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SOLID WASTE MANAGEMENT IN KENYA: A CASE STUDY OF PUBLIC TECHNICAL TRAINING INSTITUTIONS

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ABSTRACT

Technical training institutions in Kenya continuously produce solid wastes which are not disposed of safely, effectively or economically. The result is accumulation of garbage from the institutions which cause pollution and unsightliness and thus impact on the living standards in the institutions. This study examined the generation, collection and disposal of solid waste in the public technical training institutions by quantification of the various components of solid waste generated and evaluation of the attitudes of the people responsible for generation and management of waste. From 42 technical training institutions, a sample of 29 institutions (73%) was selected for study. It was established that the 29 institutions generate about 23 tons of waste per week composed of mainly vegetable and food remains (82%). Other waste includes plastics, papers, ash, metals and glass. It was also established that the cost of waste management in the institutions is dependent on both the waste generated and the institutional population. The cost of planning and managing the waste ranged from Ksh 0.13 to 0.59 /week/student while per capita waste generation ranged from 0.28kg/week/student to 0.71kg/week/student. In order for the institutions to effectively manage the solid waste, Boards of Management should incorporate waste management in their institutional planning. This can be achieved by ensuring that collection and disposal are carried out on a planned basis and allocating adequate human and financial resources.

KEYWORDS: Solid, Waste, Management, Technical, Training, Institutions, Planning, Kenya.

INTRODUCTION

Most countries in the world experience challenges in managing waste. The challenges range from reducing generation of waste, separation, change of habits, collection, transport, treatment, reuse and disposal of the waste. UNEP (2005) sees the challenges as different for different levels of industrial development. In an attempt to accelerate the pace of its industrial development, an economically developing nation may pay inadequate attention to solid waste management. Ngoc and Schnitzer (2009) argue that increasing population,

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changing consumption patterns, economic development, changing income, urbanisation and industrialisation result in increased generation of waste. Williams (2002) admits that waste generation will continue to rise.

In Kenya, the challenge of Solid Waste Management is real (Gakungu, 2011). Collection systems are inefficient and disposal systems are not environmentally friendly. 30 to 40 per cent of all solid waste generated in urban areas is uncollected and less than 50 per cent of the population is served (Otieno, 2010). He states that up to 80 per cent of collection transport is out of service or in need of repair and argues that if the issue of sustainable solid waste management in Kenya is not considered urgently, all the towns in Kenya will be engulfed in waste.

In many regions and countries, national and international targets have been set for municipal solid waste recycling, recovery and diversion from landfill (Ali, 2009). To develop and implement effective strategies to meet these targets requires reliable information on the composition of all parts of household waste stream. It is therefore necessary to examine the nature and quality of waste generated in order to contribute to improvement actions at the source. To respond to the environmental challenges, the country reviewed its laws and related policies and enacted the Environmental Management and Coordination Act (EMCA) of 1999. The Act gives rights and confers duties to individuals to safeguard and enhance the environment. It guarantees every Kenyan a clean and healthy environment. These provisions also envisage protection of the environment for the benefit of the present and future generations. This is also envisaged in Kenyan Vision 2030. The Constitution of Kenya under section 42 provides the right of every person to a clean and healthy environment which includes the right to have the environment protected for the benefit of present and future generations. Section 69(2) confers duties on every person to cooperate with state organs and other persons to conserve and protect the environment and ensure ecologically sustainable development and use of natural resources.

To ensure development in a country, the needs of present generations should be met without compromising the ability of the future generations to meet their needs (UNEP, 2010). This can be achieved by providing a vehicle for integrating the environment in socio-economic planning and management. Increasing environmental concerns and the emphasis on material and energy recovery are gradually changing the orientation of solid waste management and planning. The focus nowadays is to design sustainable and least cost solid waste management systems considering the variety of management processes. Such a model should serve as a solid waste decision support system taking into consideration both socio-economic and environmental considerations. The model accounts for solid waste generation rates, composition, collection, treatment, disposal as well as potential environmental impacts of various solid waste management techniques.

Training institutions are major sources of waste due to their multiple status of being training, commercial and domestic entities.

