PROBLEMS OF DEMERCURIZATION OF INDUSTRIAL OBJECTS WITHIN THE FORMER USSR

M. A. Ilyushchenko, **L.V. Yakovleva**

Almaty Institute of Power Engineering and Telecommunication, Kazahkstan, mai2@mail.ru, mai4Hg@gmail.com

In the first half of XX century principle consumption of mercury in Russia/USSR was confined to gold mining (in total about 4000 tons till 1945 and 2000 tons more after 1945 /1/). In the second half of XX century within USSR as well as all over the world mercury use increased abruptly in technological processes especially in chemical industry, including chlor-alkali production with mercury cathode (in total about 13000 tons and more than 100 tons per a year nowadays – Table 1), acetaldehyde production (in total about 2500 tons) /2/, pesticides production (up to 200 tons per year in the 60s-70s) /1/ and other chemicals production (more than 15 tons per year to present day) /1/, vinyl chloride monomer production (more than 7 tons per year to present day) /1/. Total inventory of mercury consumers by independent experts has not been completed yet. At present besides chemical industry mercury is still used in production of thermometers and other measuring devices, light sources, chemical sources of electricity and other electrotechnical equipment. As a result despite tightening mercury normative documents and safety guidelines in the 1970s and introduction of restrictions on mercury use in industry during the later 1980s considerable amount of mercury entered the environment. In the middle of 1990s industrial recession was expected to stop this process however when closing down industrial enterprises in conditions of economic and political crisis scale contaminations of the environment with mercury were committed while uncontrolled dismantling and utilization of equipment and wastes burial.

Scale of mercury loses entered the environment in the former USSR was in the order of a few thousand tons for each of such large-capacity productions as chlor-alkali production or acetaldehyde one and several tens/hundreds tons for smaller chlor-alkali productions within wood-pulp factories, chemical reagents, polymers and pesticide plants, amalgam productions, as well as productions of electrical equipment and measurement instrumentation etc. (in total about 30000 tons has entered the environment without taking into account mercury mobilization while combusting mineral fuel and processing metallurgical feedstock.

At present storages of liquid and solid mercury wastes, mercury contaminated production facilities and buildings (especially their floor slabs and concrete foundations), grounds and underground waters underneath, contaminated soils within industrial areas and treatment facilities as well as along roads, bottom sediments of water bodies and waterways where mercury-bearing wastewater and surface water entered are a source of secondary pollution of the environment and pose a threat to human health. In fact at the present time there occurs a spread of mercury pollution first of all with surface and underground waters at any industrial center as well as through the atmosphere due to volatilization of metallic mercury from contaminated soils and wastes storages (scale of mercury emission to the atmosphere from some territories contaminated with mercury can be comparable with mercury emission from plants for fossil fuels processing/combustion).

Table 1. Chlor-alkali production with mercury cathode within the former USSR (as of 2008)

Enterprises (in parentheses - names of soviet period)	Annual capacity of caustic (thousand tons)	Wastewater treatment method	Mercury consumption rate, g/t of caustic (losses assessment, t)
OPERATING ENTERPRISES			
1. **JSC "Kaustic" Volgograd city,** Russia. The year of mercury electrolysis production start-up - 1968	120	precipitation as sulfide	600-700 (1700)
2. **JSC " Kaustic " Sterlitamal city**, Bashkortostan, Russia. The year of mercury electrolysis production start-up with use of "Krebs" bathes - 1964, the year of shutdown - 1987. Facilities and buildings have been demercurized, wastes rich in mercury were sent to Nikitovskiy mercury factory, wastes poor in mercury were landfilled. The year of mercury electrolysis production of doubled capacity start-up with used of "De Nora" bathes in new production premises - 1982.	150	combined: ion-exchange + purge	400-450 (1300)
3. **Surface-active substances factory, Sumgait city (PO "Khimprom")**, Azerbaijan. The year of the first mercury electrolysis production start-up – 1956, the year of shutdown - 1981, facilities and electrolysis shop have been demounted, mechanically cleaned from mercury and utilized; wastes rich in mercury were sent to Nikitovskiy mercury factory, wastes poor in mercury as well as debris of floor slab and soil down to 2 m deep from under the shop were landfilled. The year of the second production of the same capacity (new electrolysis building was constructed next to the old one and all infrastructure has been kept) start-up - 1982	70	ion-exchange	600-700 (1300)

