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Assessment of some Physico-chemical water quality and total coliform density of river Usuma, Abuja, Nigeria

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The physicochemical water quality and total coliform density of River Usuma, Abuja, and Nigeria was monitored from July, 2017 to March, 2018. Eighteen (18) physic-chemical parameters were analyzed. Total Coliform assessment gave a mean most probable number value of 174, 68 and 56 (cfu/100ml) for upstream, midstream and downstream respectively. While in the dry season most probable number of coliforms ranging between 9, 6 and 4 were enumerated for upstream, midstream and downstream respectively. Faecal coliform assessment gave a mean value of 180cfu/ml, 175cfu/ml and 187.5cfu/ml in the wet season while 81.3cfu/ml, 62.5cfu/ml and 80.0cfu/ml were recorded in the dry season. Samples taken from the river were subjected to some physicochemical analyses like pH, total alkalinity, electrical conductivity, total dissolved solids, Chloride ion, total hardness, salinity, temperature, nitrate, sulphate, phosphate, total iron, manganese, turbidity, dissolved oxygen, biochemical oxygen demand and electrical conductivity. The values of pH for both wet and dry seasons (6.6±0.8, 7.80±0.57 respectively), Total alkalinity, electrical conductivity, TDS, salinity, temperature, nitrate, sulphate, phosphate, total chloride, total hardness and BOD were within the WHO, (2006), UNCED (1991) and FEPA (1991) guidelines. While manganese, turbidity, dissolved oxygen organic matter and colour showed exceedance in UNCED (1992) and FEPA (1991) guiding values for both seasons (<2.0mg/l, < 25NTU, 5.0-7.0mg/l, 2.0-5.0mg/l and 100-200 PtCo respectively). Higher concentrations were obtained for most physico-chemical parameters in the upstream signifying a high level of influx of organic and inorganic contaminants; but buffered by the River's ability for self-purification. The result showed no significant difference in the physico-chemical parameters recorded in wet and dry season (P<0.05). Salinity, sulphate, phosphate, iron, manganese, turbidity, dissolved oxygen, organic matter and BOD were significant in all stations sampled (P<0.05).

Keywords: Coliforms, physicochemical parameters, bacteriological quality, most probable number

INTRODUCTION

The Earth surface is covered in about 70% water out of which only 1.7% is accessible as freshwater in ground water, lakes, rivers and streams (Gilliom *et al.*, 2006). Water is one of the basic needs for survival of all living things (Unamba *et al.,* 2016).

Freshwater has become recognized as an increasingly important resource, with the quality of the water a great concern. Nigeria's vast freshwater resources are among those most affected by environmental stress imposed by human population growth, urbanization and agricultural practice (Adeyemo, 2003). Over one billion people lack access to safe drinking water particularly in the rural areas. That is why most people depend on any means and cheaper form of water such as well water as a source of drinking water. The scarcity of safe drinking water poses a great danger to public health and wellbeing by exposing people to the risk of water borne diseases such as diarrhea, and dysentery as well as chemical intoxication (Agbabiaka and Sule, 2010).

Deteriorating water quality in the rivers poses many health hazards to the rural and urban unsuspicious communities. Polluted water is a major cause of human

disease, misery and death. Water borne diseases kill 50,000 people annually (Herschy, 1999) and yearly, about 4million children under the age of five in developing countries (WHO, 1997). Freshwater has become recognized as an increasingly important resource, with the quality of the water a great concern. Nigeria's vast freshwater resources are among those most affected by environmental stress imposed by human population growth, urbanization, and agricultural practice (Adeyemo, 2003). Surface and ground water contamination has several known sources with routine agricultural applications of agricultural chemicals recognized as the most significant (Eana and Sridhar, 2004; Subramanian, 2004; Krantz and Kifferstein, 2005 and Mahvi *et al*., 2005). Extensive agricultural activities are reported to cause an increase in the concentration of chemical contaminants in water and the increased nutrient loads in the water bodies leading to rapid growth of aquatic plants and health complications in human beings who use the water for drinking (O'Neill, 1998). Coliform bacteria are most commonly associated with sewage, or surface and groundwater they are used as indicator group to determine the sanitary quality of drinking water. Though most coliform bacteria do not cause illness, their presence in a water system is a public health concern because it suggests that other disease causing organisms may exist in the water. Coliforms are indicator organisms, once they are found in water it simply implies that the water is not safe for human consumption. The most commonly used groups of indicator organisms include coliforms, thermotolerant coliforms, *Escherichia coli* and enterococci (Svanevik, and Bjørn, 2015).

Coliform bacteria are commonly found in the soil, on vegetation and in water. They are also found in the intestine of warm blooded animals. Coliform from animal's wastes can enter directly into water supplies and contaminate the groundwater source thereby rendering it defective (Aboh *et al*., 2015).

Agricultural chemical, as a contributing factor to poor river water quality of River Usuma has been a source of concern to the government of the Federal Capital Territory, Abuja, Nigeria. It is important to establish the extent agricultural chemicals from the farmland affect the health of the river. This will provide a framework for environmental management in relations to agricultural activities around River Usuma watershed. The health of this river is important, as it is the main source of raw water for the Federal Capital Territory Water Board. Deterioration in water quality and health of the river becomes detrimental to the health of the people and translate to increase in cost of treatment of the water. In this paper, river health is taken to mean the degree of similarity to World Health Organization (WHO, 2006) and Federal Environmental Protection Agency, Nigeria (FEPA, 1991) guidelines for surface water irrespective of its use particularly in terms of its water quality. This report highlights data on the impact of the anthropogenic activities including agricultural chemicals used in agricultural practices along the watershed on the physicochemical parameters and bacteriological status of the river. A river is a watercourse flowing freely in a self-developed bed augmented by surface and groundwater. With all its tributaries it forms a river system whose character and development is related to climate, relief, geologic structure, and the dimensions of the basin.

