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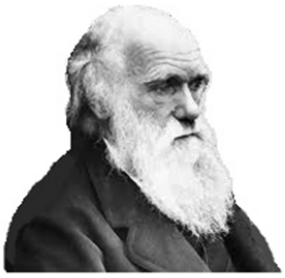

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Seasonal variations of physicochemical characteristics of water from River Wupa, Abuja, Nigeria

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ABSTRACT

Seasonal variation in the quality of water from River Wupa, Abuja, Nigeria was studied by collecting sixty water samples in both dry and wet seasons which were analyzed using standard methods. The respective results for in dry and wet seasons were pH (7.13±0.09, 7.31±0.06), temperature (21.51±0.51, 27.66±0.49 ºC), EC (247.19±46.21, 152.43±17.76 µS/cm), TDS (156.80±39.74, 75.39±9.23 mg/dm^3), TSS (33.38±14.12, 333.85±43.45 mg/dm^3), turbidity (26.20±13.04, 361.51±52.89 NTU), alkalinity (34.49±4.12, 29.31±3.78 mg/dm^3), DO (7.73±0.29, 8.95±0.87 mg/dm^3), BOD (17.00±4.90, 15.70±2.98 mg/dm^3), COD (40.36±14.01, 28.28±8.18 mg/dm^3), hardness (33.74±2.10, 34.82±3.82 mg/dm^3), sulphate (41.09±1.01, 28.82±1.05 mg/dm^3), nitrate (12.12±2.02, 12.23±1.78 mg/dm^3), nitrite (0.08±0.02, 0.06±0.02 mg/dm^3), phosphate (2.09±0.33, 2.15±0.35 mg/dm^3) and chloride (40.96±3.53, 32.23±3.82 mg/dm^3). Correlation results shows that during the dry season there is a strong and positive correlation between (EC and TDC, r =0.910), (TSS and Turbidity, r = 0.976), (TSS and BOD, r = 0.945), (TSS and COD, r = 0.912), (Turb and BOD, r = 0.868), (Turbidity and COD, r = 0.820), (BOD and COD, r = 0.979), (pH and nitrite, r = 0.750) (pH and Cl, r = 0.737), (TSS and Cl, r = 0.748) and (Turb and Cl, r = 0.761). During the wet season strong and positive correlation is between (EC and TDS, r = 0.879), (BOD and COD, r = 0.756) and (Turbidity and sulpate, r = 0.730). Results for all parameters were below the limits recommended by NSDWQ except for turbidity, DO and phosphate, also in both seasons there was no significant difference for all parameters except for turbidity and COD. It is concluded that the variation in these two parameters is attributable to runoffs from farmlands and

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direct discharge of domestic and industrial effluent during the wet season and the strong and positive correlation indicates that the pollutants that affect water quality parameters come from the same sources.

***Keywords*:** Seasonal, variations, anthropogenic, water quality, physicochemical, correlation, pollutants, runoff, wet season, dry season

1. INTRODUCTION

A large portion of the earth's surface is covered by water, at least about 71% (Tirthesh and Ramendra, 2016). Water is an important component of the environment, so much so that it is one of the most important requirements for human and industrial development (Okake and Igboanua, 2003).

In natural lotic ecosystems, different physical and chemical parameters occur in low concentrations. However, the concentrations of these physicochemical (physical and chemical) parameters increase as a result of some factors; increased urbanization, rapid population growth, and exploitation of natural resources (Mehedi *et al*., 1999). According to Raji *et al*. (2016), natural water bodies (rivers) could be contaminated in several ways; discharge of industrial effluents, agricultural practices, and domestic wastes. These have been the usual practice in densely populated areas in third world countries, Nigeria inclusive. This affects water quality and therefore, has become an issue of serious concern over the years because the quality of water which is directly linked to the health of the water body is also directly linked to human health (Tirthesh and Ramendra, 2016).

