ARPHA Proceedings

Proceedings CAUSummit 2025, 0249-0254
doi: 10.3897/ap.9.e0249

10th Anniversary
World Summit: Civil Engineering-Architecture-Urban Planning Congress

Investigation of Surface Water Characteristics Using IPO and Quality Metrics in Soummam Wadi, Algeria

Samia Bounab [1,a)]

[1] *Research Laboratory of Applied Hydraulics and Environment, Faculty of Technology, University of Bejaia, 06000 Bejaia, Algeria*

[a)] Corresponding author's email: samia.bounab@univ-bejaia.dz

Abstract. Surface water bodies are heavily impacted by human-induced pressures, particularly due to the expansion of agriculture, industrialization, and residential activities. These water sources often serve as recipients for domestic wastewater, industrial discharges, and agricultural runoff, making them vulnerable to substantial pollution. In Algeria, one of the key aquatic resources is the Soummam Valley, located in the northeastern region. This research focuses on evaluating and describing the water quality of the Soummam Wadi. To achieve this, several water quality indicators were analyzed, including pH, biological oxygen demand (BOD_5), chemical oxygen demand (COD), nitrites (NO_2^-), nitrates (NO_3^-), orthophosphates (PO_4^{3-}), dissolved oxygen (O_2%), and ammonium (NH_4^+), in order to determine the pollution level of the surface water.A number of water quality index are being used for assessing water quality and evaluated state of organic pollution in surface water in Soummam wadi including: organic pollution index (IPO), surface Water Quality Index according to Demmak.A, 2014, and nitrates (NO_3) toxicity following classification of Isaac et al 2009 were also determined. The results achieved in this study show that all sattions indicate a moderate degree of pollution based on IPO index. According to the results obtained by index quality of water, and the classification of Isaac, they looked both similar and complemented the majority of stations have high concentration of BOD_5, DCO,and NO_3 , showed the poor and very poor surface water quality.

Keywords: Surface water; pollution organic; IPO; Soummam; index

Published by CAUSummit and peer-reviewed under the responsibility of "World Summit: Civil Engineering-Architecture-Urban Planning Congress - CAUSummit-2025".

INTRODUCTION

Water is recognized as one of the planet's most vital and irreplaceable resources [1]. Surface water, in particular, serves as a critical supply for domestic consumption, industrial processes, and agricultural irrigation [2]. Assessing water quality is essential to balance water demand and availability. Understanding its quality offers a comprehensive perspective on potential hazards, supports the safeguarding of water resources, and helps identify the origins of water quality degradation [3, 4].

Because water quality has a direct impact on human health and well-being, it remains a key concern for global populations [5]. Numerous researchers have investigated pollution caused by chemical, organic, and heavy metal contaminants [6, 7]. To evaluate factors contributing to eutrophication, the eutrophication index is frequently employed [8].

This current study utilizes several evaluation tools—including the Organic Pollution Index (IPO), the Water Quality Index (WQI), and nitrate toxicity assessments—based on the physico-chemical characteristics of surface water within the Soummam basin.

The objective is to evaluate the quality and organic pollution status of surface water at four stations during two weeks in 2022.

MATERIALS AND METHODOLOGY

Study Area and Data

The valley of Soummam, is one of the largest watersheds in northern Algeria, located about 230 km east of Algiers. It is bounded to the north by the Djurdjura chain, to the south by the Bibans and Babors mountains, to the east by the Mediterranean Sea, and to the west by the Bouira plateau.The wadi Soummam is the third river of Algeria, it is formed by the confluence of the wadi Sahel which descends from the mountains of Djurdjura and the plateau of Bouira, and the wadi Bou Sellam which descends from the plateau Sétifien, it flows into the Mediterranean Sea in Béjaia after a course of about 80 km (Figure 1).

