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Surface Water Pollution In Arid And Semi-Arid Areas, Case Of Raw Water From Dams In Oranie (Algeria Nw)

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Abstract

This work examines the physicochemical quality of raw water from dams in western Algeria, focusing on the *Mactaa* basin (*Sarno*, *Cheurfa*, *Bohanifia*, *Ouerzet*, *Fergoug*) and the *Tafna* basin (*Bouhrara*, *Sekkak*, *Mafrouch*, *Sidi Abdeli*, *Beni Behdel*). Water sampling campaigns were conducted at the surface water level, assessing parameters such as temperature, pH, electrical conductivity, total suspended solids, oxygen, BOD5, COD, nutrients, salinity, turbidity, heavy metals, and mineral elements. The results indicate that organic matter in these basins originates mainly from natural sources like decomposing vegetation. Metal concentrations in the raw waters of the *Mactaa* and *Tafna* basins largely comply with required standards, with treatment processes further reducing metal levels. Standardized principal component analysis revealed varying pollution levels based on proximity to pollution sources and seasonal changes.

Keywords: Surface water, Pollution, Dam water, Water quality, Mactaa basin dams, Tafna basin dams, Principal component analysis (PCA).

1. Introduction

The quality of surface waters has deteriorated significantly in recent years worldwide, because of urban and industrial development. The discharges from urban areas as well as those from factories are often discharged directly into watercourses. This phenomenon is particularly

observed in developing countries, where the cost of treating discharges beforehand is prohibitive. Several studies worldwide have reported on the effects of industrial and urban discharges on change of surface water quality (R. Mulliss et al.,1996). The issue of surface water quality depends on the characteristics of these waters, as well as on climatic conditions, soil composition, and human activities that influence water quality. Indeed, rapid population growth coupled with accelerated urbanization has led to various disruptions in natural environments (P. Whitehead et al., 2009). The excessive and indiscriminate application of fertilizers and pesticides, coupled with a lack of environmental awareness among the populace, contributes to an imbalance in the ecosystem and generates pollutants that can adversely impact the physicochemical and biological quality of the receiving aquatic environments (Sebastian Stehle et al., 2015). Surface waters are widely used in various human activities, but often these surface waters are polluted or contaminated even before their use. Surface waters represent a crucial source for drinking water supply. They are practically never potable without any treatment due to the presence of substances of natural origin or brought by pollution. All these substances and the products of their degradation or subsequent transformations in the environment are found in various physical states, either in suspension, in colloidal form, or in solution.

In Algeria, surface waters have been increasingly used in recent years for the needs of agriculture, feeding the population, and industry. The dams in western Algeria are used both for drinking water supply and irrigation. However, these surface waters are vulnerable to various pollutants and are often of poor quality, so surface waters should undergo physical, chemical, and biological treatments to make them potable. The determination of the origin of pollution in these surface waters was addressed through a spatio-temporal exploration of physical parameters, major elements, and heavy metals. This study showed that the waters of these dams are affected by urban and industrial pollution.

In this study, we will present the physico-chemical characteristics and show the current state of the waters of the northwestern dams of Algeria and the different existing pollutants, their origins, as well as their evolution and the evaluation of contamination through statistical analysis.

1.1. Presentation of the study area: Choice of sampling locations

The objective of our study is to determine the physicochemical quality of raw waters from the *Mactaa* basin dams (*Sarno*, *Cheurf*, *Bohanifia*, *Ouerzet*, *Fergoug*) and the five major dams of the *Tafna* basin (*Boughrara*, *Sekkak*, *Mafrouch*, *Sidi Abdeli*, *Beni Behdel*) in order to have a satisfactory representativeness. For this study, we carried out 12 monthly samplings of raw waters from ten dams throughout the year 2023. The figure 1 illustrates the geographical distribution of key dams within the *Mactaa* and *Tafna* basins.

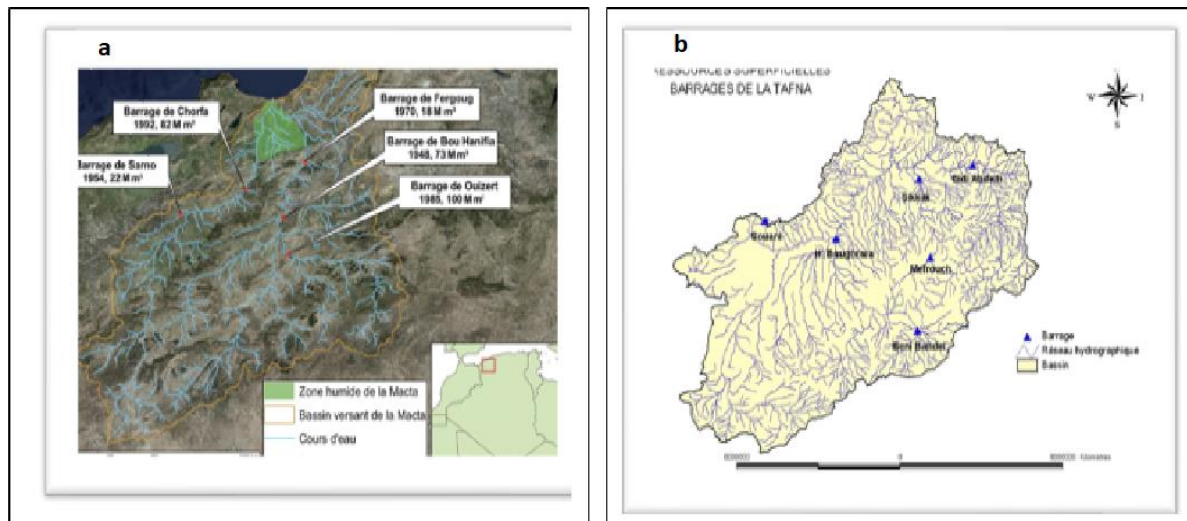


Fig (1): Geographical Overview of (a) Mactaa and (b) Tafna Basin Dams in Western Algeria

1.2. Geographical situation of the Mactaa watershed:

The *Mactaa* Basin is bordered to the North by the Mediterranean Sea, to the South by a large part of the *Chott Chergui* basin, to the East by the *Cheliff/Zahrez* region, and to the West by a part of the Central Coastal, *Tafna* basin, and *Chott Chergui*. The Basin covers an area of 14,389 km² with a population of over 1,231,445 inhabitants. It is drained by main watercourses: the *Mebtouh* river, *Mekerra* river to the west, and the *El Hammam* river to the east. It combines three distinct regions:

- The low coastal plain, with altitudes usually below 9 m, which favors the presence of water bodies, marshes, and steppes.
- The massifs, which constitute the largest part of the watershed, the watershed is bordered to the west and northwest by the *Tessala* mountains, the *Beni-Chougrane* mountains occupy a good part of its middle zone.

- The large alluvial plains inserted in the mountainous massifs of the wilaya of Sidi Bel Abbès in Algeria.

