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Evaluation of Metallic Trace Elements Content (Cadmium, Copper, Zinc and Lead) in the Water of Lake Azili in the Municipality of Zangnanado (Centre-Benin)

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Abstract

This study focuses on the assessment of the level of contamination in metallic trace elements (cadmium, copper, zinc and lead) in the waters of lake Azili in the municipality of Zangnanado. The methodology adopted to achieve these results is the method of molecular absorption spectrophotometry. Four sites were sampled at the beginning of November 2020 (period of the long dry season). The results obtained show that the copper content varies between 1.04 mg/l and 1.67 mg/l. The zinc content between 0.2 mg/l to 0.62 mg/l and those of lead recorded are all above 0.05 mg/l. As for their cadmium concentration, they are all above 0.001 mg/l. These results from water analysis of Azili lake show that the sources of this type contamination of the lake are due on the one hand to human activities (dumps of household waste, use of motorized boats) and others other hand to the contributions of the effluents of the lake carrying pesticides. The water quality of Lake Azili is therefore influenced by these various metallic trace elements found there. These results show that the waters of lake Azili are at their beginning of pollution even if it is not yet alarming at the time of our study. Under these conditions, if nothing is done to mitigate it, the pollution will be critical over time.

Keywords

Pollution, Lake Azili, Zangnanado, Quality, Environment

1. Introduction

Life on earth is possible thanks to the existence of certain vital resources, including water, a commodity of great importance for living beings (Houssou, 2010). It is an essential element for life and for the real and sustainable socio-economic development of a country, it is therefore necessary to have a better knowledge of the quality of existing water resources. However, the problems related to groundwater pollution and anthropogenic pressure on highly vulnerable aquatic ecosystems require permanent monitoring of their physico-chemical, hydrodynamic and biological properties. Generally, the assessment of surface water quality is based on the measurement of physico-chemical parameters as well as the presence or absence of aquatic organisms and microorganisms, indicators of water quality (Ballouki, 2012).

The demographic expansion and economic growth experienced by the countries of the world without obscuring those of Africa, in particular Benin, have consequences on the environment and on water bodies (Hawa, 2011).

Thus, water resources are under strong pressure from human activity (agriculture, industry, livestock, fishing, domestic, hospitals, etc.). Human activities of a socio-economic nature coupled with those of natural processes (soil erosion, precipitation, evaporation, runoff of river water) accelerate the degradation of surface water resources (Hawa, 2011). They cause disturbances of the natural balance and increase the organic load of water and sediments, then the congestion of water resources, with problems of eutrophication, asphyxiation of the aquatic environment as well as the health problems of populations (Babadjidé, 2011).

For more than ten years, surface water (river, lake, pond, sea, river, lagoon) was used for watering market gardening and agricultural products. Thus, the source of life water can become a danger for the environment and for users if it is not of acceptable quality (Agassounon et al., 2014). In addition, surface water is exploited and treated to supply the population with drinking water (Lamizana Diallo et al., 2008).

Thus, among other things, the poor management of waste, the anarchic installation of latrines influences the quality of water resources. Similarly, Dégbey (2008) discussed the quality of well water in the municipality of Abomey-Calavi in Benin. He concluded that the well waters studied present bacteriological pollution. Lake Azili is not faced with these environmental problems. Water degradation is observed due to the overexploitation of fishery resources, the use of fishing gear that does not comply with the regulations in force and the discharge of liquid and solid waste by local populations (Golf Expertises, 2008). This study's objective is then to assess the level of contamination in metallic trace elements in the waters of Lake Azili.

2. Presentation of the Study Area

The Commune of Zagnanado is located on the Zagnanado plateau, the smallest of the plateaus north of the Lama depression between 7˚ and 7˚30' north latitude

and between 2˚15' and 2˚30' east longitude (Africa Conseil, 2010). It occupies a total area of 750 km² and is bounded to the north by the Commune of Dassa-Zoumè, to the south by the Communes of Ouinhi and Zogbodomey, to the east by the Communes of Kétou, Adja-Ouèrè and to the west by the Communes of Covè, Zakpota and Djidja. The Municipality of Zagnanado is subdivided into six (6) districts which are Zagnanado, Agonlin-Houégbo, Banamè, Kpédékpo, Dovi and Don-Tan. These districts are subdivided into 27 villages and 7 city districts. It is located 47 km from the municipality of Abomey, the capital of the Department of Zou. As shown in Figure 1, Lake Azili is located in the municipality of Zangnanado precisely in the village of Agonvè.

