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EVALUATION OF THE WATER QUALITY OF ALGERIEN DAMS

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ABSTRACT

This study aims to give an overview of the water quality of forty dams located in the west and east of Algeria. It included a physico-chemical characterization to highlight many factors that play a role in determining the quality of these waters such as: pH, Dissolved oxygen (O_2), Nitrate (NO_3), Nitrite (NO_2), Phosphates (PO_4), Organic matter (OM), Dry residue (DR), Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD). The waters of the western dams have very high dry residues, which could be linked to the terrain crossed and the high erodibility of the soils in these regions. The highest level of nitrate (10 mg/l) was recorded in the BaniBahdel dam in the west and similarly high values of BOD_5 and COD, which show another indicator of water quality deterioration water at the dams in the western region. The application of statistical methods, Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA) made it possible to give a classification to these dams according to the degree of water contamination. The results placed the western dams in the medium to very high pollution category. The eastern dams seem less affected by pollution.

KEY WORDS: Dam, Surface water, Physico-chemical parameters, Pollution, Algeria

INTRODUCTION

Water is a natural circulating resource, available in abundance on the Earth's surface (Karthik *et al.,* 2019). Water resources have an important place in the development of many different economic sectors in the world. In Algeria, which is characterized by a semi-arid climate, water has been mainly supplied by surface water for a long time (EL Ghachtoul *et al.,* 2005).

Access to water is a qualitative rather than a quantitative problem (Rousseau and Guyard, 2014; Simonovic, 2002). Nevertheless, the factors of surface and groundwater degradation are multiple and are attributed to different groups of water users. Yet water pollution is a major resource management problem. This is often defective due to the lack of wastewater collection, purification and disposal systems or wastewater storage infrastructure. Indeed, water quality is influenced by a wide range of natural and human phenomena (rainfall, weathering processes, sediment transport, urban development, industrial and agricultural practices (Wimbaningrum *et al.,* 2015; Koull *et al.,* 2013; Etteieb *et al.,* 2017; Guemmaz *et al.,* 2019). As a result, the degradation of water quality leads to infant mortality, morbidity and malnutrition (Baechler, 2012).

In Algeria, the degradation of water quality in aquatic ecosystems is a problem of increasing importance as in the rest of the other countries, especially in the Mediterranean basin where water resources are limited, weak and threatened by overexploitation. (Hamdy *et al.,* 1995; Correia, 1999; Scozzari and El Mansouri, 2011; Verdier and Viollet, 2015; Pierros *et al.,* 1999). On the other hand, freshwater consumption leads to inevitable pollution through wastewater discharge, which directly threatens water quality and the integrity of aquatic ecosystems (Errochdi *et al.,* 2012). Thus the issue of water resources at the national level remains very worrying due to unfavorable climatic conditions, rapid population growth and the quantitative and qualitative degradation of surface

and groundwater (Bennabi *et al.,* 2012). According to Algeria suffers from a deficit of 3758 hectares in terms of surface water mobilization. This prompted the authorities to launch a vast program aimed at increasing the national capacity for the mobilization of surface water resources to more than 10 billion cubic meters. However, controlling the quality of water intended for human consumption and/or irrigation is essential to protect human health, soils, plants and water bodies and to prevent the deterioration of water infrastructure in irrigation and treatment (Boyd, 2015; Negm *et al.,* 2020).

Several studies have been published regarding the assessment of water quality in rivers and dams using physical, chemical and biological parameters that have made it possible to assess the quality of these water bodies and identify pollutants released and their effect on water quality. This approach can give warnings to consumers to avoid dangerous and catastrophic situations (Hadji *et al.,* 2020). However, various natural processes (hydrological, physical, chemical and biological) can affect the properties of chemical elements and compounds in fresh water. In this context, fits this work which aims to analyze the different physico-chemical factors of the water of the Algerian dams in order to classify them according to their water quality, with the aim and to reduce the phenomena of pollution, and to evaluate their suitability for use in human activities.

MATERIALS AND METHODS

Forty water dams located throughout the Algerian territory with a concentration in the east and west of the country were used for this study. The results of this article are based on the average calculation of ten parameters (pH, dissolved O_2, NO_3, NO_2, NH_4, DR, PO_4, BOD_5, COD, MO) measured during the year 2019. The data was provided by the 'ANBT (National Agency for Dams and Transfers). The analyses of these parameters are carried out, according to the Algerian standards in force, by laboratories officially authorized for the realization of the water characterization operation and this, in accordance with the regulations in force in Algeria. The data obtained were presented in graphical form and are compared to the Algerian quality standards adopted by the Ministry of Water Resources, Algeria (2011). A statistical analysis is then started by applying the Principal Component Analysis (PCA) to extract information on the correlation between the analysed variables and the Hierarchical Cluster Analysis (CAH) to allow the classification of the dams studied into similar groups.

