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RESEARCH ARTICLE

INFLUENCE OF THE WATER QUALITY OF LAKE TOHO LOCATED IN THE MONO DEPARTMENT, SOUTHWEST BENIN, BY GLYPHOSATE AND METALS (COPPER, ZINC, LEAD, CADMIUM)

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Abstract

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In order to assess the pollution status of the waters in Lake Toho, water samples were collected and analyzed using the spectrophotometer. Researched elements such as glyphosate are in high concentrations in the lake waters. The same goes for Trace Metal Elements such as copper, zinc, lead, cadmium in the waters of the said lake. The metal contents are beyond the tolerable limit by the Canadian standard following the Criteria for the protection of Aquatic Life according to Chronic effects (CVAC: 0.0085 $mg.L^{-1}$ for copper and lead, 0.11 $mg.L^{-1}$ for zinc, 0.0093 $mg.L^{-1}$ for cadmium). Likewise, the copper, zinc and lead contents (during the long dry season and end of the long rainy season) recorded exceed the same standard according to the Criteria for the protection of Aquatic Life according to Acute effects (CVAA: 0.012 $mg.L^{-1}$ for copper, 0.11 $mg.L^{-1}$ for zinc and 0.22 $mg.L^{-1}$ for lead). These levels of herbicide and metals present would contribute to the toxicity of the waters of Lake Toho and constitute a green threat for the aquatic organisms present in the said lake. It is urgent to put in place a management and control system for actions around the lake.

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Introduction:-

Water is a vital resource necessary for all living beings.But water in terms of good quality is rare. This resource is unevenly distributed around the world. It is necessary for health and of great importance for domestic, agricultural and industrial activities. The wetlands of Benin, ecosystems with significant resources, are concentrated in the South. According to da Matha-Sant'anna(2001), the southern Benin is home to more than 50% of the Beninese population (with densities rarely less than 150 inhabitants per km^2) over 10% of the national territory. This situation justifies the fact that the surrounding ecosystems are subject to anthropogenic pressure which does not guarantee the sustainability of natural resources. Gold (2002) showed that in some ecosystems, chemicals (fertilizers, pesticides, herbicides, metals, etc.) can be the cause of the disappearance of some animal and/or plant species and consequently

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lead to the imbalance of the trophic chain (low biodiversity, etc.). Among these chemical pollutants, glyphosate and trace metal elements (TMEs) such as copper, zinc, lead and cadmium are responsible for the phenomenon of surface water toxicity, therefore the death of fish and of other forms of aquatic life (Chouti, 2011).

Glyphosate, that herbicidal activity was discovered in 1970, began to be marketed in 1974 by Monsanto and was approved in Canada in 1976 (Trotterand al., 1990; Franz and al., 1997). Since its launch, more than 100 formulations containing it have been sold and used throughout the world. Glyphosate is a non-selective post-emergent organophosphate herbicide used to control broadleaf weeds and annual and perennial grasses (British Crop Protection Council, 2000). Its chemical name is “N-(phosphonomethyl)glycine”. Glyphosate can be released into the aquatic environment during its production, storage or use as a result of spills, accidental releases or waste disposal, or by wind erosion of treated fields. Likewise, metals, such as copper, zinc, lead, cadmium, etc. brought by runoff water or an industrial spill constitute a potential danger to human health.

Unlake is a body of water completely surrounded by land, generally fresh water: it is a stretch of stagnant water and does not flow into a watercourse. Lake Toho, the subject of our study, constitutes an environment of biological productivity and fishery production possibilities. This is based on the fact that Tossavi reported that it contains around twenty species (Tossavi, 2012).

In Benin, Lake Toho is one of the most productive bodies of water where annual fish catches reached 603.60 metric tons(Welcomme, 1979). It should be noted that artisanal fishing and fish farming in enclosures or ponds, pig farming, cane farming, commerce, crops (sometimes using fertilizers) and crafts are activities carried out by residents in the department. However, hydro-agricultural resources (marshes, lowlands and bodies of water) can be developed for tilapia farming throughout the year (Kple, 2008).

With an area of 9.6 km^2 at low water, 15 km^2 during flood periods, Lake Toho is located in the southwest of Benin, and has on average 7 km in length, 2.5 km in southern width and approximately 500 m in northern width (Ahouansou, 2003). Lake Toho is subject to hydrological dynamics characterized by freshwater inputs from the Mono River (also from the Diko and Akpatohoun streams) and the Sazoé River during the high water season (Adite, 2002). The Kpakohadji channel plays the roles of outlet and tributary.

