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Studies on Microbial Load in Surface and Borehole Water in Owerri Area of Imo State.

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ABSTRACT

Background: The study was carried out to investigate the microbiological and physicochemical status of surface and borehole waters in Owerri area of Imo State, Nigeria with respect to rainy and dry seasons. **Methodology:** Water samples were collected from different sampling points within the study areas reflecting five sites and coded as follows: Otammiri river (Site A), Nworie river (Site B), Okitankwo stream (Site C), Onumurukwa (Site D) and Onukwu (Site E), using clean sterilized 250 ml bottles from 20 to 30 cm depth (to avoid floating materials). Water samples were randomly collected from pre-selected sampling points within the study areas in triplicates during the dry season (January-March 2023) and rainy season (April-August 2023) and were transported to the laboratory for analysis. **Results** :In all samples of water from both rainy and dry seasons, E. coli was identified in entire sampling stations (100%), Salmonella and faecal coliform occurred 83.3% while Vibrio and Shigella were detected in 1 out of the 5 sampling locations for both surface and borehole waters. Five fungal species (Aspergillus niger, Penicilium spp., Rhizopus spp, Candida spp and Mucor racemosus were isolated from the selected borehole and surface water samples. Mean heterotrophic count of processed surface water from the various sampling points ranged from 1.0 x102 ±0.33 to 7.4 x103 ±0.31CFU/ml, mean coliform count of surface ranged from 0.5 x101 ±0.13 to 1.5 x102 ±0.10 CFU/ml while mean fungal count of water samples ranged from 2.9 x101 ±0.08 to 3.3 x103 ±0.14 CFU/ml. The highest bacterial count was obtained in rainy season though it was not significantly ($p<0.05$) different from dry season. Bacterial count in surface and borehole for both seasons exceeded WHO permissible limits (0/100 ml). **Conclusion:** The results obtained in this study provide baseline information that can be used by researchers and government authorities such as NESREA and SON to improve on the quality of borehole and surface waters in Owerri Imo State.

Keywords: microbial, borehole, surface water, imo state.

Introduction

Water is considered as one of the essential components of diet that support all forms of life [1]. According to [2] water covers about 70.9% of the earth‟s surface. Freshwater, which is vital for sustainable development, covers less than 2% of earth‟s surface. Surface and underground water are major sources of fresh water but surface water is vulnerable to contamination as contaminants can easily flow into it [3].

Many people lack access to potable water and about 22% of the world‟s population per year are affected by water borne diseases [4]. [5] reported that worldwide approximately 1.7 million deaths recorded annually are attributed to unsafe water supplies. Most of these deaths are due to diarrheal diseases which mostly affect about 90% of children. In Africa and Asia, access to potable water is a major problem with above 800 million people affected [6]. Approximately half a million children die annually due to diarrheal diseases [7]. Water resources particularly rivers in the world are degraded by discharge of untreated sewage, untreated industrial wastes for example solvent chemicals, papers and sludge; leaching of agricultural chemicals (fertilizers and pesticides) due to increased human activities.

For instance, assessment of surface water quality in India by [8] reported that human activities contributed to water pollution. Contaminated water serves as a medium of transmitting dangerous pathogens into humans, animals and plants and about 80% of human diseases are caused by water [9]. Worldwide, indicator microbes like E. coli, Coliform bacteria and Faecal streptococci have been used to assess water faecal contamination [10].

According to [11] potable water is the fundamental need of man to sustain life. Potable water is defined as the water that is devoid of disease producing microorganisms and chemical substances which are deleterious and detrimental to health. Water is a good solvent and as a result picks up impurities easily. Pure water is tasteless, colorless, and often called the universal solvents [12]. One of the most important human needs is safe and good quality drinking water. The provision of potable water to the public to prevent health hazards should be a paramount necessity on the part of the municipality [4].

