CITY OF BOQUIRA

geochemical STUDIES

SGB
GEOLOGICAL SURVEY OF BRAZIL - CPRM

GEOCHEMICAL STUDIES IN THE CITY OF BOQUIRA

STATE OF BAHIA

GEOLOGICAL SURVEY OF BRAZIL - CPRM

MINISTRY OF MINES AND ENERGY

SECRETARY OF GEOLOGY, MINING AND MINERAL TRANSFORMATION

GEOCHEMICAL STUDIES IN THE CITY OF BOQUIRA

STATE OF BAHIA

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SGB
GEOLOGICAL SURVEY OF BRAZIL - CPRM

Rio de Janeiro, RJ
2022

TECHNICAL CREDITS

GEOCHEMICAL STUDIES IN THE CITY OF BOQUIRA

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Graphic Design and Diagramming

DIG / DEPAT / DIEDIG

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Dados Internacionais de Catalogação-na-Publicação (CIP)

G342 Geochemical studies in the city of Boquira: state of Bahia / Fernanda Gonçalves da Cunha, Eduardo Paim Viglio, José Ângelo Sebastião Araújo dos Anjos, Thais Belloti Loureiro. – Rio de Janeiro : CPRM, 2022.
1 recurso eletrônico : PDF.

ISBN 978-65-5664-239-0

1. Geoquímica – Brasil – Bahia. I. Cunha, Fernanda Gonçalves da. II. Viglio, Eduardo Paim. III. Anjos, José Ângelo Sebastião Araújo dos. IV. Loureiro, Thais Belloti.

CDD 551.9098142

Ficha catalográfica elaborada pela bibliotecária Priscila Ururahy CRB7 5665

PRESENTATION

In the Environmental Geochemistry and Medical Geology field, the Geological Survey of Brazil – SGB/CPRM has highlighted the Geochemical Surveys Action, with the Low-Density Geochemical Mapping Project in Brazil, under development since 2008, and whose objective is to evaluate, throughout the national territory, the composition of the rocky substrate, soils, active stream sediments, surface waters and human supply waters.

In this objective, a detailed geochemical study was carried out in the urban perimeter of the city of Boquira, in the Midwest of the state of Bahia, which is characterized as one of the main environmental liabilities in Brazil, derived from the mining activity of lead and zinc, in urban area, causing risks of environmental contamination and human health.

The field studies were developed between 2013 and 2014, with the collection of various materials: the groundwater used for domestic supply, the waste from the waste pile, the street sediments and the dust collected inside the residences (dust indoor).

The results achieved, that are available in this report, can be useful for the implementation of Municipal, State and/ or Federal Government policies and actions, to improve the life's quality of the population that live in the city of Boquira, both in the environmental and in the public health.

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GEOCHEMICAL STUDIES IN THE CITY OF BOQUIRA

INTRODUCTION

The lead ore exploration in Boquira began in the late 1950s by Penarroya S.A., which created the Companhia Brasileira de Chumbo – Cobrac (Lead Brazilian Mining Company) to operate in Brazil such its subsidiary. Subsequently, the company was incorporated into Plumbum Mineração e Metalurgia Ltda, that belonged to the Trevo Group (Anjos and Sanchez, 2001). The lead ore mined and benefited in Boquira was used to produce lead alloys in Santo Amaro, in the region of Recôncavo Baiano, being transported by trucks and railway, covering the distance of 500 km. The ore processing used produce 83% of tailings that was improperly deposited during the development of open pit and underground mining. After the production peak in the 1970s, the economically viable reserves were exhausted and the Plumbum Mineração e Metalurgia Ltda was sold in 1986 to the Brazilian groups Companhia Minas da Passagem (CMP) and Luxma. In addition to the high operating costs, the oversupply of international lead caused the ore falling prices, in addition to the exhaust of lead ore from open pit and underground mines exploited in the area led to the abandonment of the Boquira mine in 1992, leaving an environmental liability and a population potentially exposed to chemical elements, considered toxic, which still nowadays are present in the material of the tailings basin.

Macroscopic analysis of the tailings performed by Assumpção et al (2015) allowed its classification as fine granulometry in the fractions very fine sand to clay (between 0.062 mm and 2 mm), with predominant gray coloration, although there are whitish and dark crusts indicating probably salt precipitations. Given this assessment, this fine material has great potential for transport over long distances, whether carried by rain or winds. And it is observed that, frequently, the material is dispersed by the constant winds in the region, which may present a source of risk to human health, due to the proximity to the population of Boquira and the surrounding villages. Another aggravating factor is the use of the site for disposal of household and hospital trash, with the practice of burning trash, that may cause the emission of toxic substances, as well the air pollution. The presence of recyclable material collectors is also common in the waste disposal area that was installed in the tailings basin.

Bertolino et al (2015) conducted a study to characterize the tailings basin material in order to determine the levels and distribution of metals, as a subsidy to the evaluation of their possible damage to the health of the population living around the tailings basin. The characterization of the mineralogical composition of the samples was performed using the X-ray Fluorescence (XFR) methods, reflected light petrographic microscope, X-ray diffractometry (XRD) and Scanning Electron Microscope (SEM). The results indicated that are high lead levels in the samples collected at different points of the old dam or tailings basin and in its surroundings, higher than those allowed by the National Council of the Environment (CONAMA). Lead is distributed in the minerals galena (PbS), cerussite (PbCO3) and anglesite (PbSO4), which represent a potential risk to human health. It was also observed the presence of lizardite – a fibrous habit mineral of the serpentine group – which, when inhaled, may also entail health risks, in addition to the amphibole group minerals actinolite and cummingtonite.

National Department of Mineral Production - DNPM (2006) apud Assumpção et al (2015) conducted a study to analyze the geochemical aspects of the Boquira tailings basin in relation to heavy metal contamination, detecting high levels of zinc, cadmium, arsenic, silver, as well as lead and other metals, which indicate a risk of environmental contamination to the exposed population and the ecosystem, depending on the proximity of the tailings basin.

Historically, air emissions, materials accumulated in tailings basins, slag and sterile piles resulting from mineral industry activities contribute to raising the levels of airborne heavy metals. This material transported by air is associated with increased levels of heavy metals in soils, street dust and household dust (EPA, 1998).

OBJECTIVES

The main objective of this study is to characterize – through sampling and chemical analysis – the physical environment of the urban area of the city of Boquira, aiming to determine the grade and distribution of metals that occur in the tailings basin, groundwater, sediments and indoor dust, as a subsidy to the assessment of their possible damage to the health of the population living in the city of Boquira.

CHARACTERIZATION OF THE CITY OF BOQUIRA

The city of Boquira, located in the central-western mesoregion of the state of Bahia, between the west of the Northern Espinhaço mountain range and east of Chapada Diamantina (Figure 1), has become exponent in the national scenario for the exploration of lead ore in the 70's and 80's of the last century, was considered one of the largest reserves in Brazil. It has a population of 22,448 inhabitants (IBGE, 2016) at 1,426.233 km2, approximately 650 km from Salvador. The majority of the Boquira`s population resides in the country side area and agriculture is the main activity, especially family farming, characterized as the main alternative of employment and income. Agricultural establishments, in addition to animal breeding, produce corn, beans, cassava and sugarcane, which are generally benefited by causing flour, tapioca, beiju, rapadura (a kind of sugar cane tablet), cakes, biscuits, etc. (SEI, 2011). Data from the United Nations Development Program show that 60% of Boquira's population is linked to the issue of poverty (UNDP, 2013).

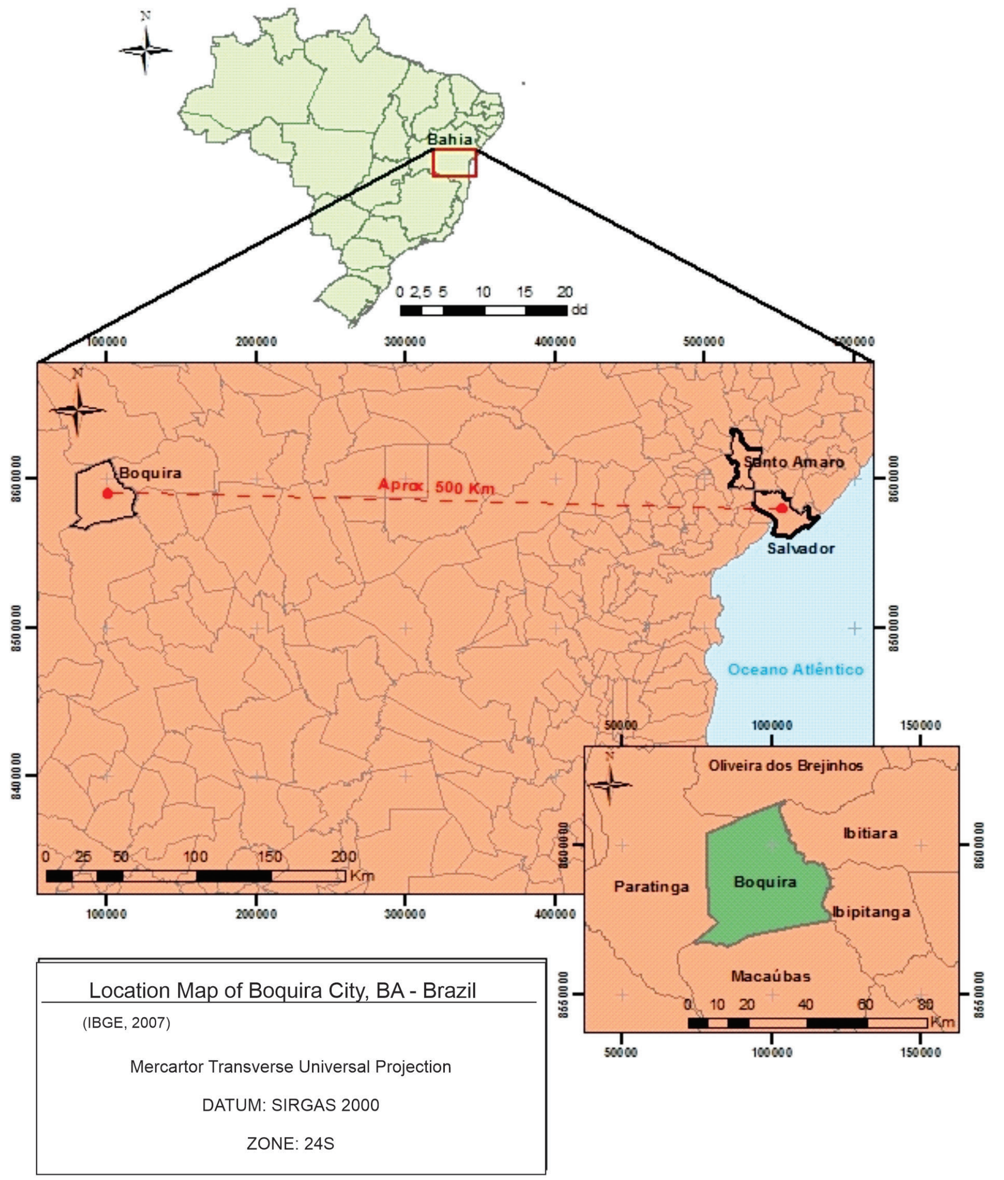

Figure 1: Location of the City of Boquira in the State of Bahia (Fernandes, 2015)

The climate is sub-humid to dry, with an average annual temperature of 23.8oC and annual rainfall of 894.8 mm with rainy season from October to April (Andrade et al, 2017).

