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Determination of Gross Organic and Micro-biological Content of Wastewater Drains from vicinity of Cement and Gas associated Activities, Port Harcourt, Nigeria.

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Abstract

This study was designed to assess the level of microbial load of the drain water and the gross organic pollutants (BOD and COD) around the Dangote cement industry, gas tank farm and other associated activities in the Iwofe by Eagle cement road. The BOD and COD levels were above permissible limits while the BOD/COD ratio was an indication of high biodegradability status within the range of 0.5787 and 0.8598. This was premeditated by the industrial activities and high employment rate within the study area. Three sample points for each station made up of three composite samples were made labelled K, L, M selected based on distance from target cement factory (100m, 250m and 400m respectively) and corresponding control points of Kc, Lc and Mc respectively were used. The microbiology parameters studied were THB, TCB and FCB determined by the Spread plate, MPN and MPN but with ranges of (4.5± 35355-6.5±28284) x 10^5 Cfu/ml; 4000±412-5500±648 MPN/100ml and 3450±69-4050±153 MPN/100ml respectively. The results showed that the bacteriological results were above regulatory limits (WHO, NSDWQ, FEPA, NESREA, USEPA, SON *etc*) much above allowable limits by these regulatory agencies which poses great danger to both ground water and water usage for other beneficial uses. Water bacteriology showed high level pollution from fecal waste which must be checked to avoid water borne diseases and epidemics. The concentrations of THB, TCB and FCB were not just above permissible limits but most importantly, their mere presence is an indication of pollution and contamination of the water body. Government should as a matter of urgency carry out post treatment of the abandoned waste dump and monitor the indiscriminate human waste dump around the drains by providing public toilets around busy and industrial areas creating jobs and revenue at minimal cost to the notary public.

Keywords: microbiological, total heterotrophic bacteria, total coliform count, fecal coliform count, Dangote, Eagle cement, drain water, BOD, COD

1.0 Introduction

Most developing countries have challenges relating to clean water supply and adequate sanitation services hence are prone to diseases associated to water, poor sanitation (Muhammed, Nicolas, & Joachim, 2016). According to Muhammed *et al.* (2016), such diseases are diarrhea, impetigo and trachoma. About 88% of cases linked to diarrhoea are caused by unsafe water, poor sanitary habits and hygiene globally (WHO/UNICEF, 2009). Similarly, waterborne diseases result from the ingestion of water contaminated with human or animal faeces or urine containing pathogenic bacteria or viruses including cholera, typhoid, bacillary dysentery, adenoviruses, retroviruses, and other diseases (Duressa, Assefa & Jida, 2009). Other sources of health challenges in our villages emanate from diseases in water got from dissolved inorganic and organic substances. Similarly, poor water quality is considered as one of the practical proofs of poverty in developing countries. Accordingly, improvement in drinking water supply, quality, and sanitation and reducing waterborne diseases have been major components of the sustainable development goal (SDG) programmes in goal 6 formulated (UN, 2015).

The effort of delivering safe water to the population has faced many encumbrances such as population growth, poor sanitation, and contamination of water sources with domestic wastes and industrial effluents (Alemu *et al*., 2015; Troyer, Mereta, Goethals & Boets, 2016). This shows that despite the worldwide efforts of delivering safe drinking water, the transmission of waterborne diseases is still a matter of major concern. Industrial development is often associated with the generation of industrial effluents which can bring about water, sediment and soil pollution if not monitored and controlled (Fakayode, 2005).

BOD (biological Oxygen Demand) is a measure of the amount of oxygen required for the bacteria to degrade the organic components present in water or waste water (Lee & Nikraz, 2015). Conversely, COD or Chemical Oxygen Demand is the total measurement of all chemicals (organics & inorganics) in the water or waste water. According to Samudro and Mangkoedihardjo (2010), various compounds of organic matter containing materials can be measured in two simple parameters, *i.e.* biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The zonation of BOD/COD ratio is characterized by the limits of toxic, biodegradable and acceptable or stable zone (Samudro & Mangkoedihardjo, 2010). By Biodegradable zone means the limit of organic matter that can be decomposed by microbes in natural and man-made treatment conditions. The biodegradable zone gives the limits of BOD/COD ratio as between 0.1 and 1.0, though may be segmented into several levels such as low, moderate and high biodegradable that requires further research (Samudro & Mangkoedihardjo, 2010). BOD/COD ratio was described as the biodegradability level of materials by which organic matter containing wastewater is readily broken down in the environment (Samudro & Mangkoedihardjo, 2010).

