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Determination of the Physico-Chemical Quality of the Waters of the Mamouwol River in the Urban Commune of Mamou, Republic of Guinea

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Abstract: Water is one of the most important elements on which our daily lives depend, because of its many uses in various fields. To ensure that people have the right of access to water, the authorities must provide them with treated water that complies with the regulations and standards in force, particularly from a physico-chemical point of view, for all possible uses to avoid any health problems for consumers. The aim of this research is to study the water in the Mamouwol River by measuring physico-chemical parameters: (1) pH, it varies from 5.2 "Mam3" to 7.8 "Mam4" in August 2021 then from 5.5 "Mam3" to 7.7 "Mam4" in March 2022, i.e. an average of 6.9 for all sampling points; (2) Turbidity varies from 0.3 NTU "Mam1" to 26.3 NTU "Mam4" in August 2021, then from 0.3 NTU "Mam1" to 30.6 NTU "Mam4" in March 2022, i.e. an average of 9.0 NTU for all sampling points; (3) Suspended matter, varying from 0.6 mg/L "Mam1" to 17.6 mg/L "Mam4" in August 2021, then from 0.6 mg/L "Mam1" to 30.0 mg/L "Mam4" in March 2022, i.e. an average of 8.8 mg/L for all the sampling points "Mam1", "Mam2", "Mam3" and "Mam4"; (4) Dissolved oxygen, varying from 2.07 mg/L "Mam3" to 6.12 mg/L "Mam1" in August 2021, then from 1.05 mg/L "Mam3" to 5.05 mg/L "Mam1" in March 2022, i.e. an average of 2.77 mg/L for all sampling points; (5) Nitrates vary from 1.32 mg/L "Mam1" to 3.96 mg/L "Mam4" in August 2021, then from 1.49 mg/L "Mam1" to 5.27 mg/L "Mam3" in March 2022, i.e. an average of 5.53 mg/L for all sampling points; (6) Nitrites, varying from 0 mg/L "Mam1' and "Mam2" to 0.06 mg/L "Mam3" in August 2021, then from 0 mg/L "Mam1" and "Mam2" to 0.13 mg/L "Mam3" in March 2022, i.e. an average of 0.03 mg/L for all sampling points. The results show the presence of organic pollution.

Key words: River water, Mamouwol, physico-chemistry, pollution.

1. Introduction

Watercourses and their banks are biotopes for humans, animals and plants [1]. The condition of watercourses depends not only on pollution from sewage [2, 3], but also to a large extent on disturbances to the water regime, such as the use of hydraulic power, drainage of built-up areas and flood protection [4]. Aquatic biocenoses are sensitive to morphology, hydrology and water quality [5]. The physical, chemical and microbiological characteristics of water are decisive for the species it supports, and must therefore be analysed as part of in-depth studies [6].

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In recent years, the Mamouwol river has come under considerable threat from climatic hazards, demographic pressure and human pollution. It is polluted by the increasing discharge of wastewater from the districts of the urban commune and from public and private infrastructures (the regional hospital, the civil prison, the markets, etc.).

The development of unhealthy habits such as leaching into the river (especially in the dry season), the use of fertilisers for market gardening along its entire length and various other activities such as tanning are not to be outdone. There are no functional water police and no regulations are respected. Even the ancestral methods of water management, which had their coherence, have been neglected and forgotten. Information and awareness-raising programmes in the local media, organised by certain NGOs (Non-Governmental Organizations) in collaboration with the prefectoral and communal authorities responsible for environmental protection, have had little or no effect. As a result, the sustainability of the resource in both qualitative and quantitative terms is open to question.

Surface water quality is assessed by measuring physico-chemical parameters and the presence or absence of aquatic organisms and micro-organisms, which indicate the quality of the water [7].

These data can be supplemented by analysis of the sediments (sludge), which provide a record of the river's life, particularly episodes of pollution by heavy metals or other non-biodegradable organic matter.

Taken together, these factors make it possible to assess the degree of pollution in watercourses and their capacity for self-purification [8].

In order to make our contribution to the knowledge and preservation of the quality of the water in our rivers, and in particular that of Mamouwol, and to draw the attention of decision-makers at all levels to the phenomenon of pollution, we have carried out a study of the physico-chemical pollution of this watercourse in the urban district of Mamou.

2. Materials and Methods

2.1 Presentation of the Study Area

2.1.1 Geographical Location of the Mamou Prefecture

The Mamou prefecture is located in the southern and south-eastern foothills of the Fouta Djallon massif, between 10°23′ north and 12°05′ west. It covers an area of 8,000 km^2 and occupies a transitional position between Lower Guinea and the continental hinterland. It is bordered to the north by the prefectures of Dalaba and Tougué, to the east by the prefectures of Dabola and Dinguiraye, to the south by the Republic of Sierra Leone and to the west by the prefecture of Kindia. Its surface area is divided between one urban commune and 13 rural communes, namely Bouliwel, Dounet, Gongoret, Kégnéko, Nyagara, Porédaka, Saramoussaya, Soyah, Téguéréya, Timbo and Tolo.[1]

According to the results of the 3rd general census of the population and housing carried out from 1 March to 2 April 2014, the Mamou prefecture has a population of 318,981 people, including 148,157 men and 170,824 women, divided between 14 communes (13 rural communes and one urban commune) [9].