The surface waters of the basin are mobilized by 5 dams:

- *Ouizert* Dam (intended for irrigation of the *Habra - Sig* perimeter and for drinking water supply)
- *Bouhanifia* Dam (intended for irrigation of the *Habra - Sig* perimeter and for drinking water supply)
- *Cheurfa* Dam intended for irrigation of the *Sig* perimeter and drinking water supply of *Sig*
- *Sarno* Dam intended for drinking water supply of Sidi Bel Abbes town.
- *Fergoug* Dam (intended for irrigation of the *Habra - Sig* perimeter and drinking water supply)
- It should be noted that the *Bouhanifia* and *Fergoug* dams have recorded a significant siltation rate estimated at: *Bouhanifia* (37.50%) - *Fergoug* (95%)

1.3. Situation and geography of the *Tafna* watershed:

The *Tafna* watershed is situated in the northwestern region of Algeria, primarily within the Tlemcen province and partially extending into Morocco. The *Tafna* River originates from *Djebel Merchiche*, located in the Tlemcen mountain range near the town of *Sebdou*. At an altitude of 1,600 meters, stretching into the wilaya of Tlemcen. It enters the wilaya of Aïn Témouchent town, passes through the ancient city of *Siga*, and flows into the Mediterranean in front of the island of *Rachgoun*. The lower *Tafna* is represented by the lower course of the *Oued Tafna*, which crosses the plain of *Remchit* town and reaches the Mediterranean Sea at the *Rachgoun* beach.

The five major dams in the *Tafna* basin:

- *Beni-Bahdel* Dam
- *Sekkak* Dam is located on the *Oued Sekkak*, near the village of Ain Ouahab town.
- *Hammam Boughrara* Dam, located in the extreme northwest of the Wilaya of Tlemcen (northwest Algeria).

- *El-Izdihar* Dam is located on the Oued Isser north of the village of Sidi Abdelli (intended for supplying drinking water to the wilaya of Sidi Bel Abbes, with a portion reserved for agricultural development).
- *Mafrouch* Dam (intended to supply the city of the wilaya of Tlemcen and its industrial zone with drinking water).
- *Beni-Bahdel* Dam

2. Materials And Methods

2.1. Sampling:

For water sampling for physicochemical analysis, clean plastic bottles with a capacity of 1500 ml were used. The samples are preserved and transported in good conditions in a cooler for later analysis in the laboratory. We monitored the quality of raw water through analyses carried out at the Algerian Water Company laboratory, for an estimated duration of 12 months.

The sample bottles are properly labeled for future processing. It is also important to have a sampling form indicating the data related to the sampling period, the analysis objective, the sample nature, and the sampling locations.

2.1.1. Sampling Method

The main aspects to consider in obtaining a representative water sample are as follows: proper selection of the sampling point; strict adherence to sampling procedures. and adequate sample preservation (Ramsey., 2015).

In our study, we conducted 12 monthly samplings of raw water from ten dams throughout the year 2023 in one-liter polyethylene bottles. All sampling bottles are clearly identified and accompanied by sufficient information regarding the sample nature and the reasons for the analysis, transported in a cooler with a maximum delay of 8 hours before analysis.

2.1.2. Transport And Preservation Of Samples:

The preserved bottle is stored in darkness and at a low temperature to prevent the proliferation of undesirable species, bacterial or planktonic, or chemical reactions that could alter the sample

composition (Widyastuti et al. 2020). Raw water samples from dams were collected between January 2023 and December 2023.

The samples are transported from the sampling point to the laboratory in a cooler at 4 °C. When the samples are stored, they are placed in the refrigerator. Before proceeding with the analytical operations, it is essential that all necessary measures are taken, such as homogenization at the time of analysis.

2.1.3. Water Sampling Techniques For Physicochemical Analysis

For physicochemical analyses, water samples were collected in polyethylene bottles specially washed with acid and then rinsed thoroughly with ordinary water. Afterwards, they were rinsed several times with distilled water.

At the time of sampling, the bottles that have been rinsed again 3 times with the water to be analyzed are then filled to the brim, then tightly sealed in such a way that there are no air bubbles.

2.1.4. Water Sampling Techniques For Heavy Metal Analysis

Plastic bottles (PE) were used in all samplings, which must be washed with nitric acid beforehand; acidification with nitric acid must be carried out to bring the sample to a pH <2. For most waters, acidification to 0.5% (v/v) is suitable, this acidification should preferably take place in the field (at the latest within 48 hours of sampling). Indeed, there is a risk of rapid metal adsorption on the bottle walls if the sample is not acidified.

2.1.5. Materials

The different physicochemical parameters were measured at the ADE laboratory in Algeria, using the operating methods and principles used on site.

2.2. Physico-Chemical Analysis Techniques

Physico-chemical quality is a fundamental entity in determining water potability. For the different water samples, parameter measurement is systematically carried out and the physico-chemical analyses carried out at the regional laboratory of the Algerian water company.

2.1. pH

pH, which is an indication of water's tendency to be acidic or alkaline, is determined by potentiometric measurement using a glass electrode (pH meter) that determines the activity of hydrogen ions present in the water. pH measurements were carried out in the laboratory using a "HACH" pH meter.

2.2. Temperature

Temperature measurement was carried out in the field, as well as air temperature at the same location and time. The reading is taken after a 10-minute immersion. The temperature of the raw water studied is measured using a "SELECTA" thermometer.

2.3. Dissolved Oxygen

Dissolved oxygen is an essential compound in the aquatic environment as it is the limiting parameter of the main pathway for organic pollution biodegradation. It is measured using an HQ Model 40 D "HACH" oximeter.

2.4. Turbidity

Turbidity is measured in the laboratory using a "HACH" turbidimeter with a photoelectric cell, by the nephelometric method. Results are expressed in nephelometric turbidity units (NTU).

2.5. Conductivity

The electrical conductivity (expressed in siemens/meter) of water is the conductance of a column of water between two metal electrodes with a surface area of 1 cm² and separated by 1 cm. The measurement is based on the Wheatstone bridge principle using an electrical conductometer.

2.6. Total Alkalinity (TAC)

Total alkalinity or TAC corresponds to the water content of free alkalis, carbonates, and bicarbonates. TAC was measured in the laboratory using the volumetric method, based on the principle of neutralizing a certain volume of water with a diluted mineral acid in the presence of a colored indicator.

2.7. Determination Of Physico-Chemical Parameters Of Water By Spectrophotometry

UV visible spectrophotometry. It is a technique that exploits the properties of compounds to absorb light. Generally, complexing agents are used to give colors with the elements to be dosed. In fact, it is a technique like in the case of SAA, intended to dose trace compounds in aqueous solution such as (NO_3^- , NO_2 , SO_4^{2-} , $\text{P}_2\text{O}_4^{3-}$... etc.) and which exploits the Beer Lambert law. In this case, the intensity of the solution color is a function of the element concentration to be dosed. A calibration curve is necessary to exploit the experimental results.

In this study, the parameter measurements were carried out on an HACH UV/Vis spectrophotometer Dr 5000, with an optical path length of 10 mm using quartz cuvettes. The wavelengths used are 245 nm. The measurement methods used in our work are described by ISO standards.

