AMERICAN UNIVERSITY OF ARMENIA
Center *for*
Responsible Mining

Results of Soil and Drinking-Water Testing in Kindergartens and Schools of Akhtala City, Lori 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

ACKNOWLEDGMENTS

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[1] Other communities included in the soil monitoring series include Ararat in the Ararat Marz, Armanis and Alaverdi 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 and UNDP 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 Akhtala (Lori Marz, Republic of Armenia) performed by the American University of Armenia (AUA) Center for Responsible Mining (CRM). The Akhtala city is known as a mining community with copper mines, tailing ponds, and wastewater runoff.

The soil monitoring in the City of Akhtala was performed for 3 kindergartens and 2 secondary schools. A total of 368 children study in the kindergartens and schools. Permissions were obtained from authorized bodies to conduct the sampling and testing. This included permissions from the municipality of Akhtala for kindergartens and the Marz government for the 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.[4] A total of 23 soil samples were collected from the playgrounds and exterior common spaces of Akhtala's kindergartens and schools. The representative water sample was collected from the water tap in the Kindergarten after G. Beroyan, 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, boron, 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 the Trace2o Company (see Annex 3 for Methodology of Water Sampling and Testing).

The determination of background level (BL)[5] 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 2 soil samples and 2 reference 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. Complete test results of soil samples are presented in Annex 10.

Key Findings

With respect to drinking water, high levels of heavy metals in drinking water were not detected (Annex 5). The drinking water for the Akhtala community is supplied from the Lori-Berd major water pipeline, with intake structure consisting of 19 groundwater catchments located near Lori Berd

[3] Surface water, such as the Akhtala river, which is used for irrigation, was not investigated due to the scope of the study was limited to the school. Agricultural soil and water will have to be studied separately.

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

[5] The BLs for metals were determined based on the results of a preliminary study that was performed for soil at 10 and 20cm depth and distance site. This preliminary study is not sufficient for establishing the exact BLs for each metal in the soil of Akhtala community. IT needs further deep investigation (seasonal sampling, soil testing at 50cm depth).

village and 32km far from mineral processing or other industrial activities. Also, reportedly, the pipes distributing water were replaced with new pipes in 2013 and do not contain lead.[6]
With respect to soil, our key findings for each of our 5 test metals are summarized in Figure 1 and described in the text below.

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

		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*
Kinder. after Ts.Bludyan	5	27.76	100%	0.24	-	453.48	100%	219.75	100%	1.85	0%
Kinder. after G.Beroyan	2	37.64	100%	0.30	-	234.46	100%	261.55	100%	1.27	0%
Kinder. after A. Bekjanyan	5	55.26	100%	0.38	-	410.62	100%	350.89	100%	1.96	20%
Secondary school №1	6	44.86	100%	0.36	-	239.34	100%	306.60	100%	1.87	16.7%
Secondary school №2	5	42.36	100%	0.39	-	304.97	100%	352.86	100%	1.95	20%
Total GM	***23***	***41.14***	***100%***	***0.33***	***-***	***325.40***	***100%***	***298.63***	***100%***	***1.84***	***13%***
Standard deviation	-	***11.27***	***-***	***0.12***	***-***	***108.99***	***-***	***93.05***	***-***	***0.31***	***-***
Minimum	-	***23.40***	***-***	***0.17***	***-***	***140.81***	***-***	***185.25***	***-***	***1.25***	***-***
Maximum	-	***67.98***	***-***	***0.66***	***-***	***579.62***	***-***	***536.97***	***-***	***2.52***	***-***
Background level***	***10***	***18.3***		***0.22***		***227.2***		***146.3***		***1.14***	
International maximum allowable concentrations (mg/kg)*****											
Russia		*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 (BL).
(****) See Annex 8 for percentage of soil samples exceeding international standards.

- **Arsenic** concentrations in our soil samples ranged from 23.40 to 67.98 mg/kg. The geometric means (GMs) of all samples exceeded the Armenian Soil Standard (SS)[7] by 20.6 times.

  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. However, all

[6] The pipes distributing water in Akhtala city were replaced in the frame of Water Supply and Sewerage Sector Project sponsored by Asian Development Bank, 2013. The report is available at http://armwater.am/files/adb/armenian/IEE/III.%20Lori_IEE-arm/III.%20Lori%20IEE%20armenian.pdf

[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.

soil samples also exceeded standards set by Canada (12 mg/kg), Sweden (15 mg/kg), United States EPA (22 mg/kg) and China (30 mg/kg), as well as some of soil samples exceeded standards set by France (37 mg/kg), Germany (50 mg/kg) and Netherlands (55 mg/kg). Annex 8 details the percentage of soil samples exceeding these international standards.

The soil tests data were also compared with 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 reference area study (Annex 6) shows that the BL for arsenic in soil of Akhtala is 18.3 mg/kg. The GM of all soil samples exceeded the BL by 2.2 times. Based on our current level of BL 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 high concern in the Akhtala community. Arsenic exceeded almost all international comparatives in Annex 8. Our recommendation is that the playgrounds in kindergartens and schools 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 a need for a national discussion to update the country's soil standard for arsenic.

- **Cadmium** concentrations in soil samples ranged from 0.17 to 0.66 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 (0.3 mg/kg) and Sweden (0.4 mg/kg), countries with the 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 0.22 mg/kg (Annex 6), lower than 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 exposure to soil and dust containing metals of concern—will also minimize exposure risk to cadmium.

- **Copper** concentrations ranged from 140.81 to 579.62 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 being 108.5 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). However, copper in the most soil samples exceeded all international standards in Annex 8. Our

comparative countries have soil standards ranging from 50 mg/kg in China to 400 mg/kg in Belgium.

Our analysis shows a background level of 227.2 mg/kg for copper in Akhtala, about 76 times higher than Armenian SS. The total GM of copper for all samples exceeded the BL about 1.4 times.

Our findings, however, compel us to conclude that copper is a heavy metal of concern in the Akhtala 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. We recommend the same solution as for arsenic specified above—viz., covering playgrounds with materials that reduce children's exposure to soil and dust containing metals of concern.

- **Lead** levels in soil samples ranged from 185.25 to 536.97 mg/kg. The Armenian SS for lead is 32 mg/kg. This is among the most stringent standards (along with Russia) among international comparatives presented in Figure 1.

  Notwithstanding, all our soil samples exceeded standards set by Norway (60 mg/kg), Sweden (80 mg/kg), Canada (140 mg/kg), as well as some of the soil samples exceeded standards set by China (250 mg/kg), Germany, France and US EPA (400 mg/kg for each) (Annex 8).

