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MUNICIPAL SOLID WASTE GENERATION AND MANAGEMENT IN OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

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Abstract
Waste disposal and management have always been a problem to people in every part of the world of which Nigeria is not left out. This research work assesses the waste management system in Obafemi Awolowo University, Ile-Ife focusing on the central campus. It also aims, among others, at determining the quantity of waste generated within the O.A.U campus (per capita waste generation) and projecting toward a period of 10 years, the population of inhabitants with a view to estimating the possible amount of waste that may be generated over the said period. The research was carried out through the administration of questionnaires, interview, observations and field work. Data were collected on the storage, collection and disposal systems. It comprised an estimation of the volume of solid waste generated per capita per day and involved the determination of the number and capacity of refuse storage bins. Necessary information was gathered over the duration which the observation and field work of the research was carried out. The Result reveals that the amount of waste generated per day within the Obafemi Awolowo University Campus is 0.69kg/day = 0.00038m^3/day that is judging by the density of municipal solid waste being 1800kg/m^3. The result also reveals there is little or no difference comparing the situation of the University fifteen years ago with the present in relation to the way waste is managed and sensitization of the inhabitants of the university campus should not be relented on.

Key Words: *Waste disposal, Waste management system, Obafemi Awolowo University, per capita waste generation*

Introduction

Wastes are materials that are not prime products (that is products produced for the market) for which the generator has no further use in terms of his/her own purpose of production, transformation or consumption, and of which he/she wants to be disposed (Ahsan and Ismail, 2013; Bourtsalas and Seo, 2019).

Waste may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final product, the consumption of final products and other human activities. In

view of this, practically every material used by man appears at some point in time as waste even the most precious materials involving stones, gold and silvers are found as component of waste (Ahsan *et al.,* 2012; Alwaeli, 2015).

Proper management of these wastes is essential as: with the growing population of the world, increase in industrial activity and material expansion comes a proportionate increase in the amount of waste generated (Fadipe *et al.,* 2011; Antonio *et al*., 2017; Annepu, 2012). Improper management of these wastes culminates to littering of the environment with these waste matters, drain blockage and subsequent flooding, insect pest breeding ground and a whole list of factors that are detrimental to man who produced such waste. This goes a long way in ascertaining the general societal saying that "what goes around comes around".

Obafemi Awolowo University (O.A.U) established in 1962, within Osun state, has a very well-planned campus with facilities located at appropriate location to serve the needs of the populace of the O.A.U community members. But it has become evident that with the passage of time, these facilities are overstretched to meet the needs of the growing number of students and community members on campus so also is the waste management facility. This has resulted in non-effectiveness of these facilities for use to the benefit of the populace within the campus, thus resulting in indiscriminate littering of the environment.

In the light of the growing concern about increasing waste generation, seemingly non activeness of the appropriate authorities in charge of waste management, and in a bid to improve the waste management method within the University campus, this research work was embarked on. It is hoped that to a great extent, this research work will go a long way to further stimulate awareness about waste generation, its effect on the environment and proper management processes.

Materials and Methods

The area of study is Obafemi Awolowo University, Ile-Ife, Osun State Nigeria. The University is situated geographically within the rain forest zone, on latitude 7° 28' N and 7° 35' N longitude 4°33' E and 4°35' at average altitude of 200m above sea level. It covers a land area of 11,855 hectares with its central campus covering 112 hectares.

The university has a total of 13 faculties and 95 departments (Figure 1), as at the time of this research, and of basic importance is that students, artisans, workers, traders, spends the most active period of everyday especially the weekdays at the central campus area and at such generate more waste in this area.

