Theoretical and Empirical Researches in Urban Management
Number 8(17) / November 2010

SOURCE SPECIFIC QUANTIFICATION AND CHARACTERISATION OF SOLID WASTE ALONG A SANDY BEACH IN CAPE COAST, GHANA

Isaac M. BRYANT
University of Cape Coast, Department of Environmental Science, Cape Coast, Ghana; maranathabless@yahoo.com

Frederick A. ARMAH
University of Cape Coast, Department of Environmental Science, Cape Coast, Ghana; atoarmah@yahoo.com

Alex N.M. PAPPOE
University of Cape Coast, Department of Environmental Science, Cape Coast, Ghana; anmpappoe@yahoo.com

Abstract
Ghana is dealing with extensive urban periphery settlements due to the massive migration of rural inhabitants to the cities, especially to the political and economic capital, Accra and other regional capitals including Cape Coast. This phenomenon has culminated in indiscriminate solid waste disposal. With no effective municipal solid waste collection system in place, heaps of refuse have become ubiquitous in Cape Coast especially along the beaches. The quantity and composition of solid waste at two locations along a sandy beach in the Cape Coast municipality was investigated in this study. Using five permanent 20 x 4 quadrats over seven weeks in each of the two locations, the amount and composition of solid waste were assessed. The results indicated that paper, bottle, wood, leather, textile, metal, plastics, organic matter and styrofoam were the main categories of solid waste found at the sandy beach. The results also indicated that the quantity of solid waste generated at Duakor and West Gate was 514 $kgha^{-1}$ and 374 $kgha^{-1}$ respectively. This study suggests that source specific waste quantification and characterisation of solid waste at different scales should be a vital part of planning in municipal solid waste management systems.

Keywords: solid waste characterisation; quantification; sandy beach; Ghana.

1. INTRODUCTION

An estimated 46 million inhabitants occupy a narrow coastal margin of 60km in Central and West African Regions with the highest population densities focusing in coastal cities. This coupled with rapid urban expansion has lead to negative human and environmental impacts along the coastal regions (Barrios *et al.*, 2006; Cohen, 2006). The United Nations Environment Programme (UNEP, 1999) estimates the rate of urban growth in Ghana at more than three per cent per annum, ranking Ghana

53rd among 184 countries covered by UNEP (Armah et al., 2009). Ghana is dealing with extensive urban periphery settlements due to the massive migration of rural inhabitants to the cities, especially to the political and economic capital, Accra (Boadi and Kuitunen, 2002; Boadi *et al*., 2005). However, regional capitals including Cape Coast have equally witnessed extensive in-migration over the last few years. Solid waste has become an important issue in Ghana. Piles of wastes are often found by roads, rivers and many other open spaces in cities, and this is causing significant health and environmental problems (Asomani-Boateng, 2007). These wastes need to be stored, collected, transported, processed and disposed of in an environmentally friendly manner in order to keep cities neat and clean (Gawaikar and Deshpande, 2006). Severe housing needs and urban poverty compel migrants to settle on marginal lands within and at the periphery of the cities. Persons in these settlements have low-income and the settlements in themselves often lack essential social services, especially those related to sanitation (clean water, sewerage and waste management system), resulting in heavy environmental pollution (Armah et al., 2009). Water resources usually become the key environmental component that suffers foremost from such unbridled pollution (Armah et al., 2009); a situation epitomised by the sandy beaches in Cape Coast. As cities develop, land use becomes increasingly complex and the wastes generated increase in volume and variety (Karani and Jewasikiewitz, 2007). Consequently, solid waste management has to be considered from a holistic or systems perspective (Post, 2002). As the system handles huge quantities of solid waste it is imperative to acquire detailed information on quantification and characterisation of solid waste for proper handling of solid waste at different stages of the system (Gawaikar and Deshpande, 2006).

According to (Oteng-Ababio, 2010)the sources of waste produced in Ghana are residues from energy production, industry, agriculture, mining, construction, demolition and sewage sludge. Over the years, the amount of municipal solid waste in Ghana has grown steadily, in part because of increasing population, but more so because of changing lifestyle and the increasing use of disposal materials and containers.

The volume of solid waste produced in Ghana has increased tremendously over the years due largely to economic development activities involving productions and consumption of goods and services. For example, it is estimated that the total municipal solid waste generated in the country increased from about 2,200,000 metric tons in 1984 to about 3,730,000 metric tons in the year 2000. The volume of solid waste produced in Ghana has also increased with population growth over the years. While the total population of Ghana increased by about 54% between 1984 and 2000, the total solid waste generation grew 69.5% within the same period (Oteng-Ababio, 2010).. According to the Accra

Theoretical and Empirical Researches in Urban Management
Number 8(17) / November 2010

Metropolitan Authority (AMA), Metropolitan Solid Waste (MSW) generated by the 3 million inhabitants' amount to 1800 tons daily, with a large portion of this quantity being plastics (Oteng-Ababio, 2010).

In Ghana, though the decentralized municipal authorities are responsible for district planning, waste removal and enforcement of sanitation regulations, other line agencies such as Environmental Health and Environmental Protections Agency also have overlapping responsibilities of ensuring that cities are void of waste nuisances, through compliance enforcement actions. The duplication of functions in the waste management sectors in any country is recipe for conflicts, which, undoubtedly, result in inefficiencies in the waste management sector (Thuy, 1998; Armah et al., 2009). Presently, majority of metropolitan and municipal authorities do not weigh their waste. However, the quantities are estimated on the basis of number of trips of trucks which carry the waste to the disposal site. The most significant aspect of solid waste management is the quantity of waste to be managed. The quantity determines the size and number of functional units and equipment needed for managing the waste (Gawaikar and Deshpande, 2006). The quantities are measured in terms of weight and volume. The weight is fairly constant for a given set of discarded objects whereas volume is highly variable.

