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## Leading role of Dombrowski quarry as the source of groundwater contamination

**S. M. Bagriy, E. D. Kuzmenko, \*U. O. Dzoba, L. I. Davybida** (*Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk*)

### SUMMARY

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The probability of salinisation for the quaternary aquifer within the area of the Kalush-Golyna potassium salt deposit (Precarpathian) was analyzed. Currently, the salt piles, tailings ponds and storage tanks are the main sources of salinisation. In the long term, Dombrovsky quarry will play a dominant role in groundwater pollution. Comparison of the brine filling dynamics with digital geological-hydrogeological models of the surrounding territory proves that intensive contamination of the alluvial aquifer with brines from the quarry will begin no later than 2026.

## Introduction

The Kalush-Golyn potash salt field is situated within the Precarpathian salt basin. Salt extraction was carried out using the open-pit and close-pit mining method. The Dombrowski quarry was operated from 1967 to 2003. Currently, there is a natural filling of brines. Resulting from this, the problem of the quarry filling dynamics and, thoroughly, the contamination (water salinization) of a surrounding aquifer, which is hydraulically connected to the river system of the Dniester basin, is considered.

Investigation of man-made burden on the environment within the area of the mine lease of Kalush-Golyn deposit was carried out by many Ukrainians researchers (*Rudko and Deputat, 2003, Dolin et al., 2010, Haydin et al., 2013; 2014; Dyakiv, 2015*), as well as the authors of this thesis (*Hurska et al, 2015; Bagriy et al., 2017*).

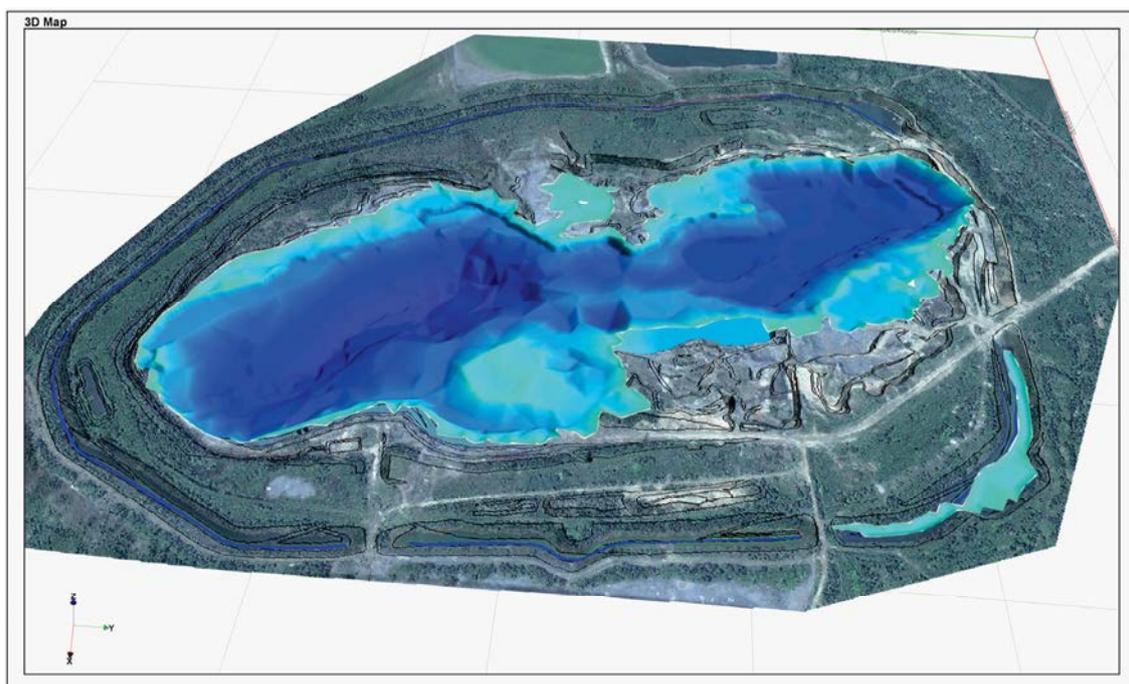
At the same time the issues of pollution and disturbance of the existing environment were distinguished due to the following types of activities and the corresponding natural and man-made processes: creation of salt dumps with the subsequent separation of salt fractions, creation of tailing dams and storage tanks with the subsequent leakage of brine from them, existence of mining caves and infiltration processes intensification with the subsequent karstification and the occurrence of subsidence and sinkholes, as well as the impact of the Dombrowski quarry on the hydrodynamic regime of groundwater.