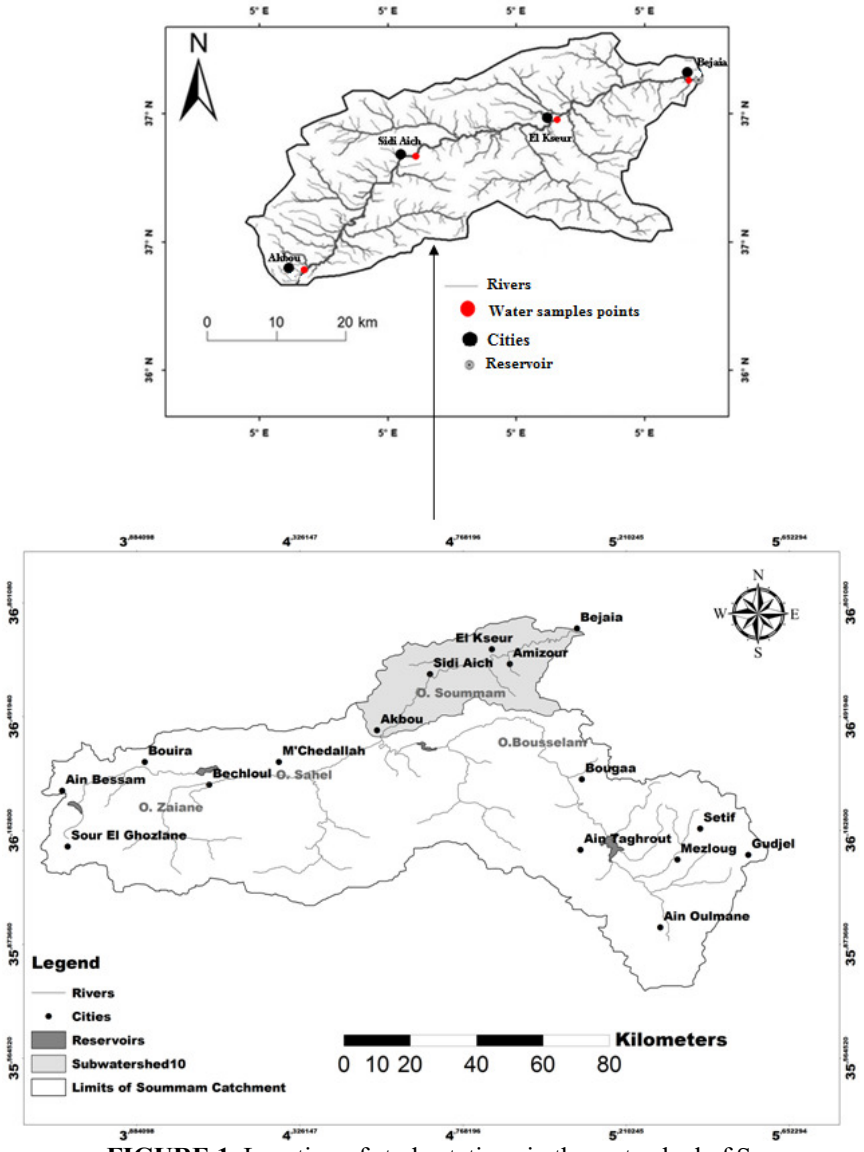

FIGURE 1. Location of study stations in the watershed of Soummam

The study area has a Mediterranean climate that alters between mild winters and wet summers, with a 700 mm of the mean annual rainfall and 11.8 °C, and 24.8 °C of the minimum and maximum temperatures respectively [5]. Numerous intense tectonic faults affect the geological formations in the valley, indicating the complex geology of this region. The geology of this area is dominated by thrust sheets, and there are many contacts that are covered with Triassic materials. A few eruptive outcrops are visible in this region [9].

