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Contributions to the protection of a lentic system in the tropical region against chemical pollutions: A case study of "Toho Lake" in Southeastern Benin, West Africa

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ABSTRACT

The protection of aquatics ecosystems leads to the biological equilibrium which secures the safe foods from the aquatics products. Toho Lake located to the southeastern of Benin is threatened by human pollution due to the chemical fertilizers, waste housekeeper, and both human and animal excrement result agglomeration. The aim of the present study is to Toho lake protection against chemical and bacteriological pollution of these wet ecosystems. Samples of water and sediment were collected and analyzed by HACH DR 3900 after undergone treatment The different analysis results revealed mean oxygenation of water (4,95mgo$_2$/l), the Biochemical Oxygen Demand (21.5 mgo$_2$/l), the Chemical Oxygen Demand (149, 39 mg/l) with the azote in Nitrate (NO_3:0,18mg/l), ammoniacal azote ($N\text{-}NH_4^+$:0,47mg/l) phosphorous (2,06mg/l) are very high. The lake is also polluted by fecal matters. The high contents of heavy metals in the sediment show that the sediments of the lake are polluted by the zinc (340mg/kg), the cadmium (7mg/kg), the lead (60,75mg/kg), and the copper (8,25mg/kg).

Key Words: Protection, Pollution, Lentic system, Lake Toho, Tropical region

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1. INTRODUCTION

Water resource variation in the world is due to climate changes and the growth of the population. To ensure the safety of drinking water, acceptable quality in terms of its physical, chemical and bacteriological parameters should be checked, WHO (2004) and (Reda, A.H., 2016). The pollution affects dangerously available water resources and caused many issues to the potable drinking water in the world. However, no water quality or water quantity data exists for tributaries rivers and the lake itself, except the work of Talling and Talling and Bagalwa et al. These last years, many African countries saved a demographic growth which leads to the acceleration of the urbanization and the use of large surface by agricole and industrial activities. Forever the level of development of a country has an impact on its waste management choices (V. Francois, G. Feuillade, N. Skhiri, T. Lagier, and G., 2006). All this caused is not well managed particularly the solid and liquid garbage, the effect of various pollutants throwing augmentation in the watercourses, disturbing the different aquatic environmental components and reduce the fishing productivity. Moreover, heavy metal pollution is a worldwide problem that preoccupies regions that like to hold up at a high-quality degree their heritage water Ressources (Belhamra et al, 2001). In some ecosystems, the presence of the chemical product can cause the death of animals and vegetables but also can be the source of animal or vegetable disappearance, which leads to the dysfunction of the trophic channel (Gold et al, 2002).

Thus, despite the use of water both for our health and environment, we contribute to pollute and deteriorate its quality by our activities. For this reason, available water, especially clean water in quality and aquatic ecosystem conservation is becomes a challenge and many countries try to resolve it. Benin is as well as concerned.

The climate changes of these last years and the hydrologic regime of the valley of Ouémé(In Benin) have undergone a lot of disturbing events which manifest by runoff in 1963, 2003, 2007, 2009 et 2010. The loss generate in 2010 has been evaluated at $81333300.

On this day, these bad functions have many effects on the ecosystem, the aquatic species life and surface water too. The best environmental functioning must permit to highlight some questions:

- What is the present quality of the water stream in Benin?
- Is there some contribution to the best lake protection against various pollutions?

Surface water appreciation quality is based on physicochemical and chemical parameters evaluation and the detection of the aquatic microorganisms, the best indicator of water quality. Some data can be added by the sediment analysis, which constitutes the memory of the river life. The presence of component pollution could have some effects on the natural ecosystem (Dèdjiho, 2013). Availability water quality data on lake water allow the best protection which leads to ecosystem conservation. For this reason, our paper deals *«Contribution to the protection of a lentic system in tropical region against chemical pollutions: Case study of "Toho lake" in Southeastern Benin, West Africa"* The richness of hydro-ecosystemic heritage and the accidental boom death of the fish in 2018 May is the reason of Toho lake choice.

