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Environmental and human health impacts of agricultural activities around Lake Toho in Southern Benin

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Abstract

As civilization has evolved, agriculture has contributed to a clear deterioration in the quality of the environment. The aim of this study is to assess the impact of agricultural practices around Lake Toho on the environment and human health. To do so, a survey was carried out among 112 people chosen according to their experience and their farms size. In addition, lake water samples were collected at 10 stations to measure chlorophyll *a* content. The results showed that cropping association (42%) and crop rotation (34%) are the most widely practiced cropping systems around Lake Toho. The majority of growers surveyed use synthetic products such as fertilizers (71.43%) and pesticides (67.86%), with no respect for standards and conditions of use. Poor management of pesticide waste, such as the sale and reuse of packaging (67% of respondents), exposes people to several risks, with a potential direct impact on health and environmental components (soil, water, etc.). Laboratory analyses showed a high level of chlorophyll *a*(211 µg/L on average) in the water, indicating a significant and excessive production of algal biomass.

Recommendations have been made to promote rational pesticide management and improved farming practices in order to safeguard the environment and human health

Keywords: Cropping systems, pesticides, risks, chlorophyll *a*, mismanagement, Lake Toho.

Introduction

Water is essential to all forms of life: for health, agriculture, industry, tourism, leisure and navigation (Azonnakpo et al., 2020). In agriculture, water is a vital resource, essential for crop growth. Thus, the link between agriculture and water is intrinsic and complex, since water is essential for agricultural production, while agricultural practices influence water quality. Unfortunately, ever-increasing demographic growth is accompanied by a revolution in agriculture, with ever-increasing intensity of production, where producers are always seeking to maximize output (Goura et al., 2023). The challenge of feeding an ever-growing population is leading to the extension of agricultural production areas, resulting in deforestation and the use of chemicals to improve crop yields (Adjovi et al., 2020). Phytosanitary products are substances used to prevent and treat disease, and to control crop pests and parasites (Blanchon, 2021). Herbicides restrict the growth of other plants to facilitate access to water, mineral salts and light for the grain produced (Blanchon, 2021). However, notwithstanding the effectiveness of pesticides on pests and their positive effect on increasing yields, several studies in Benin (Ahouangninou and Fayomi, 2011); (Agbohessi et al., 2011), in Togo (Kanda et al., 2013) and Burkina Faso (Lehmann et al., 2016) have shown that the repeated and poorly controlled use of chemicals for pest control is not without consequences for the health of farmers and consumers, and for the environment. What's more, excessive use of these products destabilizes soil life, in particular by stripping it of its organic matter. These substances are not purified, and leave the soil with residues of numerous toxic and poorly mobile metalloids and metals (Lansari, 2024).

When crops are treated, most of the pesticides applied reach the soil, either because they are applied directly to it, or because rain has washed off the foliage of treated plants (Mamy et al., 2011). Generally speaking, water laden with soluble contaminants runs off the surface of the soil downstream of the watershed, or infiltrates the subsoil and leaches into the water table (Macary, 2013). These contaminants can eutrophy lakes and rivers, posing risks to human health. Groundwater pollution is therefore the result of infiltration and diffusion of leachates in permeable or fissured subsoil (Soncy et al., 2015). Indeed, chronic non-communicable diseases are also due to the exposure of foodstuffs to pollutants, some of which are of agricultural origin, such as pesticides (Duru and Therond, 2024; Wolf et al., 2023). Understanding the mechanisms of this pollution and potential solutions is essential to guarantee the sustainability of water resources, protect the health of ecosystems and, by extension, that of human populations. The aim of the present study is to assess the impact of agricultural practices around Lake Toho in the Republic of Benin on the environment and human health, in order to advocate sustainable agricultural production.

Materials and Methods

Study environment

Lake Toho lies between latitudes 6°35' and 6°40' north and 1°45' and 1°50' east. It has the shape of a crescent, oriented south-north, and crosses three communes in the Mono department of southern Benin: Lokossa, Houéyogbé and Athiémé. It forms part of the alluvial valley hydrographic complex of the Mono basin and covers an area of 9.6 km² at low water and 15 km² at high water; its volume is also influenced by that of the Mono River during flooding. On average, it is 7 km long, 2.5 km wide to the south and 500 m wide to the north (Codjo et al., 2018).