2.1.2 Hydrography of Mamou Prefecture[2]

The three most important rivers are: Bafing, Kaba and Konkouré, with numerous tributaries, most of which dry up in the dry season. Each river has its own basin, as follows:

- The Bafing basin is located to the north of the town of Mamou, where the Bafing river has its source; this same river is known as the "Senegal river". It drains from south to north, crossing the mountainous Fouta Djallon region.
- The Kaba basin, located in the south-eastern part of the prefecture, drains its waters into Sierra Leone, where it is known as "Little Castle". Its main tributary is the Mamowol, which rises to the west of the town of Mamou.
- The Konkouré basin is located in the heart of the town of Mamou and drains its waters into the prefecture of Kindia.

2.1.3 Mamou Urban Community

The administrative centre of the Mamou region, the urban district of Mamou is located in the heart of Guinea, and is bordered to the north by the sub-prefectures of Bouliwel and Tolo, to the north-east by Dounet, to the east and south-east by Soyah and to the west by Konkouré, as shown in the (Fig.1).

The town is located on the right bank of the Bafing (or "black river") which rises between Mamou and

[1] http://www.foutapedia.net/prefectures/mamou.htm.

[2] http://www.foutapedia.net/prefectures/mamou.htm.

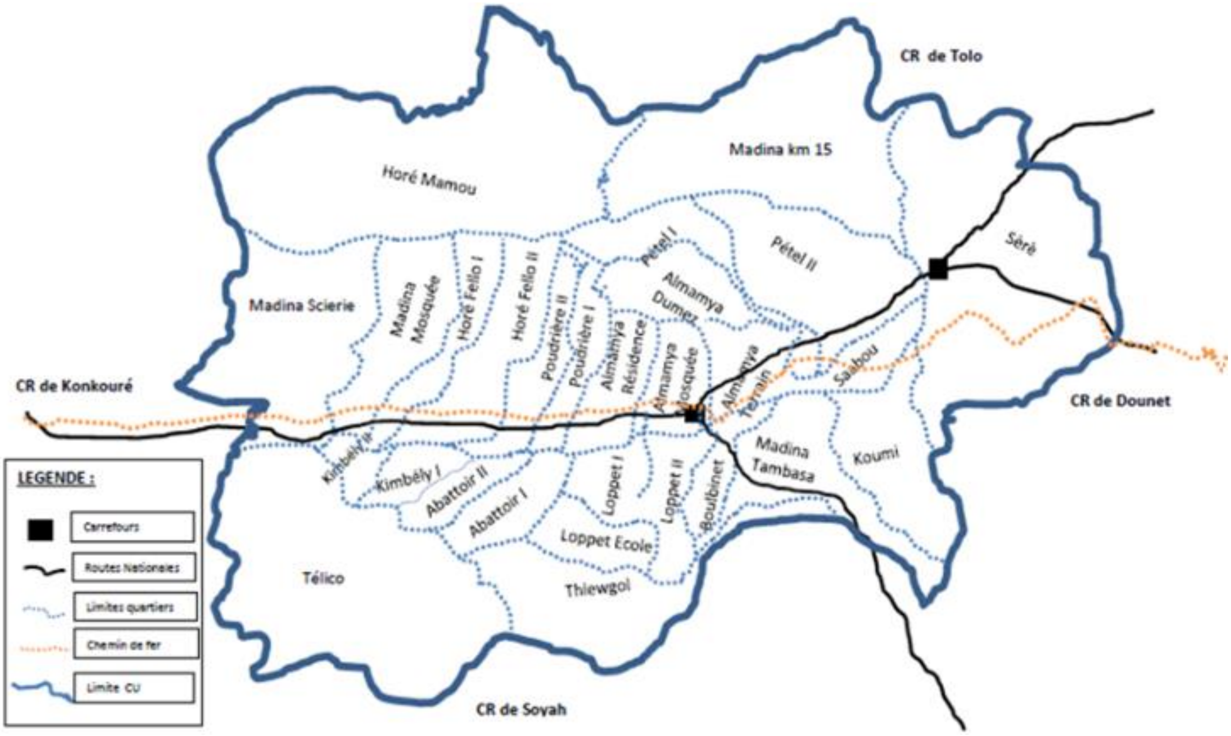

Fig. 1 Map of the urban district of Mamou.

Dalaba, before joining the Bakoye (or "white river") to form the Senegal River at Bafoulabé in Mali [10].

2.2 Work Equipment

2.2.1 Field Equipment

The equipment we used in the field was:

- A Garmin eTtex GPS (Global Positioning System);
- A HANNA HI 8424 multifunction pH meter;
- A HACH CO 150 conductivity meter;
- 1.5 L spas;
- A cool box.

2.2.2 Laboratory Equipment

We used:

A Hach LANGE DR 2800 spectrophotometer;

30 mL working cells;

10.0 mL and 1.0 mL sterile pipettes;

Thermometer;

Analytical balance accurate to 0.0001 g;

A stirring hot plate.

2.3 Sampling Method

We worked on two campaigns, namely August 2021 (flood period) and March 2022 (low-water period). Samples were taken at four (4) points along the watercourse (in and around the town). The sampling points were as follows:

A point designated "Mam1" (10°24.205′ N latitude and 12°05.865′ W longitude, height 725 m), located upstream of the urban commune, towards the source.

Two points called "Mam2" (10°23.088′ N latitude and 12°05.181′ W longitude, height 714 m) and "Mam3" (10°22.862′ N latitude and 12°04.726′ W longitude, height 718 m), located in the urban district of Mamou.

