

Geological and economic aspect of brine processing as a tool for normalization of the Pre-Carpathian Depression's natural balance in the context of general monitoring of the region's ecological state

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SUMMARY

Brines are one of the reasons of a number of environmental and economic problems in the Pre-Carpathian Depression. The permanent ecosystem's imbalance, in particular of the water one, as well as the need for regular budget allocations to prevent environmental disasters, including situations within protected areas, demonstrates the imperfection of existing methods and tools aimed to ensure the planned development of the region. Based on the analysis of monitoring data for the recent years and the main characteristics of global brine processing technologies, the theory of brine accumulation sites integration into region's healthy ecosystem by optimizing the industry's technological base in terms of economic and environmental benefits was proposed. The success indicators of the proposed approach and its direct impact on the stabilization of the level of ecological safety and level of material welfare increase are determined.



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Introduction

The Pre-Carpathian Depression's territory, by the example of which the possibility of natural balance normalization is considered, is the one, where efforts aimed to solve problem of region's sustainable development are constantly made. The presence of deposits, in the study region, the development of which significantly affects a number of country's economic indicators is the main reason for the steady accumulation of negative impact on the environment and human, which can be observed in areas of potassium salt production.

Regular discharges of drainage waters with significantly exceeded salt content from water reservoirs and potassium salt deposits' tails into surface river flow leads to disturbance of geochemical (landscape-geochemical), medical&geological, hydrogeological parameters (*Maniuk et al, 2009*) of the geological environment, which in one way or another reflects the population' level of well-being, bringing the issue of environmental safety to the list of priorities.

Theory

One of the reasons of a number of environmental and economic problems' occurrence in the Pre-Carpathian Depression is salt facilities, including those that are currently inactive - for example, Kalush-Golynske and Stebnytske deposits. The analysis of anthropogenic stress' indicators of the environment of Ivano-Frankivsk and Lviv regions was done. According to the obtained results - the excessive brine volumes left after previous years' mining are identified as the main factor that affects almost all elements of the biosphere at the present time. Monitoring data processing results of the state of the most important waterways of mentioned regions are the evidence of the brines processing increasing topicality, which permanently imbalance the ecosystem. Among the illustrative examples of the last statement are:

- the disturbance of natural nutrition conditions, transit and ground & surface water unloading, including salinization of groundwater on an area of over 1000hectares, which were removed from the land use system due to the regular infiltration of brines from the Dombrovsky quarry (Kalush-Golynske deposits) and its tailings (*Holovchak, 2012*);
- well-marked changes in average annual mineralization and concentrations of pollutants in Limnitsa River (which is the cleanest one in Ukraine), caused by connection of highly concentrated brines of the Dombrovsky quarry with the drinking aquifer (Fig.1-3);

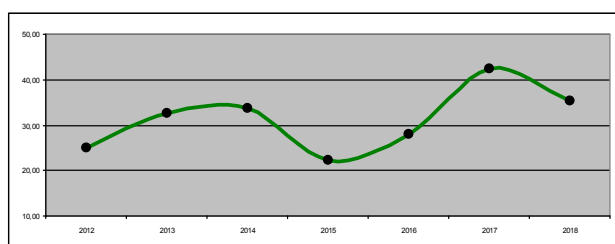


Figure 1 Changes in average annual concentrations of sulphate in the Limnitsa River, mg/l

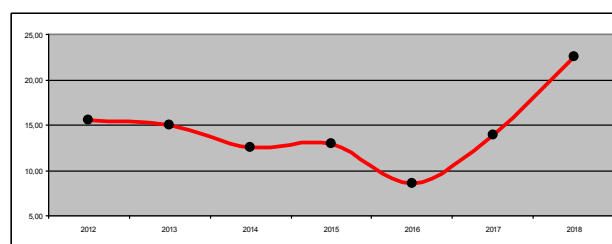


Figure 2 Changes in average annual concentrations of chloride in the Limnitsa River, mg/l

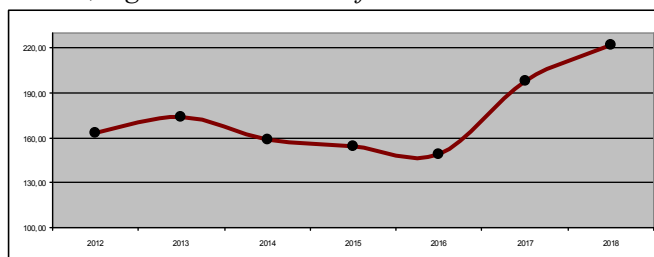


Figure 3 Changes in average annual mineralization in the Limnitsa River, mg/l



- the continuous brine infiltration (concentrations of which increase annually) to the sources of drinking water supply in the basin of the Dniester and Tysa rivers, which is followed by the enrichment of their aquatic environment with a number of synthetic substances and heavy metals (*Results of water screening..., n.d.*);
- the changes of the natural characteristics of protected areas and sanitary protection zones of the Truskavets' resort, in particular of the River Solonitsa where the discharges of drainage waters with significantly exceeded salt content from Stebnytske deposit's water header are fixed (Fig. 4-5); (*Snitynskyi et al., 2015; Monitoring and environmental assessment..., n.d.*)

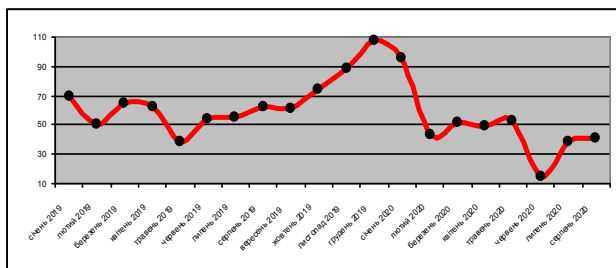


Figure 4 Contamination of the Truskavets protected area main water intake with chlorides

