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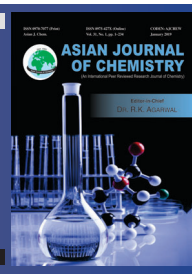

Presence of Toxic Metals in Fluids and Tissues of People of Xochitlán, Hidalgo, Mexico

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To determine levels of metal bioaccumulation (Cd, Cr, Pb and Al) in weaves and corporal fluids of the inhabitants of Xochitlán, Hidalgo, has been the objective of this study. With a view to realising valuations of risk and probable damages to the health of its settlers, the study with a sociodemographic characterization began, with settlers between 6 and 90 years of age. As exclusion criterion were considered, congenital malformations, immunosuppressive sufferings and less than five years of residence in the locality. An inverted population pyramid appeared; of a total of 1947 inhabitants, the population between 10 and 19 years occupies the center of the pyramid, that thins in the ends of the life (5> X> 60 years). A methodology, combined with the established by the ATSDR and the EPA has seted out and adding an instrument of survey (clinical anamnesis) for the characterization of individuals and populations with ample clinical approach. Of the interrelation of flowed and woven metal concentrations in, with aspects of environmental risks it will be possible to be poured off a present, retrospective situational diagnosis and a vision to future, on the behaviour of the contamination and its impact in health factors. The evaluated metal bioaccumulation was present in all the fluids and weaves of the settlers selected between 6 and 90 years of age. One has been a probable relation between these results and those of previous studies of metal accumulation in waters, grounds and cultures.

Keywords: Bioaccumulation, Toxic metals, Health Hazards, Monitoring epidemiologist.

INTRODUCTION

Heavy metals have a great capacity to bind with different types of organic molecules. The processes of bioaccumulation are basically due to the impossibility, on the part of the affected organism, to maintain the necessary levels of excretion of the contaminant, for which it suffers a retention inside it. The process is aggravated along trophic chains, because the levels of incorporation suffer a strong increase along their successive links, being in the superiors where the highest levels of contaminants are found. Its specific toxic effects on a biological system depend on reactions with ligands that are essential for the normal function of that system. The metals show great affinity for sulfhydryl groups and to a lesser extent, for amino, phosphate, carboxyl, imidazole and hydroxyl radicals, belonging to enzymes and other essential proteins. Nucleic acids are also affected by heavy metals. These cause a genotoxic effect that can be cataloged in genetic mutations, chromosomal aberrations, alterations in the synthesis and repair of nucleic acids and cell transformations [1].

The metals that have the greatest potential to cause disease are those that bioaccumulate in the body. They come in the form of dissolved salts to the biological systems and dissociate easily in aqueous media allowing their transport to the biological membranes in the form of metal ions. Absorption is more when gastrointestinal ingestion occurs during fasting. In addition, metals that bind strongly to tissues, its removal is slow [2-4]. Potentially there are several effects on the health of exposed individuals, but there are two main effects that generate more social concern *i.e.*, cancer and congenital malformations. Although in many places pollutants exceed the critical concentration to generate cancer, the value of this concentration has been estimated for an increase of one cancer case in one million inhabitants.

The enormous difficulty of having enough people to carry out a good epidemiological study is evident; therefore "the absence of evidence is not evidence of absence". In Mexico,

studies on the effects on health in populations exposed to environmental toxicants are minimal. The most relevant are the works on lead (atmospheric pollution and glazed ceramics); arsenic (natural pollution); pesticides (occupational exposure) and fluorine (natural pollution and occupational exposure), relevant studies, but that do not address the problem in all its magnitude, which shows how scarce the studies are in this aspect [5].

More than 75 % of Mexico's surface is classified as semi-arid or arid, so the wastewater from some cities is used to irrigate agricultural land. The irrigation district 03 (DR03) has 48 thousand hectares that are irrigated with sewage or black waters. Mexico City evicts around 60 m^3/s of wastewater through three collectors that lead it to Mezquital Valley where it irrigates 85,000 hectares of DR03 and DR100 [5,6].

One of the problems that arise with irrigation with wastewater, is related to heavy metals, which can contaminate soils, cause alterations in the development of agricultural products, and therefore enter the food chains. Studies carried out in areas of DR03 have reported high levels of lead, cadmium and chromium in soils, waters, crops and livestock herds, therefore the possibility of affecting health in humans is latent [7,8]. Characterization, evaluation and determination the levels of bioaccumulation of heavy metals in inhabitants of populations surrounding this irrigation area, potentially affected by the consumption of agricultural products and water of the region, is very useful in order to perform risk assessments and determine the magnitude of the damage to the health of its inhabitants.

