PHYSICOCHEMICAL AND BACTERIOLOGICAL QUALITY OF WATER FROM LOTIC AND LENTIC ECOSYSTEMS IN AGBEDE WETLANDS, EDO STATE, SOUTHERN NIGERIA

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ABSTRACT

The bacteriological and physicochemical characteristics of surface water from three (3) sampling stations (SS) on Omodo stream and four (4) SS on three ponds all located in the Agbede wetlands was determined at monthly intervals between December, 2012 and May, 2014. Routine procedures such as; Usage of relevant meters, spectrophotometric-based analysis and multiple tube methods were employed in evaluating the physicochemical and coliform content of the water samples. Air temperature mean values ranged from 28.17 to 32.19^{O}C at station 1 and station 4, whilst, the mean values for water temperature ranged between 25.42 and 29.11 ^{O}C at stations 1 and 4 respectively. The pH values (5.10 – 7.20) ranged between slightly acid and slightly alkaline condition. The differences in the mean air temperature, water temperature, flow rate, electrical conductivity (2.67 - 140 μScm^{-1}), turbidity (0.00 – 78.20 NTU) and chemical oxygen demand (COD) values (12.15 – 96 mgL^{-1}) were significantly different (*P<0.05, P<0.001*) across the study stations. The Dissolved oxygen (DO) (1.20 – 14.80 mgL^{-1}) and Biochemical oxygen demand (BOD) (0.00 – 8.20 mgL^{-1}) had their values within the FMEnv set limits 0f 7.5 mgL^{-1} and 30 mgL^{-1} respectively. The study revealed varying levels of culturable coliform counts in the examined surface waters with values not exceeding 13 $MPN100mL^{-1}$. Coliform values were slightly higher within the lentic environments. Sensitization of the communities residing within the wetlands by relevant governmental and non-governmental bodies on the urgent need to treat the water by boiling prior to drinking should be conducted.

Key Words: Coliform, Agbede wetlands, Environmental Condition, Set limits

INTRODUCTION

Microbial contamination as a consequence of the presence of human and/ or animal faeces is the most common reason for water to be considered unsafe for drinking because of the high probability of the presence of pathogenic organisms. In addition, high concentration of bacteria and nitrates discharged into water can occur from animal husbandry operation like grazing and this can result in health hazards due to the presence of pathogens (Obasohan *et al*., 2010; Enerijiofi *et al*., 2013). World Health Organisation (2003) estimated that 80% of ill-health especially in developing countries stems from lack of safe drinking water.

Chao *et al*. (2004) opined that the use of normal intestinal organisms as indicators of faecal pollution is universally accepted for the monitoring and assessment of the microbiological safety of water supply. For example, the Coliform group of enteric bacteria which include *Escherichia coli*, *Klebsiella* sp. and *Enterobacter* sp. are used as indicators of water purity (Grant *et al*., 2002; Chao *et al*., 2004).

A large proportion of the rural population in developing world sourced surface water from natural sources (i.e. rivers) directly for drinking (Akaninwor *et al*., 2007). Rivers have a limited absorptive capacity for sewage and fertilizer from farmland and if this limit is exceeded, the proliferation of bacteria, algae and plant life will consume all the oxygen dissolved in water leading to eutrophication (Agbabiaka and Oyeyiola, 2012).

Some notable works on microbiological and faecal coliform count studies include Shekha *et al*., (2013) on Duhok Dam reservoir in Duhok city in Iraq. The authors reported faecal coliform count below 12 MPN $100mL^{-1}$. In Nigeria, Enerijiofi *et al*.,

(2013) reported high heterotrophic bacterial counts for samples collected from an inland river at Ujiogba. Dirisu and Olomukoro (2015) earlier investigated the water quality of two Rivers in Agbede wetlands and recorded low mean values of faecal coliform count bacteria (5.75 to 33.75MPN $100mL^{-1}$).

This study was aimed at evaluating the bacteriological quality of Agbede wetlands in order to determine how safe the water bodies are upon consumption by animals and humans alike. It further identifies and compares the Coliform count species of the ecosystems. Of course, it is the very first study assessing the bacterial quality of water of lentic systems in Agbede wetlands together with a lotic environment for comparison.

