Organic Chemical Characterization of Water of the Northwestern Algerian Dams

Fatiha Hadji, Imen Guasmi, and Chahrazed Aggab

Contents

Abstract The aim of this study concerns the water quality of the western Algerian dams. Various analyses of water were made for ten dams belonging to Tafna and Macta watersheds. They are generally used for human consumption and for irrigation purposes.

The analyzed parameters were pH, dry residue (DR), dissolved oxygen (DO), nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+),orthophosphate (PO_4^{3-}), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and organic matter (OM). Analyses were done monthly during 2013 and concerned ten dams of the aforementioned basins.

Waters of the dams were very alkaline with values ranging between 7.01 and 8.97, and important DR concentrations were observed at Sarno dam (Macta watershed) located upstream of the confluence of Mekerra and Sarno wadis and where

F. Hadji (✉) and C. Aggab
Department of Earth and Universe Sciences, University of Tlemcen, Tlemcen, Algeria
e-mail: fm_hachemi@yahoo.fr; chrzd_a90_2005@yahoo.fr

I. Guasmi
Department of Hydraulics, University of Tlemcen, Tlemcen, Algeria
e-mail: guasmi_imen@yahoo.fr

Abdelazim M. Negm, Abdelkader Bouderbala, Haroun Chenchouni, and Damià Barceló (eds.), *Water Resources in Algeria - Part II: Water Quality, Treatment, Protection and Development*, Hdb Env Chem (2020) 98: 35–56, DOI 10.1007/698_2020_531,

values were between 2,700 and 4,000 mg L^{-1}. The highest BOD_5, COD, and MO contents were recorded at Hammam Boughrara dam situated within Tafna watershed with maximum BOD_5 and MO in July and maximum COD in December. The organic pollution index (2.25–4.00) and COD/BOD_5 (3.7–7.2) values indicated moderate to strong pollution and reveal that all waters were more or less difficult to biodegrade.

Keywords Dams, Quality, Standards, Water, Watersheds, Western Algeria

1 Introduction

In order to meet the needs of fresh water for different uses, the most logical solution is the surface water storage in dams. To ensure its independence and guarantee its water resource needs [1], Algeria has already taken this problem very seriously. In 1962, there were only 15 dams to store 450 million m^3 of water mainly for irrigation use. Currently, there are 79 [2] for a total capacity of about 8 billion m^3 of water. These dams are located within 17 watersheds (Fig. 2) which some of them are the aim of this study, (1) the endorheic basins occupying the High Plains whose waters are largely lost by evaporation in the chotts. The annual flow is estimated at 700 hm^3 and (2) the Saharan basins with an average intake of 650 hm^3 per year [1]. This surface water collected in dams may be polluted and contain important levels of salts, toxic ions, heavy metals, and organic residues [3]. Accumulation of these pollutants when in water and soils may cause a threat to agricultural production and the environment [4]. For example, release of phosphorus and nitrogen into water-courses then in dams can lead to severe pollution problems, such as eutrophication [5, 6], which cause profuse algal blooms, excessive growth of harmful plants, oxygen depletion, habitat degradation, and problems related to water treatment [7, 8]. In addition to contributing to eutrophication, forms of nitrogen such as ammonia, nitrite, and nitrate have the potential for direct toxicity [8, 9].

Organic matter content in water comes generally from crop wreckage, food waste, other degradable solid wastes [10], and fecal matters [11]. Algal and phytoplankton growth is enhanced by nutrients which are supplemented by fertilizers and finally results in eutrophication [12].

Monitoring the water quality for human consumption and/or irrigation purpose becomes necessary to protect human health, soil, plants, and water bodies and to prevent the deterioration of irrigation and treatment infrastructures [13].

Many studies have been published concerning the assessment of water quality in rivers [14–19] and dams [20–25] using physical, chemical, and biological parameters and permitted (1) the assessment of water quality in these water bodies and (2) the identification of the pollutants discharged into and their effects on water quality. This way of doing can give warnings to consumers in order to prevent dangerous and unhealthy situations.

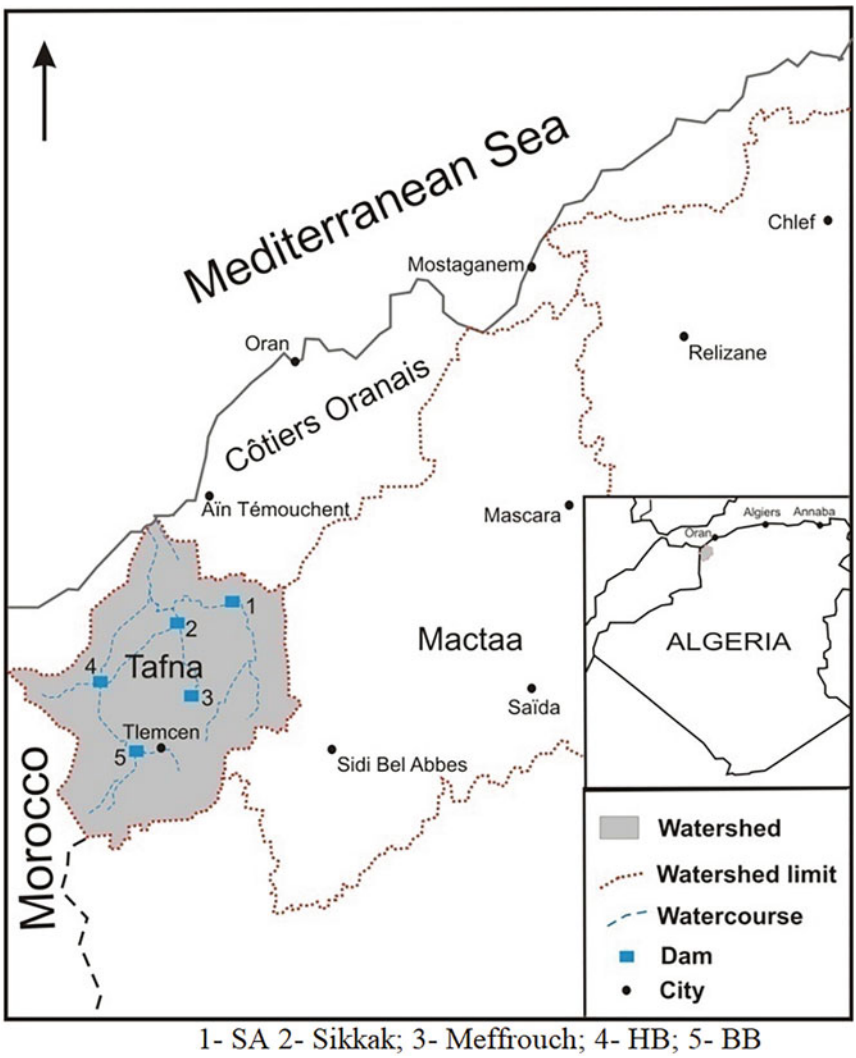

Fig. 2 Location of Tafna watershed dams

The aim of this study concerned the assessment of water quality of ten dams belonging to Tafna and Macta watersheds. The prime objectives were to evaluate physical and organic chemical characteristics of water, to identify polluted dams, and to assess the difference in water quality of dams and watersheds. The second objective was the assessment of spatial and temporal variability in the water quality and their suitability for irrigation purposes.

2 Materials and Methods

The study dams (Fig. 1) are located in the northwest of Algeria. They administratively belong to four wilayas: Tlemcen, Ain Temouchent, Mostaganem, Sidi Bel-Abbes, and Mascara. Their basins are limited by the Oran coastal watersheds at north, by Morocco at west, by Chott Ech Chergui watershed at south, and to the east by Chelif watershed .The dams covered by this study are included in Tafna (5) (Fig. 2) and Macta (5) (Fig. 3) watersheds.

Table 1 summarizes the dams of concern, the watersheds they drain, and the water use.

The analyzed parameters were pH, dry residue (DR), dissolved oxygen (DO), nitrate (NO_3^-), nitrate (NO_2^-), ammonium (NH_4^+), phosphate (PO_4^{3-}), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and organic matter (OM). Analyses were done monthly during January–December 2013 year.

