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Case of Akhtala Community, Armenia: Environmental and Health Consequences of Mining Industry

Prepared by Ruzanna Grigoryan, MD, MPH

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The Republic of Armenia (RA) is a lower middle income country with a population of 2,871,771 and an area of 29,743 km^2 located in the South Caucasus region at the mean altitude of 1,800 meters above sea level (RA National Statistical Service, 2013a, 2013b; World Bank, 2014). It is bordered by Georgia to the north, Azerbaijan to the east, Turkey to the west and Iran to the south (RA National Statistical Service, 2014). Forests make up 11.2% of the country, 11.1% is classified as special protection territory, 68.9% is agricultural land and 8.8% of the land is reserved for other purposes (RA National Statistical Service, 2014). The nine largest rivers of Republic of Armenia are Aghstev, Akhuryan, Araks, Arpa, Debed, Hrazdan, Pambak, Qasagh, and Vorotan. The largest lake is Sevan, which has an area of 1,275 $meter^2$. The country is divided into 10 marzes or regions (Aragatsotn, Ararat, Armavir, Gegharkunik, Lori, Kotayk, Shirak, Syunik, Vayots Dzor and Tavush). The capital city is Yerevan (RA National Statistical Service, 2014).

According to Armenia's National Statistical Service mining and quarrying is the largest industry of the country by volume of production (RA National Statistical Service, 2013b). The metal resources of the country include iron, copper, molybdenum, lead, zinc, gold and silver (RA Ministry of Energy and Natural Resources & Armenian Development Agency, 2011; RA National Statistical Service, 2013b). Under-regulation has resulted in increased foreign investment in the mining sector of the country (Ishkanian, Gyulkhandanyan, Manusyan, & Manusyan, 2013). As a result of the recent growth of the

mining and quarrying industries, there are currently 670 mines in Armenia, including 30 base metal mines, fourteen of which are gold and gold-polymetallic mines, seven copper-molybdenum mines, four copper mines, two polymetallic mines, two iron-ore mines and one aluminum mine (ALS Minerals et al., 2011). Of the 30 base metal mines, 22 are currently in operation (ALS Minerals et al., 2011). Additionally, Armenia has 19 tailing ponds - 9 currently active, 8 in cultivation phase, 1 ready for utilization and 1 abandoned, with no officially responsible party (RA Ministry of Emergency Situatoins, 2013).

The main pollutants produced as a result of mining and smelting activities that are dangerous to human health are heavy metals including but not limited to lead and arsenic. Lead does not degrade in nature (Agency for Toxic Substances and Disease Registry (ATSDR), 2007b). It has high bioaccumulation and is toxic for both the environment and human health. Lead is a possible human carcinogen (B2) which means that there is sufficient evidence that it is carcinogenic for experimental animals and almost sufficient evidence that it is carcinogenic for humans (Agency for Toxic Substances and Disease Registry (ATSDR), 2007b). There is no safe dose of lead for the human body - even a small dose may affect a child's neurobehavioral development. In other words, there is no evidence-based threshold for safety (US Environmental Protection Agency, 2014). Nonspecific symptoms of lead poisoning include headache, weakness, muscle or joint pains, loss of appetite and insomnia (The Risk Assessment Informaiton System, 2013). More specific signs of exposure to lead are metallic taste in the mouth, colic that may occur with abdominal pain and constipation, anemia, impaired function of the liver, signs of neurotoxicity as a result of damage to the central nervous system (malaise, irritability, dizziness, headache, lethargy, forgetfulness, vomiting, ataxia, visual disturbance), nephropathy, and chromosomal defects (The Risk Assessment Informaiton System, 2013). Children are more vulnerable than adults to lead exposure (US Environmental Protection Agency, 2015a). The reasons include tissues more sensitive to lead exposure due to anatomic-physiological structure, not fully developed brain blood

barrier, poor hygiene, active hand-to -mouth activities, higher absorption of lead and higher dose of exposure because of low body weight (Ide & Parker, 2005; US Environmental Protection Agency, 2014). Lead may lead to decreased intelligence, shortened attention span, reading, learning and hearing disabilities, and hyperactivity among children (US Environmental Protection Agency, 2015b).

