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Species diversity of fish in shabu stream, Nasarawa state, Nigeria

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Abstract
The fish species diversity and abundance of Shabu stream was studied for a period of four months (October 2016 – January 2017). Fish and water samples were collected at three stations where riparian activities were highest inclusive of fishing. Water samples were analysed of BOD (1.82-2.30 mg/L), DO (4.72-5.37 mg/L), temperature (25.81-26.14 ºC), total alkalinity (4.82-5.35 mg/L), pH (5.00-5.14) and carbon dioxide (11.95-19.37 mg/L) were found to be within productive ranges for fish growth. The diversity indices showed *Tilapia zilli* (Shannon Weiner 1.25, Berger-Parker 0.45, Margalef 0.71 and species richness 4.00) to be the most dominant species followed by *Oreochromis niloticus* and *Clarias gariepinus.* Further, the month of January, 2017 had the highest species abundance in the four months. It was concluded that if harnessed through proper fishing practices and other riparian activities, the Shabu stream would grow into a veritable source of fisheries products to the inhabitants of Nasarawa state.

Keywords: species diversity, shabu stream, water quality, monthly variation, fish abundance

1. Introduction
Fish contributes as much as 17% of the world's animal protein [1]. Inland fisheries play an important role in the provision of protein to Nigerians with a high population of about 178.5 million people [2], especially when imported fish is becoming too expensive for low income earners as observed by [1]. It is important to know the fish species diversity, abundance and distribution in the reservoirs in order to develop management and conservation programs. Studies of spatial and temporal patterns of diversity, distribution and species composition of freshwater fishes are useful to examine factors influencing the structure of the fish community [1].

The global freshwater biodiversity is declining more rapidly than the terrestrial biodiversity [3]. Freshwater fishes are highly threatened taxa. Nigeria is currently experiencing stock decline due to over exploitation and inadequate management of her fisheries resources. For sustainability of these resources, an adequate knowledge of species composition, diversity and relative abundance of her water bodies must be understood and vigorously, pursued [4]. According to [4] Habitat variability alone is considered as the biggest causal of loss of freshwater fish diversity.

Shabu stream has a remarkable fisheries resource potential but their identity, diversity and abundance has not been well established and documented. Only one review work has been able to identify the diversity and abundance of Tilapia Species (*Tilapia melanopleura* and *Tilapia zilli*) which are the most dominant species in Shabu stream. Biodiversity information within an area is vital for the development of adequate conservation strategies. This work therefore provides information on the abundance and diversity of the species of the stream so as to put in place appropriate measures for the conservation of the fishery of Shabu stream.

2. Materials and Methods
Experimental site
Shabu stream is located in Lafia Main Township which is the capital of Nasarawa state. The state is situated within the Guinea Savanna Ecological Zone of Nigeria (8º-9º east of GMT and 8º-9º North of equator [5] The stream is perennial in nature because of its constant flow throughout the year and the outcome to this include extensively human activities, fishing activities as well as agricultural production through irrigation particularly during dry season. The stream flows through Akurba village, College of Agriculture Lafia (COAL) and through

Nasarawa State Polytechnic Lafia, Nassarawa State.

Sample collection

The fish were collected fortnightly for a period of four months (October, 2016 – January, 2017) with the aid of long lining with baited/unbaited hooks, cast net and traps at three stations designated S1, S2, and S3. These stations were the points on the stream where riparian activities including fish landing were most prominent. The distance between these stations were approximately 5km. The fish species were identified into families and species using the key according to [6]. Water samples were equally collected at each sampling visit.

Water quality determination

The pH was determined with a digital pH meter (Mettle Toledo 320). Temperature was determined in-situ using a mercury-in-glass thermometer. Dissolved oxygen, biological oxygen demand (BOD), free carbon dioxide (CO_2), total alkalinity were determined using standard methods according to [7].

Statistical analysis

Data analysis was conducted using Genstat Edition 12 to assess variation of water quality at the various sampling stations. Species diversity was also evaluated using the Shanno-Weiner H, Berger-Parker D, Margalef and Species Richness indices to determine the variability of fish species in the stream.

