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Baseline

Assessment of the anthropogenic influx of metallic pollutants in the Sefidrud delta, Gilan Province, Iran

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ABSTRACT

Understanding the anthropogenic effects on the Sefidrud delta, the concentration of six metals (Cr, Co, Cu, Ni, Pb and Zn) was measured in two sites included the old Sefidrud delta (Amirabad, 23 samples) and the new Sefidrud delta (Kiashahr, 24 samples). Geoaccumulation Index (I_{geo}), Enrichment Factor (EF), Contamination Factor (CF) and Pollution Load Index (PLI) were used to determine the metal pollution in all sediment samples. Although the EF, I_{geo}, CF and PLI results in the old delta indicate no significant pollution, sediment samples in the new delta show a considerable pollution. Since the sediment source and the lithology of the Sefidrud River drainage basin did not change in the past 500 years, the metal pollution in the new delta must be from anthropogenic sources.

Heavy metals are known as a major anthropogenic contaminant in coastal and marine environments worldwide (Ruilian et al., 2008). Due to their toxicity, persistence and bioaccumulation characteristics, heavy metals are considered a threat to human health, living organisms and natural ecosystems (Tam and Wong, 2000; DeForest et al., 2007; Erdoğrul and Erbilir, 2007). Since the Industrial Revolution and urbanization, tremendous amounts of toxic pollutants have been discarded into coastal environment and the sediments of bays, estuaries and deltas have represented huge sinks of heavy metals (Fukue et al., 1999; Turner, 2000; Billon et al., 2002; Fan et al., 2002). Industrialization of coastal areas is very common in countries characterized by exploitation and importation economics, causing serious damage to coastal ecosystems, e.g. contamination of metals (Cardoso et al., 2001).

The Sefidrud River is the largest river flowing into the Southern coasts of the Caspian Sea in Iran. The Sefidrud Delta is located on the coast of the Caspian Sea, just north of the mouth of the Sefidrud River (Fig. 1). Similar to other deltas, the Sefidrud River has experienced numerous large and small changes to its main course. Through avulsion or delta switching, the lower Sefidrud River has shifted its final course to the sea (Salavati et al., 2009). This phenomenon occurs because the deposits of sand and sediment begin to clog its channel, raising the river's level and causing it to eventually find a steeper, more direct route to the Caspian Sea. Sea level changes, the Caspian Sea currents, human activities (e.g. road and dam constructions, instream sand-and-gravel mining), and tectonic activities (earthquake) are the other factors affecting the avulsion (Sarvar, 2008). The Sefidrud Dam was constructed from 1956 to 1962 as a buttress dam, with 106 m height, 425 m width and total capacity of 1.82 km^3. Course changes, over the past 500 years, caused the Sefidrud River to migrate from east to west. Since the source of sediments deposited in the Sefidrud Delta is not changed through the last 500 years, comparison of heavy metals contents in delta front and subaqueous deposits of the present active lobe with that of abandoned lobes may indicate anthropogenic roles in marine sediments pollution.

The research presented in the paper identified the range of heavy metals founded in the sediments of delta front and continental shelf of the currently active lobe and a large abandoned lobe of the Sefidrud River. The study also determined the enrichment and source of heavy metals. Comparing these two areas shows the influence of human activities on marine environment pollution.

Located on the north of Iran (37° 00′ 16″ to 37° 27′ 00″ N and 49° 28′ 00″ to 50° 16′ 00″ E), the Sefidrud Delta is bordered by the Caspian Sea in north, the Alborz Mountains in south, Chamkhaleh District in east and the Anzali Lagoon in west. The Sefidrud River with the drainage basin about 5.8×10^4 km^2, is the most important river constructing this delta. The Sefidrud Delta's plain covers an area of over 1700 km^2. The Sefidrud River fluvial style is changing from braided to meandering, migrated a lot from time to time and leaving delta deposits in different parts of the Caspian Sea coast. Annual total precipitation of the watershed area is about 1350 mm. The study area comprises subaqueous parts of current active delta lobe and shelf in the Kiashahr area and an abandoned delta lobe in the Amir Abad area (Fig. 1).

The sampling points were systematically selected to reflect distribution of heavy metals within shelf sediments in the Kiashahr area