With a succession of four seasons (02 rainy and 02 dry) and average rainfall varying between 800 mm and 1200 mm, the average temperature around Lake Toho is 27.9°C, with relative humidity varying between 55% and 95% and average annual insolation of 2,024 h/year. (Amoussou et al., 2014; Méteo, 2017). This climate is conducive to mixed farming and exuberant vegetation, which attracts animals. The relief around Lake Toho is very flat, offering a diversity of soils for various uses. The dominant soils around the lake are ferralitic and hydromorphic (Igué et al., 2019; Kplé, 2008). Agriculture plays a key role (82.4% of farming households) in this area, offering significant opportunities for production, processing and export. Fishery products (tilapia, black catfish, heterostars, gymnarchus, etc.) are sold fresh or processed for local consumption (RGPH4, 2013). Demographically, the commune of Houéyogbé has a population of 1,018,893, that of Lokossa is 104,961 and that of Athiémé is estimated at 56,483 (RGPH4, 2013).

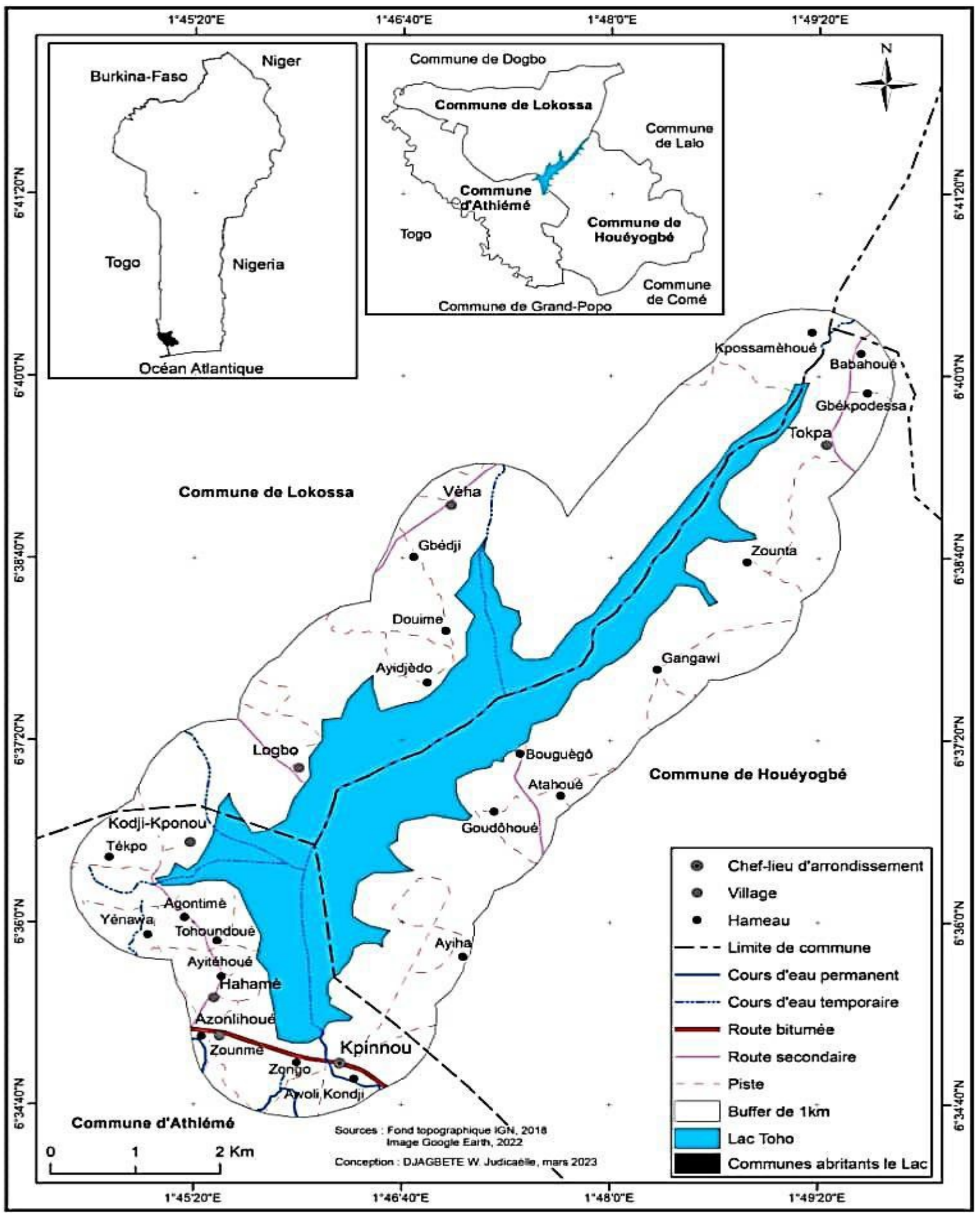

Figure 1: Map of study area

Data collection and techniques

Three (03) techniques were used to collect data: field survey, direct observation and chlorophyll *a* measurement. These techniques enabled us to gather information relevant to the problem. A database was then compiled to analyse the data, identify major trends and compare the results with each other.

Sampling

Field survey

Three (03) districts were identified for the field surveys. These were the arrondissements of Houin (commune of Lokossa), Zoungbonou (commune of Houéyogbé) and Kpinnou (commune of Athiémé), according to the importance of agricultural production and the use of chemical agricultural inputs (chemical fertilizers and pesticides) around Lake Toho.

The sample was made up of local residents, farmers and resource persons. Sample size was determined using the Dagnelie method (Dagnelie, 1998). A total of 112 people were surveyed in the study area.

Impact analysis