For Tafna watershed, analyses concerned water dams of Sidi-Abdelly (SA), Sikkak, Meffrouch, Hammam Boughrara (HB), and Beni Behdel (BB) (Fig. 2). As for Macta basin, analyzed water concerned Fergoug, Bouhanifia, Ouizert, Cheurfa, and Sarno dams (Fig. 3). These surface waters are generally used for human consumption and irrigation purposes (Table 1).

3 Results and Discussion

Tables 2 and 3 summarize the minimum and maximum values of the analyzed parameters of the water dams.

3.1 Physical and Chemical Characterization

3.1.1 Variations in pH and Dissolved Oxygen

The recorded pH values in Tafna (7.36–8.97) (Fig. 4a) and in Macta (7.01–8.62) (Fig. 4b) watershed dams show that all water dams are alkaline (Tables 2 and 3).

Depletion of dissolved oxygen in water can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide and cause an increase in the concentration of ferrous iron [19]. Its consumption results from excessive algae growth and decomposition caused by phosphorus and nitrogen compounds [26]. Dissolved oxygen values (Tables 2 and 3) range from 36.3% to 154.3% in Tafna dams (Fig. 5a) where the highest values were recorded at HB (in January) and Sikkak (in July) dams. As for Macta watershed, DO levels were greater than in Tafna dams. They vary from 54.4 (in January) to 160.3% (in September) (Fig. 5b) in Cheurfa dam. DO can be affected directly by biochemical and chemical demands; the greater the BOD_5, the

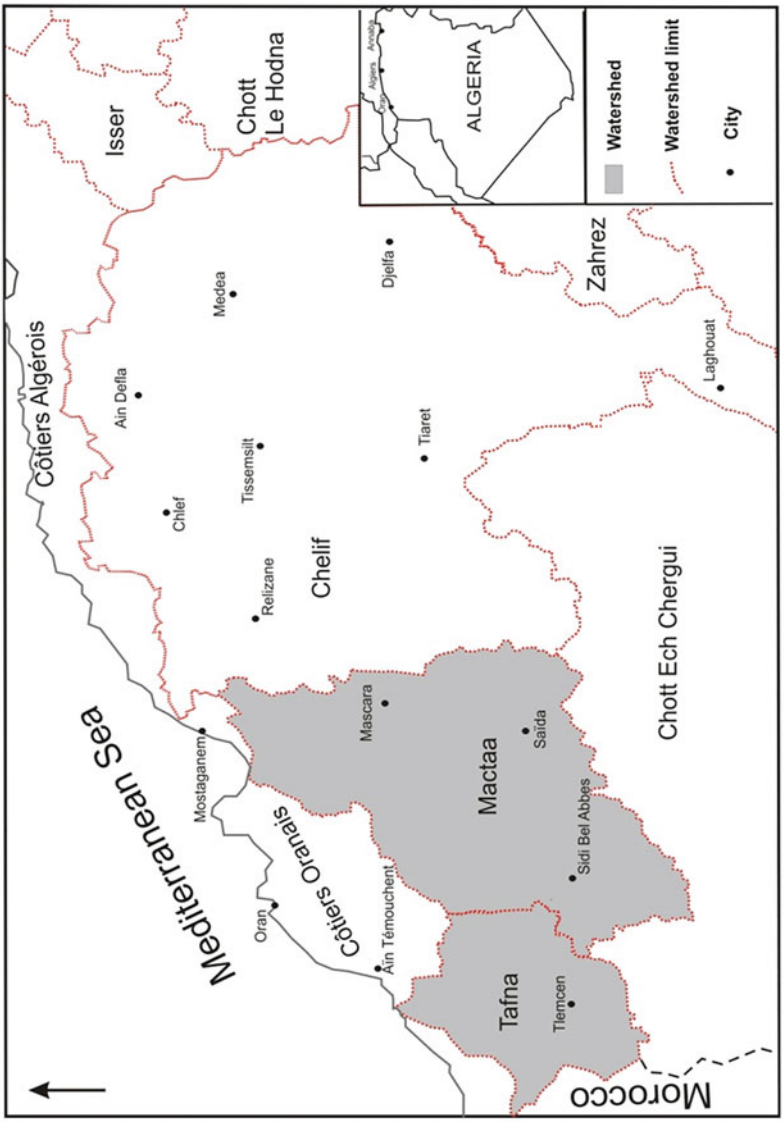

Fig. 1 Location of study area

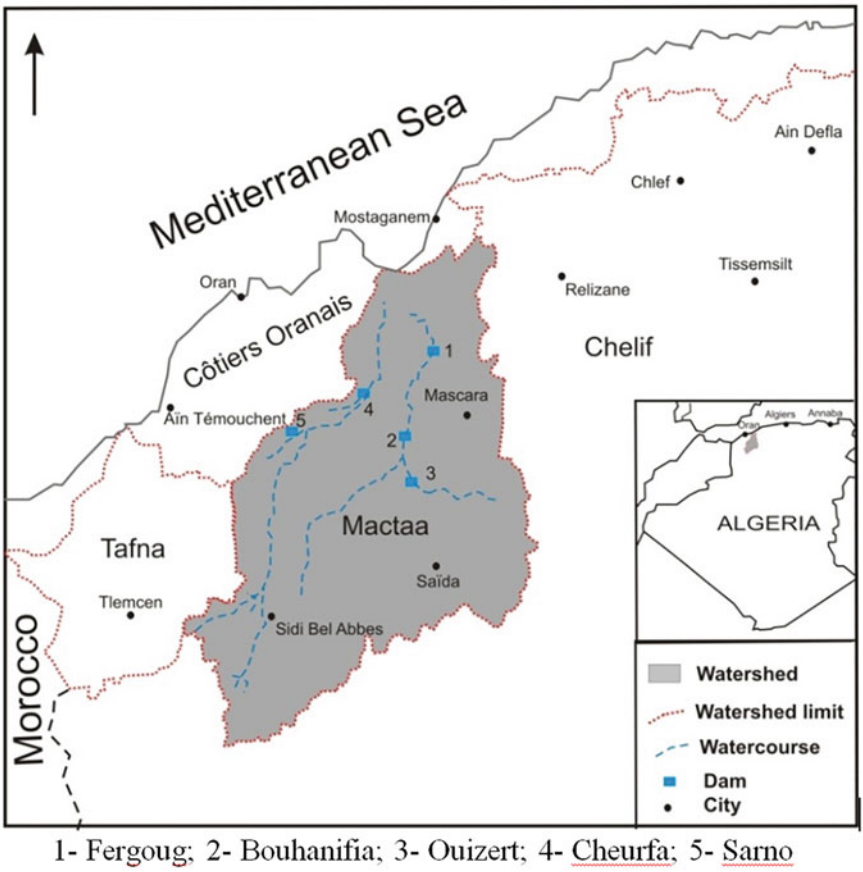

Fig. 3 Location of Macta watershed dams

more rapidly dissolved oxygen is depleted in the water bodies. This means that less oxygen is available to aquatic life forms [27]. BOD_5 refers to the amount of oxygen required for the destruction of decomposable organic matter by biochemical processes. It is a measure of the dissolved oxygen consumed by microorganisms during the oxidation of reduced substances [27]. High BOD_5 levels can cause water quality deterioration and generate problems such as eutrophication leading to severe DO depletion [28].

