AMERICAN UNIVERSITY OF ARMENIA
Center *for*
Responsible Mining

Results of Soil and Water Testing in Kindergartens and Schools of Kajaran and Artsvanik Communities, Syuniq Marz, Republic of Armenia

Prepared by

AUA Center for Responsible Mining

Funded by

OneArmenia's crowdfunding campaign
"Let's Protect Armenia from Toxic Pollution"

Equipment donated by

Organization for Cooperation and Security in Europe (OSCE) Yerevan
United Nations Development Program (UNDP) Armenia

September 2016

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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

The AUA Center for Responsible Mining wishes to thank RA Ministry of Nature Protection, Syuniq Marz, Kajaran Municipality, and individual kindergarten and school directors for their assistance and permissions to conduct soil and water testing in subject areas.

In addition, our work was greatly enhanced by the invaluable contribution of our Technical Advisory Board members, Dr. Robert Kurkjian (USA), Dr. Natella Mirzoyan (Armenia), and Dr. Gagik Melikyan (USA). Detail information on our Technical Advisory Board is available at the AUA Center for Responsible Mining webpage dedicated to environmental monitoring of mining communities in Armenia (http://crm.aua.am/independent_monitoring).

This report—fifth in a series of reports dedicated to 10 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.

The equipment used to prepare this report was donated by the Organization for Security and Cooperation in Europe (OSCE) and United Nations Development Program (UNDP) as a matching contribution in the same crowdfunding campaign.[2] We reiterate our gratitude to all our donors.

[1] Other communities included in the soil monitoring series include Ararat in the Ararat Marz, Armanis, Alaverdi and Akhtala in the Lori Marz, as well as Agarak, Kapan, Achanan and Syunik communities 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 water[3] monitoring for heavy-metal pollution in the kindergartens and schools of the City of Kajaran and Village of Artsvanik (Syuniq Marz, Republic of Armenia) performed by the American University of Armenia (AUA) Center for Responsible Mining (CRM). The city of Kajaran has one of the largest mining companies in Armenia, the "Zangezur Copper Molybdenum Combine" (ZCMC) CJSC that is a recognized leader in the mining industry, as well as Artsvanik village, which is located near the largest tailing pond in Armenia (Artsvanik tailing pond), where the ZCMC transported its industrial wastewater.

The soil monitoring in the Communities of Kajaran and Artsvanik was performed for 2 kindergartens and 3 secondary schools. A total of 1206 children study in the kindergartens and schools. Permissions were obtained from authorized bodies to conduct the sampling and testing. This included permissions from the municipalities for kindergarten 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 communities'' kindergartens and schools. The representative drinking water sample was collected from the water tap in Kindergarten №1 of Kajaran, as well as 3 surface water samples collected from the Voghji (upstream and downstream Kajaran) and Artsvanik rivers. The water 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 samples, 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 Trace2o Company (see Annex 3 for Methodology of Water Sampling and Testing).

The determination of background level (BL)[5] for each metal in the soil of Kajaran city 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 and 2 reference samples in the qualified laboratories of the RA Ministry of Nature Protection's Environmental Impact Monitoring Center SNCO and EcoAtom LLC research center. 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 soil test results are shown in Annex 10.

Key Findings

With respect to drinking water, high levels of heavy metals in drinking water in Kajaran community were not detected (Annex 5). The drinking water for the Kajaran community is supplied from the "Yughot Dzor" tributary of Voghji river, located at a height of 2063 m above sea level and about 8 km

[3] Drinking water and surface water that is used for irrigation were tested. Underground water was not investigated due to a limited amount of them in the community.

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

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

far from Zangezur Copper Molybdenum Combine's mineral processing. Also, as reported, lead pipes were never used for the distributing drinking water in the city of Kajaran. The drinking water for Artsvanik community is supplied from nearby natural springs, which are about 2-3 km up and far from the Artsvanik tailing pond and other mining activities. The water distribution system is 15 km long, in poor condition, and supplies two hours once every two days.[6] Drinking water sampling was not available when we made our site visits on 13 May 2016. The results are presented in Figure 7 (Annex 5).

With respect to surface water, the water quality of the Voghji River upstream and downstream of Kajaran city corresponds to Excellent (I) class by 12 tested metals and Moderate (III) class by iron, accordingly. The water quality of the Artsvanik River downstream of Artsvanik village corresponds to Bad (V) class by manganese. The results are presented in Figure 8 (Annex 5).

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

Figure 1. Heavy metals concentrations in soil samples from Kajaran and Artsvanik communities' 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*
Kajaran city											
Kindergarten №1	5	45.33	100%	0.43	-	271.71	100%	26.57	40%	<0.1	0%
School №1	6	60.72	100%	0.26	-	223.67	100%	28.63	33.3%	0.11	0%
School №2	6	43.59	100%	0.45	-	368.73	100%	30.76	33.3%	<0.1	0%
Artsvanik village											
Kindergarten	3	17.46	100%	0.47	-	182.31	100%	37.70	66.7%	<0.1	0%
School	3	21.45	100%	0.31	-	74.32	100%	15.57	0%	<0.1	0%
Total GM	***23***	***38.78***	***100%***	***0.37***	***-***	***224.19***	***100%***	***27.48***	***34.8%***	<0.1	***0%***
Standard deviation	-	***20.23***	***-***	***0.16***	***-***	***173.13***	***-***	***16.06***	***-***	***<0.1***	***-***
Minimum	-	***16.77***	***-***	***0.13***	***-***	***52.00***	***-***	***11.85***	***-***	***<0.1***	***-***
Maximum	-	***78.82***	***-***	***0.69***	***-***	***573.58***	***-***	***68.59***	***-***	***<0.1***	***-***
Background level***	***9***	***28.1***		***0.37***		***224.19***		***27.48***		***<0.1***	
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.

[6] See http://www.un.am/up/library/Artsvanik%20Community_eng.pdf

- **Arsenic** concentrations in our soil samples ranged from 16.77 to 78.82 mg/kg. The geometric means (GMs) of all samples exceeded the Armenian Soil Standard (SS)[7] by 19.4 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, the majority of soil samples exceeded the standards set by the countries listed in Figure 1. Annex 8 details the percentage of soil samples exceeding these international standards.

  The soil test data for Kajaran city 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 in the city. Our reference area study (Annex 6) shows that the BL for arsenic in the soil of Kajaran is 28.1 mg/kg. The GM of all soil samples exceeded the BL by 1.8 times. Based on our current level of BL analysis, it is not possible for us to link the level of arsenic in the soil to industrial and mineral processing activities in the city. Further analysis would have to be done to find or exclude a causal link.

  Our findings, however, compel us to conclude that arsenic is a heavy metal of high concern in the Kajaran and Artsvanik communities. Arsenic exceeded almost all international comparatives in Annex 8. Our recommendation is that the playgrounds in kindergartens and schools 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 0.13 to 0.69 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: Belgium 6 mg/kg, Netherlands 12 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 in Kajaran city's soil shows an average of 0.26 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 with metals of concern—will also minimize exposure risk to cadmium.