3.Results and Discussion

Physico-Chemical Quality

We will present the results (Table 1, 2, 3 and 4) and their discussions concerning the physico-chemical quality and heavy metals of surface waters in western Algeria. The concentrations of the different parameters are represented in the figures below. The interpretation of these results is carried out according to the water quality decree. Which was established according to Algerian standards (Official Journal of The Democratic and People's Republic of Algeria, 2011a, 2014b).

Temperature

The temperature of surface waters depends on the climate and atmospheric conditions (Aranda et al., 2021). In this study, the temperature values recorded during the four quarters at the 10 dams are very variable, ranging between 14.65°C and 16.70°C (first quarter) (Figure 2) and between 17.24°C and 18.70°C during the 2nd quarter (Figure 2), and with maximum values ranging between 19.88°C and 22.46°C during the 3rd quarter and with average values ranging between 16.45°C and 17.46°C during the 4th quarter they are close to ambient temperatures. These results remain lower than those reported by (Mehanned et al. 2014).

Hydrogen potential

The pH of drinking water should be between 6.5 and 8.5.. The pH values recorded during the four quarters are close to neutrality and more or less alkaline vary between (7.23 and 7.85) at

the 7 dams such as (*bouhanifia, fergoug, sarno, benbahdel, sekkak, sidiabdeli* and *mafrouch*) (Figure 3) and a maximum noted at the *cheurfa, ouizert* and *boughrara* dams between 8.09 and 8.93 which explains significant alkalinity.

Dissolved Oxygen

Oxygen is one of the parameters particularly useful for water and is an excellent indicator of its quality. It is one of the parameters most sensitive to pollution (Makhoukh et al., 2011). In our study, the seasonal evolution of dissolved oxygen shows higher concentrations in the wet period than in the dry period. The values obtained for this parameter show a fluctuation ranging from 8.12 mg/l to 9.65 mg/l during the 1st and 2nd the 4th quarter recorded at all dams (*bouhanifia, fergoug, sarno, benbahdel, sekkak, sidiabdeli* and *mafrouch*), with an average of 8.53 mg/l, 8.45 mg/l, 8.78 mg/l at the *cheurfa, ouizert* and *boughrara* dams respectively (Figure 5). Low levels of dissolved oxygen are observed during the hot months with an average of 7.02 mg/l, 7.63 mg/l, 7.28 mg/l at the *cheurfa, ouizert* and *boughrara* dams respectively (because cold water contains a greater amount of dissolved oxygen than water at high temperature (N'guessan et al., 2020)).

Nitrate

Nitrates are used as a pollution indicator. They act as a fertilizer for plants that assimilate nitrogen in the form of NO_3^- (Tariq et al., 2020). Nitrate levels (during the 1st and 2nd the 4th quarter) do not exceed the standards, ranging between 4.43 and 10 mg/l (at all dams) except for the 3rd quarter where a decrease in concentrations was observed.

The increase in nitrate levels in the waters during the rainy season compared to the dry season may be due to the leaching of fertilizers used in the agricultural soils located on the edges of the dam. These results are much lower than those marked by (Xiao-long Liu et al., 2020), we can conclude that the nitrate contents recorded in the surface waters of the 10 dams are lower than the content suggested by Algerian and international standards (50 mg/ L). This indicates that the waters studied are not subject to a risk of nitrate pollution.

Nitrite

Nitrite is considered a toxic element. Its origin is linked to urban and industrial discharges, or to the reduction of nitrogen forms (nitrates and nitrites) in reduced conditions. Seasonal

variations in nitrite contents in the study area show that the nitrite content varies over the four quarters between 0.017 mg/l (*B. mefrouch*) to 0.403 mg/l (*B.Bouhrara*) and 0.045 mg/l (*B.cheurfa*) in the 1st trimester cold season and 0.022 mg.L-1 (Generally speaking, the results do not exceed the standards. The values of this parameter in the studied waters are very variable and range between 0.057 mg/l (in the month of June) and 0.27 mg/l (in the month of April).

Ammonium

The content of ammoniacal nitrogen in natural waters should be relatively low since ammonia is gradually oxidized to nitrite and nitrates. Ammonia concentration can serve as a useful indicator of pollution in water bodies from urban wastewater discharges. In surface waters, ammonia originates from nitrogenous organic compounds and gas transfer processes between the water and the atmosphere (Bahroun et al., 2023).

The histogram of quarterly variations in ammonium levels shows fluctuations ranging from 0.10 mg/l to 0.680 mg/l during the 1st, 2nd, and 4th quarters recorded at all dams (*Bouhanifia*, *Fergoug*, *Sarno*, *Benbahdel*, *Sekkak*, *Sidiabdeli*, *Mafrouch*, *Cheurfa*, *Ouizert*, and *Bouhrara*).

The rainy season records the highest level of ammonium compared to the dry season at the *Cheurfa* dam, 0.680 mg/l, which reflects the process of leaching of the agricultural lands surrounding the dam (flood period). Our results are in line with the Algerian standards of 4 mg/l in raw waters, and they are comparable to those found by (Tiri et al., 2020) in the groundwater and surface waters of the cotton production area of Apla Houé.

Phosphate

High levels of this element in surface waters can lead to eutrophication. However, they have a beneficial effect by playing a regulatory role: they promote all fertilization phenomena, fruit setting, and the maturity of vegetative organs.

Phosphate levels in the waters studied during the 4 quarters are very low, ranging between 0.1mg/l and 0.86mg/l in the waters of the dams (*bouhanifia*, *fergoug*, *sarno*, *benbahdel*, *sekkak*, *sidiabdeli*, and *mafrouch*, *cheurfa*, *ouizert*, and *bouhrara*), they are below the established standard. Our results remain largely inferior compared to those reported by (Akatumbila et al., 2016) and (Makhoukh et al., 2011).

Organic Matter

In our study, the values of organic matter during the 1st quarter vary between 7mg/LO₂ and 8mg/O₂ in the waters of 9 studied dams and 10.33mg/LO₂ (in the waters of the *Cheurfa* dam, as well as the values recorded during the 2nd quarter vary between 8.48 mg/LO₂ and 9.86 mg/LO₂ in the raw waters of the dams (*Sarno*, *Benibahdel*, *Sekkak*, *Sidi Abdeli*, and *Mafrouch*) with high values recorded at the *Cheurfa* dam 13.93mg/LO₂ and between 10.32mg/LO₂ and 12.23 mg/LO₂ at the *Bouhanifia* dams.

During the summer season, the values of organic matter increase, ranging between 9.28mg/LO₂ and 10.97mg/LO₂ at the *Sarno*, *Benibahdel*, *Sekkak*, *Sidiabdeli*, *Ouzert*, and *Mafrouch* dams, and 16.22mg/LO₂ at the *Cheurfa* dam, and between 12.36mg/LO₂ and 14.20mg/LO₂ recorded at the *Bougrara*, *Bouhanifia*, and *Fergoug* dams, which explains that organic matter increases with temperature.

