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Solid waste generation and characterization in the University of Lagos for a sustainable waste management

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ABSTRACT

Waste characterization is the first step to any successful waste management policy. In this paper, the characterization and the trend of solid waste generated in University of Lagos, Nigeria was carried out using ASTM D5231-92 and Resource Conservation Reservation Authority RCRA Waste Sampling Draft Technical Guidance methods. The recyclable potential of the waste is very high constituting about 75% of the total waste generated. The estimated average daily solid waste generation in Unilag Akoka campus was estimated to be 32.2 tons. The solid waste characterization was found to be: polythene bags 24% (7.73 tons/day), paper 15% (4.83 tons/day), organic matters 15%, (4.83 tons/day), plastic 9% (2.90 tons/-day), inert materials 8% (2.58 tons/day), sanitary 7% (2.25 tons/day), textile 7% (2.25 tons/day), others 6% (1.93 tons/day), leather 4% (1.29 tons/day) metals 3% (0.97 tons/day), glass 2% (0.64 tons/day) and e-waste 0% (0.0 tons/day). The volume and distribution of polythene bags generated on campus had a positive significant statistical correlation with the distribution of commercial and academic structures on campus. Waste management options to optimize reuse, recycling and reduce waste generation were discussed.

1. Introduction

In today's world, University communities can be regarded as "mini cities" with large territorial coverage, diverse human activities, these having different degrees of effect on the environment (Alshuwaikhat and Abubakar, 2008). Nigerian Universities in Oyo and Lagos state for example, have been said to act as their own municipalities (Adeniran, 2014, 2015). The Universities and Colleges are required by state and international bodies to adopt sustainable development strategies in all their operations in order to have a positive impact on the socio–economic and environmental wellbeing of their immediate and extended communities. The importance of Universities in promoting sustainable development has been highlighted in a number of significant declarations, including the Talloires Declaration (1990), the Halifax Declaration (1991), the Swansea Declaration (1993), the Kyoto Declaration (1993), the Copernicus Charter (1993), Students for a Sustainable Future (1995), (IISD, 2002) and (Greyson, 2007,).

An integrated waste management system is one of the major challenges for sustainable development. According Rick Leblanc (2016) "Integrated Solid Waste Management (ISWM) represents a contemporary and systematic approach to solid waste management. The U.S. Environmental Protection Agency (EPA) defines ISWM as a complete waste reduction, collection, composting, recycling, and disposal system. An efficient ISWM system considers how to reduce, reuse, recycle, and manage waste to protect human health and the natural environment." Amijo de Vege et al. (2008) identified waste characterization as the first step to any successful waste management policy, in order to estimate potential materials recovery, identify sources of component generation, facilitate design of processing equipment, estimate physical, chemical, and thermal properties of the wastes, and maintain compliance with regulations. The composition of generated waste varies as a result of seasonal variation, lifestyle, demographic, geographic, and local legislation impacted (Hockett et al., 1995; Irwan et al., 2011; AbdAlqader and Hamad, 2012).

Effective waste management program is generally low in Nigeria. Although, there are legislations and regulatory bodies established to drive the program at the three tiers of government (Local, State and Federal) but less success had been recorded (Nathaniel et al., 2012). There are a host of policies and regulations on solid waste management (SWM) in Nigeria. Despite these, waste management is in its lowest ebb. Nigeria generates more

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than 32 million tons of solid waste annually, out of which only 20–30% is collected. MSW are indiscriminately disposed leading to blockage of canals, drainages and causing pollution to water bodies. Despite being a model for other states in the country, MSW is a big challenge for the Lagos State Waste Management Agency (LAWMA) to manage alone, hence the need to engage the services of private waste firms and other franchise to reduce the burden of waste collection and disposal (Bakare, 2016; UNEP, 2009). Some research works have been carried out on collection and characterization of solid wastes in some cities like Enugu, Onitsha, Ota and Ojo Local Government area (Uwadiegwu and Chukwu, 2013; Nwachukwu, 2010; Olukanni and Ugwu, 2013; Longe and Ukpebor, 2008), There is little or no data on the volume or characteristics of waste generated in most tertiary institution in the country on which to initiate a design for waste management system for the institutions. The work of Amori et al. (2013) focused on solid waste generation from residential areas in three institutions in South West Nigeria.