EXPERIMENTAL

The permits and approvals of the official bodies that regulate and sanction research on human beings were obtained from Bioethics Committee of the Mexican Institute of Social Security, Hidalgo delegation, State Commission of Human Rights in Hidalgo, Obregón Progress Jurisdiction of the Secretariat of Health and Local Subdelegation of Xochitlán, Mexico. The community of DR03, Xochitlán (Fig. 1), belonging to Progreso de Obregón Municipality, was selected; located between the coordinates latitude north at 20°17'47" and longitude west at 99°11'15", at an altitude of 2000 meters above sea level.

A cross-sectional study was conducted in selected residents aged between 6 and 90 years, with exposure factors present. The sample size was taken from the calculation criterion [9,10]:

$$n = \frac{Z^2 \times p \times q \times N}{N \times e^2 + Z^2 \times p \times q}$$

where, n is the size of the sample to be taken; p is the probability in favour; q is the probability against; Z is the level of confidence; N as universe or total population and the level of estimation error.

Exclusion criteria were taken into account by residents who presented congenital malformations, immunodepressive disorders or treatments and with less than five years of residence in the municipality. Cases of change of residence, cases of death, refusal of the mother to take blood samples from children and/

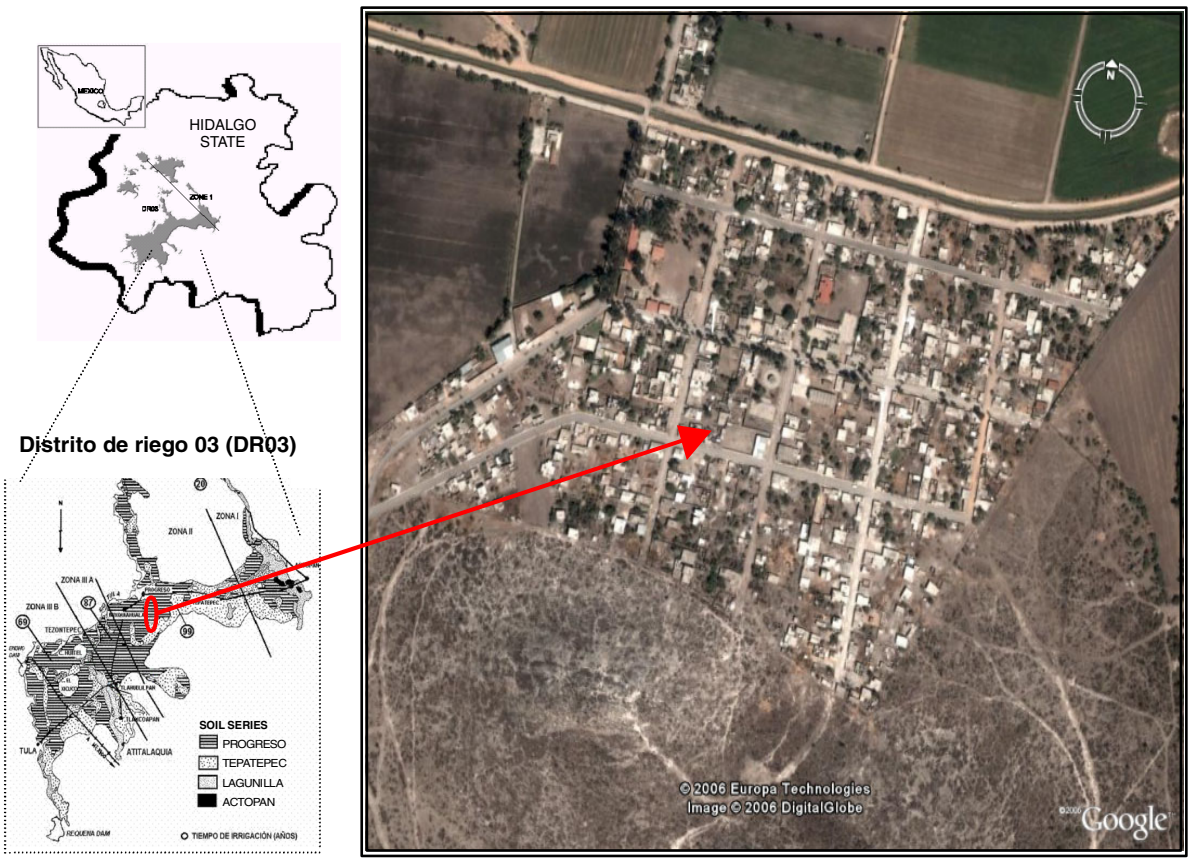

Fig. 1. Map of the study area populated by Xochitlán, belonging to the Irrigation District 03 (DR03). On the left a view of the DR03. The times of irrigation with black waters for the area are of an average time of 99 years [Ref. 8]. On the right an enlarged view of the town of Xochitlán

or adults and other people's causes that cause individuals to refuse the continuation of the study were considered as elimination criteria study, once started.

The study was planned in 4 stages: **Stage I**-Documentary research; **Stage II**-Construction of scenario to assess the risk of exposure; **Stage III**-Characterization of the population; and **Stage IV**-Sampling, analysis and interpretation of results. A survey was applied that included 10 sections (**I**: Participant identification data, **II**: Habits and customs, **III**: Hereditary background, **IV**: Labor background of interviewee, **V**: Pathological personal history, **VI**: Psychological sphere, **VII**: Gynecological background obstetrics; **VIII**: Antecedents of the school, **IX**: vital signs and **X**: Somatometry). The groups of surveys were processed and aimed at forming a validation criterion for a good selection of individuals to be included in the study and to compile records of each one and their subsequent follow-up. The relationship between the results in the determination of metals (Cd, Cr, Pb) in water-soil-crops that indicate the degree of bioaccumulation in the zones, obtained from previous studies [6-8,11,12].

