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# Monitoring of the Physico-Chemical Parameters of the Waters of Lake Sonfonia, Municipality of Ratoma (Republic of Guinea) 2021

Mohamed Lamine Komara[1], Adama Moussa Sacko[2], Aboubacar Diallo[3], Cheick Ahmed Tawel Camara[4] and Mamadou Kabirou Bah[5]

*1. Teacher-Researcher Department of Biology Gamal Abdel Nasser University of Conakry, Republic of Guinea*

*2. Laboratory technique, Higher Institute of Technology of Mamou, Republic of Guinea*

*3. DGA-Research/ISAU, Conakry 324 Republic of Guinea*

*4. Director of the Biochemistry degree program at Gamal Abdel Nasser University of Conakry, Republic of Guinea*

*5. Center for Environmental Studies and Research (CERE), Conakry 324 Republic of Guinea*

**Abstract:** As part of the determination of the possible impact of human activities on surface waters, case of Lake Sonfonia, six sampling sites were selected according to their solicitation by the population and their exposure to probable sources of pollution. The objective of this work is to monitor the physico-chemical quality of the waters of Lake Sonfonia during the low water level (March) and during the flood period (August) of the year 2021. Two sampling campaigns of water were carried out in dry weather and two others in cold weather. Parameters such as temperature, pH, EC (Electrical Conductivity), dissolved oxygen, TDS (Total Dissolved Solids) were measured *in situ*. Suspended matter, phosphate, nitrate, nitrite, sulphates, total iron, COD (Chemical Oxygen Demand) were measured in the laboratory by the colorimetric method. Stata 15 software was applied for the statistical analysis of the data and the correlation test between the parameters gave highly significant correlations. It has been noted that the situation is not very good and that this pollution comes mainly from human activities.

**Key words:** Surface water, physico-chemical parameters, Lake Sonfonia, anthropogenic, eutrophication.

## 1. Introduction

Surface water pollution is defined by the presence in the water of various pollutants released into the environment by human activities. These discharges are considered contaminants when they have a harmful effect or are the cause of an alteration in the quality of the water. This can result in the presence of dead fish, color changes in water color, etc. [1].

Surface water pollution can have significant environmental impacts in terms of impaired water quality, public health issues related to the use of contaminated water and environmental management needs. water for human and economic activities in the region [2].

The World Water Forum in Dakar 2022: "Water security for peace and sustainable development".

During this forum, there were four priorities, namely the improvement of water quality, waste management and pollution at the origin of most water-related diseases.

Indeed, according to the latest United Nations estimates, 2 billion people still did not have access to drinking water at home in 2020. About 771 million people would have to travel at least 30 min from their home to access to safe water and more than one hundred million worldwide drink untreated water of poor quality [3].

Many studies [4-7] have highlighted the poor chemical and bacteriological quality of these waters in developing countries.

**Corresponding author:** Mohamed Lamine Komara, Master, research field: surface water pollution.

Water pollution is a difficult problem in countries where populations are growing rapidly, where development needs are great and where governments have other investment priorities. In these countries, 90% to 95% of all wastewater and 75% of all industrial waste, on average, are discharged into surface waters without having undergone any treatment [8].

The presence of nitrate ions in large quantities in surface waters contributes to the eutrophication of aquatic environments and to the degradation of water resources [9].

We have just recently published an article on "Evaluation of the bacteriological pollution of the waters of Lake Sonfonia Commune of Ratoma (Republic of Guinea) 2021" in the *Journal of Agricultural Chemistry and Environment* (Vol. 12, No. 2, May 17, 2023).

To carry out this study, we carried out field visits, interviews with resource persons and the taking of photos which enabled us to identify the different points of water sampling for physico-chemical analysis of sources of pollution.

This interview also made it possible to know the various uses made of the waters of the lake by the local population, namely: watering vegetable crops, fishing, washing vehicles, swimming, etc. exposing them to a health risk.

