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Full Length Research Paper

Characterization and analysis of medical solid waste in Osun State, Nigeria

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This paper reports the study of quantum and characterization of medical solid wastes generated by healthcare facilities in Osun State. The work involved administration of a questionnaire and detailed studies conducted on facilities selected on the basis of a combination of purposive and random sampling methods. The results show that the facilities are well spread among the 30 Local Government Areas; that the total quantity of medical waste generated in the state is 2672 kg/day and when domestic wastes are included the total is 5832 kg/day; that the medical wastes are not being properly disposed of as pathology wastes such as unclaimed dead bodies, placentas, umbilical cords are being dumped into unlined pits and other wastes in open dumps. A centralised system is proposed state–wide involving use of incinerators, landfills, aerobic lagoons, and reed beds. The Federal Ministry of Environment has responsibility to push for development of legislation and codes of practice that would guide facilities to achieve waste segregation, packaging in colour-coded and labeled bags, safe transportation and disposal of medical waste.

Key words: Medical solid wastes, pathological wastes, incinerators, landfills, aerobic lagoons, reed beds.

INTRODUCTION

There is some concern among environmental profess-sionals and the enlightened citizenry in Nigeria that wastes generated in hospitals and other healthcare facilities are not being managed properly. The concern seems understandable because there are no structures to be seen near any of the major healthcare facilities that they could be presumed to be using to properly incinerate pathological wastes such as unclaimed dead bodies, placentas, umbilical cords, amputated parts, and so on, that commonly result from their daily activities; no properly constructed landfills to take the less hazardous wastes from them; and no man-made lagoons to treat leachates from any form of landfill.

Furthermore a close look at the dumpsites for municipal wastes that are common sites along highways and city streets throughout the country would suggest that elements of healthcare wastes such as used syringes, needles, gloves, scalpels, cotton wool, bandages, catheter bags, etc. are finding their way there (Fadipe, 2006; Ngwuluka et al., 2009; Bassey et al., 2006). The sites where wastes disposal crews officially dump wastes from domestic, industrial and commercial sources and those created unofficially and haphazardly by individuals and households all constitute eyesore and danger to the physical and human environment.

Urban and semi–urban Nigeria are already overwhelmed by the growing loads of solid wastes produced by a rapidly increasing population pressure. It is common to see politicians during electioneering campaigns promise to clear the waste rubbish (if elected) but they always fall far short of requirements. In the circumstance, city dwellers who collectively generate the wastes in the first place–seem to accept to live with these rubbish heaps together with the rodents, roaches and loads of microorganisms that they harbour. However, it should be considered completely unacceptable that wastes from healthcare facilities are wittingly or unwittingly added to the problem. Any indication or sign

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that hospitals are not handling their wastes in an environmental friendly manner needs to be brought to the attention of the nation's health and environmental agencies. For it is generally known that several groups of people are at risk when toxic, infectious and otherwise hazardous wastes are mismanaged by healthcare authorities. These include healthcare workers (nurses, doctors, administrators, etc), patients, visitors, the waste disposal crew, and scavengers at waste dumps (Ngwuluka et al., 2009; Rao et al., 2004).

Published works are in general agreement as to how medical solid wastes should be classified, managed and treated in terms of final disposal. This is as to how different countries, or cities within them, are handling the menace of medical wastes (Remigios, 2010; Patil and Shekdar, 2001; Hassan et al., 2008).

Classification is in terms of segregation at source into infectious, sharps, pathological, pharmaceutical, radioactive and other components. There is much sophistication in the economically developed countries (USA, UK, etc) as to differences in terminologies used by researchers and practitioners that make them to distinguish and define hospital waste, medical waste, regulated medical waste (RMW), infectious waste and clinical waste (Klangsin and Harding, 1998; RCN, 2007).

It seems adequate for developing countries to use these terms interchangeably, or to stick to use of any one of them, such as 'medical waste'. Furthermore, there is a trend at simplification by which medical waste is seen as hazardous or non-hazardous. This classifies hazardous wastes to include infectious, pathological, pharmaceutical, genotoxic, sharps, chemical, radioactive wastes and those with high heavy metal content (Pruss et al., 1998; Blenkharn, 2006). Non-hazardous wastes would thus be similar to domestic waste (kitchen, paper, packaging, etc).