2. MATERIALS AND METHODS

2.1. Area of study

Toho Lake is located between the Agamé plateau and the North-west plateau of Bopa (in Benin Republic). It extends from 6°35 to 6°40 north latitude and of 1°45 to 1°50 East Longitude.The area in the dry season is 9.6km^2 and 15km^2 in a rainy season. It has 7km of length and 2.5km of meridional width and approximately 500km northern width (Ahouansou-montcho, 2003). Toho lake has a crescent form orientated south-north and covered by tree districts: Kpinnou in the municipality of Athiémé, Zoungbonou in the municipality of Houéyogbé and Houin in the municipality of Lokossa.

2.2. Sampling

Water and sediment specimens sampled were collected during the small rainy season. Sampling work has taken place on 5 October at 8h30. Some parameters as temperature, pH, turbidity, salinity, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were measured with a multi-parameter on the site. Dissolved oxygen was measured at the laboratory via a chemical method. The depth of the lake was measured with the graduated cord and riband meter. The sample of sediment was collected with a Schipeck benne.

Water for the physicochemical and microbiology analysis was sampled in 500 mL polyethylene bottles with double plugs and sterilized. It was conserved in the glacial at 4°C and carried to the laboratory.

2.3. Methods of analysis

Physicochemical and chemical parameters

In the purpose to have a general view and reach the aim of this work, many parameters as temperature, pH, turbidity, salinity, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were measured with multiparameter PCSTest+^{TM}35. The depth of the lake was measured with a graduated cord. The sound was cleaned before putting in the sampled water for reading the different parameters in situ. The DBO was measured by a DBO meter noticed OxiTop.

2.3.2 Eutrophisant substances

Nitrate, nitrite, total phosphorus, phosphate and ammonia are nutriments and were evaluated with HACH DR 3900 spectrophotometer in the laboratory. Heavy metals in the sediment were also evaluated.
The sample of sediment was collected with a Schipeck benne. Heavy metal amounts (zinc, lead, copper, and cadmium) were determined by kits MERCK using the HACH DR 3900 spectrophotometer.