Currently the situation of Lake Sonfonia is alarming, it has become an uncontrolled dump, all liquid waste and household waste water are dumped into the lake. Given its advanced level of pollution, it is no longer used as a source of drinking water by the SEG (Société des Eaux de Guinée). As a contribution to the monitoring and protection efforts against pollution, we have chosen the present study: Monitoring of the physico-chemical parameters of the waters of Lake Sonfonia Municipality of Ratoma (Republic of Guinea) in 2021.

The main objective is to characterize the physical and chemical properties of the water of Lake Sonfonia for sustainable use.

## 2. Materials and Methods

### *2.1 Study Zone*

Sonfonia Lake is located in the Sonfonia district in the municipality of Ratoma, more precisely opposite the General Lansana Conté University. The length is about 2.5 km, the width is 100 to 200 m, the depth varies between 6 and 7 m in the rainy season and between 3 and 4 m in the dry season. The lake is fed by natural sources of underground water and houses the drinking water treatment point of the SEG. See Fig. 1.

### *2.2 Collection and Sampling*

Sampling covered six stations, taking into account the representativeness of pollution sources and operational feasibility. Each station was geolocated as shown in Table 1.

At each station, two sampling campaigns were carried out during the low water period corresponding to the dry season March 2021 and two others during the flood period corresponding to the rainy season August 2021. Sample collection, transport and storage complied with the protocol defined by AFNOR and Rodier 2009 [10].

### *2.3 Determination of Physico-Chemical Parameters*

2.3.1 Methods of Analysis

The analyses were carried out *in situ* and in the laboratory according to the techniques of Rodier 2009 [10]. The values obtained were compared with WHO (World Health Organization) standards.

2.3.2 *In Situ* Measurement

They concern the following parameters: temperature and pH, EC (Electrical Conductivity) and TDS (Total Dissolved Solids), and dissolved oxygen. The measurements were carried out respectively using three (3) devices: a branded pH meter (70+WATERPOOF), a branded Conductimeter (70+WATERPOOF) and a branded Oximeter (70+WATERPOOF).

