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Heavy Metal and Microbiological Characteristics of Wastewater Impacted by Anthropogenic Activities around Ntanwogba Creek in Port Harcourt City

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Ntanwogba creek is associated with beehive of anthropogenic activities such as mechanics and workshops, welders, sale of various household materials/accessories, motor parts, washing of cars and so many other sources of income for families living around the area in Port Harcourt. This study also investigates the impact of these human activities and its negative impact on the open drainage system along the Ntanwogba creek and the environment. Wastewater and sediment samples were collected at five different sampling points designated along the Ntanwogba creek with sterile containers using standard microbiological methods. Sampling was done by plunging about 30 cm below the water surface with the mouth of the sample container positioned in an opposite direction to water flow. The sediment samples were collected with plastic scooper to scoop the samples. The samples were labelled and transported in a cooler packed with ice blocks to the laboratory for analysis. This exercise was repeated at all the sampling stations starting from the upstream by Afam /Kaduna Street behind the Winners Chapel in D-Line to the downstream at Abacha Road off the Agip roundabout. Standard analytical protocols were employed to determine the heavy metal and microbiological characteristics of the wastewaters and sediments for a period of one year.Results obtained from the study showed that the bacterial isolates were identified as *Vibrio cholerae*, *Shigella* sp, *E.coli, Vibrio parahaemoliticus, Salmonella* sp, *Bacillus* sp, *Klebsiella*

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sp, *Actinomycetes*, *Serratia* sp, *Listeria* sp, *Acinetobacte*r and *Pseudomonas* sp while the fungal isolates were *Aspergillus niger, Penicillium* sp*, Aspergillus flavus, Rhizopus, Mucor* sp *and Candida* sp. The cumulative percentage distribution of bacterial isolates across the sampling stations revealed that *E. coli* had the highest with 15.22%, *Vibrio cholerae* 13.69%, *Pseudomonas* 12.43%, *Klebsiella* 11.31% and *Shigella* 10.61%. Total heterotrophic count showed that bacteria was more than the fungi in both sediment and wastewater samples. Results of heavy metal analyses revealed that the mean values for all the metals determined were significantly higher ($P<0.05$) in the sediments than in the wastewater samples. Metals like Cadmium (Cd), Vanadium (V), Iron (Fe), Zinc (Zn), Nickel (Ni) and Copper (Cu) concentrations were significantly higher ($P<0.05$) in the sediments than in the wastewater samples across sampling stations. Cd had 1.25 ppm, Cu 18.30 ppm, Ni 5.26 ppm, Pb 58.12 ppm, and Zn 57.28 ppm thus suggesting impairment of the water quality in the Ntanwogba creek and the alteration of the ecological dynamics of the receiving water bodies. Pollution of water resources by human activities might lead to destruction of primary producers and this in turn leads to diminishing consumer populations in water resources. The consequences of such anthropogenic pollution can also lead to the transmission of diseases by water borne pathogens. Consequently this may cause changes in environmental conditions in such ecosystems due to their toxicity and biomagnification attributes of metals.

Keywords: Anthropogenic activities; waste generation; wastewater; sediments; microorganisms; heavy metals; Ntanwogba creek.

1. INTRODUCTION

Waste generation and indiscriminate disposal of solid wastes into open drains located within urban centres have been a major problem to residents in most developing cities of the world. Open dumping of refuse and other waste materials into gutters indiscriminately can pose major public health threats and environmental effects in urban cities [1]. Due to poor and ineffective waste management practices by various stakeholders, the open drainages turn to dumpsites and receives all manner of wastes due to anthropogenic and socioeconomic activities of people doing business around drainage channels in Port Harcourt (Figs. 1-3).

Ntanwogba creek drainage system is one of the oldest water courses that channels water through various streets/roads in Port Harcourt metropolis into the Bonny River. But the infrastructure for long has not received government attention and therefore lacks the capacity to discharge excess water into the tributaries leading to the main water courses in the urban centre. This eventually results to frequent flooding from torrential rains causing several damages and losses of properties belonging to residents in the area. People do businesses along the creek and houses are built around the paths of water courses and this activity eventually results in generation of all manner of wastes which blocks the drainages thus preventing the free flow of water to its desired destination (Fig. 1). Government has not done so much in the desilting of the blocked drainages inspite of the regular monthly environmental sanitation in Rivers State. Stakeholders lacks education and training of basic waste management practices, therefore wastes generated by residents as a result of both anthropogenic and socioeconomic activities empties and block the drains with plastics, spent oil or lubricant cans, weeds etc. The anthropogenic and socioeconomic related activities around the creek include mechanics and workshops, welders, sale of various household materials/accessories, motor parts, washing of cars and so many other sources of income for families living within the urban centres. All these activities takes place around the Ntanwogba creek in Port Harcourt resulting in indiscriminate dumping of refuse, agricultural wastes. Also worrisome is the late refuse removal after clean up exercises on sanitation days, street trading and storage facilities which has been attributed to cause blocking of drains [2]. People are now predisposed to public risks because of the stench emanating from the fouled drainage systems and this therefore encourages the proliferation of water related and water borne diseases which also aids in the spread of infectious diseases, very often causes public health concerns which results in bad smell and generally constitute nuisance to the environment [3;4;5].