  It should be noted that our analysis demonstrates a background level for lead in Akhtala of 146.3 mg/kg, about 4.6 times higher than the Armenian SS.

  These findings compel us to conclude that lead is a heavy metal of concern in the Akhtala city. Based on knowledge of international research on lead contamination in soil and background levels, the amounts detected in Akhtala raise immediate alarm for children's health risk due to the lead toxicity. So, our recommendation is that the playgrounds should be covered by surface materials that reduce children's exposure to soil and dust containing metals of concern and minimize exposure risk to lead.

- **Mercury** levels in Akhtala soil samples range from 1.25 to 2.52 mg/kg. Our analysis shows that the background level for mercury is 1.14 mg/kg, which is 2 times less than mercury allowable level set by Armenian SS (2.1 mg/kg).

  The detected amounts of mercury slightly exceeded the Armenian SS in 13% of soil samples. They also exceeded standards set by China (0.30 mg/kg), 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

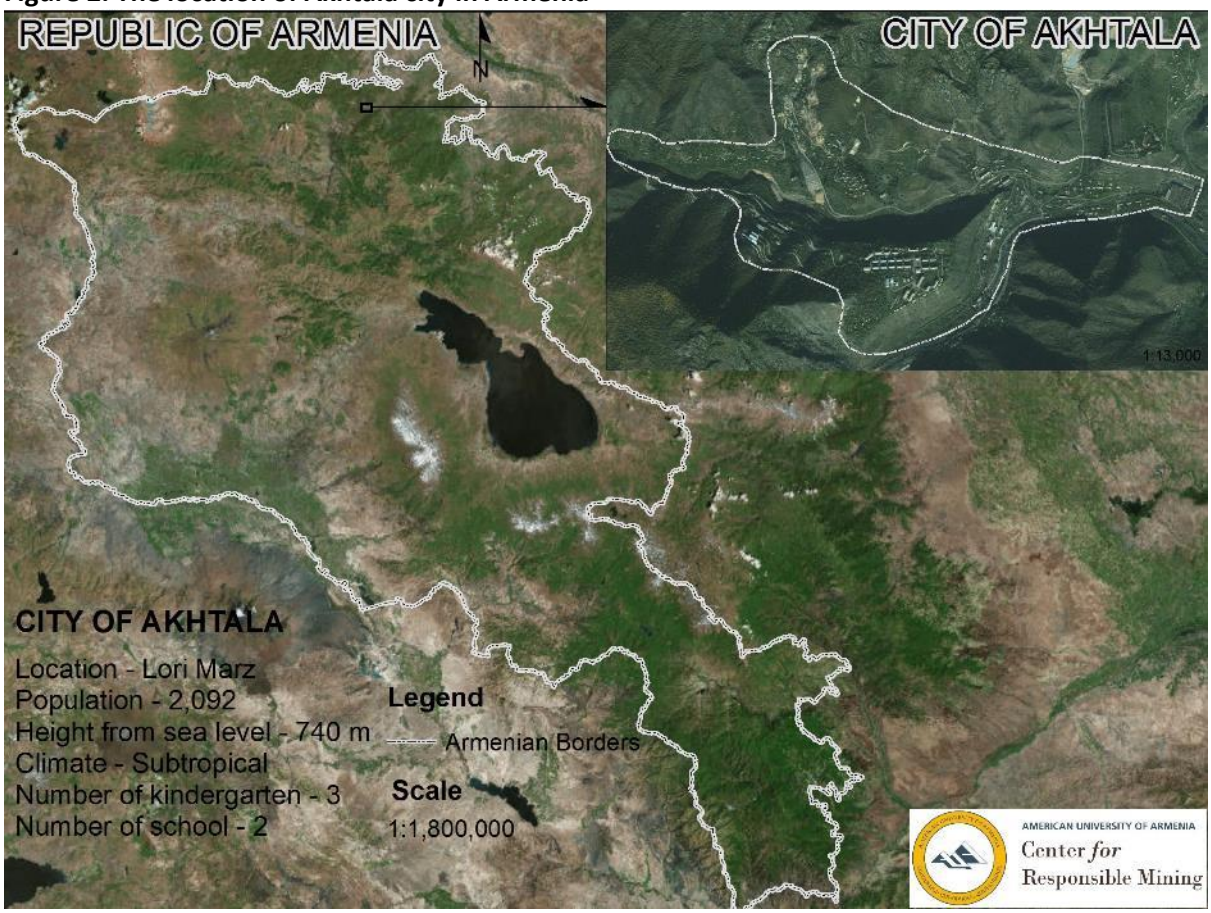
- Discuss findings with community leaders as well as school and kindergarten heads to determine effective action needed.
- Investigate the Akhtala river pollution by heavy metals due to leaching from mining activity (tailing ponds) in the Akhtala community.

- Apply this study method for other parts of Akhtala city (park, yard, public place, playfield), whenever possible increasing the list of investigated metals, such as chromium, zinc, nickel, manganese, etc.
- Implement continuing soil monitoring every couple of years in Akhtala community to monitor changes in soil contamination by heavy metals due to mining and other industrial activities.
- Check the source and quality of a new soil to be brought to the playground of kindergartens and schools.
- 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.

BACKGROUND ON AKHTALA COMMUNITY

City of Akhtala is located at 740m above sea level, along the slopes of Lalvar mountain in Lori Marz in the north part of Armenia (Figure 2). The Akhtala river, the left tributary of Debed river, flows along the city. It is about 186 km north of the City of Yerevan and 62 km from the Lori Marz capital, City of Vanadzor. Akhtala was a village until 1939 when it was granted the status of an urban community, with its 400 population. Akhtala was given the status of a city in 1995 and is divided into the following four districts-- Transport, Svinets, Barit and Sarahart.

Figure 2. The location of Akhtala city in Armenia



Climate and landscapes. The city is distinguished by a subtropical climate with cool and dry summers and mild winters. The average temperature is -1.3°C during the winter months, while during summer months the temperature reaches 20 to 23°C. The maximum temperature recorded in Akhatala is 37°C and the minimum is -22°C. The annual atmospheric precipitation reaches up to 600mm.

The community of Akhtala is distinguished by mountainous forest landscape that was significantly changed due to mining activities. The area is associated with copper mining and the signs of this industry can be seen across the landscape of the area.

Population. As of the 2011 census, the permanent population of the city is 2,092 with 987 males and 1,105 females. The population in the age group 0-19 is 535 (Annex 1).