To carry out a systemic analysis of the impacts of agricultural practices around Lake Toho on the environment and human health, the Léopold Matrix (Leopold, 1971), the checklist of (Bisset, 1983) and an approach based on environmental impact studies (A.B.E, 2002), the matrix for identifying impact components and sources (André et al., 1999) and the reference framework for assessing impact significance (A.B.E, 2002) were used.

Water sampling and chlorophyllaa measurement

Ten (10) water sampling stations were selected (S_1: Gontinmin, S_2: Tohonou, S_3: Douimè, S_4: Goudohoué, S_5: Ayidjedo, S_6: Logbo, S_7: Saganou, S_8: Kpinnou, S_9: Ganganhoui, S_{10}: Ganhonou) on Lake Toho according to their accessibility, and also according to the intensity of activities taking place there. All water samples were collected in 1.5 L plastic mineral water bottles that had been emptied, washed without detergent and rinsed three times with distilled water. Before sampling, the bottles were again rinsed three times with the water to be sampled. After sampling, the vials were labelled, wrapped in aluminium foil to prevent photosensitivity of the sample, stored in a cooler and sent to the laboratory (Applied Hydrology Laboratory of the Faculty of Science and Technology, University of Abomey-Calavi) for chlorophyll *a* measurement. Once in the laboratory, these water samples were kept cool at 4°C until analysis.

The chlorophyll *a* content of the water was measured spectrophotometrically, using the method described in (Pechar, 1987).

Data processing

Data collected in the field and from laboratory analysis were processed using Epi Data and SPSS software. These programs were used to calculate statistical data for parameters such as means, frequencies and standard deviations, and to produce graphs and tables. Excel and Word were also used.

Results and Discussion

Typology of cropping systems

Cropping systems in the study area vary from one farmer to another, and are applied according to means, soil types and the availability of labor and land. According to figure 2, cropping association (42%) and crop rotation (34%) are the most common cropping systems around Lake Toho, while fallow (13%) and monoculture (11%) are the least common.