Water Sampling

In order to have a realistic description and monitoring of the pollution that has occurred in the region. The sampling was conducted during two campaigns spread over two months successively in April and May 2022. The sampling stations were taken from 4 stations distributed along the Soummam wadi, S1: in Akbou; S2: in Sidi aiche; S3: in El-kseur; S4: at the 4 paths in Bejaia (Figure 1). The samples are taken from the middle of the riverbed. The selection of these sites was based on the different wastewater discharge points. At the CRAPC laboratory Bousmail in Tipaza, the water samples were analyzed for the following parameters indicators of pollution organic: pH, the biological oxygen demand (BOD_5), chemical oxygen demand (COD), nitrites (NO_2^-), nitrates (NO_3^-), orthophosphate (PO_4^{3-}), dissolved oxygen (O_2%), and ammonium (NH_4^+). The samples were analyzed using the methods outlined in Rodier [10].

Organic Pollution Index (OPI)

Organic pollution is commonly assessed using specific parameters such as Biological Oxygen Demand (BOD_5), ammonium ions (NH_4^+), nitrites (NO_2^-), and phosphates (PO_4^{3-}). Various methodologies exist for evaluating the degree of water contamination by organic substances. Among them, Leclercq & Maquet [11] introduced the Organic Pollution Index (OPI) as a tool to quantify organic load in aquatic environments. The fundamental concept behind OPI involves categorizing the concentrations of key pollutants—namely BOD_5, ammonium, nitrites, and phosphates—into five quality classes, each associated with a commonly recognized color code (see Table 1).

Using the mean values presented in Table 2, each parameter is assigned a class number. The overall organic pollution index is then calculated by averaging these class values, as determined by the evaluation grid (Table 2).

TABLE 1. POI parameters and classes [11]

Class	NH_4^+ (mg/l)	NO_2^- (µg /l)	PO_4^{3-} (µg/ l)	BOD_5 (mg O_2/l)	Colors
5	<0.1	≤ 5	≤ 15	< 2	
4	0.1 – 0.9	6 – 10	16-75	2 – 5	
3	1 - 2.4	11 - 50	76 - 250	5.1 - 10	
2	2.5 – 6.0	51 – 150	251 – 900	10.1 – 15	
1	> 6	> 150	> 900	>15	

TABLE 2. Grid evaluation of pollution types [11]

Limits of classes	Organic pollution level
5 - 4,6	Null - **None**
4,5 – 4,0	Low - Weak
3,9 – 3,0	Moderate
2,9 – 2,0	strong
1,9 – 1,0	Very strong

Water Quality Index according to Demmak A, 2014

In Algeria, the assessment of the quality of dam and river water is estimated by measuring certain physicochemical parameters, indicators of pollution (mineral, organic, nitrogenous and phosphorous), (Tab.3). It is given by comparing the results of analyses with the quality limits. The evaluation of the water quality index was carried out using eight distinct parameters: pH, chemical oxygen demand (COD), biochemical oxygen demand over five days (BOD_5), percentage of dissolved oxygen (DO%), ammonium (NH_4^+), nitrates (NO_3^-), nitrites (NO_2^-), and phosphates (PO_4^{3-}). The principle is to cclassify the values of polluting elements obtained in the study into four classes, C1 (Good), C2 (Acceptable), C3 (Poor), and C4 (Very Poor) Table 3.

TABLE 3. Grid classification of river water quality [13]

Parameters	Classification			
	C1 - Good	**C2 - Acceptable**	**C3 - Poor**	**C4 - Very Poor**
pH	6,5 - 8,5	6,5 - 8,5	8,5 - 9,0	> 9,0 et < 6,5
DO %	100 - 90	90 - 50	50 - 30	< 30
NH_4	0 - 0,01	0,01 - 0,1	0,1 – 3	> 3
NO_3	0 - 10	10 - 20	20 - 40	> 40
NO_2	0 - 0,01	0,01 - 0,1	0,1 – 3	> 3
PO_4	0 - 0,01	0,01 - 0,1	0,1 – 3	> 3
BOD_5	0 - 5	5 - 10	10 - 15	> 15
COD	20	20 - 40	40 - 50	> 50

Toxicity by Nitrates

On the other hand, the toxicity of waters of Soummam wadi with nitrates was assessed following Isaac et al. 2009 classification Table 4.

