Sustainable management of areas impacted by elemental mercury generated in chlor-alkali processes

Group 2

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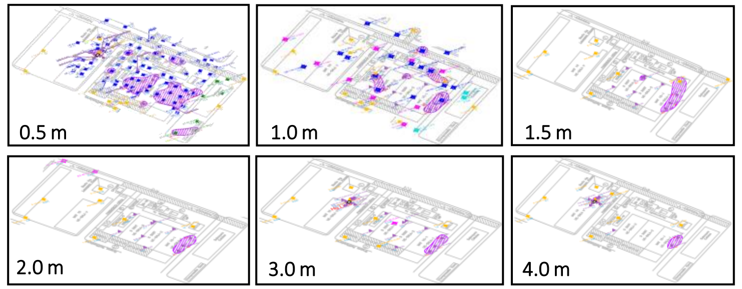
Background

The study was carried out in a chlor-alkali unit located in the Metropolitan Region of São Paulo, SP, Brazil. The unit, now deactivated, operated from 1948 to 1980. At that time, Soda, Hydrogen and Chlorine were produced by electrolytic processes using Metallic Mercury (Hg^0) as a cathode for reactions, which resulted in occasional losses of this element into the physical environment (surface soils, subsurface soils and aquifers).

The investigative processes covered the entire production area, revealing the presence of mercury up to 6 meters deep in the soil, and elemental mercury being diagnosed at 3 meters deep. Dissolved mercury plumes were delineated three-dimensionally in the phreatic aquifer.

According to Human Health Risk Assessment results, risks for outdoor industrial workers due to Hg inhalation exposure were identified, because of the concentrations found in surface and subsurface soil, ambient air and soil vapors. The **Figure 1** below represents mercury plumes at different depths.

Figure 1 – Human Health Risk Maps – Inhalation of Hg Vapors



An intervention plan was developed with the objective of adopting a technique with the lowest possible environmental impact, aiming to maximize the potential for soil reuse and make it suitable and safe for industrial use. Among the techniques evaluated, the option chosen was geotechnical capping.

Remediation Goals

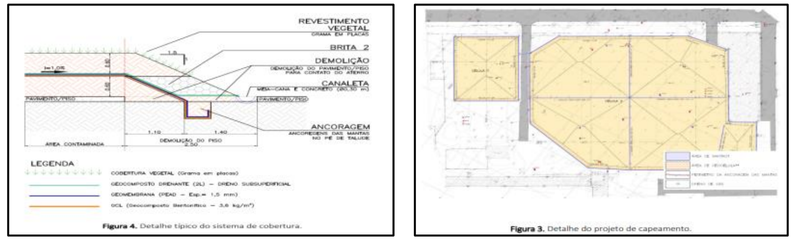
The objective of the intervention measure is to mitigate the risk and isolate the contamination, eliminating the route of exposure to the recipients.

Approach/Activities

The evaluated criteria included availability, performance in the impacted environment, ease of application, application consequences, cost, history of using techniques or actions for similar cases, time required to achieve remediation goals, technology, and sustainability. The capping technique prevents the infiltration of rainwater, preventing the leaching of contamination, as well as inhibiting vapor intrusion.

In this way, the geometric characteristics of the site were surveyed in order to choose the best system for covering hazardous waste landfills, taking into consideration not only the permeability, but also the geotechnical stability of the system. The work layout and the anchoring system of the blankets are shown in **Figure 2** below.

Figure 2 – Layout of the Geotechnical Capping Work



The adopted containment technique stands out for its safety, sustainability, shorter implementation time and economic feasibility in relation to the other techniques evaluated. In addition to the aforementioned factors, there is a reduction in the risks for workers involved in civil construction interventions. The foundation stage, application of the geocomposites are presented in **Figures 3 and 4**.

Foundation layer: it constitutes in the removal of vegetation and soil reconformation of the site.

Figure 3 – Foundation Layer

Clay geocomposites: these are installed below the geomembrane, working as a composite barrier.