Figure 2 shows the location of the city of Boquira in relation to the sterile piles and the tailings basin, which resulted from the extraction and processing of Pb-Zn mining whose started in 1959 and were closure in 1989. The ore processing produced 83% of tailings, and 17% of lead and zinc concentrate, used to be sent to metallurgy in the city of Santo Amaro, in the region of Recôncavo Baiano, in addition to the sterile, unquantified and improperly deposited during the development of open pit and underground mining. The sterile (rejected fraction of the ore concentration is formed by minerals without commercial or industrial use) and the tailings (discarded material after the flotation of the ore, in the production process of the concentrate) were deposited without technical criteria and they are characterized as the main environmental liability, due to the risks of contamination to human health. The tailings basin (Figure 3) is located very close to the neighborhoods and municipal town, as shown in Figure 4.

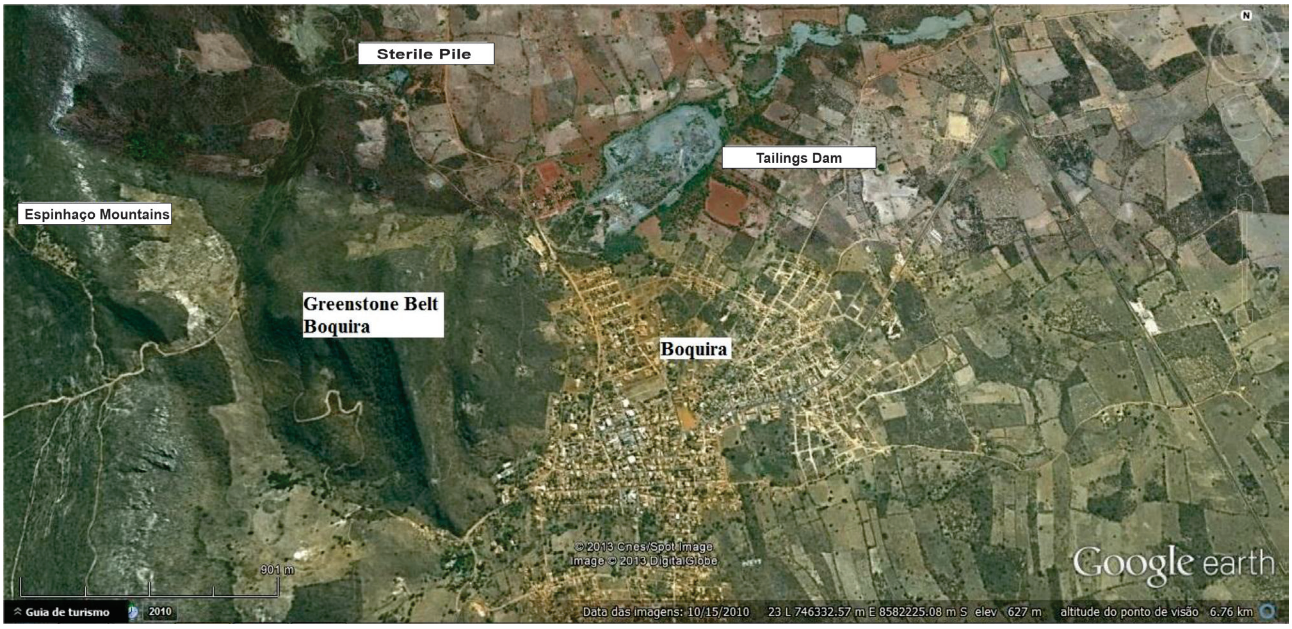

Figure 2: Disposal of tailings basin in the urban perimeter of the city of Boquira.

Figure 3: Tailings basin

The tailings basin also keeps a disposal area for household and hospital trash (Figure 5), where some residents of neighboring communities and Boquira collect the material for recycling.

According to Andrade et al (2017) the mayor reported that the processes of extraction and processing of Pb ore, which gave rise to the materials of the tailings basin, generated through the movements of

Figure 5: Disposal area of household and hospital trash existing on the tailings basin with waste pickers.

Figure 6: Location of wells where water for human consumption samples were collected.

the winds the risks of contamination that may be the cause of respiratory problems in the population that living around the basin.

MATERIALS AND METHODS

In 2013 and 2014, 19 samples of the tailings basin material were collected in the urban area of Boquira in 3 auger drilling holes at different depths, 7 drinkable water samples used for human consumption, 59 samples of street sediments and 109 dust samples inside the residences (indoor dust).

1. Drinkable water samples used for human consumption

Seven well water samples were collected (Figure 6), which are used for distribution for use by population. This samples were filtered in the field, with 0.45µm porosity filters and packed in two 50mL polyethylene tubes for cation and anion analysis. The samples for cation analysis were preserved with nitric acid. All samples were preserved under refrigeration until the moment of analysis. Seven anions (bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate) were analyzed by Ion Chromatography and twenty-eight cations (Al, As, B, Be, Ba, Ca, Co, Cd, Cu, Cr, Li, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Se, Si, Sb, Sn, Sr, Ti, V and Zn) by ICP OES (inductively coupled plasma atomic emission spectrometry) in the Technology Center of Analysis - CETAN, in the city of Vitória and in the laboratory SGS GEOSOL, in Vespasiano (MG), respectively.

2. Samples of tailings dam material

Three auger drilling holes were sampled at various depths, with manual work, in a total of 19 samples, plus a whitish and gray sample of surface materials, probably salt precipitations (Figures 7, 8 and 9). The samples were dried at 50ºC, sieved at 80# and grounded at 200#, digested with aqua regia and analyzed for 53 elements (Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, In, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Re, S, Sb, Sc, Se, Sn, Sr, Ta, Tb, Te, Th, Ti, U, V, W, Y, Yb, Zn and Zr) by ICP-OES (inductively coupled plasma atomic emission spectrometry) and ICP-MS (inductively coupled plasma mass spectrometry) in the Technological Center of Analysis– CETAN, in the city of Vitória.

Figure 7: Location of sampling stations in the tailings basin.

Figure 8: Samples collected from whitish and grey material.

Figure 9: Collection of samples from tailings basin material.

3. Samples of street sediments

Fifty-nine samples of street sediments were collected at different points in the city in paved and unpaved streets (Figure 10). The collection was performed using a plastic shovel, small broom, bowl and plastic sieve (Figure 11). They were packed in plastic bags and labeled.

Samples were analyzed by ICP-OES (inductively coupled plasma atomic emission spectrometry) and ICP-MS (inductively coupled plasma mass spectrometry) for the same 53 chemical elements, in the fraction <80#, with opening of aqua regia. The analyses were carried out at the Technological Center of Analysis - CETAN, in the city of Vitória.

4. Dust samples inside homes

One hundred and nine indoor dust samples were collected in randomly chosen residences, throughout the downtown of Boquira and inside almost all the residences of the old working class neighborhood (Figure 12). The samples were collected in places where accumulates the most of dust (roofs, half-walls, on top of furniture, behind frames, etc.). For the collection were used brushes, plastic shovel and the samples were packed in plastic bags properly labeled and sealed (Figure 13).

The samples were analyzed by ICP-OES (inductively coupled plasma atomic emission spectrometry) and ICP-MS (inductively coupled plasma mass

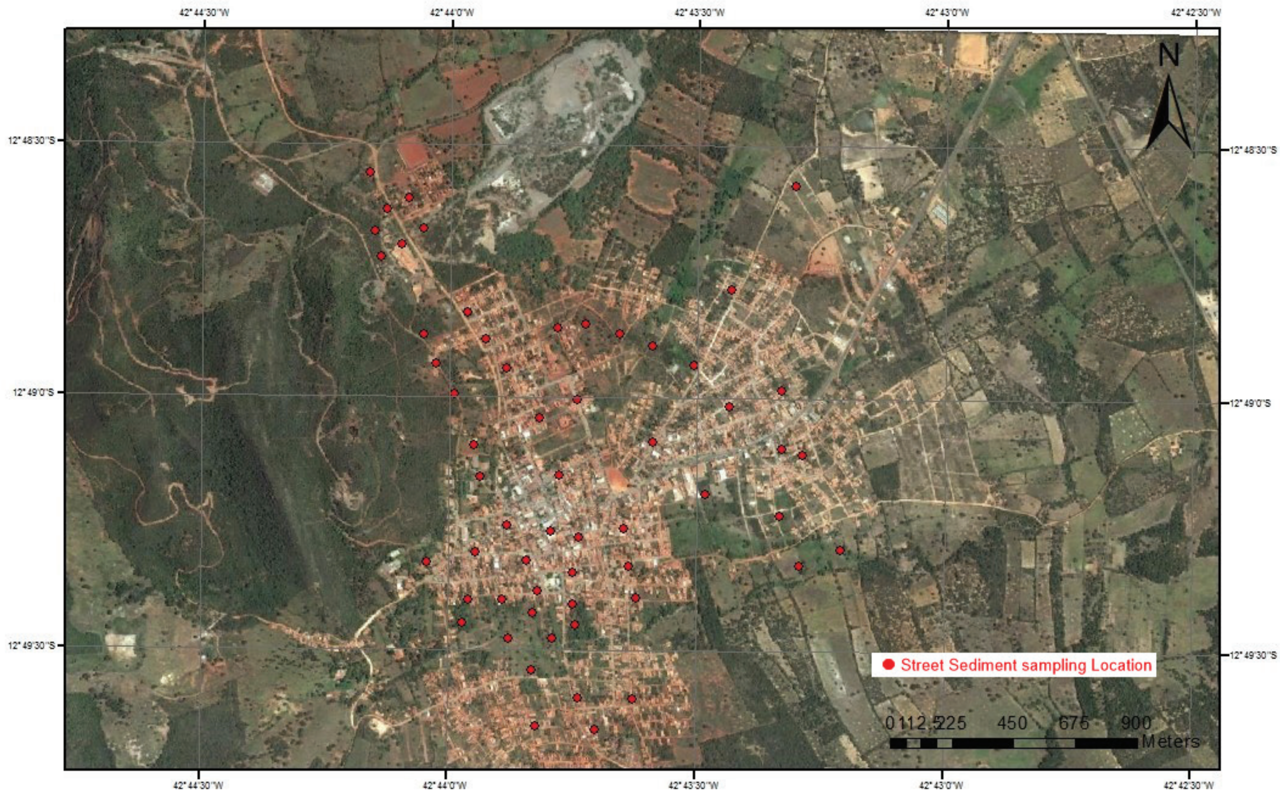

Figure 10: Location of street sediment sampling collection stations.