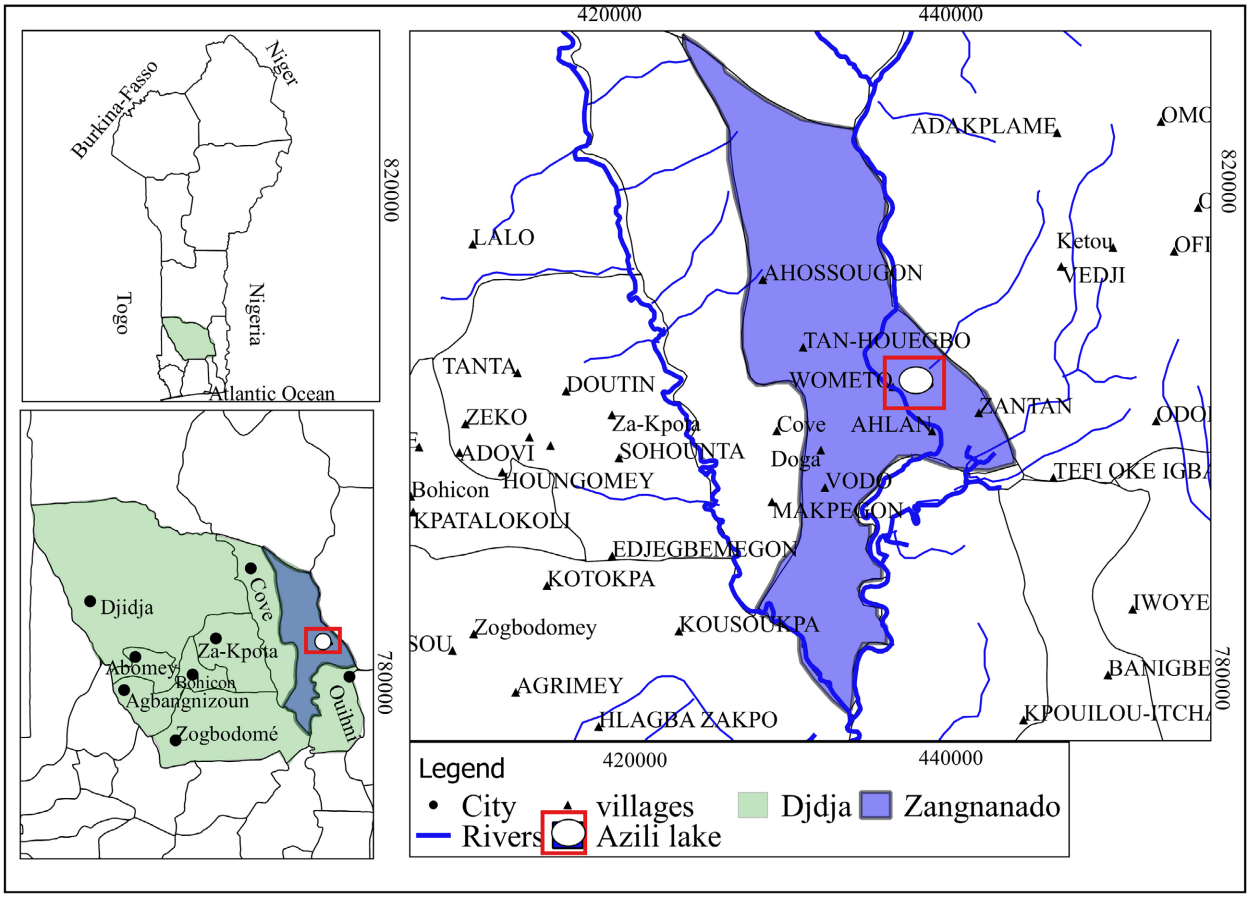

Figure 1. Location of the study area (Azili Lake) in the Zangnanado municipality.

3. Materials and Methods

3.1. Field Equipment

Table 1 presents the materials used in this study as well as their respective roles.

Table 1. Materials and roles.