In the following we present the results of the next stage of research:

- a brief characterization of the Dombrowski quarry as a geomorphological structure;
- dynamics of filling and variation of brine surface absolute altitudes;
- geological and hydrogeological characteristics of the surrounding area;
- characterization of the dynamics of filling the aquifer with quarry brines.

## Results

The Dombrowski quarry has a volume of 50,1 million m<sup>3</sup> with an area of 2,008 km<sup>2</sup>. Its maximum depth is 125,2 m and the perimeter is 5311 m. The DEM of the quarry has been created for objective morphological assessment and determination of the quarry filling at any time. One of the options of the quarry filling (May 2019, the absolute water level – + 282,34 m) is shown in fig. 1. Quarry surface absolute altitudes are +298,7 m at the north field and +301 m at the south field.



**Figure 1** The DEM of Dombrowski quarry with modelling brines filling

The dynamics of changes of the brine surface absolute altitudes and the volume of quarry filling is clearly characterized by graphs of Figs. 2. The two branches of the graph on its left side are characterized by different modes of filling the south and north fields of the quarry. In 2008, these fields connected and one whole artificial lake was created. The quarry was been filling by waters of the alluvial aquifer, the surface absolute altitudes of which were for some time above the quarry level, and by the water filtration from the Sivka Kaluska River, which is flowing along the northern side of the quarry. However, precipitation is the main and stable source of filling. At 750 mm of precipitation per year, 1,5 million m<sup>3</sup> of them per year enters in the quarry with its area in 64 ha. The percentage of evaporation is estimated at 40% for the actual brine area, which increases every year. Instead, water nutrition from the groundwater aquifer is reduced due to the brines displacement.