Figure 11: Collection of street sediment samples.

spectrometry) for 53 chemical elements, in the fraction <80#, at the Technological Center of Analysis – CETAN, in the city of Vitória. Questionnaires were also applied to the house residents.

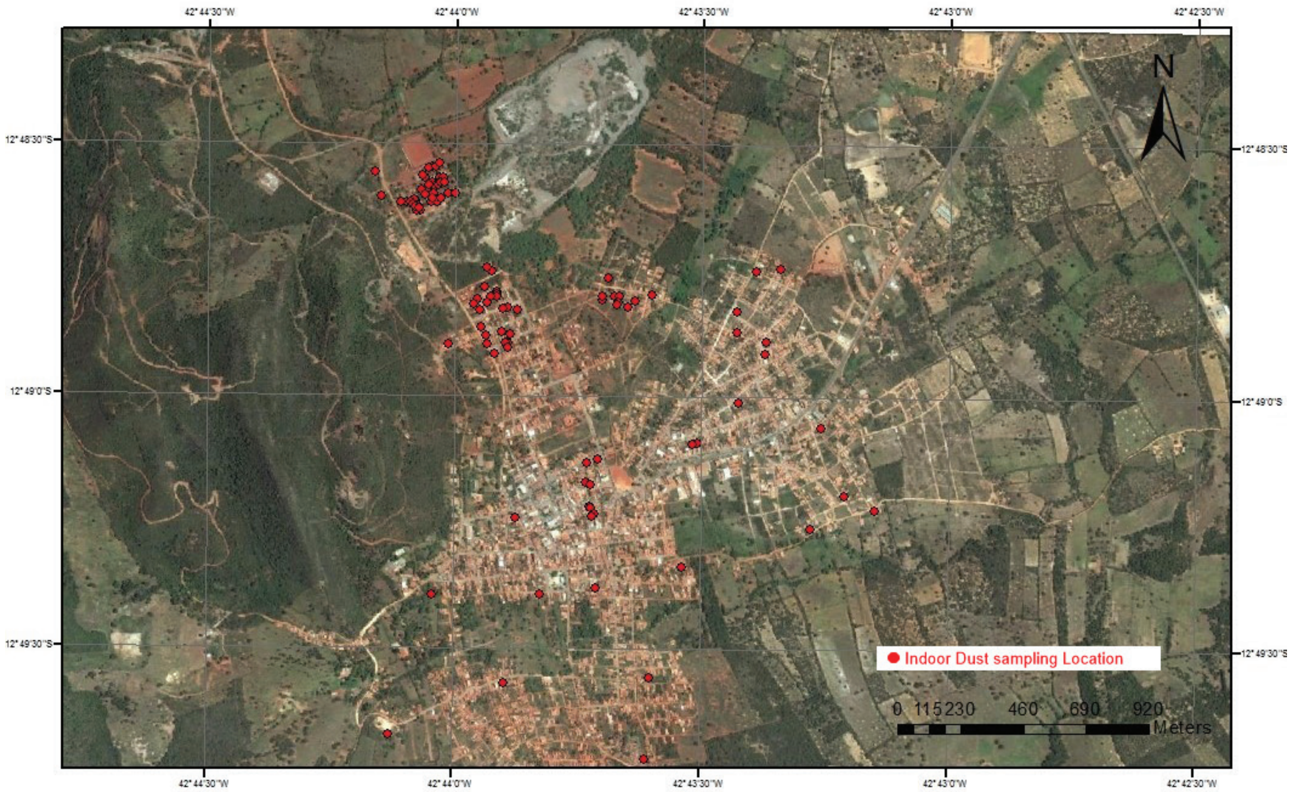

Figure 12: Location of the residences where dust samples were collected.

Figure 13: Collection of indoor dust samples.

RESULTS OBTAINED

Tailings basin material

Figure 14 illustrates the location of holes 1, 2 and 3 and samples of whitish and dark crust materials collected in the tailings basin, whose analytical results of some metals are represented in the histograms of figures 16 (A and B), 17 (A and B), 18 (A and B) and 19 (A and B). Winds are constant in the tailings basin area causing resuspension of the fine material deposited there (Figure 15), which may be contributing to the composition of street sediments and residential dust of the working class neighborhood and urban center of the city. Table 1 presents the results of the chemical analyses of the samples collected in the tailings basin at their different depths.

Figure 14: Location of the auger driller holes and whitish and dark crusts.

Figure 15: Resuspension of the fine material deposited in tailings basin by the region's constant winds.

TABLE 1: Analytic results found in samples collected in the tailings basin.

SAMPLE	DEPTH (m)		Ag (ppm)	As (ppm)	Ba (ppm)	Cd (ppm)	Cr (ppm)	Cu (ppm)	Hg (ppm)	Mn (ppm)	Ni (ppm)	P (ppm)	Pb (ppm)	Sb (ppm)	Sr (ppm)	Th (ppm)	U (ppm)	V (ppm)	Zn (ppm)
Hole 1	0	0,5	5,29	5,00	51,00	102,72	30,0	72,6	0,09	3124	22,6	612	>10000	4,49	26,5	4,00	9,34	30,00	4454
	0,5	1,0	3,28	3,00	99,00	72,97	27,0	55,2	0,03	3734	20,5	527	>10000	1,23	10,1	3,70	7,53	33,00	2765
	1	1,5	4,31	4,00	101,00	73,44	31,0	115,8	0,08	3135	26,4	395	>10000	3,53	11,0	10,20	11,13	39,00	4946
	1,5	2,0	5,34	2,00	22,00	91,58	18,0	101,3	0,07	2656	14,9	507	7945	3,80	16,9	11,20	43,45	35,00	4849
	2	2,5	5,53	2,00	13,00	281,01	17,0	135	0,23	2174	12,5	391	6439	3,47	17,2	2,70	10,34	29,00	>10000
	2,5	3,0	5,00	3,00	34,00	184,24	18,0	164,8	0,19	2741	15,1	604	7827	3,05	9,7	2,90	12,37	27,00	>10000
	3	3,5	3,86	3,00	90,00	85,19	22,0	78,4	0,06	2854	18,9	579	>10000	3,42	8,9	4,90	12,11	41,00	5209
Median			4,65	3,14	58,57	127,31	23,29	103,30	0,11	2917	18,7	516	7403	3,28	14,3	5,66	15,18	33,43	4445
Hole 2	0	0,5	8,93	5,00	69,00	95,29	38,00	109,40	0,16	2807	24,30	882	>10000	6,69	4,60	9,40	12,33	51,00	8614
	0,5	1,0	5,30	5,00	70,00	121,44	35,00	103,90	0,15	2643	22,20	675	>10000	6,67	7,00	8,80	12,22	44,00	>10000
	1	1,5	6,13	4,00	47,00	182,19	34,00	99,40	0,17	2491	19,00	723	>10000	6,74	7,80	6,50	13,13	43,00	>10000
	1,5	1,75	5,67	13,00	140,00	358,63	49,00	123,00	0,14	3023	40,60	670	>10000	5,04	7,00	5,50	12,99	39,00	>10000
Median			6,51	6,75	81,50	189,39	39,00	108,93	0,16	2741	26,53	738	>10000	6,29	6,60	7,55	12,67	44,25	8614
Hole 3	0	0,5	6,49	6,00	175,00	194,93	133,00	204,20	0,12	3124	70,10	885,00	>10000	7,13	11,10	8,80	11,36	32,00	>10000
	0,5	1,0	7,19	7,00	243,00	151,49	100,00	508,80	0,14	3739	69,10	843,00	>10000	7,06	11,50	8,30	21,33	31,00	>10000
	1	1,5	7,63	6,00	196,00	142,26	114,00	337,60	0,20	3560	67,50	903,00	>10000	9,54	11,20	9,00	18,16	31,00	>10000
	1,5	1,75	8,71	7,00	174,00	195,66	113,00	294,50	0,27	3286	64,20	979,00	>10000	10,59	10,40	9,10	17,99	33,00	>10000
Median			7,51	6,50	197,00	171,09	115,00	336,28	0,18	3427	67,73	902,50	>10000	8,58	11,05	8,80	17,21	31,75	>10000
Tailings median			6,22	5,46	112,36	162,60	59,10	182,84	0,15	3028,33	37,65	793,00	>10000	6,05	10,65	7,34	15,02	36,48	8614,00
Dark crust			5,29	3,00	36,00	180,87	19,00	109,50	0,16	2400	14,00	591	9930	2,73	20,90	4,40	15,69	30,00	>10000
Dark crust			2,03	4,00	<5	2502,78	3,00	30,60	0,05	4373	7,90	110	3034	0,87	1,50	0,80	3,18	6,00	>10000

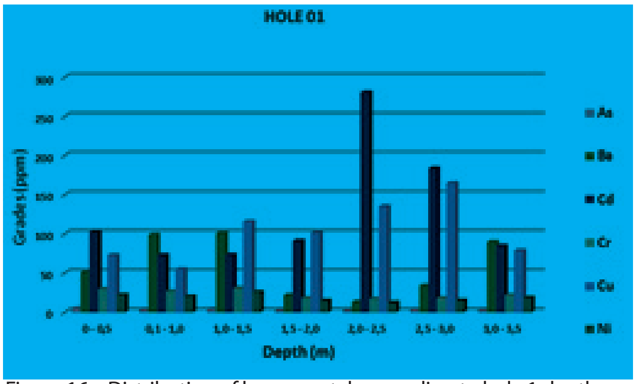

Figure 16a: Distribution of heavy metals according to hole 1 depths.