The wet season (sometimes called the rainy season) is the time of year when most of a region's average annual rainfall occurs. Generally, the season lasts at least a month. In the wet season, air quality improves, fresh water quality improves, and vegetation grows substantially, leading to crop yields late in the season. Rivers overflow their banks, and some animals retreat to higher ground. Soil nutrients diminish and erosion increases [12]. The incidence

of malaria and dengue increases in areas where the rainy season coincides with high temperatures, particularly in tropical areas. The length of the rainy season decreases from south to north. South raining season lasts from March to November while north raining season lasts only from mid-May to September. Temperature and humidity in the south remain relatively constant throughout the year while for the northern part, their season varies. This season brings about the watering of plants and crops, humidification of the air, replenishing the water table, and creating healthy ions. The first rainy season begins around March and last to the end of July with a peak in June, this rainy season is followed by a short dry break in August known as the August break which is a short dry season lasting for two to three weeks in August [13]. This break is broken by the short rainy season starting around early September and lasting to mid-October with a peak period at the end of September [14]. The ending of the short rainy season in October is followed by long dry season. This period starts from late October and lasts until early March with peak dry conditions between early December and late February. Rainfall in the wet season is mainly due to daytime heating, which leads to diurnal thunderstorm activity within a pre-existing moist airmass , so the rain mainly falls in late afternoon and early evening in savannah and monsoon regions. Much of the total rainfall each day occurs in the first minutes of the downpour, before the storms mature into their stratiform stage [15]. Most places have only one wet season, but areas of the tropics can have two wet seasons, because the monsoon trough, or Intertropical Convergence Zone, can pass over locations in the tropics twice per year.

Materials and methods

The study was carried out in Owerri metropolis. Its metropolitan class informed its selection (Okere, *et al.*, 2018). A typical representation of an urban area (Ogwueleka, 2009, Okere *et al*, 2018) lying on coordinates 5°28'3.59"N, 7°02'06.0E on a land spanning over 550 km^2 and comprising of three Local Government areas of the twenty seven in Imo State, namely Owerri West, Owerri municipal and Owerri North (Okere *et al*., 2018). It is the commercial, entertainment and administrative Centre of Imo State (see Figure 1). According to National Population Commission of Nigeria (2007) in the extraordinary gazette of 2006 census dated May 15, 2007, the population was 401,873 with female and male population of 190,575 and 211,298 respectively (NPC, 2007; Okere *et al*., 2018). Hence a population density of about 730/km2 which is about 370% more than the national rate (Okere et al., 2018), based on Nigeria's land area of 923,768 km2 with a population estimate of 175,000,000 (Okere, *et al*., 2018).

