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Assessing of Tonga Lake Water Quality in the coastal basin of Northeastern Algeria

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Abstract— Tonga Lake, which situated in the north east of Algeria, is a Ramsar site and a part of the larger El Kala wetland system which is generally recognised as one of the four major wetland complexes in the Western Mediterranean. This seasonal freshwater lake is linked to the Mediterranean Sea. The principal objective of this study is to assess in a particular context, the impact of inorganic pollution induced by ammonium (NH_4^+), nitrates (NO_3^-), nitrites (NO_2^-), and dissolved oxygen, on the quality of Tonga lake water. The samples studied to that end are those taken in 2013 and 2014 from the superficial waters of the Tonga Lake in far north-east Algeria. Results show that the nutrient and the degree of pollution varies by zone, as well as by month to month with contents often close to recommendations made by the World Health Organization (WHO). The protection of water quality and the reduction of the risk contamination are of great importance in the region to a reliable and sustainable this precious ecosystem.

Index Terms— Tonga lake, Eco-hydrobiology, Water quality, Nutrients, Fertilizers, Organic waste, El-Tarf region.

1. INTRODUCTION

IN recent years, pollution increase within aquatic systems as well as the progressive nature of pollutants and the subsequent chemical transformations leading to toxicity in both the short and long term. These have made hydrological monitoring and water quality assessment of foremost concern in hydro-ecological research [1], [2]. Nitrates, Nitrites and Ammonia, constitute the main parameters of inorganic pollution. These nitrogenous compounds are essentially found in chemical fertilizers, and manures; and constitute the major source of nitrogen to crops.

Farmers have augmented fertilizer use up to 500 kg/ha so as to assure successful crop production. However, if too much fertilizer is used, an excess of nitrates will result. This excess may become a potential contaminant to the all hydrological system surface water and groundwater, via nitrate infiltration through amended soils to the river, lake or groundwater table.

Inorganic contaminants are responsible for the "bad taste" aggravated by chlorination, stimulate the proliferation of microbes, molds and algae resulting in eutrophication [3]; and high level of nitrates have also been linked to detrimental effects in human health [1],[4], [5], [6].

Surface water and groundwater are one of the most precious natural resources in northeastern Algeria, as it is the principal source of irrigation water for the majority of the agricultural activities.

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The water system of El-Tarf region is extremely susceptible to surface-derived contamination because of the topography and the high permeability of sands and gravels that compose in general the soil profile of El-Tarf region [7].

Several studies in El-Tarf region reported various degradations levels of surface water system as one of the major concerns among the public and governmental decision makers [8], [9], [10] but these studies did not include a precise evaluation of inorganic pollution in the surface waters.

River, lake and ground water contamination can occur if input of (NO_3^-) into soil exceeds the consumption of plants and denitrification processes [11]. Nitrate (NO_3^-) and nitrite (NO_2^-) are naturally occurring inorganic ions, which are produced in the Nitrogen (N) cycle [12], [13]. Microbial action in soil or water decomposes wastes containing organic nitrogen first into ammonia, which is then oxidized to (NO_2^-) and (NO_3^-) [11]. Because (NO_2^-) is easily oxidized to (NO_3^-), (NO_3^-) is the compound predominantly found in surface waters (River and lake) and groundwater under oxidizing conditions. Contamination with N containing fertilizers, including anhydrous ammonia, as well as animal or human natural organic wastes, can raise the concentration of (NO_3^-) in surface water [14], as nitrate (NO_3^-) containing compounds within the soil matrix are generally soluble and readily migrate into river, lake and groundwater systems [15], [16]. The main objectives of this study were: (1) to determine the average levels and distribution of NO_3^-, NO_2^-, NH_4^+, and PO_4^{3-} in the Tonga Lake water of the El-Tarf region (National Park of El Kala), and (2) to assess during all the year the temporal evolution of nutrients and inorganic pollution parameters.

2. CHARACTERISTICS OF STUDY REGION

The Tonga watershed is situated in the extreme northeast of Algeria and adjoins the Mediterranean Sea with the "Messida" chanel in the North [17], [18].

The region of study is subjected to a Mediterranean climate characterized by two different seasons: one wet, marked by

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high rainfall and low temperatures from October to May, and other dry and warm with high temperatures reaching their maximum in August with low rainfall. Prevailing southernly winds blow off of the sea during the winter; and in summer, the hot Sirocco blows in a south-southwesternly direction, carrying with it a drying effect that is strongly felt during a one month period of time [19], [20].