The aim of this research is to characterize the waste generated in the University of Lagos (Unilag) Akoka campus with the view to determining the trends in the volume of waste generated and examine possible integrated solid waste management strategies.

2. Materials and method

2.1. Sampling area

University of Lagos, Akoka campus is located in the Western part of Lagos, Nigeria. It is one of the major University campuses in Nigeria with an estimated 561 hectres of land area hosting 10 faculties, 330 staff housing units, 15 students' hostels and several administrative and academic buildings. It has 52,779 students' enrollment and 4688 members of staff for the 2014/2015 academic year. Only about 25% of the student population and 10% of staff are resident on campus. The University campus has an estimated 87,000 day population. Major activities on campus focused on teaching, research and community services. In carrying out these functions, academic, administrative, residential and commercial spaces are provided. Majority of the area have permanent structures which are often purposely built for specific activity. Fig. 1 shows the map of Africa showing the location of Nigeria, Lagos and the University of Lagos.

2.2. The University waste collections system

For the purpose of waste collection, the University campus landmass was divided into four (4) zones A, B, C and D (Fig. 2). Two private waste managers were employed to collect waste for zone A and B and the other to collect for zone C and D respectively. The Waste is disposed to the University Sorting Centre where each waste manager sorts the recyclable wastes and package for onward transfer to recycling company. The residues are disposed for land reclamation where feasible.

2.3. Activity grouping of zones

Structures within each zone were categorized into four main groups viz. (i) academic and research, (ii) commercial, (iii) residential and (iv) administrative. A structure is block(s) of buildings constructed for specific utility. The number of structure within each zone was grouped together based on the nature of activity. The breakdown of structural grouping of all zones is presented in Table 1. A correlation analysis using SPSS 21 was used to investigate the relationship between waste generation in each zone and the activity distribution of the structures on campus.

2.4. Waste categorization and recycling potential rating

Three weeks trial sampling was conducted to determine the regular waste types generated on campus and the grouping pattern suitable for the sampling exercise. Waste were classified into major categories using grouping system of the College and University Recycling Council (CURC, 2001), with modifications to accommodate peculiar waste stream generated on campus (Table 2). The recycling potential of each waste was evaluated based on the availability of recycling market for each material within the locality.

2.5. Sampling procedure

Sampling was carried out using the ASTM D5231-92 and Resource Conservation Reservation Authority RCRA Waste Sampling Draft Technical Guidance methods. The ASTM method requires that: (1) statistical criteria should be used to determine the number of samples; (2) vehicles sampling should be random and performed over a 5–7-days period and; (3) the initial sample should weigh approximately four times the subsample that will be sorted (Gidarakos et al., 2005). The RCRA method provided basis for field sampling after the vehicles had discharged. The number of sample (n) required was determined using the equation:

$$n = (T^{*}S/EX)^{2} \quad (1)$$

where

T^{*} = the student's *t*-test corresponding to the desired level of confident,
S = the estimated standard deviation,
E = the desired level of precision, and
X = the estimated mean.

The number of samples to be collected was statistically determined using the student T^{*} value at 90% confident level and 10% precision level. The standard deviation (S) and mean X was calculated using polythene bags as the governing waste composition. A total of 48 samples were collected based on Eq. (1) (S = 0.52, X = 0.95). Twelve samples were collected from each zone. Sampling was carried out thrice every month. The waste trucks were randomly selected for sampling based on the waste collection zone. After discharge, samples were collected at different layers using shovel and polythene bags. The composite sample from each truck is mixed and weighed. Average sample size is between 30-50 kg . The samples were sorted into each category of waste manually and the average weights of each component determined. Samples were collected between October 2014 and September 2015.

2.6. Daily waste generation

The daily waste generation on campus was determined by measuring the dimension of each waste truck at 90% of its capacity to accommodate loading error that could be associated with non- compactor waste trucks. Two waste trucks of 16.5 m^3 capacity and a compactor truck of 18.6 m^3 were used for waste collection. The waste volumes (m^3) were converted to weight (in tons) using the NALAS Municipal Solid Waste Information System (SWIS) management software for municipal waste. The numbers of trips per day by each waste truck are recorded in the waste collection log book at the University sorting centre which is used to determine the average daily waste generation on campus (Table 3).