Industry. Akhtala has an underground mine (Shamlugh mine) and an open pit barite-polymetallic mine (Akhtala mine).[8] The operation of Akhtala mine has started 250 years ago by "Akhtala Mining and Processing Enterprise" CJSC that located in the west of Sarahart district of the Akhtala city. It stopped during the 1990s due to the economic breakdown of the country, then was privatized by Metal Prince Ltd. and reopened in 2001. In 2010 monthly production of copper concentrate was 1000 tons. The estimated lifetime of the open pit mine was calculated to be 25 years given the current exploitation rate.[9] Nowadays, Akhtala mine doesn't operate. The "Akhtala Mining and Processing Enterprise" CJSC currently produces copper concentrate from the Shamlugh copper mine (located in nearby Shamlugh village, 3-4km far from Akhtala city). The approved operating mine reserves of the Shamlugh are around 4.46 mln tons, with the following average metal content: 4.2% of copper, 0.7g/t of gold, 5.88g/t of silver, 9.1g/t of silicon and 4.2g/t of tellurium.[10]

There are 3 tailing dump adjacent to the Akhtala city-- "Nazik", "Paytucikneri Dzor" and "Nahatak" (Photograph 1). 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[11], the "Nazik" tailing pond is located in the east part of the Akhtala city, just next to Akhtala Monastery and the Kindergarten after Ts. Beroyan. The "Paytucikneri Dzor" tailing pond is located about 1.5-2 km north-west to the Akhtala city, as well as the "Nahatak" tailing pond is located about 3-4 km north-east to the city.

Photograph 1. The tailing ponds of (a) "Nazik", (b) "Nahatak" and (c) "Paytucikneri Dzor"

(a) (b) (c)

Source: http://www.ecolur.org/hy/news/mining/6978/

The area of the "Nazik" tailing pond is 2ha and the designed volume of the tailing is 0.5 million m^3, of which 0.4 million m^3 was already filled as of 2012. The area of the "Paytucikneri Dzor" tailing pond is 3.6ha and the designed volume of the tailing is 0.45 million m^3, of which 0.3 million m^3 was already

[8] The data is available at http://www.envsec.org/publications/mining_in_armenia.pdf

[9] The data was given in the report of the Program of Environmental Protection Measures in Akhtala. UNDP GEF LEAP Project http://www.sgp.am/res/Publications/CD/LEAP_Akhtala.pdf

[10] The data is provided by the RA Ministry of Emergency Situation and the RA Ministry of Energy and Natural Resources in a letter response to inquiry by the Transparency International Anticorruption Center. October 2014.

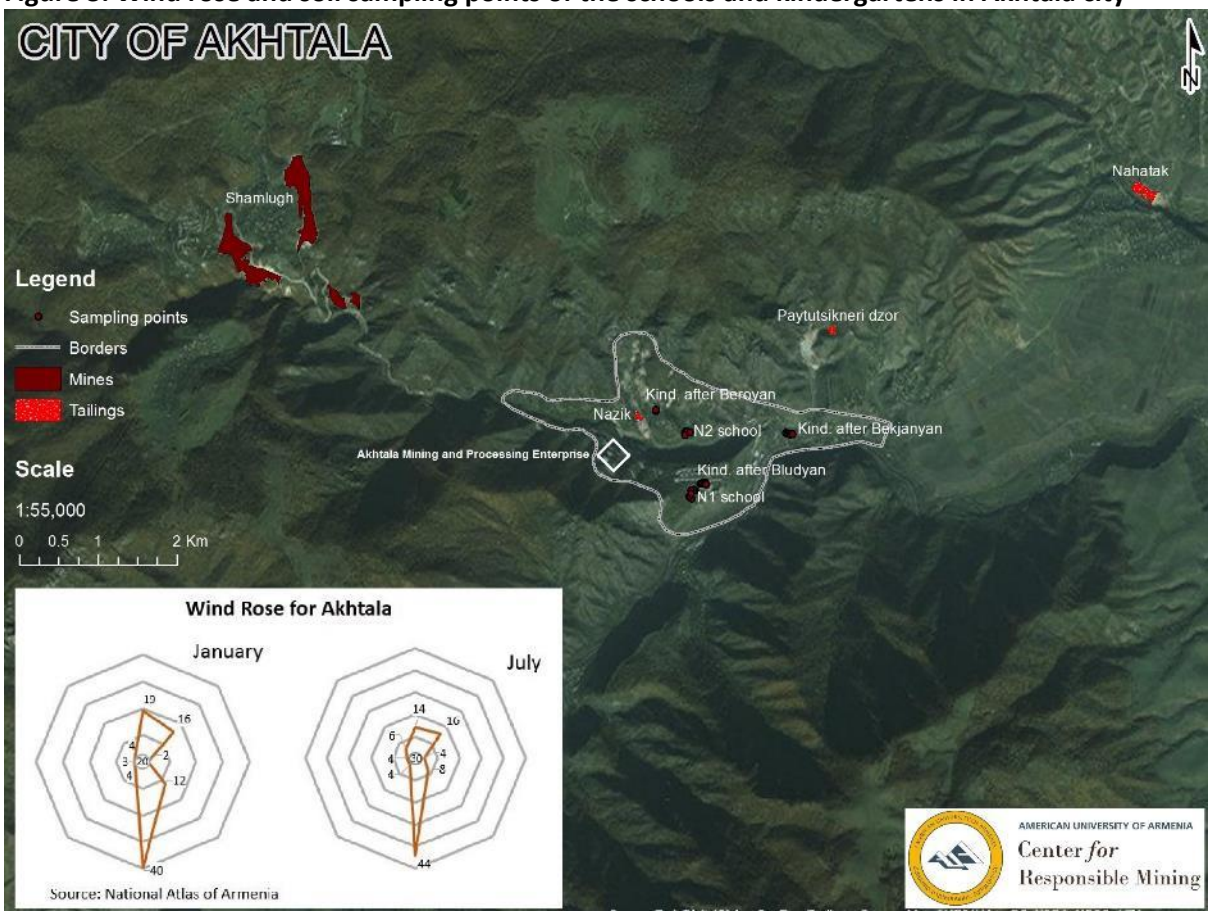
[11] The inventory was a part of the Toxic Site Identification Program (TSIP) in Armenia that was led by the Blacksmith Institute and AUA School of Public Health. 2012.

filled as of 2012. The current heights of the retaining walls of "Nazik" and "Paytucikneri Dzor" tailing ponds are 40 meters of each that are equal to the designed heights. These two tailing ponds are not exploited-- the "Nazik" tailing pond was conserved and the "Paytucikneri Dzor" tailing pond was frozen as of 2012.

