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Physical, Chemical and Biological Parameters of Water from Medical Waste Dumpsites in South-Western Niger Delta, Nigeria

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Abstract: Water pollution by effluent has become a question of considerable public and scientific concern in the light of evidence of their extreme toxicity to human health and to biological ecosystems. Hospital wastewater poses serious health hazard to healthworkers, the general public and the environment. This study was conducted to determine the physical, chemical and biological parameters of hospital wastewater in South-Western Niger Delta, Nigeria. Water samples were collected from the Federal Medical Center, Owo, Ondo State, University of Benin Teaching Hospital, Irrua Teaching Hospital, Irrua, Stella Obasanjo Hospital, Benin City, Edo State and Central Hospital, Warri, Delta State and from general (non-medical) dumpsites in all the locations where the medical wastes were collected, and these served as controls. The water samples collected were analyzed using standard techniques. There was no significant difference in physical, chemical and biological qualities of water from medical and non-medical waste dumpsites ($P > 0.05$). The only organism isolated was Bacillus species while *Aspergillus* species was the only fungi found in this study with total counts within acceptable limits. Medical and non-medical wastes do not have significant impact on physical and chemical properties of surface water.

Key words: Biological, chemical, medical wastes, physical, water, Nigeria.

Introduction

Freshwater has become a scarce commodity due to over exploitation and pollution (Patil and Rajendra, 2001; Singh and Mathur, 2005; Gupta and Shukle, 2006). Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affect quality of human life including other animals' life and plant (Okoye et al., 2002). Over 5.2 million people including four million children die each year from waste-related diseases (Akter, 2000). Hospital waste poses serious health hazard to health workers, the general public and the environment (Ekhaise and Omovwoya, 2008; Alabi and Shokunbi, 2011). Hospital wastewater may be considered as a reservoir of genotoxins and may be risky for humans and the environment due to the research activity, tests in its laboratories, release of chemicals, disinfectants and excretion of drugs into wastewater (Giuliani et al., 1996; Hartmann et al., 1998; Kummerer, 2001). If these hospital wastewaters are not treated properly, hospital effluents can damage the natural environment and create a biological imbalance by inducing hereditary defects, exhibiting teratogenic properties, inducing substantial loss of reproductive dysfunction in exposed populations (OSPAR Commission, 2002; Gautam et al., 2007) and influencing individual fitness by toxicity-related phenomena (Abdel-Massih et al., 2013).

Water pollution by effluent has become a question of considerable public and scientific concern in the light of evidence of their extreme toxicity to human health and to biological ecosystems (Katsuro et al.,

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2004). Medical waste management practices differ from hospital to hospital (Omoruyi et al., 2011). There has been conflicting reports on the physical, chemical and biological parameters on the hospital wastewater. Many studies have focused on wastewater from hospitals either from particular sections such as medical and non-medical, or streams into which these wastes are discharged (Omoruyi et al., 2011; Ojo and Adeniyi, 2012). Information is lacking on the physical, chemical and biological parameters of water from hospital wastewaters in south-western Niger Delta, Nigeria. Against this background, this study was undertaken to determine the physical, chemical and biological parameters of hospital wastewater in south-western Niger Delta, Nigeria.

Materials and Methods

Study Area

This study was carried out at some tertiary hospitals in the south-western region of Nigeria. A total of five sampling stations were selected for this study. The sampling sites consisted of Federal Medical Center, Owo, Ondo State, University of Benin Teaching Hospital, Irrua Teaching Hospital, Irrua, Stella Obasanjo Hospital, Benin City, Edo State and Central Hospital, Warri, Delta State. Water samples were collected from each site. Water samples were also taken from general (non-medical) dumpsites in all the locations where the medical wastes were collected, and these served as controls.

Collection and Processing of Water Samples

A total of 20 samples consisting of 10 samples from medical waste dumpsites (two samples from each dumpsite) and 10 samples from non-medical waste dumpsites (two samples from each dumpsite) were collected in this study. Water samples were collected from groundwater (borehole) around the dumpsites in one litre plastic bottles. Water for dissolved oxygen was collected in transparent oxygen bottle while that for biological oxygen demand (BOD) was collected in brown bottle. Immediately after collection, the dissolved oxygen (DO) samples were fixed using Winkler's method. Water for metal analysis was collected in 500 ml bottles and 2 ml of nitric acid was added. Samples for microbial analysis were put in sterile universal containers.

The physico-parameters and method used are shown in Table 1.