This work seeks to assess the quantum of solid waste generated at two locations on a sandy beach at Duakor and the West Gate of the University of Cape Coast in the central region of Ghana where solid waste has been accumulating over the past few years due to indiscriminate waste disposal and inefficient waste collection services. Specifically, the objectives of the study were to:

- Identify and characterize solid wastes based on their physical properties.
- Determine the quantum of solid wastes at the two locations.

2. MATERIALS AND METHODS

Study Area

Duakor is a small village that lies between Elmina and Cape Coast University on the Cape Coast-Takoradi highway, about one minute drive from the University of Cape Coast West Gate along the highway. Cape Coast lies between latitude 5^0 and 5^0 30'N and longitude 1^0 and $1^0$30'W. The highway separates the village from the sandy beach of the Gulf of Guinea of the Atlantic Ocean. The climate of the area falls within the general climate of Cape Coast. Cape Coast experiences high temperatures year round, the hottest months being February and March i.e. just before the main rainy season, while the coolest months are between June and August. The invariability in climate in the metropolis is influenced more by rainfall than temperature. The major drainage system at the sandy beach is the sea water. The soil type found is mostly sandy soil with occasional particles of mud mixing with the sandy soil as a result of wave actions that constantly move the particles ashore. The vegetation at this sandy beach is mostly *Opuntia sp., Euphorbia glaucophylla*, *Thespesia sp.* (grasses), *Dodder sp.* with some few thickets of *Chromolaena odorata,* because of their adaptive potentials to xeric conditions.

Collection of solid Waste

A randomly selected location was chosen at the sandy beach along the shores of Duakor, across the intertidal zone to include the supratidal zone. Five 20.0m by 4.0m quadrats were demarcated. The distance between contiguous quadrats was maintained at 4.0m. The quadrats were labeled Da, Db, Dc, Dd and De, consecutively, from east to west. The solid waste found within this demarcated area was collected, sorted out into their various components as paper, leather, bottle, plastics, textile, Styrofoam, organic matter, metal and wood. The categorized wastes were weighed using a US PAT. No. 2,729,439 Triple Beam Balance, with capacity of 26108g. The values obtained were recorded. The procedure was followed at UCC West Gate, about 500m east of Duakor. Here the quadrats were labeled Wa, Wb, Wc, Wd, and We. For collection, sorting and weighing of solid waste. Data were collected at weekly intervals for seven weeks at both sites.

Calculations for Composition

The compositions of the waste corresponding to the two locations (Duakor and UCC west gate) were calculated using the method described below. The method was applied separately to each waste category being studied.

Calculating the Mean Estimate:

For a given material, j, which in this case refer to paper, plastic, leather, bottle, textile, Styrofoam, organic matter, metal or wood , in all of the relevant samples, i, the ratio, r, of the material weight, m, to the total sample weight, w is given by:

$$r_j = \frac{\Sigma_i m_{i,j}}{\Sigma_i w_{i,j}}$$

At Duakor Sandy Beach

$$r_{paper} = \frac{122.1}{587.2} = 0.208$$

$$rplastics = \frac{128.2}{587.2} = 0.218$$

$$rleather = \frac{30}{587.2} = 0.051$$

$$rleather = \frac{30}{587.2} = 0.051$$

$$rbottle = \frac{22.9}{587.2} = 0.039$$

$$rtextile = \frac{66.6}{587.2} = 0.113$$

$$rstyrofoam = \frac{35.1}{587.2} = 0.060$$

$$rorganic\ matter = \frac{154.8}{587.2} = 0.264$$

$$rmetal = \frac{7.8}{587.2} = 0.013$$

$$rwood = \frac{19.7}{587.2} = 0.034$$

At UCC Sandy Beach

$$rpaper = \frac{18.4}{427.8} = 0.043$$

$$rplastics = \frac{146.8}{427.8} = 0.343$$

$$rleather = \frac{8.1}{427.8} = 0.019$$

$$rbottle = \frac{1.0}{427.8} = 0.002$$

$$rtextile = \frac{42.7}{427.8} = 0.073$$

$$rstyrofoam = \frac{19.2}{427.8} = 0.045$$

$$rorganic\ matter = \frac{150.8}{427.8} = 0.353$$

$$r_{metal} = \frac{9.8}{427.8} = 0.023$$

$$r_{wood} = \frac{31.0}{427.8} = 0.072$$

Calculating the Error Range:

For each mean estimate, *rpaper, rplastics, rleather, rbottle, rwood, rorganic matter, rtextile, rstyrofoam and rmetal,* r calculated as described above, the confidence interval (error range) surrounding the mean estimate was calculated as follows:

First, the variance, *V rpaper*, of the mean estimate is given by.

$$Vrj = \frac{1}{n} \times \frac{1}{w^2} \times \frac{\sum i\,(mij-rjwi)^2}{n-1}$$

Where n is the number of samples, and mean sample weight $w = \frac{\sum iwi}{N}$

Confidence level is ± (t X $\sqrt{Vi,j}$), where t depends on the number of samples, n, and the desired confidence level.

Moisture Content

Moisture content is a very important factor that influences the decisions for converting organic waste into compost and biogas, using solid waste as a fuel, and designing landfills or incineration plants. Currently there are various types of moisture meters available to check the moisture content. However, the traditional test could also be done on certain types of materials. The moisture content was measured by heating the sample at 105°C in an oven until the weight loss stabilized. The weight of the sample before and after gave the moisture content. The different fractions of the waste at the two locations and their moisture contents were measured separately. Representative samples were selected from the sorted fractions depending on the waste materials. Solid plastics do not need to be dried to find the moisture content, but bottles need to be emptied before weighing whereas plastic films do need to be dried to find moisture content. The moisture content measurement was carried out on the same day of the sample collection to avoid drying out.