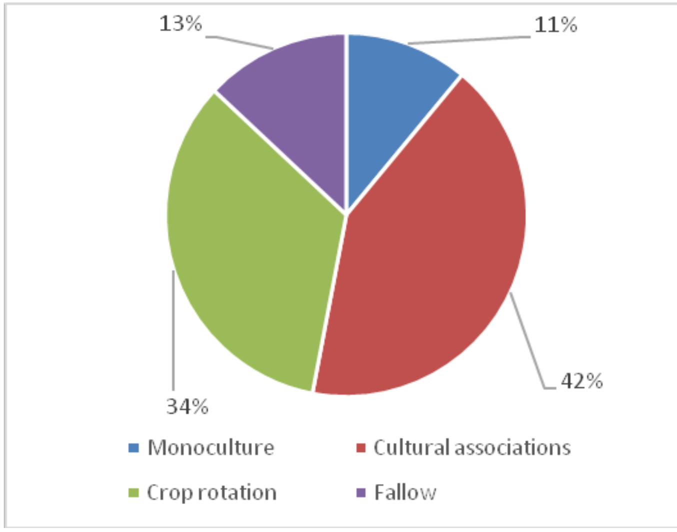

Figure 2: Typology of cropping systems around Lake Toho

Main crops

Analysis of figure 3 shows that 56.25% of the agricultural area at the time of the survey was devoted to cereals, followed by oilseeds (16.07%) and legumes (13.39%). The remaining agricultural area is divided between market garden crops (8.93%) and forage crops (5.36%).

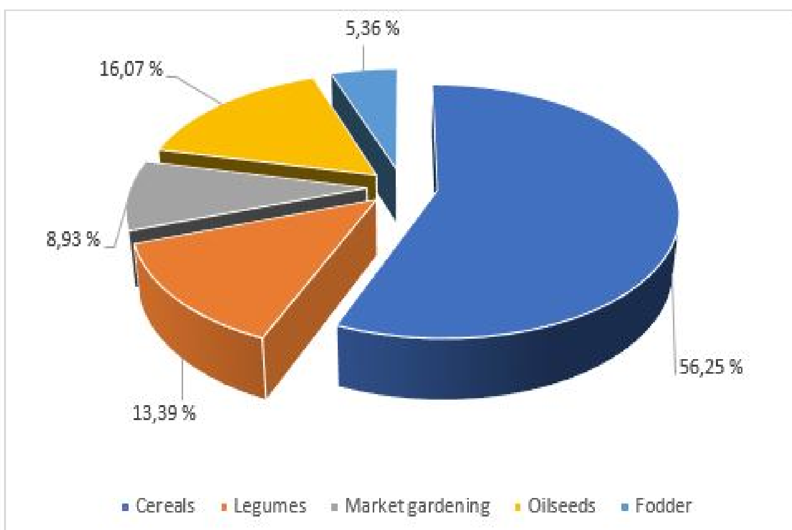

Figure 3: Distribution of surveyed area by crop type
Source: Field survey, September 2022

Fertilizers and pesticides

According to figures 4 and 5, the majority of growers surveyed around Lake Toho do not respect the dosages recommended by the supervisory agents for the use of chemical products, respectively, fertilizers (71.43%) and pesticides (67.86%). They use them as they see fit; some reduce the doses to save money, while others increase them thinking they'll get a good yield.

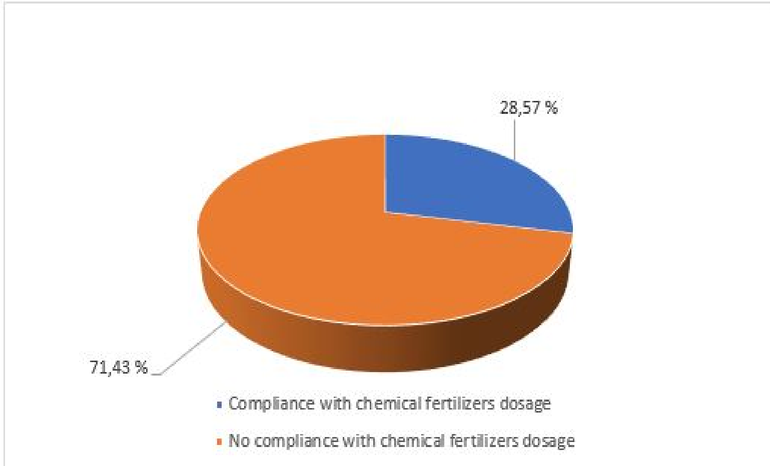

Figure 4: Distribution of growers according to whether or not they respect the recommended doses of chemical fertilizers
Source: Field survey, September 2022

