Characterization of Hospital Wastewater and Management Treatment Practices in Minna, Niger State, Nigeria

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Abstract

Hospitals generate large quantities of both solid and liquid wastes. High public health and environmental risks are involved in managing these wastes. Objectives of this study were: To determine the characteristics of hospital wastewater and examine the current wastewater management practices system. Hospital wastewater contains various potentially amount of hazardous pathogenic organisms, organic and heavy metals, as well as hazardous chemicals, and one of the most important source of pollution factors. In this study, two general government hospitals in Niger State were selected for this studied, i.e., General Hospital Minna, and New General Hospital Minna. Wastewater characteristics were determined by taking samples from each hospital. Results were compared with World Health Organization (WHO). Measurements and monitoring of ten environmental parameters determined. Physical properties: pH, Total Suspended Solids (TSS). Chemical properties: Biolo gical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), trace elements, Dissolved Oxygen (DO), Chloride, Sulphate. Microbiological properties: Total Coliforms (TC), Faecal Strep (FS) and Faecal Wastewater analysis revealed that BOD, COD and Chloride concentrations were more than the permissible limits prescribed in WHO. Coliforms others indicators such as physiochemical and biological indicated that the quality of wastewater in the investigated hospitals was similar to domestic wastewater. Physiochemical parameters studied revealed that the hospital wastewaters showed most of parameters values are within WHO and Federal Ministry of Environment Nigeria acceptable limits. The study of wastewater treatment and disposal methods clarified that the discharge to municipal wastewater collection system will be able to discharge their wastewater into sewerage network. This process is the best solution for wastewater management in General Hospitals Minna. The researchers recommended that the hospitals have to select onsite separate wastewater treatment

alternative. Indeed, efforts must be undertaken by hospitals to integrate environmental control and safe programme to avoid a higher risk safety factor of hospital facility operational facilities Key words: Hospital, Wastewater, Water quality, Wastewater treatment.

INTRODUCTION

Hospital wastewater are known sources of several chemicals'including remnants of disinfectants, medicine, pharmaceuticals, radionuclides and antineoplastic drugs are widely used in hospitals for medical purposes and research are regarded as risky wastewater for humans and the environment and if left untreated, these could lead to outbreak of communicable diseases, water contamination, and radioactive pollution (Gautam *et al.*, 2007). Medical waste (MW) is an environmental as well as public health issue that attracts attention in both advanced and developing countries this is because both, liquid and solid waste generated from medical activities has become a serious concern because of its implications on the environment and public health Nazik, (2010). Hospitals generate on average 750 liters of wastewater by bed per a day which loaded with pathogenic microorganisms, pharmaceutical partially metabolized, radioactive elements and other toxic chemical su bstances (Babanyara *et al.,* 2013). The huge volume of hazardous wastewater needs special attention, left untreated; these could lead to outbreak of communicable diseases, water contamination and radioactive pollution Evens *et al.* (2014) and Babanyara *et al.* (2014).

Discharge and penetration of these substances into the human environment especially groundwater and surface water would cause major hazards and health implications. Therefore, we need to monitor hospital effluent precisely and provide necessary measures in order to prevent from entry of non-treated hospital wastewater into human environment. Also, we have to protect surface water and groundwater from wastewater disposal, otherwise serious contamination and diseases will spread among healthy peoples Ashouri and Sadhezari (2016)

The UN Basel Convention considers health care waste as the second most dangerous wastes after nuclear wastes. WHO, WPRO; (2011). Health care waste includes all the waste generated by all health care establishments, health research facilities, and health-related laboratories. It also includes waste generated by home health care activities, such as dialysis, insulin injections WHO (Retrieved 23-5-2018). There are many potential hazards associated with handling health care wastewater through transmission of diseases posing risks not only to the patients and health care workers and their families, but also to, their relatives, environment and neighborhood communities especially

children due to their fragility, developing immune systems and for the fact that they often play at such sites increases their contact with medical waste, thus exposing them to injuries and infections. WHO, (2011).Despite the great potential for environmental hazards and public health risks of hospital wastewater, its proper handling and management is substantially undermined in many developing countries. The hazardous waste has a small portion of healthcare waste, but the absence of appropriate waste segregation practices leads mixing hazardous waste with general (non-hazardous) waste results the entire bulk of waste becoming potentially hazardous. Esubalew (2015). The management of health care waste is an integral part of a national healthcare system. However, many countries do not have minimum standards or practices, essentially in developing countries. Research conducted by (Chimchirian *et al*., 2007), revealed that the use of ground water for supplying drinking water has profoundly increased and in case of failure in effective management wastewater treatment plant as well as controllingcontamination, hospital wastewater spreads into surface and ground water (Seifrtová *et al*., 2008), Pena *et al*, (2010). Consequently, this,leads to prevalence of different kind of diseases. Therefore, huge costs would be imposed on the public and the government. For that reason, investigating hospital wastewater treatment is germane.

