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Original Paper

Ecological Risk Assessment of Nickel Pollution in The Khozestan Coasts

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Abstract

The Persian Gulf as one of the important economic areas in the southern region of Iran, is necessary to be protected by conduct numerous studies. In this study, the ecological risk of nickel in surface sediments of this areas between the tidal zone of Arvandkennar, Bahregan, Bandar Imam Khomeini, and Abadan Wharf in Khuzestan was investigated. The concentration of nickel in these sediments was variable with an average of 60.7±6.9 $mgKg^{-1}$ dry weight and ranged from 55.4 to 66.7 $mgKg^{-1}$ dry weight. According to the threshold limit of 15.9 mgKg-1, it is found that the concentration of this metal in the sediments of the studied area is higher than its threshold effect level. The ecological risk index (Eij) due to nickel in the sediments of Khuzestan region was variable from 13.9 to 16.7, which are classified as low ecological risk. The data analysis and results obtained from ecological risk assessment showed that despite the fact that nickel concentration in sediments of the studied area (Arvandkennar, Bahregan, Bandar Imam Khomeini, and Abadan Wharf) was higher than the average earth crust and within a high pollution range, it has low bioavailability.

Keywords: Surface Sediments, Persian Gulf, Musa Estuary, Nickel, Ecological Risk Assessment.

1- Introduction

The increase in human activities and developments in the industrial and agricultural sectors, as well as the improvement of human life in recent decades, have made the use of heavy metals unavoidable in various fields. As a result, the entry of human-origin heavy metal pollutants into aquatic ecosystems has increased significantly over the past decade. These pollutants gradually absorb suspended particles after entering a water source and settle on its bed. If the amount of sediment pollution exceeds certain levels, it can disrupt the ecosystem balance and create a vital threat to aquatic life and at the top of the food chain for humans. Many heavy metals are naturally part of aquatic ecosystems and even some of them such as iron, copper, zinc, cobalt, manganese, and molybdenum play an important role as trace elements in biological processes and in the survival of living organisms (Agah et al., 2011; Bryan, 1984; Lionetto et al., 2003). However, some heavy metals that are highly toxic and persistent play a fundamental role in marine pollution. Examining the amount of metal accumulation in sediments makes continuous monitoring and environmental protection management possible. Among different ecosystems, coastal areas are considered more vulnerable to environmental pollutants (Morrisey et al., 2003).

Nickel is one of the most common metals in surface waters. Although this metal naturally exists in water sources, the entry of polluted urban sources can increase these levels by more than five times the normal levels. Low amounts of nickel are necessary for producing red blood cells in humans, but high amounts can be toxic. It seems that nickel does not cause problems in the short term but can cause weight loss, damage to the heart, liver, irritation, and high sensitivity in the long term. Nickel can accumulate in fish but does not magnify along the food chain. The highest concentration of nickel is found in bones, lungs, kidneys, and liver.

Changes in water physicochemical properties such as pH, temperature, salinity, oxidation potential, reduction potential, and organic ligand concentration can help dissolve metals from solid phases and make them available (Cukrov et al., 2011; Gholizadeh et al., 2019; Liu et al., 2019; Mashiatullah et al., 2013; Nobi et al., 2010; Sany et al., 2013).

Multiple studies in the Persian Gulf area indicate a high concentration of nickel as a toxic pollutant in the sediments of this semi-closed ecosystem (Agah et al., 2011; Lahijanzadeh et al., 2019; Madadi et al., 2021; Vaezi et al., 2014). In this study, the ecological risk of nickel in the sediments of Musa estuary region was determined based on the study data of (Heidari, 2017) (Figure 1).

(Lahijanzadeh et al., 2019) studied the ecological risk of heavy metals such as mercury, copper, cadmium, zinc, lead, molybdenum, and antimony in the sediments of Mousa estuary. (Vaezi et al., 2014) investigated the concentration and source of some elements such as aluminum, arsenic, barium, cobalt, chromium, copper, manganese, nickel, strontium, and zinc (Madadi et al., 2021). examined the release of heavy metals such as cobalt, chromium, copper, nickel, lead, vanadium, and zinc under predetermined redox potentials in the sediments of Mousa estuary in the northwestern Persian Gulf (Vaziri, 2021). studied the ecological risk of mercury, nickel, lead, cadmium, and vanadium in the sediments of Majidieh estuary, Zangi, Smaeili and Maryamous from the total Mousa estuary and showed that except for Zangi which had a significant ecological risk of nickel pollution, other estuaries (Maryamous, Majidieh and Smaeili) had a very high ecological risk. The Mousa estuary was shown to have a moderate ecological risk as a reference station based on the ecological risk index. The sampling stations in this study were different from those examined in recent research.

