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Relationship between fish species abundance and physico-chemical parameters of Tagwai Lake, Minna, Nigeria.

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Abstract
The study was carried out to investigate the temporal variations, in terms of physico-chemical parameters as well as the fish species abundance in Tagwai Lake, Minna, Nigeria and establish a relationship between both parameters using Canonical correspondence analysis ,from January 2013 to December, 2014. The results of the physico-chemical parameters investigated revealed that the Dissolved Oxygen (DO) ranged from 6.60±0.75 (mg/l) to 12.7±0.66 (mg/l), in 2013 and 6.00±0.31 (mg/l) to 11.20±1.35 (mg/l) in 2014. The BOD ranged from 2.40±0.24 (mg/l) to 7.00±1.52 (mg/l) in 2013; and from 3.28±0.41 (mg/l) to 5.60±1.02 (mg/l) in 2014. The DO values in the rainy season months were significantly different ($p > 0.05$) from those of the dry season months. A total of ten (10) species of fishes belonging to seven families were identified namely, Clariidae (*Clarias gariepinus*), Claroteidae (*Chrysicthys auratus),* Bagridae (*Auchenoglanis occidentalis),* Characidae (*Alestes dentex),* Mormyridae *(Mormyrus hasselquistii)* and Cichlidae (*Sarotherodon galiliaeus, Tilipia zillii and Tilapia aurea, Hemichromis fasciatus, and* Clupeidae (*Odaxothrissa mento*). Correlation between fish species and physico-chemical parameters revealed strong correlation of *Tilapia galileae* and *Mormyrus hasselquistii* with phosphate. *Hemichromis fasciatus* correlated strongly with nitrate, BOD and DO. *Auchenoglanis occidentalis* and *Clarias gariepinus* weakly correlated with pH. This indicate the influence of physico-chemical parameter on the domestication and productivity of the lake

Keywords: Fish species, Physico–chemical parameters, Tagwai Lake

Introduction
Tagwai Lake Minna is the major source of water supply in Minna metropolis. The Lake serves as a primary reservoir for the city of Minna, the largest metropolis in Niger State NSWB (1991). The reservoir has a capacity of 28.3 million cubic meters, thus increasing the flow of river Chanchaga and the supply to the existing water treatment plant of the Niger state water board (Alkali, 1994). Also, the lake serves as sources of primary occupation to the people of the area, trough fishing and farming. However, the significance of fishing activities are often under estimated especially in Nigeria. In many parts of Nigeria, Niger State inclusive, demand for fish has continuously out-weighed supply. Fishing activities in Tagwai lake is all –year- round, with fishermen landing different species of fish (Chukwuemeka, *et al*., 2014). However, due to the recent explosion in human population, environmental degradation and habitat destruction, the supply of fishery resources from the wild have diminished greatly with tremendous impact on human health. This development, expectedly led to the productivity of wild fishery and ultimately the domestication of certain fish species for intensive culture in captivity. Unfortunately, the few fish species successfully domesticated have not been able to meet the increasing human demand for fishery resources. For sustainability of these resources, an adequate knowledge of species composition, diversity and relative abundance of her water bodies must be properly understood and vigorously pursued (Lawson and Olusanya, 2010). Very importantly, the success of any aquaculture is based on a sound knowledge of the biology, ecology and habitat of targeted species. Experts have alluded to the strong positive relationships that exist between the biology, ecology and environmental requirement of fish species and productivity performance in captivity. Understanding these aspects of fish requirements for successful domestication will enhance the cost effective management protocol for the targeted fish species thus increasing productivity, commercial domestication and improved nutrition status of the populace. Thus, there is an urgent need for domestication and intensive culturing of more fish species with great potentials. On these premises the fish species diversity and pysico-chemical parameters of Tagwai Lake, Minna, Nigeria was carried out to determine correlation between both factors in relation to domestication and productivity of the fishes.