The area of the "Nahatak" tailing pond is 8.8ha and the designed volume of the tailing is 3 million m^3, of which 1.1 million m^3 was already filled as of 2012. The current height of the retaining walls of "Nahatak" tailing is 60 meters that is equal to the designed height, as well. "Nahatak" tailing pond is currently the only one exploited.

Wind patterns. Geodesy and Cartography Center SNCO prepares the wind rose[12] for Akhtala city based on long-term meteorological data. The wind rose indicates that the 40-44% of total winds over the year are in the north to south direction (Figure 3).

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



Environmental issues of the community. Akhtala community has several environmental issues. According to monthly and annual reports[13] of RA Ministry of Nature Protection's Environmental

[12] The wind rose map for Akhtala city was given in the National Atlas of Armenia, prepared by Geodesy and Cartography SNCO. 2007.

[13] The reports are available at http://www.armmonitoring.am/

Impact Monitoring Center SNCO and a number of reports[14] provided by EU Project: Trans-Boundary River Management Phase II for the Kura River basin – Armenia, Georgia, Azerbaijan, the Akhtala and Debed rivers' water quality correspond to bad (V) and poor (IV) classes due to mining activities in Akhtala community. The reports indicate that the Debed river's ecosystem has suffered and the Akhtala river's ecosystem has been destroyed[15], due to high level of water contamination by heavy metals (copper, zinc, iron, cadmium, manganese, etc.).

Based on the reports of "Akhtala Pilot Project on Community Empowerment" prepared by AUA School of Public Health partnered with the Blacksmith Institute[16] and the "Case of Akhtala Community, Armenia: Environmental and Health Consequences of Mining Industry" prepared by AUA Center Responsible Mining partnered with Caucasus Environmental NGO Network (CENN)[17], the soil in Akhtala community is contaminated by toxic metals, such as lead and arsenic, and the community faces health risks.

In addition, a number of NGOs, including the Alaverdy Aarhus Center (Lori Marz)[18] when interviewed for during our site visit, expressed their concerns about air, soil and water pollution in Akhtala community, believing that such pollution has led to the increased health risks.

[14] The reports are available at http://www.kura-aras.org/

[15] http://kura-aras.iwlearn.org/EU-Kura_River_Basin.html accessed June 13, 2016

[16] The report is available at http://auachsr.com/UserFiles/File/2015%20CHSR/Akhtala%20Pilot%20Project_Final%20Report_2014.pdf

[17] The report was prepared in the scope of the partnership between AUA Center for Responsible and Caucasus Environmental NGO Network, "Promoting Environmental Social Accountability in the Mining Sector in the Caucasus" Projects and is available at http://www.armecofront.net/wp-content/uploads/2015/03/Case-of-Akhtala-Community-Armenia-Environmental-and-Health-Consequences-of-Mining-Industry.pdf

[18] The reports are available at
http://aarhus.am/publications/report_Alaverdi_2010_En1.pdf
http://aarhus.am/?page_id=11508
http://www.ecolur.org/en/news/?keyword=Akhtala
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ANNEXES

Annex 1. Population of Akhtala city by age and gender

Age	Total	Male	Female
0-4	147	83	64
5-9	149	71	78
10-14	108	60	48
15-19	131	73	58
20-24	202	96	106
25-29	172	86	86
30-34	115	59	56
35-39	121	52	69
40-44	109	54	55
45-49	187	78	109
50-54	153	74	79
55-59	127	51	76
60-64	91	38	53
65-69	43	18	25
70-74	90	33	57
75-79	68	29	39
80-84	58	23	35
85+	21	9	12
Total	***2092***	***987***	***1105***

Source: Population Census 2011 for Armenia, National Statistic Service of the Republic of Armenia, http://armstat.am/file/doc/99482563.pdf

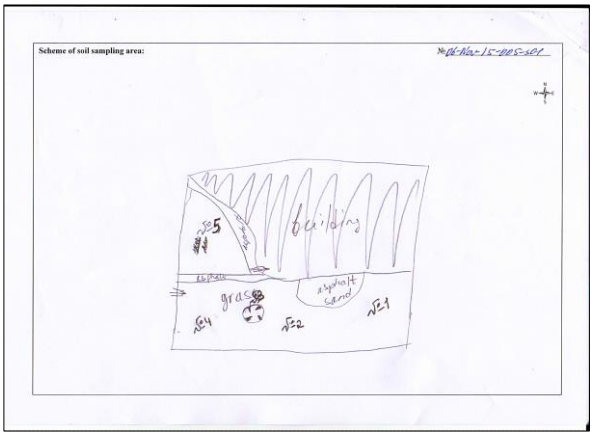
Annex 2. Methodology on Soil Sampling and Testing

The methodology on soil sampling and testing for Akhtala city based on the appropriate standard protocols and forms developed by the AUA Center for Responsible Mining based on international standards and guidance[19], in particular, ISO 17025, ISO 5667, ISO 10381, EPA IWRG 701-2009, EPA 540-R-01-00.

Soil sampling. The soil monitoring in the City of Akhtala was implemented during November 2015. A total of 38 soil samples were collected from 3 kindergartens and 2 schools and 5 reference sampling points (5 cm, 10 cm, 20 cm) for determination of metals' Background Levels in Armanis, Alaverdy and Akhtala communities. 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 2 samples and average 5 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 5 cm depth. The scheme of sampling site and locations of sampling points was drawn in the appropriate protocol/form (Figure 4). The sampling for BLs determination is given in Annex 6.

Figure 4. Example of a scheme for soil sampling area in kindergartens and schools of Akhtala city



The cardinal sampling layout was used for collecting the soil samples from the large sites of the kindergartens/schools. These sampling locations were spaced approximately 5-10m 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°C condition) for the further test. In the laboratory, the soil samples were stored in the refrigerator, for no more than six months.

Soil 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, based on Anodic Stripping Voltammetry method, in the AUA Center for Responsible

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

Mining's laboratory. Before starting the measurements, the soil samples were dried in the oven at 100°C, for an hour. Then, the soil samples were dissolved in the deionized water for digestion. After 5 min, required for efficient extraction of metals from soil to water, the liquid fraction was filtered. From the filtrate 3.5ml was mixed with the appropriate buffer solution and diluted by 60ml deionized water, and analyzed for heavy metal concentrations.

Low concentration measurements. The Metalyser Deluxe HM2000 device that was 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 5 below.

Figure 5. 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 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[20] 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.

Sampling. The drinking water sample in the City of Akhtala was collected in November 2015. The representative water sample was collected from the water tap in the Kindergarten after G. Beroyan in Akhtala city. 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.