Besides, and considering the porous soil structures and permeable nature of the subsurface geologic formation and the shallow depth of water table of the Niger Delta region,

Fig. 1. Blockage of drainage channel with plastics and other materials to stop free flow of water along the Ntanwogba creek due to anthropogenic activities

Fig. 2. Car wash activities around the drainage channel thus introducing assorted

Fig. 3. House structures erected close to drainage channel and weeds taken over the Ntanwogba creek due to indiscrimninate discharge of wastes into the drains.

the ground water bodies eventually becomes highly vulnerable to leachates from these wastes which find its way into boreholes, rivers, lakes, wells and other water bodies [6- 11]. The flat estuarine terrain and impermeable alluvial soil makes drainage difficult and provision of infrastructure, utilities and sanitation is still inadequate. The consequence is that, water quality is highly affected which becomes highly dangerous [8,12,13]. These unwholesome practices create negative effects such as health deterioration or outbreak of communicable diseases like cholera and gastroenteritis, rodent/insect infestation, fire hazard accidents, flood occurrences, and environmental pressures on existing structures and this eventually contributes in defacing the aesthetics of the environment. The aim of this study was to determine the levels of heavy metal concentrations and microbial characteristics of both wastewater and sediments around the Ntanwogba creek in Port Harcourt.

2. MATERIALS AND METHODS

2.1 Area of Study

The Ntanwogba Creek is located on the western flank of Port Harcourt city of Rivers State, Nigeria. The stream lies between latitude 40 50'' and 50 00''N and longitude 60 55''N and 70 00''E. The climate of the area is that of tropical equatorial latitude with rainfall occurring almost all year round [14]. The Ntanwogba creek is a black water stream with its water source running through Orazi forest of Rumueme town across Abacha Road, Cherubim Road, Olu-Obasanjo Road, Okija Road and Afam Street (D/line), and meanders through the densely populated city of Port Harcourt into the Upper Bonny Estuary. Five sampling sites were studied. Sampling was done 500 m apart along the stream (Fig. 1).

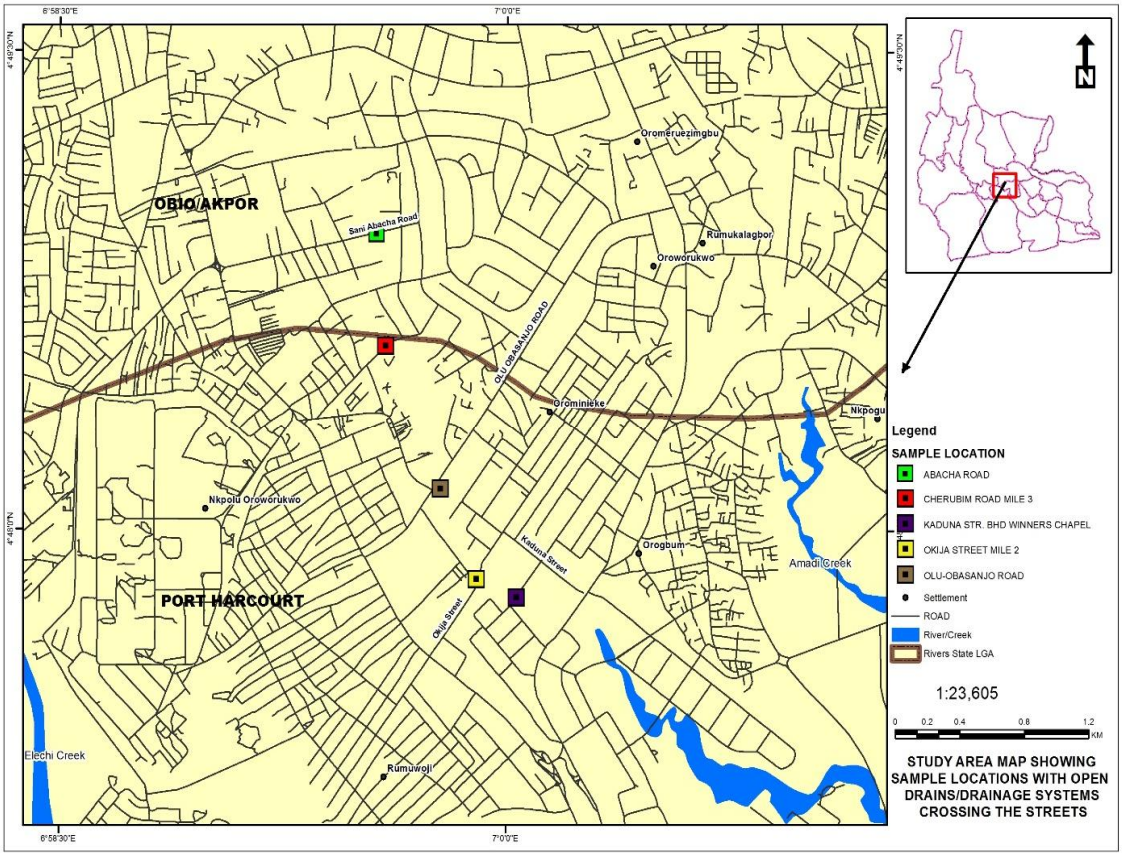

Fig. 4. Map of Port Harcourt showing sampling stations along the Ntanwogba creek (Source: Rivers State Ministry of Lands and Survey)