Materials	Roles
GPS	to take the coordinates of the various sampling sites

Continued

1 L plastic bottle	allowed water to be sampled for physicochemical analysis
a cooler with ice packs ±5˚C temperature	allowed to keep the sample intact until the laboratory
A multi-parameter	to measure in-situ parameters such as: pH, temperature, conductivity
A digital camera	allowed to take pictures
A marker and adhesive paper	to label samples
A pen and a notebook	to record in situ values
A motorized boat	for trips on the lake

3.2. Methods

3.2.1. Literature Search

The documentary research made it possible to identify the problem and to take stock of the knowledge. This information was obtained from the libraries of the entities of the University of Abomey-Calavi (polytechnic school of abomey calavi, Faculty of Agronomic Sciences). The nature of these documents concerns is Master's theses, DEA's theses, doctoral theses, articles, books, journals, etc. The information sought relates to subjects that address issues related to the pollution of surface waters with trace elements.

3.2.2. Field Investigation

Surveys are methodical research based on questions and testimonies. They were made for women, fishermen, farmers. They were mainly focused on the way of life of the local population about the body of water and the environment.

3.2.3. Water Sampling in the Field

As shown in **Figure 2**, the water sampling on the lake was carried out according to four points namely: upstream, downstream, the middle of the lake and the proximity of the isle of Agonvè. It was done in november 2020. **Figure 2** shows the sampling sites used.

3.2.4. Measuring of Physico-Chemical Parameters *in Situ*

The physico-chemical parameters measured in situ in the water samples taken are pH, temperature, TDS and conductivity. These parameters were measured in situ with a Combo by HANNA multi-parameter probe mark. During this measurement, the electrode is immersed in the sample and the values of the various parameters are read directly on the screen of the device.

3.2.5. Laboratory Analysis

The method used to measure the chemical parameters (copper, zinc, lead and cadmium) is method by absorption spectrometry.

