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Heavy metals analysis in the water of Mellah, Oubeira and Tonga Lakes of El kala wetland complex, North east Algeria

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ABSTRACT: This study aims to quantify the pollution levels in the main Lakes of El Kala National Park; Mellah, Oubeira, and Tonga, which constitute an important source of water supply and a National Heritage according to Ramsar convention, by monitoring five heavy metals (Al, Cr, Zn, Cu, Pb) and the phosphates content. This park contains up to 33% of the population of El Kala district, which liquid wastes are discharged directly in the lakes ecosystem. Results revealed that the Aluminum is present in the three Lakes, Lead was detected in the lakes of Oubeira and Mellah, Zinc and Cr were inexistent in the three lakes, Copper was detected only in Oubeira Lake. Phosphates were present in three lakes with a maximal content of 6 mg/l. This value remains superior to the limit content of phosphates for a lake eutrophication (0.2 mg/l). This situation threatens seriously the Lakes water quality and then its ecosystem.

KEYWORDS: El Kala aquatic system, eutrophication, water, metal pollution.

1 INTRODUCTION

The contamination of surface water systems by heavy metal constitutes an important surface water environmental problem that has received a great deal of attention. Heavy metals in surface water systems can be from natural or anthropogenic sources [1]. Indeed, industrial wastes, agricultural wastewaters, runoffs and atmospheric deposition are major sources of contamination of many surface waters. Runoffs for example cause sedimentation problems [2]. Chemical, toxicological and ecological approaches have been studied extensively in assessing impacts of heavy metal pollution in aquatic environments [3].

Eutrophication is frequently a result of nutrient pollution such as the release of sewage effluent and run-off from lawn fertilizers into natural waters (rivers or coasts). It may also occur naturally in situations where nutrients accumulate [4] (e.g., depositional environments) or where they flow into systems on an ephemeral basis (e.g., intermittent upwelling in coastal systems). This phenomenon generally promotes excessive plant growth and decay, favors certain weedy species over others,

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and is likely to cause severe reductions in water quality. It induces many problems such as a lack of oxygen in water. The water becomes cloudy with coloring of a green, yellow, brown, or red hue. The eutrophication decreases the resource value of rivers, lakes, and estuaries such that recreation, fishing, hunting, and aesthetic enjoyment are hindered. Runoff from agriculture and development, pollution from septic systems and sewers, and other human-related activities increase the flux of both inorganic nutrients and organic substances into terrestrial, aquatic, and coastal marine ecosystems (including coral reefs) [5].

Elevated atmospheric compounds of nitrogen can increase soil nitrogen availability. Phosphorus is often regarded as the main culprit in cases of eutrophication in lakes subjected to point source pollution from sewage. The concentration of algae and the trophic state of lakes correspond to phosphorus levels in water [6, 7]. The limit content admits of phosphorus for a lake eutrophication is about 0.1 mg/l, approximately 0.3 mg/l of phosphates or 0.2 mg/l of total phosphates.

Anthropogenic toxic heavy metals that accumulate in the environment and in the food chain are threatening the world's freshwater resources used for drinking and recreational purposes [8]. Under certain environmental conditions, metals may accumulate to toxic concentration and cause ecological damage [9]. Apart from mercury toxicity and risk, other heavy metals such as cadmium, chromium, copper, nickel, lead and zinc at unacceptable concentrations can seriously affect biota in view of their persistence and bioaccumulation potential [10].

This study aims to quantify the pollution levels of El Kala Aquatic System by heavy metals (Al, Pb, Zn, Cu, and Cr) and phosphates. In the present study, the considered watershed covers an overall area of 76 438 ha. El Kala region located at the Northeast of Algeria, received 1000 mm of precipitation annually [11, 12], and it is influenced by a sub-humid Mediterranean climate. The El Kala area receives more rain the any other part of Algeria [13].

The Kroumerian Mountains rising to the South east trap the prevailing wet NNW winter winds to give an unusually moist climate (900mm on the coast, rising to 2000mm on the mountain slopes), and easily accessible ground and surface water [14]. The temperatures reach 40 °C in summer and low temperatures are recorded in winter with 5 to 6 days of hoar-frost each year in January. The humid environment considered formerly as initiatory and transmit ant of diseases, has today a great ecological, social and economical value.

There are a number of factors which are likely to influence the ecological status of the El Kala region. Each of these needs to be carefully evaluated, and proposals need to be made for the ecological management of the most important sites within and outside the National Park [14].

