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ASSESSMENT OF SOLID WASTE MANAGEMENT IN TARKWA MUNICIPALITY GHANA: TIME SERIES APPROACH

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Abstract

This study intends to examine the means of waste disposal by households (place of disposal), analyze how the waste collected is finally disposed of, and predict the amount of waste that ends up at the landfill in the next five years using Time-Series and make recommendations for effective management of solid waste in Tarkwa Municipality. The historical data and the characteristic of the historical data show that the amount of waste generated in tonnes increased from year 2006 to 2011. The average waste generated was found to be 85612.8 tonnes. The graph of the projected waste using Time Series Method also showed an increase in the trend. It is observed that as the year progresses, there is increase in the amount of waste generated, the reason for this may not be far from increase in the population and urbanization of Tarkwa Municipality.

Keywords: Waste, Landfill, Time-series method, Household, Disposal, Population, Urbanization,

1. Introduction

Waste is defined as substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provision of the national law. A waste is a discarded material, which has no consumer value to the one who disposed of it but another person picks it up and puts it to use it becomes a resource to the person. Solid waste is defined in accordance with the U.S Environmental Protection Agency as any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial or commercial operations or from community activities. Solid waste can also be defined as any material which comes from domestic, commercial, and industrial sources arising from human activities which has no value to people who possesses it and is discarded as useless. Solid waste is composed of combustibles and non-combustible materials. The combustible materials include paper, plastics, yard debris, food waste, wood, textiles, disposable diapers, and other organics. Non-combustibles also include glass, metal, bones, leather and aluminum (Denison and Ruston 1990,). Solid waste consists of many different materials. Some can burn, some cannot. Some can be recycled; some cannot. Information on the characteristics of solid waste is important in evaluating alternative equipment needs, systems, management programs and plans especially with respect to the implementation of disposal, resource and energy recovery options. Solid waste is characterised into two headings i.e. physical (density, particle size, moisture content) and chemical (calorific value and the carbon to nitrogen *ratio*)

Solid waste management is also explained as that discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations and that is also responsive to public attitude (Tchobanoglous et al 1993). Waste generation encompasses those activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal (Momoh and Oladebeye, 2010). Waste prevention is of higher importance in integrated waste management. This is a preventive action whose objective aims at reducing the amount of waste that individuals, businesses and other organizations generate. Source reduction can be an effective method of reducing waste generation. Source reduction has many environmental benefits. It prevents emissions of many greenhouse gases, reduces pollutants, saves energy, conserves resources and reduces the need for new landfills and combustors (Medina, 1999). Recycling is the material recovery option after the reuse of materials and products (Medina, 1999). Recycling is the recovery of materials for melting, and reincorporating them as raw materials (Onibokun and Kumuyi, 2003). It is technically feasible to recycle a large amount of materials such as plastics, wood, metals, glass, textiles, paper, cardboard, rubber, ceramics, and leather (Holmes, 1981). Recycling can render social, economic and environmental benefits. For scavengers who recover recyclable materials, it serves as a source of income. Composting municipal solid waste involves managing conditions to accelerate the biological decomposition of some of its organic components. The conditions for efficient biological decomposition of organic waste depend on optimum temperatures (130^0–150° F), moisture (46–56%), oxygen (15–21%), pH (6.0–7.5) levels, and carbon to nitrogen (25:1–30:1) ratios of the feedstock (Mamo et al*,* 2002). If conditions deviate from these optimum levels, the composting process is slowed down and chemically unstable compost may be produced. When microorganisms degrade the organic materials under optimum oxygen levels, the process is called aerobic composting. In contrast, a different group of microorganisms can degrade the organic material under limited oxygen levels, where the process is called anaerobic composting (Bilitewski et al, 1997). Aerobic composting is usually preferred over anaerobic composting because it is faster in biological oxidation and does not generate as many foul odours (e.g. ammonia, sulphur compounds and organic acids). Sanitary landfill as the final disposal site for solid waste is given the least priority in an Integrated Waste Management approach (Tchobanoglous et al, 1993). A sanitary landfill is a facility designed specifically for the final disposal of wastes, which minimizes the risks to human health and the environment associated with solid wastes (Medina, 1999). Waste arriving at landfill is compacted and then covered with a layer of earth, usually every day. This prevents animals from having access to the organic matter to feed. Sanitary landfills may also include other pollution control measures such as collection and treatment of leachate and venting or flaring of methane. It is possible to produce electricity by burning the methane that landfills generate. Proper management of landfill site is of a major concern because landfill might cause environmental impacts, such as bad odour in the neighborhood, leachate leakage, and ground water contamination. Events of the 20^{th} and early into the 21^{st} century indicate that waste in whatever form or classification- solid, liquid or toxic have become a major consequence of modernization and economic development. In the quest for 'Western-styled' development, humanity did not budget for the problems related to the management of waste hence the need for the management of waste. The management of solid waste has become a bane to the society becoming one of the primary environmental concerns of public debate. As a result of rapid rate of urbanization and economic growth, increasing amount of solid waste is being generated. This presents greater difficulty for solid waste disposal. Over the years, solid waste disposal has become a major problem in the Tarkwa Municipality because only one landfill exists to accommodate the amount of solid waste generated. There is no form of any practice to reduce the increasing volume of waste that ends up at the landfill at Bompieso.