Several studies have been done on physicochemical and bacteriological quality of drinking water from various sources which showed that water sources were contaminated with pollution indicators such as faecal and total coliforms (Alemu *et al.*, 2015; Tabor, Kibret & Abera, 2011; Admassu, Wubshet & Gelaw, 2004; Birhanu, 2007; Yasin, Ketema & Bacha, 2015; Damite *et al.*, 2014; Aberra *et al.*, 2011; Eliku & Sulaiman, 2009; APHA, 1998). This necessitates establishment of sustainable monitoring, evaluation and punitive measures of municipal water distribution systems such as drains which gives typical cases of freshwater. Therefore an assessment of the nutrient, chemical and biological content of the drain water is also necessary for the preservation and protection of groundwater due to the dependence of inhabitants on individual boreholes even around the study area. Biological parameters are very significant factors at determining the quality of drinking water and more relevant than the physicochemical parameters as it relates to human health. Some of the relevant biological features and organisms affecting quality of water are bacteria (TCB, THB), pathogenic protozoa, algae and viruses (NRC, 1977).

This preliminary study offers good literature to the academia, government and the notary public especially those living within that vicinity of the pending and increasing concentration of nutrient and bacteriological parameters due to the influence of industrial actions, waste dump and human activities around them on their ground and surface water quality. The biological parameters are TCB, THB and FCB. All the recorded values for TCB and FCB were extremely above the permissible limits by federal ministry of environment of 400-500 MPN/100ml (FMENV, 2002).

2.0 Materials and Methods

2.1 Site Selection and Location

Samples of wastewater from the drains were collected from 3 different sites along the stretch of the drainage adjoining the study stations in 3 composite sites for each station. These study stations are labelled K, L and M which were 100m, 250m and 400m respectively away from the cement and gas stations at the Iwofe- Rumuolumeni axis of Port Harcourt. Site selection was guided by the presence of certain influential anthropogenic activities. These activities range from the industrial, waste dumps and drinking bars. The geographical location was mapped using a Techno android phone installed GPS. The following locations for the composited site samples were R ($4^0$47’53”N and $6^0$56’36”E, S($4^0$48’23”N and $6^0$56’16”E), and T($4^0$48’42”N and $6^0$56’35”E) with the following corresponding control stations Rc ($4^0$48’6”N and $6^0$56’36”E), Sc ($4^0$48’15”N and $6^0$56’16”E and Tc ($4^0$48’47”N and $6^0$56’44”E).

2.2 Sample Collection

The effluent water samples were collected using water sampler to a depth of about 20 cm below the water surface. Three (3) samples were taken from each station and then composited to make up the three stations of K, L, M respectively. These stations are monitored by the control samples around each station labelled Kc, Lc and Mc respectively. The water samples collected were then stored in ice-packed coolers and preserved in accordance with part VII Section D of the DPR Environmental Guidelines and Standards. Similarly, laboratory methodologies for wastewater are from Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995.

2.3 BOD and COD Determination

Samples collected were stored in the cooler of ice to maintain a temperature of 4^{o}C and sent for laboratory analysis. Samples are then analyzed for BOD and COD in accordance to Standard Methods (APHA, 1999).

2.4 Microbiological Analysis

Water samples for bacteriology were collected from the sampling stations at a depth of about 20 cm and placed into sterile bottles with a capacity of 100 ml. This was immediately transported to the IPS laboratory of the Rivers State University in ice-packed containers at a temperature of about +5 °C. The number of total heterotrophic bacteria (THB) was determined by the spread-plates method using plate-count agar, total coliform and fecal coliform bacteria, *E. coli* (TCB and FCB) were determined using the method of Most Probable Number (MPN). All inoculations were conducted in three parallel repetitions. Inoculums from the tubes showing fermentation were streaked on EMB agar. Isolated colonies of *E.coli* from EMB agar (round colonies with green metallic sheen) were confirmed by biochemical tests.

2.5 Summary of Analytical Technique

The following analytical techniques and guidelines were employed for the analysis of the parameters under study. All quality control measures were made and standard methods for examination of water and wastewater was also adopted. Table 1 shows the summary of analytical techniques employed for biological parameters determination respectively.

Table 1: Summary of Analytical Techniques for Microbiological Parameters

Parameters	Unit	Analytical Methods
BOD	mg/l	APHA(1999)
COD	mg/l	APHA(1999)
THB	Cfu/ml	Spread Plate
TCB	MPN/100ml	MPN (Most Probable Method)
FCB	MPN/100ml	MPN (Most Probable Method)

2.6 Statistical Analysis

Data obtained from the laboratory analysis of the water samples were analyzed using descriptive and inferential statistical techniques, notably tables, mean and one-way analysis of variance (ANOVA).

