Characterization of Medical Wastes from selected Hospitals in Umuahia, Nigeria

E. I. Ugwu1*, A.C. Ekeleme2, S. T. A. Okolie3, O. P. Ibe4, C. F. Chieke 4, H. O. Ibearugbulem4, M. Omeje5, A N Ede6 P.O Awoyera,6, E.C. Ugwu7

1Department of Civil Engineering, College of Engineering and Engineering Technology, Michael Okpara University of Agriculture Umudike, P.M.B.7267 Umuahia Abia state, Nigeria.
2 Department of Civil Engineering, College of Engineering, Gregory University Uturu P.M.B. 1012 Amaokwe Achara Uturu Abia State.
3 Department of Mechanical Engineering, College of Engineering, Gregory University Uturu Uturu P.M.B. 1012 Amaokwe Achara Uturu Abia State.
4 Department of Civil Engineering, Federal Polytechnics Nekede, Owerri, Imo State.
5 Department of Physics, College of Science and Technology, Covenant University P.M.B. 1023 Ota Ogun state, Nigeria.
6Department of Civil Engineering, College of Engineering, Covenant University P.M.B. 1023 Ota Ogun state, Nigeria.
7Department of Agricultural and Bioresources Engineering, College of Engineering and Engineering Technology, Michael Okpara University of Agriculture Umudike, P.M.B.7267 Umuahia Abia state, Nigeria.
E-mail address: emmanuelugwu@mouau.edu.ng

Abstract. Medical wastes are classified as special types of wastes owing to their non-biodegradability. Inadequate medical waste management has been identified as a problem that needs urgent attention in developing countries, especially Nigeria. This study was aimed at estimating the status of medical waste management in Umuahia, southeast Nigeria and making recommendations, which will go a long way in curbing the menace of environmental pollution. The medical facilities studied include Government hospitals, private hospitals and primary health centres/maternity; categories A, B, C respectively. A descriptive study was carried out between February to July 2016, and it involved the use of personal interviews, on-site investigations as well as questionnaires, which were administered to health workers as respondents using multistage sampling. Inventory of medical wastes was taken daily, and the data analysis was carried out with the aid of statistical package for social sciences (SPSS). Results showed that the total quantity of medical wastes generated was found to be 59.811 kg/ward/day, 32.53 kg/ ward/day and 31.53 kg/ward/day for categories A, B and C medical facilities respectively. Results also showed that category C lack training on handling while 75% and 50% of A and B respectively conducted training on handling waste. The percentage of adequate knowledge of waste segregation obtained from category A, B and C are 85.7%, 33.3% and 0% respectively. The findings further showed that 57.1% and 28.6% of large and medium hospitals respectively use colour-code for disposal while small hospitals do not. The results obtained indicated low compliance with medical waste management standards. Thus, recommendations are made for pre-service training of health professionals as well as waste handlers, in order to ensure adequate compliance with environmental laws and policies.

Key words: Medical wastes, status, Environmental pollution, Compliance, Environmental laws and policies.

1. Introduction
Medical wastes wastes are classified as special types of wastes. The category of wastes originating from laboratories, hospitals and clinics is referred to as medical, biomedical, hospital or clinical wastes [1-3]. Medical wastes are hazardous in nature and they constitute environmental pollution. It is paradoxical that clinics and other health institutions that offer assistance to the sick and alleviate their pain as well as prolong their life, can equally generate and dispose wastes sporadically which constitute threat to life [4]. Medical wastes pose a great risk to
patients, cleaners, health technicians etc. This is because of improper management of wastes arising from health establishments [5-7]. In the course of healthcare delivery, medical wastes are generated, and it includes body parts or human tissues, sharps or other infectious materials [8]. Some of the wastes generated contain heavy metals, which are toxic to man and the environment. Other wastes such as pathological wastes, stock of infectious agents, wastes from autopsy or surgery, which are exposed to sharps, infectious agents, laboratory waste, products of blood, and waste from human blood all belong to the category of medical wastes [9]. This category of wastes also includes wastes from clinical test, autopsy and chemotherapy arising from different forms of curative methods [10]. Enormous wastes are generated from these forms of curative methods with very high toxicity level. These therapeutic methods not only generate hazardous wastes and sharp objects but also lead to production of radioactive wastes and compounds, which are detrimental to health as well as the environment [5; 11].