3. RESULTS

The results obtained at both study sites indicated that nine categories of solid waste were identified at the sandy beaches. These categories of solid waste included paper, leather, bottle, plastics, textile,

Theoretical and Empirical Researches in Urban Management
Number 8(17) / November 2010

Styrofoam, organic matter, metal and wood. Organic matter was the most significant solid waste collected and weighed at the Duakor beach, because it had the highest percentage component of solid waste of 27%. The most significant solid waste collected and weighed at the UCC West Gate sandy beach was organic matter. This category had the percentage component solid waste of 36%. The least abundant solid waste at the Duakor sandy beach was bottle and metal (with mean weights of 22.9 g and 7.8 g respectively). These were encountered only two times throughout the study period. The least abundant solid waste collected and weighed at the UCC West Gate sandy beach was bottle (with mean weight of 1.0g). It was recorded only once, that is in the fifth week. The following solid wastes were common for both study sites: paper, plastics, Styrofoam, textile and organic matter for Duakor and UCC West Gate sandy beaches, but their quantities varied ranging from 8.1 g to 150.8 g out of the mean total of 427.8 g at UCC West Gate and 19.7 g to 154.8 g out of the mean total of 587.2 g at Duakor sandy beach.

Generally, the quantity of paper weighed and recorded at the Duakor sandy beach decreased as the number of weeks increased, except in the sixth week. There was consistent variation in the quantity of paper weighed and recorded at the UCC West Gate sandy beach. The quantity of leather weighed and recorded at both the Duakor and UCC West Gate sandy beach varied with the weeks. The quantity of plastics weighed and recorded varied with the weeks at both study sites. There were variations in the quantities of textiles weighed at both study sites over the period of study. The mean weight values for Styrofoam kept fluctuating over the weeks at both locations. The highest mean weight was recorded at Duakor sandy beach for organic matter in the first week. One–way ANOVA indicated that the quantity of solid waste collected at Duakor significantly differs from that at the UCC West Gate.