Blood sampling was performed by venous puncture in vacutainer tubes with anticoagulant (heparin 0.2 mL), refrigerated in thermos for hematological samples for transport to the laboratory. They were taken in fasting conditions of the participants. To evaluate the levels of Cd, Cr and Pb in blood, the official Mexican standard [13] was taken as reference. They were digested (2-10 mL of sample) in a Marx 5 model microwave oven with the addition of 10 mL of conc. HNO_3 and according to the equipment program (1200 watt, 150 psi pressure at 210 ºC for 10 min). Once cooled, the digestates were diluted to 50 mL with deionized water and reserved for metal determinations.

Urine sample collection was carried out under the official Mexican standard [14]. The samples, preferably 24 h (with restriction of liquids from the afternoon of the previous day), were taken in polyethylene bottles containing 0.5 mL of 4 % v/v nitric acid. Up to the time of analysis, the samples were kept refrigerated. They were digested (10 mL of sample) in a microwave oven under conditions similar to those already described and equally calibrated with deionized water at 50 mL and reserved for the determinations of the metals under study.

The hair samples were previously weighed in ranges between 0.05 to 0.50 g, depending on the amount that was obtained by each individual. Teflon cups were taken from the microwave oven and 5 mL of HNO_3 were added and digested according to the program (similar conditions as above described). In an analogous manner, samples of nails that were cut at the time of the hair samples collection were collected. They were also processed by microwave oven digestion.

The contents of Pb, Cd, Cr and Al were determined by flame atomic absorption spectrophotometry in Varian 1300 equipment. The accuracy of the methods of analysis was verified by the evaluation of samples of participants (negative controls, supposedly not exposed to the contamination by metals) taken in another territory (Pachuca Municipality). The statistical criteria of means of replicates (n = 5) and percentage of standard deviation (% SD) were evaluated, considering that all values of % SD < 10 are acceptable.

Based on the official Mexican standard [15], the evaluation of health risks was carried out as a consequence of environmental agents. Afterwards, a bivariate analysis will be carried out, with the purpose of structuring a mathematical model of logistic regression, whose dependent variable will be the level of Pb, Cd, Cr and Al in blood, nails, urine and hair, which will allow to assess the degree of risk of a given population, whether exposed to the agents, such as for various reasons that remain for a long time in the neighborhood where the risk factors are generated and that may be affected in their health.