Both natural processes (precipitation and weathering process) and anthropogenic activities (domestic sewage, industrial pollution, and agricultural practices), all affect the quality of water (Varol *et al*., 2011). The levels of contaminants in surface water bodies like loctic aquatic ecosystems vary with the season due to variations in precipitation (Temesgen and Seyoum, 2018).

Seasonal changes or variations in water quality simply mean changes or variations in components of water that hitherto are to be present at optimum levels for the good growth of plants and animals. These components of water are not only important but also crucial to the growth of both plants and animals in the aquatic ecosystem (Raji *et al*., 2016, Tirthesh and Ranmendra, 2016). Regular and periodic changes with regards to climate reflect in environmental quality parameters and that in turn influences the population of plankton as much as other living organisms. The distribution of abiotic and biotic processes in seasons influences the nutrient cycles of the different aquatic environments (Choudhury and Panigraphy, 1991). There have several research works on seasonal variations of the physicochemical characteristics of surface water bodies and these include; Frenette and Assani (2018), Suravi *et al*. (2013), Kadarshahib and Sundaraj (2014), Ladipo *et al*. (2011), and a host of others.

River Wupa runs through the Federal Capital Territory, Abuja, Nigeria. It receives wastewater from Wupa power station. Along the length of the river at different points, it serves different purposes. These range from serving as points of discharge for domestic sewage, industrial effluents, and agricultural runoffs as well to the water from the river being used for domestic and industrial purposes and also for irrigation agriculture. This research work aims to assess the effect of seasonal variation on water quality (physicochemical characteristics) during the dry and wet seasons. The objectives of this research work are; 1.

To assess the physicochemical parameters of water from River Wupa and 2. To establish if there is a significant difference between these parameters in the different seasons.

2. MATERIAL AND METHODS

2. 1. Study Area

River Wupa is the loctic ecosystem that was studied and it is located in Federal Capital Territory, Abuja, Nigeria. Abuja lies on latitude 8º58'30" to 9º7'30"N and longitude 7º19'30" to 7º31'30"E. River Wupa originates from Aso Rock in Abuja and runs through the metropolis down to Wuye District. The river receives heavy inflows of wastes from both point and non point source discharges most especially during the wet season. During the dry season the water from the river is used for irrigation and fishing also takes place along the river. Different human activities take place along the river bank from car wash, block moulding, and auto mechanic workshops. Domestic wastes, industrial wastes, and runoff from irrigation farmlands are constantly discharged into the water body.

