Chromium and Lead Bio-Accumulation in Relation to Physico-Chemical Parameters in Water and Fish of Wasai Reservoir, Kano State

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Heavy metals bio-accumulation in fish organs consumed by man generated issues of public health concern. This study was conducted to determine the levels of Chromium and Lead bioaccumulation in liver and muscles of two fish species (*Clarias gariepinus* and *Oreochromis niloticus*) obtained from Wasai Reservoir in relation to physico-chemical parameters of the surface water. Water and fish samples were collected using standard protocols for a period of ten months. Four different locations were mapped out as sampling stations. Heavy metals concentrations in water, liver, and muscles of the two fish species were assessed. The experiment was arranged in completely randomized design with three replications. Data obtained were analysed using Analysis of Variance with Duncan's New Multiple Range Test used to separate the means that were significant at 5% level. No significant difference was found in the surface water temperature and pH of the water body for a period of ten months. However, significant difference ($P \leq 0.05$) was found in pH, DO and BOD among the locations. The high DO and BOD values were found in station A where there is high discharge of agricultural and domestic wastes. The results for the levels of heavy metals in water and fish organs of Wasai reservoir revealed significant difference ($P \leq 0.05$) in the levels at different locations with months. More so, the levels of Pb (0.01-0.08 mg/L) and Cr (0.03-0.35 mg/L) bio-accumulation in liver and muscles of the fish showed a pattern of trend in the heavy metals bio-accumulation in the two fish species following the order: Cr>Pb with their bio-accumulation in liver and muscles of the fish species above tolerable limits. Thus, the highest value of heavy metal in liver (0.17 mg/L) obtained from Wasai reservoir especially during the dry season of the year should not be consumed by the general populace.
Keywords: Bio-accumulation, Chromium, Heavy metals, Lead, Wasai reservoir

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Introduction

The aquatic ecosystem have been seriously threatened by all forms of human activities (Meijide *et al.*, 2018) as large amount of chemicals are being constantly discharged into the aquatic environment and these persist in biota, water and sediment thereby affecting the aquatic biota (Schmeller *et al.*, 2018). Wasai reservoir serves as a sink of one of Jakara River where domestic and industrial effluents, mechanics and agricultural wastes were discharged into within the metropolitan Kano. Although trace metals are essential for normal physiological processes, high concentrations are toxic, affecting various organs and tissues in fish (Ramazan *et al*., 2011). It also causes death of fish and their absence in polluted areas, hence affecting ecological balance.

Research conducted in relation to the reservoir such as that of Imam (2012) investigated the effects of Heavy metals concentrations in the surface water of Bompai-Jakara drainage basin which is the major tributary of Wasai reservoir, Kano state, Northern Nigeria. The result shows that there are heavy metals in the surface water and the concentrations of chromium, iron, copper, zinc and lead was above the FEPA (2011) standard limit for effluents discharge into the surface. Similarly, Jamila and Sule (2010) examined the water quality Index of River Getsi which is a tributary of Wasai reservoir and found the levels of identified heavy metals such as chromium as higher than the WHO (2007) standard. More so, Dike *et al*. (2013) studied the pollution levels of River Jakara in Kano Nigeria in relation to physico-chemical parameters. The result also shows that suspended solids, chloride, dissolved oxygen and biochemical oxygen demand are not in consistent with the international limits for irrigation. None of these studies focused on the fish species heavy metals bio-accumulation. This study therefore aimed at assessing the physico-chemical parameters in relation to Cr and Pb bio-accumulation in fish species of Wasai reservoir, Kano state.

Materials and Methods

Study area

The Wasai- Reservoir is situated on the Jakara River at a point about 2 km South– East of Wasai village in Minjibir Local Government Area of Kano State (Amin, 1992). It is situated on latitude 12^{o}N and 13^{o}N and longitude 8ºE and 9ºE. The reservoir was constructed in 1976 for recycling purposes. The dam has a maximum height of 9.33 m, while reservoir has a surface area of 1,250 hectares and a total storage capacity of 65.38 m3, this places the reservoir among the medium size man-made lakes in Kano state (Figure 1).

