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# Evaluation of heavy metal content in Qaroun Lake, El-Fayoum, Egypt. Part I: Bottom sediments

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## ABSTRACT

This paper was undertaken in order to assess the extent of contamination in bottom sediments of Qaroun Lake, El-Fayoum, Egypt. Sediment samples were analyzed for grain size distribution and heavy metals concentration. Ten heavy metals were determined (in ppm) by X-Ray Fluorescence Spectrometry. The average concentration values in sediments are 2.99 (As), 124.89 (Cr), 38.91(Cu), 14.21 (Pb), 54.74 (Ni), 58.76 (Zn), 3.27 (Sn), 6.77 (Mo), 162.77 (V) and 11.70 (Co). Most of these metals are found with high concentrations in the eastern part of the lake, comparing with them in sediments of the central and western parts. The impact of drains effluents on the lake sediment-metals content is revealed. The dependence of concentrations on the sediment grain size is examined and high correlations between silt and clay-sized grains and the concentrations of Cr, Cu, Ni and Mo are deduced (*R* ranges from 0.61 to 0.73). Potential contamination of the lake is assessed using the contamination indicators, the geo-accumulation index, *I*<sub>geo</sub> and contamination factor, *C*<sub>f</sub> and the degree of contamination, *C*<sub>d</sub>. Based on the obtained results, it is concluded that the lake sediments are found in contamination conditions. They are moderately contaminated with Cr, Mo, V and Co metals.

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## 1. Introduction

Investigation of heavy metals in sediments of aquatic ecosystems is an essential requirement in order to understand their effects on water and living organisms. In the recent years, heavy metals have been greatly considered in the studies of water environments because of their potential toxic effect, persistence, and bioaccumulation problems (Censi et al., 2006 and Carr & Neary, 2008). Heavy metals exist naturally in the

earth's crust rocks and originate from anthropogenic activities. They can reach the water environments via the atmospheric deposition, surface runoff agricultural drainage water, effluents of industrial, petroleum, sewage and household cleaners (Gomez et al., 2007; Mortatti & Probst, 2010; Santos, Silva-Filho, Schaefer, Albuquerque-Filho, & Campos, 2005).

Sediments, as one of the water ecosystem components, act as a reservoir of heavy metals (ECDG, 2002 and Mwamburi, 2003). Sediments reflect the environmental changes occurred in sedimentary basins and provide useful information about

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E-mail address: [saelwahab132@yahoo.com](mailto:saelwahab132@yahoo.com) (S.A. El-Sayed).Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications. <http://dx.doi.org/10.1016/j.jrras.2015.02.011>1687-8507/Copyright © 2015, The Egyptian Society of Radiation Sciences and Applications. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

accumulation of heavy metals, reflecting the natural (geogenic) and anthropogenic impacts. Oftentimes, mixtures of metals pollutants are present in the impacted sediments, which may result in severe contamination leading to destroying the entire aquatic life (Milenkovic, Damjanovic, & Ristic, 2005). The extent of sediment contamination with heavy metals should be investigated extensively to avoid the serious environmental risks. Contamination levels are, usually, determined by comparing the present day metal concentrations with their natural background (regional or local) levels in earth's crust sedimentary rocks or with the preindustrial background values (Dickinson, Dunbar, & McLeod, 1996; Hakanson, 1980; Muller, 1969; Ong, Menier, Shazili, & Kamaruzzaman, 2013; Raulinaitis, Ignatavicius, Sinkevicius, & Ockinis, 2012).

Qaroun Lake is one of the most important inland-aquatic ecosystems in Egypt. It is a distinctive landform lying in El-Fayoum area situated approximately 80 km southwest of Cairo (Fig. 1). Besides its significance as a natural discharge area for El-Fayoum province, the lake is an important place for fishery, salt production, tourism and migratory birds in the Autumn and Winter seasons. Therefore, Qaroun area was declared as a natural protectorate according to the provisions of Law 102/1983, by Prime Ministerial Decree No. 943/1989.

Monitoring the concentration of heavy metals and evaluating their contamination levels in Qaroun lake sediments are imperative and crucial issues to ensure sustainable ecosystem function well in the future. The objective of this paper is to determine the concentration and distribution of some heavy metals (As, Cr, Cu, Pb, Ni, Zn, Sn, Mo, V and Co) in the lake sediments and to assess the degree of contamination. Results of this study may be insights for the decision maker to improve the protection procedures of the lake against the potential serious risks.