The highest values in organic matter expressed in oxidizability with KMnO₄ (Figure 3) exceed 12mg/LO₂ and 16.22 mg/LO₂ and are recorded at the *Bougrara*, *Bouhanifia*, *Fergoug*, and *Cheurfa* dams. These results are comparable to those found by (Hadji et al., 2020) in a study of surface waters from dams in northwest Algeria where the values varied between 8 and 15 mg/LO₂, which is far from the ideal value of 2.

DAMS	PH	O2 mg/l	PO4	N03	N02	NH4	T	oxidizabilitywith kmno4
Cheurfa	8,93	8,52	0,56	10,5	0,453	0,35	16,7	10,33
Bouhanifia	7,85	9,32	0,43	10,13	0,234	0,24	15,9	9,43
Fergoug	7,82	9,36	0,23	9,84	0,31	0,32	15,28	9,24
Sarno	7,43	9,65	0,09	7,67	0,24	0,24	15,54	8,56
Ouzert	8,09	8,45	0,12	8,19	0,23	0,28	15,28	9,32
Benibahdel	7,23	9,34	0,21	7,34	0,19	0,17	15,36	8,78
Sekkak	7,65	9,65	0,18	7,09	0,18	0,21	14,65	8,34
Tboughrara	8,62	8,78	0,21	9,26	0,4	0,346	15,85	9,76
Sidi Abdeli	7,26	9,45	0,32	5,04	0,23	0,134	15,55	9,87
Mafrouch	7,62	9,12	0,28	6,22	0,17	0,21	16,34	7,98

Table 1: Evolution of physicochemical parameters of raw waters during the 1st quarter

Column1	PH	O2 mg/l	PO4	N03	N02	NH4	T	oxidizabilitywith kmno4
Cheurfa	8,9	9,42	0,66	11,5	0,503	0,545	18,7	13,93
Bouhanifia	7,75	8,32	0,53	9,23	0,12	0,44	18,58	12,23

Fergoug	7,62	9,36	0,33	8,87	0,41	0,442	18,25	11,24
Sarno	7,53	8,65	0,12	5,67	0,324	0,234	18,58	9,86
Ouizert	8,59	9,43	0,32	7,89	0,123	0,38	18,28	10,32
Benibahdel	7,33	8,34	0,231	5,54	0,219	0,217	18,56	9,98
Sekkak	7,65	9,65	0,18	6,89	0,18	0,21	17,25	9,14
Bouhrara	8,62	9,78	0,21	8,46	0,45	0,346	18,45	11,36
Sidi Abdeli	7,96	8,45	0,242	7,34	0,23	0,274	17,55	9,97
Mafrouch	7,82	8,22	0,18	5,32	0,137	0,121	17,24	8,48

Table 2: Evolution of physicochemical parameters of raw waters during the 2nd quarter

Column1	PH	O2 mg/l	PO4	NO3	NO2	NH4	T	oxidizabilitywith kmno4
Cheurfa	8,8	7,02	0,56	9,15	0,48	0,68	22,43	16,22
Bouhanifia	7,65	8,12	0,93	7,23	0,25	0,52	21,08	14,2
Fergoug	7,52	8,26	0,73	8,23	0,47	0,53	20,95	12,54
Sarno	7,93	8,45	0,2	6,65	0,214	0,32	20,38	9,96
Ouizert	8,6	7,63	0,53	7,8	0,203	0,34	19,88	10,82
Benibahdel	7,53	8,04	0,25	6,84	0,32	0,21	21,46	10,07
Sekkak	7,85	8,15	0,23	5,39	0,2	0,22	20,65	10,14
Bouhrara	8,02	7,28	0,35	7,56	0,56	0,54	21,85	12,36
Sidi Abdeli	7,76	8,25	0,23	6,24	0,12	0,47	20,55	10,97
Mafrouch	7,22	8,32	0,24	4,22	0,15	0,2	20,44	9,28

Table 3: Evolution of physicochemical parameters of raw waters during the 3rd quarter

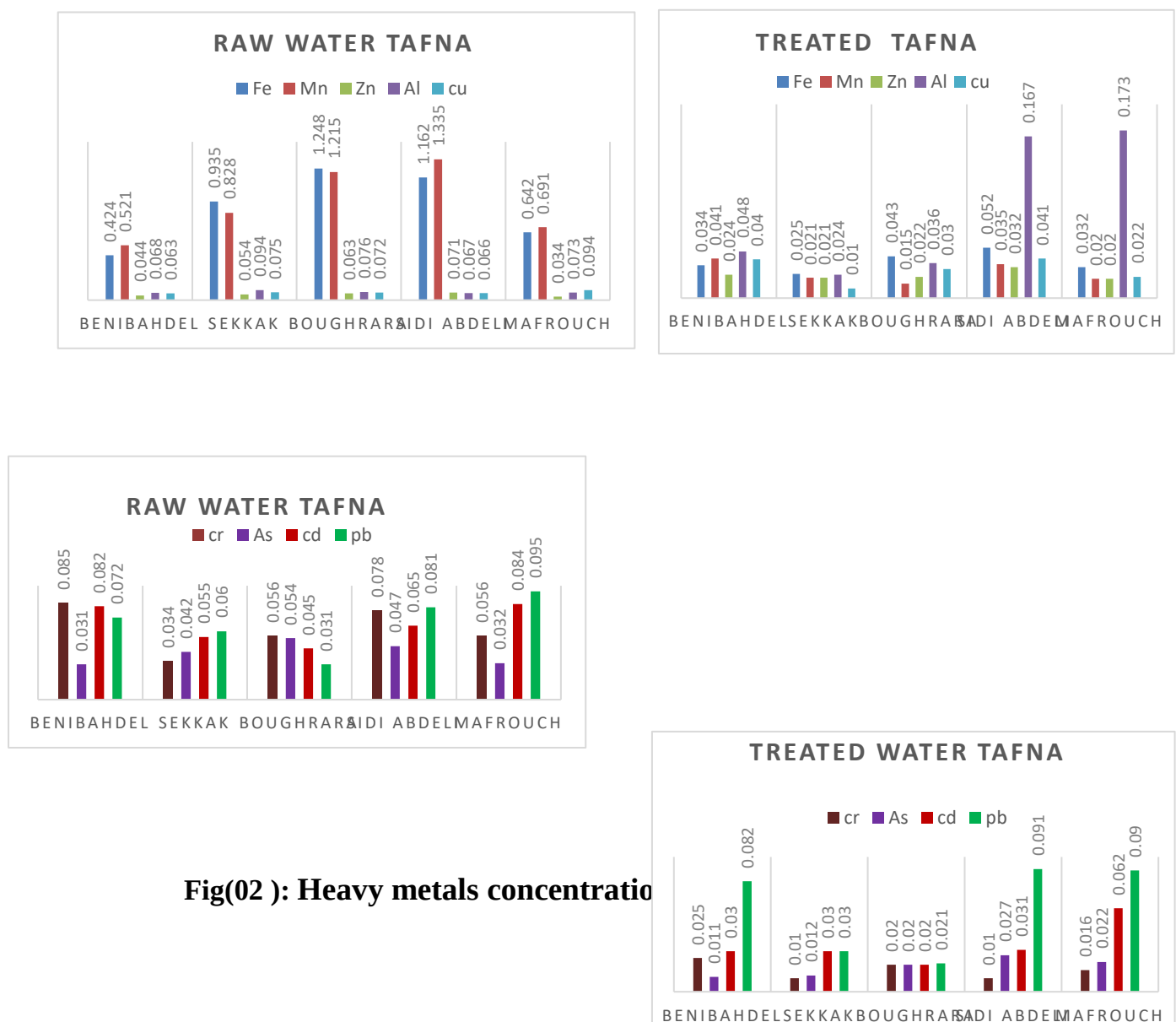
Column1	PH	O2 mg/l	PO4	NO3	NO2	NH4	T	oxidizabilitywith kmno4
Cheurfa	8,92	9,52	0,86	9,33	0,52	0,52	18,43	11,42
Bouhanifia	7,85	9,42	0,73	6,83	0,18	0,22	17,22	10,32
Fergoug	7,62	7,24	0,52	8,53	0,32	0,4	16,05	10,2
Sarno	8,33	9,45	0,22	5,25	0,25	0,22	16,2	7,26
Ouizert	7,4	9,23	0,43	7,3	0,13	0,24	16,08	8,52
Benibahdel	7,33	9,24	0,21	4,84	0,12	0,11	17,2	6,48
Sekkak	7,45	9,35	0,28	6,23	0,02	0,12	16,25	8,84
Bouhrara	8,82	9,48	0,15	5,55	0,46	0,24	16,35	10,26
Sidi Abdeli	7,4	9,2	0,13	7,2	0,1	0,37	17,45	9,07
Mafrouch	7,4	9,42	0,1	5,12	0,09	0,12	16,44	6,23