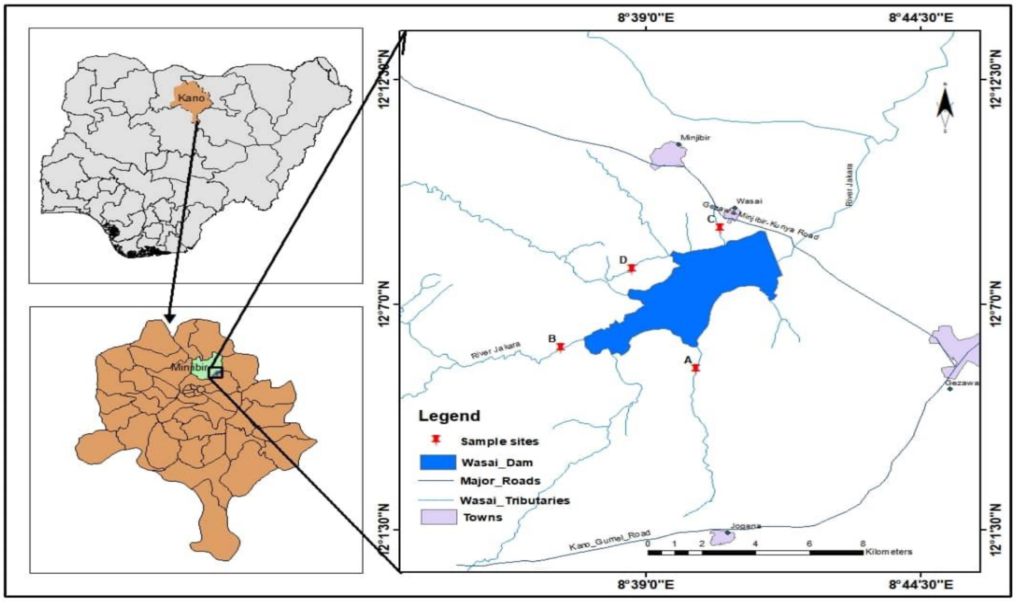

Figure 1: Map of study area showing the landing site
Source: GIS Lab Department of Geography Using Arc GIS 10.3 Software

Sampling stations
Four sampling stations were identified and designated for the purpose of this study, namely A, B, C, and D respectively. Transect sampling across the basin was carried out, starting from the two tributaries i.e. Jakara river, the confluence where the two rivers meet, the entry point where the water drains into the Wasai Reservoir, the spillway of the reservoir. Samplings were conducted from 06:00 am-07:00 am monthly. Water and sediment samples were collected from the reservoir during the period from September 2018 to June 2019.

Water sampling procedure
Samples were collected in 250 mL plastic bottle for chemicals parameters analysis. The samplings were carried out midstream by dipping the sample plastic bottle to approximately 20-30 cm below the water surface, projecting the mouth of the containers against the direction of flow direction. Some physico-chemical parameters of the water samples such as pH, temperature, and electrical conductivity were analysed on the spot using HANNA instrument (Model: H193703). Nitrates were analysed in the Fisheries laboratory of the Department of Biological Science, Bayero University, Kano. Water samples for heavy metals analysis was collected in 1L bottles, with 2 drops of HNO_3 (APHA, 2005).

Fish samples collection
A total of two hundred *Clarias gariepinus* and *Oreochromis niloticus* adults and fingerlings of both sexes were procured from local fishermen around the reservoir. Fish samples obtained were immediately kept in pre-cleaned polythene bags, sealed, labelled and kept in ice boxes for transportation to the Biological Science Laboratory, Bayero University, Kano. The samples were dissected for liver and muscles followed by oven drying at 105ºC for 24 h and then powdered using mortar and pestle.

Preparation of water samples for heavy metals analysis
Three samples of water from each sampling site were homogenized before digestion. A preservative, nitric (V) acid (HNO_3) was added to the original sample in order to ensure that metals do not adhere to the walls of the container. Sample aliquots for digestion were taken after vigorous shaking to ensure suspension of solids that may have settled. Water samples were digested on a hot plate using hydrochloric acid (HCl) and HNO_3 on a volume: volume ratio (1:0.5 %).