Lake Toho is impacted by anthropogenic activities and poor waste management. These activities are of significant economic interest and are growing with population growth. The decline in fishery resources was perceived by 91.47% of respondents compared to 6.20% and 2.33% of respondents who respectively perceived an increase or stability in fishery resources (Codjoandal.,2018). The indicators through which fishermen perceive this decline in fishery resources are: the disappearance of certain fish species, the reduction in the size of fish collected.

Material and Methods:-

Study zone

The study was carried out in the communes of Athiémé, Lokossa and Houéyogbé which are the communes surrounding Lake Toho in the south of Benin.

Located between the Agamè plateau and the northwest of the Bopa plateau, Lake Toho extends on average during low water from 6°35' to 6°40' north latitude and from 1°45' to 1° 50' east longitude. It is part of the Mono basin. The latter covers an area of 374 km² and is located in the western complex of the wetlands of southern Benin (Ramsar Site, 1017). It has the shape of a crescent oriented South-North.

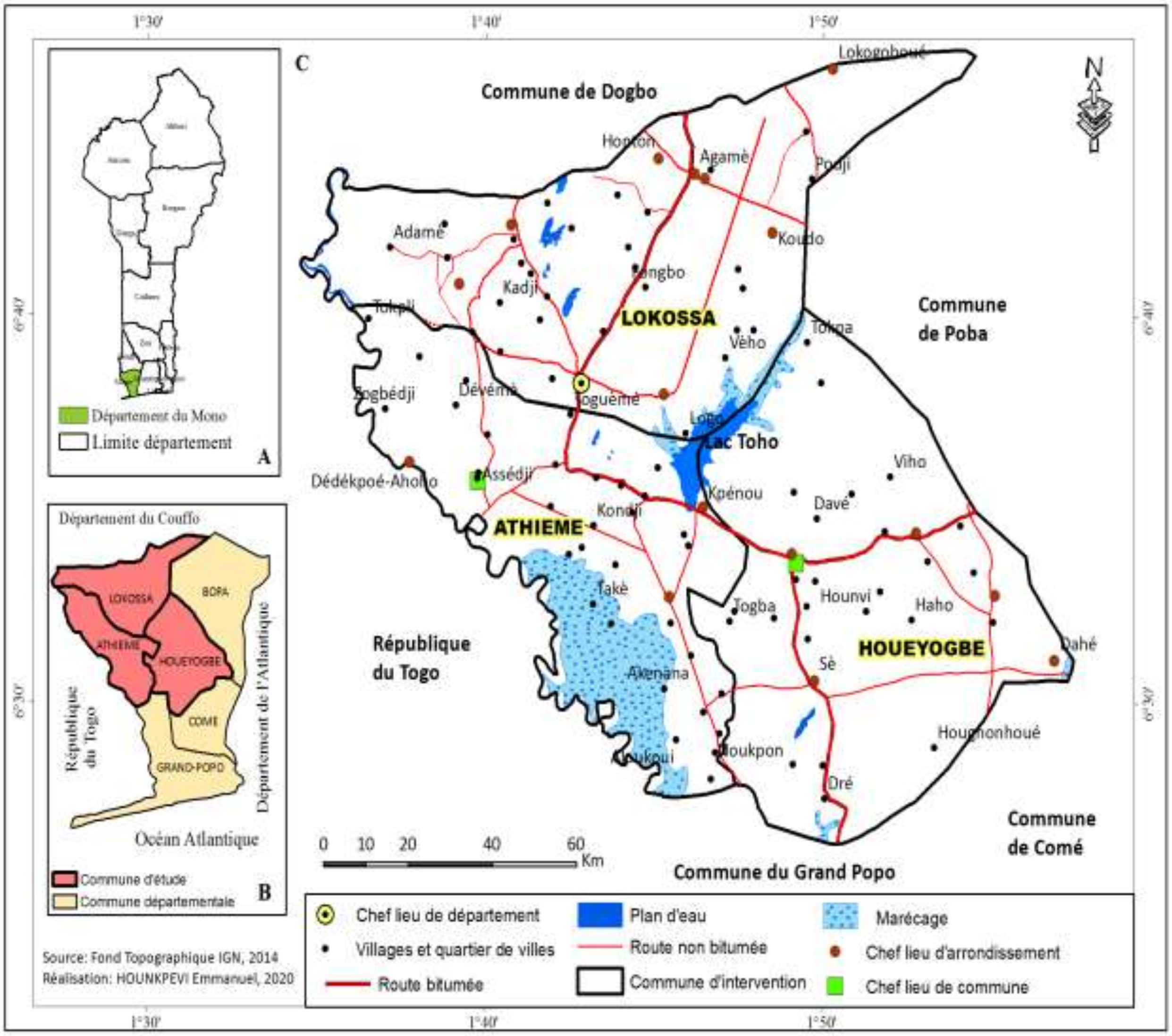


Figure 1:- Map of the study area.

