Site characterization of mercury polluted area prior to soil remediation activities

U. Zielonka*, A. Sas-Nowosielska*, R. Kucharski*, J. M. Kuperberg **
*Institute for Ecology of Industrial Areas, 6 Kossutha Str.40-832 Katowice, PL
** Florida State University, 226 Morgan Building, 2035 East Paul Dirac Drive, Tallahassee, FL USA

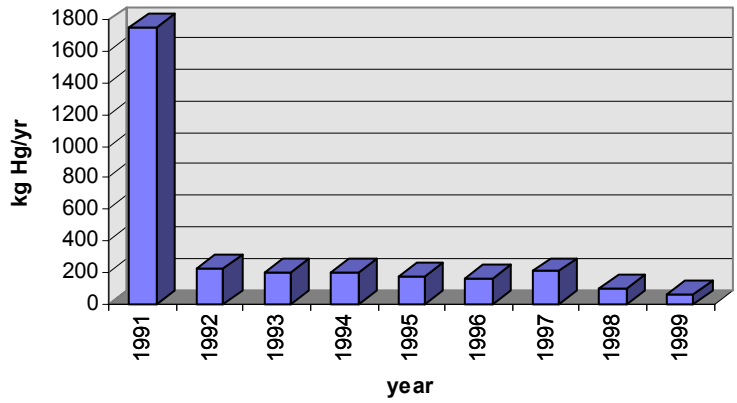
Abstract
The results of a U.S. Department of Energy sponsored project that was carried out by Florida State University and the Institute for Ecology of Industrial Areas, Katowice, Poland, are presented. The purpose of the project, entitled "Evaluation of Novel Mercury Remediation Technology," was to identify and evaluate promising technologies for the remediation of mercury-contaminated soil. The technology binds mercury and its compounds in soil, using an inexpensive substance, and then maintains soil condition that inhibits the transport of mercury. During the first year of the project the polluted site was characterized.
The site is a chemical facility, where mercury and its compounds are used in multiple manufacturing processes. The characterization effort included:

- determination of changes in Hg emissions over the last decade,
- contamination of surface and ground water with Hg in the vicinity of the facility site, and
- soil contamination with Hg.

Introduction
Mercury-polluted environment is a very serious problem, which we have to face not only in industrial regions, but also in developing countries. Numerous industrial activities, e.g. chlor-alkali production, have caused mercury contamination of terrestrial and aquatic ecosystems.
Literature review, focusing on the technologies for remediation of soil contaminated with mercury, revealed that the applied technologies have a number of significant drawbacks [1,2,3,4,5].
Few published data exist on mercury content in contaminated soils, although mercury contamination in soil is a problem found at many production (active and inactive) sites.
Soil contents in the order of few to several thousands mg/kg Hg were found in the vicinity of manufacturing processes where mercury and its compounds are or were used.

Results and Discussion
There are three sources of mercury emission to the atmosphere from chemical works: chlorine production using electrolysis, recovery of mercury from waste materials and coal combustion in the facility's power and heating plant. Annual mercury emission volumes from chlorine production are presented in Figure 1.
Hg emission reduction between 1991 and 1992 was a result of changes in technology:
- replacement of graphite anodes to fixed parameter titanium anodes,
- installation of carbon filters at alkaline-exhausting gases outlet,
- recirculation of acid-exhausting gases.

Fig.1 Annual mercury emission volumes



In order to determine surface water contamination, data from the measurements carried out for the Rivers of Dunajec and Biala up and down the river course were used. Annual median mercury concentrations in these rivers are presented in Figures 2 and 3. The permissible mercury concentration for Class I surface waters is 1.0 μg/l.