In developing countries like Nigeria, many people lack the awareness that medical wastes constitute environmental hazard. Coker et al., [12] articulated that lack of specific policy and awareness aimed at addressing the menace of medical waste brings about hazardous effect of medical waste. In addition, sorting of the wastes at the source is also disregarded which makes all types of wastes to commingle along the disposal route starting from collection to elimination, and the risks emanating from treatment of wastes as well as poor handling tend to be ignored by all the concerned people including the general public, medical professionals and authorities [12]. It is worthy to note that medical waste, if not properly managed, can pose more dangers than known sicknesses. WHO [13] gives an estimate of about 80,000-160,000 cases of HIV cases, 2.3-4.7 million cases of Hepatitis C Virus and 8 to 16 million new cases of Hepatitis B Virus that are observed yearly owing to unsafe disposal of injection needles and syringes as well as improper waste management system. Toxic emission emanating from inadequate incineration of medical wastes as well as the odour from the medical waste dumps constitutes environmental pollution. Some of the adverse environmental effects of medical wastes include contamination of groundwater by untreated medical waste dumped in landfills, environmental defacing and diseases transmission by microorganisms and Virus. In addition, the collection and re-use of some health care materials such as syringes, needles etc without properly sterilizing it could lead to serious disease burden to the people [14-17].

Previous researches have been carried out on medical waste management in Nigeria, which covered mainly the Northern and Southwest parts of the country [9; 18]. However, in Umuahia, one of the cities in south east Nigeria, no research has been carried out in that regard. Therefore, this study is aimed at the assessment of the state-of the art of medical waste management in order to make recommendations for sustainable medical waste management practices, which will go a long way in curbing the menace of environmental pollution. Medical waste management has not been taken into consideration in developing countries such as Nigeria. In Nigeria, medical wastes are usually disposed together with municipal solid wastes, which creates hazard to both man and the environment. It is the responsibility of the medical professionals to ensure that medical wastes are properly managed to avert the toxic effect of such wastes on the environment. The process for medical waste management must actually be in conformity with both national and international regulatory standards such as World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA). Some solutions that may be adopted include sensitization, ensuring healthy and neat environment for the community as well as workers. Adequate medical waste management involves handling, proper segregation, storage, treatment and disposal since the connection of medical waste with municipal wastewater transport route constitutes a threat to the microbial communities, biological treatment process as well as public health [9].

2.0 Materials and method
2.1 The study area
The study area is Umuahia, the capital of Abia state, in the Southeast region of Nigeria. It has an area of 245 km² and a population of 359, 230, according to the 2006 Nigeria census. The city lies between latitude 5°N and longitude 7°E of the Greenwich Meridian. By its tropical location, it has a temperature ranging from 20°C - 36°C and a heavy rainfall of about 2400 mm/year. The city is known for its medical facilities, particularly the Federal Medical Centre with over 380 bed spaces. Patients come from all over the states to
patronize the facilities. These facilities with clinics, wards or units offer a variety of in-patient and outpatient services.

2.2. Sampling and analysis
The sampling was conducted between February to July 2016 and it involved ten (10) medical facilities, which were used as representatives for the medical facilities in the study area. They were categorized into three; A, B and C for Government owned, Private Hospitals and Primary health centres/ maternity respectively. In this study, Federal Medical Centre (FMC), Abia Specialist Hospital (ASH), Amachara General Hospital (AGH) and MOUAU Medical Centre (MMC) represent government owned hospitals (Category A). Chukwuebuka Hospital (CH), Obioma Private Hospital (OPH), Amarajane Hospital (AH) and St. Vincent Great Private Hospital (SGPH) represent private hospitals (Category B) while Angelica Maternity (AM) and Obizi Health Centre (OHC) are primary health centre/maternity (Category C). This study consisted in the use of personal interviews, on-site investigations as well as questionnaires administered to respondents on each sampled facility. An inventory of the wastes generated was taken using the methods suggested by UNEP and WHO, [19] and Townend and Cheeseman [20]. The wastes generated from the medical facilities were recorded in an inventory form [19]. For convenience, the questionnaires were categorized as I, II and III. Questionnaire I was designed to collect information on health care wastes generation and storage at the ward/unit levels and the transportation and disposal methods for the entire health care facility. Questionnaire II was designed to obtain information on health care waste management policy. This covered a wide range of questions on existing or proposed policy and awareness of any federal or state policy on health care wastes management. This was also administered to the Chief Executive of the facility. Questionnaire III was specifically designed for waste handlers. These include handlers within the health care facilities and private waste management agents handling wastes for such facilities. The questionnaire was used to obtain information on types of wastes handled, frequency and methods of handling and transportation of the waste starting from the source of generation up to the disposal site, the workers’ awareness to the health risks of the wastes handled and the protective measures adopted in waste handling. The questionnaires were administered to medical doctors, cleaners, nurses, medical laboratory scientists and other health workers. The questionnaires were designed so as to collect data on; the status of the respondents, waste composition, categories of waste generated and managed, the kind of protective overall used, the methods of waste management in use, waste treatment, transport and methods of treatment used, medical officers’ awareness to management of waste as well as sorting of health-care wastes. Data analysis was done using statistical package for social sciences (SPSS 2015 version).