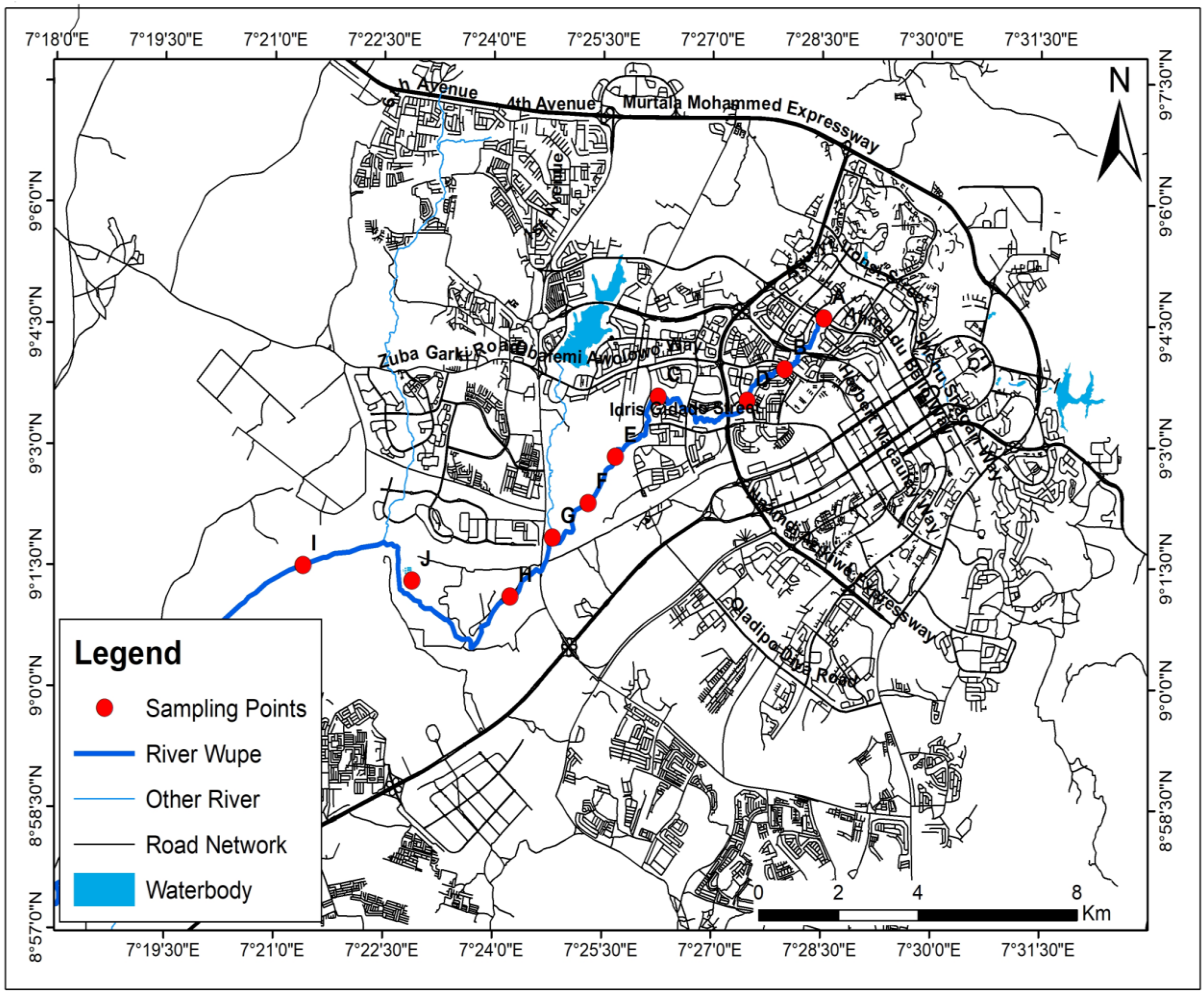

Figure 1. Map of Federal Capital Territory, Abuja showing River Wupa

2. 2. Sample Collection and Preparation

Water samples were collected in two different seasons: January 2023 for the dry season and September 2023 for the rainy season. A total number of sixty water samples were collected; from ten points at a distance of about 3 km and the samples were taken 5.0 cm below the water surface (to reduce the contamination of the water sample through surface films). Each sample was taken into prewashed 1.0 dm^3 plastic bottle. The sample was filtered through 1.0 mm Whatman filter paper using a vacuum pump to remove particulate matter, and preserved in the refrigerator pending analysis.

2. 3 Determination of Physicochemical Characteristics

pH, Temperature, EC, TDS, and DO were determined at the point of collection of the samples. The temperature was determined using the thermometer. pH was determined using a hand-held pH meter (JENWAY 430). HANNA digital model pH/conductivity/TDS meter (Model No. HI2550 Digital) was used for the determination of EC and TDS. DO was determined using a DO meter, DO 150 (Model No. 50150), and a five-day BOD test method 521.0 was used to determine the BOD. Turbidity was determined using a turbidimeter (Model No. HACH2100Q). TSS was determined using the gravimetric method of analysis and total alkalinity, total hardness, COD, sulphate, and chloride were determined using a titrimetric method of analysis. Nitrate and nitrite were determined using spectrophotometric method while phosphate was analysed with photometer method.