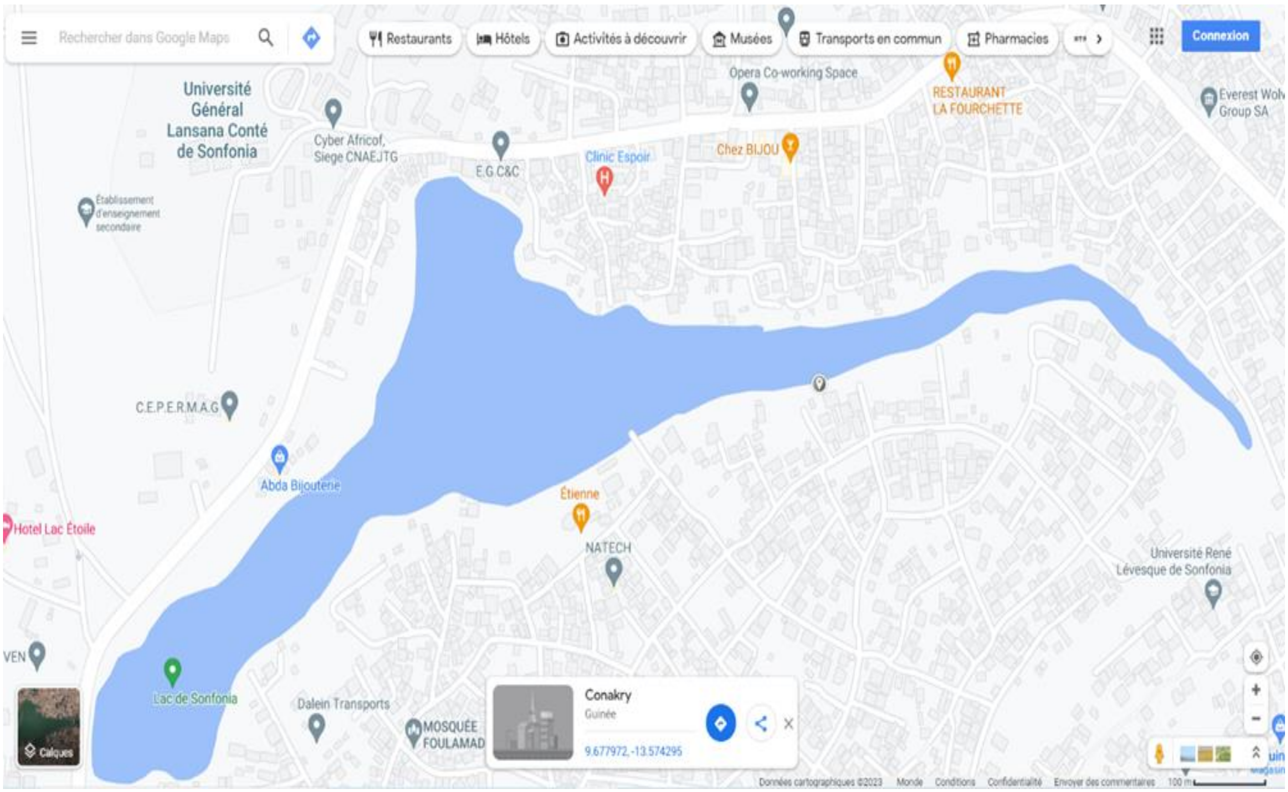



**Fig. 1 Map of Lake Sonfonia on Google maps.**

**Table 1 Stations and geographic coordinates.**

| Stations | North latitude | West longitude |
|---|---|---|
| SEG | NO: 09 °40′28.6″ E | WO: 13 °34′55.5″ N |
| YAT | NO: 09 °40′26.4″ E | WO: 13 °34′58.1″ N |
| FLM | NO: 09 °40′26.5″ E | WO: 13 °34′54.0″ N |
| SOC | NO: 09 °40′43.1″ E | WO: 13 °34′25.6″ N |
| BLZ | NO: 09 °40′40.9″ E | WO: 13 °34′47.9″ N |
| USF | NO: 09 °40′46.1″ E | WO: 13 °34′46.2″ N |

2.3.3 Laboratory Analysis

A brand Turbidimeter (Lovibond Model TB210 IR) was applied to measure turbidity by optical method. This instrument sends a ray of light through a sample of water and measures the amount of light that passes through the water versus the amount of light that is reflected from particles in the water.

The Spectrophotometer (DR/850 HACH) was applied to determine the following parameters: the concentration of SS (Suspended Solids) by measuring the absorbance (Beer-Lambert law).

Colorimetric assay was used to determine COD, nitrates, nitrites, total iron, sulfates and phosphates using the Spectrophotometer (DR/850 HACH).

The principle of colorimetry consists of mineralization in a digester and the measurement of the intensity of the coloration which is proportional to the concentration of the element to be dosed in the colorimeter. Mineralization takes place in an acid medium at a temperature of 150 ℃ for 2 h [11].

The analyses of the water samples were carried out at the laboratory of the CERE (Center for Environmental Studies and Research), Conakry, BP: 3817.

The following devices were applied for the physico-chemical analyses of the waters of Lake Sonfonia 2021 (Fig. 2).

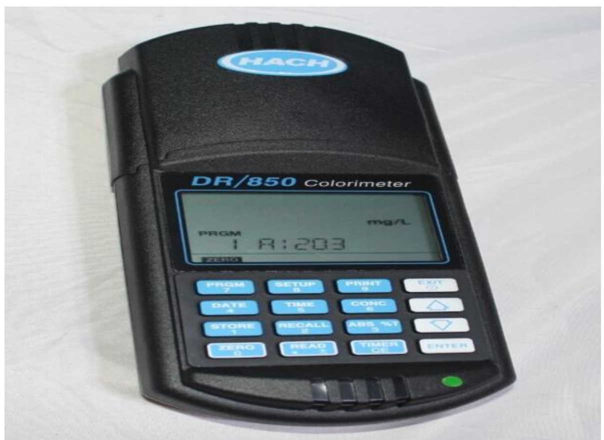
PH 70+DHS

COND 70+

PH 70+DHS

TURB LOVIBOND

THERMOREACTEUR HANNA




DR/850 COLORIMETER HACH

**Fig. 2 Applied apparatus for physico-chemical analyses.**

## 3. Results and Discussion

### *3.1 Temperature*

Table 2 shows that the water temperature varies according to the stations and the sampling period. The temperatures observed are above 25 ℃, the WHO limit value for surface water.