Figure 4: Evolution of physicochemical parameters of raw waters during the 4th quarte

Toxicity and Environmental Impact of Heavy Metals: Sources, Characteristics, and Industrial Contributions

Heavy metals are elements with atomic weights ranging from 63.5 to 200.6 and a density exceeding 5.0 g/cm³(Srivastava and Majumder, 2008). Due to the rapid growth of various industries, such as metal plating facilities, mining operations, fertilizer production, battery manufacturing, paper mills, and pesticide formulation, heavy metals are being increasingly discharged, either directly or indirectly, into the environment, particularly in developing nations. In contrast to living organisms and many heavy metal ions, heavy metals are recognized for their toxic and carcinogenic properties. Toxic heavy metals of particular interest in the treatment of industrial wastewater are zinc, copper, nickel, mercury, cadmium, lead, and chromium.

3.1. Interpretation of heavy metals results in the *Tafna* watershed



Fig(02): Heavy metals concentration

Iron: The results show that the highest iron contents were found in the raw waters of the *Boughrara* and *Sidi Abdeli* dams, 1.248mg/l and 1.162mg/l respectively. These results exceed the established standards of 1mg/l in raw waters. These concentrations have been eliminated and reduced by the treatment carried out at each dam treatment station, with iron levels ranging between 0.043mg/l (*B Boughrara*) and 0.052 mg/l (*B Sidi Abdeli*), which are below the established standards of 0.3mg/L in treated waters.

Meanwhile, concentrations recorded in the raw waters of the 3 dams (*B. BeniBahdel*, *B. Sekkak*, and *B. Mafrouch*) range between 0.424mg/l, 0.935mg/l, and 0.642mg/l respectively, which are below the established standards in raw waters. For treated waters, the values range between 0.034mg/l (*B. BeniBahdel*) and 0.025 mg/l (*B. Sekkak*), and between 0.032 mg/l (*B. Mafrouch*), which are below the established standards. Iron removal can be done by oxidation-aeration followed by filtration or by biological oxidation.

Manganese: The highest manganese concentrations were found in the raw waters of the *Boughrara* and *Sidi Abdeli* 1 dams, 1.215mg/l and 1.335mg/l respectively. These results are higher than the established standards of 1mg/l in raw waters.

These concentrations have been eliminated and reduced by the treatment carried out at the treatment stations of each dam, with manganese levels ranging between 0.015mg/l (*B. Boughrara*) and 0.035mg/l (*B. Sidi Abdeli*). These results are lower than the established standards of 0.05mg/L in treated waters. While concentrations recorded in the raw waters of the 3 dams (*B. BeniBahdel*, *B. Sekkak*, and *B. Mafrouch*) vary between 0.521mg/l, 0.828mg/l, and 0.691mg/l respectively, they are lower than the established standards in raw waters. For treated waters, the values range between 0.041mg/l (*B. BeniBahdel*) and 0.021mg/l (*B. Sekkak*), and between 0.020mg/l (*B. Mafrouch*). These results are lower than the established standards.

Zinc: Zinc is an essential trace element, but becomes toxic at high concentrations. For zinc, the concentrations found in the raw and treated waters of the studied dams in the *Tafna* watershed are lower than the established standards of 5mg/l. The values found in the raw waters of the dams are slightly higher than in the treated waters. The concentrations recorded in the raw waters vary between 0.044mg/l (*B. BeniBahdel*), 0.054mg/l (*B. Sekkak*), 0.063mg/l (*B. Boughrara*), 0.071mg/l (*B. Sidi Abdeli*), and 0.034mg/l (*B. Mafrouch*). These results are lower than the established standards in raw waters of 5mg/l. For treated waters, the values range between 0.024mg/l (*B. BeniBahdel*), 0.021mg/l (*B. Sekkak*), 0.022mg/l (*B. Boughrara*), 0.032mg/l (*B. Sidi Abdeli*), and 0.020mg/l. These results are lower than the established standards in raw waters of 5mg/l.

Aluminum: Aluminum levels were found in the raw waters of the dams ranging between 0.068mg/l (B. BeniBahdel), 0.094mg/l (B. Sekkak), 0.076mg/l (B. Boughrara), 0.067mg/l (B. Sidi Abdeli), and 0.073mg/l (B. Mafrouch. These results are lower than the established standards in raw waters of 1mg/l. For treated waters, an increase in concentrations was recorded in the treated waters of the AidiAbdeli and Mafrouch dams, between 0.167mg/l and 0.173mg/l respectively, due to the use of aluminum sulfate coagulant.

While the values recorded in the treated waters range between 0.048mg/l (B. BeniBahdel), 0.024mg/l (B. Sekkak), 0.036mg/l (B. Boughrara) are lower than the required standard of 0.2mg/l. Knowing that the treatment stations of the Boughrara and Sekkak dams use ferric chloride as a coagulant.

Copper: Copper is widely used in alloys (brass, bronze, nickel silver), the electrical industry, surface treatment, electroplating, as well as in agricultural treatments. Algerian regulations set a limit of 2 mg/L in raw and treated waters. The values found for the 5 dams studied in the Tafna watershed are well below the prescribed standards, ranging between 0.063mg/l (B. BeniBahdel), 0.075mg/l (B. Sekkak), 0.077mg/l (B. Boughrara), 0.066mg/l (B. Sidi Abdeli), and 0.094mg/l (B. Mafrouch). For treated waters, the values range between 0.040mg/l (B. BeniBahdel), 0.010mg/l (B. Sekkak), 0.030mg/l (B. Boughrara), 0.041mg/l (B. Sidi Abdeli), and 0.022mg/l.