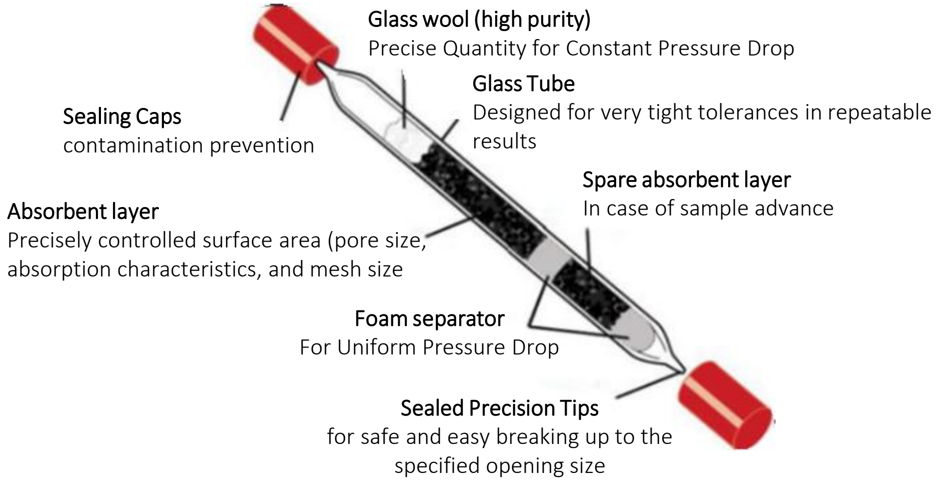
Figure 4 – Clay geocomposites

The construction process included the use of a mercury-resistant high-density polyethylene geomembrane (smooth HDPE with 1.5 mm thickness). In addition, layers of drainage and bentonite geotextiles were applied, with a layer of clay soil for mechanical protection. **Figures 5 and 6** show the final stages of the work.

Figure 5 and 6 – Application of the geomembrane and completion of the work

And finally, the containment technique aims at sustainability, observing a minimum consumption of energy and resources, generating less waste, eliminating the need for expensive water and steam treatment systems and not transferring mass to other locations, as some treatment options do.

Regarding the monitoring carried out, quarterly soil vapor and ambient air matrixes sampling has been carried out for Hg analysis, in accordance with the Intervention Plan. The selected method was based on NIOSH 6009, which is a guideline established by the National Institute for Occupational Safety and Health (NIOSH) of the United States for the sampling and analysis of mercury in air samples.



Analysis:
Technique: Atomic Absorption, Cold Vapor Generation
Analyte: Elemental Mercury
Desorption: conc. HNO_3/HCl – 25 ºC, dilute to 50 mL
Calibration: Standard Hg^{2+} solutions in HNO_3 1%
Range: 0.1 to 1.2 µg per sample
Estimated DL: 0.03 µg per sample (tube)

Sampling:
Sampler: Solid sorbent tube (Hopcalite Resin)
Sampling flow: 0.15 to 0.25 L/min
Volume: 2L to 100L – 0.5 mg/m³
Sample Stability: 30 days – 25 ºC
SQL – determined by contracted ISO17025 accredited laboratory

Results

After capping work conclusion, five monitoring campaigns were carried out for Hg analysis in ambient air and soil vapor matrixes:

- April/2023
- August/2023
- October/2023
- December/2023
- February/2024

Results < QL

The obtained results show concentrations below the quantitation limit, proving the effectiveness of the selected intervention. **Figure 7** below shows the quarterly sampling.

Figure 7 – Soil vapor sampling

Conclusion and Lesson Learned

The area can therefore be occupied and incorporated to outdoor industrial activities. The project is being monitored and has been approved by the São Paulo's Environmental Sanitation Technology Company (CETESB).

In this way, it can be concluded that the capping system has adequate conditions to perform its waterproofing function, preventing the rainwater infiltration into the contaminated mass, as well as the escape of Hg vapor into the atmosphere.

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