keywords: solid waste, biodegradable, non-biodegradable, composting

Introduction

With the rapid increase of population and technology, the waste produced by various activities has been in the increasing phase. However, in many developing countries like Sri Lanka, proper management of solid waste (SW) is not yet available.

The SW generation normally depends on seasonal, environmental, geographical and cultural changes, thus making it a difficult task to manage using common methods. To implement a sound solid waste management (SWM) plan, a thorough analysis should be done on the waste composition, moisture content, calorific value etc. Application of the Integrated Solid Waste Management (ISWM), which incorporates a combination of several management options with the usage of state-of- the- art technology, is the best solution for the SW problem at present.

Galle is the major city in the southern province of Sri Lanka, with a population of 125,000 and an area of 16 km^2. SWM of the Galle municipality has been carried out by the Galle Municipal Council (GMC) for over a hundred years. The existing SWM system in the GMC is unsatisfactory is far from a proper solid waste management system. The municipality has been divided into fourteen wards, and SW in all the wards is daily collected. A small portion of the biodegradable solid waste is treated at a few composting plants and anaerobic digesters and the rest is disposed at a semi-controlled landfill. The energy from the anaerobic digester is used for some activities in the municipal council office and the compost produced is used at a farm and sold to the public on small-scale. The composting quality is low due to not using modern machineries like huller machines and cutters. Source separation is hardly practiced and unsorted solid waste is dumped on a semi-controlled landfill with no engineering principles. Therefore, this study is significant because it is timely and crucial to implement ISWM in the GMC.

The quantity of SW generation and solid waste characterization in a city is imperative for a sound SWM system. Physical and chemical characteristics of SW are important to implement an ISWM plan that includes the selection of resources and energy recovery potentials. The interrelationships between SW characteristics, socio-economic parameters, behavioral characteristics and seasonality can be used to develop efficient SWM strategies. Hence, with a thorough analysis of the quality and characteristics of solid waste in the Galle municipality, a proper waste management practice can be implemented. The aim of this study was to design a SWM plan in the GMC using an analysis of quality and characteristics of the municipal SW.

Materials and Methods

The study area (Figure 1) consisted of fourteen wards of the GMC, which are Fort, Bazaar, China Garden, Pettigalawatta, Magalle, Katugoda, Eliot Road, Kaluwella, Richmond Hill, Hirimbura, Ginthota, Kanampitiya, Market and Talapitiya. The study was based on three aspects, namely the waste characterization of the GMC; the public awareness and involvement; and the existing solid waste management system.