3.1.2 Dry Residue

Dry residue contents are greater in Macta watershed dams (400–4,000 mg L^{-1}) than in Tafna one (200–1,200 mg L^{-1}) (Fig. 6a). Important concentrations were observed at Sarno dam (Fig. 6b) located upstream of the confluence of Mekerra and Sarno

Table 1 Different water uses of the study dams [2]

Watershed	Dam	Watershed surface (km^2)	Wadi	Use
Tafna	BB	1,016	Tafna	• Drinking water supply of Oran, Aïn Temouchent, and Tlemcen cities • Irrigation of Maghnia perimeter
	HB	90	Tafna	• Drinking water supply of Oran and Maghnia cities • Irrigation Tafna perimeter
	Meffrouch	1,138	Nachef	• Drinking water supply of Tlemcen city
	SA	248	Isser	• Drinking water supply of Oran and Aïn Temouchent cities
	Sikkak	4,000	Sikkak	• Drinking water supply of Tlemcen city • Irrigation of Hennaya plain
Macta	Cheurfa	7,850	Mebtouh	• Irrigation
	Fergoug	2,100	El Hammam	• Drinking water supply of Oran, Mohamadia, and neighboring localities; • Industrial water supply of Arzew city • Irrigation of Habra perimeter
	Ouizert	264	Sahouat	• Bouhanifia dam transfer
	Sarno	8,270	Sarno	• Water drinking supply of Sidi Hamadouche locality (Sidi Bel Abbes)
	Bouhanifia	4,190	El Hammam	• Water drinking supply of Sfisef and Bouhanifia localities • Irrigation of Hacine perimeter

Table 2 Minimum and maximum values of the analyzed parameters of Tafna dams

Parameter	SA	Sikkak	Meffrouch	HB	BB
pH	7.6–8.3	7.44–8.76	7.36–7.95	7.48–8.97	7.51–8.12
DR (mg L^{-1})	700–1,000	680–860	200–430	960–1,200	400–640
DO (%)	74.1–119	47.4–154.3	54.7–120	36.3–148.9	63.7–124.1
NO_3^- (mg L^{-1})	1–6	2–15	1–8	1–35	1–6
NO_2^- (mg L^{-1})	0.01–0.1	0.16–0.65	0.06–0.11	0.02–2.1	0.08
NH_4^+ (mg L^{-1})	0.05–0.25	0.05–1.02	0.06–0.38	0.07–4.46	0.22–0.83
PO_4^{3-} (mg L^{-1})	0.05–0.19	0.06–0.16	0.05–0.1	0.1–1.86	0.05–0.12
COD (mgL^{-1})	29–66	19–56	19–59	7.1–96	19–49
BOD_5 (mgL^{-1})	5.5–13	3.4–11.7	3.1–10.5	5.4–38	4.2–8.7
OM (mgL^{-1})	3.4–8.4	4.4–8.3	2.8–6	4.8–17.6	1.8–6.2
COD/BOD_5	4.5–6.2	4.5–7.2	4.5–6.7	4.4–5.7	4.5–6.7

wadis and where values were between 2,700 and 4,000 mg L^{-1} (Avg., 3,161.7 mg L^{-1}; SD, 668.8 mg L^{-1}) (Fig. 6a) during all the sampling period except in December (1,600 mg L^{-1}).

Table 3 Range of values of the analyzed parameters of Macta dams

Parameter	Fergoug	Bouhanifia	Ouizert	Cheurfa	Sarno
pH	7.57–8.33	7.01–8.29	7.65–8.48	7.59–8.62	7.77–8.37
DR (mg L^{-1})	1,400–2,260	400–1,500	600–1,360	1,000–2,200	1,600–4,000
DO (%)	74–152.3	87.5–141.1	70.4–154.3	54.4–160.3	76.8–120
NO_3^- (mg L^{-1})	1–9	1–8	1–18	1–20	1–11
NO_2^- (mg L^{-1})	0.03–0.90	0.02–0.26	0.03–0.80	0.03–0.80	0.01–0.14
NH_4^+ (mg L^{-1})	0.15–0.5	0.13–0.57	0.06–0.50	0.07–4.08	0.07–0.66
PO_4^{3-} (mg L^{-1})	0.08–0.30	0.02–0.15	0.04–0.19	0.22–1.30	0.04–0.22
COD (mg L^{-1})	56–94	47–96	47–125	75–154	38–67
BOD_5 (mg L^{-1})	10.5–22.7	8.7–19.4	11.5–23.7	17.1–37.9	7.9–15
OM (mg L^{-1})	5.50–15.40	5.3–9.4	4.7–13	1.7–20.5	7.8–11.2
COD/BOD_5	3.9–5.3	4.4–6.0	4.7–5.4	4.0–4.9	4.2–5.9

3.1.3 Variations in MO, BOD_5, and COD

In Tafna Basin, the highest BOD_5 (5.4–38 mg L^{-1}; Avg., 11.9 mg L^{-1}; SD, 9.4 mg L^{-1}) and COD (7.1–96 mg L^{-1}; Avg., 43.8 mg L^{-1}; SD, 21.7 mg L^{-1}) contents were recorded at HB dam with BOD_5 and COD maximum values in July and December, respectively (Fig. 7d). This dam receives, among others, wastewater of the complex of greasy substance via surface water flow of Mouillah wadi [29]. Organic matter contents were also maximum at HB dam (5.2–16 mg L^{-1}; Avg., 8.8 mg L^{-1}; SD, 3.8 mg L^{-1}) compared to those of Meffrouch (2.8–6.0 mg L^{-1}; Avg., 4.1 mg L^{-1}; SD, 1.1 mg L^{-1}), SA (3.4–8.4 mg L^{-1}; Avg., 5.2 mg L^{-1}; SD, 1.5 mg L^{-1}), Sikkak (4.4–8.3 mg L^{-1}; Avg., 6.3 mg L^{-1}; SD, 1.2 mg L^{-1}), and BB (1.8–6.2 mg L^{-1}; Avg., 4.0 mg L^{-1}; SD, 1.4 mg L^{-1}).

As for Macta watershed, maximum BOD_5 (17.1–37.9 mg L^{-1}; Avg., 24.1; SD, 6.4) and COD (75–154 mg L^{-1}; Avg., 104 mg L^{-1}; SD, 26.5 mg L^{-1}) values were found at Cheurfa dam (Fig. 8d). Organic matter levels were high than in Tafna dams. The maximum values (1.7–20.5 mg L^{-1}; 12.9 mg L^{-1}; 4.8 mg L^{-1}) were found at the aforementioned dam. The high contents of MO, BOD_5, and COD may probably be due to agricultural runoff, waste disposal, and wastewater effluent discharged into the watercourses feeding the dams.

3.1.4 Nitrate, Nitrite, and Ammonium

Nitrates come to water dams through surface water flow. They probably originate from the fertilizer uses as well as human and animal wastes. Nitrate concentrations range between 1 and 35 mg L^{-1} in the ten study dams. In Tafna watershed, nitrate ions were found in the following concentrations: HB (1–35 mg L^{-1}; Avg., 5.9 mg L^{-1}; SD, 9.6 mg L^{-1}) (Fig. 7d), Meffrouch (1–8 mg L^{-1}; Avg., 3.0 mg L^{-1}; SD, 1.9 mg L^{-1}) (Fig. 7c), SA (1–6 mg L^{-1}; Avg., 2.6 mg L^{-1}; SD, 1.5 mg L^{-1}), Sikkak (2–15 mg L^{-1}; Avg., 8.2 mg L^{-1}; SD, 5.2 mg L^{-1}) (Fig. 7b),