Materials and Methods
Study area
The study was carried out in Tagwai Lake (longitude 6°39' E and longitude 91°41'E and latitude 9°34' N and latitude 9°37' N) Minna, Niger State, covering a land area of 88km^2 with an estimated human population of 1.2

million. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30°C, 61.00% and 1334.00mm, respectively (Alkali,1994)

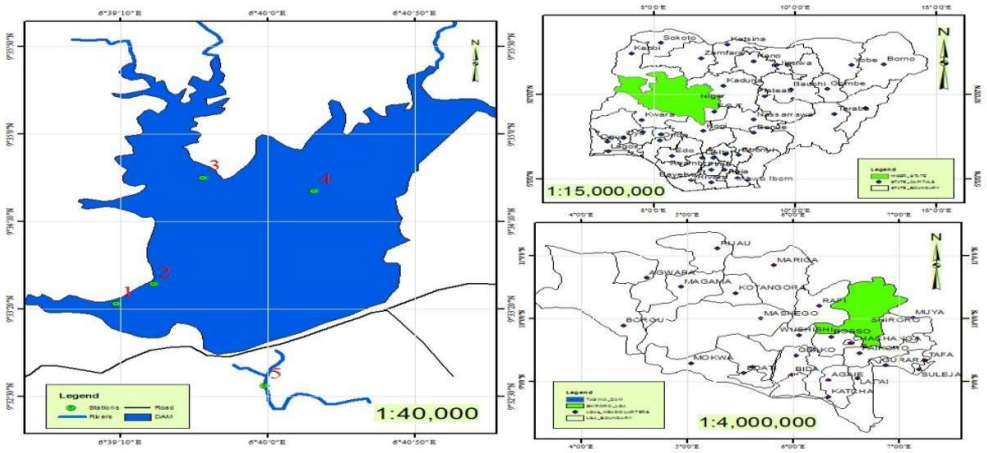

Figure 1. Map of Niger State indicating Tagwai Lake in Bosso Local Government
Sources: Centre for Remote Sensing, Department of Geography, FUT, Minna (2018).

Sample Collection (Physico-Chemical Parameter)
The water samples were collected in 50 cl plastic containers at 10 cm depth from five different stations on the lake (station I, station II, station III, station IV and station V). These stations were selected based on the accessibility of the major tributaries into the lake. Samples were collected bi-weekly and taken to Water Resources Aquaculture and Fisheries Technology laboratory of Federal University of Technology Minna to test for physico-chemical parameter.

Physico-Chemical Parameters
Physic-chemical analysis of the water samples were carried using standard procedures of American Public Health Association (APHA, 2009). Parameters such as Dissolved Oxygen, Hardness, BOD, Nitrate and Phosphate were analysed for and dissolved Oxygen was determined using the modified Winkler - Azide method (APHA, 2009)

Fish Sampling and Identification of Fish Species
Routine sampling of fish in the Lake was conducted bi-weekly for two years (January 2013-December 2014). Sampling was done in the early hours of the day with the assistance of the local fisher folks in the area. Identification and listing of all fish species landed was done using the monographs, standard identification keys and field guide in accordance with Reed *et al* (1967) and Idodo-Umeh (2003). Identification was done from family to species level for different fishes caught.

Statistical Analysis
Data collected for physico-chemical parameters of the surface water and monthly data on species composition were all subjected to analysis of variance (ANOVA) using Statistical Packages of Social Science (SPSS).Canonical Correspondence Analysis (CCA),was used to ascertain the relationship between Physico-chemical parameters and Fish species abundance of Tagwai Lake. All analysis were considered at 0.05 level of significance.

Results
Physico-Chemical Parameter in Tagwai Lake, Minna
The monthly analysis of water quality parameters of Tagwai Lake, Minna during the sample period (2013 - 204) are presented below in Table.1 and 2. The results of monthly dynamic physico-chemical parameters revealed significant variation were in all the parameters from January to December for both years with higher values recorded in 2014. The Dissolved Oxygen (DO) ranged from 6.60±0.75 (mg/l) to 12.7±0.66 (mg/l) in 2013 and 6.00±0.31 (mg/l) to 11.20±1.35 (mg/l) in 2014. The DO values in the rainy season months were significantly different from those of the dry season months. The highest and the lowest BOD was obtained in 2013 with the value of 7.00±1.52 mg/l and 2.40±0.24 mg/l, respectively. The BOD obtained in 2014 fell within the range of the values obtained for 2013 (3.28±0.41 mg/l to 5.60±1.02 mg/l). Significant variation in alkalinity level were recorded in both years with the highest and the lowest alkalinity been 42.20± 0.66mg/l and 10.00 ± 0.37 mg/l, respectively. There was also variation in the hardness values from January to December in both year with values ranged from 29.60 ± 1.33 (mg/l) to 65.20 ± 2.40 (mg/l).The chloride values in September, October, November, December and January were significantly different from those of February, March, April, May, June, July and August. The temperature values ranged from 26.00 ± 0.32ºC to 32.60 ± 2.68 ºC. Between January and April, there was no

significant difference in temperature. This result is in conformity with that of Kolo *et al*,(2009),who reported that all the physico-chemical parameters fell within permissible limit set by WHO in Dam Zaria.Karanth 1987 reported that almost all the physical chemical parameters assessed were high and this made the water of that Lake not favourable for Aquatic use.