Arsenic is classified as metalloid indicating that it has chemical and physical characteristics typical for both metal and non-metal elements (Agency for Toxic Substances and Disease Registry (ATSDR), 2007a). There are three types of arsenic: inorganic, organic, and arsine gas (International Agency for Research on Cancer, 2012). The sources of inorganic arsenic are copper and lead containing ore and smelting activities. (Agency for Toxic Substances and Disease Registry (ATSDR), 2007a). According to the International Agency for Research on Cancer inorganic arsenic is a known human carcinogen (International Agency for Research on Cancer, 2012). Arsenic may cause rhinitis, bronchitis, laryngitis, hypotension, arrhythmias, cyanosis of fingers and toes, Raynaud's disease, nausea, vomiting, diarrhea, abdominal pain and hemorrhage, anemia and leucopenia, hepatic injury, dermatitis, encephalopathy, spontaneous abortion, and low birth weight (Agency for Toxic Substances and Disease Registry (ATSDR), 2007a).

Akhtala is a small town located in the northern part of Lori marz, situated along the Debed river, close to the Georgian and Azerbaijani borders. Akhtala is 4.3 square kilometers in area and has a population of 2,400 (55% female) (RA Lori Marzpetaran, 2014). The town is divided into the following four districts – "Transport", "Svinets", "Barit" and "Sarahart" (Petrosyan, Grigoryan, Melkomian, & Akopian, 2014). Akhtala has a Soviet-era underground mine and an open pit barite-poly-metallic mine (Bekchyan, 2013; Zoï Environment Network, 2012). It also has a processing factory – "Akhtala Mountain Enrichment Combinat," which processes the copper ore extracted from Akhtala and Shamlugh, a nearby town (Bekchyan, 2013; USAID, 2014). Mining has been taking place in Akhtala for approximately 250 years. The mine ceased operations in 1990s with the

economic collapse after the fall of the Soviet Union. In 2001, Akhtala's mine was privatized and its operation restarted. Currently the annual production of the mine in Akhtala is 12,000 tons (USAID, 2014). It is estimated that with the current exploitation rate the mine will have a lifetime of 25 years. The mine has three tailing ponds (Zoï Environment Network, Environment and Security Initiative, 2012). The first called "Nazik" is non-operational and located below the church, in the center of town (RA Lori Marz Rescue Department of the Ministry of Emergency Situations, 2014). The main operating "Nahatak" tailing pond is located 8 kilometers from Akhtala. The third tailing pond "Paytutsik Nyuteri Dzor" is located 2 kilometers outside of Akhtala (RA Lori Marz Rescue Department of the Ministry of Emergency Situations, 2014).

There have been several attempts to assess the environmental and public health risks stemming from mining in Akhtala. In a study conducted in 2001, Petrosyan and colleagues revealed that 11% of soil samples taken from the yards of residential areas and 17% of loose soil samples taken from the front of the residential buildings exceeded the Maximum Allowable Concentration (MAC) for lead, which is 400 mg/kg (Petrosyan et al., 2004). Moreover, 58% of soil samples exceeded the MAC for arsenic, which is 12 mg/kg (Petrosyan et al., 2004).

The American University of Armenia School of Public Health (AUA SPH) in partnership with Blacksmith Institute conducted several studies and community empowerment activities in Akhtala from 2012-2014 (Petrosyan et al., 2014). The first study was the Initial Site Screening conducted in 2012. It targeted Akhtala along with 18 other mining and smelting communities in Armenia (Petrosyan et al., 2014) . The Screening included general observation of the potentially toxic site and community, and testing of soil samples taken from the community for heavy metals. At the moment of observation the researchers identified the following potential toxic sources: the re-cultivated "Nazik" tailing pond; tailings discharge from the processing factory into the river due to the damaged pipes;

and yellow abandoned tailings located across the river, isible from the Akhtala churchyard. In addition to their observations, the research team also collected seven soil samples from Akhtala – two targeted (from the churchyard and a kindergarten playing yard) and five composite (from gardens in "Transport" and "Svinets" districts, from the front-yards of houses in "Transport", "Svinets" district as well as from the front of the entrances of multi-storied buildings in the "Sarahart" district). According to the results of the laboratory analysis of the various soil samples, the research team concluded that all seven soil samples exceeded the MAC for arsenic; lead levels exceeded MAC in the churchyard sample, front-yard sample in "Transport" district and garden samples in "Svinets" and "Transport" districts. The most polluted area was the churchyard where the level of arsenic and lead exceeded the MAC by 12 and 11 times, respectively (Petrosyan et al., 2014).