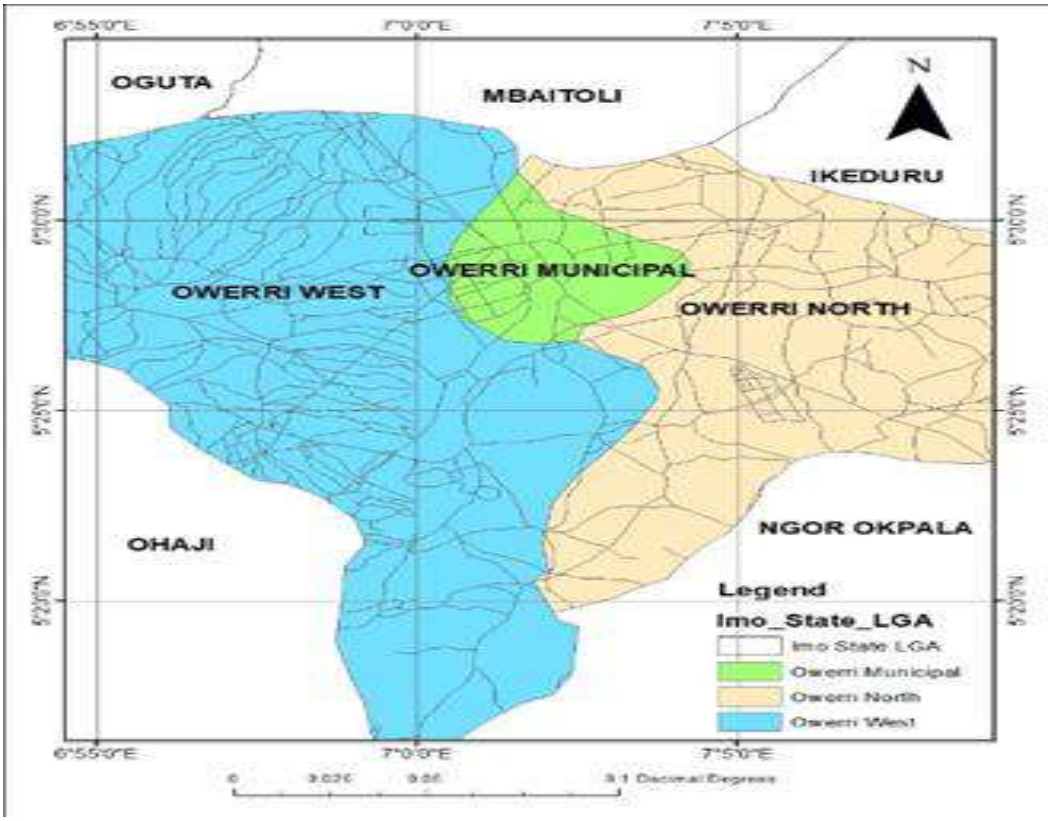

Figure 1: Map of the study areas showing Local Government Areas (LGAs)

SAMPLING SITES AND POINTS

Sampling was carried out within Owerri area of Imo State. During rainy season surface water samples were collected from determined (chosen) points along Otammiri , Nworie River, Okitankwo stream, Onumurukwa and Onukwu from the various villages where they are situated in the sampled local government area and evaluated. The sampling was done in the evening when human activities were less. The samples were collected at the same point in the various sampling rivers for the dry and rainy season for microbiological evaluation at the points where hospital waste effluents, city garbage is continuously washed into the rivers (Okere *et al.* 2018).

3.3 METHOD OF WATER SAMPLE COLLECTION

Water samples were collected from five sites and coded as follows: Otammiri river (Site A), Nworie river (Site B), Okitankwo stream (Site C), Onumurukwa (Site D) and Onukwu (Site E), using clean sterilized 250 ml bottles from 20 to 30 cm depth (to avoid floating materials) according to Mgbemena *et al.* (2012). All protocols were observed including ensuring all screens or aerators are removed and taking at least 100ml of water sample after moderate flow of about 2-3 minutes, making sure about 2.5cm of head space is available in sample container.

Water for dissolved oxygen (DO) and biological oxygen demand (BOD) determination were collected in 250 ml dark glass containers. The bottles were carefully closed and transported on ice and stored at 4ºC in a refrigerator until the analysis of microbiological and physicochemical parameters. Water samples were collected one meter from the shoreline in triplicates once per season from the five different sites chosen based on accessibility in terms of slope angle, human activities and health problems reported in the regions during the dry season (January-March) and wet season (April-July) in 2023 respectively (Mgbemena *et al*. 2012). Water quality does not change drastically and therefore sampling once in dry and wet season was sufficient to indicate the quality of water. This ensured that both the rainy and dry periods were captured so as to investigate the effect of seasons on microbial (bacteria and fungi) and physicochemical parameters in study areas.

STASTICAL ANALYSIS

The data obtained from the study was analyzed using Analysis Of Variance (ANOVA) followed by Dennett's Test. P-Values <0.05 was considered.

