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Calculation of Lead and Cadmium Elements Concentrations in Sediments Using Atomic Analysis Technique

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This study aimed to determine the concentrations of lead and cadmium in ten samples of Euphrates River sediment. The results showed that the average concentrations of lead and cadmium were all below the internationally permissible limits of 10 ppm for lead and 0.06 ppm for cadmium. All results of the current study are within the internationally permissible values mentioned in the reports of the International Committee on Radiation and its Protection. This indicates that the sediments of the Euphrates River in Babylon Governorate do not pose a radioactive risk.

Keywords: Heavy elements; Sediment; Atomic absorption; Radioactivity

1. Introduction

Heavy elements are among the largest environmental pollutants. Their continued emission from various sources (both natural and industrial) leads to increased concentrations in the atmosphere. They are characterized by their high atomic number and high density. Heavy elements comprise a wide range of elements, some of which are essential for biological processes, such as iron, and others that are toxic, such as lead and cadmium, which are highly toxic to living organisms. The most important sources of heavy elements are either minerals or rocks in the Earth's crust, or human-made sources, such as industrial, agricultural, and domestic sources. These sources also pollute groundwater and cause numerous physical, chemical, and biological changes [1]. Other researchers have indicated that the presence of heavy elements poses a threat to human life. Studies conducted in the Jabila plains in Syria found that concentrations of some elements fall within the permissible limit. Only the concentration of lead was found to be higher than the permissible limit [2]. Heavy elements have a high atomic weight higher than 20 and also have a specific density that exceeds the specific density of water by five times or more [3], and other researchers have also studied pollution with heavy elements resulting from their cumulative effect and absorption by crops, which leads to neurological diseases and cancer as a result of irrigating crops contaminated with heavy elements [4-8]. Lead and cadmium are heavy elements that are considered among the largest and most widespread environmental pollutants.

Lead (Pb) is found in the Earth's crust in small quantities, but it is present in the atmosphere primarily as a result of industrial sources. Fertilizers are among its most important sources, leading to soil and water pollution. Lead remains in the environment it inhabits for long periods of time, migrating through the soil and water and then to plants, fish, and animals. Its concentration becomes toxic when present in high concentrations in the soil. It sometimes combines with sulfide ions. Under reducing conditions, it precipitates and becomes sulfur, increasing its composition in sediments [9,10].

Cadmium (Cd) is found in normal soil at a low concentration of 0.5 ppm, but in sedimentary soil, its concentration reaches 25 ppm. Sources of cadmium pollution include some phosphorus ores and the use of commercial fertilizers associated with zinc mining. As a result of its widespread use in industries, including the manufacture of electrical panels, batteries, dyes, and rubber and plastic pipes, it is a toxic element and affects human health, as it is transmitted through the food chain and increases in nature through industrial and agricultural pollution, as well as through fertilizers [11].

The study aims to investigate the hypothesis formulated based on a basic problem. There are changes in the concentrations of both lead and cadmium in the sediments of the Euphrates River in Babylon Governorate. Babylon Governorate is located in central Iraq, 100 km south of the capital, Baghdad. It is currently the fifth-largest governorate in terms of population in Iraq. It is located within the alluvial plain

area, bounded between longitudes 44° 0' 0" and 45° 0' 0" east, and between latitudes 32° 0' 0" and 33° 0' 0" north. It occupies the northern part of the middle Euphrates region, which is 27 m above sea level. The Hillah River, which represents the main source of surface water, is located in the middle of the city [12]. The purpose of this study was to determine the concentrations of lead and cadmium in ten samples of Euphrates River sediment [13].

2. Experimental Part

Lead and cadmium levels were measured in ten samples of Euphrates River sediment using an atomic absorption spectrometer (AAS), shown in Fig. (2), available in the service laboratories of Ibn al-Haytham College of Education, University of Baghdad.

The AAS device consists of the following parts: a radiation source (light source), an atomization cell (spray or burner), the appropriate method for selecting the wavelength, and the measurement process. The radiation source generates a narrow emission line suitable for the desired metal. The atomization cell represents the location where the sample is introduced and the atoms of the metals to be measured are generated. The most important part of this process is isolating the desired spectral line from the rest of the lines emitted by other radiation sources. The atomic absorption process is characterized by a high degree of selectivity and the application of a potential difference between 100 and 400 V and a current of 2-30 mA.

