ISERDAR
International Science and Engineering Reviews: Development, Analysis and Research

Review Article

Heavy Metal Pollution Assessment Methods

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ARTICLE INFO

Article history:

Received Jul 8, 2024
Received in revised form Aug 18, 2024
Accepted Aug 21, 2024
Available online Aug 31, 2024

Keywords:

heavy metal, pollution indeks, sediments, soils

Doi: 10.5281/zenodo.13624736

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ABSTRACT

Considering the effects of anthropogenic activities such as industry, agriculture etc. in a region, different approaches have been developed to assess the extent of heavy metal pollution in soils and sediments. Besides evaluation methods based on total concentrations, there are also methods based on whether an element is reactive or not. Pollution indeks are; Enrichment Factors (EF); Contamination Factor (Cf); Pollution Load Index (PLI); and Geoaccumulation Index (Igeo). With this review study, Heavy Metal Pollution Assessment Methods were examined.

1. Introduction

In recent years, the direct or indirect effects of pollutants on ecosystems have increased at different scales in the world and these effects have started to be examined by researchers within the framework of sustainable environmental management. Studies have shown that heavy metals are among the important pollutants emerging due to developing industrial activities. Metals with a density higher than 5 g/cm3 are defined as heavy metals. Due to their composition, these metals are generally found in the earth as carbonate oxide, silicate and sulfur compounds or sheltered in silicates. Heavy metals entering the receiving environment through anthropogenic activities cause pollution in water, soil, fish fins and plants [1.2].

2. Pollution Indices

2.1. Calculation of the Enrichment Factor (EF)

The Enrichment Factor (EF) normalized to a representative element is one of the indicators of the accumulation and concentration of contaminants in cores and surface sediments. Aluminum is the most common element used for normalization in marine sediments because it represents aluminosilicates, the main mineral group of fine-grained sediments [3]. Aluminum has been successfully used by researchers in such studies due to its conservative nature and being one of the structural elements of clay minerals [2, 4].

Buat-Menard and Chesselet [5] used the metal EF to determine the value of soil pollution [6]. This factor was calculated by normalizing metal values by the amount of Al or Fe in the same sample as reported in many studies [7, 8, 9, 10]. The purpose of using EF values instead of metal concentrations is to take Fe as a reference element and to allow standardization by eliminating effects such as carbonate dilution, mineral content and grain size. The average concentration of metals in shales is used to assess metal concentrations in seafloor sediments. It also provides information about the upper part of the earth's crust, which is free of anthropogenic pollutants [11, 12, 13, 14].

The Enrichment Factor is formulated as follows [15, 16];

$$EF = \frac{(M/Fe)sample}{(M/Fe)background}$$

Here, in the EF factor calculation, M analyzed element and Fe the reference Fe element [16].

As a result of the calculated EF value indicates, EF<1 is no enrichment, 2 < EF < 3 is a small amount, 3 < EF < 5 is a moderate amount, 5< EF < 10 is moderate - significant, 10 < EF < 25 is significant, 25 < EF < 50 is very significant and EF >50 extremely significant enrichment [17].

2.2. Calculation of Contamination Factor (CF)

To determine contamination in sediments the Contamination Factor (CF) was formulated by Hakanson [18] [2]. This factor is obtained by the ratio between the value of the analyzed metal in the sediment and the value of the same metal in its natural geochemical state [18]. The formula of the Pollution Factor is calculated as follows [17];

$$CF = \frac{C(metal)}{C(background)}$$

Calculated CF values indicates CF<1 low; 1≤ CF <3 moderate; 3≤CF<6 high; and CF≤6 very high contamination [17, 19, 20].

2.3. Calculation of Pollution Load Index (PLI)

The Pollution Load Index (PLI) calculates the amount of pollution caused by heavy metals in the sample location [17]. This index is the value recommended by Tomlinson et al. [21] for a given area. This index is expressed as follows [16]:

$$PLI = \sqrt[n]{CF1xCF2xCF3xCF4x \ldots\ldots CFn}$$

CF: contamination factors, n: number of metals

PLI value of 0 indicates an excellent (extraordinary) condition, a value of 1 indicates that the sediment is in reference conditions (natural condition), and values greater than 1 indicate that it is degraded depending on the degree. PLI gives information about the toxicity of the sediment sample depending on the metals measured [17].

2.4. Calculation of geographical accumulation index (Igeo)

Geographical Index (Igeo), first defined by Müller [22], was defined for metal values in the 2 micron fraction and was used as the global standard shale amount. The Geographical Index is formulated as follows [23].

$$Igeo = log2(\frac{Cn}{1.5*Bn})$$

Here Igeo is the geographical accumulation index, Cn is the analized value of the element, Bn is the mean background value of the element and 1.5 is the correction coefficient of the background matrix due to soil effects [16].

Igeo values are subjected to the following classification indicates Igeo < 0 no pollution, 1 > Igeo > 0 beginning of pollution, 2 > Igeo > 1 little pollution, 3 > Igeo > 2 moderate pollution, 4 > Igeo > 3 high pollution, 5 > Igeo > 4 very high pollution and 6 > Igeo > 5 extremely high pollution [2].

3.Conclusions

Accurate identification of anthropogenic heavy metal accumulation in sediments and soils is the most important aspect in understanding inorganic pollution. Therefore, it is of utmost importance to determine the anthropogenic metal input in sediment and the toxic effect of this input on all ecosystems. Many methods have been developed to determine this input and its effect and many limit values have been determined. In this study, EF, Cf, PLI and Igeo indices were gathered together.

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