By 2010, the forty two technical training institutions in Kenya had a population of about 100,000 students and a staff of 1,602. These institutions generate considerable amounts of

waste in their respective areas of locations and proper management of solid waste in these institutions will go a long way in ensuring solid waste management principles are replicated throughout the country. As key providers of skills in Kenya, technical training institutions (TTIs) are responsible for training artisans, technicians and technologists for the various spheres of the economy. These young professionals are the ones who will guide the production processes and use of resources. The institutions are therefore in a position to introduce the concepts of clean environment by ensuring good practices. They can therefore strive to conduct their activities and use of resources in a manner that develops environmental awareness and fosters responsible solid waste management. A study on how these institutions manage the waste will guide good practices which can result in reduced municipal waste and in effect reduced environmental pollution.

The broad objective of this study was therefore to examine solid waste management practices in public technical training institutions in Kenya. The specific objectives were to

a) assess the annual generation, collection and disposal of waste in public technical training institutions;
b) quantify the various components and annual rates of solid waste generated in public technical training institutions;
c) examine the attitudes of those responsible for generation and management of the solid waste in the institutions;
d) develop a model for solid waste management in technical training institutions in Kenya.

1. MATERIALS AND METHODS

There are forty two (42) public Technical Training institutions in Kenya directly under the Ministry of Higher Education, Science and Technology. They include National Polytechnics, Institutes of Technology and Technical Training Institutes. The methodology in this study involved three key activities. Assessment of generation, collection and disposal of solid waste with the quantities were examined through administration of questionnaires to selected respondents in the institutions. Through questionnaires, attitude of those responsible for the generation of solid waste and its management was evaluated.

A sample of twenty nine (29) institutions representing 73% of the population size was applied. This was computed using the sample size determination formula

$$ss = \frac{N}{1 + N(e)^2}, \tag{1}$$

where ss is sample size (29)

N is the population size (42)

e is the level of precision (0.1)

A multi-stage sampling approach was used to arrive at this sample. At the first stage of sampling, all the technical institutions were grouped according to the provinces they are located in. Using random sampling and also considering the type of technical institution available in the province, institutions were chosen from each province to add up to 29 the size of the sample required. Proportionate sampling was used to get a proportion that represents the size of that particular category since the institutions selected may be a National Polytechnic (NP), Institute of Technology (IT) or a Technical Training Institute (TTI). The researcher ensured there was a representation of each type of institution as much as possible. In evaluating the attitude of students in the institutions, a random sample of ten (10) students was selected from each institution.

The main source of information was respondents. The students who are the primary generators of waste were interviewed. The Principal of each institution was also interviewed or the deputy where the Principal was unavailable. Other persons interviewed included the officer in-charge of cleanliness and waste disposal in the institutions. The response constituted the primary source of information. Documentary sources were also utilized for secondary data. A questionnaire was used to conduct a structured interview. The questionnaires included open ended and close ended questions. The questionnaires were administered by the researcher with the help of one research assistant. In addition to the questionnaires, direct observations were used. This enabled the researcher to establish the seriousness of the problem in the institutions.

Weighing was done by collecting the waste and putting in bags. A loop was then made for hanging the bag. The portable electronic weighing balance was set to zero and then the waste was put on the hook. The weight was read and then tabulated. For the same bag, three readings were taken and an average of the three computed and recorded as the weight. The accuracy of the balance was 0.01Kg. The total waste per week was determined on the basis of a daily average which in itself was an average of the waste generated in three consecutive days from Monday to Wednesday. The assumption that this average could represent a typical day at all the institutions may not be true. For some institutions this may not be the days when waste generation is at its peak. It is also most likely that some institutions collect their waste at the end of the week rather than at the beginning of the week and hence the big variations in the amounts.

Information on waste storage facility use was obtained by interviewing the persons in charge of waste management in the institutions and also by use of the questionnaires administered to the principals. The cost of waste management in the institution was computed from the expenses incurred in waste collection services in a term and thereafter in a year. The measurements were analysed to establish any variations between institutions, categories of institutions and types of waste. The coefficient of variation which is obtained by dividing the standard deviation by the mean of the sample was used to measure this variation. The following equations were used to calculate the standard deviation and coefficient of variation:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}\,, \tag{2}$$

where σ = standard deviation,

x_i = each value of dataset,

$\bar{x}$ = the arithmetic mean of the data,

N = the sample population.

Analysis of material and energy flow into the institution which partly ends up in wastes was done through desk work using the results of the data analysis. Analyzing the various possibilities to prevent the generation of wastes was done through review of literature and analysis of the rates of generated wastes.