2.2 Collection of Samples

Wastewater samples were collected with sterile containers (already sterilized in the laboratory). Each sample bottle was rinsed with the appropriate sample before the final collection. To collect the water sample, base of the sterilized sample bottle was held with one hand, plunged about 30 cm below the water surface with the mouth of the sample container positioned in an opposite direction to water flow [15]. The container was filled with wastewater samples and this repeated at all the sampling stations starting from the upstream (Afam /Kaduna Street behind the Winners Chapel) to the downstream (at Abacha Road) leaving a gap of about 2 cm and then covered. Sediment samples for analysis were also collected along the same water course. To collect the sediment sample, the bottles were opened and held with the left hand while using the right hand with a plastic scooper to scoop the sediment sample. The sample bottles were filled with sediment sample and covered immediately. After collection, the samples were immediately labelled and transported in a cooler packed with ice blocks to the laboratory for analysis. Sample collection was carried out twice monthly from February to June 2017.

2.3 Microbiological Analyses

The presence of various microorganisms in the sediments and waste water in open drainage systems were analysed using standard microbiological procedures [16]. One millilitre each of the wastewater and sediments samples were separately added to 9 ml of 0.1% peptone water diluents to give a 10^{-5} dilution. After thorough shaking, a further 10- fold (v/v) serial dilutions were made by transferring 1 ml of the original solution to freshly prepared peptone water diluents to a range of 10^{-6} dilutions. Aliquots (0.1 ml) of various dilutions were transferred to surface dried appropriate medium in triplicates and inoculated by spreading with flamed bent glass spreader and incubated at 37ºC for 24 hours. Bacterial isolates were subjected to further identification according to determinative schemes of Cowan and Steel [19].

2.3.1 Total heterotrophic bacterial counts

This was determined with the nutrient agar using the spread plate technique as described by Prescott *et al* [16]. Here 0.1ml of the serially diluted samples each was inoculated onto different sterile nutrient agar plates in triplicates. The plates were incubated for 24 hours at 37°C. After incubation, colonies that appeared on the plates were counted and the mean expressed as colony forming units per gram (cfu/g) of the sediment samples. The colony forming unit per gram sample was calculated using the formula below;

$$\text{cfu/ml} = \frac{\text{number of colonies}}{\text{Dilution x volume plated}} \text{ [17]}$$

2.3.2 Total coliform counts

The method of Prescott *et al* [16] was adopted where 0.1 milliliter of the serially diluted samples each were inoculated onto different sterile MacConkey agar plates in triplicates, the inoculums were then spread evenly on the pre-dried surface media using a flamed bent glass rod. Incubation was done at 37°C for 24 hours, after which the colonies were counted and the mean total coliform count expressed as cfu/g.

2.3.3 Feacal coliform counts

The method of Prescott *et al* [16] was adopted where 0.1 milliliter of the serially diluted samples were each inoculated onto different sterile MacConkey agar plates in triplicates, the inoculums were then spread evenly on the pre-dried surface media using a bent glass rod. Incubation was done at 45.7°C for 24 hours, after which the colonies were counted and the mean total coliform count expressed as cfu/g.

2.3.4 Total *Salmonella-Shigella* counts

This was determined with the *Salmonella-Shigella* agar using the spread plate method as described by [16]. One milliliter of the serially diluted samples was inoculated onto sterile pre-dried *Salmonella-Shigella* agar plates in duplicates. The inocula were then spread evenly on the surface of the media using a sterile spreader. The plates were then incubated at 37°C for 24 hours, after which the colonies that developed were counted and the mean total *Salmonella-Shigella* counts were recorded from sample for each of the stations.

2.3.5 *Vibrio species* count

Total *Vibrio* count was determined with the Thiosulphate Citrate Bile Salt (TCBS) agar using the spread plate technique as described by [16]. One milliliter of the serially diluted samples was

inoculated onto sterile pre-dried TCBS agar plates in triplicates and then spread evenly with a flamed bent glass rod. The plates were incubated at 37^{o}C for 24 hours, after which the colonies that developed were counted and the mean recorded accordingly for the waste water and sediment from each of the sampling stations respectively

2.3.6 Total fungal counts

This was determined using the potato dextrose agar (PDA) onto which sterile streptomycin (50 mg/ml) had been added to suppress bacterial growth [18]. The spread plate technique as described by Prescott *et al* [16] was adopted. An aliquot (0.1ml) of the serially diluted samples were inoculated in triplicates onto sterile pre-dried PDA plates and then spread evenly with a sterile glass spreader. The plates were incubated at room temperature for about 3-5 days after which the colonies were counted and the mean of the count recorded accordingly.

2.3.7 Identification of Bacterial Isolates

The cultural, morphological and biochemical characteristics of the discrete bacterial isolates were compared with the schemes of Cowan and Steel [19]. The morphological and biochemical test include; Gram' reaction, motility, catalyse, oxidase, spore formation, indole production, methyl red, citrate utilization, voges proskauer test and sugar fermentation.