Preparation of fish organs samples
The fishes were washed with distilled water in the laboratory. Dissection was done using a sharp stainless

steel knife and each organs of interest such as liver and muscles were isolated. The organs of investigation were kept in oven and dried at a temperature of 105ºC following the method of Eneji *et al*. (2011). 10g portion of the grounded samples were carefully weighed using digital chemical balance, 10 ml of HNO_3 and 2 ml of $HClO_3$ were added and heated over a hot plate for one hour. After complete digestion, the residue was diluted with 0.2 % v/v HNO_3 to 20 mL (APHA, 2005). Bio-Accumulation Factor (BAF) was calculated according to Evans and Engel (1994) formula:

$$BAF = \frac{M_{tissue}\ (mg/l)}{M_{water} (mg/l)}$$

Where: M_{tissue} = Metal concentration in the tissue of fish
M_{water}= Metal concentration in water

Data analysis

Data collected were subjected to analysis of variance (ANOVA) with Duncan's New Multiple Range Test used to separate significant means at 5% level. SAS (2012) Version 9.1 was used for the analysis.

Results

The result for the analysis of mean temperature and pH variations for ten months across the sampling stations along Wasai reservoir, Kano State is presented in Table 1. The result indicated no significant difference (P≥0.05) in the water temperature across all the station in all the ten months. The result showed that, the highest mean temperature value (27.20 ºC) was found in Station 1 in March 2019 while the lowest mean temperature value (23.66 ºC) was found in station 4 in January 2019. The trend in monthly variation in temperature showed that, the temperature values decrease from September 2018 to November 2018 across all the stations except in station 3 where the temperature increases in November. The temperature values continue to decrease from December 2018 up to March 2019; where the temperature values increased. The temperature then continued to decrease from March 2019 to June 2019 across all the stations.

The values of the water pH revealed that, the water is alkaline throughout the period of study. The highest mean pH value of 8.49 was found in March 2019 at station 1 with the lowest mean value recorded in March (7.19) in station 2. The trend in the monthly variation of pH showed that, the pH values increased from September to November in stations 1 and 4 but decreased in stations 2 and 3. The pH values in all the stations fluctuate with variations in monthly mean values.

Table 1: Monthly Mean Variations of Temperature (ºC) and pH

Parameter	Months	STATION 1 Mean ± S.D	STATION 2 Mean ± S.D	STATION 3 Mean ± S.D	STATION 4 Mean ± S.D
Temperature	SEPT	25.03±0.95^{a}	25.05±1.95^{a}	25.57±1.43^{a}	25.20±0.91^{a}
	OCT	24.70±0.66^{a}	23.90±1.57^{a}	24.46±0.15^{a}	24.97±0.42^{a}
	NOV	24.33±0.15^{a}	23.80±1.08^{a}	25.17±0.85^{a}	24.63±0.66^{a}
	DEC	25.33±0.06^{a}	23.86±0.71^{a}	24.67±0.42^{a}	25.03±0.74^{a}
	JAN	24.10±0.45^{a}	23.73±0.65^{a}	24.47±0.47^{a}	23.66±046^{a}
	FEB	24.60±0.36^{a}	24.20±0.30^{a}	24.80±0.62^{a}	24.53±0.42^{a}
	MAR	27.20±2.21^{a}	26.03±1.50^{a}	25.73±1.42^{a}	26.23±2.01^{a}
	APRIL	25.77±1.36^{a}	25.57±1.45^{a}	25.10±0.85^{a}	25.90±1.93^{a}
	MAY	25.27±0.94^{a}	25.97±1.54^{a}	25.63±1.35^{a}	25.03±0.95^{a}
	JUNE	25.07±0.90^{a}	24.57±0.40^{a}	25.10±0.85^{a}	25.53±0.42^{a}
pH	SEPT	7.35 ± 0.14^{bc}	7.24±0.05^{c}	7.61±0.03^{bc}	7.22±0.05^{c}
	OCT	7.62 ± 0.02^{b}	7.23±0.01^{c}	7.23±0.03^{c}	8.14±0.12^{a}
	NOV	8.16 ± 0.14^{a}	7.27±0.02^{c}	7.90±0.01^{ab}	7.95±0.02^{b}
	DEC	7.75 ± 0.26^{b}	8.17±0.05^{a}	8.27±0.23^{a}	8.27±0.04^{a}
	JAN	7.85 ± 0.04^{b}	7.81±0.06^{b}	7.61±0.02^{b}	7.32±0.02^{c}
	FEB	7.58 ± 0.07^{b}	8.22±0.02^{ab}	7.68±0.16^{b}	8.37±0.32^{a}
	MAR	8.49 ± 0.05^{a}	7.19±0.04^{c}	7.25±0.05^{c}	7.68±0.03^{b}
	APRIL	7.84 ± 0.02^{b}	7.23±0.01^{c}	7.32±0.07^{c}	7.63±0.03^{b}
	MAY	7.66 ± 0.04^{b}	7.25±0.05^{c}	7.22±0.19^{c}	7.49±0.05^{c}
	JUNE	7.21 ± 0.22^{bc}	7.47±0.02^{b}	7.62±0.07^{b}	7.25±0.05^{c}