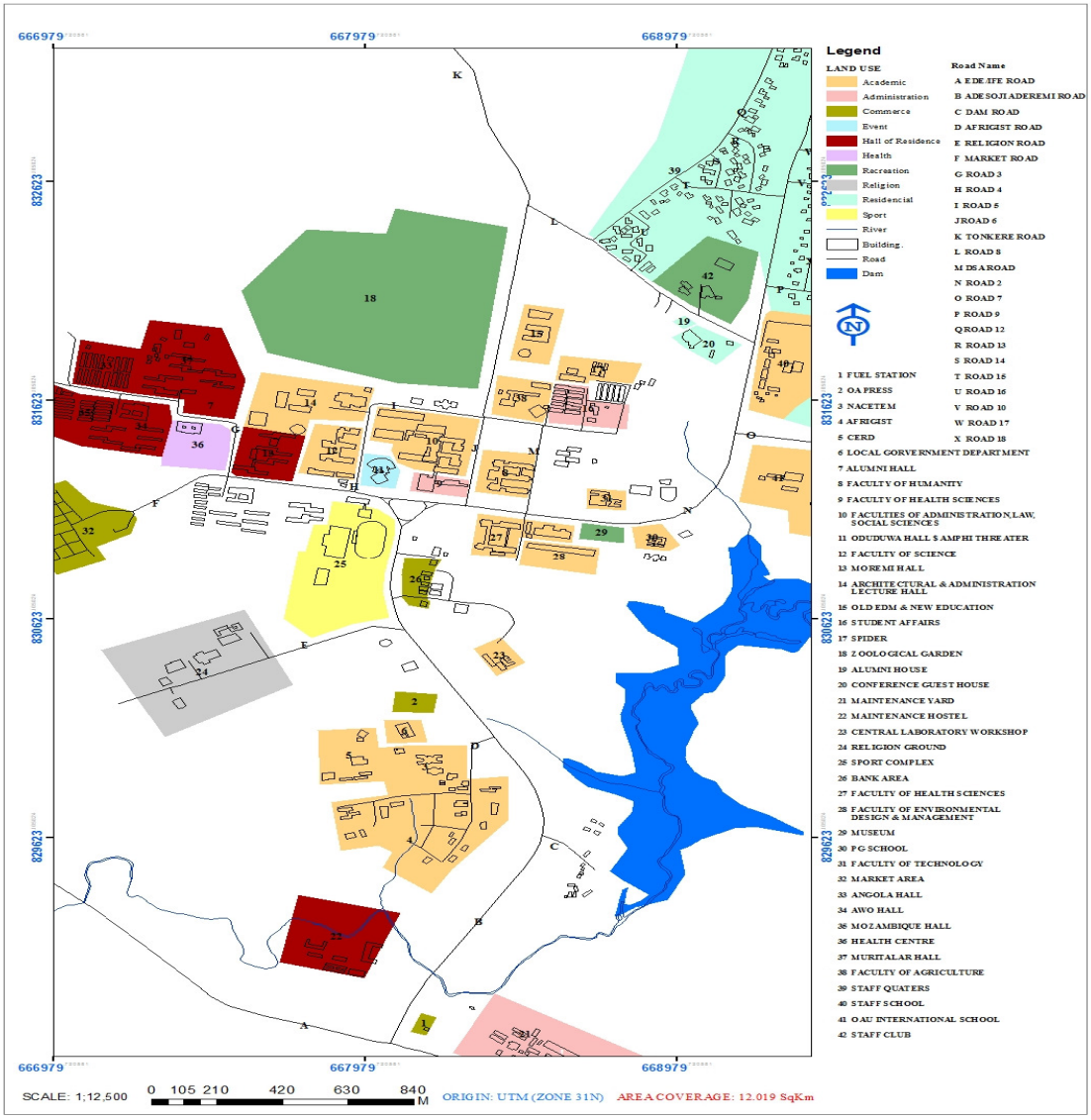

Fig. 1: Map of Obafemi Awolowo University central campus showing all the thirteen Faculties and other facilities

The research work covered the central campus for which the faculties and department within the campus, secretariat, organisations, buildings and units within the university central campus were taken into consideration.

The methodology adopted in carrying out this research work is divided into three:

i) Obtaining research resource
ii) The use of questionnaires and interviews
iii) Observation and field study

Obtaining Research Resource

Information on staff (Academic and Non-Academic) population over a period of nine academic sessions in each department of the university was obtained from the Planning, Budget and

Monitoring Unit of the university as against the Directorate of Personnel Affairs (DPA) unit of the university. The population data obtained over this period (nine years) was owing to data at the disposal of the unit as records of population over earlier than this could not be retrieved. The information is necessary as it was used for population projection and per capita waste generation.

