AMERICAN UNIVERSITY OF ARMENIA
Center *for*
Responsible Mining

Results of Soil and Drinking-Water Testing in Kindergartens and Schools of Ararat City, Ararat Marz, Republic of Armenia

Prepared by

AUA Center for Responsible Mining

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ABBREVIATIONS

1A	OneArmenia
AUA	American University of Armenia
BL	Background level
CRM	Center for Responsible Mining
MAC	Maximum allowable concentration
OSCE	Organization for Security and Cooperation in Europe
SS	Soil Standard

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Finally, this report—first in a series of reports dedicated to 8 communities near mining or mineral processing facilities[1]—is funded by OneArmenia's crowdfunding campaign "Let's Protect Armenia from Toxic Pollution." Additional financial contributions were made by the UK Embassy Yerevan and a number of private donors.

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[1] Other communities included in the soil monitoring series include Axtala, Armanis and Aralverdi in the Lori Marz as well as Kapan, Kajaran, Agarak, and Syunik Village in the Syunik Marz.

[2] The OneArmenia crowdfunding closed in November 2014. OSCE-Yerevan donated equipment arrived May 2015.

OVERVIEW AND KEY FINDINGS

This report provides the results of independent soil and drinking water[3] monitoring for heavy-metal pollution in the kindergartens and schools of the City of Ararat (Ararat Marz, Republic of Armenia) performed by the American University of Armenia (AUA) Center for Responsible Mining (CRM). The City of Ararat has two main industrial facilities, the Ararat Gold Recovery Plant with its tailing pond and the Ararat Cement factory.

The soil monitoring in the City of Ararat was performed in October 2015 for 3 kindergartens, 4 primary schools and 1 secondary school.[4] A total of 2,347 children study in the kindergartens and schools studied. Permissions were obtained from authorized bodies to conduct the sampling and testing. This included permissions from the municipality of Ararat for kindergartens and the Marz government for primary and secondary schools.

The soil and water sampling and testing were conducted and documented according to protocols developed by the AUA Center for Responsible Mining based on international standards and guidance.[5] Total of 52 soil samples were collected from the playgrounds and exterior common spaces of Ararat's kindergartens and schools. The representative water sample was collected from the water tap in the School №2, located in the middle of the water distribution system of the city. The samples were brought to the AUA Center for Responsible Mining's laboratory. In soil samples the concentrations of total arsenic, copper, cadmium, mercury and lead were tested using Trace2o, Metalyser HM2000 Deluxe, Soils (see Annex 2 for Methodology of Soil Sampling and Testing). In water sample, the concentrations of total arsenic, arsenic (III), cadmium, copper, lead, mercury, zinc, manganese, aluminum, bor, chromium (VI), iron and nickel were tested using the portable heavy metals analysis system, with a combination of electrochemical and photometric instruments (Metalyser Deluxe HM2000 and Metalometer) from Trace2o Company (see Annex 3 for Methodology of Water Sampling and Testing).

The determination of background level (BL)[6] for each metal is given in Annex 6. Quality control of the results was carried out by conducting inter-laboratory comparisons (Annex 7). The comparison tests were conducted for 3 soil samples in the qualified laboratories of the RA Ministry of Nature Protection's Environmental Impact Monitoring Center SNCO and the RA Ministry of Health's National Center for Disease Control and Prevention SNCO. The comparison of soil test results with International Soil Standards is shown in Annex 8. Results for each individual kindergarten and school are presented in Annex 9.

Key Findings

With respect to drinking water, high levels of heavy metals in drinking water were not detected (Annex 5). This finding is not surprising as the drinking water for the Ararat community is supplied from the Garni Source, intake structure of which is located in the Garni Canyon (a distance of 36 km) and far from

[3] Irrigation water, which is supplied from artesian groundwater, was not available due to seasonal reasons when we made our site visits in October 2015. Also as the scope of the study was limited to kindergartens and schools, agricultural soil and water will have to be studied separately.

[4] No samples were taken from one Ararat high school as it was deemed that high-school students are less vulnerable to exposure to contaminated soil because of their height and less frequent outdoor playtime.

[5] Protocols used are available at http://crm.aua.am.

[6] The BLs for metals were determined based on preliminary study data that is not sufficient for establishing the exact BLs for each metal in soil of Ararat community. The determination of BL needs further deep investigation.

mineral processing or other industrial activities. Also, reportedly, the pipes distributing water are relatively new and, to the best of our knowledge, do not contain lead.

With respect to soil, our key finding for each of our 5 test metals are summarized in Figure 1 and described in text below.

Figure 1. Heavy metals concentrations in soil samples from Ararat's kindergartens and schools, % out of exceeding Armenian SS, statistical summary, and international comparatives.

		Arsenic		Cadmium		Copper		Lead		Mercury	
Armenian Soil Standard *(mg/kg)*		***2***		*******		***3***		***32***		***2.1***	
Kindergarten/ School	**No. of samples**	GM** mg/kg	*% of total*	GM mg/kg	*% of total*	GM mg/kg	*% of total*	GM mg/kg	*% of total*	GM mg/kg	*% of total*
Kindergarten №1	6	15.89	100%	0.37	-	19.25	100%	45.42	50%	1.62	0%
Kindergarten №2	6	15.49	100%	0.24	-	55.41	100%	49.59	83.3%	1.88	0%
Kindergarten №3	6	11.03	100%	0.29	-	27.34	100%	29.67	33.3%	1.40	0%
Primary school №1	4	14.84	100%	0.28	-	46.74	100%	35.31	50%	1.33	0%
Primary school №2	9	14.06	100%	0.32	-	58.32	100%	39.75	100%	1.42	0%
Primary school №3	8	12.02	100%	0.32	-	65.61	100%	52.05	100%	0.84	0%
Primary school №4	8	11.30	100%	0.33	-	42.13	100%	40.84	100%	1.15	0%
Secondary school №5	5	10.64	100%	0.28	-	52.64	100%	53.83	100%	1.36	20%
Total GM	***52***	***12.94***	***100%***	***0.31***	***-***	***44.08***	***100%***	***42.76***	***86.5%***	***1.31***	***1.92%***
Standard deviation	-	***3.18***	***-***	***0.17***	***-***	***22.42***	***-***	***13.83***	***-***	***0.47***	***-***
Minimum	-	***7.35***	***-***	***0.10***	***-***	***11.15***	***-***	***25.30***	***-***	***0.37***	***-***
Maximum	-	***23.94***	***-***	***0.82***	***-***	***103.40***	***-***	***96.57***	***-***	***2.37***	***-***
Background level***	***12***	***11.0***		***0.5***		***32.1***		***35.5***		***0.5***	
International maximum allowable concentrations (mg/kg)*****											
Russian		*2*		*-*		*3*		*30*		*2.1*	
Belgium		*110*		*6*		*400*		*700*		*15*	
Netherlands		*55*		*12*		*190*		*530*		*10*	
Germany		*50*		*20*		*-*		*400*		*20*	
France		*37*		*20*		*190*		*400*		*7*	
Sweden		*15*		*0.4*		*100*		*80*		*1*	
Norway		*2*		*3*		*100*		*60*		*1*	
Canada		*12*		*14*		*63*		*140*		*6.6*	
China		*30*		*0.3*		*50*		*250*		*0.3*	
US EPA screening level		*22*		*85*		*250*		*400*		*-*	

Notes:
(*) Armenian SS has not established a MAC for cadmium.
(**) Geometric mean (GM) is a type of average, which indicates the typical value of a set of numbers by using the product of their values (as opposed to the arithmetic mean which uses their sum).
(***) See Annex 6 for methodology for calculating background levels.
(****) See Annex 8 for percentage of soil samples exceeding international standards.

- **Arsenic** concentrations in our soil samples ranged from 7.35 to 23.94 mg/kg. The geometric means (GMs) of all samples exceeded the Armenian Soil Standard (SS)[7] by 6.5 times.

[7] The Armenian Soil Standards are specified in Order #01, issued by the Minister of Health of RA on 25.01.2010 on "Hygienic requirements N 2.1.7.003-10 establishing sanitary norms and rules for soil quality." It should be noted that there is yet another soil standard RA Government Decision # 92-N, 25.01.2005 on "Establishment of the assessment procedure of the economic activities impact on soil resources" but this regulation is neither implemented by the RA Ministry of Health nor RA Ministry of Nature Protection.

Armenian SS for arsenic, at 2 mg/kg of soil, is among the most stringent in the world (Figure 1). It matches that of Norway and Russia, the latter being the basis of the Armenian SS. Some of the samples also exceed standards set by Canada (12 mg/kg), Sweden (15 mg/kg), and United States EPA (22 mg/kg). Annex 8 details the percentage of soil samples exceeding these international standards.
Another critical factor to take into account is the background level of arsenic, that is, in areas that are either distant from sources of pollution and/or are deep enough underground to make it unlikely to have been impacted by industrial/mining activity. Our background level analysis (Annex 6) shows that the arsenic level is 11 mg/kg. Based on our current level of analysis, it is not possible for us to link the level of arsenic in soil to industrial and mineral processing activities in the city. Further analysis would have to be done to find or exclude causal link.

Our findings, however, compel us to conclude that arsenic is a heavy metal of concern in the Ararat community. While it may be reasonably argued that soil cannot be expected to be cleaner than background level, our recommendation is that kindergarten and school soil has to be kept to a higher standard. The playgrounds should be covered by surface materials (asphalt, concrete, rubber, etc.) that are "washable" (by rain or hosing down) and would minimize children's exposure to arsenic in soil.

In addition, we are compelled to raise the question about the currency and relevance of Armenian SS. There is need for national discussion to update the country's soil standard for arsenic.

- **Cadmium** concentrations in soil samples ranged from 0.10 to 0.82 mg/kg. As the Armenian SS does not specify allowable concentrations for cadmium, it is not possible to draw conclusions based on Armenian law.