3.0 Results and Discussions

3.1 BOD and COD

Table 2 shows the mean results of BOD, COD and the BOD/COD ratio for the drain water from the study stations for April, May and June. The results showed that for BOD (mg/l) in April, May, June and control; 11550±1036, 9065±721, 9640±314 and 7555±1789 while for COD (mg/l) for April, May, June and control were 7555±1789, 15665±45, 15665±45 and 8787±908 respectively. Similarly, the BOD/COD ratio for April, May, June and that of the control were respectively 0.7578, 0.5787, 0.5921 and 0.8598. The range for BOD was 9065±721-11550±1036 while that for COD was 15240±345-16280±390. Similarly, the observed range for the BOD/COD ratio was 0.5787-0.8598.

The concentration of BOD level was significantly higher than those observed by Samudro and Mangkoedihardjo (2010) on the review of BOD, COD and BOD/COD ratio and also Lee & Nikraz (2015) on similar environments. These values correspond to those recorded earlier by Iyama and Edori (2019) on the determination of chemical and gross organic pollutant levels in leachates from government approved dumpsites in Port Harcourt Metropolis, Nigeria. The range of the BOD/COD ratio indicates that of high biodegradability level within the range of 0.1-1.0mg/l as described by Samudro and Mangkoedihardjo (2010) in their earlier study. Results of certain investigation revealed that BOD: COD ratio is a good indicator for pollution measurement in river and could be used as indicator to predict the relationship of BOD and COD in the river, hence reliable and useful indicator to relate organic matter content in the river water or water body (Lee & Nikraz (2015).

Similarly, Monitoring of biochemical parameter has become a routine water quality assessment for river quality assessment where pollution is of concern due to rapid urbanization and industrialization that can pose danger to the sustainability of river conservation (Lee & Nikraz (2015). Several studies on BOD and COD have been conducted to seek for reliable data to evaluate data for efficient management of water quality in river (Mouri, Takizawa & Oki, 2011; Su *et al*., 2011; Bellos, Sawidus, & Tsekos, 2004).

Table 2: Gross Organic Pollutants for the Study

	Parameters		
Months	BOD (mg/l)	COD (mg/l)	BOD/COD
April	11550±1036	15240±345	0.7578
May	9065±721	15665±45	0.5787
June	9640±314	16280±390	0.5921
Control	7555±1789	8787±4908	0.8598

3.2 Microbiological Parameters

The results of the microbiology in April, May and June for the different stations of K, L and M are shown in Tables 3, 4 and 5 while the spatial and temporal mean concentrations for the microbiological parameters are in Tables 6 and 7 respectively. The concentrations of THB (Cfu/ml) for the study stations of K, L, M in the months of April, May and June were $6.5 \times 10^5 \pm$ 28284, $6.2 \times 10^5 \pm 7071$, $5.5 \times 10^5 \pm 42426$ and control of 1.8×10^2; 5.4x105± 0.00, $6.0 \times 10^5 \pm 42426$, $4.8 \times 10^5 \pm 42426$ with control of 1.5×10^2; and $5.0 \times 10^5 \pm 0.00$, $5.5 \times 10^5 \pm 35355$, $4.5 \times 10^5 \pm 35355$ and control of 1.0×10^2 respectively. Similarly, TCB (MPN/100ml) recorded concentrations in the months of April, May, June for the study stations of K, L, M as 4000 ±412, 4250 ± 235, 5500 ± 648 and control of 3050; 4015 ±158, 4150± 62, 4550± 220 with control of 2500; and 4000 ±12, 4000± 12, 4050± 23 and control of 2100 respectively. Finally, the concentrations for measured FCB (MPN/100ml) in April, May, June at the study stations of R, S and T were 4050 ± 153, 3800±23, 3650 ± 129 and control of 1050; 3450± 69, 3650±780, 3540 ± 4.95 and control of 980; and 3450± 52, 3560±26, 3560 ± 26 and control of 950 respectively. The ranges for the microbiological parameters are shown in Table 8. The overall range for the THB was (4.5-6.5) $\times 10^5$ Cfu/ml; TCB was 4000-5500 MPN/100ml and FCB was 3450-4050 MPN/100ml. The concentration of THB, TCB and FCB is well above permissible limits but most importantly, their mere presence is an indication of pollution and contamination of the water body. This agrees with results of bacteriological assessments by Ugbaja and Ephraim (2019) which was apparently high though lower than those of this study which he attributed to indiscriminate, uncontrolled discharge of untreated domestic sewage into the river. The presence of coliform bacteria in any water body renders the surface waters unfit for human consumption especially at very high concentrations (WHO, 1999; NSDWQ (2008); SON (2007). The presence of E.coli is an indication of fecal pollution (especially fecal coliform count) in a sample of water (Iyama, Brown & Okpara, 2018). The respective high values of Fecal coliform bacteria (FCB), total coliform bacteria(TCB) and total heterotrophic bacteria (THB) by this study is an indication of human and animal faeces which is evident around station S and much down the slope to T as sediment . These result, do not only exceed the prescribed respective limits by the regulatory Authority, alarmingly high bacteriological inputs into the surface waters of the study area which stands a threat to ground water especially from the poor or near absence of proper drainage system. These high values were also observed by Iyama, Waribo and Okpara (2016) on the assessment of nutrient and biology status of Bassan River Water in Bayelsa State, Nigeria. This is a great threat potential threat to human population in the vicinity that depends on the ground water from the area. The human and animal waste (from the herdsmen who virtually occupy the area adjoining station S) is evident as most businesses around the study area do not have toilet systems so the drains serve as toilets especially for mechanics, food sellers and waste scavengers. Richman (1997) observed that the presence of coliforms group in water samples generally suggests that a certain selection of the water may have been contaminated with faeces of either human or animal origin. Simpi *et al.* (2011) emphasized the need for proper understanding of the hydro-biological relationship caused by metabolic interactions in the ecosystem. All samples were also positive for total coliform (Duressa *et al*., 2019).