The analysis of water samples also shows during the dry season, temperatures vary between 33.80 ℃ (FLM) and 33.90 ℃ (USF) with a temperature difference of

2.1 ℃ while during the rainy season temperatures vary between 27 ℃ (SEG and BLZ) and 28.50 ℃ (YAT) with a temperature difference of 1.5 ℃.

This rise in the water temperature of Lake Sonfonia is a limiting factor, in fact the higher the water temperature, the more the quantity of dissolved oxygen decreases, leading to the disappearance of species [12].

*3.2 pH*

It appears in Table 2 that the minimum value of pH 7.00 was observed at the station (USF) during the dry season and the maximum value of pH 7.50 at the station (USF) during the rainy season. The pH obtained complies with the WHO recommendation for surface water ($6.5 < pH < 8.5$) where life will develop optimally.

The pH of water depends on its origin [13]. A drop in pH can lead to the dissolving of trace metals that are often harmful and sometimes fatal at low doses for aquatic organisms [14]. A high pH increases the concentration of ammonia toxic to fish [15].

*3.3 EC and TDS*

The conductivity of water is a measure of its ability to conduct electric current. It allows you to quickly assess the mineralization of the water. The EC is proportional to the overall content of chemical species with a decrease in pH [14]. The conductivity rises gradually from upstream to downstream of the lakes [14, 16]. Fresh water has a low EC of less than 100 µs/cm.

TDS is a measure of the total amount of dissolved solids in water, including salts, mineral ions and organic compounds. The salts of lakes and rivers come from rocks that degrade over time and other compounds resulting from human activity.

The EC values vary between 1,350 µs/cm (at the SEG site) and 1,680 µs/cm (at the YAT site) during the dry season and between 1,306 µs/cm (at the SEG site) and 1,607 µs/cm (on the YAT website) during the rainy season. These values are higher than the WHO standard (200 to 1,000 µs/cm). This strong mineralization of the waters of Lake Sonfonia could be explained by a probable contribution of saline water and discharges of untreated wastewater discharged directly into the lake.

TDS provides information on the salt content of water. It can be seen that the highest values are obtained on the sites (YAT) 994 mg/L and (BLZ) 887 mg/L. High levels may indicate the presence of contaminants such as heavy metals, chemicals or other substances potentially harmful to human health or the environment [14]. This state of affairs is positively correlated with the high conductivities measured in the various stations.

*3.4 Dissolved Oxygen*

The analysis of Table 4 also shows that: the warm period (March) recorded a maximum of 6.5 mg/L at the YAT station and a minimum of 5.6 mg/L at the USF station. The cold period (August) had its maximum of 7.5 mg/L at the YAT station and its minimum of 6.9 mg/L at the stations (FLM, SOC and USF). However, during the wet period, the dissolved oxygen concentrations observed are relatively higher than in the warm period, mainly due to the cooling of the waters during the cold season, which maintains the oxygen in the body of water [17]. A level of dissolved oxygen that is too high or too low can harm aquatic life and water quality.

These values obtained are below 10 mg/L limit value accepted by the WHO. This low level of dissolved oxygen indicates a probable decrease in biological diversity. It should be noted that temperature and dissolved oxygen are negatively correlated. This means that the higher the temperature, the less oxygen there is available, the same is true between temperature and pH.

*3.5 COD (Chemical Oxygen Demand)*

COD is the consumption of oxygen by strong chemical oxidants to oxidize organic and mineral substances in water. This is one of the most widely used methods to assess the overall load of organic pollutants in water [18].