2 MATERIALS AND METHODS

2.1 STUDY AREA

The National Park of El Kala is situated in the North-east of Algeria and comprises of several lakes with a unique ecosystem in the Mediterranean basin. It has been classified as a part of the National Heritage of Algeria and as a biosphere reserve by UNESCO in 1990.

The Mellah, Oubeira and Tonga lakes are the final outlet of domestic wastewater. 80% of waters used by the domestic population returned to nature as wastewater. The volume of polluted water which can regain the lakes by surface or carried away by underground water, was estimated to be 42188.16 m^3/year for Mellah Lake, 205603 m^3/year for Oubeira Lake and 282077 m^3/year for Tonga Lake.

The National Park of El Kala is situated between (36°55’; 36°90’) N and (8°16’; 8°43’) E (Fig. 1). The region is bound in the North by the Mediterranean Sea, in the South by the mounts of Souk Ahras and Cheffia, in the East by the Tunisian border and in the West by the Seybousse watershed.

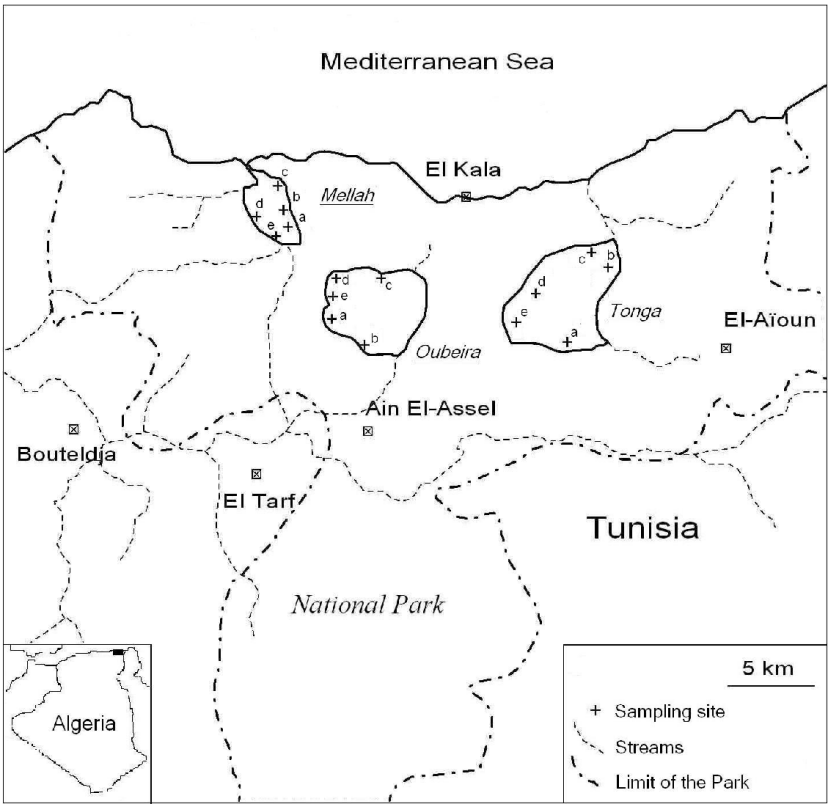

Fig. 1. Situation of study area and sampling sites

The Mellah Lake is located between the Cap Rosa and Roux. The stretch of brackish water has an ovoid form which tends towards the North. Its greatest axe is oriented NW–SE and measures approximately 5 km, with a maximal breadth of 2.5 km. This lake covers a surface of 865 ha, the medium depth is about 3.5 m, and the maximal depth does not exceed 6 m. In the Northwest exists a dune with a peak of 177 m oriented north – east [15]. Mellah Lake is inserted between hills of quaternary alluvium where frequent tectonic movements occur [16]. According to this configuration and to the rivers which flow into this lake [17], an old fluvial valley has been invaded by the sea.

The Tonga Lake is situated in the Southeast of El Kala town at 10 km; it has a surface of 2400 ha of shallow freshwater, fed by two rivers: Serhir and Messida. It constitutes an outlet long of 5 km communicating with the sea. This lake is characterized by its richness in vegetables species [18]. Geological formations of the lake are dated from Quaternary [19]. The tectonic movements of this area permit its digging up until the sea level; then it forms a navy Laguna.

