Addressing environmental and security threats at the arsenic mining sites in Tsana, Georgia

Arsenic contamination in Tsana

November 2014

Arsenic (As) is a metalloid that occurs in different inorganic and organic forms found in the environment both from **natural** and from **anthropogenic source.**

Arsenic and inorganic arsenic compounds are classified as carcinogenic **to humans** (Group 1). The World Health Organization (**WHO**) established a threshold of **10 µg/l for drinking water** quality; an intervention value for soil (20 cm) of **200 mg/kg** for agricultural and residential land uses was applied.

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Photo 1: Scattered drums, Tsana 3

Table 1: Arsenic level in Tsana area

Location	Arsenic level
Tsana 1	90,000 mg/kg
Tsana 2	21,000 mg/kg
Tsana 3	14,500 mg/kg
Tskhenistskali River	up to 88 µg/l

In Georgia, **arsenic mining**, processing and storage has been undertaken for up to 52 years at three sites referred to as Tsana 1, 2 and 3.

All arsenic-related activities at the Tsana sites ended in 1992 and the **arsenic facilities and arsenic materials were abandoned.**

Over 50,000 tons of waste have reportedly been stored in unprotected steel containers that are currently in a deteriorated condition such that arsenic materials escape from the drums and enter soils, groundwater and surface water. As a consequence, the **wastes pose a threat to both the nearby residing population and the whole western part of Georgia**, since the Tsana sites are adjacent to the Tskhenist-skali River, which is a tributary of the Rioni River that flows into the Black Sea.

In this area the main economic activity is **small scale agriculture and cattle breeding.** Moreover, the area is located within the proposed **"Central Caucasus Protected Area"** and has **high potential for tourism** in a **zone of great natural beauty.**

Site description

The arsenic mining and processing sites are located in **north-west Georgia**. More specific, there are three sites called Tsana 1, Tsana 2 and Tsana 3, that are all located on the road that links Lentekhi with Mestia, adjacent to the Tskhenistskali River. The sites are positioned in remote locations without access to power, at heights ranging from 1,325 m to 1,985 m.

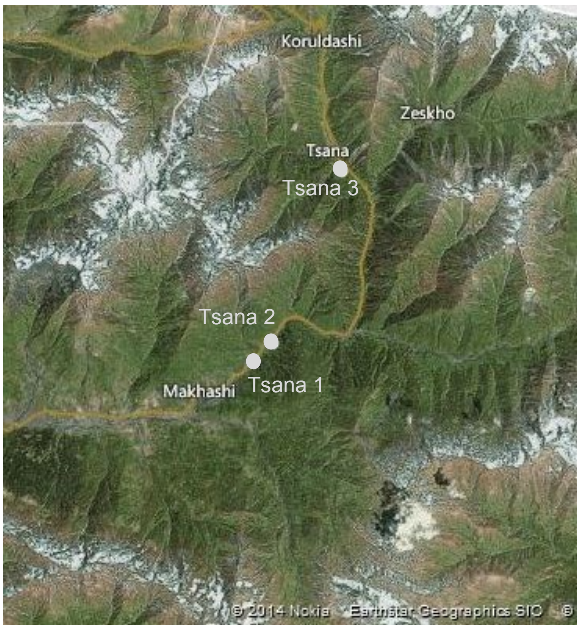

Figure 1: Map of Tsana sites

History and background

During Soviet times, mining and processing operations in this area produced arsenic anhydride and metallic arsenic. Arsenic produced at Tsana was used in Georgia for pharmacology, agriculture, production of glass and crystal, and veterinary treatment; meanwhile white arsenic was exported to Russia. An assessment of the arsenic waste facilities in Tsana, and elsewhere in Georgia, was conducted in **2012** by the Dutch team of **Witteveen+Bos Consulting** engineers. The team determined that the most appropriate option for managing the waste was on-site disposal/containment.

Immediately after the flooding at Tsana 1 in **2013**, and at the request of the Ministry of Environment and Natural Resources Protection (MoENRP), the German Government dispatched an **Analytical Task Force** to conduct assessments and took samples at Tsana 1. The Task Force confirmed that no arsenic had spread as a result of the floods and also recommended proper on-site containment of arsenic wastes.

However, **Georgia lacks experience in the management of hazardous waste sites**. In **November 2013,** the MoENRP sent a formal letter to the Office of the Co-ordinator of the **OSCE Economic and Environmental Activities**, requesting assistance from the **Environment and Security Initiative** (ENVSEC).