Climatic characteristics

Lake Toho is located in the Mono department which benefits from a subequatorial climate characterized by two rainy seasons and two dry seasons alternating as follows (Kple, 2008): a major rainy season from mid-March to mid-July, a short dry season from mid-July to mid-August, a short rainy season from mid-August to mid-November and a long dry season from mid-November to mid-March.

Sample collection

The choice of sampling points was made in order to haveprecise information on the global factors of lake pollution,and depending on the areas of domestic spills, runoff and other inputs. Thus nine sampling points were defined.The sampling campaigns took place following the four seasons of the year.

Plastic bottles of 1.5 L were used for water samples; they were washed beforehand, then rinsed three times with simple water and distilled water. At the time of sampling, the bottle is carefully rinsed with the water to be sampled at each site. Water sampling is carried out at each site approximately 5 cm from the surface of the lake and the water samples were transported to the laboratory at 4°C in a cooler and stored in the refrigerator at 4°C. These samples were then mineralized in order to be analyzed with a spectrophotometer.

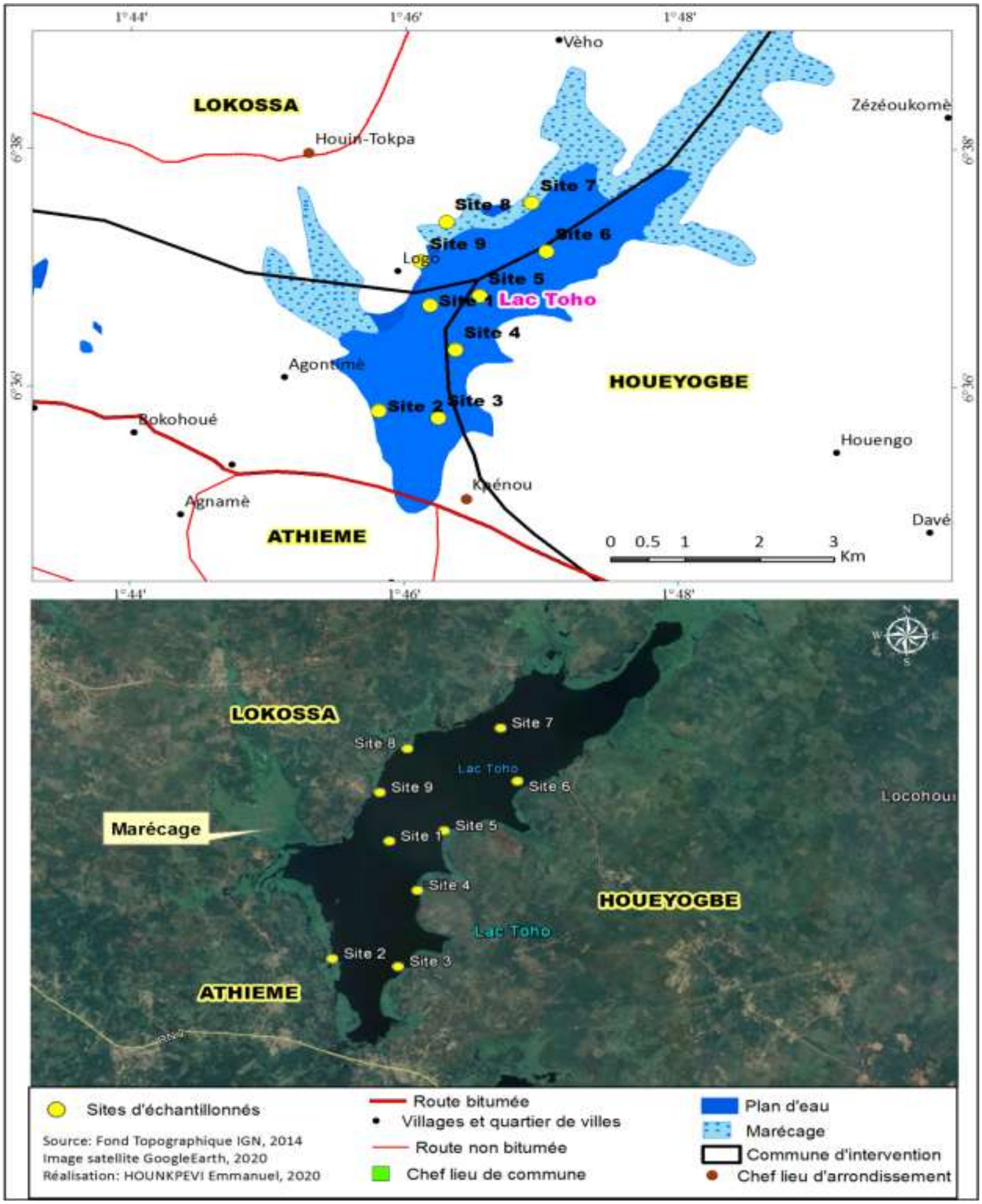


Figure 2:- Spatial distribution of the different sampling sites.