Aims and objectives of the study

The research paper is aimed at assessing the impact of the agricultural chemicals used in agricultural practices along the watershed on the water quality of River Usuma via:

(a) Evaluation of some physical and chemical parameters of Usuma River, in FCT Abuja Nigeria.

(b) Assessment of the bacteriological quality of the river.

MATERIALS AND METHODS

Sampling stations

Three sampling stations were selected and sampling was conducted fortnightly. The sampling stations were divided into three. Three sites were selected for the purpose of this research. These sites are located along the River Usuma catchments. These sites are strategic because they are the main feeder runoffs that feed the River Usuma and eventually fill up the Usuma reservoir. They are the upstream, midstream and downstream, and were designated A, B and C respectively. River Usuma flows through Mpape down to the reservoir in lower Usuma dam.

WATER QUALITY ANALYSIS METHODOLOGY

Sample collection, preservation, and storage

Plastic containers of 2.5 l were used for this collection and were washed with dilute hydrochloric acid (0.05M) so that substances from the plastic containers and their caps do not leach into the sample. This may alter the chemistry of sample. The containers were later rinsed with distilled water and sun dried. Glass wares used were soaked in 1 M Nitric acid overnight in order to remove residues of previous samples (Onianwa and Ajayi, 2001) and vigorously rinsed with tap water and finally with distilled water,(APHA, 2012). The containers were air-dried. At the collection point, containers were rinsed with the water samples twice and filled with samples and then corked tightly.

Sampling devices and containers were thoroughly cleaned to prevent carryover from previous samples.

Preservation of the samples was done according to test-specific information by HACH (2005). The quality of the analytical data was ensured through careful standardization, blank measurements and triplicate samples. All equipment was duly calibrated according to manufacturer's specification. For the validity of the determination procedure, the standard deviation methodology was used. All chemicals used were AnalaR grade (BDH, England). Samples for total dissolved solids (TDS), dissolved oxygen, total alkalinity, total hardness, free carbon dioxide, colour, sulphate, nitrate, and iron were collected manually during period of stable flow in the pre- cleaned polythene bottles with necessary precautions. All the samples were analyzed in the departments of Biological Sciences and Chemistry of the University of Abuja and the Federal Capital Territory Water Board Quality Control Laboratory situated at Lower Usuma Dam.

Collection of water samples

Water samples were collected in the months July to September 2017 (representing wet season) and January to March 2018 (representing dry season). This period covered a hydrological regime. Stratified random sampling technique was used. The water samples were collected weekly from three strategic sites namely the upstream, midstream and downstream along the River Usuma catchments. Sampling was done according to the procedure recommended by Standard methods for examination of water and waste water (APHA, 2012).

PHYSICO-CHEMICAL PARAMETERS

On- site analysis

Water temperature, pH, Dissolved Oxygen, electrical conductivity and total dissolved solids were done in-situ (Agbogu *et al*., 2006). They were measured on the spot using digital multi meter (EXTECH Exstik II EC 500) (APHA, 2012) with the exception of Dissolved Oxygen which was tested using Jenway DO meter model DO2 9150 (Agbogu *et al*., 2006).

Laboratory analysis

Biochemical oxygen demand, nitrate, phosphate, sulphate, total alkalinity content, and total hardness and total iron were analyzed in the laboratory. Biochemical oxygen demand was determined using the 5-day BOD method (APHA, 2012). Nitrate, phosphate, sulphate and total iron were determined with the HACH DR 5000 Spectrophotometer. 10 ml of the replicate samples were prepared by adding the appropriate recommended reagent pillows. The Trimetric method was used to determine total alkalinity content and total hardness (HACH, 2005), (APHA, 2012).

Water sample for bacteriological assessment

Water samples were collected using sterile 250ml borosilicate bottles. At each point of sampling, bottle was opened and immediately immersed in the river to a depth of about 35 cm with its mouth against the water current. The bottle was filled to three quarters its capacity and stoppered immediately to prevent contamination. The sample was then transported to laboratory stored in ice packed coolers. Bacteriological analyses of the samples commenced within three hours of collection.

Bacteriological analysis of the water samples

Heterotrophic plate count (HPC)

The water samples from the various sites were aseptically inoculated onto the dry, sterile surfaces of three nutrient agar (Oxoid) plates per sample, using the spread plate technique and incubated at 37°C for 48 h for aerobic mesophilic bacterial count. The numbers of colony forming units were counted using a digital illumination colony counter (Gallenkamp, UK). The values obtained were multiplied by the dilution factor to get the actual microbial levels. Counts were expressed as colony forming units (CFU) per ml of sample.

Total coliform assessment (TCA)

The Multiple tube fermentation technique was used to assess the total coliform (faecal and non faecal) contents of the water samples (APHA, 2012). Water samples of 0.1 ml, 1 ml and 10 ml of the 10^{-3} dilution from the various sites were inoculated into the fermentation tubes.

This involved the presumptive test using lauryl tryptose broth, confirmatory test using brilliant green lactose bile broth and completed test using brilliant green lactose bile broth simultaneously with EC broth for fecal coliforms. The tubes and plates were incubated at their appropriate temperatures. All isolates that produced gas at 44.5°C were regarded as faecal coliform. The green metallic sheen colonies were also counted as *E. coli* using a digital illumination colony counters (Gallenkamp, UK) and counts were expressed as colony forming units (CFU) per 100ml of sample. Number of positive tubes were recorded and results were reported in terms of the Most Probable Number (MPN) index of coliforms present (APHA, 2012).