  Many of our soil samples, however, had cadmium at levels exceeding standards set by China and Sweden, countries with most stringent standards internationally (Figure 1). Other comparatives we've studied have significantly higher allowable concentrations: Norway 3 mg/kg, Germany 20 mg/kg, and US EPA 85 mg/kg, to name a few. None of our samples had cadmium levels that exceeded the allowable limits set by these standards.

  Background level analysis for cadmium shows an average of 0.5 mg/kg, again higher than standards set by China and Sweden but lower than other international comparatives in Annex 8.

  These findings compel us to conclude that: a) Armenian SS for cadmium are in need of updating and b) if Armenia concludes that the Swedish and Chinese standards or even more stringent ones are the relevant ones for Armenia, then the solution for arsenic specified above—viz., covering playgrounds with materials that reduce children's to soil and dust with metals of concern—will also minimize exposure risk to cadmium.

- **Copper** concentrations ranged from 11.15 to 103.40 mg/kg. The Armenian SS for copper is 3 mg/kg. Hence, all soil samples exceeded Armenian SS for copper, with the mean for all samples 14.7 times of the Armenian SS.

  Armenia, along with Russia (on which Armenian standards are based), has the most stringent standards with respect to copper from our international comparatives (Figure 1). China (50 mg/kg) and Canada (63 mg/kg) are the next most stringent. Some of the soil samples from Ararat exceeded these standards as well.

Our analysis shows a background level of 32.10 mg/kg for copper in Ararat, about 10 times higher than Armenian SS. The maximum level of copper detected in our samples (viz., 103.40 mg/kg) is significantly higher than the background level. But evidence suggests that copper at these levels in soil may not pose a health risk for children.[8] We do, however, recommend that discussion on acceptable levels in the environment take place in Armenia as part of revising the Armenian SS.

- **Lead** levels in soil samples ranged from 25.30 to 96.57 mg/kg. The Armenian SS for lead is 32 mg/kg. This is among the most stringent standards among international comparatives presented in Figure 1.

  Notwithstanding, some of our soil samples exceed the Norwegian (60 mg/kg) and Swedish (80 mg/kg) standards.

  It should be noted that our analysis shows a background level for lead in Ararat is 35.50 mg/kg, slightly above Armenian SS. Additional research is needed to establish a causal relationship between the level of lead in soil and industrial and mineral processing activity in Ararat.

  These findings compel us to conclude that Armenian SS for lead are in need of evaluation and possible updating. Moreover, based on knowledge of international research on lead contamination in soil and background levels, the amounts detected in Ararat do not raise immediate alarm although lead is a toxic metal and needs to be monitored.

- **Mercury** levels in Ararat soil samples range from 0.37 to 2.37 mg/kg. Our analysis shows that the background level for mercury is 0.50 mg/kg.

  These amounts, for the most part, do not exceed the Armenian SS, which is set at 2.10 mg/kg. They do, however, exceed standards set by China (0.30 mg/kg). Also, almost all samples exceed standards set by Norway and Sweden (both 1 mg/kg). US EPA has not established an allowable level for mercury. Our comparative countries have soil standards ranging from 6.6 mg/kg in Canada to 20 mg/kg in Germany (Figure 1).

Recommendations

- Discuss findings with community leaders as well as school and kindergarten heads to determine effective action needed.
- Investigate irrigation water (artesian groundwater) pollution by heavy metals due to leaching from mining activity in the Ararat community.
- Apply this study method for other parts of Ararat city (park, yard, public place, playfield), whenever possible increasing the list of investigated metals, such as chromium, zinc, nickel, manganese, etc.
- Check the source and quality of a new soil to be brought to the playground of kindergartens and schools.
- Implement continuing soil monitoring every couple of years in Ararat community to monitor changes in soil contamination by heavy metals due to mining and other industrial activities.
- Establish a soil-quality database using this first study as a baseline.
- Initiate discussion at the national level to review and revise Armenia's soil standards, including the methodologies for determining these standards. Armenia should utilize global best-practice approaches when revising its standards.

[8] http://www.atsdr.cdc.gov/phs/phs.asp?id=204&tid=37#bookmark06 accessed April 22, 2016.

BACKGROUND ON ARARAT COMMUNITY

City of Ararat is located at 818m above sea level in Ararat Marz in the central part of Armenia (Figure 2). It is about 50 km southeast of the City of Yerevan and 20 km from the Ararat Marz capital, City of Artashat. Ararat city was established in the Ararat Plain in 1920. Due to rapid growth and gradual increase of the population after starting the operation of Ararat Cement factory (since 1927), Ararat was given the status of a city in 1962.

Figure 2. The location of Ararat city in Armenia

Climate and landscapes. The city is distinguished by extremely dry continental climate from the southeast to northwest movement of air masses. The average temperature is -4°C during the winter months, while during summer months the temperature reaches 24 to 26°C. The maximum temperature recorded in Ararat is 42°C and the minimum is -30°C. The annual atmospheric precipitation is 200-250mm. Natural landscapes are semi-desert transformed into cultural-irrigated landscapes using irrigation. From the agro-climatic point of view, the community is located in the absolute irrigation zone. The economy of the city relies on agriculture, such as wine production (Ararat wine factory), as well as growing of fruits and vegetables.

Population. As of the 2011 census, the permanent population of the city is 19,270 with 8,833 male and 10,437 female. The population in the age group 0-19 is 5,778 (Annex 1).

Industry. Ararat city is known as an industrial center. Its main productions are cement, lime and asbestos-cement items. There is the large cement factory ("Ararat Cement") established on the base of the local rich limestone mine, which industrial activity leads to significantly increase the dust in the air of Ararat city.[9] Other manufacturing enterprise in the city includes a building materials production plant.

In addition, located in close proximity to the cement factory is the Ararat Gold Recovery Plant (GeoProMining LTD), founded in the 1970s. The Plant extracts gold from the raw ore sent from the gold mine in Sotk, about 20 km east of Lake Sevan. Approximately 0.46g of gold is extracted from each ton of ore. The extraction process involves first pulverizing the raw material, and then filtering out the gold using a cyanide nitrate chemical process.[10] The soupy by-product of the cyanide nitrate chemical process is toxic, radioactive, and consists of several heavy metals, such as lead, arsenic, chromium, mercury, etc. This residue material (tailings) is collected in a tailing pond about 5 km from the facility (Photograph 1).

Photograph 1. The tailing pond of the Ararat gold processing facility

Source: https://en.wikipedia.org/wiki/Ararat,_Armenia

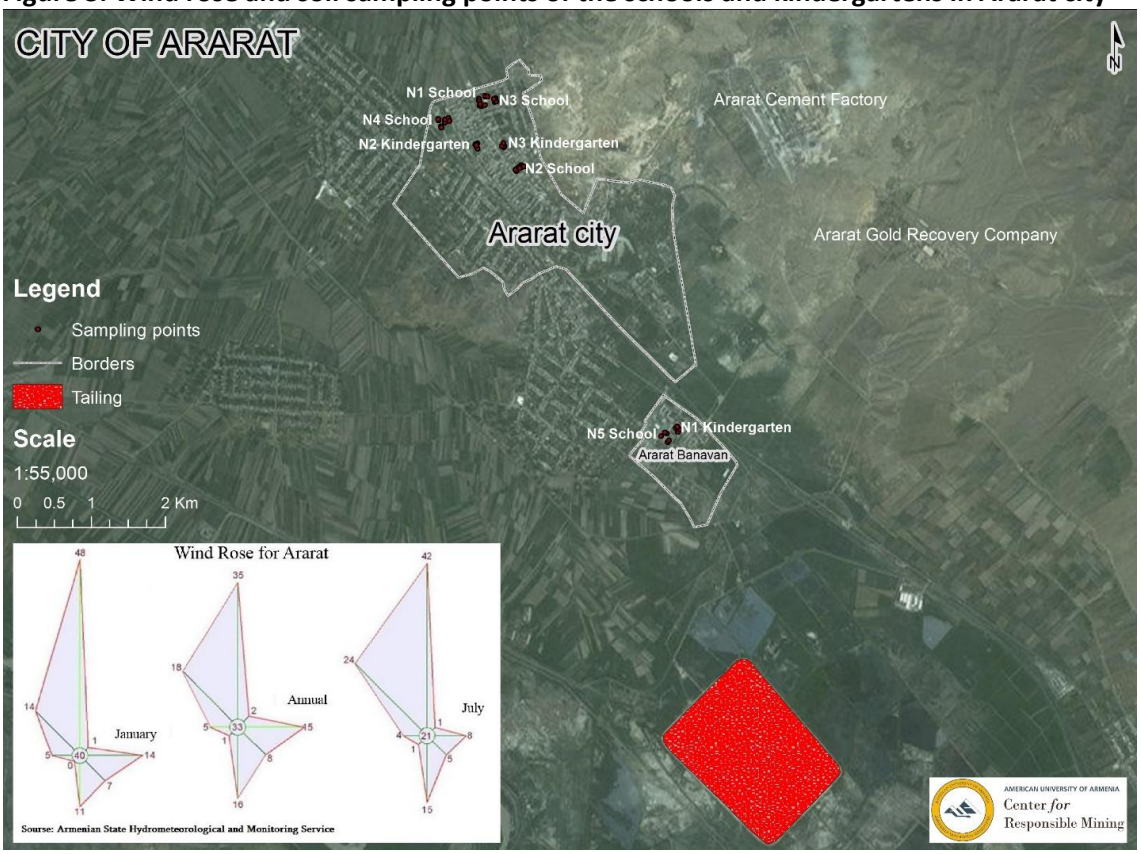
The designed volume of the Ararat Gold Recovery Plant's tailing pond is 12 million m^3, of which 10 million m^3 was already filled as of 2012.[11] The area of the tailing is 134ha with 19m of current height of the retaining walls (designed height is 17m). According to the inventory of toxic waste sites in Armenia conducted by AUA School of Public Health and the AUA Acopian Center for the Environment partnered with the Blacksmith Institute[12], the tailing pond is located next to Surenavan village and Ararat city. Surenavan, Yeraskh and Armash villages, as well as a part of Ararat city take irrigation water from Kakhanov canal (artesian groundwater), which is located adjacent to the tailing pond. Surface water, such as the Vedi River, which is the nearest to the Ararat community, flows north from the city, at a 7-10km distance from the mineral processing and tailing pond. Also, a private fish farm with an area of 584ha is located to the south of the tailing pond. The fish farm extracts its water from artesian wells.