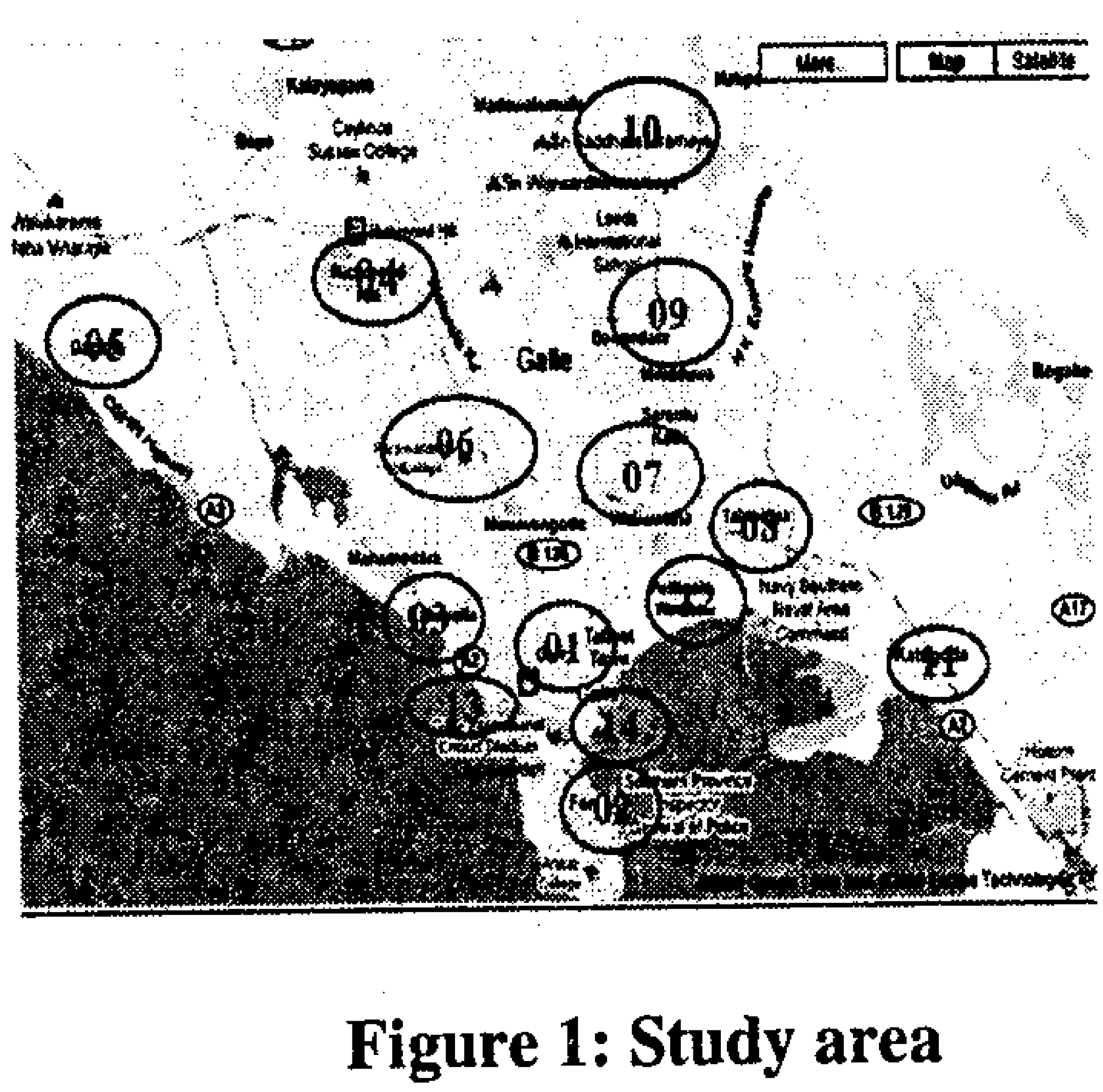

Figure 1: Study area

In characterizing the municipal SW, wastes were collected from the 14 wards and were subjected to the following analyses: SW composition, bulk density, percentage moisture and total solids contents, percentage volatile solids content and the energy content.

In order to determine the social awareness and involvement, a questionnaire survey was done among the waste handling personnel and general public of the GMC. A questionnaire was distributed among 100 households in the GMC to gather data on their awareness and involvement in SWM activities. It was also used to know their suggestions and weaknesses of the current SWM system from their viewpoint. The output of the survey was analyzed to understand the extent of the public awareness and involvement.

In addition, another questionnaire was distributed among 25 workers in the SWM sector of the GMC in order to collect data about their capability, safety and requirements. Based on the output, their level of training, job satisfaction, awareness on safety etc. were understood.

The study on the existing SWM system of the GMC was mainly focused on the existing transformation techniques. Composting and anaerobic digestion are the transformation techniques followed by the current system. In order to evaluate the performances of the existing composting plant at Heenpanthala, representative samples were collected from each of composting piles ranging from 1st to 8th weeks. Those samples were analyzed for the percentage moisture and volatile solids content.

Finally, based on the results of three afore-mentioned categories, key strategies for an ISWM plan for the GMC were suggested.

Results and Discussion

Characterization of solid waste

Composition

Figure 2 shows the composition of SW in each ward. It is significant that the SW from all wards contain a very high organic content. Almost all wards contain a considerable amount of polyethene, plastic and paper. Due to the high organic content, there is no doubt that the best treatment for this type of SW would be composting. Considering the organic content of the SW produced by each ward, waste from Dewata, Thalapitiya and Hirimbura have the highest percentages of organic content, 93.81%, 84.67% and 84.18% respectively. Therefore, SW from these three wards will give the maximum outputs in composting.

Figure 3 shows the variation of the average composition of SW of GMC with time. Comparing with the values of the year 2006 (Karunasiri, 2006) and the year 2005 (Pepper, 2007), there is a clear decrease of organic fraction of SW. The developmental activities and the changes in lifestyles of people can be a reason for the reduction of organic content by 7 % in three years. On contrary, the amount of polythene, plastic and paper have increased very much. It may be due to the extensive utilization of plastic and polythene. Modern technological advances in the packaging of goods create a constantly changing set of parameters for the designer of solid waste facilities. Of particular significance are the increasing use of the plastics and the use of frozen foods, which reduce the quantity of food wastes in the home but increase the quantities at agricultural processing plants (Tchobanoglous *et al.*, 1993).