Faecal coliform assessment

Ten-fold serial dilution of the water sample was prepared in sterile distilled water. The 10^{-2} dilution was used. From this, 1 ml of sample was aseptically transferred to the centre of a prepared Eosine Methylene Blue (E.M.B) agar. Using a sterile rod, the water dropped was spread evenly on the agar surface. This was duplicated and the plates were incubated at 44.5°C for 24 h. Lactose fermenting colonies formed were counted as faecal coliform in cfu/ml and the value multiplied by the dilution factor to get the actual level of the bacteria in each of the water samples collected.

Faecal Coliform Test

Samples from the presumptive tests were inoculated into EC Broth fermentation tubes containing inverted Durham tubes, and incubated in a water bath at 44.5°C for 24 ± 2 h. Tubes exhibiting gas production and growth within 24 h or less are considered a positive faecal coliform reaction. 1 ml inoculum from gassing tubes of presumptive tests were also spread onto EMB Agar and incubated at 44.5°C for 18-24 h. Lactose fermenting colonies with brilliant green metallic sheen colonies were also counted as faecal coliform (*E. coli)* in cfu/ml and the number obtained multiplied by the dilution factor and expressed as colony forming units (CFU) per 100 ml of sample (APHA, 2012) .

Characterization of bacterial isolates

Holt *et al*. (1994) method was used for the characterization of bacterial isolates. Isolates were observed for growth and morphological characteristics after gram staining. The following biochemical tests were done and isolates were identified. Indole test (Kovac's reagent), Triple sugar iron test (TSI slants), Voges Proskauer Test (peptone), Methyl red test(Buffered glucose broth), Citrate utilization (Simmons Citrate agar), Catalase test (3% hydrogen peroxide), Gram's reaction, Urease test (Christensen Urea agar), Starch hydrolysis (Starch agar), Sugar utilization (Nutrient broth containing 0.5% of fermentable sugars with 0.01% phenol red indicator).

Statistical analysis

All data obtained were analyzed using the SPSS for windows 20 package. The data were subjected to descriptive statistics to assess the impacts at the various levels of sampling. Test of Homogeneity of Variances was also carried out. The analysis of variance (ANOVA) was used to test the mean differences in stations and seasons. Correlation coefficient was employed to assess the degree of relatedness between the physicochemical parameters and coliform density. Bacteriological results were subjected to paired sample T-test for significant differences for wet and dry season.

RESULTS AND DISCUSSION

The physico-chemical parameters analyzed were pH, total Alkalinity, conductivity, total dissolved solids, salinity, temperature, nitrate, sulphate, phosphate, iron, manganese, turbidity, colour, chloride, total hardness, dissolved oxygen, organic matter and biochemical oxygen demand. Parameters such as total alkalinity, conductivity, total dissolved solids, salinity, Nitrate, sulphate, phosphate, iron, manganese, turbidity, colour, chloride ion, total hardness, organic matter and biochemical oxygen demand decreased downstream. Temperature was relatively stable downstream. In the dry season, conductivity (70.2mg/l), total dissolved solids (39.92mg/l), salinity (1.15mg/l), temperature (27.12oC), nitrate (6.3mg/l), manganese(1.18mg/l), turbidity (95.5NTU), colour (120.4PtCo), chloride ion (65.92mg/l) and total hardness(54.3mg/l) were relatively higher Downstream, these values reduced in concentration. This may be attributed to reduction in water volume due to evaporation, increased temperature and increased rate of decaying of vegetation as observed, due to increased microbial activities, high influx of organic load from upstream as well as concentration effect due to reduced flow volume which will increase the concentration of ions present in the water. These are mainly anthropogenic factors. This observation is similar to that made by Babatunde and Hassan, (2015) in their determination of some physicochemical parameters of Adeyemo stream a tributary to river Kaduna, Nigeria.

The levels of nitrate for both wet and dry season were within the WHO (2004) limits for surface water. The nutrient level (phosphate; 0.8-5mg/l,nitrate;25mg/l and sulphate 50 mg/l) was highest at the upstream sites for both seasons and were above the acceptable limits for surface water. This increase in phosphate is related to the 67% of farmers farming in the wet season and 46% of same farmers using inorganic fertilizer. The results of the pH measurement revealed that the water was slightly acidic in the wet season (6.6±0.8) and exhibited trace of alkalinity in the dry season (7.80±0.57). This is not in agreement with Lawal *et al*., (2014) in their Quality Assessment of Kampani River, Plateau State, Nigeria where The results of the pH measurement revealed that the water is slightly alkaline in both seasons due the presence of carbonates of Calcium and Magnesium.

Low acidity (low pH value) was observed upstream. This may be due to the decomposition of refuse, sewage and other organic wastes dumped into the river at that point due to the human settlement. This may be a likely indication of pollution. This point to the high density of

Table 1. Physico-chemical parameters showing seasonal ranges of occurrence and WHO (1996), FEPA (1991) and UNCED (1992) guidelines.