Ten samples were selected from different areas of Babylon Governorate, including Al-Tali'ah District, Al-Qasim District, Hillah Center, Al-Musayyab District, and Al-Hashemia District, with two samples from each area, as shown in Fig. (1) and table (1). They were then transferred to the laboratory to determine the concentration of lead and cadmium elements using an atomic absorption spectrometer.

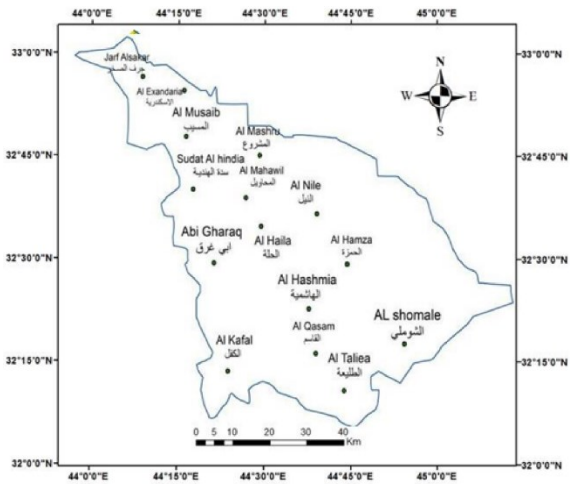

Fig. (1) A map of Babylon Governorate in which the study was conducted [2]

Table (1) Code and location of samples collected for the purpose of determining the concentration of lead and cadmium elements using atomic absorption spectrometer

Site	Code
Al-Tali'a District, Imam Aoun Water Complex	A1
Al-Tali'a District, Jurf Al-Masfa	A2
Al-Qasim District, Al-Jarbou'iya	B1
Al-Qasim District, Al-Tiyas Village	B2
Al-Hillah, Women's Park	C1
Al-Hillah Tourist	C2
Al-Musayyab District, near Ibn Saif	D1
Al-Musayyab District, Al-Zahraa Neighborhood	E1
Al-Hashimiyyah District, Al-Mazidiyah Village	E2

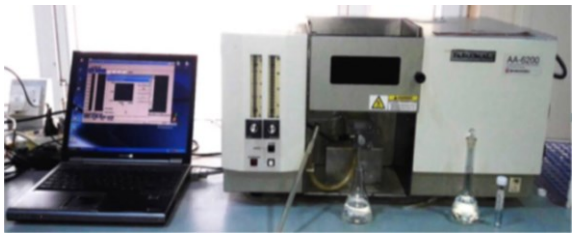

Fig. (2) The atomic absorption spectrometer used in this work

The preparation process was started by grinding the sediment samples using a copper mortar after drying them in an electric oven at 100°C for two hours. The ground sample was then sifted using a 65-µm sieve. One gram of the dried sample was weighed and placed in a clean 250 ml beaker using a sensitive balance. The sample was digested by adding 15 mL of concentrated hydrochloric acid (HCl) and 5 mL of concentrated nitric acid (HNO_3). The sample was then placed in a hot sand bath until the air vapors stopped appearing, and the sample was dried for 10 minutes. After 45-60 seconds, the beaker was cooled to laboratory temperature, and 5 ml of hydrochloric acid was added and heated in a sand bath until dry. This stage takes about 5-10 seconds. The beaker was cooled, and 5 ml of hydrochloric acid and 50 ml of distilled water were added to wash the sides of the beaker of any traces of the dissolved sample. The mixture was heated to the boiling point for 3-4 seconds, then filtered through No. 42 filter paper. The filtrate was placed in a 100 ml volumetric flask and then sent for analysis.

3. Results and Discussion

Heavy metal (toxic) contamination leads to changes in some physical and chemical properties of soil, disrupting the biological balance. Lead and cadmium are elements that can be absorbed by plants and then enter the food chain. Much research on elemental toxicity has focused on lead and cadmium [14]. Lead and cadmium were studied and analyzed in sediment samples from selected areas of Babylon Governorate to determine the concentration of each element, the extent of its contamination, and the study area.

As shown in Fig. (3), the highest lead concentration in ppm was recorded in Sample E (Al-Hashimiyah

District - near the Al-Hashimiyah Education Directorate) at 0.2479, while the lowest lead concentration was recorded in Sample A (Al-Tali'ah District, near the Imam Aoun Water Complex) at 0.2077, and the overall average was 0.2318. The results obtained in this study for lead are lower than the accepted global average of 10 ppm [13].