Medical waste management has not received sufficient attention and the priority it deserves in developing countries such as Nigeria, where health concerns are competing with limited resources Abahand and Ohimain, (2011);Ibijoke *et al.*,2013).In this case hazardous medical wastes are still handled and disposed-off together with non- hazardous wastes thus posing a great health risk to the healthcare workers, the public and the environment (Silva *et al.*,2005; Ogbonna e*t al*.,2012;Ibijoke *et al.*,2013).

In Niger State, MWs in different hospitals are managed improperly in which they are dumped in open landfills, surface dumping sites or by the use of sub-standard incinerators. In addition, unavailability of adequate data with regards to waste generation rate, composition and management practices have posed profound challenges in planning appropriate MW management methods in the state. Furthermore, both non-hazardous and infectious MWs in the state are burnt together in incinerators leading to the more accumulation of more heavy metals as well as organic compounds and other caneer causing organics in the bottom ash of the incinerators which if not properly disposed of can pollute the environment and pose public health problems such as acute respiratory syndromes,

gastrointestinal abnormalities and various cancers. These has been proved in the studies conducted by (Zhao *et al.*, 2010; Auta and Morenikeji, 2013; Mohajer *et al.*, 2013).

Hospital waste management in Nigeria and Niger State in particular has not also received sufficient attention and the priority it deserves both at local and national levels. Some studies have been carried out on solid waste management of hospitals but little or no previous data is available on wastewater in the state Shaibu (2014). However, practices from daily observation indicate that, most health facilities had not put in place an organized management system to address Health Care Waste Management. In countries' where the management of healthcare wastes is often poor; they could pose a potential risk to public health through the circulation of agents in the environment, animals and people Babanyara *et al.* (2014)

2. MATERIALS AND METHODS

2.1 *Description of the Study Area*

The study area is located in Minna town, Chanchaga Local Government Area of Niger State, Nigeria. Minna is the Capital of Niger State and also the largest commercial centre in the state and its proximity to Federal Capital attract more population. The study area lies between latitude 9°33 to 9°4 N and longitude 6°29 to 6°35 E. The mean annual rainfall is between 1334mm and 3000mm, the mean monthly temperature is highest in March at 39.5 °C and lowest in August at 22.3°C. (Ministry of Land and Housing Minna, 2015). Minna has a total population of approximately 201,429 people out of the total population of Niger State, which has 3,950,249 with an annual growth rate of 2.3%. (National Population Commission, 2006). Also, Minna has become a cosmopolitan city with most of residents engaging in white collar jobs. As a state capital, majority of the inhabitants are civil servants, the proximity to Abuja capital of Nigeria influence the increasing influxes of population and boosted commercial activities a result, the volume of wastewater generated has increased due to increase number of inpatients and outpatients that visited the hospital Shaibu (2014). Figure 1.1 shows the location of the study area