RESULTS AND DISCUSSION

Results

Morphological and biochemical features of the isolated microorganisms

The various sampling points and their corresponding domiciled microorganisms are displayed in Tables 1a and 1b; 2a and 2b. There were detectable amount of microbial activates in surface and borehole water of both dry and rainy seasons. Eleven (11) pure bacterial isolates were tentatively identified in both surface and borehole waters during the rainy seasons while nine (9) bacterial isolates were identified during the dry season. In all samples of water from both rainy and dry seasons, *E.coli* was identified in entire sampling stations (100%), *Salmonella* and faecal coliform occurred 83.3% while *Vibrio* and *Shigella* were detected in 1 out of the 5 sampling locations for both surface and borehole waters. The analysis of the bacterial contaminants of both borehole and surface water showed consistent presence of *E. coli*, *Chromobacteria violaceum, Pseudomonas* spp, *Bacillus* spp, *Klebsiella* spp, *Proteus spp, Serratia marcescens, Staphylococcus aureus, Salmonella* spp and *Vibrio cholera,* and *Shigella sp.* respectively. The cellular shape and biochemical characteristics of the isolates were all congruent with these identifications (Plate 4.1).

Table 1a: Occurrence of the bacteria isolates from surface waters during rainy season

Organisms	**sampling Stations**				
	OTMS1	**NWS2**	**OKS3**	**ONKS4**	**ONUKS5**
Shigella sp.	+	+	-	+	+
Vibrio cholerae	-	+	-	+	+
Faecal coliform	+	+	+	+	+
E. coli	+	+	+	-	+
C. violaceum	+	+	-	-	+
Pseudomonas spp	+	_	+	+	_
Bacillus spp	+	_	+	+	+
Klebsiella spp	+	+	+	+	+
Proteus spp	+	+	_	+	_
Staphylococcus aureus	+	+	_	+	+
Salmonella spp	+	+	+	+	+

***LEGENG**: OTMS1= Otammiri River; NWS2= Nworie River; OKS3=Okitankwo stream, ONKS4=Onumurukwa and ONUKS5=Onukwu*

Table 1b: Occurrence of the bacteria isolates from surface waters during dry season

Organisms	**sampling**	**Stations**		
	OTMS1	**NWS2**	**OKS3**	**ONKS4**	**ONUKS5**
Faecal coliform	+	+	+	+	+
E. coli	+	+	+	-	+
C. violaceum	+	+	-	-	+
Pseudomonas spp	+	_	+	+	_
Bacillus spp					
Klebsiella spp	+	_	+	+	+
Proteus spp	+	+	+	+	+
Staphylococcus aureus	+	+	_	+	_
	+	+	_	+	+
Salmonella spp					
	+	+	+	+	+

***LEGENG**: OTMS1= Otammiri River; NWS2= Nworie River; OKS3=Okitankwo stream, ONKS4=Onumurukwa and ONUKS5=Onukwu*

Table 2a: Occurrence of the bacteria isolates from borehole waters during rainy seasons

Organisms	**sampling**	**Stations**		
	OTMS1	**NWS2**	**OKS3**	**ONKS4**	**ONUKS5**
Shigella sp.	+	+	-	+	+
Vibrio cholerae	-	+	-	+	+
Faecal coliform	+	+	+	+	+
E. coli	+	+	+	-	+
C. violaceum	+	+	-	-	+
Pseudomonas spp	+	_	+	+	_
Bacillus spp					
Klebsiella spp	+	_	+	+	+
Proteus spp	+	+	+	+	+
Staphylococcus aureus	+	+	_	+	_
	+	+	_	+	+
Salmonella spp					
	+	+	+	+	+

***LEGENG**: OTMS1= Otammiri River; NWS2= Nworie River; OKS3=Okitankwo stream, ONKS4=Onumurukwa and ONUKS5=Onukwu*

Table 2b: Occurrence of the bacteria isolates from borehole waters during dry seasons

Organisms	**sampling**	**Stations**		
	OTMS1	**NWS2**	**OKS3**	**ONKS4**	**ONUKS5**
Shigella sp.	+	+	-	+	+
Vibrio cholerae	-	+	-	+	+
Faecal coliform	+	+	+	+	+

E. coli	+	+	+	-	+
C. violaceum	+	+	-	-	+
Pseudomonas spp	+	_	+	+	_
Bacillus spp					
Klebsiella spp	+	_	+	+	+
Proteus spp	+	+	+	+	+
Staphylococcus aureus	+	+	_	+	_
Salmonella spp	+	+	_	+	+
	+	+	+	+	+