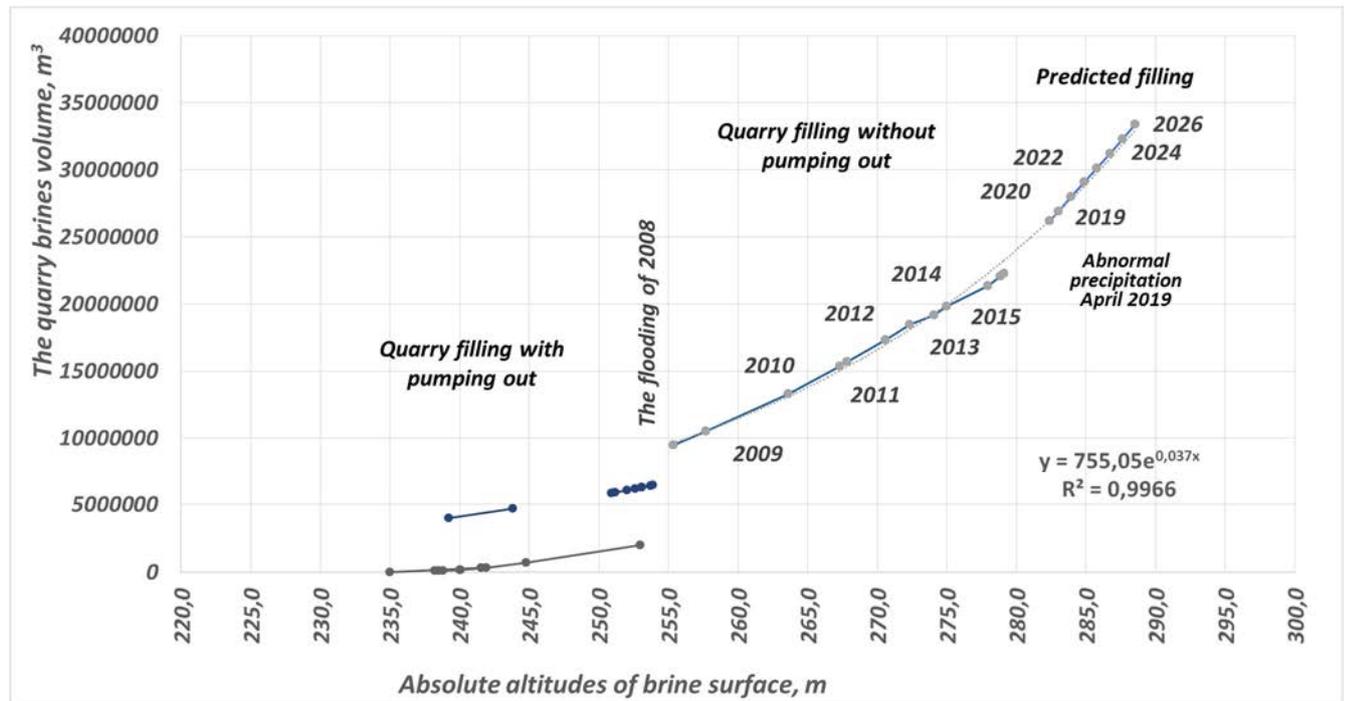


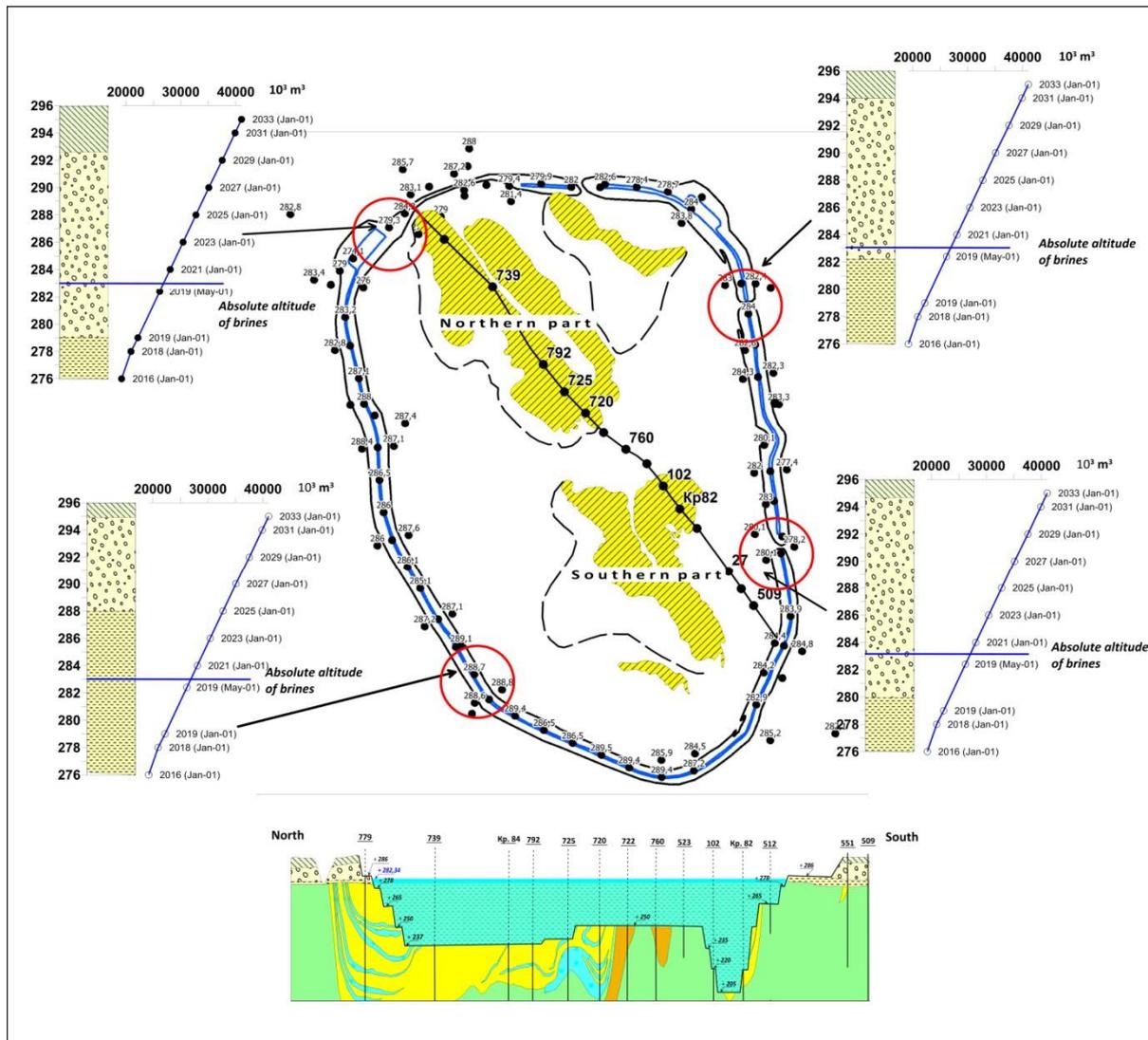
Figure 2 The prediction curves of the Dombrowski quarry filling for the brine volumes and brine surface absolute altitudes