N.B: Value(s) with the same superscripts across a row are not significantly different at P=0.05

The results for the mean values of Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) in four stations along Wasai reservoir for ten months are shown in Table 2. The results revealed significant difference (P≤0.05) in the values of DO and BOD in the four stations across the months. The result also indicated highest DO value of 4.60 mg/L at station 3 in February 2019. However, the least DO value of 2.10 mg/L was found in station in November 2018. A significant increase in DO values was observed from 2.57 mg/L in December 2018 to as high 4.60 mg/L in the month of February 2019. The trend in the monthly variations in DO showed that, the values almost remain constant from September 2018 to April 2019 in station 1. However, the DO values increased from May to June 2019. Furthermore, in station 4, the values increased from September 2018 to March but decreased in April to June. However, station 2 and 3 showed variation in DO with months. Similarly, highest BOD value of 8.57 mg/l was found in station 1 in March 2019 with the lowest BOD value of 2.25 mg/L June at the same station 1. The result also indicated monthly variation in BOD in all the stations.

Table 2: Variations in Dissolved Oxygen and Biological Oxygen Demand (mg/L)

Parameter	Months	STATION 1 Mean ± S.D	STATION 2 Mean ± S.D	STATION 3 Mean ± S.D	STATION 4 Mean ± S.D
DO	SEPT	$2.33±0.05^{c}$	$4.23±0.06^{a}$	$3.16±0.05^{c}$	$2.27 ± 0.12^{c}$
	OCT	$2.26±0.15^{c}$	$4.20±0.10^{a}$	$3.17±0.21^{c}$	$2.37 ± 0.15^{c}$
	NOV	$2.27±0.12^{c}$	$2.10±0.10^{e}$	$3.50±0.10^{bc}$	$4.23 ± 0.06^{ab}$
	DEC	$2.20±0.10^{c}$	$2.33±0.15^{de}$	$2.57±0.15^{d}$	$3.47 ± 0.25^{b}$
	JAN	$2.30±0.34^{c}$	$3.53±0.30^{c}$	$3.67±0.15^{bc}$	$4.53 ± 0.21^{a}$
	FEB	$2.26±0.15^{c}$	$2.53±0.15^{d}$	$4.60±0.20^{a}$	$4.30 ± 0.17^{ab}$
	MAR	$2.20 ±0.26^{c}$	$3.43±0.21^{c}$	$3.93±0.06^{b}$	$4.20 ± 0.26^{ab}$
	APRIL	$2.46±0.15^{c}$	$3.60±0.20^{b}$	$2.66±0.05^{d}$	$2.77 ± 0.15^{bc}$
	MAY	$3.23±0.05^{b}$	$2.40±0.10^{d}$	$4.30±0.26^{ab}$	$3.23 ± 0.06^{b}$
	JUNE	$4.47±0.2^{a}$	$3.33±0.11^{cd}$	$4.40±0.20^{ab}$	$3.33 ± 0.25^{b}$
	F	47.178	67.255	58.588	61.088
BOD	SEPT	$8.23±0.21^{eb}$	$3.48±0.02^{e}$	$5.35±0.33^{c}$	$7.70±0.26^{b}$
	OCT	$7.13±0.61^{b}$	$2.73±0.46^{f}$	$5.45±1.77^{c}$	$8.20±0.26^{a}$
	NOV	$7.33±0.72^{b}$	$6.23±0.40^{a}$	$2.91±1.05^{ef}$	$2.96±0.45^{f}$
	DEC	$6.65±1.06^{c}$	$6.13±0.51^{a}$	$7.30±0.10^{a}$	$3.87±0.51^{de}$
	JAN	$6.35±0.13^{c}$	$4.00±0.61^{c}$	$3.37±0.14^{d}$	$2.88±0.57^{ab}$
	FEB	$8.03±0.21^{ab}$	$6.30±0.61^{a}$	$2.97±0.50^{ef}$	$2.53±0.51^{f}$
	MAR	$8.57±0.57^{a}$	$5.23±0.06^{b}$	$2.53±0.59^{f}$	$3.17±1.15^{e}$
	APRIL	$7.00±0.20^{b}$	$3.47±0.05^{e}$	$6.17±1.41^{b}$	$6.03±0.49^{c}$
	MAY	$3.63±0.50^{d}$	$4.43±2.80^{c}$	$2.30±0.10^{f}$	$4.42±1.58^{d}$
	JUNE	$2.25±0.12^{e}$	$3.47±0.03^{e}$	$3.10±0.10^{d}$	$4.19±0.54^{d}$
	F	44.669	5.767	13.199	22.346