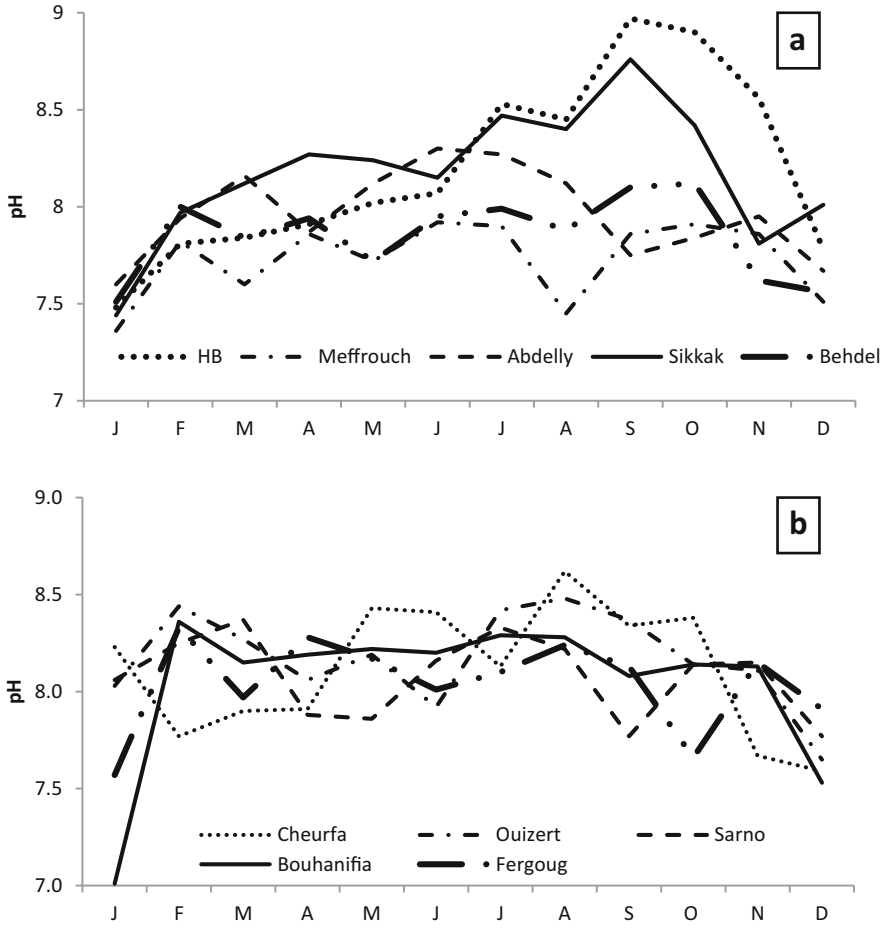

Fig. 4 pH spatial variations at (**a**) Tafna and (**b**) Macta dams

and BB (1–6 mg L^{-1}; Avg., 2.8 mg L^{-1}; SD, 1.5 mg L^{-1}) (Fig. 7e). The maximum content (35 mg L^{-1}) was recorded at HB during July.

In Macta watershed NO_3^- ions were found with the following concentrations: Cheurfa (1–20 mg L^{-1}; Avg., 9.3 mg L^{-1}; SD, 7.2 mg L^{-1}) (Fig. 8a), Ouizert (1–18 mg L^{-1}; Avg., 8.8 mg L^{-1}; SD, 6.7 mg L^{-1}) (Fig. 8c), Fergoug (1–9 mg L^{-1}; Avg., 4.6 mg L^{-1}; SD, 2.6 mg L^{-1}) (Fig. 8a), Bouhanifia (1–8 mg L^{-1}; Avg., 4.1 mg L^{-1}; SD, 2.4 mg L^{-1}) (Fig. 8b), and Sarno (1–11 mg L^{-1}; Avg., 3.3 mg L^{-1}; SD, 2.8 mg L^{-1}) (Fig. 8e).

Nitrites and ammonium ions were also present with concentrations varying from 0.01 to 2.1 mg L^{-1} and 0.06 to 4.46 mg L^{-1}, respectively (Figs. 7a–e and 8a–e). In Macta watershed, the concentration of NH_4^+ was at a maximum at Cheurfa dam during November. However, the values of this parameter were lower than those obtained in HB dam where NH_4^+ contents were between 0.07 and 4.46 mg L^{-1}(Avg.,

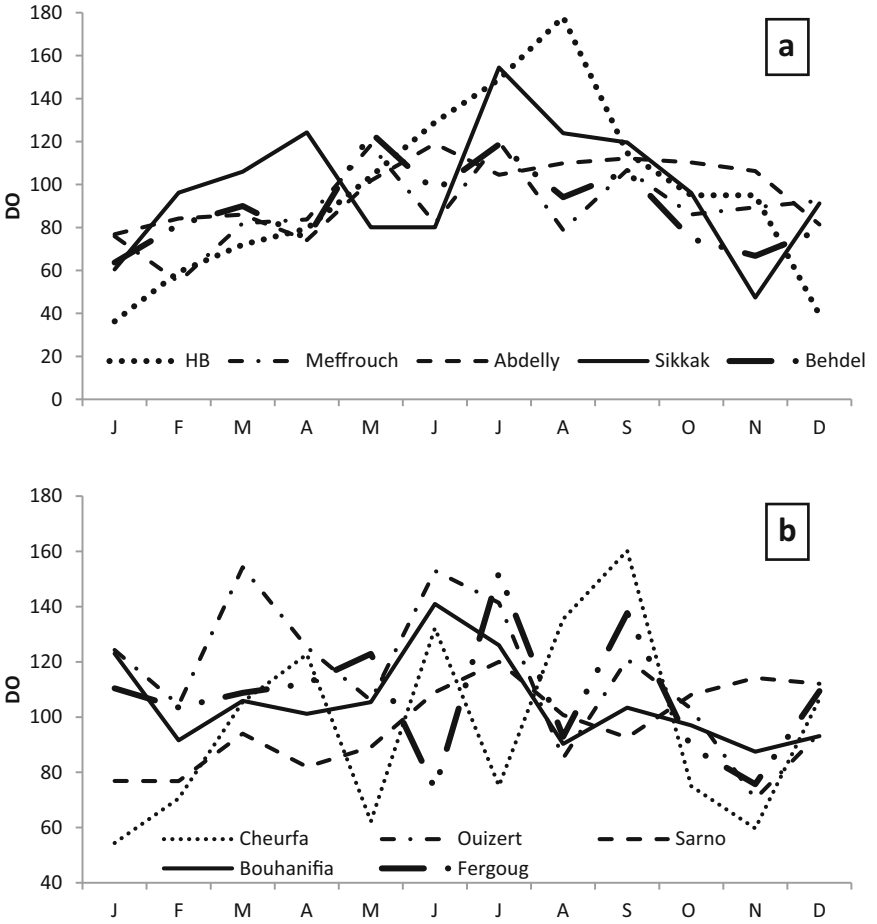

Fig. 5 DO spatial variations at (**a**) Tafna and (**b**) Macta dams

1.73 mg L^{-1}; SD, 1.71 mg L^{-1}). The highest values were recorded in HB dam during the first semester (Fig. 7d). Ammonium concentrations lowered during the sampling period inversely to pH values. These two parameters are negatively and well correlated ($r = -0.7$). The same situation was observed at SA with a correlation coefficient of −0.63.

3.1.5 Orthophosphates (PO_4^{3-})

At Tafna watershed, the maximum PO_4^{3-} concentration values ranging between 0.1 and 1.86 mg L^{-1} (average: 1.01 mg L^{-1}) were found at HB dam. The maximum value was recorded during March in the aforementioned dam. In the other dams belonging to Tafna watershed, PO_4^{3-} contents were less than 0.16 mg L^{-1} with