MATERIALS AND METHODS

The Study Area

The study area (06°16.3"E, 06° 18.7"E) and latitude (06°52.2"N, 06°55.4"N) is part of Agbede wetlands located in Etsako West Local Government area of Edo State (Fig. 1). The features of this locality have been extensively and exhaustively described (Olomukoro and Dirisu, 2014; Dirisu and Olomukoro, 2015). The region is predominantly agrarian and all forms of human activities like washing, bathing, scattered settlements, fishing, mining of top soils and trading amongst others are observed in the locality. Rainfall data between December, 2012 and May, 2014 as obtained from the Benin Meteorological Station during the sampling regime revealed that precipitation was lowest in January, 2013 (15.4mm) and December, 2012 (18.9mm), and highest in September, 2013 (564mm).

Sampled Stations

A total of seven sampling stations were designated for this study and included one Stream with three (3) stations and three Ponds (3) with four stations.

Station 1: This is a stretch of Omodo Stream located just by the confluence between Omodo and Egwavo Streams, accessible through Ayuele Secondary School in Agbede town. There is a dense canopy cover from the Bambusa tickets (*Bambusa* sp). All forms of human activities which included; bathing, washing of clothes, fermentation of cassava for starch and fishing take place here. This station serves several indigenous and non-indigenous communities.

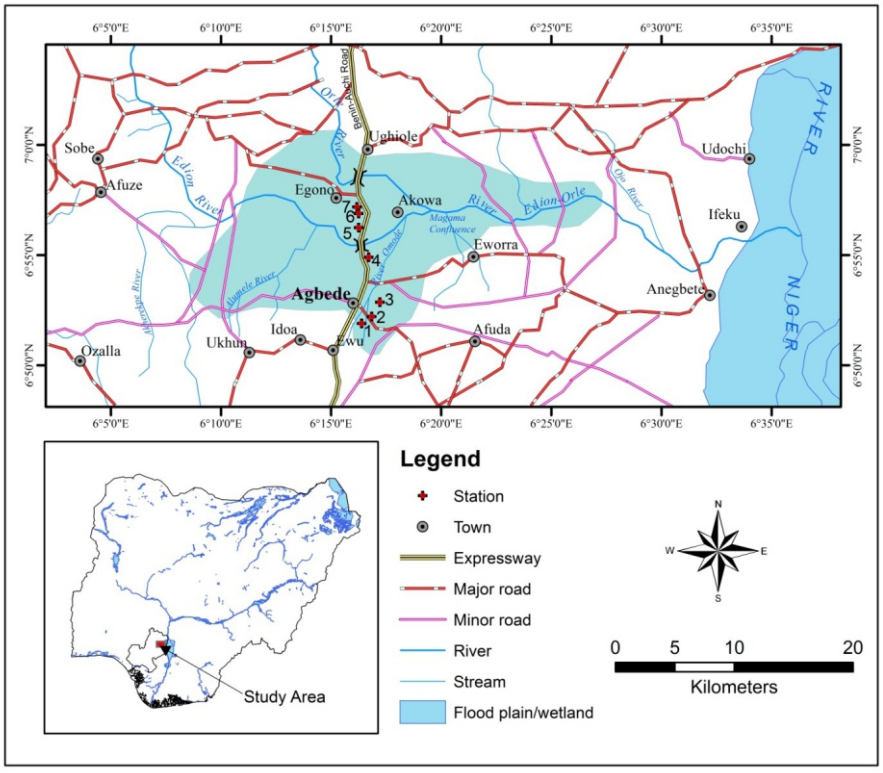

Fig. 1: Map of the Study Area

Station 2: It is located at Odighie village by the bridge linking Agbede and Ama/Idegun towns in Etsako West Local Government Area, which is over 987m from Station 1. There is more canopy cover by *Bambusa* sp. washing of auto-bikes, bathing and washing of clothes are the major human impact here. It serves over four communities within Agbede.

Station 3: This is about 1.11km from Station 2 and the last sampling point on the stream stretch which is located by the bridge at Egho village unto Rabho-Imes farm land. It is the major source of water for every form of activity by the various Fulani, Igbo and other Etsako-speaking Tribes Farm Camps. Nomadic activities are very high here and consequently there are always litters of cattle fecal matter onto the water andon the river banks.