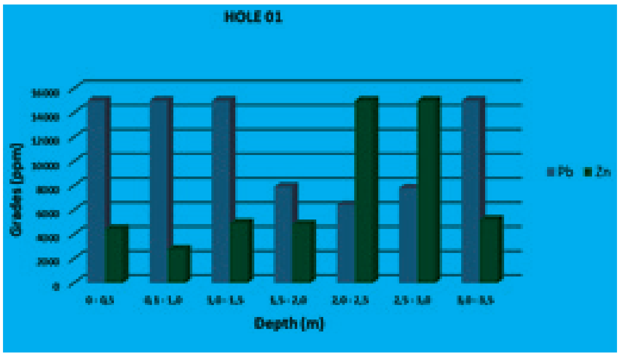

Figure 16b: Distribution of Pb and Zn according to hole 1 depths.

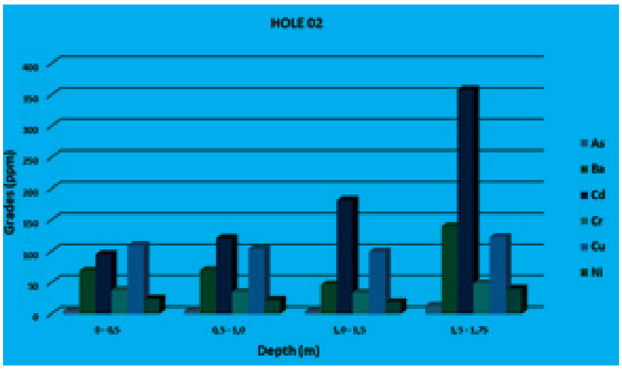

Figure 17a: Distribution of heavy metals according to hole 2 depths.

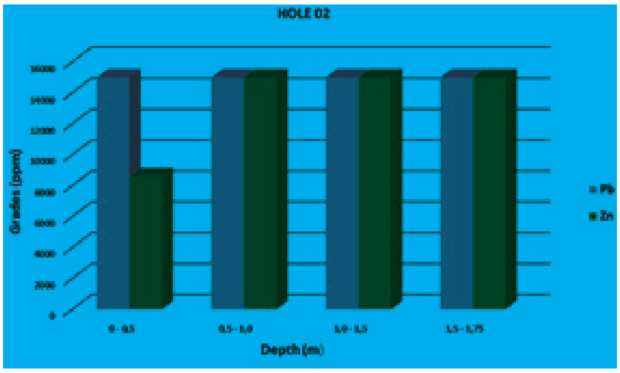

Figure 17b: Distribution of Pb and Zn according to hole 2 depths

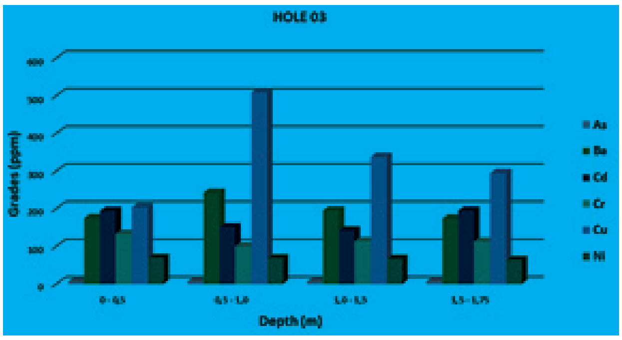

Figure 18a: Distribution of heavy metals according to hole 3 depths.

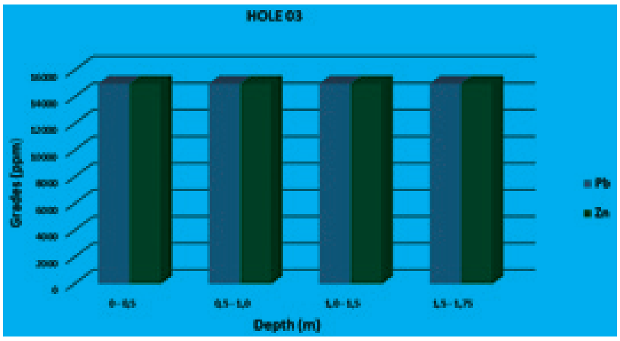

Figure 18b: Distribution of Pb and Zn according to hole 3 depths.

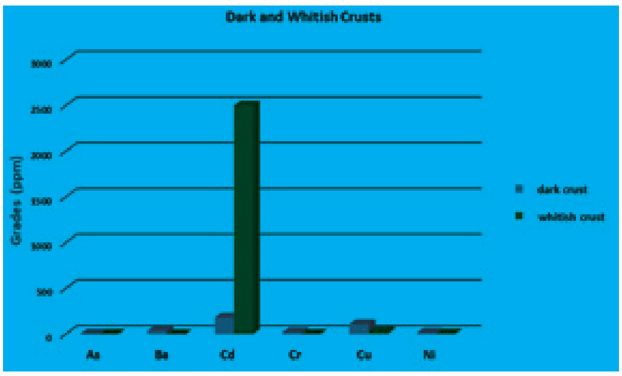

Figure 19a: Distribution of heavy metals in the whitish and dark crusts samples.

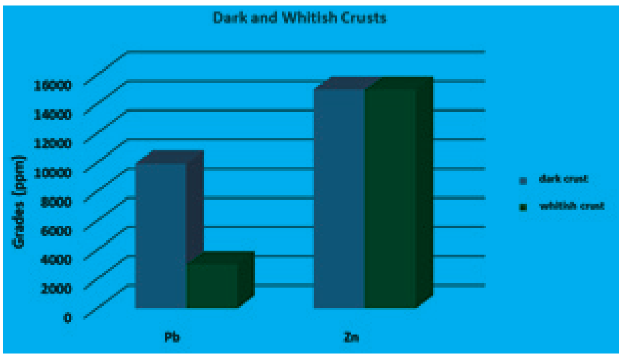

Figure 19b: Distribution of Pb and Zn in the whitish and dark crusts samples.

These results indicate that the distribution and dispersion of heavy metals in the tailings basin is quite heterogeneous, especially in relation to the concentrations of barium, cadmium, lead and copper, but in relation to lead and zinc levels, it is observed that most of the time a high concentration were obtained, above 10,000 ppm.

The samples of the tailings basin material characterized as whitish and gray crusts, which may indicate precipitation of salts (Figure 8) presented high concentrations for most of heavy metals, and lead and zinc presented levels above 10,000 ppm.

Comparing the contents obtained for barium, cadmium, lead, copper, chromium, nickel, silver and zinc in the samples collected in the tailings basin, with CONAMA guiding values used by Bertolino et al (2015) it is verified that they are extremely high, characterizing contaminated areas, and may constitute a serious risk to public health and the environment. This corroborates the results obtained in the study of DNPM (2006) and Bertolino et al (2015). These last authors also highlight the occurrence of the fibrous mineral (Figure 20), lizardite, hydrated magnesium and iron silicate from the serpentine group, which ones when inhaled may also involve health risks, in addition to the minerals actinolite and cummintonite of the group of amphibolies.

2. Water used for human supply

Table 2 shows the heavy metals average concentrations in water samples collected in water wells used for domestic consumption. The analytical results of the water samples indicate that they can be considered suitable for human use, being almost all the elements analyzed in concentrations lower than the values allowed by CONAMA Resolutions 357/2005 and 396/2008 and Ordinance 2914/2011 of the Ministry of Health, with the exception of Fe which is quite high in relation to these legislations.

3. Street sediment

From the analytical results of the elements analyzed in the street sediments samples were detected only Al, Ca, Fe, Mg, Na and Pb above the quantification limits of the analytical equipment, indicating the regional chemical composition of rocks and soils, these elements also are found in construction materials. The statistical summary of the analytical results is shown in table 3. CONAMA Resolution 420/2009, which provides guiding values

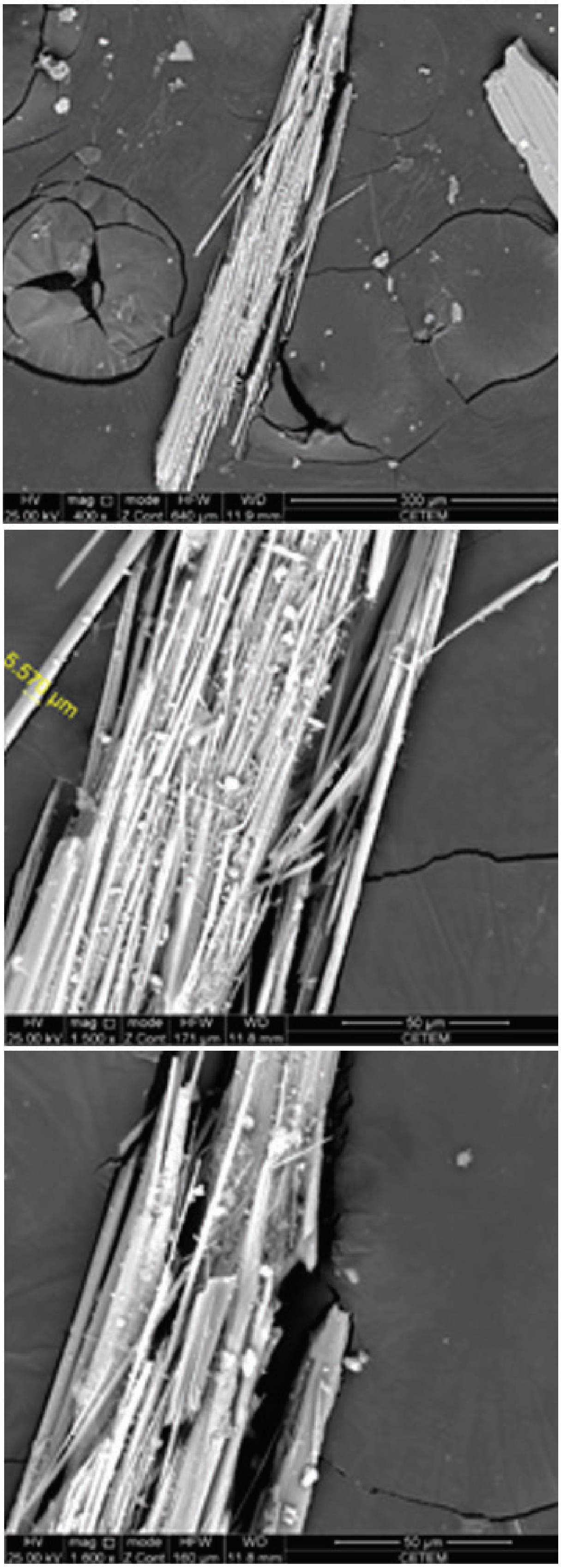

Figure 20: Fibrous mineral (hydrated Mg silicate) detected by Scanning Electron Microscopy - SEM, according to Bertolino et al (2015).