3. Results

Table 1 shows the diversity indices of fish species in Shabu Stream. Eighteen (18) fish species where caught during the sampling period. The most dominant species was *Tilapia zilli. Tilapia zilli* had the highest Shannon Weiner index (1.25), *Clarias gariepinus* (1.03), *Oreochromis niloticus* (0.67), *Channus channus* (0.63) and the other 14 Fish species had 0.00.The values for Berger Parker Dindex had *Tilapia zilli* 0.45, *Clarias gariepinus* 0.50, *Clarias gariepinus* 0.66 and *Oreochromis niloticus* 0.78. Margalef indicated *Clarias gariepinus* 0.91, *Tilapia zilli* 0.71, *Clarias gariepinus* 0.66 and *Oreochromis niloticus* 0.63. In species richness, *Tilapia zilli* had 4.00; *Clarias gariepinus* 3.00, *Oreochromis niloticus* 3.00, *Channus channus* 2.00 and other 14 Fish species caught had 1.00 species richness indices.

Table 1: Diversity indices of fish species in shabu stream

Fish species	Diversity Indices			
	Shannon-Weiner H	**Berger-Parker D**	**Margalef**	**Species Richness**
Alestes imberi	0.00	1.00	0.00	1.00
Chrysichthys furcatus	0.00	1.00	0.00	1.00
Channus channus	0.63	0.66	0.91	2.00
Xenomystus sp	0.00	1.00	0.00	1.00
Synodontis eupterus	0.00	1.00	0.00	1.00
Schilbe mystus	0.00	1.00	0.00	1.00
Gnathonemus abadii	0.00	1.00	0.00	1.00
Labeo coubie	0.00	1.00	0.00	1.00
Mormyrus hasselque	0.00	1.00	0.00	1.00
Pentodon buchal	0.00	1.00	0.00	1.00
Petrocephalus simus	0.00	1.00	0.00	1.00
Synodontis sorex	0.00	1.00	0.00	1.00
Auchenoglanis occidentalis	0.00	1.00	0.00	1.00
Malapeterurus electricus	0.00	1.00	0.00	1.00
Clarias gariepinus	1.03	0.50	0.66	3.00
Heterobranchus longifilis	0.00	1.00	0.00	1.00
Oreochromis niloticus	0.67	0.78	0.63	3.00
Tilapia zilli	1.25	0.45	0.71	4.00

Figure 1 shows the monthly abundance of fish species. *Tilapia zilli* was noticed to be more abundance all through the experimental period with an increase in diversity from October – January. In October 2016, *Tilapia zilli* recorded 30 in number while *Oreochromis niloticus* was next in abundance (18). Only one *Channus channus* was encountered. The month of November had a comparatively lower abundance. *Tilapia zilli* had 18, while the least was *Malapterurus electricus*. Only three species of fish (*Tilapia zilli* 8, *Channus channus* 2 and *Clarias gariepinus* 6) were encountered in the month of December. Fourteen species of fish were caught in January. *Tilapia zilli*, 10 had the highest number while *Chrysichthys furcatus*, *Mormyrus hasselqusti* and *Pentadon buchalzi* were the least caught.

