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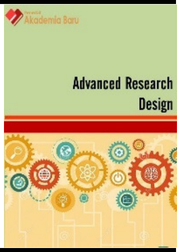

Determination of physicochemical parameters and riparian land effect on Kwadon stream

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ABSTRACT

Water quality is defined in terms of its physical, chemical and biological contents. Human activities around the riparian landscape of streams have resulted in environmental changes, causing irregularities in the zone and affect the stream physicochemical parameters. This study aimed at examining the physicochemical characteristics of Kwadon stream, Gombe state, Nigeria and possible effect of riparian land use on these parameters. Three sites of the stream (site A, B and C) were selected for the analysis for a period of six months and ten (10) physicochemical parameters were analyzed. The data obtained were statistically analyzed using SAS, Pearson correlation and SPSS (ANOVA) to determine the level of significance of the parameter. Interestingly, almost all the physicochemical parameters values studied are within the safety limit which make the stream a conducive environment for growth of aquatics. Also, the obtained data indicated that activities such as fishing, irrigation and domestic acts has less effect on the physicochemical parameters of the stream.

1. Introduction

Water bodies to be precise ocean, streams and lakes are essential habitat for many organisms. The territory remains a valuable resource for human's life activities such as fishing, irrigation and also for hydro-power generation. Such acts really influenced the environment as well as the living systems not only in the near-stream (riparian) zone, but also over the entire watershed. Studies on the effects of riparian land use on stream benthic communities have been carried out by [1]. The vegetation effects can be observed on the benthic ecological zone which comprises the community of the benthos (benthic invertebrate including crustaceans and polychaetes). The benthic boundary layer is an integral part of the riparian-benthic as it greatly influences the biological activities and affect the water body as well as other commercial activities of the surrounding areas [2, 3].

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Riparian zone is the green ribbon of life and a mixture of vegetation types which varies greatly in terms of physicochemical parameters from one place to another. The floral riparian vegetation along a desert stream may be small or sparse, while along the mountain stream is tall and lush. Such zone is critical to the health of every stream and its surrounding environment, as it connect the upland neighborhood to the actual aquatic zone [2]. Similarly, the riparian landscape has been significantly degraded by human developmental projects such as urbanization, agriculture and grazing. These activities can result in environmental changes and caused irregularities in the zone like stream bank erosion, increased sedimentation and alteration of geomorphology of the vegetation [4]. Reports indicated that any slight changes in the environment has a considerable response on the benthic community and it avails to measure the degree of pollution along the riverine areas and water body [5, 6]. Usually, increase in the use of chemicals, herbicides, pesticides, insecticides, fertilizer and improper disposal of sewage around the region induced the problem by affecting the physicochemical parameters of the water. These actually leads to water contamination and exposes aquatic organisms to disease and other health related problems [7].

Considering the above, water quality is defined in terms of its chemical, physical and biological contents. Also, the stream quality changes with alteration of those parameters due to human's activities, season and geographical areas. Thus, to present stream and its water quality, basic scientific information about the water parameters and ecological relevant need to be provided [8]. The water quality assessment is usually aimed at controlling the pollution, plan for water resource management and data generation that may be useful in development of fisheries resources and a vector of water borne diseases. Therefore, this study aimed at examining the physicochemical characteristics of Kwadon stream and possible effect of riparian land on the parameters towards distribution and abundance of benthic communities in the area. Studying the water quality of a stream would help in protecting and maintaining the aquatic ecosystem, control pollution and water resources management.

2. Materials and Methods

2.1 Study Area

The study area is a stream located in Kwadon town of Yamaltu Deba LGA, Gombe State, Nigeria. The area lies between latitude 10^{o} $16^{'}$ 15'N to 10^{o} $17^{'}$ 7^{o}'N and longitude $11^{o}16^{1}$ 44''E to 11^{o} $18^{'}$ 28''E. The various activities going-on around the stream includes farming and fishing. Three sampling sites of the stream were selected and marked as; site A (the up-stream i.e. the fishing site), site B (mid-stream which characterized as domestic activity site) and site C (down-stream; the site for irrigation) [9, 10].