***LEGENG**: OTMS1= Otammiri River; NWS2= Nworie River; OKS3=Okitankwo stream, ONKS4=Onumurukwa and ONUKS5=Onukwu*

Morphological characterization of fungi from water collected from the study areas

Morphological characterization of fungi from water collected from the study areas is presented in Table 4.3. Five fungal species (*Aspergillus niger, Penicilium spp., Rhizopus spp, Candida spp* and *Mucor racemosus*) were tentatively isolated from the selected borehole and surface water samples analyzed in this research (Plate 4.2). The pure fungal isolates were tentatively differentiated based on morphological and microscopic characters. Based on the reference made using mycology manual vol. 1.1 and Alexopolous *et al.* (2002), the five isolates were identified to be *Aspergillus niger, Mucor racemosus, Penicilium spp., Rhizopus spp*, and *Candida spp* as shown in Table 4.3.

Mean bacterial load from surface water (rainy and dry seasons)

The mean microbial load from surface waters obtained during the dry and rainy seasons are presented in Tables 4.4 and 4.5 while that of mean fungal count from the various sampling points is shown in Table 4.6 and 4.7. Results obtained showed that the mean heterotrophic count of processed surface water from the various sampling points ranged from 1.0 $x10^2$ ±0.33 to 7.4 $x10^3$ ±0.31CFU/ml, mean coliform count of surface ranged from 0.5 x101 ±0.13 to 1.5 $x10^2$ ±0.10 CFU/ml while mean fungal count of water samples ranged from 2.9 x101 ±0.08 to 3.3 $x10^3$ ±0.14 CFU/ml. In overall assessment, samples of water collected during the rainy seasons had highest microbial load (counts), while the least counts were observed with samples of water from dry seasons. The highest bacterial count was obtained in rainy season though it was not significantly different from dry season. Bacterial count in surface and borehole for both seasons exceeded WHO permissible limits (0/100 ml). All values obtained in this study were statistically significant when compared ($p<0.05$).

TABLE 1: MEAN BACTERIAL LOAD OF SURFACE WATER SAMPLES (rainy season)

Sampling Points/ Code	**SAMPLE LOCATIONS**				
	Otammiri River (CFU/g)	**Nworie River (CFU/g)**	**Okitank Strem (CFU/g)**	**Onumurukwa (CFU/g)**	**Onukwu (CFU/g)**
S1	3.7 $x10^2$ ±0.17^a	7.4 $x10^2$ ±0.19^a	3.7 $x10^2$ ±0.19^a	6.7 $x10^2$ ±0.19^a	3.7 $x10^2$ ±0.19^{ac}
S2	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d
S3	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}
S4	1.0 $x10^2$ ±0.25^b	1.0 $x10^2$ ±0.65^b	1.0 $x10^2$ ±0.65^b	1.0 $x10^2$ ±0.65^b	1.0 $x10^2$ ±0.65^b
S5	3.7 $x10^2$ ±0.27^a	5.7 $x10^2$ ±0.29^a	4.7 $x10^2$ ±0.19^a	5.7 $x10^2$ ±0.19^a	6.7 $x10^2$ ±0.19^a
S6	1.4 $x10^2$ ±0.15d	1.4 $x10^2$ ±0.35^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d	1.4 x102 ±0.15^d
S7	1.0 $x10^3$ ±0.13^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	7.4 $x10^3$ ±0.31^{ab}
S8	1.0 $x10^2$ ±0.35^b	1.0 $x10^2$ ±0.65^b	1.0 $x10^2$ ±0.65^b	1.0 $x10^2$ ±0.65^b	1.0 $x10^2$ ±0.65^b
S9	4.7 $x10^2$ ±0.19^a	4.7 $x10^2$ ±0.39^a	1.7 $x10^2$ ±0.19^a	4.7 $x10^2$ ±0.19^a	5.7 $x10^2$ ±0.19^a
S10	1.4 $x10^2$ ±0.35^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d	1.4 $x10^2$ ±0.15^d
S11	1.0 $x10^3$ ±0.19^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}	1.0 $x10^3$ ±0.09^{ab}