RESULTS AND DISCUSSION

The sociodemographic data base was obtained, distribution of the population according to censuses by age and sex, population growth rate, birth rate, morbidity, mortality and others. An inverted population pyramid with a rhombus shape is presented with a total population of 1947 inhabitants, of which the population of 10 to 19 years old occupies the base of the pyramid and it gets thinner and smaller at the extremes of life, under 5 years and over 60 years. More than half of the population are women (51.82 %) (Table-1); 2.82 % (55 people/ year) of the economically active population migrates to the United States. Its growth rate in the period August 2004-July 2005 was 2.88 per 100 inhabitants. The average birth rate between the years 2000-2005 was 47 children born. The fertility rate expresses that on average for the same period, it is 1.54 per 100 women of child-bearing age. It can be said that life expectancy has gradually increased; in 1940 it was 36 years for men and 39 years for women, for 1993 it was 64 and 70 years, respectively, and for 2002, 72 and 76 years, respectively. Percentage means increases of 76.4 % for women and men of the population. Life expectancy shows a notable increase, which undoubtedly reflects a better level of health in the municipality [16]; for 2010 it was estimated that it remain between 74 and 78 years.

According to the marginalization indexes, the community of Xochitlán is considered of low marginality since there is a poor development of infrastructure of services, however increasingly the supports for infrastructure of services and means of communication are increasing.

The characteristics of the houses are diverse. It was observed that of a total of 433 inhabited dwellings, 85.45 % of population has their own house, while 7.62 % rent a property and 5.77 % live in a borrowed house. In addition, due to the type of housing, it was found that the majority of population built their individual and block dwellings; so that 96.77 % of population has individual housing, 1.39 % have semi-isolated housing, 0.23 % have isolated housing and 0.46 % live in a neighborhood; 1.15 % is unknown. Not all homes have the same type of fuel for cooking, 97.46 % use gas and 1.39 % still cook with firewood.

Almost 100 % of homes have potable water and was found that 67.21 % of population has piped water outside the home and the remaining 31.64% have it inside their home. There is a source of water supply, through a well located within the community, which has 25 m^2 of water mantle and 108 m depth, in turn is connected through pipes to three tanks. They cleaned every six months. There are a total of seven discharges of wastewater but there is no sewage channel or wastewater treatment

TABLE-1
POPULATION PYRAMID OF THE TOWN OF XOCHITLÁN, MEXICO

Age range	Mens	%	Women	%	Total	%
< 1 year	9	0.46	15	0.77	24	1.23
1-4 years	87	4.47	74	3.80	161	8.27
5-9 years	109	5.60	107	5.50	216	11.09
10-14 years	121	6.21	127	6.52	248	12.74
15-19 years	106	5.44	118	6.06	224	11.50
20-24 years	83	4.26	98	5.03	181	9.30
25-29 years	73	3.75	75	3.85	148	7.60
30-34 years	63	3.24	88	4.52	151	7.76
35-39 years	68	3.49	70	3.60	138	7.09
40-44 years	52	2.67	53	2.72	105	5.39
45-49 years	41	2.11	46	2.36	87	4.47
50-54 years	30	1.54	39	2.00	69	3.54
55-59 years	26	1.34	35	1.80	61	3.13
60-64 years	29	1.49	19	0.98	48	2.47
65 and over years	41	2.11	45	2.31	86	4.42
Total	938	48.18	1009	51.82	1947	100.00

Source: Micro-diagnosis of Xochitlán community [Ref. 16]

plants. The disposal of garbage in the town is a public health problem, it was found that 79.21 % of population throws their garbage in the collection truck, 0.92 % throw it in the open, 18.48 burn it, 0.23 % bury it and 1.15 % is unknown.

A situational diagnosis was made that included the type of community feeding. This reflected a low quality of nutrients, *i.e*. food that is not balanced, adequate, enough and varied. It was observed that it is influenced by rules of conduct and customs, education, monetary income and the number of members of the family. The majority of population bases its diet on foods derived from corn, such as tortillas, corn, bread, pasta soups, milk-derived foods such as cheese, cream, some vegetables that are harvested in the field as flowers of pumpkin, cabbage, carrots, onions, beets, jicama, potatoes and chili. At least twice a week they consume meat either from chicken or red meat and include the egg twice a week or more since most of the villagers raise birds. As for the fruits, not everyone has the budget to eat them every day, so they consume them once a week and of only one type, be it mango, watermelon, melon, pineapple or banana. As legumes lentils are consumed in a small amount, like beans. The beans at any time of the day or the rice that cannot be missing in a meal. Pulque or beer according to the custom of each family, are the most consumed beverages. Usually the majority of the population makes at least two to three meals a day and at breakfast and dinner they only get bread and milk. In the period January-July 2006, it was found that the morbidity rate is 49.37 % (Table-2) and 10 main causes of general morbidity that affect health in the community of Xochitlán.