In response to an immediate follow up by the ENVSEC, the OSCE, the **Joint UNEP/ OCHA Environment Unit** (JEU) and UNDP Georgia in close cooperation with the MoENRP agreed upon a project proposal to address **immediate security threats at the three Tsana sites**, and specifically to address **waste management options and solutions** for the area and to design appropriate waste containment structures.

Subsequently, a **technical mission**, during the period **1-6 May 2014**, was assembled to verify actual conditions on the ground, agree upon a remediation concept and to develop an implementation plan.

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Photo 2: Tskhenistkali River, Tsana 1

Tsana 1

The factory in Tsana was used to produce **super-pure metallic arsenic** and refining raw arsenic oxide imported from Russia to produce **pure white arsenic** (As_2O_3), through refining burners.

The factory produced between **150 and 170 tons of finished white arsenic per year** from the waste imported from Russia, for which it utilized 25-27 thousand tons of imported white arsenic waste, and generated **30-35 tons of highly concentrated arsenic cinder**.

In the southern and western part of the Tsana 1 site, **arsenic cinder, arsenopyrite cinder, metal arsenic waste, and deteriorated arsenic drums** are scattered over an area of 5,890 m^2. Almost **the whole area had been polluted with white arsenic gas** resulting from refining without trap filters. The former main building of the mining factory, including building rubble, scattered materials and buried drums, are seriously contaminated with arsenic. In addition, small amounts of **asbestos debris** are disseminated over certain parts of the site. All these need to be managed in an environmentally sound manner. **Soil should be removed from this area to a depth of up to 50 cm** and within 1 m of the **excavated drums** in the rest of the area.

G. Pardini

Photo 3: Abandoned filters from arsenic-mineral roasting operations, Tsana 1

Table 2: Specifications of sites

Specifications of the sites	Sites		
	Tsana 1	Tsana 2	Tsana 3
Factory type	Refining burner	Storage	Production from ore/ Refining burner
Start year	1983	1986	1934
End year	1992	1992	1992
Contaminated area	22,360 m^2	1,800 m^2	31,620 m^2
Wastes to be disposed of	10,386 m^3	1,050 m^3	29,238 m^3

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Photo 4: Open drums with As-waste spread into the soil, Tsana 2

Tsana 2

The site was used as a **storage area for arsenic oxide** imported from Russian metallurgy plants.

The imported materials were placed in metal drums. Upon request, drums of white arsenic were transported from the storage area to Tsana 1 and Tsana 3 factories for refining and production of **pure white arsenic.**

Metal barrels with unutilized white arsenic were left in the open air for 22 years.

The amount of waste that was abandoned in this way was **450-500 tons of material.**

The drums have corroded and now are distributed randomly: some on the ground surface, some partially buried and some fully buried and **arsenic has been disseminated all over the area.**

Tsana 3

The production site made use of refining burners to burn **arsenopy-rite ore** to obtain **pure white arse-nic.**

The outdated construction, the poor sealing and the **absence of trap filters** caused significant losses of arsenic within the building and around the facility. Wastes to be disposed of included: drums con-taining white arsenic, spent arseno-pyrite ore cinder and a further **2-2.5 tons of cinder produced through refining.**

In 1986, the factory stopped burn-ing arsenopyrite and switched to **processing raw arsenic oxide** im-ported from Russia.

However, at the time the factory closed, **90-100 tons of imported white arsenic remained unproc-essed in drums.** These scattered drums are now deteriorated, un-sealed, cracked and **arsenic com-pounds are disseminated in the surrounding area.**

At the same time, **factory build-ing's debris are also partly con-taminated** with arsenic.

Thus, up to 10,122 m^3 of soil should be removed and in total up to 29,238 m^3 of **arsenic contami-nated waste requires sound man-agement.**

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Photo 5: Arsenic-containing drums and debris from the old factory, Tsana 3

Objectives of remediation

Measures to address contamination in Tsana sites will achieve a level of remediation that is consistent with international practice for the treatment of industrial sites. **The objective is to allow the return of land to agricultural use**, providing **technical assistance** in developing an action plan for the **safe transportation and disposal** of the hazardous waste.

In the Tsana area, there is a very high potential for tourism development. It is recommended creating **information panels** that describe the mining and industrial history of the sites and the work that has been done to address arsenic contamination, to add tourism and **educational value** to the area.

Remediation options

Options for remediation of soils contaminated with arsenic fall into two categories:

1. **Bioremediation technologies**
2. **Engineering technologies**

Bioremediation technologies use **plants and naturally occurring materials** to remediate or mitigate arsenic and its impacts.
Several plant species show important **root bioaccumulation of arsenic** that can be useful to **minimize arsenic mobility and diffusion** in contaminated areas. These techniques are still not well developed and require **extensive knowledge and research** in order to design an appropriate intervention.