Management of medical waste consists of segregation, storage, collection and transportation. These steps lead to the final treatment and disposal step. In the highly developed countries (for example USA and UK) and to varying extents, in developing countries (for example Pakistan, India, Bangladesh, Iran and Egypt) there is direct legislation (and an obvious effort at enforcement) that medical solid waste be segregated at point of production so that hazardous wastes are not mixed with non-hazardous components; that hazardous wastes be packed in colour-coded containers such that pathological/anatomical wastes are packed and labeled differently in leak-proof and puncture-resistant polyethylene bags; and that transportation to points of final disposal be in carefully designated vehicles, which must be cleaned and disinfected regularly (Klangsin and Harding, 1998; RCN, 2007, Pruss et al., 1998; Blenkharn, 2006).

Treatment technologies used for final disposal of medical wastes are many, especially in highly developed countries. These include incineration, steam sterilization, thermal inactivation, pirolysis and chemical disinfection, or combinations of these plus engineered landfill systems. Details of each of these and the waste components for which it is considered most appropriate are ample in literature (Klangsin and Harding, 1998; Pruss et al., 1998; NIOSH, 1988). Developing countries (with their obvious financial constraints would do well to concentrate on a combination of incineration, engineered landfill system, and lagoon treatment of leachate drawn from landfills. To be sure, some research works have been done in Nigeria on this subject (Ngwuluka et al., 2009; Bassey et al., 2006; Coker et al., 1998). However, much remains to be done to quantify and characterize the medical wastes generated by healthcare facilities in Nigeria and assess how they are being managed.

This paper presents the report on the study that is a response to the urgent need to using Osun State, Nigeria as case study identify and locate healthcare facilities, determine the quantities and characteristics of the solid waste they generate; assess the methods of storage, collection, transportation and final disposal being used, and to recommend appropriate remedial measures as may be needed.

METHODOLOGY

The activities involved in the process of carrying out this study consisted of collection of data from official records, preparation and administration of' a questionnaire, field study, analysis of data and assessment of existing methods of waste handling. A broad set of design specifications is then proposed as advisory for possible use by the relevant health and environmental authorities in the state.

Specifically, a list of all registered healthcare delivery facilities, both public and private, was obtained from the State Ministry of Health records at Osogbo, the Osun State capital. A questionnaire was prepared, fine-tuned and used to obtain data from selected healthcare authorities as to type of institution, location, number of in-patient beds, types of wastes generated, methods of storage, collection, transportation and final disposal. A combination of purposive and random sampling techniques was used to select facilities to be visited with the questionnaire. The facilities, having been listed and classified, the three university-based hospitals were purposely selected for detailed field studies; by way of ground-truthing (to borrow a terminology from remote sensing) the data obtained from records and questionnaire responses. Six secondary facilities, fifty primary, six private and five special services facilities were similarly subjected to field studies.

At the planning stage of this study, the list of all registered healthcare-delivery facilities having been obtained from the state Ministry of Health records, it was intended that Epi-Info, Version 6 (a statistical tool for estimating samples from population) (Dean et al., 1995) would be applied. This would be followed by use of random numbers (Johnson, 2003) to pick the health facilities to be included in the study. However, the reality on ground did not permit a rigorous statistical procedure. About 400 questionnaires were distributed and were followed up but it soon became clear that many relevant staff were not willing to provide information on what they considered a sensitive matter.

Institutions whose members of staff were willing to provide and even assist in the physical labour of weighing and recording were carefully selected. Fortunately these included all the three tertiary institutions in the state. Data collection then involved using the

Figure 1a. Map of Nigeria

techniques of oral interviews, researcher's observation strategy and physical involvement. Involvement of nurses and cleaners was simple enough but interactions with hospital management and health professionals needed care to confirm the credibility of stories and understand the empirical reality in the face of pre-determined answers (Martin et al., 2002).

At the tertiary institutions bins were supplied to departments treating patients and the laboratories. They were labeled 'sharps', 'medication materials' and 'general waste'. The weight of each was recorded before they were transferred to bigger bins outside the building. These wastes were monitored from the point of storage to collection, transportation and final disposal.

The results from questionnaires and field study were analysed with simple descriptive statistics to arrive at quantities and types of wastes generated. The methods of handling were assessed and photographs taken to document proper containment as well as any evidence of spillage.

Interaction with relevant staff at state and local government levels was deemed a necessary element of the work. This is because interplay of data collection and analysis, and dialogue continues to be essential (Ogedengbe et al., 1984), as these problems persist in spite of the existence of the Federal Ministry of Environment, State Ministries of Health, State Environmental Protection Agencies (SEPA) and health offices at local government levels.

RESULTS AND DISCUSSION

The location maps of the study area are shown in Figure 1a and b. Administratively, the country is made up of 36 states and a Federal Capital Territory (FCT), Abuja as shown in Figure 1a, in a federal structure; Osun State is one of them. The state is divided into 30 Local Government Areas (LGAs) as shown in Figure lb. It could have been an ideal setup with respect to solid waste management as a whole: LGAs to collect and transport the wastes, state government to provide disposal facilities, after all, the country's land use decree vests ownership of land in each state on the state governor. But this is not the case.

