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A Model of Nano-Processing Methods to Remove Heavy Elements from Soil Samples from the City of Shatrah

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Abstract: Background: A field A study was carried out to determine the levels of some harmful substances in samples of some areas of the city of Shatrah, which are different in terms of their residential, commercial and industrial nature. Methodology: Some strategies approved by scientific centers were implemented, such as grinding, heating and digesting the samples, then sending them to measure the concentrations of the elements with an atomic spectrometer, and then comparing them with the values specified by the World Health Organization and research centers. Results: We noticed that the elements of lead and cadmium were higher than the permissible limits in most of the study models, and the industrial city recorded the highest results, which were (165, 1.6, and 34) ppm , respectively (lead, cadmium, copper). This is due to the fact that the area is industrial and has many blacksmith shops, painting and lubrication workshops, in addition to the movement of cars and the high smoke from exhausts supported by lead compounds, in addition to the smoke transmitted from the neighboring areas from the factories that manufacture plaster, marble and ceramics, and the desertification of the are from trees. We recommend using some nano - solutions that can be used by planting some plants that absorb elements (sunflower and Indian mustard) or if possible replacing the soil or washing it and adding lime or phosphate or compost or using microbes that fix metals.

Keywords: Environmental risk assessment, Nanotechnology remediation, Phytoremediation, Eco friendly solutions, Human health risk, Sustainable soil management

Research objectives:

1. Estimating the levels of contaminating elements in soil.
2. Attempting to reduce the transferability of these elements in soil.
3. Developing methods and nanomaterials, including magnetic methods, for recovery and reproducibility.
4. Determining the extent of environmental impact to ensure biosecurity.

Introduction

Soil is among the most crucialbiological components of the ecosystem, playing a pivotal role in agricultural production and biodiversity, in addition to contributing to maintaining the balance of natural elements. However, soil pollution with heavy elements such as lead, cadmium, mercury, and arsenic poses a growing threat to environmental and human health, especially in areas close to industrial and mining activities and waste disposal sites.Recent studies have shown that the accumulation of these elements in soil disrupts the biological functions of microorganisms, reduces soil fertility, and is passed down the food chain, posing a health risk to humans and animals. Although traditional treatment methods exist, they are often costly, ineffective in the long term, and may have additional negative environmental impacts (Harshitha, 2024).

In this context, nanoremediation techniques have emerged as innovative and effective solutions for reducing soil pollution, due to their unique properties such as high surface area, high chemical activity, and functional modifiability. This research aims to review the latest fine particles used in heavy metal contaminated moisture, with a focus on the effectiveness in multi-microorganisms on soil organisms, and continuing on the safety of the food chain (Lightowlers, 2022). Heavy elements such as arsenic, mercury, cadmium, and lead are hazardous even in little amounts and can lead to radical changes in the microbiological structure of the soil, hindering the biodegradation of organic matter and directly affecting soil fertility. In addition, their ability to bioaccumulate and move through the food chain poses a direct threat to human and animal health alike .These elements can enter the body through ingestion or inhalation, and less likely through the skin. Among the effects inside the human body is interference with vital enzymes, as the sulfhydryl present in proteins and enzymes reacts and inhibits their work, including the ALA enzyme responsible for producing heme (the iron part of hemoglobin). Which results in a deficiency in hemoglobin (anemia). Lead can also be replaced by calcium ions due to its similarity in structure. It enters nerve or muscle cells through calcium channels, which can cause an imbalance in electrical and nerve signals. Lead also stimulates the production of reactive oxygen species, which attack protons, lipids, and nucleic acids, leading to widespread cellular damage, inflammation, and cell death.(Laidlaw, 2024).

Although many of these conventional techniques share the same goal of reducing the speed of light, such as clear transmission, filtering, and radiation decay, most of these methods suffer from the limitations of electronics, the cost of implementation, and the high, thick targets that may result from them. Here, nanoremediation technologies emerge as a promising solution that combines high efficiency, chemical specificity, and the ability to precisely treat soil components without affecting beneficial organisms or their ecological balance (Ali,2023).