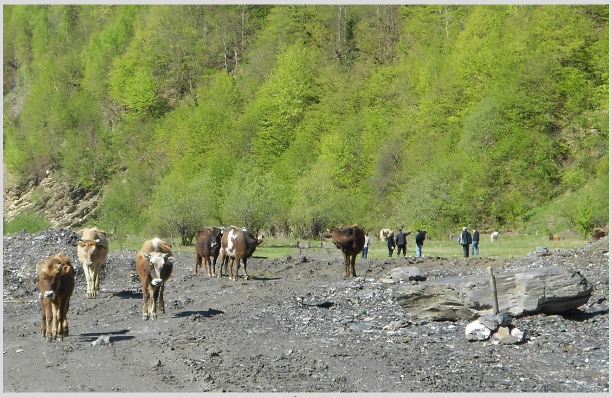

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Photo 6: presently, cattle graze freely at both Tsana 1 and Tsana 2

On the other hand, engineering technologies use **man-made devices or processes** to remediate or mitigate arsenic and its impacts.
A wide variety of such technologies are available but often are very specific and may have high infrastructural needs, *e.g.,* require **large amounts of power.**

Figure 2: impression of Tsana 1 after the remediation works

Source: final report

Figure 3: impression of Tsana 3 after the remediation works

Engineering solution

The recommended option for the sound management of hazardous materials (arsenic and asbestos) at Tsana sites is the **engineered containment** through the use of a **secure sarcophagus**.

The sarcophagus will be fully **sealed** using an **impermeable liner**, together with associated materials, **to prevent the entry of groundwater or surface water into the sarcophagus.** Moreover, it will be **profiled to blend in with the surrounding landscape**, as far as possible, and **covered with soil materials and seeded.**

The main goal is to **ensure that the sarcophagus facilities are not damaged in any way.**

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Photo 7: Construction of a protective dyke - Tsana 1

Key steps of remediation:

1. Construct sarcophagus in Tsana 1 and Tsana 3;
2. Remove and secure vegetation in order to not be available to animals or blown away;
3. Remove top 20 cm of soil in contamination zone, together with drums, asbestos debris and building rubble;
4. Monitor arsenic in soil at 20 cm depth;
5. Intervention level of 200 mg As/kg soil is recommended;
6. Place all removed/excavated materials into sarcophagus, and close sarcophagus;
7. Place vegetation in excavation and fill with clean rock and soil;
8. Re-vegetate with grass.

Technology advantages:

- Proven to be **effective** in environments compatible with the Tsana context.
- It is a **secure method** for ensuring that contaminants cannot enter the environment.
- It is **cost-effective** as a capital cost.
- Requires **little maintenance** and therefore **low maintenance costs**.

Cost estimates

Table 3 summarizes the costs for the remediation of each of site in Georgian Lari and Euro, assuming an exchange rate of **2.39 GEL/1 EUR**.

There are two options for the remediation of Tsana 2:

- **Option 1**: which involves the **removal of only the drums of arsenic waste** on the site and adjacent soils, together with trees necessary to access the drums.
- **Option 2**: which involves the **removal of the drums of arsenic waste and all surface soils**, together with all trees.

The costs shown in Table 3 include the direct costs of remediation, together with **labour, equipment and materials.**

Remediation costs are slightly less for Option 2, because they are offset by the higher costs of purchase and **installation of a fence in Option 1** to protect against the entry of animals and people into the Tsana 2 site, where contaminants will remain in some of the surface soils.

Table 3: Costs estimates for remediation

	Georgian Lari	Euro
Tsana 1	1,874,255	780,809
Tsana 2 - Option 1	88,416	36,832
Tsana 2 - Option 2	82,416	34,333
Tsana 3	3,829,634	1,595,348
Total Option 1	5,792,305	2,412,990
Total Option 2	5,786,305	2,410,490

Timing

In accordance with MoENRP priorities, **the immediate need is to undertake required actions at Tsana 1 together with measures at Tsana 2.** Actions should be undertaken at the same time: since the construction and the disposal of contaminated materials into the secure sarcophagus located in Tsana 1 will be technically complex and expensive, re-opening of the sarcophagus to fill the materials from Tsana 2 shall be avoided.

The Georgian Government intends to complete the required engineering work in 2014.

In any case, the **re-cultivation of soils cannot be undertaken until the engineering works have been completed**; hence, if engineering works can be completed in 2014, then re-cultivation of soils will need to be undertaken in 2015.

Regarding **Tsana 3**, although environmental contamination is severe, conditions are not expected to significantly deteriorate in the short term. Therefore, the **remediation activities at Tsana 3 may be undertaken in 2015**.

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