RESULTS AND DISCUSSION

Evaluation of the physico-chemical quality of dams waters

Knowledge of the physico-chemical characteristics of water constitutes one means of investigation among others for the assessment of pollution risks and the state of water contamination. The results of water analyzes at all the dams studied recorded a variation between the majorities of the contents of the elements analyzed during the observation period. The average values of the measured parameters are shown in Figures 1 from (a) to (f).

The BOD_5 and COD parameters are used to assess the quantity of organic matter present in the water. The BOD_5 values show an average of 2.85 mg/l O_2 in the eastern dams and 6.89 mg/l O_2 in the western dams (Figure 1a). These values comply with Algerian standards. The COD shows an average value of 38.6 mg/l O_2 in the western dams, which is slightly above the pollution limit (30 mg/l O_2). This indicates that some dams in the west contain enough polluting organic matter.

Oxygen is an indicator of biological activity; it makes it possible to assess the self-purifying capacities of water. Organic pollution consumes oxygen (oxidation). Compared to the western dams, the eastern dams show a high oxygen saturation rate (95.18%) (Figure 1a), indicating a good biological quality of the water. The western dams contain low oxygen saturation levels; this is in perfect agreement with the relatively high COD values of this group of dams.

Pollution by nitrates (NO_3^-) depends on the supply of agricultural land with fertilizers (spreading, livestock waste and fertilizers) and the discharge of sewage. They also come from an incomplete oxidation of ammonium, or from the reduction of nitrites. Nitrates are found in their natural state, in the soil, surface and ground water and all plant matter and reach dams mainly through runoff from agricultural land in winter. They are often used as a pollution indicator. The analyses revealed an average nitrate concentration of 4.70 mg/l in the eastern dams and 3.3 in the western dams. The concentrations recorded (Figure 1b) are well below the pollution limit set by Algerian regulations (50 mg/l). Nitrite levels reached average

values of 0.1 mg/l in the eastern dams and 0.22 mg/l in the western dams (Figure 1c). Although the Algerian regulations do not give a fixed limit for nitrates, these average concentrations of nitrites remain below the limit value given by the WHO (1 mg/l). On the other hand, these low concentrations therefore result from the rapid transformation of this unstable element into nitrates.

Ammonium is the product of the final reduction of nitrogenous organic substances and inorganic matter in water and soil. It also comes from the excretion of living organisms and the reduction and biodegradation of excrement, without neglecting the contributions of domestic and urban origin. On the other hand, the transformation of ammonium into nitrite and nitrate is done by oxidation; this reaction is rapid in the presence of oxygen. Ammonium ion concentrations range from an average of 0.16 in the eastern dams to 0.58 in the eastern dams (Figure 1d). These values remain well below the limit value given by the Algerian regulations setting a rate of 4 mg/l.

The evolution of phosphate concentrations showed an average value of 0.03 mg/l in the eastern dams and an average of 0.081 mg/l in the western dams (Figure 1e). Although the Algerian regulations do not give a fixed limit for phosphates, these average concentrations remain clearly lower than the limit value fixed for phosphorus which is 10 mg/l.

The dry residue (DR) represents all the mineral and organic particles present in the water in a dissolved or suspended state. It depends on the nature of the land crossed, the season, the rainfall, the flow regime, the nature of the effluents, etc. The data collected show that the waters of the western dams have a high dry residue of an average of 1325.63 mg/l. the eastern dams have an average of 647.05 mg/l (Figure 1f). This result is certainly linked to the high load of organic and mineral matter in the waters of this group of dams.