Chromium: Natural concentrations of chromium in surface waters and aquifers are directly dependent on regional geological characteristics, mineral weathering, rate of sediment accumulation and precipitation regimes. The concentrations found in the raw waters of the dams studied in the Tafna watershed vary between 0.085 mg /l (B. Beni Bahdel), 0.034µg /l (B. Sekkak), 0.056µg /l (B Boughrara) 0.078µg /l (B Sidi Abdelli) and 0.056µg /l (B. Mafrouch), these results are lower than the established standards 100µg/l. For treated water the values range between 0.025µg /l (B.BeniBahdel), 0.010µg /l (B.Sekkak), 0.020µg /l (B Boughrara) 0.01µg /l (B Sidi Abdeli) and 0.016µg /l L. are below the established standards of 50µg /l

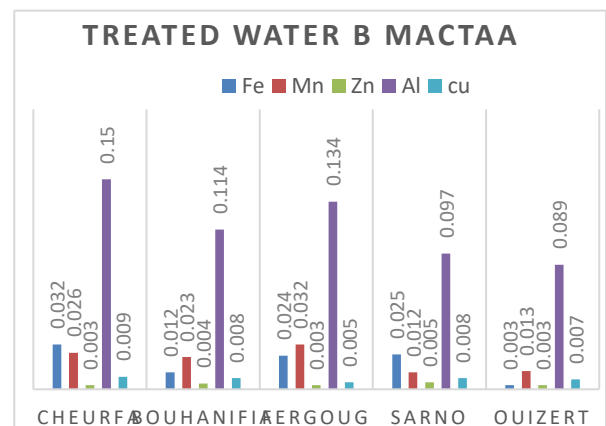
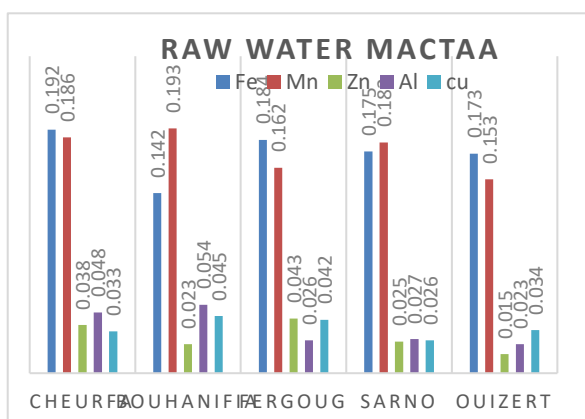
The Arsenic: Groundwater is generally more vulnerable to contamination than surface water, due to its interaction with aquifer minerals which leads to the release of arsenic under physico-chemical conditions favorable to arsenic exposure through drinking water (groundwater) has caused a serious disease of the blood vessels leading to gangrene, known as "black foot disease" (Mcguigan., 2012). The concentrations found in the raw waters of the studied dams in the

Tafnawatershed range from 0.031 µg/l (*B.BeniBahdel*), 0.042 µg/l (*B.Sekkak*), 0.054 µg/l (*B Boughrara*), 0.047 µg/l (*B Sidi Abdeli*) and 0.032 µg/l (*B. Mafrouch*). These results are below the established standards of 100 µg/l. For treated waters, the values found range between 0.011 µg/l (*B.BeniBahdel*), 0.012 µg/l (*B.Sekkak*), 0.020 µg/l (*B Boughrara*), 0.027 µg/l (*B Sidi Abdeli*) and 0.022 µg/l. These values are below the established standards of 10 µg/l.

Cadmium: It is one of the most toxic metallic contaminants, mainly originating from anthropogenic inputs. In fresh waters and for pH < 8, dissolved Cd is predominantly found in the form of Cd²⁺ complexed preferentially by humic substances. In general, the cadmium levels in the 5 studied dams in the Tafnawatershed vary between 0.082 µg/l (*B.BeniBahdel*), 0.055 µg/l (*B.Sekkak*), 0.045 µg/l (*B Boughrara*), 0.065 µg/l (*B Sidi Abdeli*), and 0.084 µg/l (*B. Mafrouch*) are lower than the standard of 5 µg/l in raw water. For treated water, the values found range between 0.03 µg/l (*B.BeniBahdel*), 0.03 µg/l (*B.Sekkak*), 0.020 µg/l (*B Boughrara*), 0.031 µg/l (*B Sidi Abdeli*), and 0.062 µg/l are lower than the standard 3 which represents the limit values provided by the Algerian standard.

Lead: Lead is naturally present in the earth's crust in the form of minerals such as galena (PbS), which represents the primary source. Lead is found at varying levels between 0.072 µg/l (*B.BeniBahdel*), 0.06 µg/l (*B.Sekkak*), 0.031 µg/l (*B Boughrara*), 0.081 µg/l (*B Sidi Abdeli*), and 0.095 µg/l (*B. Mafrouch*), which are below the established standards of 50 µg/l. The values found in treated waters range between 0.082 µg/l (*B.BeniBahdel*), 0.03 µg/l (*B.Sekkak*), 0.021 µg/l (*B Boughrara*), 0.091 µg/l (*B Sidi Abdeli*), and 0.090 µg/l, not exceeding the standard set by Algerian regulations of 10 µg/l.

3.3. Interpretation of heavy metals results in the Mactaa watershed.



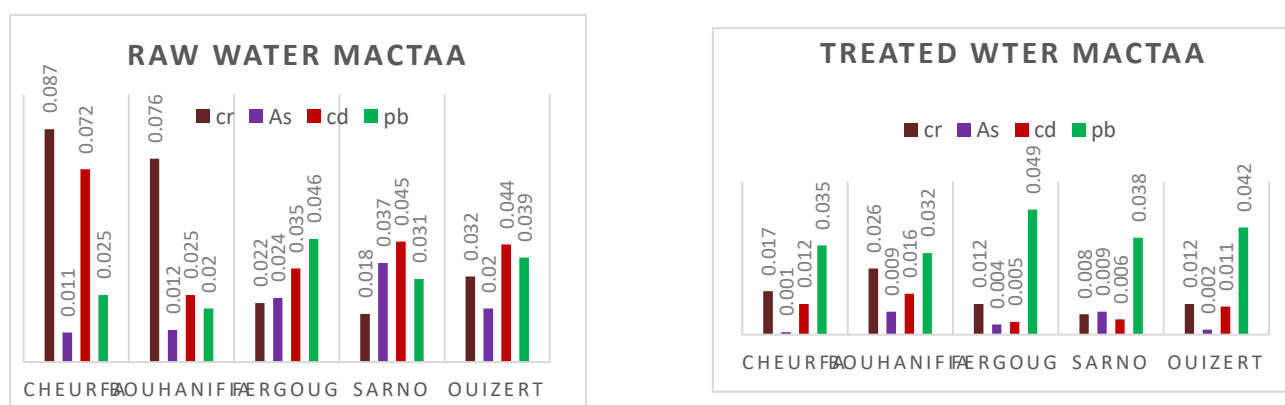


Figure 3: Heavy metals concentration in the *Macta* watershed

The iron: The concentrations recorded in the raw waters of the 5 dams in the Mactaa watershed (*B.Cheurfa*, *B. Bouhanifia*, *B.Fergoug*, *B Sarno*, *B. Ouizert*) vary between (0.192mg/l, 0.142mg/l, 0.184mg/l, 0.175mg/l, and 0.179mg/l) respectively are lower than the established standards of 1mg/l in raw waters. For treated waters, the values range between 0.032 mg/l, 0.012 mg/l, 0.024 mg/l, 0.025 mg/l, and 0.003 mg/l at the level of treated waters from the 5 dams (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*) respectively. These results are below the established standards of 0.3 mg/L in treated waters. Iron removal can be done by oxidation-aeration followed by filtration or by biological oxidation.