2.3.8 Identification of Fungal Isolates

The presence or absence of septa in the mycelium, type of spore, presence of primary or secondary sterigmata, and other microscopic characteristics as well as cultural characteristics were used in the identification of the fungal isolates [20].

2.4 Heavy Metal Analysis

For heavy metals, the samples were collected in 1 litre plastic bottles and preserved with concentrated nitric acid to maintain pH of ≤ 2. Metal analyses were carried out using the Atomic Absorption Spectrophotometer (AAS) Unicam 939 (Lead, Iron, Copper, Chromium, Arsenic, Nickel, Cadmium and Zinc). This involved the direct aspiration of the samples into an acetylene flame ignited by a hollow cathode lamp at specific wavelength peculiar to only the metal lamp used for the analysis. All metals were analysed with each adopting the following: ASTM D method (Lead-Pb ASTM D 3559), (Iron - Fe ASTM D 1068), (Copper-Cu ASTM D 1688), (Chromium-Cr ASTM D 1687), (Nickel-Ni ASTM D 1886), (Cadmium-Cd ASTM D 3557), (Arsenic-As ASTM D 3972) and (Zinc ASTM D 1691).

2.5 Statistical Analysis

Statistical analysis was carried out on the data obtained during the study using a computer based program SPSS version 20 for Analysis of Variance (ANOVA) across the five sampling stations.

3. RESULTS

3.1 Microbial Characteristics

The results of the microbial counts obtained for the wastewater and sediments from five sampling points are presented in Tables 1 and 2. Total heterotrophic count of both 5.4x10^{9} cfu/ml was obtained from Olu Obasanjo for wastewater while 9.8x10^{9} cfu/g was recorded for sediment at the same station. The least count for all the five sampling stations were recorded for 2.5x10^{9} cfu/ml at Kaduna street and 4.5x10^{9} cfu/g for Cherubim road for both wastewater and sediment samples respectively. Results further showed that the microbial counts for Total heterotrophic bacteria were more in number than the fungal isolates in both wastewater and sediment samples. Table 3 shows the biochemical characteristics of bacterial isolates from both wastewater and sediment samples on Nutrient media. The bacterial isolates were identified as *Vibrio cholerae*, *Shigella* sp, *E.coli, Vibrio parahaemoliticus, Salmonella* sp, *Bacillus* sp, *Klebsiella* sp, *Actinomycetes*, *Serratia* sp, *Listeria* sp, *Acinetobacte*r and *Pseudomonas* sp (Table 3). However, the percentage distribution of bacterial isolates across the sampling stations indicate that *E.coli* had the highest with 15.22%, *Vibrio cholerae* 13.69%, *Pseudomonas* 12.43%, *Klebsiella* 11.31% and *Shigella* 10.61% (Table 4; Fig 5). Morphological characteristics and identification of fungal isolates are shown in Table 5. The fungal species were identified as *Aspergillus niger, Penicillium* sp*, Aspergillus flavus, Rhizopus, Mucor* sp *and Candida* sp. The percentage distribution of fungal isolates shows that Aspergillus niger and Mucor species had the highest with 37.18% and 25.64% respectively while Candida species had the least value with 10.26%

Table 1. Microbial counts of wastewater samples from the Sampling stations

Sample stations	THBC (cfu/ml)	THFC (cfu/ml)	TCC (cfu/ml)	TFC (cfu/ml)	TSS (cfu/ml)	TVC (cfu/ml)
Abacha Road	$2.3x10^9$	$1.9x10^5$	$1.08 x10^6$	$1.9 x10^5$	$1.4 x10^5$	$1.6 x10^5$
Cherubim Road	$3.6x10^9$	$2.2 x10^5$	$1.20 x10^6$	$1.2 x10^5$	$1.6 x10^5$	$1.9 x10^5$
Kaduna Street	$2.5x10^9$	$2.0 x10^5$	$1.15 x10^6$	$1.7 x10^5$	$1.9 x10^5$	$2.7 x10^5$
Okija Street	$4.0x10^9$	$1.5 x10^5$	$1.02 x10^6$	$1.7 x10^5$	$1.1 x10^5$	$3.0x10^5$
Olu-Obasanjo Road	$5.4x10^9$	$2.8 x10^5$	$1.28 x10^6$	$2.0 x10^5$	$3.8 x10^5$	$4.5x10^5$

Key: THBC; *Total Heterotrophic Bacterial****, THFC;*** *Total heterotrophic Fungal,* ***TSSC****; Total Salmonella and Shigela,* ***TCC;*** *Total coliforms,* ***TFC;*** *Total feacal colifom,* ***TVC****; Total Vibrio*

