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Article

Quantification of heavy metals in agricultural soil of Lampotal Vetagrande Zacatecas

Cuantificación de metales pesados en suelo agrícola de Lampotal Vetagrande Zacatecas

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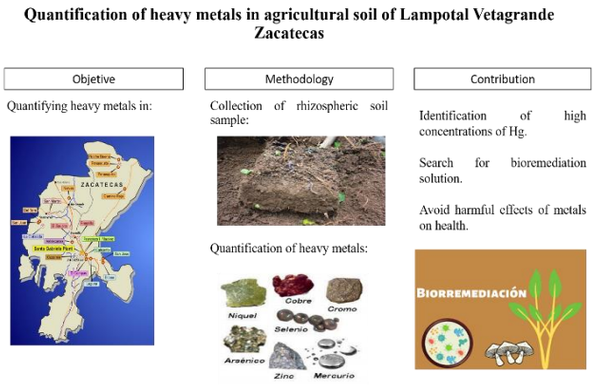
Abstract

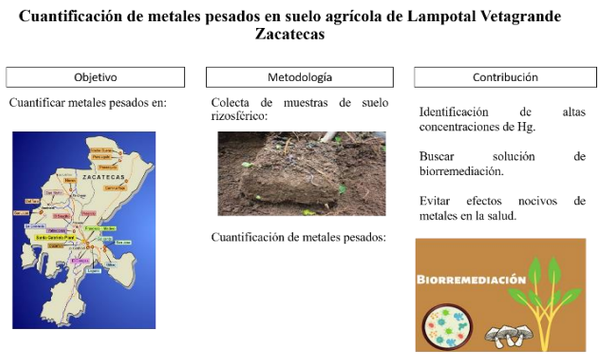
Soil contamination with heavy metals (PMs) is a serious environmental and public health problem. These produce conditions that range from damage tovital organs to cancerous developments. The objective of this research was to quantify metals in agricultural fields of Lampotal. The concentration ofMPs was determined in samples of agricultural soils from Lampotal, Vetagrande Zacatecas and plant species from the study site were identified in agricultural fields. The sample results for As, Pb and Cd are in a normal range, while for Hg, the concentrations are high (M1=405.20 ppm,M2=225.37 ppm, P3=246.14 ppm and P4=285.80 ppm). Environmental pollution is a serious problem that must be addressed immediately. The concentration of Hg at the sampling site is high,while, for Cd, As and Pb, the values are within the permitted range of standard 147-SEMARNAT/SSA-1-2004



Pollution, Heavy metals, Agricultural soil

Resumen

La contaminación del suelo con metales pesados(MPs) es un grave problema ambiental y de salud pública**.** Estos producen afecciones que van desde daños en órganos vitales hasta desarrollos cancerígenos. El objetivo de esta investigación fue cuantificar metales en campos agrícolas de Lampotal. Se determinó la concentración de MPs en muestras de suelos agrícolas de Lampotal, Vetagrande Zacatecas y se identificaron especies vegetales del sitio de estudio en campos agrícolas. Los resultados de las muestran para As, Pb y Cd están en un rango normal, mientras que para Hg, las concentraciones son altas (M1=405.20 ppm, M2=225.37 ppm, P3=246.14 ppm y P4=285.80 ppm). La contaminación ambiental es un problema grave que se debe atender de forma inmediata. La concentración de Hg en el sitio de muestreo es alta, mientras que, para Cd, As y Pb, los valores están dentro del rango permitido de la norma 147-SEMARNAT/SSA-1-2004.



Contaminación, Metales pesados, Suelo agrícola

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Introduction

Soil contamination with heavy metals (PMs), due to the discharge of untreated mining waste, is an important problem and threat to ecological integrity and human well-being (Gil-Martínez, 2020).

Over time, the problem has been increasing due mainly to anthropogenic activities. Worldwide, pollution by PMs increases daily due to different human activities, such as mining, metallurgy, agriculture and waste from urban areas that generate a large amount of waste combined with PMs (Pouresmaieli et al., 2022).