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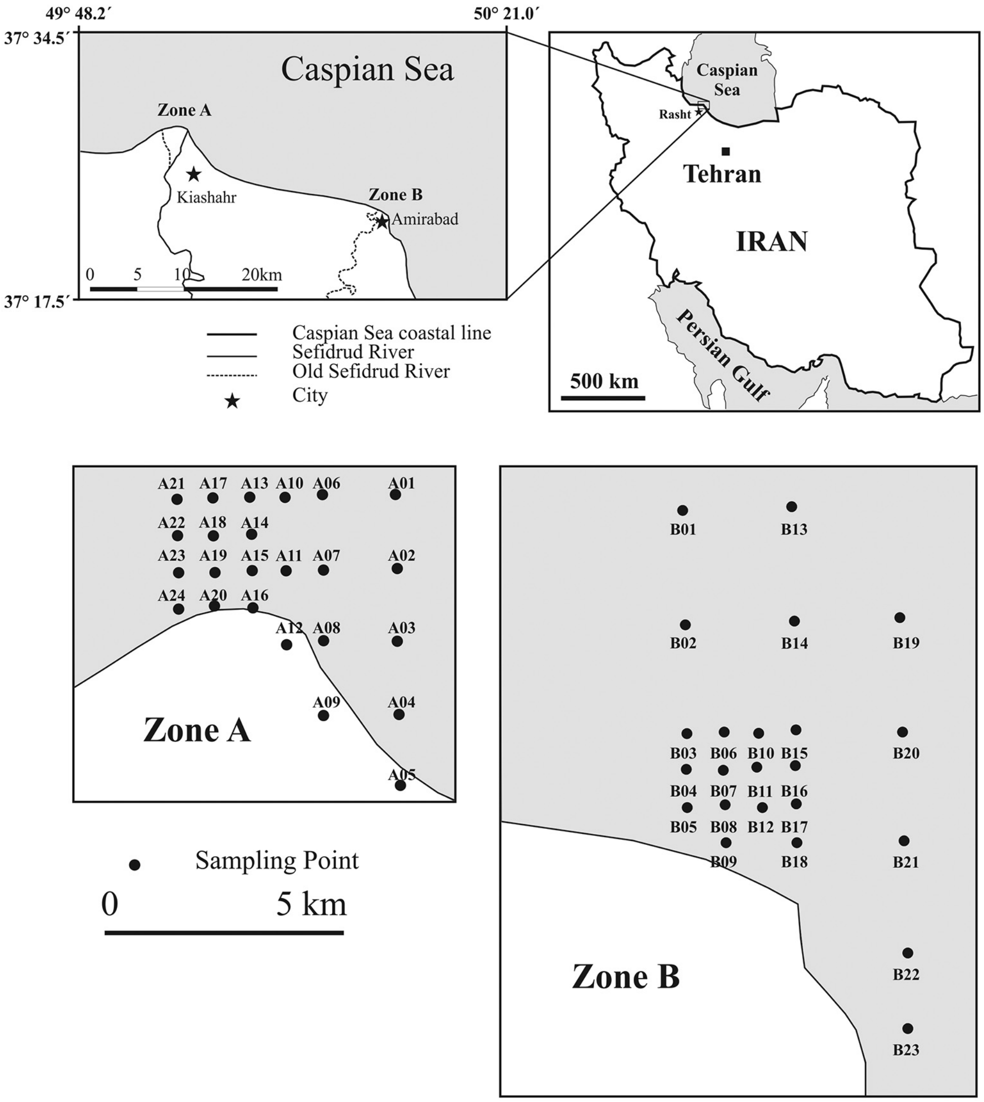

Fig. 1. The Sefidrud Delta location map and sampling points. Zone A is the current active delta lobe where Zone B is the abandoned lobe.

(active lobe, Zone A) and the Amir Abad area (abandoned lobe, Zone B) and also to determine the real differences in the contents of various elements at these two areas.

A total of 24 sediment samples were collected from Zone A and 23 samples from Zone B (Fig. 1). The samples were collected with a Van-Veen grab sampler from the top of the sediment layers. At each area, the samples were collected from the bottom sediments of shallow to deep water, along and across the coast line. After collection, sediment samples were stored in acid-washed plastic bags at 4 °C and transferred to the laboratory.

Granulometric analysis was performed using the sieving technique after Folk and Ward (1957). Particles finer than 63 μ analyzed using laser particle size analyzer (Fritsch, Analysette A23) in sedimentology laboratory, Bu Ali Sina University. Total concentrations of elements (Al, Fe, Ca, K, Na, Mg, Mn, Ti, P, Cr, Co, Ni, Cu, Zn, Pb, Sr and Ba) were determined in all finer than 2 mm samples. The measurements were carried out by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES, Varian 735) and four-acid mixture (HCl, HF, HNO_3, $HClO_4$) digestion in Geological Survey of Iran (GSI) geochemical laboratory. Calibration with standards, standard operating procedures and analysis of replicates were performed to ensure the quality of analytical data. The validation of laboratory methods was tested by using a certified reference material (NCSDC73371, China) and the recovery rates of metals were as follow: 102.5% for Cr, 98.2% for Co, 98.18% for Ni, 101.2% for Cu, 98.77% for Zn and 98.4% for Pb. Avoiding contamination, all glassware were soaked in 10% HNO_3 acid wash for at least 48 h, soaked, rinsed and washed by deionized water before use.

Enrichment Factor (EF), Geoaccumulation Index (I_{geo}), Contamination Factor (CF) and Pollution Load Index (PLI) were used to examine the contaminant level of sediments. The indices have been widely used for the assessment of heavy metal contamination in various environments such as coastal, estuarine, fluvial, lacustrine and agricultural sediments (Håkanson, 1980; Tomlinson et al., 1980; Bhuiyan et al., 2010; Rafiei et al., 2012). In the interpretation of sediment contamination, choice of background concentration values plays an important role. The best alternative proposed is to compare concentrations between contaminated and uncontaminated sediments (Covelli and Fontolan, 1997; Rubio et al., 2000; Sakan et al., 2009; Rafiei et al., 2010). The background values in the present study were calculated from the median concentrations of heavy metals at Zone B.

Enrichment Factor was used to evaluate the level of contamination and the possible anthropogenic impact on sediments (Loska et al., 2004; Choi et al., 2012; Martin et al., 2012). The EF value of a given element was based on the normalization of a given element against a reference element. A reference element is often an element having low concentration variability, such as Al, Fe, Ti, Si, Sr, K, etc. (Yongming et al., 2006; Hao et al., 2007). Aluminum is one of the main components of the Earth's crust and was used as the reference element for which the concentration in marine sediments is often exclusively affected by the