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Challenges of plastic waste disposal in Ghana: a case study of solid waste disposal sites in Accra

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ABSTRACT

In Accra (Ghana), it is estimated that, plastic waste takes about 16.5% of the waste stream. In the past two decades, plastics have become the most favoured materials in the food and water packaging industry, contributing to an increase in their proportions in the waste stream in the region. Much earlier in the late 1980s and early 1990s, the use of paper in conventional packaging gave way most especially to polyethylene (low density, linear low density and high density polyethylene) film bags and other plastics as stringent quality standards were required in food and water packaging industries so as to minimize the incidence of food and water related epidemics. In recent years the use of plastics packaging for water and food has become favorable and very convenient. The public has therefore developed a strong desire for the use of plastics since it is less expensive, portable and can easily be carried from one place to another. After using the content, these plastics are indiscriminately discarded, littering the whole environment. These plastics however constitute a major proportion of the waste generated throughout the country, replacing leaves, glass and metals as a cheaper and more efficient means of packaging. In addition plastics collect around the city, choking gutters and drainages, threatening small animals in rivers and streams, affecting soil fertility and polluting beaches and other water bodies since resources available for the management of this waste and, for that matter plastic waste, are inadequate making it difficult to effectively and efficiently manage the waste generated.

Introduction

Background to the study

A major challenge facing developing countries is the collection, transportation, treatment and disposal of solid waste of which the great majority is destined for landfills, with significant but smaller amounts incinerated or recycled (Rader *et al.*, 1995). Most urban areas in the developing world use the crude dumping system to dispose of their solid waste, sometimes the waste is burnt openly. That is, waste is tipped into a dump, with very little on-site management. The Accra Metropolitan Assembly for instance, has no properly engineered sanitary landfills and waste is simply dumped into open pits and excavations resulting from quarrying and sand mining. In Zimbabwe, at least 60% of municipal solid wastes generated in large cities are dumped as crude, also known as open disposal sites, which do not meet basic environmental standards (Masocha, 2002). Mukuka and Masiye (2002) observed that disposal sites in Zambia used the open dumping method, with no control over the type of waste dumped at these sites. Wastes remain uncovered making them a potential health hazard.

Sustainable solid waste management is a problem not only faced by developing countries but the developed countries as well. Very large amounts of waste are generated throughout the world and the major challenge is how to manage these wastes effectively, efficiently and sustainably to ensure a clean, sound and safe environment for both the present and future generation (Wienaah, 2007). Many municipalities, cities and towns are continuously faced with the problem of solid waste management and the Metropolis of Accra, and for that matter Ghana, is no exception.

Over the last decades there has been a steady increase in the use of plastic products resulting in a proportionate rise of plastic waste in the municipal solid waste stream in large cities in sub-Sahara Africa (World Bank, 1996; Yankson, 1998). Most countries in sub-Sahara Africa do not have data on waste stream composition, but individual management authorities recognize and acknowledge the growing magnitude and prominence of plastic waste problems in the region. In Nigeria, Federal agencies are still busy working to find the total per capita generation of plastics per day and in Mauritania, this has been done and documented (World Bank, 1996). Waste composition studies are also being done in many sub-Sahara African countries of which Ghana is no exception, so that knowledge of the amounts of various waste components would be obtained.

Plate1. Open dumping of municipal solid waste in the Accra Metropolis

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In many southern African countries including the Republic of South Africa, Madagascar, Lesotho, Botswana, Zambia Zimbabwe and Angola, a lot of progress has been made in waste management in general, but detailed knowledge in the waste composition is lacking (World Bank, 1996). This is also the case with their counterparts in West and East Africa. In Ghana, for example, waste composition studies by Fobil (2001), estimate the percentage of plastics in the waste stream at 9%. Littering of plastic bags and other plastic waste is associated with numerous environmental problems; first, it causes visual pollution that affects sectors such as tourism. Secondly, plastic wastes block gutters and drains creating serious storm water problems and provides bleeding place for mosquitoes. In Bangladesh, for instance, a ban was imposed on plastic bags since March 2002, following flooding caused by blockage of drains (EPHC, 2002). Thirdly, plastic wastes that find their way into the sea and other water bodies kill aquatic wildlife when the animals ingest the plastics mistaking them for food. Ingestion of plastic bags by livestock also leads to death, since plastics takes many years to break down in the environment.