2. RESULTS AND DISCUSSION

There are different types of waste generated from institutions. The type of waste generated usually depends on the items used and consumed. The items commonly used in institutions include packaging materials, papers, pens, food remains, glass, old clothes, computers, metals, wood, medicine and plastics.

2.1. WASTE GENERATION RATES

Waste generation rates are dependent on several factors. The basic factor is population, which is the number of people generating the waste in the area in question. The greater the number of people generating the waste, the greater the rate of waste generation. However, waste generation rates are dependent on other factors. Ngoc and Schnitzer (2009) argue that waste generation rates are affected by socio-economic development, degree of industrialization and climate. This argument is true for public places like municipalities but for technical training institutions, the waste generation rate is dependent on factors like the institution type. For example, institutions with boarding students generate more waste than institutions without boarding facilities. The courses offered also affect the waste generation rates. Institutions with technical courses including wood work and metal work produce more waste than institutions with business courses. Total technical waste generation rate for public technical training institution was 23 tonnes in a week. Organic materials continue to be the largest component of institutional solid waste. Vegetable remains account for 82% of the waste, paper account for 4%, metal 4% and glass 1%.

2.2. RECYCLING RATES

There are different recycling rates of wastes in institutions. The recycling is mainly done in the workshops where the metal and wood used in demonstrations are recycled for other relatively similar experiments requiring their use. Vegetable and food remains were used as animal feeds.

2.3. INSTITUTIONAL COMPARISONS OF GENERATION RATES

The total waste generation for Technical Training Institutes is higher than the total waste generation rate for National Polytechnics and Institutes of Technology. The total waste generation rate for the sampled Technical Training Institutes was 14.02 tonnes per week while for National Polytechnics the value was 2.76. This difference can be attributed to the number of Technical Training Institutes which is higher than the number of NPs. The percent recycled rate of the waste is also higher for Institutes of Technologies (20%) while for Technical Training Institutes it is 12% as illustrated in Figure 1. This percentage recycling rate is low compared to the recycling rate of 33.4% for municipal councils in US and Africa (US EPA 2007). Waste from hostels amounted to (both ladies' and men's hostels) to be 55 to 65 percent of total Institutional Solid Waste generation. Waste from classes and laboratories amounted to 35 to 45 percent are different recycling rates wastes in institutions.

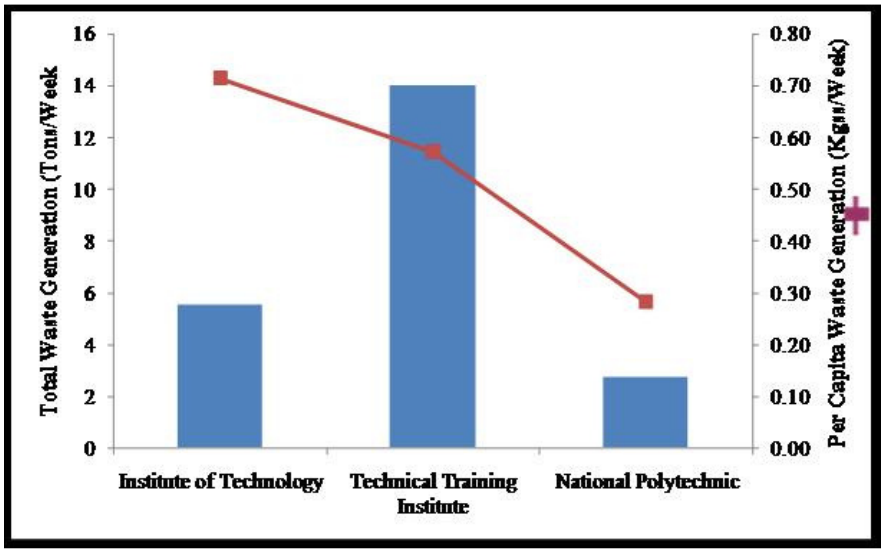

Figure 1. Total and per capita waste generation in technical training institutions

The per capita waste generation is highest for Institutes of Technology at 0.71Kg/week/student. National Polytechnics have the lowest per capita waste generation of 0.28 Kg/week/student. Types of programmes at the institution were found to influence the types and amounts generated. Institutions offering Institutional Management and Food and Beverages courses contributed the highest portion of the waste being responsible for 67% of the total waste generated. These institutions are required to operate training kitchens as additional facilities to the main kitchens. On the other hand, institutions with Mechanical and Agricultural Engineering courses generated the highest amounts of metals.