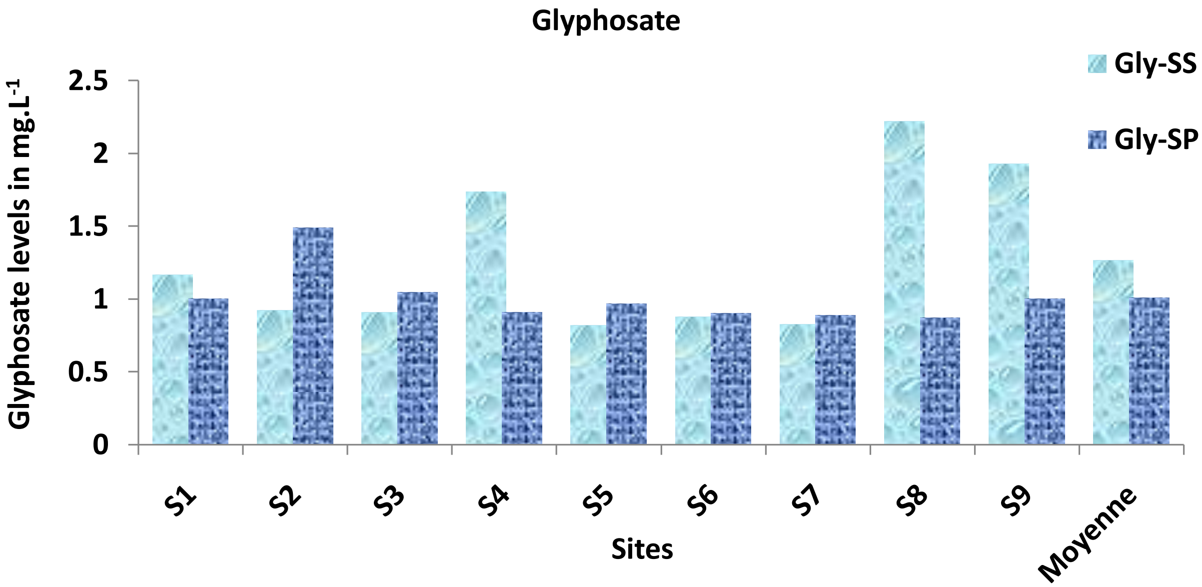
Physico-chemical analyzes

Analysis of metallic trace elements was carried out by directly sucking the acidified liquid samples into the Micro Plasma Atomic Emission Spectrophotometer (MP-AES 4200), coupled to a computer and operated using the MP-AES software interface. Glyphosate was determined in the water samples by determination with a UV 1600 spectrophotometer. The method is based on the reaction of glyphosate with ninhydrin in the presence of sodium molybdate in a neutral aqueous medium at 100°C to give a purple product at measure at 570 nm.

Results:-

Herbicides

❖ **Glyphosate**



SS = dry season ;**SP** = rainy season

Figure 3:- Spatio-temporal variation of glyphosate levels in the waters of Lake Toho.

The study in Figure 3 presents the different levels of glyphosate found in the water samples from Lake Toho. The analysis shows that glyphosate is more concentrated in waters in the dry season than in the rainy season. The highest content is observed at site 8 (2.8 $mg.L^{-1}$) while the lowest (0.83 $mg.L^{-1}$), at site 7 during the same dry season. The dilution effect would be at the origin of the levels observed during the rainy period. Among these sites are the locality of Kpinnou (site 3) where fish farming is carried out. More than ten (10) tonnes of fish died in May 2018 following a fishing carnage which began in this locality.