TABLE 2: Average concentrations, in mg/L, of cations (heavy metals) and anions in water samples used for human consumption in relation to the values allowed by environmental legislation.

ELEMENTS	AVERAGE (mg/L)	BRASILIAN LEGAL RESOLUTIONS		
		CONAMA 357/2005	CONAMA 396/2008	PORTARIA MS 2.914/2011
Cations				
Al	0,15	0,1	0,2	-
As	0,0015	0,01	0,01	0,01
Ba	0,6	0,7	0,7	0,7
Cd	< 0,01	0,001	0,005	0,005
Cr	0,002	0,05	0,05	0,05
Cu	0,003	0,009	2,0	2,0
Fe	5,68	0,3	0,3	-
Mn	0,23	0,1	0,1	-
Ni	0,01	0,025	0,02	0,07
Pb	< 0,002	0,01	0,01	0,01
Sb	0,001	0,005	0,005	0,005
Se	0,0036	0,01	0,01	0,01
V	0,018	0,1	0,05	-
Zn	0,079	0,18	5,0	-
Anions				
Brometo	0,093	-	-	-
Cloreto	136,25	250	250	250
Fluoreto	0,038	1,4	1,5	1,5
Fosfato	0,068	-	-	-
Nitrato	47,51 (≈10,73 N)	10N	10N	10N
Nitrito	0,045 (≈0,199 N)	1N	1N	1N
Sulfato	39,14	250	250	250

for contaminated soils by anthropic activities, shows that only Pb has a guiding value of prevention – 72 ppm, but the levels obtained in the street sediments samples in Boquira are all of them far below this value, ranging from 0.1 to 1.2 ppm.

4. Dusts from inside residences (indoor dust)

Table 4 provides a statistical summary of the results of the detected elements that were above the quantification limit of the analytical method in the indoor dust samples collected in Boquira. There is no

Table 3: Statistical summary of the elements detected.

ELEMENTS	MAX. VALUE	MIN. VALUE	MEDIAN
Al (%)	4,65	0,005	0,94
Ca (%)	23,10	0,005	0,83
Fe (%)	12,40	0,02	2,17
Mg (%)	4,52	0,005	0,44
Na (%)	3,73	0,005	0,005
Pb (ppm)	1,20	0,10	0,10

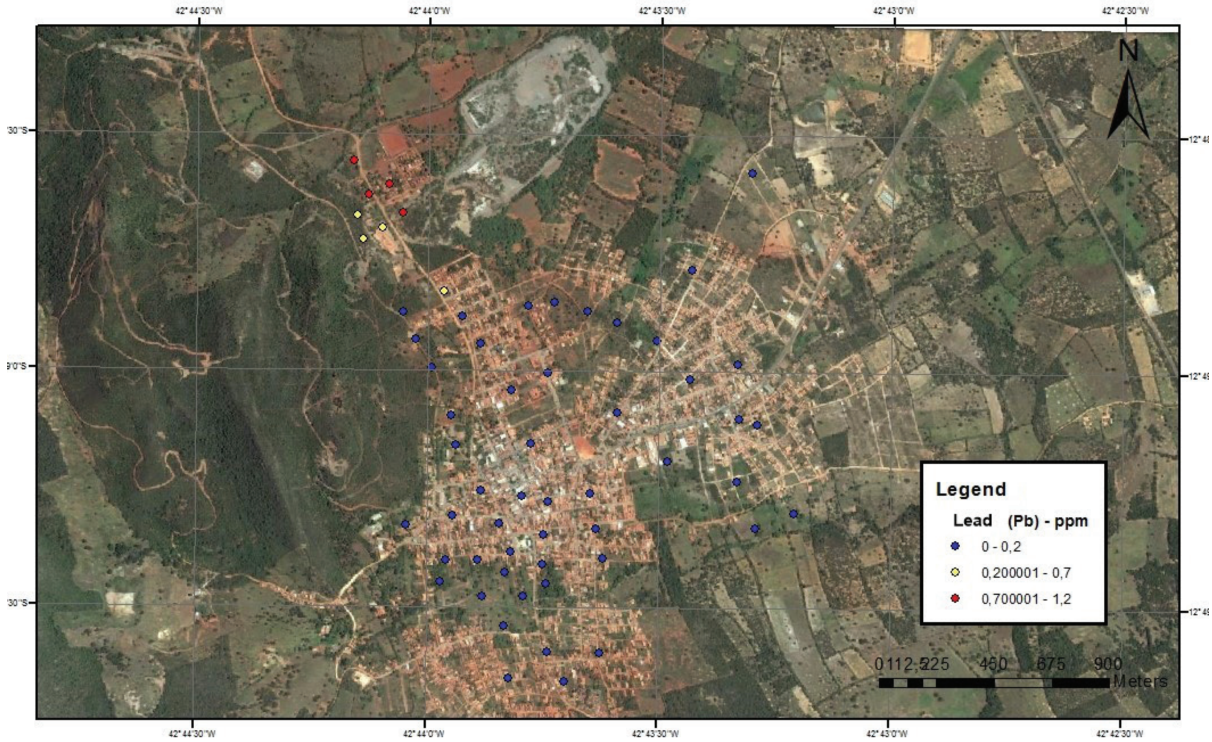

Figure 21: Distribution of lead grades in street sediment sampling stations in Boquira..

TABLE 4: Statistical summary of the elements detected in indoors dust samples.

ELEMENTS	MAX. VALUE	MIN. VALUE	MEDIAN
Al (%)	4,1	0,8	2,3
As (ppm)	170	0,5	0,5
Ba (ppm)	4,1	0,8	2,3
Bi (ppm)	156	0,025	0,025
Cd (ppm)	95	0,005	0,005
Ca (%)	95	0,7	2,5
Pb (ppm)	9.020	0,1	326
Co (ppm)	28	0,05	8
Cu (ppm)	3.710	0,25	42,5
Cr (ppm)	91	9	39
S (%)	0,4	0,005	0,005
Sr (ppm)	755	36	91
Fe (%)	11	0,6	3,85
P (ppm)	2.770	26	788,5
Li (ppm)	6	0,5	0,5
Mg (%)	5.790	0,1	0,6
Mn (ppm)	4.350	99	583
Mo (ppm)	11	0,025	0,025
Ni (ppm)	41	0,25	12
K (%)	1.340	0,1	0,5
Na (%)	1.230	0,005	0,1
V (ppm)	108	0,5	50,5
Zn (ppm)	5.790	0,5	212,5

Brazilian legislation that determines guiding values for this type of material in relation to human health. However, observing the table, the elements considered toxic to humans show very high levels, such as lead, copper and manganese.

Figures 22 to 31 provide dispersion maps of elements Al, Ba, Cr, Cu, Mn, Ni, Pb, Sr, V and Zn, respectively, in residential dust samples. These elements are considered dangerous to human health, especially Ba, Cr, Mn, Ni and Pb, which are spread throughout the urban area of Boquira, and the higher levels of Mn and Pb are concentrated in the former working class neighborhood, nearby the tailings basin.

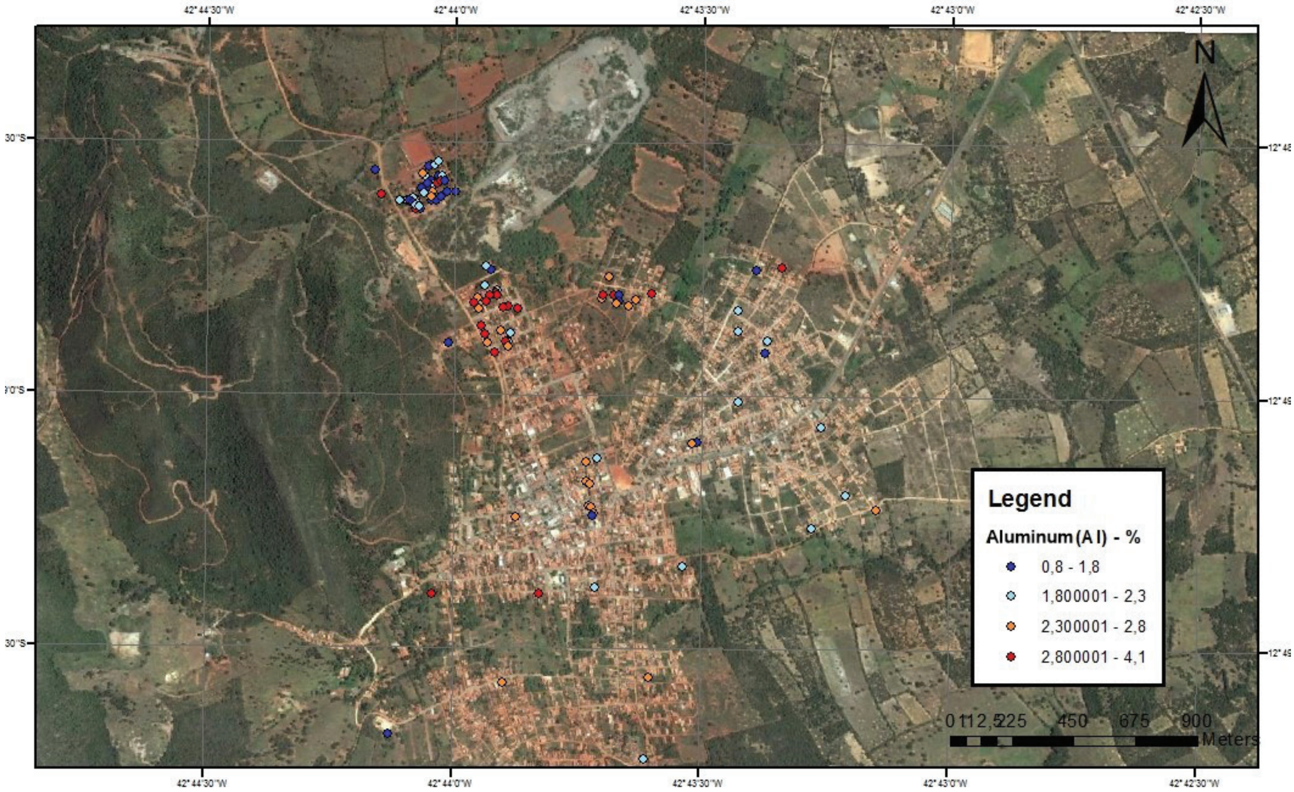

Figure 22: Distribution of Al grades in indoors dust sampling stations.