N.B: Value(s) with the same superscripts across a row are not significantly different at P=0.05

The result for the level of Chromium (Cr) and Lead (Pb) at Wasai reservoir is presented in Table 3. The result revealed highest level of Chromium (0.41 mg/L) in samples collected at station 4 in May 2019. This is followed by the value (0.37 mg/L) obtained at station 3 in October 2018. The lowest Chromium level of 0.02 mg/l of the water samples was found in station 4 in September 2018.More so, the result for the levels of lead indicated an increasing trend from the month of September, October to June in both the study stations along Wasai reservoir. However, the levels of lead in water during the three months were found to be significantly higher in December. The highest value of Pb(0.055 mg/L) was found at station 3 in April 2019. This is followed by the value (0.051 mg/L) obtained at station 1 in February 2019. The lowest values of Pb in the water samples (0.002 mg/l) were found in September and October at station 2.

Table 3: Means levels of chromium and Lead in water (mg/L)

Heavy Metal	Months	STATION 1 Mean ± S.D	STATION 2 Mean ± S.D	STATION 3 Mean ± S.D	STATION 4 Mean ± S.D
Cr	SEPT	$0.11±0.01^{a}$	$0.12±0.01^{a}$	$0.04±0.01^{a}$	$0.02±0.01^{a}$
	OCT	$0.33±0.12^{d}$	$0.04±0.01^{a}$	$0.37±0.06^{e}$	$0.24±0.04^{c}$
	NOV	$0.15±0.02^{abc}$	$0.22±0.01^{bcde}$	$0.22±0.01^{c}$	$0.24±0.04^{b}$
	DEC	$0.15±0.01^{abc}$	$0.21±0.02^{bcd}$	$0.20±0.01^{c}$	$0.12±0.01^{b}$
	JAN	$0.13±0.02^{ab}$	$0.16±0.01^{bc}$	$0.33±0.03^{de}$	$0.13±0.01^{b}$
	FEB	$0.15±0.01^{abc}$	$0.31±0.02^{de}$	$0.33±0.03^{de}$	$0.14±0.01^{b}$
	MAR	$0.31±0.01^{d}$	$0.13±0.01^{bc}$	$0.31±0.01^{d}$	$0.23±0.02^{c}$
	APRIL	$0.20±0.01^{bc}$	$0.28±0.04^{de}$	$0.22±0.01^{c}$	$0.25±0.04^{c}$
	MAY	$0.21±0.01^{c}$	$0.32±0.01^{e}$	$0.23±0.01^{c}$	$0.41±0.01^{d}$
	JUNE	$0.21±0.01^{d}$	$0.22±0.03^{cde}$	$0.15±0.01^{b}$	$0.13±0.01^{b}$
	F	10.366	9.213	45.288	67.712
Pb	SEPT	$0.025±0.008^{bc}$	$0.008±0.001^{a}$	$0.029±0.016^{bc}$	$0.022±0.011^{b}$
	OCT	$0.028±0.007^{bc}$	$0.008±0.001^{a}$	$0.034±0.013^{c}$	$0.024±0.006^{bc}$
	NOV	$0.02±0.002^{ab}$	$0.02±0.006^{b}$	$0.029±0.003^{bc}$	$0.033±0.006^{cd}$
	DEC	$0.019±0.001^{ab}$	$0.022±0.001^{b}$	$0.029±0.004^{bc}$	$0.034±0.006^{d}$
	JAN	$0.05±0.001^{d}$	$0.02±0.000^{b}$	$0.031±0.002^{bc}$	$0.037±0.003^{d}$
	FEB	$0.051±0.011^{d}$	$0.020±0.001^{b}$	$0.025±0.004^{bc}$	$0.038±0.006^{d}$
	MAR	$0.020±0.009^{ab}$	$0.019±0.001^{b}$	$0.009±0.001^{a}$	$0.017±0.005^{ab}$
	APRIL	$0.036±0.005^{cd}$	$0.043±0.005^{d}$	$0.055±0.005^{d}$	$0.009±0.001^{a}$
	MAY	$0.009±0.001^{a}$	$0.040±0.010^{cd}$	$0.037±0.005^{c}$	$0.043±0.005^{d}$
	JUNE	$0.030±0.010^{bc}$	$0.033±0.005^{c}$	$0.018±0.01^{ab}$	$0.018±0.002^{ab}$
	F	7.820	20.572	7.460	9.712