[9] The dust exceeds the mid daily maximum allowable concentration (MAC) in air by 2.9-3.9 times according to annual reports of RA Ministry of Nature Protection's Environmental Impact Monitoring Center (see http://armmonitoring.am/).
[10] The information is provided by the GeoProMining LTD (see http://www.geopromining.com/).
[11] The only available data is provided by the Ministry of Emergency Situation in a letter response to inquiry by the Armenian Environmental Front (see http://www.armecofront.net/lrahos/vtangavor-pochambarner/).
[12] The inventory was a part of the Toxic Site Identification Program (TSIP) in Armenia that was led by the Blacksmith Institute and AUA School of Public Health. 2012.

Two Main Districts (Ararat and Ararat Banavan). Ararat city consist of two main districts: Ararat (main town) and Ararat Banavan. Ararat Banavan is located in the south-east part of the city, about 1.5-2km from the tailing pond (Figure 3).

Wind patterns. The RA Ministry of Emergency Situations' Armenian State Hydrometeorological and Monitoring SNCO prepares the wind rose for Ararat city based on long-term meteorological data. The wind rose indicates that the 35-48% of total winds over the year are in the south-east to north-west direction (Figure 3).

Figure 3. Wind rose and soil sampling points of the schools and kindergartens in Ararat city



Environmental issues of the community. Ararat community faces several environmental issues, such as air pollution according to monthly and annual reports[13] of RA Ministry of Nature Protection's Environmental Impact Monitoring Center SNCO, and environmental pollution and irrigation water shortage according to several reports[14] of Marz government. In addition, a number of NGOs, including the Ararat Aarhus Center[15] when interviewed for during our site visit, expressed their concerns about

[13]The reports are available at http://www.armmonitoring.am/
[14]The reports are available at http://ararat.mtaes.am/about-communities/82/ and http://ararat.mtaes.am/files/docs/11632.pdf
[15]The reports are available at http://aarhus.am/?page_id=498&lang=en

air, soil and water pollution in Ararat community, believing that such pollution has led to the increased health risks.

Based on the several media sources[16], there have been numerous incidents of animals dying near and around the areas of the gold processing plant. Also, during the 2003 to 2008 period, media reported at least 10 accidents at the same plant, some of which have resulted in the discharge of the cyanide soup into neighboring agricultural lands and fisheries, killing off cows and fish stock.[17]

[16]Media sources are available at http://www.ecolur.org/en/news/mining/ararat-gold-fever-and-health-disease/67/ http://armenianow.com/special_issues/ecology/6361/dirt_poor_ararat_residents_face_ch http://hetq.am/arm/print/4953/

[17]The source is available at http://hetq.am/eng/news/40198/behind-golds-luster-lie-lands-torn-asunder-and-urgent-questions.html

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ANNEXES

Annex 1. Population of Ararat city by age and sex

Age	Total	Male	Female
0-4	1635	822	813
5-9	1436	730	706
10-14	1373	696	677
15-19	1334	658	676
20-24	1931	887	1044
25-29	1848	793	1055
30-34	1654	737	917
35-39	1230	613	617
40-44	1091	475	616
45-49	1136	489	647
50-54	1331	543	788
55-59	1049	445	604
60-64	730	335	395
65-69	389	171	218
70-74	525	209	316
75-79	303	132	171
80-84	199	74	125
85+	76	24	52
Total	***19270***	***8833***	***10437***

Source: Population Census 2011 for Armenia, National Statistic Service of the Republic of Armenia, http://armstat.am/file/doc/99492633.pdf

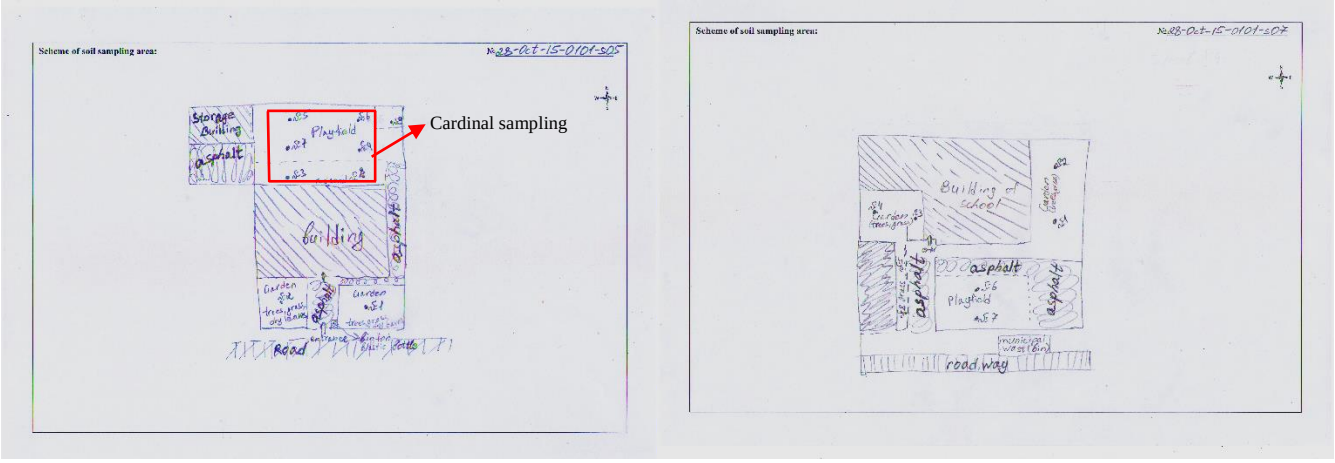
Annex 2. Methodology on Soil Sampling and Testing

The methodology on soil sampling and testing for Ararat community based on the appropriate standard protocols and forms developed by the AUA Center for Responsible Mining based on international standards and guidance[18], in particular, ISO 17025, ISO 5667, ISO 10381, EPA IWRG 701-2009, EPA 540-R-01-00.

Sampling. The soil monitoring in Ararat community was implemented during October 2015. Total of 64 soil samples were collected from 3 kindergartens and 5 schools, as well as 4 reference sampling points for determination of metals' Background Levels. The soil sampling was done according to ISO 10381 and the requirements of the developed protocols and forms.

The number of soil samples, collected from each school/kindergarten, was determined by the size of sampling site: the minimum 4 samples and average 6 samples for each school/kindergarten. Prior to starting the fieldwork, a baseline location of sites to be used for the collection of soil samples was established. The leaves, grasses, branches, garbage or other items were removed from sampling point before taking the sample from 5cm depth. The scheme of sampling site and locations of sampling points was drawn in the appropriate protocol/form (Figure 10). The sampling for BLs determination is given in Annex 6.

Figure 10. The examples of schemes for soil sampling area in schools/kindergartens



The cardinal sampling layout as shown in Figure 10 was used for collecting the soil samples from large sampling sites, such as playfields and gardens. These sampling locations were spaced approximately 5-10 m apart. The soil temperature was measured for each sampling point *in situ*.

All collected soil samples were labeled and transported to the laboratory in the special cooler box (under the <6^{o}C condition) for the further test. In the laboratory, the soil samples were stored in the refrigerator, for no more than six months.

Testing. The concentrations of arsenic, cadmium, copper, lead and mercury in the soil samples were measured with the Metalyser Deluxe HM2000 portable heavy metals analyzer from Trace2o Company,

[18] Protocols used are available at http://crm.aua.am.

based on Anodic Stripping Voltammetry method, in the AUA Center for Responsible Mining's laboratory. Before starting the measurements, the soil samples were dried in the oven at 100^{o}C, for an hour. Then, the soil sample was dissolved into the deionized water with digestion. The prepared solution should be left 5 min for extraction of metals from soil to water. After, the solution is filtered and the 3.5ml filtrate, as well as appropriate buffer solution, added in the 60ml deionized water, then the prepared solution was measured by the device.

Low concentration measurements. The Metalyser Deluxe HM2000 device that used for soil tests has a limitation for detecting low concentrations of metals. The Limit of Detection (LOD) for each metals given in the Figure 11 below.

Figure 11. The LOD's range for each metal.

Metal	LOD's range (mg/kg)
Arsenic	10-500
Cadmium	5-500
Lead	5-500
Copper	10-500
Mercury	5-500

The measurements were performed by using the single-point standard addition method. A problem with LOD was resolved by manual calculation (eq. 1), where sample and standard peak heights were obtained from "Metaware" software.

$$Cu = \frac{IuVsCs}{IsVs+(Is-Iu)Vu} \qquad \text{(eq. 1)}$$

Iu = sample peak height,
Is = standard addition peak height,
Vs = volume of standard solution added,
Vu = volume of original sample,
Cs= concentration of standard solution,
Cu= concentration of original sample.

Annex 3. Methodology on Water Sampling and Testing

The methodology for drinking water sampling and testing is based on the appropriate standard protocols and forms[19] developed by the AUA Center for Responsible Mining based on international standards and guidance, in particular, ISO 17025, ISO 5667, EPA IWRG 701-2009, EPA 540-R-01-00. For details see crm.aua.am.

Sampling. The drinking water sample in the City of Ararat was collected in October 2015. The representative water sample was collected from the water tap in the School №2 in Ararat city (Figure 12). The water sampling point was located in the middle of water distribution system and represented the content of supplied water for the whole city. The water sampling was done according to ISO 5667 and the requirements of the developed protocols and forms.

Figure 12. Water sampling point location

The collected water sample was labeled and transported to the laboratory in the special cooler box (under the <6°C) for the further test. In the laboratory, the water sample was stored in the refrigerator for no more than a day.