S12	$3.7 \times 10^2 \pm 0.39^a$	$3.7 \times 10^2 \pm 0.19^a$	$5.7 \times 10^2 \pm 0.19^a$	$3.4 \times 10^2 \pm 0.19^a$	$4.7 \times 10^2 \pm 0.19^a$
S13	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.25^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$
S14	$1.0 \times 10^3 \pm 0.39^{ab}$	$1.0 \times 10^3 \pm 0.19^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S15	$1.0 \times 10^2 \pm 0.25^b$	$1.0 \times 10^2 \pm 0.05^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$
S16	$2.7 \times 10^2 \pm 0.29^a$	$5.7 \times 10^2 \pm 0.09^a$	$2.7 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$
S17	$1.4 \times 10^2 \pm 0.35^d$	$1.4 \times 10^2 \pm 0.25^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$
S18	$1.0 \times 10^3 \pm 0.19^{ab}$	$1.0 \times 10^3 \pm 0.19^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S19	$1.0 \times 10^2 \pm 0.25^b$	$3.0 \times 10^2 \pm 0.35^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$
	$1.7 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.29^a$	$1.7 \times 10^2 \pm 0.19^a$	$4.7 \times 10^2 \pm 0.19^a$	$937 \times 10^2 \pm 0.19^a$

Within rows, values followed by the same alphabets are not significantly different but those followed by different alphabets are significantly different (p<0.05).

TABLE 2: MEAN BACTERIAL LOAD OF SURFACE WATER SAMPLES (Dry season)

Sampling Points/ Code	**SAMPLE LOCATIONS**				
	Otammiri River (CFU/g)	**Nworie River (CFU/g)**	**Okitank Strem (CFU/g)**	**Onumurukwa (CFU/g)**	**Onukwu (CFU/g)**
S1	$2.7 \times 10^2 \pm 0.19^a$	$0.7 \times 10^2 \pm 0.19^a$	$3.7 \times 10^2 \pm 0.19^a$	$1.9 \times 10^2 \pm 0.19^a$	$0.6 \times 10^2 \pm 0.19^a$
S2	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$0.4 \times 10^2 \pm 0.15^d$
S3	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S4	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$
S5	$2.7 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$	$3.7 \times 10^2 \pm 0.19^a$	$0.7 \times 10^2 \pm 0.19^a$	$3.7 \times 10^2 \pm 0.19^a$
S6	$1.4 \times 10^2 \pm 0.15$d	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$
S7	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S8	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.1 \times 10^2 \pm 0.65^b$
S9	$1.7 \times 10^2 \pm 0.19^a$	$1.8 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$	$1.7 \times 10^2 \pm 0.19^a$	$2.7 \times 102 \pm 0.19^a$
S10	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$
S11	$2.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S12	$2.7 \times 10^2 \pm 0.19^a$	$0.7 \times 10^2 \pm 0.19^a$	$1.5 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$	$4.7 \times 10^2 \pm 0.19^a$
S13	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$
S14	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S15	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$
S16	$3.7 \times 10^2 \pm 0.19^a$	$4.7 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$	$0.3 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$
S17	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$	$1.4 \times 10^2 \pm 0.15^d$
S18	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$	$1.0 \times 10^3 \pm 0.09^{ab}$
S19	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$	$1.0 \times 10^2 \pm 0.65^b$
	$0.7 \times 10^2 \pm 0.19^a$	$3.7 \times 10^2 \pm 0.19^a$	$2.7 \times 10^2 \pm 0.19^a$	$4.7 \times 10^2 \pm 0.19^a$	$1.5 \times 10^2 \pm 0.19^a$

Within rows, values followed by the same alphabets are not significantly different but those followed by different alphabets are significantly different (p<0.05).