The scenario for risk assessment was constructed. The survey carried out and processed were in total 329 (Table-3), which represents 18.7 % of the population of Xochitlán. The impact on health by Pb, Cd, Cr and Al in the inhabitants of the town of Xochitlán was evaluated, based on a cross-sectional study applying a proposal of environmental clinical methodology based on that of the Agency for Toxic Substances and Disease Registry [17].

The health diagnoses of three consecutive years (2003 to 2005) were analyzed and there were no records of diagnoses of conditions where the etiology or comorbidity by heavy metals was established. To this end, the annual morbidity and mortality reports were analyzed, as well as the indicators of health and population dynamics such as the birth rate, life expectancy at birth, fertility rate, population growth rate as well as the migratory phenomenon.

These items were compared with those of the national average and with the results of the clinical survey, and no significant differences were detected. In the risk assessment of routes or routes of exposure (second phase), drinking water, consumption of local crops, agricultural labor activity and proximity to irrigation channels were considered.

TABLE-2
GENERAL MORBIDITY BY AGES, TEN MAIN CAUSES (JANUARY-JULY 2006) IN XOCHITLÁN, MEXICO

Cause	Total	< 1	1-4	5-14	15-49	50-64	> 65	Rate
Acute respiratory infections	549	51	168	158	132	25	15	28.19
Dental caries	190	0	13	160	14	3	0	9.75
Gingivitis	63	0	0	12	39	10	2	3.23
Urinary tract infections	38	0	1	7	26	2	2	1.95
Intestinal diseases	32	4	11	12	4	1	0	1.64
Gastritis	31	0	0	2	20	4	5	1.59
Conjunctivitis	24	7	7	5	3	2	0	1.23
Chickenpox	15	1	3	8	1	0	0	0.77
Wounds	11	0	2	4	4	1	0	0.56
Dog bites	9	0	3	2	3	1	0	0.46
Total	962	63	208	370	246	49	24	49.37

Source: Suive 2005 (rate for 100 inhabitants) [Ref. 16]

TABLE-3
RESULTS OF SURVEYS CARRIED OUT IN THE MUNICIPALITY OF XOCHITLÁN, MEXICO

Group	Age range	Mens N	Women N	Total N	Total N group	Sample total "n"	Mens "n"	Women "n"
Group A	5-9	109	107	216	688	128	62	66
	10-14	121	127	248				
	15-19	106	118	224				
	Total	336	352	688				
Group B	20-24	83	98	181	480	90	35	55
	25-29	73	75	148				
	30-34	63	88	151				
	Total	219	261	480				
Group C	35-39	68	70	138	330	62	29	33
	40-44	52	53	105				
	45-49	41	46	87				
	Total	161	169	330				
Group D	50-54	30	39	69	261	49	21	28
	55-59	26	35	61				
	> 60	70	64	131				
	Total	126	138	261				
Total		842	920	1762	1762	329	147	182
%		47.8	52.2	100	100	18.7	17.5	19.8

N = Size of the population; n = Sample size

The investigation contributed that the residents have drinking water from the well whose quarterly monitoring is in charge of National Water Commission and the Water & Sewerage Commission of Municipality of Progreso (CNA and CAAMPAO). The health sector prohibits as a rule the cultivation of vegetables irrigated with wastewater. Most of the crops in the region are listed as fodder and are sent mostly to other places for marketing and consumption. The people who dedicate themselves to the agricultural activities represent a reduced number by two causes, the population dynamics shows a great migration by scarce sources of employment and the other by agricultural technification that displaces to a great extent the manpower.

When this phase was compared with the results of survey, the result was that need to carry out a more thorough monitoring of drinking water, taking into account periods of the year, especially during the rainy season and during the irrigation season is imperative. There are crops of vegetables irrigated with black water, as well as high consumption of wild vegetables, despite the prohibition of health and agricultural sector, which translates as a risk route. The people studied are considered to live in places or areas near the irrigation channels, so contamination by adjacency and by air is very feasible.