Testing. The concentrations of total arsenic, arsenic (III), cadmium, copper, lead, mercury, zinc, manganese, aluminum, bor, chromium (VI), iron and nickel in the water sample were measured using the Metalyser Deluxe HM2000 and Metalometer portable heavy metals analyzer system from Trace2o Company, based on electrochemical and photometric methods, in the AUA Center for Responsible Mining's laboratory.

Total arsenic, arsenic (III), cadmium, lead, mercury and zinc were not detected by Anodic Stripping Voltammetry method due to high interferences in the water sample during the measurement. Copper, manganese, aluminum, bor, chromium (VI), iron and nickel in the water sample were detected only by Photometric method. Water sample preparation for the photometric test was performed with the appropriate buffers and reagents.

[19] Protocols used are available at http://crm.aua.am.

Annex 4. Soil Independent Monitoring Data

Kindergarten №1

Sampling point №	Arsenic (As), mg/kg	Cadmium (Cd), mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s01-01	17.58	0.82	38.38	50.68	2.18
28-Oct-15-0101-s01-02	13.79	0.23	17.18	32.64	1.57
28-Oct-15-0101-s01-03	11.08	0.22	36.09	32.26	1.46
28-Oct-15-0101-s01-04	14.79	0.52	13.72	64.87	1,16
28-Oct-15-0101-s01-05	16.92	0.28	13.99	32.59	1.57
28-Oct-15-0101-s01-06	23.94	0.43	11.15	77.85	1.43
Geometric mean	**15.89**	**0.37**	**19.25**	**45.42**	**1.62**

Kindergarten №2

Sampling point №	Arsenic (As), mg/kg	Cadmium (Cd), mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s02-01	15.09	0.30	58.81	96.57	1.84
28-Oct-15-0101-s02-02	15.84	0.57	49.24	66.34	1.84
28-Oct-15-0101-s02-03	19.93	0.10	76.31	35.60	1.75
28-Oct-15-0101-s02-04	19.30	0.53	103.40	52.12	1.85
28-Oct-15-0101-s02-05	11.49	0.19	40.70	38.80	1.99
28-Oct-15-0101-s02-06	13.10	0.10	31.12	32.25	2.04
Geometric mean	**15.49**	**0.24**	**55.41**	**49.59**	**1.88**

Kindergarten №3

Sampling point №	Arsenic (As), mg/kg	Cadmium (Cd), mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s03-01	11.37	0.33	21.25	27.12	1.18
28-Oct-15-0101-s03-02	9.73	0.50	24.64	25.30	1.84
28-Oct-15-0101-s03-03	12.07	0.30	26.40	35.04	1.30
28-Oct-15-0101-s03-04	10.31	0.20	29.12	29.02	2.00
28-Oct-15-0101-s03-05	12.08	0.29	26.15	34.35	1.02
28-Oct-15-0101-s03-06	10.80	0.22	39.70	28.49	1.28
Geometric mean	**11.03**	**0.29**	**27.34**	**29.67**	**1.40**

School №1

Sampling point №	Arsenic (As) mg/kg	Cadmium (Cd) mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s04-01	18.79	0.29	37.75	31.02	1.38
28-Oct-15-0101-s04-02	12.10	0.35	58.34	36.18	0.84
28-Oct-15-0101-s04-03	18.77	0.52	41.77	29.97	1.99
28-Oct-15-0101-s04-04	11.35	0.12	51.90	46.20	1.36
Geometric mean	**14.84**	**0.28**	**46.74**	**35.31**	**1.33**

School №2

Sampling point №	Arsenic (As) mg/kg	Cadmium (Cd) mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s05-01	15.75	0.27	98.03	35.20	1.05
28-Oct-15-0101-s05-02	13.41	0.26	43.71	33.29	1.40
28-Oct-15-0101-s05-03	13.36	0.17	27.97	41.69	1.24
28-Oct-15-0101-s05-04	14.58	0.31	76.00	38.72	1.64
28-Oct-15-0101-s05-05	16.97	0.40	71.52	49.28	2.15
28-Oct-15-0101-s05-06	14.53	0.25	52.32	40.70	1.69
28-Oct-15-0101-s05-07	14.65	0.39	61.86	37.09	1.25
28-Oct-15-0101-s05-08	12.50	0.35	81.83	36.11	1.43
28-Oct-15-0101-s05-09	11.58	0.69	45.24	48.79	1.23
Geometric mean	**14.06**	**0.32**	**58.32**	**39.75**	**1.42**

School №3

Sampling point №	Arsenic (As) mg/kg	Cadmium (Cd) mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s06-01	10.99	0.29	81.95	49.05	1.04
28-Oct-15-0101-s06-02	8.71	0.37	62.07	50.80	1.55
28-Oct-15-0101-s06-03	14.41	0.38	63.69	50.65	1.09
28-Oct-15-0101-s06-04	12.67	0.34	56.16	43.34	1.08
28-Oct-15-0101-s06-05	12.39	0.54	86.02	58.56	1.02
28-Oct-15-0101-s06-06	13.59	0.23	51.76	43.44	0.64
28-Oct-15-0101-s06-07	12.76	0.34	55.43	65.56	0.56
28-Oct-15-0101-s06-08	11.62	0.20	76.49	59.03	0.37
Geometric mean	**12.02**	**0.32**	**65.61**	**52.05**	**0.84**

School №4

Sampling point №	Arsenic (As) mg/kg	Cadmium (Cd) mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s07-01	11.41	0.41	67.31	42.02	0.84
28-Oct-15-0101-s07-02	12.48	0.19	41.88	41.41	1.35
28-Oct-15-0101-s07-03	10.53	0.23	43.98	36.07	1.28
28-Oct-15-0101-s07-04	10.72	0.15	66.80	37.17	1.34
28-Oct-15-0101-s07-05	9.80	0.78	11.96	43.79	0.85
28-Oct-15-0101-s07-06	11.14	0.59	29.96	45.28	1.29
28-Oct-15-0101-s07-07	10.35	0.62	46.73	42.75	0.97
28-Oct-15-0101-s07-08	14.57	0.20	71.64	39.16	1.50
Geometric mean	**11.30**	**0.33**	**42.13**	**40.84**	**1.15**

School №5

Sampling point №	Arsenic (As) mg/kg	Cadmium (Cd) mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg
28-Oct-15-0101-s08-01	10.04	0.37	57.67	40.44	1.33
28-Oct-15-0101-s08-02	12.20	0.27	46.95	65.80	2.37
28-Oct-15-0101-s08-03	9.76	0.20	35.40	59.84	1.12
28-Oct-15-0101-s08-04	15.54	0.18	54.75	52.11	1.32
28-Oct-15-0101-s08-05	7.35	0.50	77.03	54.47	0.98
Geometric mean	**10.64**	**0.28**	**52.64**	**53.83**	**1.36**

Annex 5. Drinking Water Monitoring Data

Metals	Measurement results, mg/l	Armenian Drinking Water Standard,[20] mg/l
Aluminum	<0.01	0.5
Bor	0.3	0.5
Chromium (VI)	0.02	0.05
Iron	0.02	0.3
Nickel	<0.1	0.1
Copper	<0.05	1.0
Manganese	<0.1	0.1

Note: Concentrations of total arsenic, arsenic (III), cadmium, mercury, zinc and lead were not detected due to high interferences during the measurements.

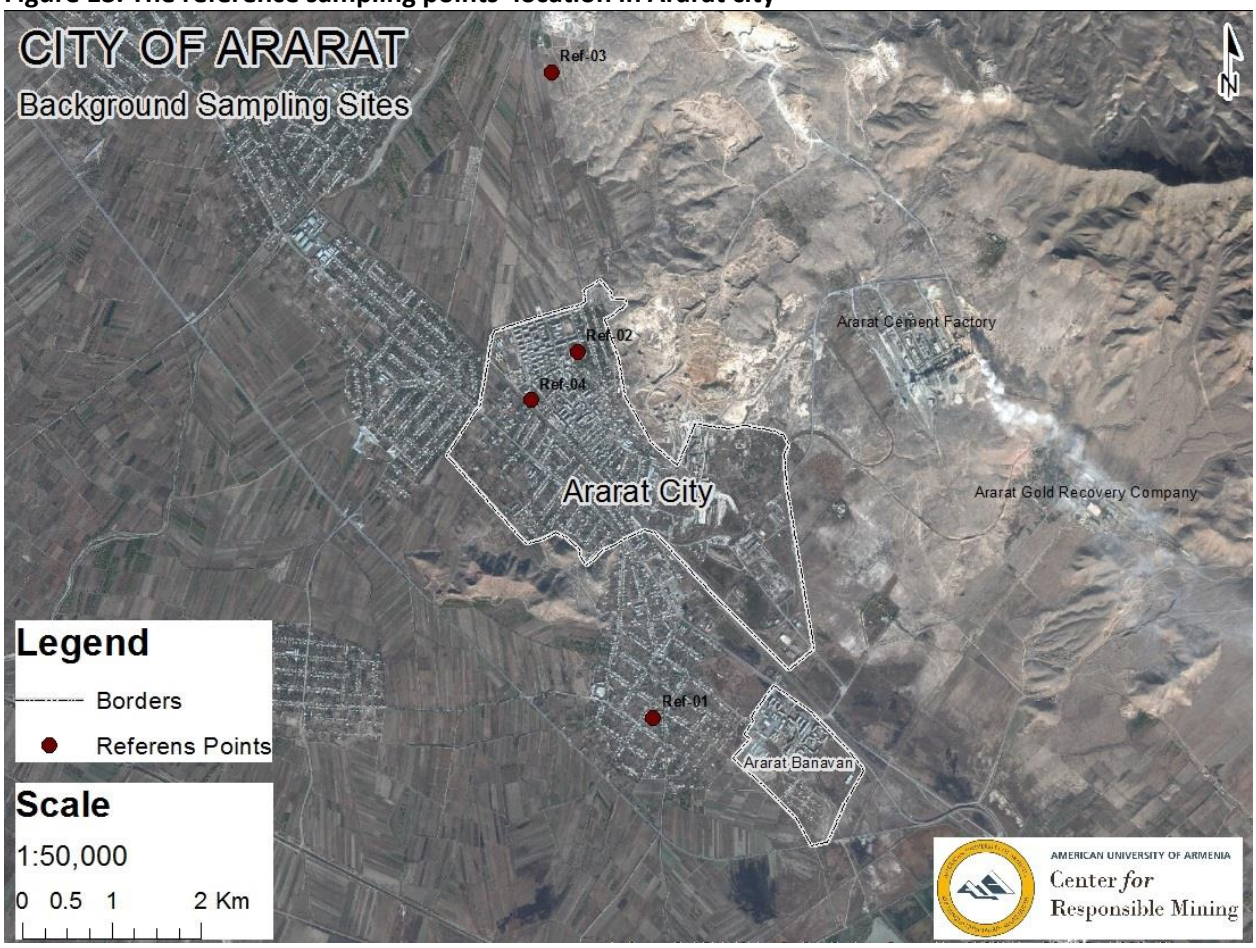
[20]The Armenian Drinking Water Standards are specified in Order # 876, issued by the Minister of Health of RA on 25.12.2002 on "Drinking Water: Hygienic requirements for water quality supplied by centralized systems and establishing sanitary norms and rules for water quality control N 2-III-A 2-1".