Industrial activities have the potential to contaminate soils with a wide variety of heavy metals (Obiri-Nyarko et al 2024). In the case of mining, it is due to poor management of "mining tailings", which causes pollution problems in states such as Zacatecas, San Luis Potosí, Durango, Guerrero and Sonora. (Yáñez et al., 2003; Meza-Figueroa et al., 2009; Mireles et al., 2012; Cortés-Jiménez et al., 2013).

As a result of mining exploitation, a large amount of waste or tailings is continually generated. These are generally characterized by having very high concentrations of various potentially toxic elements that can be toxic (Sánchez-López et al., 2017).

MPs are those chemical elements that have a density equal to or greater than 5 g/cm3 when they are in elemental form, or with an atomic number greater than 20, excluding alkali or alkaline earth metals (Velusamy et al., 2022).

The main receptor that comes from anthropogenic pollution is the soil. These metals do not behave as statically unalterable elements, but rather follow a dynamic course.

The dynamics of MPs in the soil can be classified mainly into four pathways: a) mobilization to surface or groundwater, b) transfer to the atmosphere by volatilization, c) absorption by plants and incorporation into food chains, and d) retention of MPs in the soil in different ways: dissolved in the soil solution or can be fixed by adsorption, complexation or precipitation processes (Navarro-Aviñó, Aguilar, & López-Moya, 2007).

Metals most likely to cause problems include Cu, Cd, Hg, Mg, Co and Ni. They are considered toxic if they are harmful to the growth or metabolism of cells when exceeding a certain concentration; some of them constitute serious poisons even at very low concentrations. The toxicity of these MPs is proportional to the ease of being absorbed by living beings, a metal dissolved in ionic form can be absorbed more easily than in elemental form, and if it is finely reduced it increases the possibilities of its oxidation and retention by the various organs (Vega and Reynaga, 1990). Copper, lead, nickel and cadmium are elements that are found in low concentrations in the environment. Their increase in ecosystems is due to anthropogenic processes, making the environment toxic for living beings and being a risk factor for human health , causing irreversible damage (Khan et al., 2021). Recent studies have investigated heavy metal contamination of soils and suspended sediments in a Nurzec River basin (eastern Poland), focusing in particular on the effects of land use in the basin. (Bojanowski, 2024).

Methodology

The collection of rhizospheric soil samples was collected from agricultural fields of Lampotal, Vetagrande Zacatecas, which was obtained in the month of September 2022.

Rhizospheric soil sample

The rhizosphere soil was taken approximately 15 to 20 cm deep. The samples were collected in plastic bags and stored at room temperature until later analysis in the laboratory. The soil samples were obtained by taking four sub-samples at 4 agricultural sites of interest, thus forming a representative sample.

Of these samples, 3 repetitions were analyzed. The samples were taken to the Chemical Analysis Laboratory of the Academic Unit of Chemical Sciences of the Autonomous University of Zacatecas, where the quantification of MPs was carried out by atomic absorption spectroscopy prepared based on a certified PE PURE brand standard of 1000 ppm Pb.

Results

The soil samples collected at the study site were analyzed in the special studies laboratory of the Academic Unit of Chemical Sciences of the Autonomous University of Zacatecas.

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As can be seen in Table I, II, III and IV, the results of plots 1, 2, 3 and 4 are shown. The tables show the repetitions carried out in each of the plots, as well as the values obtained from arsenic, lead, mercury and cadmium in each of the samples.

Box 1

Table 1

Concentrations of MPs in soil from plot 1. Values of As, Pb, Hg and Cd in the soil samples

Parcela 1	Arsénico ppm	Plomo ppm	Mercurio ppm	Cadmio ppm
M1 SA1	1.90	32.38	400.00	3.81
M1 SA2	1.98	29.77	456.53	3.97
M1 SA3	1.99	61.84	359.07	3.99
	5.88	123.99	1,215.60	11.77
	1.96	41.33	405.20	3.92

M1 SA1=Sample 1, repeat 1, M1 SA2= Sample 1, repeat2, M1 SA3= Sample 1 repeat 3.