[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.

- **Copper** concentrations ranged from 52.00 to 573.58 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 74.7 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). 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 149.7 mg/kg for copper in Kajaran, significantly higher than Armenian SS.

  Our findings, however, compel us to conclude that copper is a heavy metal of concern in the Kajaran and Artsvanik communities. Worldwide evidence suggests that it is not able to predict the extent of exposure or potential health effects of the high levels of copper in the soil,[8] even though they are toxic to aquatic organisms. While it may be reasonably argued that soil cannot be expected to be cleaner than the 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 11.85 to 68.59 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. The GM of all samples didn't exceed the Armenian SS. Notwithstanding, lead exceeded the Armenian SS by 1.2-2.1 times in 34.8% (8/23) of soil samples.

  In addition, a few of our soil samples (2/23) slightly exceeded the standards set by Norway (60 mg/kg) (Annex 8).

  It should be noted that our analysis shows a background level for lead in Kajaran is 18.2 mg/kg, about 1.8 times less than the Armenian SS.

  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 Kajaran and Artsvanik communities do not raise immediate alarm although lead is a toxic metal and needs to be monitored.

- **Mercury** levels in the soil samples collected from Kajaran and Artsvanik communities, as well as from the reference sites were not detected.

Recommendations

  - Discuss findings with community leaders as well as school and kindergarten heads to determine effective action needed.
  - Investigate the Voghji and Artsvanik rivers pollution by heavy metals due to mining activity and its suitability for irrigation in the communities.

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

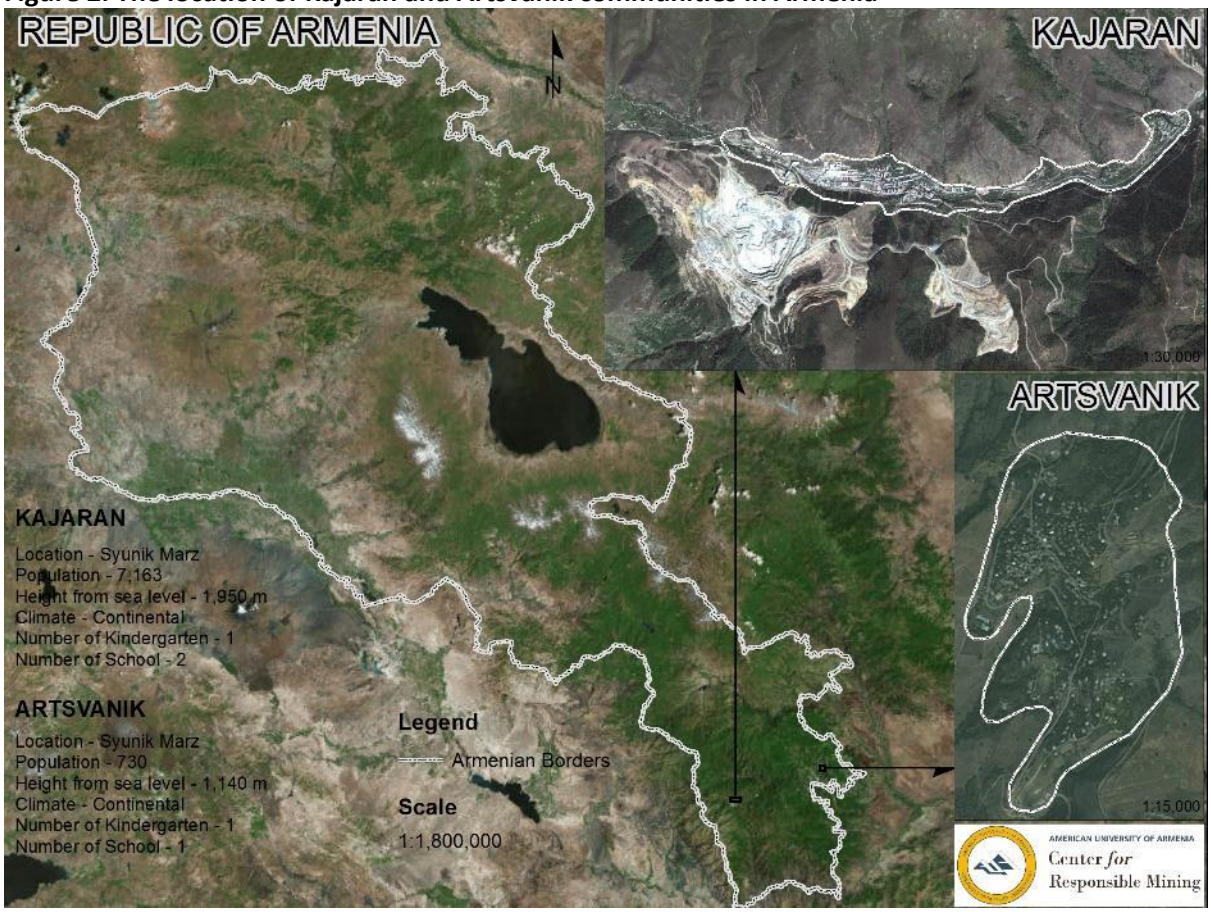
- Apply this study method for other parts of Kajaran and Artsvanik communities (park, yard, public places, playing fields), whenever possible increasing the list of investigated metals, such as chromium, zinc, nickel, manganese, etc.
- Implement continuing soil monitoring every couple of years in Kajaran and Artsvanik communities 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 KAJARAN AND ARTSVANIK COMMUNITIES

Kajaran Community. Kajaran is a city in the southern Syunik region of Armenia. The city is located at a height of 1950m above sea level, about 356 km south of the City of Yerevan, 25 km from the Syuniq Marz capital, City of Kapan, and 50 km from the border of Armenia and Iran. The highest point is Kaputjugh peak of the Zangezur Mountain Range at elevation of 3904 m above sea level is located to the west of Kajaran (Figure 2).

The area of Kajaran has been occupied by dwellers since the 3rd-2nd millenaries B.C. The first copper mines of the area were built in 1850. After the discovery of huge copper deposits in 1930, a city was built in the area of Verin Hand and Okhchi villages that was called Kajarants. The majority of the population of Kajaran were immigrants from Kapan and Karabakh.