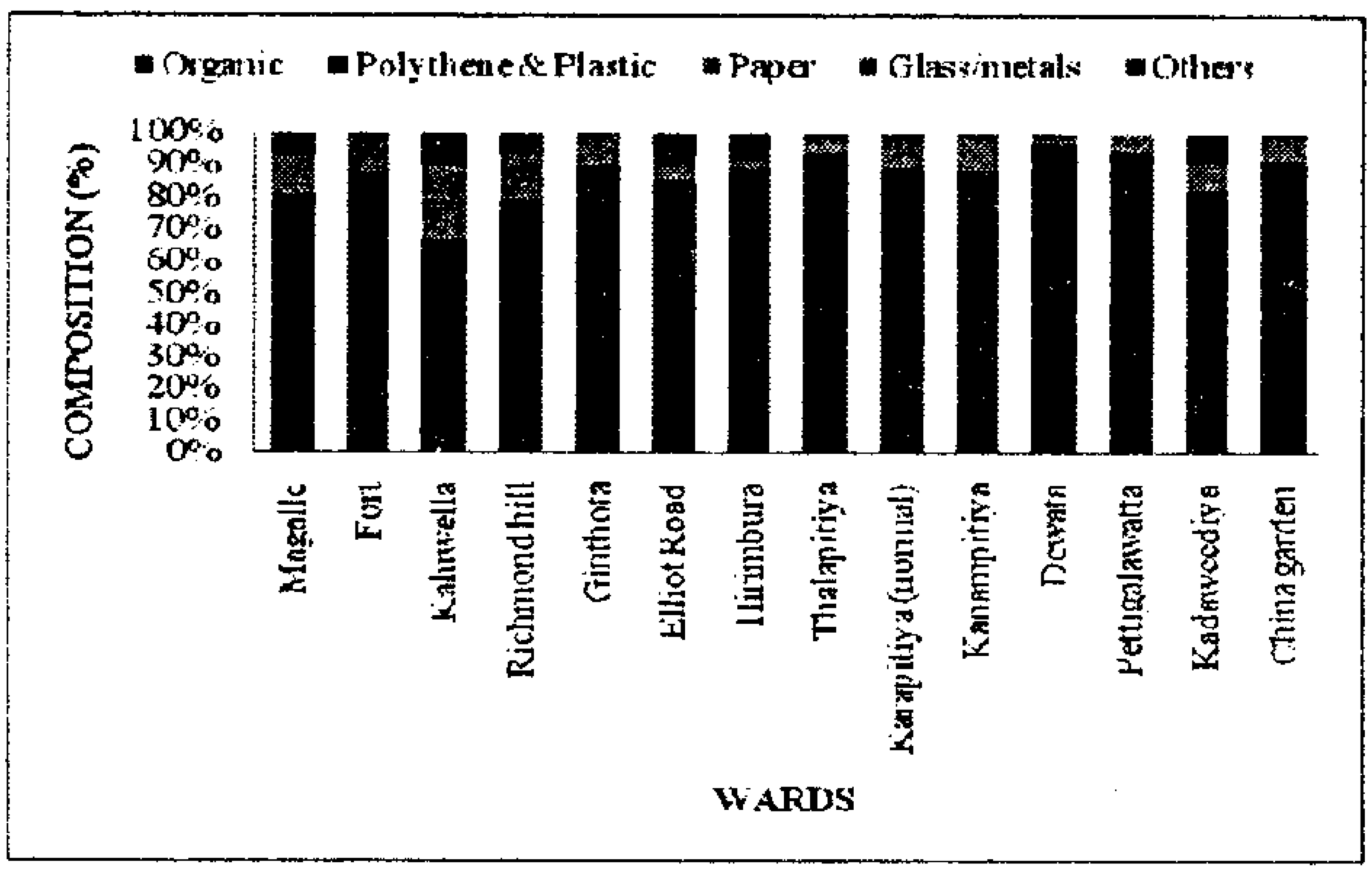

Figure 2: The composition of the solid waste in each ward

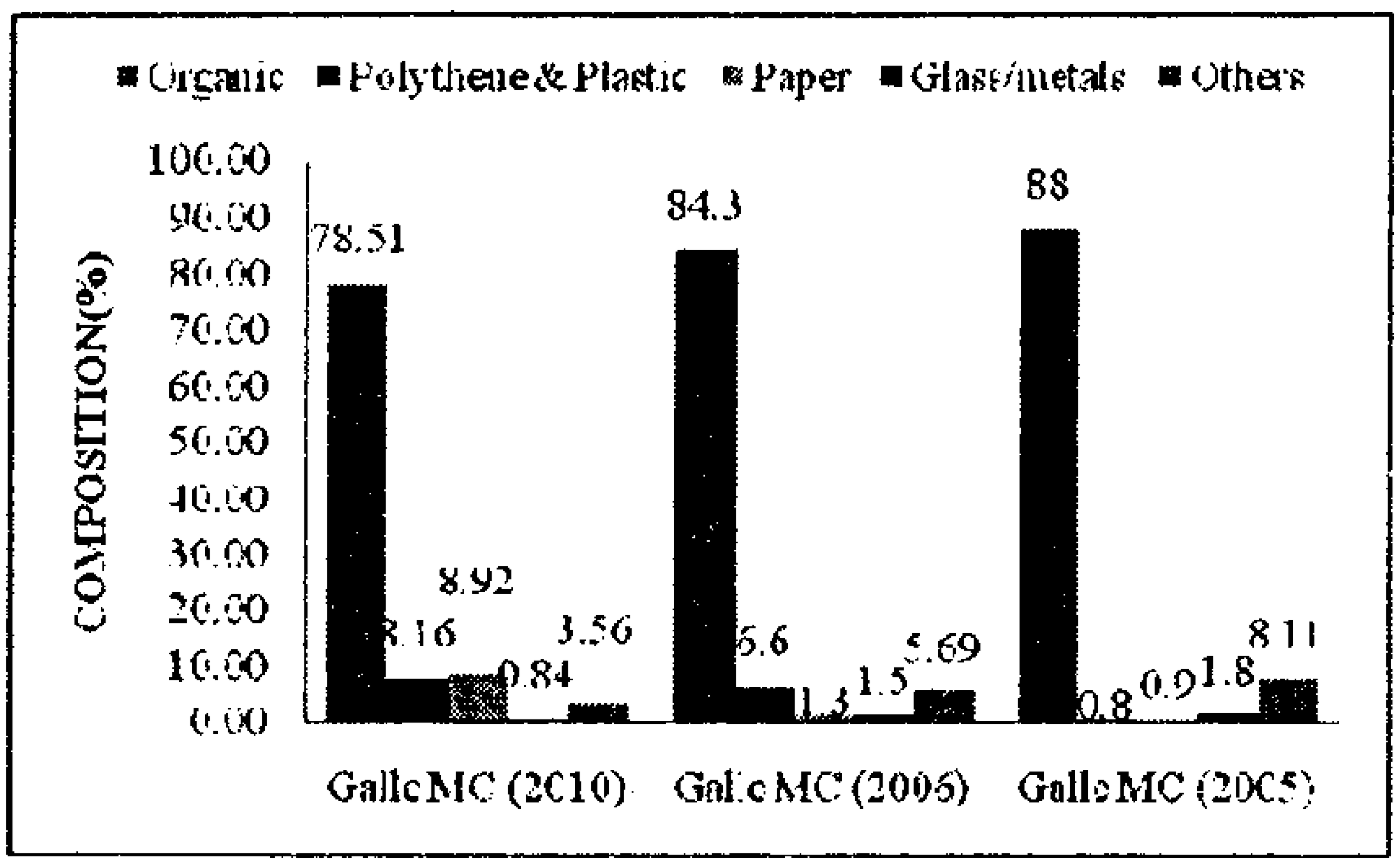

Figure 3: Variation of the average composition of GMC-SW with time

<u>Total solids and moisture content</u>

It is evidenced by Figure 4 that all the wards excluding Kaluwella, Ginthota and Elliot Road contain more than 50% of moisture in the SW. In many wards, the moisture content is more than the solid content. Thus it is very impractical to use methods like incineration to treat this waste. The disposal of waste with no treatment can be highly harmful to the environment as the leachate generation will be high due to the high moisture content.

The liquid that collects at the bottom of the landfill is known as leachate. In deep landfills, leachate is often collected at intermediate points. Leachate contains a variety of chemical constituents derived from the solubilization of the materials deposited in the landfill and from the products of the chemical and biochemical reactions occurring within the landfill (Tchobanoglous *et al.*, 1993). Hence, many adverse effects can occur due to the mixing of leachate with the water bodies, soil etc.