Table 2. Microbial count of Sediment samples from the five sampling points

Sample Location	THBC (cfu/g)	THFC (cfu/g)	TCC (cfu/g)	TFC (cfu/g)	TSS (cfu/g)	TVC (cfu/g)
Abacha Road	$6.8x10^9$	$2.7x10^5$	$1.08 x10^6$	$1.3 x10^5$	$2.8 x10^5$	$2.6 x10^5$
Cherubim Road	$4.5x10^9$	$3.6 x10^5$	$1.12 x10^6$	$3.0 x10^5$	$2.8 x10^5$	$2.5 x10^5$
Kaduna Street	$6.5x10^9$	$3.4 x10^5$	$1.00 x10^6$	$3.9 x10^5$	$2.8 x10^5$	$3.5 x10^5$
Okija Street	$7.9x10^9$	$2.2 x10^5$	$1.06x10^6$	$1.8 x10^5$	$3.0 x10^5$	$4.2x10^5$
Olu-Obasanjo Road	$9.8x10^9$	$3.9x10^5$	$1.52 x10^6$	$4.0 x10^5$	$4.2 x10^5$	$5.8x10^5$

Key: THBC; *Total Heterotrophic Bacterial****, THFC;*** *Total heterotrophic Fungal,* ***TSSC****; Total Salmonella and Shigela,* ***TCC;*** *Total coliforms,* ***TFC;*** *Total feacal colifom,* ***TVC****; Total Vibrio*

The distribution of fungal isolates from both the wastewater and sediments across the sampling points show that *Aspergillus niger* had 37.18%, while *Mucor* had 25.64%, *Penicillium* sp 15.38%, *Aspergillus flavus* 11.54% and the *Candida* sp had 10.26% (Table 6).

3.2 Heavy Metal Concentrations

The results of metal analysis for wastewater and sediments from the different sampling points are shown in Tables 7 and 8 respectively. Individual wastewater and sediment samples generally displayed a wide difference in metal concentrations during the sampling periods, indicating not only the temporal but the spatial variation among each sampling site. With the exception of cadmium and (Cd) and vanadium (V), contents of heavy metals in sediments effluents seemed relatively higher than that in the wastewaters across the sampling stations along the open drainage channels. Similar mean values for Fe, Zn, Ni, Cu concentrations were significantly higher ($P<0.05$) in the sediments than in the waste water samples (Table 8) at the various sampling points While the highest mean concentration of Cd (1.25 ppm), Cu (18.30 ppm), Ni (5.26 ppm), Pb (58.12 ppm), Zn (57.28 ppm), mean Cd concentration was higher in the sediment samples in P3 (Kaduna street open drains) compared to the other sections of the drainage channel which were below the EU recommended limit of 3.00 mg/kg (ANZECC 2000). Mean Cr concentrations were significantly higher ($P<0.05$) in the sediments in P1 and P4, P5 sections than in the other sections of the open drains studied. However, mean Pb concentration in P3 with 58.12ppm was significantly higher ($P<0.05$) than P1 whose value was 23.13ppm. These differences in concentrations can result to exposures of aquatic flora and fauna to unacceptable effects.

4. DISCUSSION

4.1 Microbial Characteristics

In this study, *E. coli* and species of *Vibrio,* Pseudomonas*, Klebsiella, Bacillus, Shigella, Staphylococcus, Salmonella, Actinomyces, Serratia, Listeria, Acinetobacter*, and five fungal isolates, namely, *Penicillium* sp *Candida* sp, *Mucor* sp, *Aspergillus flavus* and *Aspergillus niger* were obtained from the wastewater and sediments samples analyzed over the sampling period. Even though most of them may not be pathogenic, their presence in the wastewater system is indication of fecal contamination [21]. *E. coli* is a subgroup of fecal coliforms used as an indicator of fecal contamination. Although vast majority of *E. coli* are completely harmless, some strains of the bacteria have acquired genetic capabilities which enable them to encode virulence factors [22]. Pathogenic *E. coli* strains cause diverse forms of bacterial induced illnesses with symptoms ranging from mild diarrhoea to severe complication and death [23].

Table 3. Biochemical Characteristics of Bacteria Isolates from sampling points

Isolates code	Colonial and Cell Morphology	Gram Reaction	Biochemical Reactions										Growth on special media				Probable. Identity
			Catalase	Oxidas	Motility	Citrate	Glucose	Sucrose	Lactose	Manitol	MR	VP	Indole	SSA	MacConky	TCBS	
1	Creamy large colonies, moist with entire edges elevated, rods	-	+	+	+	+	+	+	+	+	+	-	-	-	-	+	*Vibrio. cholera*
2	Moist, mucoid, round, colonies, rods	-	+	-	-	-	+	+	-	-	+	-	-	+	+	-	*Shigella sp*
3	Large mucoid/Pinkish colonies, straight rods in chains or singles	-	+	-	+	-	+	+	+	+	+	-	-	-	+	-	*E. coli*
4	Small, dry, flat and whitish colonies ,straight rods	-	+	+	+	+	+	+	-	+	+	-	-	-	-	+	*V.parahaemoliticus*
5	Entire, raised and creamy white, smooth colonies, cocci in clusters	+	+	nd	-	+	+	+	+	+	nd	nd	-	-	+	-	*Staphylococcus sp*
6	Central black colonies	-	+	nd	-	+	+	-	-	-	nd	nd	-	+	+	-	*Salmonella sp*
7	Large, flat, dried and milky colonies, appear singly or in chains	+	+	nd	-	+	+	-	-	-	nd	nd	-	-	-	-	*Bacillus sp*
8	Mucoid, milky colonies, entire edge, slightly curved, pleomorphic rods	+	+	-	-	+	+	+	+	+	+	+	-	-	+	-	*Klebsiella sp.*
9	Moist, metallic silver colonies, large coccobacilli with long filaments	+	+	-	+	-	+	+	-	-	nd	nd	+	-	+	-	*Actinomyces sp*
10	Moist greenish, round colonies, large coccobacilli with long filament	+	+	-	+	+	+	+	+	+	-	+	+	-	+	-	*Serratia* sp
11	Moist, translucent, deep greenish colonies, short flat rods	-	+	nd	+	+	+	+	-	-	nd	nd	-	-	-	-	*Listeria* sp
12	Colonies are translucent, opaque, smooth, entire edges, rods	-	+	-	-	+	+	-	-	+	-	-	-	-	-	-	*Acinetobacter* sp
13	Large, flat greenish colonies, rods are slightly curved but occur in pairs	-	+	+	+	+	+	+	-	+	nd	nd	+	-	+	-	*Pseudomonas* sp