**Table 2 Results of the analysis of the physical parameters of the water samples from Lake Sonfonia March 2021.**

| Stations | Settings | | | | | |
|---|---|---|---|---|---|---|
| | T (℃) | pH | CE (μs/cm) | TDS (mg/L) | SS (mg/L) | Turbidity (mg/L) |
| SEG | 32.90 | 7.01 | 1350 | 623 | 7 | 10 |
| YAT | 31.90 | 7.02 | 1680 | 994 | 9 | 32 |
| FLM | 31.80 | 7.05 | 1464 | 702 | 15 | 20 |
| SOC | 32.80 | 7.02 | 1570 | 784 | 31 | 18 |
| BLZ | 33.00 | 7.01 | 1650 | 887 | 6 | 14 |
| USF | 33.90 | 7.00 | 1486 | 802 | 28 | 31 |
| Mean | 32.71 | 7.01 | 1,533.33 | 798.66 | 16.00 | 20.83 |

**Table 3 Results of the analysis of physical parameters of water samples from Lake Sonfonia August 2021.**

| Stations | Settings | | | | | |
|---|---|---|---|---|---|---|
| | T (℃) | pH | CE (μs/cm) | TDS (mg/L) | SS (mg/L) | Turbidity (mg/L) |
| SEG | 27 | 7.50 | 1306 | 653 | 11 | 18.5 |
| YAT | 28.5 | 7.30 | 1607 | 803 | 39 | 38.3 |
| FLM | 27.4 | 7.20 | 1550 | 775 | 35 | 40 |
| SOC | 28 | 7.40 | 1465 | 732 | 38 | 46 |
| BLZ | 27 | 7.20 | 1468 | 734 | 20 | 34 |
| USF | 27.6 | 7.50 | 1529 | 764 | 32 | 47.5 |
| Mean | 27.58 | 7.35 | 1487.50 | 747.50 | 29.16 | 37.38 |

**Table 4 Results of the analysis of chemical parameters of water samples from Lake Sonfonia March 2021.**

| Stations | Settings | | | | | | |
|---|---|---|---|---|---|---|---|
| | Phosphates (mg/L) | Nitrates (mg/L) | Nitrites (mg/L) | Sulfates (mg/L) | Total iron (mg/L) | $O_2$ dissolved (mg/L) | COD (mg/L) |
| SEG | 24 | 47.2 | 0.03 | 16 | 0.8 | 6 | 31 |
| YAT | 23.4 | 48.3 | 0.05 | 20 | 0.7 | 6.5 | 36 |
| FLM | 27.2 | 52 | 0.07 | 13 | 0.5 | 5.8 | 54 |
| SOC | 35 | 51.6 | 0.05 | 6 | 0.6 | 5.7 | 95 |
| BLZ | 54 | 49 | 0.03 | 11 | 0.5 | 6.4 | 35 |
| USF | 15 | 22.5 | 0.08 | 18 | 0.7 | 5.6 | 62 |
| Mean | 29.76 | 45.1 | 0.05 | 14 | 0.63 | 6 | 52.16 |

**Table 5 Results of the analysis of chemical parameters of water samples from Lake Sonfonia August 2021.**

| Stations | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Phosphates (mg/L) | Nitrates (mg/L) | Nitrites (mg/L) | Sulfates (mg/L) | Total iron (mg/L) | $O_2$ dissolved (mg/L) | COD (mg/L) |
| SEG | 15.5 | 20.3 | 0.02 | 7 | 0.6 | 7 | 23 |
| YAT | 24 | 33 | 0.06 | 11 | 0.6 | 7.5 | 28 |
| FLM | 24 | 21.8 | 0.06 | 7 | 0.6 | 6.9 | 30 |
| SOC | 26 | 18.6 | 0.05 | 7 | 0.4 | 6.9 | 75 |
| BLZ | 25 | 17.5 | 0.02 | 7 | 0.5 | 7.3 | 25 |
| USF | 16.6 | 29.2 | 0.06 | 9 | 0.6 | 6.9 | 43 |
| Moyenne | 21.85 | 23.4 | 0.04 | 8 | 0.54 | 7.08 | 37.33 |

The high COD values are recorded during the warm period with extreme values: the SEG station (31 mg/L) and the SOC station (95 mg/L). In the wet period, extreme values are observed: the SEG station (23 mg/L) and the SOC station (75 mg/L). These values are > 20 mg/L WHO standard for surface water, which shows a shortage of dissolved oxygen in the lake, compromising the future of the lake. The high COD value observed indicates the presence of a significant load of organic matter in the lake, particularly in the SOC and USF stations, and is linked to the deposits of branches and waste water from the surrounding localities.