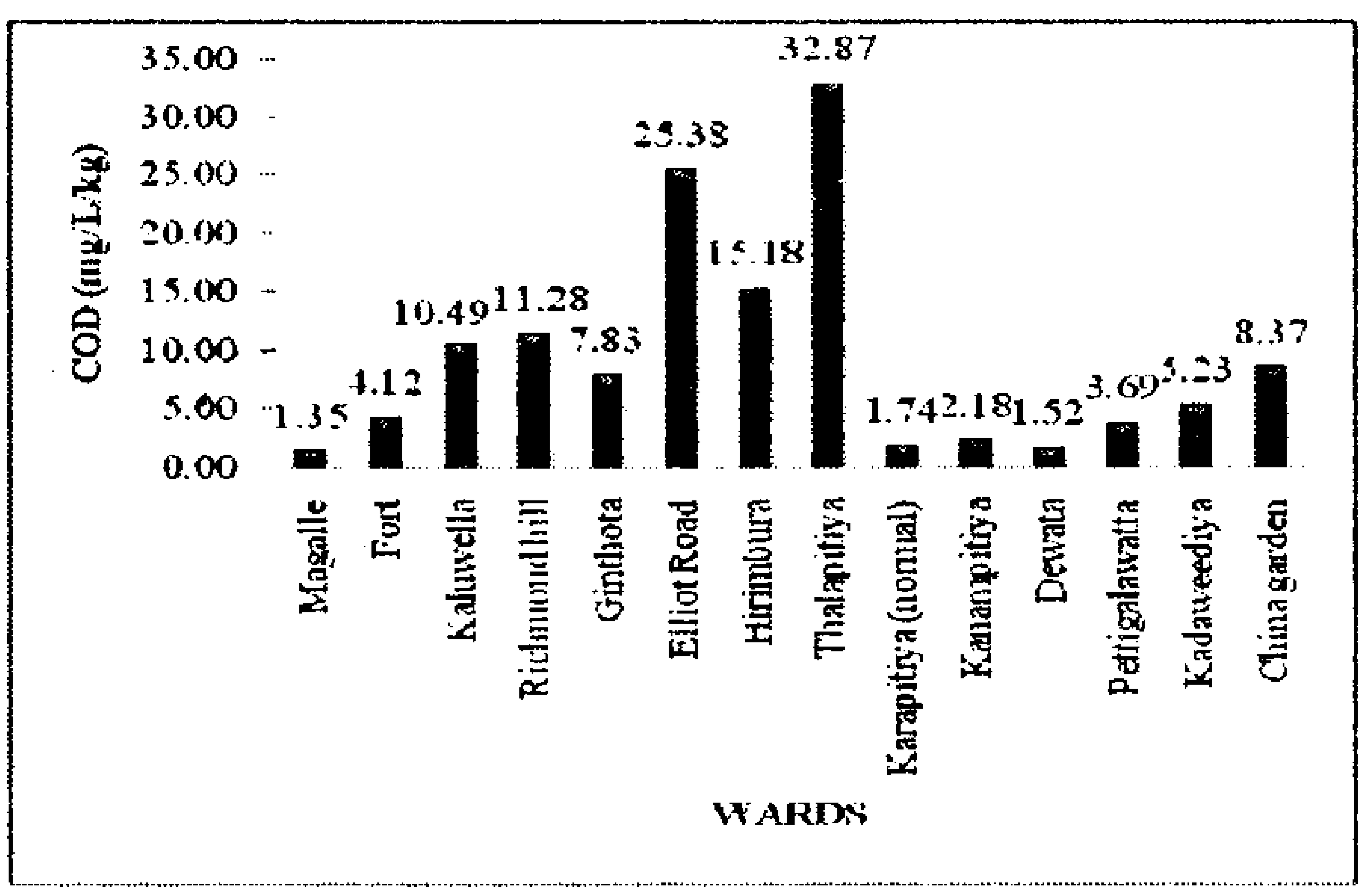

Figure 4: Total solids and the moisture content of the solid waste

<u>Colorific values</u>

The calorific value of a substance is the amount of heat released during the combustion of a specified amount of it. When comparing the calorific values of SW (Figure 5) produced in GMC with those of some fuels, it can be seen that the GMC-SW has very low values. Thus it may not be possible to use the waste for energy generation directly. The waste treatment methods like incineration will not be suitable for this waste. It can be assumed that this is due to the high organic content in the waste and the high moisture content. If the waste contained high amounts of paper, polythene and plastic, high calorific values could be expected.