Also, information on student population over a nine-year period was obtained from the Planning, Budgeting and Monitoring Unit as against the Division of Student Affairs (DSA) unit of the university. The information obtained was also used for the projection of population and estimation of waste generated per capita. The information obtained from the preceding paragraphs was studied and projection using the least mean squared method of population projection was performed on the university community population to a further 10-year period.

The Use of Questionnaires and Interview

Questionnaires were administered at the environmental health and sanitation unit of the university to obtain information on:

i) The structure of the unit
ii) Available facilities at the disposal of the unit
iii) Work personnel or staff strength
iv) Schedule of work
v) Working hour per day
vi) Method of waste management adopted by the university
vii) Problems associated with the method of waste management
viii) Problems encountered while executing their function

Another set of questionnaires, totaling 200, was administered at different location within the study area to collect information on

a. Method of waste storage
b. Problems associated with storage method
c. Alternative refuse management method
d. Characteristics of waste generated daily and possibilities of sorting

Observation and Field Study

This process includes monitoring of waste bins and visitation of dumpsite. Over the period of the research, the waste dumpsters located within the campus was counted and their location noted. These dumpsters were monitored for a period of two months, i.e. both midday and evening, by members of the research group in a bid to provide answers to the following questions:

a) How often does the bin fill up after the waste has been carted away?
b) Are the bins adequate for the catchments they are to serve, or should more be added?
c) Who uses the bin in a particular catchment?
d) Are the personnel saddled with the responsibility of waste carting within a particular period performing their function as at when due?
e) Is waste dumped indiscriminately around the bin? If so, why?

The monitoring of waste bin within the campus aided the determination of per capita waste generation estimation. The dumpsite was visited by the research team to carry out an assessment of the site and to determine the size of the dumpsite, the mode and manner of operation on the dumpsite.

Analysis of Data

Data analyses were performed using the statistical package for social science

(SPSS) on questionnaires administered at different location within the school campus to obtain representative responses of the respondents.

Results and Discussion

The waste dumpsters in the area under consideration are provided by the university authority and they were monitored by the research team and the result is discussed.

Waste Management in Obafemi Awolowo University

The waste management in Obafemi Awolowo University is as discussed below.

The Storage Method Adopted

At each building, housing faculties and departments, there are provisions of waste bins, usually plastic, made by either staff or student body within the structure of such department. The bins range between $0.021m^3$ and $0.072m^3$ in volume and in most cases bins of these sizes are provided by those transacting business within the central campus area. Example of such people are photocopy machine operators at the side of Hezekiah Oluwasanmi library. More so the university management made provision for metallic basket bin, $0.025m^3$ in volume, suspended at various point within the university.

The Environmental Health Unit

The unit responsible for the management of waste within the O.A.U community is the environmental health unit of the university. The collection method adopted by the unit within the central campus is the use of refuse dumpsters placed centrally between structures to serve these structures. These dumpsters are metallic covered and uncovered and their volume obtained by actual measurement by the research team reveals that the covered metallic bin has a volume of $4.36m^3$ while the uncovered metallic bin has volume of $0.71m^3$.

Structure of the Environmental Health Unit

The unit is under the university's medical and health services department and has cadres of offices that are depicted in the organogram in Figure 2. There are vacant posts that exist in the unit especially those of higher offices of such is the post of a principal health officer, deputy environmental health officer and chief environmental health officer.

As at the time of research, the number of health assistance in the unit were 45 in number with quite a few involved in the daily (Monday to Friday) collection of waste. And the unit operate an eight-hour daily program from 8am to 4pm.

The equipment used for collection of waste, are 10 rakes, 6 shovels, 15 boots and 15 gloves which include those in stock. One cannot but notice the inadequacy of these tools. The personnel collecting waste do not sometimes use nose guard and are ill informed on the hazard associated with inhaling of gases that emanate from waste dumpsters and handling of wastes. The unit make use of one lorry out of two available and one tractor as well. The use of one lorry was attributed to non-availability of personnel to man the vehicle.

Dumpster Location and Source of Waste Generated

The factors that were considered for the choice of area for which the dumpsters serve are security, convenience and a 30 m radius. Table 1 shows where the dumpsters are serving.