N.B: Value(s) with the same superscripts across a row are not significantly different at P=0.05

The result for the heavy metals bio-accumulation in the organs of two species of fish obtained from Wasai reservoir is presented in Table 4. The result showed that, the highest accumulation of Pb (0.07 mg/l) in *C. gariepinus* is found in January and March 2019. Similar trend was found in *O. niloticus* with a bio-accumulation value of 0.08 mg/L. However, Cr bio-accumulation in the muscles of *C. gariepinus* showed highest value (0.32 mg/L) in September 2018. Similarly, the result in *O. niloticus* showed highest value (0.35 mg/L) of Cr was found in September,2018. The trend for heavy metals bio-accumulation in the two species of fish showed that Cr>Pb

However, in the liver of two fish species the highest value of Pb (0.17 mg/L) was accumulated in *Oreochromis niloticus* followed by 0.16 mg/L in the liver of *Claris gariepinus* in October 2018. The least value of Pb (0.02 mg/L) was found in the liver of *C. gariepinus* in September 2018. The highest value of Cr bioaccumulation was found in the liver of *C. gariepinus* and *O. niloticus* in June 2019. The least value of Cr was found in the liver of *C. gariepinus* in February 2019.

Table 4: Mean levels of Heavy Metals in the Muscles and Liver of Fish Species

Organ	Month	Lead		Chromium	
		Clarias gariepinus	*Oreochromis niloticus*	*Clarias gariepinus*	*Oreochromis niloticus*
Muscle	SEPT	0.02 ± 0.00	0.03 ± 0.01	0.32 ± 0.01	0.35 ± 0.03
	OCT	0.02 ± 0.002	0.02 ± 0.006	0.10 ± 0.01	0.09 ± 0.05
	NOV	0.06 ± 0.01	0.06 ± 0.01	0.03 ± 0.01	0.04 ± 0.01
	DEC	0.01 ± 0.001	0.02 ± 0.004	0.16 ± 0.12	0.17 ± 0.11
	JAN	0.07 ± 0.01	0.08 ± 0.02	0.03 ± 0.006	0.04 ± 0.002
	FEB	0.02 ± 0.002	0.02 ± 0.001	0.03 ± 0.001	0.04 ± 0.03
	MAR	0.07 ± 0.01	0.08 ± 0.01	0.31 ± 0.015	0.32 ± 0.03
	APRIL	0.06 ± 0.01	0.06 ± 0.007	0.13 ± 0.01	0.133 ± 0.01
	MAY	0.03 ± 0.002	0.03 ± 0.002	0.04 ± 0.005	0.04 ± 0.01
	JUNE	0.04 ± 0.004	0.04 ± 0.006	0.07 ± 0.006	0.07 ± 0.01
	F	51.952	17.134	22.636	20.786
Liver	SEPT	0.02 ± 0.003	0.03 ± 0.006	0.12 ± 0.03	0.22 ± 0.11
	OCT	0.16 ± 0.01	0.17 ± 0.01	0.12 ± 0.01	0.14 ± 0.005
	NOV	0.03 ± 0.001	0.04 ± 0.004	0.07 ± 0.10	0.07 ± 0.03
	DEC	0.025 ± 0.01	0.03 ± 0.006	0.02 ± 0.001	0.022 ± 0.01
	JAN	0.03 ± 0.006	0.03 ± 0.004	0.02 ± 0.001	0.02 ± 0.001
	FEB	0.03 ± 0.013	0.03 ± 0. 01	0.016 ± 0.003	0.12 ± 0.02
	MAR	0.06 ± 0.007	0.04 ± 0.02	0.11 ± 0.01	0.09 ± 0.010
	APRIL	0.05 ± 0.002	0.06 ± 0.002	0.08 ±0.015	0.046 ± 0.01
	MAY	0.05 ± 0.002	0.06 ± 0.001	0.04 ± 0.01	0.05 ± 0.01
	JUNE	0.07 ± 0.003	0.07 ± 0.004	0.08 ± 0.006	0.08 ± 0.01
	F	92.253	93.484	4.596	5.774