2.2 Analysis of Physicochemical Parameters of Kwadon Stream Water

Ten (10) different physicochemical parameters of Kwadon stream were analyzed between the month of July – December as detailed below.

2.2.1 Determination of Temperature

Temperature (^{o}C) of the stream was the first parameter determined at the sampling sites at every day of sampling. It was directly measured using mercury bulb thermometer (glaswekwer Tein model). The thermometer bulb was inserted deep into the water body and was allowed for about two minutes before recording. The readings were taken in triplicate at each site.

2.2.2 Determination of pH

The pH of the water body was determined from the sites using a pH meter (Hanna instruments). The meter was initially standardized and deep into water sample to record the pH following the manufacturer's instruction.

2.2.3 Turbidity Measurement

Spectrophotometric analysis was carried out on the samples to measure turbidity. For blank, distilled water was used in 4 mL cuvette and first inserted into the spectrophotometer to calibrate. The same volume of water samples in another cuvette was read at 580mn.

2.2.4 Determination of Free Carbondioxide (CO_2)

The stream sites CO_2 content was determined as described by Saxena [11]. A 50 mL of stream water was put into flask and two drops of phenoptaline reagent was added. A change in colour to pink indicates the absence of free CO_2 in the sample. Where the actual colour was displayed, the water was titrated against NaOH solution until pink colour appeared as determined using the formulae below,

$$\text{Free } CO_2 \text{ (mg/L or PPM)} = \frac{Vt \times 100}{Vs}$$

Where

Vt = Volume of titrant (mL)
Vs = Volume of the sample (mL)

2.2.5 Determination of Dissolved Oxygen (DO)

DO was determined as described by Saxena [11]. A glass stopper of 100mL of the water samples were used by avoiding air bubbles. Manganese-sulphate and alkaline reagents (potassium iodide plus potassium hydroxide) 1mL each was added into the different sample until precipitate appeared. H_2SO_4 (reagent) 2mL was added and shaken vigorously to dissolve the precipitate. A 50mL of content was transferred gently (by also avoiding air bubbles) to a conical flask and added four (4) drops of starch indicator. Titration was observed against sodium thiosulphate solution and the end point was noted when initial blue colour turn to colourless. The DO was calculated after the titration using the formulae below.

$$DO(mg/L) = \frac{V_1 \times N \times 8 \times 1000}{V_4 (V_2 - V_3)}$$

Where,

DO = Dissolved Oxygen
V_1 = Volume of titrant (mL)
N = Normality of titrant (0.025)
V_2 = Volume of sampling bottles after placing stoppers(mL)
V_3 = Volume of $MnSO_4$ + (KI+KOH) added (mL)
V_4 = Volume of the content used for titration (50mL)

2.2.6 Determination of Conductivity

Electrolyte conductivity of the water body was determined at the different sites using conductivity meter (PHYTE 65667.00). The unit of measurement was expressed in µs/cm. All measurements were made at temperature other than 25^oC and calculated using the below formulae.

$$\text{Conductivity (K)} = \frac{C \times 1}{R}$$

Where

C = Cell constant

R = Resistance

2.2.7 Nitrogen Content Determination

To determine the nitrogen content, the water sample from different sites was filtered separately through pre-rinsed Whatman No. 1 GF/C filter paper immediately after its collection. A 25 mL of the water were transferred into 150 mL conical flask, 1mL of H_2SO_4 and a dozen of anti-bumping granules were added. The samples were undergone boiling on a hot plate until white fumes of sulphur-trioxide appeared. The flask was removed from the hot plate and added 1g of potassium tri-sulfate. The mixtures were strongly heated at fuming temperature for exactly 10 minutes and allowed to cool. A 15 mL of distilled water was added and completely transferred to a 50mL volumetric flask. One drop of methyl red solution and 10M NaOH were added until the solution turns clear. The solution was titrated by adding 4M H_2SO_4 drop by drop until the solution turned red. Phenol nitroprusside 1.0mL and 1.5mL of alkaline hypochloride were added to the sample during titration and distilled water was used as blank. Sample was incubated for 24hours before reading the absorbance at 635 nm [12]. Also, calibration curve was prepared using standard nitrogen concentration.

