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Assessment of metal contamination in coastal sediments, seawaters and bivalves of the Mediterranean Sea coast, Egypt

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ABSTRACT

In order to assess metal contamination on the Mediterranean coast of Egypt, 45 sediment samples, seawaters and bivalve specimens were collected from Rosetta coastal area for Mg, Al, K, Fe, Sr, Zn, Pb, Mn, As, Ce, Ni, Cr and Zr analyses by Inductively Coupled Plasma-Mass Spectrometer. The Enrichment Factor (EF), the Geoaccumulation Index (Igeo) and the Contamination Factor (CF) indicated that the coastal sediments of Rosetta area were severely enriched, strongly polluted with As, Pb and very highly contaminated with As, Pb, Ni, Ce, mostly as a result of anthropogenic inputs. Comparison with other samples from the Arabian Gulf, Red Sea and abroad coasts suggested that the studied samples have higher concentrations of Fe, Pb, As, Zn and Ni. The natural sources of heavy metals in the study area are attributed to weathering and decomposition of mountain ranges of the Sudan and Ethiopia, while the anthropogenic ones are the metals produced from industrial, sewage, irrigation and urban runoff.

Metals are introduced into the aquatic system as a result of weathering of soil and rocks, volcanic eruptions and from a variety of human activities involving mining, processing and use of metals and/or substances containing metal contaminants (Karageorgis et al., 2003; Lin et al., 2012, El-Sorogy 2012, 2013a,b). Sediments act as both carriers and sinks for contaminants in aquatic environments. Heavy metal concentrations in sediment are many times greater than the same metals in the water column. Sediments can act as a scavenger agent for heavy metal and an adsorptive sink in aquatic environment. It is therefore considered to be an appropriate indicator of heavy metal pollution (Idris et al., 2007; Gupta and Singh, 2011).

The Egyptian black sands are the end products of the disintegrated materials from the igneous and metamorphic rocks (Dabbour, 1995; Dawod and Abdelnaby, 2007). These deposits comprise huge reserves of the six common economic minerals that include ilmenite, magnetite, garnet, zircon, rutile and monazite (El-Askary and Frihy, 1987; Hedrick, 1989). The Rosetta black sands have been the subject of many articles concerning the mineralogy and economics of these black sands (El-Miligy and El-Azab, 1994; Mahmoud et al., 2013).

Rosetta area as one of the Egyptian coastal areas on the Mediterranean Sea receives different types of pollutants, therefore this study is designed to assess the current status of metal contamination in the coastal sediments, seawaters and bivalves from Rosetta beach, Mediterranean Sea, Egypt and to identify potential sources of contamination. This evaluation helps developing effective coastal management guidelines and strategies for better management of coastal activities.

Study area is bordered by the north western part of Suez Canal from the east and northern side of Manzala Lake from the south, between longitudes 30° 21′–30° 28′ E and latitudes 31° 26′–31° 29′ N. It is located northeast of Abu Khashaba village, east of Rosetta and bounded by the Mediterranean Sea shoreline from the north. Rosetta beach area is an open area, nearly flat, very gently dipping to north and occupied mainly by sabkha.

The study area is characterized by a low relief mainly below 2 m above sea level, and slope gently from south to north. Geomorphologically, it is represented by a flat coastal plain dissected by some hummocky sand dunes in the south. The beach face slope increases from zero near the Rosetta mouth and becomes relatively steeper eastwards where it reaches about 15° at a distance of about 20 km from the mouth (Wassef, 1973).

The beach deposits are composed of loose fine sands with a considerable amount of heavy minerals. The sand particles are composed of quartz, feldspars and mafic minerals with specific gravities between 2.65 and more than 5 g/cm^3. The heavy minerals of the black sands are ilmenite, magnetite, zircon, garnet, rutile, and monazite. The black sands also contain traces of gold, cassiterite, beryl, chromite, corundum, apatite, collophane, uranothorite and gangue minerals. The latter include hornblend, actinolite, augite, hedenbergite, hyperthene, enstatite and minor amounts of biotite, epidote, sturolite, sphene, tourmaline, sillimanite and olivine (Hammoud, 1966).