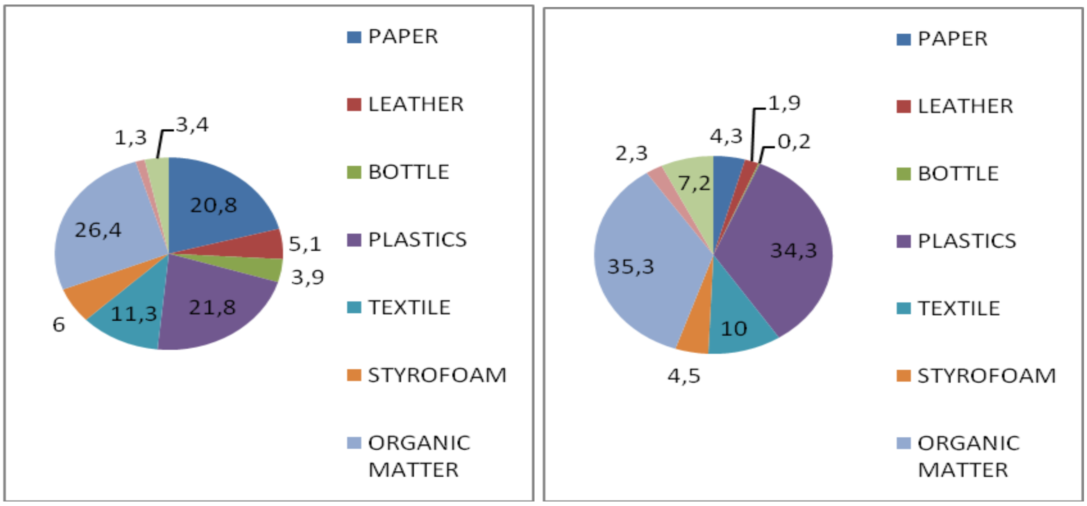

FIGURE 1: WEEKLY MEAN % OF COMPONENT OF SOLID WASTE AT DUAKOR AND UCC WEST GATE

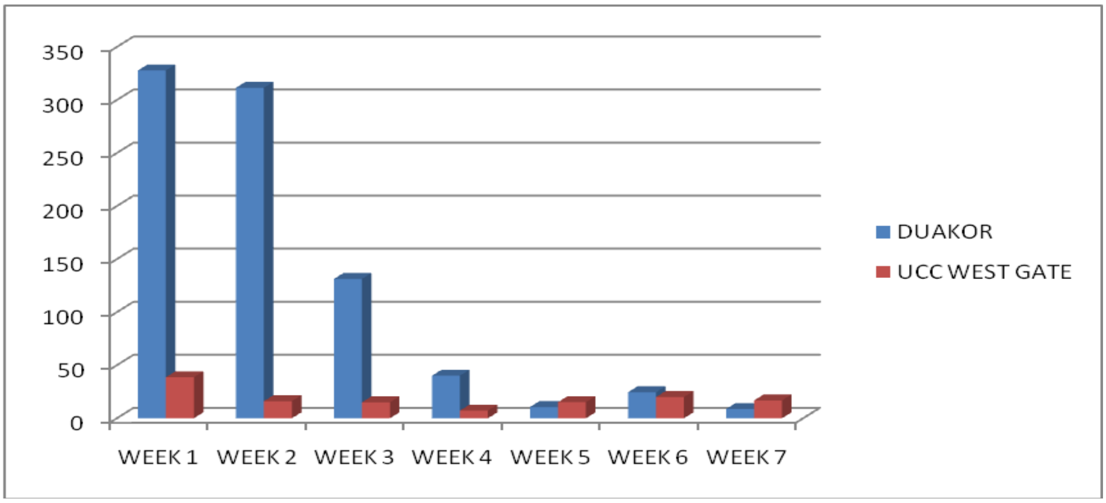

FIGURE 2: QUANTITY OF PAPER WEIGHED AT BOTH STUDY SITES

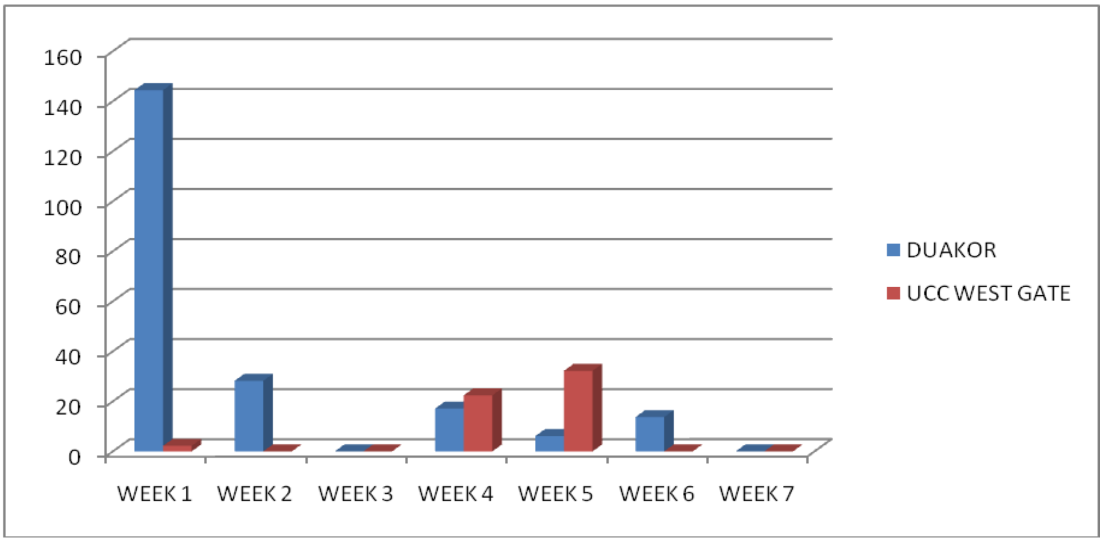

FIGURE 3: QUANTITY OF LEATHER WEIGHED AT BOTH STUDY SITES

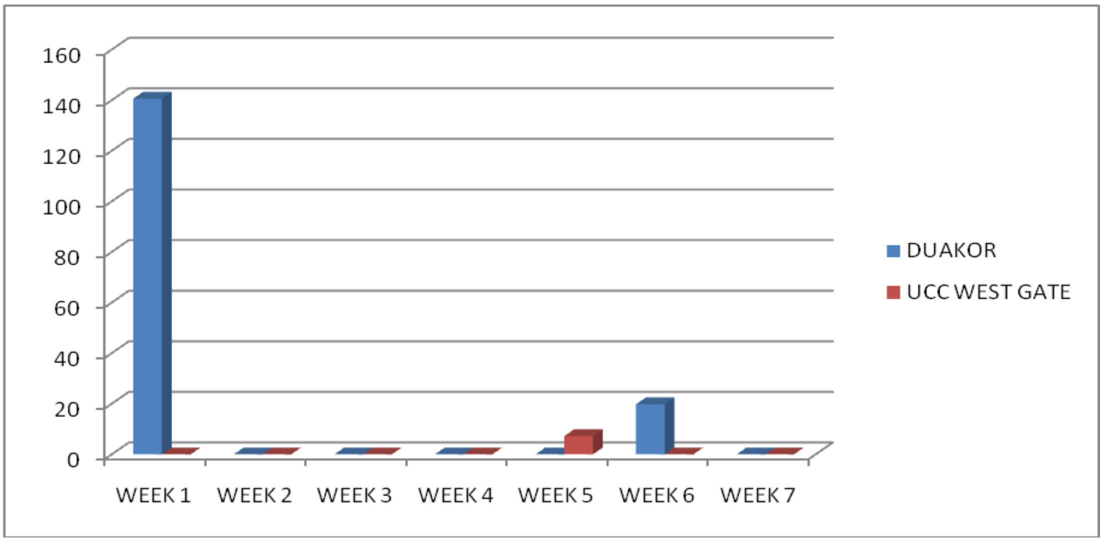

FIGURE 4: QUANTITY OF BOTTLE WEIGHED AT BOTH STUDY SITES

Theoretical and Empirical Researches in Urban Management
Number 8(17) / November 2010