3.0 Results and discussion
Table 1 shows the average daily generation of medical wastes in the three categories of medical facilities. The category A facility has the highest average daily waste generation of 59.811kg followed by category B which has 32.53kg, while category C has 31.85kg.

| Type of waste  | Category A Daily (kg/day) | Mean (kg) | Category B Daily (kg/day) | Mean (kg) | Category C Daily (kg/day) | Mean (kg) |
|---------------|--------------------------|-----------|--------------------------|-----------|--------------------------|-----------|
| Domestic waste| 28.90                    | 2.98      | 29.00                    | 7.25      | 15.00                    | 7.50      |
The single factor ANOVA is shown in Table 2. The result of a one way ANOVA showed that there was no statistical variation in medical waste generated between categories A, B and C medical facilities as evidenced by $p>0.05$. Hence, the result obtained may be by chance.

### Table 2: Single factor ANOVA for category A, B, C medical facilities

| Groups          | Count | Sum  | Average | Variance |
|-----------------|-------|------|---------|----------|
| Column 1        | 11    | 59.9 | 5.445455| 193.6202 |
| Column 2        | 11    | 32.53| 2.957273| 6.203562 |
| Column 3        | 11    | 31.85| 2.895455| 5.632727 |
| ANOVA Source of Variation |       |      |         |          |
| Between Groups  | 46.55702 | 2   | 23.27851| 0.339904 | 0.714544 | 3.31583 |
| Within Groups   | 2054.565 | 30  | 68.48551|          |          |        |
| Total           | 2101.122 | 32  |         |          |          |        |

Tables 3 - 5 show the demographic features of the respondents in categories A, B and C medical facilities. The results indicated that majority of the respondents in category A are males (55.5%), and category B had females as the greatest respondents (58.3%), while category C had the greatest percentage of females as respondents (55.5%).

### Table 3: The demographic features of the Respondents for category A

| Age    | Frequency | Percentage |
|--------|-----------|------------|
| 20-30  | 1         | 5.6        |
| 31-40  | 4         | 22.2       |
| Age      | Frequency | Percentage |
|----------|-----------|------------|
| 20-30    | 3         | 25.0       |
| 31-40    | 7         | 58.0       |
| 41-50    | 2         | 16.0       |
| Total    | 12        | 100        |

**Table 4. The demographic features of the Respondents for category B**

| Level of Education | Frequency | Percentage |
|--------------------|-----------|------------|
| Secondary          | 1         | 8.3        |
| Technical          | 3         | 25         |
| Bachelor's degrees | 4         | 33.3       |
| PG                 | 3         | 25         |
| Others             | 1         | 8.3        |
| Total              | 12        | 100        |

| Age      | Frequency | Percentage |
|----------|-----------|------------|
| 20-30    | 2         | 33.3       |
| 31-40    | 1         | 16.7       |
| 41-50    | 3         | 50         |
| Total    | 6         | 100        |