The region of study is a part of the geologic whole north-oriental Algerian Tell [17], [18]. This group extends of the region of Constantine on the border between Algeria and Tunisia. In general, the study region includes the following units:

- The Triassic formation located in the South of the region of study (Triassic diapirs, vermiculated limestone and pelitic sandstone formation);
- The metamorphic formations situated in the massif of Edough (Annaba city) are dominated by schist, gneiss, marble and amphibolites;
- The sedimentary rocks of Oligocene to lower Burdigalian age are dominated by sandstone, clays and marls;
- The Quaternary formation, composed of sedimentary rocks of marine origin (e.g., alluvial deposits and beach sandstone), and continental origin (e.g., red land sand dunes, fluvial alluvium, and colluviums).

Eastern Algeria, with its highly contrasted semi-arid climate, is drained by opposing hydrographic systems trending from North to South: the tributary watersheds of the Mediterranean sea to the north, and a riverine system connected to closed drainage basins to the south. The hydrological data of most stations in the east of Algeria shows the extreme spatial variety of the specific discharges (0.32 - 16.1 L/s/km2 caused by the decisive role of the climate, particularly that of rainfall [20].

The hydrogeology of this study region is defined by a deep layer of gravels surmounted by an unconfined layer covering the entire plain. This layer is limited by two separate superficial or surface water tables: one to the South composed of gravel and pebble terraces, and the other to the North of Cordon dune composed of dune sands based on clayey substratum [7], [19].

3. Material and Methods

Water samples were collected from the Tonga lake during the period from June 2013 to May 2014.

Tonga lake water samples were filtered through 0.45 µm (Sartorius filter); the first few milliliters were used for rinsing and were discarded. The filtrate was transferred to clean polyethylene bottles and stored at 4 °C.

The temperatures (T), electrical conductivity (EC), (pH) were measured in situ using a multi parameter conduct a (pH) meter. Dissolved oxygen and turbidity were also measured at the same time. The concentration of Nitrate (NO_3^-), Nitrite (NO_2^-), Ammonium (NH_4^+) and phosphate (PO_4^{3-}) were measured using the UV spectrophotometric screening method according to standard examination methods of water and wastewater from the American Public Health Association (APHA), American Water Works Association (AWWA), and the Water Environment Federation (WEF), [21].

4. Results and Discussion

The interpretation of the diagrams representing the various parameters concerning inorganic Tonga lake water pollution gives rise to possible contamination of this particular hydro-eco system [23].

The evolution (dissolved O2- nitrates) of the surface water in the Tonga lake (fig. 1) shows a decline in nitrate concentration during the period from April to September most likely due to the lack of precipitation, and an enrichment of the environment in dissolved O2 between September and January which is confirmed by the presence of nitrates.

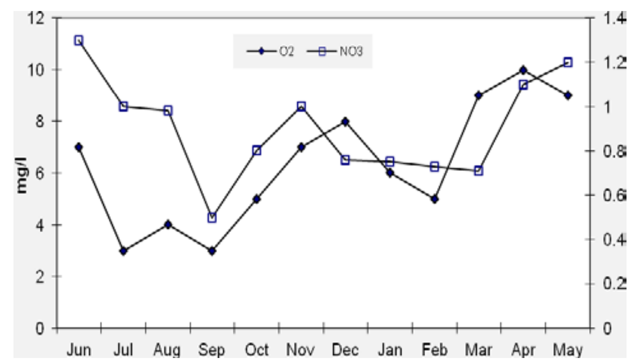

Fig. 1. Evolution of dissolved oxygen and nitrate of Tonga lake waters.

Fig. 2 (O2-Ammonium) shows an oxidized enough environment marked by small quantities of NH_4^+.

The ammonium of surface water may originate from the following sources:

- Stream vegetation;
- Animal or Human organic wastes (Man eliminates 15 - 30 g of urea a day);
- Industrial discharges;
- Chemical fertilizers, manures etc.

Its presence is relatively similar to the others Nitrogenous compounds identified in the water : Nitrites and nitrates.

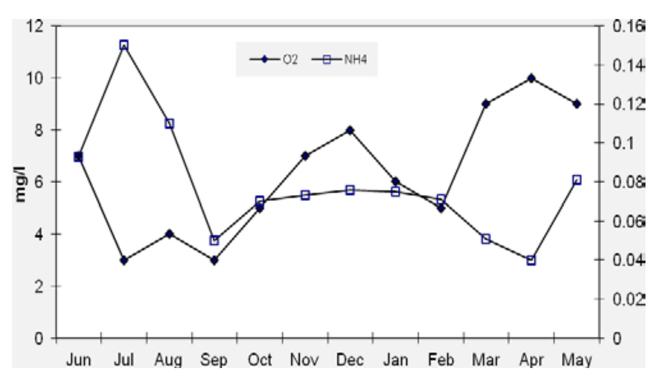

Fig. 2. Evolution of dissolved oxygen and ammonium of Tonga lake waters.