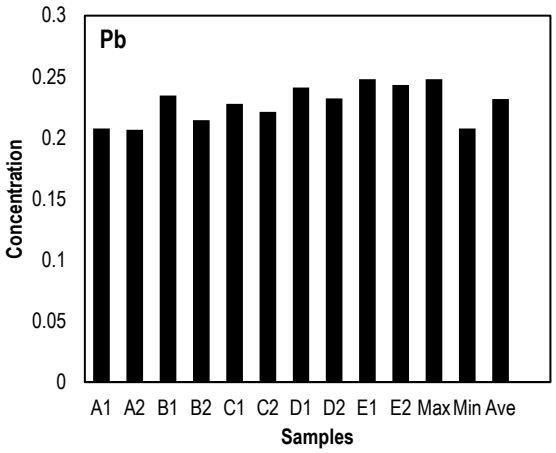

Fig. (3) Concentrations of lead (Pb) in sediments

As explained in Fig. (4), the highest cadmium concentration in ppm was recorded in Sample C (Al-Hilla - Women's Garden) at 0.0042, while the lowest concentration was recorded in Sample A (Al-Tali'ah District - Imam Aoun Complex) at 0.0031, and the overall average was 0.0039. The current results obtained in this study for cadmium are lower than the permissible global average of 0.06 ppm [15]. This indicates that the sediments of the Euphrates River in Babylon Governorate are not contaminated with cadmium.

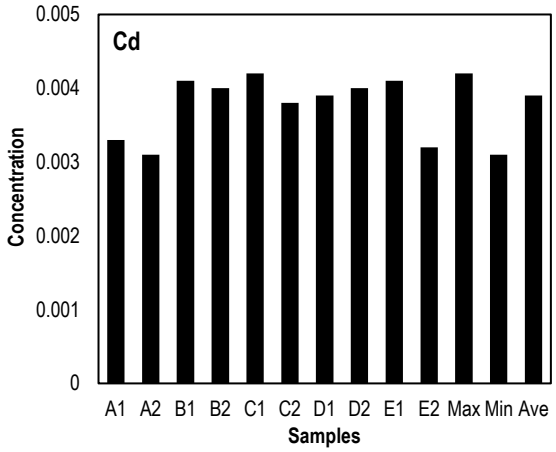

Fig. (4) Concentrations of cadmium (Cd) in sediments

From table (2), significant differences between samples are noted in terms of their lead and cadmium content, reflecting the irregular distribution or spread of these two compounds in the sediments emitted from the sources in the study areas. The concentration of lead is higher than that of cadmium. This is due to lead being less mobile in the soil and difficult to absorb into the roots and then into the tissues, while cadmium remains in the soil for thousands of years, and some of it may be absorbed.

One of the commonly used criteria for calculating element concentrations for environmental models is the ratio of lead concentration to cadmium concentration in the same sample under study. This ratio provides another parameter and dimension for selecting the quality of the results. Calculation programs have been developed for this purpose. In the current study, the ratio of lead to cadmium concentration was 59.435, the same as the globally calculated ratio of 166.66, indicating that the results of the current study are lower than the globally computed ratio.

Table (2) Concentrations of lead and cadmium in sediments

Samples Code	Concentrations (ppm)	
	Pb	Cd
A1	0.2077	0.0033
A2	0.2065	0.0031
B1	0.2345	0.0041
B2	0.2144	0.0040
C1	0.2278	0.0042
C2	0.2211	0.0038
D1	0.2412	0.0039
D2	0.2322	0.0040
E1	0.2479	0.0041
E2	0.2433	0.0032
Max	0.2479	0.0042
Min	0.2077	0.0031
Ave	0.2318	0.0039
W.Ave	10	0.06

4. Conclusions

The results of the current study fall within the internationally permissible values mentioned in the reports of the International Committee on Radiation and its Protection. This means that the sediments of the Euphrates River in Babylon Governorate do not pose a radiological risk, with the exception of some samples where high concentrations of lead and cadmium were found in some areas. However, all samples fall within the permissible limits. We note that the increased concentration of heavy elements in some areas is due to human, industrial, and agricultural influences, as these influences increase the levels of heavy elements.

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