Table 1: Physico-chemical parameters used for analysis of samples

Parameter	*Method*
pH	pH meter
Temperature	Thermometer
Turbidity	Nephlometery
Conductivity	Conductivity meter
Total dissolved solid	Datalog TDS meter
Dissolved oxygen	Titration
Biological oxygen demand	Titration
Total suspended solid	DataLog TSS meter
Anions (chloride, sulphate, phosphate and nitrate)	Chloride – titration; others – spectrophotometry
Alkalinity	Titration
Hardness	Titration
Calcium and magnesium	Titration
Iron	Spectrophotometry
Zinc	Titration
Copper	Spectrophotometry
Heavy metals (chromium, cadmium and lead)	Spectrophotometer
Nickel	Atomic absorption spectrophotometry

Bacterial and fungi counts were performed by the methods described by Ogefere et al. (2010)

Data Analysis

Data collected from the study were analyzed using general descriptive statistics, and unpaired student t-test. Data were analyzed using the statistical software INSTAT® (GraphPad Software Inc., La Jolla, CA, USA).

Results

The results of physical, chemical and biological parameters of water from medical and non-medical waste dumpsites are shown in Table 2. The values for temperature, chloride, phosphate, nitrate, iron and zinc were higher in water samples from medical waste dumpsites than that from non-medical waste dumpsites. The values of pH, TDS, conductivity, DO, TSS, sulphate, alkalinity, calcium, magnesium, copper, chromium, cadmium, lead and nickel were higher in water samples from non-medical waste than that fron medical waste. However, these differences were not statistically significant ($P > 0.05$) (Table 2).

In comparison to WHO (1993) permissible limit, heavy metal (chromium, cadmium, lead and nickel) contamination was observed in water from non-medical

Table 2: Physico-chemical parameters observed in water

	Medical waste			*Non-medical waste*			*P-Value*	*WHO, 2011*	*FMEnv, 2001*
	Mean ± SE	*Min*	*Max*	*Mean ± SE*	*Min*	*Max*			
pH	7.02±0.32	5.91	7.62	7.16±0.12	6.84	7.47	P > 0.05	8.5	9.0
Temp (º C)	24.42±1.88	21.20	28.30	20.52±0.40	19.30	21.50	*P* > 0.05	27	30
TDS (mg/l)	71.80±41.62	6.05	215.28	215.75±180.29	10.70	936.02	*P* > 0.05	1000	2000
COND	131.43±76.03	12.11	396.55	389.33±324.28	20.33	1684.84	*P* > 0.05	--	1000
DO (mg/l)	5.60±0.29	5.10	6.30	6.02±0.22	5.40	6.50	*P* > 0.05	5	50
BODs (mg/l)	1.40±0.09	1.20	1.70	1.40±0.12	1.10	1.80	*P* > 0.05	30	50
TSS (mg/l)	9.24±0.40	8.07	10.11	9.97±0.87	8.86	13.42	*P* > 0.05	-	30
Cl (mg/l)	32.93±19.12	3.41	98.72	20.80±13.96	4.02	76.41	*P* > 0.05	400	600
SO_4 (mg/l)	3.07±2.19	0.00	11.25	6.07±4.79	0.00	25.04	*P* > 0.05	400	200
PO_4 (mg/l)	1.08±0.70	0	3.44	0.91±0.73	0.03	3.81	*P* > 0.05	-	50
NO_3 (mg/l)	0.20±0.15	0	0.78	0.17±0.11	0.00	0.59	*P* > 0.05	50	20
Alkalinity (mg/l)	12.31±6.77	1.92	35.91	29.89±20.25	3.06	110.14	*P* > 0.05	-	250
Hardness (mg/l)	2.62±1.52	0.17	4.51	2.63±1.14	0.28	6.94	*P* > 0.05	500	-
Ca (mg/l)	1.09±0.67	0.03	3.27	1.36±0.51	0.06	3.18	*P* > 0.05	75	-
Mg (mg/l)	0.60±0.36	0.01	1.79	0.67±0.32	0.04	1.75	*P* > 0.05	150	200
TFC (cfu/ml)	70.00±17.75	22	117	84.60±24.55	16	159	P > 0.05	100	100
TBC (cfu/ml)	15740.00±7085.20	2300	40800	9160.00±2609.52	1700	17100	*P* > 0.05	100	100
Fe (mg/l)	0.06±0.02	0.01	0.107	0.05±0.02	0.02	0.11	*P* > 0.05	1.0	1.0
Zn (mg/l)	0.05±0.03	0.00	0.12	0.01±0.00	0	0.01	*P* > 0.05	5.0	15
Cu (mg/l)	0.00±0.00	0.00	0.01	0.01±0.00	0	0.02	*P* > 0.05	1.5	1.5
Cr (mg/l)	0.01±0.00	0.00	0.03	0.63±0.00	0	3.01	*P* > 0.05	0.01	0.01
Cd (mg/l)	0.01±0.01	0.00	0.05	0.02±0.01	0	0.04	*P* > 0.05	0.01	0.01
Pb (mg/l)	0.20±0.00	0.00	0.78	4.49±0.00	0	22.23	*P* > 0.05	0.05	0.5
Ni (mg/l)	0.01±0.00	0.00	0.02	0.63±0.00	0	0	*P* > 0.05	-	0.2

waste while only lead contamination was observed in water from medical waste (Table 2).