2.2.8 Total Ammonia Determination

Ammonia from the water samples were also determined after filtration. A 1mL of phenol-nitropruside reagent was added to 25mL of each sample and mixed. Alkaline hypochloride reagent 1.5 mL was added to sample, covered the flask and the mixture was left in the dark for 1 hour at room temperature. Standard for ammonia stock concentration and calibration curves were equally prepared.

2.2.9 Determination of Total Alkalinity

Total alkalinity was determined as described by Stirling [13]. Equally, 50 mL of the water was used and 3 drops of methyl orange as indicator were added. The sample was titrated with standard 0.01M H_2SO_4 and HCL separately until the colour changes from blue to pale pink. The total alkalinity was calculated using the equation below.

$$\text{Alkalinity in mg/L} = \frac{n \times V_2 \times 1000}{V_1}$$

Where

n = Normality of standard H_2SO_4

V_1 = Volume of sample

V_2 = Volume of acid used

2.2.10 Determination of Total Phosphorus

Total phosphorus was determined by spectrophotometric analysis. Ammonium molybdate solution 1 mL was added into 5 mL of each sample from the different sites and was allowed to stand for 20 seconds. Then, 1mL of hydroquinone solution was added and shaken the flask. Another 1 mL of Na_2SO_3 and 2ml of distilled H_2O was later added, shaken vigorously and allowed to stand for 30 minutes. The total phosphorus was measured at 650nm, alongside with blank. Also, calibration curve was prepared using standard phosphorus concentration.

2.3 Data Analysis

The data generated was analysed using SAS (Statistical Analysis System version 15.0). Frequency and mean values for physicochemical parameters were determined. Pearson correlation analysis was used to test the relationship between the parameters. ANOVA using SPSS (statistical package for the social science) was conducted to determine the level of significance of the physicochemical parameters across the three sites and effect of the riparian land use on the stream sites.

3. Results and Discussion

3.1 Characterization of Kwadon Stream Water

The use of acceptable method(s) for monitoring the stream water quality is already a widespread approach in many developed countries. This provides information and everlasting solution to the possible problem, maintain the water quality and conducive environment for aquatic organisms. Physicochemical system of monitoring is one of the most appropriate method and has shown a remarkable outcome towards pollution control in such water bodies. The seasonal and locational variation of physicochemical parameters from Kwadon stream indicated a significant different across the three different sites examined. As determined in the present study, the monthly mean water temperature of the stream was fluctuating between 23.14^{o}C and 28.33^{o}C in site A, B and C during the period of the study. This might be due to the rainy season condition between July-September and dry season advanced towards the dry harmattan period usually within the month of November and December.

The temperature falling and increase in such Nigeria river within the months of December – January is attributed to cold weather conditions of the period [7]. Equally, the temperature ranges obtained during the period of this research was in line with that of Haruna [14] as shown in Figure 1. The temperature of the sites has shown a significant difference of $F_{2, 15}$ = 22.3, p = 0.000). Similarly, water temperature determines the concentration of many variables. For example, as the water temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilization of substances. Such parameter increases as well as also decreases the solubility of gases such as O_2, CO_2, N_2 and CH_4. Evenly, the metabolic rate of aquatic organism and warm water respiration rates also rises the temperature which leads to increase in oxygen consumption and decomposition of organic matter.