From the records there are 1032 registered health facilities in the state. In this study they are classified as tertiary, secondary, primary, private and special services facilities. Table 1 shows the broad grouping and a broad definition and characterization of each. Altogether there are 3 tertiary, 50 secondary, 828 primary, 77 private and 74 special services facilities in the state, totaling 1032. The distribution of the facilities is shown in Table 2. It reflects obvious efforts to spread the facilities fairly equitably among the 30 LGAs.

The type of solid waste encountered at the various levels of the healthcare facilities are highlighted in Table 3. The grouping from A to I in the table is not intended to reflect any special order. However, wastes in groups A to E would be considered infectious and hazardous to public health (Rao et al., 2004). Casual viewers of pathological wastes such as unclaimed dead bodies, and various anatomical parts at different stages of decomposition (placenta, umbilical cords, etc) tend to avert their eyes from what they generally consider offensive. On the other

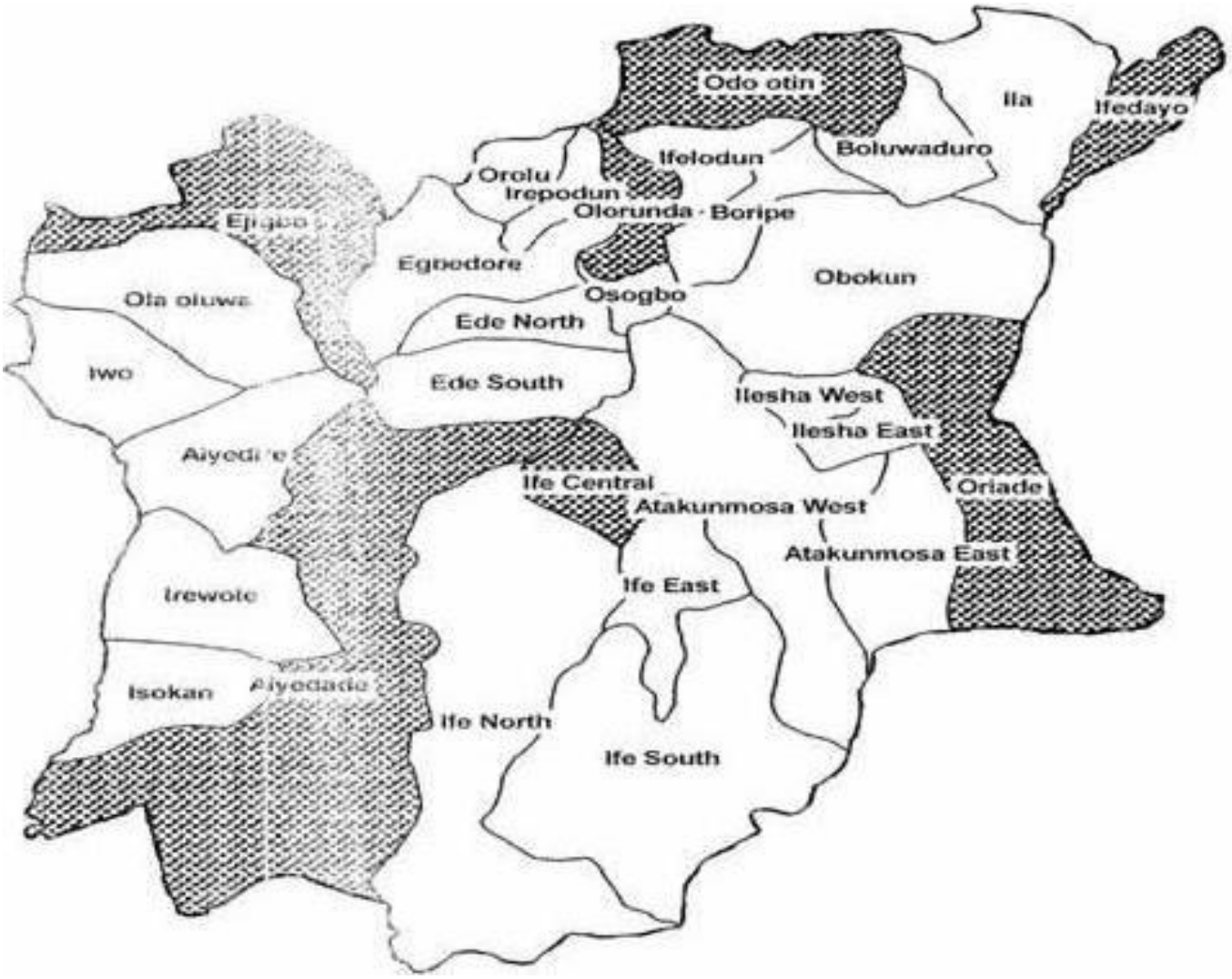

Figure 1b. Location map of the study area,

Table 1. Grouping of the health facilities in Osun State.