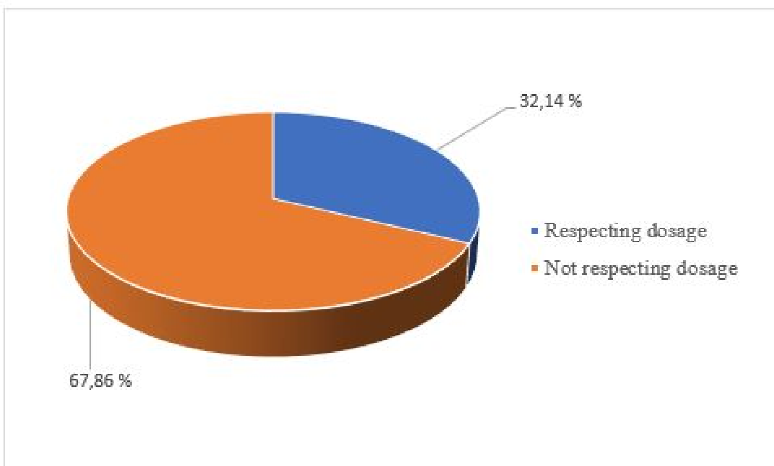

Figure 1: Distribution of producers respecting the dosage of pesticides and those not respecting it
Source: Field survey, September 2022

In this study area, growers use plant protection products, which they spread with the aid of spraying equipment and often without any protective measures (figure 6). Non-compliance with fertilizer and plant protection product spreading conditions is one of the factors that increase ecological and health risks.

Figure 6: Phytosanitary treatment

Management of pesticide packaging

Analysis of figure 7 shows that 42% of growers surveyed resell pesticide packaging, highlighting the exposure of packaging in local markets. 25% of those surveyed reuse the packaging, which increases the risk of poisoning. 23% of producers destroy this packaging, while 10% abandon it in nature. All these practices also increase the environmental and health risks around Lake Toho.

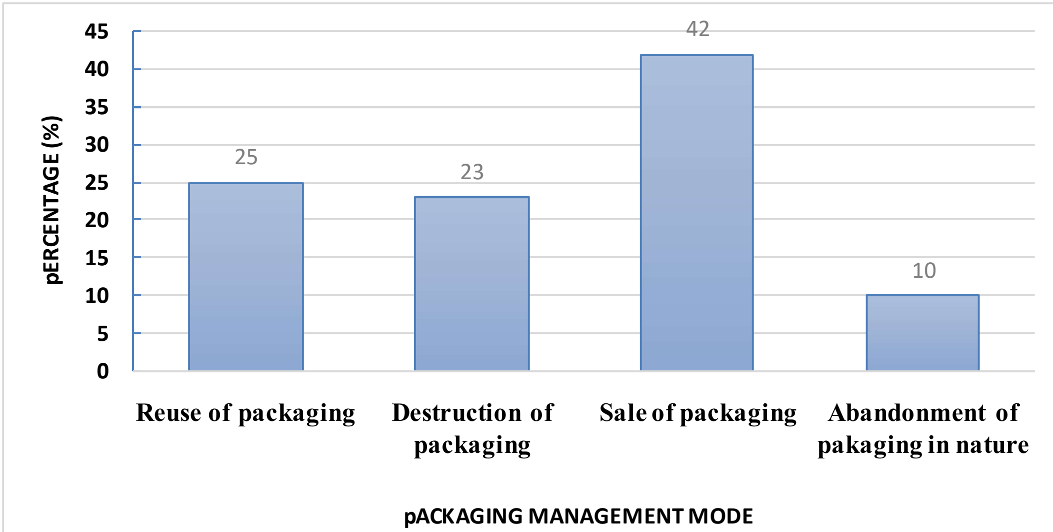

Figure 7: Management of pesticide packaging after use

Impact of agricultural inputs on people's health

The impacts of agricultural inputs on the health of people living near Lake Toho are well perceived. The symptoms observed by respondents are mainly: breathing difficulties (15.18%), vision problems (12.5%), dizziness (10.71%), fatigue (8.04%), headaches (7.14%), colds (7.14%), abdominal pain (6.25%), and skin disorders (3.57%). There was also nausea or vomiting (2.68%) (figure 8).