Parameters (mg/l)	W/S	Range	D/S	Range	WHO (mg/l)	FEPA	UNCED
pH	6.6±0.8	5.9-7.4	7.80±0.57	6-8.2	6.5-8.5	6.5-9.0	6.5-9,0
Total Alkalinity	36.3±24.8	30-56	75.48±18.69	30-98	20-200	NS	>200
Conductivity	55.6±9.2	44-69	69.96±4.89	64-74	200-1000	200	NS
TDS	26.5±7.9	20-38	39.68±4.61	34-42	3000	3000	3000
Salinity (PPT)	0.7±0.45	0.09-1.6	1.13±0.34	0.6-1.8	0 - 5 ppt	2000	NS
Temperature(°C)	26.2±0.99	25-27.1	27.12±1.11	25-28	26-30	16-27	NS
Nitrate	2.7±4.86	1.75-6	6.3±0.74	5.8-7.2	25	100	NS
Sulphate	21.7±4.86	16-25	17.8±6.03	8-28	50	1000	NS
Phosphate	11.1±5.7	4-19	14.8±5.5	4-28	0.8 -5	NS	NS
Iron	1.5±0.45	0.3-2.6	1.11±0.32	0.4-1.8	3.0	NS	NS
Manganese	0.5±0.52	0.1-1.8	1.14±0.37	0.2-1.6	0.2	0.2	0.2
Turbidity(NTU)	89.6±17.2	78-98	94.6±22.9	74-170	25-50	NS	NS
Colour (PtCo)	424.5±174	140-645	118.12±92.3	64-400	100-200	NS	NS
Chloride ion	37.25±18.4	28-45	64.64±16.1	34-88	100-200	NS	NS
Total hardness	28.67±14.24	22-46	53.6±8.9	38-66	>130	NS	NS
Dissolved Oxygen	3.16±0.97	1.8-4.6	3.02±1.03	1-4.8	5.0-7.00	8-10	>7.0
OM	5.60±1.6	2.2-7.4	4.55±1.5	1.8-7.4	2-5	NS	NS
BOD	8.7±2.6	5.6-15	7.64±2.5	4.2-16	3.0 – 6.0	10	NS

W/S= wet season, D/S=dry season, mg/l = Milligram per litre, TDS= Total Dissolved Solids, BOD= biochemical oxygen demand, OM=organic matter, NTU= nephelometric turbidity unit, PtCo=PlatinumCobalt , NS= Not seen.

heterotrophic organisms, faecal and total coliforms observed upstream. This trend in pH is in consonance with the observation of Babatunde *et al*., (2014) in the study of the phytoplankton population productivity in Relation to Some physicochemical Parameters of Kudiddiffi-Kubanni stream Zaria, Nigeria. The results of the physico-chemical parameters of the different samples showed that in both seasons,phosphate, manganese, turbidity, dissolved oxygen and biochemical oxygen demand exceeded the WHO guidelines whereas organic matter and colour showed exceedandce in wet season only. The concentrations of the other parameters were within the WHO (2004) guidelines for surface water as shown in (Table 1). Overall, its inferred that metallic, trasprency, nutrient and oxygenation elements are impacting on the river in all seasons. Salinity, sulphate, phosphate, total iron, manganese, dissolved oxygen and Biochemical oxygen demand were shown to be significant within and among stations sampled as indicated in multiple comparisons (Table 2). In both wet and dry season, the ANOVA showed that there was a significant difference ($P<0.05$) in salinity, sulphate, Phosphate, Iron, Manganese, dissolved Oxygen and BOD within and between stations with the exception of organic matter which was only significant in the wet season (Tables 3 and 4).

The result of the paired sample t-test showed no significant difference in the physico-chemical parameters recorded in wet and dry season ($P<0.05$) (Table 5). Correlation analysis was used to determine the degree of relatedness between the physicochemical parameters and the coliform density in MPN. Salinity ($r= .60$, $p<0.05$), Phosphate ($r= .60$, $p<0.05$), Manganese ($r= .70$, $p<0.05$) and biochemical Oxygen Demand ($r= .33$,$p<0.05$) exhibited positive correlation while dissolved oxygen indicated a negative correlation with coliform ($r= -3.49$, $p<0.01$). This means that any increase in dissolved oxygen value will translate to a corresponding decrease in coliform density (Table 6). Figure 3 indicates that there was a higher concentration of fecal coliform in the wet season than in the dry season ranging from 56-174 MPN/100ml in the wet season and 4.0 – 9.0 MPN/100ml in the dry season with a downward reduction trend in both seasons dropping from 174-56 counts/ml in the wet season to 9-4 counts/ml in the dry season. Figure 4 shows that there was a higher concentration of total coliform in the wet season than in the dry season ranging from 175-187.5 MPN/100ml and 62.5 – 81.3MPN/100ml respectively. There is a sudden shoot-up (187.5 in total coliform concentration downstream in the wet season.

Six (6) isolates of bacterial species (Table 4) were identified in the water samples and mostly belong to the *Enterobacteriaceae* Family. They include *E. coli*, *Klebsiella spp*, *pseudomonas spp, Enterobacter spp, Enterococcus spp* and *streptococcus spp.*

The bacteriological data obtained from this study showed high heterotrophic counts in the river.There was a higher concentration of total bacterial concentration in the wet season than in dry season. The counts ranged from 1.9×10^5 cfu/ml– 2.7×10^5 cfu/ml in the wet season and 4.3×10^3cfu/ml-6.9×10^4 cfu/ml in the dry season. In the wet season, there is a transitional

Table 2. Multiple comparisons of significant Physico-chemical parameters of river Usuma for all stations sampled.