Station 4: This is the first pond before Edion River when transiting to Auchi at Ogwedion in the same local Government. It is a major source of drinking water to cattle and a nestling ground to some birds' species. It is fed by Edion River during the pick of wet seasons. Macrophytes are sparsely distributed here (*Nymphae lotus, Sacciolepis africana and Chromolaena odorata*).

Station 5: This is the major but easily accessible Pond at Ukatosoma farm district still in Agbede town. It is also a major fishery ground and there is an abundance of macrophytes (*Nymphaea lotus* and *Acroceras zizanoides*).

Station 6: It is about 830m away from station 5 while travelling toward Auchi town. It is a major source of drinking water to cattle herds within Ukatosoma farm district in Agbede. It is mostly surrounded by Gmelina trees (*Gmelina arborea*) with macrophytes (*Nymphaea lotus* and *Sacciolepis africana*). Fishes are harvested here occasionally and it supports a number of vegetable farms with irrigation.

Station 7: This is the second station established on the same pond described in station 6 above. The entire pond/burrow pit measures about 215m x 23m and located at less than 10m away from the high way. There are yam farms on the west bank. Macrophytes are in abundance here and the dominant species include; *Sacciolepis africana and Chromolaena odorata*.

Sampling for Physicochemical and Bacteriological Analysis

Monthly samplings were carried out (total, n=126) in each of the seven stations on every sampling day between 0900h and 1200h from December, 2012 to May, 2014. A total of 18 replicate samples were collected from each sampled station on a monthly basis. Before sampling, all containers were pre-washed. For microbiological samples, we used sterile vials (universal sample containers). At each sampling station, water quality and microbiological samples were taken concurrently from the sub-surface waters. The resulting composite samples were put into the appropriate sample containers preserved as appropriate (APHA, 1998) and transferred to the laboratory for analyses. All analytical quality control (QC) and quality assurance requirements were strictly adhered to.

Determination of the Physical and Chemical Characteristics in Surface Water

Air and water temperatures were measured using mercury – in – glass thermometer calibrated from $0^0C – 100^0C$ (Krisson model-59) (Olomukoro and Dirisu, 2012). Air temperature was usually measured before that of water at each station. The modified floatation method earlier used by Olomukoro and Dirisu (2012) was adopted to determine the velocity of flow and the current was calculated in meters per seconds (ms^{-1}). The water level at specific points in the study stations were measured using a straight stick and a field tape calibrated in meters (Ogbeibu and Victor, 1995). The pH, Electrical conductivity (EC) and Total dissolved solids (TDS) were measured *in-situ* using the potentiometric method with pH/Conductivity/TDS meter (Hach pH meter sense ion 2 Model). Total suspended solids measured in mgL^{-1} were determined using the photometric method with HACH UV/VIS Spectrophotometer (model DR/2000) (APHA, 2005). Turbidity was measured in the laboratory in NTU, using a HACH Turbidimeter Model 2100p (APHA, 2005). Dissolved oxygen and Biochemical Oxygen Demand (BOD_5) was estimated using the Winkler's method (APHA, 2005). Samples for Dissolved Oxygen (DO) were

fixed in the field using 1.0 ml each of Winkler's solution A and B and determined titrimetrically in the laboratory using the Azide modification techniques of the Winkler's method (Ogbeibu and Victor, 1995; APHA, 1998). Chemical oxygen (COD) demand was measured in the laboratory (APHA, 1998). Chloride was determined using the argentometric method (Olomukoro, 1996; APHA, 1998). Nitrate was determined following with the Cadmium Reduction method and optical density read at 410nm in a Spectrophotometer (Hach UV/VIS Model DR 2000) (APHA, 2005). Phosphate was determined using the ascorbic acid method and optical density read ar 890nm in a Spectrophotometer (Model DR 2000) (APHA, 2005) and Sulphate was determined following the turbidimetric method reading the optical density at 450nm in a Spectrophotometer (DR/2000) (APHA, 2005).