Table 3: Microbiological Content of the Drain Wastewater (April, 2020)

Parameters (units)	Stations			
	K	L	M	Control
THB (Cfu/ml)	$6.5x10^5$± 28284	6.2x 10^5 ± 7071	5.5 x 10^5 ± 42426	$1.8x10^2$
TCB (MPN/100ml)	4000 ±412	4250 ± 235	5500 ± 648	3050
FCB (MPN/100ml)	4050 ± 153	3800±23	3650 ± 129	1050

Table 4: Microbiological Content of the Drain Wastewater (May, 2020)

Parameters (units)	Stations			
	K	L	M	Control
THB (Cfu/ml)	$5.4x10^5$± 0.00	6.0x 10^5±42426	4.8 x 10^5 ± 42426	$1.5x10^2$
TCB (MPN/100ml)	4015 ±158	4150± 62	4550± 220	2500
FCB (MPN/100ml)	3450± 69	3650±780	3540 ± 4.95	980

Table 5: Microbiological Content of the Drain Wastewater (June, 2020)

Parameters (units)	Stations			
	K	L	M	Control
THB (Cfu/ml)	$5.0x10^5$± 0.00	5.5 $x10^5$±35355	4.5 x 10^5 ± 35355	$1.0x10^2$
TCB (MPN/100ml)	4000 ±12	4000± 12	4050± 23	2100
FCB (MPN/100ml)	3450± 52	3560±26	3560 ± 26	950

Table 6: Spatial mean concentration of Microbiological Content for the Drain Wastewater

Parameters (units)	Stations			
	K	L	M	Control
THB (Cfu/ml)	$5.63x10^5$±17677	$5.57x10^5$±13435	$4.93x10^5$ ± 31820	$1.43x10^2$
TCB (MPN/100ml)	4005 ±194	4133± 103	4700± 298	2550
FCB (MPN/100ml)	3650± 11	3670±25	3583± 36	993

Table 7: Temporal mean concentration of Microbiological Content for the Drain Wastewater

Parameters (units)	Stations			
	K	L	M	Control
THB (Cfu/ml)	$6.1x10^5$±42426	$5.4x10^5$±7071	$5.0x10^5$ ± 35355	$1.43x10^2$
TCB (MPN/100ml)	4583 ±215	4238± 29	4017± 185	4279
FCB (MPN/100ml)	3833± 140	3547±62	3523± 78	3634

Table 8: Ranges for the Microbiological Parameters for Wastewater Drains

Parameters	Stations		
	April	May	June
THB (Cfu/ml)	$(5.5\text{-}6.5)x10^5$	$(4.8\text{-}6.0)x10^5$	$(4.5\text{-}5.5)x10^5$
TCB (MPN/100ml)	4000-5500	4015-4550	4000-4050
FCB (MPN/100ml)	3650-4050	3450-3650	3450-3560

4.0 Conclusion

This study for the determination of biological status of the wastewater drains from vicinities around cement and associated factories in Port Harcourt, Nigeria has revealed serious microbiological impact from human activities around. The result showed that TCB, THB and FCB were above regulatory limits (WHO, NSDWQ, FEPA, NESREA, USEPA, SON *etc*). Water bacteriology showed high level pollution from fecal waste which must be checked to avoid water borne diseases and epidemics. The best bet is for government to establish central toilet systems and monitor human activities but above all ensure punitive measures to ensure compliance.

Conflict of Interest

There was no conflict of interest among the authors.

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