Nanomaterials such as nano-zero-valent iron oxides (titanium, magnesium), magnetic oxides, and carbon nanotubes have demonstrated high efficiency in absorbing, reducing, and immobilizing heavy metals, thus reducing their mobility and transfer to living organisms. However, despite these benefits, the introduction of nanomaterials into the environment can produce unexpected side effects and environmental safety risks, especially in the long term (Akinola, 2018).

Lead interacts with the cells of the human body and may cause disturbances in its effectiveness. It can enter the body by inhalation or ingestion , and the least likely way is absorption through the skin. It interferes with vital enzymes, including the sulfhydryl group found in proteins and enzymes, inhibiting their function and the enzyme responsible for manufacturing heme (the iron part of hemoglobin). (Rothman, K. J.2021). Lead is an element similar to calcium ions in its structure and enters nerve or muscle cells through calcium channels and accumulates inside nerve cells, causing an imbalance in electrical and nerve signals. It also stimulates the production of reactive oxygen species that attack proteins, fats, and nucleic acids, leading to inflammation and cell death.

The practical part

Samples were collected from different areas, placed in nylon bags, and data were fixed. After the modeling was completed, the samples were transferred to the laboratory, and analyses were conducted to determine the concentration of toxic elements in parts of the sample using atomic absorption spectroscopy and comparing them with international standards. The samples were prepared based on the strategy of the General Company for Geological Survey and Mining, as follows :

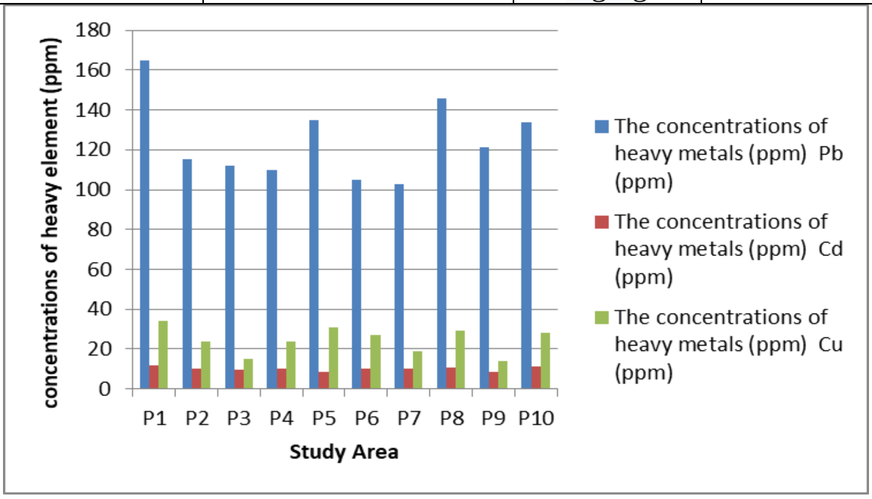
1. The ground sample was sieved using a 0.063 mm sieve after grinding the sample using a ceramic hand grinder after drying the samples at 100°C for 2 hours (Su etal., 2014).
2. To digest the 1 gram sample, 150 milliliters of hydrochloric acid and 5 milliliters of strong nitric acid were added. The sample was then left in a water bath for 45 to 60 minutes.
3. After cooling to lab temperature, the beaker, (5 ml) of hydrochloric acid is added, and it is heated in a sand bath until dry. This stage takes (5-10) minutes.
4. Add (5 ml) of hydrochloric To clean the beaker side, use 50 milliliters of distilled water and acid. Heat the mixture to boiling point for 2-3 minutes and filter it through filter paper No. 42. Place the filtrate in a bottle and complete the volume to 100 ml and send it for analysis use a spectrometer for atomic absorption.