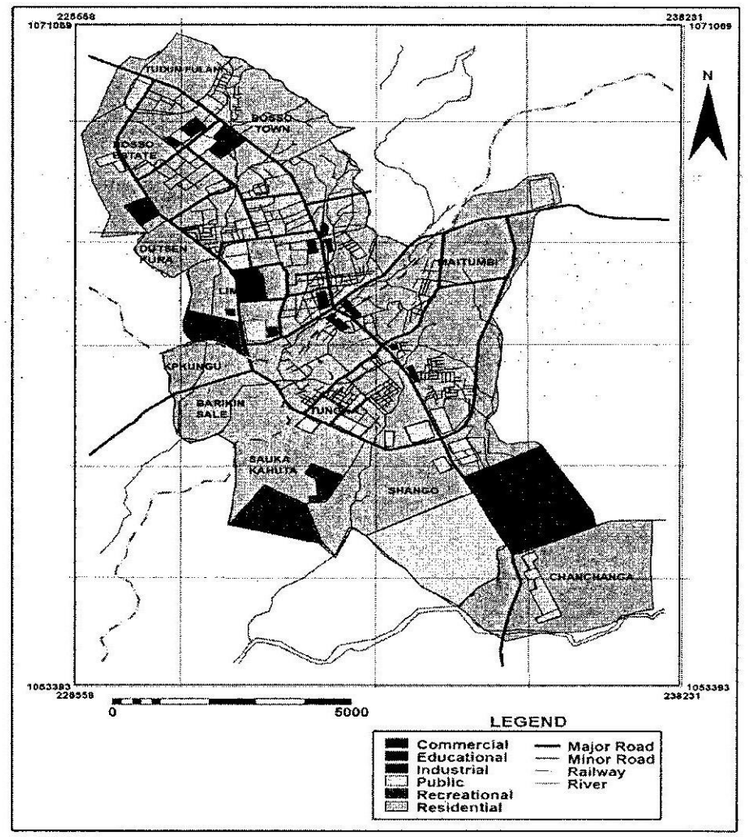

Figure 1.1: Location of the Study Area

Source: Ministry of Land and Housing, 2015

The General Hospital has six wards: Surgical, Pediatrics, Gynecology and obstetrics, Ophthalmology, Pharmaceutical, Medical, and Labor wards, with 296 maximum bed capacities More so, Minna General Hospital has a new extension located at opposite site with 150 bed capacities. .These are the largest hospital which generate considerable amount of wastewater and the outpatient flow on

average is 150-200 per day. The hospitals consumes considerable amount of water. It is one of the largest hospital which releases considerable amount of wastewater to the soaker- way

In this study, management and quality of wastewater in the government hospital in Minna Niger State, Nigeria have been investigated. The raw wastewater discharge of the hospital was collected to determine various physico-chemicals, trace organic pollutants, trace elements, biochemical indicators (BOD and D.O) and microbiological measurements. The wastewater quality was compared with WHO limits (1996) and Nigeria Federal Ministry of Environment (1991). In addition, the current wastewater management practices was equally examine. All of the examinations were performed according to the instructions of "Standard Methods for the Examination of Water and Wastewater" (APAH, 2005). Similarly, Focus Group Discussion and Field Observations were utilizedfor the investigations of wastewater management treatment practices

2.2 *Sampling Collection and Analysis of Wastewater*

There were several wards in the selected hospitals. Each ward generated wastewater having different characteristics. All these wastewaters discharge into soaker-ways untreated. Collection tank of disposal station not available in both hospital selected in this study. To take a representative sample, it was decided to collect wastewater from each of the soaker way to form a composed sample. The testing procedures for the parameters tested are mentioned in Table 1. The heavy metals in the wastewater were analysed.

Table 1. Parameters tested and the testing procedures.

Parameters	**Testing Method**
PH @ 25.0 0C	APHA
Suspended Solid (mg/L)	COLOMETRIC
COD (mg/L)	APHA 5220 (D)
BOD (mg/L)	APHA 5210B

D.O (mg/L)	APHA 4500-OC
Chlorides (mg/L)	APHA 4500 Cl-(B)
Sulphate (mg/L)	APHA 4500 SO4 E
Tata Coliform (Cfu/100ml)	APHA 9222 B
Faecal Strep (Cfu/100ml)	APHA 9222 B
Faecal Coliforms (Cfu/100ml)	APHA 9222 B

- C.O.D = Chemical Oxygen Demand
- D.O = Dissolved Oxygen
- B.O.D = Biological Oxygen Demand

All the testing methods are based on Standard Methods for the Examination of Water and Wastewater, 20th edition (1998), www.standardmethods.org.

3.0 RESULT AND DISCUSSION

3.1 *Characteristics of Hospital Wastewater*

Hospital wastewater quality and management has become a critical issue as it poses potential damage to the environment and health risks as well, which has taken a central place in the national health policies of many countries Hanan and Amira, (2011). Hospitals investigated had no wastewater treatment plant. The results of physico- chemical parameters are presented and compared with WHO in Table 2 that indicated the quality characteristics of raw wastewater in the investigated hospital for pH, TSS, D.O, BOD, COD,T.C, F.C. F.S, Sulpate and Chloride.