N.B: Value(s) with the same superscripts across a row are not significantly different at P=0.05

Principal component analysis of physico-chemical parameters of surface water variables based on stations is shown in Figure 2. It shows three groups: Station 1 (PC1), and station 4 stood out independently while Station 2 and 3 (PC2) (PC3) clustered together as one group indicating a strong link among these stations.

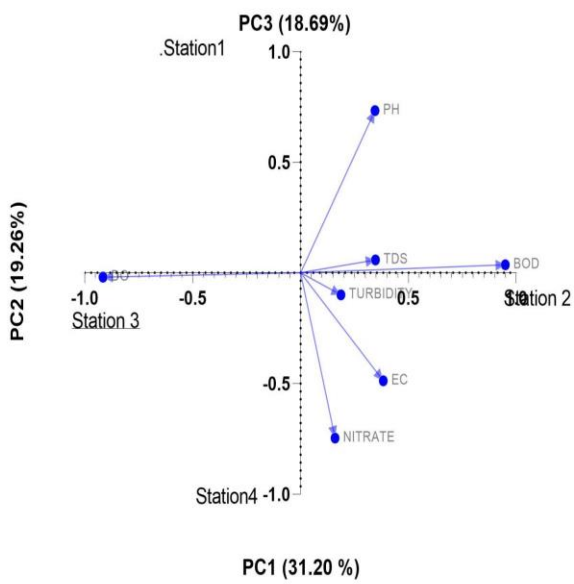

Figure 2: Principal component analysis of the physico-chemical parameters

Discussion

Variation in physico-chemical parameters of a water body with different location have been reported by several studies. In the present study, the range of surface water temperature in the four stations was below the limits of the Federal standard (<35°C) and also within the values reported by some other researchers such as 26.5-33°C by Oluyemi *et al*. (2010), 24.2-26.2°C by Nwoko *et al*. (2015) and 25.6-27.8 ºC by Andong *et al*. (2019). The slight variation in water surface temperature can be attributed to the changes in the atmospheric temperature which on the other hand, influence other water quality indices (Dirican, 2015). The slight variation in pH values reported by the present study corroborates with the finding of Ahmad *et al*. (2018) who reported slight variation in pH between months at Kafinchiri reservoir Kano. The pH value recorded by this study falls within the acceptable limits of 5.9-9.3 for fresh water bodies according to FAO (2004) standards. High level of DO noticed is an indication of aquatic life sustenance as WHO stipulates 5 mg/L as adequate limit for aquatic organisms whereas concentration below this level could adversely affect aquatic life. Even, concentration below 2 mg/L may lead to death for most fishes as suggested Chapman (1997). Elevated levels of DO recorded could be attributed to precipitation of nutrients associated with organic matters brought in by domestic and fertilizer application as suggested by Yasmeen *et al*. (2010). High concentration in DO observed could be traced to heavy application of chemicals as dissolved oxygen is a measure of the degree of pollution by organic matters. WHO (1985) sets 9.20 mg/L as maximum limit for DO in wastewater indicating this site is less in dissolved oxygen with International standards limit.

