ASPECTS OF THE LIMNOLOGY OF KUTI STREAM, ABAJI AREA COUNCIL, FEDERAL CAPITAL TERRITORY, ABUJA, NIGERIA

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Received *February 13, 2021;* ***Revised*** *April 26, 2021;* ***Accepted*** *April 27, 2021*

ABSTRACT

Physicochemical parameters of Kuti stream, Abaji Area Council, Abuja were studied for twelve months (January - December, 2019). Water samples were collected from the study area monthly from four sampling points that were 500 m distance apart into a clean 2-litre transparent plastic container and screw capped between the hours of 06.00 – 10.00. Samples were preserved in ice and taken to the laboratory for analysis. Temperature, pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in-situ with portable HANNA meter (HI 70007 pH/EC/TDS/℃), while chloride (Cl^-), sodium (Na^+), nitrate (NO_3^-), phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), magnesium (Mg^{2+}), potassium (K^+), calcium (Ca^{2+}), dissolved oxygen (DO), alkalinity and turbidity were analyzed ex-situ using standard methods. Descriptive statistics revealed that all parameters were within permissible limits recommended by the World Health Organization (WHO) and FRN's national environmental (surface and underground water quality control) regulations except PO_4^{3-} and turbidity. Analysis of Variance showed that all parameters are significantly different ($p>0.05$) except pH across sampled points, while paired sample t-test showed that there was a significant difference ($p<0.05$) of all parameters between seasons except pH and Na. The high concentration of PO_4^{3-} and turbidity observed may be linked to the influx of runoff from nearby farms and degree of anthropogenic activities that took place in the stream during the study. PO_4^{3-} combined with NO_3^- to cause eutrophication, which lead to higher oxygen demand and subsequent death of aquatic organisms. To reduce the concentration of PO_4^{3-}, sustainable agriculture and healthy activities around the stream should be practiced.

Keywords: Kuti Stream**,** Physicochemical parameters, Water quality, Seasonal dynamics, Anthropogenic activities

INTRODUCTION

Water is a vital and abundant resource that has a unique role on the planet earth (Amusat *et al.*, 2019). It covers about 70% of the earth surface and almost all living biota depend on it for survival and metabolism (Pimple, 2013; Abdisa and Abebaw, 2014; Okoye, 2016). It is a major constituent of all living organisms, occupying two-thirds of the human body, and a universal solvent that dissolve almost everything in the environment (Abdisa and Abebaw, 2014). It served as habitat and breeding sites of insects, fish, amphibians, reptiles, mammals etc. It can be classify based on sizes (ocean, river, stream, spring, lake and pond), the degree of movement (lentic and lotic), location (surface and underground) and salt concentration (freshwater, marine and brackish) (Pimple, 2013; Nwonumara, 2018).

Freshwater is a limited resource that is essential for domestic, agriculture, industrial and even human existence (Abdisa and Abebaw, 2014). Adequate quantity and quality of freshwater is needed for sustainable development and economic growth, but it availability in the ecosystem are being threaten by anthropogenic activities such as obnoxious fishing, intense application of agrochemicals on agricultural farmlands, construction of dams or reservoirs for unplanned population, and improper disposal of industrial and domestic wastes into aquatic bodies (Abdisa and Abebaw, 2014; Amusat *et al*., 2019; Nwonumara, 2018). The pollution of aquatic ecosystems in Nigeria, especially in rural communities is on the increase, due to the high level of poverty, the quick adoption of intense agricultural practices such as the use of herbicides to kill weeds so as to reduce cost of production and maximize profits, and the increased in human population which compel inhabitants around water bodies to unsustainably exploit aquatic resources for their livelihood (Adegbe, 2014; Madu, 2016). Agrochemicals gained entrance into aquatic ecosystem through run-off from nearby farms, direct application or aerial spray which impact on aquatic lives through the increase in their mortality, alter aquatic ecological processes such as food chain and food web which create imbalance in the trophic level, causes ill-health in man and change the ambient physicochemical parameters of water which affect its quality (Carter, 2000; Madu, 2016; Nwonumara, 2018).

Physicochemical parameters assess the integrity of an aquatic ecosystem by providing significant information about its status and available nutrients that supports different life forms (Adakole and Anunne*,* 2003). It regulates the trophic level in aquatic ecosystem through the productivity and distribution of aquatic organisms (Adakole *et al.,* 2008; Nwonumara, 2018). It determines the healthiness and biological features of an aquatic ecosystem and data collected from its analysis can serve as base line information to investigate the impacts and sources of aquatic pollution (Venkatesharaju *et al.,* 2010). Therefore, determination and monitoring of physicochemical parameters of water for both long and short term is vital for the survival and sustenance of aquatic organisms and ecosystem (Adakole *et al.,* 2008), and also for evaluating the suitability of water for different purposes such as drinking, domestic, industrial and irrigation (Amusat *et al*., 2019). This study assessed the physiochemical parameters of Kuti stream in order to provide baseline data for further research in the study area.

MATERIALS AND METHODS

Description of Study Area: Kuti stream is located on a coordinate of longitude 08° 38' 51.0"N, Latitude 006° 46' 30.2"E and elevation of 90.00 m (Figure 1).