Metal Trace Elements

❖ **Copper (Cu)**

The analysis of Figure 4 shows that copper is permanently present in the waters of the lake during all seasons of the year. It is more concentrated in waters in the rainy season (end of the long rainy season) with the highest concentration of 0.88 $mg.L^{-1}$ at sites 4 and 7. The lowest concentration is observed during the short dry season at site 5 which is 0.063 $mg.L^{-1}$. The averages obtained during the long and short rainy seasons respectively exceed those recorded for this metal during the long and short dry seasons. It appears that the rainy period which corresponds to that of the crops and the various discharges in the form of runoff influence the water quality of Lake Toho through copper inputs.

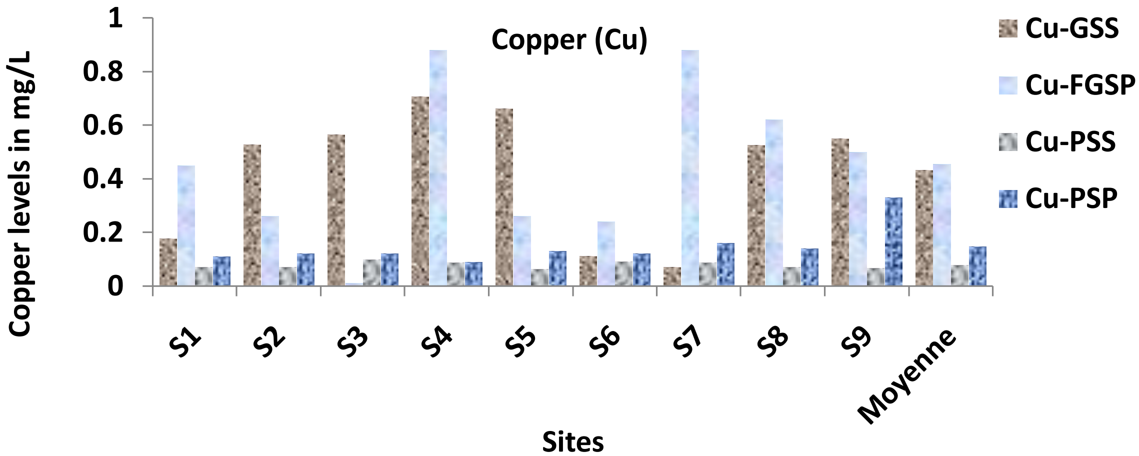


Figure 4:- Spatio-temporal variation of copper contents in the waters of Lake Toho.
PSP = short rainy season;**PSS** = short dry season; **GSS** = long dry season ;**FGSP** = the end of the long rainy season

- **Zinc (Zn)**

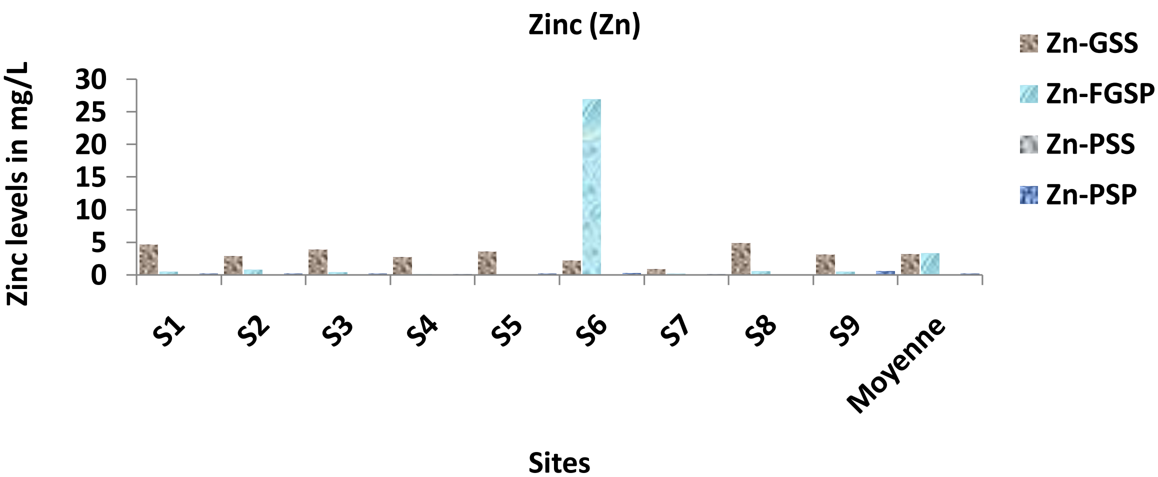


Figure 5:- Spatio-temporal variation of Zn contents in the waters of Lake Toho.