The organic components of municipal solid waste may not be of too much problem since it is degradable. The management of plastic waste through combustion is not environmentally friendly and sustainable since it may release carbon dioxide and toxic gases such as HCl, dioxins, PAHs and some heavy metals. Landfilling with plastic waste is not also desirable since plastics take about 20 to 1,000 years to degrade and no economic values will be derived from the waste in that case. The management options for sustainable plastic waste management by recycling, energy recovery, re-use and reduction has its own environmental and socio-economic challenges, since there is no source separation of waste.

Numerous plastic waste management tools have been used around the world to manage the problem associated with plastic bags, with various degrees of success. The instruments range from such command and control tools like outright bans, to voluntary schemes such as codes of practice and promotion of alternative bags (http://www.livingearth.org.uk/2010). Despite the present concerns and efforts of some individuals and the government in ensuring effective management of plastic waste, there has not been any advancement in the plastic waste management and for that matter; the country is still faced with serious plastic waste management problems.

Aims of the Study

The aim of the study is to assess the effectiveness of plastic waste management by dumping on the environment, health and socio-economic challenges.

The specific objectives of the study include;

- To undertake waste stream analysis of current waste disposal site;
- To undertake waste composition analysis of two old waste disposal site;
- To determine plastic waste density from the waste disposal sites;

Literature Review

Solid Waste Management

Waste is often referred to as useless, unwanted, discarded, or undesired material or substance. Depending upon the type of material and regional terminology, it is referred to as rubbish, trash, garbage or junk (Peavy et al., 1985). Human activities generate waste that is often discarded because they are considered unless or unwanted at a point and place in time (Kreith, 1994). In living organisms, waste relates to unwanted substances or toxins that are expelled from them. A material is considered to be a waste when its owner or generator discards it without expecting to be compensated for its inherent value. Waste can be classified depending on the source of the waste, the form in which it is found, the inherent properties and the effects that it has on the environment. Cointreau (1982), therefore, defined solid wastes as the organic and inorganic waste materials, produced by households, commercial, institutional and industrial activities, which have lost their value in the eyes of the first owner. Sources of waste could be domestic, industrial or agricultural. Waste could be in the form of solid, liquid and gaseous. These various sources and forms are either biodegradable or non-biodegradable waste.

Waste management is the collection, transportation, processing, recycling or disposal of waste materials. The term usually relates to materials produced by human activities and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances with different methods and field expertise for each.

Solid waste can also be described as waste materials containing less than 70% water (Baid, 1999). This waste is normally collected and transported by various means other than water. Solid waste comes in so many forms which includes degradable and non- degradable forms. These wastes are recycled, re-used or end up being buried in the ground. Most often than not house hold waste are non-hazardous. They do not pose immediate threat to human health and the environment as compared to the hazardous waste which has the potential to cause harm e.g. Corrosion, explosive toxic radioactive from commercial chemical and industrial substances for example, the percentage of plastics in the waste stream is 9% by weight shown in recent waste composition studies (Fobil, 2001). Waste in the environment is either harmless or harmful depending on the source of the waste and the method use for its disposal. The methods of waste disposal include landfilling, recycling, incineration and composting.

Profile on Waste Management in Ghana

According to Mr. Kpodo, the senior Environmental health technologist, waste management in Ghana started in July 1986, by the then Accra City Council with the assistance of the then German government. Before then, waste was been managed by individual in their own ways. The purpose of this was to improve on waste collection in the country as a result of the increasing waste generation in the country. Their responsibility was to collect waste from all sources of generation, transportation, treatment and final disposal suitable and acceptable to the metropolis.