Key: + positive, - negative, nd; not determined

Table 4. Distribution of bacterial isolates within the sampling stations and their frequency of occurrence

S/N	Bacterial isolate	P1		P2		P3		P4		P5		F-TOTAL	F %
		Occurrence	F	Occurrence	F	Occurrence	F	Occurrence	F	Occurrence	F		
1	*V. cholera*	+	21	+	18	+	21	+	20	+	18	98	**13.69**
2	*Shigella* sp	+	14	+	16	+	19	+	15	+	12	76	**10.61**
3	*E. coli*	+	25	+	23	+	24	+	26	+	27	109	**15.22**
4	*V.parahaemoliticus*	+	10	-	0	+	11	+	13	+	9	43	**6.01**
5	*Staphylococcus* sp	+	12	+	11	+	13	+	10	-	0	46	**6.42**
6	*Salmonella* sp	+	9	+	12	+	11	-	0	+	12	44	**6.15**
7	*Bacillus* sp	+	11	+	9	+	10	+	14	+	11	55	**7.68**
8	*Klebsiella* sp	+	17	+	18	+	18	+	15	+	13	81	**11.31**
9	*Actinomyces* sp	+	4	+	2	-	0	+	1	+	3	10	**1.40**
10	*Serratia* sp	+	9	-	0	+	6	+	8	+	6	20	**2.79**
11	*Listeria* sp	+	3	+	5	+	2	+	4	+	8	22	**3.07**
12	*Pseudomonas* sp	+	19	+	20	+	13	+	20	+	17	89	**12.43**
13	*Acinetobacte*r sp	+	8	+	5	+	6	-	0	+	4	23	**3.22**
	TOTAL		162		139		154		146		140	716	**100**

KEY: P= Sampling Point, F= Frequency,

Table 5. Morphological Characterization and identification of fungal Isolates

Isolates	Macroscopy	Microscopy	Probable Identification
A	Cream large round	Oval budding blastoconidia	*Candida* sp
B	Black spores surrounded by cream background, brown reverse	Septate hyphae with aeseptate conidiosphore bearing conidia	*Aspergillus niger*
C	Fluffy white cottony, white reverse	Aeseptate hyphae bearing sporangiospores	*Mucor* sp
D	Orange small round raised	Spherical budding blastoconidia	*Candida* sp
E	Green powdery surface surrounded by white lawn, brown reverse	Septate hyphae with septate conidiophores bearing conidia	*Penicillium* sp
F	Black spores surrounded by white lawn-like growth	Aeseptate conidiophores bearing conidia	*Aspergillus niger*
G	Light green lawn surrounded by white lawn-like growth	Septate hyphae with aeseptate conidiosphore bearing conidia	*Aspergillus flavus*
H	Fluffy white cottony, white reverse	Aeseptate hyphae bearing sporangiospores	*Mucor* sp
I	Cream large round	Oval budding blastoconidia	*Candida* sp
J	Black spores surrounded by cream background, brown reverse	Septate hyphae with aeseptate conidiosphore bearing conidia	*Aspergillus niger*