Discussion

Many studies have focused on waste water from hospitals either from particular sections such as medical and non-medical, or streams into which these wastes are discharged (Ekhaise and Omovwoya, 2008; Omoruyi et al., 2011; Ojo and Adeniyi, 2012). Some hospitals discharge all their solid wastes on a dumpsite (usually within the hospital land area) and leave it for days or weeks before incineration, removal by the general municipal waste management or left to compost naturally. The effect of such practice on the soils and surface water has not been studied. Against this background, this study was conducted to determine the physical, chemical and biological effects of the medical waste on the soil and surface water in dumpsites and to compare the results with those from non-medical (municipal) waste dumpsites.

Temperature plays an important role in wetland dynamism affecting other various physical parameters in water (Akter, 2000), as well as a factor for the biological activity that takes place within the aquatic environment (Tahiri et al., 2011). The temperature of waste water that has been reported for hospital or medical waste varies from study to study. Tahiri et al. (2011) reported a temperature range of 14.2-19ºC taken at various times of the day. Wyasu and Okereke (2012) reported mean temperature range between 14.12 and 46.33ºC. In this study, a mean temperature of 24.42ºC was observed for medical waste while for non-medical waste a mean temperature of 20.52ºC was observed. However, the temperature did not differ significantly between medical and non-medical waste ($P > 0.05$). All temperature recorded in this study were below the acceptable limit of WHO (30ºC) for the discharge of hospital waste water as reported by Wyasu and Okereke (2012). This may imply that the temperature value in this study may not have significant impact on surface water.

It has been reported that the pH limit for acceptable waste water ranges between 5 and 9 (WHO, 2011). The average pH of water observed in this study for both medical and non-medical wastes were 7.02 ± 0.32 and 7.16 ± 0.12 respectively. This indicated that both medical and non-medical wastes do not affect the pH of surface waters close to their respective dumpsites. The pH of surface water observed was within the WHO (2011) and Federal Ministry of Environment (FEMenv) (2001) acceptable range. This may indicate that medical wastes do not have effect on the pH of surface water.

The turbidity of surface water around the dumpsites of medical waste (2.06 ± 0.68 NTU) and non-medical waste (18.34 ± 14.98) did not differ significantly ($P > 0.05$) in this study. These values were lower than the mean values of unimpacted stream (20.60 ± 12.35) effluent discharge (105.22 ± 66.34) and impacted stream (29.04 ± 15.94) reported in Ile-Ife (Ojo and Adeniyi, 2012). It would appear that medical waste does not affect turbidity of surface water in the Niger Delta locality.

The WHO limit for total suspended solid (TSS) is put at 100 mg/L (WHO, 2011) and values above this have been reported in hospital waste water collected from hospital waste collection system (Abd El-Gawad and Aly, 2011). The TSS for medical waste observed in this study is 9.24 ± 0.40 mg/L and is within the WHO limit for TSS. The reason for the difference in TSS obtained in this study and that of Abd El-Gawad and Aly (2011) could be due to the type of waste water used. The surface or tap water within or around a medical dumpsite was used in this study as against the collection of all waste water from various sections of the hospital that were collected into a system and treated, used by Abd El-Gawad and Aly (2011). The TSS values of surface water for medical waste dumpsite did not differ significantly ($P > 0.05$) from TSS values of non-medical waste.

Electrical conductivity did not differ significantly in surface water from medical and non-medical dumpsites. These values of electrical conductivity observed in this study were below the permissible limit of 1000 mg/L by FMEnv (2001).

The mean alkalinity observed in this study in both medical and non-medical wastes was lower than the permissible limit of 600 mg/L reported by Kumar and Puri (2012). Therefore, the medical and non-medical wastes do not affect the alkalinity of surface water. The hardness of surface water observed in this study did not differ significantly ($P > 0.05$) between medical and non-medical waste dumpsites, and they are very low compared to the permissible limits in drinking water.

The dissolved oxygen level of surface water from medical and non-medical dumpsites did not differ significantly ($P > 0.05$) in both sites and are lower than the permissible limit of 14 mg/L by WHO (2011).