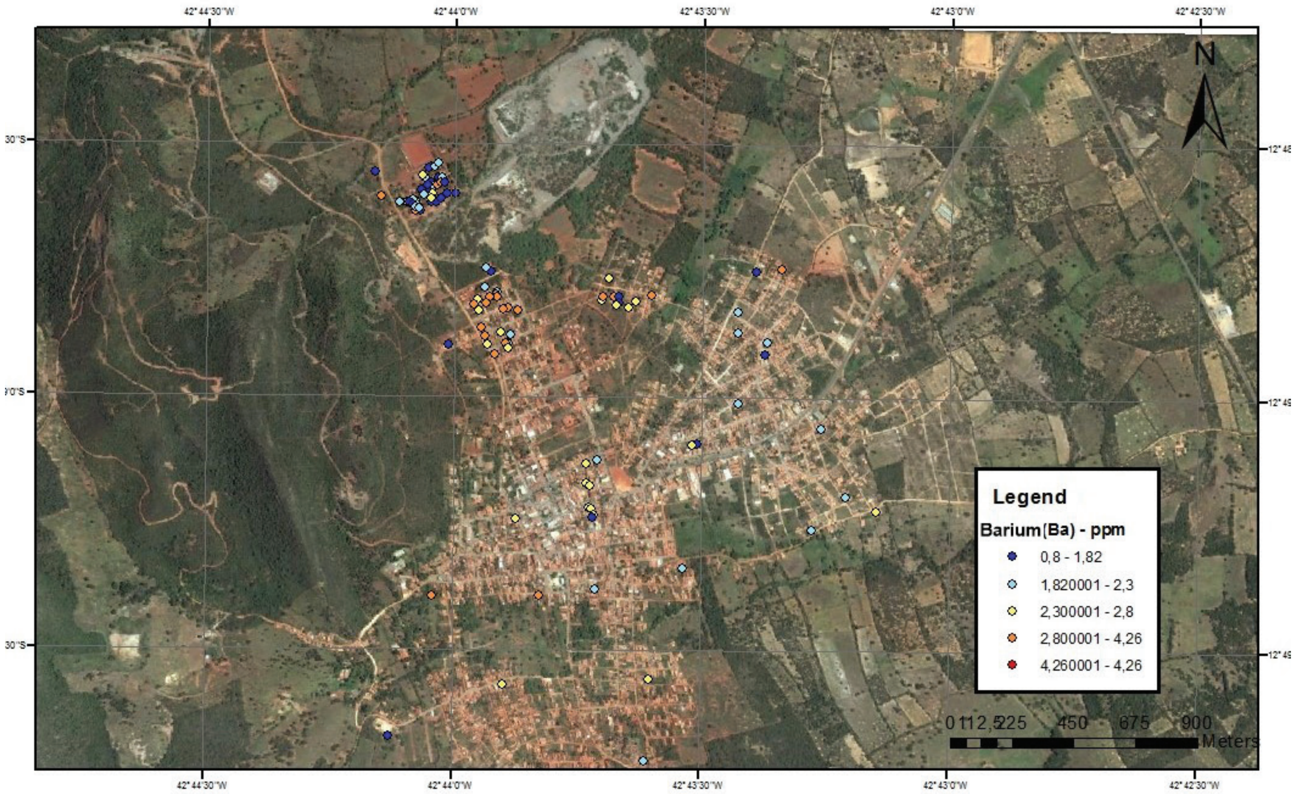

Figure 23: Distribution of Mg grades in indoors dust sampling stations.

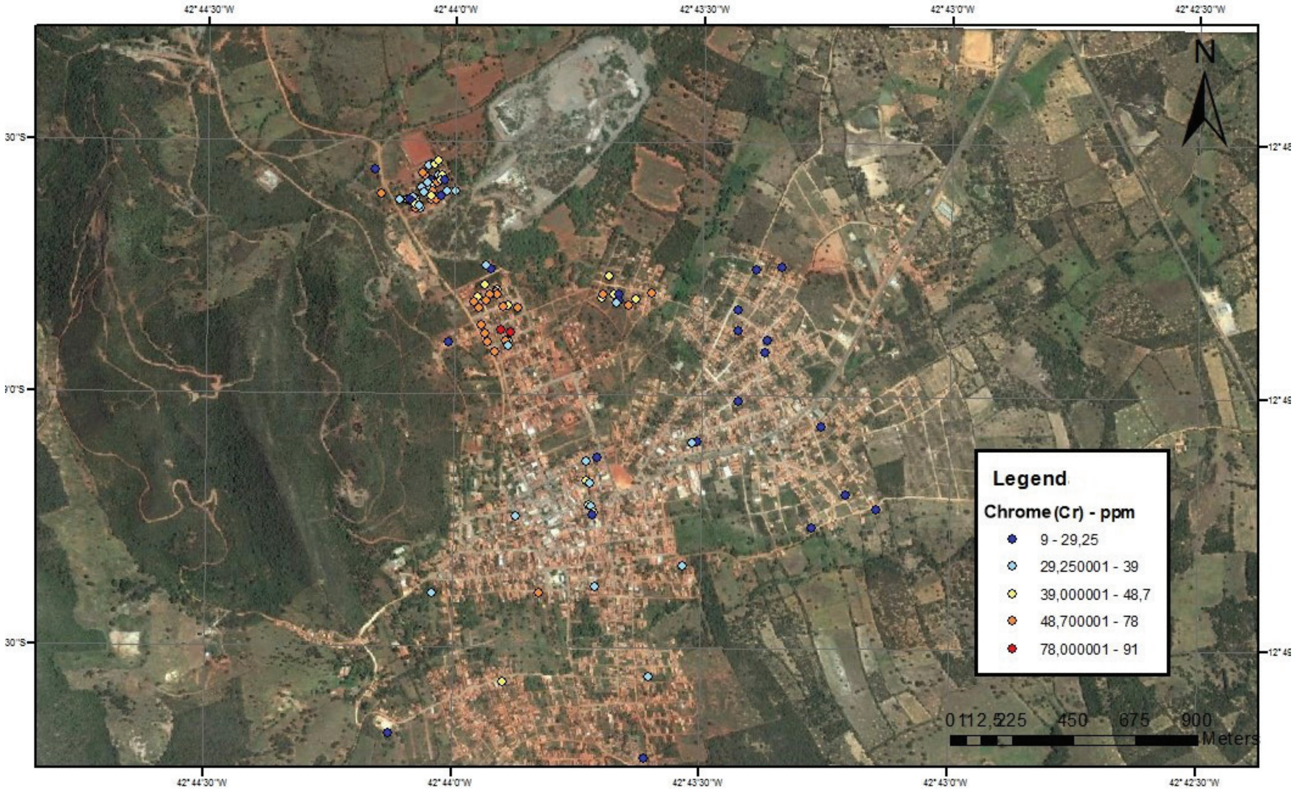

Figure 24: Distribution of Cr grades in indoors dust sampling stations.

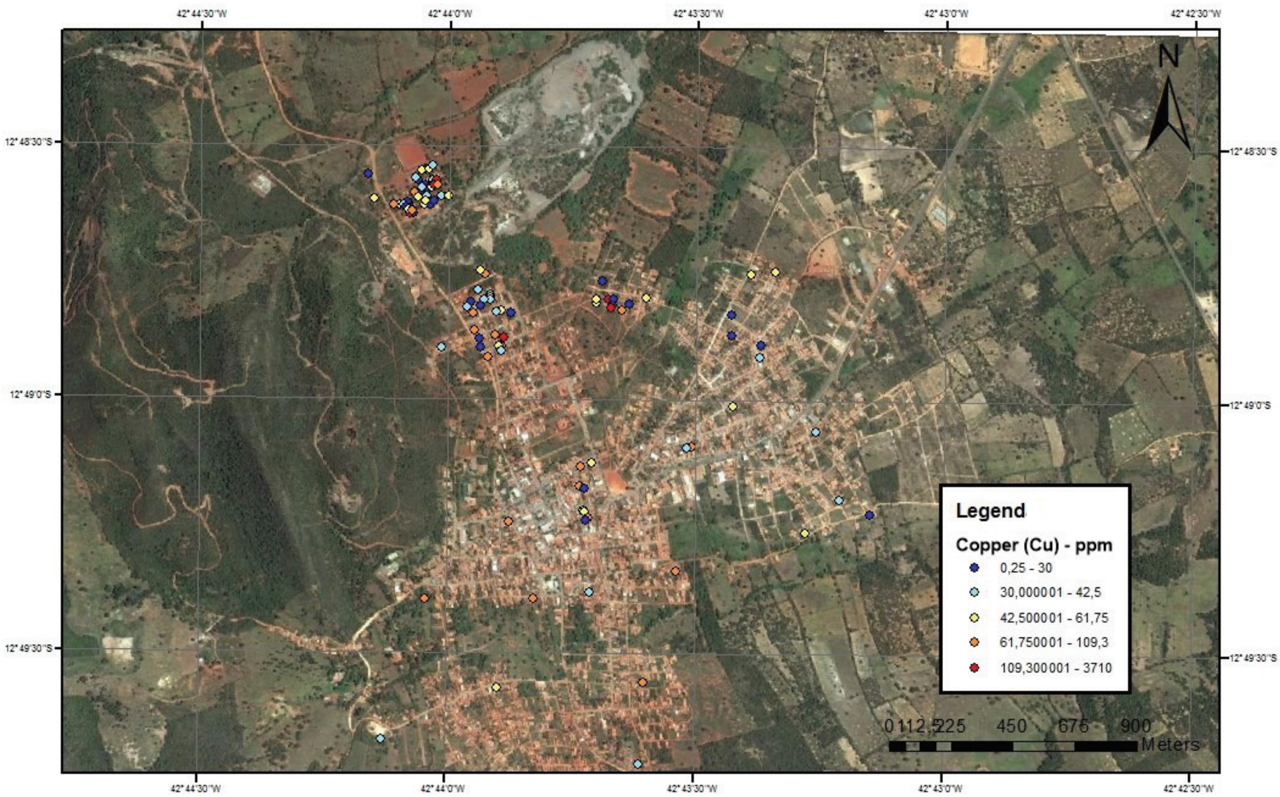

Figure 25: Distribution of Cu grades in indoors dust sampling stations.