The pH of Kwadon stream water ranges from 7.67 - 11.55 during the period of this research as shown in Figure 1. Equally, the pH statistical analysis showed a significant difference among the sites (pH $F_{2, 15}$ = 15.8, p = 0.000). Considering the temperature values and pH plus the statistical analyses, these have shown a significant positive correlation between the two parameters. Consistently, the pH was positively correlated with other factors like turbidity, DO and conductivity. Such indicated that the various anthropogenic activities did not really alter the ambient pH. In fact, high water pH affects aquatic organism productivity and cause death to those that have less ability to dispose metabolic waste. Also, the turbidity and conductivity from the diverse sites indicated a significant variance at $F_{2, 15} = 15.6$, $p = 0.000$ and $F_{2, 15} = 45.2$, $p = 0.000$ respectively (Figure 2). In addition to the former two analyzed parameters, this significant difference has demonstrated a clear dissimilarity in terms of activities going on there, as well as distribution of trees.

Furthermore, the high turbidity content between the months of the study may be due to water runoff and suspended matter during the rainy season, although, the turbidity is expected to reduce as the season ceased. In contrast, previous findings indicated that highest range of turbidity was attributed to absence of flood water, surface runoff and settling effect of suspended solids after the seizure of rainfall as well as human agricultural activities [15]. The water conductivity is attributed to high concentration of pH (particularly site B and C of the stream). Therefore, the mean distribution of the parameters is tabularized in Table 1. For parameters like CO_2, DO, Nitrogen content, Ammonia, Alkalinity and Phosphorus indicated no significant difference. The statistical values were; for DO ($F_{2, 15} = 2.7$, $p = 0.10$), nitrogen ($F_{2, 15} = 0.86$, $p = 0.44$), ammonia ($F_{2, 15} = 0.24$, $p = 0.78$), alkalinity ($F_{2, 15} = 0.03$, $p = 0.97$) and phosphorus ($F_{2, 15} = 1.31$, $p = 0.29$). In fact, the results indicated a significant positive correlation between the free CO_2 with alkalinity and phosphorus.

The correlation analysis between free CO_2, ammonia and phosphorus indicated a negative result which was due to dissimilar activities within the three sites of riparian vegetation. Precisely, the mean of monthly variation of free CO_2 was discovered to be within the safety limit (Figure 3) as also reported Haruna [14]. The monthly mean for DO (5.36 to 7.46 mg/l) may be characterized by greater and frequent rate by wind current at the period of data collection (October - December) which does not encourage or enhance decay of organic matter (Figure 3) [16]. In addition, the monthly total nitrogen from the stream sites was fluctuating as shown in Figure 4. Though, the result of nitrogen content higher than 0.02mg is actually within the acceptable limit as recommended by USEPA (2002). Still such amount may be connected with the amount of rainfall in the area. Hence, increase in rainfall and its runoffs from farmlands increase the concentration of total nitrogen in the water body.

For ammonia content, diverse mean ranges were observed as shown in Figure 4. The high values from the monthly mean calculated could be as a result of decomposition of organic matter. Ammonia in water body is released as an end product of organic matter decomposition and/or as excretory product of some aquatic animals [11, 17]. The next chemical compound analyzed was alkalinity which indicated a little bit high amount in the water, but also within the acceptable range (Figure 5). Normally, much limestone such as carbonate ($CaCO_3$) deposition in the surrounding soils and along the course of the stream can cause high alkalinity in water. Therefore, the stream might have lower buffer capacity. This correspond with the finding of Stirling [13] which reported that limestone deposition at the surrounding soil and along the course of water body causes high alkalinity content. Equally, the mean of monthly variation of phosphorus indicated a slightly higher amount which may be as a result of anthropogenic activities and waste sedimentation associated with the sites (Figure 5). This agrees with the report of ACTFER (2002) that artificial sources of phosphorus such as fertilizers, detergents, industrial affluent and animals' excreta increases phosphorus amount in water.