The analysis of Figure 5 shows that zinc is permanently present in the lake waters during all seasons of the year. It is more concentrated in waters in the rainy season (end of the main rainy season) with the highest concentration of 27 mg.L^{-1} at site 6. The lowest concentration is observed during the short dry season at site 3 which is 0.005 mg.L^{-1}. The averages obtained during the long and short rainy seasons respectively exceed those recorded for this metal during the long and short dry seasons. It also appears that the rainy period which corresponds to that of the crops and the different discharges in the form of runoff influence the quality of thewaters of Lake Toho by zinc contributions.

- **Lead**

The study of Figure 6 reveals the permanent presence of lead in the waters of the lake during all seasons of the year with the highest value of 0.31 mg.L^{-1} at site 3 during the long dry season. The lowest concentration is observed during the short rainy season at site 7 which is 0.03 mg.L^{-1}. The average lead levels obtained during the long and short rainy seasons exceed those recorded during the short dry season. It also appears that rainwater and various discharges in the form of runoff constitute sources of lead input to Lake Toho.

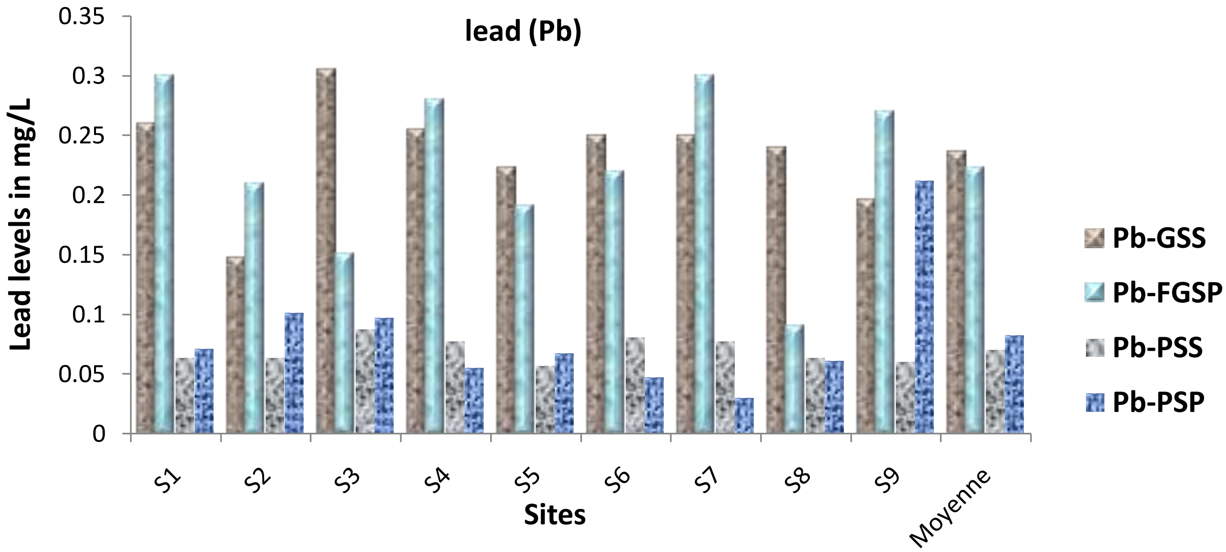


Figure 6 : Spatio-temporal variation of lead levels in the waters of Lake Toho.

❖ **Cadmium (Cd)**

Figure 7 of the spatio-temporal variation of cadmium contents reveals that this metal is more concentrated in the waters of Lake Toho in the dry season than in the rainy season. The highest content is observed at site 3 with a value of 0.34 $mg.L^{-1}$ during the short dry season while the weakest, at site 7 (0.002 $mg.L^{-1}$) during the short rainy season.