Determination of the Total Coliform and Fecal Coliform (*E. coli*) Counts

Multiple tube dilution procedure as described by Cheesebrough (2006) was used to determine the total coliform and faecal (thermo-tolerant) coliform (*Escherichia coli*) flora of the water samples. Each count was conducted in three stages as outlined below;

Presumptive Stage

Fifty (50) millilitres of the surface water sample was added to 100 ml Erlenmeyer flask containing 50 ml of double strength MacConkey broth with an inverted Durham tube. Ten milliters of the sample was dispensed into 30 ml test tubes containing 10 ml of double strength medium with an inverted Durham tube. The procedure was carried out under aseptic conditions and the inoculated flasks and tubes were incubated at 30^{O}C for 48 h. This stage was repeated for the *E. coli* count but the flasks and tubes were incubated at 44^{O}C for 24 h. Upon incubation, the flasks and tubes were examined for both acid production (as indicated by color change in the medium) and gas production (as indicated by the presence of gas bubble in the Durham tube). Reference was made to MPN statistical tables to ascertain the total coliform and faecal coliform count in 100 ml of the respective water samples.

Confirmatory Stage

Zero point one (0.1) millilitres of aliquot from the positive presumptive test tubes and flasks was transferred onto freshly prepared tubes containing 9 ml of single strength MacConkey broth and inverted Durham tubes to detect gas production. The tubes were incubated at 30^{O}C for 48 h for total coliforms and 44^{O}C for 24 h for *E. coli.*

Statistical Analyses of Results

Inter-stations comparisons were carried out using the single factor analysis of variance (One-way ANOVA) and if significant differences existed, the source(s) of the significant difference were located using the Duncan Multiple range test, (DMR) at 95% confidence with an SPSS (Statistical Package for the Social Scientists) version 20.0.Graphical presentations were carried out using MS Excel pack of Window 7. Correlation coefficient to test for any existing relationship between the physico-chemical characteristics and the bacterial count was carried out with the same SPSS.

RESULTS AND DISCUSSION

Environmental Condition

The result of the seventeen (17) physico-chemical characteristics in the surface water is presented below while, the summary containing the minimum, maximum and mean values are presented in Table 1. All the physical and chemical characteristics in the surface waters had their concentration values within the set limits of the Federal Ministry of Environment of Nigeria (FMEnv.), except for turbidity whose mean concentration values were >5mgL^{-1} at stations 4 to 7 (the lentic environments). In all the parameters investigated, very few of them which included air temperature, water temperature, flow rate, EC, turbidity and COD showed a significant difference (*P<0.05, P<0.001*) amongst the tested mean values across the study stations. The results also revealed that the lentic ecosystems recorded slightly higher values amongst the characteristics than the lotic ecosystem as presented below.

Table 1: Summary of the Mean, Minimum and Maximum Values of the Physico-Chemical Characteristic values in Surface Water of Selected Water Bodies in Agbede Wetlands from December, 2012 to May, 2014