S/N	Health facilities	Broad characteristics
1	Tertiary health facilities	They are teaching hospitals usually affiliated to a university. They have facilities to teach and train medical students, nurses, paramedical officers, etc. They are made up of large numbers of departments and wards. They normally carry out advanced surgery. They are owned by federal or state government; mission hospitals (for example seventh-day at Ile-Ife) can be placed in this group, or in the secondary group.
2	Secondary health facilities	These are full-fledged hospitals but they do not practice routine teaching. They are normally equipped to carry out minor surgery only. They have far fewer departments. They are owned by state governments.
3	Primary health facilities	Nurses (rather than doctors) are normally in charge of these. They attend routinely to out-patients who need to have their wounds dressed or have some basic drugs dispensed. Some are maternity homes.
4	Private Health facilities	These are owned by qualified medical practitioners. If well funded they may have some facilities similar to those of secondary or tertiary institutions.
5	Special services	They are licensed to perform specific functions. They are normally owned by qualified medical doctors or paramedical officers. Examples include eye clinics, medical laboratories, and mortuaries.

Table 2. Distribution of the health facilities across Local Government Areas (LGA).

S/N	L.G.A	Tertiary	Secondary	Primary	Private	Specialized	Total
1	Atakunmosa East		3	48			51
2	Atakunmosa West		2	27			29
3	Ayedaade		2	21		2	25
4	Ayedire		2	19			21
5	Boripe		2	28		2	32
6	Boluwaduro		3	13		1	17
7	Ede North		1	15	1	4	21
8	Ede South		1	18	1	2	22
9	Egbedore		1	19		1	21
10	Ejigbo		1	30	3	3	37
11	Ifedayo		2	20			22
12	Ife Central	1	3	18		8	54
13	Ife East		2	29	4	3	38
14	Ife North		1	32		3	36
15	Ife South		2	57			59
16	Ifelodun		1	38	5	8	52
17	Ila		1	39	5		45
18	Ilesa East		1	40	3	3	47
19	Ilesa West	1	1	28	6	3	39
20	Irepodun		1	13		2	16
21	Irewole		1	21	1	4	27
22	Isokan		1	27			28
23	Iwo		1	56	1	3	61
24	Obokun		1	28			29
25	Odo – Otin		3	27		4	34
26	Ola – Oluwa		1	19			20
27	Olorunda	1	2	28	10	8	49
28	Oriade		5	37	1		43
29	Orolu		1	21	1	1	24
30	Osogbo		1	12	11	9	33
	Grand Total	3	50	828	77	74	1,032

hand, wastes in groups F to I would be considered relatively less infectious and much less offensive.

The names and location of the healthcare facilities studied in detail are presented in Table 4. The table also shows the quantities of medical wastes generated by each, the average among each group and the range. The average values, in kg/day, are 111.7, 38.1, 0.3, 2.0 and 0.4 respectively for the tertiary, secondary, primary, private and special services facilities. These values are low when compared with published figures for some other cities in the country, such as Jos (Ngwuluka et al., 2009), Abuja (Bassey et al., 2006) and Ibadan (Coker et al., 1998). Nevertheless, as they are largely infectious and offensive it is important that the wastes be given a befitting handling.

Table 5 summarizes the finding as to the management of the wastes in the facilities under study. This is in terms of how the wastes are collected, stored, transported and disposed of at final resting places. Samples of containers being used at tertiary level and, to some extent, at primary level, can be glimpsed from Figures 2 and 3. The disposal consists generally of open dumping in designated places. Wastes were not segregated at any of the institutions. There were no incinerators or properly designed landfills. At the maternity centres at the primary facilities level and also at other levels, placentas, umbilical cords, still birth fetuses, if not taken away by families are usually dumped in latrines and shallow dug holes. Unclaimed dead bodies, amputated parts and other such wastes were seen dumped in unlined and uncovered pits. Such a location was photographed (Figure 4).

Whereas the collection, storage and transportation of these wastes reflect the good intention of management, much improvement is still required in all cases to segregate wastes; to train waste handlers regularly and provide them with suitable and adequate clothing and other covers for body, mouth and nose. For, during the

Table 3. Types of solid wastes encountered at the various levels of healthcare services.