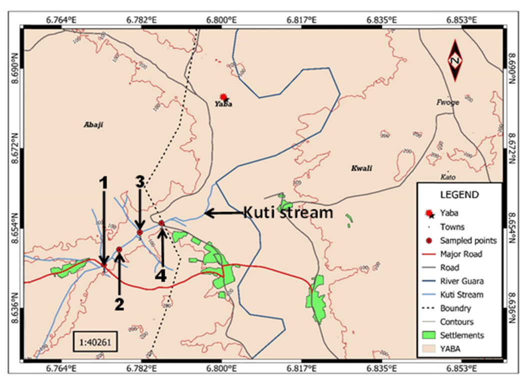

Figure 1: Sampling points and other features in the study area. Source: Google Earth Map (2021)

It has an average depth of 0.5 m. It is located north (at the entrance) of Kuti village, down the slope 500 m away from Leventis Agricultural Training Farmland, Yaba, Abaji Area Council, Federal Capital Territory (FCT), Abuja Nigeria. It is a meandering stream that served as the major source of drinking water for an inhabitant of about 6,000 persons, and source of irrigation for fadama farming (NPC, 2006). The climate is tropical with an average annual rainfall of 2000 ± 40.26 mm and mean temperature of 27 ± 1.12°C. The months of May to October experience heavy rainfall, while November to February observed high temperature, low rainfall and humidity.

Description of Sampling Points: Kuti stream was sectioned into four sampling points that were 500 m distance apart (Adakole *et al.,* 2003) as shown in Figure 1. Point 1, is at the entrance to Kuti village from Yaba, the defunct headquarter of Abaji Area Council, FCT, Abuja. It is located on longitude 08^0 64′ 52.00″N , Latitude 06^0 77′ 36.00″E 08° and elevation of 90.00m. It is characterized by a high degree of anthropogenic activities such as washing of clothes, cars, motorbikes and knapsack. It has less vegetation surrounding it bank and a large surface area exposed to environmental factors. Point 2, is 500 m up east of Point 1. It has a coordinate of longitude 08^0 64′ 91.00″N, Latitude 06 77′ 71″E and elevation of 90.04m. It is characterized by farming activities at its bank, especially during the dry season. Point 3, is 500m due west of Point 1. It has a coordinates of longitude 08^0 65′ 29.00″N, Latitude 06^0 78′ 16.00″E 08° and elevation of 90.05m. It has less human interference and farming activities, but nomads take their cattle for drinking, which makes water at this point always turbid. Point 4, is 1000m due west of Point 1. It has a coordinates of longitude 08^0 65′ 53.00″N, Latitude 06^0 78′ 62.00″E and elevation of 90.08 m. It has less human activities due to thick vegetation surrounding it bank.

Collection of Water Samples: Sampling of water was carried out monthly for 12 months (January – December, 2019). Water samples were collected between the hours of 6.00 and 10.00 am into a pre-cleaned 2-litre transparent plastic container, fixed immediately, screw capped, preserved in a box containing ice and transported to the Laboratory of Fisheries Department, Kogi State University, Anyigba for analyses.

Determination of Physicochemical Parameters

Temperature, pH, electrical conductivity (EC), total dissolved solids (TDS): These were measured in-situ with portable HANNA meter (HI 70007 pH/EC/TDS/℃) following the procedures given in the manufacturer's instruction manual.

Dissolved oxygen (DO), turbidity, chloride (Cl^-), alkalinity and sulphate (SO_4^{2-}): DO was determined by Winkler Azide modified titrimetric method. Alkalinity was assay by titrimetric method using phenolphthalein as indicator. SO_4^{2-} was determined using Nephelometry method, turbidity by Nephelometric method, and Cl^- by Argentometric titration method (APHA, 1995).

Phosphate (PO_4^{3-}), nitrate (NO_3^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+) and potassium (K): PO_4^{3-} was determined by ascorbic acid spectrophotometric method, NO_3^- by ion selective electrode method, Ca^{2+} by EDTA titrimetric method, Mg by gravimetric method and Na^{2+} and K^+ by flame emission photometric method. All analyses were done using the standard methods for evaluation of water and wastewaters (APHA, 1995).

Statistical Analysis: Data collected were subjected to descriptive statistics. One-way analysis of variance (ANOVA) was used to test the significant difference across stations and months, while paired sample t-test was used to compare variations between seasons (Dry and Wet). The results were presented in tables as means ± standard errors (S.E), minimum, maximum, and median values.

RESULTS AND DISCUSSION

Physicochemical Parameters: The 15 physicochemical parameters of Kuti stream analysed are shown in Table 1. All the parameters are within the permissible limits recommended by the World Health Organization (WHO, 2008) and Federal Republic of Nigeria's national environmental (surface and underground quality control) regulations (FRN, 2011) except PO_4^{-3} and turbidity. The acceptable limit of PO_4^{-3}

by FRN is 3.50 mg/L but in this study, 5.44 ± 0.35 mg/L was recorded as the concentration level of PO_4^{-3} in Kuti stream. This high concentration may be due to wastes generated from the washing of cars and motorbikes with detergents inside the stream especially at point 1 and inflow of flood from nearby farms especially at points 2 and 3. This result was in correlation with the study of Dike *et al.* (2010), where they observed that high value of PO_4^{3-} recorded in River Jakara during their study may be linked to wastes emanated from homes, abattoir and car washing activities. Also supported by the study of Amusat *et al*. (2019), where they reported that the high concentration of PO_4^{3-} observed in Erelu reservoir in Oyo town, Nigeria emanated from flood or runoff from nearby farms. Similar results were reported by Ibrahim *et al.* (2009) in water reservoir in Kontagora, Nigeria and Patil *et al.* (2011) in Lotus Lake, Maharashtra, India.