3.1.1. *pH- Value*

One of the most germane parameters in biological waste water treatment processes is pH and its variances. Overall, suitable pH for bacteria growth and activity ranges between 6.5 to 8.5. The activity

of most of bacteria effective on wastewater treatment is disrupted or stopped at pH> 9.5 (Emmanuel *et al.*, 2001). While, acceptable effluent pH for discharge into surface water and rivers ranges between 6.5 to 8.5, and for agricultural purposes and green spaces irrigation ranges between 6 to 8.5 (Giger *et al* 2003). In the current study, hospitals raw wastewater and effluent was measured to be 7.31 and 7.49, respectively. These values were within the permissible limits of WHO (5-9) and Nigeria Federal Ministry of Environment (6-9),these amount are acceptable. Similar results were obtained in other studies. Beyene and Redaie, determined pH value in hospital wastewater to be 7.4. Study on hospital wastewater in India showed pH value of 7.36 (Gautam *et al.*, 2007). Other environmental studies (Onesios, *et al.*, 2009 and Metcalf and Eddy, 2003) that within WHO limits (pH: 5-9) (WHO, 1996). All these results agree with the current study results and therefore, safe for discharge into surface water and rivers

Table 2. Physicochemical characterizations of hospital wastewater

Parameter	General Hospital	General Hospital Extension	WHO (Permissible Limit)
PH	7.31	7.21	5-9
TSS (mg/L)	212	49	100
COD (mg/L)	215	23	60
BOD (mg/L)	86	10	50
DO (mg/L)	1.60	1.80	6.0
Chloride (mg/L)	62,70	59.9	1000
Sulphate (mg/L)	63.0	11.0	250
Total Coliform (CFU/100 mL)	1100	72000	1000
Faecal Strep (CFU/100 mL)	402	34000	1000
Faecal Coliform (CFU/100 mL)	400	60000	1000

3.1.2 *Total Suspended Solids (TSS)*

This is one of the common parameters used in defining a wastewater. The result indicates that TSS concentration of hospital raw wastewater from the General hospital was 212mg/L. This concentration is more than the 100 mg/L permissiblelimit by the WHO and Nigeria Federal Ministry of Environment of 30 mg/L. Similar studies which investigated wastewater samples of some government hospitals obtained TSS concentrations in the range of 120-400mg/L (Metcalf and Eddy, 2003).The value of this parameter in the current study of the New General Hospital Extension was 49mg/L which is lower than theWHO 100 mg/L permissiblelimit but, closed to Nigeria Federal Ministry of Environment limit of 30mg/L. Other studies measured TSS value to be 50 mg/L and 49.27 mg/L Ashouri and Sadhezari (2016) and all these values are lower than theWHO standard limit but similar to the one obtained for the New General Hospital Extension.

3.1.3 *Dissolved Oxygen (DO)*

Dissolved oxygen is one of the most important bio- monitoring parameters of water quality in the aquatic environment.The DO values in the current study hospitals obtained to be 1.60 and 1.80 mg/L respectively, these values were lower than theWHO 6.0 mg/L permissiblelimit. Therefore, safe for discharge into surface water and rivers

3.1.4 *BOD and COD*

The parameters of BOD and COD are widely used to characterize the organic matter contents of wastewater (Puangrat and Nattapol, 2010). BOD is an index of the oxygen-demanding properties of the biodegradable materials in water that are useful in assessing water pollution loads and for comparison purposes. Also, COD is a measure of pollutant loading in terms of complete chemical oxidation using strong oxidizing agents. It provides a good index of chemical-oxygen demanding properties of natural waters. BOD and COD values in the studied hospitals varied from 10 mg/L to 86 mg/L and 23 mg/L to 215 mg/L respectively.These concentrations are higher than the permissiblelimits of WHO (COD: 60, BOD: 50 mg/L). Highest concentrations of BODand COD were obtained for the General Hospital. Generally, values of hospital wastewater BOD vary due to differences in their medical services (Purdara, *et al.*, 2004). In some studies, the BOD values of 272.98 mg/L and 240 mg/L have been reported; Ashouri and Sadhezari (2016) and Rafaat *et al,* (2010) respectively. The findings in thecurrent study not in accord with all of these results. Another