Dependent Variable		(I) sampling point	(J) sampling point	Mean Difference (I-J)	Std. Error	Sig.
Salinity	LSD					
			3	0.41250(*)	0.15335	0.013
		3	1	-0.41250(*)	0.15335	0013
Sulphate	LSD	1	2	5.36111(*)	1.61787	0.003
			3	12.50000(*)	1.66477	0.000
		2	1	-5.36111(*)	1.61787	0.003
			3	7.13889(*)	1.61787	0.000
		3	1	-12.50000(*)	1.66477	0.000
			2	-7.13889(*)	1.61787	0.000
Phosphate	LSD	1	2	3.94444(*)	1.36741	0.009
			3	11.50000(*)	1.40705	0.000
		2	1	-3.94444(*)	1.36741	0.009
			3	7.55556(*)	1.36741	0.000
		3	1	-11.50000(*)	1.40705	0.000
			2	-7.55556(*)	1.36741	0.000
Iron	LSD					
			3	0.45000(*)	0.13270	0.003
			3	0.38194(*)	0.12897	0.007
		3	1	-0.45000(*)	0.13270	0.003
			2	-0.38194(*)	0.12897	0. 0007
Manganese	LSD					
			3	0.58750(*)	0.14337	0.000
			3	0.45417(*)	0.13933	0.004
		3	1	-0.58750(*)	0.14337	0.000
			2	-0.45417(*)	0.13933	0.004
Dissolved oxygen	LSD					
			3	-1.17500(*)	0.46880	0.020
		3	1	1.17500(*)	0.46880	0.020
Organic matter	LSD					
			3	1.66250(*)	0.69166	0.025
		3	1	-1.66250(*)	0.69166	0.025
Bio chemical oxygen demand	LSD	1	2	2.44028(*)	0.76010	0.004
			3	5.00000(*)	0.78214	0.000
		2	1	-2.44028(*)	0.76010	0.004
			3	2.55972(*)	0.76010	0.003
		3	1	-5.00000(*)	0.78214	0.000
			2	-2.55972(*)	0.76010	0.003

*The mean difference is significant at the 0.05 level.*values (parameters) with significant difference at P<0.05.

Table 3. Analysis of variance of Physico-chemical parameters of river Usuma for dry season.

Parameters		Sum of Squares	DF	Mean Square	F	Sig. 0.05
Salinity	Between Groups	0.681	2	0.341	3.621	0.044*
	Within Groups	2.069	22	0.094		
	Total	2.750	24			
Sulphate	Between Groups	629.551	2	314.776	28.394	0.000*
	Within Groups	243.889	22	11.086		
	Total	873.440	24			
Phosphate	Between Groups	547.778	2	273.889	34.585	0.000*
	Within Groups	174.222	22	7.919		
	Total	722.000	24			
Total Iron	Between Groups	0.952	2	.476	6.756	0.005*
	Within Groups	1.550	22	.070		
	Total	2.502	24			
Manganese	Between Groups	1.529	2	0764	9.298	0.001*
	Within Groups	1.809	22	0.082		
	Total	3.338	24			
Dissolve oxygen	Between Groups	6.022	2	3.011	3.425	0.051*
	Within Groups	19.340	22	0.879		
	Total	25.362	24			
Biochemical oxygen demand	Between Groups	100.021	2	50.010	20.438	0.000*
	Within Groups	53.833	22	2.447		
	Total	153.854	24			

*values (parameters) with significant difference at P<0.05.

Table 4. Analysis of variance of physico-chemical parameters of river usuma for wet season.

Parameters		Sum of Squares	df	Mean Square	F	Sig.
Salinity	Between Groups	2.424	2	1.212	7.633	.001**
	Within Groups	7.144	46	0.159		
	Total	9.568	48			
Sulphate	Between Groups	29.020	2	0.645	17.800	0.000**
	Within Groups	31.932	46	13.782		
	Total	1110.813	48			
Phosphate	Between Groups	967.530	2	483.765	39.721	0.000**
	Within Groups	548.064	46	12.179		
	Total	1515.595	48			
Total Iron	Between Groups	2.057	2	1.028	5.907	0.005**
	Within Groups	7.833	46	0.174		
	Total	9.890	48			
Manganese	Between Groups	2.794	2	1.397	6.410	0.004**
	Within Groups	9.806	46	0.218		
	Total	12.600	48			
Dissolved oxygen	Between Groups	9.653	2	4.826	6.196	0.004**
	Within Groups	35.054	46	0.779		
	Total	44.707	48			
Organic matter	Between Groups	29.580	2	14.790	6.872	0.002**
	Within Groups	96.854	46	2.152		
	Total	126.435	48			
Biochemical oxygen demand	Between Groups	215.515	2	107.758	47.992	0.000**
	Within Groups	101.039	46	2.245		
	Total	316.555	48			

*Reveals that there is some level of significance (t (P<0.05)) difference. ** shows that the metal and other requirements are significant (P<0.05) in quantity or in activity.

Table 5. Comparative analysis of physic-chemical parameters in the wet and dry season paired samples test.

		Paired Differences					t	Df	Sig.(2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	wet season - dry season	-6.93944	23.53549	5.54737	-18.64337	4.76448	-1.251	17	0.228

The result showed no significant difference in the physic-chemical parameters recorded in wet and dry season (P<0.05).

Table 6. .Correlation coefficient between physico-chemical quality and coliform density.

	Salinity	Sulphate	Phosphate	Iron	Manganese	Dissolved oxygen	Organic matter	Bio chemical oxygen demand	MPN index for coliforms
Salinity	1	.							.
Sulphate	0.245	1		.			.		
Phosphate	0.635(**)	0.381(**)	1		.			.	.
Iron	0.138	0.485(**)	0.202	1				.	.
Manganese	0.471(**)	-0.033	0.677(**)	-0.261	1			.	
Dissolved oxygen	-0.215	-0.301(*)	-0.220	-0.460(**)	-0.151	1	.		
Organic matter	0.139	0.357(*)	0.143	0.634(**)	-0.047	-0.755(**)	1		
Bio chemical oxygen demand	0.417(**)	0.679(**)	0.593(**)	0.405(**)	0.286(*)	-0.287(*)	0.302(*)	1	.
MPN index for coliforms	0.551(**)	0.265	0.613(**)	0.029	0.663(**)	-0.349(*)	0.037	0.333(*)	1

KEYS: MPN= Most Probable Number
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

decrease up to midstream and a sudden upsurge downstream from 1.9X 10^5 cfu/ml- 2.59× 10^5cfu/ml. While in the dry season, there was a continuous decrease downstream of river strip (Table 7). There was no significant difference (p<0.05) between the total bacteria count of the wet and dry season.