	Types of wastes	Levels of service where found				
		Tertiary	Secondary	Primary	Private/mission	Special services
A	Soiled cotton wool, under pads, diapers, gloves, plasters, bandages, catheters, and sharps (syringes, scalpels, needles, broken glass)	Yes	Yes	Yes	Yes	Yes
B	Surgery wastes: As in A above plus human anatomical parts, tissue, organ, amputated parts. Also from autopsy and histopathology procedure	Yes	Yes (in some cases)	No	Depends on level of service	Depends on level of service
C	O and G. wastes: As in A above plus placenta, umbilical cords	Yes	Yes	Yes (in maternity centre)	Depends on service	Depends on service type
D	Morbid anatomy wastes: unclaimed dead bodies	Yes	No	No	No	No
E	Haemodialysis wastes: filters, cartridges, blood tubing	Yes	No	No	No	No
F	Orthopedics waste: plaster of Paris (POP) plus much of A above	Yes	No	No	No	No
G	Pharmacy wastes mostly expired drugs and contaminated drugs, plastic and glass containers, cartons	Yes	No	No	No	No
H	Radiology wastes: x–ray films	Yes	Yes (partially)	No	No	No negligible
I	Wastes from kitchen, residential areas: mostly domestic wastes consisting of garbage and trash	Yes	-	Negligible	Used sanitary pads	

study, workers could be seen from time to time to spit out sputum, phlegm and other expectorated matter. Most strikingly, however, the disposal methods being used in all the facilities are grossly unsatisfactory. Disposal of wastes, especially medical wastes, in unlined pits and open dumps is detrimental to groundwater resources (Benient et al., 1999) and even more directly to surface waters. The fact that the OAUTHC Ile-Ife is situated right within the catchment area of the Opa waterworks which serve the entire community of staff, students and other full–time and part–time water consumers at Obafemi Awolowo University, Ile-Ife, should be of great concern.

The quantities of medical wastes in these facilities are relatively small. However they are mixed at the disposal end. It is generally recognized that when non-hazardous waste is mixed with hazardous ones the mixture becomes hazardous (Ngwuluka et al., 2009; Rao et al., 2004), and should be treated as such. It is therefore concluded that solid wastes from the healthcare facilities in the state need better

Table 4. Names and location of health facilities studied in detail and average quantities of medical waste (kg/day).

Tertiary	Secondary	Primary	Private	Special services
1. Obafemi Awolowo University Teaching Hospital Complex (OAUTHC), Ile-Ife in Ife Central Local Government Area (LGA) (121.6 kg/day)	1. State Hospital Ikire, in Irewole LGA (152.5	1. Healthcare, Iperindo in Atakunmosa East LGA (1.0)	1. Oba Adenle Memorial Hospital (Ilesa East) (1.7)	1. Bethel Medical Laboratory (Ilesa East LGA) (0.6)
2.Wesley Guild Hospital, Ilesa in Ilesa East LGA also known as OAUTHC, Ilesa (95.6 kg/day)	2. State Hospital Ede in Ede North LGA (45.3)	2. Ido Ijesa Health post in Ilesa East LGA (0.2)	2. Layo Model Hospital (Irewole LGA) (2.0)	2. Opsin Medical Laboratory at Ikire (Irewole LGA) (0.4)
3. Ladoke Akintola University of Technology Teaching Hospital in Osogbo LGA (117.7 kg/day)	3. General Hospital Ijebu – Jesa in Oriade LGA (13.0)*	3. Primary Health Care, Ido Osun in Egbedore LGA (0.7)	3. Abake Hospital (Osogbo LGA) (2.8)	3. Better choice Eye clinic (Osogbo LGA) (6.1)
	4. General Hospital Ikirun in Ifelodun LGA (42.5)	4. Omolara Maternity Home, Osogbo in Osogbo LGA (0.2)	4. Temitope Hospital (Egbedore LGA) (2.8)	4. Life support Laboratory Ijebu-Jesa (Oriade LGA) (0.8)
	5. General Hospital Osogbo in Osogbo LGA (27.6	5. Primary Health Center, Ijebu–Jesa in Oriade (1.0)	5. Holy Trinity Hospital West LGA (1.8)	5. Inukan Dental Unit (Ilesa West LGA) (0.1)
	6. General Hospital Ilesa in Ilesa West LGA (22.44 kg/day)	6. Health Center Oba-Ile in Olorunda LGA (0.3)	6. Oluyinko Hospital (Oriade LGA) (1.0)	
Total: 335.1 kg/day Average: 111.7 kg/day Range: 95 to 121.6 Three facilities altogether	Total: 190.3Average: 38.1 Range: 22.4 to 52.5 Five facilities used	Total (of 50): 17.30Average: (over 50) 0.3 Range: 0.2to1.0 Fifty facilities	Total: 12.1 Average: 2.0 Range: 1.0 to 2.8 Six facilities	Total: 2.0 Average: 0.4 Range: 0.1 to 0.8 Five facilities

* The facility's patient load was low at time of study; weight of 13.0 kg/day obtained was therefore ignored.

management.