Figure 2. The location of Kajaran and Artsvanik communities in Armenia



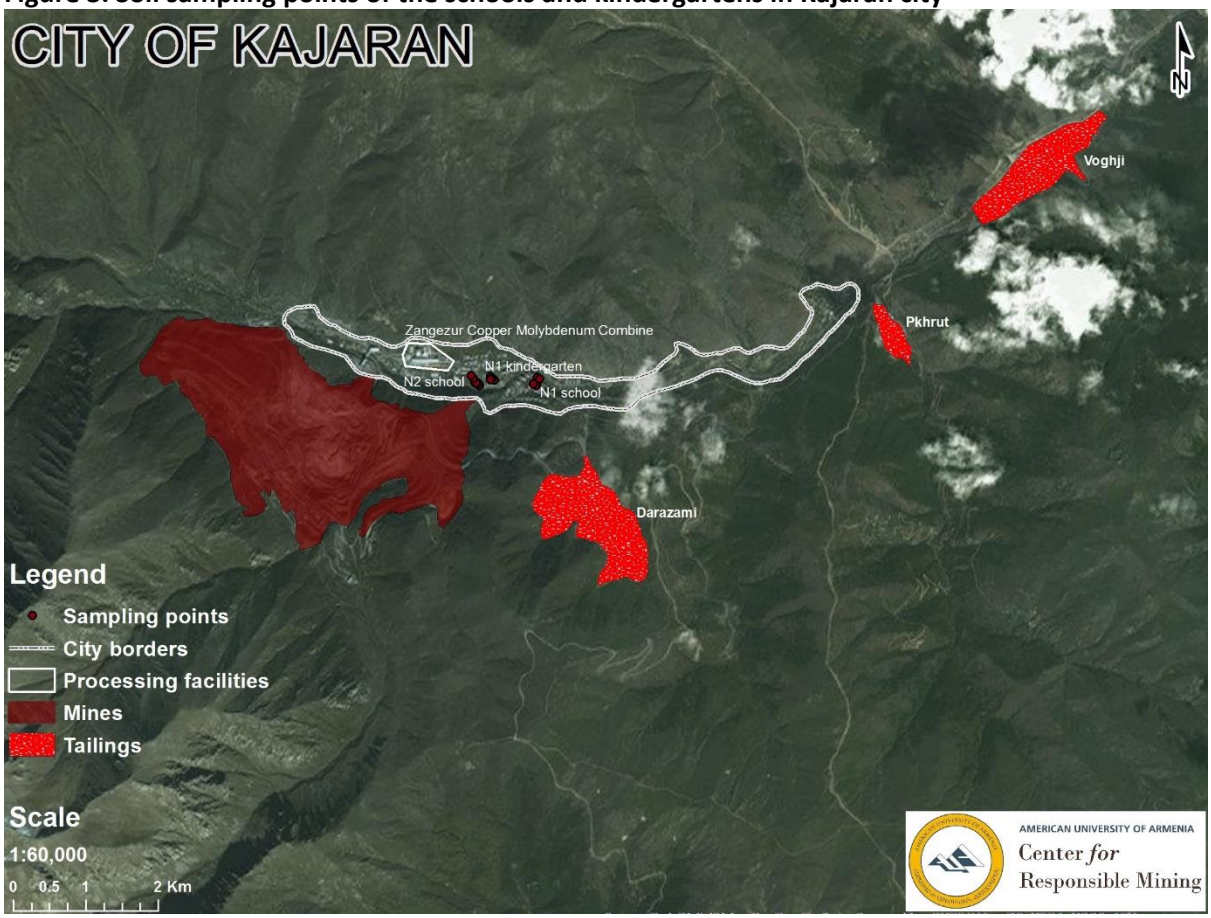
Artsvanik Community. The Village of Artsvanik is located on the hills of the Bargushat Mountains—1,140 meters above sea level, in the Kapan District of the Syunik Marz, 10 kilometers to the north-east of the City of Kapan, on the Kapan-Yerevan highway. The administrative territory of the village is 1,980.4 hectares, of which 1,316 hectares (66.5%) is agricultural land (Figure 2).

The Village has a long history. It was first called Yeritzvank, then Yeritzvanik, and after Artsvanik. Artsvanik is a historic village with famous monasteries. The old village, which is 1 kilometer to the south-west of the present village, was named Yeretz or Yeretzvanik.

Climate and landscapes. Kajaran and Artsvanik are located in an alpine climate zone and are characterized by a continental and relatively humid climate (Figure 3 and 4). The Artsvanik village is mostly characterized by subtropical climate features. The communities are situated in the east-to-west air flow movement region. The average annual temperature is +6.9°C, with the absolute maximum of +33.5°C and the absolute minimum of -18.5°C. The annual precipitation level is 600-705mm, mostly occurring in May-June, when it reaches 99-104mm, with maximum daily level of 66mm. The average humidity is 69% with May being the most humid month of the year (74%).

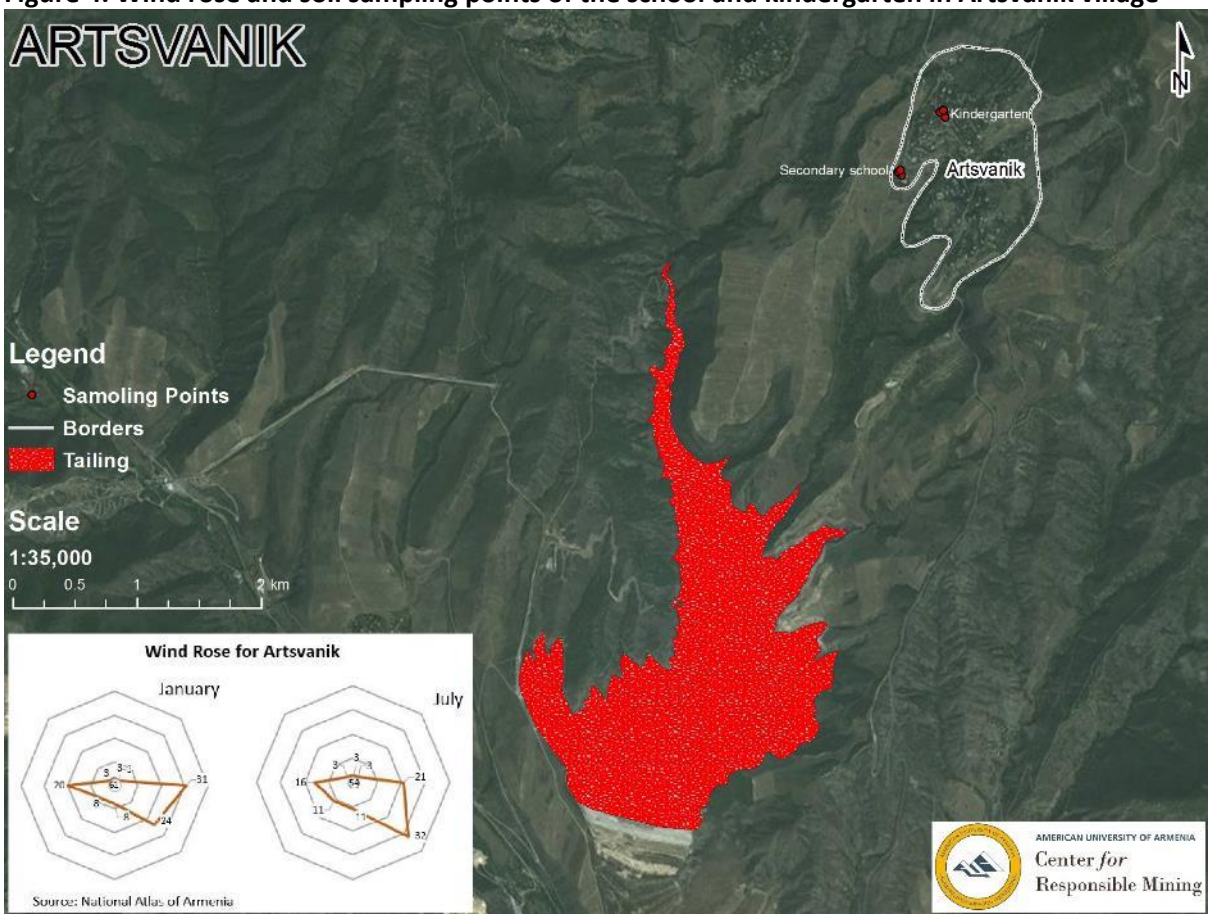
Kajaran city is located on the border of two natural landscapes, alpine and highland forests, on the banks of river Voghji, between the Zangezour and Meghri mountain ranges. The relief is composed of plicate rock strata of river Araks basin and is characterized by active erosion (Figure 3).