The mean value of turbidity 6.01 ± 0.09 NTU recorded in this study was above the recommended limits of 5.00 NTU (WHO, 2008). This may be attributed to the influx of debris from nearby farms and the drinking activities of cattle especially at point 3. This result was in agreement with the study of Koloanda and Oladimeji (2004) in Shiroro Lake, Niger State, Nigeria and Ayoade *et al.* (2006) in Oyan and Asejire lakes, South-Western Nigeria. Higher turbidity in streams prevents light penetration which affects the photosynthetic activities of phytoplankton and other green plants (Amusat *et al*., 2019). A turbid stream is a source of waterborne diseases to people that consumes it raw without treatment (Ugbaja and Ephraim, 2019).

Spatiotemporal Variation of Physicochemical Parameters of Kuti Stream

Spatial variation: All the physicochemical parameters except pH were significantly different ($p>0.05$) across sampled points (Table 2). pH recorded it highest mean value 6.63 ± 0.07 at point 3, lowest 6.48 ± 0.01 at Point 4. This observation may be attributed to the surface area of each point, level of anthropogenic activities, depth and water level (Amusat *et al*., 2019). Point 3 is shallow with large surface area exposed to intense heat which results to high evaporation and reduction in water level. This agreed with the study of Amusat *et al*. (2019). The highest mean value 110.42 ± 7.63 µs/cm of EC was observed at point 2, while the lowest level of 104.64 ± 4.48 µs/cm was observed at point 4. Point 2 had farms that surrounded it bank and large surface area for evaporation which reduce water level, making chemical presence in ionic form to be more concentrated. This correlates with the finding of Adegbe (2014) in the waste water treatment plant of Ahmadu Bello University Teaching Hospital Zaria, Nigeria.

Turbidity highest mean value of 6.11 ± 0.20 NTU was observed at point 3, while the lowest value of 5.88 ± 0.23 NTU occurred at point 4. This difference may be attributed to the open nature, drinking activities of cattle and inflow of debris from nearby farms into point 3. This result was in accordance with the findings of Agaoru (2012) in Opi Lake, Nigeria and Adegbe (2014) in selected waters of Ahmadu Bello University Teaching Hospital Zaria, Nigeria.

Point 4 had the highest mean value of 6.64 ± 0.09 mg/L of DO, and lowest value of 6.61 ± 0.08 mg/L was recorded at point 1. This difference may be attributed to the atmospheric aeration, amount of heat exposed to each point and vegetation cover. Point 1 had a large surface area with little vegetation, while point 4 had small surface area with much vegetation cover. The higher the temperature, the lower the DO (Ibrahim *et al.,* 2009). Similar result was observed by Chakraborty *et al.* (2013) in Buriganga River, Bangladesh.

Point 1 had high anthropogenic activities such as washing of domestic and farm equipment (Knapsack) and its sloppy location that allow large amount of runoff into it. This finding is similar with the observation of Adegbe (2014).

TDS recoded its highest mean value of 62.50 ± 5.28 mg/L at point 1 and the lowest value of 60.03 ± 6.40 mg/L at point 4 which correlate with the finding of Amusat *et al.* (2019) which reported that the high value of TDS recorded in stations 6 and 7 was due to the high influx of flood and surface area exposed to anthropogenic activities.

Table 1: Some physicochemical parameters of Kuti stream, Abaji Area Council, Abuja, Nigeria between January – December 2019

Parameters	Mean ± S.E	Values			Standard Limits	
		Min.	Max.	Median	WHO (2008)	FRN (2011)
Temperature (℃)	26.72 ± 0.14	24.80	29.00	26.51	25.00-30.00	-
pH	6.55 ± 0.01	6.00	7.01	6.57	6.50-8.50	6.50-8.50
Total Dissolved Solid (mg/L)	61.42 ± 2.69	29.50	93.42	62.97	1500.00	-
Electrical Conductivity(μs/cm)	106.97 ± 2.29	76.44	179.00	106.85	500.00	-
Turbidity (NTU)	6.01 ± 0.09	5.02	7.90	6.01	5.00	-
Dissolved Oxygen (mg/L)	6.63 ± 0.04	5.90	7.08	6.70	6.00-9.00	6.00-9.00
Cl^- (mg/L)	10.68 ± 0.29	5.22	16.34	10.55	-	300.00
NO_3^- (mg/L)	0.75 ± 0.03	0.42	1.82	0.72	-	9.00
PO_4^{3-} (mg/L)	5.44 ± 0.35	0.03	11.36	5.85	-	3.50
SO_4^{2-} (mg/L)	5.37 ± 0.2	2.17	8.42	5.15	-	100.00
Na^+ (mg/L)	7.01 ± 0.45	3.60	17.30	5.90	-	120.00
Mg^{2+} (mg/L)	8.98 ± 0.53	3.32	18.90	8.55	-	40.00
K^+ (mg/L)	2.79 ± 0.21	0.93	7.90	2.60	-	50.00
Ca^{2+} (mg/L)	19.34 ± 0.95	4.20	72.80	19.60	-	180.00
Alkalinity (mg/L)	11.18 ± 0.45	6.81	17.36	10.56	-	200.00-600.00