		Lotic Stations			Lentic Stations					
		Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Limits	
Parameters	Unit	×±SD (Min-Max)	×±SD (Min-Max)	×±SD (Min-Max)	×±SD (Min-Max)	×±SD (Min-Max)	×±SD (Min-Max)	×±SD (Min-Max)	FMEnv	p-Value
Air Temperature	^{0}C	28.17^{b} ±1.96 (23.00-31.50)	28.44^{b} ±1.81 (24.00-31.00)	31.67 ^{a}±1.37 (29.00-33.00)	32.19^{a} ±1.72 (29.00-36.00)	31.22^{a} ±1.33 (28.50-33.00)	31.92^{a} ±1.20 (29.50-33.50)	31.31^{a} ±1.63 (27.00-33.50)	NS	0.00
Water Temperature	^{0}C	25.42^{d} ±1.77 (20.00-28.00)	25.75^{d} ±1.96 (20.00-28.00)	26.58^{cd} ±1.78 (22.00-30.00)	29.11^{a} ±1.64 (26.00-32.00)	27.36^{bc} ±1.46 (24.50-29.00)	28.17^{ab} ±1.55 (25.00-30.00)	27.92^{c} ±1.57 (25.00-30.00)	<40	0.00
Depth	M	0.30±0.29 (0.10-0.90)	0.30±0.28 (0.10-0.90)	0.26±0.16 (0.12-0.80)	0.32±0.17 (0.16-0.90)	0.31±0.13 (0.13-0.56)	0.28±0.13 (0.12-0.58)	0.26±0.09 (0.13-0.38)	NS	0.42
Flow Rate	ms^{-1}	0.27^{b} ±0.06 (0.20-0.50)	0.30^{ab} ±0.07 (0.19-0.50)	0.33^{a} ±0.12 (0.09-0.50)	0.00^{c} ±0.00 (0.00-0.00)	0.00^{c} ±0.00 (0.00-0.00)	0.00^{c} ±0.00 (0.00-0.00)	0.00^{c} ±0.07 (0.00-0.00)	NS	0.00
pH		6.06±0.30 (5.50-6.70)	6.11±0.31 (5.80-6.85)	6.16±0.34 (5.70-7.00)	5.99±0.40 (5.50-7.20)	6.04±0.43 (5.10-6.80)	6.23±0.42 (5.70-7.20)	6.29±0.37 (5.70-7.10)	6 – 9	0.18
Electrical Conductivity	µScm^{-1}	29.78^{c} ±13.61 (3.92-48.00)	31.26^{c} ±17.00 (3.48-56.00)	35.75^{c} ±25.13 (3.54-80.00)	39.63^{bc} ±31.04 (3.03-90.00)	37.17^{c} ±28.17 (3.11-76.00)	61.33^{ab} ±52.36 (2.67-140.00)	62.87^{a} ±46.60 (2.76-130.00)	1000	0.01
Turbidity	NTU	4.39^{b} ±5.33 (0.00-16.50)	3.34^{b} ±5.76 (0.00-18.50)	4.54^{b} ±6.07 (0.00-20.50)	6.11^{b} ±10.41 (0.00-34.00)	6.06^{b} ±12.12 (0.00-39.00)	9.57^{b} ±19.24 (0.05-62.00)	21.25^{a} ±31.46 (0.04-78.20)	5	0.01
Total Hardness	mgl^{-1}	43.61±13.76 (27.16-68.98)	75.66±57.86 (28.42-168.90)	76.57±66.15 (20.40-189.78)	76.35±57.71 (28.63-182.30)	76.70±50.99 (23.89-184.98)	96.00±72.47 (21.46-210.10)	101.09±83.49 (28.16-235.01)	NS	0.14
Dissolved Oxygen	mgl^{-1}	7.68±2.52 (3.50-14.80)	5.77±2.55 (1.20-8.20)	6.57±2.60 (1.30-12.30)	4.83±2.49 (2.00-10.90)	6.56±4.05 (1.70-14.80)	6.06±3.15 (1.50-11.60)	5.23±2.86 (1.60-12.90)	7.5	0.09
Biochemical Oxygen Demand	mgl^{-1}	3.91±1.60 (1.40-6.80)	2.77±1.69 (0.40-5.20)	2.97±1.24 (0.50-4.80)	1.83±1.41 (0.00-4.30)	3.12±2.78 (0.00-8.20)	3.27±2.36 (0.00-6.80)	2.60±1.46 (0.80-4.80)	30	0.06
Chemical Oxygen Demand	mgl^{-1}	18.80^{c} ±5.97 (12.15-30.00)	24.23^{bc} ±11.47 (14.83-64.00)	27.42^{ab} ±9.12 (13.00-41.52)	34.84^{a} ±10.15 (15.00-50.60)	33.29^{a} ±19.37 (19.68-96.00)	18.42^{c} ±3.72 (15.19-25.80)	28.84^{ab} ±11.91 (13.26-48.09)	150	0.00
Total Dissolved Solids	mgl^{-1}	61.18±48.53 (18.85-153.29)	44.42±36.09 (18.50-130.10)	61.49±45.49 (20.25-150.61)	65.52±42.71 (16.17-151.60)	51.32±29.93 (15.45-120.10)	70.48±38.41 (19.22-134.80)	83.45±64.33 (21.31-243.80)	2000	0.20
Total Suspended Solids	mgl^{-1}	16.38±20.61 (0.04-53.40)	10.41±16.53 (0.00-59.20)	14.13±17.01 (0.02-57.40)	13.98±19.13 (0.00-59.80)	12.49±18.26 (0.00-61.20)	17.92±23.01 (0.01-61.20)	27.51±34.78 (0.03-93.80)	30	0.34
Chlorine	mgl^{-1}	19.23±11.15 (9.34-43.17)	19.35±10.00 (10.09-42.12)	18.80±7.41 (8.92-30.55)	19.96±7.69 (9.08-31.45)	19.73±8.47 (9.89-42.17)	23.89±14.63 (5.65-51.15)	23.15±13.83 (8.00-49.92)	600	0.69
Sulphate	mgl^{-1}	0.52±0.86 (0.03-2.37)	2.89±5.08 (0.03-14.95)	2.01±2.84 (0.05-7.67)	1.82±2.39 (0.07-5.41)	7.99±28.13 (0.06-120.45)	0.92±1.41 (0.06-3.91)	3.52±6.98 (0.02-21.98)	500	0.50
Phosphate	mgl^{-1}	0.53±0.44 (0.00-1.25)	0.40±0.41 (0.02-1.50)	0.54±0.49 (0.00-1.90)	0.32±0.32 (0.02-0.94)	0.40±0.29 (0.02-0.95)	0.45±0.34 (0.02-1.00)	0.54±0.55 (0.02-1.87)	5	0.61
Nitrate	mgl^{-1}	0.38±0.79 (0.01-2.22)	0.25±0.51 (0.00-1.71)	0.37±0.76 (0.00-2.09)	0.34±0.70 (0.00-1.92)	0.36±0.75 (0.00-2.01)	0.48±1.00 (0.00-2.71)	0.63±1.37 (0.01-4.29)	20	0.91