Following the Initial Site Screening, the American University of America School of Public Health conducted a thorough environmental risk assessment in Akhtala in 2013 (Petrosyan et al., 2014). Overall, 202 targeted surface samples were taken from all 4 districts of the town. The samples were categorized into the following sample types – 111 yard samples, 37 garden, 20 school/kindergarten yards, 20 churchyard, 9 background (taken from the depth of 10 or 20 cm), 5 tailing pond samples taken from "Nazik". The samples were collected, stored, transported, prepared and analyzed via an XRF testing machine based on the pre-developed evidence-based protocols. The research team found that the lead in 26.7% of all soil samples (54/202) exceeded the MAC (400 mg/kg) with the geometric mean (GM)[1] of 294 mg/kg. The geometric mean of lead was below the Maximum Allowable Concentration for lead. For arsenic 93.6% (169/175) of samples exceeded the MAC (12 mg/kg) with the GM of 38 mg/kg. The geometric mean of arsenic was 3.1 fold the Maximum Allowable Concentration for arsenic. The most polluted

[1] Geometric mean is a specific way of averaging data by multiplying N numbers and taking Nth root of the multiplication.

districts were those located nearest to the processing factory and "Nazik" tailing pond – "Transport" district with 40.5% and "Svinets" district with 27.0% of samples exceeding MAC for lead. Less polluted districts were "Sarahart" and "Barit" with only 4.0% and 10.6% of samples exceeding MAC for lead, respectively. Arsenic exceeded the MAC in more than 93% of samples in all four districts. The most polluted sample type in the community was the churchyard where 95% of soil samples exceeded MAC for lead with GM exceeding the MAC by 13 times. Arsenic in the churchyard was above MAC in all samples with the GM exceeding the MAC for arsenic by 5 times. The second most polluted sample type was those taken from gardens, followed by yard samples (Petrosyan et al., 2014).

Following the environmental risks assessments the AUA School of Public Health conducted another study to assess the level of lead in blood samples taken from children 4 to 6 years of age from three communities of Armenia: Akhtala, Alaverdi, and Erebuni district of Yerevan (Petrosyan et al., 2014). Overall 162 children were tested by a LeadCare II Analyzer – 39 from Akhtala, 69 from Alaverdi and 54 from Yerevan Erebuni district. Approximately 53% of children were males. Nearly 26% of the children had a family member working in a mine, processing factory or a smelter. Though scientific literature reports there is no safe level of lead in blood, the Centers for Disease Control and Prevention (CDC)-recommended 5mcg/dl was selected as a reference level for lead in blood. In Akhtala 84.6% of children exceeded the CDC-recommended reference level with a geometric mean of 6.8 mcg/dl. In Alaverdi 75.4% of children exceeded the reference level with a geometric mean of 6.4 mcg/dl. The least exposed community was Yerevan's Erebuni district with 57.4% of children exceeding the reference level of lead in blood with a geometric mean of 5.2 mcg/dl. The percentage of children in Akhtala exceeding the reference level of lead in blood was statistically significantly higher compared to the same percentage for children from Yerevan's Erebuni district. The percentage of children in Alaverdi was also statistically significantly higher compared to Yerevan. No statistically significant difference was found between Alaverdi and Akhtala. This data suggests that

children from Akhtala and Alaverdi are at higher risk for lead exposure than children from Yerevan (Petrosyan et al., 2014).

In addition to the studies assessing the environmental and health risks in Akhtala, the AUA School of Public Health also conducted community capacity building and empowerment activities (Petrosyan et al., 2014). An evidence-based training package was developed based on the international and local literature review. It covered the environmental and health risks from the mining industry in general and the health consequences of heavy metals, in particular. Using the final results of the above mentioned environmental and health risk assessments conducted in Akhtala, AUA SPH developed preventive measures to reduce the associated risks among the general population and particularly among children, the most vulnerable segment of the population. From December 2013 to July 2014, ten training sessions were conducted in Akhtala for 122 community members that included various stakeholder groups such as the staff of kindergartens and schools, healthcare providers, representatives from mayor's office, active community members, parents of young children, and high school students. To assess the effectiveness of the training sessions, pre-training and post-training evaluations were conducted with the participants to measure the difference in their knowledge, if any, before and after the training. This assessment found that the knowledge score of the participants was statistically significantly increased by 39.0% as a result of attending the training (Petrosyan et al., 2014).

The research team in close collaboration with 15 community members from NGOs, the local council and the mayor's office, conducted an assessment of Local Needs and Capacity followed by a Local Action Plan to reduce the environmental and health risks due to the mining industry in the community (Petrosyan et al., 2014). The most urgent preventive action recommended by the Local Action Plan was clean-up of the Akhtala churchyard. For this purpose a more thorough assessment of the churchyard was

recommended to find a more comprehensive and detailed picture of the pollution at that site in terms of shape and depth. It was also recommended that this be followed by the technical design of remediation and implementation plans (Petrosyan et al., 2014).

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