Annex 6. Determination of Background Levels of Metals in Soil of Ararat City

The determination of background level for each metal in soil in Ararat community was conducted by horizontal and distance sampling, based on requirements of the Protocol for Determining Background Levels of Metals in Soil developed by the AUA Center for Responsible Mining based on international standards and guidance.[21] Onsite background reference areas were selected by horizontal sampling at depth 5cm, 10cm and 20cm, as well as an offsite reference area for distance sampling was defined from about 2km out of the city.

Totally 12 reference samples were taken from the sites that were located in the Saint Hakob Church of Ararat (0101-sRef-01), the Ararat City Park (0101-sRef-02), the yard of the Medical Center of Ararat (0101-sRef-04) and 2km out and north of the city (0101-sRef-03) (Figure 13).

Figure 13. The reference sampling points' location in Ararat city



The BL was calculated for each metal based on the results of the non-parametric statistical analyses (Figure 14). The calculated BL is the concentration value against which site concentration data are compared to determine whether the data represent site contamination. Sample concentrations greater

[21] Protocols used are available at http://crm.aua.am.

than the maximum BL are categorized as likely site contamination, whereas sample concentrations less than or equal to the maximum background levels are categorized as ambient conditions.

Figure 14. The calculation of heavy metals' Background levels in soil of Ararat city

Number of sampling point	Metals, mg/kg				
	Arsenic	Cadmium	Copper	Lead	Mercury
Armenian SS	***2***	***-***	***3***	***32***	***2.1***
0101-sRef-01(5cm)	19.19	1.01	89.6	67.66	0.51
0101-sRef-01(10cm)	11.49	0.73	68.29	49.89	0.44
0101-sRef-01(20cm)	10.50	0.36	17.42	48.57	0.34
0101-sRef-02 (5cm)	24.05	0.46	31.67	56.38	1.49
0101-sRef-02 (10cm)	13.99	0.58	29.79	32.57	0.96
0101-sRef-02 (20cm)	13.24	0.42	30.12	24.68	0.50
0101-sRef-03 (5cm)	17.25	0.33	41.94	41.00	0.80
0101-sRef-03 (10cm)	9.05	0.34	22.78	30.93	0.53
0101-sRef-03 (20cm)	11.11	0.32	21.03	36.37	0.51
0101-sRef-04 (5cm)	13.13	0.43	34.14	38.17	0.41
0101-sRef-04 (10cm)	10.47	0.47	11.94	33.68	0.37
0101-sRef-04 (20cm)	8.25	0.38	12.23	26.40	0.25
Number of Samples*	8	8	8	8	8
Arithmetic mean	11.01	0.45	26.70	35.39	0.49
Median	10.81	0.40	21.91	33.13	0.47
Standard deviation	1.93	0.14	18.17	9.34	0.21
Minimum	8.25	0.32	11.94	24.68	0.25
Maximum	13.99	0.73	68.29	49.89	0.96
Lower band	10.1	0.4	23.3	31.5	0.4
Upper band	11.9	0.5	41.0	39.4	0.7
Background Level	***11.0***	***0.5***	***32.1***	***35.5***	***0.5***

*Included the data only for 10cm and 20cm depth.

Annex 7. Inter-laboratory Comparison Tests Results

The inter-laboratory comparison tests were performed for assuring the quality of test and calibration results for the AUA Center for Responsible Mining's laboratory. The comparison tests were conducted for 3 soil samples in the qualified laboratories of RA Ministry of Nature Protection's Environmental Impact Monitoring Center (EIMC) SNCO and RA Ministry of Health's National Center for Disease Control and Prevention (NCDCP) SNCO.

The soil samples for comparison tests were selected according to following principles:

- One sample with low or high concentrations of the measured parameters,
- Arbitrary selection,
- One reference sample.

Determination of metals in the soil samples was performed by ICP-Mass Spectrometric Method (by Perkin Elmer MS device) in the EIMC's laboratory and by Atomic Adsorption Spectrometric Method (by Agilent AAS device) in the NCDC's laboratory. Determination of mercury in both laboratories was conducted by Mercury Atomic Adsorption Analyzer. The data is provided in the Figure 15 below.

Figure 15. The inter-laboratories tests results

Name of Laboratory	Metals, mg/kg				
	Arsenic	Cadmium	Lead	Copper	Mercury
Armenian Soil Standards	***2***	***-***	***32***	***3***	***2.1***
Background Levels	***11.0***	***0.5***	***35.5***	***32.1***	***0.5***
	0101-sRef-01(20cm)				
AUA CRM	10.5	0.36	17.42	48.57	0.34
EIMC	8.59	0.253	17.35	55.88	0.35
NCDCP	5.0	n.d.*	27.0	42.05	0.20
	Sampling point 28-Oct-15-0101-s01-02				
AUA CRM	13.79	0.225	32.64	17.18	1.57
EIMC	15.43	0.265	29.81	34.81	0.05
	Sampling point 28-Oct-15-0101-s04-03				
AUA CRM	18.77	0.52	41.77	29.97	1.99
NCDCP	7.5	n.d.*	31.0	38.5	0.15

(*) n.d. stands for not detected

Annex 8. Measurements Exceeding the Armenian and International Soil Standard (SS)[22]

Figure 16. Arsenic Measurements

School/ kindergarten	Total number of tests	% of tests exceeding SS and US EPA screening level for As										
		Armenia	Russia	Belgium	Netherlands	Germany	France	Sweden	Norway	Canada	China	US EPA
Soil Standard (mg/kg)		***2***	***2***	***110***	***55***	***50***	***37***	***15***	***2***	***12***	***30***	***22***
Kindergarten №1	6	100%	100%	0	0	0	0	50%	100%	83.3%	0	16.7%
Kindergarten №2	6	100%	100%	0	0	0	0	50%	100%	83.3%	0	0
Kindergarten №3	6	100%	100%	0	0	0	0	0	100%	0	0	0
Primary school №1	4	100%	100%	0	0	0	0	50%	100%	50%	0	0
Primary school №2	9	100%	100%	0	0	0	0	22.2%	100%	88.9%	0	0
Primary school №3	8	100%	100%	0	0	0	0	0	100%	62.5%	0	0
Primary school №4	8	100%	100%	0	0	0	0	0	100%	25%	0	0
Secondary school №5	5	100%	100%	0	0	0	0	20%	100%	20%	0	0

Figure 17. Cadmium Measurements

School/ kindergarten	Total number of tests	% of tests exceeding SS and US EPA screening level for Cd										
		Armenia	Russia	Belgium	Netherlands	Germany	France	Sweden	Norway	Canada	China	US EPA
Soil Standard (mg/kg)		*******	*******	***6***	***12***	***20***	***20***	***0.4***	***3***	***14***	***0.3***	***85***
Kindergarten №1	6	-	-	0	0	0	0	33.3%	0	0	50%	0
Kindergarten №2	6	-	-	0	0	0	0	33.3%	0	0	33.3%	0
Kindergarten №3	6	-	-	0	0	0	0	16.7%	0	0	33.3%	0
Primary school №1	4	-	-	0	0	0	0	25%	0	0	50%	0
Primary school №2	9	-	-	0	0	0	0	11.1%	0	0	44.4%	0
Primary school №3	8	-	-	0	0	0	0	12.5%	0	0	62.5%	0
Primary school №4	8	-	-	0	0	0	0	37.5%	0	0	50%	0
Secondary school №5	5	-	-	0	0	0	0	20%	0	0	40%	0

(*) Soil standard has not established.

Figure 18. Copper Measurements

School/ kindergarten	Total number of tests	% of tests exceeding SS and US EPA screening level for Cu										
		Armenia	Russia	Belgium	Netherlands	Germany	France	Sweden	Norway	Canada	China	US EPA
Soil Standard (mg/kg)		***3***	***3***	***400***	***190***	***N.A.***	***190***	***100***	***100***	***63***	***50***	***250***
Kindergarten №1	6	100%	100%	0	0	-	0	0	0	0	0	0
Kindergarten №2	6	100%	100%	0	0	-	0	0	0	33.3%	50%	0
Kindergarten №3	6	100%	100%	0	0	-	0	0	0	0	0	0
Primary school №1	4	100%	100%	0	0	-	0	0	0	0	25%	0
Primary school №2	9	100%	100%	0	0	-	0	0	0	44.4%	55.6%	0
Primary school №3	8	100%	100%	0	0	-	0	0	0	37.5%	87.5%	0
Primary school №4	8	100%	100%	0	0	-	0	0	0	37.5%	37.5%	0
Secondary school №5	5	100%	100%	0	0	-	0	0	0	20%	60%	0

[22]The references to international soil standards and US EPA soil screening levels of metals are given in Bibliography section.