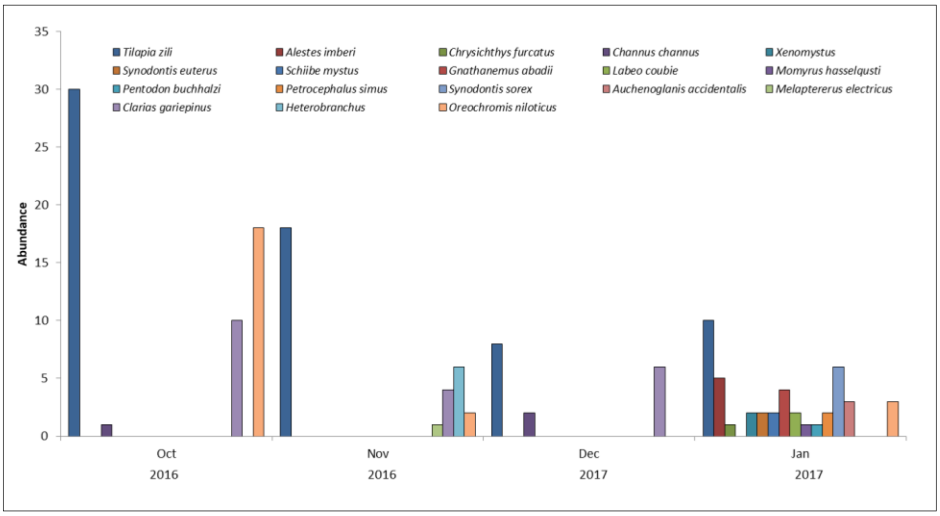

Fig 1: Monthly variation of abundance of fish species in shabu stream

The variation in the some water quality parameters measured during the period is presented in Table 2. Apart from carbon dioxide which varied significantly ($p<0.05$) across the three sampling stations, dissolved oxygen, biological oxygen demand, total alkalinity, temperature and pH did not vary significantly across the stations. The highest value for DO (5.37±0.52 mg/L) was recorded in station S1 while the least (4.72±0.50 mg/L) was at station 3. In a similar vein, BOD was highest in station S1 (1.85±0.29 mg/L) and least at S3. Carbon dioxide was however highest at S3 (19.37±1.19 mg/L) while S1 had 19.37±1.19 mg/L. Total alkalinity (S1 5.35±0.47 mg/L, S3 4.82±0.32 mg/L) and Temperature (S1 26.14±0.75 ºC, S3 25.81±0.72 ºC) followed similar trend as Carbon dioxide. pH was highest at S1 (5.14±0.14) and least at S2 and S3 (5.00±0.00).

Table 2: Mean variation of water quality parameters in Shabu Stream

Variables	Sites			P-Value
	S1	S2	S3	
Dissolved Oxygen (mg/L)	5.37±0.52	5.02±0.56	4.72±0.50	0.70^{ns}
BOD (mg/L)	1.85±0.29	1.82±0.47	2.30±0.31	0.61^{ns}
CO_2 (mg/L)	$11.95±0.99^{b}$	$16.69±1.37^{a}$	$19.37±1.19^{a}$	<0.01
Total Alkalinity (mg/L)	4.82±0.32	5.21±0.25	5.35±0.47	0.57^{ns}
Temperature (ºC)	25.81±0.72	25.92±0.80	26.14±0.75	0.95^{ns}
pH	5.14±0.14	5.00±0.00	5.00±0.00	0.38^{ns}

Means on the same row with different superscript are statistically significant ($p<0.05$); not significant

Figures 2-7 shows the change trend in the water quality parameters during the study period. The dissolved oxygen was highest in the month of October 2016 (S1 7.6 mg/L, S2 7.4 mg/L, S3 5.5 mg/L). There was a drop to S1 4.2 mg/L, S2 3.9 mg/L, S3 3.4 mg/L in the month of December 2016. A gentle rise was however recorded in January 2017 where the highest DO was at station S2 (5.6 mg/L).

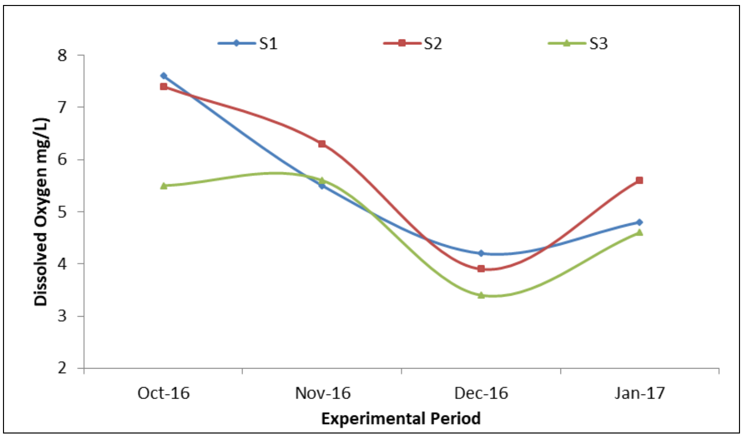

Fig 2: Mean monthly variation of dissolved oxygen in Shabu Stream

Biological Oxygen Demand (BOD) assumed a similar trend as dissolved oxygen becoming lowest in the month of December 2016. The highest BOD (3.8 mg/L) was in October 2016 while the least (1.2 mg/L) was in December 2016. Sampling station S3 however showed a slight variation in BOD during the sampling period.