Discussion

Eleven (11) bacteria were isolated and identified from both surface and borehole waters, namely, *Shigella sp*., *Vibrio cholera, Faecal coliform, E. coli, C. violaceum, Pseudomonas spp, Bacillus spp, Klebsiella spp, Proteus spp, Staphylococcus aureus, Salmonella spp*. Fungal isolates encountered in the water samples were *Aspergillus niger, Rhizopus spp, Candida spp*, and *Mucor spp.* Similar microbial species had been reported by previous authors in both surface [15] and borehole waters *[12]* in Imo State.

The mean total heterotrophic bacteria counts recorded in both suraface and borehole water samples during the rainy season season than the dry season were slightly above WHO stipulated for drinking water. This study agrees with the report of [16] that extremely high total heterotrophic bacterial load in water suggested that the water has been contaminated by potentially dangerous microorganism and unfit for human consumption. Bacterial occasionally find their way into ground water sometimes in dangerously high concentrations through runoffs or seepage. From this present study, it is evident that borehole and suraface water could be contaminated through floodwater forming after rainfall, depending on the depth of the groundwater or through broken underground pipes under this condition, the surrounding floodwater flows into the pipe through the cracks [17]. The major diseases that could arise from bacteriological contamination of the borehole water include typhoid, diarrhea and cholera. The deeper ground water contains little or no presence of bacteria could have been removed by extensive filtration as water percolates through the soil [4]. This was confirmed by the characterization of the isolates from the borehole water samples from the sampling locations under study that were highly contaminated with one or more bacterial pathogens.

The high bacterial load of genera like *Enterobacter, Proteus, Escherichia,* Salmonella and *Shigella* were isolated from surface and borehole samples respectively. The high abundance of bacteria isolated in borehole water sample as seen in this study indicate the presence of high feacal contamination and health risk for the human consumption due to high pathogens presence in the water sample [6]. According to WHO recommendations, there should no fecal coliforms in 100 ml drinking water and the reason for the gross contamination of borehole waters by pathogens as observed in this study may be due to openness and shallowness of this water that allows easy entrance of particles from the surroundings. It may also be due to poor sanitary condition around the areas where such boreholes are located.

The availability of bacteria in surface waters can be associated with the activities like washing, agricultural, livestock, soil erosion, swimming and waste discharge going on in these sites. The bacteria isolates mainly belonged to the family Enterobacteriaceae that is known to consist of several pathogenic bacteria [17]. *Salmonella spp* and *E. coli* are considered as food and waterborne pathogens and *E. coli* is a good indicator of fecal contamination of water.

The isolation of *Klebiesiella spp, Clostridium spp*, and *Enterobacter spp.* from the different sites can be attributed to soil erosion. Microorganisms such as *Klebiesiella spp, Clostridium spp*, and *Enterobacter spp* colonize rhizosphere of trees such as Pine; this might have contributed to the presence of the bacteria in the surface water (Aishvarya *et al*., 2020). Some species from respective genera are known to be pathogenic e.g. *Clostristridium botulum* is associated with botulism in food and tetanus. Pathogenic *Staphylococcus* is a member of family *Staphylococcaceae* and is associated with inflammation and suppuration [19].

Conclusion

All domestic water samples analyzed were contaminated with different types of Bacterial species such as Enterobacter, Escherichia, Salmonella, Shigella and Proteus indicated faecal pollution that can cause waterborne diseases. Nine bacteria namely; Clostidium spp., Staphylococcus spp., Enterobacter spp., Streptococcus spp., Proteus spp., E. coli, Klebsiella spp., Shigella spp. and Salmonella spp. were isolated and identified and three fungi namely; *Aspergillus flavus*, Rhizopus spp, Mucor spp and species were isolated and identified. This finding indicates that surface and borehole water is contaminated with disease causing microorganisms. The bacterial and fungal counts in in the selected study locations were above WHO permissible limits (0/100ml) indicating that the water is microbiologically contaminated and unsafe for direct human usage.

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