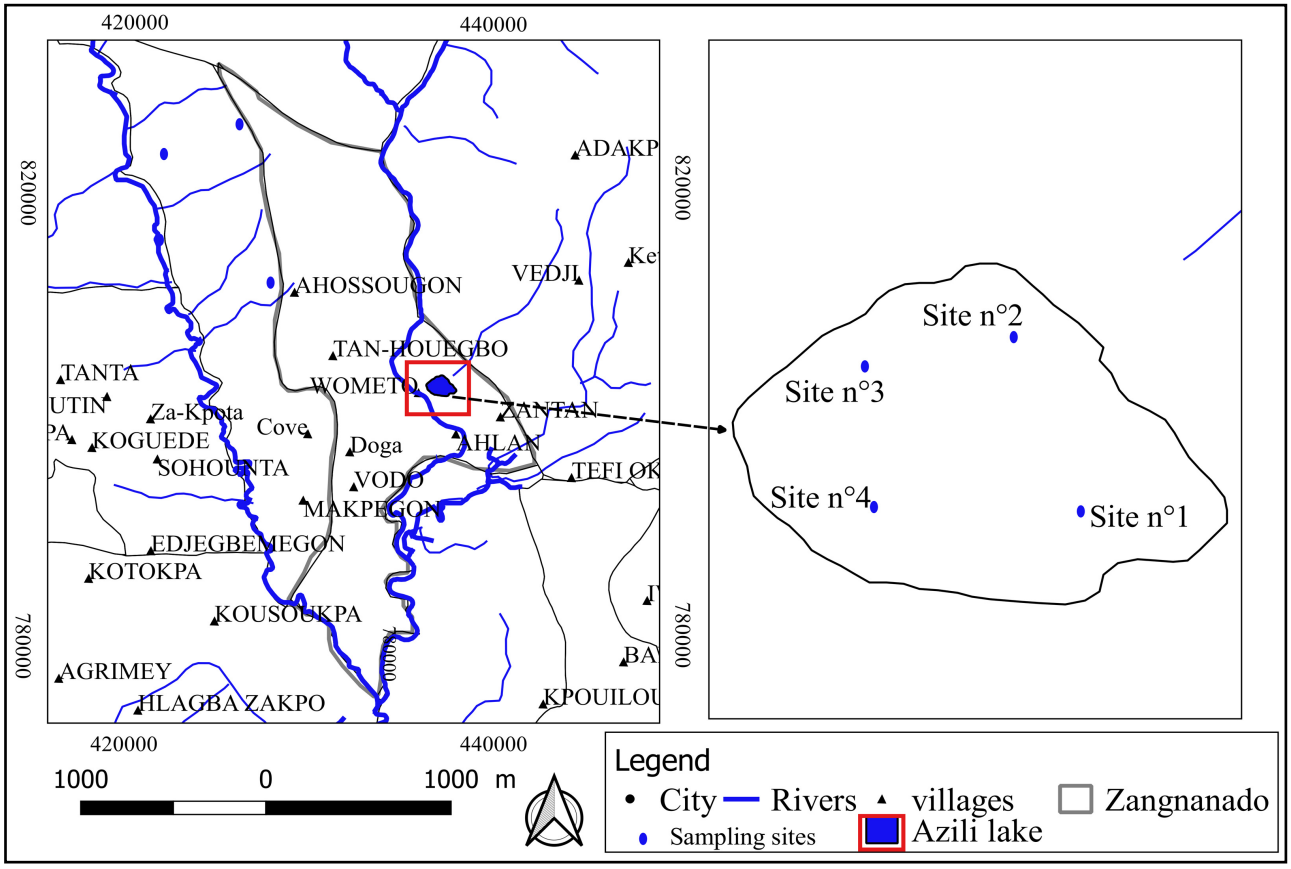

Figure 2. Water sampling sites in Azili Lake.

4. Results

The results are those coming from information based on: The survey of the local population about the way of life regarding the environment; Analyzes of the physico-chemical parameters of the waters; Statistical processing of data.

4.1. Survey of the Local Population

This survey was conducted with users (fishermen, motorized boat drivers, farmers), local authorities and in health structures. The table below (Table 2) summarizes the percentages of the main items surveyed in the case of this study.

Table 2. Results of field surveys.

	yes	No
Open defecation	80%	20%
Dumping of waste in nature	100%	0%
Use of chemicals for market gardening	4%	96%

4.2. Physico-Chemical Characterization of Lake Water

The results of the analysis of the physico-chemical parameters are summarized in Figures 3-10.

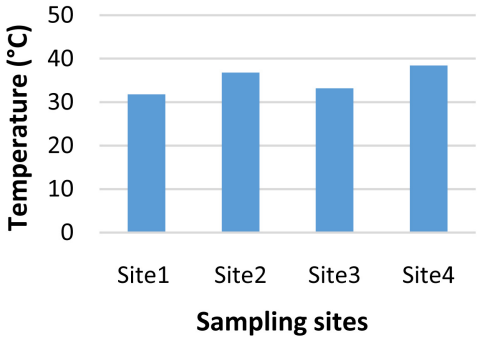

Figure 3. Variation of the temperature in the water of Lake Azili according to the sites sampled.

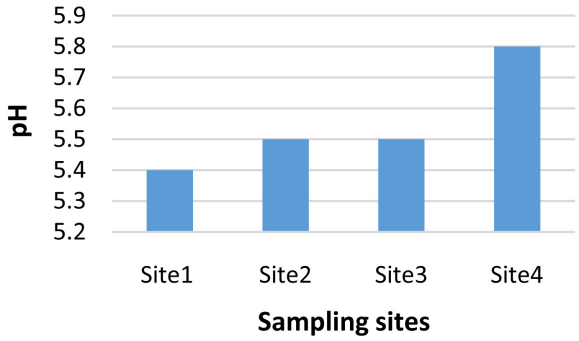

Figure 4. Variation of pH in the water of Lake Azili according to the sites sampled.

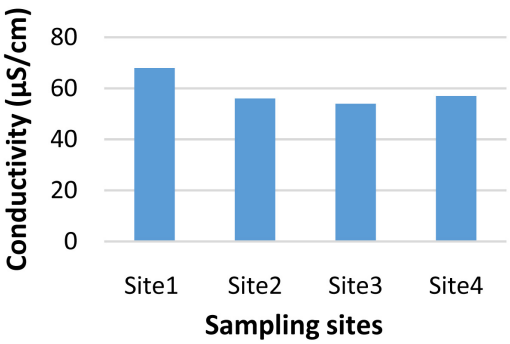

Figure 5. Variation of conductivity in the water of Lake Azili according to the sites sampled.