3. RESULTS AND DISCUSSION

Table 1 shows the summary of the physicochemical parameters during dry and wet seasons for water samples from River Wupa, Abuja, Federal Capital Territory. The summary is in ranges for all the parameters from the minimum values to the maximum values. The Table also shows the mean values for all the physicochemical parameters for the dry and wet seasons, standard deviation, and coefficient of variation (variability amongst the parameters). The correlation matrices for physicochemical parameters in water from Wupa River are presented in Tables 2 and 3 for dry and wet seasons respectively.

Table 1. Seasonal variation in the physicochemical parameters of water samples from River Wupa, Abuja

Parameters	Dry Season					Wet Season					NSDWQ (2007)	(P<0.05)
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV (100%)		
pH	7.01	7.29	7.13	0.09	1.23	7.24	7.43	7.31	0.06	0.81	6.50 – 8.50	0.564
Temp (°C)	20.70	22.10	21.51	0.51	2.35	26.70	28.30	27.66	0.49	1.76	Ambient	0.482
EC (µS/cm)	172.20	293.00	247.19	46.21	18.70	121.60	176.40	152.43	17.76	11.65	1000.00	0.096
TDS (mg/dm^3)	102.00	207.00	156.80	39.74	25.35	62.00	86.50	75.39	9.23	12.24	500.00	0.801

TSS (mg/dm^3)	15.90	65.00	33.38	14.12	42.31	287.00	430.00	333.85	43.45	13.01	30.00	0.053
Turbidity (NTU)	11.00	58.00	26.20	13.04	49.76	299.00	492.00	361.50	52.89	14.63	5.00	0.000
T. Alkalinity (mg/dm^3)	27.50	38.90	34.49	4.12	11.96	23.70	35.00	29.31	3.78	12.90	100	0.498
D.O (mg/dm^3)	7.00	8.00	7.73	0.29	3.77	7.00	9.87	8.95	0.87	9.71	5.00	0.035
BOD (mg/dm^3)	10.00	25.00	17.00	4.90	28.82	12.00	20.00	15.70	2.98	19.00	-	0.023
COD (mg/dm^3)	15.50	60.10	40.36	14.01	34.72	14.60	45.00	28.28	8.18	28.93	-	0.000
T. Hardness (mg/dm^3)	30.40	36.50	33.74	2.10	6.22	28.00	40.00	34.82	3.38	9.70	-	0.334
Sulfate (mg/dm^3)	39.90	42.70	41.09	1.01	2.45	27.60	30.80	28.82	1.05	3.63	100.00	0.327
NO_3^- (mg/dm^3)	10.00	15.00	12.12	2.08	17.15	9.00	15.00	12.23	1.78	14.58	50.00	0.288
NO_2^- (mg/dm^3)	0.05	0.10	0.08	0.02	20.76	0.03	0.09	0.06	0.02	29.38	0.20	0.933
Orthophosphate (mg/dm^3)	1.70	2.70	2.09	0.33	15.70	1.80	2.70	2.15	0.35	16.15	-	0.904
Chloride (mg/dm^3)	37.00	49.00	40.96	3.53	8.61	27.90	38.00	32.23	3.82	11.84	250.00	0.987

SD = Standard Deviation, CV = Coefficient of Variation

The mean values of pH for water samples from River Wupa, Abuja were 7.13±0.09 and 7.31±0.0 during the dry and wet seasons respectively. These values are in the same range and so are not significantly different and this was confirmed by the value 0.564 ($p<0.05$). This slightly basic pH could be attributed to wastewater discharges consisting of surfactants from residential and commercial activities, plus the use of concrete in the border and bed of the river in some areas which tend to increase the pH value of the surface water in both seasons (Mena Rivera *et al.*, 2017).