Figure 3. Soil sampling points of the schools and kindergartens in Kajaran city



Population. As of the 2011 census, the permanent population of the Kajaran city is 7,163 with 3,489 males and 3,674 females. The population in the age group 0-19 is 1,975 (Annex 1). The permanent population of the Artsvanik village is 730.

Figure 4. Wind rose and soil sampling points of the school and kindergarten in Artsvanik village



Industry. The first copper mines in the Kajaran community were built in 1850. After the discovery of huge copper deposits in 1930, the Soviet government proposed to build a copper-molybdenum plant, the Zangezur Copper Molybdenum Combine, which was put in service 1952, becoming one of the biggest enterprises of the USSR at that time.

The ZCMC operates its Kajaran copper and molybdenum deposit as an open pit mine, which lends itself to bulk mining techniques with currently some 12.8 Mt of ore (and a similar amount of waste) removed each year. Kajaran mine is located near Kajaran town, at the right-bank section of Voghji River. The approved mine reserves are around 774ha, with the following average metal content: 0.0349% of molybdenum, 0.278% of copper, 0.026g/t of gold, 1.48g/t of silver.[9]

Based on the most recent geological explorations completed 2006, the Karajan balance in-pit resources: B+C1 total to 2.21 billion metric tons of ore, 5.22 million metric tons of copper, 0.72 million metric tons of molybdenum. The ore is processed and molybdenum and copper concentrates are produced, which are roasted and smelted in and outside of Armenia.[10]

[9] 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.
[10] The data is available at http://www.zcmc.am/eng/our-operations/mining/

Photograph 1. Mining industry (a) Kajaran mine and (b) Artsvanik tailing pond, Syunik Marz

(a)

(b)

Source: https://www.emaze.com/@AIFOOTIR/Presentation-Name

The Zangezur copper-molybdenum combine's wastewater system is centralized, and ore leach solutions are transported to the Artsvanik tailing pond via pipeline. Artsvanik tailing, which was considered to be the largest tailing in the world, is located in Artsvanik river basin, near Artsvanik village. The tailing capacity is designed at 310 million m^3, according to the EIA of the company. Currently, the tailing already contains 95 million m^3. The amount of waste discharged into the tailing per annum amounts to 14 million tons mixed with 40 million m^3 water. According to Republic of Armenia decisions during 2008-2012, some 102 ha of Artsvanik community lands and 43 ha of private lands were handed over under the disposal of Artsvanik tailing.[11]

Voghji, Pkhrut and Daravazam tailing ponds belonging to the Zangezur copper-molybdenum combine are re-cultivated. The designed volumes of the Voghji, Pkhrut and Daravazam tailing ponds are 35, 3.5 and 3 million m^3, accordingly.

Environmental issues of the community. Kajaran and Artsvanik communities face several environmental issues. As reported, due to regular pipeline leaks, the Zangezur copper-molybdenum combine's wastewater directly percolates into the surface waters and surrounding areas, causing pollution of rivers and agricultural lands.[12]

Based on the monthly and annual reports[13] of the RA Ministry of Nature Protection's Environmental Impact Monitoring Center SNCO, the surface water quality in these communities, particularly Voghji and Artsvanik Rivers, correspond to poor (IV) and bad (V) classes due to high levels of water contamination by heavy metals, such as copper, zinc, molybdenum, vanadium and iron. Based on the report[14] of the Southern Basin Management plan prepared by USAID Clean Energy and Water Project, the Voghji River waters can be used for irrigation of frequently irrigated and leached out soils with good drainage capacity. Waters further downstream on the Artsvanik River can be used for irrigation

[11] The data is given in the report of the Voghji River Basin Management plan preapered by USAID Clean Energy and Water Project.

[12] The information is given in the Voghji River Basin and Southern Basin Management plans preapered by USAID Clean Energy and Water Project.

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

[14] The reports are available at http://www.mendezengland.com/site/index.php/news/312-government-of-armenia-adopts-southern-basin-water-management-plan

purposes only in a case where contact with crop leaves is minimized. In addition, due to high levels of mineralization in the river waters, water use for irrigation purposes becomes impermissible.

According to the final report of "Thorough Risk Assessment of 11 Communities in Armenia" prepared by AUA School of Public Health partnered with the Blacksmith Institute,[15] the soil in Kajaran and Artsvanik communities is contaminated by toxic metals, such as arsenic, chromium and lead.

In addition, a number of NGOs, including the Kapan Aarhus Center, and scientific researches[16] expressed their concerns about air, soil and water pollution in Kajaran and Artsvanik communities. Artsvanik community lacks irrigation water and instead uses the surface water flow originating from the Artsvanik tailing pond. The stakeholders indicate that environmental pollution in these communities pollutes plants and livestock with heavy metals, which increases health risks.[17]

[15] The report is available at http://chsr.aua.am/files/2015/01/TRA-report-_ENG-webpage-June_2015.pdf
[16]The reports are available at
http://www.ysu.am/files/4%20POLLUTION%20LEVEL%20OF%20THE%20MEGHRIGET,%20VOGHCHI%20AND.pdf
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ANNEXES

Annex 1. Population of Kajaran city by age and sex

Age	Total	Male	Female
0-4	498	253	245
5-9	489	256	233
10-14	484	260	224
15-19	504	242	262
20-24	697	333	364
25-29	644	312	332
30-34	557	258	299
35-39	460	230	230
40-44	433	222	211
45-49	463	229	234
50-54	619	291	328
55-59	475	225	250
60-64	270	134	136
65-69	112	49	63
70-74	209	92	117
75-79	122	49	73
80-84	79	38	41
85+	48	16	32
Total	***7163***	***3489***	***3674***

Source: Population Census 2011 for Armenia, National Statistic Service of the Republic of Armenia, http://armstat.am/file/doc/99483288.pdf