The collected water sample was labeled and transported to the laboratory in the special cooler box (under the <6^{o}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, boron, 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, boron, 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.

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

Annex 4. Soil Independent Monitoring Data

Kindergarten after Ts. Bludyan

Sampling point №	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
06-Nov-15-0601-s01-01	23.40	0.17	468.01	197.88	1.69
06-Nov-15-0601-s01-02	28.49	0.24	390.31	185.25	2.01
06-Nov-15-0601-s01-03	32.94	0.26	389.46	230.31	1.67
06-Nov-15-0601-s01-04	25.48	0.28	465.09	202.94	1.83
06-Nov-15-0601-s01-05	29.47	0.30	579.62	299.08	2.06
Geometric mean	**27.76**	**0.24**	**453.48**	**219.75**	**1.85**

Kindergarten after G. Beroyan

Sampling point №	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
06-Nov-15-0601-s02-01	37.04	0.25	248.41	190.07	1.29
06-Nov-15-0601-s02-02	38.25	0.36	221.29	359.92	1.25
Geometric mean	**37.64**	**0.30**	**234.46**	**261.55**	**1.27**

Kindergarten after A. Bekjanyan

Sampling point №	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
06-Nov-15-0601-s03-01	55.54	0.25	401.18	278.82	2.52
06-Nov-15-0601-s03-02	67.98	0.39	308.11	272.51	1.97
06-Nov-15-0601-s03-03	50.58	0.31	507.23	348.81	2.12
06-Nov-15-0601-s03-04	53.81	0.65	437.94	536.97	1.6
06-Nov-15-0601-s03-05	50.16	0.39	425.17	373.80	1.73
Geometric mean	**55.26**	**0.38**	**410.62**	**350.89**	**1.96**

School №1 after A. Margaryan

Sampling point №	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
06-Nov-15-0601-s04-01	53.13	0.43	276.32	351.14	2.36
06-Nov-15-0601-s04-02	47.69	0.38	290.00	322.44	1.64
06-Nov-15-0601-s04-03	38.61	0.29	140.81	242.31	2.13
06-Nov-15-0601-s04-04	57.33	0.44	214.04	351.14	1.74
06-Nov-15-0601-s04-05	41.82	0.36	284.82	306.12	1.65
06-Nov-15-0601-s04-06	34.75	0.28	273.30	281.66	1.79
Geometric mean	**44.86**	**0.36**	**239.34**	**306.60**	**1.87**

School №2

Sampling point №	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
06-Nov-15-0601-s05-01	41.60	0.66	348.18	525.74	1.74
06-Nov-15-0601-s05-02	47.61	0.49	311.83	402.52	2.21
06-Nov-15-0601-s05-03	38.23	0.34	404.54	307.18	1.74
06-Nov-15-0601-s05-04	36.46	0.33	292.73	334.77	2.02
06-Nov-15-0601-s05-05	49.44	0.24	205.17	251.36	2.11
Geometric mean	**42.36**	**0.39**	**304.97**	**352.86**	**1.95**

Annex 5. Drinking Water Monitoring Data

Metals	Measurement results, mg/l	Armenian Drinking Water Standard,[21] mg/l
Aluminum	0.01	0.5
Boron	<0.1	0.5
Chromium (VI)	0.02	0.05
Iron	0.24	0.3
Nickel	<0.1	0.1
Copper	<0.05	1.0
Manganese	<0.1	0.1

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

[21]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 Akhtala City

The determination of background level for each metal in the soil of Armanis, Akhtala and Alaverdy communities was conducted by horizontal and distance sampling, based on the 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.[22] The background reference area was selected by horizontal sampling at depth 5 cm, 10 cm and 20 cm and distance sampling from about 18 km out of the city of Akhtala.

Totally 15 reference samples from 5 cm, 10 cm and 20 cm depth were collected from the sites that were located near the Village of Odzun (distance is 500-600 m) and far from mining activities and industrial processing. The calculation of BLs for each metal is shown the Figure 6 below.

Figure 6. The calculation of metals' BLs in soil for Akhtala city

Number of sampling point	Metals, mg/kg				
	Arsenic	Cadmium	Copper	Lead	Mercury
Armenian SS	***2***	***-***	***3***	***32***	***2.1***
06(01;03;07)-sRef-01 (10cm)	22.80	0.22	208.97	167.54	2.13
06(01;03;07)-sRef-02 (10cm)	19.90	0.24	192.93	176.55	1.92
06(01;03;07)-sRef-03 (10cm)	18.81	0.21	210.94	167.31	1.97
06(01;03;07)-sRef-04 (10cm)	20.60	0.23	189.14	175.30	2.00
06(01;03;07)-sRef-05 (10cm)	20.00	0.21	188.89	166.67	2.08
06(01;03;07)-sRef-01 (20cm)	14.51	0.21	233.00	123.82	0.21
06(01;03;07)-sRef-02 (20cm)	14.65	0.22	231.40	123.32	0.22
06(01;03;07)-sRef-03 (20cm)	14.79	0.23	229.82	117.81	0.27
06(01;03;07)-sRef-04 (20cm)	16.73	0.21	258.45	121.58	0.21
06(01;03;07)-sRef-05 (20cm)	16.28	0.22	276.84	120.96	0.24
Number of samples	10	10	10	10	10
Arithmetic mean	17.91	0.22	222.04	146.09	1.13
Median	17.77	0.22	220.38	145.24	1.10
Standard deviation	2.91	0.01	29.66	26.17	0.95
Minimum	14.51	0.21	188.89	117.81	0.21
Maximum	22.80	0.24	276.84	176.55	2.13
Lower band	16.8	0.22	211.9	136.0	0.8
Upper band	19.7	0.23	242.6	156.6	1.5
Background Level	***18.3***	***0.22***	***227.2***	***146.3***	***1.14***

The BL was selected for each metal based on the results of the non-parametric statistical analyses. 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 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.

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

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 4 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 are provided in the Figure 7 below.