TABLE 4. Interval of classes for Nitrates parameters [12]

Nitrate (mgL^{-1})	**Classification**
$NO^-_3 < 5\ mgL^{-1}$	No toxicity
$5 < NO^-_3 < 30\ mgL^{-1}$	Moderate toxicity
$NO^-_3 > 30\ mgL^{-1}$	Severe toxicity

RESULTS AND DISCUSSION

Organic Pollution index (OPI)

Following the calculation of the Organic Pollution Index (IPO), based on analytical results of key pollution indicators (NH_4^+, NO_2^-, PO_4^{3-}, and BOD_5), water quality classification was established for eight samples obtained from four sampling locations, as outlined in Table 5. This table highlights both spatial and temporal variations in surface water quality as reflected by the IPO. The average IPO values for all samples fall within the range of 3 to 3.5, corresponding to the yellow-coded classification (Tab. 5). These results suggest that surface waters exhibit a moderate degree of organic contamination. Such levels indicate the presence of organic matter likely introduced through human-related activities.

TABLE 5. Determining the IPO index for surface water in Soummam wadi during two campaigns of the year 2022

Class	NH_4^+ Class		NO_2^- Class		PO_4^{3-} Class		BOD_5 Class		IPO		Color		Organic Pollution	
	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp
S1	3	4	5	5	4	3	1	1	3,25	3,25			Moderate	Moderate
S2	3	4	5	5	3	4	1	1	3	3,5			Moderate	Moderate
S3	3	4	5	5	4	4	1	1	3,25	3,5			Moderate	Moderate
S4	4	4	5	5	4	3	1	1	3,5	3,25			Moderate	Moderate

Water Quality Index According to Demmak A, 2014

The methods used for measuring water quality indicators and their permissible limits are outlined in Tables 3 and 6. In this research, surface water quality in the Soummam Wadi was assessed using the approach proposed by Demmak [13], based on physico-chemical analysis results. For the eight samples collected across four different sampling sites (Table 6), each physico-chemical parameter was assigned a relative quality class.

Eight key indicators were considered in this classification framework: pH, ammonium (NH_4^+), nitrates (NO_3^-), nitrites (NO_2^-), chemical oxygen demand (COD), dissolved oxygen percentage (DO%), phosphates (PO_4^{3-}), and biochemical oxygen demand (BOD_5). If any parameter deviated from Class C1 (good) or C2 (acceptable), the water was classified as poor quality.

According to the findings, BOD_5, COD, and NO_3^- values placed the surface water in Class C4 (very poor quality) for all samples across the four stations, during both sampling campaigns (Table 6). This could be mainly linked to the high volume of domestic and industrial wastewater, mainly from agro-food industries. With respect to the parameters of Ammonium (NH4) and Nitrites (NO2), the analysis indicated that all samples from the four sampling stations during the two sampling campaigns were categorized within the poor quality class (C3) (Tab.6). the source of nutrient pollution in water is attributed to waste from daily life and industrial activities [14] both orthophosphate (PO_4) and dissolved oxygen % (DO%) parameters in the surface water of the Soummam wadi were fluctuated between the acceptable (C2) and poor (C3) quality classes respectively(Tab.6). the agricultural activities, aquaculture and elevated domestic wastewater leading to a decrease in the DO in water [14].

As indicated in Table 6, pH levels are mildly alkaline and remain relatively consistent across both sampling campaigns. The water samples fall within the acceptable quality category (Class C2).

TABLE 6. Classification of surface water parameters using, Demmak [13] method.