± S.E= Standard Error; Min = Minimum value, Max = Maximum value; Cl^- = Chloride; NO_3^- = Nitrate; PO_4^{3-} = Phosphate, SO_4^{3-} = Sulphate; Na^+ = Sodium, Mg^{2+} = Magnesium, K^+ = Potassium, Ca^{2+} = Calcium, WHO = World Health Organization; FRN = Federal Republic of Nigeria

Table 2: Spatial variations of some physicochemical parameters of Kuti stream, Abaji Area Council, Abuja, Nigeria between January – December 2019

Parameters	Point 1	Point 2	Point 3	Point 4
Temp (℃)	28.56 ± 0.27[a]	26.88 ± 0.28[b]	26.73 ± 0.28[c]	26.70 ± 0.27[d]
pH	6.59 ± 0.05	6.49 ± 0.05	6.63 ± 0.07	6.48 ± 0.01
TDS (mg/L)	62.50 ± 5.28[a]	62.06 ± 4.97[b]	61.50 ± 5.47[c]	60.03 ± 6.41[d]
EC (μs/cm)	106.24 ± 5.50[a]	110.42 ± 7.63[b]	106.6 ± 4.77[c]	104.64 ± 4.48[d]
Turb. (NTU)	6.05 ± 0.14[a]	6.00 ± 0.16[b]	6.11 ± 0.20[c]	5.88 ± 0.23[d]
DO (mg/L)	6.61 ± 0.08[a]	6.63 ± 0.08[b]	6.62 ± 0.07[c]	7.64 ± 0.09[d]
Cl^- (mg/L)	12.52 ± 0.62[a]	10.34 ± 0.56[b]	9.93 ± 0.43[c]	9.94 ± 0.40[d]
NO_3^- (mg/L)	0.74 ± 0.04[a]	0.98 ± 0.08[b]	0.66 ± 0.03[c]	0.62 ± 0.04[d]
PO_4^{3-} (mg/L)	5.92 ± 0.83[a]	4.99 ± 0.62[b]	4.84 ± 0.66[c]	4.54 ± 0.71[d]
SO_4^{2-} (mg/L)	5.90 ± 0.41[a]	5.61 ± 0.50[b]	4.90 ± 0.34[c]	5.05 ± 0.36[d]
Na(mg/L)	8.75 ± 1.13[a]	6.74 ± 0.91[b]	6.60 ± 0.81[c]	5.97 ± 0.55[d]
Mg (mg/L)	10.27 ± 1.05[a]	8.37 ± 1.06[b]	9.26 ± 1.27[c]	8.12 ± 0.85[d]
K(mg/L)	3.37 ± 0.66[a]	2.31 ± 0.36[b]	3.04 ± 0.35[c]	2.42 ± 0.23[d]
Ca^{2+}(mg/L)	19.06 ± 2.29[a]	18.41 ± 1.98[b]	20.21 ± 2.06[c]	19.68 ± 1.43[d]
Alkan (mg/L)	11.65 ± 1.13[a]	11.01 ± 0.37[b]	11.66 ± 0.90[c]	10.42 ± 0.75[d]

Mean values on a row with heterogeneous superscripts letters are significant different ($p \leq 0.05$), Cl^- = Chloride; NO_3^- = Nitrate; PO_4^{3-} = Phosphate, SO_4^{2-} = Sulphate; Na^+ = Sodium, Mg^{2+} = Magnesium, K^+ = Potassium, Ca^{2+} = Calcium, DO = Dissolved Oxygen; Alkan = Alkalinity

Chloride ion (Cl^-) recorded it highest mean value of 12.52 ± 0.62 mg/L at point 1, while lowest value of 9.93 ± 0.07 mg/L was at point 3. This may be attributed to the level of domestic activities at each point. Point 1 had high domestic activities compared to point 3. Similar result was observed in the study of Amusat *et al*. (2019) in Erelu reservoir, Oyo, Nigeria.

Ca^{2+} recorded it highest mean value of 20.21 ± 2.06 mg/L at point 3, while the lowest value of 19.06 ± 2.29 mg/L occurred at point 1. This difference may be attributed to the low level of water in point 3 compared to point 1. This observation is supported by the study of Amusat *et al*. (2019), were they recorded low value of Ca^{2+} in stations 6 and 7 of Erelu reservoir, Nigeria when compared to other studied stations.

Magnesium ion (Mg^{2+}) recorded it highest mean value of 10.27 ± 1.05 mg/L at point 1, and the lowest value of 8.12 ± 0.85 mg/L at point 4. This may be attributed to the inflow of flood which comes along with $MgSO_4$

from nearby farms directly into point 1. This result was supported by the study of Ayoola and Ajani (2009) in wetlands of Ajinapa, Orire LGA, Oyo State, Nigeria.

Sodium ion (Na^+) recorded its highest mean value of 8.75 ± 1.13 mg/L at point 1, and lowest value of 5.97 ± 0.55 mg/L at point 4. This may be attributed to the level of domestic activities at point 1 compared to point 4. Point 1 had higher domestic activities than point 4. Similar levels of sodium ion in water have been reported in areas impacted by oil activities in Ecuador (Maurice *et al.*, 2019).