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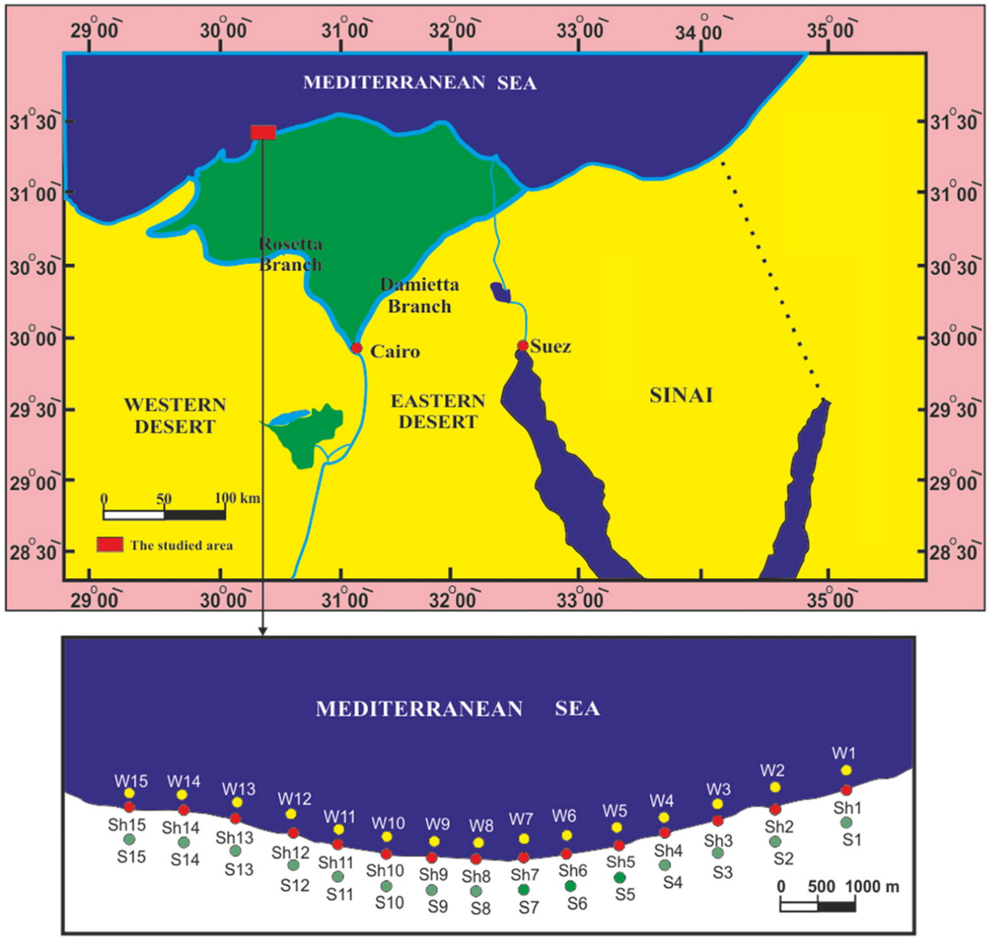

Fig. 1. Location map of Rosetta coastline and sample sites along the coast.

45 coastal sediment samples, seawaters and bivalves were analyzed for Mg, Al, K, As, Fe, Sr, Zn, Pb, Mn, Ce, Ni, Cr, and Zr from Rosetta beach area along the Egyptian Mediterranean Sea (Fig. 1). The sediment samples were prepared by accurately weighing around 100 mg of samples into a dry and clean Teflon microwave digestion vessels, 2 ml of HNO_3, 6 ml HCl and 2 ml HF were added to the vessels (Trabzuni et al., 2014). Samples were digested using scientific microwave (Model Milestone Ethos 1600). The resulting digest was transferred to a 15 ml plastic volumetric tube and made up to mark using deionized water. A blank digest was carried out in the same way. The analytical determination of trace metals was carried out by ICP-MS (Inductively Coupled Plasma-Mass Spectrometer): NexION 300D (Perkin Elmer, USA). The bivalve shells (*Ostrea* sp.) were chosen for heavy metals analysis due to their abundance and occurrence all over the studied stations and they are benthic epifauna and easy to sampling. Also they are filter feeders and have the potential to bioconcentrate contaminants, which would normally be present in the water or within sediments.

Table 1
Concentrations of heavy metals in coastal sediments of Rosetta beach, Egyptian Mediterranean coast.

Samples	Al	Fe	K	Mg	Mn	Ce	Cr	Ni	Sr	Zr	Zn	As	Pb
S1	240	193,900	90	570	610	1690	0.26	894.17	162.34	0.21	298.50	352.65	476.45
S2	240	193,100	70	560	600	1740	0.29	819.24	128.88	0.22	314.42	315.86	457.99
S3	240	194,900	100	560	610	1740	0.26	744.32	175.01	0.32	320.91	279.06	465.94
S4	240	189,800	130	590	610	1670	0.26	722.54	143.61	0.28	324.50	325.35	471.47
S5	240	192,600	60	570	610	1720	0.26	877.94	121.10	0.30	347.25	299.06	388.22
S6	240	193,000	110	580	610	1750	0.26	706.91	132.30	0.28	336.46	234.32	338.50
S7	240	195,400	120	580	610	1690	0.25	839.54	148.43	0.35	334.35	309.99	460.57
S8	240	198,100	130	570	620	1680	0.23	844.37	123.42	0.28	348.50	376.14	378.45
S9	240	191,500	110	530	640	1720	0.25	722.74	126.73	0.24	387.91	399.16	364.86
S10	240	196,200	60	540	630	1690	0.27	817.74	118.81	0.34	353.25	344.53	368.23
S11	240	189,600	130	581	602	1653	0.26	732.11	140.16	0.23	394.11	361.31	333.47
S12	240	192,294	82	566	615	1742	0.25	847.71	178.22	0.37	340.19	227.96	388.73
S13	240	193,123	119	579	609	1711	0.26	776.92	151.35	0.27	318.40	282.39	391.54
S14	240	195,233	122	568	613	1682	0.24	849.50	152.48	0.37	339.00	367.91	411.51
S15	240	198,000	119	583	610	1683	0.23	854.70	139.49	0.27	333.50	389.99	391.22
Min.	240	189,600	60	530	600	1653	0.23	706.91	118.81	0.21	298.50	227.96	333.47
Max.	240	198,100	130	590	640	1750	0.29	894.17	178.22	0.37	394.11	399.16	476.45
Average	240	193,791.18	102.47	567.47	614.06	1703.76	0.26	803.03	143.49	0.29	340.23	323.11	405.71