The relieving of Lake Bottom until the maximal altitude of 5.75 m is due to terrigenous contributions derived by rivers along slopes of surrounding mountains. Various geological formations constitute the Tonga Lake watershed; they are represented by silt alluvium, Pontian formations, sandstones, Numidian clays, sandstones, clays, and limestone blocks.

The Oubeira Lake has a surface of 2 200 hectares and an altitude of 25 m. Its contour has a Neo-Pleistocene age; made of recent sands and silts which correspond to the actual aquifer. This Lake was shown to be amongst the 22 Ramsar sites that were most likely to suffer major ecological change [20].

2.2 GEOLOGICAL SETTING

The study region belongs to the Northeast Algerian Tell and the geological formations are from the Tertiary to Quaternary period. This unit extends from Constantine province to the Algero-tunisian border [21] and is constituted by sedimentary formations from Oligocen age with inferior Burdigalian (sandstone, clays, marls) and Quaternary deposits: some from marine origin (alluvial deposits, beach sandstone) and others from continental sedimentation (sandstone, red ground, dunes, Quaternary alluvial deposits).

Moreover, an unconfined dune aquifer is located in the Bouteldja province. The massif dune of Bouteldja is formed by wind sands with a thickness from 20 to 120 m and often with clay intercalations in the lenses form (Fig. 2). The massif dune forms an unconfined aquifer with an impermeable and semi impermeable clay and sandstone substratum [22]. Atmospheric

precipitations and marshes (Righia and Oum Agreb) streaming from favorable slopes of the Numidian formations and effluents of Kebir East River supply the aquifer. The massif dune of Bouteldja is characterized by a permeability which varies from zero in zones constituted by clay and red sand passages to 6 10^{-4} m/s in white sand formations. Measured transmissivity varies between 5 10^{-4} and 1.3 10^{-2} m^2/s.

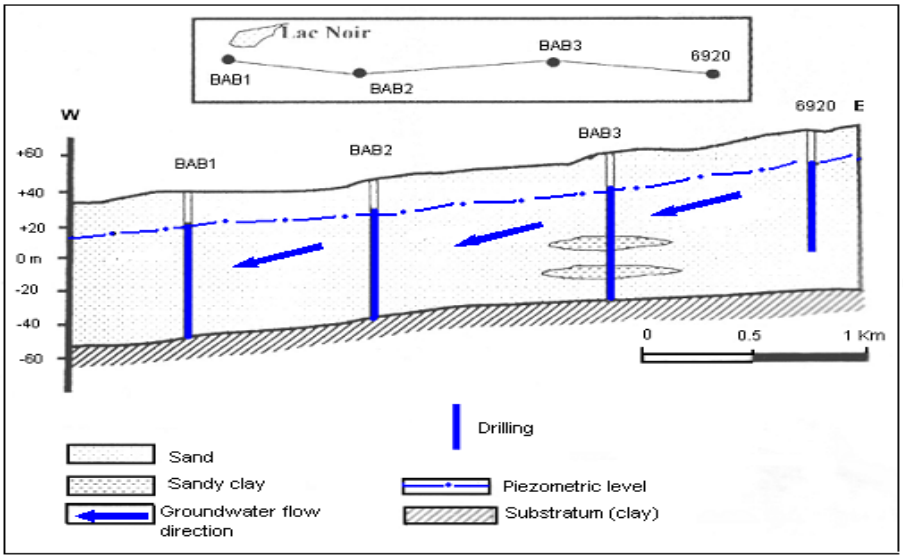

Fig. 2. Hydrogeological section of the unconfined dune aquifer

The confined deep aquifer of Bouteldja and El Tarf province extends from East to West; with a marly substratum and a clay roof. The reservoir is formed by rollers and gravels. The thickness of this aquifer varies, according to the morphology of the marly substratum, between 4 and 15 m. This aquifer is tapped by drilling (in its major part) and by wells (in its superficial part). These installations are in continual exploitation.

The Bouteldja aquifer has a clay substratum; made by gravels, rollers, and sands resulting from the Numidian complex, with marl passages. The whole is surmounted by a muddy-clay layer which constitutes the roof of the confined aquifer. The thickness of the aquifer varies from 50 to 150 m. According to [23], the transmissivity ranges between 10^{-3} and 2 10^{-3} m^2/s.

These aquifers have an important role in the drinking water supply for the local population, where it undergoes a strong solicitation which generates an anthropogenic pollution.