A point called Mam4 (10°22.284′ N latitude and 12°04.262′ W longitude, height 721 m), located downstream of the urban district of Mamou.

The width of the river at these sampling points varied from 7 to 10 m and the depth from 1 to 2 m.

For the samples, we used plastic or glass flasks or spas, which were rinsed with distilled water and then with the water to be analysed before filling.

After sampling, the samples were placed in a cool box at 4 ℃, then sent to the laboratories for analysis.

2.4 Determining the pH

- Rinse the pH meter electrode with distilled water and then with the sample to be analysed at least three times;
- Place a quantity of the sample in a beaker and immerse the pH meter electrode in it;
- Press the ON/OFF button on the instrument, which will display the pH value of the sample and its temperature on the screen;
- Read and record the corresponding value.

2.5 Determination of Conductivity and Dissolved Salt Content

- Rinse the electrode of the multifunction conductivity meter with distilled water and then with the sample to be analysed at least three times;
- After shaking, place a representative quantity of sample in a beaker;
- Immerse the electrode in the beaker containing the sample;
- Press the ON/OFF button to switch on, then press the "X" search button to display the conductivity (in µS/cm) and Dissolved salt rate value (expressed in mg/L).

2.6 Determination of Turbidity

- Rinse the turbidimeter tube with distilled water at least three times, then with the sample;
- After shaking, fill it with the sample up to the mark;
- Close tightly and insert into the instrument;
- Press the ON/OFF button to switch on, then the RED button to display the sample turbidity value expressed in NTU.

2.7 Determination of Suspended Solids

- Rinse the cell with distilled water at least three times, then with the sample;
- Fill to the mark with the sample;
- Close tightly and insert into the instrument;
- Close the instrument cover;
- Press the ON/OFF button to switch on, then select the programme;
- Press the RED button to display the result in mg/L.

2.8 Determination of Dissolved Oxygen

After selecting the analysis programme (445 Dis. Oxygen HR AV), we used the method, which is summarised as follows. The AccuVac high range dissolved oxygen ampoule contains a 14 mL vacuum sealed reagent. When the tip of the AccuVac ampoule is broken in a sample containing dissolved oxygen, a yellow to violet coloration is formed. The intensity of the violet coloration is proportional to the concentration of dissolved oxygen. The concentration reading (in mg/L) is obtained at 535 nm.

2.9 Determination of Nitrites

After selecting the analysis programme (371 N Nitrite LR PP), we used the method, which is summarised as follows. The nitrite present in the sample reacts with sulphanilic acid to form an intermediate diazonium salt. This combines with chromotropic acid to produce a pink complex whose intensity is directly proportional to the concentration of nitrite in the solution. The concentration reading is obtained at 507 nm.

2.10 Determination of Nitrates

After selecting the programme, we used the method, which is summarised as follows. Cadmium reduces the nitrate in the sample to nitrite. The nitrite ion reacts with sulphanilic acid to form an intermediate diazonium salt. This salt reacts with gentisic acid to form an amber coloured complex. The concentration reading is obtained at 400 nm.

3. Results

The average results for pH, turbidity, suspended solids, dissolved oxygen, nitrites and nitrates for August and March and the physicochemical analyses for April 2024 are shown in figures 2, 3, 4, 5, 6, 7 and 8 respectively.