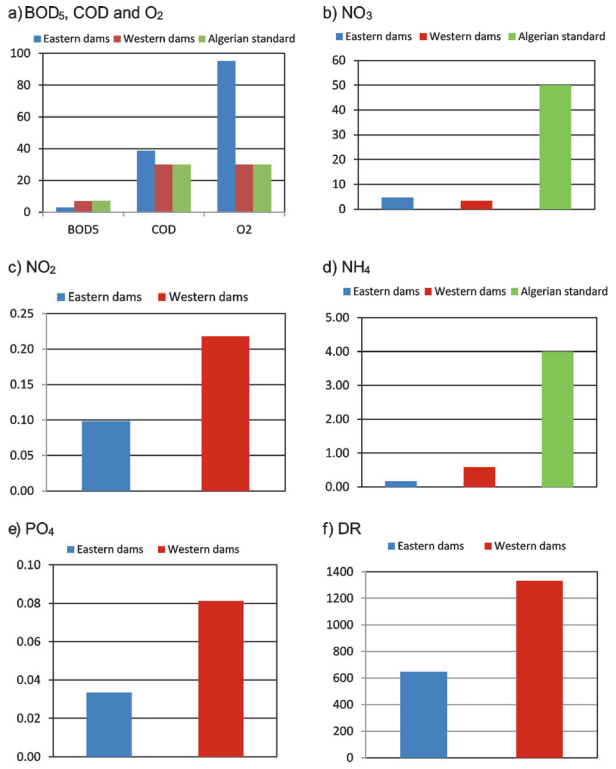

Fig. 1. Water quality parameters of Algerian dams

Statistical analysis of data

East dams

Principal component analysis (PCA)

Principal component analysis (PCA) allows the creation and synthesis of a data set, thus studying the linear relationships between variables (correlations) (Noori *et al.*, 2009). A primary data matrix, including 20 eastern dams each containing ten physico-chemical variables was studied.

The analysis was extended to five factors, but two were retained (F1 and F2) (Figure 2). These factors account for 74.23% of the total variance, which is quite good and can be used to identify major variations in hydrochemistry. The F1 axis expresses 60.46% of the variance and includes most of the parameters describing organic-type pollution (BOD_5, COD, MO and NO_2) and F2 expresses 13.77% of the variance, it is described negatively by the parameters (pH, O_2, NO_3 and PO_4).

The first axis is clearly linked to the parameters of anthropogenic pollution; the second is the

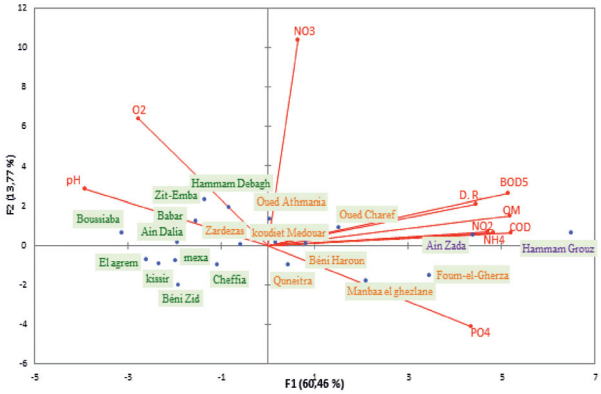

Fig. 2. Projection of observations and correlations between parameters on axes F1 and F2 - East dams

consequence of the supply of nutrients. So F1 and F2 are assumed to be representative of the water chemistry acquisition process.

Hierarchical Cluster Analysis (CAH)

The Phénonline was selected at a correlation distance of 26.34.

This made it possible to distinguish the different groups according to their hydrochemical variables, as shown in Figure 3. The eastern dams were classified according to the visual examination, into three groups. The first group includes (Manbaaelghezlane, Foum-el-Gherza, OuedCharef, Oued Athmania, Béni Haroun, koudiet Medouar, Quneitra, Zardezas). This group is characterized by high concentrations of dry residue (DR) and this also shows that the water is "rich in minerals" (calcium, magnesium and/or sodium). A high COD characterizes the second group (HammamGroz, Ain Zada). This is due to industrial and domestic activity upstream of the dams and natural erosion processes. The third group consists of (Boussiaba, Kissir, Babar, Zit-Emba, BéniZid, El agrem, Mexa, Hammam Debagh, Cheffia, Ain Dalia). All the elements of this group are homogeneous, except that for NO_3, which marks high concentrations, this is probably due to neighboring agricultural activity.

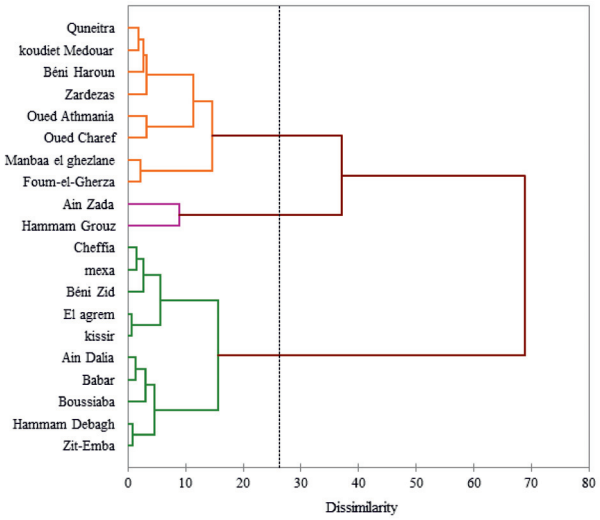

Fig. 3. Dendrogram of the grouping of dams in eastern Algeria

Westdams

Principal component analysis (PCA)

In the graph illustrating the observations and the correlations between the variables (Figure. 4), the first component (F1), which contributes 27.52 % of the inertia, is determined by parameters characterizing DR, BOD_5, COD and NO_2. These variables depend, in particular human activity. The second component (F2) represents only 23.78 % of the information, and it is selected according to the pH, the nutrients (nitrogen, phosphorus, nitrate, ammonium, phosphate) and the O_2. The representation of the western dams by the PCA would not seem particularly useful in this case, since the first two components accounted for only 51.3% of the total variance.