Relative Abundance of Ichthyofaina of Tagwai Lake Minna

The species composition and relative abundance of fishes showed that Tilapia *galileae* has the highest number abundance of 2474 equivalent to 31.92%. This was followed by O*daxothrissa mento* which was 1701 in number and 21.95% and *Tilipia zillii* with 1250 individuals and 16.13 in percentage. The least abundance of the fish species encountered was *Heamichromis fasciatus* which was about 0.12%.This result also conformed with the findings of Adeyemi *et al (2010)*,Ojutiku et al (2008) and Chukwuemeka (2014) who reported that Tilapia species always dominated most water bodies.

Table 3: Species Composition and Relative Abundance of the Ichthyofauna in Tagwai Lake

SPECIES	FAMILY	NO.OF SPECIES	%
Tilapia galileae	Cichlidae	2474	31.92
Tilapia zillii	Cichlidae	1250	16.13
Tilapia aurea	Cichlidae	274	3.53
Hemichromis fasciatus	Cichlidae	9	0.12
Clarias gariepinus	Clariidae	111	1.43
A*uchenoglanis occidentalis*	Bagridae	346	4.46
Chrysicthys auratus	Claroteidae	554	7.15
Mormyrus hasselquistii	Mormyridae	26	0.34
Alestes dentex	Alestidae	1107	14.28
Odaxothrissa mento	Clupeidae	1701	21.95
TOTAL NUMBER		7750	100%

Table 1: Physico-chemical parameters of Surface Water of Tagwai Lake during sampling period 2013

Sample	DO (mg/l)	BOD (mg/l)	Conductivity (µΩ/cm)	pH	Alkalinity (mg/l)	Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Temperature (°C)	Depth (m)
January	7.10±0.24^{b}	4.10±0.24^{c}	175.80±5.77^{e}	7.46±0.02^{b}	38.20±3.67^{g}	64.40±1.60^{e}	10.78±1.16^{b}	2.76±0.66^{e}	2.30±0.19^{d}	26.60±0.68^{a}	8.64±0.59^{a}
February	8.80±1.02^{b}	7.00±1.52^{d}	160.60±5.11^{e}	7.50±0.14^{b}	32.60±1.08^{f}	65.20±2.40^{e}	12.24±0.60^{c}	0.50±0.12^{b}	2.54±0.09^{d}	26.30±0.37^{a}	8.76±0.62^{a}
March	7.20±0.64^{b}	2.92±0.22^{a}	162.60±2.33^{e}	7.76±0.04^{b}	37.40±1.17^{g}	29.60±1.33^{a}	9.20±0.68^{b}	0.38±0.09^{a}	1.88±0.26^{c}	26.00±0.32^{a}	9.00±0.71^{a}
April	6.60±0.75^{b}	3.00±0.32^{b}	149.00±2.50^{d}	6.08±0.05^{b}	19.20±1.07^{d}	51.60±4.17^{d}	13.92±2.32^{c}	0.58±0.09^{b}	1.40±0.22^{c}	26.60±0.51^{a}	8.60±0.87^{a}
May	7.30±0.20^{b}	2.80±0.25^{a}	160.60±1.46^{e}	6.90±0.05^{b}	20.00±1.26^{d}	52.40±4.31^{d}	14.52±2.43^{c}	0.36±0.04^{a}	0.78±0.06^{b}	25.44±1.53^{b}	8.60±0.71^{a}
June	6.80±0.37^{b}	2.60±0.19^{a}	117.50±0.74^{c}	5.74±0.13^{a}	25.40±1.21^{e}	47.70±1.04^{d}	7.68±1.25^{ab}	0.26±0.04^{a}	0.46±0.05^{a}	32.60±2.68^{b}	8.50±0.71^{a}
July	8.00±0.71^{b}	3.46±0.28^{b}	169.00±2.17^{e}	7.90±0.07^{b}	38.40±0.87^{g}	42.30±0.80^{c}	6.24±0.22^{a}	0.24±0.02^{a}	0.44±0.05^{a}	29.80±0.58^{b}	7.64±0.73^{a}
August	6.90±0.33^{b}	3.50±0.61^{b}	80.00±2.76^{a}	6.92±0.04^{b}	13.40±0.94^{b}	48.20±3.02^{d}	5.98±0.29^{a}	2.06±0.16^{d}	0.20±0.05^{a}	27.32±0.99^{a}	11.60±0.96^{b}
September	4.80±0.58^{a}	2.40±0.24^{a}	63.80±1.88^{a}	6.70±0.15^{b}	10.06±0.37^{a}	33.60±0.68^{b}	8.64±0.78^{b}	2.42±0.12^{d}	0.78±0.08^{b}	31.40±2.18^{b}	13.36±1.04^{c}
October	9.60±0.73^{c}	4.40±0.43^{c}	\84.32±7.17^{b}	8.14±0.04^{b}	11.10±0.62^{a}	41.70±1.58^{c}	11.16±0.51^{b}	1.76±0.12^{c}	0.38±0.12^{a}	30.40±2.73^{b}	13.72±0.99^{c}
November	12.70±0.66^{d}	6.06±0.48^{d}	64.90±0.91^{a}	7.30±0.11^{b}	11.70±0.54^{a}	36.20±1.10^{b}	8.86±0.35^{b}	2.10±0.13^{d}	0.64±0.05^{b}	30.50±1.88^{b}	11.96±0.85^{b}
December	11.60±1.33^{d}	5.60±0.51^{c}	80.64±0.52^{b}	7.14±0.09^{b}	16.00±0.89^{c}	47.60±2.48^{d}	8.44±0.88^{b}	2.12±0.50^{d}	0.72±0.05^{b}	29.40±0.19^{b}	11.68±0.59^{b}