This has resulted in littering, heaping of waste and overflowing of skips with waste in the Municipality most especially in the low class residential and around urban areas. The recent use of polythene bags for packaging has seriously aggravated the situation in the study area. This makes the above mentioned residential areas filthy and unattractive for living. Therefore, if the situation is left unchecked it can result in the outbreak of communicable diseases such as cholera, typhoid and this will affect people exposed to this unsanitary conditions.

On the basis of these, this study intends to examine the means of waste disposal by households (place of disposal), analyze how the waste collected is finally disposed of, and predict the amount of waste that ends up at the landfill in the next five years using Time-Series approach and make recommendations for effective management of solid waste in Tarkwa Municipality.

1.1 Profile of the study area Tarkwa:

Location and size

Tarkwa is the administrative capital of the Tarkwa-Nsuaem Municipal Assembly (TNMA) of Western Region of

Ghana. It is about 100 km away from Takoradi which is the regional capital. It is a noted centre for gold and manganese. The Municipality has a total land area of 2,354 sq. km.

Climate

Climatically, the Municipality lies within the South-Western Equatorial Zone and is marked by double maximum rainfall. The first and more pronounced rainy season extends from late March to the end of July and the second season is from October to mid-November. Annual mean rainfall is 1878.3 mm and a fairly uniform temperature ranging between 26° C in August and 30° C in March is common within the area. Torrential rains are the norm with bright sunshine and a high humidity throughout the year. Sunshine duration for most part of the year averages 7 hours per day. Relative humidity is generally high throughout the year between 70 – 80 percent in the dry season and 75 – 80 percent in the wet season (Dickson and Benneh, 1995).

Fig. 1 Map of Ghana showing Tarkwa

2. Materials and Methods

In this research, participatory methodologies were employed. This was done to ensure that the output of the survey is reflective of what is on the grounds in various suburbs of Tarkwa and also to facilitate the effective involvement of most residents in the area of study (Tarkwa). The Waste Management Department's solid waste management facilities at the various dump sites and the final waste dump site at Bompieso where data was collected was visited. Face to face interviews and observations were chosen as the qualitative data method since this project is a case study. Participatory methods were employed to have an idea about the effects of the solid waste on human health, impact of aesthetics on the environment and location of the dump site in the suburbs. Primary data were collected through preliminary field investigation and face-to-face interviews. Secondary data were obtained from books, articles, newspapers and internet sources to review literature.

2.1 Solid Waste Collection

Refuse collection is mainly by either house-to-house or central container collection and the waste collected is finally disposed of in the landfill located at Bompieso.

In the house-to-house collection system which is very common in areas like Tamso Estate, dustbins are provided for each house generated. This is subsequently emptied by a collection crew who come around for them. Residents are charged a fee for the service and an additional fee to lease the garbage containers.

Fig. 2 House-to-House Collection Systems at Tamso Estate

Fig. 3 Containers Used for the Central Collection System at Aboso

2.2 Final Disposal of Waste

The final disposal of waste at the landfill at Bompieso is characterized by inappropriate location (because the site is closer to the town) and no engineering design of the landfill. Before it began to be used in early 2004 there was not any installation of clay lining or any plastic liner. The site has no engineered containment for leachate. At present, the dumping grounds are not engineered to serve as a sanitary landfill site. It therefore constitutes a high potential for the spread of infections through run offs during rains and contamination of underground water (where most people get their source of water) through leachate. Leachate is a liquid generated as a result of percolation of water or other liquids through landfilled waste and the compression of the waste as the weight of the overlying materials increases. Leachate is considered as a contaminated liquid since it contains many dissolved and suspended materials.Open air burning and spreading of waste is mostly done to reduce the volume of the solid waste at the dump sites.