The figure 3 below (fig.3) illustrates high concentrations in ammonium, nitrate and nitrite ions in Tonga lake water, as opposed to an evident decrease in dissolved oxygen content during the dry period between June and November, where lack of precipitation is common. It follows that nitrates decrease to be transformed nitrites (NO_2^-) and to be finally reduced to NH_4^+. We therefore bear witness to the natural microbial respiration process of denitrification, which most likely led to the consumption of dissolved O2 in the majority of hydro-system like river, lake and groundwater [24]. Nitrites result from the incomplete oxidation of ammonia in water. Therefore, either the nitrification process is not driven to completion, or nitrite production is a direct result of nitrate reduction during the denitrification process. Water which contains nitrites is to be considered as suspect because a deterioration of the biological quality is often associated with it.

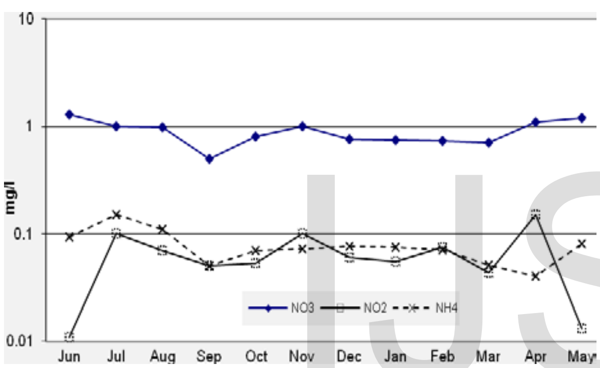

Fig. 3 Evolution of nitrite, nitrate and ammonium of Tonga lake waters.

All this is confirmed by the agreement or correspondence between the evolution of the pluvio-thermal diagram and dissolved oxygen (Fig. 4) during the dry and wet periods previously discussed.

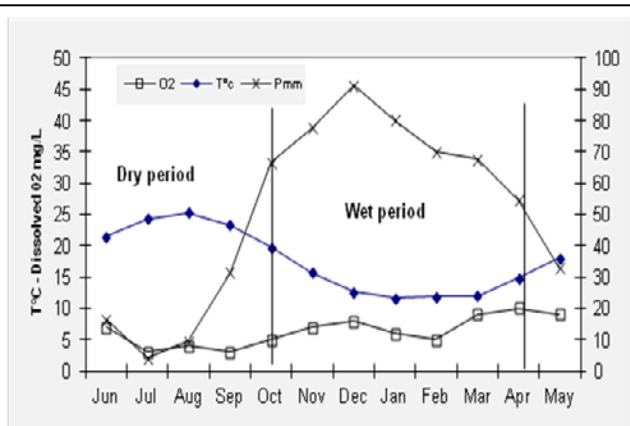

Fig. 4 Graphical representation of climate diagram and dissolved oxygen.

The evolution of the concentrations in ammonium, nitrates and nitrites of the surface water in the down of Tonga lake (Fig. 3) shows between January and April an increase of NO_3^-, NO_2^-, and NH_4^+ provoked by the contribution of fertilizer. The presence of organic matters is due to the washing.

Indeed, the migration of nitrates is increases rapidly on cultivable surfaces left naked exposed during winter. Communal and, in some instances, industrial discharges of chemical fertilizers and explosives may also contribute to nitrate enrichment of the surface water and thus groundwater.

The pluvio-thermal and dissolved oxygen diagram (Fig. 4) are in agreement. We note an increase of dissolved O2 during the dry period (from May to November) and a decrease between November and May (wet period).

5. Conclusion

The pollution represents a severe problem for the environment because of discharges in the rivers of Oued El Hout and Oued El Erg [24] due to the excessive use of fertilizers in agriculture.
The degree of pollution varies by zone, as well as by month to month with contents often don't exceeding recommendations made by the World Health Organization (WHO) [25]. We can note a significant agreement between pluvio-thermal variations and dissolved oxygen in surface water of Tonga Lake.
In this region of study, even if Tonga lake water concentration of inorganic contaminants (especially NO_3^-) does not exceed accepted standard limits, the situation still poses serious risk. The current state of surface water pollution is the reflection of nitrated substances infiltrated a few years before. The importance of the transfer time dependent on the topography, the depth of the lake and on the nature of the soil [1][26].
In spite of efforts made to raise awareness to nitrate water pollution, nitrate fertilizer use has not decreased, but has increased due to surface tilling practices linked to increased crop production and progressive agricultural development.
Finally we recommend:
– An integrated monitoring program should be conducted. The municipal wells should be sampled 3–6 times a year for the analysis of anions, cations, heavy metals and pesticides. The data of the rivers, lakes and groundwater quality should be centralized in a data bank or a water archive.
– The objective of the Algerian water institutions should be how to safeguard all the water resources system from pollution. The protection of water quality and the reduction of the risk contamination are of great importance to a reliable and sustainable water supply in the region [27], [28].
– Several studies should be conducted mainly on bioindicator monitoring of risk assessment and water toxicology [29].

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