### *3.6 SS and Turbidity*

3.6.1 SS

SS refers to insoluble solid matter, visible to the naked eye, present in suspension in water. They include clays, sands, silts, planktons or other water microorganisms. The quantity of SS varies according to the season and the water flow regime, they arise from erosion and soil leaching in rainy weather, especially when rainfall is intense and in flood situations.

Biodegradable SS contributes significantly to oxygen demand and cause the concentration of dissolved oxygen to decrease in the aquatic environment [16]. These materials affect the transparency of the water and reduce the penetration of light, therefore photosynthesis, they can also interfere with the breathing of fish.

3.6.2 Turbidity

Turbidity is the reduction in the transparency of a liquid due to the presence of colloidal matter and suspended matter. It is due to the presence of finely divided suspended matter: clay, silica grains, silt, organic matter, etc. [19].

SS concentrations fluctuate between 7 mg/L (SEG)-31mg/L (SOC) during the dry season (March) and between 11 mg/L (SEG)-39 mg/L(SOC) during the rainy season (August).

Turbidity varies between 10 NTU (SEG)-32 NTU (YAT) during the dry season and between 18.5 NTU (SEG)-47.5 NTU (USF) during the rainy season. The values obtained are greater than 20 mg/L or NTU limit value accepted by WHO.

The peaks of values are observed during the rainy season in the stations (USF, YAT and SOC) and are probably the consequence of the presence of landfills around the lake. These landfills are formed by the natural fermentation of the leachate. This turbid water would explain the low dissolved oxygen rate observed (Table 1).

### *3.7 Nitrates, Nitrites, Phosphorus and Eutrophication*

Eutrophication causes the proliferation of microscopic algae and aquatic plants on the surface of the water. This gives a green color to the water. These algae give off oxygen to the surface of the water, but have a short lifespan. Once dead and on the bottom, these algae still need a lot of oxygen for their decomposition. This is massively subtracted from the water [20].

3.7.1 Nitrates ($NO^{3-}$)

Nitrates are anions representing the most oxygenated and most stable form of nitrogen. Their presence in the water is due to the leaching of agricultural land following the spreading of fertilizers, livestock effluents (slurry), domestic and industrial discharges. Nitrates come from the mineralization of organic nitrogen and the oxidation of the ammonium ion present in the soil, which is oxidized to nitrite and then to nitrate by nitrification bacteria [21]. In water, nitrates react with amines to form potentially carcinogenic nitrosamines.

3.7.2 Nitrites ($NO^{2-}$)

Compounds resulting from the reduction of nitrates in water or soil by micro-organisms. In the blood, nitrites cause the formation of methemoglobin, in large quantities reduces the oxygenation of the cells, by inability to transport oxygen from the lungs to the tissues [22].

3.7.3 Phosphorus (P)

Phosphorus in the natural environment is found in the form of phosphates (calcium, iron and aluminum) in volcanic and sedimentary rocks. Its passage through water is done by the erosion of soil and rocks. Plants take up the phosphates thus solubilized for photosynthesis. It is transferred along the food chain by consumption of plants by animals. Phosphorus is again solubilized thanks to the decomposition of dead matter by microorganisms [23].

The analysis of Tables 4 and 5 show that: the values of total phosphorus, nitrates and nitrites vary according to the season and the station. For total phosphorus, the average values are higher than the WHO standard which is 0.5 mg/L. During the dry season the average values are 29.76mg/L and 21.85mg/L in the rainy season; the average nitrate values are all below the WHO 45.1 mg/L and 23.4 mg/L in the rainy season. For nitrites, the averages are also slightly lower than the limit accepted by the WHO, which is 0.06 mg/L. In the dry season the average value is 0.05 mg/L and 0.04 mg/L in the rainy season.

A phosphate concentration greater than 0.5 mg/L of water is sufficient, in the presence of nitrate and ammonium, to trigger excessive vegetation growth, i.e. eutrophication [24].