Table 7. Heterotrophic plate count (cfu/ml).

	WET SEASON	DRY SEASON
UPSTREAM	$2.73X\ 10^5$	$6.96X10^4$
MIDSTREAM	$1.91X10^5$	$6.48X10^4$
DOWNSTREAM	$2.59X10^5$	$4.3X10^4$

Tables 8 and 9 showed that most isolated organisms; *Escherichia coli*, *Klebsiella* sp., *Pseudomonas* sp., *Proteus* sp., *Enterococcus* sp. *and Streptococcus* sp. are indicator organisms. Most of the isolates are pathogenic. Total coliforms correlated positively with salinity, pH, manganese, dissolved oxygen and biochemical oxygen demand. There was a sharp increase in most parameters upstream (Figures 1 and 2). Figure 1 indicates that transparency variables (Turbidity and colour) showed a significant escalation in all stations sampled.

Figure 2 showed that in the dry season, there was also a downward trend in reduction in concentration of parame ters analysed from upstream to downstream and also present a similar cascading pattern in physico-chemical parameters. The results of the physico-chemical parameters of the different samples showed that in both seasons, Phosphate, manganese, turbidity, dissolved oxygen and biochemical oxygen demand exceeded the WHO guidelines whereas organic matter and colour showed exceedandce in wet season only. The concentrations of the other parameters were within the WHO, (2004) guidelines for surface water. Overall, its inferred that metallic, transparency, nutrient and oxygenation elements are impacting on the river in all seasons. The results of physicochemical analyses of river Usuma is at variance with the observation of Aremu *et al*., in their assessment of physicochemical contaminants in waters and fishes from selected Rivers in Nasarawa State, Nigeria which is within the same geographical region showing that phosphate and nitrate ions were not present in the water samples during dry season. Total iron and manganese varied significantly in both seasons and stations. This may be due to various factors such as trace metal contents of all the soil and crops, geographical location, fertilizers and fungicides applied in the area, environmental pollutions due to automobile emissions, industrial effects, other agricultural activities and weathering of rocks (Abulude *et al.,* 2007). The dissolved oxygen is below the WHO requirement for surface water (5 8mg/l); slightly highest in the wet season than the dry season. This corresponded with the concentration of organic matter and biochemical oxygen demand, which are 5.6mg/l and 8.7mg/l for wet season and 4.7mg/l and 7.8mg/l for dry season respectively. It is common to observe high organic matter in water after a rain storm as observed by Agbogu et al. (2006). Dissolved oxygen is often used as an indicator of environmental stress on aquatic life, reflecting the impact of human activities such as discharging pollutants into streams, estuaries and the sea on aquatic flora and fauna (Brady and Weil, 1999). The river is not oxygen balanced. BOD and organic matter were within the WHO acceptable limits for surface water. The high turbidity and colour recorded were higher than the limits for surface water (15PtCo) and may either increase cost of water treatment or inhibit the effectiveness of disinfection of water and also makes the river unaesthetic (Reiff, 1987; Mbajiorgu, 2003). The upstream section had higher concentrations for both seasons indicative of the impact of the agricultural chemicals. There is also a likely contribution from the dense settlement at Mpape. These values are above the acceptable limits for surface water. Parameters Such as total alkalinity, conductivity, total dissolved solids, salinity, nitrate, sulphate, phosphate, iron, manganese, turbidity, colour, chloride ion, total hardness, organic matter and biochemical oxygen demand decreased downstream due to self purification of river and decrease in activities downstream. Temperature was relatively stable downstream. The sharp increase in most parameters upstream was as a result of decrease in dilution by tributaries and increase in agricultural runoff from farms upstream (Izonfuo and Bariweni, 2001). This implies that impact of agricultural activities on the quality of the river is significant. It is common to observe high organic matter in water after a rain storm (Agbogu et al., 2006). Dissolved oxygen is often used as an indicator of environmental stress on aquatic life, reflecting the impact of human activities such as discharging pollutants into streams, estuaries and the sea on aquatic flora and fauna (Brady and Weil, 1999).

Based on the (WHO, 2004) guidelines for coliform;(0 counts /100 ml faecal and 0-200 for surface water, the water from the river is not suitable for direct domestic use and may pose a health risk to those in Mpape who may use it directly for consumption and other domestic usage as well as other users along the river-catchments communities. They are exposed to a higher risk of gastrointestinal infection during both seasons as a result of full-contact recreation or direct consumption of untreated water or consumption of vegetables directly without cooking. Highest density of total coliforms was observed upstream in both seasons. This may be attributed to contributions from peri-urban- and urban runoffs from informal settlements at Mpape where majority of the settlement lack proper sanitation (Fatoki et al., 2001).

Carcasses of dead animals and human faeces are washed into the river during rains (Agbogu et al., 2006). Most isolated organisms are indicator organisms (APHA, 2012) and pathogenic. This was similar to the observations of Aliyu et al. (2016). The faecal coliform density in River Usuma exhibited the highest counts in the wet season.