Parameters	Classification							
	S1		S2		S3		S4	
	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp	1st camp	2sd camp
pH	C2	C2	C2	C2	C2	C2	C2	C2
DO%	C2	C3	C2	C3	C2	C3	C3	C3
NH_4	C3	C3	C3	C3	C3	C3	C3	C3
NO_3	C4	C4	C3	C4	C4	C4	C4	C4
NO_2	C3	C3	C3	C3	C3	C3	C3	C3
PO_4	C2	C3	C3	C2	C2	C2	C2	C2
BOD_5	C4	C4	C4	C4	C4	C4	C4	C4
COD	C4	C4	C4	C4	C4	C4	C4	C4

Toxicity by Nitrates

Nitrates are found in highly soluble forms in water and are commonly linked to the extensive application of chemical fertilizers [15]. To evaluate nitrate-induced toxicity in the waters of the Soummam Wadi, the classification system proposed by Isaac [12] was applied (Table 4). Based on this system, the nitrate-related water quality class was determined for the eight collected samples from four sampling stations across two sampling periods. It shows, that all samples have severe toxicity of nitrates ($NO^-_3 > 30\ mgL^{-1}$).

CONCLUSIONS

The monitoring of quality and organic pollution indices (OPI) as well as water nitrates toxicity during this study show consistent and very similar results. Surface water is of poor quality with moderate organic pollution. This anthropogenic pollution is due to the very high levels of certain physico-chemical parameters (Nitrates, Ammonium COD and BOD_5) exceeding the standards and are directly related to wastewater discharges and nitrogen and phosphate fertilizers used in agriculture.

REFERENCES

1. P. L. Kannel, Application of water quality indices and dissolved oxygen as indicators for river water classification and urban impact assessment. *E nvironemental Monitoring and Assessment, 132:*, 93 - 110, (2007).
2. Z. Z. Yan An, Descriptive Characteristics of surface Water Quality in Hong kong by a Self-Organising Map. *International Journal of Environmental Research and Public Health*, (2016).
3. D.N. Myers, *Foundation of Water Quality Monitoring and Assessment in the Unted States.* Elsevier Inc.p. 21 - 92, (2015).
4. A. R. Normatov P.I., Hydro+. 40 P 347 - 354 (2015).
5. L. M. Lazhar Belkhiri, Geochemical characterization of Surface Water and Qroundwater in Soummam Basin, Algeria . *Natural Resources Research*, (2014).
6. A. B. Boujghad, Groundwater quality evaluation in the vicinity of the Draa Sfar Mine in Marrakesh, Morocco. Euro-Mediterr. *J. Environ. Integr.* (2019).
7. K. N. Loucif, Phhysico-chemical and bacteriological quality assessment of surface water at lake Tonga in Algeria. *Environ. Nanotechnol.Monit. Manag.* (2020).
8. C. T. Son, N. T. H. Giang, T. P. Thao, N. H. Nui, N. T. Lam, V. H. Cong, Assessment of Cau River water quality assessment using a combination of water quality and pollution indices. *J. Water Supply: Res. Technology*—AQUA 69, 160–172 (2020).
9. H. S., Ahcéne Semar, Multiparametre Cartographic Assessment of the Hydrchemical Groundwater of the Soummam Valley (Kabylia,Algeria). *Environmental Progress & Sustainable Energy, Vol.33, No.4, (2014).*
10. J. Rodier, The analysis of the water. 9th ed. Paris: Dunod; 2009.
11. L, M. B. Leclercq, *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.* . Belgique: Institut Royal des Sciences Naturelles de Belgique, (1987).
12. K. T. Isaac RK, Surface and subsurface water quality appraisal for irrigation. *J Environ Monit Assess 159*, 465-473, (2009).
13. A. Demmak, *Report on the state of water in Algeria" Project for the evaluation and monitoring of the water sector in North African countries (MEWINA).* Minstry of Water Resources (MRE), Algeria, (2014).
14. N. H. Nguyen Thanh Giao, Evaluating Surface Water Quality in Cai Nuoc River,Ca Mau Province, Vietnam. *Journal of Energy Technology & Environment*, (2025).
15. B. H. Guasmi, Assessing the organic pollution of surface water of Medjerda watershed (NE Algeria). *Environ Earth Sci.* (2009).