

MERCURY AND OTHER POTENTIALLY TOXIC ELEMENTS IN THE SIERRA GORDA (QUERETARO AREA, MEXICO): AFFECTION TO ENZYMATIC ACTIVITY.

Karen Arroyo¹; Juan A. Campos²; José M. Esbrí³; Jesús D. Peco²; Gilberto Hernández⁴ and Pablo Higuera³

¹ Facultad de Ingeniería, Universidad Nacional Autónoma de México (UNAM), Ciudad de México, México

² Escuela Técnica Superior de Ingenieros Agrónomos de Ciudad Real, Universidad de Castilla-La Mancha, Spain

³ Instituto de Geología Aplicada, UCLM. Almadén, Ciudad Real (Spain)

⁴ Instituto de Geociencias, UNAM, Campus Querétaro (México)

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CONTEXT: SIERRA GORDA DE QUERÉTARO

The ecological region are centered on the northern third of the Mexican state of Querétaro for a total of 250 km² of territory and extending into the neighboring states of Guanajuato, Hidalgo and San Luis Potosí.



The Sierra Gorda Biosphere Reserve was created by presidential decree on May 19, 1997.

CONTEXT: SIERRA GORDA DE QUERÉTARO

The area is extremely rugged with high steep mountains and deep canyons.



HG MINING IN SAN JOAQUÍN AND PEÑAMILLER AREAS



The miners dedicated to the extraction of mercury work clandestinely, without the slightest preventive measures for their health and safety, who look for the metal in the abandoned mines or who make a change in a commission for their findings.



Hg MINING Hg IN SAN JOAQUÍN AND PEÑAMILLER AREAS



Most of this mercury mines have a rustic beneficiation plant, consisting of a furnace, where the ore is placed in decline to be burned, inside a 12-inch steel tube closed on both sides with a connection to a 4-inch tube, through which the liquid mercury and associated vapors flow to the condenser, located on one side. Once the liquid mercury is obtained, it is stored in steel containers.