As per the category of institutions, National Polytechnics, which are at the apex of the hierarchy of Technical Training Institutions, generated 69% of the papers as compared to 9% for the TTIs which are at the lower level. This is an indication of the level of activities at each category of institution. Waste from institutions is mainly collected by institutional workers. It is only institutions in places under the municipal council where the waste is collected by trucks. In most institutions, the workers collect the waste from the points of generation using wheelbarrows. Waste is usually collected in bins which are located at various places. For example, in hostels, the waste bin is placed at the entrance of the hostel. For collecting waste which are outside the hostels, kitchen and classes, litter bins are placed at strategic points in the institution. However, some institutions do not have enough waste bins.

2.4. COLLECTION OF WASTE FROM POINTS OF GENERATION

Frequency of collection of waste can be used as a measure of good waste management practices. It is an indicator of awareness by all concerned on the need for a clean environment. To evaluate this aspect of Solid Waste Management (SWM), the officers in charge of cleanliness, waste collection and disposal at the institutions had been asked to indicate how often waste was collected from generation points for disposal in a week. From the results it was established that the frequency of collecting waste varies depending on the category of the institution. However, some of the institutions collected the waste on a daily basis. All the TTIs also collected their waste on a daily basis. Considering that there are five working days in a week, this implied that waste was collected daily from the generation points.

Collection of waste from the points they are generated is either done by workers employed by the respective institutions or a contracted private company and students. Seventy six percent of the institutions use workers to collect the waste, 4% use contracted company, 10% use both workers and contracted company, while another 10% of the institutions use both students and workers. The collection is usually through dirt bins located in strategic places including entrance to classrooms, canteens, near kitchen, in the hostels and where students usually gather. The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be materials processing facility, a transfer station, or a landfill disposal site. Given that majority of the generators of the waste are students and therefore the need to

involve them in the management they indicated where the waste generated was disposed. The information was corroborated by responses from the twenty nine officers at the institutions who are responsible for cleanliness, waste collection and disposal.

2.5. DISPOSAL OF INSTITUTIONAL WASTE

Most of the respondents indicated that the solid waste collected was disposed of in the rubbish pits by the institutions or collected by the municipality. The use of rubbish pits as disposal sites was observed to be common in all the categories of the institutions. Seventy five percent (75%) of all the respondents indicated this as a preferred mode of disposing waste. There were several varieties of the rubbish pits at the institutions ranging from simple open pits to some that had enclosures.

2.6. INSTITUTIONAL WASTE MANAGEMENT

The results of the evaluation of the various components of the waste show that there is a substantial amount of recyclable waste that is generated at the institutions. It is generally accepted that recycling as a strategy in SWM has both positive economic and environmental impacts. Recycling can be a source of employment while at the same time ensuring a clean environment since there is always a reduction in the waste stream. Institutions are expected to be innovative and this is one area where new technologies could be introduced. For example, it would be encouraging to see whether institutions could explore the energy potential of the organic waste in their institutions and develop it as a way of saving the current high energy costs. Further it would be appropriate for students to experiment using recycled materials as a way of developing new materials for use by similar institutions. It was therefore important in this study to establish whether institutions have embraced this strategy. 21 % of the institutions recycle some of the wastes while 79 % do not recycle.

From the results, this aspect of SWM is only used to a small extent at the institutions as it was only 21 percent of the respondents who indicated that they recycled their solid waste. On further investigation it was however found that the type of solid waste that is mostly recycled / reused are vegetable and food remains which were used for animal feed. The concept of recycling was interpreted by the respondents as reuse of the waste for other purposes.

2.7. COST OF WASTE MANAGEMENT

Resource allocated for solid waste management has an impact on how effective and efficient the process will be. It also indicates a level of awareness by institutional managers on SWM. This aspect was evaluated based on the number of workers employed at the institutions for waste collection and disposal and the amount of funds allocated for the whole SWM process. Further analysis of the results was carried out to establish the relationship between the waste generated per week and the number of students in an

institution, waste generated per week and the number of workers employed for waste collection and disposal. The Pearson product-moment correlation coefficient, which is obtained by dividing the covariance of the two variables by the product of their standard deviations, was used to measure the degree of correlation.