4. **JSC Kirovo-Chepetskiy Chemical factory. Kirovo-Chepetsk,** Kirovskaya oblast, Russia. The year of mercury electrolysis production start-up - 1955	200	combined: precipitation as sulfide + ion-exchange	300 (1600)
STOPPED ENTERPRISES			
5. **Factory of chemical concentrates, Novosibirsk city**, Russia. The year of mercury electrolysis production shutdown - 2006. Facilities and buildings have been demercurized, new chlor-alkali production of smaller capacity based on a membrane method is being set up in the same production premises.	200	ion-exchange	300 (1000)
6. **JSC "Sayanskkhimplast", Sayansk city (Ziminskiy Chemical Plant)**, Irkutskaya oblast, Russia. The year of mercury electrolysis production start-up - 1979, the year of shutdown - 2006. Facilities and buildings have been demercurized, new chlor-alkali production of smaller capacity based on a membrane method operates in the same production premises.	150	Combined: ion-exchange + evaporation	600-700 (1400)
7. **JSC "Usolyekhimprom", Usolye Sibirskoe city**, Irkutskaya oblast, Russia. The year of mercury electrolysis production start-up - 1970, the year of shutdown – 1998. The production is being closed down. Design of demercurization of buildings and the territory has been prepared.	110	precipitation as sulfide	600-700 (1100)
8. **JSC "Radikal", Kiev city (Chemicals Plant)**, Ukraine. The year of mercury electrolysis production start-up - 1954, the year of shutdown - 1996. The production has been closed down. Facilities have been demounted. Feasibility study of a design of demercurization of buildings and the territory has been prepared.	60	ion-exchange	600-700 (900)

9. **JSC "Kaustik", Pavlodar city (PO Khimprom)**, Kazakhstan. The year of mercury electrolysis production start-up - 1975, the year of shutdown - 1993. Facilities, buildings (have been demounted) as well as territory (partially) has been demercurized; new chlor-alkali production of smaller capacity based on a membrane method is being set up in other production premises.	120	ion-exchange	1500 (1600)

Besides mercury plants of small capacity operated at: **PO "Kaprolaktam", Dzerzhinsk town**, Nizhegorodskaya oblast (start-up – 1948, shutdown – 1982) – 10 000 tons/year, and also **Arkhangelskiy, Novodvinsk town**, Arkhangelskaya oblast (start-up – 1962, shutdown – 1996) – 16400 tons/year, **Svetogorskiy, Svetogorsk town**, Leningradskaya oblast (start-up – 1951, shutdown – 1993) – 1300 tons/year, **Kotlasskiy, Koryazhma town**, Arkhangelskaya oblast (start-up – 1964, shutdown – 1998) – 19600 tons/year, and **Amurskiy, Komsomolsk-na-Amure city**, Khabarovskiy kray (start-up – 1970, shutdown – 1997) – 7400 tons/year **pulp and paper milks.** Wastewater treatment method used there is precipitation as sulfide. Kotlasskiy plant was demounted and utilized, buildings were demercurized, mercury wastes and heavily contaminated facilities were landfilled; at present chlor-alkali production of the same capacity operates based on a membrane method. Information on demercurization at the other productions is not available.

In total mercury losses during production of chlorine and alkali can be estimated to be 11900 tons + 900 tons = 12800 tons that is twice more than during gold mining in Russia/USSR for all historical period (about 6000 tons) /1/.

At present owing to a number of reasons the principle of which is opportunity of authorities not to account for mistakes of the soviet period in countries arisen at the post soviet space, concealment of industrial pollution of the environment with mercury (apart from a few special cases) has not been a matter of public policy any more. However regional authorities and in particular managers of ongoing enterprises using mercury try to conceal a scale of existent emissions in order to preserve profitability of a production or not to harm to plans of its modernization and development. As a result as a rule local authorities controlling state of the environment do nothing and scientists specialized in the area of environmental protection are not able to get any financing to carry out independent researches. It worth mentioning extremely limited number of new chemical-analytical laboratories having state-of-the-art equipment and highly qualified personnel capable of implementation of such kind of researches as well as degradation of laboratories survived since the soviet time.