This is similar to the findings of Oyeleke, (2008) who had also observed that wet months recorded the highest counts of microorganisms in the various sampling points on river Kaduna.

Table 8. Biochemical characterization of bacteria isolated from river Usuma, FCT Abuja.

MORPHOLOGICAL CHARACTERISTICS			BIOCHEMICAL REACTION									SUGAR FERM			A
Bacterial Code	**Gram's Reaction**	**Shape**	**MR Test**	**VP Test**	**Citrate**	**Catalase**	**Starch hydrolysis**	**Indole test**	**Urease test**	**Growth at 37oc**	**Growth on EMB**	**Growth on NA**	**Lactose**	**Glucose**	**Sucrose**	**PROBABLE IDENTITY**
U1	-	R	+	-	-	-	-	+	-	+	GMS	+	+	+	AG	*Escherichia coli*
U2	-	R	-	+	+	-	-	-	+	+	+	+	+	+	+	*Klebsiella sp*
U3	-	R	-	-	-	-	+	-	+	+	-	+	-	+	-	*Pseudomonas sp.*
M1	-	R	+	+	+	-	-	+	+	+	+	+	-	+	-	*Proteus sp*
M2	+	C	-	+	-	-	-	-	-	+	+	+	+	+	-	*Enterococcus sp.*
M3	-	R	+	-	-	-	-	+	-	+	GMS	+	+	+	AG	*Escherichia coli*
D1	+	C	-	+	-	-	-	-	-	+	+	+	+	+	-	*Enterococcus sp.*
D2	+	C	-	-	-	-	-	-	-	+	+	+	-	+	-	*Streptococcus sp.*
D3	-	R	-	-	-	+	+	-	+	+	-	+	-	+	-	*Pseudomonas sp.*
D4	-	R	-	+	+	-		+	+	+	+	+	+	+	AG	*Enterobacter spp*

GMS = Green Metallic Sheen, A = acid, AG = Acid/Gas, + = Positive, - = Negative, R = Rod, C=*Cocci*

Table 9 Triple sugar iron test.

Suspected organism	slant	butt	gas	H_2S
Shigella	Alk	A	-	-
Pseudomonas	Alk	Alk	-	-
Escherichia,	A	A	+	-
Klebsiella,	A	A	+	-
Enterobacter	A	A	+	-
Proteus	Alk	A	+	+

A= Acid, Alk=Alkaline, - = Negative , += Positive

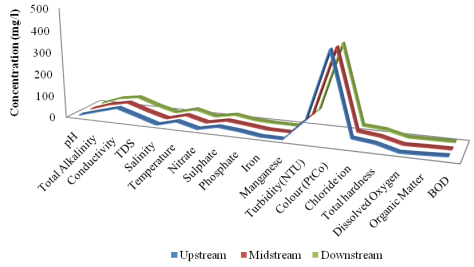

Figure 1. Physico-chemical result for wet season at all sampling points. Key: Mg/l = Milligram per litre, TDS= Total Dissolved Solids, BOD= Biochemical Oxygen Demand.

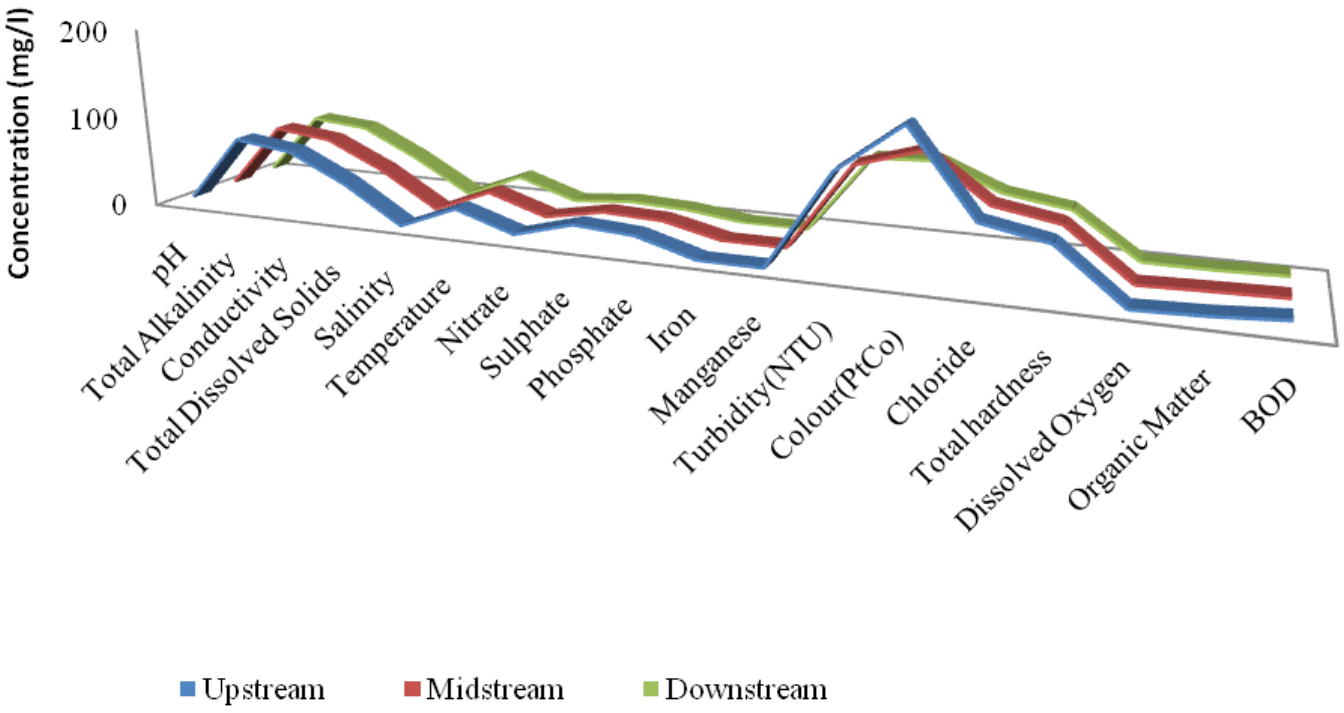

Figure 2. Physicochemical result for dry season at all sampling points.