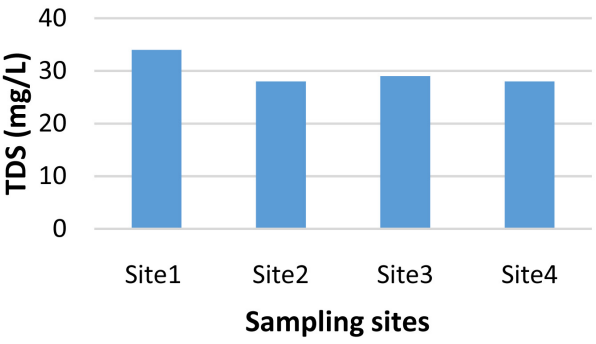

Figure 6. Variation of TDS in the water of Lake Azili according to the sites sampled.

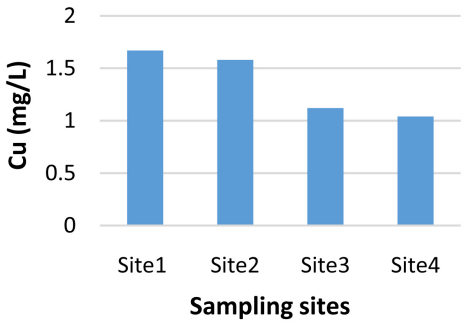

Figure 7. Variation in the copper content in the water of Lake Azili according to the sites sampled.

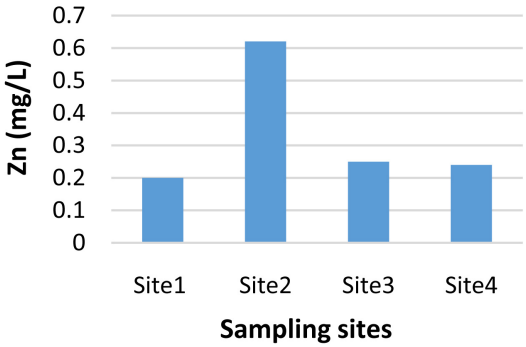

Figure 8. Variation of the zinc content in the water of Lake Azili according to the sites sampled.

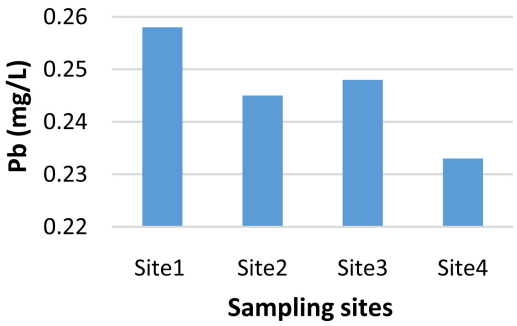

Figure 9. Variation in the lead content in the water of Lake Azili according to the sites sampled.

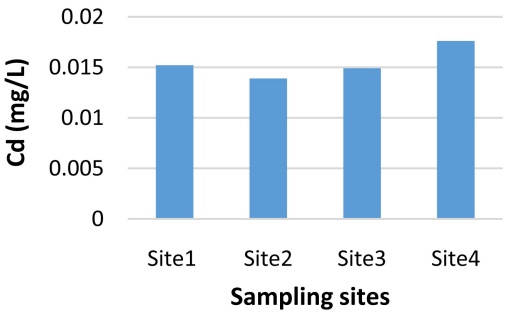

Figure 10. Variation in the cadmium content in the water of Lake Azili according to the sites sampled.

Figures 3-6 provide information on the concentrations of physical parameters in the lake water. For all four sampled sites we note an average of 35.05˚C for the temperature, an average of 5.55 for the pH, an average of 58.75 µS/cm for the electrical conductivity and an average of 29.75 mg/l for the TDS.

Figures 7-10 tell us about the metallic trace elements in the water of Lake Azili. Thus, the average copper content is 1.35 mg/L with an elevation downstream (site 1) and upstream (site 2); the average zinc content is 0.33 mg/L with an upstream elevation (site 2); the average lead content is 0.25 mg/L with a downstream elevation (site 1) and the average cadmium content is 0.015 mg/L.

4.3. Distribution of Pollutants on the Lake

Figure 11 shows the distribution of pollutants in the water of Lake Azili. The distribution maps of cadmium and lead pollution are very similar and opposite to that of zinc pollution (Figure 11): the areas of high zinc concentrations correspond globally to the areas of low cadmium and lead concentrations, and conversely, thus these pollutants are more present almost over the entire study area.