METHODOLOGY

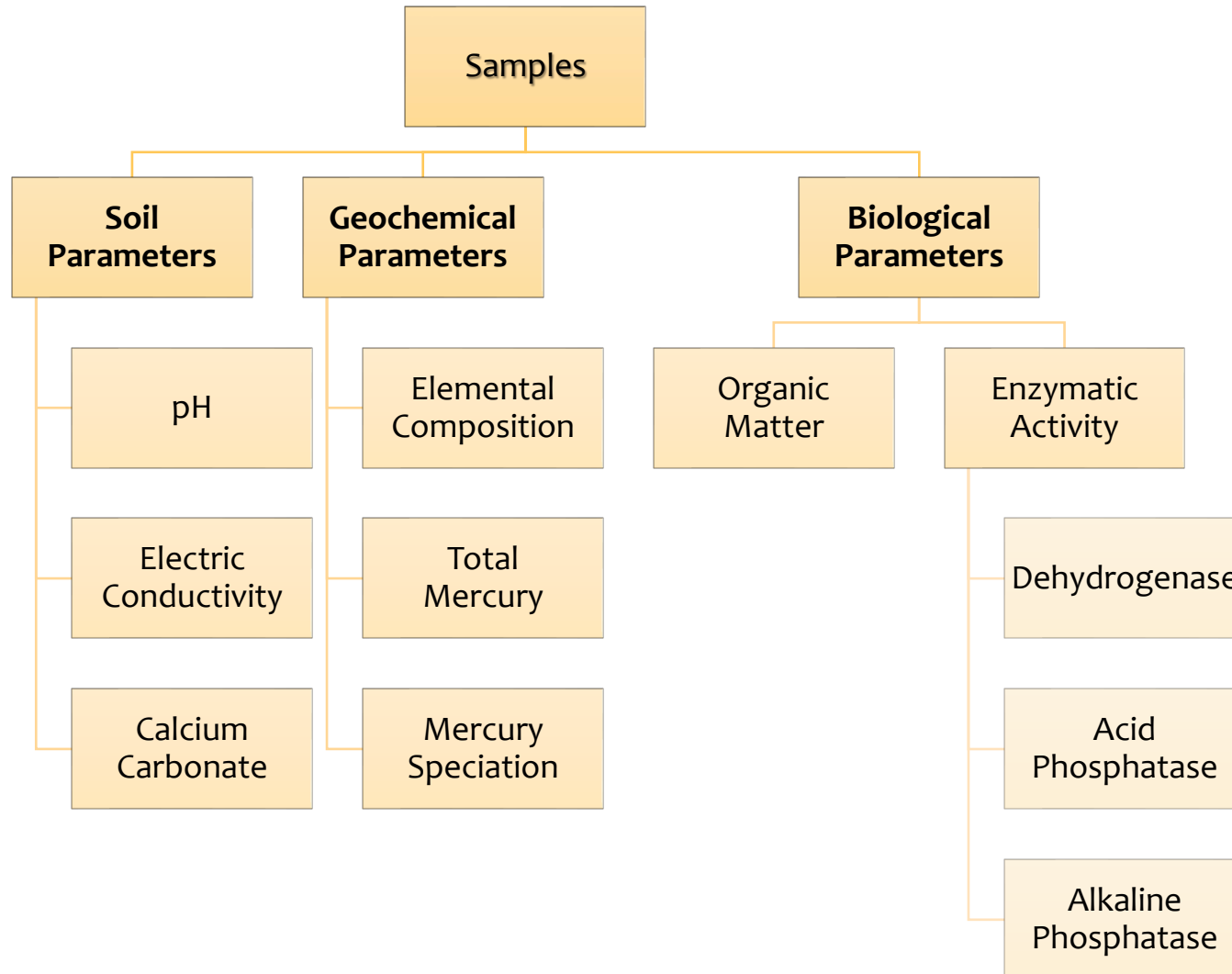
Seven samples of agricultural soils were taken near mines in the San Joaquín and Peñamiller region, at a depth of 0 - 25 cm. Each sample is made up of 5 subsamples, mixed, homogenized, ground and sieved to <2 mm.



SAMPLE	MUNICIPALITY	MINE	DISTANCE
S-1b	San Joaquín, Qro.	La Maravilla	300 m
M-15	San Joaquín, Qro.	Azogues o El Rincón	230 m
M-23	San Joaquín, Qro.	El Durazno	300 m
S-56	San Joaquín, Qro.	Azogues o El Rincón	400 m
S-26	San Joaquín, Qro.	El Pacífico	150 m
P-41	Peñamiller, Qro.	La Estrella	80 m
P-12	Peñamiller, Qro.	La Tranca	200 m



METHODOLOGY



In order to assess the quality and contamination of the soils as a result of local mining activity, analyzes based on the soil, geochemical and biological parameters of the samples from the two Sierra Gorda areas.

RESULTS AND DISCUSSION – EDAPHOLOGICAL PARAMETERS

	<i>pH</i>	<i>ELECTRIC CONDUCTIVITY (cS m^{-1})</i>	<i>CALCIUM CARBONATE (%)</i>	<i>ORGANIC MATTER (%)</i>
<i>S-1b</i>	8.00	2.04	7.39	12.91
<i>M-15</i>	8.30	0.69	4.61	8.75
<i>M-23</i>	8.22	1.35	4.67	12.93
<i>S-56</i>	7.98	2.76	29.9	12.32
<i>S-26</i>	7.88	2.16	7.75	11.9
<i>P-41</i>	8.29	1.63	39.16	10.36
<i>P-12</i>	8.36	1.49	41.24	10.21

Edaphological analyses showed that:

- the soils are moderately alkaline
- they have a low electrical conductivity for what they are non-saline soils
- the soils of the municipality of Peñamiller show a high content of calcium carbonate compared to those of San Joaquín; and
- the organic matter content is generally low.