Figure 19. Lead Measurements

School/ kindergarten	Total number of tests	% of tests exceeding SS and US EPA screening level for Pb										
		Armenia	Russia	Belgium	Netherlands	Germany	France	Sweden	Norway	Canada	China	US EPA
Soil Standard (mg/kg)		***32***	***30***	***700***	***530***	***400***	***400***	***80***	***60***	***140***	***250***	***400***
Kindergarten №1	6	50%	100%	0	0	0	0	0	33.3%	0	0	0
Kindergarten №2	6	83.3%	100%	0	0	0	0	12.5%	33.3%	0	0	0
Kindergarten №3	6	33.3%	33.3%	0	0	0	0	0	0	0	0	0
Primary school №1	4	50%	75%	0	0	0	0	0	0	0	0	0
Primary school №2	9	100%	100%	0	0	0	0	0	0	0	0	0
Primary school №3	8	100%	100%	0	0	0	0	0	12.5%	0	0	0
Primary school №4	8	100%	100%	0	0	0	0	0	0	0	0	0
Secondary school №5	5	100%	100%	0	0	0	0	0	20%	0	0	0

Figure 20. Mercury Measurements

School/ kindergarten	Total number of tests	% of tests exceeding SS and US EPA screening level for Hg										
		Armenia	Russia	Belgium	Netherlands	Germany	France	Sweden	Norway	Canada	China	US EPA
Soil Standard (mg/kg)		***2.1***	***2.1***	***15***	***10***	***20***	***7***	***1***	***1***	***6.6***	***0.3***	*****
Kindergarten №1	6	0	0	0	0	0	0	100%	100%	0	100%	-
Kindergarten №2	6	0	0	0	0	0	0	100%	100%	0	100%	-
Kindergarten №3	6	0	0	0	0	0	0	100%	100%	0	100%	-
Primary school №1	4	0	0	0	0	0	0	100%	100%	0	100%	-
Primary school №2	9	0	0	0	0	0	0	100%	100%	0	100%	-
Primary school №3	8	0	0	0	0	0	0	100%	100%	0	100%	-
Primary school №4	8	0	0	0	0	0	0	100%	100%	0	100%	-
Secondary school №5	5	20%	20%	0	0	0	0	100%	100%	0	100%	-

Annex 9. Soil Test Results for Each Kindergarten and School

Kindergarten №1

The Kindergarten №1 is located in the Ararat Banavan (Zod), south of Ararat city. Totally 170 children attend this kindergarten. The kindergarten is the nearest to the Ararat Gold Recovery Plant's tailing dump, the distance is about 2.5 km.

The soil monitoring for Kindergarten №1 was conducted for the soil-covered area that belongs to the kindergarten and separated by a fence (Figure 21a). Totally 6 soil samples were collected that shown in Figures 21b, 22a and 22b. The soil testing results are presented in Annex 3.

Figure 21. The Kindergarten №1 (a) main view and (b) soil sampling points' location

(a) (b)

Figure 22. The Kindergarten №1 (a) playfield and (b) entrance

(a) (b)

The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 5.5-12.0 and 3.7-12.8 times, accordingly. The concentrations of lead exceeded the Armenian SS by 1.6-2.4 times in a few soil samples that were taken from the south and north corners of the kindergartens, next to roads and the main and second entrances. The concentrations of cadmium exceeded China's SS by 1.4-2.7 times in 50% (3/6) of the soil samples. China has the most stringent cadmium MAC known to us. The concentrations of mercury didn't exceed the Armenian SS.[23]

Kindergarten №2

The Kindergarten №2 is located in the north of Ararat city. Totally 120 children attend this kindergarten. The distance from the kindergarten to the Ararat Gold Recovery Plant's tailing dump is about 6 km.

The soil monitoring for Kindergarten №2 was conducted for the soil-covered area that belongs to the kindergarten and separated by a fence (Figure 23a). Totally 6 soil samples were collected that shown in Figure 23b and 24.

Figure 23. The Kindergarten №2 (a) main view and (b) soil sampling points' location

(a) (b)

Arsenic, lead and copper exceeded the Armenian SS by 5.7-10.0 times, 1.1-3.0 times and 10.4-34.5 times, accordingly, in all soil samples taken from the entire area of the Kindergarten №2. The concentrations of cadmium exceeded China's SS by 1.8-1.9 times in 33.3% (2/6) of the soil samples. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS and equally distributed in the soil of the whole kindergarten.[24]

[23]Arsenic and mercury exceeded the BLs by 1.3-2.2 times and 2.3-4.4 times, accordingly. The BLs for cadmium, copper and lead were exceeded in a few cases by 1.2-2.2 times.

[24]Arsenic, copper and mercury exceeded the BLs by 1.2-1.8 times, 1.3-3.2 times and 3.7-4.1 times, accordingly. Lead exceeded the BL by 1.5-2.7 times in a few cases. Cadmium didn't exceeded BL.

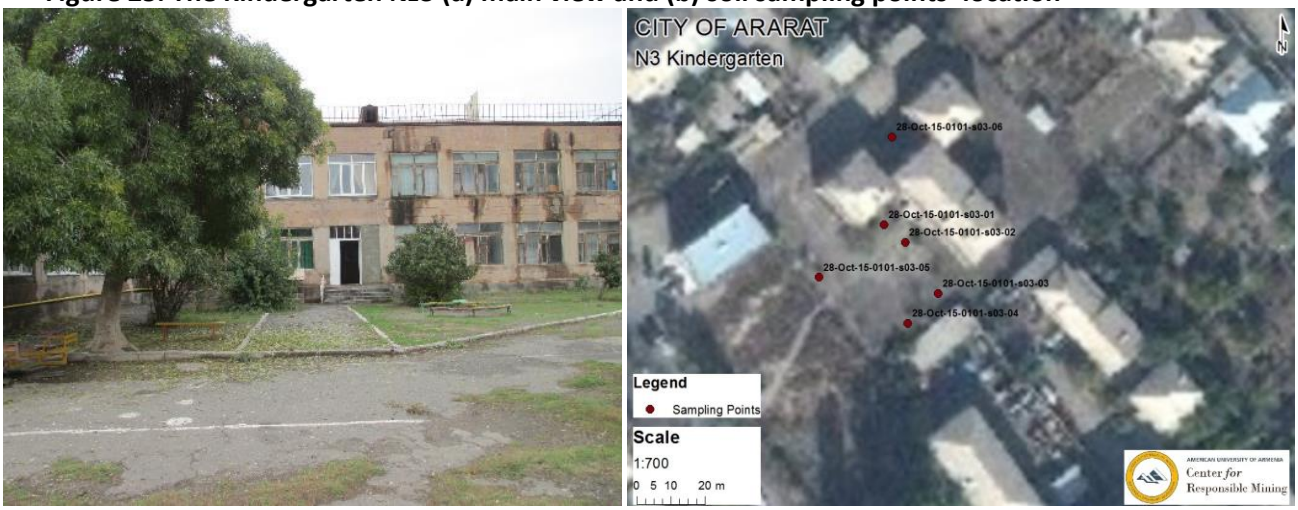
Figure 24. The playfield of the Kindergarten №2

Kindergarten №3

The Kindergarten №3 is located in the north of Ararat city. Totally 120 children attend this kindergarten. The distance from the kindergarten to the Ararat Gold Recovery Plant's tailing dump is about 5.9 km.

The soil monitoring for Kindergarten №3 was conducted for the soil-covered area that belongs to the kindergarten and separated by a fence (Figure 25a). About half ground of the kindergarten is covered by asphalt. Totally 6 soil samples were collected from a soil-covered area that shown in Figure 25b.

Figure 25. The Kindergarten №3 (a) main view and (b) soil sampling points' location



(a) (b)

Arsenic and copper exceeded the Armenian SS by 4.9-6.0 times and 7.1-13.2 times, accordingly, in all soil samples taken from entire area of the Kindergarten №3. The concentrations of lead and mercury didn't

exceed the appropriate Armenian SS. The concentrations of cadmium exceeded China's SS by 1.1-1.7 times in 33.3% (2/6) of the soil samples. China has the most stringent cadmium MAC known to us.[25]

School №1

The Primary School №1, after Zhores Mkrtchyan is located in the north of Ararat city. Totally 349 children attend this school. The distance from the school to the Ararat Gold Recovery Plant's tailing dump is about 6.4 km.

Figure 26. The entrance of the School №1

The soil monitoring for School №1 was conducted for the soil-covered area, particularly garden and flowerbeds of the school. The football field of the School №1 is shared between School №3, so the soil monitoring results for the football field was done in the section for the School №3. Another part of the ground that belongs to the School №1 is covered by asphalt (Figure 26 and 27b). Totally 4 soil samples were collected from the soil-covered ground of the School №1, which locations are shown on Figure 27a.

Arsenic and copper exceeded the Armenian SS by 5.7-9.4 times and 12.6-19.4 times, accordingly, in all soil samples taken from the entire area of the School №1. The concentrations of lead were near the Armenian SS and in one sample exceeded it by 1.4 times. Mercury didn't exceed the Armenian SS. The concentrations of cadmium exceeded China's SS by 1.2-1.7 times in 50% (2/4) of the soil samples. China has the most stringent cadmium MAC known to us.[26]

[25]Mercury exceeded the background level (BL) by 2-4 times, as well as arsenic, copper, cadmium and lead didn't exceed the appropriate BLs.

[26]The BLs were exceeded for mercury by 1.7-3.9 times and for arsenic by 1.1-1.7 times, accordingly. Copper, cadmium and lead didn't exceed the BLs.

Figure 27. The School №1 (a) soil sampling points' location and (b) large flower-bed

(a)

(b)

School №2

The Primary School №2, after Paruyr Sevak is located in the north of Ararat city (Figure 28a). Totally 438 children attend this school. The distance from the school to the Ararat Gold Recovery Plant's tailing dump is about 5.6 km.

The soil monitoring for School №2 was conducted for the soil-covered area, particularly garden and football field of the school. Totally 9 soil samples were collected that shown in Figure 28b and 29.