Results and Discussion

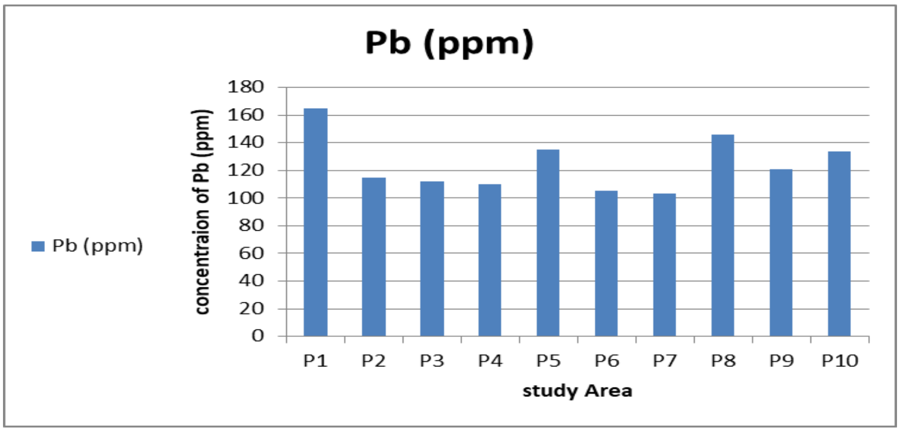
The results were recorded for the concentrations of lead, cadmium, and copper elements, varying by region, element, and the compositional nature of the area, according to Table (1) and fiq(1,2,3,4).

Tabei (1) the concentrations of heavy metals (ppm) of the study Area

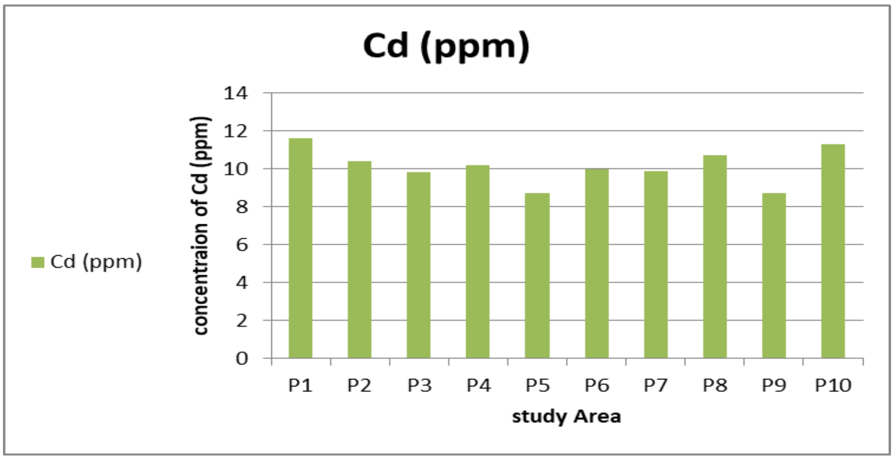
The study Area	Symbol of specimen	The concentrations of heavy metals (ppm)		
		Pb (ppm)	Cd (ppm)	Cu (ppm)
Hay Al-Industrial	P1	165	11.6	34
Hay Baghdad	P2	115	10.4	24
Hay Akkad	P3	112	9.8	15
Hay Al-Hussein	P4	110	10.2	24
Hay Al-Amen	P5	135	8.7	31
Hay Al-mashteal	P6	105	10	27
Hay Al-Askariy	P7	103	9.9	19
Hay Al-Saeida Zaiman	P8	146	10.7	29
Hay Al-Moalemeen	P9	121	8.7	14
Hay Al-Shalei	P10	134	11.3	28
Lindsay, 1979		10	0.06	50
WHO,USEPA		< 100 mg/kg	< 3 mg/kg	



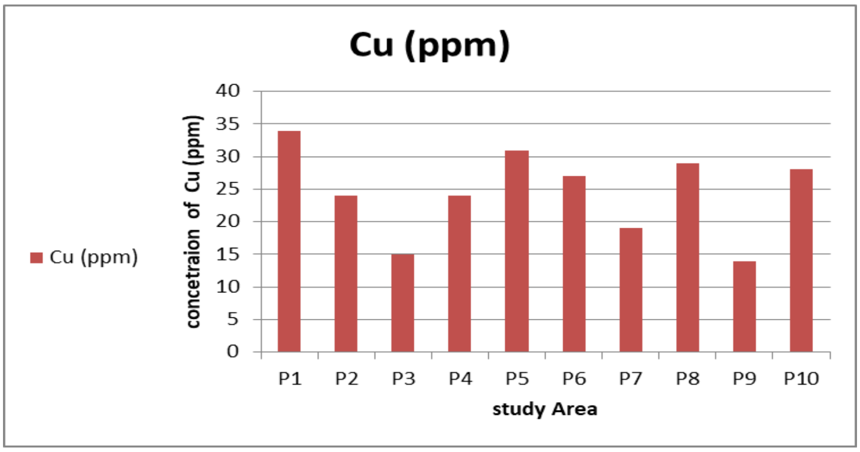
Fiq (1)The concentrations of heavy metals (ppm) in the study Area