Air and water temperatures generally recorded higher values in the lentic environments than the lotic environment. Mean air temperature values ranged from 28.17 to 32.19^{O}C at Station 1 and Station 4 respectively. While, that for water temperature was between 25.42 and 29.11 ^{O}C at Stations 1 and 4. The increase in thermometric values in the lentic waters may be attributed to their non-flow status. However, the values for both temperatures were consistent with the earlier findings by Dirisu and Olomukoro (2015) for two rivers in Agbede wetlands. This may be better explained by the effect of canopy cover (Ogbeibu and Victor, 1995). pH and EC concentrations were equally higher in the lentic waters. pH values ranged between slightly acid and slightly alkaline condition (Table 1) throughout this study. The EC values were extremely low when compared with the Federal Ministry of Environment of Nigeria (FMEnv.) set limit of 1000 mgL^{-1}.

Dissolved oxygen (values ranged from 1.20 to 14.80mgL^{-1}) and Biochemical Oxygen Demand (from 0.00 to 8.20 mgL^{-1}) had their values within the FEMnv set limits (7.5 mgL^{-1} for the former and 30 mgL^{-1} for the latter) and conformed to tropical reaches. Nutrient levels (Nitrate, Sulphate and Phosphate) recorded extremely low concentrations when compared with the set limits.

Bacteriological Quality of the Surface Water

The spatial and temporal variations in the two bacteriological parameters investigated in this study are presented in Table 2, and Figures 2 and 3. Total coliform count (TCC) had values in the surface water slightly higher than those of faecal coliform count (FCC). No significant difference was observed statistically between the mean values (*P>0.05*, p = 0.819 and p = 0.851) across the stations for the two bacteriological parameters (TCC and FCC). Bacterial count distribution did not follow any definite seasonal pattern throughout the study, instead TCC and FCC values were highest at Station 1 (lotic system) in June and August, 2013.

Table 2: Mean, Minimum and Maximum Values of Coliform Count across the Sampled Stations in Agbede Wetlands from December, 2012 to May, 2014