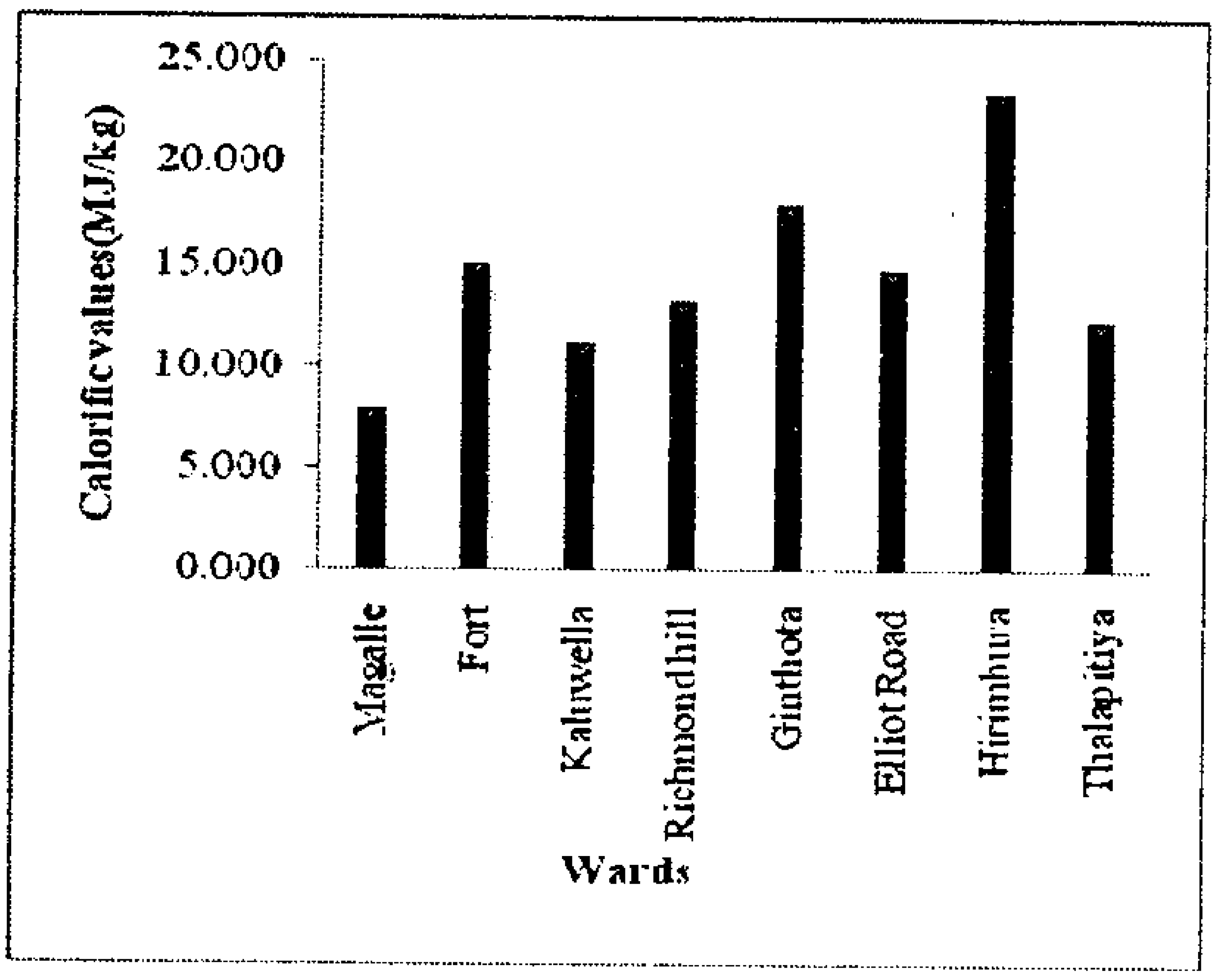

Figure 5: Calorific values

Public awareness and involvement

According to the results obtained from the social survey done in 100 households in GMC, the public are aware of the SWM system in GMC. They appreciate the daily collection. Nearly 100% of the public give their cooperation to the system by placing the garbage bins outside at the correct time for collection by the GMC workers. Some households do source separation of SW as biodegradable and non-biodegradable wastes. Separate containers have been provided to them by the GMC. About 37% from the surveyed community dispose separated waste. However, it can also be stated that the public awareness on waste transformation and waste disposal is very less. Less than 10% is interested in home based composting. Thus it can be stated that the public awareness on waste collection is satisfactory, while the awareness on transformation, disposal have to be improved.

By the survey done among the workers of the landfill site, composting plant and collection scheme, it can be said that workers are enthusiastic about their profession even under limited facilities. 86% of .the labors satisfy with their job and 86% have received training on waste management prior to work. However, their concern on safety is very less. Only 21% use boots, 28% use gloves and none uses masks. Among the problems they face, are not receiving vaccination at regular intervals, not being provided with sanitary facilities etc. They require proper uniforms and rain coats suitable to their work type and the climate. By providing those will increase their efficiency and enthusiasm about the job.

Existing SWM system in GMC

Only the wastes from 3 wards are currently used for producing compost. Figure 6 shows the variation of the percent moisture content of the composting pile with time. The optimum moisture content for composting is 55 % or at least between 50-60 %. For most organic wastes, once the moisture content is brought to a suitable level (50-60%), the microbial metabolism speeds up (Tchobanoglous *et al.*, 1993). Hence, the optimum moisture content is not maintained even in the initial piles. The lack of water added to the piles can be identified as the cause for this problem. Because the water to the site is given by the National Water Supply and Drainage Board, the officials are reluctant to use a large amount of water for the composting piles. Figure 7 shows the reduction of the volatile solids content with time. This indicates the efficiency of the plant. The overall reduction of volatile solids during composting is about 40 %.

The composting piles show signs of lack of moisture and the piles of latter weeks have white fungus, *Aspergillus fermigatus* growing on them, which are bad for the human health, thus a threat to workers. This fungus is believed to be responsible for causing respiratory problems if inhaled. Most fungi have the ability to grow under low moisture conditions, which do not favor the growth of bacteria (Tchobanoglous *et al.*, 1993). The compost produced in the Heenpanthala plant is not efficient as a soil conditioner, and there is also no clear characterization of the compost. This can be due to not maintaining the optimum conditions of temperature, moisture content, pH level etc.