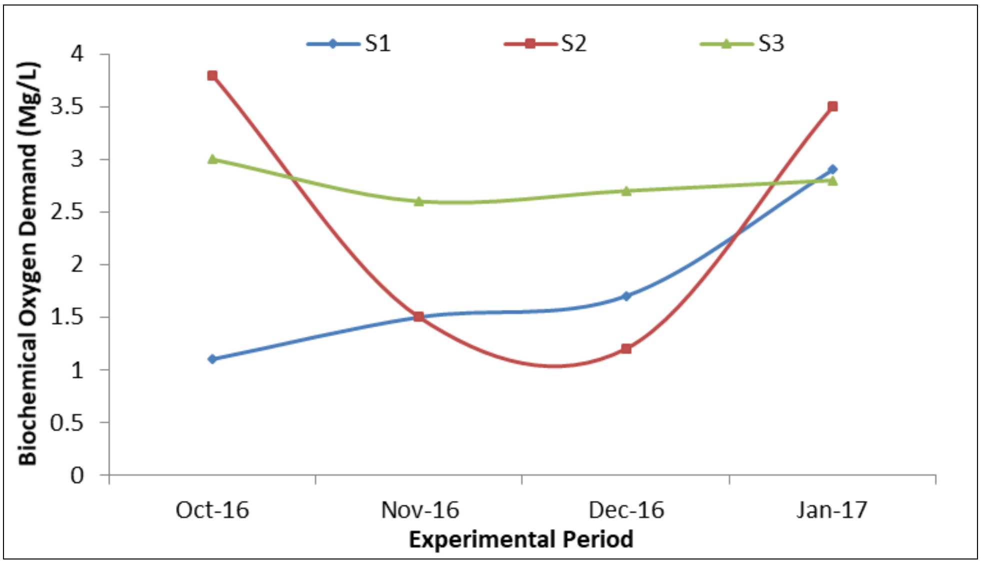

Fig 3: Mean monthly variation of biological oxygen demand in Shabu Stream

The mean monthly variation of carbon dioxide is presented in figure 4. There was a slight variation of carbon dioxide during the sampling period. The most varied station was S1 which had the highest value (14.52 mg/L) in October 2016 and the least (10.56 mg/L) in January 2017. Station S3generally recorded higher concentrations than S1 and S2.

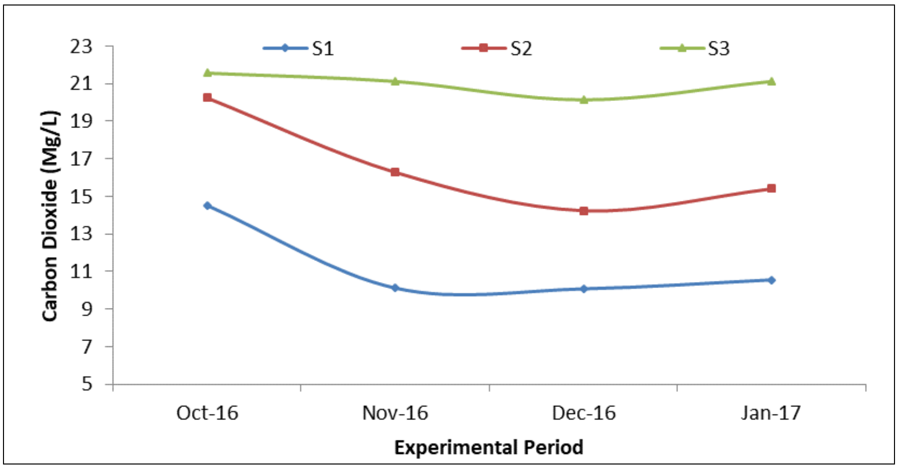

Fig 4: Mean monthly variation of carbon dioxide in Shabu Stream

The variations in total alkalinity during the sampling period are presented in figure 5. Stations S1 and S2 assumed a similar trend. They slightly dropped from S1 4.0 mg/L, S2 5.0 mg/L in October 2016 toS1 3.5 mg/L, S2 4.5 mg/L in November 2016. Concentration at all the stations rose steadily to S2, S3 5.5 mg/L and S1 in November 2016.