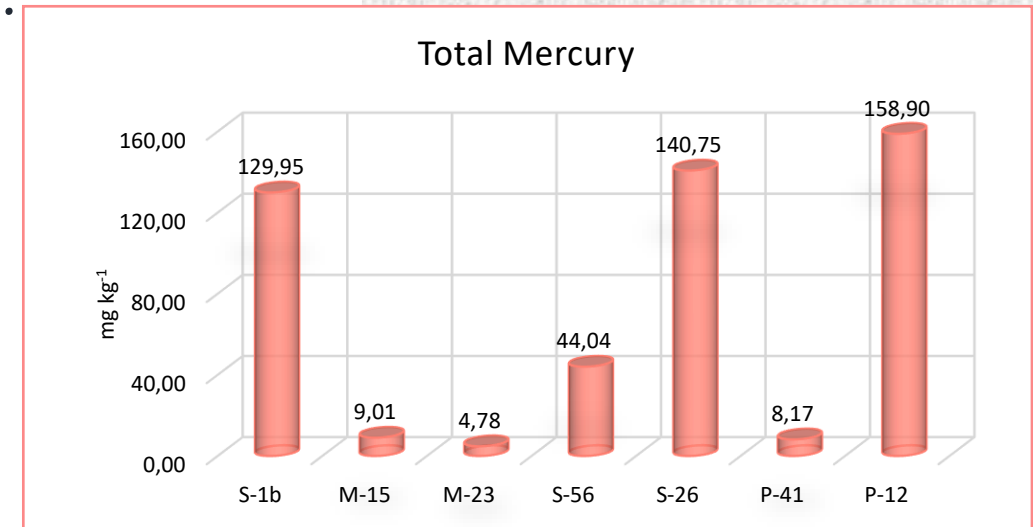
RESULTS AND DISCUSSION – PTEs

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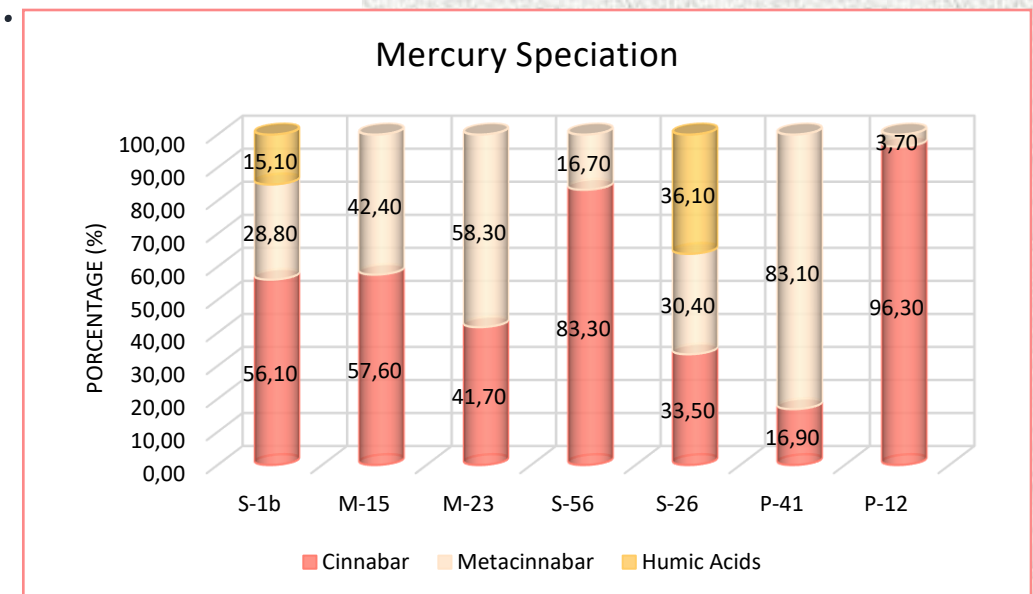
	<i>Hg</i> Total (mg kg ⁻¹)	<i>Pb</i> (mg kg ⁻¹)	<i>Cu</i> (mg kg ⁻¹)	<i>Zn</i> (mg kg ⁻¹)	<i>As</i> (mg kg ⁻¹)	<i>Sb</i> (mg kg ⁻¹)
<i>S-1b</i>	129.95	128.9	45.4	275.9	159.1	30.9
<i>M-15</i>	9.01	110.3	48.2	163.3	90.7	52.4
<i>M-23</i>	4.7825	143.9	61	186.2	88.2	40.2
<i>S-56</i>	44.035	250.9	94.2	555.8	1590	67.4
<i>S-26</i>	140.75	814.1	75.6	436.6	449.7	169.6
<i>P-41</i>	8.1695	18.7	69.4	145.1	30.5	18.3
<i>P-12</i>	158.9	19.2	78.1	160.1	38.6	30.8