Recent years have seen an increasing concern for the management of municipal solid waste in Ghana. This is as a result of the escalating production of municipal solid waste, especially in the large urban areas. Mr. Kpodo said, currently, 2000 tons of waste is generated in Accra daily and AMA is able to collect averagely 1500 tons per day. The 500 tons of waste is left in the environment unattended to, accumulates and litters the environment. Mr. Kpodo complained of inadequate logistics, funding, limited public awareness and education, weak enforcement of our bi-laws, inadequate skilled personnel and negative attitude. The waste composition includes; organic waste 65%, plastic waste 9%, paper waste 7%, glass waste 2%, metal waste 4%, textile waste 4% inert waste 13% and other waste 2% (Fobil *et al*, 2002).

There are two main methods of waste collection employed in Accra. House to house collection in middle to high income areas, where collection of waste is paid for by the residents in the area. This constitutes about 20% of the population in Accra. The next category is the communal central collection for middle to low income residential areas. They do not pay for the service according to policy and regulation and they constitute about 80% of the population in Accra. All the solid wastes collected are dumped at the Oblogo dump site, Mallam, Abokobi and the Teshie-Nungua compost plant. These waste dump sites are abandoned quarry sites with its own environmental dangers.

Study Area

Location of the Study Area

Oblogo and Mallam in the Greater Accra Region constitute the focus of this study. The Greater Accra Region lies between latitude $6^0 25^1$ N and $5^0 30^1$N and longitude $0^0$381 E and $0^0 31^1$ W (Fig. 3.1). The Greater Accra region is located in the southern part of the country. It shares common boarders with Central Region on the west, Volta Region on the east, Eastern Region on the north and the Gulf of Guinea on the south. It is the smallest of the ten administrative regions of Ghana occupying a land surface area of 3,245 square kilometers or 1.4 per cent of the total area of Ghana. It has a coastline of approximately 225 kilometers, stretching from Kokrobite in the west to Ada in the east. Greater Accra region comprises of ten administrative districts; Accra Metropolitan Area (AMA), La Municipal assembly, Ledzekuku-Krowor Municipal Assembly, Tema Municipal Assembly (TMA), Ga West District Assembly, Ga East District Assembly, Dangme East, Dangme West, Adenta Municipal Assembly and Ashiaman Municipal Assembly (www. ghanadistricts.gov.gh).Oblogo waste dump site is located in the south-western part of central Accra, in the Ga district. It is about 1km off Accra- Winneba off the Kasoa road. Oblogo waste dump was once a quarry site that belonged to Ghana Stone Quarry Ltd. It is situated between approximately 12km west of Accra Central and 200m to Oblogo township, and located on latitude $5^0 33^1 19^{11}$N and $5^0 33^1 40^{11}$N and longitude $0^0 18^1 53^{11}$W, $0^0 18^1 41^{11}$W(Fig.3.1). Mallam waste dump is located in Ga South, with its local administrative center at Weija. Mallam is located between latitudes $5^0 34^1 24^{11}$N and $5^0 34^1 05^{11}$N and longitude $0^0 17^1 28^{11}$W and $0^0 17^1 05^{11}$W.

Dumping of waste started at Oblogo in 2001 and closed in 2008 whilst dumping of waste commenced at Mallam dump site in the late 1990`s and was closed in the later part in 2007 and a new dumping site opened in February 2008 at Mallam. The Mallam and Oblogo waste dumps are not engineered landfills. The only activity there is dumping and compaction of waste, push and spread and pest control. There are no monitoring boreholes to check on the groundwater pollution. Control of odour and vectors by the use of cover materials at the end of each working day is absent, but there is pest control by spraying. Leachate that comes from the waste is stored in manhole temporary and eventually flows into natural drainages to join the Densu River (Kpodo, 2010).