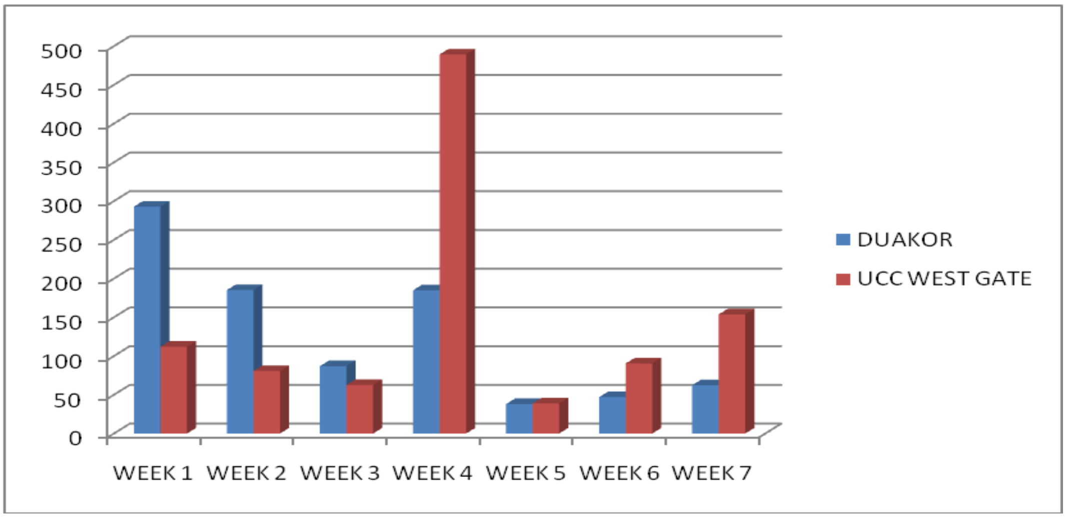

FIGURE 5: QUANTITY OF PLASTICS WEIGHED AT BOTH STUDY SITES

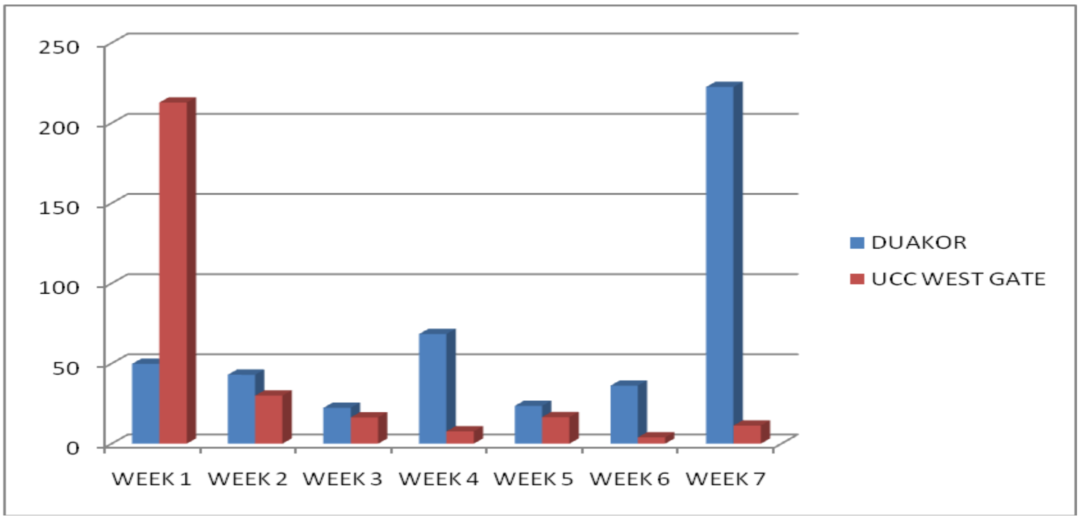

FIGURE 6: QUANTITY OF TEXTILE WEIGHED AT STUDY SITES

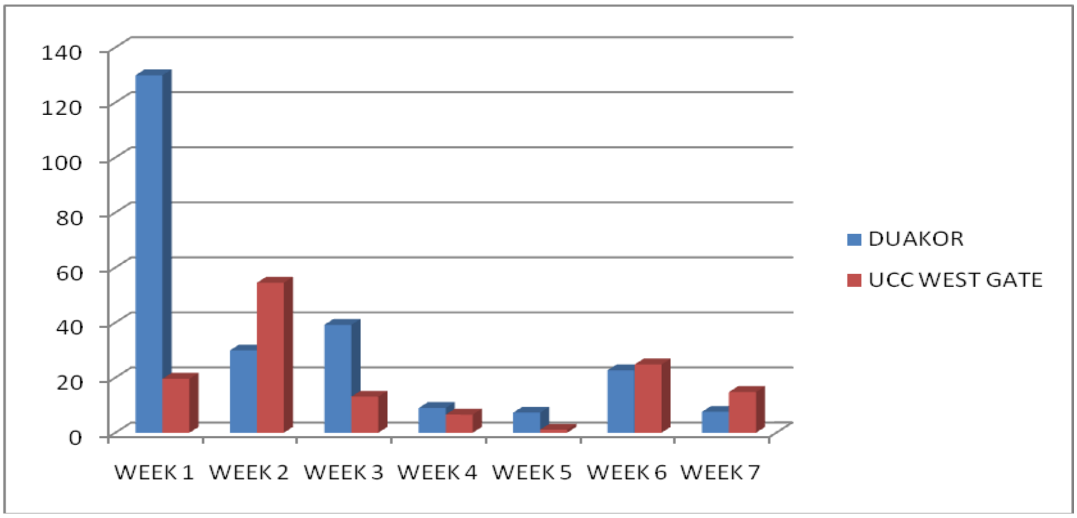

FIGURE 7: QUANTITY OF STYROFOAM WEIGHED AT BOTH STUDY SITES

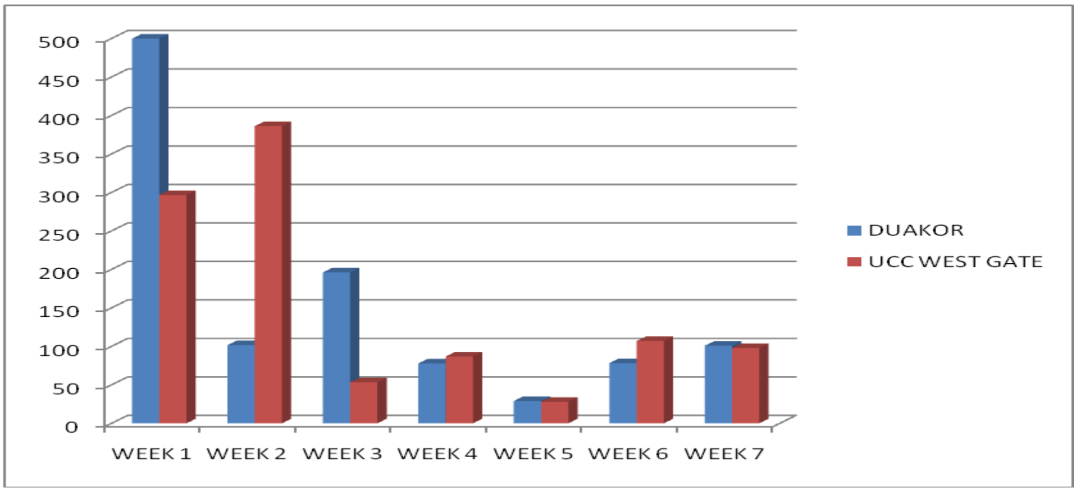

FIGURE 8: QUANTITY OF ORGANIC MATTER WEIGHED AT BOTH SITES

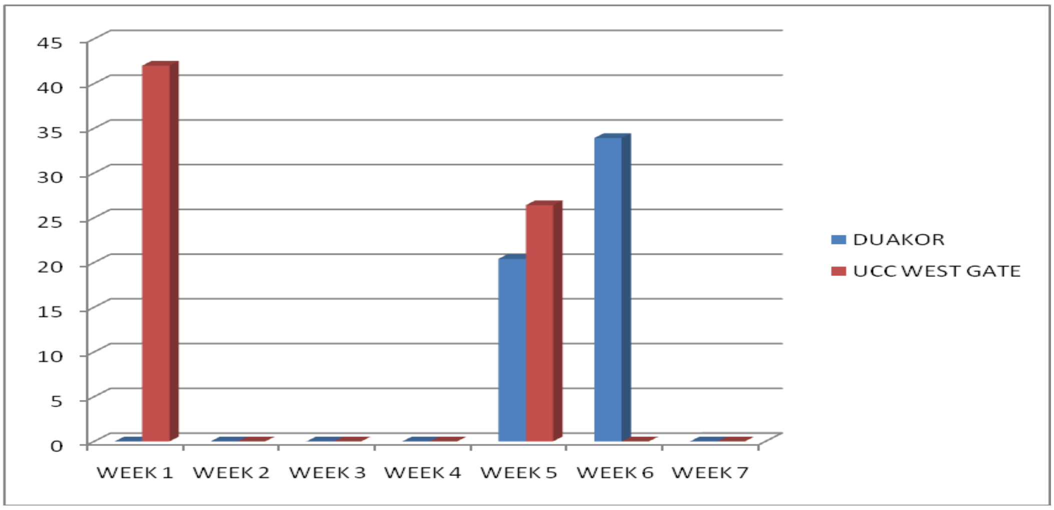

FIGURE 9: QUANTITY OF METAL WEIGHED AT BOTH STUDY SITES

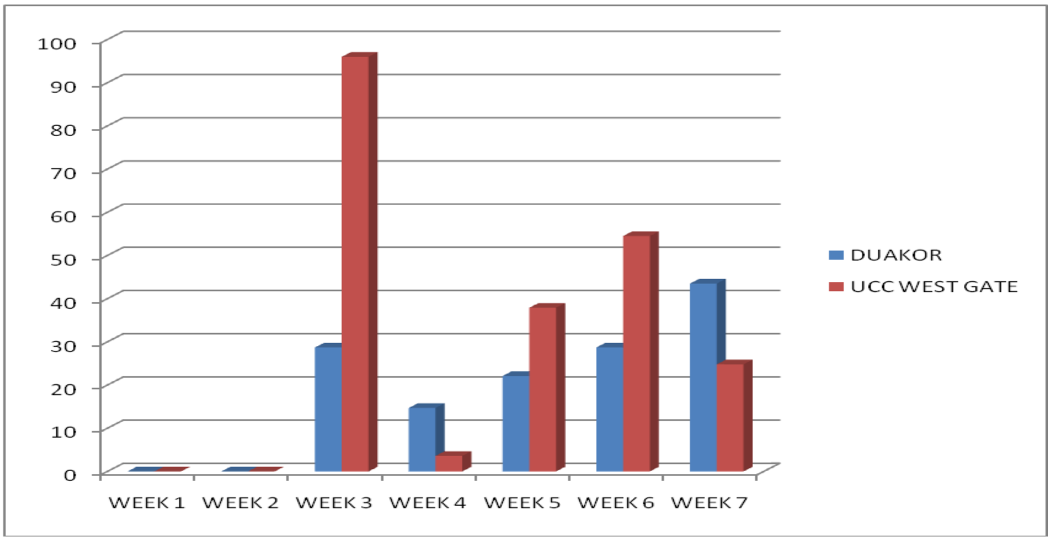

FIGURE 10: QUANTITY OF WOOD WEIGHED AT BOTH STUDY SITES

Theoretical and Empirical Researches in Urban Management
Number 8(17) / November 2010

4. DISCUSSIONS

This work assessed the quantum of solid waste on sandy beaches at two locations in the Central region over seven weeks. It was observed from the results obtained at Duakor sandy beach that, the quantity of paper collected and weighed decreased steadily from the first week through to the sixth week where there was a little increase in the quantity of paper weighed and decreased again in the seventh week. The highest value of paper recorded was 321.8g, in the first week at the Duakor sandy beach while the highest value of paper recorded at the UCC West Gate sandy beach was 20.0g in the sixth week.