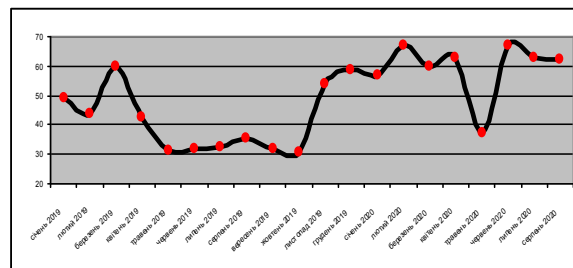


Figure 5 Contamination of the Truskavets protected area main water intake with sulphates

The significant funds from the state budget are regularly allocated to eliminate the environmental problems created by brines from mentioned facilities, but the treatment of consequences, instead of causes, does not contribute to the growth of regions on the path of sustainable development.

Brine processing is one of the most promising solutions to the problem, which opens up opportunities to balance economically profitable activities with the nature preservation. Among methods that have become the most widespread in Ukraine are simple evaporation, vapor compression distillation, vacuum evaporation, desalination using hydrophobic liquids, helio-desalination. Today, all these approaches are referred to traditional ones and are characterized by a number of disadvantages, including cost and low productivity.

At the same time, at the global level, there is a growing interest and growing number of cases when new technologies aimed to ensure the high quality brine management (including the most complete water purification and direct extraction of salts) has been implemented effectively. And the mentioned salt extraction is considered as a potential source of increasing the country's income.

Considering the mentioned above, the integration of brine accumulation sites within the Pre-Carpathian Depression into regions' healthy ecosystem might have a positive dynamics so long as the approaches to work with highly mineralized brines will be transformed, and will be accompanied by the optimization of technological base of the industry concerning economic and environmental benefits. Primarily, the approach which is assumed as an appropriate is the introduction of hybrid technologies, which are as close as possible to the definition: "cost-effective, with zero discharge of pollutants." This stage will ensure a smooth transition to a complete reorganization of existing system of approaches aimed to solve the existing environmental problems which emerge from the contact of environment with the mining facilities' brines.

Results

The comparison of brine evaporation technology, which at the moment is considered as the most realistic for use in Ukraine with new membrane technologies (as, for an example, the full-scale process of electrochemical separation (brine electro dialysis (ED)) and experimental method (pilot-scale one) of membrane distillation (MD)) (Table 1) (*Pramanik et al., 2017; Jevons et al., 2010,*



Charisiadis, 2018), clearly demonstrates the expediency of revising the domestic brine work approach taking into consideration the involvement of advanced technologies in solving problem.

Table 1 The comparison of brine processing technologies

Technology		Advantages	Disadvantage	Technical peculiarities	Economic observations
Evaporation technology		Suitable for inland and coastal facilities	Need the control of erosion&seepage (if it is an evaporation pond)	Possible contamination of groundwater	Comparatively high capital costs
		Easy to construct and implement	Low productivity High energy consumption		
		Economical if land is inexpensive	Significant physicochemical footprint	Simple operation	
		Possible commercial salt exploitation			
		Do not require the involvement of significant technological resources and management			
Membrane technologies	ED	High limits of the total amount of dissolved solids in water (more than 100000 mg/l)	High energy consumption and cost in the processing of highly mineralized brines	Salts' subsidence on the electro dialysis membrane	Moderate electric energy is required
		Effective for use during the work with concentrates with a high silica content	Organic fouling of membranes can create problems with the system and may require pre-treatment of brines		
		Low tendency to malfunction			
	MD	High limits of the total amount of dissolved solids in water (more than 200000 mg/l)	Post-treatment is needed if volatile pollutants are present	Flux reduction due to the scale formed by the subsidence of salts on the membranes	Energy consumption is less than in case of using traditional evaporation systems
		No requirements for brine supply pressure			
		Low tendency to malfunction	Low water flux and water recovery	The treatment of brine concentrate is expediential	



The cost of processing brines with membrane technologies (ED = 0.6 - 10.5 \$/m³; MD = 0.64 - 1.23 \$/m³) provides a multi-million investment (if we take as an example the Dombrovsky quarry, where about 10 million m³ of brines have been accumulated) which, however, will be fully recompensed after realization of the received product (for example, technical salt). This statement is substantiated by significant potential volumes of its extraction from 1m³ of brine (210kg of technical salt/m³), as well as the average price (≈2 UAH/kg) set on the market.

Thus, even partial use of mentioned methods, accompanied by correct strategic management will lead to the regular budget receipts and partial reduce of the the need to allocate funds to prevent environmental disasters due to the impact of brines on the environment.

As success indicators of the proposed approach to the natural balance of the Pre-Carpathian Depression normalization, there might be accepted the mineralization decrease and the reduction of pollutant concentrations in the main regions' waterways, as well as the lack of a corresponding cost item in the regional development annual budget of expenditure.

Conclusions

The possibility of works' reorientation at the objects under study from traditional to modern ones in combination with the most perspective proposals on ecosystem balance restoration is an obvious chance for the regions to stabilize the level of ecological safety and increase the level of material welfare by: full compensation for work costs, reducing the impact of direct environmental aspects and making a profit through the sale of raw materials obtained as a result of brines processing on the market.

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