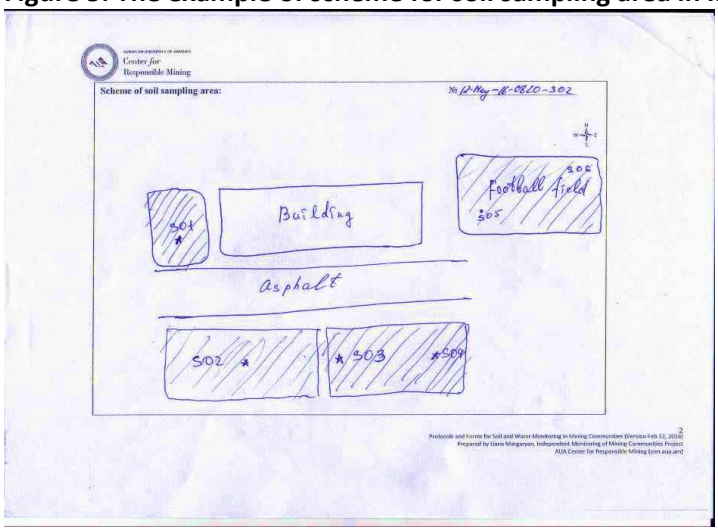
Annex 2. Methodology on Soil Sampling and Testing

The methodology on soil sampling and testing for Kajaran and Artsvanik communities were 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.

Soil sampling. The soil monitoring in the Communities of Kajaran and Artsvanik was implemented during May 2016. A total of 32 soil samples were collected from 2 kindergartens and 3 schools, and 3 reference sampling points (5 cm, 10 cm, 20 cm) for determination of metals' Background Levels in Kajaran community. 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 5). The sampling for BLs determination is given in Annex 6.

Figure 5. The example of scheme for soil sampling area in kindergarten and school



The cardinal sampling layout was used for collecting the soil samples from large sampling sites, such as playfields and gardens of the kindergartens/schools. 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 a special cooler box (under the <6°C condition) for further tests. In the laboratory, the soil samples were stored in the refrigerator, for no more than six months.

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

Soil testing. The concentrations of arsenic, cadmium, copper, lead and mercury in the soil samples were measured with the Metalyser Deluxe HM2000 portable heavy metal analyzer from Trace2o Company, based on Anodic Stripping Voltammetry method, in the AUA Center for Responsible Mining's laboratory. Before starting the measurements, the soil sample was dried in the oven at 100°C, for an hour. Then, the soil sample was 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 3.5 ml was mixed with the appropriate buffer solution and diluted by 60ml deionized water, and analyzed for heavy metal concentration.

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 6 below.

Figure 6. 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 and surface 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.

Sampling. The drinking and surface water samples in the Communities of Kajaran and Artsvanik were collected in May 2016. The representative drinking water sample was collected from the water tap in the Kindergarten №1 in Kajaran city, and 3 surface water samples were collected from the Voghji river upstream and downstream the Kajaran city and Artsvanik river, as well. The water sampling was done according to ISO 5667 and the requirements of the developed protocols and forms.

The collected water samples were labeled and transported to the laboratory in a special cooler box (under the <6 °C) for further tests. In the laboratory, the water samples were 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 samples were measured using the Metalyser Deluxe HM2000 and Metalometer portable heavy metal 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 detected by Anodic Stripping Voltammetry method, as well as copper, manganese, aluminum, boron, chromium (VI), iron and nickel in the water sample were detected by Photometric method. Water sample preparation for the 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, Kajaran city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
12-May-16-0820-s01-01	7.0	55.91	0.69	519.15	26.53	<0.1
12-May-16-0820-s01-02	7.5	69.69	0.46	267.39	18.38	<0.1
12-May-16-0820-s01-03	7.5	34.72	0.30	191.22	12.94	<0.1
12-May-16-0820-s01-04	5.0	62.45	0.47	504.58	44.64	<0.1
12-May-16-0820-s01-05	8.0	22.66	0.34	110.56	47.04	<0.1
Geometric mean	**6.91**	**45.33**	**0.43**	**271.71**	**26.57**	**<0.1**

Secondary school №1, Kajaran city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
12-May-16-0820-s03-01	8.0	41.22	0.32	158.95	21.87	<0.1
12-May-16-0820-s03-02	7.5	65.57	0.19	168.53	17.31	<0.1
12-May-16-0820-s03-03	7.5	44.31	0.34	151.2	20.23	<0.1
12-May-16-0820-s03-04	7.5	70.89	0.18	182.2	16.1	<0.1
12-May-16-0820-s03-05	8.0	74.88	0.28	408.82	65.16	<0.1
12-May-16-0820-s03-06	7.5	78.82	0.29	415.05	68.59	<0.1
Geometric mean	**7.66**	**60.72**	**0.26**	**223.67**	**28.63**	**<0.1**

Secondary school №2, Kajaran city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
12-May-16-0820-s02-01	7.0	30.25	0.13	154.85	20.66	<0.1
12-May-16-0820-s02-02	5.5	46.57	0.58	573.58	27.52	<0.1
12-May-16-0820-s02-03	6.0	50.35	0.693	565.1	28.97	<0.1
12-May-16-0820-s02-04	6.0	52.87	0.66	556.62	30.42	<0.1
12-May-16-0820-s02-05	6.5	44.34	0.5	302.18	42.11	<0.1
12-May-16-0820-s02-06	6.0	41.25	0.47	297.72	40.11	<0.1
Geometric mean	**6.15**	**43.59**	**0.45**	**368.73**	**30.76**	**<0.1**

Kindergarten of Artsvanik village

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
13-May-16-0807-s01-01	7.5	17.50	0.42	318.17	25.26	<0.1
13-May-16-0807-s01-02	7.0	16.77	0.48	132.73	44.30	<0.1
13-May-16-0807-s01-03	7.0	18.13	0.52	143.49	47.90	<0.1
Geometric mean	**7.16**	**17.46**	**0.47**	**182.31**	**37.70**	**<0.1**

Secondary school of Artsvanik village

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
12-May-16-0820-s02-01	8.0	23.06	0.29	85.69	17.30	<0.1
12-May-16-0820-s02-02	7.5	17.27	0.33	52.00	11.85	<0.1
12-May-16-0820-s02-03	7.5	24.79	0.31	92.11	18.42	<0.1
Geometric mean	**7.66**	**21.45**	**0.31**	**74.32**	**15.57**	**<0.1**

Annex 5. Water Monitoring Data

Figure 7. Kajaran city's drinking water test data

Metals	Measurement results, mg/l	Armenian Drinking Water Standard,[20] mg/l	US EPA maximum contaminant levels for Drinking water (MCLs),[21] mg/l
Measured by Electrochemical method			
Cadmium	<0.003	0.001	0.005
Lead	<0.005	0.03	0.015
Arsenic (III)	<0.005	-	-
Arsenic, Total	<0.01	0.05	0.010
Mercury	<0.005	0.0005	0.002
Zinc	<0.005	5.0	-
Copper	<0.005	1.0	1.3
Manganese	<0.005	0.1	-
Measured by Photometric method			
Aluminum	0.01	0.5	1.0
Boron	<0.1	0.5	-
Chromium (VI)	0.04	0.05	0.01
Iron	0.11	0.3	-
Nickel	<0.1	0.1	0.1
Copper	<0.05	1.0	1.3
Manganese	<0.1	0.1	-