Table 2: Physico-chemical parameters of Surface Water of Tagwai Lake during sampling period 2014

Sample	DO (mg/l)	BOD (mg/l)	Conductivity (µΩ/cm)	pH	Alkalinity (mg/l)	Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Temperature (°C)	Depth (m)
January	8.80±2.20^{b}	5.10±0.48^{b}	159.3±9.74^{f}	7.22±0.07^{a}	29.00±2.42^{b}	46.80±1.30^{a}	13.4±0.33^{c}	0.40±0.07^{b}	0.44±0.09^{c}	29.20±2.59^{a}	9.96±1.44^{a}
February	7.80±1.04^{b}	3.50±0.35^{a}	204.50±5.27^{g}	6.50±0.07^{a}	25.40±0.87^{a}	49.40±2.38^{b}	12.08±0.22^{c}	0.46±0.12^{b}	0.10±0.00^{b}	30.27±2.08^{a}	8.64±0.73^{a}
March	6.00±0.31^{a}	3.28±0.41^{a}	149.40±1.72^{e}	6.22±0.02^{a}	31.20±3.20^{b}	52.80±3.82^{b}	10.00±0.33^{b}	0.32±0.10^{b}	0.10±0.00^{b}	29.40±1.28^{a}	8.76±1.37^{a}
April	11.20±1.35^{c}	5.60±1.02^{b}	588.20±4.04^{h}	6.10±0.03^{a}	24.80±1.62^{a}	54.00±2.00^{b}	14.56±0.39^{c}	0.48±0.12^{b}	0.10±0.00^{b}	25.80±1.98^{a}	6.02±0.31^{a}
May	11.20±0.58^{c}	5.60±0.48^{b}	132.90±6.98^{d}	7.48±0.11^{a}	32.00±0.83^{b}	58.40±2.11^{c}	16.56±0.28^{d}	0.24±0.02^{a}	0.10±0.00^{b}	26.40±1.51^{a}	6.58±0.56^{a}
June	8.70±1.03^{b}	3.90±0.33^{a}	58.50±1.20^{a}	7.52±0.08^{a}	29.80±1.35^{b}	62.40±4.91^{c}	14.66±.26^{c}	0.16±0.02^{a}	0.10±0.00^{b}	27.40±1.90^{a}	7.72±0.53^{a}
July	10.60±0.67^{c}	5.50±0.59^{b}	54.00±0.47^{a}	7.46±0.05^{a}	42.20±0.66^{c}	80.00±0.54^{d}	14.16±0.10^{c}	0.18±0.02^{a}	0.10±0.00^{b}	28.10±1.23^{a}	8.00±0.41a
August	10.60±0.67^{c}	4.96±0.34^{a}	61.70±2.10^{b}	7.50±0.03^{a}	22.70±2.23^{a}	58.46±5.40^{c}	10.94±0.18^{b}	0.10±0.00^{a}	0.08±0.01a	29.40±2.14^{b}	8.72±0.49^{a}
September	8.40±0.60^{b}	4.30±0.33^{a}	72.40±6.51^{b}	7.22±0.02^{a}	25.40±0.87^{a}	59.80±1.90^{c}	0.14±0.12^{a}	0.10±0.00^{a}	0.10±0.00b	31.00±1.07^{a}	10.24±0.75^{a}
October	7.20±0.37^{b}	4.10±0.18^{a}	97.50±3.94^{c}	6.82±0.03^{a}	25.90±1.96^{a}	64.00±3.61^{c}	9.12±0.19^{b}	0.10±0.00^{a}	0.10±0.00b	30.90±1.48^{a}	11.44±1.25^{a}
November	8.00±0.65^{b}	4.60±0.48^{a}	64.90±2.21^{b}	6.92±0.03^{a}	24.20±1.52^{a}	56.70±1.85^{b}	8.82±0.12^{b}	0.10±0.00^{a}	0.10±0.00b	30.60±1.26^{a}	11.32±1.38^{a}
December	8.10±1.14^{b}	4.00±0.00^{a}	58.80±2.15^{a}	6.68±0.02^{a}	22.10±2.87^{a}	53.80±3.18^{b}	8.46±0.08^{b}	0.10±0.00^{a}	0.10±0.00b	30.40±1.38^{a}	10.26±0.94^{a}