Climate

The study area is relatively dry since it falls within the dry coastal equatorial climatic zone with temperatures ranging between 22^0C and 33^0C and annual rainfall ranging from 635mm along the coast to 114mm in the northern parts, with two rainfall peaks notably in June and October (Ghana Meteorological Service, 2010). The highest average monthly temperature occurs in April and the lowest in July. The study area falls within the dry equatorial region of Ghana with climate governed by three distinct air masses namely; the monsoon, the harmattan and the equatorial air masses. Mean relative humidity is high within a twenty-four hour period, occurring in January and highest in August (Ghana Statistical Service, 2005). The first rainfall season between April and July is associated with the major season in parts of the cropping season in the region, with the recent floods during the major season in parts of the region.

Fig. 3.1 Map showing Mallam and Oblogo – Waste Dumpsites

Relief and Drainage

The areas under study are characterized by an undulating terrain and relief ranging from 20m and100m. The Oblogo waste dump gently slopes in the south-eastern, with patches of hills rising shapely at about 2km adjacent to the Oblogo waste dump. These hills forms part of the continuous chain of the Akwapim - Togo range (Dickson and Benneh, 1995). Storm water runs through Oblogo Township and finally joins the sea via the Densu River. Surface runoff is high when it rains probably due to impermeable Togo series and clay cover, coupled with the topography of the area (Tigme, 2005)

Vegetation cover and Land Use

The vegetation is characterized by shrubs and grasses. Thin grass and occasional patches of shrubs characterized the waste dump area. The vegetation runs gradually from the Densu River and joins the surrounding wetlands around the coast (Dickson and Benneh, 1995). The region is not well endowed with mineral resources and possesses only granite, clay and salt (Ghana Statistical Service, 2005). The study area is a residential area, lacking infrastructure such as schools, health post and market (Tigme, 2005).

Industry and Water Resources

The major economic activities of the people in the area include: petty trading, stone quarrying and fishing. Some of the inhabitants are involved in recycling and scavenging activities at the waste dumpsite. Pipe borne water is the main source of drinking water and as such, there is inadequate exploration and exploitation of ground water in the area. As such boreholes and wells are scarce and the provision of amenities will be of immense help to people in the area (Tigme, 2005).

Geology of the area

The rock formation consists of metamorphosed sedimentary rocks, namely quartzite, schist and phyllites, which may be susceptible to fracturing upon stress. These rock forms the range of mountains and hills known as Akwapim-Togo range. The Akwapim-Togo range is bounded by two major thrust faults; one with the Dohomeyan contact at its eastern margin and its western contacts with the Cape Coast granitoids, the Voltain and the Buem. The trust fault along the western frank has been referred to as the western boundary fault and which occurs along the eastern margin as the eastern boundary fault. Both faults separate rocks at different lithologic facies. The underground water table ranges between 4.8m and 70m. The main soil types include, drift materials from wind-blown erosion, alluvial and marine mottled clays.

Hydrogeology and Seismicity

From its closest point, the Oblogo waste dump site is about 250m from the Densu River and 3km downstream off the Weija dam. The landfill is almost circular, about 4.5 acres in area with nearly vertical sides originally 9m high but almost 7m filled. Water infiltration rate is expected to be high in diverse directions due to extensive structural openings (Tigme, 2005). The raw leachate overflows from sumps and drains through the township and finally joins the Densu River.

Methodology

Sources of Data

The method employed in this study involved primary gathering of information from three main sources, namely, field study, chemical analysis and questionnaire administration.

Field Methodology

Field studies were conducted for waste characterization and plastic waste dispersal. Site visits and consultations with several plastic recycling companies and waste management companies were also undertaken.

Waste Stream Characterization

Waste stream analysis was undertaken for the current or ongoing waste dump at Mallam. From the three distinct identifiable municipal solid waste zones (Songsore, 1998): High Income Low Density Waste Zone (HILDWZ), Middle Income Medium Density Waste Zone (MIMDWZ) and Low Income High Density Waste Zone (LIHDWZ), waste was collected as the vehicles from these waste zones emptied their content at the Mallam dumpsite. About 60kg – 70 kg of waste is collection each time the vehicles empties its content. The wastes were then separated into the various components and weighed. Sorting of the waste was carried out with the help of scavengers at the waste dump sites.