Elements of better handling can be viewed to include waste segregation at source, incineration of pathological waste, properly designed and constructed landfills and treatment of leachates from the landfills. The technology for the design and construction of incinerators, landfills and other structures is well covered in existing literature (Benient et al., 1999; SPDC, 1997). Figure 5 is aschematic diagram of what is being proposed in this study for handling all the medical wastes in the state. However, none of the teaching hospitals (let alone healthcare facilities at other levels) can finance on its own the waste disposal scheme envisioned in Figure 5. Therefore a centralized system is proposed state-wide. The Osun State Environmental Protection Agency (OSEPA) should be in charge of this central system in cooperation with the state Ministry of Health.

Table 6 shows, in addition to the quantities of medical wastes generated in the state, the estimated quantities of domestic wastes in the healthcare institutions. The domestic wastes come from the hospital kitchen, the canteen and the staff and student residential quarters. A total of about 6,000 kg/day is estimated, which comes to about 2000 metric tonnes per year.

Wastes from the primary, private and centralized facilities would be transported to the nearest secondary or tertiary facilities through an arrangement by OSEPA. The wastes from the secondary and tertiary facilities (along with those sent from the other facilities) would be transported to the central disposal site.

Table 5. Collection, storage, transportation and disposal of medical wastes by the health institutions.

S/N	Institution	Collection and transportation	Disposal	
1	Tertiary (OAUTHC, Ile-Ife, Wesley Guild Hospital, Ilesa, LAUTECH (Teaching Hospital, Osogbo)	Waste is taken from the ward in 0.01 m^3 plastic bins or buckets by cleaning women into 0.12 m^3 covered plastic bin outside the ward. From there into central steel bins 3 m^3 by hospital environmental labourers and finally compacted into 12 m^3 refuse transport lorry. No segregation	Disposal by open dumping in designated places. No landfill or incinerator facilities	Tissues and organs removed during surgery taken to histopathology for analysis and later stored in formalin in bowls. Eventually into waste lorry periodically. This happens at OAUTHC Ile-Ife and Ilesa.
2	Secondary	Waste is collected into containers such as broken pails, perforated bins into bigger bins by hospital labourers. No segregation	Open dumping No landfill or incinerator	Unclaimed dead bodies and recognizable parts are disposed into an unlined dug pit. More or less same at the three tertiary institutions.
3	Primary	The wastes are small. Just colleted in perforated plastic bins or bucket	Open dumping and sometimes burning within the premises	At primary pathological wastes such as placenta, umbilical cords and still births (if not taken away by owners) are disposed in latrines, dug holes etc.
4	Private	Generally same as secondary	Open dumping	
5	Special services	Generally same as secondary	Open dumping	

Figure 2. Typical plastic and steel bins in use at OAUTHC, Ile-Ife.

Figure 3. Central steel bins in use at LAUTECH, Osogbo and perforated bins in use at primary and secondary health facilities.

Figure 4. Unclaimed dead bodies, liquid in bags, dumped indiscriminately in unlined uncovered pit.