Figure 28. The School №2 (a) main entrance and (b) soil sampling points' location

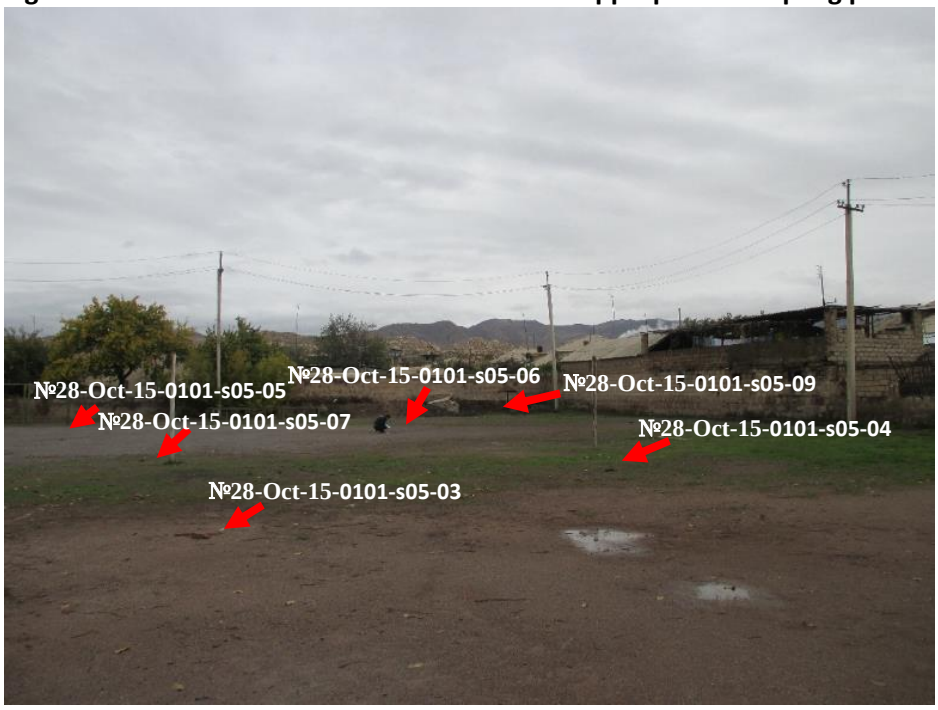
(a)

(b)

Arsenic, lead and copper exceeded the Armenian SS by 5.8-8.5 times, 1.1-1.5 times and 9.3-32.7 times, accordingly, in all soil samples taken from the entire area of the School №2. The concentrations of

cadmium exceeded China's SS by 1.2-2.3 times in 44.4% (4/9) of the soil samples. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS.[27]

Figure 29. Football field of Schools №2 and the appropriate sampling points



School №3

The Primary School №3 is located in the north of Ararat city. Totally 296 children attend this school. The distance from the school to the Ararat Gold Recovery Plant's tailing dump is about 5.9 km.

Figure 30. The School №3 (a) main entrance and (b) vegetable garden

(a)

(b)

[27]The BLs were exceeded for mercury by 2.1-4.3 times, for arsenic by 1.1-1.5 times, for copper by 1.4-3.1 times, as well as for lead by 1.1-1.4 times in a few samples. Cadmium didn't exceed the BLs.

The soil monitoring for School №3 was conducted for the soil-covered area, particularly garden, vegetable garden (Figure 30a and 30b) and football field of the school that was shared between School №1. The back part of the school, before the football field, was covered by rosehip bushes and separated by a fence. However, the area near by rosehip bushes polluted by municipal waste (Figure 31a). Another part of ground (entrance) that belongs to the School №3 is covered by asphalt.

Figure 31. The School №3 (a) municipal waste bins next to the playfield and (b) soil sampling points location

(a)

(b)

Totally 8 soil samples were collected from the soil-covered ground of the School №3, which locations are shown in Figure 31b.

Arsenic, lead and copper exceeded the Armenian SS by 4.4-7.2 times, 1.4-2.0 times and 18.5-58.7 times, accordingly, in all soil samples taken from the entire area of the School №3. The concentrations of cadmium exceeded China's SS by 1.1-1.8 times in 62.5% (5/8) of the soil samples. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS.[28]

School №4

The Primary School №4 is located in the north of Ararat city and separated by the fence. Totally 349 children attend this school. The distance from the school to the Ararat Gold Recovery Plant's tailing dump is about 6.4 km.

The soil monitoring for School №4 was conducted for the soil-covered area, particularly in the two gardens and football field of the school (Figures 32a and 33). Totally 8 soil samples were collected from the soil-covered ground of the School, which locations are shown in Figure 32b.

[28]The BLs were exceeded for mercury by 1.1-3.1 times, for lead by 1.2-1.8 times, for copper by 1.7-2.7 times, as well as for arsenic by 1.2-1.3 times in half of soil samples. Cadmium didn't exceed the BLs.

Figure 32. The School №4 (a) main view and (b) soil sampling points' location

(a) (b)

Figure 33. The entrance of the School №4

Arsenic, lead and copper exceeded the Armenian SS by 4.9-7.3 times, 1.1-1.4 times and 4.0-23.9 times, accordingly, in all soil samples taken from the entire area of the school. The concentrations of cadmium exceeded China's SS by 1.4-2.6 times in 50% (4/8) of the soil samples. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS.[29]

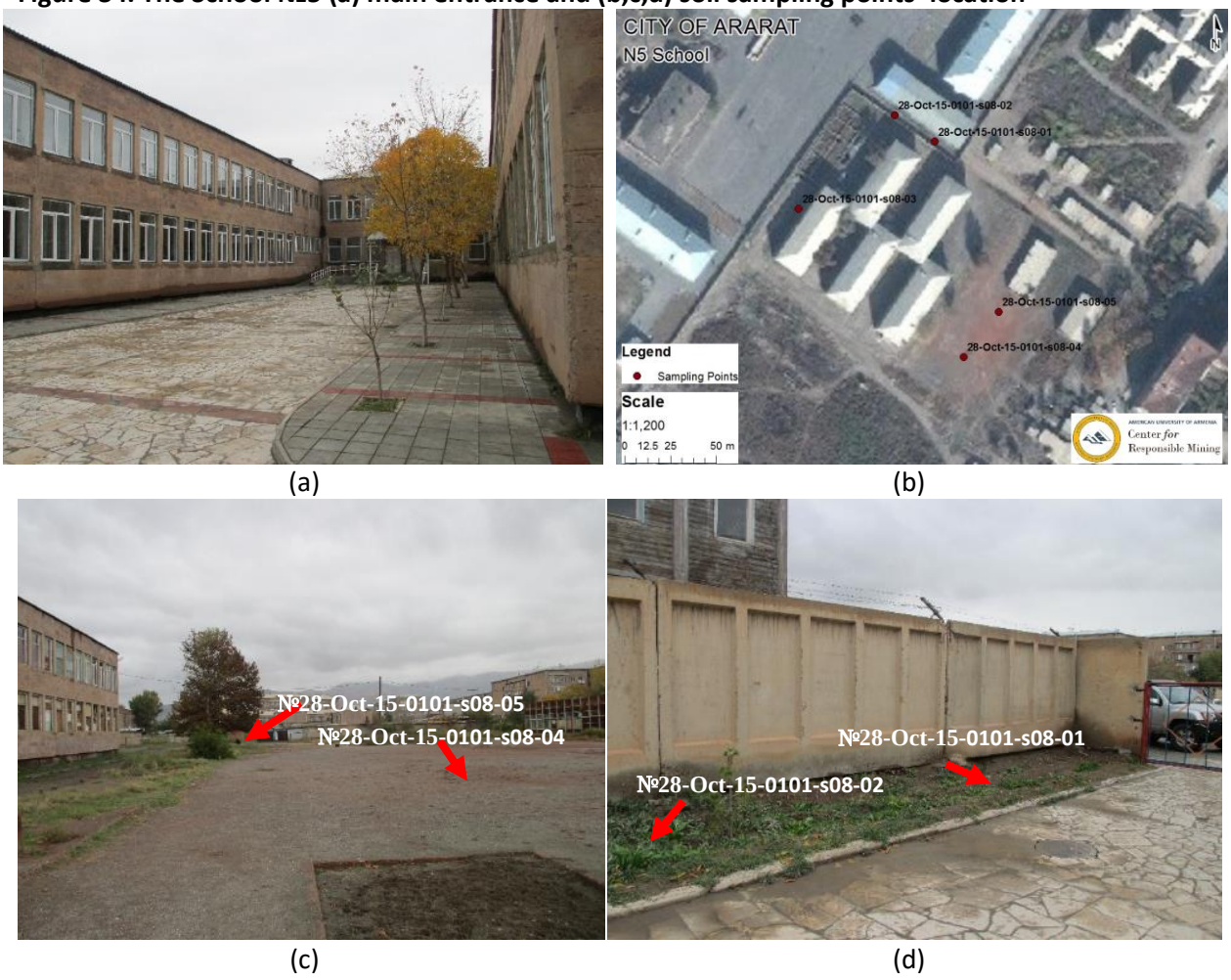
School №5

The Secondary School №5 is located in the Ararat GMF Banavan (Zod), the south of Ararat city. Totally 505 children attend this school. The school is the nearest to the Ararat Gold Recovery Plant's tailing dump, the distance is about 2.5 km.

The soil monitoring for School №5 was conducted for the soil-covered area, particularly in the garden, flowerbed and football field of the school. The main ground of the school was covered by asphalt (Figure 34a). Totally 5 soil samples were collected from the soil-covered ground of the School, which locations are shown in Figures 34b, 34c, 34d.

[29]Mercury exceeded the BLs by 1.7-3.0 times. Lead and copper exceeded the BLs by 1.2-1.3 times and 1.3-2.2 times, accordingly, in the 75% (6/8) out of total soil samples, as well as arsenic and cadmium exceeded the BLs by 1.1-1.3 times and 1.2-1.6 times, accordingly, in 37.5% (3/8) out of total soil samples.