Figure 1: Localisation of the sampling site of water, fishes and sediments

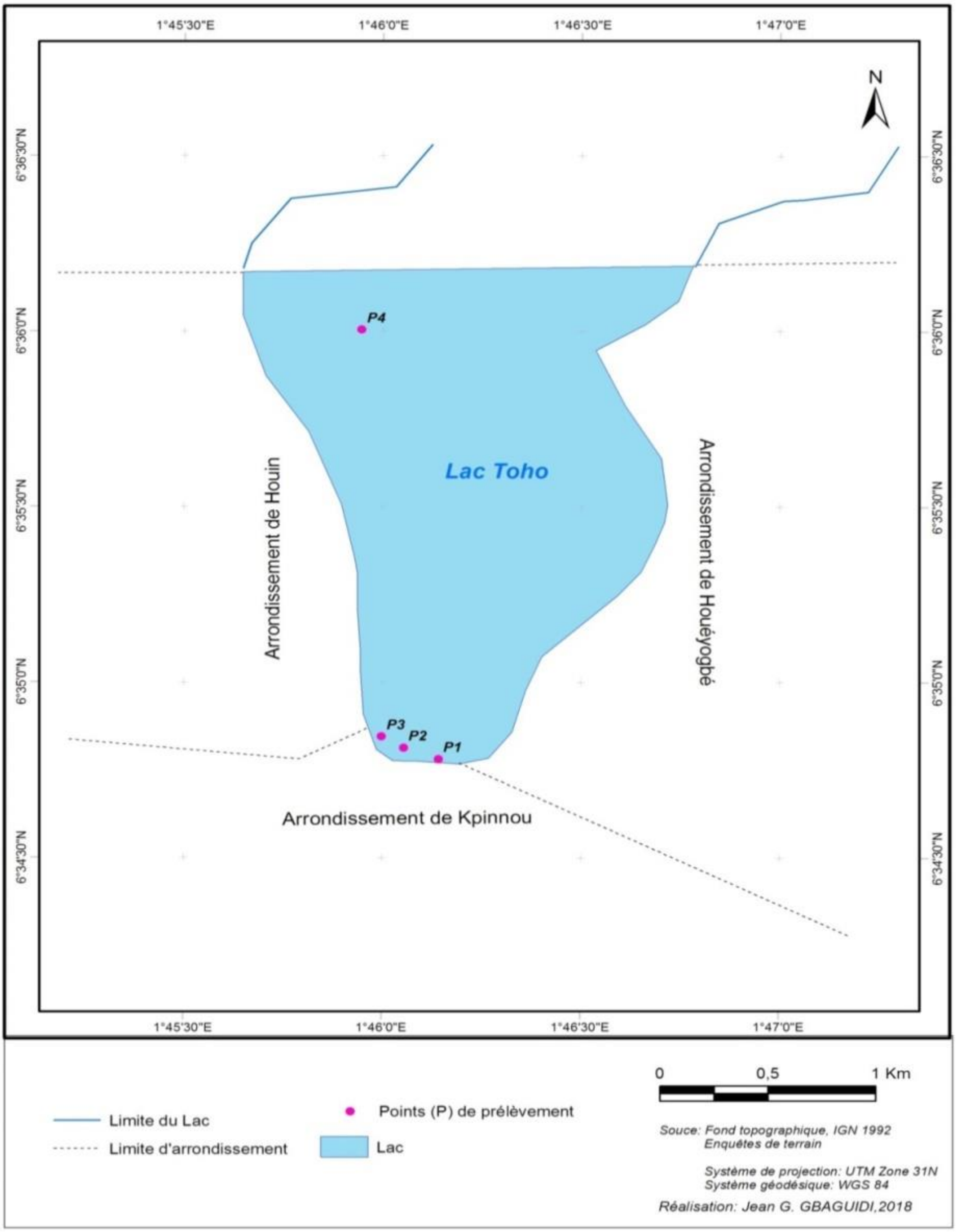

Tableau I: Sampling station of Toho lake

Sites	Names	Reason of the choice o the site	Geographic Coordinated
1	Kpinnou 1	In front of the farmhouse of the fish farmed	N6°33 ; E1°46°10''
2	Kpinnou 2	Medium of the farmhouse of the fish farmed	N6°33°5'' E1°46°5''
3	Kpinnou 3	Behind of the farmhouse fish farmed	N6°34 E1°46'
4	Houin	Out of the farmhouse fish farmed.	N6°36 E1°45°90''

3. RÉSULTS AND DISCUSSIONS

3.1.1 Physicochemical parameters

Table II presents the conformity tests which test the water state through physicochemical regarding limit values. It suggested a significant statistic difference ($P<0,005$) for the Electric conductivity Physicochemical, the temperature, (32.33°C), the salinity (0,18g/l) the Biochemical Oxygen Demand (21.5 mgO_2/l), the Chemical Oxygen demand (149,39 mgO_2/l, the Solid Total Dissolved (180,25mg/l) and the turbidity (33,78 NTU) (Table III).

3.1.2 Eutrophisant substances

Table V shows the conformity means test which tests the water state through chemical

Regarding limit values. It display a significant statistic difference ($P<0,005$) for the following parameters: Nitrate ($N\text{-}NO_3$: 0,18mg/l), nitrite, total phosphorus (2.06mg/l), phosphate (0,05mg/l), and ammonia ($N\text{-}NH_4^+$: 0,47mg/l), NTK (0,80mg/l) (Tableau IV).

3.1.3 Principal Component Analysis (PCA)

Principal result Components Analysis indicates that the two-axis explain 84,91% leaving information, which is better to have precision in the interpretation.