Figure 8. Voghji and Artsvanik rivers water tests data

Metals	Measurement results for, mg/l			Armenian background concentration for Voghji River Basin,[22] mg/l
	Sample number 12-May-16-0820-w02	Sample number 12-May-16-0820-w03	Sample number 13-May-16-0807-w04	
	Measured by Electrochemical method			
Cadmium	<0.003	<0.003	<0.003	0.0001
Lead	<0.005	<0.005	<0.005	0.0001
Arsenic (III)	<0.005	<0.005	<0.005	-
Arsenic, Total	<0.001	<0.001	0.003	0.00027
Mercury	<0.005	<0.005	<0.005	-
Zinc	<0.005	<0.005	0.018	0.003
Copper	<0.005	<0.005	0.015	0.004
Manganese	<0.005	<0.005	0.133	0.004
	Measured by Photometric method			
Aluminum	<0.01	0.02	<0.01	0.03
Boron	<0.1	<0.1	<0.1	0.032
Chromium (VI)	<0.02	<0.02	<0.02	0.046*
Iron	0.02	0.12	0.13	0.031
Nickel	<0.1	<0.1	0.2	0.00064
Copper	<0.05	<0.05	<0.05	0.004
Manganese	<0.1	<0.1	0.15	0.004

* defined for total chromium

[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".

[21] The US EPA drinking water MCLs are specified in the National Primary Drinking Water Regulations document that is available at https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants

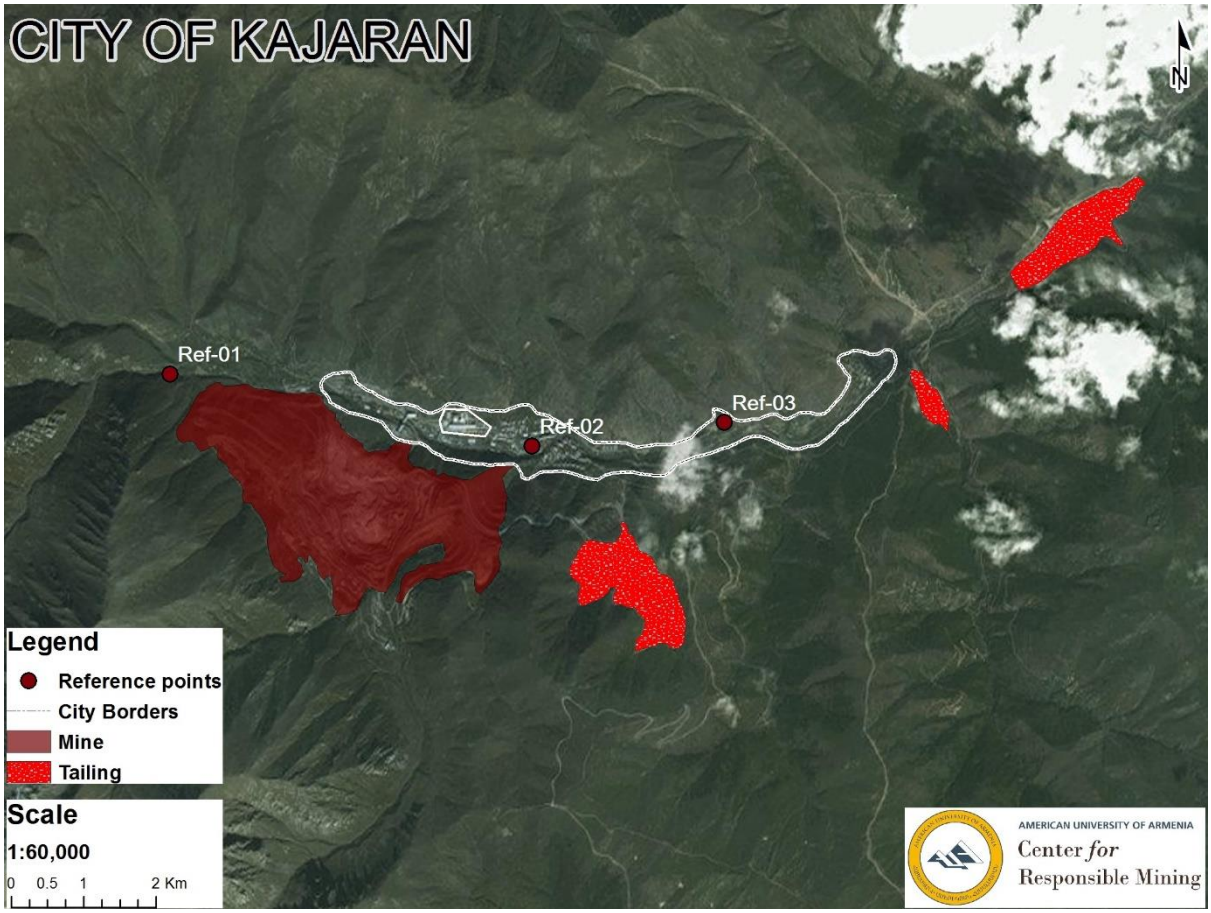
[22] The Armenian background concentrations for Voghji River Basin are specified in the RA Government decision # 75-N adopted on January 27, 2011 "On defining water quality norms for each water basin management area taking into consideration the peculiarities of the Locality".

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

The determination of the background level for each metal in soil of Kajaran city 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.[23] The background reference area was selected by horizontal sampling at depth 5 cm, 10 cm and 20 cm and distance sampling from about 1.7 km out of the city of Kajaran.

In total, 9 reference samples from 5 cm, 10 cm and 20 cm depth were collected from the sites that were located 1.7km out and west of Kajaran city (0820-sRef-01), the public yard near the Kindergarten №1 (0820-sRef-02) and the Saint Astvatsatsin Church in Verin Hand (0820-sRef-03) (Figure 9). The calculation of BLs for each metal are shown the Figure 9 below.

Figure 9. The reference sampling points' location in Kajaran city



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.

