

Characterization of lead and arsenic levels in sediment of the lower basin of the San Pedro River, Mexico and its importance regarding human health

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Abstract

This study was conducted in a major agricultural area in the state of Chihuahua, Mexico. Sediment samples were collected from five sites in the San Pedro River basin with the objective of detecting levels of cadmium (Cd), arsenic (As) and lead (Pb). Site 1 was located near the Presa las Virgenes dam (PV), site 2 near the locations of Delicias-Rosales (RD), site 3 near the town of Meoqui (M), site 4 in the community of El Torreón (ET) and site 5 near the communities of Junta de los Ríos Conchos and San Pedro (LJ). The metals analysis was conducted using an Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-OES) Perkin Elmer 2000. The results were compared with NOM-147-SEMARNAT/SSA1-2004. Cd levels were not determined in any soil sample. The results indicated that Pb levels were below the established NOM-147 and that location M had the highest value with a mean of 9.15 mg kg^{-1} . The highest concentration levels of arsenic were found in the RD locale with 14.56 mg kg^{-1} during the December sampling. In conclusion, lead and arsenic levels in mud from the San Pedro River basin are below the norm. Still, As levels might be significant to human health, especially for the communities established along the San Pedro River.

Keywords: metals, lead, arsenic, Mexico, human health.



1 Introduction

Certain anthropogenic industrial, agricultural and domestic activities have energized some soil parameters to increase above Maximum Permissible Limits (MPL). These limits are specified in both international and national standards. For example, norm NOM-147-SEMARNAT/SSA1-2004 [1] is specific to Mexican standards. Concentration values in any natural resource like water or soil are higher than those established in the norm and will represent a lower quality in that particular environment. Each bioaccumulation process is due to the inability of any environment or particular organism to release a given contaminant. This process is aggravated throughout the chain trophy.

The presence of metals in water may come from two independent processes. It could come from a natural weathering process occurring in soils and rocks [2, 3] with the results then transmitted in the air [4, 5] and water [6]. Another factor could be anthropogenic activities [7–10]. Subsequently, those metals in water might be deposited in sediments, mud or soils where they can exist for several years as a contaminant. Thus, some metals could accumulate in biota or in a human body as a result of the chain trophy and become a potential health risk.

It is a well-known fact that some metals are essential to the human body while others are toxic even in small quantities. The toxicity will depend on the metal, its quantity and the toxic prospective. For instance, metals Pb, Cd and As are considered highly toxic even in a minimal amounts. Detecting metal in water is the first step in explaining some of the pathology and becoming aware of the level of metals in sediments or soils. Gutierrez *et al.* [11] conducted research concerning the level of metals in water of the San Pedro River located in Chihuahua, Mexico. Although to our knowledge there is no information about the level of metals in sediments of this river. The objective was then to quantify the amount of Pb and As in sediments from the San Pedro River. These results will be essential in learning the pollution level in this environment and to discuss health risks to humans, established in communities throughout this river.

2 Materials and methods

The study was carried out in the San Pedro River, a tributary of the Conchos River located in the State of Chihuahua, Mexico. The Conchos River joins the Rio Bravo/Rio Grande, which is the natural boundary between Mexico and the United States. The study area is located within Irrigation District 005 which is considered the most important in the state because it irrigates about 84,528 ha [12]. The stretch of the San Pedro River studied here began near Presa las Virgenes (348 million m³ capacity) and continued on to the confluence of the San Pedro River with the Conchos River, before the water was stored again in the Luis L. Leon dam (356 million m³ capacity).

Five site locations throughout the San Pedro River were selected for collection of sediment samples (Figure 1). The samples were obtained in October and December 2005 and April 2006. Site 1 was located near the Presa las Virgenes dam (North Latitude 28° 09' 898'; West Longitude 105° 37' 541') at



1,206 meters above sea level (masl) and will be referred to as Presa las Virgenes (PV). Site 2 was located between the community of Rosales and the city of Delicias (North Latitude 28° 15' 406'; West Longitude 105° 29' 409') at 1,150 masl and will be referred to as Rosales-Delicias (RD). Sampling site 3 was near the city of Meoqui (North Latitude 28° 16' 343'; West Longitude 105° 27' 699') at 1,132 masl and will be referred to as Meoqui (M). Site 4 was located in the vicinity of the El Torreón community (North Latitude 28° 19' 335'; West Longitude 105° 25' 140') at 1,129 masl and will be referred to as El Torreón (ET). Site 5 was in the proximity of the Junta de los Ríos community (North Latitude 28° 20' 998'; West Longitude 105° 24' 882') at 1,117 masl and will be referred to as La Junta (LJ).