Additionally, we should focus on the level of groundwater mineralization. An attempt of analytical estimation of mineralization was given in (Dyakiv, 2015). However, the observation of the surface mineralization indicates that it is not significant and fluctuates within 10-20 g/dm<sup>3</sup>. The regularity of the fluctuation with the depth, which was given in the scientific reports of Limited Liability Company "GIRHIMPROM", indicates that at a depth of 5 m mineralization is 33,5 g/dm<sup>3</sup>, at 10 m – 92,2 g/dm<sup>3</sup>, at 20 m – 205,5 g/dm<sup>3</sup>. Near the bottom, the mineralization reaches its possible maximum – 400 g/dm<sup>3</sup>. So, when the level of brines in the quarry exceeds the absolute altitude of the aquifer, the latter will be intensively filled with brines.

Geological section of the adjacent to the quarry territory is characterized by covering rocks with a capacity of 1-3 meters, then – ancient alluvial quaternary formations of the Limnitsa River (a tributary of the Dniester), which lie on the indigenous neogene rocks (saline breccia), layers of potassium.

The alluvial aquifer has a pebble composition with a sandy-clay filler. Its capacity ranges from 11,2 to 18 meters. The values of the filtration coefficients range from 5 to 457 m per day, with an average of 155 m per day. Above mentioned geological section of surface rocks, including the aquifer, has been studied in detail around the quarry with wells drilled along its perimeter. Around the quarry, the absolute altitudes of the aquifer sole fluctuate within the absolute mark of 280-286 m, and of the aquifer roofs – within 297,2-298 m. Comparison of data Fig. 2 and the aquifer altitudes (x-axis of the plot) indicates that the process of infiltrating the brines is currently ongoing. 4 points at the perimeter

of quarry were selected to analyze the degree of flooding (Fig. 3). For these points, the dynamics of quarry brines filling and groundwater levels are shown according to the geological section.



**Figure 3** Comparison of the brines absolute altitudes in the Dombrowski quarry and groundwater levels within the surrounding territory

From the above figure, it is clear that intensive filtration and groundwater leakage from the alluvial aquifer into the quarry from the northeast direction is currently continuing. Raising the brines level in the quarry will “crush” the aquifer, which will cause it to be heavily salinized. At present, salinity of the aquifer is related only to the salt dumps, tailings dams and storage tanks. Therefore, it is a well-timed action to assess the aquifer nutrient basin taking into account quarry brines and assess the possibility of contamination with brines for the Dniester tributaries.

**Conclusion**

1. Within the territory of Kalush Golyn deposit of potassium salt, which is situated in the Precarpathian region, salinity of the quaternary aquifer is observed. This aquifer is hydraulically related to the tributaries of the Dniester basin, which are drains for it.
2. The sources of salinity of the aquifer are salt dumps, tailings dams and reservoirs, which have been proved by hydrogeochemical and geophysical studies.

3. Obviously, the Dombrowski quarry will play a dominant role among the pollution sources in the future.
4. Based on the created digital geological-morphological and geological-hydrogeological models and their analysis, it is proved that the quarry brines will start entering the aquifer not later 2026 year due to raising their levels in Dombrowski quarry, which is an insurmountable force factor. This impact will reach its maximum until 2030 year.
5. The next necessary research stage should be the calculation of the level of pollution for the Dniester river basin (taking into account its transboundary status) in order to develop measures to prevent a catastrophic situation.

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