Aspects Of The Organization Of Regulated Assignment Of Excessive Brines In Superficial Water Objects Of The Entities Of The Potash Industry (on the example of the Verkhnekamsky field of potash and magnesian salts)

Andrey Bogomolov, Anatoly Lepihin

Mining institute of the ural branch of the Russian Academy of sciences 78-a, Str. Sibirskaya, Perm, 614007, Russia, whitewing85@mail.ru

Abstract

One of the world's largest the Verkhnekamsky field of potash and magnesian ores (VKFPMO) is actively developed. The main industrial complexes on development of this field are located within the Solikamsk-Berezniki industrial hub. Large volumes of production will inevitably make substantial effects on the environment, her separate components. The volume of formation of excess brines at the enterprises of the potash industry of VKFPMO is ≈ 107 m^3/year. Naturally, the problem of minimization of influence of such large amount of the polluted sewage is one of main ecological problem of Perm Krai.

Keywords: Verkhnekamsky field of potash salts, excess brines, hydrodynamic modeling, removal of sewage, potash salts, enrichment of potash ore, Kama River (Kama Reservoir).

Introduction

Until recently only PJSC Uralkali was engaged in development of the Verkhnekamsky field of potassium and magnesian salts, however now other large companies are actively connected to its development. LLC EuroChem-Usolye Potash Plant plans to start the large Usolye mine in the nearest future, production objects of PJSC ACRON are under construction. At the same time total production of finished goods can reach over 20 million tons/year. Such large volumes of production will inevitably make substantial environmental impact, its separate components. The superficial water objects are subject to the greatest loading that is caused by specifics of the accepted productions of both extraction of ore, and extraction from it the useful components.

Assignment of the considerable volumes of excess brines led to increase in content of chlorides in the Kama River (The Votkinsk reservoir) even around Perm more than by 10 times in comparison with the period before the fissile development of VKFPMO. In the foreseeable future at expansion of production capacity on PJSC Uralkali, start of production of LLC EuroChem-Usolye Potash Plant and PJSC Acron it is necessary to expect increase in volume of excess brines ≈ 20 million m^3/year.

Several solutions of a problem are possible

1. Technological path. Creation of waste-free schemes of productions of finished goods, introduction of the combined schemes of enrichment allowing to reduce substantially specific volumes of formation of excess brines, transfer of technological processes of the bound to enrichment of ore in the developed space of mines.
2. Use of excess brines in the national economy. Transfer to their "beneficiary", accepting at the same time that he undertakes all subsequent scratches from effect of these brines on a surrounding medium.

Possible directions of use of excess brines:

- downloading in oil wells for maintaining of intra reservoir pressure;
- in quality:
- tools for fight against frosting of roads;
- liquid mineral fertilizers;
- raw materials of chemical productions.

If to consider excess brines as raw materials for chemical production, then considering volumes their education, it owes

very large-capacity chemical production. To the most meeting these requirements production of soda is. So by production of 1 million soda 1-1.5 million m^3 of brines can be used, it is necessary for consumption of 20 million m^3/year productions of at least 13 million tons per year of soda. Now annual production of soda in our country is 3 million, respectively utilization of the considered volume of excess brines requires increase in the output of at least 4 times. Upon transition to the combined schemes of enrichment and decrease in specific indicators of formation of excess brines in to 3 times, it is required smaller increase in production of soda is substantial.

3. Burial in the geological structures.

Key characteristic for assessment of possible scales of these actions is the effective jointing (porosity) containing breeds (ξ). In approximate estimates as an estimated value we accept $\xi \approx 0.018$.

In view of that in the long term $\approx 20 \times 10^6$ tons/year the potash enterprises will work with annual production rate at least ≈ 10 years, in this case burial of the accompanying volume of the formed excess brines will require existence of the containing breeds by W volume $\approx 1^* 10^{10}$ м3, at the characteristic power of the containing thickness of HW ≈ 100 m, its area has to be $F \approx 10^8$ м2 ≈ 10 km × 10 km. At the combined scheme of enrichment according to $W \approx 0.3^*10^{10}$ м3.

4. Dilution to ecologically acceptable levels, by their assignment in the superficial water objects.

Now has experience of realization of assignment of excess brines in the main water object within the Solikamsk and Berezniki industrial hub of the Kama River (Kama Reservoir).

We calculated assimilative ability of the main water intake of sewage of this area – the Kama River (Kama Reservoir) around Berezniki. The assimilative ability of a water object is understood as ability of a water object to accept a particular mass of pollutants (also particular amount of heat) in unit of time without violation of standards of water quality in the checkpoint or point of water use.

In work potential volumes of pollutants which the considered water objects can assimilate within a year were calculated. Calculations were executed for the long-term period covering years of various water content. The analysis of results of calculation of potential containment of pollutants, the Kama River within the Solikamsk and Berezniki industrial hub showed that this water intake can successfully assimilate chloride (up to 4 million tons/year), a magnesium (up to 800 thousand tons/year), sulfate (up to 1.5 million tons/year) and calcium (up to 3 million tons/year) even in the most shallow years. However it is necessary to consider that very essential intra annual nonuniformity of a drain therefore in work the possibility of the organization of adjustable dumping of sewage is considered is characteristic of the Kama River.

Formally in the presence of the adjustable capacity capable to accumulate thrown off drains during rather long time term, it is possible to allocate two limit types of the adjustable (operated) dumping:

1) tough regulation depending on the hydrological and hydrochemical mode of a waterway receiver in strict accordance with condition: concentration of pollution/ the allowed concentration≤1;
2) the dumping with some constant expense during the particular period of T focused on minimum monthly flow with security of 95% for the considered T period. At the same time the single adjustable parameter is a priori established duration of dumping of T during passing of high water discharges.