A total of 35 sediment samples were obtained as follows; in October 2005, one sample was obtained from every site (five samples) and then during December 2005 and April 2006 three samples were again taken from every site (30 samples). The samples consisted of 1-2 kg that were drawn with a plastic shovel, collected in plastic bags and transported to the lab at the Faculty of Zootechnology and Ecology of the Autonomous University of Chihuahua for further analysis. Samples were dried, ground and passed through a 0.355 mm sieve to purge rocks, roots and larger particles. The digestion of the samples was accomplished following method 3050A EPA and the results were compared with the values established in Mexican Norm NOM-147-SEMARNAT/SSA1-2004 [1]. The metal concentration of Pb, As and Cd were determined using a Coupled Inductively Plasma-Optical Emission Spectrometry (ICP-OES) Perkin Elmer 2100.

3 Results and discussion

Table 1 shows the As levels detected in mud of the San Pedro River. It is obvious that the values are below the limits established by the Mexican Norm [1] that points out a MPL of 22 mg kg⁻¹ for agricultural, residential and commercial use. The higher As mean concentration was observed in RD with 14.56 mg kg⁻¹ which was detected in December, compared to the LJ location where the concentration was 1.11 mg kg⁻¹. Gutierrez *et al.* [11] who in a water sample study of the Rio San Pedro, detected the level of metals and metalloids, found high variability for As concentration concerning both sampling location and sampling month. These authors reported that the As concentration in water was higher than the values of the Mexican and International standards for drinking water. These As concentration values in water and mud are important because rural inhabitants along river have direct contact with some metals and metalloids by such activities as bathing and crop irrigation. In addition, these results are important because this element has been associated with different diseases [13, 14] specifically its relationship with the development of leukemia [15], cancer [16, 17] and abnormalities in children [18]. Another concern is that inhabitants in the communities along the San Pedro River consume fish or other products collected directly from the river that can be potentially toxic due to the chain



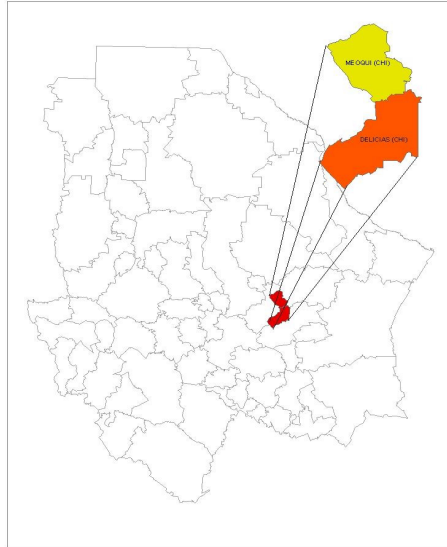


Figure 1: Map of the state of Chihuahua, Mexico, showing the study area.

Table 1: Values of As (mg kg^{-1}) in mud of the San Pedro River in five locations and during three sample months.

Month	LP ^a	RD ^a	M ^b	ET ^b	LJ ^b
October	5.31	11.00	6.15	4.75	5.68
December	0.56	14.56	4.91	2.83	1.11
April	0.0	7.11	4.11	12.2	2.93

a and b represent the calculated mean for location where equal letters are similar (Tukey; 0.05 level of significance)

trophy [19]. Furthermore, these products are sold in urban areas near the river, a logical concern to health agencies in Chihuahua.

Table 2 shows the Pb concentration in mud of the San Pedro River. Obviously, all values are below the limits established in the Mexican Norm [1] that specify a MPL of 400 mg kg^{-1} . The higher Pb concentration was noted in M during the October sampling with 11.73 mg kg^{-1} . This value is far from MPL values. Even in LP, the Pb was not detected in the October sample. Here, we must recall that LP is the higher location and this result may be explained by lixiviation due to water irrigation. It is interesting to note that Gutierrez *et al.* [11] found values of Pb in the water in the same locations points of 0.019 mg L^{-1}

(LP), 0.016 mg L⁻¹ (RD), 0.020 mg L⁻¹ (M), 0.022 mg L⁻¹ (ET) and 0.018 mg L⁻¹ (LJ) that are comparatively less than the values noted in this research, meaning that this element precipitates and accumulates over years. The Pb concentration reported in this study is generally lower than that reported by Rubio *et al.* [5] in some Mexican soils; likewise, in soils of India with 10.4 mg kg⁻¹ [20] and Japan with 21 mg kg⁻¹ [21].

Table 2: Values of Pb (mg kg⁻¹) in mud of the San Pedro River in five locations and during three sample months.

Month	LP ^a	RD ^a	M ^b	ET ^a	LJ ^a
October	0	3.05	11.73	4.75	5.68
December	5.05	3.42	8.65	5.28	5.34
April	5.78	4.11	7.09	3.83	5.24

a and b represent the calculated mean where equal letters are similar (Tukey; 0.05 level of significance).

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