Fig. 3 Mercury concentration in Biala Rver

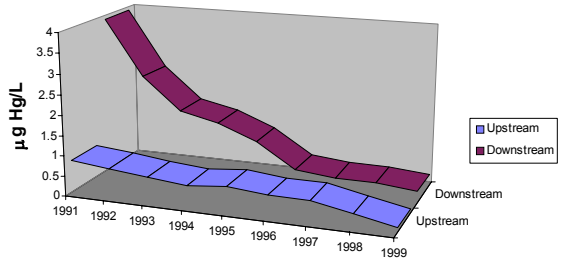
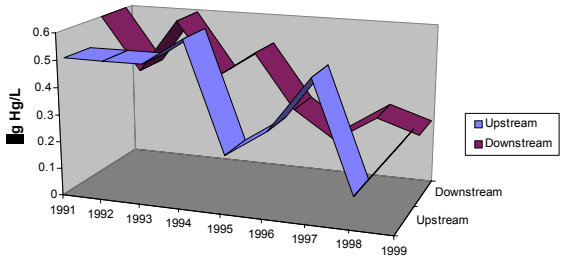


Fig. 2 Mercury concentration in Dunajec River



Data analysis from the facility's long-term environmental monitoring programs reveals that the area in the vicinity of the chemical works has not been contaminated with mercury from airborne deposition. Data for annual emission, mercury deposition and surface water concentrations (Dunajec and Biala Rivers) indicate that mercury contamination at the facility site has not spread to surface water or groundwater. Thus, the contaminated area is enclosed within the facility boundaries.
Results of total mercury concentrations (median) at four sites are presented in Table 1.

Table 1. Total mercury concentration [mg/kg of dry matter] in soil by depth .

Depth (cm)	Electrolysis Cells		Mercury regeneration facility		PVC - production facility		Incineration site	
	Range	Median	Range	Median	Range	Median	Range	Median
0 - 20	4.09 - 165.5	40.0	410.1 - 821.0	557.0	21.28 - 830.5	261.6	5.97 - 3663.0	161.5
40 - 60	2.04 - 49.18	9.83	10.57 - 13.36	12.23	0.67 - 44.53	9.13	37.86 - 133.2	37.86
90 - 110	0.40 - 13.15	4.95	1.36 - 47.75	18.55	0.28 - 7.26	2.23	1.94 - 45.57	12.18
140 - 160	0.48 - 7.36	2.60	1.47 - 6.55	3.28	0.25 -1.32	0.93	0.55 - 13.98	4.90

The highest mercury concentrations are found in surface soils and decrease rapidly with depth; however, the vertical distribution of mercury concentrations in soil and mercury concentrations in the piezometer samples indicate the downward migration of mercury. In view of technical limitations in mercury removal technologies, it was decided to focus our efforts on the immobilization of mercury and its compounds. At present, our research is focused on the selection of chemical substances and plants that would effectively bind/stabilize mercury and its compounds in soil.

The current best available control technologies (BACT), combine chemical/biological methods. New bioremediation technologies for mercury stabilization in soils, combine the activity of chemical compounds, microorganisms and plants, to effectively confine the contaminant.

Inexpensive chemical substances (i.e. sulfur, zeolite, dolomite), which are known for their ability to bind metals, were investigated. Changes in mercury content in the soil as a function of time were also determined.

After a 6-week addition of 0.5% granular sulfur to soil, 78% of water soluble and exchangeable mercury fraction was bound, while in the case of zeolite addition to soil, 49% of these fractions was bound.

Plants studied to date for mercury remediation accumulate mercury compounds mainly in their roots. The highest amounts of mercury were found in the roots of willow (*Salix virminalis*). Both investigated grasses (meadow-grass and fescue) have accumulated less mercury when compared to the willow, but created a very good soil stabilization system though their root mats.

References

1. Ebinghaus R. et al., 1999, Mercury Contaminated Sites, Characterization, Risk Assessment and Remediation, Springer New York.
2. Anderson C.W. (Ed.), 1994 ”Innovative Site Remediation Technology”, Stabilization/Solidification, Vol. 4, Springer-Verlag, Berlin, Heilderberg, New York.
3. Anderson C.W. (Ed.), 1993 ”Innovative Site Remediation Technology”, Thermal destruction, Vol.6, Springer-Verlag, Berlin, Heilderberg, New York.
4. Rough L.C, et al., 2000, Phytoreduction of Environmental Mercury Pollution in I. Raskin and B. Ensley (Ed.), Phytoremediation of toxic Metals: Using plants to clean up the environment, John Wiley & Sons, Inc.
5. Sobral L., J. Thoeming ,1998, Remediation of contaminated residue from the chlor-alkalli industry, with elemental mercury, by using an electrolytic process, in Thomas Telford (Ed.) Contaminated Soil’98, London, 1133-1134.