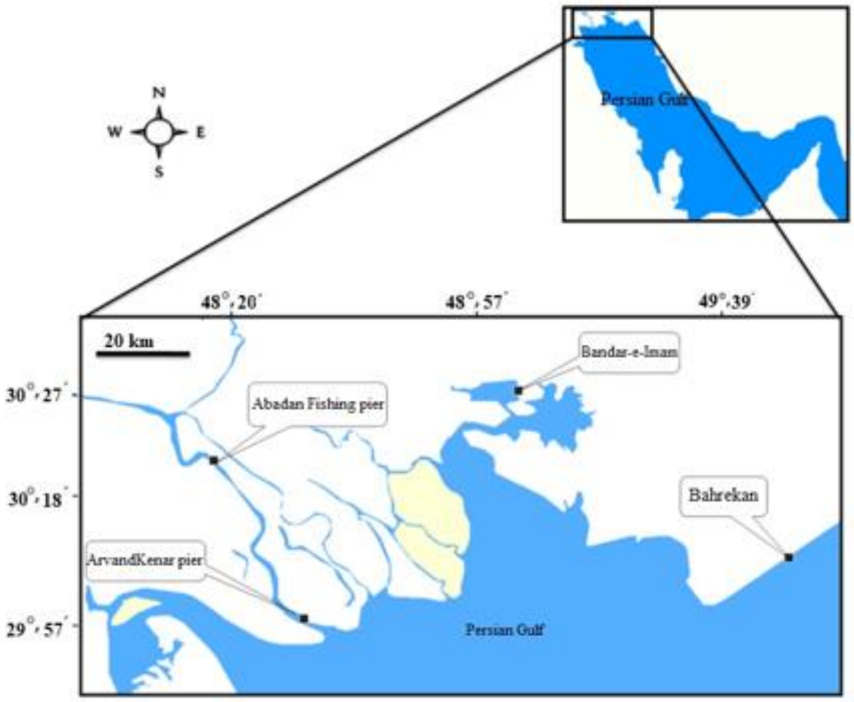


Fig 1- Map of Khuzestan coastal areas and sampling areas.

(Qasemi, 2021) studied the concentration of copper, vanadium, lead, and nickel in the sediments of Mousa estuary and its fish, as well as their ecological risk assessment. Their studies showed that Mousa estuary is one of the ecologically sensitive and environmentally low-risk areas. Ghaemi's research in Musa estuary was near to the Bandar Imam station in recent study.

2- Materials and Method

Threshold effect level (TEL) and probable effect level (PEL) indices were used to determine the level of sediment pollution in this study (Gao et al., 2019) (Table 1). Among the cumulative factors, the ecological risk and potential risk factor (Eij) were calculated for assessing the potential environmental risks of nickel in the sediments of the study area by multiplying the toxicity and contamination factor (CF) (Formula 1 and 2).

Eij=Tij*CF Formula2

CF=Ci/Cij Formula 1

Where Ci is the concentration of each metal, Cij is the concentration of that metal in the earth's crust, Tij is the toxicity index of heavy metals, and Eij is the ecological risk potential of each element (in this study, nickel). Eij values less than 30 are considered low ecological risk, 30-60 are moderate ecological risk, 60-120 are acceptable ecological risk, 120-240 are high ecological risk, and Eij values greater than 240 are very high ecological risk. In addition, this study's data was compared with marine sediment standard data SQGs (Grecco et al., 2011; Hu et al., 2013; Zhuang & Gao, 2014).