Con 2, M2 SA3= Sample 2 repeat 2, M2 SA3= Sample 2 repeat 3

Box 2

Table 2

Concentrations of MPs in soils of plot 2. Values for As, Pb, Hg and Cd in the soil samples

Parcela 2	Arsénico ppm	Plomo ppm	Mercurio ppm	Cadmio ppm
M1 SA1	1.99	35.91	239.38	1.99
M1 SA2	1.98	41.68	198.49	1.98
M1 SA3	1.99	67.50	238.24	1.99
	5.97	145.09	676.11	5.97
	1.99	48.36	225.37	1.99

M1 SA1=Sample 2, repeat 1, M2 SA2= Sample 2, repeat2, M2 SA3= Sample 2 repeat 3.

Box 3

Table 3

Concentrations of MPs in soils of plot 3. Values for As, Pb, Hg and Cd in the soil samples

Parcela 3	Arsénico ppm	Plomo ppm	Mercurio ppm	Cadmio ppm
M3 SA1	2.00	43.97	219.87	9.99
M3 SA2	2.00	29.95	179.71	3.99
M3 SA3	1.99	89.70	338.85	5.98
	5.99	163.62	738.43	19.97
	2.00	54.54	246.14	6.66
M3 SA2	2.00	29.95	179.71	3.99

M3SA1=Sample 3, repeat 1, M3SA2= Sample 3, repeat 2, M3SA3= Sample 3 repeat 3.

Box 4

Table 4

Concentrations of MPs in soils of plot 4. Values for As, Pb, Hg and Cd in the soil samples

Parcela4	Arsénico ppm	Plomo ppm	Mercurio ppm	Cadmio ppm
M4 SA1	1.99	99.64	259.07	1.99
M4 SA2	1.99	103.50	318.47	5.97
M4 SA3	2.00	101.96	279.89	4.00
	5.98	305.10	857.43	11.96
	1.99	101.70	285.80	3.98

M4SA1=Sample 4, repeat 1, M4SA2= Sample 4, repeat 2, M4SA3= Sample 4 repeat 3

The figure I shows the comparison of the concentration values in ppm of Pb of each of the analyzed soil samples, graph II shows the results of Cd, graph III shows the results of Hg, while graph IV shows the results of the As samples.

Box 5

Figure 1

Pb concentration in soil samples from plot 1

Box 6

Figure 2

Cd concentration in soil samples from plot 2

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Box 7

Figure 3

As concentration in soil samples from plot 3

Box 8

Figure 4

Hg concentration in soil samples from plot 4

Conclusions

Environmental contamination by PMs in the State of Zacatecas is a serious problem that must be addressed immediately, since there are different sites contaminated with PMs in the state of Zacatecas, such is the case of the agricultural fields of Lampotal, Vetagrande, Zacatecas, where high concentrations of Hg were found, which exceeds what is established in standard 147-SEMARNAT/SSA-1-2004, while for other metals, the values turned out to be within the normal range in this investigation.

Declarations

Conflict of interest

Los autores declaran no tener ningún conflicto de intereses. No tienen ningún interés financiero en conflicto conocido ni relaciones personales que pudieran haber influido en el artículo presentado en este artículo.

Author contribution

Hernández-Salas, Claudia: Contributed by taking soil samples and identifying the site of interest and contributed to the writing of this article

Olarte-Saucedo, Maricela: Contributed to soil processing to quantify heavy metals.

Moreno-Longoria, Julieta: Contributed to the search for the background and analysis of the data obtained from the research.

Orta-Martínez, Felipe: Contributed to the writing of this article

Availability of data and materials

Open databases were accessed for this research, since platforms such as Google Scholar, Scopus, and Mexican Official Standard NOM-147-SEMARNAT/SSA1-2004 served as the basis for said work.

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Abbreviations

Cd Cadmium
Cu Copper
HM Heavy Metals

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