3.1 Average pH Results for August and March

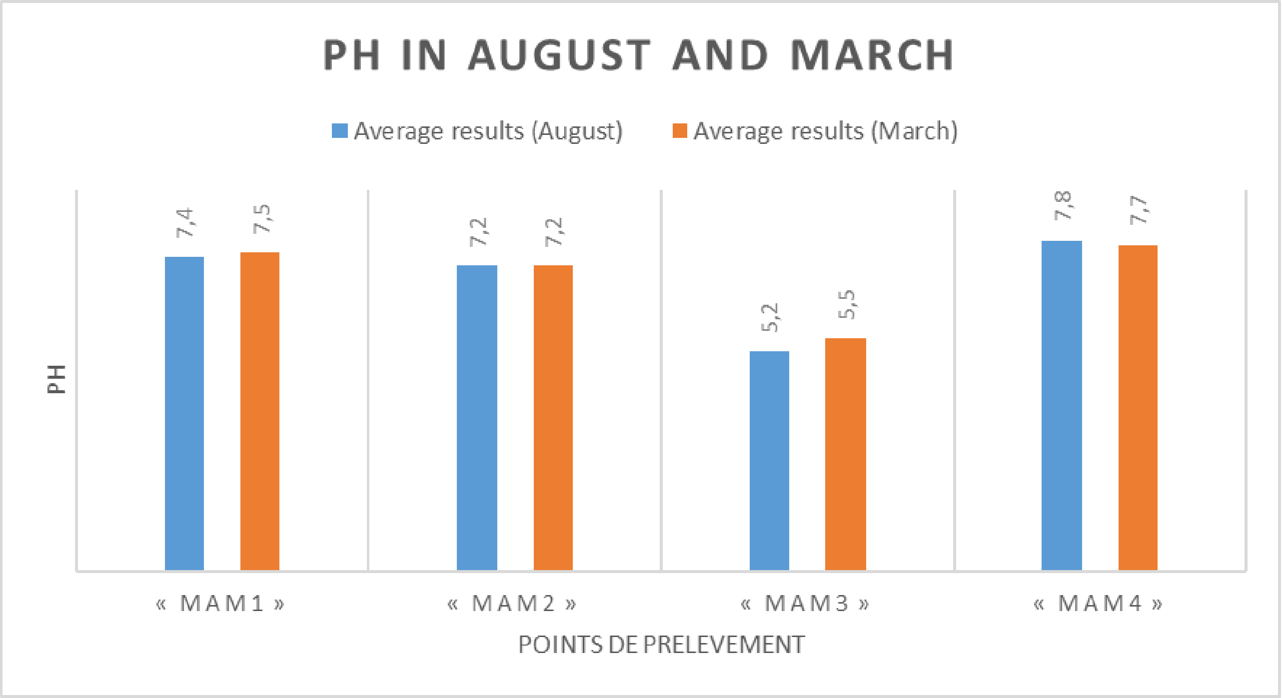

Fig. 2 Showing pH in August and March.

3.2 Average Turbidity Results for August and March

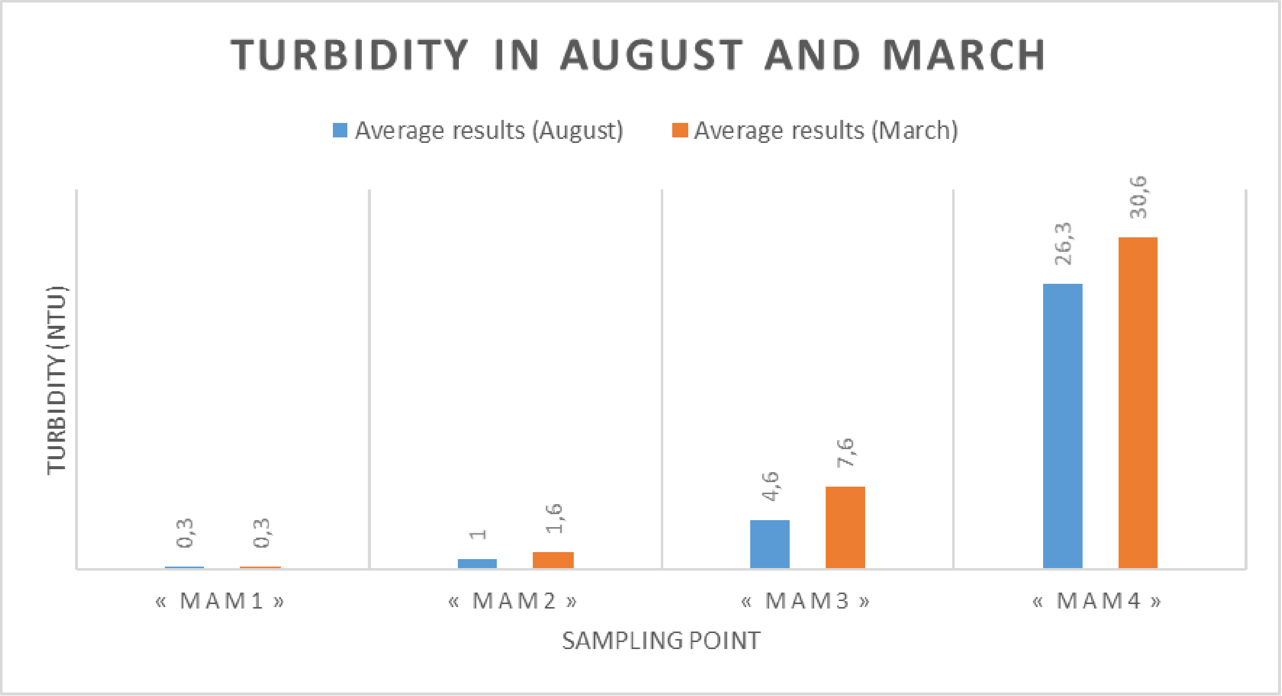

Fig. 3 Showing turbidity in August and March.