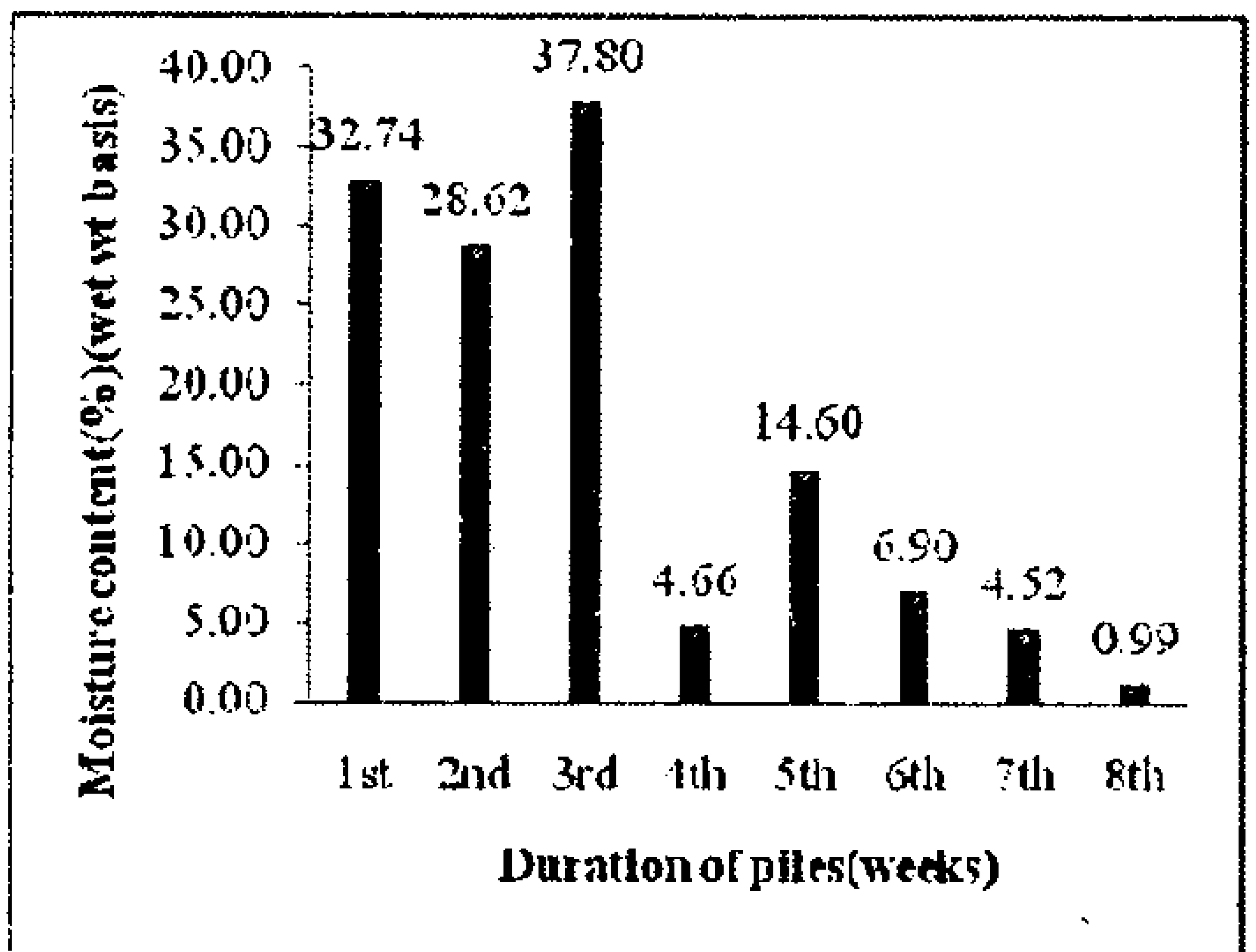

Figure 6: Variation of percent moisture content of the composting pile with time

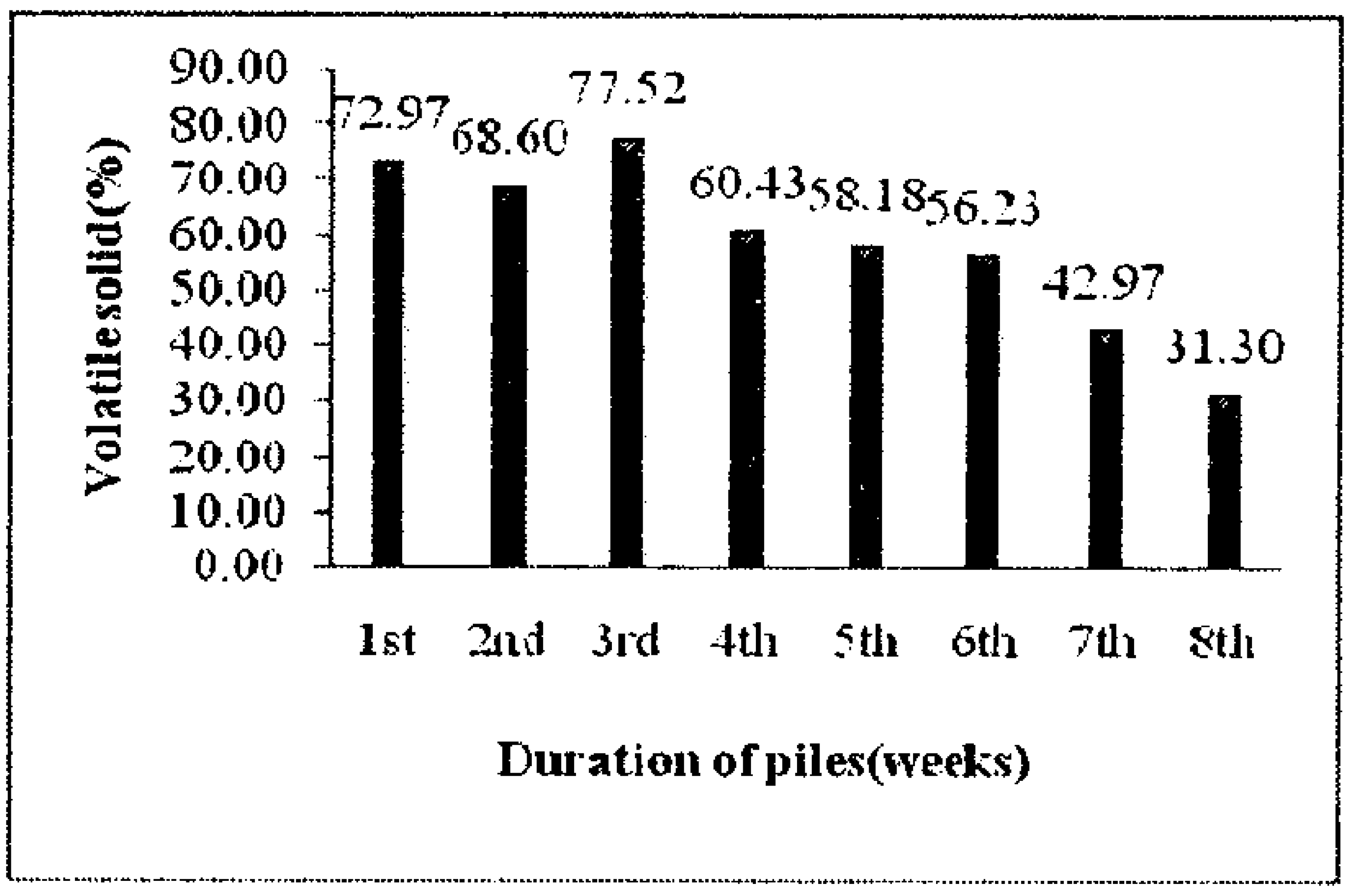

Figure 7: Variation of percent volatile solid content of the composting pile with time

Key strategies for an ISWM plan

The key strategies are suggested according to the following functional elements of ISWM: waste handling and separation, storage and processing at the source; waste collection; separation, processing and transformation of solid waste; transportation; and disposal.

Source separation of SW is of major concern. The SW can be categorized into organic waste, reusable or recyclable waste and unusable items, and disposed in different bins. A suitable color code can be introduced for easy identification. The households can be advised to implement home based composting systems for organic waste. Several households can get together and implement an anaerobic digester for their organic wastes. The gas from digesters can be used for cooking purposes. The compost can either be used or sold to outsiders. Reusables and recyclables can be collected by GMC once a week.

The waste should be transported to the treatment facilities or disposal sites by covered vehicles, thus the odor and vector attraction would be minimal. The vehicles should fit to transport waste with high density and moisture content. The vehicles selected should be more suitable for roads of Sri Lanka and the type of SW generated here. Heavy vehicles like the compactor truck used by the GMC at present, are a cause of traffic in narrow roads and also not easy to repair when broken down.

The biodegradable waste is sent to either composting or anaerobic digestion. The non-biodegradable waste is again divided to recyclables and non-recyclables. Recyclables like polyethene, plastic, paper, cardboard can be sent to the relevant recycling centers. The non recyclables can be dumped on an engineered landfill. As home based composting is a key strategy, the composting plants managed by the GMC may not be very large. Turning of piles, moisture content, C: N ratio etc. should be properly maintained in the composting plant, thus the best quality compost is produced, which is sold to the public at various outlets.

The gas from the anaerobic digesters can be used for energy recovery purposes and the slurry can be sold as a fertilizer to the farms. Recycling shops have to be established so that the people can give their paper, metal, glass for recycling or reusing and earn some money. The remaining waste after all the treatment is disposed in an engineered landfill. The existing semi-controlled landfill should be improved to an engineered landfill by providing a proper liner, landfill gas and leachate collection systems and daily and final soil covers.