At the old waste dumps at Oblogo and Mallam where dumping has ceased, waste composition was determined by digging trenches of one cubic meters at randomly selected points on the dump. The dug waste was then shaken to separate the soil from the waste dug. The wastes were than separated into the various components and weighed. The waste load gave a representation of the general area with a sample size between 10 – 15 kg. Hand gloves, nose mask and all other protective materials were employed to prevent contamination. The percentages of the various waste components were then estimated.

Estimation of plastic waste density

The density of plastic waste dispersal by wind, littering and indiscriminate dumping from the dumping site to the township is important as it measures the mass of plastic waste dispersed in a given area to ascertain its environmental, socio-economic and the health impacts. Density of the waste is the mass of waste per unit area, expressed as kg/m^2. The density of a waste stream depends on the variety of waste constituents, the degree of compaction, the state of decomposition and the total depth of waste at the landfill. Density is important because it is needed to assess the total mass and volume of waste to be managed. Density varies with geographical location, season and length of time in storage. In the determination of the density of dispersed plastic waste, an area $100m^2$ was chosen using four mounted electric poles to designate the corresponding locations or points. The sampling locations were taken with the help of a hand held Germin legend HCX 16C120719 geographical positioning system (GPS). At each designated area, as much plastic that were seen was collected, gathered, weighed and recorded for both Mallam and Oblogo respectively. The density of plastic waste was calculated using the formula;

Plastic Density = weight of Plastic waste / area.

The rate of plastic waste dispersion at Oblogo and Mallam were determined as expressed by the gradient from each plotted graph as the weight of the plastic wastes against the area (Fig.5.7 and 5.8 respectively).

Results and Discussion

Waste Stream Characterization at current Mallam Waste Disposal Site

Characterization of municipal solid waste was based on the three distinct socio-economic municipal solid waste zones; High Income low density waste zone, Middle income medium density waste zone and Low income high density waste zone. It can be observed from Fig 5.1 that, the majority of the waste sorted was organic waste with a mean value of 39% followed by plastic waste with a mean value of 16%, with the least mean value of 1% for Other Waste (shells, animal hooves etc.). Textiles and papers had mean values of 14% and 11% respectively with glass of a mean value of 3%.

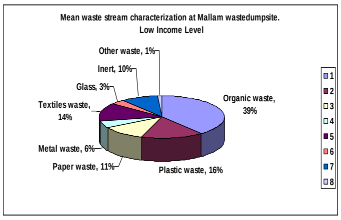

Fig 5.1% waste stream characterization at Mallam waste dumpsite. (Low income level)

The Middle Income Medium Density Waste Zone also followed the similar trend as that of the Low Income High Density Waste Zone. But it was observed that, there is an increase in the mean value of plastic waste with a value of 18%, which is skewed towards the maximum value of 25%. This indicates that, there is much plastic waste generated at the Middle Income Medium Density Waste Zone as compared to the organic waste whose mean value is skewed to the minimum value of 42%.

Subsequently, the waste sorted at the High Income Low Density Waste Zone, showed the same trend as that of fig 5.1 and 5.2 respectively but with a decrease in the mean value of organic waste (39%) as compare to Middle Income Medium Density Waste Zone of mean value of 42% and 39% of Low Income High Density Waste Zone (Fig 5.2).

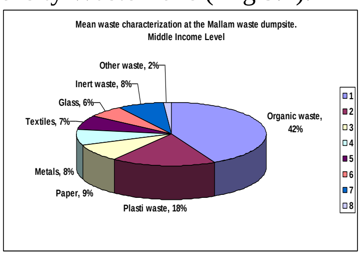

Fig 5.2% waste stream characterization at Mallam waste dumpsite. (Middle income level)

From fig. 5.3, it was observed that, there was a decrease in the mean value of organic waste sorted. Plastic waste had a mean value of 29% which is a bit closer to the mean value of the organic waste of 39%. The median value of plastics (30 %) is skewed towards the maximum value of 21% suggesting that more then half of the plastic waste sorted have higher values.