Fiq (2)The concentrations of Pb (ppm) in the study Area



Fiq (3)The levels of Cd (ppm) in the research area



Fiq (4)The concentrations of Cu (ppm) in the study Area

The elemental content in the study samples was studied using the atomic absorption spectrometer and some calculations and statistical equations. Within the values we obtained, the standard deviation and Pearson's linear correlation coefficient were calculated. The Excel program was also used to perform the calculations and extract the values.

$$S.\ D=\sqrt{\frac{(Xn-\bar{X})2}{N}} \ldots\ldots.(1)$$

S.D : Standard Deviation , Xn :Focus on the first reading ,$\bar{X}$:Arithmetic mean of readings (average), N :Number of readings per model .

We notice a high percentage of elements in the industrial area because the area witnesses a large traffic movement, as a result of the increase in the number of cars and repair and maintenance workshops for cars, machines and equipment, which results in solid waste, in addition to the proximity of factories that manufacture tiles, bricks and ice and oil change shops .In addition to the combustion of lead additives, the volatility of the two compounds and the increase in their concentrations in the surrounding environment, in addition to the fuel used to generate electricity, which is widespread in all areas of the city, the use of detergents, the accumulation of waste and poor sanitation add to the increase in the concentration of elements.**(Rahman, M.2023) .**According to the table, we note that the lead element recorded values higher than the normal limit, and the values varied according to the nature of the area and the extent of pollution. It is also clear that lead is high in areas under construction, which confirms the role of rubble, brick components, and raw materials used in construction and its relationship to increasing the concentration of the element.(**Yilmaz, B.2024)** .While we note that the high concentration of cadmium is not only due to industrial waste, but has a clear relationship with agricultural activities, while the concentration of copper did not exceed the limits permitted by international bodies, as most bodies such as (**WHO,USEPA)** recommended**.(Jaishankar, M.2014).**

It is necessary to monitor the levels of these elements accurately, as they should not exceed certain limits (pb <100kg/mg) ,(Cd<3kg/mg). However, measurements in many cities, especially developing ones, indicate clear violations of these limits, which requires effective interventions in soil management.**(Nduka, J. K., & Rashed, M. N,2022)**

Conclusions

1. High concentrations of heavy metals in urban and residential soil have become an environmental and health problem, particularly near commercial and industrial roads, where levels have exceeded internationally permissible limits in some studies.
2. Residential areas near busy roads and commercial and industrial areas exhibit higher accumulations of heavy metals than agricultural areas or areas with less human activity, increasing the risk of population exposure.
3. Health risks associated with lead, cadmium, and copper include neurological disorders, anemia, and effects on the kidneys, liver, and bones, in addition to an increased risk of cancer.
4. The use of nano-treatment is considered a promising approach to stabilize or remove heavy metals from soil, especially the use of iron oxide nanoparticles (nFe_3O_4), activated carbon nanoparticles, and magnetic particles, which are characterized by their ability to selectively absorb and recycle after treatment.
5. The use of some low-cost environmental solutions such as phytostabilization using heavy metal sorbents and plant extracts (turmeric and cumin) may be viable options in areas with limited resources.
6. Benefit from the integration of nano-solutions and environmentally friendly technologies to ensure sustainability and reduce costs, while imposing strict controls on pollution sources from industrial emissions, waste, vehicle exhausts, and the use of chemical fertilizers.

Recommendations

1. Adopting bioremediation and nanotechnology technologies (such as nanocarbon or nanocurcumin)
2. Afforestation and the use of metal-absorbing plants
3. Improving waste disposal systems

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