In third phase, the population was characterized by applying the survey instrument. The survey, consisting of 10 sections and 130 qualitative and quantitative variables, was applied to three groups within the same participating population called "general population", "school age" and "women". A population of 275 participants was surveyed and characterized, whose age group ranged from 6 to 65 years and over, grouped into 4 ranks called A, from 6 to 17; B from 18 to 45; C from 46 to 60 and D from 65 and up; Men and women from the town of Xochitlán and three surrounding communities (El Moreno, La Ranchería and La Mora) also participated.

The bioaccumulation behaviour of heavy metals was analyzed in the four age ranges, in the urban, peri-urban, suburban and rural areas. The values found as Biological Tolerance Limits (BTL) and reported [2-4] are shown in Table-4; the values from which the comparison was made with the results obtained.

TABLE-4
VALUES REPORTED AS BIOLOGICAL TOLERANCE LIMITS (BTL) FOR METALS IN HUMANS

	Pb	Cd	Cr	Al
Urine (µg/g creatinine)	150	10	30	150
Blood (µg/L)	600	500	200	1000
Hair (µg/kg)	70	200	NR	NR
Nail (µg/kg)	NR	NR	NR	NR

The corresponding calibration curves were prepared for the analysis by spectroscopy. For all cases, a linearity regression higher than 0.99 was obtained. The average values found for each of the metals evaluated in the different bodily fluids and tissues sampled are shown in Table-5.

With respect to bioaccumulation of the metals evaluated, it is noteworthy that all of them were present (or at least detectable and measurable) in all the fluids and tissues valued. This may be associated with the proximity of the settlers to the channels of irrigation of black water and the relative proximity to the Tula river, an area of greater contamination.

Compared these results with those obtained in samples of fluids and tissues of the controls (residents of another area not contaminated), it can be said that the concentrations of Cd and Cr in blood and urine fluids and from 5 to 20 times higher are 2 to 5 times higher in tissues of nails and hair. This makes evident and showed that there is a potential health risk in the people who inhabit these contaminated areas, either due to the use and reuse of sewage, as well as other anthropogenic factors that make possible the contamination by metals of these media. This also corresponds to what was pointed out by some authors [18] that indicate that Cr, for example, is present in the hair of children and young people as a reference to their strength.

On the other hand, it cannot be defined that these concentrations of Cr are high or harmful, since it is also known that

TABLE-5
AVERAGE RESULTS FOUND FOR EACH METAL EVALUATED IN THE FLUIDS AND BODY TISSUES SAMPLED IN RESIDENTS OF THE MUNICIPALITY OF XOCHITLÁN

	Cd	Cr	Pb	Al	Cd	Cr	Pb	Al
	Nail (µg/kg)				Blood (µg/L)			
Average	4.95	0.032	0.037	0.133	1.18	12.05	4.76	31.31
Maximun	7.09	0.073	0.082	0.318	6.45	81.00	44.00	210.00
Minimun	< 0.024	< 0.002	< 0.002	< 0.009	< 0.024	< 0.002	< 0.002	< 0.009
SD	0.01	0.03	0.07	0.46	0.27	0.28	0.11	0.38
n	244	244	244	244	253	253	253	253
	Urine (µg/g creatinine)				Hair (µg/kg)			
Average	4.55	1.79	< 0.002	11.16	2.99	43.56	0.27	3.88
Maximun	16.55	6.55	0.36	67.27	3.18	71.00	1.59	33.00
Minimun	< 0.024	< 0.002	< 0.002	< 0.009	0.03	7.00	< 0.002	< 0.009
SD	0.18	0.02	< 0.002	0.21	0.16	0.25	0.40	0.39
n	237	237	237	237	240	240	240	240

SD: Standard deviation

chromium is an essential mineral especially for all those people suffering from diabetes or arteriosclerosis as well as high triglycerides and cholesterol [19]. It is not necessarily an indication of contamination by this metal.

It has also been reported that people living near waste sites where there is Cr can be exposed to higher environmental quantities, by breathing air, touching land or eating food contaminated with dust particles or dirt [17,18,20]. For example, children 5 years of age or younger who live in contaminated areas have higher Cr levels in their urine or saliva than adults and children who live outside these areas. Very few studies have investigated how Cr can affect children and although it is known that children need small amounts of Cr(III) to maintain a normal growth and development level, it is likely that the effects observed in children exposed to high amounts of Cr are similar to those observed in adults. It is not known with great certainty whether children differ from adults in their susceptibility to chromium.