Parameters	Unit	STN 1 ×±SD (Min-Max)	STN 2 ×±SD (Min-Max)	STN 3 ×±SD (Min-Max)	STN 4 ×±SD (Min-Max)	STN 5 ×±SD (Min-Max)	STN 6 ×±SD (Min-Max)	STN 7 ×±SD (Min-Max)	P-Value
Total Coliform Count (after 48 hours)	MPN100ml^{-1}	4.44±3.62 (0.00-13.00)	3.61±2.89 (0.00-10.00)	4.56±2.38 (2.00-10.00)	4.89±2.42 (2.00-10.00)	4.67±3.05 (0.00-10.00)	4.22±2.76 (1.00-9.00)	4.94±2.04 (2.00-9.00)	0.819
Fecal Coliform Count (after 24 hours)	MPN100ml^{-1}	2.44±2.43 (0.00-8.00)	1.94±1.80 (0.00-6.00)	2.00±1.61 (0.00-5.00)	2.17±1.92 (0.00-7.00)	2.67±2.09 (0.00-7.00)	2.28±1.87 (0.00-6.00)	2.67±1.33 (0.00-6.00)	0.851

Note: Number of Samples was 18 each for both Total Coliform Count and Fecal Coliform Count

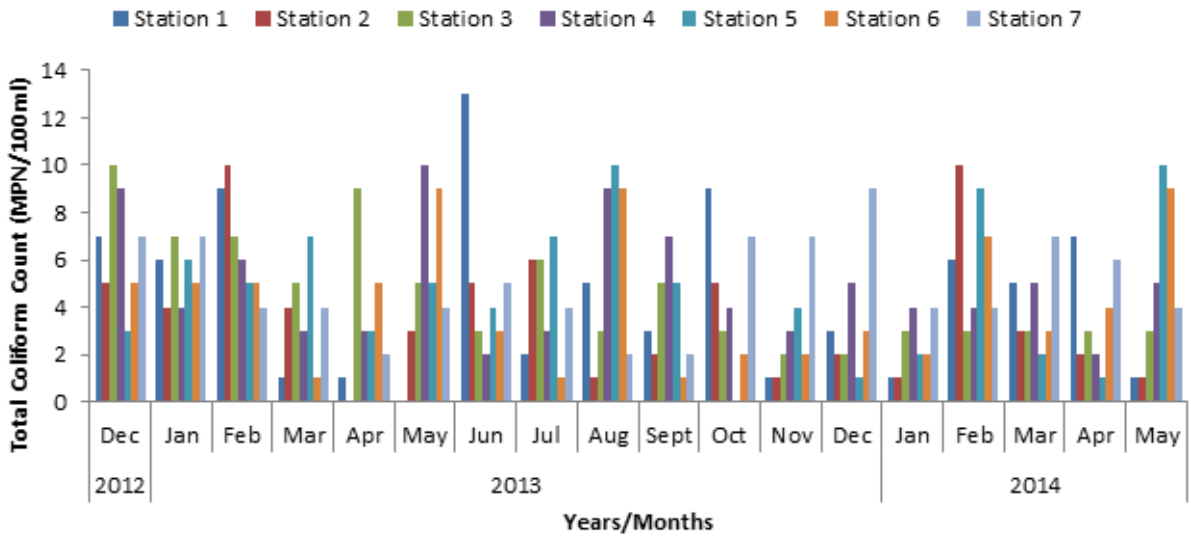

Fig. 2: Temporal and Spatial Variations in Total coliform count in the surface waters of Agbede Wetlands