3.3 Average Results for Suspended Solids in August and March

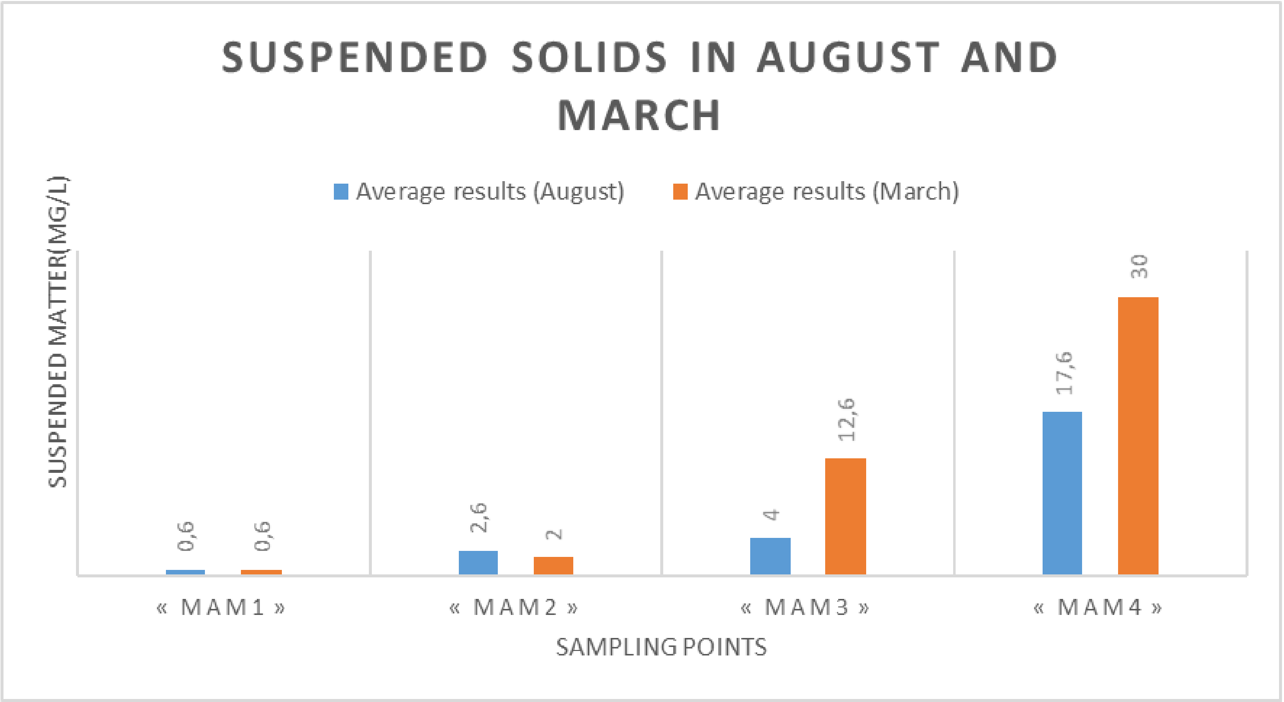

Fig. 4 Showing suspended solids in August and March.

3.4 Average Dissolved Oxygen Results for August and March

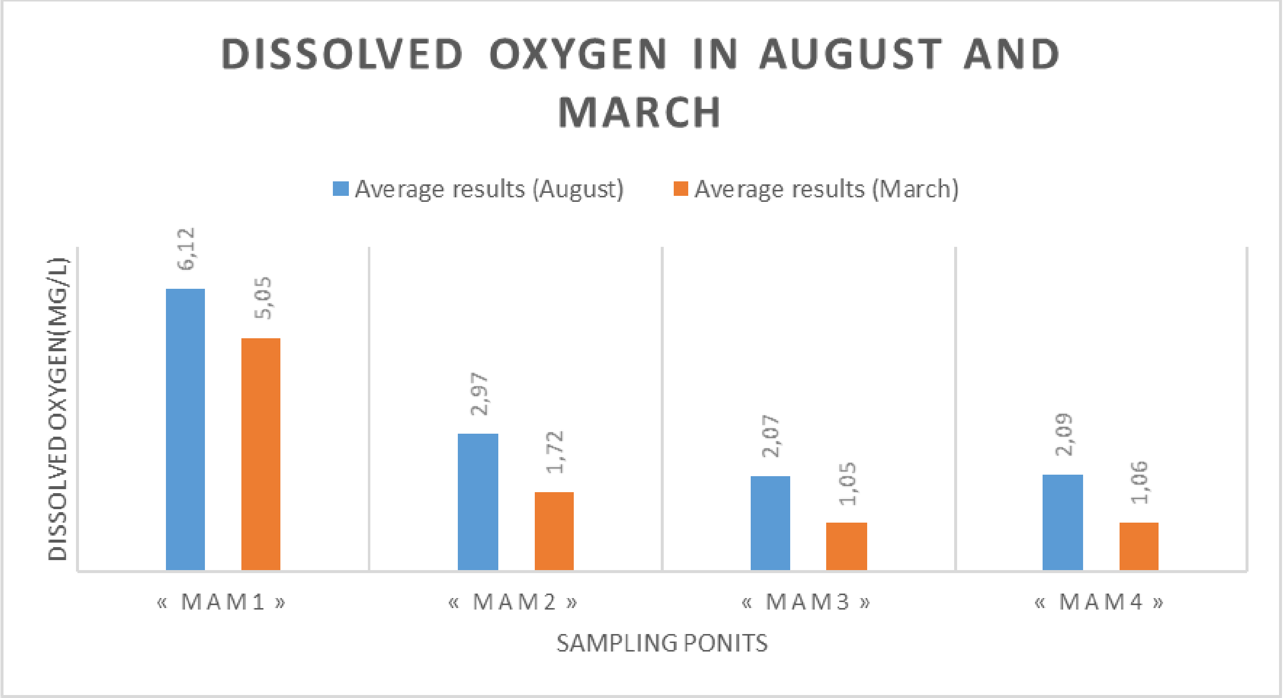

Fig. 5 Showing dissolved oxygen in August and March.