Water samples from River Wupa, Abuja had mean temperature values of 21.51±0.51 and 27.66±0.49 ºC during the dry and wet seasons respectively. The mean temperature of water samples during the wet season is slightly higher than that of the dry season and this could be attributed to variations in the landscape which contribute to the pattern in temperature change of the river, where protected riparian zones have been reduced, resulting in increased surface water temperature (Mena Rivera *et al.*, 2017) as well as lower temperatures of water during the dry season which could probably be due to the Harmattan cold which causes the water temperature to reduce (Makwe and Chup, 2013). However, the statistical analysis which shows 0.482 ($p<0.05$) indicates that there was no significant difference in water temperatures between the two seasons.

The mean electrical conductivity values for water samples from River Wupa, Abuja in the dry and wet seasons were 247.19±46.21 and 152.43±17.76 µS/cm respectively. Most of the conductivity values from dry season samples are a little higher than the ones for the wet season. This could be traced to the run-offs that are discharged into the receiving water at different points during the wet season which increases the volume of water in relation to the total dissolved solids during the wet season.

Table 2. Correlation matrix for physicochemical parameters of water in dry season

Parameters	pH	Temp	EC	TDS	TSS	Tub	T. Alk	DO	BOD	COD	T. Hard	Sulf	Nitrate	Nitrite	O-Phos	Cl
pH	1.00															
Temp	-0.05	1.00														
EC	0.393	0.234	1.00													
TDS	0.208	0.290	**0.910**	1.00												
TSS	0.674	0.237	0.105	0.010	1.00											
Tub	0.688	0.313	0.252	0.105	**0.976**	1.00										
T. Alk	-0.117	0.096	-0.170	-0.327	-0.347	-0.251	1.00									
DO	0.324	-0.437	0.017	-0.026	0.133	0.094	-0.420	1.00								
BOD	0.585	0.085	-0.031	-0.034	**0.945**	**0.868**	-0.539	0.237	1.00							
COD	0.473	0.190	-0.098	-0.050	**0.912**	**0.820**	-0.555	0.096	**0.979**	1.00						
T. Hard	-0.609	-0.219	-0.507	-0.249	-0.404	-0.488	-0.142	0.342	-0.172	-0.153	1.00					
Sulf	0.609	0.203	0.020	0.047	0.396	0.365	0.107	-0.102	0.394	0.406	-0.290	1.00				
Nitrate	-0.103	0.537	0.099	-0.086	0.149	0.277	0.276	-0.198	-0.037	-0.016	-0.247	0.043	1.00			
Nitrite	**0.750**	0.192	0.294	0.295	0.640	0.602	-0.126	-0.164	0.560	0.560	-0.632	0.591	-0.296	1.00		
O-Phos	0.375	0.146	0.557	0.357	0.015	0.179	0.301	0.364	-0.151	-0.281	-0.178	0.195	0.477	-0.105	1.00	
Cl	**0.737**	0.337	0.148	-0.042	**0.748**	**0.761**	-0.125	0.350	0.598	0.538	-0.495	0.365	0.304	0.524	0.336	1.00

Table 3. Correlation matrix for physicochemical parameters of water in wet season.