Interestingly, almost all the values of physicochemical parameters obtained from the experiments are within the safety limit which makes the stream a favorable environment for growth of aquatics and their planktons across the different sites. While the impact of riparian land use in the study area helped in structuring the Ephemeropteran larval communities in the stream. Based on the results of the physiochemical parameters obtained, it indicated that activities such as fishing, irrigation and washing of clothes do not affect the stream greatly (Table 1 and 2). The significance variation in the different parameters observed could be attributed to flow variability and changes in water shed condition as reported by Chukwu and Nwankwo [18]. The authors communicated that high variability in water quality parameters may be due to the impact of extrinsic factors such as rainfall and catchments activities which prevailed during the raining and dry season period.

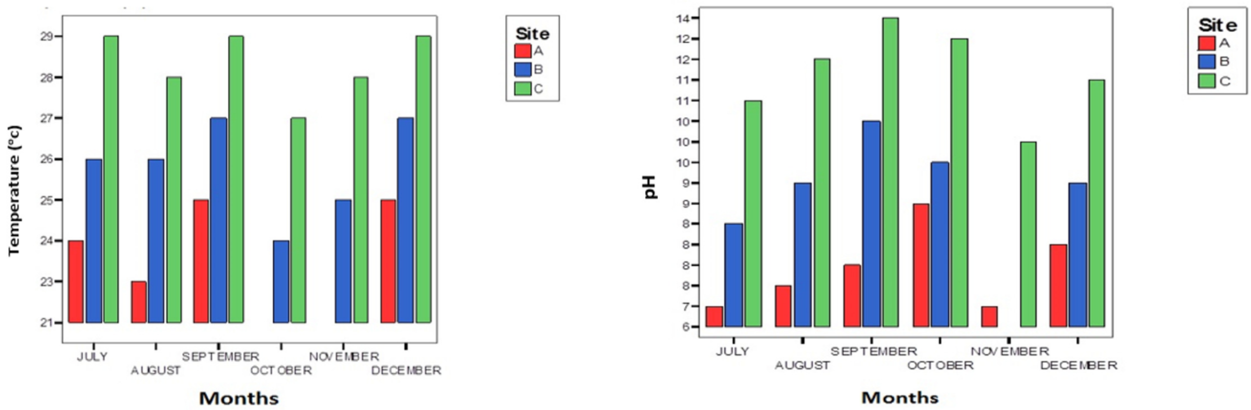

Fig. 1. Mean temperature (°C) value (left) and mean pH value (right) value of Kwadon stream according to Months

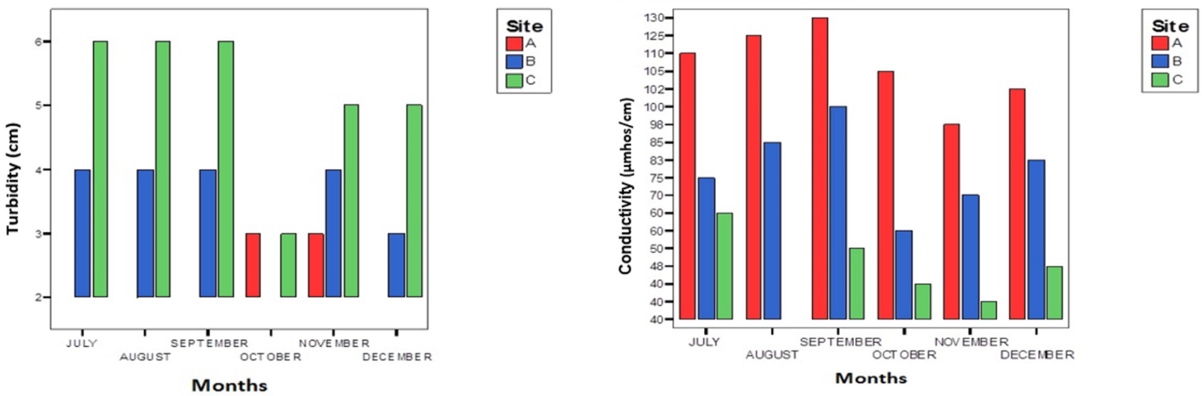

Fig. 2. Mean turbidity value (left) and mean conductivity (µmhos/cm) value (right) of Kwadon stream according to months