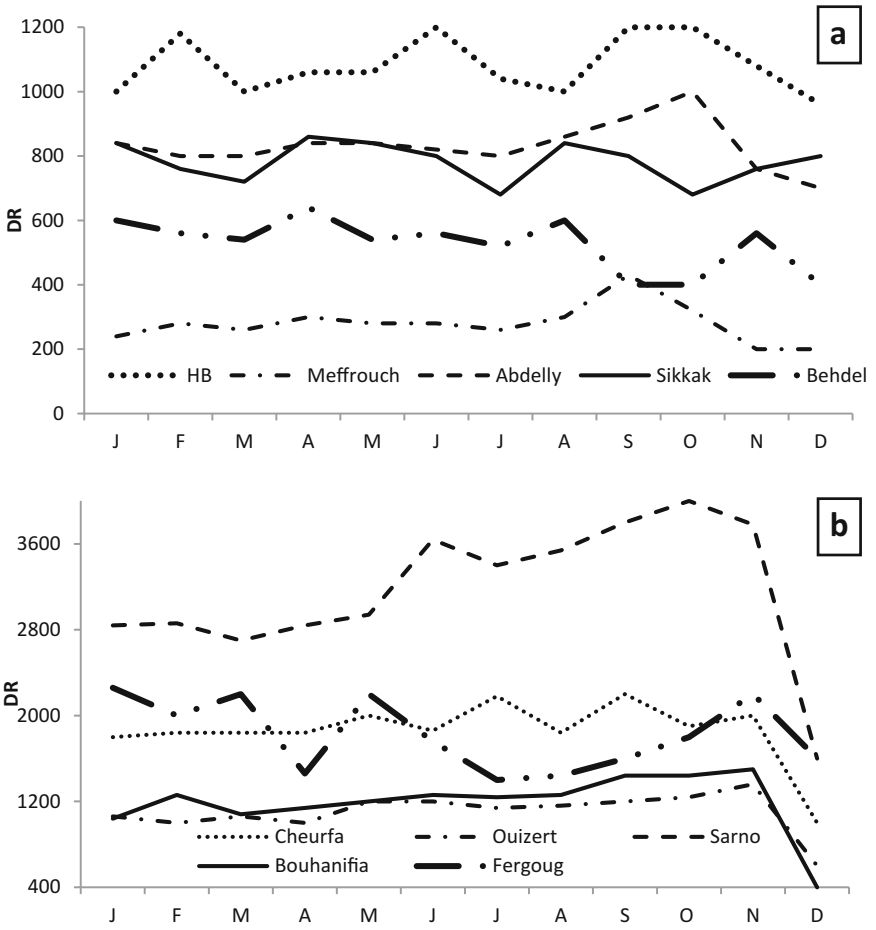

Fig. 6 DR spatial variations at (**a**) Tafna and (**b**) Macta dams

values ranging from 0.05 to 0.15 mg L^{-1} (average, 0.08 mg L^{-1}) at Meffrouch, 0.05 to 0.19 mg L^{-1} (average, 0.09 mg L^{-1}) at SA, 0.06 to 0.16 mg L^{-1} (average, 0.11 mg L^{-1}) at Sikkak, and 0.02 to 0.12 mg L^{-1} (average, 0.07 mg L^{-1}) at BB (Fig. 7a–e).

As for Macta, PO_4^{3-} concentration values recorded at Cheurfa dam were between 0.22 and 1.16 mg L^{-1} (average: 0.71 mg L^{-1}) (Fig. 8a–e). The yearly average PO_4^{3-} concentration values for the other dams were less than 0.71 mg L^{-1}; the calculated averages were 0.15, 0.13, 0.11, and 0.09 mg L^{-1} for Fergoug, Ouizert, Bouhanifia, and Sarno dams, respectively. The presence of phosphates in water dams is due to domestic wastewater discharges, particularly those containing detergents, fertilizer runoff, and industrial effluents.

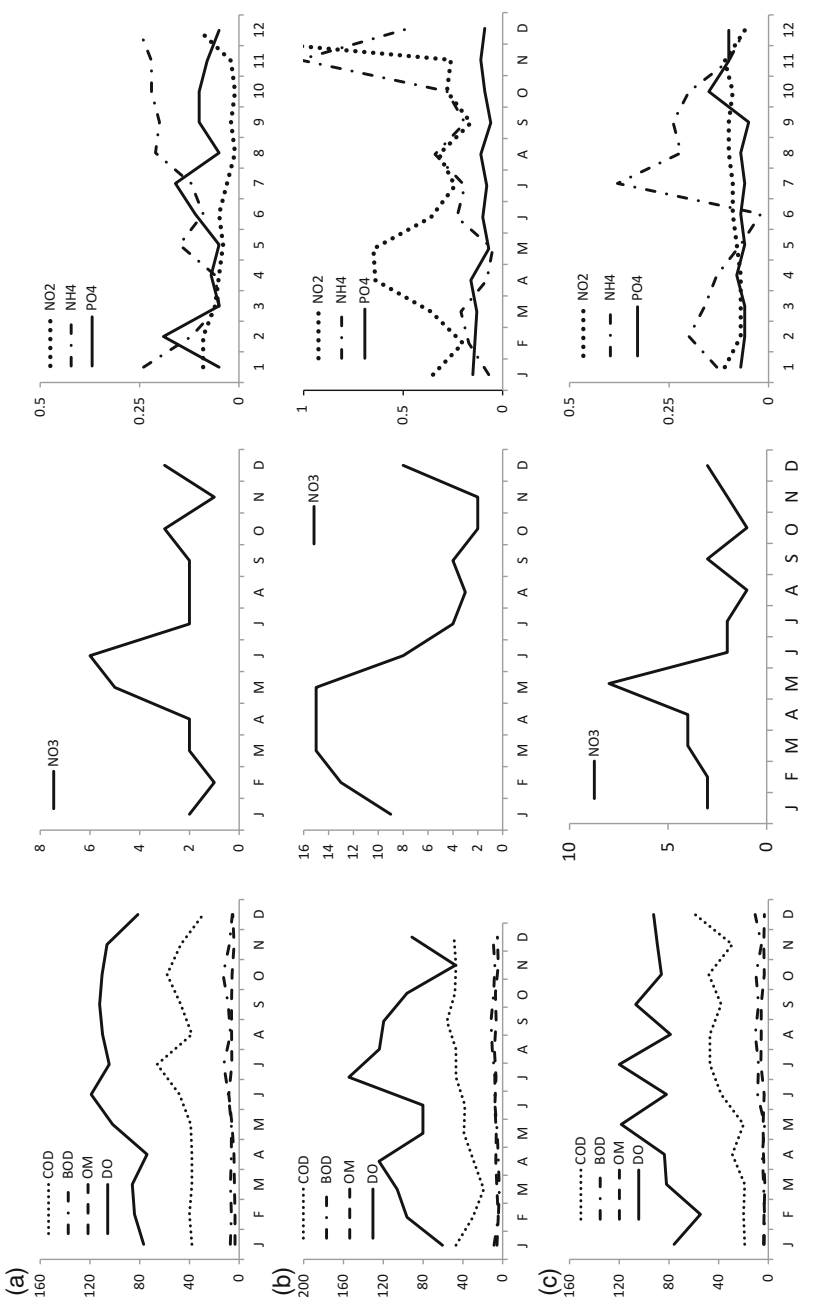

Fig. 7 Variations of organic parameters of (**a**) SA dam, (**b**) Sikkak dam, (**c**) Meffrouch dam, (**d**) Boughrara dam, (**e**) BB dam

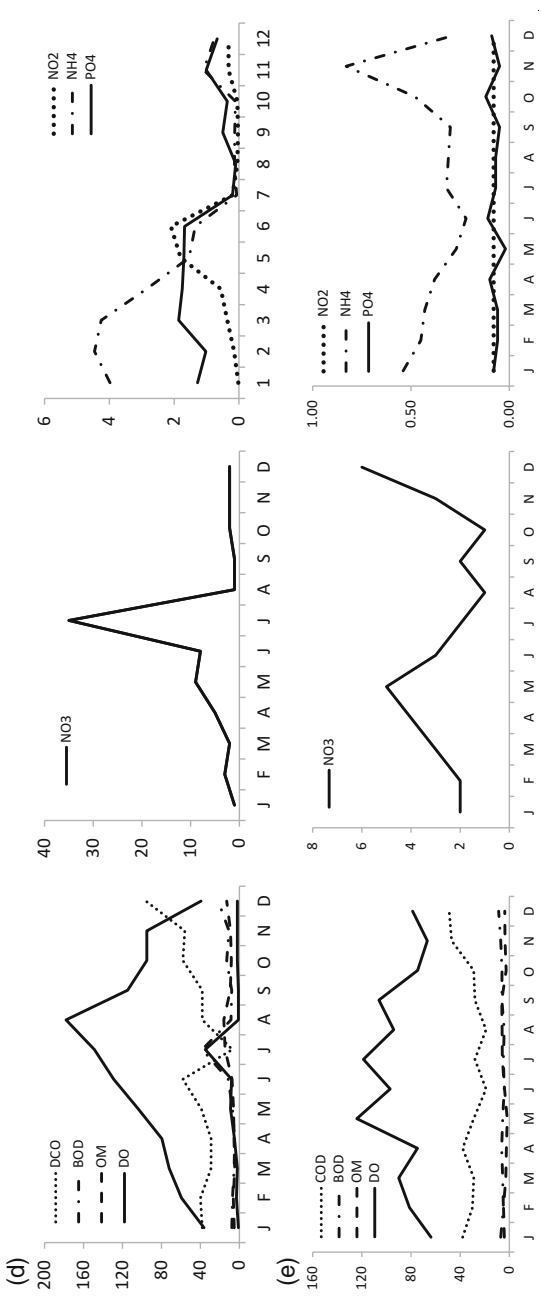

Fig. 7 (continued)