The table VI displays the correlation coefficient between physicochemical parameters and the principals component axis indicate a high positive correlation between the first axis (axis 1), the PH, CE, TDS, N-NO2 and the DBO in the first part. In the second part, it indicates a high negative correlation between the first axis, temperature, turbidity, the ammonia (N-NH3), and the NTK. The positive side of the first axis display that water presented a high pH, present also high DBO, Electric Conductivity, TDS and nitrite($N\text{-}NO2^-$).In besides, The negative side indicates that when water presents a high temperature, the value of ammonia($NH3^+$) and NTK.

Elsewhere, the table indicates a high positive correlation between axis2, Dissolved oxygen, salinity, phosphorus concentration, and the DBO. Besides, there is a high negative correlation between the same axis, the nitrate (N-NO3) and the phosphorus. The positive side of the axis2 display that water presented a high DBO value present also high values of Dissolved oxygen, salinity, and orthophosphorus. The negative side of the axis2 displays that when water present a high nitrate value leads to a high phosphorus value.

In the light of the work above, when water present a high-value pH value, the value of TDS, nitrite, dissolved oxygen, salinity, orthphosphorus, DBO, and the Conductivity Electricity are high whereas water presented a high-temperature present also high value of ammonia (N-NH3), NTK, nitrate (N-NO3) and phosphorus.

3.2 Heavy metals in the sediment

The table VII presents the results of the Kruskal test testing the average concentration of heavy metals in the sediment breadth stations indicates a significant statistic difference ($p<0.05$).

The graph (a) presenting lead median concentration in each station shows a high concentration at all stations. The lowest concentration is 37mg/kg (and the highest concentration is obtained at Houin (60,75mg/kg, at Kpinnou1 50.5mg/kg and at Kpinnou2 49.90mg/kg). These highest indicate that sediment is polluted. That pollution becomes anthropic sources that are solid garbage and chemical fertilizer utilization.

The graph (b) presents cadmium median concentration. It displays the highest concentration (7mg/kg) at Houin ant the lowest concentration (1,5mg/kg) at Kpinnou2 and Kpinnou3.

The graph© displays zinc median concentration. The highest value (340mg/kg) was obtained at Kpinnou2. The lowest concentration was 50mg/kg.

The graph (d) presenting copper median concentration displays the highest concentration (2100mg/kg) at Kpinnou1 and the lowest concentration (420mg/kg) at Kpinnou3.

Tableau II: conformity test result testing the water state through physicochemical

Components	Statistic	
	Value of t	Probability
pH (Potentiel d'Hydrogène)	0,14	0,897
TDS	-89,04	0,0003
Oxygen dissolved	-0,2	0,854
Turbidity	-16,44	0.00005
Electric Conductivity (EC)	-71,82	0,00005
Salinity	-37,77	0,00004
Temperature	15,08	0,0006
Biochemical Oygen Demand	5,69	0,011
Chemical oxygen demand	9,65	0,002

Tableau III: Descriptif statistic(means and error types, of physicochemical parameters.

Components	Mean	Errorr type	Minimum	Maximum
pH	7,94	0,46	7,02	8,96
Electric Conductivity(EC)	355,25	2,02	352,00	361,00
Temperature	32,33	0,29	31,50	32,80
Turbidity	33,78	2,21	28,30	37,40
TDS	180,25	3,59	176,00	191,00
Oxygen Dissolved	4,95	0,25	4,40	5,60
Salinity	0,18	0,01	0,16	0,20
Biochemical oxygen demand	21,50	2,02	18,00	27,00
Chemical Oxygen demand	149,39	11,34	128,13	176,61

Tableau IV: conformity test result testing the water state through lake pollutants

Components	Statistic	
	Value of t	Probability
$N\text{-}NH_3$	8,67	0,003
$N\text{-}NO_2$	2,42	0,094
NTK	-7,87	0,004
$N\text{-}NO_3$	6,6	0,007
Total Phosphorus	3,46	0,040
Orthophosphate	--6,33	0,008

Tableau1 : Descriptif statistic (means and error types, of lake pollutants.