With reference to the levels of Cr in nails, no significant significant differences were found with the control group or the controls. It can be noted that it was expected, higher values will be found in the study area because it is a contaminated area. However, the presence of Cd in urine may be associated with contamination by both recent and past exposure [18,21]; although it should be noted that the values found as averages are not high or at least higher than those established as LTB (> 10 µg/g creatinine); only two cases of the rural area with exceeded values were found (12.42 and 16.55 µg/g creatinine). These two cases monitored systematically and as part of monitoring this work.

On the results of cadmium, it can be said that the blood levels indicate recent exposure to Cd. On the other hand, the levels in the urine indicate both recent and past exposure. Cadmium(II) tests in urine can even detect damage to the kidneys [20]. On the other hand, cadmium does not easily pass from the pregnant woman to the fetus, although a certain portion can cross the placenta and can also be found in breast milk. Changes in behavior and in learning ability were observed in the offspring of animals exposed to high levels of Cd during pregnancy. Cadmium can also impair birth weight and the skeleton of developing animals [18]. Although none of this has been evaluated in humans, this study can lay the foundation for the beginnings of this type of assessment in Mexico. The beginnings of a similar study have been reported in children from 3 to 11 years old, who live near the Pilcomayo river in Bolivia [16].

The results of cadmium in urine presented the highest maximum values, although it should be noted that in cases of blood and nails there were also cases of relatively high maxima. According to some authors [7,8,21], the average amount of Cd that accumulates annually in the soil of the region ranges between 384 and 640 g/ha, considered these amounts as a high accumulation rate, due to the age of the use of irrigation with black water (around one hundred years). This may be the probable cause of greater incidence in the levels found, according to which these authors indicate a high mobility of cadmium species from water to soil and crops. It is assumed that these levels found in body fluids and tissues should be of primary attention and systematic monitoring for diagnoses of patients with kidney disorders at an early age.

With regard to the levels of lead, it is indicated that it is only appreciated as bioaccumulated in blood. It is also important to note that the levels of lead in hair and nail tissues were not expected, which is similar to what was found for Al, without there being a correlation to explain this. It is interesting to note that some dyes to darken the hair usually contain Pb, and although this may be a potential possibility of their presence, it should be noted that the surveys took into consideration that the participants had not used dyes or hair treatments. less two months prior to taking samples.

Lead poisoning can lead to death. Recently, it was known (Agencia EFE, El Universal, Vienna, August 29, 2007) that lead found in Beethoven's hair came from the medicines he was taking to treat his pneumonia and that it was partly a cause of his death . The study was conducted by Viennese forensic physician Christian Reiter in cooperation with the University of Edaphology in Vienna. The hair is a kind of rule over time, because they allow a medical vision of the last 400 days of his life. Thus, among other things, it was determined that lead poisoning began 111 days before the date of his death in Vienna, March 26, 1827.

It has been reported that 1 out of every 9 American children under 6 years of age shows high rates of Pb in the body [22]. In France, a study conducted, showed that during pregnancy babies are not safe from an eventual lead poisoning. These

children were followed until their schooling and a correlation could be demonstrated between the level of lead in the hair when they were born and the delay in schooling with respect to which the level of intoxication was low. This was the result of an INSERM study, September 1992, on the dose of lead in the hair of 110 women and their babies [19].

The values of Al that were found were absolutely normal and within permissible levels (Table-1) and comparable with those of the negative controls (control group). Slightly superior to this last group, but the most outstanding of these values is that the levels found in children were higher than in adults. As an interesting fact, it was only found in nails, mainly in males. In general, it has been possible to find a relationship between the results obtained in previous studies of metal accumulation in water, soil and crops with metal levels (Cd, Cr and Pb, not so with Al) that have been found in bodily fluids and tissues in residents of Xochitlán, Valle del Mezquital, in the state of Hidalgo, Mexico. In this way, epidemiological and environmental surveillance criteria for the area can be established and systematic monitoring of pathologies such as renal and school delays, among others, can be carried out. Heavy metal removal treatment usually involves the removal of the heavy metal source or the treatment of patients with chelating agents.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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