Manganese: The concentrations recorded in the raw waters of the 5 dams in the Mactaa watershed (*B.Cheurfa*, *B. Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.Ouizert*) vary between (0.186 mg/l, 0.193 mg/l, 0.162 mg/l, 0.182 mg/l, and 0.153 mg/l) respectively, and are below the established standards of 1 mg/l in raw waters. After treatment by oxidation-aeration, the values of treated waters range between 0.026 mg/l, 0.023 mg/l, 0.032 mg/l, 0.012 mg/l, and 0.013 mg/l at the level of the 5 treatment stations of the dams (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*) respectively. These results are below the established standards of 0.3 mg/L in treated waters.

Zinc: The concentrations found in the raw and treated waters of the studied dams in the *Mactaa watershed* are below the established standards of 5 mg/l. The values found in the raw waters of the 5 dams (*B.Cheurfa*, *B. Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*) vary between (0.038 mg/l, 0.23 mg/l, 0.43 mg/l, 0.25 mg/l, and 0.15 mg/l) respectively. These results are below the established standards of 5 mg/l in raw waters.

For treated waters, the values range between (0.003 mg/l, 0.004 mg/l, 0.003 mg/l, 0.005 mg/l, and 0.003 mg/l) at the level of the 5 treatment stations of the dams (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*) respectively. These results are below the established standards of 5 mg/l. Our results are comparable to those found by (Pang et al.,2011).

Aluminum: The aluminum levels found in the raw waters of the dams vary between 0.048 mg/l (*BCheurfa*), 0.054 mg/l (*B.Bouhanifia*), 0.026 mg/l (*B Fergoug*), 0.027 mg/l (*B sarno*), and 0.023 mg/l (*B. ouizert*). These results are below the established standards of 1 mg/l in raw waters. The values of the treated waters are higher due to treatment with the coagulant (alum sulfate), an increase in concentrations was recorded in the treated waters of the dams (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*).with concentrations ranging between 0.150 mg/l, and 0.114 mg/l, 0.134 mg/l, 0.097 mg/l, and 0.089 mg/l) respectively. These results comply with the required standard of 0.2 mg/l.

Copper: The values found for the 5 dams studied in the *Mactaa watershed* are well below the prescribed standards of 2 mg/l, ranging between 0.033 mg/l, 0.045 mg/l, 0.042 mg/l, 0.026 mg/l, 0.044 mg/l in the raw waters of the dams (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*) respectively. For treated waters, the values range between 0.009 mg/l (*B.Cheurfa*), 0.008 mg/l (*B.Bouhanifia*), 0.005 mg/l (*B Fergoug*), 0.008 mg/l (*B Sarno*), and 0.007 mg/l (*B Ouizert*).

Chromium: The concentrations found in the raw waters of the studied dams in the *Mactaa watershed* (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*) range from 0.087mg /l, 0.076µg /l, 0.022µg /l, 0.018µg /l, and 0.032µg /l respectively, these results are lower than the established standards of 100µg /l in raw waters. For the treated waters, the values range between 0.017µg /l, 0.026µg /l, 0.012µg /l, 0.008µg /l, and 0.012µg /l at the dam treatment stations (*B.Cheurfa*, *B.Bouhanifia*, *B.Fergoug*, *B Sarno*, *B.ouizert*), the results are lower than the established standards of 50µg /l in treated waters.

Arsenic: The concentrations found in the raw waters of the studied dams in the *Mactaa watershed* range from 0.011µg /l (*B.Cheurfa*), 0.012µg /l (*B.Bouhanifia*), 0.024µg /l (*B Fergoug*), 0.037µg /l (*B Sarno*), and 0.020µg /l (*B. Ouizert*), these results are lower than the established standards of 100µg /l. And for the treated waters, the values found range between 0.001µg /l (*B.Cheurfa*), 0.009µg /l (*B. Bouhanifia*), 0.004µg /l (*B Fergoug*), 0.009µg /l (*B*

Sarno), and $0.002\mu\text{g/l}$ (B. Ouizert). These values are lower than the established standards of $10\mu\text{g/l}$.

Cadmium: The cadmium levels of the 5 dams studied in the *Mactaa watershed* range from $0.072\mu\text{g/l}$ (B.cheurfa), $0.025\mu\text{g/l}$ (B.Bohanifia), $0.035\mu\text{g/l}$ (B Fergoug), $0.045\mu\text{g/l}$ (B Sarno), and $0.044\mu\text{g/l}$ (B. Ouizert) are lower than the standard of $5\mu\text{g/l}$ in raw waters and for the treated waters the values found range between $0.012\mu\text{g/l}$ (B.Cheurfa), $0.016\mu\text{g/l}$ (B.Bouhanifia), $0.005\mu\text{g/l}$ (B Fergoug), $0.006\mu\text{g/l}$ (B Sarno), and $0.011\mu\text{g/l}$ (Ouizert) are lower than the standard of $3\mu\text{g/l}$ which represents the limit values provided by the Algerian standard.

Lead: Lead is found at variable levels between $0.025\mu\text{g/l}$ (Cheurfa), $0.20\mu\text{g/l}$ (B.Bouhanifia), $0.046\mu\text{g/l}$ (B Fergoug), $0.031\mu\text{g/l}$ (B Sarno), and $0.039\mu\text{g/l}$ (B. Ouizert) are lower than the established standards of $50\mu\text{g/l}$, while the values found in the treated waters are slightly higher than in raw waters due to the release of lead in the treatment station equipment such as pumps and lead pipes manufactured in lead. These values range between $0.035\mu\text{g/l}$ (B.BeniBahdel), $0.032\mu\text{g/l}$ (B.Sekkak), $0.049\mu\text{g/l}$ (B Boughrara), $0.038\mu\text{g/l}$ (B Sidi Abdeli) and $0.042\mu\text{g/l}$, they do not exceed the standard established by the Algerian regulation of $10\mu\text{g/l}$.

4. Conclusion

In nature, water is a true source of life, but it can carry many diseases, some of which can be deadly. The use of surface waters requires us to treat these waters to make them potable while preserving their physicochemical qualities and controlling the presence of heavy metals. The results of physicochemical analyzes show that the levels recorded in organic matter of the two *Tafna* and *Mactaa watershed* basins could mainly come from natural pollution (decomposing vegetation) and very little from exogenous pollution (urban discharges and agricultural practices). The levels of organic matter in surface waters vary according to the vegetal and animal characteristics of the watershed.