## 2. Materials and methods

### 2.1. Characterization of the study area

El-Fayoum area (comprising Qaroun Lake, the study area) is a depression excavated naturally in the northeastern part of the

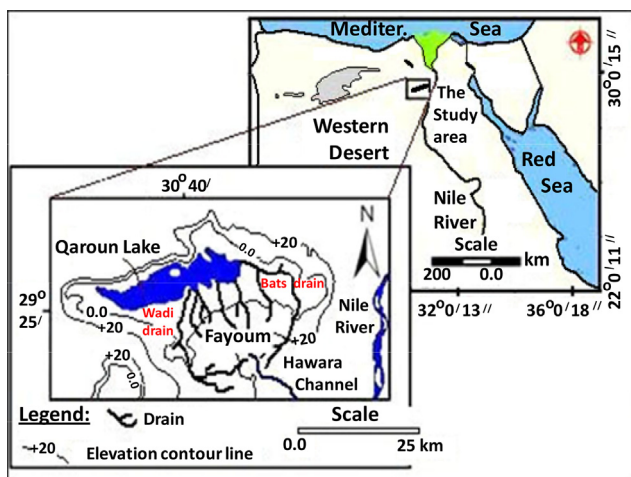


Fig. 1 – . Location map showing the location of Qaroun lake and the relevant drains, El Fayoum, Egypt.

Western Desert of Egypt. The surface of the depression is almost flat and slopes downward in a northwesterly direction, from a level of +23 m (MSL) at El-Hawara channel to –35 m (MSL) at the central part of Qaroun Lake (Fig. 1). The major part of the depression is cultivated using a dense net of irrigation canals and drains.

The depression is occupied by the Quaternary sediments, clay, silt, sand, gravels, lacustrine and sabkha (CONOCO Coral, 1987; EAAA/NCS (Egyptian Environmental Affairs Agency/ Nature Conservation Sector), 2007; Wendorf & Schild, 1976). It is surrounded from all sides by hills or escarpments composed mainly of Tertiary rocks, hard limestone, calcareous sandstone, shale, basalt sheets, sands and gravels (Abd-Elshafy, Metwally, Abd El Azeam, & Mohamed, 2007; Bown & Kraus, 1988; Koopman, 2007; Said, 1962).

Qaroun Lake is a closed saline basin lying in the lowest-northwest part of El-Fayoum depression, between longitudes 30° 24' and 30° 50' E and latitudes 29° 24' and 29° 33' N. It has an elongated rectangular shape with average dimensions 45 km length, 5.7 km width and 4.2 m depth in average (Gohar, 2002). It is bounded from the south and east by the urban and cultivated areas and from the north and west by the uninhabited desert areas. The drainage in El-Fayoum depression is mainly by gravity. The drainage network consists of three main drains (El-Bats, El Mashroah and El-Wadi drains) and a number of small drains, which terminate into the lake. The lake receives huge mixture of untreated agricultural, industrial, sewage, and household effluents (about 450 million m<sup>3</sup>/year) from El-Fayoum province (Gohar, 2002).

### 2.2. Sample collection and analysis

Contamination of Qaroun Lake sediments with heavy metals was evaluated using some of geochemical tools. In this study, the lake was divided geographically into three parts (east, middle and west) according to the presence of the relevant drains. Fourteen samples were taken from the bottom sediments of the lake for grain size and heavy metal analysis. Their distribution is as follows: 6 samples from the eastern part of the lake, 4 samples from the central part and 4 samples from the western part (Fig. 2). In addition to that, nine samples were collected from the relevant drain bottom sediments and analyzed for heavy metals to reveal their impact on the lake. All samples were taken from 0.0 to 10 cm depth using a suitable grab sampler. The collected samples were put directly in air sealed polyethylene bags and kept at 4 °C until analyses.

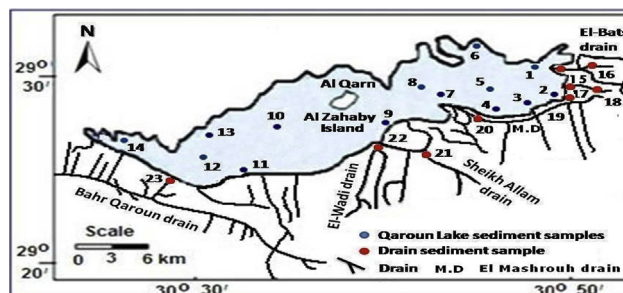


Fig. 2 – . Sediment sampling points, Qaroun lake and relevant drains.

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