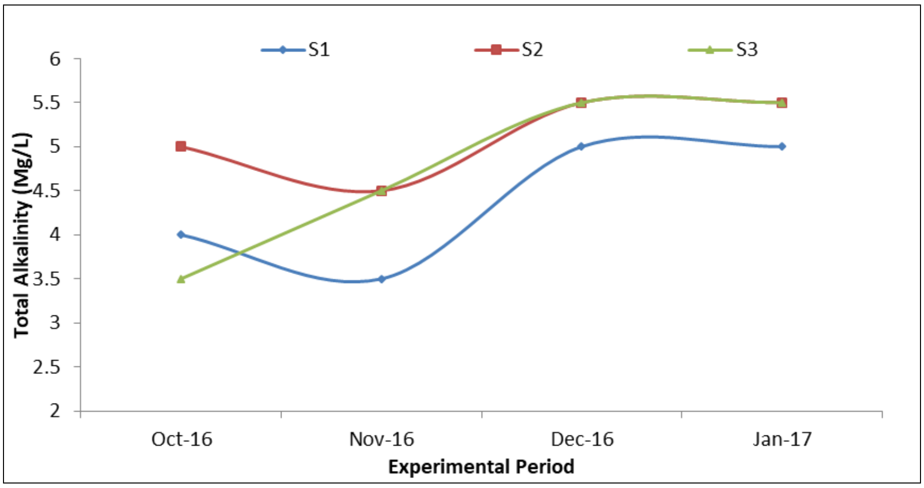

Fig 5: Mean monthly variation of total alkalinity in Shabu Stream

Figure 6 depicts a trend for the change in temperature during the study period. There was a drop in temperature from a mean of 28.5 °C at all stations in October 2016 to a mean temperature 21.2 °C in November 2016.There was however a rise to 27.4 °C at all stations in January 2017.

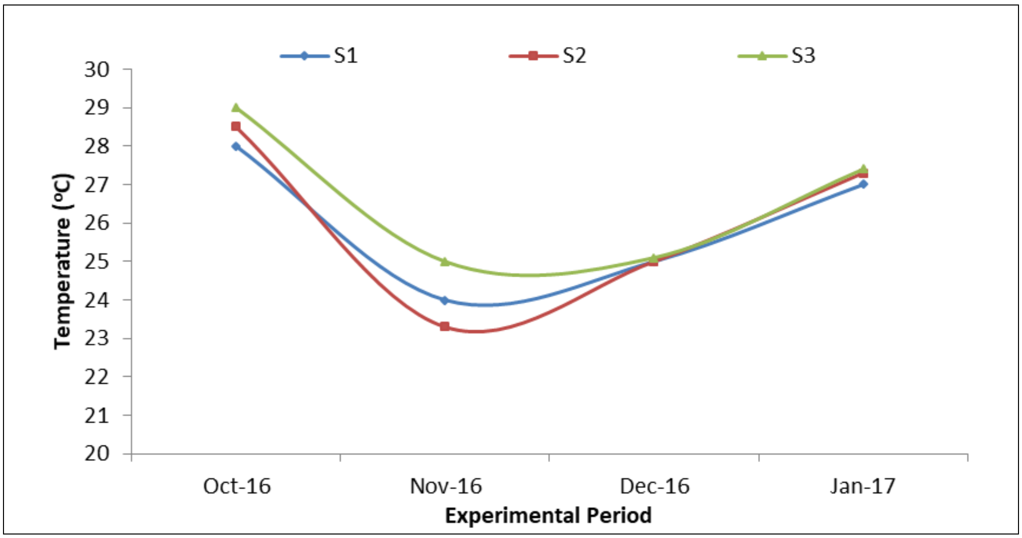

Fig 6: Mean monthly variation of temperature in shabu stream pH showed no monthly variation during the period of sampling.

Table 3 shows the correlation relationship between water quality and fish abundance. The relationship shows how the various species of fish reacted to the various water quality parameters in the inhabiting water. Dissolved oxygen generally showed a negative correlation with fish abundance. *Clarias gariepinus* (-0.69), *Oreochromis niloticus* (0.91) and *Tilapia zilli* (-0.99) showed strong correlations to dissolved oxygen indicating their swift change in abundance to dissolved oxygen variations. There was a positive correlation of the fish abundance with biological oxygen demand. The abundance of *Clarias gariepinus* (0.99), *Synodontis eupterus* (0.77) and *Labeo coubie* (0.77) were noticed to react to respond more to increase in the BOD of the water. Carbon dioxide also had a positive relationship with the abundance of the fish species. The relationship was however not statistically significant ($p>0.05$). A similar trend was established in total alkalinity where no significant variation was recorded. Most of the fish species showed an increase in abundance as temperature decreased but *Channus channus* (0.83), *Oreochromis niloticus* (0.54) and *Tilapia zilli* (0.30) showed an increase in abundance as fish abundance increased. All species responded negatively to changes in pH although they were all statistically not significant ($p>0.05$).