Regression analysis was conducted to determine the relationship between amount of waste generated and population of the institutions and also the cost of SWM in the institutions. The relationship of the variables is such that the cost of waste management in public technical institutions is dependent on both the waste generated and institutional population. The equation for determining the cost of managing the waste generated from an institution is given by:

$$C = \frac{W_g + 0.069P}{0.134} \tag{3}$$

where C is the money in KShs invested in solid waste management per month
W_g is the Waste Generated in a week
P is the population of the institution

CONCLUSIONS

The study assessed the generation, collection and disposal of waste in Public Technical Training Institutions. The study established that 29 institutions generate 23 Tonnes of waste per week. The amount of waste generated at each institution was directly related to the number of students. The type and amount of waste can be predicted and hence the management of the waste planned. It was also established that there was adequate awareness by students who are the main generators of waste on the need for a clean environment and their responsibility in ensuring this is achieved. With this level of awareness at the institutions it is easy to incorporate SWM programmes that will involve students. The quantities of waste measured on site gave the first indication of an individual institution's inability to effectively manage waste. Smaller quantities were interpreted to be indicators of continuous collection and disposal. Analysis of results has indicated that all the institutions evaluated, collected and disposed of solid waste from their institutions without involving the local authorities where the institutions are located in handling the solid waste. Ineffectiveness of the institution in collecting and disposing of the waste can therefore be attributed to the institutions only and not any other agent. The results of data analysis indicated that all the institutions disposed of their waste in open disposal sites. The waste is then left to decompose or burnt which affect the environment. Decomposing waste makes a good breeding place for vectors such as flies and rats. There is also the danger of water pollution when leachate from the dump sites enters surface water or groundwater resources. Uncontrolled burning which is also the most favoured method of disposing of the waste

causes air pollution within the institution and beyond. By these solid waste management practices, the institutions were causing environmental pollution within their localities. The researchers therefore recommend an improvement in the method of disposal of waste at the institutions by use of landfills instead of open dumping. A properly designed and managed landfill will be a relatively inexpensive method of disposing waste in a way that minimises their impact on the local environment.

Name of institution	Population	Waste generated	Cost (KShs/Week)	Size of landfill (m^3)
Michuki Technical Training Institute	530	58.65	710.60	10.34
Nyeri Technical Training Institute	1936	48.22	1356.75	8.50
Murang'a College of Technology	797	88.18	1068.46	15.54
Kirinyaga Technical Institute	550	127.46	1234.40	22.47
Kaiboi Technical Training Institute	948	83.02	1107.70	14.63
OL'Lessos Technical Training Institute	1180	133.59	1604.55	23.55
Eldoret Polytechnic	5780	68.91	3490.52	12.15
Rift Valley Technical Training Institute	1960	76.17	1577.69	13.43
Machakos Technical Training Institute	2587	111	2160.47	19.57
Thika Technical Training Institute	2143	91.15	1783.71	16.07
Kiambu Institute of Science and Technology	1446	114.97	1602.57	20.27
Kenya Technical Teachers College	1050	167.97	1794.18	29.61
Nairobi Technical Training Institute	2129	74.895	1655.19	13.20
Meru Technical Training Institute	1676	125.457	1799.26	22.11
Rwika Technical Institute	486	65.65	740.18	11.57
Nkabune Technical Training Institute	501	113.94	1108.28	20.08
Wote Technical Training Institute	173	47.89	446.47	8.44
Kabete Technical Training Institute	2123	312.49	3425.20	55.08
PC Kinyanjui Technical Training Institute	762	51.83	779.16	9.14
Gussi Institute of Technology	2152	151.23	2236.70	26.66
Keroka Technical Training Institute	284	38.21	431.39	6.74
Kisumu Polytechnic	2954	157.59	2697.13	27.78
Ramogi Institute of Advanced Technology	635	97.8	1056.83	17.24
Mawego Technical Training Institute	785	110.93	1232.05	19.55
Sang'alo Institute of Science and Technology	1635	135.28	1851.46	23.85
Sigalagala Technical Training Institute	1814	127.1	1882.58	22.40
Friends College Kaimosi	908	128	1422.78	22.56
Mombasa Technical Training Institute	1634	259.43	2777.43	45.73
Maasai Technical Training Institute	430	10.95	303.13	1.93

Note: *Volumes of landfill were calculated using equation 3. These sizes of the landfill need to be increased to leave space for increase in population of the institutions.*

Table 1. Size of landfill required for each institution

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