**Table 5. The demographic features of the Respondents for category C**

| Age      | Frequency | Percentage |
|----------|-----------|------------|
| 20-30    | 2         | 33.3       |
| 31-40    | 1         | 16.7       |
| 41-50    | 3         | 50         |
| Total    | 6         | 100        |

| Level of education | Frequency | Percentage |
|--------------------|-----------|------------|
| Secondary          | 2         | 33.3       |
| Bachelor's         | 1         | 16.7       |
| PG                 | 3         | 50         |
| Total              | 6         | 100        |
Table 6 shows the procedures for handling of medical wastes in category A, B and C medical facilities. The highest percentage of respondents in category A agreed on medical waste treatment which exceeds that of B and C. The highest percentage of category C agreed on recycling of waste collected which is greater than that of A and B. The greatest percentage of respondents in category A medical facilities agreed on the use of protection gadgets, training on wastes handling, health care management policy, adequate fund for management of medical wastes. While the highest percentage of respondents from category B medical facilities agreed on records on medical wastes generated and designated officer on medical wastes.

| Procedures                        | A medical facilities | B medical facilities | C medical facilities |
|-----------------------------------|----------------------|----------------------|----------------------|
|                                   | YES   | NO   | YES   | NO   | YES   | NO   |
| Treatment to waste generated      | 50    | 50   | 25    | 75   | 0     | 100  |
| Recycling of waste collected      | 25    | 75   | 75    | 25   | 100   | 0    |
| Use of protection gadgets         |        |      |        |      |        |      |
| Apron                             | 100   | 0    | 100   | 0    | 0     | 100  |
| Nose mask                         | 75    | 25   | 25    | 75   | 50    | 50   |
| Gloves                            | 100   | 0    | 100   | 0    | 100   | 0    |
| Boot                              | 75    | 25   | 75    | 25   | 100   | 0    |
| Training on handling wastes       | 75    | 25   | 50    | 50   | 0     | 100  |
| Healthcare waste management policy| 75    | 25   | 50    | 50   | 50    | 100  |
| Adequate fund for management of medical wastes | 100   | 0    | 75    | 25   | 0     | 100  |
| Records on medical waste generated| 50    | 50   | 25    | 75   | 0     | 100  |
| Designated officer on medical wastes | 50    | 50   | 25    | 75   | 0     | 100  |

Table 7 shows the awareness on the adverse effects of medical wastes. The greatest percentage of respondents in category A agreed on awareness of natural policy on medical wastes and health hazards associated with medical wastes. On the issue of the risk posed by medical wastes, all the respondents in the three medical facilities agreed on awareness on the risk.

| AWARENESS                                      | A | Y | B | Y | C | Y |
|------------------------------------------------|---|---|---|---|---|---|
| Awareness on risk posed by medical wastes       | 100| 0 | 100| 0 | 100| 0 |
| Awareness on natural policy on medical wastes    | 100| 0 | 75 | 25| 0  | 100|
| Awareness on healthcare hazards associated with wastes | 75 | 1 | 100| 0 | 50 | 50|

Tables 8 and 9 show the methods of collection, transportation and disposal of medical wastes in category A, B and C medical facilities. The greatest percentage of category A medical facilities use plastic bins while the greatest percentages of category B use plastic bins, incinerator, bucket and polythene bag. The greatest percentage of category C medical facilities on the other hand use plastic bins, outside drum, open dust bin, septic tank, bucket, bags and wheel barrow.

| Table 8. Methods of collection, transportation and disposal of medical wastes in category A medical facilities |
Methods of collection, transportation and disposal | Frequency | Percentage |
--- | --- | --- |
Plastic bins | 10 | 13.89 |
Incinerator | 8 | 11.11 |
Open dust-bin | 7 | 9.72 |
Dispose waste bin | 3 | 4.17 |
Drum tank | 2 | 2.78 |
Drums outside | 2 | 2.78 |
Bury in the hole | 2 | 2.78 |
Degradation tank | 1 | 1.39 |
Wash basin | 2 | 2.78 |
Septic tank | 5 | 6.94 |
Bucket | 8 | 11.11 |
Bottles | 1 | 1.39 |
Polythene bag | 4 | 5.56 |
Near sewage disposal | 6 | 8.33 |
Pit toilet | 2 | 2.78 |
Soak away | 4 | 5.56 |
Bags | 3 | 4.17 |
Measuring jug | 2 | 2.78 |
Total | 72 | 100 |