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

Figure 10. The calculation of metals' BLs in soil for Kajaran city

Number of sampling point	Metals, mg/kg				
	Arsenic	Cadmium	Copper	Lead	Mercury
Armenian SS	***2***	***-***	***3***	***32***	***2.1***
0820-sRef-01 (5cm)	19.62	0.46	137.35	25.27	<0.1
0820-sRef-01 (10cm)	18.11	0.29	128.62	26.32	<0.1
0820-sRef-01 (20cm)	16.88	0.19	74.10	21.53	<0.1
0820-sRef-02 (5cm)	32.3	0.28	177.88	12.04	<0.1
0820-sRef-02 (10cm)	15.59	0.25	156.23	10.29	<0.1
0820-sRef-02 (20cm)	60.84	0.24	291.15	16.48	<0.1
0820-sRef-03 (5cm)	16.23	0.24	104.36	8.81	<0.1
0820-sRef-03 (10cm)	12.30	0.22	91.02	9.45	<0.1
0820-sRef-03 (20cm)	14.94	0.36	65.11	20.87	<0.1
Number of samples	6	6	6	6	6
Arithmetic mean	23.11	0.26	134.37	17.49	-
Median	16.24	0.25	109.82	18.68	-
Standard deviation	18.59	0.06	84.14	6.68	-
Minimum	12.30	0.19	65.11	9.45	-
Maximum	60.84	0.36	291.15	26.32	-
Lower band	22.0	0.2	121.4	16.1	-
Upper band	34.2	0.3	177.9	20.3	-
Background Level	**28.1**	**0.26**	**149.7**	**18.2**	**<0.1**

Annex 7. Inter-laboratory Comparison Tests Results

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 5 soil samples in the qualified laboratories of RA Ministry of Nature Protection's Environmental Impact Monitoring Center (EIMC) SNCO and EcoAtom LLC research center.

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 both laboratories of EIMC and EcoAtom. The data is provided in Figure 11 below.

Figure 11. 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	***28.1***	***0.26***	***18.2***	***149.7***	***<0.1***
	0820-sRef-01 (10cm)				
AUA CRM	18.11	0.29	26.32	128.62	<0.1
EIMC	21.40	0.25	26.36	63.24	-
	0820sRef-03 (20cm)				
AUA CRM	14.94	0.36	20.87	65.11	<0.1
EcoAtom	9.14	0.23	19.68	96.58	3.27
	Sampling point 12-May-16-0820-s01-05				
AUA CRM	22.66	0.34	47.04	110.56	<0.1
EIMC	12.83	0.64	25.69	270.09	-
	Sampling point 12-May-16-0820-s03-06				
AUA CRM	78.82	0.29	68.59	415.05	<0.1
EcoAtom	11.32	0.36	21.19	2283.02	1.81
	Sampling point 13-May-16-0807-s01-02				
AUA CRM	16.77	0.48	132.73	44.30	<0.1
EIMC	12.46	0.34	16.51	48.06	-

Annex 8. Measurements Exceeding the Armenian and International Soil Standard (SS)[24]

Figure 12. 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	5	100%	100%	0	40%	60%	60%	100%	100%	100%	80%	80%
School №1	6	100%	100%	0	66.7%	66.7%	100%	100%	100%	100%	100%	100%
School №2	6	100%	100%	0	0	16.7%	83.3%	100%	100%	100%	16.7%	100%
Artsvanik Kindergarten	3	100%	100%	0	0	0	0	100%	100%	100%	0	0
Artsvanik School	3	100%	100%	0	0	0	0	100%	100%	100%	0	66.7%

Figure 13. 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	5	-	-	0	0	0	0	60%	0	0	80%	0
School №1	6	-	-	0	0	0	0	0	0	0	16.7%	0
School №2	6	-	-	0	0	0	0	83.3%	0	0	83.3%	0
Artsvanik Kindergarten	3	-	-	0	0	0	0	33.3%	0	0	100%	0
Artsvanik School	3	-	-	0	0	0	0	0	0	0	33.3%	0

(*) Soil standard has not established.

Figure 14. 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	5	100%	100%	40%	60%	-	60%	100%	100%	100%	100%	60%
School №1	6	100%	100%	0	33.3%	-	33.3%	100%	100%	100%	100%	33.3%
School №2	6	100%	100%	50%	83.3%	-	83.3%	100%	100%	100%	100%	83.3%
Artsvanik Kindergarten	3	100%	100%	0	33.3%	-	3.3%	100%	100%	100%	100%	33.3%
Artsvanik School	3	100%	100%	0	0	-	0	0	0	66.7%	66.7%	0

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

Figure 15. 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	5	40%	40%	0	0	0	0	0	0	0	0	0
School №1	6	33.3%	33.3%	0	0	0	0	0	33.3%	0	0	0
School №2	6	33.3%	33.3%	0	0	0	0	0	0	0	0	0
Artsvanik Kindergarten	3	66.7%	66.7%	0	0	0	0	0	0	0	0	0
Artsvanik School	3	0	0	0	0	0	0	0	0	0	0	0

Figure 16. 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	5	0	0	0	0	0	0	0	0	0	0	-
School №1	6	0	0	0	0	0	0	0	0	0	0	-
School №2	6	0	0	0	0	0	0	0	0	0	0	-
Artsvanik Kindergarten	3	0	0	0	0	0	0	0	0	0	0	-
Artsvanik School	3	0	0	0	0	0	0	0	0	0	0	-

Annex 9. Soil Test Results for Each Kindergarten and School

Kindergarten №1, Kajaran city

Kindergarten №1 is located in the central part of Kajaran city. In total, 148 children attend this kindergarten. The distance from the kindergarten to the Zangezur Copper Molybdenum Combine is 0.5 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbeds and playfields that belong to the kindergarten and separated by a fence (Figure 17a, 18b). In total, 5 soil samples were collected that shown in Figures 17b. The soil testing results are presented in Annex 4.

Figure 17. The Kindergarten №1 (a) main view and (b) soil sampling points' location

(a) (b)

Figure 18. The Kindergarten №1 (a) playfield and (b) flowerbed

(a) (b)

The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 11.3-34.8 and 36.9-173.1 times, accordingly. Lead exceeded the Armenian SS by 1.4-1.5 times in 40% (2/5) of all soil samples. The concentrations of cadmium exceeded China's SS by

1.1-2.3 times in all soil samples collected from the kindergarten. China has the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury didn't detect in the soil samples.[25]

School №1, Kajaran city

The Secondary School №1 is located in the central south part of Kajaran city. In total, 574 children attend this school. The distance from the school to the Zangezur Copper Molybdenum Combine is 1 km.

The soil monitoring for School №1 was conducted from soil-covered areas, particularly flowerbeds and the football field of the school (Figure 19a, 20). Six soil samples were collected from the soil-covered ground of School №1, of which the locations are shown on Figure 19b.

Figure 19. The School № 1 (a) main view and (b) soil sampling points' location

(a) (b)

Figure 20. The School № 1 football field

[25] Arsenic, cadmium and copper in all soil samples exceeded the BLs by 1.2-2.5 times, 1.2-2.7 times and 1.3-3.5 times, accordingly. Lead exceeded the BL by 1.5-2.6 times in 60% (3/5) of all soil samples.

Arsenic and copper exceeded the Armenian SS by 20.6-39.4 times and 50.4-138.4 times, accordingly, in all soil samples collected from the soil covered areas of the school. Lead exceeded the Armenian SS by 2.0-2.1 times in 33.3% (2/6) of all soil samples. Cadmium slightly exceeded China's SS by 1.1 times only in one sample. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.[26]

School №2, Kajaran city

The Secondary School №2 is located in the east part of Kajaran city. In total, 409 children attend this school. The school is the nearest to the Zangezur Copper Molybdenum Combine, with a distance of about 0.3 km.

The soil monitoring for School №2 was conducted from soil-covered areas, particularly from flowerbeds and football fields around the school (Figure 21a, 21b, 22). Six soil samples were collected which are shown in Figure 21b.

Figure 21. The School №2 (a) main entrance and (b) soil sampling points' location

(a)

(b)

Figure 22. The School №2 football field

Arsenic and copper exceeded the Armenian SS by 15.1-26.4 times and 51.6-191.2 times, accordingly, in all soil samples collected from the soil covered area of the school. Lead exceeded the Armenian SS by 1.3 times in 33.3% (2/6) of all soil samples. Cadmium exceeded China's SS by 1.6-2.3 times in all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.[27]

[26] Arsenic and copper exceeded the BLs by 1.5-2.8 times and 1.1-2.8 times, accordingly, in all soil samples. Lead and cadmium exceeded the BL by 1.1-1.3 and 1.1-3.8 times, accordingly, in 66.7% (4/6) of all soil samples.

[27] Arsenic, cadmium, copper and lead exceeded the BLs by 1.1-1.9, 1.8-2.7, 1.1-3.8 and 1.1-2.3 times, accordingly, in all soil samples.

Kindergarten in Artsvanik village

The Kindergarten of Artsvanik village is located in the north part of Artsvanik village. Ten children attend this kindergarten. The distance from the kindergarten to the Artsvanik tailing pond is 2.6 km.

The soil monitoring for the kindergarten was conducted from the soil-covered areas, particularly from flowerbeds and playfields that belong to the kindergarten, which are separated by a fence (Figure 23a, 24). Three soil samples were collected that are shown in Figures 23b. The soil testing results are presented in Annex 4.

Figure 23. The Artsvanik's Kindergarten (a) main view and (b) soil sampling points' location

(a) (b)

Figure 24. The Artsvanik Kindergarten's playfield

The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 8.4-9.1 and 44.2-106.1 times, accordingly. Lead exceeded the Armenian SS by 1.4-1.5 times in 66.7% (2/3) of all soil samples. The concentrations of cadmium exceeded China's SS by 1.4-1.7 times in all soil samples collected from the kindergarten. China has the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detected in the soil samples.

School in Artsvanik village

The Secondary School of Artsvanik village is located in the west part of Artsvanik village. Sixty-five children attend this school. The distance from the school to the Artsvanik tailing pond is 2.2 km.

The soil monitoring for the school was conducted from the soil-covered areas, particularly from flowerbeds and football field around the school (Figure 25a, 26). Three soil samples were collected from the soil-covered ground, of which the locations are shown on Figure 25b.

Figure 25. The Artsvanik School (a) main view and (b) soil sampling points' location

(a) (b)

Figure 26. The Artsvanik School's football field

Arsenic and copper exceeded the Armenian SS by 8.6-12.4 times and 17.3-30.7 times, accordingly, in all soil samples collected from the soil covered area of the school. Lead didn't exceed the Armenian SS. Cadmium didn't exceed the most stringent cadmium MAC known to us, China's SS. Mercury was not detected in the soil samples.

Annex 10. Complete Test Results of Soil Samples

Within the inter-laboratory comparison, the complete tests of metals were conducted for 5 soil samples. The total concentrations of 26 metals were measured in the qualified laboratories of RA Ministry of Nature Protection's EIMC SNCO and EcoAtom LLC 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 27.

Figure 27. Complete soil 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 0820-sRef-03(20cm)	Sample number 0820-sRef-01(10cm)	Sample number 12-May-16-0820-s01-05	Sample number 12-May-16-0820-s03-06	Sample number 13-May-16-0822-s01-02					
Antimony	1.03	1.05	1.94	1.34	1.88	4.5	-**	-	-	-
Arsenic	9.15	21.40	12.83	11.32	12.46	2.0	2.0	12	30	22
Barium	857.97	137.90	161.10	72.21	372.76	-	-	-	-	-
Beryllium	n.m.	0.82	0.65	n.m.	1.63	-	-	-	-	-
Bismuth	0.79	n.m.	n.m.	1.14	n.m.	-	-	-	-	-
Cadmium	0.23	0.25	0.64	0.36	0.34	-	3.0	14	0.3	85
Calcium	59526.23	1963.98	6854.87	1315.22	186564.92	-	-	-	-	-
Chromium	42.18	32.68	36.87	10.94	170.20	6.0	25	64	150	230
Cobalt	16.45	9.47	15.78	16.22	35.79	5.0	-	-	-	-
Copper	96.58	63.24	270.09	2283.02	48.06	3.0	100	63	50	250
Iron	56033.32	13847.54	23818.64	20035.93	48400.27	-	-	-	-	-
Lead	19.68	26.36	25.69	21.19	16.51	32.0	60	140	250	400
Lithium	n.m.	4.81	10.73	n.m.	33.03	-	-	-	-	-
Magnesium	15243.20	1315.61	3145.12	677.27	6207.89	-	-	-	-	-
Manganese	1002.33	324.11	476.60	340.60	681.59	700.0	-	-	-	-
Molybdenum	18.98	21.05	107.93	68.63	8.92	-	-	-	-	-
Mercury	3.27			1.81		2.1	1.0	6.6	0.3	-
Nickel	21.71	21.57	38.75	15.16	95.94	4.0	50	50	40	1,600
Potassium	18768.55	14675.98	14593.76	12544.01	10666.49	-	-	-	-	-
Selenium	8.78	3.38	4.45	2.28	5.97	-	-	-	-	-
Sodium	17193.51	3658.21	3662.84	3604.05	16.62	-	-	-	-	-
Strontium	573.52	83.97	70.33	31.53	687.88	-	-	-	-	-
Tin	3.16	1.02	1.65	1.49	0.89	-	-	-	-	-
Titanium	2168.46	1219.04	2233.07	2497.06	3251.72	-	-	-	-	-
Vanadium	114.66	59.24	113.44	145.85	86.59	150.0	-	-	-	-
Zinc	64.87	43.34	68.06	68.52	78.02	23.0	100	200	200	23,000

(*) n.m. stands for not measured
(**) Soil standard has not established.

Arsenic, chromium, cobalt, copper, nickel and zinc exceeded the Armenian SS by 4.6-10.7, 1.8-28.4, 1.9-7.2, 16.0-761.0, 3.8-24.0, 1.9-3.4 times accordingly, in the soil samples collected from the reference sites and soil-covered area of the Kajaran Kindergarten №1 and School №2 and Artsvanik kindergarten. Manganese exceeded the Armenian SS by 1.4 times in the reference soil sample depth 20 cm. Antimony, lead and vanadium didn't exceed the Armenian SS.