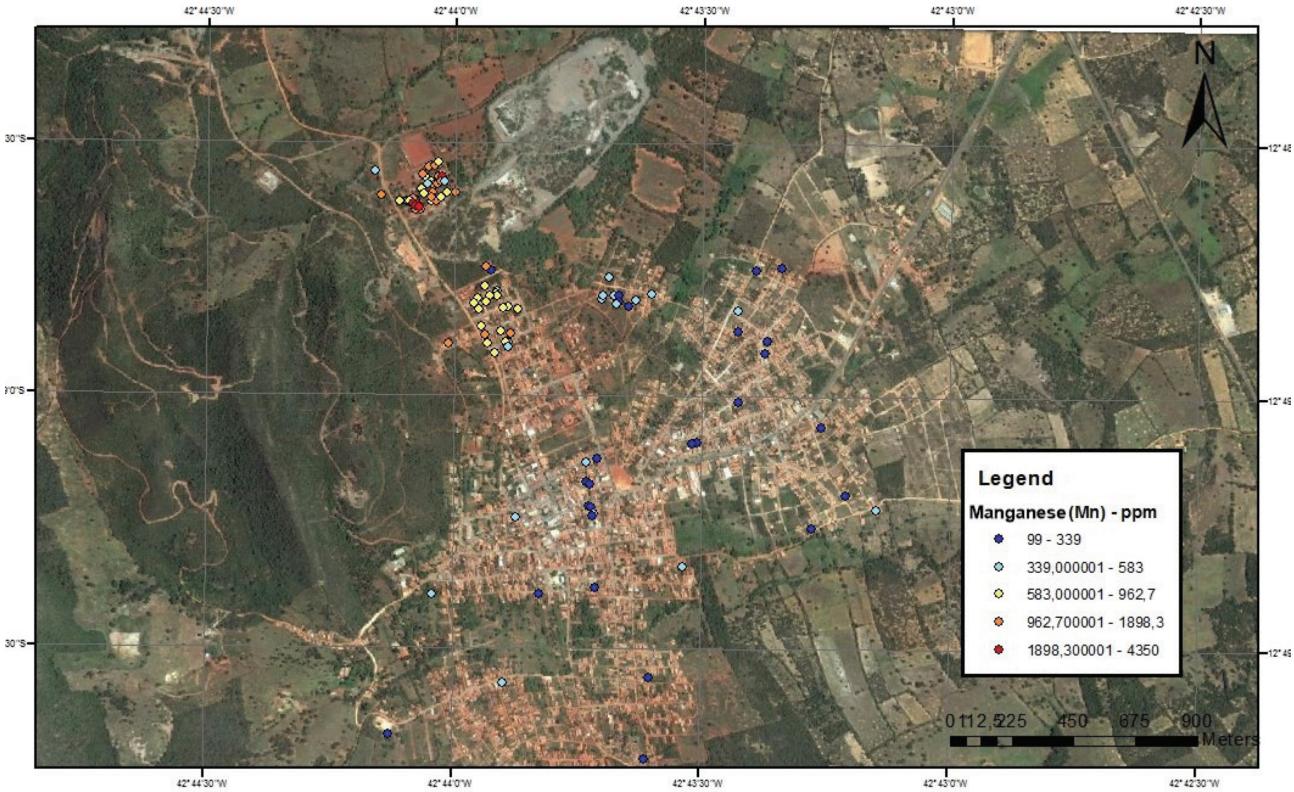

Figure 26: Distribution of Mn grades s in indoors dust sampling stations.

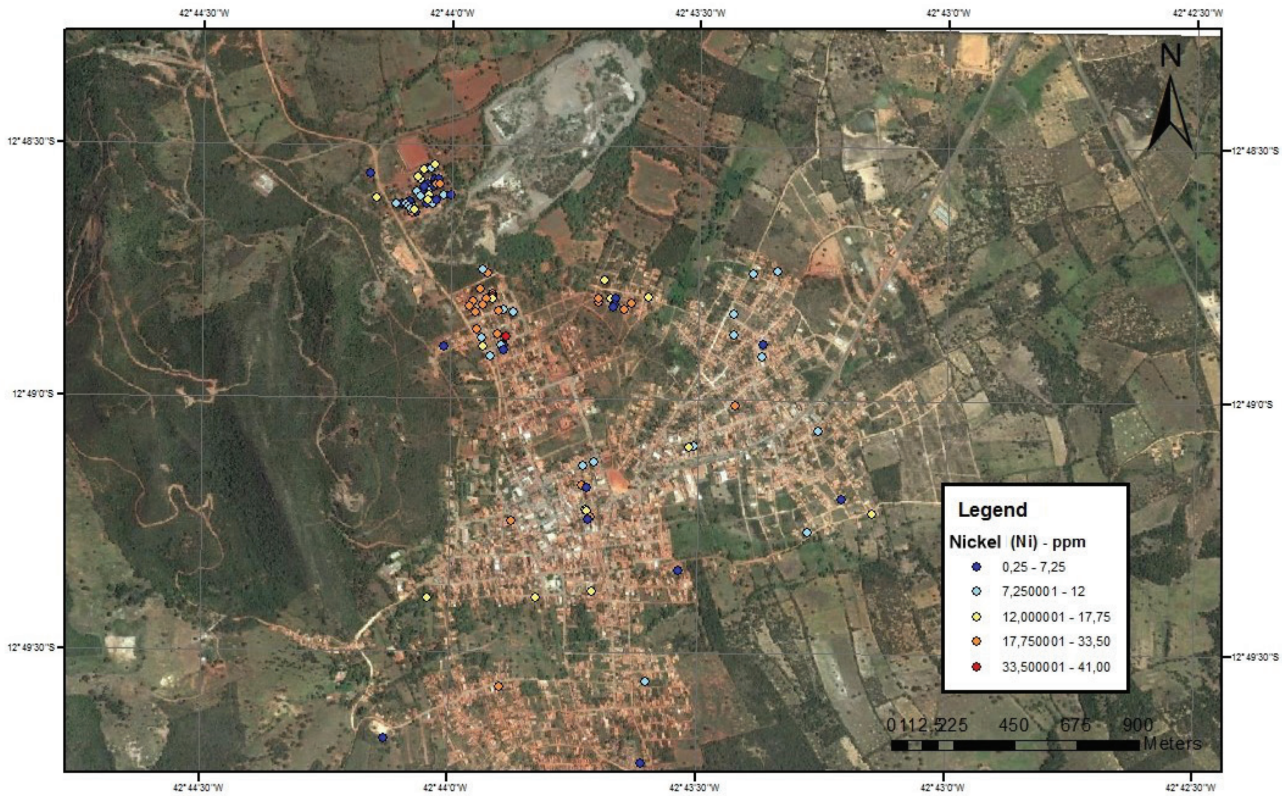

Figure 27: Distribution of Ni grades in indoors dust sampling stations.

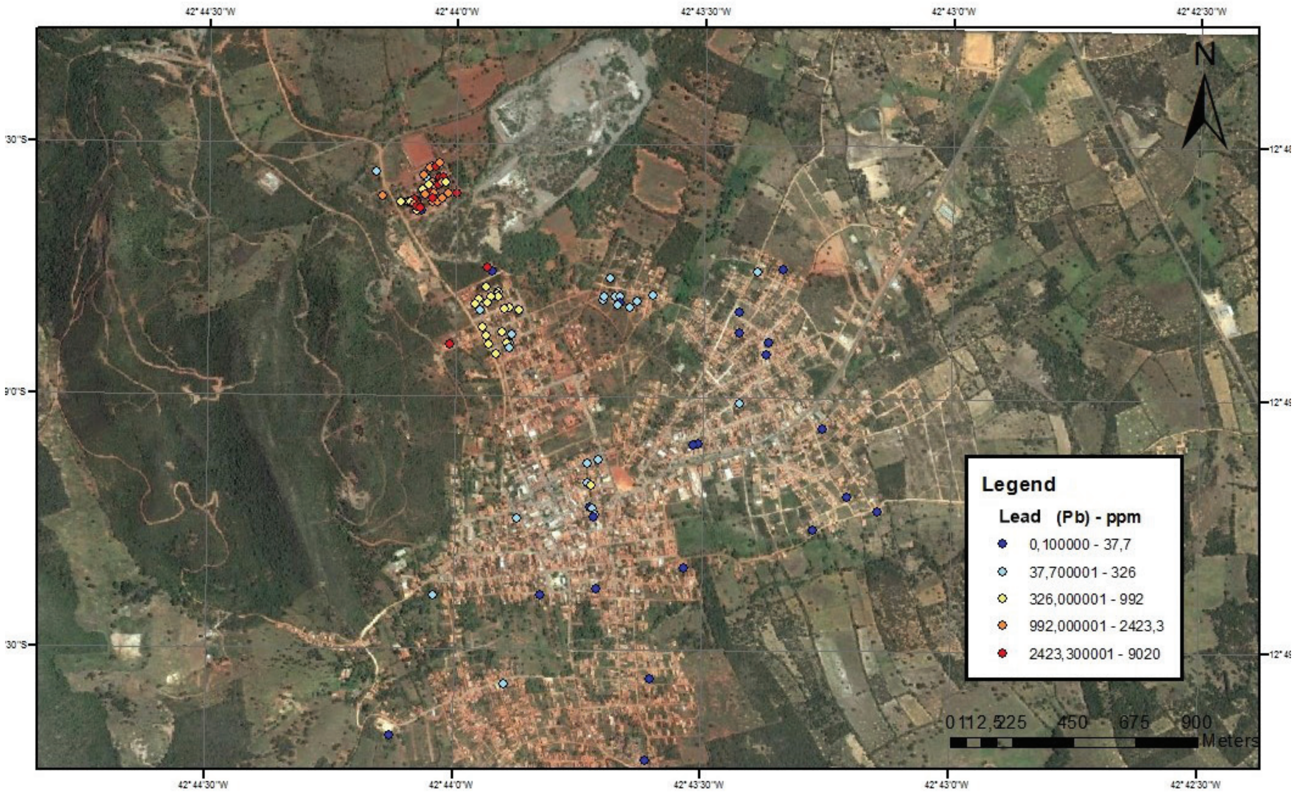

Figure 28: Distribution of Pb grades in indoors dust sampling stations.