Parameters	pH	Temp	EC	TDS	TSS	Tub	T. Alk	DO	BOD	COD	T. Hard	Sulf	Nitrate	Nitrite	O-Phos	Cl
pH	1.00															
Temp	0.249	1.00														
EC	0.617	-0.346	1.00													
TDS	0.564	-0.024	**0.879**	1.00												
TSS	-0.144	-0.371	0.145	-0.060	1.00											
Tub	-0.062	0.018	0.030	0.187	0.579	1.00										
T. Alk	0.526	0.451	-0.086	-0.097	-0.280	-0.086	1.00									
DO	-0.465	-0.307	-0.370	-0.490	0.115	-0.280	-0.318	1.00								
BOD	-0.447	-0.372	0.055	0.060	0.605	0.379	-0.633	0.131	1.00							
COD	-0.299	-0.165	-0.174	-0.075	0.600	0.685	-0.391	0.198	**0.756**	1.00						
T. Hard	0.041	-0.108	0.023	-0.106	0.035	-0.148	0.210	0.468	-0.124	-0.214	1.00					
Sulf	-0.128	-0.031	-0.169	-0.152	0.481	**0.730**	0.226	-0.398	0.128	0.419	-0.428	1.00				
Nitrate	-0.266	-0.088	-0.118	-0.099	0.028	0.262	0.312	-0.074	-0.017	-0.134	0.575	0.233	1.00			
Nitrite	0.235	0.084	0.544	0.529	-0.075	-0.228	0.134	-0.275	-0.252	-0.554	-0.030	-0.108	0.060	1.00		
O-Phos	-0.128	0.170	-0.433	-0.481	0.504	0.503	0.402	0.179	-0.123	0.293	0.148	0.660	0.279	-0.141	1.00	
Cl	-0.379	-0.156	-0.412	-0.368	-0.500	-0.376	0.146	0.209	0.069	-0.022	0.078	-0.145	0.290	-0.340	-0.255	1.00

Whereas during the dry season the volume of water reduces and the total dissolved solids concentrate thereby increasing the electrical conductivity. This agrees with the report of Makwe and Chup (2013). However, the statistical analysis which shows 0.096 ($p<0.05$) indicates that there was no significant difference in water temperatures between the two seasons

The mean values for total suspended solids and total dissolved solids are 33.38±14.13, 333.85±43.45 and 156.80±39.74, 75.39±9.23 mg/dm^3 during the dry and wet seasons respectively. The difference in the mean value of TSS obtained during the wet season compared to that obtained during the dry season and TDS mean value during the dry season being higher than that during the wet season could be attributed to the fact that during the wet season the volume of water increases reducing the TDS but with increased TSS because of the runoff that is discharged into the River Wupa with a lot of suspended materials whereas during the dry season the volume of water reduces and the total dissolved solids concentration and little suspended materials due to lack of runoff. For TSS and TDS there is no significant difference between the season as shown by the respective TSS and TDS statistical values 0.053 and 0.801 ($p<0.05$).

The mean turbidity values recorded for samples of water from River Wupa during the dry and wet seasons were 26.30±13.04 NTU and 361.5±52.89 NTU respectively. The turbidity of the water during the wet season was found to be far higher than the value of turbidity during the dry season and this is shown by the statistical value of 0.00 ($p<0.05$) which is an indication of a significant difference in turbidity of River Wupa water between dry and wet seasons. Material that causes water to be turbid includes clay, silt, finely divided inorganic and organic matter, algae, soluble colour organic compounds, and plankton and other microscopic organisms (Sharma and Singh, 2016). These are normally part of the runoff waters that the River Wupa receives during the wet season hence, its higher turbidity during the wet season.

The River Wupa water had mean total alkalinity values 34.46±4.12 and 29.31±3.78 mg/dm^3 $CaCO_3$ for the dry and the wet seasons respectively. The value for the dry season is slightly higher than that for the wet season and this is indicated in the statistical value 0.498 ($p<0.05$) which explains that for the alkalinity of water from River Wupa there was no significant difference between the two seasons. However, the slight difference in alkalinity could be attributed to the reduced volume of water due to the drying up of water during the dry season. The report from this study agrees with the mean value of total alkalinity of water sources from Benue State reported by Ocheri and Ahola (2012).

The mean values of dissolved oxygen of the River Wupa in Abuja were 7.73±0.29 and 8.95±0.87 mg/dm^3 in dry and wet seasons respectively. The DO level in water during the wet season in this study was higher than the value recorded in the dry season. This seasonal difference is revealed in the statistical value 0.035 ($p<0.05$) which explains that for the DO of water from River Wupa there was a significant difference between the two seasons.

This could be attributed to waste discharges high in organic matter and nutrients which invariably increases microbial activity occurring during the organic matter degradation which was on the high side in the dry season as a result of concentration whereas the volume of water increases during the wet season and there is also the contribution of photosynthesis during this period to the amount of DO.