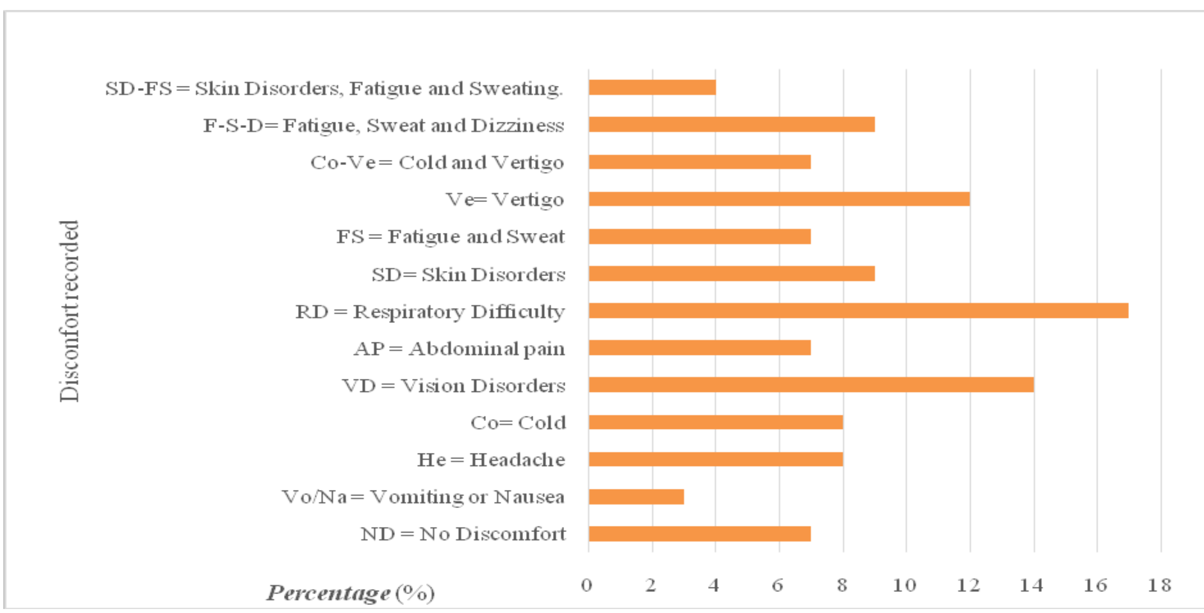

Figure 8: Discomfort felt by growers after application of chemical inputs.

Analysis of farming practices on the environment

Analysis of Table 1, showing the matrix of impact sources and environmental compositions affected (positively or negatively) by farming practices, reveals that the components of the human environment, apart from health, are the least affected; on the other hand, the physical (air, water, soil and vegetation) and biological (fauna and flora) environments as a whole are threatened. It is therefore important to characterize these different impacts.

Table 1: Matrix of impact sources and environmental components affected by farming practices

	Physical components				Biological components		Human components			
Activities/sources of impact	**Sol**	**Air**	**Water**	**Vegetation**	**Fauna**	**Flora**	**Health**	**Quality of life**	**Income**	**Jobs**
Land clearing	-	-		-	-	-		+	+	+
Plowing	-	-		-	-	-		+	+	+
Use of chemical fertilizers	-	-	-	-	-	-	-	+	+	+
Herbicide use	-	-	-	-	-	-	-	-	+	+
Use of pesticides	-	-	-	-	-	-	-	-	+	+

Legend: plus (+) = positive impacts; minus (-) = negative impacts

An analysis of Table 2, which presents the matrix for characterizing and assessing the impacts generated by agricultural practices, reveals that physical and biological components such as water, soil, vegetation, fauna and flora are subject to major negative impacts, while among human components, only health is affected.