Figure 34. The School №5 (a) main entrance and (b,c,d) soil sampling points' location



(a) (b)

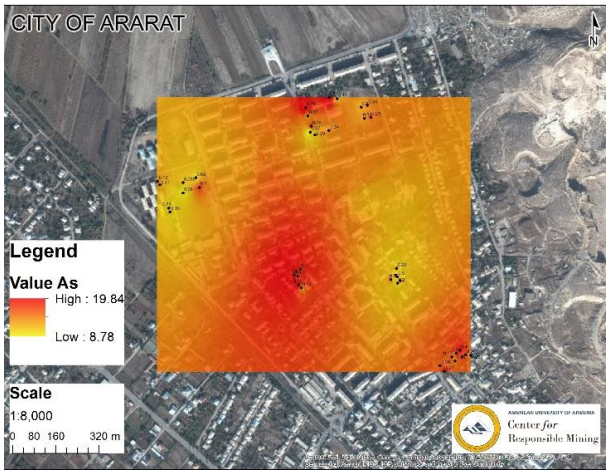
(c) (d)

Arsenic, lead and copper exceeded the Armenian SS by 3.7-7.8 times, 1.3-2.1 times and 11.8-25.7 times, accordingly, in all soil samples taken from the entire area of the school. The concentrations of cadmium exceeded China's SS by 1.2-1.7 times in 40% (2/5) of the soil samples. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS.[30]

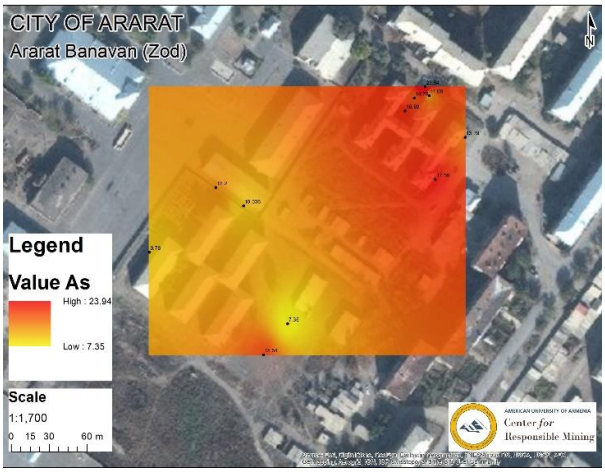
[30]Lead, copper and mercury exceeded the BLs by 1.1-1.9 times, 1.1-2.4 times and 2.0-4.7 times, accordingly. Arsenic exceeded the BL by 1.1-1.4 times in 40% (2/5) out of total soil samples. Cadmium didn't exceed the BL.

Annex 10. Distribution Maps on Heavy Metals in the Soil

Figure 35. Distribution of arsenic in school and kindergarten soil in (a) Ararat city and (b) Ararat Banavan

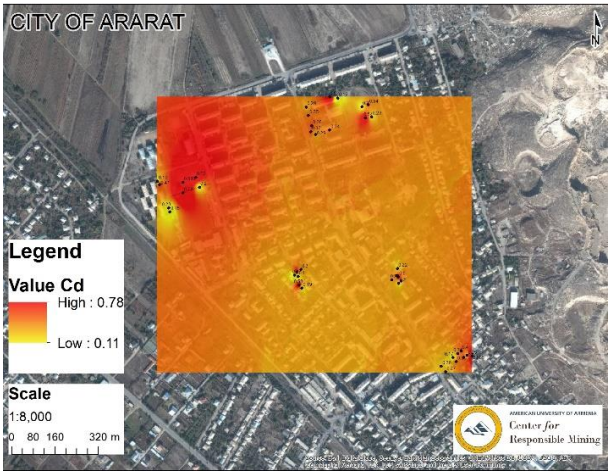


(a)

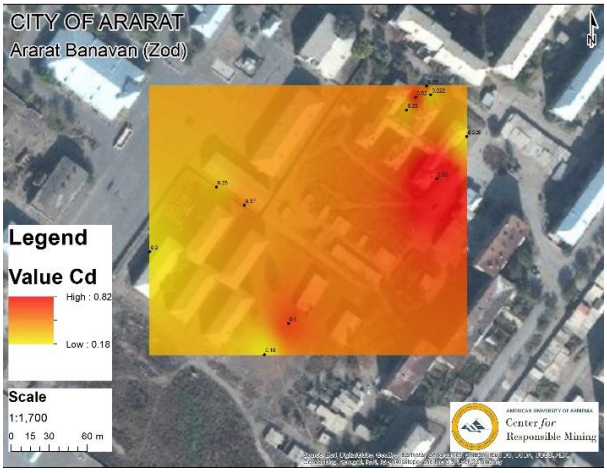


(b)

Figure 36. Distribution of cadmium in school and kindergarten soil in (a) Ararat city and (b) Ararat Banavan

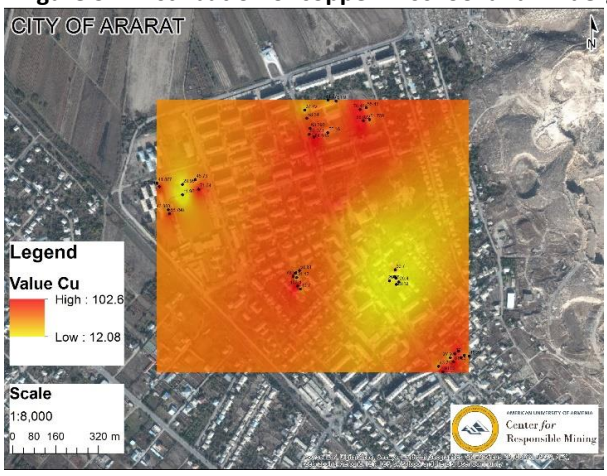


(a)

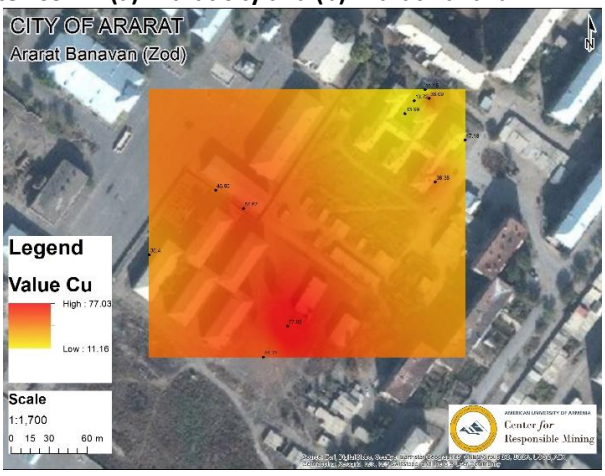


(b)

Figure 37. Distribution of copper in school and kindergarten soil in (a) Ararat city and (b) Ararat Banavan

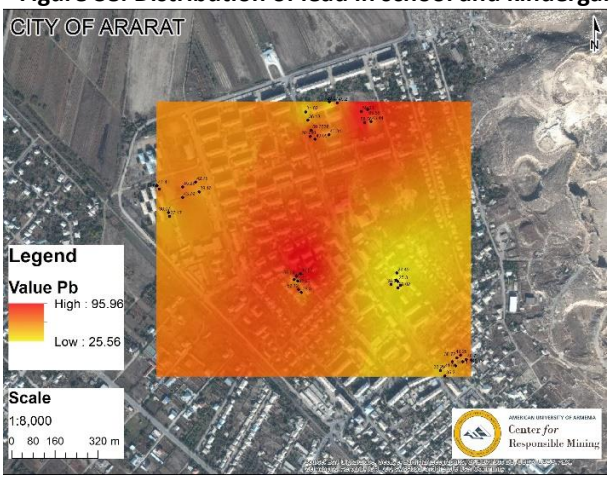


(a)



(b)

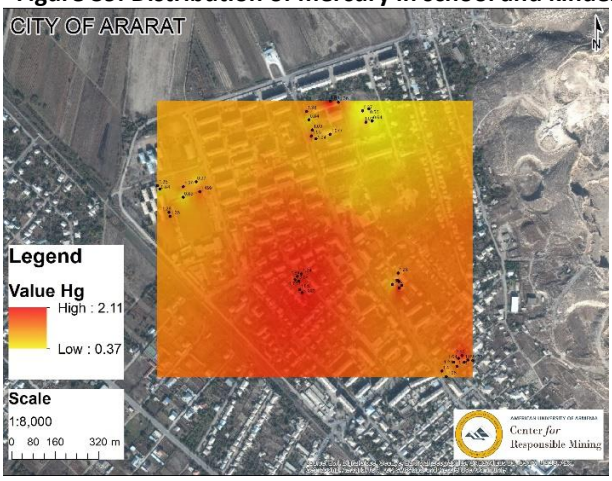
Figure 38. Distribution of lead in school and kindergarten soil in (a) Ararat city and (b) Ararat Banavan



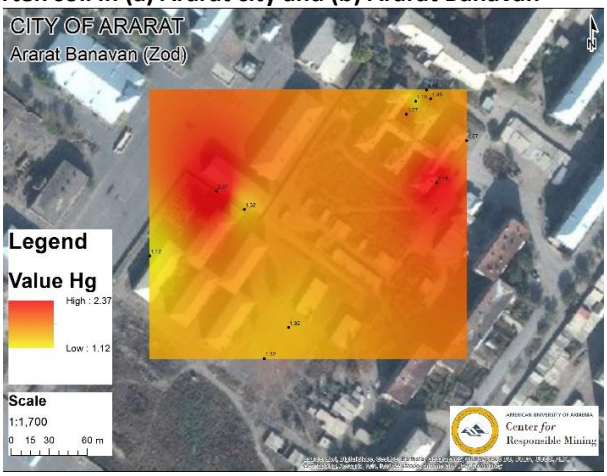
(a)

(b)

Figure 39. Distribution of mercury in school and kindergarten soil in (a) Ararat city and (b) Ararat Banavan



(a)



(b)