Nevertheless gradually productions using mercury are being closed down by some reasons or gone into new non-mercury technologies (Table 1). The situation becomes common when development of a design of demercurization starts after a production shutdown and funds for field research aimed at revealing scale and specifics of a particular case of industrial pollution are not found. Absence of objective and correct evidences on the environmental impact assessment, mercury pollution effect on public health usually result in not only serious reduction of a list of remediation measures which should be done but is an obstacles for realization of the necessity in remediation at all (especially for small productions). Moreover no incentives arise to develop and apply new non-traditional cost effective remediation technologies.

As long as mercury had some market value closing of productions using mercury in their operation process was followed by metallic mercury collection including spilt one and utilization of wastes rich in mercury (PO ‘Khimprom”, Sumgait city in the early 1980s, PO “Kaustik”, Sterlitamak town in the late 1980s) which were sent to mercury factories for processing. At present wastes rich in mercury such as heavily contaminated equipment, building structures, sludge and soil are commonly buried without mercury extraction (PO “Khimprom”, Pavlodar city, PO “Karbid”, Temirtay city). Treatment and even removal of soils and bottom sediments less contaminated with mercury has been yet a matter of discussion at the stage of feasibility study working out and not gone beyond. Within the former USSR there has not been any example of bringing a similar problem to its practical implementation because it seems unfeasible to achieve MPCs for mercury (not only the former USSR standard – 2.1 mg/kg, but even European one – 10 mg/kg) in present-day economic conditions.

Kazakhstan has become to some extent an exception when during political and economic crisis in the 1990s mercury pollution risk assessment was done for two large-scale industrial enterprises such as still operating that time acetaldehyde production in Temirtau and closed chlor-alkali production in Pavlodar /3, 4/ for quite small grants allocated by European Union Programs of science and technical cooperation as well as by World Bank and US EPA on a competitive basis. That allowed revising the Design of demercurization of chlor-alkali production developed in USSA by including non traditional approach, new technologies and post-demercurization monitoring and attracting funds of World Bank and Kazakhstan Government for remediation of the acetaldehyde production as well as areas in the vicinity including the Nura River. Results of the research including risk assessment for public health /5/, study of mechanism of mercury transport with suspended solids downstream the river /6/, of many years monitoring of groundwater and computer modeling of mercury spread with groundwater /7/, comparison of balance and actual mercury discharge with wastewater can help to assess both risks posed by similar closed and still operating enterprises in Russia, Ukraine and Azerbaijan and effectiveness of measures on elimination of consequences of their production activity.

ACKNOWLEDGEMENT

The research is funded by US Environmental Protection Agentcy (US EPA) at the support of International Science and Technology Center (ISTC projects # K-1240p).

The authors thank Leonid E. Postolov for providing data for the Table 1.

REFERENCES

1. Report of Danish Environmental Protection Agency: Assessment of mercury ingress to the environment from the territory of the Russian Federation. Version 1.0, 2005-03-23. http://www2.mst.dk/Udgiv/publications/2005/87-7614-541-7/html/kap00_rus.htm

2. M.Ilyushchenko, L.Yakovleva, S.Heaven, E.Lapshin. Mercury contamination of the Nura River. Promyshlennost Kazakstana. #3 (6), 2001, P. 56-59 (Ru).

3. Mercury pollution management in Kazakhstan. http://hg-kazakhstan.narod.ru

4. Mercury pollution management at Pavlodar. http://hg-pavlodar.narod.ru

5. Hui-Wen Hsiao. Verification of methodologies for estimating human exposure to high levels of mercury pollution in the environment. Thesis for the degree of Doctor of Philosophy. University of Southampton. Southampton 2008. 178 p.

6. V.Yu. Panichkin. Geoinformational- mathematical modelling of hydro-geological systems of Kazakhstan. Abstract of Doctor's Dissertation. Almaty, 2004, 43 p.

7. M.Ilyushchenko, E.Lapshin, A. Delibarre, T. Tanton. Impact of combustion ash of KarGRES-1 on reduction of risk posed by mercury pollution of river Nura. Promyshlennost Kazakhstana. #3(30), 2004, P. 60-63.

8. M.Ilyushchenko, P.Randall, T.Tanton, L.Yakovleva, A.Ubaskin, R.Kamberov. Mercury Risk Assessment from a Wastewater Storage Pond in Pavlodar City, Northern Kazakhstan. Fifth International Conference on Remediation of Contaminated Sediments (Jacksonville, Florida; February 2-5, 2009). Platform & Poster Abstracts. Battelle: the Business of Innovation. Tuesday Group 1 Poster. P.1.