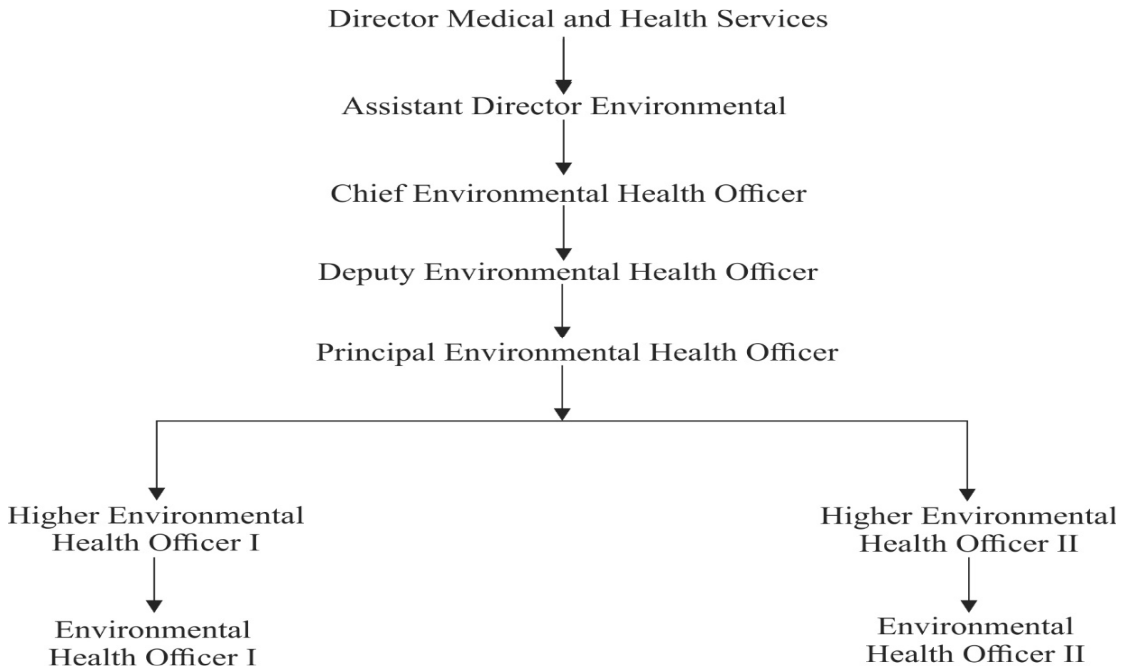

Fig. 2: Organisational Profile of the senior Staff Cadre of the Environmental Health Unit of Obafemi Awolowo University, Ile-Ife

The ease with which one accesses the dumpsters was also considered for the choice of structure each dumpster is to serve. Closeness to structure was also necessary as it determines which dumpster will be used in lieu of the other. In addition to security and convenience, for the selection of structures, a 30m radius is taken from the dumpster location and any structure within this catchment is considered as also being served by the dumpster.

Waste Generated and Collection Period

Table 2 shows the rate at which dumpsters at various locations within the central campus gets filled up during academic session. According to our findings, we discovered that each dumpster is cleared at most once in a week. Sometimes when there is much waste especially over a weekend, waste in some part of the university may be left and this stays beyond the usual period of waste collection as stated in the Table 2.

Table 1: Dumpsters Locations and Sources of Waste Generated with Population Generating Waste