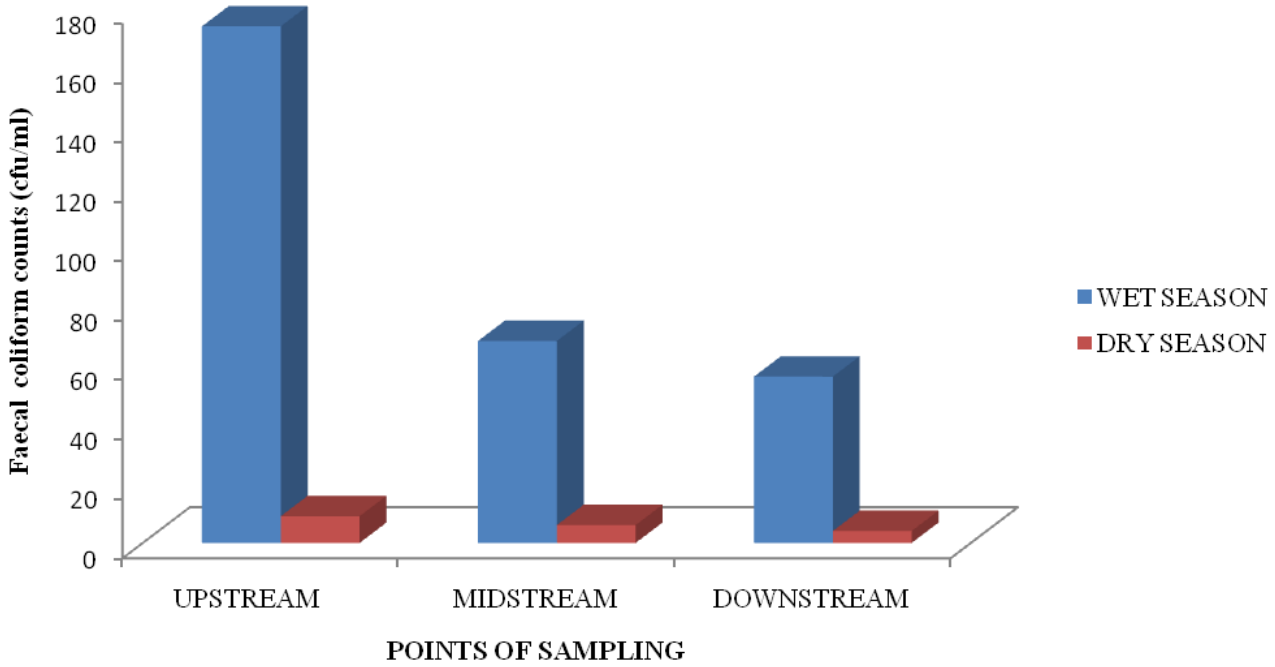

Figure 3. Estimation of faecal coliforms from the water samples.

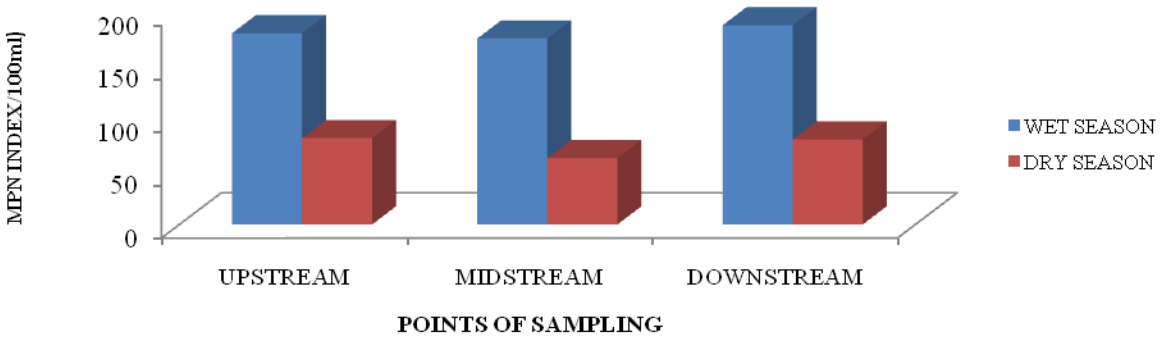

Figure 4. Estimation of total coliform.

Conclusion

The results show that the River Usuma has a self purification ability However, it is not fit for human consumption without treatment; which must as a matter of importance include disinfection for decimation of pathogens. The level of inorganic fertilizer and pesticides used need to be regulated as these could have an overwhelming consequence in the near future. Some of the physicochemical parameters of the water quality tested complied with the WHO (2006), UNCED (1991) and FEPA (1991) guidelines. The pollution level of the river is not high. Impact of agricultural chemicals on the health of this river is moderate but needs to be regulated. Regular monitoring is recommended. The dense settlement upstream may be contributing to the organic load of the river. If this is not checked, there is likely to be a case of eutrophication in the near future. This would imply increase in intensity of plant-related water quality problems and corresponding increase in water treatment cost implication.

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