Potassium ion (K^+) recorded had its highest mean value of 3.37 ± 0.66 mg/L at point 1, an lowest value of 2.31 ± 0.36 mg/L occurred at point 2. This difference may be attributed to the degree of anthropogenic activities and inflow of runoff into each point. Similar finding have been reported by Amusat *et al.* (2019) on potassium ion enrichment of Erelu Reservoir in Oyo Town, Nigeria.

Sulphate ion (SO_4^{2-}) had its highest mean value of 5.90 ± 0.83 mg/L at point 1, and lowest value of 4.90 ± 0.34 mg/L at point 3. This difference may be attributed to the level of domestic activities and inflow of flood from nearby farms.

Point 1 has much human interference and large amount of flood from farms due to it sloppy nature compared to point 3. This observation is supported by the study of Amusat *et al.* (2019).

Alkalinity recorded its highest value of 11.66 ± 0.90 mg/L at point 3, and the lowest value of 10.42 ± 0.75 mg/L at point 2. The result of this study was at variance with the report of Madu (2016) for alkalinity of River Niger at Kogi State, Nigeria.

Temperature had the highest value of 28.56 ± 0.27 ^oC at point 1, and lowest value of 26.70 ± 0.27 ^oC at point 4. Similar trends in temperature were observed by Koloanda and Oladimeji (2004) in Shiroro Lake, Nigeria.

Temporal Variations

Seasonal variations: The mean values were: alkalinity (12.70 ± 0.65 mg/L), DO (6.69 ± 0.05 mg/L), EC (110.51 ± 5.06 μScm^{-1}) and K^+ (2.94 ± 0.32 mg/L). They were all higher in dry season when compared to wet season (Table 3), while the mean values of NO_3 (0.81 ± 0.05 mg/L), SO_4 (6.35 ± 0.24 mg/L), PO_4 (7.25 ± 0.31 mg/L), turbidity (6.30 ± 0.31 NTU) and TDS (62.71 ± 3.18 mg/L) were higher in wet season compared to dry season (Table 3). The difference in these parameters between seasons may be linked to changes in temperature, volume of the water body, wind and depth. The high EC (110.51 ± 5.06 μScm^{-1}) obtained in dry season compared to the wet season EC (103.40 ± 2.26 μScm^{-l}) may be attributed to reduced water volume during the dry season. The increase in water volume in wet season diluted the concentration of ions in water (Ufodike *et al.*, 2001). Paired sample t-test revealed that the variations of all parameters except pH and Na^+ between seasons were significantly different ($p<0.05$) (Table 3). The highest mean value of alkalinity (12.70 ± 0.65 mg/L) was observed in dry season compared to the wet season (9.67 ± 0.46 mg/L). This difference may be attributed to the levels of water between the seasons. The low level of water in dry season increases the concentration of salts, while the high level of water in wet season dilutes salts present in the stream (Ufodike *et al.*, 2001).

Table 3: Seasonal variations of some physicochemical parameters of Kuti stream, Abaji Area Council, Abuja Nigeria (January – December 2019)

Physicochemical Parameters	Seasons	
	Dry	Wet
Alkalinity	12.70 ± 0.65*	9.67 ± 0.46
Ca^{2+}	16.39 ± 1.64	22.29 ± 0.52*
Cl^-	9.74 ± 0.42	10.72 ± 0.40*
DO	6.69 ± 0.05	7.57 ± 0.06*
EC	110.51 ± 5.06	103.40 ± 2.26*
K^+	2.94 ± 0.32	2.63 ± 0.25
Mg^{2+}	7.44 ± 0.84	10.52 ± 0.49*
Na^+	7.02 ± 0.72	7.01 ± 0.54
NO_3-	0.70 ± 0.03	0.81 ± 0.05*
pH	6.55 ± 0.06	6.34 ± 0.03
PO_4^{3-}	4.36 ± 0.38	7.25 ± 0.81*
SO_4^{2-}	4.39 ± 0.18	6.35 ± 0.24*
Temperature	25.00 ± 0.12	27.73 ± 0.24*
TDS	62.71 ± 3.18*	60.12 ± 14.39
Turbidity	5.72 ± 0.11	6.30 ± 0.13*

Means with asterisk are significant different ($p<0.05$), Cl^- = Chloride; NO_3^- = Nitrate; PO_4^{3-} = Phosphate, SO_4^{2-} = Sulphate; Na^+ = Sodium, Mg^{2+} = Magnesium, K^+ = potassium, Ca^{2+} = Calcium, DO = Dissolved Oxygen; Alkan = Alkalinity

This result agreed with the studies of Abubakar (2017) in River Saye, Zaria, Kaduna State, Nigeria and Ugbaja and Ephraim (2019) in waters of Oban Massif, Nigeria.

The highest mean value of calcium (22.29 ± 0.52 mg/L) was observed in dry season, which may be attributed to the rate of evaporation of the stream as a result of the intense heat during the period. This observation is in accordance with the findings of Ibrahim *et al.* (2009) in water reservoir of Kontagora, Nigeria, Sahni and Yadav (2012) in Bharawas pond, Rewari, Haryana, Akindele and Adeniyi (2013) in of Opa reservoir, Ile-Ife, Nigeria and Amusat *et al*. (2019) in Erelu reservoir, Oyo, Nigeria, but differ with the reports of Ugbaja and Ephraim (2019) in the waters of Oban Massif, Nigeria.