Dumpster Location	Area Served Using 30 m Radius from Dumpster Location	Population Served
Between Moremi Hall/White House	Moremi Hall, Part of Faculty of Science Building (White House), Mathematics Department (Yellow House)	1389
Road 3B: In front of UNIFECS	UNIFECS, Architecture Department, 1000 Seater Lecture Theatre	607
Road 3B: PTF Building/Geology Car park	1000 Seater Lecture Theatre, Part of Faculty of Science (White House), Dramatic Art Building	908
Road 3: Beside Africa Amphi Theatre	Part of The Faculty of Science (White House), ODLT 1 and 2, Oduduwa Hall	3631
Between Faculty of Administration and Hezekiah Oluwasanmi Library	Faculty of Administration, Faculty of Law, Hezekiah Oluwasanmi Library, Faculty of Education	8000
Road 4: Between Senate Extension and Humanities Block III	Secretariat, Biological Science, Humanities Blocks I,I,III	4997
Road 4: Between Faculties of Agriculture and Environmental Designs and Management	Faculty of EDM and Faculty of Agriculture	3180
Road 5: In front of Central Science Laboratory	Central Science Laboratory, Part of Utilities	750
Between Utilities and Parks and Gardens Unit	Civil Engineering Building, Urban and Regional Planning (URP) Department, Ecology, Part of Parks And Gardens	1656
Road 5: Faculty of Social Science, First Bank Lecture Theatre	Faculty of Social Sciences, First Bank Lecture Theatre, Part of Faculty of Education	5209
Behind Chemical Engineering and Food Science and Technology Department	Chemical Engineering and Food Science and Technology Department	958
Road 2: In Front of Computer Centre	Faculty of Technology Building, Computer Centre	899
Road 6: Faculty of Pharmacy and College of Medicine	Faculty of Pharmacy, College of Medicine	3711
	Total	33287

Table 2: Number of Days to Fill Waste Dumpster and Number of Days for Which it is Carted

Dumpster Location	Vol. of Dumpster in Use (m^3)	Numbers in Use	Ave. No of Days to fill Dumpster	Ave. No. of Days Before Waste is Carted
Between Moremi Hall/White House	4.36	1	2	4
Road 3B: In front of UNIFECS	0.71	1	2	4
Road 3B: PTF Building/Geology Car park	1.42	2	3	4
Road 3: Beside Africa Amphi Theatre	4.36	1	2	3
Between Faculty of Administration and Hezekiah Oluwasanmi Library	4.36	1	2	4 – 5
Road 4: Between Senate Extension and Humanities Block III	4.36	1	2	3
Road 4: Between Faculties of Agriculture and Environmental Designs And Management	4.36	1	3	4
Road 5: In front of Central Science Laboratory	4.36	1	4	5
Between Utilities and Parks and Gardens Unit	0.71	1	2	4
Road 5: Faculty of Social Science, First Bank Lecture Theatre	1.42	2	3	4
Behind Chemical Engineering and Food Science and Technology Department	0.71	1	2	5
Road 2: In Front of Computer Centre	4.36	1	4	5
Road 6: Faculty of Pharmacy and College of Medicine	4.36	1	3	4

Per Capita Waste Generation within Obafemi Awolowo University Campus

Table 3 shows the average amount of waste generated per capita. This table was developed from monitored data obtained over the two months period which the monitoring was conducted. The following were adopted for necessary calculations to determine the per capita waste generation rate.

Average Number of Days to fill Dumpster $= \frac{Total\ number\ of\ days\ to\ fill\ dumpster}{Total\ number\ of\ location\ considered}$ (Birgitte, 2013; Bakas and Milios, 2013)

Amount of waste generated per capita per day $\left(\frac{m^3}{day}\right)$

$$= \frac{Total\ dumpster\ volume\ (m^3)}{Total\ population \times average\ number\ of\ days\ to\ fill\ dumpster}$$

Average number of days to fill waste dumpster = $\frac{32}{12}$ = 2.67 days

Amount of waste generated per capita per day $\left(\frac{m^3}{day}\right) = \frac{35.49}{34506 \times 2.67}$ = 0.00038m^3/day

According to Olukanni and Orasanya (2018) the average density of municipal solid waste is estimated to be 1800kg/m^3 and from

Density = $\frac{Mass\ (kg)}{Volume(m^3)}$

So that
Mass = Density × Volume
= 1800 × 0.00038
= 0.69 kg/day

The average mass of solid waste generated in the academic area per day on Obafemi Awolowo University campus is thus 0.69 kg/day ≡ 0.00038m^3/day.
The total volume of waste generated per day in the academic area of the university is thus given by

$$\frac{Total\ dumpster\ volume\ (m^3)}{Average\ number\ of\ days\ to\ fill\ dumpsters}$$

$= \frac{35.49}{2.67}$ = 13.29 m^3

And in a week it is
= 13.29 × 5 = 66.45 m^3

Using only weekdays as a yardstick since majority of the activities in this area is done in weekdays.