The report for DO from this study agrees with the reports by Omonona *et al*. (2017) and Adetuga *et al*. (2019) for Omo Forest Reserve and Old Oyo National Park respectively which showed that DO in water was higher during the wet season than the value recorded during the dry season.

The BOD for water from River Wupa, Abuja had values 17.00±4.90 and 15.70±2.98 mg/dm^3 in the dry and wet seasons respectively. The BOD level in water during the dry season in this study was higher than the value recorded in the wet season. The seasonal difference is indicated in the statistical value 0.023 ($p<0.05$) which explains that for the BOD of water from River Wupa there was a significant difference between the two seasons. This could be attributed to the reduced volume of water due to drying up and the quantity or amount of organic contaminants that would go with a very high level of microbial activities with the eventually reduced levels of oxygen in water being on the increase (Uzoekwe and Oghosanine, 2011).

The values of COD for water from River Wupa were 40.36±14.01 and 28.28±8.18 mg/dm^3 in dry and wet seasons respectively. The COD level in water during the dry season was higher than the value observed in the wet season. The seasonal difference is shown in the statistical value 0.00 ($p<0.05$) which explains that for the COD of water from River Wupa there was a significant difference between the two seasons. This could be explained by the fact that during the dry season the level of water would have dried up with a high amount of oxidizable organic material with a high oxygen demand compared to what is obtainable during the wet season when there is dilution due to increased volume of water. This high level of COD during the drying season in this study is similar to the report by Omonona *et al*. (2019) which showed the COD for water from Borgu Sector of Kainji Lake National Park, Nigeria was found to be higher in the dry season than in the wet season Total hardness values for water from River Wupa were 33.74±2.10 and 34.82±3.38 mg/dm^3 in dry and wet seasons respectively. The value recorded in the wet season is slightly higher than that for the dry season, however, from the statistical value 0.334 ($p<0.05$), there was no significant difference in the value of total hardness between dry and wet seasons. The difference could be as a result of the solvent action of rainwater that comes in contact with soils and rocks which is capable of dissolving calcium and magnesium that promote water hardness. The slightly higher value hardness of in the wet season compared to the dry season is similar to the report presented by Ocheri and Ahola (2012) for total hardness in groundwater sources in Benue State, Nigeria.

The mean values of sulphate from River Wupa water samples during the dry and the wet seasons were 41.09±1.01 and 28.8±1.05 mg/dm^3 respectively. The value for the dry season was higher than that for the wet season. The difference could be attributed to the reduced volume of water due to the drying up of water during the dry season. However, there is no significant difference between the two seasons from the statistical value 0.327 ($p<0.05$). The high value of sulphate in water from Wupa River, Abuja during the dry season compared to that during the wet season agrees with the report for sulphate in water from Iko River, Nigeria by Usoro *et al*. (2013).

The mean concentrations of nitrate in water samples from River Wupa during the dry and wet seasons were 12.12±2.08 and 12.23±1.78 mg/dm^3 respectively. There is little difference between the results obtained during the dry season compared to that obtained during the wet season hence there is no significant difference between the two seasons as revealed by the statistical value 0.288 ($p<0.05$). However, the mean value in the wet season is slightly higher than that of the dry season due to runoff from farmlands that is discharged into the water during the wet season. A similar report for a higher level of nitrate in water during the wet season compared to its level in the dry season was given by Tech-Yee *et al*. (2017).