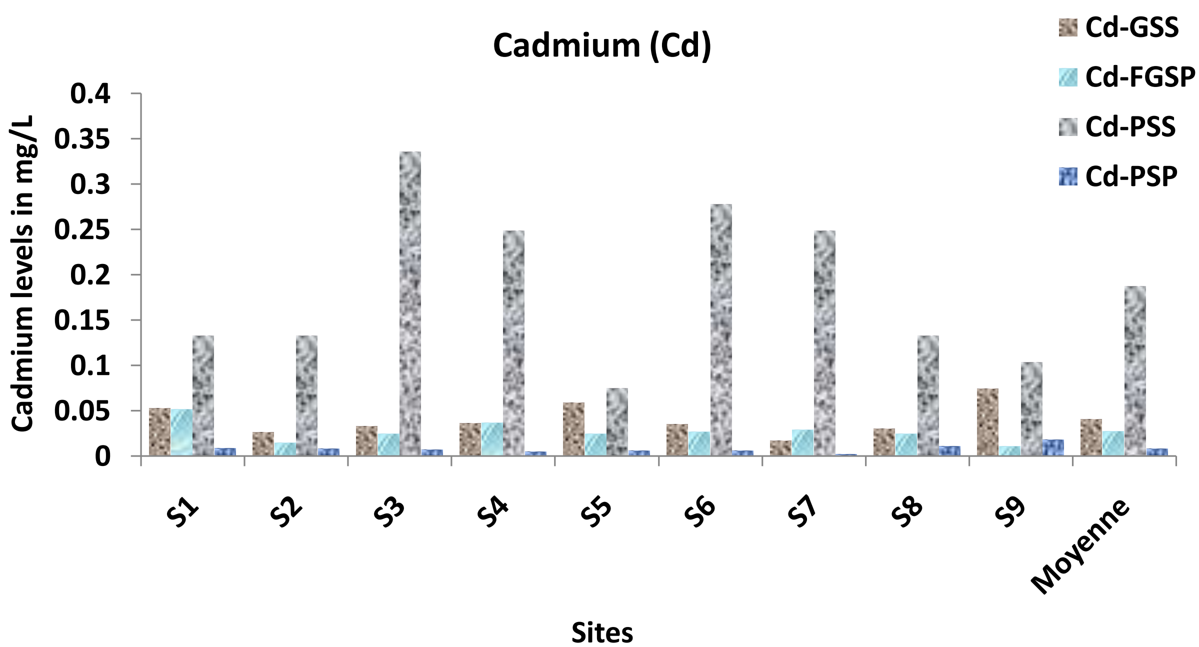


Figure 7:- Spatio-temporal variation of cadmium levels in the waters of Lake Toho.

Discussions:-

The results of the physicochemical analyzes of water samples taken at the various stations selected from Lake Toho reveal that the parameters studied to evaluate water quality follow a marked evolution. This evolution is explained by the concentration effect linked to evapotranspiration (high concentration in the dry season) and the dilution effect (low concentration) during high waters. These results also allowed us to deduce that the average values obtained for glyphosate during the dry seasons (1.27 $mg.L^{-1}$) and rainy (1.01 $mg.L^{-1}$) are very high. The values obtained vary from one site to another and are between 0.83 $mg.L^{-1}$ to 2.22 $mg.L^{-1}$ during the dry season and between 0.87 $mg.L^{-1}$ to 1.05 $mg.L^{-1}$ in rainy season. During the rainy season, sites 1, 2 and 3 become rich in glyphosate. All glyphosate levels recorded during the two seasons across the various targeted sites largely exceed the directive standard for the protection of aquatic life (65 $\mu g.L^{-1}$) set by the Ministry of Sustainable Development, Environment, Wildlife and Parks (MDDEFP, 2013; BYER andal., 2008). According to the Canadian Environmental Quality Guidelines through the Canadian Council of Ministers of the Environment (2012), long-term exposure of fish to glyphosate in fresh waters should not exceed a level of 0. 8 $\mu g.L^{-1}$.Glyphosate is a herbicide which enters aquatic environments through leaching and acts very negatively on ecosystems because of its toxicity. Fugère V. andal. (2020) noted a considerable decline in biodiversity in freshwater phytoplankton (algae) populations exposed to glyphosate. This loss could have enormous repercussions on the functioning of ecosystems and reduce their ability to adapt to new pollutants or stressors. On fish, its influence varies from one species to another. A study of 28 days of exposure to a dose of 0.5 $mg.L^{-1}$ to glyphosate revealed alteration of the gills, liver and sexual activity inJenynsiamultidentata (Huet and al., 2012) relayed by P. Agbohessi (2021).