Cl^- was high (10.46 ± 0.40 mg/L) in dry season compared to wet season (9.74 ± 0.42 mg/L), which agree with study of Abubakar (2017) and Ugbaja and Ephraim (2019).

DO have its highest value of 7.57 ± 0.06 mg/L in wet season, compared to dry season (6.69 ± 0.05 mg/L). This may be attributed to the aeration of the stream during wet season and higher temperature during dry season which in turn lower the concentration of oxygen in the stream (Amusat *et al*., 2019). This agreed with the findings of Idowu and Ugwumba (2005), Ikomi *et al.* (2005), Abubakar (2017) and Ugbaja and Ephraim (2019), but deviate with Ibrahim *et al.* (2009).

EC had its highest mean value of 110.50 ± 5.06 µs/cm in dry season, which is similar to the findings of Abubakar (2017), Amusat *et al*. (2019) and Ugbaja and Ephraim (2019). The seasonal difference in EC may be associated with reduction in the water level as a result of evaporation due to intense heat which is associated with increase evaporation due to high temperature (Amusat *et al*., 2019).

K^+ and Na^+ had their highest value in dry season compared to dry season (Table 3). These are supported by the observations of Abubakar (2017) and Ugbaja and Ephraim (2019). The difference between the seasons may be associated with water level and weather conditions.

Mg^{2+} was observed to be high in wet season (10.52 ± 0.49 mg/L) compared to dry season (7.44 ± 0.84 mg/L). These findings differ with the observations of Ibrahim *et al.* (2009) and Ugbaja and Ephraim (2019), but agree with the study of Amusat *et al*. (2019). The high value of Mg^{2+} in wet season may be attributed to the influx of flood into the stream during the period.

NO_3^-, PO_4^{3-}, SO_4^{2-} and turbidity were higher in wet season compared to dry season (Table 3). This may be associated with runoff that may wash down some nutrients and debris into the stream. These results agree with the studies of Abubakar (2017) and Amusat *et al*. (2019), but deviate from Ugbaja and Ephraim (2019).

Temperature recorded highest value of 27.73 ± 0.24 ^{0}C in wet season compared to dry season (25.02 ± 0.12 ^{0}C). The low temperature recorded during the dry season may be as a result of seasonal changes in air temperatures associated with the cool dry North-East trade winds (Harmattan). Similar observations were observed in the studies of Koloanda and Oladimeji (2004) in Shiroro Lake, Nigeria, Ibrahim *et al.* (2009) in Kontagora Reservoir, Niger State, Abubakar (2017), Amusat *et al*. (2019) and Ugbaja and Ephraim (2019).

The high value 6.55 ± 0.06 of pH was observed in dry season compared to wet season 6.34 ± 0.03; though there was no significant difference between the two seasons. These values were slightly acidic but within the acceptable limit of 6.5 – 8.5 (WHO, 2008). This result was similar with the studies of Ibrahim *et al.* (2009) and Abubakar (2017). TDS was observed to be high in dry season 62.71 ± 3.18 mg/L compared to wet season 60.12 ± 14.39 mg/L. This result was in accordance with the studies of Ibrahim *et al.* (2009), Ugbaja and Ephraim (2019) and Amusat *et al.* (2019).

Monthly variations: The mean values of each physicochemical parameter in Kuti stream across months are shown in Table 4. The month of May had the highest temperature (28.90 ± 0.36^{o}C), while the month December had the least temperature (25.61 ± 0.35^{o}C). The fluctuation in the temperature between dry and wet season may be linked to seasonal changes in air temperatures, which is associated with the cool dry North-East trade winds (Harmattan).

Analysis of variance (ANOVA) revealed that there were significant differences ($p<0.05$) in the physicochemical parameters across months. Temperature and pH had their highest values 28.58 ± 0.02 ^{0}C in October and 6.81 ± 0.04 in December, while the lowest value of temperature (24.86 ± 0.10^{0}C) occurred in December and pH (6.20 ± 0.05) in October. These findings differ from the report of Ajanwachukwu (2019) where the highest values of both parameters were recorded in December and lowest value of values in June in Opi Lake, Enugu, Nigeria. This difference may be as a result of difference in the weather conditions of the studied areas.

TDS and EC had their highest values of 90.35 ± 1.44 mg/L in February and 152.75 ± 9.75 µs/cm in January. Their lowest values of 41.27 ± 1.74 mg/L occurred in May and 80.64 ± 1.76 µs/cm in June. These findings deviate from the results of Abubakar (2017), where the highest values for both parameters were recorded in August and lowest value of in September. This difference may be attributed to the degree of anthropogenic activities occurring in the studied areas.

Turbidity had it highest value of 7.30 ± 0.24 NTU in May and lowest value of 5.13 ± 0.04 NTU in February. This finding followed similar trend with the study of Madu (2016) where turbidity was low in January and high in June. The turbidity of streams or river increase or decrease with seasons, nature of the water body and the influx of debris from nearby settlements. The months of April and May are the onset of planting season in the study area where a lot of clearing and preparation of land is done.