Component	Mean	Errorr type	Minimum	Maximum
$N\text{-}NO_3$	0,18	0,03	0,10	0,20
$N\text{-}NO_2$	0,17	0,07	0,08	0,36
$N\text{-}NH_4$	0,47	0,05	0,33	0,58
Azote Total -NTK	0,80	0,41	0,12	1,93
Orthophosphate	0,05	0,01	0,03	0,06
Phosphorus	2,06	0,45	1,31	3,37

Tableau VI : Corelation coefficient between physicochemical parameters and principal axis components

Physicochemical parameters	Axis 1	Axis 2
PH	0,89	-0,40
Electric Conductivity (EC)	0,98	0,06
Temperature	-0,86	-0,49
Turbidity	-0,94	0,23
Total Dissolved Solids (TDS)	0,97	0,24
Oxygen dissolved	-0,43	0,89
Salinity	0,73	0,66
Azote in nitrate (N-NO3)	0,49	-0,78
Azote in nitrite (N-NO2)	0,94	0,33
Azote in ammonia (N-NH3)	-0,93	-0,20
Azote NTK	-0,63	0,51
Orthophosphate	0,09	0,78
Phosphorus	0,03	-0,90
Biochemical oxygen demand	0,98	-0,16
Chemical Oxygen Demand	0,13	0,90
depht	0,12	-0,36

Tableau 2 : Result of the Kruskal test testing the median concentration of heavy metal in the sediment breadth stations

Paramters	Statistic		
	Ddl	x-square	Probability
Lead	3	40	0,000
Copper	3	40	0,000
Zinc	3	40	0,000
Cadmium	3	40	0,000