Table 2: Matrix for characterizing and assessing impacts generated by farming practices

Aspect	Source of impact	Title of impact	Nature	Duration	Extent	Degree of disturbance	Importance
Quality of air	Use of chemical fertilizers Use of pesticides	Alteration of air quality	Negative	Long	Local	Low	Medium
Water	Ploughing Use of chemical fertilizers Use of pesticides	Pollution of surface and groundwater quality	Negative	Long	Local	Strong	Major
Sol	Clearing and exposing the soil And leaching of bare soil, Ploughing	Soil drying Nutrient depletion of the soil's surface layer	Negative	Long	Punctual	Strong	Major
Vegetation	Clearing and burning	Destruction of plant cover Disappearance of gallery forest	Negative	Long	Local	Medium	Major

Fauna	Land clearing Use of pesticides	Disappearance of aquatic fauna; Loss of wildlife biodiversity	Negative	Long	Local	Strong	Medium
Flora	Land clearing Use of pesticides Herbicide use	Disappearance of aquatic plant species Disappearance of spawning grounds	Negative	Long	Local	Strong	Medium
Jobs	Land clearing, ploughing, use of chemical fertilizers, use of pesticides	Job creation	Positive	Long	Local	Strong	Major
Income	Land clearing, ploughing, use of chemical fertilizers, use of pesticides	Increased income	Positive	Average	Local	Strong	Major
Quality of life	Clearing land, ploughing, use of chemical fertilizers and pesticides	Improved quality of life through access to basic necessities, healthcare and education	Positive	Average	Local	Strong	Major
Health	Use of chemical fertilisers and pesticides	Impacts on the health of populations exposed to chemicals.	Negative	Long	Regional	Low	Major

Chlorophyll a content in lake water

Figure 9 shows the variations in chlorophyll *a* content at the various sampling stations on Lake Toho. Chlorophyll *a* level in the lake water follows a sawtooth pattern, ranging from 57.6 µg/L (S5) to 489.6 µg/L (S9), with an average value of 211 µg/L. The presence of Chlorophyll *a* in the lake water indicates significant algal biomass production at the various sites sampled, especially those above average (S2 and S9).

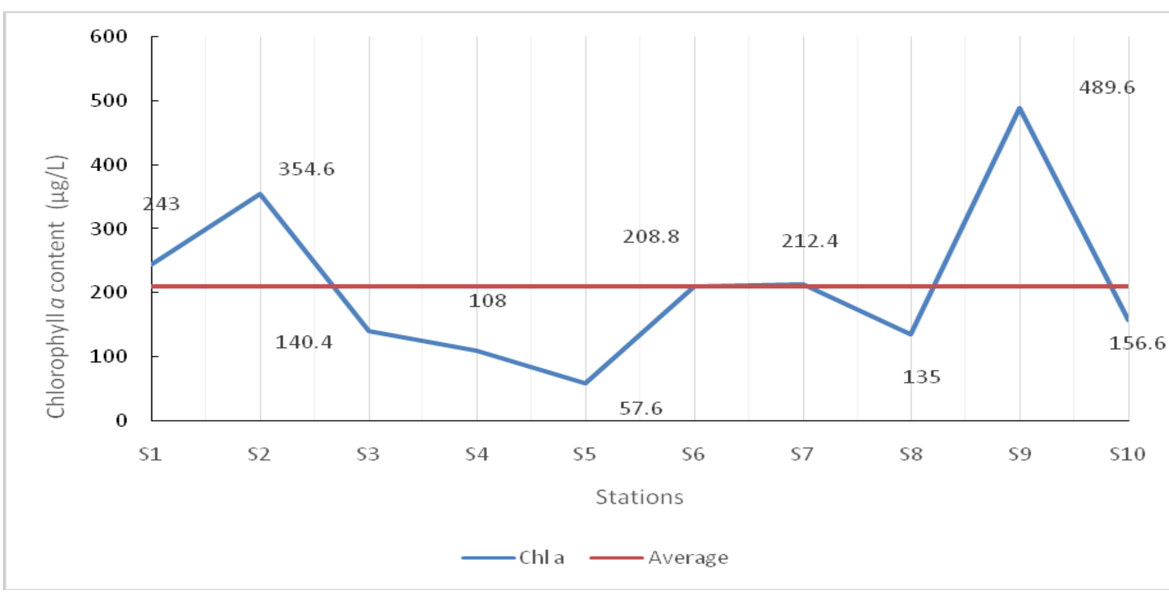

Figure 9: Chlorophyll *a* content of Lake Toho water.