As shown in Figure 11, Cadmium and lead are concentrated in the west, northeast (upstream of the lake) and southeast (downstream of the lake) while zinc is mainly concentrated in the northwest and southwest. These pollutants could come from the secondary watercourse that feeds the lake upstream. Copper having occupied half of the lake is concentrated in the southeast and southwest (downstream of the lake).

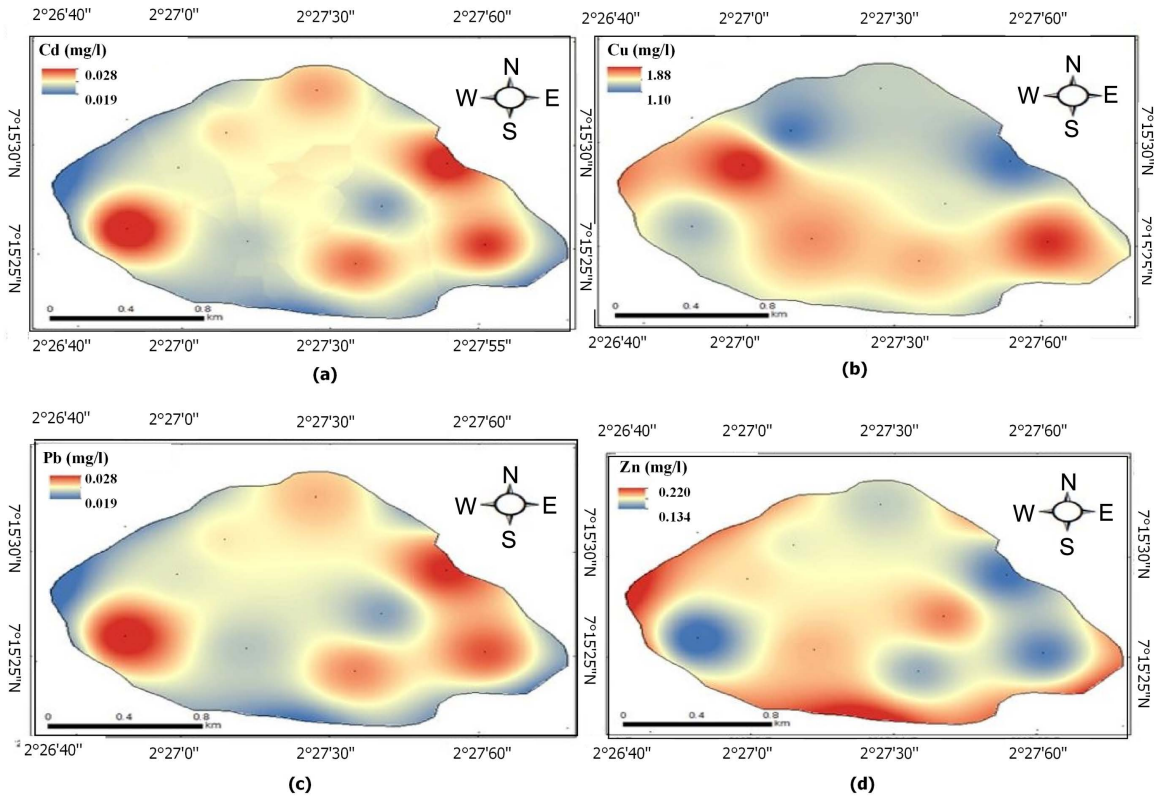

Figure 11. Pollutant distribution maps in the Lake Azili.

4.4. Correlation between Metals and Physico-Chemical Parameters of Lake Water

Table 3 and Table 4 illustrate the correlation coefficients between the various parameters measured. They show the correlation matrix between the physico-chemical variables studied. The results show that pH, conductivity, TDS, copper, zinc and cadmium are not correlated. On the other hand, pH and lead are strongly and significantly correlated and negatively (r: −0.95; p: 0.0467).

Table 3. Correlation coefficient. r: correlation value; p: probability value; significance level: r greater than or equal to 0.5.

Variables	T (˚C)	pH	CE	TDS	Cu	Zn	Pb
pH	0.83						
CE	−0.55	−0.44					
TDS	−0.81	−0.64	0.94				
Cu	−0.43	−0.76	0.66	0.61			
Zn	0.43	−0.13	−0.39	−0.50	0.38		
Pb	−0.93	**−0.95**	0.65	0.83	0.73	−0.14	
Cd	0.44	0.83	0.03	−0.13	−0.65	−0.61	−0.63

Table 4. Probability of significance.

