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FULL LENGTH ARTICLE

Ecological risk assessment and spatial distribution of some heavy metals in surface sediments of New Valley, Western Desert, Egypt

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KEYWORDS

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Abstract The southern New Valley consists of three main oases, Farafra, Dakhla and Kharga Oases in the Western Desert, Egypt. Sediment samples collected, from land (24) and in ponds (23), from the three oases were used to evaluate the potential ecological risk and spatial distribution of Zn, Cu, Pb and Cd, also to verify whether the sources of pollution were by human activities or an accumulation of different parameters from the land near the ponds. They were also collected for grain size analysis including those of sand and mud percentages along with the mean, organic carbon, total carbonate, total phosphorus and Iron values.

Sediment enrichment factor (EF) showed that the variation values were from moderate to minor enrichment. The Geo-accumulation index calculations (I_{geo}) proved that the investigated areas could be classified as unpolluted with the exception of Mute 13 and HO2 which were moderately polluted by Cd, while Ras was strongly polluted by Cd. HO1 and Ras revealed that they were a moderate to considerable ecological risk, respectively. Mean ERM quotient (MERMQ) reflected that the surface sediments of HO3 and Mute 5 have 21% probability of toxicity.

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Introduction

The study areas are located at the southern part of the Western Desert of Egypt, New Valley, including Dakhla, Kharga, and Farafra Oases (Fig. 1). Those oases depend mainly on agricultural activities from groundwater which yields a large amount of the agricultural drainage and wastewater to form wastewater ponds. Due to the occurrence of most of these ponds in the highlands, there is a risk of the wall collapsing and the land flooding to neighbouring cultivated lands and houses. So these ponds represent serious threats to the population and are a danger to those oases.

Many pollutants are accumulated in the sediments and have harmful effects on the aquatic environments (Nilin et al., 2013). These pollutants are used to detect the hazardous status of aquatic ecosystems (Camargo et al., 2015) and are an integral component in ecological integrity functions.

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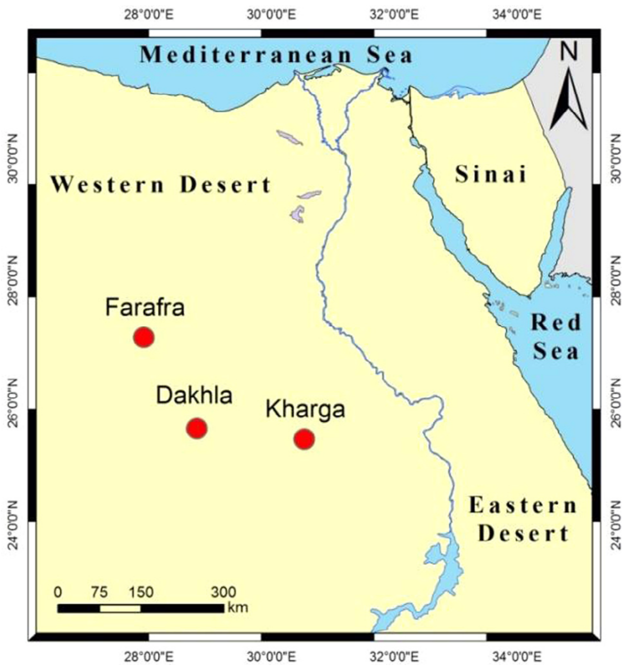

Fig. 1 Location map.

It has been found that most of the heavy metal in the aquatic systems is associated with suspended particulate matter and sediments (Amin et al., 2009), while dissolved metals adsorb onto fine particles and are carried to bottom sediments (Singh et al., 2005). Therefore, sediments act as a potential sink and are carriers for contaminants in aquatic environments, as some pollutants may be recycled through changed environmental conditions and biological processes within the water column (Wang et al., 2015). Heavy metals which have accumulated in sediments can be released into the over-lying water with some mechanisms (Zhao et al., 2014).

This study aimed at investigating the concentration of heavy metals in the sediments and assessing the risks associated with the heavy metals in the sediments. That was done through the calculation of the enrichment factor (EF), geo-accumulation Index (I_{geo}), mean ERM quotient (MERMQ), and potential ecological risk index (RI). Their effects on water ponds as fish farm or as irrigation water to the neighbouring land were also examined. They were also studied to determine the sources of pollution; whether it was caused by human activities or from the accumulation of different parameters from the land near the ponds.

The Farafra Oasis "is located ~140 km southwest of the Bahariya Oasis in the central part of the Western Desert (between 26,450 N–27,400 N and 27,000 E, 28,500 E)". It occupies an oval-shaped depression about 10,000 km^2. This Depression is surrounded by high escarpments, and its bottom rises gradually to the general level of the. Surrounding desert southwards (Issawi et al., 2009). The scarps of the Farafra Depression are composed of the Tarawan Formation (Paleocene) overlain by the Esna Shale (Paleocene-lower Eocene) and the Farafra Limestones (lower Eocene) (Issawi et al., 2009; Mohamaden et al., 2016). The eastern part of the depression is covered by sand sheets, and the depression is bounded to the west by the Great Sand Sea. The Farafra Depression forms a dome structure, and suffered from many faults where the Main trends towards NE direction (Hamouda, 2006a,b). It represents the southern extension of the Syrian Arc System, and under the trend main fault of Qattara trend to NE-SW and Pelusium Line (Hamouda, 2009; Hamouda and Abdel-Salam, 2009; Hamouda et al., 2015). Its axis stretches in the NE–SW direction effect on the sequence structure of sediment where lead to increase of the seepage water towards the ground water aquifer (Hamouda, 2010).

Materials and methods

Study area

The study areas represent the southern part of the Western Desert of Egypt (Fig. 1). These areas are characterized by parallel belts of sand dunes with NNW direction (Senosy, 2003).

Kharga Oasis

It is the largest oasis and is located in the southern part of Egypt. Kharga Oasis is located at longitude 30.54–30.91 E and latitude 25.46–25.78 N. The oasis includes Ain El Sheikh and Ain Hemed ponds (Fig. 2).

Dakhla Oasis

It is located at longitude 28.25–29.67 E and latitude 25.00–26.00 N. Mute, Rashda and El Hosha are the three ponds found there (Fig. 3).

Farafra Oasis

It is located between Lat. 26.75 and 27.67 N and Long. 27.00 & 28.83 E with an area of 10,000 km^2. It is covered by the Dakhla Shale in its southern part, and chalk in the north (Hermina, 1990). It includes Loaa Sobeh and El Nahda ponds (Fig. 4).

Sediment sampling

Forty-seven surficial sediment samples were collected from three oases (Kharga, Dakhla and Farafra); from ponds (n = 23) and land (n = 24) (Figs. 2–4) during winter 2014. The concentration of total heavy metals was measured using Flame-Atomic Absorption Spectrophotometer. Grain size analysis was applied to all samples (Folk, 1980). The carbonate content was determined according to Molnia (1974). Total organic carbon (TOC) content was determined following the procedure of Loring and Rantala (1992). The determination of total phosphorus content (TP) followed Aspila et al. (1976).

Quantification of sediment pollution

To evaluate the degree of sediment contamination with heavy metals, mean ERM quotient (MERMQ), enrichment factor (EF), geo-accumulation Index (I_{geo}), pollution and potential ecological risk index (RI) were estimated. In the present study, the background values have been nearly o the metal concentration of average shale (Turekian and Wedepohl, 1961). The used background values were 47,200 (Fe), 95 (Zn), 45 (Cu), 20 (Pb) and 0.3 (Cd).

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