Comparing the three waste zones, it was observed that, the mean values of plastic waste was increasing from 16% (LIHDWZ), 17.85% (MIMDWZ) and 29% (HIDWZ).This trend suggests that, most of the waste disposed off at the dumping sites contains more plastics as indeed, the mean values of the organic waste keeps deceasing from 42% to

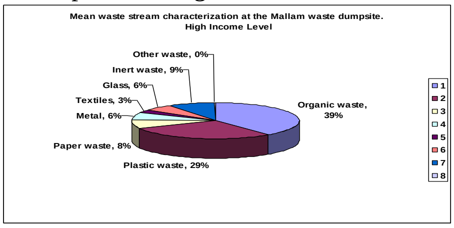

Fig 5.3% waste stream characterization at Mallam waste dumpsite. (High income level)

39%. This therefore indicates that, the percentage of plastic waste in the waste stream is increasing, since it is less expensive, can be easily carried from one place to the other, and is convenience and affordable. From Fig 5.3, it can be observed that, the percentage of plastics in the waste has increased as compare to the LIHDWZ and MIMDWZ. The percentage of plastics in the waste stream analysis carried out by Fobil, 2001, also recorded high level of plastic waste (9%) in the waste stream. This goes to prove that indeed, the percentage of plastics in the waste is increasing.

Waste Stream Composition at old Waste Disposal Site

Fig 5.4 below shows the statistical analysis of dug waste at the old mallam disposal site which has been abandoned for the past eight years. It can be observed from the table below that, the dug out waste contains more of plastics of a mean value of 56%. Other waste such as shells, hooves, rubber products etc. had a mean value of 35%.

It is significant that, no organic waste and paper waste was found for the waste stream analysis due to degradation under the influence of moisture, light and micro-organisms. Subsequently glass and metals were found but in small percentages of 2.0% and 6% probably due to sorting by scavengers on the disposal site as shown in fig 5.4.

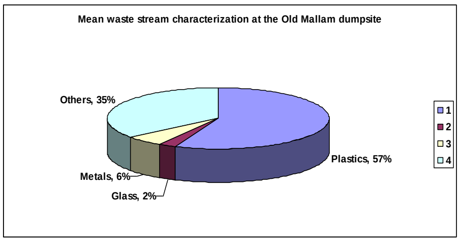

Fig. 5.4 Mean waste stream characterization at the Old Mallam dumpsite

In ascertaining the degree of Municipal Solid Waste degradation, it was observed that, the dug waste at both old Mallam disposal site and Oblogo disposal site contains more of plastic waste than glass, metals and other waste with no organic waste and paper waste. It can therefore be concluded that, indeed, the concentration of plastic waste at the disposal sites are increasing, since the organic waste and paper waste easily decomposed over a shorter period of time as compare to plastics that can stay in the environment over a longer period of time.

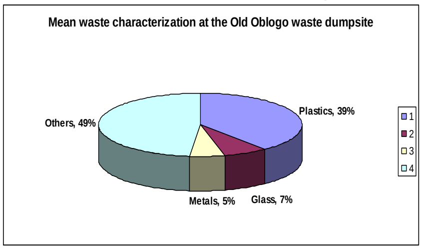

Fig. 5.5 Mean Waste Characterization at the Oblogo Waste Dumpsite

Estimation of the density of plastic waste dispersion

Plastics are generally lightweight, so can be carried away by wind. At the dumpsites and its environs, plastics especially the lightweight low density polyethylene were widely dispersed. Fig.5.6 represents the density of plastic waste dispersion at Mallam. The density of plastic waste dispersion sharply declines with respect to distance from the waste dump. Thus, the further away the area from the dumping site the lesser the density of plastic waste measured. The density of plastic waste dispersion decreases from dumping site to areas further away at a rate of 0.007 kg/m2 as can be seen from the linear equation in Fig 5.6.