The highest value of paper recorded at the Duakor sandy beach can be attributed to the fact that, the inhabitants of the village use the sandy beach as their place of convenience. They use paper to clean themselves after attending nature's call thus leaving a large chunk of paper at the sandy beach. A research conducted by UNEP (1999) indicated that tourists on expedition leave behind garbage such as coca cola tins, toilet papers, oxygen cylinders and other plastics at sandy beaches, nicknaming such sandy beaches as "coca cola trail" or "toilet paper trail". Most of the people who visit the Duakor sandy beach are fishermen, fishmongers from the Duakor village and other inhabitants of the village. Since the existing places of convenience in the village are not in good condition, the villagers have resorted to the sandy beach as their place of convenience, hence the higher value in paper at the Duakor sandy beach. The paper recorded at the UCC West Gate may also be attributed to the hawkers who normally sell at the beach. They occasionally used the sandy beach as their place of convenience when the need arose. Also, passer-by and some students who learn at beach occasionally ease themselves there, leaving those papers behind. They sometimes buy food wrapped in paper from hawkers that visit the place to sell and eventually leave the papers behind.

The highest quantity of leather (144.0g) was recorded at the Duakor sandy beach, compared to the 32.2g recorded at the UCC West Gate. They were recorded in the first and fifth weeks, respectively. Duakor sandy beach recorded the highest value for leather due to the fact that many fishmongers visit the sandy beach with their footwear which when they find out that the footwear are worn-out, discard them at the beach, which they see as a waste dumping site. In addition, the leather waste at the Duakor sandy beach might have been carried by the sea waves ashore from other places. The lower quantum of leather waste obtained at the UCC West Gate could be explained thus; majority of students who visit the sandy beach rarely dispose their footwear at the beach. The leather waste that was obtained at the West Gate might have been carried ashore from another place.

The highest mean value of glass obtained at the Duakor sandy beach was 140.6g while that obtained at the UCC West Gate sandy beach was7.2g Miller (1996), gives examples of solid waste discarded by homes and businesses in or near urban areas and sandy beaches as :newspapers, empty cans and bottles, food waste and packaging materials, worn out clothing and broken dishes. It might have occurred that some of the fishermen at the village take in alcoholic beverages which they take along when going for fishing. After they have emptied the contents of the bottles they discard the bottles at the beach. Occasionally, some of the students, who form the majority group of the visitors to the UCC West Gate sandy beach, also drink these alcoholic beverages, leaving the bottles on the sandy beach. Research work done at Mamalla city sandy beach reported that many of the solid wastes like glass and plastic are non biodegradable, causing permanent pollution at the sandy beaches.

Duakor sandy beach recorded the highest mean weight for plastics (292±53.8) g then West Gate (489±117.1)g. The higher value at the West Gate sandy beach indicates that many visitors to the sandy beach especially students, after drinking water from sachet rubber throw the sachet rubber away on the sandy beach. The majority of the plastics weighed were made of sachet rubber, fun ice and yoghurt sachet, with a few being empty plastic bottles of fizzle drinks like fanta and coke. All these wastes mighty have been generated by students who visited the sandy beach either to learn or for relaxation with friends. The plastic waste collected and weighed at the Duakor sandy beach were mainly sachet and a few polythene bags. It is reported that, in areas with high concentrations of tourist activities and appealing natural attractions, solid waste disposal is a serious problem and improper disposal can be a major despoiler of the natural environment-rivers, scenic areas, and roadsides. Solid waste and littering at the sandy beach can degrade the physical appearance of the water and shoreline and cause the death of marine animals. The source of these plastics might have been the fishermen and fishmongers who often visited the beach for their fishing activities. In the course of fishing activities, some fishermen as well as those who visit the beach to purchase fresh fish, drink waste and dispose of the sachet, on the sandy beach. Individuals visit the beach to purchase some fresh fish also drink water and dispose of the sachet. Some of the fishmongers occasionally put their fresh fish in polythene bags. When these polythene bags get torn in the course of putting the fishes in them they are disposed of at the beach making the place unsightly. Poor disposal of solid waste such as empty cans and plastics in some urban areas contributes to the spread of malaria which kills more than 1.5 million people in Africa annually. Whenever management and disposal of industrial and domestic waste is inadequate, these sources of soil and water contamination pose potential hazards to human and ecosystem health.

The highest value of textile recorded at Duakor sandy beach had a mean weighty of 222.5g. This value was recorded as a result of the regular defecating activities that go on at the Duakor sandy beach. Many people from Duakor, when they visit the beach to attend nature's call either use paper or textile for cleaning themselves, hence leaving a large quantity of textile materials at the Duakor sandy beach. At

Theoretical and Empirical Researches in Urban Management
Number 8(17) / November 2010

the UCC West Gate sandy beach, the highest quantity of textile materials could be attributed to those who visited the beach to attend to nature's call. Some of the textile materials weighed included handkerchief. Some of the handkerchiefs might have been left behind accidentally by the visitors.

The highest quantity of Styrofoam recorded at the Duakor sandy beach was 129.9g in the first week. The Styrofoam, because of its floating properties on water, is used by fishermen during their fishing activities as indicators of whether their net is moving away or coming ashore. After the fishermen have had their catch, they remove the Styrofoam materials that were attached to the fishing nets and leave them on the sandy beach, thus increasing the quantity of Styrofoam found at the sandy beach. When it is time for another fishing expedition, they go to the sea shore with different Styrofoam, increasing the existing quantities at the beach. At the UCC West Gate sandy beach, the highest quantity of Styrofoam weighed was 5405g in the second week. Since the majority of the people who visit the UCC West Gate sandy beach are students from UCC, the Styrofoam found there might have been carried ashore from either Duakor fishing area or Ola fishing area about 4km away. Some of the Styrofoam found at the beach were used "Take Away" containers. These might have been left behind by some social groups after they had organized beach party at the sandy beach. The development of economic activities and the subsequent urbanization of coastal areas have put immense pressure on the marine environment and ecosystems. Garbage left by the visitors on the beaches make them unsuitable for recreation.