Values followed by the same superscript alphabet(s) on the same column are not significantly different at p>0.05 from Duncan Multiple Range Test.
Values are means ± standard Error of mean of two determinations.

Relationship between Physico-Chemical Parameters and Fish Species Abundance of Tagwai Lake Minna

A cross correlation between fish species abundance and physico-chemical parameters revealed that in 2013, *Tilapia galilaea* and *Mormyrus hasselquistii* correlated strongly with Phosphate. *Hemichromis faciatus* correlated strongly with Nitrate, BOD, and DO. *Auchenoglanis occidentalis* and *Clarias gariepinus* correlated with pH. *Chrysichthys auratus* correlated with Depth and Temperature (Figure 1). Interestingly, similar trend of correlation was obtained in 2014. However, *Alestes dentex* and *Chrysichthys auratus* correlated with Alkalinity, Conductivity and Temperature (Figure 2). *Odaxotrissa mento* and *Tilapia zilli* did not correlate with any of the physico-chemical parameters. Nitrate did not also correlate with any of the fish species.

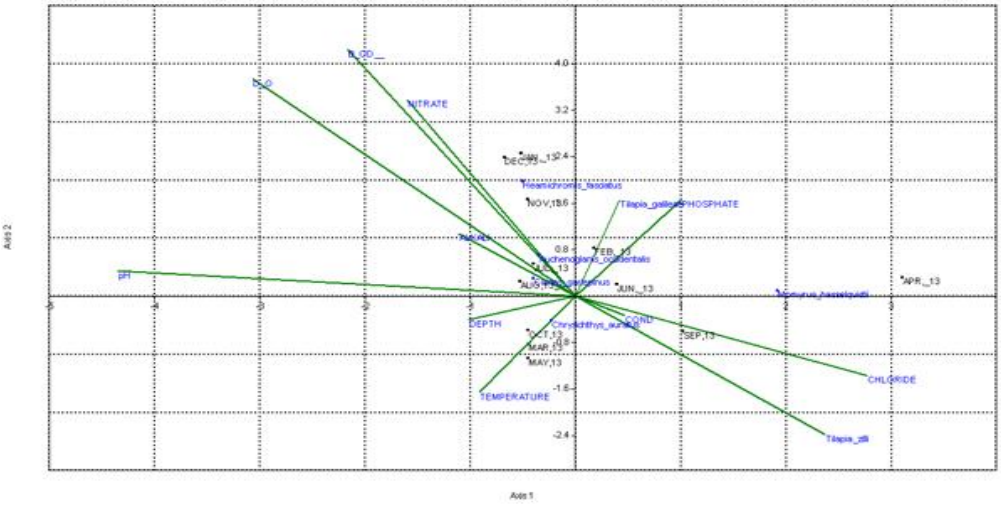

Figure 1: Canonical Correspondence Analysis showing the relationship between Physico-Chemical Parameters and Fish Species Abundance of Tagwai Lake Minna, 2013