3- Results

According to the study, the concentration of nickel in the surface sediments of the tidal flats of Arvandkennar, Bahregan, Bandar Imam Khomeini, and Abadan Wharf in Khuzestan was respectively 66.7±7.1, 55.4±5.6, 58±1.4, 62.67±8.10, and the average of the region was 60.7±6.9 $mgKg^{-1}$ dry weight, which exceeded both the threshold effect level (TEL) of 15.9 $mgKg^{-1}$ dry weight and the probable effect level (PEL) of 43 $mgKg^{-1}$ dry weight for nickel in marine sediments.

According to the SQG (Sediment Quality Guidelines) international standards the amount of nickel in the range of less than 20 mg Kg^{-1} dry weight, uncontaminated sediments, between 2-50 mg Kg^{-1} is moderate pollution and more than 50 mg Kg^{-1} indicates high nickel pollution. Comparing these data with SQG standard indicated sever nickel pollution in the sediments of the study area. Based on the nickel concentration in the earth's crust (20 mg Kg^{-1}, (Grecco et al., 2011; Hu et al., 2013; Zhuang & Gao, 2014) and its concentration in sediments, the concentration factor (CF) was calculated for Arvandkennar, Bahregan, Bandar Imam Khomeini, and Abadan Wharf stations, which were 3.3, 2.8, 2.9 and 3.1, respectively.

Based on CF values and toxicity index (Tij) of 5 (Hakanson, 1980), the ecological risk index (Eij) for nickel at these stations was calculated as 16.7, 13.9, 14.5 and 15.7, respectively. These values are classified as low ecological risk.

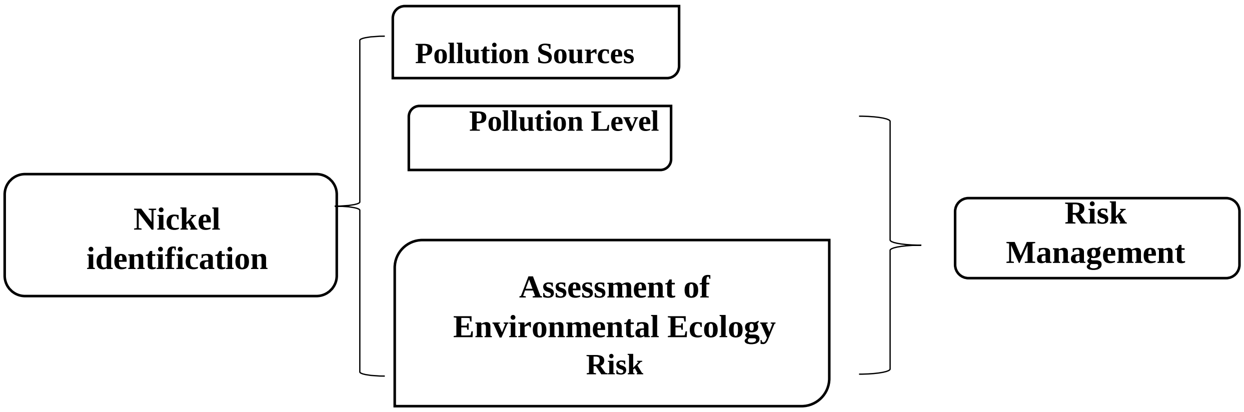
4- Discussion and Conclusion

Based on the results of the study conducted in the sampling area, it was found that the sediments of the area had a high concentration of nickel, which, apart from the natural source, could be due to industrial activities as well as municipal and industrial waste. According to the nickel concentrations in the sediments of the study area and the levels of the nickel contamination factor, it can be concluded that nickel was accumulated in considerable levels at Arvandkennar and moderate levels in the sediments of the rest of the sampling stations.

Based on the data analysis and results obtained from ecological risk assessment, it was found that nickel concentration in the sediment of Arvandkennar, Bahregan, Bandar Imam, and Abadan Wharf was higher than the average earth crust and within a high pollution range. However, despite the high concentration, the nickel had low bioavailability. This means that nickel in sediments is not easily absorbed by living organisms and is therefore less harmful to the environment.

5- Conflicts of Interest

The authors confirm that this work is original and has not been published elsewhere nor is it currently under consideration for publication elsewhere. The authors have nothing to disclose and there are no conflicts of interest to declare.



Schematic of Risk identification process

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