Variables	T (˚C)	pH	CE	TDS	Cu	Zn	Pb
pH	0.1662						
CE	0.4486	0.5565					
TDS	0.1929	0.3635	0.0639				
Cu	0.5736	0.2416	0.3408	0.3905			
Zn	0.5702	0.8676	0.6051	0.5016	0.6190		
Pb	0.0719	**0.0467**	0.3465	0.1659	0.2701	0.8614	
Cd	0.5625	0.1656	0.9730	0.8742	0.3487	0.3858	0.3704

5. Discussion

It is necessary to make an in-depth analysis of the parameters studied in order to assess the quality and environmental terms of the waters of Lake Azili. Thus, as far as the physical parameters are concerned, all the temperature values recorded do not comply with the standard in force; this could be explained by several factors: the time at which the measurements were taken; the change in elevation and slope of the watercourse. The pH results show that the pH value does not belong to the standard range 6.5 - 8.5 but below it. This shows that the waters of the lake are acidic. Indeed, this acidity of the waters depends largely on the nature of the land crossed and the discharges transported. This may also be due to a supply of humic and fulvic acids resulting from soil leaching by precipitation

(Merhabi et al., 2019). The results obtained at the electrical conductivity level show an elevation downstream. This elevation could be related to the geology of the land rich in mineral salts inducing a strong mineralization

These results confirm those of Amine and Abdelmalek (2012). The results of the analysis of the metals studied show us that the waters of Lake Azili are polluted with metallic elements (Cu, Pb, Cd) because all the averages greatly exceed the current standards. That is 1.35 mg/l for copper, 0.015 mg/l for cadmium and 0.25 mg/l for lead. These results are consistent with those of Senouvo (2002) and Dedjiho (2014) who deduced in this case that the waters of the lake are then confronted with the problems of pollution by domestic wastewater as well as those resulting from the leaching of agricultural land. The distribution of these pollutants in the lake (**Figure 11**) shows that they are strongly present in most of the lake. Among the various metallic elements emitted into the environment during anthropogenic activities, zinc, lead, copper, cadmium, chromium, and nickel are the most measured in environmental studies due to the diversity of sources of broadcast (Chiffoleau, 2001). The continual introduction of heavy metals into the aquatic environment is the cause of harmful effects on marine organisms because of their bioaccumulation property (Baby et al., 2010). Cadmium and lead are cumulative toxic substances capable of accumulating in aquatic food products and causing a certain number of disturbances in humans: renal, bone, neurological and/or digestive damage, carcinogenic disorders and/or mutagens (Oliveira et al., 2012).

Moreover, a strong negative correlation is observed between Pb and pH (−0.95). This correlation between pH and Pb shows that the evolution of the pH concentration reduces the Pb concentration. Contact between water and metallic lead inevitably gives rise to corrosion phenomena, the extent of which depends both on the physico-chemical properties of the fluid. An increase in pH therefore reduces the concentration of lead in water (Michel, 2003).

Overall, these results confirm those of the firm Golf Expertises (2008) on the management plan of the lake Azili which revealed a degradation of water due to the overexploitation of fishery resources and the use of gear. Fishing that does not comply with the regulations in force. It also revealed that the liquid and solid waste discharged by the local populations contributes to the pollution of the waters of Lake Azili.

6. Conclusion

This work allowed the evaluation of the level of contamination in metallic trace elements (Cadmium, copper, zinc and Lead) in the waters of Lake Azili in the commune of Zangnanado. For a total number of four samples from different locations in the lake, interpretive results emerge.

Thus, the waters of the various sampling sites presented levels of metallic trace elements (Cadmium, copper and Lead) above the thresholds recommended by the Beninese standard in force. As a result, the waters are not of good quality and therefore polluted. This pollution is observed more when moving from up-

stream to downstream with respect to the parameters (copper and lead). We note that the way of life of the local population (disposal of household waste, defecation in the open air, use of chemical fertilizers, etc.) could be on the one hand the cause of this pollution. The overall state of degradation of the lake is not as alarming but requires constant vigilance and awareness to avoid the worst in the years to come. Future research work will take into account the two rainy seasons (low water and high water) by broadening the field of analysis of chemical parameters.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Africa Conseil (2010). *Monographie de la commune de N'Dali* (27 p). Africa Conseil.