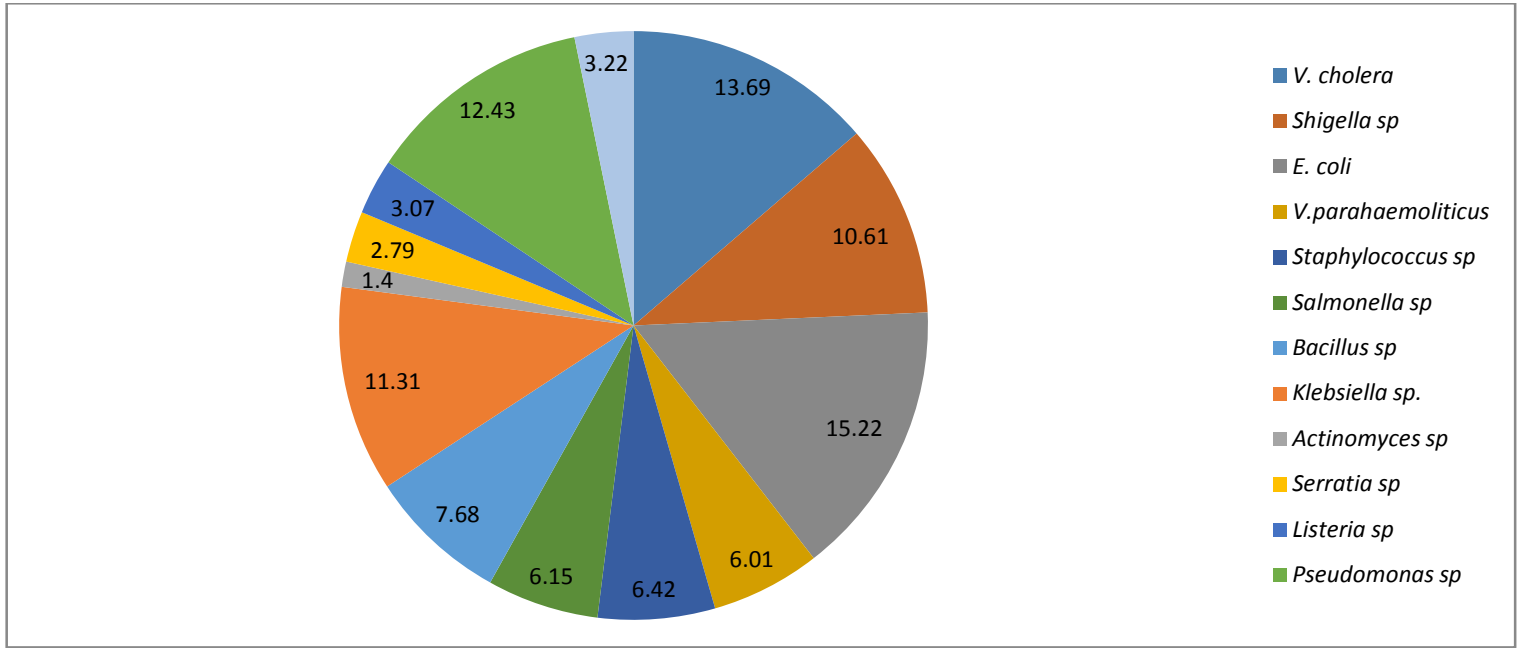

Fig. 5. Percentage of occurrence of bacterial isolates in the five sampling stations

Table 6. The distribution of fungal isolates within the sampling stations and their frequency of occurrence

S/N	Fungal isolates	P1		P2		P3		P4		P5		F- TOTAL	F %
		Occurrence	F	Occurrence	F	Occurrence	F	Occurrence	F	Occurrence	F		
1	*Candida* sp	+	2	-	0	+	1	+	3	-	2	8	**10.26**
2	*Aspergillus niger*	-	8	+	6	-	5	+	4	+	6	29	**37.18**
3	*Mucor* sp	+	4	+	5	+	2	+	3	+	6	20	**25.64**
4	*Penicillium* sp	+	3	-	2	+	4	+	2	+	1	12	**15.38**
5	*Aspergillus flavus*	-	2	+	1	+	2	+	1	-	3	9	**11.54**
	TOTAL		19		14		14		13		18	78	**100**

KEY: P= Sampling Point, F= Frequency, P1=Abacha Road; P2=Cherubim Road; P3= Kaduna Street; P4= Okija Street; P5= Olu-Obasanjo Road

Table 7. Heavy Metals concentration from Wastewater Samples (mg/kg)

Stations	Pb (Lead)	Cr (Chromium)	Fe (Iron)	V (Vanadium)	Zn (Zinc)	Ni (Nikel)	Cu Copper)	Cd (Cadmium)
P1	0.001±0.00^{a}	0.001±0.00^{a}	0.68350±0.00^{a}	0.001±0.00^{a}	0.7250±0.00^{c}	0.001±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}
P2	0.001±0.00^{a}	0.001±0.00^{a}	0.78650±0.00^{b}	0.001±0.00^{a}	0.01600±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}
P3	0.001±0.00^{a}	0.001±0.00^{a}	0.92500±0.00^{c}	0.001±0.00^{a}	0.08200±0.00^{d}	0.001±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}
P4	0.001±0.00^{a}	0.001±0.00^{a}	0.81900±0.00^{b}	0.001±0.00^{a}	0.06550±0.00^{b}	0.001±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}
P5	0.001±0.00^{a}	0.001±0.00^{a}	1.30650±0.00^{d}	0.001±0.00^{a}	0.01350±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}	0.001±0.00^{a}

Mean of the same superscript are not significant (p≥0.05)

Table 8. Heavy metals concentration of sediment samples (mg/kg)