Table 3**:** Necessary Parameters for the Determination of Waste Generation Rate Per Capita

Dumpster Location	Vol. of Dumpster in Use (m^3)	Population Served	Ave. Number of Days to fill Dumpster
Between Moremi Hall/White House	4.36	1389	2
Road 3B: In front of UNIFECS	0.71	607	2
Road 3B: PTF Building/Geology Car park	1.42	908	3
Road 3: Beside Africa Amphi Theatre	4.36	3631	2
Between Faculty of Administration and Hezekiah Oluwasanmi Library	4.36	8000	2
Road 4: Between Senate Extension and Humanities Block III	4.36	4997	2
Road 4: Between Faculties of Agriculture And Environmental Designs And Management	4.36	3180	3
Road 5: In front of Central Science Laboratory	4.36	750	4
Between Utilities and Parks and Gardens Unit	0.71	1656	2
Road 5: Faculty of Social Science, First Bank Lecture Theatre	1.42	5209	3
Behind Chemical Engineering and Food Science and Technology Department	0.71	958	2
Road 2: In Front of Computer Centre	4.36	899	4
Road 6: Faculty of Pharmacy and College of Medicine	4.36	3711	3
Total (excluding dumpster serving Moremi, Mathematics and White house)	35.49	34506	32

Population Projection using the Least Mean Squared Method of Population Projection

The population of the OAU community was obtained from the planning, budgeting and monitoring unit of the university. The data from the unit is presented in Table 4 with the growth trend established and the data is used for the projection of population over a ten-year period using the method of least mean square based on the growth trend that has been established from the subsequent calculation. This projected population is useful to establish the future waste generation rate and to relate it to the current trend of waste management with a view to recommending suitable methods for waste management in the university.

By this method

$\Sigma Y = Na + b\Sigma X = 282913 = 9a + 45b$ (Sridhar *et al*., 2017) ..... (1)

$\Sigma XY = a\Sigma X + b\Sigma X2 = 1498105 = 45a + 285b$..(2)

Solving simultaneously: Equation (1) multiplied by 5 gives

$1414565 = 45a + 225b$ …….. (3)

Subtracting equation (3) from equation (2) gives

$83540 = 60b$ i.e $b = 1392.333$

Substituting for b in equation (2) gives

$1498105 = 45a + 285 + 1392.33$

$a = 24473.111$

So that we have

$Y = 24473.111 + 1392.333X$

For the 1999/2000 session, X = 1 so that the population according to this method of population projection gives
Y = 25865 people
For the 2007/2008 session X = 7, so that
Y = 34217 people
It is evident from the result of this method that this method can be relied on since there it reduces error to its minimum.
For the session 2019/2020, X=19, (that is ten years after) so that the projected population was to be **50921** people, judging by the growth rate over a nine year period that has been established already.

For the 1999/2000 session, X = 1 so that the population according to this method of population projection gives
Y = 25865 people
For the 2007/2008 session X = 7, so that
Y = 34217 people
For the 1999/2000 session, X = 1 so that the population according to this method of population projection gives
Y = 25865 people
For the 2007/2008 session X = 7, so that
Y = 34217 people

Table 4: Necessary Data for the Projection of Population of Inhabitants of Obafemi Awolowo University

Session	Population*	Serial Number of Column 2 (X)	X^2	XY
1999/2000	25648	1	1	25648
2001/2002	25845	2	4	51690
2002/2003	27038	3	9	81114
2003/2004	30202	4	16	120808
2005/2006	36158	5	25	180790
2006/2007	33980	6	36	203880
2007/2008	34056	7	49	238392
2008/2009	34091	8	64	272728
2009/2010	35895	9	81	323055
Total	283913	45	285	1498105

*Population Source is the Digest of Statistics (2010)

It is evident from the result of this method that this method can be relied on since there it reduces error to its minimum.
For the session 2019/2020, X=19, (that is ten years after) the projected population was 50921 people, judging by the growth rate over a nine-year period that has been established already.