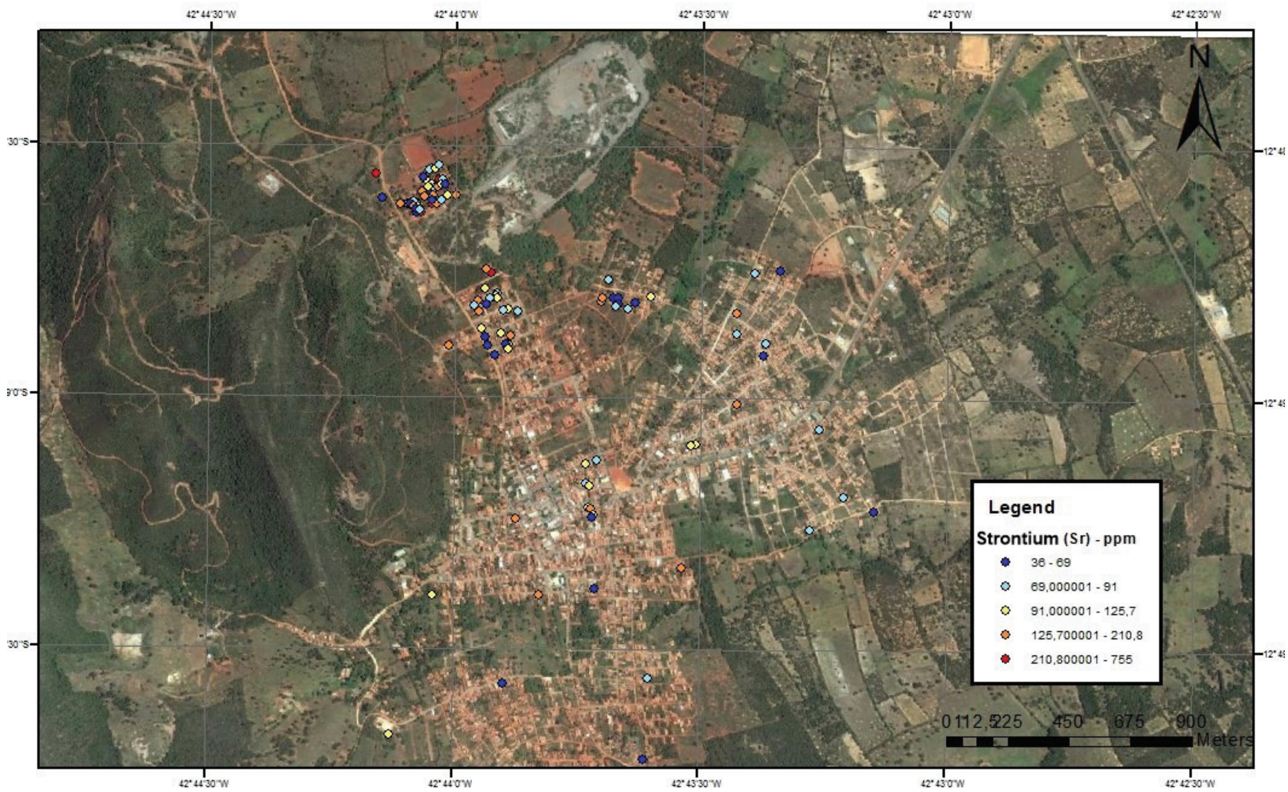

Figure 29: Distribution of Sr grades in indoors dust sampling stations.

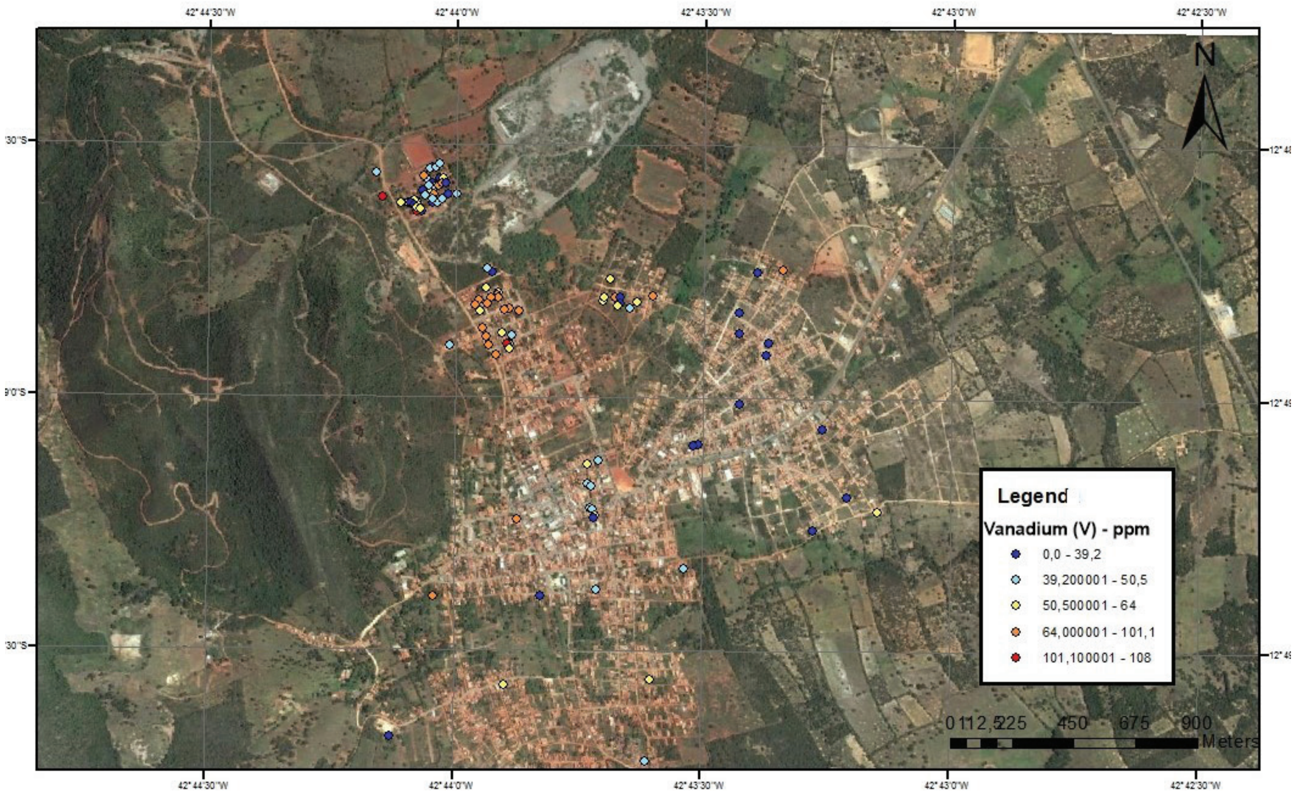

Figure 30: Distribution of V grades in indoors dust sampling stations.

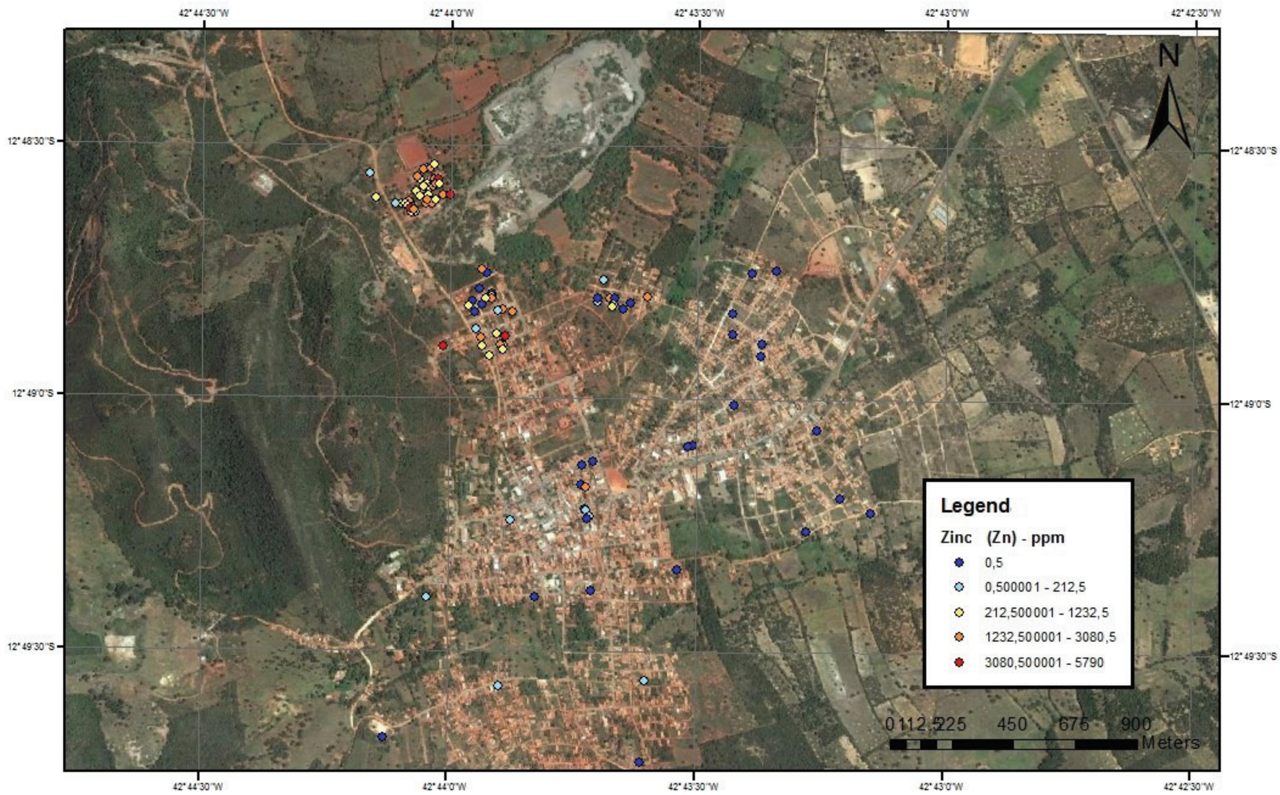

Figure 31: Distribution of Zn grades in indoors dust sampling stations.

CONCLUSIONS AND CONSIDERATIONS

The results obtained in this study indicate that the different materials samples collected, especially in the tailings basin and in the dust collected inside the residences, have considerable heavy metals levels, especially lead, which can be interpreted as a cause for concern due to the potential health risk of the population.

Results obtained in the study by Bertolino et al (2015) are also worrying. In these study was observed the occurrence of minerals such as lizardite, cummintonite and actinolite, with a morphology similar to asbestos fibers in the tailings basin material, which can result in a risk to the health of the population when subject to inhalation of such minerals.

However, it is necessary to detail the research, with bioavailability study, with speciation tests of metals considered hazardous to human health, in the material of the tailings basin and dust samples, as well as studies of the material of the tailings basin dispersions in relation to the nearest neighborhoods and the Boquira downtown, installing some equipment (large volume samplers) to determine the concentration of particulate matter in suspension and the chemical and physical characterization of this material, to assess the air quality in the city of Boquira.

These studies become important to support the assessment of the life quality of the Boquira's population, especially in relation to the health.

THANKS

The authors thank the city hall of Boquira and the residents whose opened their homes and allowed the collection of dust samples. We are also grateful to the class of geology course students of UFBA whose helped us in the stage of street sediments sampling.

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