Discussion

Agricultural activity significantly alters the quality and dynamics of water in the environment. By transforming plant cover, tilling the soil and applying fertilizers and pesticides, agriculture alters water quality and its cycle. Of the cropping systems listed, only crop rotation has beneficial consequences for the environment, both in terms of fertility and soil vulnerability to erosion. They help preserve the soil's natural resources. On the other hand, crop associations have the disadvantage of giving rise to interspecific competition for light, water and nutrients, and contribute significantly to the rapid depletion of soil nutrients (Wokou, 2009). Furthermore, the overuse of chemical fertilizers by growers to stimulate plant growth exposes the soil to high levels of acid, which can destroy microflora such as nitrogen-fixing bacteria that help improve soil fertility, restoration and protection (Idrissa et al., 2024).

Pesticides used to control pests or weeds can persist in the environment, ending up in surface and groundwater. They can affect aquatic organisms and pose risks to human health when they contaminate drinking water sources (Dabré et al., 2016). However, our study reveals a high level of pesticide and chemical fertilizer use by the majority of growers, who work without any means of protection because they are unaware of the risks associated with the use of chemical inputs. This result is in line with that of (Bühler and Waeber, 2024), which refers to a total ignorance on the part of farmers concerning the negative effects of phytosanitary products on human health during spraying. Yet during spraying, the air is polluted and laden with aerosol particles that are inhaled by people living near the fields. The European Commission, in its report (Efsa, 2022), considered that the exposure of growers to spraying over a long period of time and without adequate protective equipment constitutes the major source of risk of pesticide poisoning.

Similarly, according to (Kanda et al., 2013), the lack of personal protective equipment increases the risk of skin and respiratory tract irritation. This increases the vulnerability of populations, as children, pregnant women and the elderly are more sensitive to the effects of pesticides due to their less developed immune systems or different metabolisms (Blanchon, 2021).

As for empty packaging, some is abandoned in nature after processing; others are recovered and reused. This information was confirmed by the findings of Doumbia and Kwadjo (2009) in Côte d'Ivoire; Kanda et al. (2013) in Togo and Son et al. (2011) in Burkina Faso, who worked on the mismanagement of empty pesticide packaging. The reuse of drums containing pesticides is a practice that can lead to poisoning (Akodogbo et al., 2024). This is because, despite the clean appearance of the packaging, there are still product residues inside, absorbed into the walls of the packaging, making them special waste (Nabie, 2018).

Pesticides are one of the main causes of water contamination (Sdea, 2019), which has repercussions on water quality through ecological imbalance due to plant colonization. Indeed, chlorophyll *a* is a specific type of chlorophyll *a* that should be routinely measured. Its high concentration indicates an ecosystem in poor health or imbalance due to an overabundance and excessive growth of plants and algae, leading to eutrophication or hyper-eutrophication of a watercourse (Paerl and Otten, 2013). This reduces ecosystem productivity and disrupts the metabolism of many aquatic species (Carmichael, 2001).

Agriculture is essential for food security; but it also has a considerable influence on the environment and human health. From the different work carried out, it emerged that the populations living along the shores of Lake Toho practice modern agriculture based essentially on the use of chemical fertilizers and pesticides. These chemicals are not without consequences for the environment and the health of the lake's residents. The study also revealed pollution of Lake Toho's aquatic ecosystem. This pollution comes from several sources, but above all from agricultural activity through the various fertilization and crop protection practices used in the study area.

By adopting more sustainable agricultural practices, it is possible to reduce pollution, while maintaining high agricultural yields and preserving human health. Implementing these practices is essential to ensure the sustainability of the environment and water resources for future generations.

Suggestions:

To minimize the impact of agriculture on water resources, sustainable practices can be adopted:

- Limit the use of phytosanitary products and synthetic fertilizers; a return to basic agronomy is essential;

- Use fertilizers and phytosanitary products judiciously, when they must be used, taking into account all relevant data;

- Practice crop rotation;

- Plant strips of vegetation along Lake Toho to filter pollutants before they reach the water.

Conflict of Interest statement: The authors declare no conflicts of interest.

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