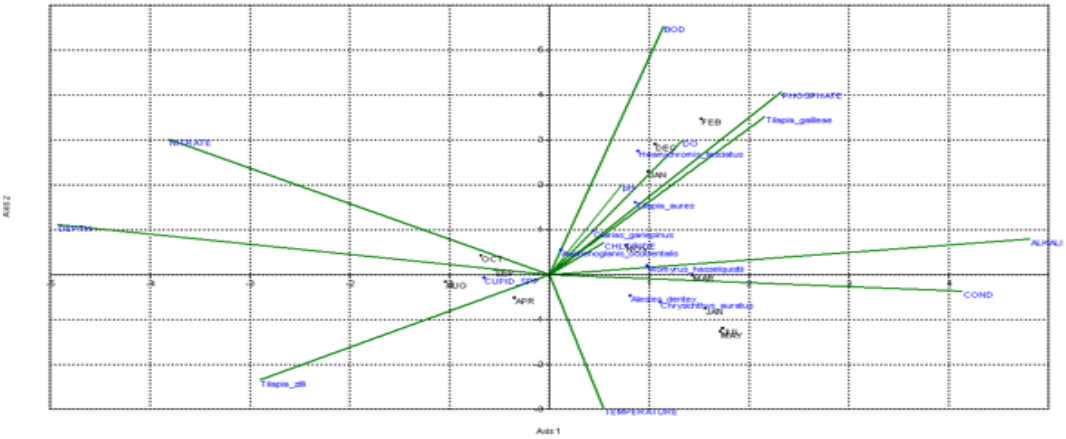

Figure 2: Canonical Correspondence Analysis of the relationship between Physico Chemical Parameters and Fish Species Diversity of Tagwai Lake Minna, 2014

When the physico-chemical parameters were correlated with the fish species abundance in Tagwai Lake.In 2013, *Tilapia galilaea* and *Mormyrus hasselquistii* were seen to correlate strongly with Phosphate; implies that increase in Phosphate in the water could bring about a corresponding increase in the production of T. *galilaea* and M. *hasselquistii* .BOD, DO and Nitrate in a water body could be manipulated to bring about increased production of *Hemichromis faciatus* since they correlated strongly with it. Other fish species such as *Auchenoglanis occidentalis* and *Clarias gariepinus* require just the normal amount of pH to survive as they were seen to cluster around the middle of the quadrant. *Chrysichthys auratus* which correlated with Depth and Temperature will just do well within the normal depth and temperature.The trend was the same in 2014 for *Tilapia galileae*, which correlated strongly with Phosphate; therefore Phosphate could be altered to increase its production. *Tilapia galileae* would do well just within the tolerable limits of BOD, DO and pH could be manipulated to increase the production of *Hemichromis faciatus* since they strongly correlate with it. *H.faciatus* would require just the normal range of Alkalinity and Chloride to survive. *Tilapia aurea*, *Auchenoglanis occidentalis*, *Clarias gariepinus* just require the normal amount

of chloride to survive as they are also seen to cluster around the middle of the quadrant. These three species just require the normal amount of Phosphate, pH, and BOD to survive*; Alestesdentex* and *C.auratus* require just the normal amount of Alkalinity, Conductivity and Temperature to survive. *Tilapia zilli* did not correlate with any physico-chemical parameter.

Conclusion

In conclusion, findings from this study revealed that most of the physico-chemical parameters of Tagwai Lake were within permissible limits set by WHO 2004. This implies that the water of this Lake can be considered fit to support the survival, growth and development of various Fish species. The study also revealed that 10 fish species, belonging to seven fish families were present in the lake. The correlation between fish species and physico-chemical parameters, revealed that most of the physico-chemical parameters correlated with all the fish species throughout the research period except Nitrate.

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