The waste produced by the hospitals of GMC will be separated as hazardous and non-hazardous waste. The hazardous waste can be incinerated within the hospital premises and the other waste have to be collected by the GMC and directed to the common waste treatment stream. The ash or residue from the incineration should be disposed in a separate area.

Conclusion

Rapid urbanization and industrialization have increased the generation of solid waste and changed the conventional solid waste composition in the Galle municipality. Though solid waste management of the Galle municipality has been carried out by the GMC for over a hundred years, the current system is unsatisfactory. It is imperative to incorporate the state-of-the art-technology in the current system. Therefore it is timely strategy to design a solid waste management plan based on ISWM for the Galle municipality.

Considering the results and the analysis of the solid waste in GMC, it can be seen that the waste is mostly organic and contains high moisture contents. Therefore, the treatment methods used by the GMC such as composting and anaerobic digestion can be decided as suitable. The study revealed that the solid waste is mostly organic with the highest percentage as 93.8. There is a significant decrease in the organic content and an increase of the polythene, paper and plastic content when compared with data for years 2005 and 2006. The moisture content is higher than the solids content. The highest calorific value is 18 MJ/kg, while the calorific values of normal fuels are higher than 45 MJ/kg. Thus, the waste cannot be directly used for fuel generation. The moisture content of the composting piles remained less than 40 % for the entire composting run of 8 weeks. This has led harmful fungus to grow. The reduction of volatile solids content in the composting piles was from 72.8% to 31.3%. It was observed that GMC has adopted reasonably good collection, treatment, disposal etc. methods, however the efficiency of those services are not to satisfactory level. The safety and health condition of the waste handling personals are also not given proper attention.

The proposed solid waste management plan has modifications to the activities which come under the following functional elements: waste handling and separation; storage and processing at the source; waste collection; separation, processing and transformation of solid waste; transportation; and disposal. In addition, some suggestions are given to ensure the safety of the solid waste handling personnel and hospital waste management.

It is concluded that if the public support can be obtained through good awareness, and if the current services and facilities are improved, ISWM could be successfully implemented in the GMC.

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