2.3 SAMPLING AND ANALYSES

Hydro-chemical analyses consisting in measurements of metal pollution (Al, Cr, Zn, Cu, and Pb) and eutrophication (phosphates) were performed in 15 stations located in the proximity of three lakes: Mellah, Oubeira, and Tonga (Fig. 1). Sampling was carried out during in May 2006. Samples were collected into new polyethylene flasks that had been rinsed two or three times with DI water. The flasks were filled until overflowing and closed underwater to minimize aeration. Samples were filtered by a 0.45 µm membrane filter and then acidified and diluted by HNO3 at 2%. All flasks were carefully labeled and numbered prior to transport. The sampling procedures were conformed US EPA standard method for surface water sampling [24]. Analyses of heavy metals (Al, Cr, Zn, Cu, and Pb) and phosphates were made in the central laboratory of the Direction Applied Research (D.R.A., metallurgy factory of El Hadjar–NE Algeria) according to methods in [25]. Dissolved metals were analysed with a spectrophotometer (Mark: *Shimadzu;* reference: *SAA 6501F*).

3 RESULTS AND DISCUSSIONS

In Mellah Lake, the contents of Al varied from 0.1 to 0.7 mg/l, the high concentration was found in Boumalek area (sample b). The observation of the graphic of lead variation (Fig. 3 and Fig.4) showed a concentration between 0.35 and 0.4 mg/l, which was generally superior to the WHO standards for drinking water (0.05 mg/l) [26]. For Tonga Lake, low concentrations were observed in the El Hout sample (d); this concentration did not exceed 0.3 mg/l. Thus, this water requires treatment before it can be used for human consumption. The concentration of Cu fluctuated between 0.05 and 0.4 mg/l (Fig. 4).

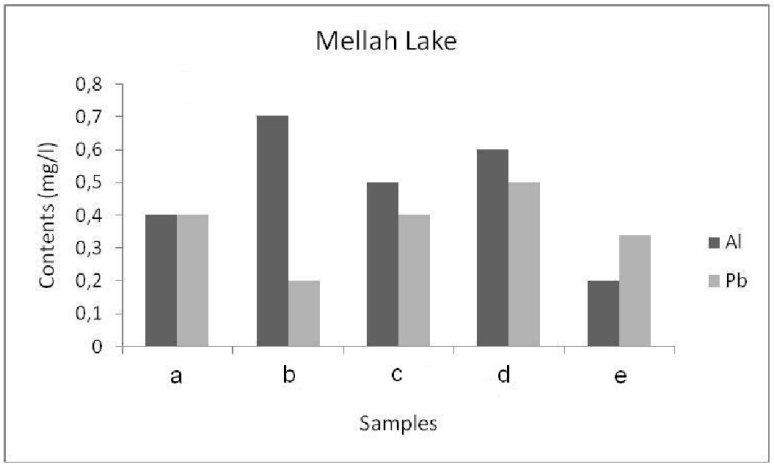

Fig. 3. Aluminum and Lead variation (Mellah Lake)

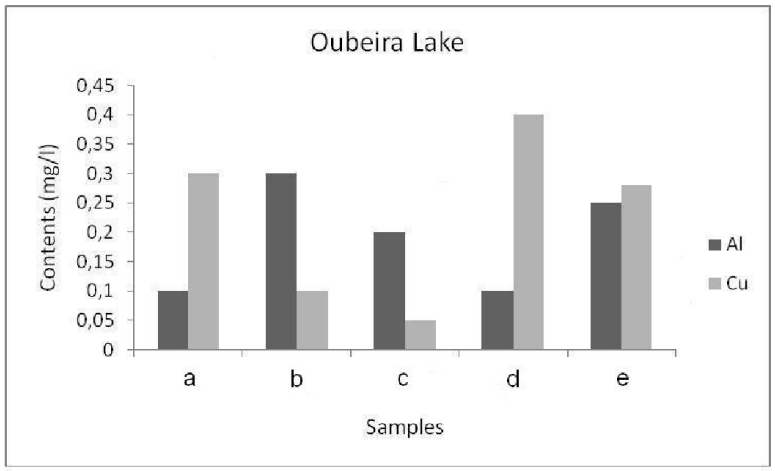

Fig. 4. Aluminium and Coper variation (Oubeira Lake)

In Oubeira Lake, aluminum concentrations fluctuated between 0.15 and 1.2 mg/l and the upper concentration was located in El Safsaf area (sample b). Lead contents surpassed required standards (0.05 mg/l) (Fig. 5).