Table 9. Methods of collection, transportation and disposal of medical wastes in category B and C medical facilities

| Methods of collection, transportation and disposal | Category B Frequency | Percentage (%) | Category C Frequency | Percentage (%) |
--- | --- | --- | --- | --- |
Plastic bins | 4 | 12.5 | 2 | 10 |
Incinerator | 4 | 12.5 | 1 | 5 |
Open-dust bin | 1 | 3.13 | 2 | 10 |
Drums outside | 1 | 3.13 | 2 | 10 |
Open drains | 2 | 6.25 | 1 | 5 |
Septic tank | 3 | 9.38 | 2 | 10 |
Bucket | 4 | 12.5 | 2 | 10 |
Bottles | 1 | 3.13 | 1 | 5 |
Polythene bag | 4 | 12.5 | 1 | 5 |
Soak away | 2 | 6.25 | 1 | 5 |
Bags | 1 | 3.13 | 2 | 10 |
Safety box | 2 | 6.25 | 1 | 5 |
GUTTER | 1 | 3.13 | 0 | 0 |
Wheel barrow | 2 | 6.25 | 2 | 10 |
Total | 32 | 100 | 20 | 100 |

Table 10 shows the awareness on segregation of medical wastes. The greatest percentage of the respondents in category A medical facilities agreed on the use of waste segregation, procedures for waste collection and handling, colour code for waste disposal.

Table 10. Awareness on segregation of medical wastes.
The results of data from the survey showed that the mean daily waste generation, which includes both hazardous and non-hazardous wastes were 59.811 kg/day, 32.53 kg/day and 31.85 kg/day for categories A, B and C respectively (Table 1). This conforms to the previous findings by Babatola, [21] in a similar research. The amount of waste generated from category A was higher than the quantity obtained from category B and category C even though the number of category B and category C medical facilities was equal to that of category A. This therefore implies that the quantity of wastes generation is a function of the size of the facility. This agrees with the result of Ogbonna et al., [22] in a similar research. The results of medical wastes generated in categories A,B and C medical facilities were subjected to statistical analysis using analysis of variance (ANOVA). The result of a one way ANOVA showed that there was no statistical variation in medical waste generated between categories A, B and C medical facilities as evidenced by p>0.05 (Table 2).