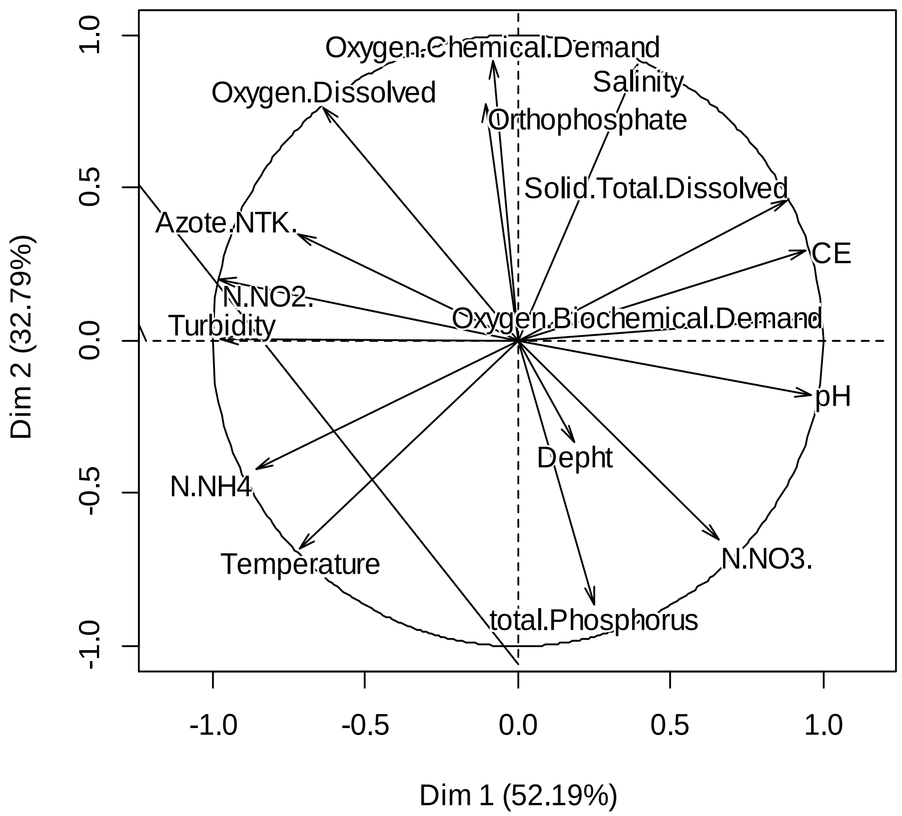

Figure 2: Correlation between physicochemical parameters and principal axis

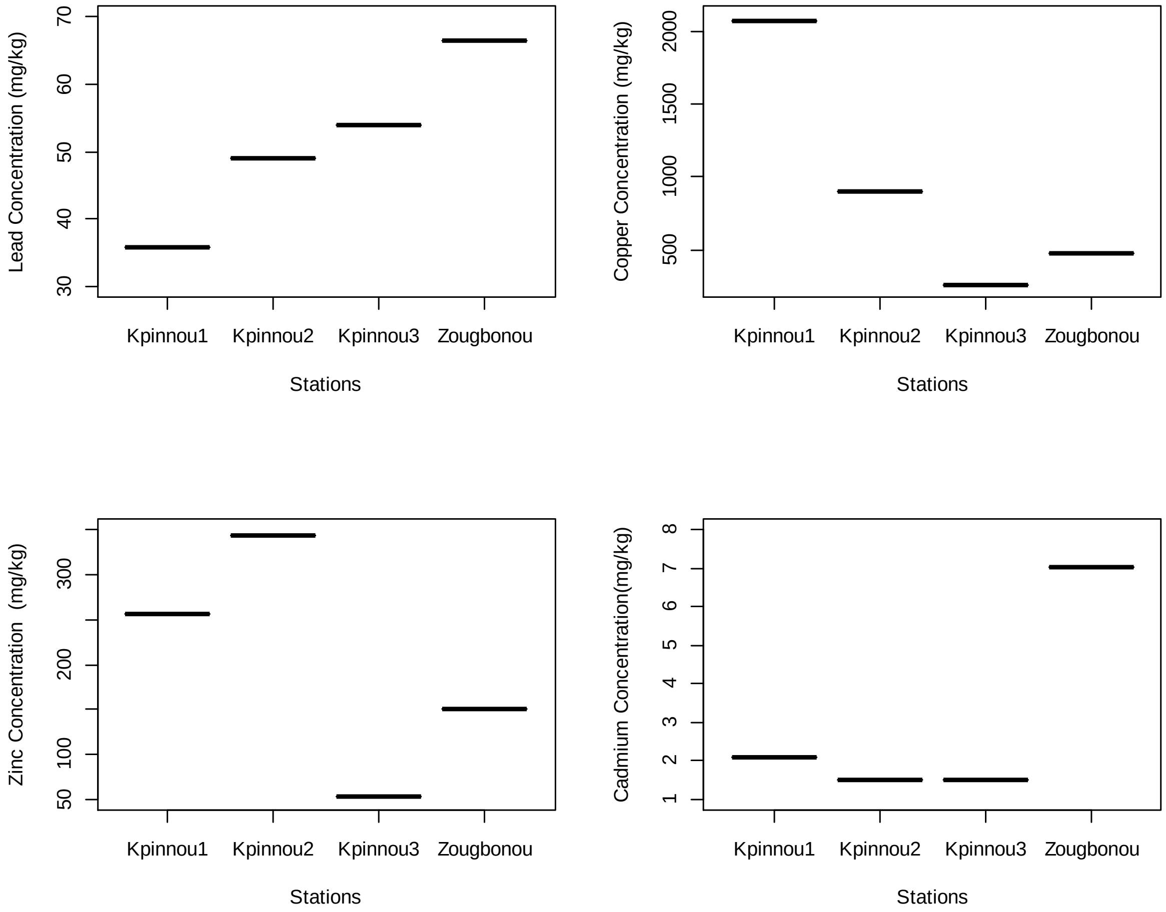

Figure 3: Moustache box presenting average concentration of the heavy metal in the sediments