Although, the mean total dissolved solids for surface water from non-medical waste dumpsites was higher than that obtained from medical waste dumpsites, the difference was not statistically significant ($P > 0.05$). Waste water effluent from University of Benin Teaching Hospital was reported to have total dissolved solid values ranging from 36 to 147 mg/L (Ekhaise and Omovwoya, 2008), while receiving streams of hospital effluent discharge from Obafemi Awolowo University, Ile-Ife was observed to have TDS ranging from 140 to 150 mg/L (Ojo and Adeniyi, 2012). The range of TDS for medical (6.50 - 215.28 mg/L) and non-medical (10.70 - 936.02 mg/L) wastes differ from the above reported ranges. It is important to note that the waste water effluent and receiving streams are different from the type of surface water analyzed in this study. However, the values obtained in this study are lower than the acceptable limits of 1000 mg/L by WHO (2011) and 2000 mg/L by FMEnv (2001).

The Nigerian FMEnv (2001) stipulates a tolerance limit of 350 mg/L as the concentration for biological oxygen demand (BOD) for effluent to be discharged into surface waters but the permissible limit for BODs in drinking water is not known. However, the BODs of surface waters from medical and non-medical waste dumpsites in this study were much lower than the FMEnv limit and they do not differ significantly between the types of dumpsites.

The anions analyzed in this study include nitrates, phosphates, sulphates and chloride. Generally, there was no significant difference in the levels of all electrolytes from both dumpsites ($P > 0.05$). The concentrations of nitrate, phosphate, sulphate and chloride ions observed in surface water from both medical and non-medical waste dumpsites were lower than their permissible limit in drinking water [nitrate 50 mg/L, sulphate 400 mg/L, phosphate 50 mg/L (FMEnv, 2001) and chloride 400 mg/L (WHO, 2011)].

Heavy metals are elements of high atomic numbers. They have high utility in industrial applications from papers to automobiles, by their very characteristic properties. Of the heavy metals analyzed in this study, only nickel was not detected in the surface waters from both medical and non-medical waste dumpsites. The levels of the other analyzed heavy metals did not differ significantly ($P > 0.05$) from both dumpsites. However, the mean values of these heavy metals depending on the dumpsite were higher than the permissible limit in drinking water (WHO, 2011); permissible limit for chromium is 0.01 mg/L, cadmium 0.01 mg/L and lead 0.05 mg/L. The WHO (2011) permissible limit for lead is 0.05 mg/L. This indicates that surface waters from both dumpsites are contaminated with lead and consumption of such water may lead to lead poison. The provisional tolerable weekly intake of lead was established to be 25 µg/L lead per kg body weight or 93.5 µg/kg body weight/day (WHO, 1993). Lead poisoning has been associated with several health hazards such as anaemia and reproductive dysfunction (Beeher et al., 2013). The mean chromium level of surface water from non-medical waste in this study was higher than the permissible limit of 0.1 mg/L by FMEnv (2001) and 0.5 mg/L by WHO (2011). The use of chromium in hospitals may be regulated or restricted, thus, reducing the amount that finds its way to the hospital solid waste and eventual dumpsites. In contrast, the use of chromium may not be regulated in the general population which may in turn increase the level of chromium in their wastes. This may explain the finding of higher levels of chromium in water from non-medical waste dumpsites in this study, albeit, the difference failed to reach statistical significance. FMEnv (2001) and WHO (2011) put the permissible limit for cadmium at 0.05 mg/L, which clearly indicated that the mean cadmium level for surface water from both medical and non-medical waste dumpsites were above the permissible limit. This implies cadmium contamination, although the level of cadmium for both dumpsites did not differ significantly ($P > 0.05$).

With regard to biological parameters, it has been reported that microbial load of clinical wastes is markedly less than that for domestic refuse (Blenkharn, 2005). However, microbial load of medical and non-medical wastes were not determined; rather total viable count (fungi and bacteria) of surface waters of the different dump sites were evaluated. In the microbiological examination of portable water, *Escherichia coli* count is used to assess water quality, but in this study *E. coli* was not used as the only organism isolated was *Bacillus* species while *Aspergillus* species was the only fungi found in this study. Generally, total microbial count $\leq 10^5$ cfu/ml is acceptable and the results obtained in this study fell within this limit. Although, *Aspergillus* species was found, fungi rarely cause infections in immunocompetent individuals. Therefore, the surface water obtained from both dumpsites may not have significantly impacted microbiologically.

There was known significant difference in the physical, chemical and biological quality of water from medical and non-medical waste dumpsites in this study. Blenkharn (2005) has reported that medical waste contains significant amount of general refuse items and this agrees with the observations in this study. The medical waste dumpsite also contained a lot of general refuse as inhabitants within and outside its vicinity also uses it as a dumpsite for their general wastes. This may explain the non-significant difference in all parameters investigated in the soil from medical and non-medical waste dumpsites.

In conclusion, medical and non-medical wastes do not have significant impact on physical and chemical properties of surface water. Heavy metal contamination of surface water was restricted to lead, cadmium and chromium and was observed only in some medical and non-medical waste dumpsites. Measures to reduce heavy metal contamination of surface water from medical and non-medical waste dumpsites are advocated.

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