The waters of Lake Toho are polluted by glyphosate. All levels of this herbicide noted exceed those found in the waters of Ontario (Canada) going to 41 $\mu g.L^{-1}$ in 2004and 30.5 $\mu g.L^{-1}$en 2005 (Struger and al., 2008), inBelgium, Ireland and Sweden inwatersuperficial going respectively to 139, 186and 370 $\mu g.L^{-1}$; in Africa precisely in Benin, in the waters of the Agbado river in Savalougoingfrom 0.10 to 1.316 ppb (Gbaguidi and al., 2011). The glyphosate concentrations measured at the lake exceed all the chronic toxicity values indicated in the dry season and in the rainy season. Glyphosate is therefore one of the causes of the poor water quality of the lake and therefore partly explains the death of fish often observed by fishermen.

The results of the analyzes also allowed us to note that the waters of Lake Toho are influenced by high levels of metals such as copper, zinc, lead and cadmium. The low values of metals obtained during rainy seasons may be due to the dilution effect resulting from the massive contribution of fresh water (rainwater in direct form and runoff). According to Chouti (2010) and Mama (2011) the evolution of the measurement parameters used can very markedly follow the concentration effect linked to evapotranspiration (high concentrations in the dry season) and the dilution effect (concentrations low during high water. In addition to the effects of dilution and concentration, the concentrations of metals obtained can also be influenced by the phenomenon of precipitation of the latter in the sediments of the lake. According to Gbaguidi (2018), in neutral or basic waters, the metals previously dissolved at an acidic pH precipitate and accumulate mainly in the solid phase (sediments). They will be deposited on the bottom substrates and over time become incorporated into the sediments. Copper and zinc are very essential elements for living beings. But their excess can cause respiratory pathologies and disorders linked to the well-being of aquatic species. As for the metals lead and cadmium, they are among the most toxic and dangerous metals for living beings especially aquatic species even at low doses. The average lead levels obtained during the long and short rainy seasons exceed those recorded during the short dry season. It also appears that rainwater and various discharges in the form of runoff constitute sources of lead input to Lake Toho. On the one hand, the levels of copper, zinc, lead and cadmium are beyond the tolerable limit by the Canadian standard following the Criteria for the protection of Aquatic Life according to Chronic effects (CVAC: 0.0085 $mg.L^{-1}$ for copper and lead, 0.11 $mg.L^{-1}$ for zinc, 0.0093 $mg.L^{-1}$ for cadmium) (MDDEP, 2007). Likewise, the levels of copper, zinc, lead (during the long dry season and end of the long rainy season) and cadmium (during the short dry season) recorded exceed the same standard according to the Criteria for the Protection of Aquatic Life according to the Acute effects (CVAA: 0.012 $mg.L^{-1}$ for copper; 0.11 $mg.L^{-1}$ for zinc; 0.22 $mg.L^{-1}$ for lead and 0.043 $mg.L^{-1}$) (MDDEP, 2007). On the other hand, the levels recorded during all seasons, particularly lead and cadmium, do not comply with any surface water quality standards. These contents are well above the set value (0.1 $mg.L^{-1}$ for lead and 0.005 $mg.L^{-1}$ for cadmium) by the guide relating to the assessment of surface water quality continental (rivers, canals, bodies of water),March 2016 of Directive 2000/60/EC of 23 October 2000 of the European Parliament and of the Council Establishing a framework for community policy in the field of water (RESE-ESC Guide, 2016). It appears that the waters of Lake Toho are therefore of poor quality and have the following consequences: reduced fish production, stunted growth, disappearance of sensitive species, high fish mortality. It is this last consequence, fish mortality, which is increasingly noticed at lake level.

Conclusion:-

The physicochemical diagnosis of Lake Toho shows that its waters are not of the quality to protect aquatic life. This stretch of water is subject to a dynamic of massive freshwater input which constitutes its source of pollution. The death of fish often observed in the lake can be justified by the high levels of herbicides and trace metal elements which have made the aquatic environment toxic. The results obtained on the one hand for glyphosate, and on the other hand for copper, zinc, lead and cadmium show that runoff constitutes a potential source of transmission of herbicides and metallic pollutants towards the lake.

The level of pollution of the lake requires an urgent reaction of the urgency of the structures in charge of water management and development partners to find adequate strategies to stop it, which are to raise awareness among farmers about the eradication of glyphosate; reduce the use of chemical fertilizers which are sources of copper, zinc, lead and cadmium through leaching; build a wastewater treatment plant, better manage waste, raise public awareness and put the polluter pays principle into practice. This practice would avoid high mortality of fishery resources and would lead to the preservation of public health.

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