DISCUSSION

The chemical products released in the environment by natural process and anthropic activities can enter the aquatic ecosystem and integrate the substance in the suspension. That can represent a danger for more aquatic organisms (Noumon et al. 2015). The average value of temperature:32.33°C (table VIII) is similar with Dèdjiho (2011) and Poumon (1998) data these authors agree that temperature between 24°C -35°C is favorable for the fish growth. Egan and Boyd (1997) reported by Abou (2001) thought that a value of temperature between 28°C-32°C is optimal for the tilapia growth. Besides, the mean electric conductivity value was 355,25µS/Cm. That value is lower than data reported by Dimon et al (2014) and Koudenoukpo's (2017) result. The lake was moderately mineralized and the Electric Conductivity value is near the standard WHO. The average Solid Total Dissolved value (180.25mg/l) measured correlates with the Electric Conductivity value. The TDS inform about the water salinity. That value was different from Dovonou et al‘s value (2011). The amount of the salinity was lower than the standard WHO for aquatic health. The salinity was low because sampling was done in the rain season and just a week after the rain. Additionally, The DBO value was (21.5mgO_2/l) was under the International standard limit. Toho lake was not a lot polluted by biochemical oxidizing substances. That was confirmed by the available oxygen dissolved in the lake. The Chemical Oxygen demand value (149,39 mg/l) was high regarding the French standard limit (40mg/l. It reflects that Toho lake was polluted by organic substances. A lot of load of organic substance rise to the tree's branch. The mean nitrate value (0,18 mg/l) was superior regarding French standard limit (0,01mg/l). It shows the pollution of the lake by human and animal dejection in the Toho lake. Elsewhere the average ammonia (N-NH3) value was high regarding the French standard limit (0.02mg/l) for soft aquatic waste. The total phosphorus and orthophosphate, the chemical fertilizer; the waste water which was rich in nitrate. That value was different to the Koudenoukpo (2017) value in the sô river and Dimon and al,(2014) value 3mg/l of nitrate value respectively 2,06mg/l and 0,05mg/l were high as compared to French standard limit (1mg/l :total phosphorus (1mg/l)and orthophosphate (0,1 mg/l).So Toho lake was polluted by phosphorus , the effect of eutrophisation and complication of aquatic respiration when phosphorus was combined to the nitrate.

The heavy metal dosage result in the Toho lake sediment were: lead (60,75 mg/Kg) ;zinc(340 mg/Kg); cadmium(7 mg/Kg) and coppery(2100mg/kg).Compared to the Dimon et al, 2014 results in the Ahémé lake: lead:26mg/kg; zinc(170mg/kg) and Chouti et al;2011 result in the Porto-Novo lagoon: lead(5.65mg/kg); copper(0.16mg/kg) and zinc(7mg/kg), these result were different. Those high value obtained in the Toho lake sediment is probably related to anthropic activities. The phosphorus of used fertilizes and the battery accumulator is transported by running water and be found in the aquatic ecosystem. The heavy metals contained in those elements will put off and integrated the suspension substance. Heavy metals are dissolved in the acid solution. It precipitates and accumulates in the basic solution. Heavy metals will deposit in the depth as well as integrate sediment. The same situation observed by revealed that water and sediment of Nokoué and Ahémé lake, Porto-Novo lagoon, and Cotonou channel were contaminated by cadmium, copper, zinc, iron, mercury and arsenic (Agonkpahoun, 2006; Lawani, 2007; Darboux, 2008, Chouti, 2011, Dimon, 2014). These authors have demonstrated that these heavy metals have many impacts as well on the aquatic ecosystem as on human health. The mortality growth, lethality, behavior changes, abnormal development, the growth diminution of the benthic species regarding Canada Environment rules are harmful biologic effects of heavy metal.

CONCLUSION

Taking into account the results of the present study, some chemical parameters were had high values regarding different standard limits. The concentration of heavy metal was very high in the sediment. Toho lake which was polluted by azote component (nitrate, ammonia) and phosphorus. The highest value of Chemical Oxygen Demand confirms that Toho lake was polluted by organic substances. Regarding different standard limits, a sediment of Toho lake was polluted by lead, cadmium, copper, and zinc. This will probably damage fishes flesh and aquatic flora.

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