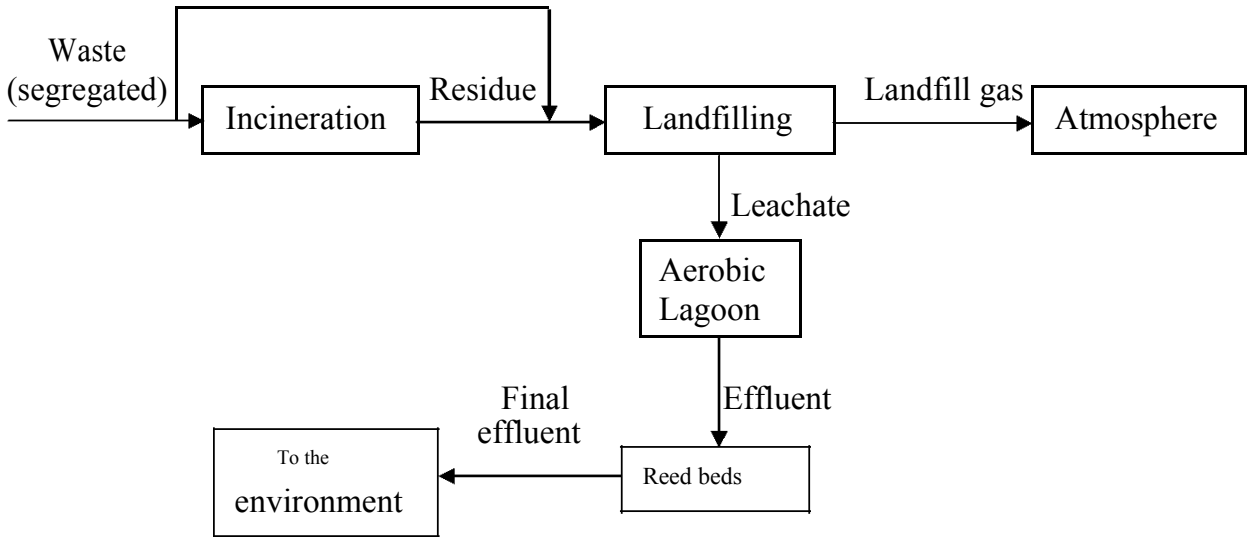

Figure 5. Operational strategies of the proposed disposal system.

Table 6. Estimated quantum of waste for the proposed centralized disposal system.

S/N	Quantum of wastes (kg/day)			
	Health facilities	**Medical**	**Domestic**	**Total**
1	Tertiary	335	1967	2302
2	Secondary	1905	605	2510
3	Primary	248	452	700
4	Private	154	66	220
5	Special services	30	70	100
	Total	2672	3160	5832

The wastes would be suitably segregated at source. And as Figure 5 indicates, the pathological wastes and others that can be reduced to ashes at about 1200°C are sent through the incinerators. The remaining, less hazardous waste, plus the ashes from the incinerators are sent to the landfills which are so designed and constructed that the bottom is impermeable clay layer topped by a synthetic liner. The leachate is drained into a suitably constructed aerobic lagoon the effluent from which goes into reed beds.

Discussion of this central scheme is taking place at preliminary level with some interested staff at OSEPA and the state Ministry of Health. This is in the spirit of gentle persuasion of public spirited individuals or groups (Ogedengbe et al., 1984), in a situation where laws and regulations made are not enforced, or where there are no rules, laws or regulations. Indeed Nigeria has no rules or regulations directed at medical wastes. The national interim guidelines and standards for industrial effluents, gaseous emissions and hazardous waste management (FEPA, 1991) is too general to capture the seriousness that proper management of hazardous wastes requires. Nigeria is signatory to the Basel Declaration. The Agreement states that it remains the responsibility of healthcare establishments to treat and dispose wastes generated by them in such a manner as to ensure that there would be no adverse health or environmental effects (Basel Declaration, 1999). However, without Nigeria's own legislation and the enforcement of such legislation the Basel Declaration is largely ignored.

In the face of the appauling disposal of human body parts reported in this article, coupled with similarly awful pictures reported by other researchers in hospitals within Jos metropolis (Ngwuluka et al., 2009) and in the Federal Capital Territory, Abuja (Bassey et al., 2006), it becomes imperative for the Federal Ministry of Environment to develop a meeting of minds with its counterpart, the Federal Ministry of Health and with state environmental protection agencies (SEPAs) and environmental units at LG (Local Government) level.

First is the need to recognize that the attitude of laissez faire that attends the management of municipal solid waste throughout the country must not be extended to that of medical solid waste. The adverse effects of hazardous wastes are not attributed to them unless a careful and thorough investigation is carried out.

Nevertheless, it is well established that when hazardous healthcare wastes are not properly managed, exposure to them could lead to infections, infertility, cancer, dermatitis, asthma, typhoid, cholera, hepatitis, AIDS, etc (Klangsin and Harding, 1998; Pruss et al., 1998; NIOSH, 1988). This recognition should lead quickly to enactment of appropriate legislation under the hands of the Federal Ministry of Environment. Ideas can be pooled from countries such as USA and UK which have a wide array of legislation, codes of practice and licensing conditions that dictate the standard of operation for both waste producers and those providing merchant clinical waste disposal services (Klangsin and Harding, 1998; Pruss et al., 1998). Developments in other countries with financial constraints, such as Egypt, Iran, Jordan, Ghana, South Africa, Kenya, Bangladesh, India and Pakistan (Rao et al., 2004; Remigios, 2010; Patil and Shekdar, 2001; Hassan et al., 2008) can provide useful tips towards efforts at developing Nigeria's own medical solid waste management legislation, rules and regulations.