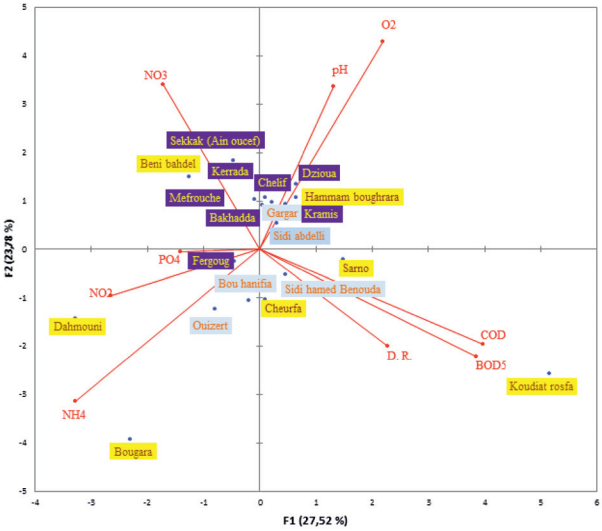

Fig. 4. Projection of observations and correlations between parameters on axes F1 and F2 – Westerndams

Hierarchical Cluster Analysis (CAH)

The application of the ascending hierarchical classification made it possible to distinguish seven different groups according to their hydrochemical variables studied, as shown in Figure 5. A first group consists of nine dams (Fergoug, Mefrouche, Bakhadda, Dzioua, Sekkak (Ain Oucef), Kramis, Chelif, kerrada). It is characterized by high concentrations of DR, which indicates a high activity of the natural erosion process and high concentrations of NO_3 due to the massive use of fertilizers in agriculture. The second group includes (Bouhanifia, Sidi Hamed, Benouda, Ouizert, Gargar, Sidi Abdelli)) and which is also characterized by high concentrations of DR. The third group (Cheurfa, Hammam Boughrara, Sarno) is marked by the highest levels of DR and pH. The fourth group (BeniBahdel) and fifth group (Dahmouni) characterized by high NO_3 contents are mainly

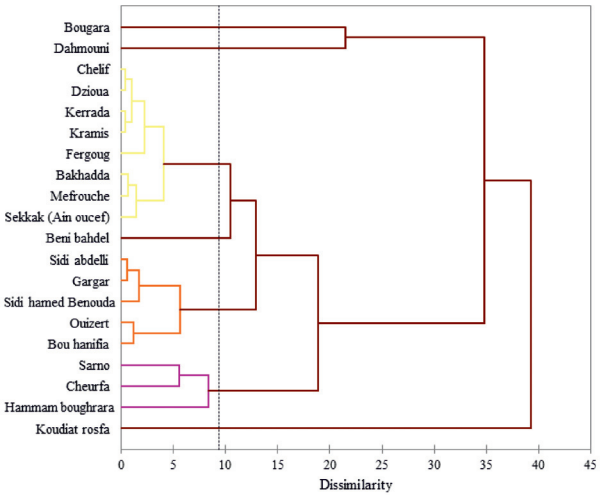

Fig. 5. Dendrogram of the group of dams in western Algeria

influenced by agricultural activity. The sixth group (Bougara) is characterized by contents which approach the average concentrations of various chemical elements studied. The seventh group (Koudiatrosfa) includes high COD, DR and BOD_5 contents. These elements are strong indicators of industrial activity and wastewater discharge.

CONCLUSION

The objective was to study the physical, chemical and organic properties of surface water from dams in eastern and western Algeria. Although the quality of surface water is affected by human, agricultural or industrial discharges, as well as by natural conditions, in particular geological, climatic and hydrogeological conditions, this study has made it possible to highlight the heterogeneity of most of the physical and chemical factors which have an impact on the development and the quality of the water of the dams of western Algeria in particular. The water quality of the eastern dams seems to be average overall.

The study clearly indicates that the water can be used for irrigation and drinking after treatment. Periodic monitoring of water quality is therefore desirable in order to develop a strategy for controlling the environmental risks due to these elements and to restore the environmental safety of all dams.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

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