In case of the organization of adjustable dumping also potential containment a water object of pollutants is of great interest if to dump them only in the period of a spring high water.

For this purpose like regulation potential volumes of pollutants which the considered water objects can take for the period of a spring high water were also calculated. At the same time, concentration paid as averages according to the measured hydrochemical tests in the period of a spring high water for the entire period of observations.

Thus, the Kama River (Kama Reservoir) within the Solikamsk and Bereznikosky industrial hub can accept without deterioration in the water management

indicators ≈ 4 million m^3 of excess brines, with orientation to the minimum monthly flow of 95% of security. At realization of adjustable assignment of brines, depending on the hydrological and hydrochemical mode, with accumulation during the low-flow period and the fissile dumping into the period of passing of a flood, removal of sewage there can be at least ≈ 4.5 times more, i.e. dumping ≈ 18 million m^3/year is possible (Lepihin 2017). Considering that specific volumes of formation of excess brines make 1 m^3 on 1 t of finished goods, the assimilative capacity of the Kama River (Kama Reservoir) quite could will cope not only with the modern volumes, but their possible body height in the short term.

However it is necessary to emphasize that these estimates are received at the following very serious assumptions:

- the full is provided of a dilution of the taken-away drains more narrow to alignments of an initial dilution;
- not operated, poorly controllable dispersed, diffuse polluters caused by filtrational unloadings from sludge collectors and pedigree dumps will completely be excluded.

The idiosyncrasy of excess brines is the their raised mineralization, and respectively and high density, in these conditions achievement efficient a dilution is very the difficult and expensive task. Also very the difficult task is decrease in their filtrational unloadings from sludge storage.

In too time removal of sewage in water objects, has such important advantage to ensuring environmental safety, in comparison with burial in the underground horizons as a minimum inertance of the considered processes. If in a control alignment in the automatic mode it is recorded excesses of acceptable level of pollution of water, then almost instantly this violation can be eliminated by change of the mode of dumping.

The main scratches at assignment of excess brines in the superficial water objects leading to decrease in reliability of the Kama River (Kama Reservoir) as main source of technical water supply for all Solikamsk and Berezniki industrial hub.

Assignment of data exuberant brines, without effective initial dilution, owing to the very high density results in the considerable vertical inhomogeneity of content of pollutants on depth of the Kama Reservoir. On certain sites of the Kama Reservoir the content of pollutants in benthonic area more than much exceeds their contents in the superficial horizons. Water intakes are located, as a rule, at the considerable depth owing to need of ensuring its work during a deep winter periods, the threat to their operational stability is created.

The brines which are taken away without preliminary initial dilution can extend to the considerable distance in benthonic area, creating very essential load of a biota.

At working off of technology and constructional solutions carrying out natural experiments is almost not possible because of their bulkiness, need of keeping of the water legislation regarding protection of waters, and laboratory researches are very not correct because of complexity of simultaneous ensuring similarity on a complex dynamic (Reynolds numbers of Re, Froude Fr) and also density criteria (Richardson's number of Ri). Therefore as the main tool of the solution of an objective computing experiments on the modern supercomputer were used (a cluster of the Uranus of IMM UB RAS). The computing experiment was realized on the basis of interface of hydrodynamic models in 1-, 2-and 3-dimensional statements. The technology of such calculations was repeatedly discussed in domestic and foreign editions (Lubimova 2016, Miguel Cañedo-Argüelles 2017).

The analysis of the presented design and technology solutions of the organization of the disseminating release for assignment of excess brines showed that for conditions of the Kama Reservoir (Kama River) near the Solikamsk and Berezniki industrial hub the option can reckon with benthonic assignment of drains as priority. It, first of all, is caused by features of the hydrological mode of the considered water intake: considerable intra annual fluctuations of level of water and ice mode. In this case when dumping excess brines it is necessary to use the selection of the taken-away drains from a sludge storage that considerably will increase overall performance of this waste device.

Realization of adjustable dumping is possible only on condition of correlation of volumes of dumpings of sewage with real water discharges in the water intake. In this work the results of numerical model operation characterizing distribution of concentration on depth and on the water area as a result of dumping of sewage into the water intake were used. These data allow to choose with deep arguments an optimum design and the scheme of assignment of excess brines.

Adjustable dumping of excess brines depending on the hydrological and hydrochemical mode of water currents receivers allows to use much more fully their assimilative potential and without holding any other additional water preserving actions is capable to lower substantially the maximum peaks of concentration of pollutants which are observed at minimum flows of water currents receivers.

References

Lepihin A.P., Wozniak A.A., Tiunov A.A., Bogomolov A.V. To a problem of correctness of methods of calculations and tasks of initial hydrological and hydrochemical information at a regulation of technogenic impacts on water objects.//Water management of Russia: problems, technologies, management. 2017. No. 1. page 58-77.

Lubimova T.P, Parshakova Y.N., Tsiberkin K.B., Lepihin A.P. Numerical modeling of liquid-waste infiltration from storage facilities info surrounding groundwater and surface-water bodies // Journal of applied mechanical physics, December 2016, Volume 57, Issue 7, pp 1208–1216.

Miguel Cañedo-Argüelles, Sandra Bruceta, Sergi Carrasco, Núria Flor-Arnau, Marc Ordeix, Sergio Ponsá, Eckhard Coring. Effects of potash mining on river ecosystems: An experimental study // Environmental Pollution. Volume 224, May 2017, Pages 759-770. https://doi.org/10.1016/j.envpol.2016.12.072.