The results of the survey showed that the mean daily waste generation, which includes both hazardous and non-hazardous wastes were 59.811 kg/day, 32.53 kg/day and 31.85 kg/day for categories A, B and C respectively (Table 1). This conforms to the previous findings by Babatola, [21] in a similar research. The amount of waste generated from category A was higher than the quantity obtained from category B and category C even though the number of category B and category C medical facilities was equal to that of category A. This therefore implies that the quantity of wastes generation is a function of the size of the facility. This agrees with the result of Ogbonna et al., [22] in a similar research. The results of medical wastes generated in categories A, B and C medical facilities were subjected to statistical analysis using analysis of variance (ANOVA). The result of a one way ANOVA showed that there was no statistical variation in medical waste generated between categories A, B and C medical facilities as evidenced by p>0.05 (Table 2). The result equally showed that the medical wastes in the medical facilities under study constituted more of infectious wastes 47.3kg/day, 5.25 kg/day and 5.0 kg/day for category A, B and C medical facilities respectively (Table 1). The demographic features of the respondents indicated that the respondents in category A medical facilities included a variety of professional, viz, doctors, nurses, laboratory technologists, administrative staff, cleaners and waste handlers. They were made up of 55.5% males and 45.5% females within the age range of 20-60 years (Table 3). About 44.4% had postgraduate degree while 5.6% had technical training (Table 3). This result is in conformity with previous result obtained by Sridhar et al., [22] in a similar research. In category B medical facilities, the respondents consist of nurses, doctors, laboratory technologists, cleaners and waste handlers. The age of the respondents with maximum frequency were 31-40 years at 58.0% while the minimum age range of the respondents were 41-50 years at 16.0%. The respondents were mostly females at 58.3%. About 33.3% of the respondents had degree while 25% had Postgraduate degree (Table 4). In category C medical facilities, the respondents include mostly nurses, doctors, laboratory technologists and waste handlers. The results showed that about 50% of the respondents within the age range of 41-50 years and 33.3% were within the middle age of 20-30 years, 45% of the respondents were male while 55% were females. From the results, 50% of the respondents had postgraduate degrees, 33.3% had secondary school education and 16.7% had their Bachelor’s degrees (Table 5). The procedures for handling of medical wastes (Table 6) showed that about 50% and 25% of the respondents in category A and category B medical facilities respectively said “YES” to the treatment of waste generated while those in category C medical facilities said “NO” to the treatment of waste. Also, about 25%, 75% and 100% of the respondents in categories A, B and C medical facilities...
facilities respectively said "YES" to waste recycling while 75% and 25% of the respondents in category A and category B medical facilities respectively said "NO" to waste recycling. The result equally revealed that safety gadgets were provided in category A medical facilities in the magnitude of Apron (100%), Nose mask (75%), Gloves (100%), 100% and Boot (75%). In category B, safety gadgets were provided in the order of Apron (100%), Nose mask (25%), Gloves (100%) and Boot (75%). Also in category C medical facilities, safety gadgets were provided in the order of Apron (50%), Nose mask (50%), Gloves (100%) and Boot (100%). Result further showed that 50% and 25% of the respondents in category A and category B medical facilities respectively have designated offices for medical waste management while category C medical facilities do not have. In addition, it was observed that categories A and B medical facilities keep records on medical waste generated while category C medical facilities do not keep. Record keeping on medical waste generated was up to 50% and 50% in the respondents for categories A and B respectively. The level of awareness on the adverse effect of medical wastes (Table 7) showed that 100% of the respondents from the three categories of medical facilities were fully aware of the adverse effect of medical wastes. 100% and 75% of the respondents, in the category A and B and medical facilities respectively were fully aware of the national policy on healthcare waste while about 75%, 100% and 50% of the respondents in category A, B, C medical facilities respectively were aware of the hazards associated with medical wastes. About 25% and 50% of category A and B medical facilities respectively, on the other hand were not aware of the hazards posed by medical wastes. About 100% of respondents in category A medical facilities indicated they have specific procedures for collection and handling of medical wastes (Table 8). About 88.9% of category B medical facilities conformed to such procedure. Also, 50% of respondents from category C medical facilities claimed they had specific procedures for collection and handling of medical wastes while 50% indicated they were not aware of such procedure (Table 9). The level of awareness on medical waste segregation showed that 85.7% of category A medical facilities claimed they segregate waste before disposal while 14.3% claimed they do not segregate waste (Table 10). In category B medical facilities, 33.3% of respondents indicated they segregate wastes, 44.5% stated they do not and 22.2% were not aware. In addition, about 66.7% respondents from category C medical facilities claimed they do not segregate waste before disposal and 4% were not aware of medical waste segregation. Okebukola, [24] pointed out that medical waste management is adversely affected by inadequate segregation of wastes together with lack of information on waste disposal and segregation practices in large, medium and small medical facilities. Segregation of wastes results in wastes that are less toxic, which can easily be recycled and managed with minimum cost [25]. The study on the use of colour-code for disposal showed that 57.1% of category A medical facilities made use of colour-code, 28.6% do not and 14.3% were not aware. For category B, only 22.3% used colour-code while 66.7% of category C did not use colour-code and 33.3% were not aware (Table 10). This is in conformity with similar results obtained by Ogbonna, [26].

4. Conclusions
This study revealed poor compliance to environmental laws and policies, such as use of colour code, segregation, protective equipment, recycling, awareness to hazardous effects of medical wastes, methods of waste collection and handling in the three categories of medical facilities studied. The total quantity of medical wastes generated was found to be 615.01kg per day, 132.1 kg per day and 63.7 kg per day for category A, category B and category C medical facilities respectively. The result of a one way ANOVA also showed that there was no statistical variation in medical waste generated between categories A, B and C medical facilities as evidenced by p>0.05. Hence, the result obtained may be by chance. It is therefore, recommended that proper training for waste handlers as well as sensitization programme on the danger of medical waste be carried out for medical workers. This will go a long way in combating the problem of environmental pollution.

References

[1] Ajadike JC. Pollution and management problems of medical waste in Nigeria. Environmental Pollution & Management in the Tropics, SNAPP Press, 2003, 243–252
[2] Bhatia SC. Environmental pollution and control in chemical process industries, Romesh Chander Khanna Publishers, Nath Market, (Nai Sarak Delhi) 110006, 2005, 2–13.

[3] Santra S C. Environmental science for Students of Indian Universities, New Central Books Agency (P) LTD 8/1 Chintamoni Das Lane, (Kolkata 700009, India), 2006.

[4] Hassan M, Ahmed S A, Rahman K A and Biswas T K. Pattern of medical waste management: existing scenario in Dhaka City, Bangladesh, *BMC Public Health* 8, DOI:10, 2008, 1186/1471-2458-36.