DO had the highest value of 6.95 ± 0.06 mg/L in August and lowest value of 6.02 ± 0.03 mg/L in October. This result was in agreement with the finding of Aende (2019) were he recorded the highest value of DO in August. This may be attributed to the amount of rainfall and the weather conditions (Amusat *et al.*, 2019).

Cl^-, NO_3, and SO_4^{2-}-had their highest values of 11.92 ± 1.21 mg/L, 1.04 ± 0.20 mg/L and 7.88 ± 0.38 mg/L in June and their lowest values of 6.69 ± 0.78 mg/L, 0.62 ± 0.01 mg/L and 3.31 ± 0.52 mg/L in January. These findings are in accordance with the finding of Madu (2016).

PO_4^{2-} had the highest value of 9.05 ± 0.07 mg/L in August which differ with Madu (2016) that recorded its highest value in June but the lowest value of 2.64 ± 0.32 mg/L recorded in January is in accordance with Madu (2016).

Na^+ had its highest value of 13.12 ± 1.64 mg/L in October and lowest value of in 4.45 ± 0.01 mg/L in January. Mg^{2+} had its highest value of 13.88 ± 0.38 mg/L in July and lowest value of 4.65 ± 0.54 mg/L in January. K^+ had its highest value of 4.83 ± 0.44 mg/L in March and lowest value of 2.07 ± 0.35 mg/L in January. Ca^{2+} had its highest value of 23.09 ± 1.59 mg/L in March and low 12.00 ± 1.55 mg/L in August. Alkalinity had its highest value of 13.49 ± 0.36 mg/L in March and lowest value of 8.32 ± 0.89 mg/L in August. These findings for Na^+ and Mg^{2+} followed this same trend of occurrence in their months with the study of Madu (2016), but K^+, Ca^{2+} and alkalinity deviated.

Conclusions: Kuti stream is the major source of water for domestic and agricultural purpose for the inhabitants of Kuti village. The high concentration of PO_4 recorded in during the study can be attributed to the level of anthropogenic activities that took place in and around the stream. In order to control this high concentration that can lead to pollution and loss of aquatic lives, borehole water should be provided for the inhabitants so as to control their washing activities at the bank of the river. Sustainable agricultural practices that are eco-friendly should be practiced by farmers farming close to the stream.

ACKNOWLEDGMENTS

The first author deeply appreciate the field assistant (Mr. Ibrahim Yaba) and the entire staff and management of Leventis Agricultural Training School, Yaba, Abaji, Area Council, Abuja Nigeria, for the accommodation provided throughout the sampling of this study.

Table 4: Sampled months of physicochemical parameters of Kuti stream, Abaji area council, Abuja FCT, Nigeria (2019)