In general, the levels of cadmium, arsenic, chromium, copper, lead, aluminum, zinc, iron, and manganese in the raw waters of the 5 dams studied in the *Mactaa watershed* (cheurfa, sarno, bouhanifia, fergoug, ouizert) comply with the required standards. After treatment, a decrease in metal concentrations was observed.

for the *Tafna basin*, the raw water from the two Boughrara and Sidi Abdeli dams has high levels of iron and manganese and after treatment by oxidation-aeration followed by filtration, the concentrations are reduced and comply with the required standard, cadmium levels, arsenic, chromium, copper, lead, aluminum, zinc in raw water from 5 dams studied in the *Tafna watershed* comply with the required standards

We can say that the surface waters of the 10 dams in the two *Mactaa* and *Tafna basins* are of good quality and present no danger for human consumption.

References

- Akatumbila, L., Mabiala Lubini, A., & Pwema, K. (2016). Contribution to the evaluation of physicochemical quality of water: case of the urban river Gombe in Kinshasa/Democratic Republic of Congo. *Larhyss Journal*, 26, 7-29. <http://larhyss.net/ojs/index.php/larhyss/article/view/410>
- Aranda, A., Rivera-Ruiz, D., Rodríguez-López, L., Pedreros, P., Arumí-Ribera, J., Morales-Salinas, L., Fuentes-Jaque, G., & Urrutia, R. (2021). Evidence of climate change based on lake surface temperature trends in south central Chile. *Remote Sensing*, 13(22), 4535. <https://doi.org/10.3390/rs13224535>
- Bahroun, S., Touioui, K., Gheid, S., & Drouiche, N. (2023). The conception of GIS to evaluate the impact of anthropogenic activities on the quality of surface waters of the dams of the hydrographic region of Constantinois-Seybouse-Mellegue, Algeria. *Desalination and Water Treatment*, 289, 35–49. <https://doi.org/10.5004/dwt.2023.29471>
- Guergazi, S., Harrat, N., & Achour, S. (2006). Organic parameters and potential formation of chloroform in surface waters of eastern Algeria. *Larhyss Journal*, 07, 45-50. <https://www.asjp.cerist.dz/en/downArticle/128/7/7/77973>
- Hadji, F., Guasmi, I., & Aggab, C. (2020). Organic chemical characterization of water of the northwestern Algerian dams. In *The Handbook of Environmental Chemistry* (pp. 35–55). https://doi.org/10.1007/698_2020_531
- Liu, X., Han, G., Zeng, J., Liu, M., Li, X., & Boeckx, P. (2020). Identifying the sources of nitrate contamination using a combined dual isotope, chemical and Bayesian model approach

in a tropical agricultural river: Case study in the Mun River, Thailand. *The Science of the Total Environment*, 760, 143938. <https://doi.org/10.1016/j.scitotenv.2020.143938>

Makhoukh, M., Sbaa, M., Berraho, A., & Van Clooster, M. (2011). Contribution to the physico-chemical study of surface waters of the Moulouya river (Eastern Morocco). *Larhyss Journal*, 09, 149-169. https://www.jmaterenvironsci.com/Document/vol8/vol8_N6/203-JMES-2576-Ech%20chafy.pdf

Mehanned, A., Chahlaoui, A., Zaid, M., & Samih. (2014). Typology of the physico-chemical quality of the water of the Sidi Chahed dam Morocco. *J. Mater. Environ. Sci.*, 5(5), 1633-1642. https://www.jmaterenvironsci.com/Document/vol5/vol5_N5/200-JMES-902-2014-Mehanned.pdf

McGuigan, M. A. (2012). Chronic poisoning. In Elsevier eBooks (pp. 88–95). <https://doi.org/10.1016/b978-1-4377-1604-7.00021-x>

Mulliss, R., Revitt, D., & Shutes, R. (1996). The impacts of urban discharges on the hydrology and water quality of an urban watercourse. *Science of The Total Environment*, 385-390. [https://doi.org/10.1016/0048-9697\(96\)05235-7](https://doi.org/10.1016/0048-9697(96)05235-7)

N'guessan, A. K., Koffi, K. M., Kamelan, M. T., & N'Douba, V. (2020). Physical and chemical characterization of the Bagoue Watershed (North-Western Cote D'Ivoire) impacted by artisanal and clandestine gold mining. *Journal of Environment Pollution and Human Health*, 8(1), 20–28. <https://doi.org/10.12691/jephh-8-1-3>

Pang, F. M., Kumar, P., Teng, T. T., Omar, A. M., & Wasewar, K. L. (2011). Removal of lead, zinc and iron by coagulation–flocculation. *Journal of the Taiwan Institute of Chemical Engineers*, 42(5), 809–815. <https://doi.org/10.1016/j.jtice.2011.01.009>

Ramsey, C. A. (2015). Considerations in sampling of water. *Journal of AOAC International*, 98(2), 316–320. <https://doi.org/10.5740/jaoacint.14-251>

Stehle, S., & Schulz, R. (2015). Agricultural insecticides threaten surface waters at the global scale. *Proceedings of the National Academy of Sciences*, 112, 5750 - 5755. <https://doi.org/10.1073/pnas.1500232112>

Tariq, M., Anayat, A., Waseem, M., Rasool, M. H., Zahoor, M. A., Ali, S., Rizwan, M., Abdel-Daim, M. M., & Alkahtani, S. (2020). Physicochemical and bacteriological characterization of

industrial wastewater being discharged to surface water bodies: significant threat to environmental pollution and human health. *Journal of Chemistry*, 2020, 1–10. <https://doi.org/10.1155/2020/9067436>

Tiri, A., Belkhiri, L., Asma, M., & Mouni, L. (2020). Suitability and assessment of surface water for irrigation purpose. In IntechOpen eBooks. <https://doi.org/10.5772/intechopen.86651>

Whitehead, P., Wilby, R., Battarbee, R., Kernan, M., & Wade, A. (2009). A review of the potential impacts of climate change on surface water quality. *Hydrological Sciences Journal*, 54, 101 - 123. <https://doi.org/10.1623/hysj.54.1.101>

Widyastuti, M., Irshabdillah, M. R., & Firizqi, F. (2020). Water quality analysis of bribin underground river as the source of raw water for a government-owned water company (PDAM) in the Bribin management unit, Gunungkidul regency-Indonesia. *IOP Conference Series Earth and Environmental Science*, 451(1), 012065. <https://doi.org/10.1088/1755-1315/451/1/012065>

Official Journal of The Democratic and People's Republic of Algeria, Executive Decree No. 14-96 of 2 Jomada El Oula 1435 corresponding to March 4, 2014 relating to the quality of water for human consumption.

Official Journal of The People's Democratic Republic of Algeria, Executive Decree No. 11-219 of 10 Rajab 1432 corresponding to June 12, 2011 setting the quality objectives of surface water and groundwater intended for the water supply of populations.