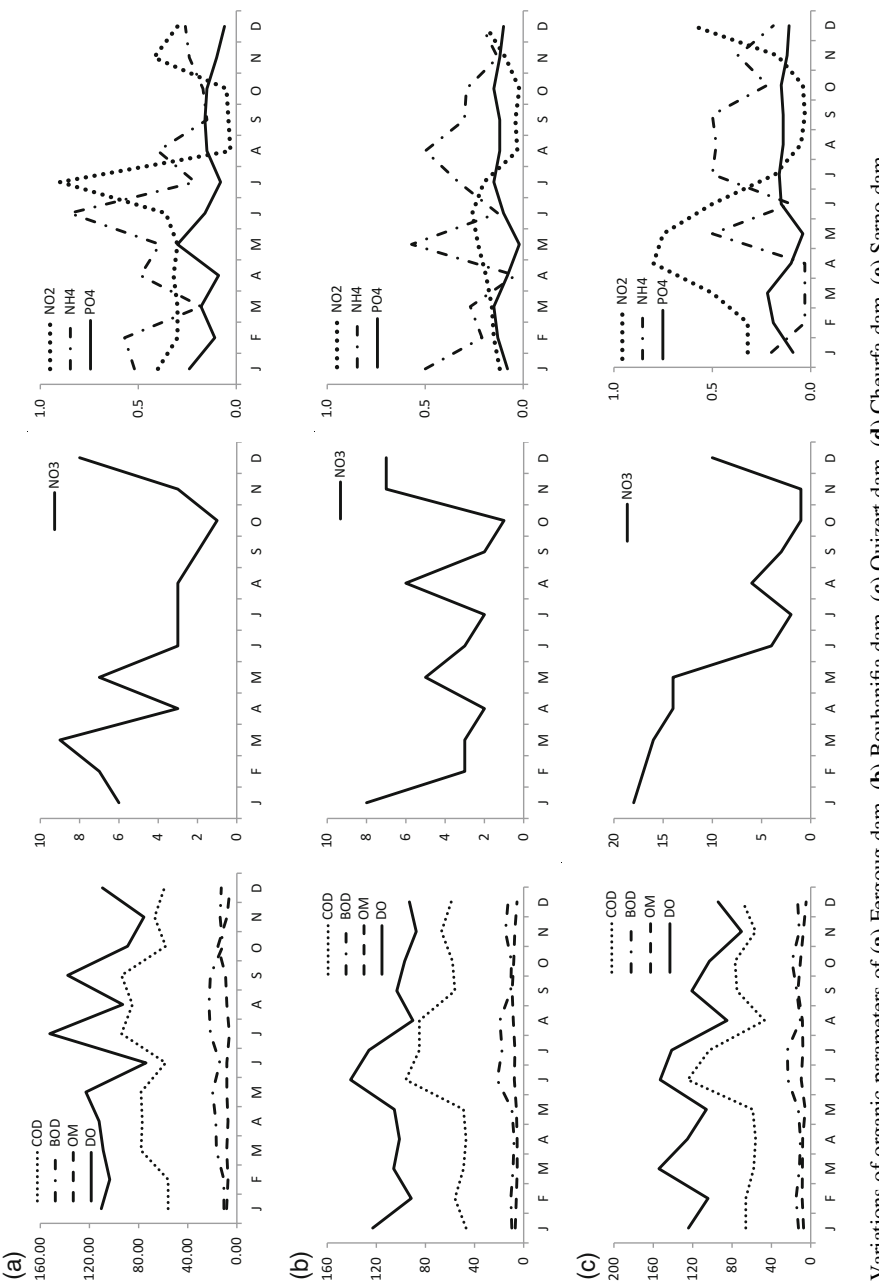

Fig. 8 Variations of organic parameters of (**a**) Fergoug dam, (**b**) Bouhanifia dam, (**c**) Ouizert dam, (**d**) Cheurfa dam, (**e**) Sarno dam

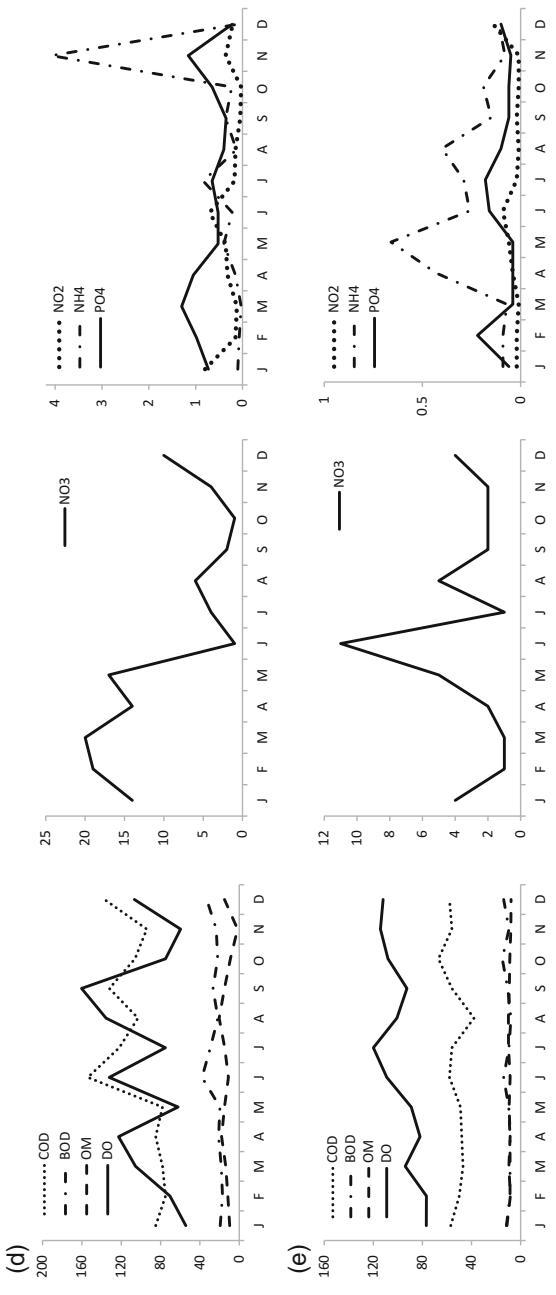

Fig. 8 (continued)

Table 4 Classes of parameters allowing the OPI calculation

Classes	BOD_5 (mg L^{-1})	Ammonium (mg L^{-1})	Nitrites (μg L^{-1})	Phosphates (μg L^{-1})
5	<2	<0.1	5	15
4	2–5	0.1–0.9	6–10	16–75
3	5.1–10	−2.4	11–50	76–250
2	10.1–15	2.5–6.0	51–150	251–900
1	>15	>6	>150	>900

3.2 Water Pollution

To understand the overall evolution of organic water pollution and the biodegradable matter proportion, we have calculated the organic pollution index (OPI) developed by [30] and the COD/BOD_5 ratio.

The principle of the OPI is to divide the pollutant values into five classes (Table 4), then to determine, from its own measurements, the corresponding class number for each parameter, and then to average it.

The limits of the OPI classes are as follow [30]:

5.0–4.6: no organic pollution

4.5–4.0: low organic pollution

3.9–3.0: moderate organic pollution

2.9–2.0: strong organic pollution

1.9–1.0: very strong organic pollution

The calculated OPI values for the ten dams during the study period indicated, generally, moderate to strong pollution. OPI values of SA (OPI, 3–3.75; average, 3.3), Meffrouch (OPI, 3.0–3.5; average, 3.25), and BB (3.0–3.5; average, 3.2) dams show that organic pollution is moderate. As for Sikkak (OPI, 2.5–3.25; average, 2.8), pollution is considered to be moderate from January to April and strong during the remainder of the year (Table 3, Figs. 9a and 10). Among the Tafna dams, HB dam water is the most polluted one. Calculated OPI values show a strong to very strong (March, July, and November) pollution.