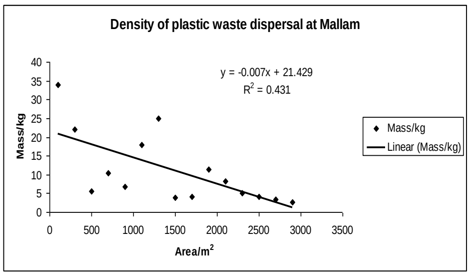

Fig. 5.6 Density of Plastic waste dispersal at Mallam

The density of plastic waste dispersion at Oblogo showed a steady decline with respect to increase in area from the dumping site as indicated in Fig.5.7. Again, the further away the area from the dumping site, the lesser the density of plastic waste. Appendix iv (b) represents the various locations of area of measurement. The density of plastic waste dispersion as described by the linear equation decreases from the dumping site to areas further away at a rate of 0.0021 kg/m2. The rate of dispersion of plastics depends on its weight of the plastic and wind, since the most dispersed plastic waste are low density polyethylene which are most commonly used.

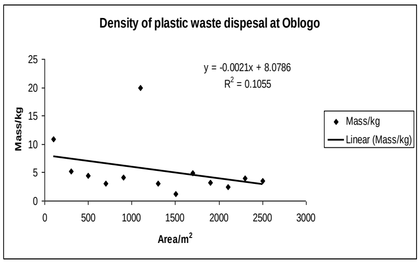

Fig. 5.7 Density of Plastic waste dispersal at Oblogo

Both Fig 5.6 and 5.7 showed a decline in density of plastic waste dispersion with respect to increase in area. However, a juxtaposition of Fig 5.6 gave a sharp decline as compared to Fig 5.7. Thus, the rate of plastic waste dispersion is greater in Mallam than Oblogo. This could be attributed to the fact that Oblogo is an old dumping site and that dumping has been halted whilst dumping was still on-going at Mallam. Therefore, density of plastic waste dispersion at new dumping sites could be said to be greater than at the old dumping sites.

Conclusion And Recommendations

Conclusion

The density of plastic waste dispersion at Mallam disposal site sharply declines with respect to increase in area. Thus, the further away the area from the dumping site the lesser the density of plastic waste measured. The density of plastic waste dispersion at Oblogo showed a steady decline with respect to increase in area from the dumping site. Again, the further away the area from the dumping site, the lesser the density of plastic waste.

Solid waste disposed by all levels of waste zones, had higher percentages of organic wastes ranging from 39%- 42% for low income high density, middle income medium density and high income low density waste zones. The percentages of other waste components of the waste stream analysis for low income high density and middle income medium density waste zone are; paper components, 9%-11% plastics, 15%-18% glass, 5%-7% metal wastes, 5%-8%, textile wastes, 7-13% inert, 7%-10% and miscellaneous or other waste between 1% and 2%. The other waste components disposed by high income low density waste zone was 7.6% paper, 29.167% for plastics, 5.68% glass,6.45% metal wastes, 2.8% textile wastes, 9.2% inert materials 0.2% miscellaneous or other wastes.

Waste characterization carried out at the old waste disposal dumpsites had no organic waste as well as paper waste in the waste composition. The ongoing waste disposal site at Mallam on the other hand gave higher percentage of organic waste as well as a representative fraction of paper waste in the waste sample characterized. This goes to explain the fact that, the old disposal waste disposal sites, Mallam and Oblogo that is eight and four years old respectively, has had a degree of decomposition since the organic and paper waste are easily degradable under the influence of moisture (water), light, temperature and micro-organisms present in the environment.

Recommendations

Once domestic solid wastes is generally generated from the households, they must be collected and managed through waste management strategies such as recycling, composting, incineration, or landfilling. There should be promotion of source-separation programmes for recycling and composting since the waste streams contained relatively higher proportions of compostable materials and plastics. However, before this could be done there should be intensive public education on waste segregation programmes. Waste segregation through source–separation may also increase the quality and value of certain valuable recyclables in the domestic solid waste stream.

The principle of 4R's of waste management which includes; waste prevention or source reduction means consuming and throwing away less, reuse materials once they are formulated, recycling process of making or creating used materials into new useful products instead of disposing and energy recovered from waste by using it as a fuel, must be encouraged through extensive education and awareness creation.

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