Stations sediments	Temperature (^{0}C)	Lead Pb (ppm)	Chromium Cr (ppm)	Iron Fe (ppm)	Vanadium V(ppm)	Zinc Zn (ppm)	Nikel (ffm) Ni (ppm)	Copper Cu (ppm)	Cadmium Cd (ppm)
P1	28.36±0.29^{b}	23.13±0.00217^{c}	6.6±0.14^{d}	2856.7±3.530^{d}	0.25±0.0a^{b}	57.28±0.68^{c}	5.26±0.007^{d}	14.26±0.93^{c}	1.25±0.00^{d}
P2	28.33±0.21^{b}	10.49±0.014^{b}	3.14±0.04^{a}	2485.8±3.3^{c}	0.13±0.021^{a}	46.24±1.20^{c}	2.22±0.138^{a}	5.24±0.11^{b}	0.5±0.007^{c}
P3	28.5±0.06^{b}	58.12±1.16^{d}	6.35±0.21^{d}	3524.9±1.98^{c}	0.40±0.14^{b}	52.84±0.63^{d}	5.11±0.042^{d}	18.30±0.57^{d}	1.7±0014^{c}
P4	26.6±2.10^{a}	6.7±0.02^{a}	5.05±0.014^{b}	1984.30±4.53^{a}	0.16±0.0021^{a}	32.5±0.75^{a}	2.51±0.9^{b}	2.02±0.021^{a}	0.33±0.007^{d}
P5	28.40±0.44^{b}	10.12±0.014^{b}	5.7±0.05^{b}	2377.0±057^{b}	0.23±0.04a^{b}	35.27±0.61^{b}	4.09±0.04^{c}	5.15±0.007^{b}	0.44±0.007^{b}

Means with the same superscript are not significantly different (p≥0.05)
P1=Abacha Road; P2=Cherubim Road; P3= Kaduna Street; P4= Okija Street; P5= Olu-Obasanjo Road

The results of the microbial counts showed that the microbial load was high in the sediments than wastewater samples across the sampling points. Total heterotrophic bacterial count ranged from $2.3x10^9$ to $5.4x10^9$ cfu/ml for wastewater and $4.5x10^9$ to $9.8x10^9$ cfu/g in the sediments samples which the highest microbial counts across the sampling stations followed by total coliforms, total *Vibrio,* total *Salmonella* and *Shigella,* total feacal coliforms, and total heterotrophic fungal counts. These results show that the wastewater and sediments are highly polluted with microorganisms. This may be as a result of the beehive of anthropogenic activities around the creek resulting in waste generation and indiscriminate disposal into the drainage channel, most of which are non- biodegradable thus causing blockage and proliferation of water borne and water related diseases. Several wastes materials are generated from discharged municipal wastewater effluents, repairs of assorted vehicles, welders, sale of various household materials/accessories, motor parts, washing of cars and so many other sources of income for families living within the urban centres. These socioeconomic activities may generate many waste constituents which have the ability to influence the microbial load. The result of this study agrees with similar works reported from sewage and abattoir wastes impacted soils, water and sediments who isolated *Pseudomonas*, *Bacillus*, *Micrococcus* and other several bacterial strains from wastewaters and sediments with similar activities elsewhere [24; 25; 14; 26]. Most worrisome is that these pathogens may be transported in leachate from decomposed waste materials through the alluvial soils into groundwater resources to cause pollution which eventually are used for both drinking, domestic and industrial uses.

4.2 Heavy Metal Concentrations

Heavy metal distribution has been one of the critical concerns in natural environments due to their toxicity and bio- magnification attributes. Many regulations have been established to avoid heavy metal concentrations in waters, sediments, and soils to exceed quality criteria for environmental protection. However, anthropogenic activities have discharged significant amounts of heavy metals into rivers and drainage systems. Metal accumulation in sediments threatens ecosystems, reservoirs and habitats or food sources for aquatic fauna and flora due to the potential of metal mobilization and the subsequent uptake into food web as bottom sediments [27]. In this study, contents of heavy metals like Cd, Cr, Cu, Ni, Pb, Zn etc. were determined for wastewaters and bed sediments that received discharges from various socioeconomic and anthropogenic activities around open drainage channels in Port Harcourt. Mean values for all the metals determined were significantly higher ($P<0.05$) in sediment samples than in wastewater samples. This is expected since sediment acts as sink for metals from the water column [28]. Mean metal concentrations in wastewater were below recommended levels in Freshwater environments [29]. Metals discharged into open drains might transport in the form of soluble species in solutions and/or insoluble species in suspended solids and consequently may cause changes in environmental conditions in such ecosystems.

5. CONCLUSION

The study was able to identify the negative impact of anthropogenic activities along the open drainage systems along the Ntanwogba creek and its environment. The human activities can cause outbreak of epidemics arising from pollution of water particularly from the distribution of both bacterial and fungal isolates across the various sampling which stations shows that there may be outbreak of communicable diseases like cholera and gastroenteritis and other water related diseases. Theses organic domestic wastes generated by the activities serves a medium for these microbes which in turn poses a serious threat, since they ferment, creating conditions favorable for the survival and growth of microbial pathogens thus increases the risk of infection through water resources which eventually are used for both drinking, domestic and industrial uses. Also the presence of heavy metals across the sampling stations especially in the sediment samples suggests substantial enrichment with metals emanating from the processing activities in the area. Establishment and enforcement of adequate environmental quality standards coupled with awareness creation among the artisans on the health and environmental implications of their practice is advocated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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