Agassounon, D. T. M., Tadjou, A., Anago, D. G., Dovonou, E. F., & Ayi-Fanou, L. (2014). Qualité physico-chimique et bactériologique des eaux de boisson dans les arrondissements de la commune de Kétou au Bénin. *Revue de Microbiologie Industrielle Sanitaire et Environnementale, 8,* 187-207.

Amine, R., & Abdelmalek, A. (2012). *Caractérisation physico-chimique des eaux superficielles de l'Oued Agrioun de la région de Bejaia* (54 p). Diplôme d'Ingénieur d'Etat en Ecologie et Environnement. Université Abderrahmane MIRA de Bejaia.

Babadjidé, C. H. (2011). *Pollution, ses conséquences, ses causes et ses incidences sur la santé humaine dans le bassin du fleuve Mono au Bénin* (222 p). Thèse de doctorat, Université d'Abomey-Calavi.

Baby, J., Raj, J. S., Biby, Etsankarganesh, P., Jeevitha, M. V., Ajisha, S. U., & Rajan, S. (2010). Toxic Effect of Heavy Metals on Aquatic Environment. *International Journal of Biological and Chemical Sciences, 4,* 939-952. https://doi.org/10.4314/ijbcs.v4i4.62976

Ballouki, K. (2012). *Etude de la qualité physico-chimique et biologique de trois sources dans la région de Midelt (Haut Moulouya)* (77 p). Mémoire de master en hydrologie de surface et qualité des eaux-Faculté des Sciences et Techniques-Fès.

Chiffoleau, J. C. (2001). *La concentration métallique. Rapport technique, programme scientifique* (pp. 6-7). Seine-Aval. IFREMER: Région Haute Normandie.

Dedjiho, A. (2014). *Etude diagnostique de la pollution chimique des plans d'eau du complexe lagunaire du Sud-Ouest du Bénin: Cas du lac Ahémé-Gbézoumè* (139 p). Thèse de doctorat unique, Université d'Abomey-Calavi.

Dégbey, C. (2008). *La qualité de l'eau de puits dans la commune d'Abomey-Calavi au Bénin* (283 p). Campus Erasme/Ecole de Santé Publique.

Golf Expertises (2008). *Plan de gestion de plan d'eau: Lac AZILI* (38 p). Rapport Final, Golf Expertises.

Hawa, S. (2011). *Analyse physico-chimique et bactériologique au L.N.S. des eaux de consommation de la ville de Bamako durant la période 2000 et 2001* (77 p). Thèse de Doctorat d'état en Pharmacie.

Houssou, C. J. L. (2010). *Gestion de l'eau au Bénin et ses impacts environnementaux: Cas de l'arrondissement de Houin dans la Commune de Lokossa* (68 p). Mémoire de maitrise professionnelle FLASH/UAC.

Lamizana Diallo, M. B., Kenfach, S., & Millogo-Rasolodimby, J. (2008). *Evaluation de la qualité physico chimique de l'eau d'un cours d'eau temporaire du Burkina Faso* (28 p). Le cas de Massili dans la Kadiogo. Diplôme d'ingenierie, 2IE.

Merhabi, F., Amine, H., & Halwani, J. (2019). Evaluation de la qualité des eaux de rivière Kadicha. *Journal scientifique libanais, 20,* 10-34. https://doi.org/10.22453/LSJ-020.1.010-034

Michel, M. (2003). *Facteurs influencant la concentration en plomb dans l'eau* (21 p). Rapport/ENS/Versaille.

Oliveira, H., Tina, L., Tania, A., Maria, L. P., & Santos, C. (2012). Cadmium-Induced Genetic Instability in Mice Testis. *Human & Experimental Toxicology, 31,* 1228-1236. https://doi.org/10.1177/0960327112445937

Senouvo, P. (2002). *Etude de l'impact des pollutions en métaux lourds (plomb, cuivre, et zinc) sur l'écologie des huîtres crassestreagascar en zones urbaines du lac Nokoué et du chenal de Cotonou (Bénin)* (64 p). Mémoire de DEA en Gestion de l'environnement FLASH/UAC.