Figure 7. The inter-laboratories tests results

Name of Laboratory	Arsenic, mg/kg	Cadmium, mg/kg	Lead, mg/kg	Copper, mg/kg	Mercury, mg/kg
Armenian SS	***2***	***-***	***32***	***3***	***2.1***
Background Level	***18.3***	***0.22***	***146.3***	***227.2***	***1.14***
	06(01;03;07)-sRef-05(20cm)				
AUA CRM	16.28	0.22	120.96	276.84	0.24
EIMC	17.98	0.70	38.60	102.32	0.0038
	06(01;03;07)-sRef-04(20cm)				
AUA CRM	16.73	0.21	121.58	258.45	0.21
NCDCP	12.0	n.d.	44.75	100.00	0.007
	Sampling point 06-Nov-15-0601-s01-01				
AUA CRM	23.40	0.17	197.88	468.01	1.69
EIMC	48.15	2.24	104.55	515.39	0.014
	Sampling point 06-Nov-15-0601-s03-04				
AUA CRM	53.81	0.65	536.97	437.94	1.6
NCDCP	18.0	n.d.	224.50	550.00	0.02

(*) n.d. stands for not detected

Annex 8. Measurements Exceeding the Armenian and International Soil Standard (SS)[23]

Figure 8. 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***
Kind. after Ts. Bludyan	5	100%	100%	0	0	0	0	100%	100%	100%	20%	100%
Kind. After G. Beroyan	2	100%	100%	0	0	0	0	100%	100%	100%	100%	100%
Kind. After A.Bekjanyan	5	100%	100%	0	20%	60%	100%	100%	100%	100%	100%	100%
Secondary school №1	6	100%	100%	0	16.7%	33.3%	66.7%	100%	100%	100%	100%	100%
Secondary school №2	5	100%	100%	0	0	0	60%	100%	100%	100%	100%	100%

Figure 9. 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***
Kind. after Ts. Bludyan	5	-	-	0	0	0	0	0	0	0	0	0
Kind. After G. Beroyan	2	-	-	0	0	0	0	0	0	0	50%	0
Kind. After A.Bekjanyan	5	-	-	0	0	0	0	20%	0	0	60%	0
Secondary school №1	6	-	-	0	0	0	0	33.3%	0	0	66.7%	0
Secondary school №2	5	-	-	0	0	0	0	40%	0	0	80%	0

(*) Soil standard has not established.

Figure 10. 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***
Kind. after Ts. Bludyan	5	100%	100%	60%	100%	-	100%	100%	100%	100%	100%	100%
Kind. After G. Beroyan	2	100%	100%	0	100%	-	100%	100%	100%	100%	100%	0
Kind. After A.Bekjanyan	5	100%	100%	60%	100%	-	100%	100%	100%	100%	100%	100%
Secondary school №1	6	100%	100%	0	100%	-	100%	100%	100%	100%	100%	66.7%
Secondary school №2	5	100%	100%	0	100%	-	100%	100%	100%	100%	100%	80%

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

Figure 11. 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***
Kind. after Ts. Bludyan	5	100%	100%	0	0	0	0	100%	100%	100%	20%	0
Kind. After G. Beroyan	2	100%	100%	0	0	0	0	100%	100%	100%	50%	0
Kind. After A.Bekjanyan	5	100%	100%	0	0	20%	20%	100%	100%	100%	100%	20%
Secondary school №1	6	100%	100%	0	0	0	0	100%	100%	100%	83.3%	0
Secondary school №2	5	100%	100%	0	0	20%	20%	100%	100%	100%	80%	20%

Figure 12. 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***	*****
Kind. after Ts. Bludyan	5	0	0	0	0	0	0	100%	100%	0	100%	-
Kind. After G. Beroyan	2	0	0	0	0	0	0	100%	100%	0	100%	-
Kind. After A.Bekjanyan	5	20%	20%	0	0	0	0	100%	100%	0	100%	-
Secondary school №1	6	16.7%	16.7%	0	0	0	0	100%	100%	0	100%	-
Secondary school №2	5	20%	20%	0	0	0	0	100%	100%	0	100%	-

Annex 9. Soil Test Results for Each Kindergarten and School

Kindergarten after Ts. Bludyan

The Kindergarten after Ts. Bludyan is located in the south part of Akhtala city. Totally 34 children attend this kindergarten. The distance from the kindergarten to the "Nazik" tailing pond is 0.8 km and to the "Paytutsikneri Dzor" tailing pond is about 2 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area that belongs to the kindergarten and is separated by a fence (Figure 13a and 13b). Totally 5 soil samples were collected that are shown in Figures 14. The soil testing results are presented in Annex 4.

Figure 13. The Kindergarten after Ts. Bludyan (a) main view and (b) soil sampling points' location

(a)

(b)

Figure 14. The Kindergarten after Ts. Bludyan playfield

The concentrations of arsenic, copper and lead exceeded the Armenian SS in the soil of the entire area of the kindergarten by 11.7-16.5, 129.8-193.2 and 5.8-9.3 times, accordingly. The concentrations of cadmium didn't exceed the MAC set by China (0.3 mg/kg) that is the most stringent standard known to us. The concentrations of mercury didn't exceed the Armenian SS.[24]

Kindergarten after G. Beroyan

The Kindergarten after G. Beroyan is located in the north-west of Akhtala city known as Svinets District. Totally 13 children attend this kindergarten. The kindergarten is the nearest to the "Nazik" tailing pond, the distance is about 0.2 km. The distance from the kindergarten to the "Paytutsikneri Dzor" tailing pond is about 1.8 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area that belongs to the kindergarten and is separated by a fence, particularly the small vegetable garden (Figure 15a). Totally 2 soil samples were collected that are shown in Figure 15a and 15b.

Figure 15. The Kindergarten after G. Beroyan (a) main view and (b) soil sampling points' location

(a) (b)

Arsenic, copper and lead exceeded the Armenian SS by 18.5-19.1 times, 73.8-82.8 times and 5.9-11.2 times, accordingly, in both soil samples taken from vegetable garden of the kindergarten. The concentrations of cadmium slightly exceeded China's SS by 1.2 times in only one soil sample. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS.[25]

[24]Arsenic, copper, lead and mercury exceeded the BLs by 1.3-1.8 times, 1.7-2.6 times, 1.3-2.0 times and 1.5-1.8 times, accordingly. The cadmium exceeded BL by 1.2-1.3 times in 40% of soil samples.