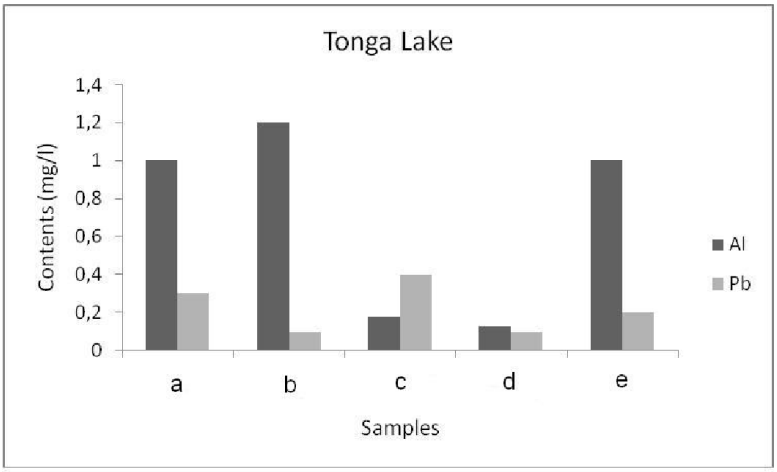

Fig. 5. Aluminum and Lead variation (Tonga Lake)

Beside wastewater, which constitute the source of the presence of lead in the two Lakes (Mellah and Oubeira); this metal may come from the atmosphere deposition.

Lead and copper were not present in Tonga Lake because this lake is located in an area which is less dense in population and in traffic.

The concentration of phosphate varied between 1.9 and 6 mg/l. High concentration was located in the Oubeira Lake at the El Safsaf area (sample 2). However, low contents of phosphate were observed in Mellah Lake (Fig. 6). The heavy metals (Al, Pb, Zn, Cu and Cr), analyses revealed that Aluminum is present in the three Lakes, Lead is detected in the lakes of Oubeira and Mellah and Copper is detected only in Oubeira Lake. However, Zinc and Chromium were not detected.

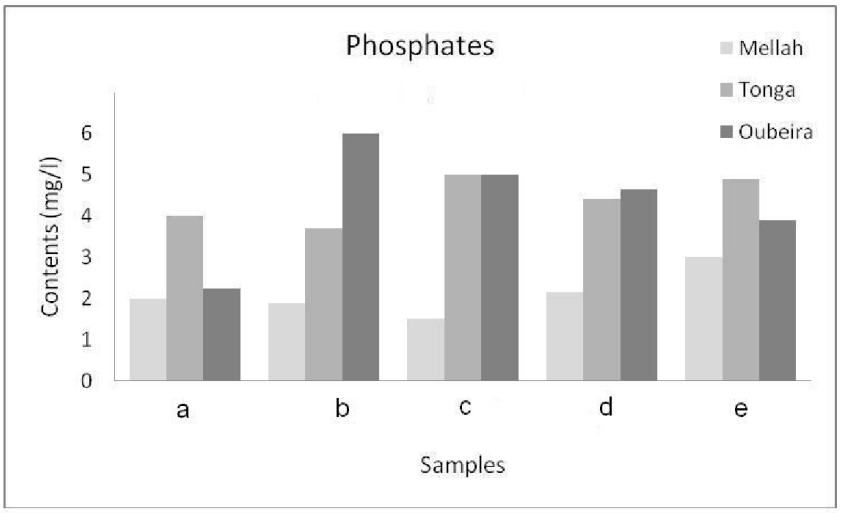

Fig. 6. Phosphates variation in the three Lakes

4 CONCLUSIONS

The hydrochemical analysis Lakes water samples reveal that the phosphates are present in three Lakes with a maximum of content of 6 mg/l. Thus, the risk of lakes eutrophication is eminent, leading to rapidly weeds growing and choking potentially the waterway and using up large amounts of precious oxygen. For the other side, Aluminum is present in the three Lakes, Lead is detected in the lakes of Oubeira and Mellah, and Copper is detected only in Oubeira Lake. Indeed, the three Lakes of El Kala region present number of factors which harm the ecological status of their ecosystem, and then water supply for riparian. The treatment of wastewater discharged into Lakes is primordial in other to preserve their aquatic ecosystem.

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