Present and Possible Future Trend in Waste Management in the University

The volume of the lorry used for the collection of waste, as measured by the research team, was obtained as 8.1 m^3 and from the monitoring embarked on by the team it was discovered that the lorry embarks on just one trip in a day round the campus whereas the tractor goes for an average of three to four trips in a day totalling
4 x 4.36 m^3 =17.44 m^3

Worthy of note is the fact that it is the same lorry and tractor that serve the entire university community so that, if in a day 13.29 m^3 of waste is generated within the

academic area and 8.1 m^3 is carted by the lorry, there will still be a leftover of
$13.29m^3 - 8.1m^3 = 5.19m^3$

Should this excess be carted on one trip by the tractor, then it implies that the student's hall of residence and staff quarters will have their waste unattended to for at least a day. This is the reason for most waste dumpsters being left uncarted for up to 5 days before they are carted even if they are filled up and overflowing.

If such continues, it therefore becomes imperative that by the 2019/2020 academic session (10 years after) where the total population expected to be 50921, the total volume of waste that will be produced in the academic area will thus be
$= 50921 \times 0.00038m^3$
$= 19.35m^3$
Leaving an excess of:
$19.35m^3 - 8.1m^3 - 4.36m^3 = 6.89m^3$

That is if the lorry was operated once a day in the academic area and if the tractor was to embark on one trip in the academic area of the university.

The Dumpsite Condition

i) The waste disposal site is located at Tonkere Road, along road 8, Obafemi Awolowo University, Ile Ife.
ii) The sorting house that is supposed to be used for sorting the waste is no longer in use.
iii) The two incinerators present are also not in use and the entire place has been taken over by scavengers. They often stay there in wait for the arrival of waste materials that are transported and dumped at the waste site.
iv) The waste brought to the site is burnt every day. However, from critical examination of the burnt waste, the burning of the waste does not really have significant impact on the volume of the waste. This is due to the fact that the large volume of the waste matter is left unburnt and the next day fresh waste materials is tipped over that which has not totally burnt off.
v) The composition of waste at the site is more of nylon and plastic waste, most especially sachet of packaged water (otherwise called pure water) and other polythene bags.
vi) From observations made, it is quite evident the waste matter has covered the entire dumpsite and has covered the land up to the road leading to Tonkere village.

Questionnaires Result from Populace

From the results of the questionnaires administered on the inhabitants of the university, it was observed that plastic waste bins were provided and the number of people that use the collection is less than those who do not use the bin. This is because those who do not use the collection believe that the placement of the bin is rather too far from their locality, while fewer people stated that there were no provisions of bins in their departments.

Paper waste is the most generated waste in the central campus of the school by the students followed by candy/biscuit wraps and nylon. Moreso, a majority of people know that the waste they generate can be recycled, but they do not know the technique used by the university management in waste management. The separation of waste which makes waste recycling easier, which can be performed by respondent majority, will not be done by a relatively large percentage of the respondent. This implies that the university management must do a little more sensitization on waste disposal if the

idea of recycling will be adopted and ensure that the facilities provided for waste management is kept within reach.

From the data collected, inadequate equipment was singled out as being the major problem facing the university management in relation to waste management. This agrees with observations from the unit in charge of waste management in the university. Workers laxity and poor funding was also recognized as other factors that affect the performance of the unit. This was also confirmed by the research team while taking several monitoring trips round the central campus of the university.

Conclusion

This study revealed the average number of days for which it takes to fill a dumpster within the central campus is about three days. There is no change in the number of waste management Lorries used since 1998. As a result of this, if the waste within the central campus of the university is adequately managed, there will be no shortcoming in handling those in other areas of the university like the students' halls of residence, and staff residential quarters.

If the current trend of waste management continues, over the next ten years the population with increase of 50921. Projected average daily waste volume will be 19.35 m^3 per day and there will be excesses of 6.89 m^3 of waste per day. This will amount to 34.45 m^3 of waste left in the central campus area of the university in a week. From the data collected, inadequate equipment was identified as the major problem facing the university management in relation to waste management. This is in agreement with observations from the unit in charge of waste management in the university. Workers laxity and poor funding was also recognized as other factors that affect the performance of the unit.

Recommendations

i) Provision of adequate personnel to manage the waste generated within the university is required.
ii) Necessary facilities for proper handling of waste within the university such as hand gloves, rakes, and nose guards should be provided.
iii) Landfill disposal method should be adopted instead of open dumped burning method which is hazardous to the environment, humans around and surrounding soil strata within and near the vicinity of the dumpsite.

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