3.5 Average Nitrate Results for August and March

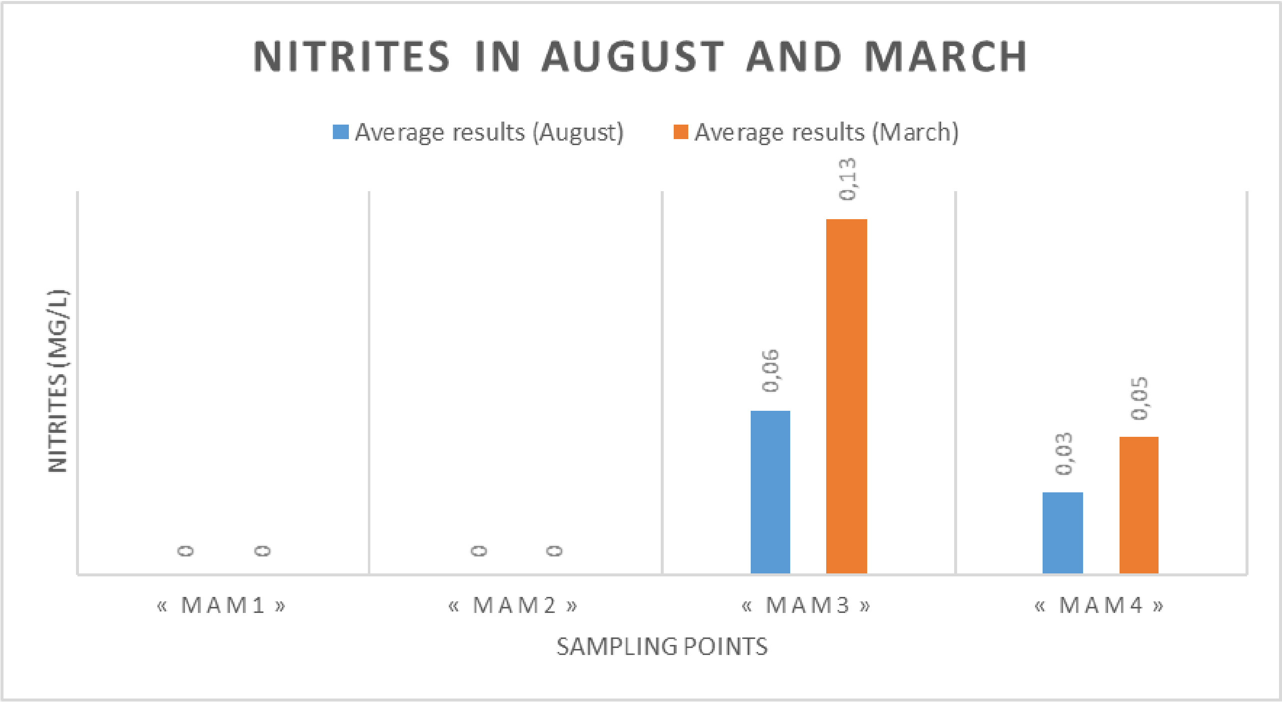

Fig. 6 Showing nitrites in August and March.

3.6 Average Nitrite Results for August and March

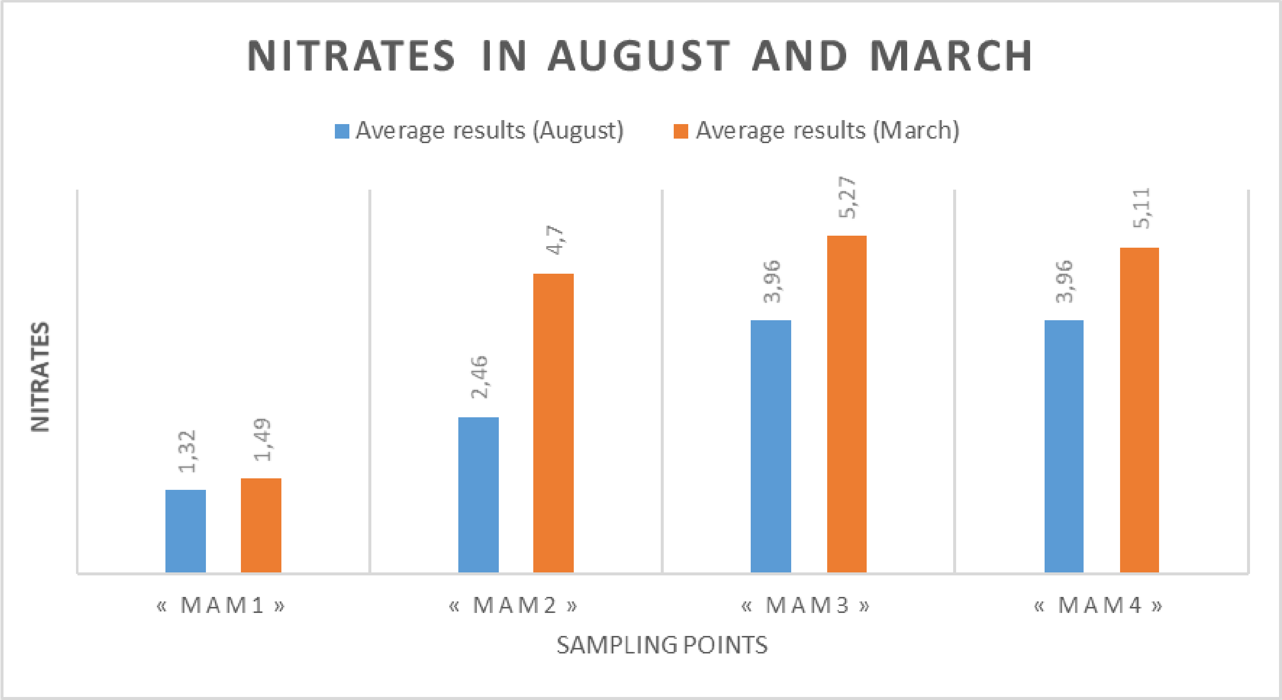

Fig. 7 Showing nitrates in August and March.