Fig. 4 Open Air Burning at Landfill

Fig. 5 Spreading at Dump Landfill

Predicting the amount of waste that ends up at the landfill in the next five years from 2011 to 2015 is completed using Time Series Forecasting Method.

2.3 Time Series Forecasting Method

The time series method makes use of two relevant items. These are the historical data and the formula for the solution of the problem. Table 1 shows the historical data of waste in tonnes whiles figure 6 shows the characteristic of the historical data.

Table: 1 Historical data of waste in tonnes from 2006 to 2010

Year	Waste in tonnes annually
2006	68208
2007	75264
2008	87024
2009	89376
2010	108192

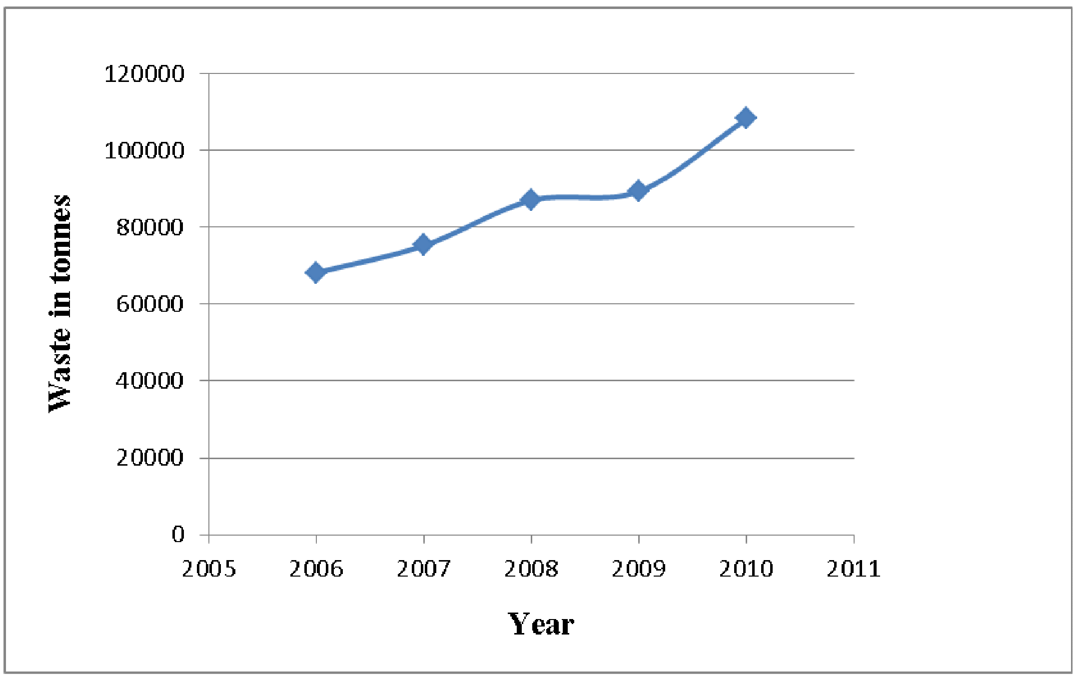

Fig. 6 Characteristic of the Historical Data from 2006-2011

From figure 6 it can be observed, that the historical data assumes a linear trend. The linear trend is represented in equation 1

$$Y = \beta_o + \beta_1 \sum_{i=1}^{n} X_i \qquad (1)$$

where,

X_i =Unknown waste driven factors

n = Number of waste driven factors

β_o =Y axis intercept

β_1 =Gradient of the line

$$\beta_1 = \frac{N\sum XY-(\sum X)(\sum Y)}{N\sum_X 2-(\sum X)^2} \quad (2)$$

$$\beta_0 = \sum\frac{Y}{N} - \beta_1\sum\frac{X}{N} \quad (3)$$

Where,

X=x-axis values (Years)

Y=y-axis values (Waste in tonnes)

N=Sample size

To obtain the values for β_1 and β_0 there is the need to compute the data given to obtain the table 2