Nitrite in water from River Wupa, Abuja had concentrations of 0.08±0.02 and 0.06±0.02 mg/dm^3 during the dry season and wet season respectively. From the results, it is shown that the value of the nitrite in the dry is slightly higher than that of the wet season but there is no

significant difference between the two seasons as revealed by the statistical value 0.933 ($p<0.05$). The higher value of nitrite in water in the dry season could be attributed to the reduced volume of water due to drying up and the quantity and thereby increased amount of chemical fertilizer and would have flowed into the water body during the wet season as well as continuous indiscriminate discharge of plants and animal wastes into the water system. This high level of nitrite in water in the dry season compared to that in the wet season does not agree with the report for seasonal values of nitrite in water from River Iko, Nigeria reported by Usoro *et al*. (2013).

The mean concentrations of phosphate from River Wupa water samples for both the dry and wet seasons were 2.09±0.33 and 2.15±0.35 mg/dm^3 respectively. The level of phosphate during the wet season was higher than that of the dry season however, there is no significant difference between the two seasons as revealed by the statistical value 0.904 ($p<0.05$). The difference in the value of phosphate in the wet season compared to that in the dry season could be attributed to run-off waters during the rainy season discharged into River Wupa from farmlands where fertilizers and pesticides that contain phosphate had been used (Ademoroti, 2006).

The mean concentrations of chloride in the water samples from River Wupa during the dry and wet seasons were 40.96±3.53 and 32.23±3.82 mg/dm^3 respectively. The mean value during the dry season was found to be higher than that of the wet season but, there is no significant difference between the two seasons as revealed by the statistical value 0.904 ($p<0.05$). However, the high value of chloride in the dry season compared to that in the wet season could be due to the drying of water volume and concentration of the chloride ion (Ajit and Padmakar, 2012). From the results, the parameter that had the highest variability during the dry season and wet season was turbidity and nitrite which had a coefficient of variations of 49.76 % and 29.38 % respectively and the least varied parameters were pH which had 1.55% and 1.18% in the dry and wet seasons respectively.

The correlation analysis of the physicochemical parameter of water from River Wupa was done for both dry and wet seasons. During the dry season there is a strong and positive correlation between (EC and TDC, r =0.910), (TSS and Turb, r = 0.976), (TSS and BOD, r = 0.945), (TSS and COD, r = 0.912), (Turb and BOD, r = 0.868), (Turb and COD, r = 0.820), (BOD and COD, r = 0.979), (pH and nitrite, r = 0.750) (pH and Cl, r = 0.737), (TSS and Cl, r = 0.748) and (Turb and Cl, r = 0.761). During the wet season strong and positive correlation is between (EC and TDS, r = 0.879), (BOD and COD, r = 0.756) and (Turb and sulpate, r = 0.730). The strong positive correlation indicates that the pollutants leading to high levels of the physicochemical parameters in water could probably be coming from the same sources which are anthropogenic. This implies that the pollutant could be from domestic wastes, runoff from agricultural lands, and other activities taking place close to the river.

4. CONCLUSION

The results of the assessment of physicochemical parameters showed that they are all below the tolerable limit recommended by NSDWQ except for turbidity, DO, and phosphate. From the results obtained it is revealed that between the dry and wet seasons, for all the physicochemical parameters there is no significant difference except for turbidity and COD for which the p-values conforms to $p<0.05$.

Turbidity is a measure of the amount of suspended sediment in the water, which can have many negative effects on aquatic life. COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies and municipal and industrial wastes. Turbidity and COD were far way high in water samples in the wet season compared to their levels in water during the dry seasons. The variability of these parameters could be attributed to runoffs from land to the river and that most of the contaminants are directly dumped into the water during the wet season.

The correlation matrices analysis showed that During the dry season there is a strong and positive correlation between (EC and TDC), (TSS and Turb), (TSS and BOD), (TSS and COD), (Turb and BOD), (Turb and COD), (BOD and COD), (pH and nitrite) (pH and Cl), (TSS and Cl,) and (Turb and Cl) and during the wet season strong and positive correlation is between (EC and TDS), (BOD and COD) and (Turb and sulpate). This is an indication that the pollutants come from the same source which includes domestic wastes, industrial effluents, and runoffs from irrigated farmlands along the River Wupa.

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