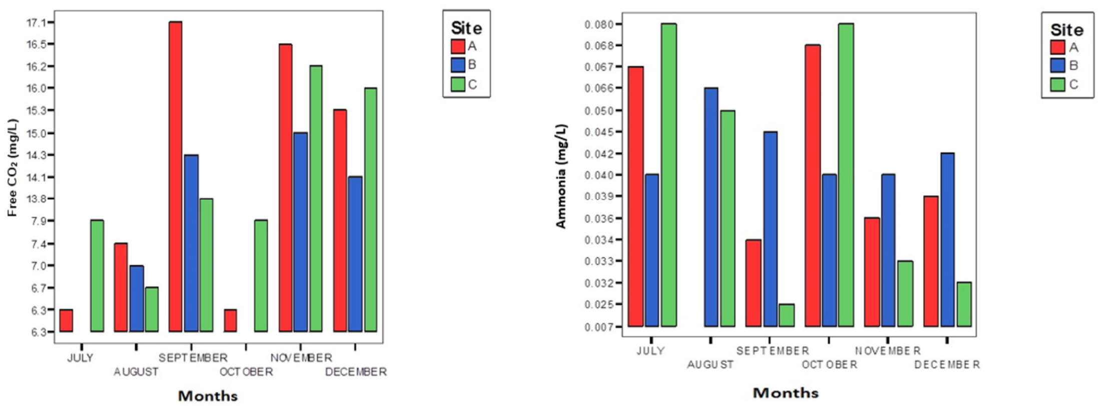

Fig. 3. Mean free CO_2 (mg/L) (left) value and mean ammonia value (right) of Kwadon stream according to months

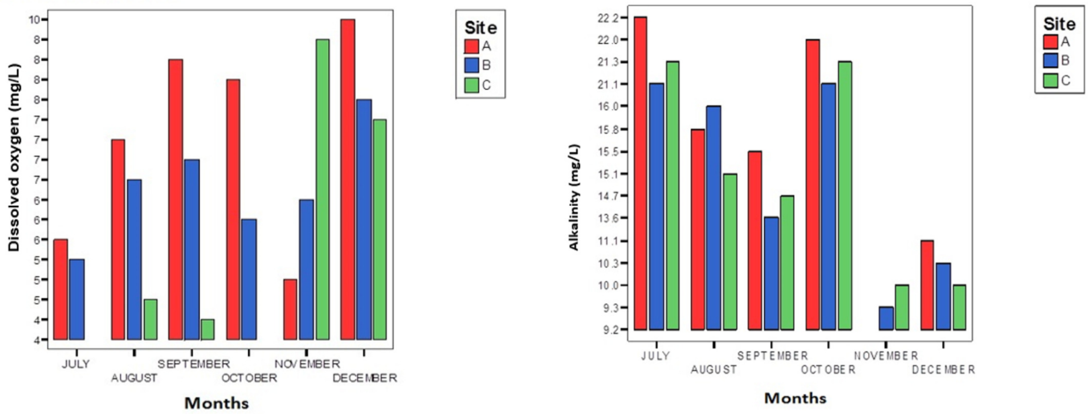

Fig. 4. Mean dissolved oxygen(mg/l) value (left) and mean alkalinity value (right) of Kwadon stream according to months