The mean BOD reported by this study is below the limits of the WHO (2011) standard of 8.5 mg/L. The high levels of BOD observed during sampling periods could be attributed to the use of chemicals such as mechanic paints sprays, herbicides, pesticides and Nitrogen fertilizer which were organic or inorganic that are oxygen demand in nature as stressed by Akan *et al*. (2008) as BOD is known as a measure of the oxygen required by micro-organisms while breaking down organic matters. WHO (2018) recommends 50 mg/L as maximum allowable limit for BOD in wastewater before it could be discharged into the stream indicating wastewaters from these sampling sites are not polluted with BOD. Similarly, Akubugwo *et al*. (2012) reported 2.48 – 20.74 mg/L and Yasmeen *et al*. (2010) reported 362 mg/L as BOD in wastewater which were higher than concentration obtained in this study.

Heavy metals are believed to be potent toxic substances due to their slow degradation rate and long half-life period (Prajapati*et al*., 2012). It was inferred from the present study that fish exhibited wide range of variations in inter specific metal concentration in all organs. Several studies indicated high metal concentration to feeding habit of the fish. Khalid (2004) argued that Sirivutas being an herbivore thus bio-accumulates higher metal concentration in their flesh than the carnivore Sargus. This suggestion is in an agreement with the current study as *Oreochromis niloticus* (herbivore) recorded higher concentration than *C. gariepinus*. This finding also agrees with that of Abalaka (2015) who reported similar finding among fish species in Tiga reservoir. The accumulation of these heavy metals differed with sampling sites and months and fish tissues and/or organs. Chromium act as regulator of metabolisms of glucose and cholesterol but in higher concentration chromium is proof to be toxic. The values of Cr obtained by the present study agrees with that of Ahmad *et al*. (2018) in tissues of *Tilapia zilli* obtained from Kafinchiri reservoir, Kano State. The chromium level recorded in this study is lower than 29.8–31.6ppm in *T. zilli* and 28.1–32.2ppm in *C. gariepinus* recorded from River Benue by Ishaq *et al*. (2011). Cr might have come from mechanic paint sprays, car-wash detergents, lubricating oils and domestic chemicals by the inhabitants along the reservoir tributaries as reported by Yilmaz (2009).

The concentration of Cr was generally high in both livers and muscles of fishes from the four sampling sites. This could be as a result of run-offs around the sampling areas where Chromium rich fertilizers are applied during agricultural activities. A similar higher concentration of chromium was reported by Moses (2018) in Abare River of Zamfara State to be 1.313 mg/kg. Similarly, Ibrahim *et al*. (2018) reported 0.77 mg/kg in gills of catfish sampled from Njuwa lake of Adamawa state. The level of Cr reported by this study is higher than that reported by Orosun *et al*. (2016) in catfish sampled from Kiru dam and River Gongola of Adamawa State.

Lead is non-essential element that constitutes body burden and a great threat to life if present in substantial quantity. It is toxic even at minimal concentrations and has no known function in biochemical processes (Moses, 2018). The standard level of Pb was reported to be 0.5 mg/kg dry weight (FAO, 2007). Similar lead concentration in this work was also found to be lower than the recommended limit. The values of Pb obtained by this study are in line with that of the work of Faye-ofori *et al*. (2015) who reported 0.039±0.009 mg/kg.

The mean concentrations of heavy metals in the fish organs reported by the present study were less than the values reported from Ajiwa dam by Musa (2021) from liver. The concentrations of Cr and Pb in the fish organs reported by this study are above the WHO and FEPA prescribed limits for food fish. This corroborates with the work of Nwani *et al*. (2009) who reported similar finding in fresh water fish species of Anambra River South-east Nigeria.

Conclusion

It was concluded that variation in physico-chemical parameters existed in the surface water of Wasai reservoir with location and months. The concentrations of lead, and chromium in water (Pb=0.008-0.05mg/kg, Cr= 0.02-0.41 mg/kg) were below tolerable limits. More so, the concentration of lead, and chromium in the liver and muscles of *Clarias gariepinus* (Pb in 0.02-0.16 mg/kg in liver, 0.01-0.07 mg/kg in muscles: Cr=0.01-0.12 mg/kg in liver and 0.03-0.16 mg/kg in muscles) and in *Oreochromis niloticus* (Pb= 0.03-0.17 mg/kg in liver, 0.02-0.08 mg/kg in muscles) were above tolerable limit of human consumption.

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