Water of Fergoug (2–3.25; average, 3.25), Ouizert (2.25–3.0; average, 2.1), Cheurfa (OPI, 1.25–2.50; average, 2.6), and Bouhanifia (OPI, 2.25–3.25; average, 2.8) dams is generally strong polluted compared to that of Sarno dam (2.75–4.00; average, 3.40) which reveals a strong pollution during May and December months and moderate to low during the rest of the year (Table 3, Figs. 9b and 10).

Calculated COD/BOD_5 ratios vary between 3.7 and 7.2 (Table 5) and were greater than 3. They revealed that all waters are more or less difficult to biodegrade in the study dams. Water with BOD_5 levels greater than 10 mg/L are considered to be polluted and less than 4 mg L^{-1} to be reasonably clean [31].

In Macta watershed BOD_5 values were, in general, above 10 mg L^{-1} and can be considered to be polluted. As for Tafna dams, they generally vary between 4.8 and 21.6 mg L^{-1} and were more or less polluted except for Meffrouch (in January, February, March, and May) and Sikkak (in March) dams where BOD_5 contents were less than 4 mg L^{-1}.

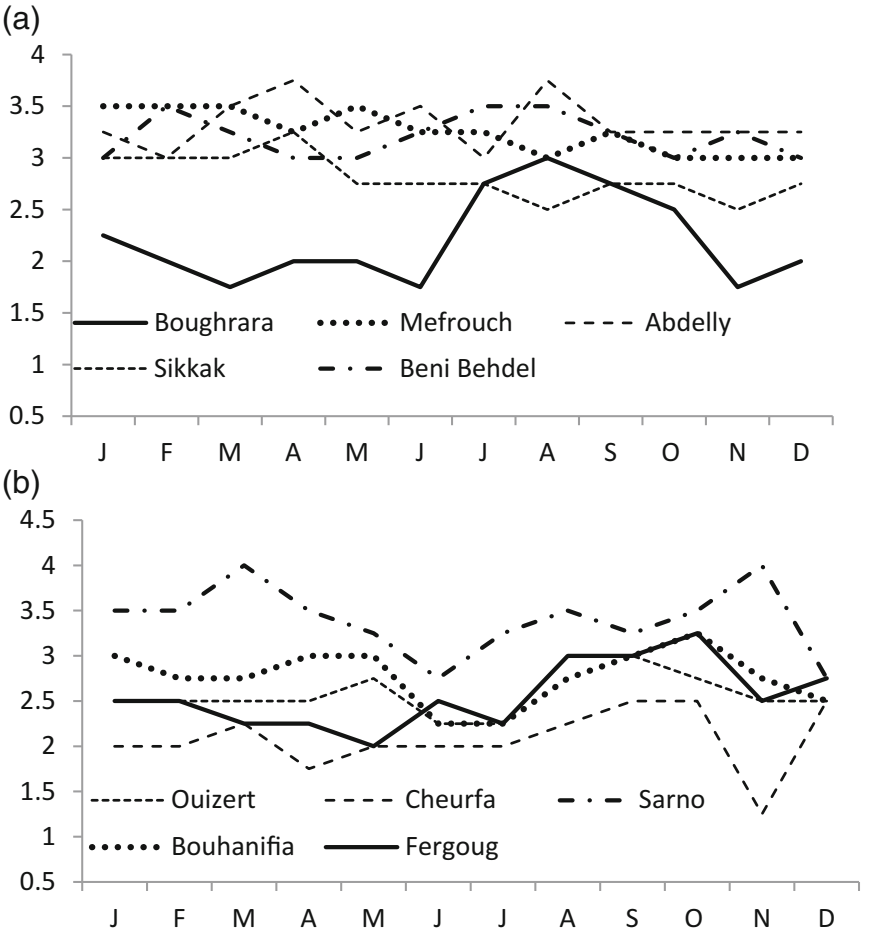

Fig. 9 OPI variation of (**a**) Tafna dams and (**b**) Macta dams

4 Conclusions

In this study, surface water quality data for 14 parameters collected from the monitoring of 10 dams located within two northwestern Algerian watersheds (Macta and Tafna) were monthly analyzed during 1 year (2003). The waters of all dams were alkaline, with pH values ranging between 7.01 and 8.97. The highest DR contents were found at Macta watershed. The maximum yearly average (3,161.7 mg L^{-1}) was recorded at Sarno dam located upstream of the confluence of Mekerra and Sarno wadis. In the other Macta dams, yearly averages were between 1,101.7 and 1,858.3 mg L^{-1}. Tafna watershed registered lesser contents varying between 279.2 mg L^{-1} at Meffrouch dam and 1,081.7 mg L^{-1} at HB.

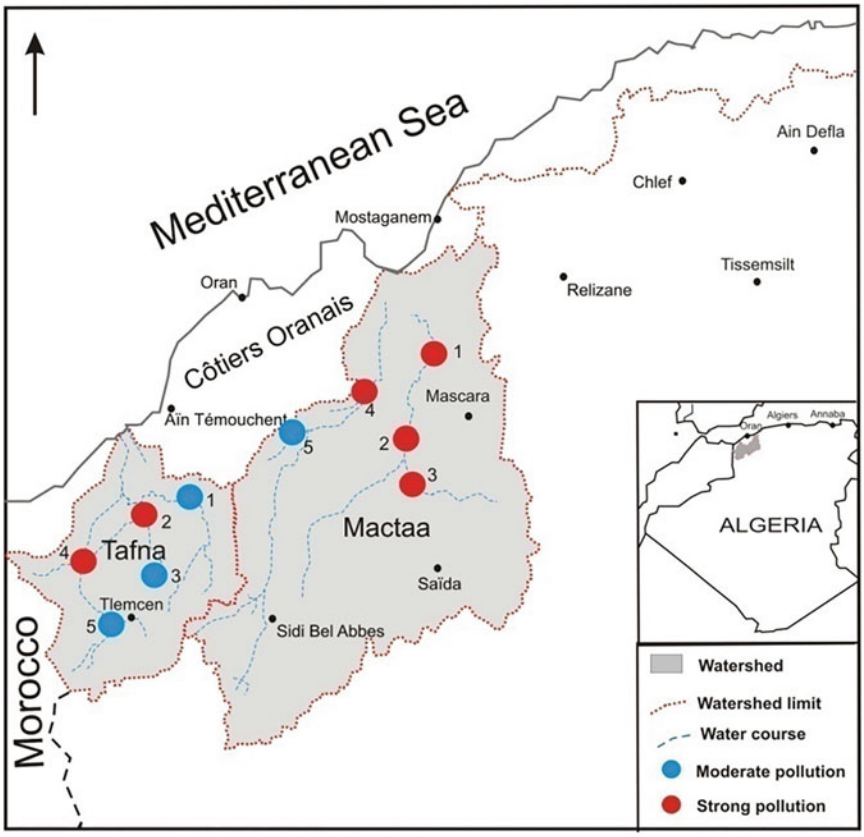

Fig. 10 Spatial variation of IPO

Table 5 OPI and COD/BOD_5 values of water of Tafna and Macta dams

Dam	OPI	COD/BOD_5	Pollution class
SA	3–3.75	4.5–6.2	Moderate
Sikkak	2.5–3.25	4.5–7.2	Moderate to strong
Meffrouch	3–3.5	4.5–6.7	Moderate
Boughrara	1.75–3	4.4–5.7	Moderate to strong
BB	3–3.5	4.5–6.7	Moderate
Fergoug	2.0–3.25	3.7–5.3	Moderate to strong
Bouhanifia	2.25–3.0	4.4–6.0	Moderate to strong
Ouizert	2.50–3.0	4.1–5.7	Strong to very strong
Cheurfa	1.25–2.50	4.0–4.9	Strong to very strong
Sarno	2.75–4.0	4.2–5.7	Weak to strong

As for BOD_5, COD, and MO average contents, they were maximum at Cheurfa (BOD_5, 24.1 mg L^{-1}; COD, 104 mg L^{-1}; 12.9 mg L^{-1}) and HB (BOD_5, 11.9 mg L^{-1}; COD, 43.8 mg L^{-1}; OM, 8.8 mg L^{-1}) dams and minimum at Sarno (BOD_5, 10.6 mg L^{-1}; COD, 53.3 mg L^{-1}; 12.9 mg L^{-1}) and Bouhanifia (MO, 6.9–10.6 mg L^{-1}) in Macta watershed and BB (BOD_5, 5.8 mg L^{-1}; COD, 31.9 mg L^{-1}; 4.0 mg L^{-1}).