The legislation should be made decidedly enforceable and should cover the whole gamut of inadequacies revealed in this study, namely the issues of segregation, colour-coding and labeling of containers, storage, transportation, treatment, final disposal, staff training, and so forth. It should be possible to simplify the handling of the waste components identified in Table 3 as follows:

1) Category A wastes should include wastes from surgery including human anatomical parts, tissue, organ, amputated parts; from autopsy and histopathology procedures; wastes from O and G, mainly placentas and umbilical cords; morbid anatomy wastes, including unclaimed dead bodies; haemodialysis wastes filters, cartridges, blood tubing, plastas; plus soiled cotton wool, diapers, gloves, bandages, catheters, etc; and wastes from laboratories, including specimen containers, slides and cover slips, disposable gloves and aprons. This grouping should be considered potentially infectious and therefore hazardous, depending on the nature of ailment of bodies to which surgery, autopsy, dialysis and other procedures are being applied – including patients isolated because of communicable diseases. This grouping should be colour coded red (or orange or yellow), similar to colour code practices in USA, UK, Bangladesh, etc (Hassan et al., 2008; Klangsin and Harding, 1998; RCN, 2007; NIOSH, 1988). The container should be strong, leak-proof plastic or polyethylene bags, labeled HIGHLY INFECTIOUS.

2) Category B wastes are mainly sharps. These include disposable needles, syringes, saws, blades, broken glasses, and other items that could cause cuts. These should be considered infectious because of the possibility of contamination with blood-borne pathogens (Pruss et al., 1998; NIOSH, 1988). Like group A wastes the colour code should also be red or orange or yellow. The container should be leak-proof and puncture-resistant and be labeled SHARPS.

3) Group C wastes should include the general wastes from the wards, laboratories, offices and also garbage and trash from kitchen and residential areas. This group should be considered non-infectious as long as the wastes are not mixed at any point with infectious wastes. The colour code for this could be purple or black. It could be labeled GENERAL WASTE.

The legislation should also specify development of guidelines for storage, transportation and disposal. The issues in this regard should be that: a bag should not be loaded beyond its weight or volume capacity; the bagged wastes should be stored for a minimum amount of time so as to ensure containment and to present penetration by rodents and vermin; access to the storage area be limited; the wastes should be transported to place of disposal in leak-proof trucks and washed and disinfected regularly. Also, transportation of (especially groups A and B wastes) should be well documented and all vehicles involved should carry a consignment note (Ngwuluka et al., 2009; Patil and Shekdar, 2001; Blenkharn, 2006; NIOSH, 1988). Treatment and final disposal can be in the form prescribed in Figure 6, with centralized use as proposed. There is much experience in Nigeria in the design and use of incinerators, engineered landfills, leachate treatment lagoons and reed beds to take effluent from the lagoons. The Shell Petroleum Development Company (SPDC) has designed, built and operated many in the Niger Delta area (SPDC, 1997). The interaction of Nigerian consultants with their foreign counterparts in design and implementation, along with preparation and defense of environmental impact assessment (EIA), and environmental audit, has provided a useful capacity-building in this regard.

Training and retraining of relevant personnel, preparation of documents policy issues and operational guidelines by each tertiary and secondary facility and provision for conduct of waste audits identifying and rectifying areas of non-compliance should be essential parts of the requirements.

Conclusion

From the results presented and discussed in this paper the following conclusions can be drawn:

1) The total quantity of medical solid waste generated in the state is 2672 kg/day and when general wastes are added the total is 5832 kg/day. These come majorly from the three tertiary and some secondary facilities.

2) The medical wastes are not being segregated from the general wastes, thus the quantity of medical waste is really 5832 kg/day rather than 2672 kg.

3) Hazardous waste such as human anatomical parts, amputated parts, autopsy tissues and organs, placentas, umbilical cords, unclaimed dead bodies, are being

dumped in unlined pits, while some elements such as soiled cotton wool, underpads, gloves, bandages catheters, syringes, scalps, etc seen openly outside and sometimes left for weeks while trucks go for repair.

4) Without a doubt the health facilities are making efforts to achieve a clean environment as litter pickers are all over the place and cleaners are numerous and busy. However, with hazardous waste being handled as mentioned in 3 the totality of waste handling is clearly unsatisfactory.

5) There is an absence of regulation directed at proper management of medical solid waste. The Federal Ministry of Environment is well placed to push for appropriate legislation and also promote action on the parts of officials at state and local government areas.

6) Practical steps that should emerge from point 5 include development of enforceable codes of practice to promote appropriate medical waste management practices segregation, colour coding and labeling, packing in strong, leak-proof and puncture-proof containers and transporting in trucks that are cleaned and disinfected regularly.

7) Due to financial and other constraints, a centralized system is proposed statewide involving the use of incinerators, landfills, aerobic lagoons (to treat leachates from landfills), and reed beds.

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