3.7 Average Physico-Chemical Results for April 2024

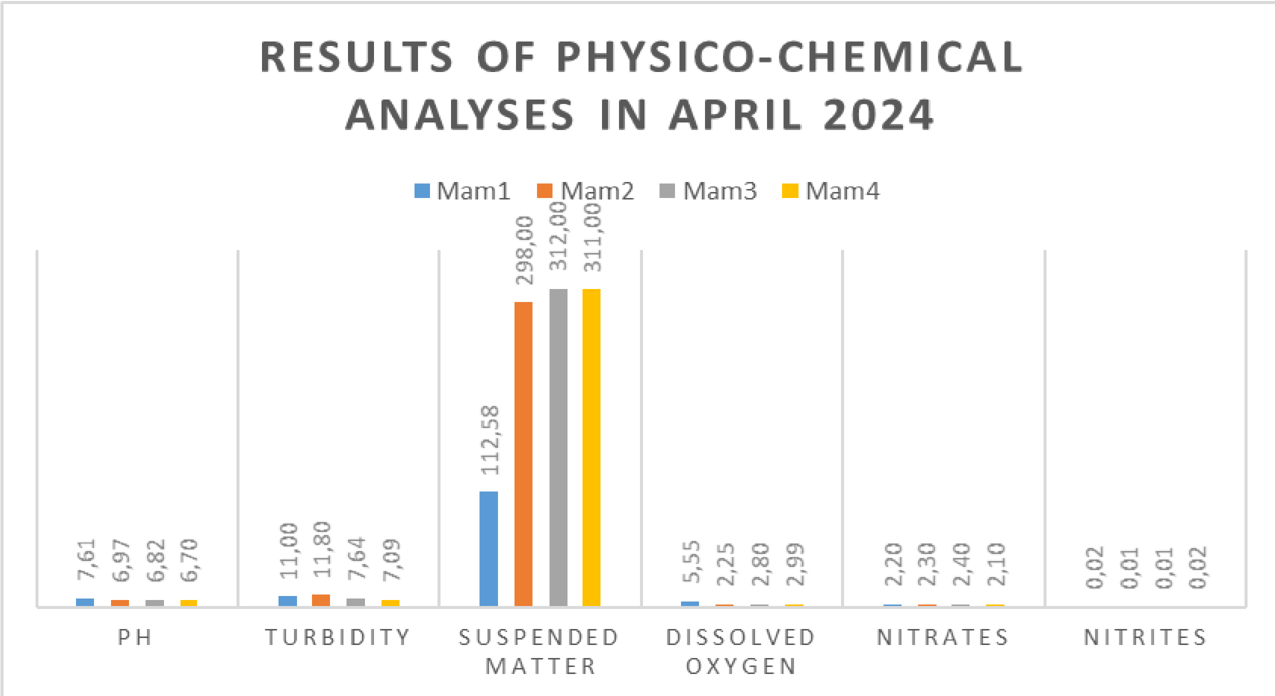

Fig. 8 Showing the physico-chemical analysis in April 2024.

4. Discussion

The pH is a measure of the acidity of water, i.e. the concentration of hydrogen ions (H^+). The hydrogen potential depends on the nature of the water, the nature of the geological material traversed and the contamination of the water by pollutants. The pH determines the solubility of metals in water; a low pH increases the concentration of metals in more toxic ionic form, while a high pH favours the formation of ammonia in water [11]. With regard to the results obtained, we note that not only is the pH generally within the norms (6.5 to 8.5), with the exception of sampling point "Mam3", but also that there is no significant variation between the two periods (August 2021 and March 2022). Point "Mam3", where we have pH values of 5.2 and 5.5 respectively, is located near the place where the shoemakers practise tanning. These values are indicative of a progression towards low pH (acidic water), thus increasing the risk of metals being present in ionic form [12]. In addition, the pH values of the samples at all the sampling points compared with Abbou et al. [13] could be favourable to the normal development of fauna and flora on the Mamouwol river.

In August 2021 and March 2022, turbidity remained constant upstream of the town (Mam1). However, in the town (Mam2 and Mam3) and downstream (Mam4), turbidity increased to 26.3 NTU in August 2021 and 30.6 NTU in April 2022. Compared with the results of Elmansouri et al. [12], turbidity has remained within the standards for surface water (from 15 to 35 NTU, the water is of good class; from 35 to 70 NTU, it is of average class) [11].

Suspended solids in river water samples increase from upstream to downstream and become more pronounced at Mam3 and Mam4 (12.6 mg/L and 30 mg/L respectively). This is probably due to the substances brought in by human activities at this level. In fact, the high Suspended matter content at the level of the town and then at its outlet can cause the water to warm up at this level and thus destroy the habitats of cold-water organisms, according to Beaumont et al. [14] and Decamps and Casanova-Batut [15].

Table 1 Extract from the general physico-chemical quality grid used to classify surface waters.