The highest quantity of organic matter collected at the Duakor sandy beach was 499.8g, in the fifth week. The organic matter collected and weighed were mostly leftover of eaten fruits like oranges, sugarcane peels, coconut and leaves of the plants along the beaches. In addition, the natives of Duakor regularly harvest the coconut trees along the sandy beach and leave behind a large quantity of eaten coconut fruits, so as the peels. At the UCC West Gate sandy beach, the highest mean value for organic matter was 386.1g in the first week. The organic matter weighed was also made of eaten oranges, coconut leftovers and sugarcane peels. This waste might have been generated by the transient population that visits the sandy beach. The mean quantity of metal weighed at the sandy beach was 33.9g in the sixth week. The metal that was weighed comprised mainly aluminium cans. At the UCC West Gate sandy beach, the highest mean quantity of metal was 42.0g, in the first week. The metal comprised empty cans like fanta and coke and empty milo tins, milk tins and nido tins. Some of these might have been carried ashore from the high seas. Also, some of the metal cans might have been generated by the students who visit the sandy beach. Thus after they have emptied the contents of their canned minerals like coke and fanta, they leave behind those empty cans at the beach. Plastic and metallic garbage found on the beaches affect marine wildlife. The highest mean value for wood that was weighed from Duakor sandy beach was 4305g, in the seventh week while that of the UCC West Gate sandy beach was 96.0g, in the third week. The source of wood recorded at both sandy beaches is from the repair works that are carried out on canoes and broken paddles.

The mean quantity of solid waste weighed at Duakor sandy beach was 4108.7g per 80.0m^2 over the seven week period of study, giving an estimate of about 514kgha^{-1}. Also, the mean quantity of solid waste weighed at the UCC West Gate sandy beach over the seven week period of study was 2994.6g per 80m^2 area which can be estimated at 374kgha^{-1}. The quantities of solid waste produced per week at both sites were 73kgha^{-1} and 53kgha^{-1} per week respectively, for Duakor and UCC West Gate. The quantity of solid waste collected at Duakor significantly differs from that at the UCC West Gate, as indicated by the one- way ANOVA.

5. CONCLUSIONS

The mean quantity of solid waste weighed at Duakor sandy beach over the seven-week study period was approximately 73kgha^{-1} per week, while the mean quantity of solid waste at the UCC West Gate sandy beach was approximately 53kgha^{-1} per week. The groups of solid waste that were identified and weighed at both study sites were plastics, glasses, wood, leather, textiles, metals, paper, organic matter and Styrofoam. Duakor sandy beach was found to be more polluted with solid waste than the UCC West Gate sandy beach. This study suggests that source specific waste quantification and characterisation of solid waste at different scales should be a vital part of planning in municipal solid waste management systems.

REFERENCES

Armah, F.A., Yawson, D.O. and Alkan, O.J. (2009). The Gap between Theory and Practice of Stakeholder Participation: the case of the management of the Korle Lagoon, Ghana. *Law, Environment, & Development Journal, 5*, pp. 73-91.

Asomani-Boateng, R. (2007). Closing the Loop: Community-Based Organic Solid Waste Recycling, Urban Gardening, and Land Use Planning in Ghana, West Africa. *Journal of Planning Education and Research , 27*, pp. 132-145

Barrios, S., Bertinelli, L. and Strobl, E. (2006). Climatic change and rural–urban migration:The case of sub-Saharan Africa. *Journal of Urban Economics , 60*, pp. 357-371.

Boadi, K. and Kuitunen, M. (2002). Urban Waste Pollution in the Korle Lagoon, Accra,Ghana. *Environmentalist , 22* (4), pp. 301-309.

Boadi, K., Kuitunen, M., Raheem, K. and Hanninen, K. (2005). Urbanisation without Development: Environmental and Health Implications in African Cities. *Environment,Development and Sustainability , 7*, pp. 465-500.

Cohen, B. (2006). Urbanization in developing countries:Current trends,future projections, and key challenges for sustainability. *Technology in Society , 28*, 63-80.

Gawaikar, V. and Deshpande, V.P. (2006). Source specific quantification and characterisation of municipal solid waste-A Review. *IE (I) Journal-EN 86*, pp. 33-38.

Karani, P. and Jewasikiewitz, S.M. (2007). Waste management and sustainable development in South Africa. *Environment, Development and Sustainability*, 9, pp.163-185

Miller, T.G. Jr. (1996). *Living in the Environment, Principles, Connections, and solutions*, 9th edition, Wadsworth Publishing Company, U.S.A., pp. 529-558.

Oteng-Ababio, M. (2010). Missing links in solid waste management in the Greater Accra Metropolitan Area in Ghana. *Waste Management and Research 28,* pp. 322-329.

Post, J. (2002). New partnerships in the collection of urban solid waste in developing world. In: Baud I.S.A., Post, J. & Furedy, C. (eds) *Urban Management, Markets and Sustainable Development, Urban Solid Waste Management in Hyderabad and Nairobi*. London: Earthscan Publication, 33–51.

Thuy, T.A. (1998). *Towards Efficient waste management in African Cities: The transformation needed, Municipal Development Programme*, BP No. 013445, Cotonou, Benin.

UNEP (1999). Overview of Land-based Sources and Activities Affecting the Marine, Coastal and Associated Freshwater Environment in the West and Coastal African Region. *Regional Seas Reports and Studies* No. 171.