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp (°C)	26.10 ± 0.76^{e}	26.15 ± 0.12^{f}	26.37 ± 0.20^{h}	26.28 ± 0.14^{g}	26.10 ± 0.17^{d}	26.06 ± 0.09^{c}	27.85 ± 0.06^{j}	27.95 ± 0.05^{k}	27.69 ± 0.17^{i}	28.58 ± 0.02^{l}	24.52 ± 0.28^{a}	24.86 ± 0.10^{b}
pH	6.55 ± 0.19^{f}	6.53 ± 0.17^{d}	6.66 ± 0.21^{j}	6.58 ± 0.08^{i}	6.51 ± 0.10^{c}	6.67 ± 0.06^{k}	6.37 ± 0.05^{b}	6.58 ± 0.05^{h}	6.55 ± 0.02^{e}	6.20 ± 0.05^{a}	6.56 ± 0.06^{g}	6.81 ± 0.04^{l}
TDS (mg/L)	44.60 ± 2.01^{a}	90.35 ± 1.44^{l}	65.99 ± 1.58^{h}	51.97 ± 2.58^{e}	48.27 ± 1.74^{c}	68.00 ± 2.64^{i}	77.07 ± 4.43^{j}	55.72 ± 2.64^{f}	65.27 ± 0.88^{g}	45.75 ± 4.20^{b}	48.54 ± 2.10^{d}	80.50 ± 4.92^{k}
EC (µs/cm)	152.75 ± 9.75^{l}	115.86 ± 3.50^{j}	117.74 ± 3.01^{k}	110.95 ± 2.65^{i}	106.75 ± 3.02^{g}	80.64 ± 1.76^{a}	109.38 ± 1.37^{h}	106.34 ± 0.94^{e}	106.45 ± 1.19^{f}	105.83 ± 1.40^{d}	88.19 ± 2.03^{c}	82.20 ± 1.11^{b}
Turb (NTU)	6.24 ± 0.32^{i}	5.13 ± 0.04^{a}	5.54 ± 0.09^{d}	6.34 ± 0.24^{j}	7.30 ± 0.24^{l}	6.18 ± 0.06^{h}	5.30 ± 0.08^{b}	6.62 ± 0.08^{k}	5.56 ± 0.10^{e}	5.95 ± 0.10^{f}	6.12 ± 0.10^{g}	5.37 ± 0.23^{c}
DO (mg/L)	6.71 ± 0.07^{g}	6.29 ± 0.21^{b}	6.79 ± 0.10^{k}	6.54 ± 0.09^{c}	6.68 ± 0.08^{e}	6.68 ± 0.06^{f}	6.73 ± 0.08^{h}	6.95 ± 0.06^{l}	6.73 ± 0.06^{i}	6.02 ± 0.03^{a}	6.78 ± 0.10^{j}	6.65 ± 0.06^{d}
Cl^- (mg/L)	6.69 ± 0.78^{a}	9.93 ± 0.59^{c}	10.53 ± 0.62^{g}	10.54 ± 0.41^{h}	9.99 ± 0.80^{d}	11.92 ± 1.21^{l}	8.73 ± 10.08^{b}	10.95 ± 0.87^{k}	10.72 ± 0.90^{i}	10.92 ± 0.90^{j}	10.02 ± 0.71^{e}	10.39 ± 0.30^{f}
NO_3^{2-} (mg/L)	0.62 ± 0.01^{a}	0.75 ± 0.04^{i}	0.86 ± 0.03^{j}	0.86 ± 0.04^{k}	0.73 ± 0.03^{g}	1.04 ± 0.20^{l}	0.71 ± 0.07^{f}	0.73 ± 0.13^{h}	0.70 ± 0.14^{e}	0.64 ± 0.12^{b}	0.68 ± 0.13^{c}	0.68 ± 0.11^{d}
PO_4^{3-} (mg/L)	2.64 ± 0.32^{a}	2.77 ± 0.16^{b}	3.81 ± 0.38^{c}	6.54 ± 0.57^{g}	7.31 ± 0.65^{l}	8.49 ± 0.76^{k}	8.41 ± 0.77^{j}	9.05 ± 0.07^{l}	6.83 ± 0.61^{h}	5.89 ± 0.76^{d}	6.29 ± 0.69^{e}	6.29 ± 0.69^{f}
SO_4^{2-} (mg/L)	3.31 ± 0.52^{a}	5.90 ± 0.52^{h}	4.42 ± 0.32^{d}	6.75 ± 0.48^{i}	7.58 ± 0.47^{k}	7.88 ± 0.38^{l}	7.25 ± 0.27^{j}	4.97 ± 0.32^{f}	5.20 ± 0.17^{g}	4.19 ± 0.17^{b}	4.25 ± 0.17^{c}	4.80 ± 0.14^{e}
Na^{2+} (mg/L)	4.45 ± 0.61^{c}	7.63 ± 0.53^{h}	8.60 ± 0.39^{j}	7.80 ± 2.20^{i}	5.63 ± 0.19^{d}	9.88 ± 1.18^{k}	6.85 ± 0.53^{g}	5.70 ± 1.16^{e}	6.20 ± 0.69^{f}	13.12 ± 1.64^{l}	4.20 ± 0.10^{b}	4.17 ± 0.70^{a}
Mg^{2+} (mg/L)	4.65 ± 0.54^{a}	5.81 ± 2.33^{c}	5.01 ± 0.39^{b}	8.73 ± 0.73^{g}	15.74 ± 0.19^{l}	10.97 ± 0.75^{i}	13.88 ± 0.33^{k}	11.27 ± 1.72^{j}	9.53 ± 0.42^{h}	6.80 ± 0.23^{f}	6.17 ± 0.20^{d}	6.61 ± 0.25^{e}
K^+ (mg/L)	2.07 ± 0.35^{b}	2.98 ± 1.64^{j}	4.83 ± 0.44^{l}	3.00 ± 0.18^{k}	2.19 ± 0.32^{c}	2.35 ± 0.49^{d}	1.81 ± 0.31^{a}	2.90 ± 0.95^{h}	2.45 ± 0.22^{e}	2.92 ± 0.24^{i}	2.62 ± 0.06^{f}	2.90 ± 0.10^{g}
Ca^{2+} (mg/L)	13.15 ± 2.62^{c}	16.4 ± 1.03^{g}	23.90 ± 1.59^{l}	20.40 ± 1.50^{k}	19.68 ± 0.81^{i}	15.88 ± 0.33^{f}	13.87 ± 1.34^{d}	12.92 ± 1.32^{a}	13.00 ± 1.55^{b}	15.37 ± 1.99^{e}	18.40 ± 10.50^{h}	20.13 ± 0.56^{j}
Alkan (mg/L)	17.03 ± 0.89^{l}	13.88 ± 1.32^{j}	15.07 ± 0.67^{k}	13.49 ± 0.36^{i}	8.45 ± 0.47^{b}	9.35 ± 0.79^{e}	9.61 ± 1.07^{f}	8.32 ± 0.89^{a}	8.79 ± 0.74^{c}	9.10 ± 0.49^{d}	10.58 ± 0.56^{h}	10.57 ± 0.56^{g}

Mean values on a row with heterogeneous superscripts letters are significant different ($p \leq 0.05$), Cl^- = Chloride; NO_3^- = Nitrate; PO_4^{3-} = Phosphate, SO_4^{2-} = Sulphate; Na^+ = Sodium, Mg^{2+} = Magnesium, K^+ = Potassium, Ca^{2+} = Calcium, DO = Dissolved Oxygen; Alkan = Alkalinity, Jan = January, Feb = February, Mar = March, Apr = April, Jun = June, Jul = July, Aug = August, Sep = September, Oct = October, Nov = November, Dec = December

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