Table 2: Coefficients for Demand Projection Line

Years	**X**	**Y(Waste In tonnes)**	**X^2**	**XY**
2006	1	68208	1	68208
2007	2	75264	4	150528
2008	3	87024	9	261072
2009	4	89376	16	357504
2010	5	108192	25	540960
Total	**15**	**428064**	**55**	**1378272**

$$\beta_1 = \frac{5(1378272)-15(428064)}{5(55)-(15^2)} = 9408$$

$$\beta_0 = \frac{428064}{5} - (9408)\frac{15}{5} = 57388.8$$

After obtaining β_1 or β_0 and substitution to equation 1 to obtain the projected waste demand from 2011 to 2015 in acquiring the table 3 with characteristic curve in figure 7

Table 3: Projected Waste Using the Time Series Forecasting Method

Year	Projected Waste (in tonnes)
2011	113837
2012	123145
2013	132653
2014	142061
2015	151469

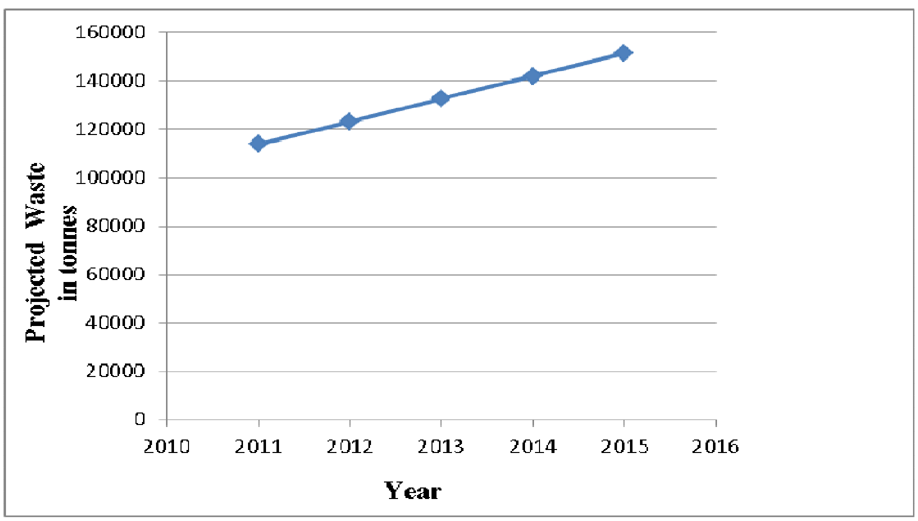

Fig. 7 Graph Showing Projected Waste From 2011-2015

3. Discussion of Results:

The historical data is shown in Table 1. while figure 6 shows the characteristic of the historical data. It is evident that the amount of waste generated in tonnes increased from year 2006 to 2011. The average waste generated is found to be 85612.8 tonnes. It is observed that the historical data assumes a linear trend as shown in figure 6; this trend is represented in equation 1. It shows increase in the trend. From the graph in figure 6, the line between 2008 and 2009 is almost a horizontal straight line which means the amount of waste generated is almost the same as could be seen in table 1. Projected waste generated from 2011 to 2015 also increased as shown in table 3. The graph of the projected waste using Time Series Method also shows an increase in the trend. It is observed that as the year progresses, there is increase in the amount of waste generated, the reason for this may not be far from increase in the population and urbanization of Tarkwa Municipality.

4. Conclusions

There is no engineered landfill in Tarkwa and this has resulted in a high level of pollution of both surface and groundwater through leachate from the dump sites. Most of the dump sites are situated near residential areas, due to this, when it rains the breeding of mosquitoes, which are potential carrier of Malaria is enhanced and also odours from these dump sites brings discomfort to the people. In 2008 the Waste Disposed was 87024 Tonnes. In 2012 and 2015 the Expected Waste Disposed would be 123145 and 151469 Tonnes respectively. This shows that an increase in the waste disposed is due to urbanization and the increase in population.

Recommendations

An engineering landfill site should be constructed to include a leachate collection system. With proper leachate collection system put in place the possibility of waste polluting groundwater in the area will be prevented. Waste dumped in the landfill should be spread, compacted and covered with soil in order to prevent heaping of waste in the landfill. The community should also employ the use of incinerators in burning the waste generated. Organizing of seminars by the Government and Non-Governmental Organizations to let the people know the need to change and become one another's keeper in making sure that people do not litter or throw waste anywhere and anyhow. This will sensitize the general public about the fact that everybody has a stake in waste management in as much as we want our city to be clean

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