[5] Ajadike J C. Urban solid waste: problems and management in Nigeria, Geographical Perspectives on Environmental Problems & Management (Jameo, Enugu), 2001, 53–6

[6] Massrouje H T N. Medical waste and health workers in Gaza Governorates, *Eastern Mediterranean Health Journal*, 2001, 7, 1017–1024.

[7] Becher S and Lichtneeker H. Immunological aspects of affection of rubbish collectors caused by bioaerosols, *Journal of Occupation Health*, 2002, 44(3) 125–130.

[8] Baveja G, Muralidhar S, Aggarwal P. Hospital waste management – An Overview. *Hospital Today*, 2000, 5(9) 485–486.

[9] Bassey B E, Benka-Coker M O and Aluyi H A S. Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja Nigeria’, *African Health Science*, 2006, 6(1) 58–63.

[10] Chima G N Ezekwe IC Digha N O. An assessment of medical waste management health institutions in Yenagoo, South-South, Nigeria, *World Review in Science, Technology and Sustainable Development*, 2011, 8(2/3/4).

[11] Henry G and Heinke G W. Environmental science and engineering, 2nd ed., Prentice-Hall of India Private Limited New Delhi 110001. Incinerator Institute of America (IIA) (1968) I.I.A (Incinerators Standards, New York, NY), 2005.

[12] Coker A, Sangodoyin A, Sridhar M, Booth C, Olomolaiye P and Hammond F. Medical waste management in Ibadan, Nigeria: Obstacles and prospects’, *Waste Management*, 2009, 29(2) 804–811.

[13] World Health Organization (WHO) Unsafe injection practices and transmission of blood borne pathogens. *Bull World Health Organization*, 1999, 77 787–819.

[14] Chua T, Puziah AL, Subramaniam AK. Medical waste management in private medical clinic Taipin, Perak. *International conference on Ecology, Environment & Bio science*, 2012 [15] Tamplin SA, Davidson D, Powis B O, Leary Z. Issues and option for the safe destruction and disposal of used injection materials. *Waste Management*, 2005, 25(6) 655–665.

[16] WHO. Basic steps in the preparation of health care waste management plans for health care establishments, *World Health Organization* (Aman), 2002.

[17] Blenkharn JI. Standards of clinical waste management in UK hospitals. *The Journal of Hospital Infection*, 2006, 62 (3) 300–303.

[18] Chauhan B S. Environmental studies. (As Per U.G.C Syllabus), University Science Press, (An Imprint of Laxmi Publications Part Ltd., New Delhi, Boston, USA). 2008.

[19] United Nations Environment Program (UNEP)/SBC and World Health Organization. Preparation of national healthcare waste management plans in sub-saharan countries – Guidance manual. (WHO document production services, Geneva, Switzerland). 2005.

[20] Townend WK Cheeseman CR. Guidelines for the evaluation and assessment of the sustainable use of resources and of wastes management at healthcare facilities. *Waste Management Research*, 2005, 23 398–408.

[21] Babatola JO. A study of hospital waste generation and management practice. 2008, Online at http://www.ajol.info/index.php/afrev/article/view/41074.5th July 2016.

[22] Ogbonna D N Chindah A and Ubani N. Waste management options for health care wastes in Nigeria: A case study of Port Harcourt hospitals. *Journal of Public Health & Epidemiology*, 2012, 4(6) 156-169, June 2012.
[23] Sridhar MKC, Wahab WB, Agbola SB and AlioneBadiane. Healthcare waste management: Handbook for developing countries, (Malijoe Soft Print, Ibadan) 2009, ISBN: 978-978 8414-01-8.

[24] Olubukola BO. Comparative Analysis of healthcare waste management practices in two general hospitals in Nigeria, 2009 Available at http://www.eco-web.com/edi/index.htm. Accessed January 28, 2011.

[25] Ndidi N, Ochekpe N, Odumosu P, John S A. Waste management in healthcare establishments within Jos Metropolis Nigeria. African Journal of Environmental Science and Technology, 2009, 3 (12) 459 – 465.

[26] Ogbonna D N. Characteristics and waste management practices of medical wastes in healthcare institutions in Port Harcourt, Nigerian Journal of Soil Science & Environmental Management, 2011, 2(5) 32-141.