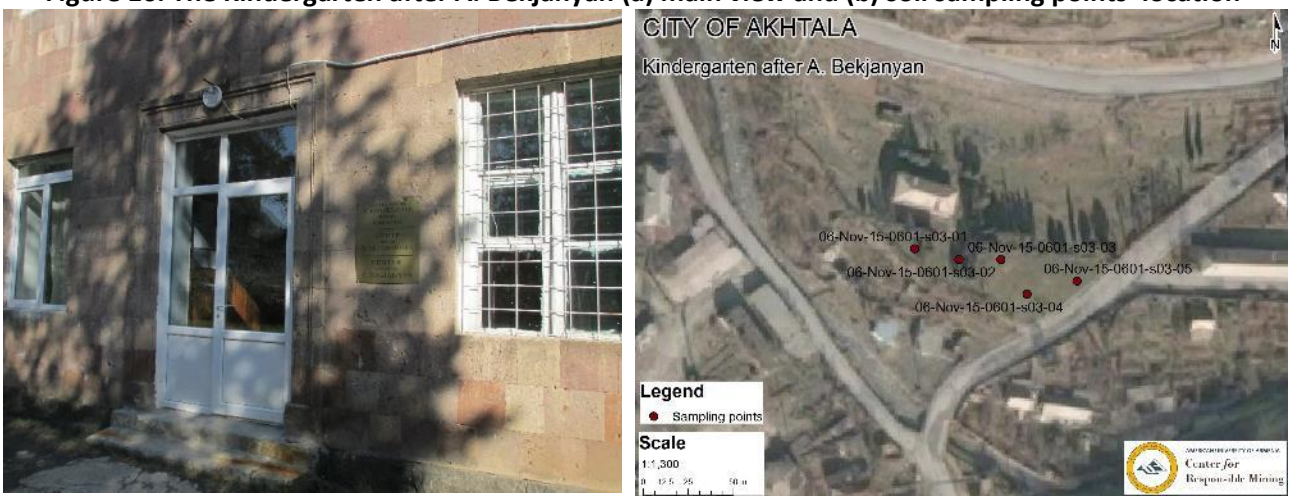
[25]Arsenic, lead and cadmium exceeded the BLs by 2.0-2.1 times, 1.3-2.5 times and 1.1-1.6 times, accordingly. Copper and mercury slightly exceeded the BL by 1.1 times in a few cases.

Kindergarten after A. Bekjanyan

The Kindergarten after A. Bekjanyan is located in the east of Akhtala city. Totally 29 children attend this kindergarten. The distance from the kindergarten to the "Nazik" tailing pond is 1.4 km and to the "Paytutsikneri Dzor" tailing pond is about 1 km.

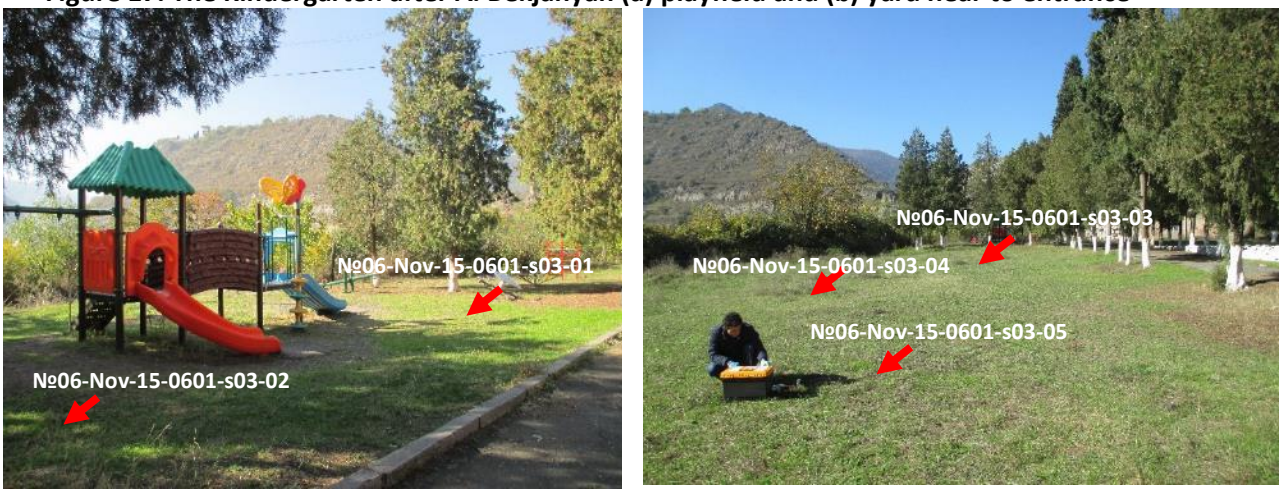
The soil monitoring for the kindergarten was conducted for the soil-covered area that belongs to the kindergarten and is separated by a fence (Figure 16a). Totally 5 soil samples were collected from a soil-covered area that are shown in Figure 16b, 17a and 17b.

Figure 16. The Kindergarten after A. Bekjanyan (a) main view and (b) soil sampling points' location



(a) (b)

Figure 17. The Kindergarten after A. Bekjanyan (a) playfield and (b) yard near to entrance



(a) (b)

Arsenic, copper and lead exceeded the Armenian SS by 25.1-34.0 times, 102.7-169.1 times and 8.5-16.8 times, accordingly, in all soil samples taken from entire area of the kindergarten. The concentrations of mercury exceeded the Armenian SS by 1.2 times in 20% (1/5) of the soil samples.

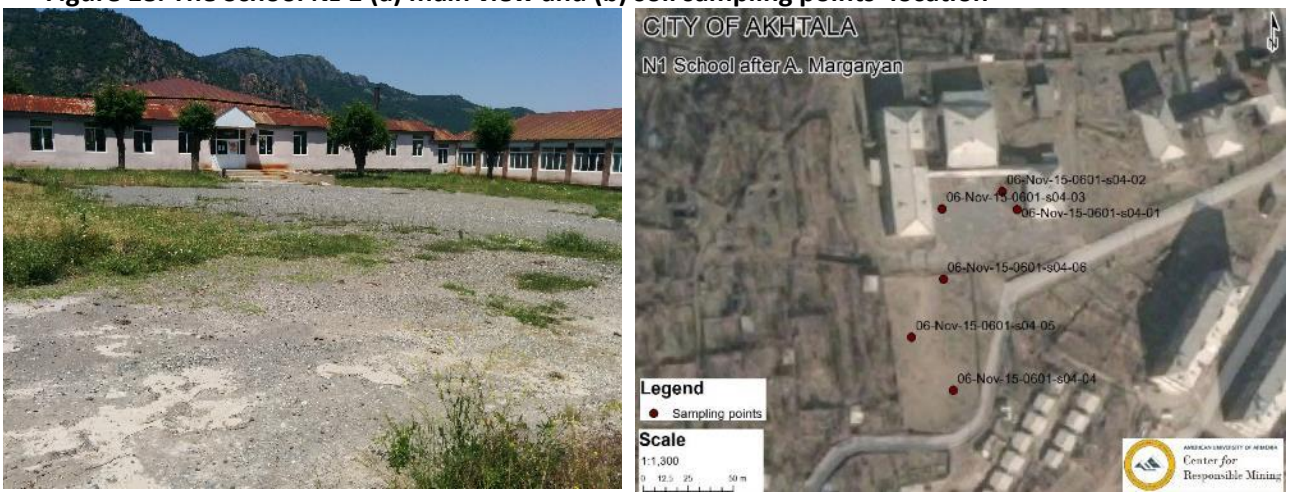
The concentrations of cadmium exceeded China's SS by 1.3-2.2 times in 60% (3/5) of the soil samples. China has the most stringent cadmium MAC known to us.[26]

School №1 after A. Margaryan

The Secondary School №1, after Andranik Margaryan is located in the south of Akhtala city. Totally 142 children attend this school. The distance from the school to the "Nazik" tailing pond is 0.8 km and to the "Paytutsikneri Dzor" tailing pond is about 2 km.