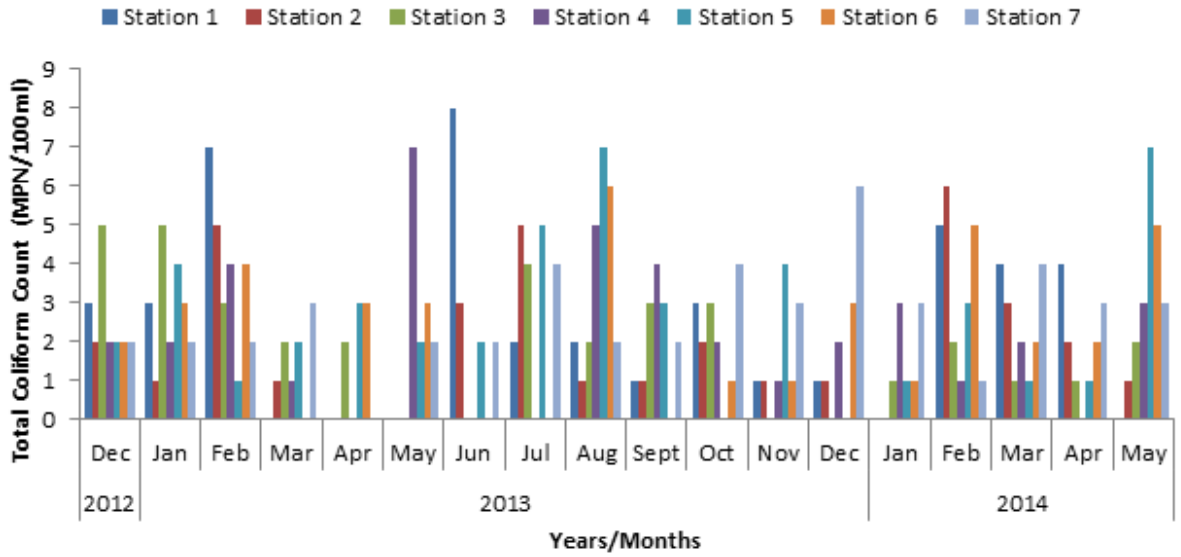

Fig. 3: Temporal and Spatial Variations in Fecal coliform count in the surface waters of Agbede Wetlands

Total coliform count recorded mean values which ranged between 3.61 MPN 100mL^{-1} at Station 2 (lotic system) and 4.94 MPN 100mL^{-1} at Station 7 (lentic system). Temporal variations ranged from 0.00MPN 100mL^{-1} at stations 1, 2, 5 to 13.00 MPN 100mL^{-1} at Station 1. Faecal coliform count had mean values between 1.94 MPN 100mL^{-1} at Station 2 (lotic system) and 2.67 MPN 100mL^{-1} at

Stations 5 and 7. Temporal variations here were between 0.00 MPN $100mL^{-1}$ across the stations and 8.00 MPN $100mL^{-1}$ at station 1.

The total coliform count in the surface water (lotic and lentic systems) consist of low values across the sampled stations (from stations 1 to 7) throughout the sampling regime. A high value of 13.00 MPN $100mL^{-1}$ was recorded in June 2013 (wet season).

The correlation matrix for the test of the relationship between surface water physicochemical and the microbial parameters only showed a strong positive relationship between calcium and fecal coliform count bacteria (Table 3) suggesting that the bacterial contamination may have flourished in the study area with the increase in the concentration of Calcium ion.

Table 3: Correlation matrix, Test of relationships between the water physicochemical and microbial parameters at the study area

PARAMETERS	*TCC*	*FCC*
Air Temperature	0.165	0.063
Water Temperature	0.115	0.061
Depth	0.085	0.138
Flow Rate	-0.043	-0.066
pH	-0.105	-0.079
Electrical Conductivity	-0.006	0.092
Turbidity	0.049	-0.011
Total Hardness	0.039	0.064
Dissolved Oxygen	0.129	0.104
Biochemical Oxygen Demand	-0.009	0.111
Chemical Oxygen Demand	-0.020	-0.057
Total Dissolved Solids	0.099	0.022
Total Suspended Solids	0.118	0.032
Chlorine	0.108	0.059
Sulphate	0.068	0.087
Phosphate	0.106	0.064
Nitrate	-0.050	0.005

The FCC values obtained in the current study were similar to values reported for Duhok Reservoir in Iraq (Shekha *et al.*, 2013). Bacterial contamination of the lotic and lentic water bodies within the wetlands might be attributed to the presence of bovine faecal matter generated during the grazing activity around the water sources by cattle herds. Other pollution activity that could be responsible for the presence of these bacterial indicators in the sampled waters includes; indiscriminate defecation by humans and other animals transported via surface run-offs (Dirisu and Olomukoro, 2015).

In conclusion, the study revealed varying levels of culturable coliform counts in the examined surface waters and were in agreement with results from an earlier study by Dirisu and Olomukoro (2015). The usage of improperly built pit toilet systems, the non restriction of nomadic activities particularly around the water bodies and the unwholesome act of open defecation onto the top

soils by individuals residing within the wetlands should be discouraged. Also sensitization of the communities residing within the wetlands by relevant Governmental and Non-Governmental bodies on the urgent need to treat the water by boiling prior to drinking should be conducted.

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