3. Comparing the measured PTEs with Bowie and Thornton (1985), anomalous concentrations of trace elements in soils with the following values are considered: Pb up to 10,000 ppm, Cu up to 2,000 ppm, Zn up to 10,000 ppm and As up to 2500 ppm. None of the determined elements exceeds these reference values.

1.



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RESULTS AND DISCUSSION – ENZYMATIC ACTIVITIES

	<i>DHA</i>		<i>ACID PHOSPHATASE</i>		<i>ALKALINE PHOSPHATASE</i>	
	$\mu\text{gTPF gh}^{-1}$	<i>SD</i>	$\mu\text{gPNF gh}^{-1}$	<i>SD</i>	$\mu\text{gPNF gh}^{-1}$	<i>SD</i>
<i>S-1b</i>	13.85	0.31	1606.34	28.39	3053.33	12.41
<i>M-15</i>	6.26	0.31	713.44	100.33	1668.63	27.88
<i>M-23</i>	10.05	0.14	713.44	28.39	3159.34	291.47
<i>S-56</i>	5.93	0.45	841.31	22.72	4070.82	97.10
<i>S-26</i>	4.75	0.45	864.26	5.68	3141.86	142.93
<i>P-41</i>	4.64	0.04	516.72	11.36	1624.92	44.35
<i>P-12</i>	8.73	0.09	554.97	41.64	3848.96	129.55

Comparative values for **acid phosphatase** and **alkaline phosphatase** correspond to those measured in Sokolov, Czech Republic, by Baldrian et al. (2008), ranging from 381 to 1510 $\mu\text{gPNF g}^{-1}\text{h}^{-1}$ for acid phosphatase and 455 to 4820 $\mu\text{gPNF g}^{-1}\text{h}^{-1}$ for alkaline phosphatase measured in topsoil layer from spoil heaps after brown coal mining.

Dehydrogenase activity (DHA) has been extensively cited as one of the best indicators of soil health (Järvan et al., 2014).

Values found in the studied samples were relatively homogeneous, not showing indications of minor activity in the most contaminated ones. The values were also lower than those measured by Campos et al. (2018) (average 484 $\mu\text{gTPF g}^{-1}\text{day}^{-1}$ in an area with very high concentrations of mercury and methylmercury), as well as much lower than values measured in uncontaminated areas (1700 $\mu\text{gTPF g}^{-1}\text{day}^{-1}$, described by Hinojosa et al., 2004).

CONCLUSIONS

- Analytical results show that the studied soils have in general low PTE's contents, that indicates low pollution.
- Total mercury has values above the maximum permissible limits in Mexico for agricultural soils but does not exceed the industrial limits.
- The enzymatic activities reflect a "good" soil health, therefore, the presence of these PTEs, and in particular the high Hg concentrations, does not have a significant impact in these parameters.
- The soils from the Sierra Gorda area can be considered, possibly with minor exceptions in the proximity of the mine areas, as suitable for commercial, residential or agricultural uses.

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