Table 3: Correlation of fish abundance with water quality of Shabu Stream

Fish Species	Water Quality Variables					
	DO	BOD	Co2	Alkalinity	Temp	pH
Alestes imberi	-0.40	0.70	0.58	0.36	-0.38	-0.33
Chrysichthys furcatus	-0.40	0.70	0.58	0.36	-0.38	-0.33
Channus channus	-0.15	0.67	0.57	0.57	0.83*	-0.52
Xenomystus sp	-0.40	0.70	0.58	0.36	-0.38	-0.33
Synodontis eupterus	-0.40	0.77*	0.58	0.36	-0.38	-0.33
Schilbe mystus	-0.40	0.70	0.58	0.36	-0.38	-0.33
Gnathonemus abadii	-0.40	0.70	0.58	0.36	-0.38	-0.33
Labeo coubie	-0.40	0.77*	0.58*	0.36*	-0.38	-0.33
Mormyrus hasselque	-0.40	0.70	0.58	0.36	-0.38	-0.33
Pentodon buchal	-0.40	0.70	0.58	0.36	-0.38	-0.33
Petrocephalus simus	-0.40	0.70	0.58	0.36	-0.38	-0.33
Synodontis sorex	-0.40	0.70	0.58	0.36	-0.38	-0.33
Auchenoglanis occidentalis	-0.40	0.70	0.58	0.36	-0.38	-0.33
Malapeterurus electricus	-0.09	0.25	0.57	0.73	-0.73	-1.00
Clarias gariepinus	-0.69*	0.99*	0.80	0.26	0.76*	-0.16
Heterobranchuslongifilis	-0.09	0.25	0.57	0.73	-0.73*	1.00
Oreochromis niloticus	-0.91	0.67	0.39	0.42	0.54	-0.30
Tilapia zilli	-0.99**	0.64	0.23	0.73	0.30	-0.10

** indicates statistical significance at 0.01%; * indicates statistical significance at 0.05%

4. Discussion

Abundance of fish populations in river, lake with river source and reservoirs widely changed from year to year and the relative frequency of different species is different in population. This change is affected by rainfall fluctuation and floods. The increasing area and flood flow time is improved spawning, growth and survived rate [4]. Bias associated with fishing gear types can greatly influence comparisons of aquatic habitats, especially when meaningful community information is desired for habitat restoration research [6].

The Stream had species richness of 18 fish species. *Tilapia zilli* was the most dominant species. The species diversity declined due to non selective gears, overfishing, distribution of spawning grounds and capture of juvenile fishes. This was similar with the findings of [8, 9]. The drastic decrease in abundance of the fish species also agrees with a number of studies that had earlier reported that declining fish catches from Lagos lagoon are the increased fishing pressure and habitat destruction [10]. Reasons for poor catch could be as Dry season in south west Nigeria, is a period characterized by poor water quality, reduced water level, high temperature and salinity [4], under these conditions, migrations of the species of fish may be responsible for the low catch recorded during these period.

During the study period, habitat loss, over-exploitation, and the indiscriminate killing of juvenile fish due to unregulated fishing pressures, the destruction of breeding and nursery grounds were observed which might be responsible for the less diversity of fish fauna in the studied wetland. [1, 6] detected more or less the same reasons behind the decline of fish diversity which supports the present findings. The difference in the species composition in this study and others may be due to difference in abiotic factors such as dissolved oxygen, temperature, pH, dissolved oxygen, biological oxygen demand, total alkalinity and carbon dioxide. Among the dissolved gases, the dissolved oxygen plays the most important role with regard to the water quality. It is critical for aquatic organisms' respiration [11]. Therefore, the dissolved oxygen is among determining factors for the survival and the growth of aquatic organisms. In this study, DO showed values that were within the permissible limits for aquatic lives [12]. The results obtained in the study were within the survival range for most aquatic organisms and recommended for fish production according to [13] and [13]. The pH of water is important because many biological activities can occur only within a narrow range. Thus, pH range for diverse fish production is between 6.5 and 9 [7]. Any variation beyond acceptable range could be fatal to many aquatic organisms. However, the pH range was within tolerable limits for the survival of aquatic life [14]. The average mean water temperature of the Shabu Stream was within the recommended range of 21 ˚C – 30 ºC [14] for the survival of warm water aquatic organisms.

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