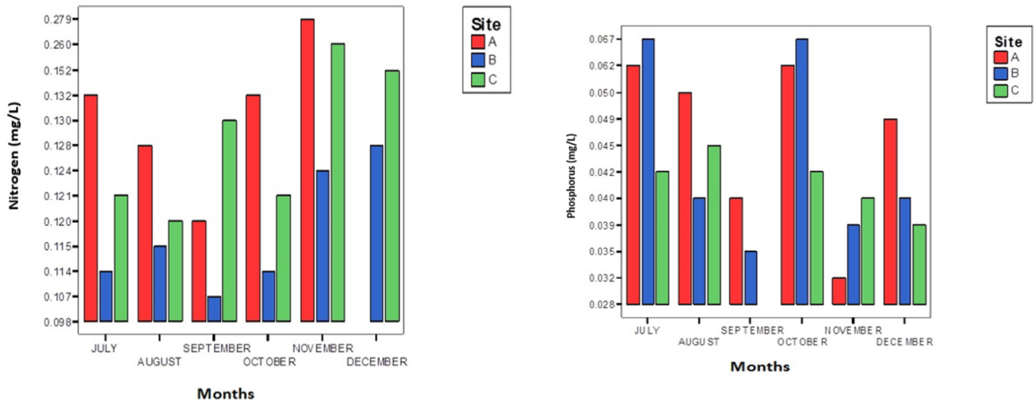

Fig. 5. Mean nitrogen value (left) and mean phosphorus value (right) of Kwadon stream according to months

3.2 Riparian Land Use Effect on the Physicochemical Parameters

Considering the diverse human activities going on at the riparian vegetation of Kwadon stream as well as the physicochemical parameters obtained in this research. The analysis signified that the domestic activities has less effect on the parameters, but may have impact on abundance and diversity of planktons. Site A has less physicochemical parameters effect compared to other sites. This could be as a result of less effects of fishing on the planktons and low temperature. But, sites B and C have low turbidity which may be due to agrochemicals used in irrigation and domestic activities. This implies that domestic usage and irrigation may have negative impact on plankton's diversity with few species that are likely to survive in irrigation site and domestic site.

4. Conclusion

Conclusively, the finding of this study showed that the value of physiochemical parameters obtained were not all within the recommended ranges; few are higher, while some are lower than the recommended safety limits. Likewise, the results show that the riparian land use has impact parameters such as turbidity which is due to the domestic and agrochemical used for irrigation within the specific sites. This implies that domestic activities have negative impact on physicochemical parameters of stream water and aquatics. Importantly, contamination of such water bodies can be reduce using natural coagulant and would serve as source of food to aquatic organism [19].

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Table 1
Mean Distribution of Physiochemical Parameters across Sites

Site		Temperature (°C)	pH	Free CO_2	Turbidity	DO	Conductivity	Ammonia	Nitrogen	Phosphorus	Alkalinity
A	Mean	23.17	7.67	11.475	2.33	7.42	111.83	0.04183	0.14817	0.04917	15.970
	Std. Dev.	1.835	0.644	5.3139	0.516	1.617	12.914	0.022956	0.065356	0.011907	5.3892
	Variance	3.367	0.415	28.238	0.267	2.616	166.779	0.001	0.004	0.000	29.043
	N	6	6	6	6	6	6	6	6	6	6
B	Mean	25.83	8.77	10.483	3.50	6.66	79.03	0.04550	0.11700	0.04800	15.233
	Std. Dev.	1.169	1.460	4.3823	0.837	0.873	13.896	0.010232	0.007642	0.014832	5.1310
	Variance	1.367	2.131	19.205	0.700	0.762	193.100	0.000	0.000	0.000	26.327
	N	6	6	6	6	6	6	6	6	6	6
C	Mean	28.33	11.55	11.392	5.17	5.36	46.48	0.05000	0.15067	0.03933	15.403
	Std. Dev.	0.816	1.419	4.4049	1.169	1.983	8.072	0.024650	0.054924	0.005922	5.0746
	Variance	0.667	2.013	19.403	1.367	3.931	65.164	0.001	0.003	0.000	25.751
	N	6	6	6	6	6	6	6	6	6	6
Total	Mean	25.78	9.33	11.117	3.67	6.48	79.11	0.04578	0.13861	0.04550	15.536
	Std. Dev.	2.510	2.039	4.4580	1.455	1.708	29.644	0.019398	0.049082	0.011708	4.8953
	Variance	6.301	4.157	19.874	2.118	2.917	878.771	0.000	0.002	0.000	23.964
	N	18	18	18	18	18	18	18	18	18	18