### *3.8 Sulphates and Total Iron*

On trouve généralement le fer dans les eaux de surface sous forme de sels contenant du fer (III) lorsque le pH est >7 [25]. Les sulfates peuvent être trouvés dans presque toutes les eaux naturelles. Ils proviennent de l'oxydation des minerais de sulfites, la présence de schistes, ou de déchets industriels [26].

Tables 4 and 5 show that: For total iron, the average value observed in the dry season is 0.63 mg/L and 0.54 mg/L in the rainy season, which are slightly higher than the WHO standard. Sulphates have an average of 14 mg/L in the dry season and 8 mg/L in the rainy season. These values are correlated with the high conductivity measured.

## 4. Statistical Studies

Stata 15 software was applied for the statistical analysis of the data. For this, the Shapiro-Wilk test for the normality of the data showed that the values observed after the *in situ* and laboratory analyses are normally distributed. Thus, for the comparison of the different averages of the parameters studied between the dry season and the rainy season, the Student test was applied. The Student test gave the following:

For the parameters: temperature ($p$-value = 0.000), pH ($p$-value = 0.002), turbidity ($p$-value = 0.0149), dissolved oxygen ($p$-value = 0.0002). The $p$-values being less than 5%, we only admit for each parameter that the variations in the values observed between the dry season and the rainy season are statistically significant.

On the other hand: CE ($p$-value = 0.5035), TDS ($p$-value = 0.3613), SS ($p$-value = 0.0669) and COD ($p$-value = 0.2722). The $p$-values are greater than 5%, it is only accepted for these parameters that the variations in the values observed between the dry season and the rainy season are not statistically significant.

The correlation test between the parameters studied showed, among other things, highly significant correlations between EC and TDS ($r$ = 0.9454 and $p$-value = 0.0044) in March 2021; the chemical demand for oxygen and suspended matter ($r$ = 0.9293 and $p$-value = 0.0073) in March 2021; turbidity and SS ($r$ = 0.8524 and $p$-value = 0.0311) in August 2021; pH and temperature ($r$ = -0.8331 and $p$-value = 0.0395) in March 2021; temperature and dissolved oxygen ($r$ = -0.4190 and $p$-value = 0.4083) in March 2021 and between COD and dissolved oxygen ($r$ = -0.7077 and $p$-value = 0.1156).

## 5. Conclusion

It was found after the analysis of the results of the water samples taken that: the average water temperature of Lake Sonfonia exceeds the limit value admitted by the WHO 25 °C. This situation favors the drop in dissolved oxygen levels, leading to a decrease in biodiversity; the pH of the water complies with the WHO recommendation; EC and TDS observed exceed WHO standards.

The waters of Lake Sonfonia are turbid, as evidenced by the high values of turbidity and SS. The average values of COD are higher than the limit value recommended by the WHO for surface waters, indicating significant pollution of organic matter. Nutrients in solution in water are generally within acceptable limits. The main source of pollution is due to human activities, i.e. discharges of household waste and domestic wastewater into the lake without any prior treatment.

The Student test gave statistically significant variations between the dry season and the rainy season for the following parameters: temperature, dissolved oxygen, turbidity. The correlation test between the EC and the TDS concentration is highly positive ($r$ = 0.9454 and $p$-value = 0.0044), on the other hand between the temperature and the pH the correlation is highly negative ($r$ = -0.8331 and $p$-value = 0.0395). The results of this study can help identify sources of pollution, assess health risks and guide water management decisions to protect health human and the environment.

## Contribution of the Authors

The contribution of the co-authors was very remarkable for the conception and realization of the present manuscript submitted for publication.

## Conflicts of Interest

We categorically declare that there is no conflict of interest that could bias the content or conclusions presented. We are not affiliated with any company, organization or interest group with a financial or other interest in the results or recommendations that may arise from this publication.

For transparency, we would like to clarify that this article has been developed independently, without any external pressure, directive or influence from third parties. No stakeholder has exercised control over the content or direction of this study, and the opinions expressed are strictly those of the authors.

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