study conducted in Imam Khomeini Hospital, with theBOD contents of 60.5 which is closed to 86 of BOD contend in the current study. Similarly, the results of CODin hospital raw wastewater were 792, 628 and 629 mg/L respectively were reported (Sabzevari *et al.*, 2005). All these results are higher than the findings of current study. According to the WHO standard, the maximum allow able concentration of BOD and COD in effluent discharge into surface water are 50 mg/L and 60 mg/L respectively, while for agricultural purposes and green spaces irrigation, the maximum allowable concentration is 100 mg/L (Giger, *et al.*, 2003). Therefore, the contends of BOD and COD in the current study of General Hospital are not safe for discharge in to surface water and this calls for special attention.

3.1.5 *Chlorides and Sulphates*

The result of Table 2 reveals that the parameters; chlorides and sulphatesobtained were 62.7, 59.9 and 63.0 and 11.0 mg/L respectively for the General Hospital and the General Hospital Extension. These values are less than the WHO limits and Nigeria Federal Ministry of Environment of 250 mg/L for discharge into surface water. Therefore, the results of this findings in the current study of General Hospital are safe for discharge in to surface water and this calls for regular monitoring and evaluation for it sustainability.

3.1.6*Microbiological Pollutants*

Treatment of patients with enteric diseases is a critical problem during outbreaks of diarrhoeal diseases, therefore, the knowledge of the microbial quality of hospital wastewater is very critical (Pauwels, *et al.*, 2006). To achieve this, some bacteriological indicators are used to reflect the presence of pollution pathogens in wastewater. These include the determination of TC. FC and FS that are the most world-wide knownparameters used for the establishment of contamination (Hanan and Amira, 2011). The microbiological quality of water varies from hospital to another due to variations in the consumption of water by the hospitals during the study. The acceptable limit of TC, FC and FSin hospital effluent discharge into surface water, for agricultural purposes and green spaces irrigation are 1000, and 400 MPN/100 ml, respectively Majlesi(2001)

Table 2 indicates that the average TC, FC and FS in the wastewater samples of the current study were 1100, 400 and 402 CFU/mLrespectively in the case of General Hospital while for the New General Hospital extension, the values obtained were 72000, 60000 and 34000 CFU/mL respectively. This

means that, the number of TC, FC and FS are higher than the 1000 MPN/100 mLgiven by WHO,indicating higher bacterial contamination.Accordingly, these hospital effluents are not ripe for discharge into surface water. These high values could be as a result of the fact that proper wastewater treatment process is not on priority list of most of the managements of the selected hospitals in this study since none of them hasa wastewater treatment plant. Another studies, the TC, FC and FS values of 99.57, 97.45, 90.63 and 29.87, 31.2 30.54 MPN/100ml, respectivelyrespectively have been reported;(Majlesi and Yazdanbakhsh,2008)and (Ashouri and Sadhezari, 2016). All these results are lower than the results of current study.This means that lack of bacterial

contamination and good treatment plant efficiency in those hospitals.

3.1.7*Study on wastewater treatment and disposal*

The result of Focus Group Discussion and Field Observationsreveals that, the two General Hospitals in this study have no wastewater treatment plant and finally dispose their wastewaters directly into their septic tanks (soaker-way). This may permit the discharge of infectious agents into groundwater and other environments which may be a hazard for both hospital personnel and the nearby community. Therefore, this present situation calls for urgent interventions by the concerned authorities in addressing these critical environmental and health risk factors.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Since wastewater treatment is not a priority of some managements of the selected hospitals because none of them haseven a wastewater treatment plant, the BOD, COD,TC, FC and FS of the wastewater samples of most of the hospitals are above the limits prescribed by WHO thus making it unsafe for direct discharge of these wastewaters into surface water. This is because this may harm the aquatic life and even human health. Therefore, this calls for special urgent attention by these establishments by way of establishing wastewater treatment plantsand improving the operation and maintenance practices by employing experienced operators in order to meet effluent discharge standards.

Furthermore since wastewater treatment and disposal methods clarified that the discharge to municipal wastewater collection system will be able to discharge their wastewater into sewerage network, this process may be the best for wastewater management in the general hospitals studied in

this work. It is also the recommendation of this study that the hospitals select onsite separate wastewater treatment alternatives that will integrate environmental control and safe programmes aimed at avoiding high risks in safety factors of hospital facility operations.

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