The calculated organic pollution index values during the study period evidenced the pollution state of the dams. They indicated moderate to very strong pollution in the water of the two watersheds. In Tafna dams, OPI averages of SA, Meffrouch, and BB dams, exhibited moderate organic pollution. As for Sikkak, pollution is considered to be moderate from January to April and strong during the remainder of the year. Water of HB was strongly to very strongly polluted.

Waters of Fergoug, Ouizert, Cheurfa, and Bouhanifia dams were generally strongly polluted except that of Sarno dam, which indicated a strong pollution only during May and December months. Indeed, water of the two watersheds was more or less difficult to biodegrade.

5 Recommendations

To ensure good water quality in order to preserve dams against pollution, several measures must be taken.

Following the observations made during the processing of the acquired information, it is important to frequently analyze other water parameters at watershed and dams, such as heavy metals, to get more information and to identify the emerging water quality issues and the extent to which existing criteria and recommendations can address these problems.

More accurate monitoring is recommended for watercourses, and setting up of mandatory regulations for polluters by requiring them to clean their wastewater by sewage treatment plants before pouring them into streams is needed.

Necessary measures must be taken to avoid the eutrophication of the dams which is the consequence of the poor quality of water and the presence of pollution.

It is also important to create treatment plants for each dam inlet regardless of the destination of these waters, as it is necessary to adjust the treatment in relation to the water quality and according to their uses.

References

1. Touati B (2010) Les barrages et la politique hydraulique en Algérie: Etats, diagnostic et perspectives d'un aménagement durable. Thèse Doct. Aménagement rural, Univ. Mentouri, Constantine, Algérie
2. ANBT (2015) Agence Nationale des Barrages et Transferts, Algérie

3. Hassanli AL, Javan M, Saadat Y (2008) Reuse of municipal effluent with drip irrigation and evaluation the effect on soil properties in a semi-arid area. Environ Monit Assess 144:151–158
4. Abbott CL, Quosy DE (1996) A procedure to assess the impacts of drain water reuse Cairo: Report OD 134, HR Wallingford in collaboration with the Water Management Research Institute
5. Ramasahayam SK, Guzman L, Gunawan G, Viswanathan T (2014) A comprehensive review of phosphorus removal technologies and processes. J Macromol Sci A 51:538–545
6. Roy ED (2017) Phosphorus recovery and recycling with ecological engineering: a review. Ecol Eng 98:213–227
7. Dunne EJ, Coveney MF, Hoge VR, Conrow R, Naleway R, Lowe EF, Battoe LE, Wang Y (2015) Phosphorus removal performance of a large-scale constructed treatment wetland receiving eutrophic lake water. Ecol Eng 79:132–142
8. Holeton C, Chambers PA, Grace L (2011) Wastewater release and its impacts on Canadian waters. Can J Fish Aquat Sci 68:1836–1859
9. Camargo JA, Alonso A (2006) Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. Environ Int 32:831–849
10. Finnveden G, Hauschild MZ, Ekvall T, Guinée J, Heijungs R, Hellweg S, Koehler A, Pennington D, Suh S (2009) Recent developments in life cycle assessment. J Environ Manag 91(1):1–21
11. Stoate C, Báldi A, Beja P, Boatman ND, Herzon I, Van Doorn A, De Snoo GR, Rakosy L, Ramwell C (2009) Recent developments in life cycle assessment ecological impacts of early 21st century agricultural change in Europe-a review. J Environ Manag 91(1):22–46
12. Khan MYA, Gani KM, Chakrapani GJ (2016) Assessment of surface water quality and its spatial variation. A case study of Ramganga River, Ganga Basin, India. Arab J Geosci 9:28
13. Ayers RS, Westcot DW (1985) Water quality for agriculture. FAO Irrigation and Drainage, 1 edn. FAO, Rome
14. Perrin JL, Raïs N, Chahinian N, Moulin P, Ijjaali M (2014) Water quality assessment of highly polluted rivers in a semi-arid Mediterranean zone Oued Fez and Sebou River (Morocco). J Hydrol 510:26–34
15. Razmkhah H, Abrishamchi A, Torkian A (2010) Evaluation of spatial and temporal variation in water quality by pattern recognition techniques: a case study on Jajrood River (Tehran, Iran). J Environ Manag 91:852–860
16. Sharifinia M, Adeli B, Nafarzadegan AR (2017) Evaluation of water quality trends in the Maroon River Basin, Iran, from 1990 to 2010 by WQI and multivariate analyses. Environ Earth Sci 76:781
17. Singh KP, Malik A, Mohan D, Sinha S (2004) Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)-a case study. Water Research 38(18):3980–3992
18. Sundara KS, Nayak BB, Dinabandhu B (2008) Environmental studies on river water quality with reference to suitability for agricultural purpose: Mahanadi river estuarine system- a case study. Environ Monit Assess 155(1–4):227–243
19. Zhai X, Xia J, Zhang Y (2014) Water quality variation in the highly disturbed Huai River Basin, China from 1994 to 2005 by multi-statistical analyses. Sci Total Environ 496:594–606
20. Al-Taani AA, El-Radaideh NM, Al Khateeb WM (2018) Status of water quality in King Talal Reservoir Dam, Jordan. Water Resour 45(4):603–614
21. Elhatip H, Kömür MA (2008) Evaluation of water quality parameters for the Mamasin dam in Aksaray city in the central Anatolian part of Turkey by means of artificial neural networks. Environ Geol 53:1157–1164
22. Farzadkia M, Djahed B, Shahsavani E, Poureshg Y (2015) Spatio-temporal evaluation of Yamchi Dam basin water quality using Canadian water quality index. Environ Monit Assess 187:168

23. Mohseni-Bandpei A, Motesaddi S, Eslamizadeh M, Rafiee M, Nasseri M, Namin MM, Hashempour Y, Mehrabi Y, Riah SM (2018) Water quality assessment of the most important dam (Latyan dam)in Tehran, Iran. Environ Sci Pollut Res 25(29):29227–29239
24. Nakashima S, Yamada Y, Tada K (2007) Characterization of the water quality of dam lakes on Shikoku Island, Japan. Limnology 8(1):1–22
25. Neissi L, Tishehzan P, Albaji M (2019) Chemical assessment of surface water quality in upstream and downstream of Jare Dam, Khuzestan, Iran. Environ Earth Sci 78:83. https://doi.org/10.1007/s12665-019-8082-x
26. Misra OP, Chaturvedi D (2016) Fate of dissolved oxygen and survival of fish population in aquatic ecosystem with nutrient loading: a model. Model Earth Syst Environ 2:112
27. Bhateria R, Jain D (2016) Water quality assessment of lake water: a review. Sustain Water Resour Manag 2:161–173. https://doi.org/10.1007/s40899-015-0014-7
28. Penn MR, Pauer JJ, Mihelcic JR (2003) Biochemical oxygen demand environmental and ecological chemistry, vol II. Encyclopedia of Life Support Systems
29. Hadji F, Guasmi I, Djabri L (2013) Suitability of surface water from Mouillah Wadi of Algeria for irrigation purposes. In: Shahid SA et al (eds) Developments in soil salinity assessment and reclamation: innovative thinking and use of marginal soil and water resources in irrigated agriculture. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-5684-7_47
30. Leclercq L, Maquet B (1987) Deux nouveaux indices chimiques et diatomiques de qualité d'eau courante. Application au Samson et à ses affluents (Bassin de la Meuse belge). Comparaison avec d'autres indices chimiques, biocénotiques et diatomiques. Institut Royal des Sciences Naturelles de Belgique, Document de travail 28:113
31. McNeely RN, Neimanis VP, Dwyer L (1979) Dissolved oxygen. In: Water quality sourcebook. A guide to water quality parameters. Water Quality Branch, Inland Waters Directorate, Environment Canada, Ottawa, ON, pp 33–34