Quality classes		CLASS 1 Excellent	CLASS 2 Good	CLASS 3 Average	CLASS 4 Wrong	CLASS 5 Very low
Weighted indices		100 - 80	80 - 60	60 - 40	40 - 20	20 - 0
Parameters	Units	Alteration				
I- Organic and oxidisable matter OOXM						
O2 dissolved	mg/l	>7	7-5	5-3	3-1	<1
Ammonium	mg/l	≤0,1	0,1-0,5	0,5-2	2-8	8 - 50
BOD5	mg/l	<3	03-06	06-10	10-25	>25
COD	mg/l	<30	30-35	35-40	40-80	>80
II- Mineralization						
Conductivity at 20 ℃	µS/cm	100 - 750	750-1300	1300-2700	2700-3000	3000 -7000
III- Suspended solids TSS						
Turbidity	NTU	<15	15-35	35-70	70-100	>100
IV- Nitrates						
Nitrates (NO3-)	mg/l	≤10	10-25	25-50	>50	
V- Nitrogen elements other than nitrates						
Ammonium	mg/l	≤0,1	0,1-0,5	0,5-2	2-8	8 – 50
Nitrite (NO2-)	mg/l	≤0,03	0,0.3-0,3	0,3-0.5	0.5-1	>1

We noted an increasing dissolved oxygen deficit from Mam2 (2.97 mg/L and 1.72 mg/L respectively in August 2021 and March 2022), to Mam4 (2.09 mg/L and 1.06 mg/L respectively in August 2021 and March 2022). According to the data in Table 1 below, entitled Extract from the general physico-chemical quality grid used to classify surface waters [11], the water samples analysed are of average class in Mam1 (upstream) and of poor class in Mam2, Mam3 and Mam4 (in the town and downstream). As a result, the balance of life (fish and other species) may be disrupted by the remarkable drop in dissolved oxygen levels [16].

Nitrates were found during both campaigns, but in small quantities, from 1.32 mg/L, the minimum value at "Mam1", to 3.96 mg/L, the maximum value at "Mam4" in August 2022. However, it is important to note their increase during the second campaign, from 1.49 mg/L, the minimum value in "Mam1", to 5.27 mg/L, the maximum value in "Mam3" in March 2023. On the one hand, improperly used fertilisers pollute groundwater (by seeping into the soil with rainwater and irrigation water) and surface water (by run-off). Excessive use of fertilisers has significantly increased the amount of nitrate in rivers and shallow groundwater [17]. Secondly, livestock effluent, is rich in nitrogen compounds in organic form (animal waste: manure, slurry) or mineral form (chemical) [18, 19]. These noxious substances concentrated in wastewater can destroy living organisms and plants in rivers and lakes, as well as the micro-organisms involved in the biological purification of wastewater [20]. The changes that can be seen in the vegetation of certain ponds or watercourses are often the result of direct pollution by toxic products. Excessive inputs of nutrients can lead to an intense proliferation of algae, resulting in the phenomenon of eutrophication, which limits the possibilities of aquatic life [21].

During the first campaign (August 2021), we noted the absence of nitrites in samples "Mam1" and "Mam2", and their presence in those of "Mam3" and "Mam4" (0.06 mg/L and 0.03 mg/L respectively). Compared with the results of Ebé et al. [22], these concentrations are low and within WHO (World Health Organisation) standards (≤ 0.1 mg/L). During the second campaign (March 2022), we did not also find nitrates in the "Mam1" and "Mam2" samples, but in those of "Mam3" and "Mam4", there is indeed the presence of nitrates (0.13 mg/L and 0.05 mg/L respectively) which have increased by almost half compared to the first campaign. In this respect, it should be noted that the result for the

"Mam3" sample (0.13 mg/L) is slightly higher than the WHO standard ($\leq$ 0.1 mg/L). This is a sign of pollution, given that nitrites can cause haemoglobin to turn into methaemoglobin, leading to poor oxygen transfer to the cells [23].

The results of the analyses of the two campaigns (August 2021 and March 2022) compared with those of April 2024 show us that an improvement in the physico-chemical quality (pH, turbidity, suspended matter, nitrates and nitrites) has been achieved recently on the Mamouwol river. With the exception of dissolved oxygen, the trend is towards normalisation of these parameters. This could be the result of action taken by the local authorities and environmental NGOs.

5. Conclusion

Rivers are subject to urban, agricultural and industrial pressures. In the absence of a wastewater treatment plant, wastewater is discharged directly into the river [24], as in the case of the Mamouwol river. According to our analyses, and based on parameters indicative of surface water quality, the water samples analysed from this river showed that:

pH, turbidity and suspended solids are within WHO standards at almost all sampling points;

Dissolved oxygen, on the other hand, leads us to say that the water samples analysed are of average quality at "Mam1" (upstream) and of poor quality at "Mam2", "Mam3" and "Mam4" (in the town and downstream). As a result, the balance of life (fish and other species) may be disrupted by the remarkable drop in dissolved oxygen levels;

Nitrates are present in the samples analysed during the two campaigns, but in small quantities. However, a remarkable increase was noted between the two campaigns. On the one hand, this could be the result of poor use of fertilisers, which pollutes the water through infiltration into the soil with rainwater and irrigation water, and surface water run-off. Secondly, it can be explained by the effluents from livestock farms, which are rich in nitrogen compounds in organic form (animal excrement: manure, slurry) or mineral form (chemical);

Nitrites are present in the "Mam3" and "Mam4" samples, with a value slightly higher than the standard (0.13 mg/L) in the "Mam3" sample. This is a sign of pollution, given that nitrites can cause haemoglobin to turn into methaemoglobin, leading to poor oxygen transfer to the cells.

This study has shown that human and agro-pastoral activities have a negative effect on the physico-chemical quality of river water in general, and that of Mamouwol in particular. This is why the study is currently being continued, with a view to adding microbiological parameters. This will enable a more accurate assessment to be made of the pollution of surface water, which could be correlated with the water-borne illnesses suffered by the people who use it.

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