Table 2
Pearson Correlation between physiochemical parameters of Kwadon Streams

Parameters		Temperature	pH	Turbidity	DO_2	Conductivity	Ammonia	Nitrogen	Phosphorus	Alkalinity	Free CO_2
Temperature	Pearson Correlation	1	0.702(**)	0.735(**)	-0.285	-0.680(**)	0.071	-0.188	-0.420	-0.146	0.162
	Sig. (2-tailed)		0.001	0.001	0.252	0.002	0.778	0.455	0.082	0.564	0.520
	N	18	18	18	18	18	18	18	18	18	18
pH	Pearson Correlation	0.702(**)	1	0.624(**)	-.455	-0.701(**)	0.131	-0.119	-0.331	0.126	-0.069
	Sig. (2-tailed)	0.001		.006	0.058	0.001	0.604	0.638	0.180	0.618	0.785
	N	18	18	18	18	18	18	18	18	18	18
Turbidity	Pearson Correlation	0.735(**)	0.624(**)	1	-0.484(*)	-0.706(**)	0.103	0.117	-0.449	-0.155	0.055
	Sig. (2-tailed)	0.001	0.006		0.042	0.001	0.683	0.645	0.062	0.539	0.827
	N	18	18	18	18	18	18	18	18	18	18
DO	Pearson Correlation	-0.285	-0.455	-0.484(*)	1	0.491(*)	-0.367	0.020	0.132	-0.401	0.413
	Sig. (2-tailed)	0.252	0.058	0.042		0.038	0.134	0.937	0.602	0.099	0.089
	N	18	18	18	18	18	18	18	18	18	18
Conductivity	Pearson Correlation	-0.680(**)	- 0.701(**)	-0.706(**)	0.491(*)	1	-0.186	-0.136	0.188	0.051	0.056
	Sig. (2-tailed)	0.002	0.001	0.001	0.038		0.461	0.591	0.454	0.839	0.826
	N	18	18	18	18	18	18	18	18	18	18
Ammonia	Pearson Correlation	0.071	0.131	0.103	-0.367	-0.186	1	-0.225	0.182	0.575(*)	-0.482(*)
	Sig. (2-tailed)	0.778	0.604	0.683	0.134	0.461		0.370	0.469	0.013	0.043
	N	18	18	18	18	18	18	18	18	18	18
Nitrogen	Pearson Correlation	-0.188	-0.119	0.117	0.020	-0.136	-0.225	1	-0.319	-0.443	0.424
	Sig. (2-tailed)	0.455	0.638	0.645	0.937	0.591	0.370		0.197	0.066	0.080
	N	18	18	18	18	18	18	18	18	18	18

Phosphorus	Pearson Correlation	-0.420	-0.331	-0.449	0.132	0.188	0.182	-0.319	1	0.673(**)	-0.686(**)
	Sig. (2-tailed)	0.082	0.180	0.062	0.602	0.454	0.469	0.197		0.002	0.002
Alkalinity	Pearson Correlation	-0.146	0.126	-0.155	-0.401	0.051	0.575(*)	-0.443	0.673(**)	1	-0.841(**)
	Sig. (2-tailed)	0.564	0.618	0.539	0.099	0.839	0.013	0.066	0.002		0.000
Free CO_2	Pearson Correlation	0.162	-0.069	0.055	0.413	0.056	-0.482(*)	0.424	-0.686(**)	-0.841(**)	1
	Sig. (2-tailed)	0.520	0.785	0.827	0.089	0.826	0.043	0.080	0.002	0.000	
	N	18	18	18	18	18	18	18	18	18	18

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed)