



AMERICAN UNIVERSITY OF ARMENIA

Center *for*  
Responsible Mining

## Results of Soil and Water Testing in Kindergartens and Schools of Kapan, Syunik and Achanan Communities, Syunik Marz, Republic of Armenia

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## ABBREVIATIONS

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

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<sup>1</sup> 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 Kajaran, Artsvanik and Agarak in the Syunik Marz.

<sup>2</sup> 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<sup>3</sup> monitoring for heavy-metal pollution in the kindergartens and schools of the City of Kapan and Villages of Syunik and Achanan (Syunik Marz, Republic of Armenia) performed by the American University of Armenia (AUA) Center for Responsible Mining (CRM). Historically, Kapan community is one of the mining centers of Armenia. The city has one of the largest mining companies in Armenia, the “Kapan Mining and Processing Enterprise” with the Kapan copper-pyrite open pit and Shaumyan gold-polymetallic underground mines and Geghanush tailing pond. The communities affected by mining activities are Kapan city and nearby located Syunik and Achanan villages.

The soil monitoring in the Communities of Kapan, Syunik and Achanan was performed for 11 kindergartens, 5 secondary and 6 primary schools.<sup>4</sup> A total of 3917 children study in the kindergartens and schools. Permissions were obtained from authorized bodies to conduct the sampling and testing. This included permissions received 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.<sup>5</sup> A total of 99 soil samples were collected from the playgrounds and exterior common spaces of communities’ kindergartens and schools. Four representative drinking water samples were collected from the water taps in Kindergarten №7, №8, №10 and School №5 in Kapan, and three surface water samples were taken from the Voghji (upstream and downstream Kapan) and Kavart rivers. The soil and 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)<sup>6</sup> for each metal in the soil of Kapan community 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 7 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

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<sup>3</sup> Drinking water and surface water that is used for irrigation were tested. Underground water was not investigated due to a limited amount in the communities.

<sup>4</sup> No samples were collected from two kindergartens (№12 and №5 kindergartens) as they are located in the residential house and don’t have soil-covered area. No samples were collected from №3 secondary school as the site was covered by asphalt. The soil monitoring was not conducted for two high schools (№2 and №9 high schools) in Kapan city as it was deemed that high-school students are less vulnerable to exposure to contaminated soil because of their height and less frequent outdoor playtime.

<sup>5</sup> Protocols used are available at <http://crm.aua.am>.

<sup>6</sup> 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 Kapan, Syunik and Achanan communities. The determination of BL needs further deep investigation (seasonal sampling, soil testing at 50 cm depth).

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 were not detected in Kapan, Syunik and Achanan communities (Annex 5). The drinking water for the communities is supplied from the Geghi river's water spring that are collected in the Geghi Water Treatment plant. The Geghi river's water spring is located at a height of about 2000 m above sea level, 700-800 m upstream of "Geghi" tailing pond and 1,5 km Hankhasar mine that currently doesn't operate and belongs to "Ler-Ex" Ltd. In 2014, the "Armenian Water Supply and Sewerage" CJSC, sponsored by Asian Development Bank, built a new lead-free water supply pipes in these communities.<sup>7</sup> The drinking water in Achanan village is distributed only several hours a day and was not available for sampling during our site visits on 13 May 2016. The results are presented in Figure 8 (Annex 5).

With respect to surface water, the water quality of the Voghji river upstream and downstream of Kapan city corresponds to Good (II) class by copper and manganese and Moderate (III) class by the same metals, accordingly. The water quality of the Kavart river corresponds to Bad (V) class by iron, nickel, copper and manganese. The results are presented in Figure 9 (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 Kapan, Syunik and Achanan communities' kindergartens and schools, % out of exceeding Armenian SS, statistical summary, and international comparatives.**

		Arsenic		Cadmium		Copper		Lead		Mercury	
<i>Armenian Soil Standard (mg/kg)</i>		<b>2</b>		<b>*</b>		<b>3</b>		<b>32</b>		<b>2.1</b>	
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
<b>Kapan city</b>											
Kindergarten №1	4	30.91	100%	0.63	-	215.82	100%	18.33	0%	<0.1	0%
Kindergarten №2	6	14.00	100%	0.14	-	190.56	100%	13.43	0%	<0.1	0%
Kindergarten №4	3	35.38	100%	0.98	-	828.02	100%	45.51	100%	<0.1	0%
Kindergarten №6	5	27.12	100%	0.37	-	564.91	100%	26.35	0%	<0.1	0%
Kindergarten №7	4	12.70	100%	0.16	-	560.47	100%	26.07	0%	<0.1	0%
Kindergarten №8	6	32.19	100%	0.27	-	496.27	100%	35.18	66.7%	<0.1	0%
Kindergarten №9	4	8.59	100%	0.14	-	244.55	100%	34.46	100%	<0.1	0%
Kindergarten №10	3	33.53	100%	0.21	-	185.58	100%	24.50	0%	<0.1	0%
Kindergarten №11	3	13.64	100%	0.35	-	40.57	100%	12.88	0%	<0.1	0%
Kindergarten №13	3	21.16	100%	0.26	-	307.63	100%	17.10	0%	<0.1	0%
School №1	5	22.05	100%	0.34	-	826.58	100%	36.91	100%	<0.1	0%
School №5	9	36.84	100%	0.33	-	567.23	100%	31.31	55.6%	<0.1	0%
School №6	6	39.66	100%	0.57	-	574.14	100%	40.29	100%	<0.1	0%
School №7	5	26.36	100%	0.23	-	325.52	100%	26.31	0%	<0.1	0%
School №8	5	27.91	100%	0.19	-	162.63	100%	20.48	0%	<0.1	0%
School №10	3	29.07	100%	0.16	-	511.41	100%	10.40	0%	<0.1	0%
School №11	5	28.72	100%	0.34	-	330.02	100%	41.04	100%	<0.1	0%

<sup>7</sup> See [http://armwater.am/files/adb/armenian/EMP/VII.%20Syunik\\_EMP-arm/VII.%20Syunik%20EMP%203\\_Kapan%20arm.pdf](http://armwater.am/files/adb/armenian/EMP/VII.%20Syunik_EMP-arm/VII.%20Syunik%20EMP%203_Kapan%20arm.pdf)

		Arsenic		Cadmium		Copper		Lead		Mercury	
<b>Armenian Soil Standard (mg/kg)</b>		<b>2</b>		<b>*</b>		<b>3</b>		<b>32</b>		<b>2.1</b>	
<b>Kindergarten/ School</b>	<b>No. of samples</b>	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
School №12	3	16.63	100%	0.33	-	87.71	100%	13.53	0%	<0.1	0%
School №13	4	13.36	100%	0.16	-	584.08	100%	50.69	100%	<0.1	0%
<b>Syunik village</b>											
Kindergarten	5	50.82	100%	0.74	-	339.47	100%	22.71	0%	<0.1	0%
School	5	24.29	100%	0.20	-	869.95	100%	19.33	0%	<0.1	0%
<b>Achanan village</b>											
School	3	15.94	100%	0.65	-	735.61	100%	20.30	0%	<0.1	0%
<b>Total GM</b>	<b>99</b>	<b>24.46</b>	<b>100%</b>	<b>0.30</b>	<b>-</b>	<b>371.76</b>	<b>100%</b>	<b>25.49</b>	<b>36.4%</b>	<b>&lt;0.1</b>	<b>0%</b>
<b>Standard deviation</b>	<b>-</b>	<b>10.80</b>	<b>-</b>	<b>0.24</b>	<b>-</b>	<b>232.92</b>	<b>-</b>	<b>10.80</b>	<b>-</b>	<b>&lt;0.1</b>	<b>-</b>
<b>Minimum</b>	<b>-</b>	<b>8.35</b>	<b>-</b>	<b>0.11</b>	<b>-</b>	<b>35.28</b>	<b>-</b>	<b>9.74</b>	<b>-</b>	<b>&lt;0.1</b>	<b>-</b>
<b>Maximum</b>	<b>-</b>	<b>56.53</b>	<b>-</b>	<b>1.43</b>	<b>-</b>	<b>897.70</b>	<b>-</b>	<b>52.76</b>	<b>-</b>	<b>&lt;0.1</b>	<b>-</b>
<b>Background level***</b>	<b>9</b>	<b>16.7</b>		<b>0.31</b>		<b>103.8</b>		<b>21.0</b>		<b>&lt;0.1</b>	
International maximum allowable concentrations (mg/kg)****											
<i>Russia</i>		2		-		3		30		2.1	
<i>Belgium</i>		110		6		400		700		15	
<i>Netherlands</i>		55		12		190		530		10	
<i>Germany</i>		50		20		-		400		20	
<i>France</i>		37		20		190		400		7	
<i>Sweden</i>		15		0.4		100		80		1	
<i>Norway</i>		2		3		100		60		1	
<i>Canada</i>		12		14		63		140		6.6	
<i>China</i>		30		0.3		50		250		0.3	
<i>US EPA screening level</i>		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 8.35 to 56.53 mg/kg. The geometric means (GMs) of all samples exceeded the Armenian Soil Standard (SS)<sup>8</sup> by 12.2 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 Kapan, Syunik and Achanan communities 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 these communities is 16.7 mg/kg. The GM of all soil samples exceeded the BL by 1.5 times. Based on our current level of BL analysis, it is not possible for us to link the level of

<sup>8</sup> 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.

arsenic in the soil to industrial and mineral processing activities in the communities. 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 Kapan, Syunik and Achanan 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 0.11 to 1.43 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 Kapan, Syunik and Achanan communities’ soil shows an average of 0.313 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.

- **Copper** concentrations ranged from 35.28 to 897.70 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 123.9 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 103.8 mg/kg for copper in these communities, significantly higher than Armenian SS. The GM mean for all samples exceeded the BL for copper by 3.6 times.

Our findings, however, compel us to conclude that copper is a heavy metal of concern in the Kapan, Syunik and Achanan 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,<sup>9</sup> even though they are toxic to aquatic organisms. While it may be reasonably argued that soil

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<sup>9</sup> <http://www.atsdr.cdc.gov/phs/phs.asp?id=204&tid=37#bookmark06> accessed April 22, 2016.

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 9.74 to 52.76 mg/kg. The Armenian SS for lead is 32 mg/kg. This is one 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 slightly exceeded the Armenian SS by 1.1-1.7 times in 36.4% (36/99) of soil samples.

It should be noted that our analysis shows a background level for lead in these communities is 21.0 mg/kg, about 1.5 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 Kapan, Syunik and Achanan 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 Kapan, Syunik and Achanan 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 Kavart rivers pollution by heavy metals due to mining activity and its suitability for irrigation in the communities.
- Apply this study method for other parts of Kapan, Syunik and Achanan 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 Kapan, Syunik and Achanan 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 KAPAN, SYUNIK AND ACHANAN COMMUNITIES

**Kapan Community.** The City of Kapan is the Syunik Marz capital, the largest city in the region. The city is located in the south-east part of Armenia, at the northern slope of Khustup Mountain, at a height of 750-1050 m above sea level, about 320 km south of the City of Yerevan and 80 km from the border of Armenia and Iran (Figure 2). The city stretches for 13 km from east to west, at the southeastern slopes of the Zangezur Mountain Range. Voghji and Vachagan rivers flow through the center of the city. The ore mining and processing plant operates in Kapan city (Figure 3). A lot of commercial entities and individual businesses for food industry, public food, domestic services operate in the community area.

Kapan is an old city that was first mentioned in the 5th century as a small settlement. It was formed as an urban community during the 19th century. In 1938, Kapan was given the status of a city, later in 1995, it became as the Syunik Marz capital.

**Figure 2. The location of Kapan, Syunik and Achanan communities in Armenia**



**Syunik Community.** The Village of Syunik is located 6 km far from Kapan city, at a height of 720 m above sea level (Figure 2). The administrative territory of the village is 2,217 hectares, of which 956 hectares (43.1%) is agricultural land. The village was settled in 1900, when the exploitation of copper-molybdenum mine was started by French. During 1926-1958 the settlement was supplementary part of Kapan Mining and Processing Combine. In 1982, it was separated from Kapan city and became the village.

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

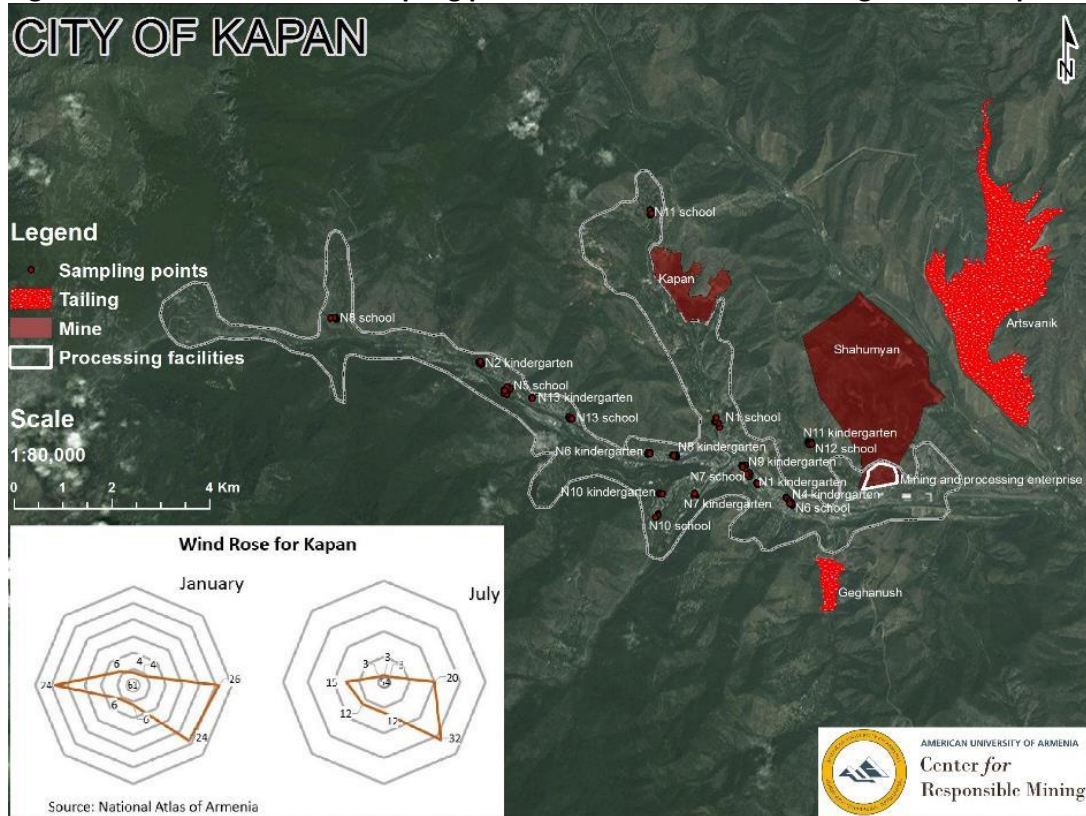
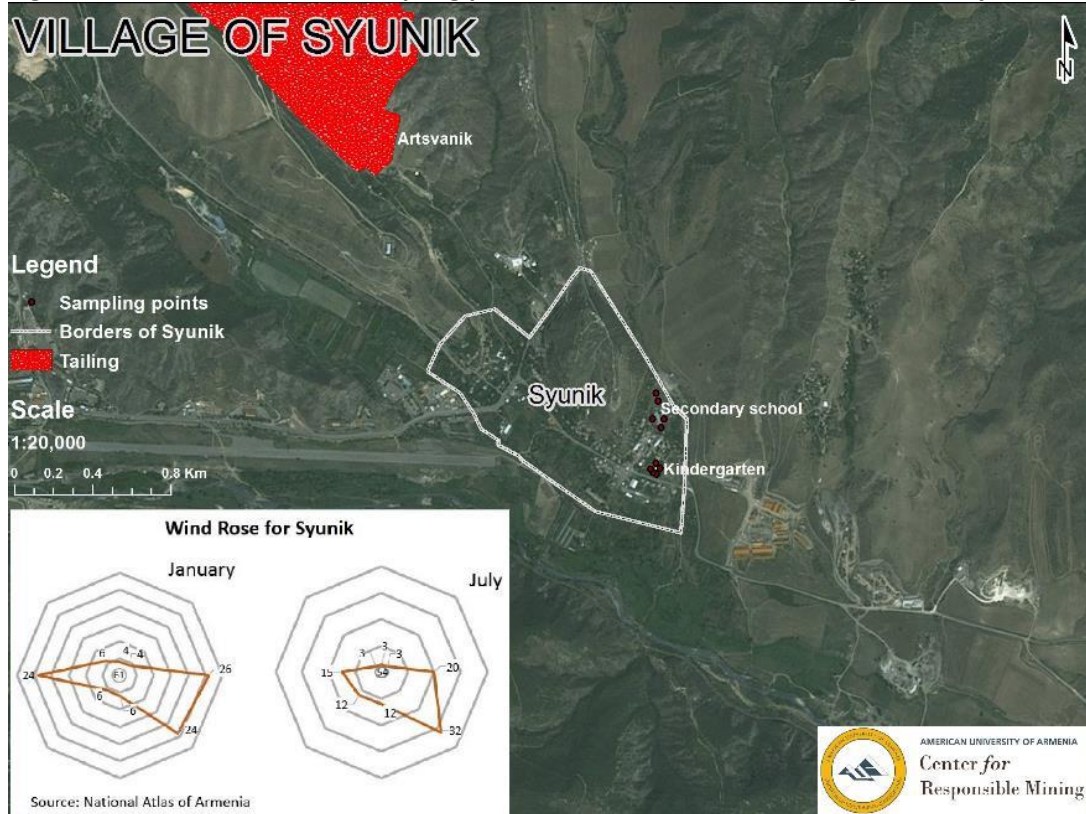
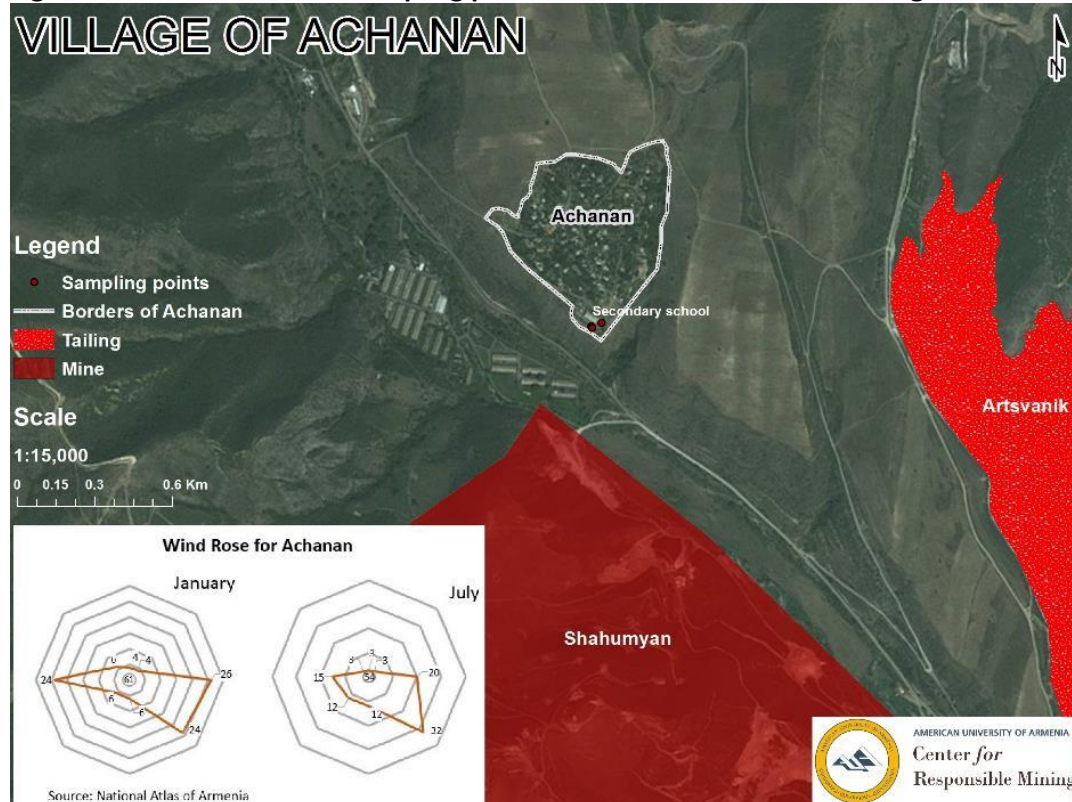


Figure 4. Wind rose and soil sampling points of the school and kindergarten in Syunik village



**Achanan Community.** The Village of Achanan is located in the Norashenik river (the tributary of Voghji river) valley, 13 km far from Kapan city, at a height of 880 m above sea level (Figure 2). The administrative territory of the village is 800 hectares, of which 440 hectares (55%) is agricultural land. The Village has an old history. It was first called Khaladzh, and after recalled Achanan. In the 1980s, it was inhabited by immigrants from Baku.

**Figure 5. Wind rose and soil sampling points of the school in Achanan village**



**Climate and landscapes.** Kapan, Syunik and Achanan are located in a continental climate zone and are characterized by subtropical climate features with warm summers and relatively calm winters (Figure 2). The communities are situated in the east-to-west air flow movement region. The average annual temperature is +12.1°C. The average temperature is 22.3°C during the summer months with the absolute maximum of +42.0°C, while during winter months the temperature reaches 1.8°C with the absolute minimum of -22.0°C. The annual precipitation level is 605mm. The average annual number of freeze-free days is 220. The multi-year average sunshine duration is 2300 hours.

The communities of Kapan Syunik and Achanan are located in lower and middle mountain forest belts landscape zone, which is characterized by moderately cold forest with predominance of xerophilous sparse forests and shibliak bushes. The majority of the mountain slopes and river valleys of Kapan, Syunik and Achanan communities are oriented towards east, thus, the air masses penetrating from the east become cooler with height resulting in the increase of relative air humidity. The western slopes are characterized by small-scale precipitations. East-facing slopes of Bargushat branches are forested, which is conditioned by higher humidity level as compared to west- and north- facing slopes which are generally devoid of forests (Figure 3, 4, 5).

**Wind patterns.** Geodesy and Cartography Center SNCO prepares the wind rose<sup>10</sup> for Kapan City and near Villages of Syunik and Achanan based on long-term meteorological data. The wind roses indicate that the 24-32% of total winds over the year are in the west to east and southeast direction (Figure 3, 4, 5).

**Population.** As of the 2011 census, the permanent population of the Kapan city is 43,190 with 21,091 males and 22,099 females. The population in the age group 0-19 is 9,762 (Annex 1). The permanent population of the Syunik and Achanan villages is 1294 and 183 of each.

**Industry.** The first exploitation of copper-molybdenum mines in the Kapan community was started by the Greeks in 1840 and the Kapan Mining and Processing Combine was built. After the liquidation of the combine, the operation of copper-molybdenum mines is carried out by the “Deno Gold Mining Company” CJSC, which renamed as a “Dundee Precious Metals Kapan” CJSC in 2013. The company had a capacity to develop 1 million tons of ore and exploited the Kapan copper-pyrite open pit and Shaumyan gold-polymetallic underground mines. In 2009, the company refused to the permit for the operation of Kapan mine.<sup>11</sup> Since 2016, the Polymetal International plc has entered into binding agreements with Dundee Precious Metals Inc. for the acquisition of "Dundee Precious Metals Kapan" CJSC and renamed the plant as "Kapan Mining and Processing Enterprise".<sup>12</sup>

**Photograph 1. Mining industry (a) Shahumyan mine and (b) Geghanush tailing pond in Kapan city, Syunik Marz**



(a)



(b)

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

The Kapan mine is located near Kapan city, at Kavart River basin, and has about 23 ha mine reserves that is not operated in present. Currently, “Kapan Mining and Processing Enterprise” company operates only Shahumyan mine that is located 4-5 km north-east from Kapan city between Voghji and

<sup>10</sup> The wind rose map for Kapan, Syunik and Achanan communities was given in the National Atlas of Armenia, prepared by Geodesy and Cartography SNCO. 2007.

<sup>11</sup> The information is provided at

<http://www.dundeeprecious.com/>

[http://www.armeniatree.org/thethreat/resources/2012\\_Zoi\\_Environment\\_Network\\_Mining\\_in\\_Armenia.pdf](http://www.armeniatree.org/thethreat/resources/2012_Zoi_Environment_Network_Mining_in_Armenia.pdf)

<sup>12</sup> The information is provided at

[http://www.polymetalinternational.com/investors-and-media/news/2016/2016-03-01.aspx?sc\\_lang=EN](http://www.polymetalinternational.com/investors-and-media/news/2016/2016-03-01.aspx?sc_lang=EN)

Kavart rivers. The approved mine reserves are around 255.87 ha, with the following average metal content: 0.64% of copper, 3.29% of zinc, 0.26% of mercury, 4.1g/t of gold and 68.4g/t of silver.<sup>13</sup>

The waste rocks of the company were located east of the mine in two ravines at Kavart river basin, one near Kapan city and the other in Achanan community of Norashenik river basin. The company's wastewater system has closed water cycle, and ore leach solutions are transported to the Geghanush tailing pond via pipeline. Geghanush tailing is located at Geghanush river gorge. The tailing capacity is designed at 8.7 million m<sup>3</sup>, according to the old EIA, while according to the new one it is 11.33 million m<sup>3</sup>. According to actual data, tailing volume makes up 4.6 million m<sup>3</sup> on 32 ha area, of which 2.5 million m<sup>3</sup> is already filled.<sup>14</sup>

**Environmental issues of the community.** Kapan, Syunik and Achanan communities face several environmental issues. Based on the monthly and annual reports<sup>15</sup> of the RA Ministry of Nature Protection's Environmental Impact Monitoring Center SNCO, the surface water quality in these communities, particularly Voghji river, correspond to 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<sup>16</sup> of the Southern Basin Management plan prepared by USAID Clean Energy and Water Project, the Voghji and Norashenik rivers waters can be used for irrigation of frequently irrigated and leached out soils with good drainage capacity. Waters further downstream on the Kavart river cannot be used for irrigation purposes, due to high levels of mineralization and toxic metals in the river waters. The report indicates that, due to snowmelt and downpours during the spring freshet and summer floods, large amounts of harmful substances are being washed and transported to rivers that leads to the impermissibility the water use for irrigation.

**Photograph 2. Environmental impact of mining (a) Kapan mine in Kavart and (b) Voghji river in Kapan city, Syunik Marz**



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

<sup>13</sup> 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.

<sup>14</sup> The data is given in the report of the Voghji River Basin Management plant prepared by USAID Clean Energy and Water Project.

<sup>15</sup> The reports are available at <http://www.armmonitoring.am/>

<sup>16</sup> The reports are available at <http://www.mendezengland.com/site/index.php/news/312-government-of-armenia-adopts-southern-basin-water-management-plan>

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,<sup>17</sup> the soil in Kapan and Syunik 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 reports<sup>18</sup> expressed their concerns about air, soil and water pollution in Kapan, Syunik and Achanan communities. 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<sup>19</sup>, there have been numerous incidents of animals grazing in adjacent fields near Geghanush tailing pond, as well as there is a point of leakage with yellowish waste opening in the community road from directly under the tailing dump.

The evidence showed that, usually, the surface flows, formed from the Kapan open mine waste dump area, discharge into Voghji river through Kavart tributary near Kapan town resulting in contamination of not only Voghji river waters, but also the central part of Kapan town.<sup>20</sup>

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<sup>17</sup> The report is available at [http://chsr.aa.am/files/2015/01/TRA-report-ENG-webpage-June\\_2015.pdf](http://chsr.aa.am/files/2015/01/TRA-report-ENG-webpage-June_2015.pdf)

<sup>18</sup>The reports are available at

<http://www.yso.am/files/4%20POLLUTION%20LEVEL%20OF%20THE%20MEGHRIGET,%20VOGHCHI%20AND.pdf>

<http://www.ecolor.org/hy/news/mining/public-discussions-of-another-project-by-vdeno-gold-mining-companyv-cjsc-in-kapan/2690/>

<https://ecolor.org/en/an/shahumyan-gold-and-polymetallic-deposit/51/>

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<http://fleg1.enpi->

[fleg.org/fileadmin/ufs/04.%20Program%20Information/4.02%20Program%20Components/4.02.05%20Public%20Awareness/Armenia\\_FLR\\_Report\\_GIZ.pdf](fleg.org/fileadmin/ufs/04.%20Program%20Information/4.02%20Program%20Components/4.02.05%20Public%20Awareness/Armenia_FLR_Report_GIZ.pdf)

[http://aarhus.am/publications/5\\_eng\\_monitoring\\_kapan\\_hashvetvwutyun\\_eng.pdf](http://aarhus.am/publications/5_eng_monitoring_kapan_hashvetvwutyun_eng.pdf)

<sup>19</sup> 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.

<sup>20</sup> The reports are available at

<http://www.aravot.am/2013/04/22/234246/>

<http://www.armecofront.net/mamlo-haghordagrutyunner/kavarti-lqvac-hanqavair/#>

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## ANNEXES

## Annex 1. Population of Kapan city by age and sex

<b>Age</b>	<b>Total</b>	<b>Male</b>	<b>Female</b>
0-4	2614	1372	1242
5-9	2380	1281	1099
10-14	2217	1093	1124
15-19	2551	1320	1231
20-24	3931	2015	1916
25-29	4124	2097	2027
30-34	3409	1730	1679
35-39	2763	1350	1413
40-44	2411	1161	1250
45-49	3190	1480	1710
50-54	3911	1832	2079
55-59	3158	1461	1697
60-64	2066	956	1101
65-69	946	426	520
70-74	1512	644	868
75-79	1011	456	555
80-84	666	302	364
85+	330	106	224
<b>Total</b>	<b>43190</b>	<b>21091</b>	<b>22099</b>

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

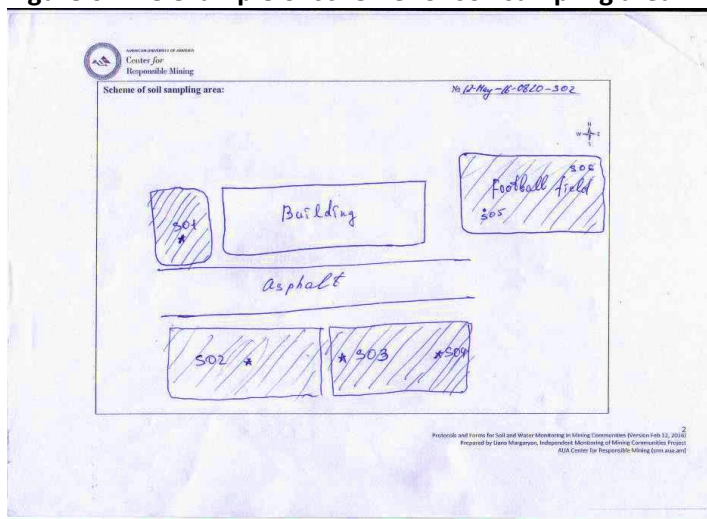
## Annex 2. Methodology on Soil Sampling and Testing

The methodology on soil sampling and testing for Kapan, Syunik and Achanan communities were based on the appropriate standard protocols and forms developed by the AUA Center for Responsible Mining based on international standards and guidance<sup>21</sup>, 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 Kapan, Syunik and Achanan was implemented during May 2016. A total of 108 soil samples were collected from 11 kindergartens and 11 schools, and 3 reference sampling points (5 cm, 10 cm, 20 cm) for determination of metals' Background Levels. The soil sampling was done according to ISO 10381 and the requirements of the developed protocols and forms.

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

**Figure 6. 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.

<sup>21</sup>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 7 below.

**Figure 7. The LOD’s range for each metal.**

<b>Metal</b>	<b>LOD’s range (mg/kg)</b>
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.

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

- 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 surface and drinking water sampling and testing is based on the appropriate standard protocols and forms<sup>22</sup> 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 Kapan, Syunik and Achanan were collected in May 2016. Four representative drinking water samples were collected from the water taps in the Kindergarten №7, №8, №10 and School №5 in Kapan city, and 3 surface water samples were collected from the Voghji river upstream and downstream the Kapan city and Kavart 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.

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<sup>22</sup> Protocols used are available at <http://crm.aul.am>.

## Annex 4. Soil Independent Monitoring Data

### Kindergarten №1, Kapan city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
18-May-16-0822-s18-01	7.0	39.10	0.56	258.95	16.55	<0.1
18-May-16-0822-s18-02	7.5	37.14	0.60	251.18	17.79	<0.1
18-May-16-0822-s18-03	8.0	24.19	0.66	178.24	20.37	<0.1
18-May-16-0822-s18-04	7.5	26.00	0.71	187.15	18.84	<0.1
<b>Geometric mean</b>	<b>7.49</b>	<b>30.91</b>	<b>0.63</b>	<b>215.82</b>	<b>18.33</b>	<b>&lt;0.1</b>

### Kindergarten №2, Kapan city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
17-May-16-0822-s09-01	6.0	15.19	0.11	191.34	14.48	<0.1
17-May-16-0822-s09-02	3.0	16.88	0.15	201.41	15.66	<0.1
17-May-16-0822-s09-03	5.5	15.61	0.13	195.37	13.31	<0.1
17-May-16-0822-s09-04	5.5	12.84	0.14	188.32	12.99	<0.1
17-May-16-0822-s09-05	4.5	11.67	0.17	181.27	11.81	<0.1
17-May-16-0822-s09-06	7.0	12.54	0.16	186.30	12.69	<0.1
<b>Geometric mean</b>	<b>5.08</b>	<b>14.00</b>	<b>0.14</b>	<b>190.56</b>	<b>13.43</b>	<b>&lt;0.1</b>

### Kindergarten №4, Kapan city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
18-May-16-0822-s20-01	7.5	37.18	0.97	826.65	46.62	<0.1
18-May-16-0822-s20-02	7.0	35.41	1.03	835.00	44.41	<0.1
18-May-16-0822-s20-03	8.0	33.63	0.95	822.47	45.52	<0.1
<b>Geometric mean</b>	<b>7.49</b>	<b>35.38</b>	<b>0.98</b>	<b>828.02</b>	<b>45.51</b>	<b>&lt;0.1</b>

### Kindergarten №6, Kapan city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
17-May-16-0822-s13-01	3.0	30.41	0.38	551.47	27.43	<0.1
17-May-16-0822-s13-02	6.0	32.88	0.41	557.10	26.12	<0.1
17-May-16-0822-s13-03	6.0	31.24	0.39	561.30	24.81	<0.1
17-May-16-0822-s13-04	6.5	22.45	0.35	574.69	26.10	<0.1
17-May-16-0822-s13-05	7.5	20.93	0.33	580.50	27.36	<0.1
<b>Geometric mean</b>	<b>5.55</b>	<b>27.12</b>	<b>0.37</b>	<b>564.91</b>	<b>26.35</b>	<b>&lt;0.1</b>

### Kindergarten №7, Kapan city

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
18-May-16-0822-s15-01	6.5	12.38	0.14	552.9	25.93	<0.1
18-May-16-0822-s15-02	7.5	12.75	0.16	569.49	24.63	<0.1
18-May-16-0822-s15-03	6.5	12.57	0.15	558.43	27.48	<0.1
18-May-16-0822-s15-04	8.0	13.12	0.18	561.19	26.31	<0.1
<b>Geometric mean</b>	<b>7.10</b>	<b>12.70</b>	<b>0.16</b>	<b>560.47</b>	<b>26.07</b>	<b>&lt;0.1</b>

**Kindergarten №8, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
17-May-16-0822-s14-01	6.5	34.14	0.29	501.2	37.8	<0.1
17-May-16-0822-s14-02	4.5	35.77	0.33	506.83	39.64	<0.1
17-May-16-0822-s14-03	6.5	36.88	0.31	511.43	40.87	<0.1
17-May-16-0822-s14-04	6.5	35.04	0.26	503.76	38.82	<0.1
17-May-16-0822-s14-05	6.0	29.08	0.24	482.53	29.27	<0.1
17-May-16-0822-s14-06	7.5	24.24	0.21	473.07	27.23	<0.1
<b>Geometric mean</b>	<b>6.18</b>	<b>32.19</b>	<b>0.27</b>	<b>496.27</b>	<b>35.18</b>	<b>&lt;0.1</b>

**Kindergarten №9, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
18-May-16-0822-s16-01	7.5	8.97	0.12	251.23	34.15	<0.1
18-May-16-0822-s16-02	7.5	8.6	0.14	245.25	33.8	<0.1
18-May-16-0822-s16-03	8.0	8.47	0.13	242.61	34.68	<0.1
18-May-16-0822-s16-04	8.0	8.35	0.16	239.27	35.21	<0.1
<b>Geometric mean</b>	<b>7.75</b>	<b>8.59</b>	<b>0.14</b>	<b>244.55</b>	<b>34.46</b>	<b>&lt;0.1</b>

**Kindergarten №10, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
16-May-16-0822-s08-01	5.5	33.81	0.21	187.15	25.29	<0.1
16-May-16-0822-s08-02	7.0	32.20	0.19	178.24	23.53	<0.1
16-May-16-0822-s08-03	6.5	34.62	0.23	191.60	24.71	<0.1
<b>Geometric mean</b>	<b>6.30</b>	<b>33.53</b>	<b>0.21</b>	<b>185.58</b>	<b>24.50</b>	<b>&lt;0.1</b>

**Kindergarten №11, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
16-May-16-0822-s05-01	7.5	12.90	0.35	35.28	12.00	<0.1
16-May-16-0822-s05-02	7.0	13.87	0.32	40.57	12.9	<0.1
16-May-16-0822-s05-03	7.0	14.19	0.37	46.66	13.8	<0.1
<b>Geometric mean</b>	<b>7.16</b>	<b>13.64</b>	<b>0.35</b>	<b>40.57</b>	<b>12.88</b>	<b>&lt;0.1</b>

**Kindergarten №13, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
17-May-16-0822-s12-01	6.5	21.97	0.27	308.15	18.25	<0.1
17-May-16-0822-s12-02	5.5	21.3	0.26	311.19	16.13	<0.1
17-May-16-0822-s12-03	6.5	20.25	0.25	303.6	16.98	<0.1
<b>Geometric mean</b>	<b>6.15</b>	<b>21.16</b>	<b>0.26</b>	<b>307.63</b>	<b>17.10</b>	<b>&lt;0.1</b>

**School №1, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
19-May-16-0822-s21-01	6.5	21.4	0.35	829.09	35.94	<0.1
19-May-16-0822-s21-02	6.5	22.78	0.37	837.3	38.7	<0.1
19-May-16-0822-s21-03	7.5	22.35	0.32	833.19	37.41	<0.1
19-May-16-0822-s21-04	3.0	21.7	0.3	820.88	36.86	<0.1
19-May-16-0822-s21-05	6.5	22.03	0.34	812.67	35.74	<0.1
<b>Geometric mean</b>	<b>5.73</b>	<b>22.05</b>	<b>0.34</b>	<b>826.58</b>	<b>36.91</b>	<b>&lt;0.1</b>

**School №5, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
18-May-16-0822-s10-01	8.0	37.27	0.33	552.84	28.84	<0.1
18-May-16-0822-s10-02	7.0	35.5	0.34	558.43	27.47	<0.1
18-May-16-0822-s10-03	7.5	38.57	0.31	578.06	33.45	<0.1
18-May-16-0822-s10-04	7.5	38.17	0.32	580.93	33.78	<0.1
18-May-16-0822-s10-05	7.5	39.37	0.29	575.18	32.96	<0.1
18-May-16-0822-s10-06	7.0	35.49	0.37	567.3	32.11	<0.1
18-May-16-0822-s10-07	7.5	36.42	0.35	573.85	35.49	<0.1
18-May-16-0822-s10-08	7.5	37.36	0.36	569.3	33.8	<0.1
18-May-16-0822-s10-09	7.5	33.72	0.31	550.05	25.41	<0.1
<b>Geometric mean</b>	<b>7.44</b>	<b>36.84</b>	<b>0.33</b>	<b>567.23</b>	<b>31.31</b>	<b>&lt;0.1</b>

**School №6, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
18-May-16-0822-s19-01	6.5	40.65	0.55	562.8	39.8	<0.1
18-May-16-0822-s19-02	7.0	40.24	0.57	568.5	39.21	<0.1
18-May-16-0822-s19-03	7.0	39.84	0.56	574.18	40.39	<0.1
18-May-16-0822-s19-04	7.0	39.63	0.59	579.87	41.05	<0.1
18-May-16-0822-s19-05	7.0	39.43	0.58	577.03	40.45	<0.1
18-May-16-0822-s19-06	7.5	38.23	0.6	582.71	40.85	<0.1
<b>Geometric mean</b>	<b>6.99</b>	<b>39.66</b>	<b>0.57</b>	<b>574.14</b>	<b>40.29</b>	<b>&lt;0.1</b>

**School №7, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
17-May-16-0822-s17-01	7.0	26.45	0.24	326.19	26.27	<0.1
17-May-16-0822-s17-02	7.5	25.19	0.22	324.57	24.44	<0.1
17-May-16-0822-s17-03	6.0	27.71	0.23	329.44	28.1	<0.1
17-May-16-0822-s17-04	6.0	28.21	0.25	327.79	29.5	<0.1
17-May-16-0822-s17-05	6.0	24.43	0.2	319.7	23.7	<0.1
<b>Geometric mean</b>	<b>6.47</b>	<b>26.36</b>	<b>0.23</b>	<b>325.52</b>	<b>26.31</b>	<b>&lt;0.1</b>

**School №8, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
16-May-16-0822-s03-01	6.0	28.24	0.18	148.11	20.82	<0.1
16-May-16-0822-s03-02	6.5	28.56	0.19	145.15	19.77	<0.1
16-May-16-0822-s03-03	6.0	27.2	0.16	137.78	18.93	<0.1
16-May-16-0822-s03-04	7.0	26.52	0.17	144.67	19.88	<0.1
16-May-16-0822-s03-05	6.5	29.13	0.28	265.48	23.28	<0.1
<b>Geometric mean</b>	<b>6.39</b>	<b>27.91</b>	<b>0.19</b>	<b>162.63</b>	<b>20.48</b>	<b>&lt;0.1</b>

**School №10, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
16-May-16-0822-s07-01	6.5	27.42	0.16	520.82	10.47	<0.1
16-May-16-0822-s07-02	4.5	28.87	0.15	510.61	9.74	<0.1
16-May-16-0822-s07-03	6.0	31.03	0.17	502.95	11.02	<0.1
<b>Geometric mean</b>	<b>5.60</b>	<b>29.07</b>	<b>0.16</b>	<b>511.41</b>	<b>10.40</b>	<b>&lt;0.1</b>



**School №11, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
16-May-16-0822-s04-01	7.0	29.96	0.36	340.8	42.22	<0.1
16-May-16-0822-s04-02	7.5	28.53	0.34	324.57	41.8	<0.1
16-May-16-0822-s04-03	7.0	29.38	0.35	329.44	40.96	<0.1
16-May-16-0822-s04-04	8.0	27.67	0.31	321.32	40.54	<0.1
16-May-16-0822-s04-05	7.5	28.1	0.33	334.31	39.71	<0.1
<b>Geometric mean</b>	<b>7.39</b>	<b>28.72</b>	<b>0.34</b>	<b>330.02</b>	<b>41.04</b>	<b>&lt;0.1</b>

**School №12, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
16-May-16-0822-s06-01	7.0	15.81	0.36	87.9	14.58	<0.1
16-May-16-0822-s06-02	7.0	16.65	0.33	95.03	13.56	<0.1
16-May-16-0822-s06-03	7.0	17.48	0.31	80.77	12.54	<0.1
<b>Geometric mean</b>	<b>7.00</b>	<b>16.63</b>	<b>0.33</b>	<b>87.71</b>	<b>13.53</b>	<b>&lt;0.1</b>

**School №13, Kapan city**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
17-May-16-0822-s11-01	7.0	13.75	0.16	574.7	48.8	<0.1
17-May-16-0822-s11-02	3.0	14.08	0.18	589.2	50.12	<0.1
17-May-16-0822-s11-03	7.0	13.1	0.15	580.5	52.76	<0.1
17-May-16-0822-s11-04	5.5	12.58	0.14	592.1	51.18	<0.1
<b>Geometric mean</b>	<b>5.33</b>	<b>13.36</b>	<b>0.16</b>	<b>584.08</b>	<b>50.69</b>	<b>&lt;0.1</b>

**Syunik Kindergarten**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
13-May-16-0839-s01-01	5.5	56.53	1.41	481.67	27.24	<0.1
13-May-16-0839-s01-02	5.0	55.7	1.43	476.9	25.94	<0.1
13-May-16-0839-s01-03	4.5	45.23	0.49	271.9	20.46	<0.1
13-May-16-0839-s01-04	8.8	47.61	0.46	258.95	19.49	<0.1
13-May-16-0839-s01-05	5.7	49.99	0.48	278.73	21.43	<0.1
<b>Geometric mean</b>	<b>5.74</b>	<b>50.82</b>	<b>0.74</b>	<b>339.47</b>	<b>22.71</b>	<b>&lt;0.1</b>

**Syunik School**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
13-May-16-0839-s02-01	8.0	27.74	0.23	851.5	20.24	<0.1
13-May-16-0839-s02-02	6.0	29.2	0.24	860.1	21.31	<0.1
13-May-16-0839-s02-03	8.0	20.18	0.19	888.72	19.37	<0.1
13-May-16-0839-s02-04	7.5	19.22	0.18	897.7	18.45	<0.1
13-May-16-0839-s02-05	3.5	26.93	0.17	852.81	17.53	<0.1
<b>Geometric mean</b>	<b>6.32</b>	<b>24.29</b>	<b>0.20</b>	<b>869.95</b>	<b>19.33</b>	<b>&lt;0.1</b>

**Achanan Shcool**

Sampling point №	pH	Arsenic, mg/kg	Cadmium, mg/kg	Copper, mg/kg	Lead, mg/kg	Mercury, mg/kg
13-May-16-0801-s01-01	7.0	17.16	0.64	710.4	22.03	<0.1
13-May-16-0801-s01-02	7.5	15.97	0.7	768	20.35	<0.1
13-May-16-0801-s01-03	6.0	14.77	0.61	729.6	18.67	<0.1
<b>Geometric mean</b>	<b>6.80</b>	<b>15.94</b>	<b>0.65</b>	<b>735.61</b>	<b>20.30</b>	<b>&lt;0.1</b>

## Annex 5. Water Monitoring Data

**Figure 8. Kapan city's drinking water test data**

Metals	Measurement results, mg/l				Armenian Drinking Water Standard, <sup>23</sup> mg/l	US EPA maximum contaminant levels for Drinking water (MCLs), <sup>24</sup> mg/l
	Sample number 18-May-16-0822-w01	Sample number 21-Aug-16-0822-w02	Sample number 21-Aug-16-0822-w03	Sample number 21-Aug-16-0822-w03		
	<i>Measured by Electrochemical method</i>					
Cadmium	<0.003	<0.003	<0.003	<0.003	0.001	0.005
Lead	<0.005	<0.005	<0.005	<0.005	0.03	0.015
Arsenic (III)	<0.005	<0.005	<0.005	<0.005	-	-
Arsenic, Total	<0.01	<0.01	<0.01	<0.01	0.05	0.010
Mercury	<0.005	<0.005	<0.005	<0.005	0.0005	0.002
Zinc	n.d.	n.d.	n.d.	n.d.	5.0	-
Copper	n.d.	n.d.	n.d.	n.d.	1.0	1.3
Manganese	n.d.	<0.005	n.d.	n.d.	0.1	-
	<i>Measured by Photometric method</i>					
Aluminum	<0.01	<0.01	<0.003	<0.003	0.5	1.0
Boron	<0.1	<0.1	<0.005	<0.005	0.5	-
Chromium (VI)	0.02	0.03	0.03	0.03	0.05	0.01
Iron	0.07	0.46	0.13	0.07	0.3	-
Nickel	<0.1	<0.1	<0.005	<0.005	0.1	0.1
Copper	0.05	0.05	0.05	0.05	1.0	1.3
Manganese	<0.1	<0.1	<0.1	<0.1	0.1	-
<b>Other parameters</b>	<i>Measured by WTW 320i multi-parameter meters</i>					
pH	-	7.09	6.76	7.07	6-9	6-9
Water temperature, °C	-	15.43	13.2	13.95	-	-
Conductivity, µSim/cm	-	265	261	250	-	-
Salinity, mg/l	-	0.12	0.12	0.12	-	-
Total dissolved solids, mg/l	-	123	170	163	1000	1000
Dissolved oxygen, mg/l	-	9.6	8.8	9.3	-	-
Oxygen saturation, %	-	90.8	85.1	89.8	-	-

\* defined as not detected

- the data does not exist

<sup>23</sup> 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".

<sup>24</sup> 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>

**Figure 9. Voghji and Kavart rivers water tests data**

Metals	Measurement results for, mg/l			Armenian background concentration for Voghji River Basin, <sup>25</sup> mg/l
	Sample number 13-May-16-0822-w01	Sample number 13-May-16-0822-w01	Sample number 19-May-16-0822-w03	
<i>Measured by Electrochemical method</i>				
Cadmium	<0.003	<0.003	-**	0.0001
Lead	<0.005	<0.005	-	0.0001
Arsenic (III)	<0.005	<0.005	-	-
Arsenic, Total	<0.001	<0.001	-	0.00027
Mercury	<0.005	<0.005	-	-
Zinc	0.003	0.010	-	0.003
Copper	0.007	0.020	-	0.004
Manganese	0.006	0.009	-	0.004
<i>Measured by Photometric method</i>				
Aluminum	<0.01	<0.01	0.2	0.03
Boron	<0.1	<0.1	<0.1	0.032
Chromium (VI)	<0.02	<0.02	<0.02	0.046*
Iron	<0.02	0.2	2.6	0.031
Nickel	<0.1	<0.1	0.5	0.00064
Copper	<0.05	<0.05	8.16	0.004
Manganese	<0.1	<0.1	7.60	0.004

\* defined for total chromium

\*\* concentrations of total arsenic, arsenic (III), cadmium, mercury, zinc and lead were not detected due to high interferences during the measurements.

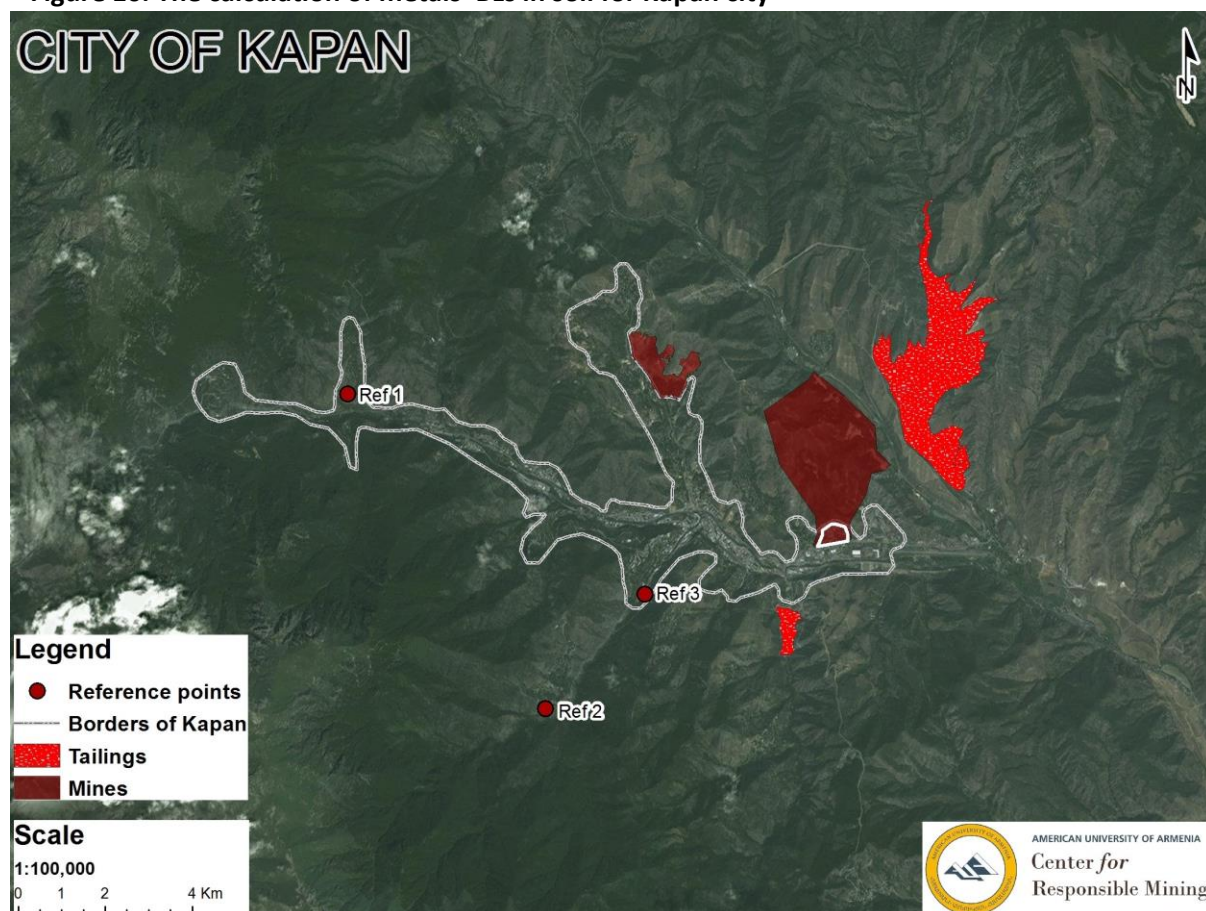
<sup>25</sup> The Armenian background concentrations for Voghji River Basin are specified in the RA Government decision # 75-N adopted on January 27, 2011 "On defining water quality norms for each water basin management area taking into consideration the peculiarities of the Locality".

## Annex 6. Determination of Background Levels of Metals in Soil of Kapan Community

The determination of the background level for each metal in soil of Kapan community was conducted by horizontal and distance sampling, based on requirements of the Protocol for Determining Background Levels of Metals in Soil developed by the AUA Center for Responsible Mining, based on international standards and guidance.<sup>26</sup> The background reference area was selected by horizontal sampling at depths 5 cm, 10 cm and 20 cm and distance sampling from about 2.5 km out of the city of Kapan.

In total, 9 reference samples from 5 cm, 10 cm and 20 cm depth were collected from the sites that were located 2.5km out and south of Kapan city (0822-sRef-02), in the Shgharshik district near the School №8 (0822-sRef-01) and in the public park of the city (0822-sRef-03) (Figure 10). The calculation of BLs for each metal are shown the Figure 11 below.

**Figure 10. The calculation of metals' BLs in soil for Kapan 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.

<sup>26</sup> Protocols used are available at <http://crm.aua.am>.

**Figure 11. The calculation of metals' BLs in soil for Kapan city**

Number of sampling point	Metals, mg/kg				
	Arsenic	Cadmium	Copper	Lead	Mercury
<b>Armenian SS</b>	<b>2</b>	<b>-</b>	<b>3</b>	<b>32</b>	<b>2.1</b>
0822-sRef-01 (5cm)	27.2	0.16	137.78	18.93	<0.1
0822-sRef-01 (10cm)	24.62	0.4	161.75	26.68	<0.1
0822-sRef-01 (20cm)	22.18	0.58	201.4	37.26	<0.1
0822-sRef-02 (5cm)	11.75	0.24	45.34	8.29	<0.1
0822-sRef-02 (10cm)	12.79	0.18	104.79	5.83	<0.1
0822-sRef-02 (20cm)	13.42	0.24	41.6	8.8	<0.1
0822-sRef-03 (5cm)	22.90	0.2	81.74	10.95	<0.1
0822-sRef-03 (10cm)	14.39	0.37	71.57	39.59	<0.1
0822-sRef-03 (20cm)	9.82	0.39	59.46	21.69	<0.1
Number of samples	9	9	9	9	9
Arithmetic mean	17.67	0.31	100.60	19.78	-
Median	14.39	0.24	81.74	18.93	-
Standard deviation	6.48	0.14	55.59	12.62	-
Minimum	9.82	0.16	41.60	5.83	-
Maximum	27.2	0.58	201.4	39.59	-
Lower band	13.8	0.2	77.2	15.4	-
Upper band	19.6	0.4	130.5	26.7	-
<b>Background Level</b>	<b>16.7</b>	<b>0.31</b>	<b>103.8</b>	<b>21.0</b>	<b>&lt;0.1</b>

## 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 9 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 12 below.

**Figure 12. Inter-laboratories tests results**

Name of Laboratory	Arsenic, mg/kg	Cadmium, mg/kg	Lead, mg/kg	Copper, mg/kg	Mercury, mg/kg
<i>Armenian SS</i>	<b>2</b>	-	<b>32</b>	<b>3</b>	<b>2.1</b>
<i>Background Level</i>	<b>16.7</b>	<b>0.31</b>	<b>21.0</b>	<b>103.8</b>	<b>&lt;0.1</b>
<b>0822-sRef-01 (20cm)</b>					
AUA CRM	22.18	0.58	37.26	201.4	<0.1
EcoAtom	9.74	0.30	15.94	141.94	0.89
<b>0822sRef-03 (20cm)</b>					
AUA CRM	9.82	0.39	21.69	59.46	<0.1
EIMC	8.49	0.19	6.44	76.57	-
<b>Sampling point 17-May-16-0822-s11-04</b>					
AUA CRM	12.58	0.14	50.69	584.08	<0.1
EIMC	19.32	0.47	12.94	106.94	-
EcoAtom	15.81	0.43	14.03	99.34	0.76
<b>Sampling point 18-May-16-0822-s16-04</b>					
AUA CRM	8.35	0.16	35.21	239.27	<0.1
EcoAtom	13.45	0.71	47.39	670.07	1.65
<b>Sampling point 18-May-16-0822-s19-01</b>					
AUA CRM	40.65	0.55	39.80	562.8	<0.1
EIMC	13.92	0.39	22.40	180.23	-
<b>Sampling point 13-May-16-0801-s01-02</b>					
AUA CRM	15.97	0.70	20.35	768.0	<0.1
EIMC	10.55	0.28	12.57	40.25	-
<b>Sampling point 13-May-16-0839-s01-01</b>					
AUA CRM	56.53	1.41	27.24	481.67	<0.1
EIMC	5.56	0.49	8.83	77.26	-
<b>Sampling point 13-May-16-0839-s02-04</b>					
AUA CRM	19.22	0.18	18.45	897.7	<0.1
EcoAtom	8.34	0.28	9.25	56.73	0.66

## Annex 8. Measurements Exceeding the Armenian and International Soil Standard (SS)<sup>27</sup>

**Figure 13. 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
<b>Soil Standard (mg/kg)</b>		<b>2</b>	<b>2</b>	<b>110</b>	<b>55</b>	<b>50</b>	<b>37</b>	<b>15</b>	<b>2</b>	<b>12</b>	<b>30</b>	<b>22</b>
Kindergarten №1	4	100%	100%	0	0	0	25%	100%	100%	100%	50%	100%
Kindergarten №2	6	100%	100%	0	0	0	0	16.7%	100%	83.3%	0	0
Kindergarten №4	3	100%	100%	0	0	0	0	100%	100%	100%	100%	100%
Kindergarten №6	5	100%	100%	0	0	0	0	100%	100%	100%	20%	60%
Kindergarten №7	4	100%	100%	0	0	0	0	0	100%	100%	0	0
Kindergarten №8	6	100%	100%	0	0	0	0	100%	100%	100%	66.7%	100%
Kindergarten №9	4	100%	100%	0	0	0	0	0	100%	0	0	0
Kindergarten №10	3	100%	100%	0	0	0	0	100%	100%	100%	100%	100%
Kindergarten №11	3	100%	100%	0	0	0	0	0	100%	100%	0	0
Kindergarten №13	3	100%	100%	0	0	0	0	100%	100%	100%	0	0
School №1	5	100%	100%	0	0	0	0	100%	100%	100%	0	0
School №5	9	100%	100%	0	0	0	33.3%	100%	100%	100%	100%	100%
School №6	6	100%	100%	0	0	0	100%	100%	100%	100%	100%	100%
School №7	5	100%	100%	0	0	0	0	100%	100%	100%	0	100%
School №8	5	100%	100%	0	0	0	0	100%	100%	100%	0	100%
School №10	3	100%	100%	0	0	0	0	100%	100%	100%	0	100%
School №11	5	100%	100%	0	0	0	0	100%	100%	100%	0	100%
School №12	3	100%	100%	0	0	0	0	100%	100%	100%	0	0
School №13	4	100%	100%	0	0	0	0	0	100%	100%	0	0
Syunik Kindergarten	5	100%	100%	0	0	40%	100%	100%	100%	100%	100%	100%
Syunik School	5	100%	100%	0	0	0	0	100%	100%	100%	0	60%
Achanan School	3	100%	100%	0	0	0	0	66.7%	100%	100%	0	0

<sup>27</sup>The references to international soil standards and US EPA soil screening levels of metals are given in Bibliography section.

Figure 14. 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
<b>Soil Standard (mg/kg)</b>		<b>*</b>	<b>*</b>	<b>6</b>	<b>12</b>	<b>20</b>	<b>20</b>	<b>0.4</b>	<b>3</b>	<b>14</b>	<b>0.3</b>	<b>85</b>
Kindergarten №1	4	-	-	0	0	0	0	100%	0	0	100%	0
Kindergarten №2	6	-	-	0	0	0	0	0	0	0	0	0
Kindergarten №4	3	-	-	0	0	0	0	100%	0	0	100%	0
Kindergarten №6	5	-	-	0	0	0	0	0	0	0	100%	0
Kindergarten №7	4	-	-	0	0	0	0	0	0	0	0	0
Kindergarten №8	6	-	-	0	0	0	0	0	0	0	16.7%	0
Kindergarten №9	4	-	-	0	0	0	0	0	0	0	0	0
Kindergarten №10	3	-	-	0	0	0	0	0	0	0	0	0
Kindergarten №11	3	-	-	0	0	0	0	0	0	0	66.7%	0
Kindergarten №13	3	-	-	0	0	0	0	0	0	0	0	0
School №1	5	-	-	0	0	0	0	0	0	0	60%	0
School №5	9	-	-	0	0	0	0	0	0	0	55.6%	0
School №6	6	-	-	0	0	0	0	100%	0	0	100%	0
School №7	5	-	-	0	0	0	0	0	0	0	0	0
School №8	5	-	-	0	0	0	0	0	0	0	0	0
School №10	3	-	-	0	0	0	0	0	0	0	0	0
School №11	5	-	-	0	0	0	0	0	0	0	80%	0
School №12	3	-	-	0	0	0	0	0	0	0	66.7%	0
School №13	4	-	-	0	0	0	0	0	0	0	0	0
Syunik Kindergarten	5	-	-	0	0	0	0	100%	0	0	100%	0
Syunik School	5	-	-	0	0	0	0	0	0	0	0	0
Achanan School	3	-	-	0	0	0	0	100%	0	0	100%	0

(\*) Soil standard has not established.



**Figure 15. 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
<b>Soil Standard (mg/kg)</b>		<b>3</b>	<b>3</b>	<b>400</b>	<b>190</b>	<b>N.A.</b>	<b>190</b>	<b>100</b>	<b>100</b>	<b>63</b>	<b>50</b>	<b>250</b>
Kindergarten №1	4	100%	100%	0	50%	-	50%	100%	100%	100%	100%	0
Kindergarten №2	6	100%	100%	0	16.7%	-	16.7%	100%	100%	100%	100%	0
Kindergarten №4	3	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
Kindergarten №6	5	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
Kindergarten №7	4	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
Kindergarten №8	6	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
Kindergarten №9	4	100%	100%	0	100%	-	100%	100%	100%	100%	100%	0
Kindergarten №10	3	100%	100%	0	0	-	0	100%	100%	100%	100%	0
Kindergarten №11	3	100%	100%	0	0	-	0	0	0	0	0	0
Kindergarten №13	3	100%	100%	0	100%	-	100%	100%	100%	100%	100%	100%
School №1	5	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
School №5	9	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
School №6	6	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
School №7	5	100%	100%	0	100%	-	100%	100%	100%	100%	100%	100%
School №8	5	100%	100%	0	20%	-	20%	100%	100%	100%	100%	20%
School №10	3	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
School №11	5	100%	100%	0	100%	-	100%	100%	100%	100%	100%	100%
School №12	3	100%	100%	0	0	-	0	0	0	100%	100%	0
School №13	4	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
Syunik Kindergarten	5	100%	100%	40%	100%	-	100%	100%	100%	100%	100%	40%
Syunik School	5	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%
Achanan School	3	100%	100%	100%	100%	-	100%	100%	100%	100%	100%	100%

Figure 16. 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
<b>Soil Standard (mg/kg)</b>		<b>32</b>	<b>30</b>	<b>700</b>	<b>530</b>	<b>400</b>	<b>400</b>	<b>80</b>	<b>60</b>	<b>140</b>	<b>250</b>	<b>400</b>
Kindergarten №1	4	0	0	0	0	0	0	0	0	0	0	0
Kindergarten №2	6	0	0	0	0	0	0	0	0	0	0	0
Kindergarten №4	3	100%	100%	0	0	0	0	0	0	0	0	0
Kindergarten №6	5	0	0	0	0	0	0	0	0	0	0	0
Kindergarten №7	4	0	0	0	0	0	0	0	0	0	0	0
Kindergarten №8	6	66.7%	66.7%	0	0	0	0	0	0	0	0	0
Kindergarten №9	4	100%	100%	0	0	0	0	0	0	0	0	0
Kindergarten №10	3	0	0	0	0	0	0	0	0	0	0	0
Kindergarten №11	3	0	0	0	0	0	0	0	0	0	0	0
Kindergarten №13	3	0	0	0	0	0	0	0	0	0	0	0
School №1	5	100%	100%	0	0	0	0	0	0	0	0	0
School №5	9	55.6%	66.7%	0	0	0	0	0	0	0	0	0
School №6	6	100%	100%	0	0	0	0	0	0	0	0	0
School №7	5	0	0	0	0	0	0	0	0	0	0	0
School №8	5	0	0	0	0	0	0	0	0	0	0	0
School №10	3	0	0	0	0	0	0	0	0	0	0	0
School №11	5	100%	100%	0	0	0	0	0	0	0	0	0
School №12	3	0	0	0	0	0	0	0	0	0	0	0
School №13	4	100%	100%	0	0	0	0	0	0	0	0	0
Syunik Kindergarten	5	0	0	0	0	0	0	0	0	0	0	0
Syunik School	5	0	0	0	0	0	0	0	0	0	0	0
Achanan School	3	0	0	0	0	0	0	0	0	0	0	0

**Figure 17. 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
<b>Soil Standard (mg/kg)</b>		<b>2.1</b>	<b>2.1</b>	<b>15</b>	<b>10</b>	<b>20</b>	<b>7</b>	<b>1</b>	<b>1</b>	<b>6.6</b>	<b>0.3</b>	<b>*</b>
Kindergarten №1	4	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №2	6	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №4	3	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №6	5	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №7	4	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №8	6	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №9	4	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №10	3	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №11	3	0	0	0	0	0	0	0	0	0	0	-
Kindergarten №13	3	0	0	0	0	0	0	0	0	0	0	-
School №1	5	0	0	0	0	0	0	0	0	0	0	-
School №5	9	0	0	0	0	0	0	0	0	0	0	-
School №6	6	0	0	0	0	0	0	0	0	0	0	-
School №7	5	0	0	0	0	0	0	0	0	0	0	-
School №8	5	0	0	0	0	0	0	0	0	0	0	-
School №10	3	0	0	0	0	0	0	0	0	0	0	-
School №11	5	0	0	0	0	0	0	0	0	0	0	-
School №12	3	0	0	0	0	0	0	0	0	0	0	-
School №13	4	0	0	0	0	0	0	0	0	0	0	-
Syunik Kindergarten	5	0	0	0	0	0	0	0	0	0	0	-
Syunik School	5	0	0	0	0	0	0	0	0	0	0	-
Achanan School	3	0	0	0	0	0	0	0	0	0	0	-

## Annex 9. Soil Test Results for Each Kindergarten and School

### Kindergarten №1

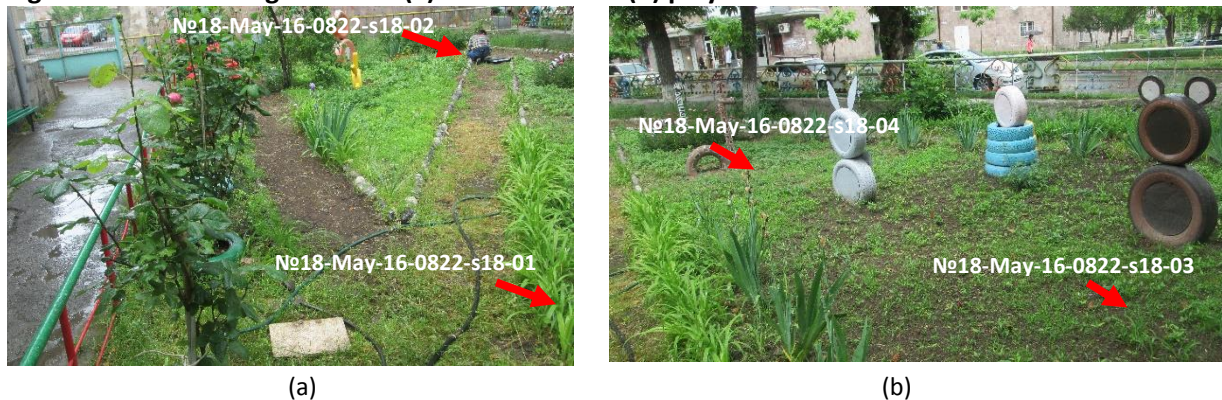
The Kindergarten №1 is located in the central part of Kapan city. In total, 174 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 1.6 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbed and playfield that belong to the kindergarten and separated by a fence (Figure 18a, 19b). In total, 4 soil samples were collected that shown in Figures 18b. The soil testing results are presented in Annex 4.

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



**Figure 19. The Kindergarten №1 (a) flowerbed and (b) playfield**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 12.1-19.6 and 59.4-86.3 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium exceeded China's SS by 1.9-2.4 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.<sup>28</sup>

<sup>28</sup> Arsenic, cadmium and copper in all soil samples exceeded the BLs by 1.4-2.3, 1.8-2.3 and 1.7-2.5 times, accordingly. Lead didn't exceed the BL.

## Kindergarten №2

The Kindergarten №2 is located in the north-west part of Kapan city. In total, 132 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 5.6 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbed and playfield that belong to the kindergarten and separated by a fence (Figure 20a, 21a and 21b). In total, 6 soil samples were collected that shown in Figures 20b. The soil testing results are presented in Annex 4.

**Figure 20. The Kindergarten №2 (a) main view and (b) soil sampling points' location**



**Figure 21. The Kindergarten №2 (a) right site playfield and (b) left site playfield**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 5.8-8.4 and 60.4-67.1 times, accordingly. Lead didn't exceed the Armenian SS. Cadmium didn't exceed China's SS that is the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detected in the soil samples.<sup>29</sup>

<sup>29</sup> Copper in all soil samples exceeded the BL by 1.7-1.9 times. Arsenic, cadmium and lead didn't exceed the BLs.

## Kindergarten №4

The Kindergarten №4 is located in the north east part of Kapan city. In total, 190 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 1.5 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbed and playfield that belong to the kindergarten and separated by a fence (Figure 22a, 23). In total, 3 soil samples were collected that shown in Figures 22b. The soil testing results are presented in Annex 4.

**Figure 22. The Kindergarten №4 (a) main view and (b) soil sampling points' location**



**Figure 23. The Kindergarten №4 playfield**



The concentrations of arsenic, copper and lead exceeded the Armenian SS in the soil of the entire area of the kindergarten by 16.8-18.6, 274.2-278.3 and 1.4-1.5 times, accordingly. The concentrations of cadmium exceeded China's SS by 3.2-3.4 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.<sup>30</sup>

## Kindergarten №6

The Kindergarten №6 is located in the central west part of Kapan city. In total, 199 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 2.9 km.

<sup>30</sup> Arsenic, cadmium, copper and lead in all soil samples exceeded the BLs by 2.0-2.2, 3.1-3.3, 7.9-8.0 and 2.1-2.2 times, accordingly.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly small garden, flowerbeds and playfield that belong to the kindergarten and separated by a fence (Figure 24a, 25a and 25b). In total, 5 soil samples were collected that shown in Figures 24b. The soil testing results are presented in Annex 4.

**Figure 24. The Kindergarten №6 (a) main view and (b) soil sampling points' location**



**Figure 25. The Kindergarten №6 (a) garden and (b) flowerbed**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 10.5-16.4 and 183.8-193.5 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium exceeded China's SS by 1.1-1.4 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.<sup>31</sup>

<sup>31</sup> Arsenic, cadmium, copper and lead in all soil samples exceeded the BLs by 1.3-2.0, 1.1-1.3, 5.3-5.6 and 1.2-1.3 times, accordingly.

## Kindergarten №7

The Kindergarten №7 is located in the central part of Kapan city. In total, 160 children attend this kindergarten. The distance from the kindergarten to the the Shahumyan mine is 2.5 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbed and playfield that belong to the kindergarten and separated by a fence (Figure 26a, 27a and 27b). In total, 4 soil samples were collected that shown in Figures 26b. The soil testing results are presented in Annex 4.

**Figure 26. The Kindergarten №7 (a) main view and (b) soil sampling points' location**



**Figure 27. The Kindergarten №7 (a) flowerbed and (b) playfield**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 6.2-6.6 and 184.3-189.8 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium didn't exceed China's SS that is the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detected in the soil samples.<sup>32</sup>

<sup>32</sup> Copper and lead in all soil samples exceeded the BLs by 5.3-5.5 and 1.2-1.3 times, accordingly. Arsenic and lead didn't exceed the BLs.



## Kindergarten №8

The Kindergarten №8 is located in the central part of Kapan city. In total, 36 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 2.5 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbed and playfields that belong to the kindergarten and separated by a fence (Figure 28a, 29a and 29b). In total, 6 soil samples were collected that shown in Figures 28b. The soil testing results are presented in Annex 4.

**Figure 28. The Kindergarten №8 (a) main view and (b) soil sampling points' location**



**Figure 29. The Kindergarten №8 (a) playfield and (b) flowerbed**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 12.1-18.4 and 157.7-170.5 times, accordingly. Lead exceeded the Armenian SS by 1.2-1.3 times in 66.7% (4/6) of all soil samples. The concentrations of cadmium slightly exceeded China's SS by 1.1 times in one soil sample (16.7%) 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.<sup>33</sup>

<sup>33</sup> Arsenic, copper and lead in all soil samples exceeded the BLs by 1.5-2.2, 4.6-4.9 and 1.3-1.9 times, accordingly. Cadmium didn't exceed the BL.

## Kindergarten №9

The Kindergarten №9 is located in the central part of Kapan city. In total, 145 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 1.6 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbeds and playfield that belong to the kindergarten and separated by a fence (Figure 30a, 31). In total, 4 soil samples were collected that shown in Figures 30b. The soil testing results are presented in Annex 4.

**Figure 30. The Kindergarten №9 (a) main view and (b) soil sampling points' location**



**Figure 31. Kindergarten №9 playfield**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 4.2-4.5 and 79.8-83.7 times, accordingly. Lead slightly exceeded the Armenian SS by 1.1 times in all soil samples. The concentrations of cadmium didn't exceed China's SS that is the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detected in the soil samples.<sup>34</sup>

<sup>34</sup> Copper and lead in all soil samples exceeded the BLs by 2.3-2.4 and 1.6-1.7 times, accordingly. Arsenic and cadmium didn't exceed the BLs.

## Kindergarten №10

The Kindergarten №10 is located in the central north part of Kapan city. In total, 98 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 3.0 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbeds that belong to the kindergarten and separated by a fence (Figure 32a, 33). In total, 3 soil samples were collected that shown in Figures 32b. The soil testing results are presented in Annex 4.

**Figure 32. The Kindergarten №10 (a) main view and (b) soil sampling points' location**



**Figure 33. The Kindergarten №10 flowerbeds**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 116.1-17.3 and 59.4-63.9 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium didn't exceed China's SS that is the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detected in the soil samples.<sup>35</sup>

<sup>35</sup> Arsenic, copper and lead in all soil samples exceeded the BLs by 1.9-2.1, 1.7-1.8 and 1.1-1.2 times, accordingly. Cadmium didn't exceed the BL.

## Kindergarten №11

The Kindergarten №11 is located in the “Barabatum” district, the east part of Kapan city. In total, 15 children attend this kindergarten. The kindergarten is the nearest to the Shahumyan mine, the distance is 0.6 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly flowerbed and garden that belong to the kindergarten and separated by a fence (Figure 34a, 35). In total, 3 soil samples were collected that shown in Figures 34b. The soil testing results are presented in Annex 4.

**Figure 34. The Kindergarten №11 (a) main view and (b) soil sampling points' location**



**Figure 35. The Kindergarten №11 garden**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 6.5-7.1 and 11.8-15.6 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium exceeded China's SS by 1.1-1.2 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.<sup>36</sup>

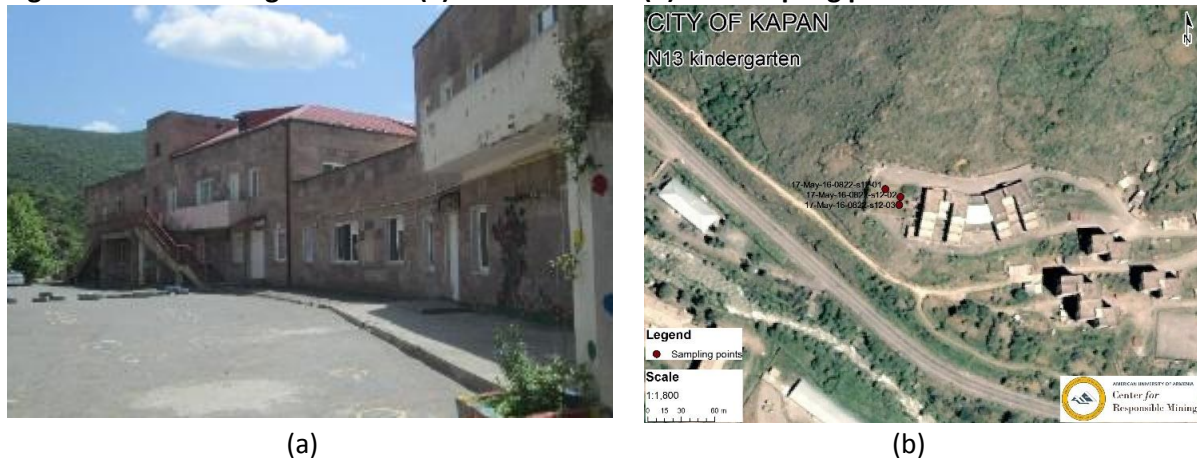
<sup>36</sup> Cadmium exceeded the BLs by 1.1-1.2 times in 66.7% (2/3) of all soil samples. Arsenic, copper and lead didn't exceed the BLs.

### Kindergarten №13

The Kindergarten №13 is located in the west part of Kapan city. In total, 132 children attend this kindergarten. The distance from the kindergarten to the Shahumyan mine is 4.7 km.

The soil monitoring for the kindergarten was conducted for the soil-covered area, particularly garden that belong to the kindergarten and separated by a fence (Figure 36a, 37). In total, 3 soil samples were collected that shown in Figures 36b. The soil testing results are presented in Annex 4.

**Figure 36. The Kindergarten №13 (a) main view and (b) soil sampling points' location**



**Figure 37. The Kindergarten №13 flowerbed**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 10.1-11.0 and 101.2-103.7 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium didn't exceed China's SS that is the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detected in the soil samples.<sup>37</sup>

### School №1

The Primary School №1 is located in the central part of Kapan city. In total, 308 children attend this school. The distance from the school to the Shahumyan mine is 1.8 km.

The soil monitoring for School №1 was conducted from soil-covered areas, particularly from flowerbeds and garden around the school (Figure 38a, 39). Five soil samples were collected which are shown in Figure 38b.

<sup>37</sup> Arsenic and copper in all soil samples exceeded the BLs by 1.2-1.3 and 2.9-3.0 times, accordingly. Lead and cadmium didn't exceed the BLs.

**Figure 38. The School №1 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

**Figure 39. The School №1 garden**



Arsenic, copper and lead exceeded the Armenian SS by 10.7-11.4, 270.9-279.1 and 1.1-1.2 times, accordingly, in all soil samples collected from the soil covered area of the school. Cadmium exceeded China's SS by 1.1-1.2 times in 60% (3/5) of all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>38</sup>

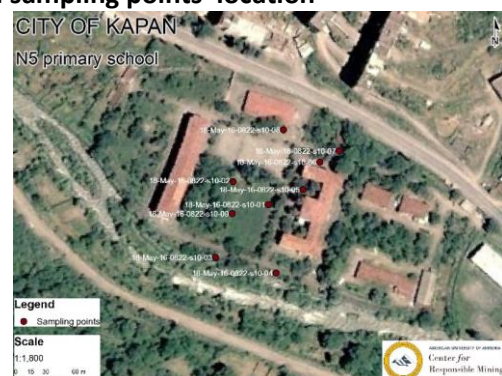
### School №5

The Primary School №5 is located in the central part of Kapan city. In total, 534 children attend this school. The distance from the school to the Shahumyan mine is 5.1 km.

**Figure 40. The School №5 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

<sup>38</sup> Arsenic, copper and lead exceeded the BLs by 1.3-1.4, 7.8-8.1 and 1.7-1.8 times, accordingly, in all soil samples. Cadmium exceeded the BL by 1.1-1.2 times in 60% (3/5) of soil samples.

The soil monitoring for School №5 was conducted from soil-covered areas, particularly from flowerbeds and football field around the school (Figure 40a, 41). Nine soil samples were collected which are shown in Figure 40b.

**Figure 41. The School №5 football field**



Arsenic and copper exceeded the Armenian SS by 16.9-19.7 and 183.4-192.7 times, accordingly, in all soil samples collected from the soil covered area of the school. Lead slightly exceeded the Armenian SS by 1.1 times in 33.3% (3/9) of all soil samples. Cadmium exceeded China's SS by 1.1-1.2 times in 55.6% (5/9) of all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>39</sup>

### School №6

The Primary School №6 is located in the south east part of Kapan city. In total, 323 children attend this school. The distance from the school to the Shahumyan mine is 1.6 km.

**Figure 42. The School №6 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

The soil monitoring for School №6 was conducted from soil-covered areas, particularly from two gardens around the school (Figure 42a, 43). Six soil samples were collected which are shown in Figure 42b.

<sup>39</sup> Arsenic, copper and lead exceeded the BLs by 2.0-2.4, 5.3-5.6 and 1.2-1.7 times, accordingly, in all soil samples. Cadmium exceeded the BL by 1.1-1.2 times in 55.6% (5/9) of all soil samples

**Figure 43. The School №6 garden**



Arsenic, copper and lead exceeded the Armenian SS by 19.1-20.3, 187.6-194.2 and 1.2-1.3 times, accordingly, in all soil samples collected from the soil covered area of the school. Cadmium exceeded China's SS by 1.8-2.0 times in all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>40</sup>

**School №7**

The Primary School №7 after Andranik Margaryan is located in the central part of Kapan city. In total, 593 children attend this school. The distance from the school to the Shahumyan mine is 1.6km.

The soil monitoring for School №7 was conducted from soil-covered areas, particularly from flowerbeds and garden around the school (Figure 44a, 45). Five soil samples were collected which are shown in Figure 44b.

**Figure 44. The School №7 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

**Figure 45. The School №7 garden**



Arsenic and copper exceeded the Armenian SS by 12.2-14.1 and 106.6-109.8 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 China's SS that is the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>41</sup>

<sup>40</sup> Arsenic, cadmium, copper and lead exceeded the BLs by 2.3-2.4, 1.8-1.9, 5.4-5.6 and 1.9-2.0 times, accordingly, in all soil samples.

<sup>41</sup> Arsenic, copper and lead exceeded the BLs by 1.5-1.7, 3.1-3.2 and 1.1-1.4 times, accordingly, in all soil samples. Cadmium didn't exceed the BL.

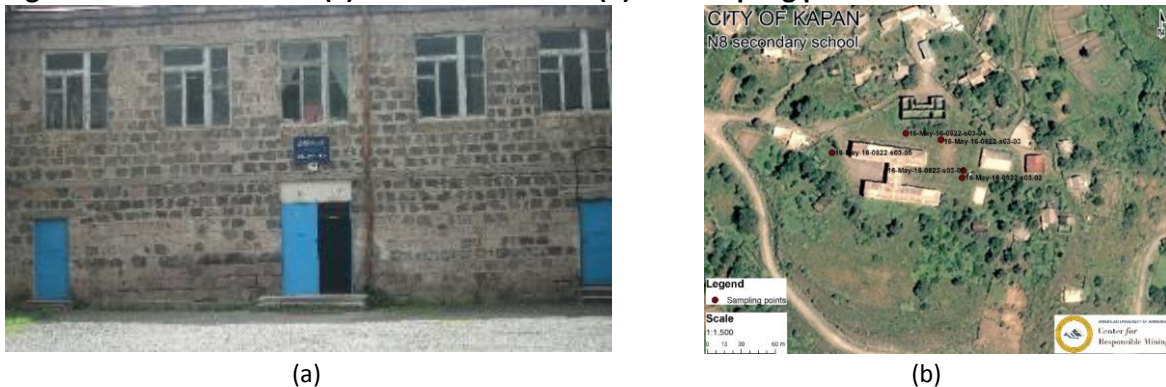


## School №8

The Secondary School №8 is located in the “Shgharshik” district, the west part of Kapan city. In total, 72 children attend this school. The distance from the school to the Shahumyan mine is 7.8 km.

The soil monitoring for School №8 was conducted from soil-covered areas, particularly from football field around the school (Figure 46a, 47). Five soil samples were collected which are shown in Figure 46b.

**Figure 46. The School №8 (a) main entrance and (b) soil sampling points' location**



**Figure 47. The School №8 football field**



Arsenic and copper exceeded the Armenian SS by 13.3-14.6 and 45.9-88.5 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 China's SS that is the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>42</sup>

## School №10

The Secondary School №10 is located in the central south part of Kapan city. In total, 206 children attend this school. The distance from the school to the Shahumyan mine is 3.2 km.

The soil monitoring for School №10 was conducted from soil-covered areas, particularly football field around the school (Figure 48a, 49). Three soil samples were collected which are shown in Figure 48b.

<sup>42</sup> Arsenic and copper exceeded the BLs by 1.6-1.7 and 1.3-2.6 times, accordingly, in all soil samples. Cadmium and lead didn't exceed the BLs.

**Figure 48. The School №10 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

**Figure 49. The School №10 football field**



Arsenic and copper exceeded the Armenian SS by 13.7-15.5 and 167.7-173.6 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 China's SS that is the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>43</sup>

### School №11

The Secondary School №11 after Rafael Minasyan is located in the north part of Kapan city. In total, 45 children attend this school. The distance from the school to the Shahumyan mine is 3.1 km.

**Figure 50. The School №11 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

<sup>43</sup> Arsenic and copper exceeded the BLs by 1.6-1.9 and 4.8-5.0 times, accordingly, in all soil samples. Lead and cadmium didn't exceed the BLs.

The soil monitoring for School №11 was conducted from soil-covered areas, particularly from flowerbed and garden around the school (Figure 50a, 51). Five soil samples were collected which are shown in Figure 50b.

**Figure 51. The School №11 garden**



Arsenic, copper and lead exceeded the Armenian SS by 13.8-15.0, 107.1-113.6 and 1.2-1.3 times, accordingly, in all soil samples collected from the soil covered area of the school. Cadmium slightly exceeded China’s SS by 1.1-1.2 times in 80% (4/5) of all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>44</sup>

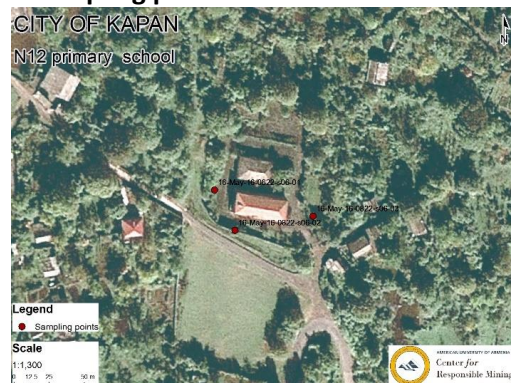
### School №12

The Primary School №12 after Hrant Voskanyan is located in the “Barabatum” district, the east part of Kapan city. In total, 16 children attend this school. The school is the nearest to the Shahumyan mine, the distance is 0.6 km.

**Figure 52. The School №12 (a) main entrance and (b) soil sampling points’ location**



(a)



(b)

The soil monitoring for School №12 was conducted from soil-covered areas, particularly from flowerbeds around the school (Figure 52a, 53). Three soil samples were collected which are shown in Figure 52b.

<sup>44</sup> Arsenic, copper and lead exceeded the BLs by 1.7-1.8, 3.1-3.3 and 1.9-2.0 times, accordingly, in all soil samples. Cadmium exceeded the BL by 1.1-1.2 times in 80% (4/5) of all soil samples.

**Figure 53. The School №12 flowerbeds**



Arsenic and copper exceeded the Armenian SS by 7.9-8.7 and 26.8-31.7 times, accordingly, in all soil samples collected from the soil covered area of the school. Lead didn't exceed the Armenian SS. Cadmium slightly exceeded China's SS by 1.1-1.2 times in 66.7% (2/3) all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>45</sup>

### School №13

The Primary School №13 is located in the west part of Kapan city. In total, 182 children attend this school. The distance from the school to the Shahumyan mine is 4 km.

The soil monitoring for School №13 was conducted from soil-covered areas, particularly from flowerbeds and garden around the school (Figure 54a, 55). Four soil samples were collected which are shown in Figure 54b.

**Figure 54. The School №13 (a) main entrance and (b) soil sampling points' location**



(a)



(b)

**Figure 55. The School №13 garden**



Arsenic, copper and lead exceeded the Armenian SS by 6.3-7.0, 193.5-197.4 and 1.5-1.6 times, accordingly, in all soil samples collected from the soil covered area of the school. Cadmium didn't exceed China's SS that is the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>46</sup>

<sup>45</sup> Cadmium exceeded the BLs by 1.1-1.2 times, accordingly, in 66.7 (2/3) all soil samples. Arsenic, copper and lead didn't exceed the BLs.

<sup>46</sup> Copper and lead exceeded the BLs by 5.5-5.7 and 2.3-2.5 times, accordingly, in all soil samples. Arsenic and cadmium didn't exceed the BLs.

## Syunik Kindergarten

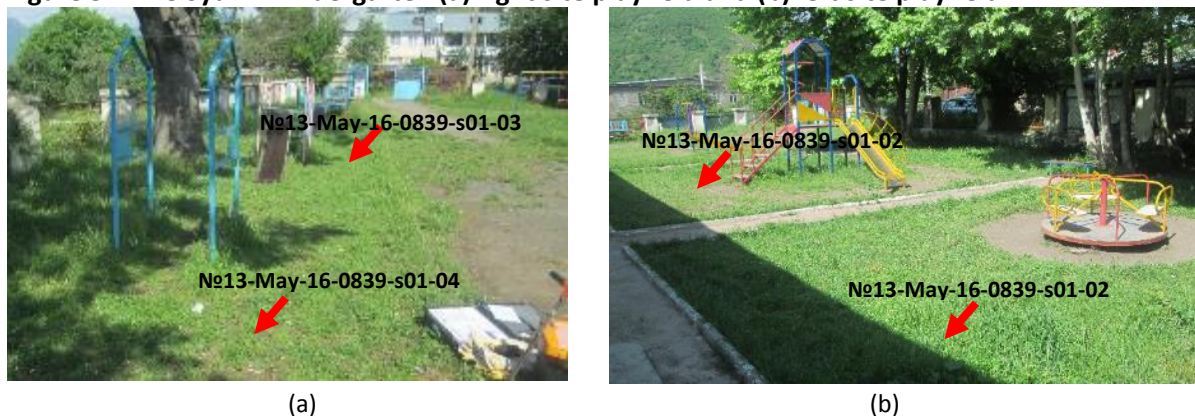
The Syunik Kindergarten is located in the south east part of the village. In total, 36 children attend this kindergarten. The distance from the kindergarten to the Artsvanik tailing pond is 3.5 km and to the Shahumyan mine is 3 km.

**Figure 56. The Syunik Kindergarten (a) main view and (b) soil sampling points' location**



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 56a, 57). In total, 5 soil samples were collected that shown in Figures 56b. The soil testing results are presented in Annex 4.

**Figure 57. The Syunik Kindergarten (a) right site playfield and (b) left site playfield**



The concentrations of arsenic and copper exceeded the Armenian SS in the soil of the entire area of the kindergarten by 22.6-28.3 and 86.3-160.6 times, accordingly. Lead didn't exceed the Armenian SS. The concentrations of cadmium exceeded China's SS by 1.5-4.8 times in all soil samples. China has the most stringent cadmium MAC (0.3 mg/kg) known to us. Mercury was not detect in the soil samples.<sup>47</sup>

<sup>47</sup> Arsenic, cadmium and copper in all soil samples exceeded the BLs by 2.7-3.3, 1.5-4.6 and 2.5-4.6 times, accordingly. Lead exceeded the BL by 1.2-1.3 times in 40% (2/5) of all soil samples.

## Syunik School

The Syunik Secondary School is located in the central east part of the village. In total, 111 children attend this school. The distance from the school to the Artsvanik tailing pond is 2.5 km and to the Shahumyan mine is 2.8 km.

The soil monitoring for School was conducted from soil-covered areas, particularly flowerbeds and the football field of the school (Figure 58a, 59). Five soil samples were collected from the soil-covered ground of School №1, of which the locations are shown on Figure 58b.

**Figure 58. The Syunik School (a) main view and (b) soil sampling points' location**



**Figure 59. The Syunik School football field**



Arsenic and copper exceeded the Armenian SS by 9.6-14.6 and 283.8-299.2 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 China's SS. Mercury was not detected in the soil samples.<sup>48</sup>

## Achanan School

The Achanan Secondary School is located in the east part of village. In total, 53 children attend this school. The distance from the school to the Artsvanik tailing pond is about 1 km and to the Shahumyan mine is 0.3 km.

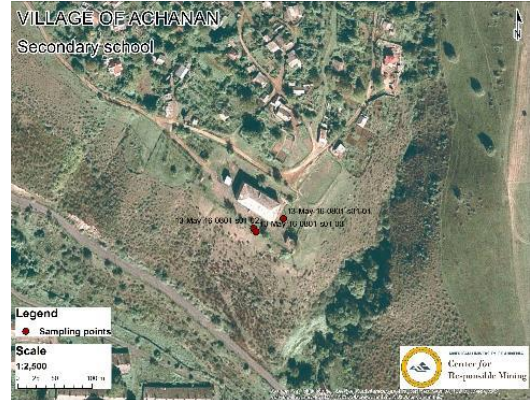
The soil monitoring for Achanan School was conducted from soil-covered areas, particularly from flowerbeds (Figure 60a, 61). The school's football field was covered by grass. Three soil samples were collected which are shown in Figure 60b.

<sup>48</sup> Arsenic and copper exceeded the BLs by 1.2-1.7 and 8.2-8.6 times, accordingly, in all soil samples. Cadmium and lead didn't exceed the BLs.

**Figure 60. The Achanan School (a) main entrance and (b) soil sampling points' location**



(a)



(b)

**Figure 61. The Achanan School flowerbed**



Arsenic and copper exceeded the Armenian SS by 7.4-8.6 and 243.2-256.0 times, accordingly, in all soil samples collected from the soil covered area of the school. Lead didn't exceed the Armenian SS. Cadmium exceeded China's SS by 2.0-2.3 times in all soil samples. China has the most stringent cadmium MAC known to us. Mercury was not detected in the soil samples.<sup>49</sup>

<sup>49</sup> Cadmium and copper exceeded the BLs by 2.0-2.3 and 6.8-7.4 times, accordingly, in all soil samples. Arsenic and lead didn't exceed the BLs.

## Annex 10. Complete Test Results of Soil Samples

Within the inter-laboratory comparison, the complete tests of metals were conducted for 9 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 and Figure 28.

**Figure 27. Complete soil test results from EIMC**

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 0822-sRef- 03(20cm)	Sample number 13-May-16- 0839-s01-01	Sample number 16-May-16- 0801-s01-02	Sample number 18-May-16- 0822-s19-01	Sample number 17-May-16- 0822-s11-04					
Antimony	0.45	0.41	0.74	0.97	1.07	4.5	-**	-	-	-
Arsenic	8.49	5.57	10.55	13.92	19.32	2.0	2.0	12	30	22
Barium	91.47	77.10	133.55	184.94	482.17	-	-	-	-	-
Beryllium	0.52	0.63	1.14	0.87	1.35	-	-	-	-	-
Boron	0.73	n.m.	9.37	4.77	6.09	-	-	-	-	-
Cadmium	0.19	0.49	0.28	0.39	0.47	-	3.0	14	0.3	85
Calcium	21084.4	16797.9	19194.7	31834.2	113966.1	-	-	-	-	-
Chromium	32.26	46.46	49.21	61.46	147.20	6.0	25	64	150	230
Cobalt	25.83	17.46	16.47	23.13	36.47	5.0	-	-	-	-
Copper	76.57	77.26	40.25	180.23	106.94	3.0	100	63	50	250
Iron	41613.8	21324.7	15726.4	38211.4	85897.7	-	-	-	-	-
Lead	6.44	8.83	12.57	22.40	12.94	32.0	60	140	250	400
Lithium	13.50	7.72	9.73	16.13	31.92	-	-	-	-	-
Magnesium	11937.5	6915.0	4992.6	10593.4	30203.9	-	-	-	-	-
Manganese	875.48	479.09	458.49	750.36	1090.02	700.0	-	-	-	-
Molybdenum	0.62	1.76	2.56	2.69	7.10	-	-	-	-	-
Mercury	-	-	-	-	-	2.1	1.0	6.6	0.3	-
Nickel	22.71	41.04	41.18	42.15	58.30	4.0	50	50	40	1,600
Potassium	7557.9	5435.9	13301.4	10142.8	13403.7	-	-	-	-	-
Selenium	7.66	5.94	4.89	7.02	12.66	-	-	-	-	-
Sodium	9566.0	12561.6	4494.3	9701.1	11349.2	-	-	-	-	-
Strontium	110.07	116.29	250.49	185.91	602.63	-	-	-	-	-
Tin	0.81	0.96	1.46	1.58	2.80	-	-	-	-	-
Titanium	1905.1	1710.0	1667.6	1845.2	2132.5	-	-	-	-	-
Vanadium	188.14	82.61	89.92	137.75	142.73	150.0	-	-	-	-
Zinc	87.46	105.51	102.02	135.35	229.05	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 2.8-9.7 times, 5.4-24.5 times, 3.3-7.3 times, 13.4-223.4 times, 5.7-14.6 times and 3.7-125.5 times accordingly, in the soil samples collected from the reference sites and soil-covered area of the Kapan city's Kindergarten №9, Schools №6 and №13, Syunik village's school and kindergarten and Achanan kindergarten. Manganese exceeded the Armenian SS by 1.1-1.5 times in three samples collected from the reference site №3, Kapan's School №6 and №13. Lead exceeded the Armenian SS by 1.5 in one soil sample collected from Kapan's Kindergarten №9, as well as vanadium exceeded the Armenian SS by 1.3 in the reference soil sample. Measured other metals, such as antimony and mercury, didn't exceed the Armenian SS.



**Figure 28. Complete soil test results from EcoAtom**

Metsals	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 0822-sRef- 01(20cm)	Sample number 13-May-16- 0839-s02-04	Sample number 18-May-16- 0822-s16-04	Sample number 17-May-16- 0822-s11-04					
Antimony	0.85	0.53	1.94	1.07	4.5	.*	-	-	-
Arsenic	9.74	8.34	13.45	15.81	2.0	2.0	12	30	22
Barium	122.19	113.80	307.82	314.36	-	-	-	-	-
Beryllium	0.72	0.69	0.67	0.96	-	-	-	-	-
Bismuth	0.27	0.14	0.28	0.27	-	-	-	-	-
Cadmium	0.30	0.28	0.71	0.43	-	3.0	14	0.3	85
Calcium	16019.7	17463.1	43592.1	59977.3	-	-	-	-	-
Chromium	50.35	47.45	61.26	92.31	6.0	25	64	150	230
Cobalt	18.33	18.14	20.68	24.72	5.0	-	-	-	-
Copper	141.94	56.73	670.07	99.34	3.0	100	63	50	250
Iron	23755.7	27682.7	38714.8	43453.2	-	-	-	-	-
Lead	15.94	9.25	47.39	14.03	32.0	60	140	250	400
Lithium	8.30	8.45	9.57	16.70	-	-	-	-	-
Magnesium	4607.5	6975.3	10841.1	14902.0	-	-	-	-	-
Manganese	610.85	522.11	579.82	703.24	700.0	-	-	-	-
Molybdenum	2.29	1.87	6.01	3.57	-	-	-	-	-
Mercury	0.89	0.66	1.65	0.76	2.1	1.0	6.6	0.3	-
Nickel	41.29	36.88	40.18	50.58	4.0	50	50	40	1,600
Potassium	8376.8	8455.2	8130.6	11198.4	-	-	-	-	-
Selenium	5.39	6.39	8.39	12.15	-	-	-	-	-
Sodium	4609.2	7713.2	7910.9	7464.9	-	-	-	-	-
Strontium	84.14	151.85	397.49	354.17	-	-	-	-	-
Tin	3.77	1.27	3.23	2.38	-	-	-	-	-
Titanium	1704.49	2426.33	189.14	1784.62	-	-	-	-	-
Vanadium	112.57	110.56	95.72	116.27	150.0	-	-	-	-
Zinc	170.56	85.20	2887.35	178.88	23.0	100	200	200	23,000

(\*) Soil standard has not established.