The soil monitoring for School №1 was conducted for the soil-covered area, particularly flowerbeds and football field of the school. Another part of the ground that belongs to the school is covered by asphalt (Figure 18a). Totally 6 soil samples were collected from the soil-covered ground of the School №1, which locations are shown on Figure 18b and 19.

Figure 18. The School № 1 (a) main view and (b) soil sampling points' location



(a) (b)

Arsenic, copper and lead exceeded the Armenian SS by 17.4-28.7 times, 46.9-96.7 times and 7.6-11.0 times, accordingly, in all soil samples taken from the soil covered area of the school. The concentrations of mercury slightly exceeded the Armenian SS by 1.1 times in 16.7% (1/6) of the soil samples. The concentrations of cadmium exceeded China's SS by 1.2-1.5 times in 66.7% (4/6) of the soil samples. China has the most stringent cadmium MAC known to us.[27]

[26]Arsenic, cadmium, copper, lead and mercury exceeded the BLs by 2.7-3.7 times, 1.1-3.0 times, 1.4-2.2 times, 1.9-3.7 times and 1.4-2.2 times, accordingly.

[27]Arsenic, cadmium, lead and mercury exceeded the BLs by 1.9-3.1 times, 1.3-2.0 times, 1.7-2.4 times and 1.4-2.1 times, accordingly. Copper exceeded the BL by 1.2-1.3 times in 66.7% (4-6) of the soil samples.

Figure 19. The School № 1 football field

School №2

The Secondary School №2 is located in the central of Akhtala city. Totally 150 children attend this school. The distance from the kindergarten to the "Nazik" tailing pond is 0.4 km and to the "Paytutsikneri Dzor" tailing pond is about 1.7 km.

The soil monitoring for School №2 was conducted for the soil-covered area, particularly flower-beds and football field of the school. Another part of the ground that belongs to the school is covered by asphalt (Figure 20a). Totally 5 soil samples were collected that shown in Figure 20a and 21.

Figure 20. The School №2 (a) main entrance and (b) soil sampling points' location

(a) (b)

Arsenic, copper and lead exceeded the Armenian SS by 18.2-24.7 times, 68.4-134.8 times and 7.9-16.4 times, accordingly, in all soil samples taken from the soil-covered area of the School №2. The concentrations of cadmium exceeded China's SS by 1.1-2.2 times in 80% (4/5) of the soil samples. China has the most stringent cadmium MAC known to us. Mercury didn't exceed the Armenian SS.[28]

Figure 21. Football field of Schools №2 and the appropriate sampling points

[28] Arsenic, cadmium, copper, lead and mercury exceeded the BLs by 2.0-2.7 times, 1.1-3.0 times, 1.1-1.8 times, 1.7-3.6 times and 1.5-1.9 times, accordingly.

Annex 10. Complete Test Results of Soil Samples

Within the inter-laboratory comparison, the complete tests of metals were conducted for 2 soil samples. Up to 25 metals' total concentrations were measured in the qualified laboratory of RA Ministry of Nature Protection's EIMC SNCO using the ICP-Mass Spectrometric Method (by Perkin Elmer MS device). The test results and appropriate Armenian and International SS for each metals are given in Figure 30.

Figure 30. EIMC's laboratory complete test results

Metals	Measurement results, mg/kg		Armenian SS, mg/kg	Norwegian SS, mg/kg	Canadian SS, mg/kg	Chinese SS, mg/kg	US EPA screening level, mg/kg
	Sample number 06(01;03;07)-sRef-05(20cm)	Sample number 06-Nov-15-0601-s01-01					
Antimony	1.47	5.09	4.5	-	-	-	-
Arsenic	17.98	48.15	2.0	2.0	12	30	22
Barium	7.52	30.31	-	-	-	-	-
Beryllium	0.76	0.54	-	-	-	-	-
Bismuth	0.79	1.87	-	-	-	-	-
Boron	11.41	8.50	-	-	-	-	-
Cadmium	0.70	2.24	-	3.0	14	0.3	85
Calcium	162.51	226.87	-	-	-	-	-
Chromium	34.22	98.01	6.0	25	64	150	230
Cobalt	11.60	19.37	5.0	-	-	-	-
Copper	102.32	515.39	3.0	100	63	50	250
Iron	7584.37	15481.32	-	-	-	-	-
Lead	38.60	104.55	32.0	60	140	250	400
Lithium	4.53	2.45	-	-	-	-	-
Manganese	462.74	495.51	700.0	-	-	-	-
Molybdenum	1.22	4.76	-	-	-	-	-
Mercury	0.0038	0.014	2.1	1.0	6.6	0.3	-
Nickel	40.77	66.31	4.0	50	50	40	1,600
Potassium	6368.97	3594.55	-	-	-	-	-
Selenium	2.18	2.56	-	-	-	-	-
Strontium	23.84	18.21	-	-	-	-	-
Tin	2.53	4.93	-	-	-	-	-
Titanium	2241.87	2944.98	-	-	-	-	-
Vanadium	68.13	87.57	150.0	-	-	-	-
Zinc	77.38	323.18	23.0	100	200	200	23,000

(-) Soil standard has not established.

Arsenic, chromium, cobalt, copper, lead, nickel and zinc exceeded the Armenian SS by 9.0-24.1 times, 5.7-16.3 times, 2.3-3.9 times, 34.1-171.8 times, 1.2-3.3 times, 10.2-16.6 times and 3.4-14.1 times, accordingly, in the soil samples collected from the reference site and soil-covered area of the Kindergarten after Ts. Bludyan in the Akhtala city. Antimony slightly exceeded the Armenian SS by 1.1 times in the soil sample collected from the kindergarten. Vanadium and manganese didn't exceed the Armenian SS.