WATER QUALITY IN A DISTURBED MINING LANDSCAPE. CZECH REPUBLIC

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ABSTRACT

In this article we assess the impact of water flow system and precipitation on choose hydro chemical parameter in water-bearing subside areas. Key findings of this study are significant correlation coefficient values obtained from the precipitation amount and occurrence of total phosphorus and phosphates. Therefore the significant effect of other anthropogenic activities on water reservoirs was excluded. The conclusion of this study is that inflowing water (in the case of relatively clean streams) and precipitation can have a positive influence on hydrochemical parameters in water-bearing subside areas and generally contribute to dilution.

Keywords: water-bearing subside areas. precipitation. hydro chemical parameters

1 INTRODUCTION

When assessing the mining influence on our environment. the influence on nature and landscape conditions and development means a very specific feature. Considering the fact that controlled caving without backfilling applied in Ostrava-Karvina mining region. the changes of relief are rather big. In addition to transforming the terrain. which often leads to disruption of indigenous ecosystems. there are also changes of groundwater regime and surface water. microclimate conditions. physico-chemical and strength characteristics etc. These changes lead to destructions of buildings and utility networks. The mined out ground subsides and these areas are called subside areas. Size of these areas and subsidence speed depend on many circumstances. e.g. mining technologies. mining speed. seam thickness. [1], [2].

The process of areas subsiding is not yet finished in Ostrava - Karvina district and will still occur even after closing local mines. Already existing subside areas might be further deepened and broadened due to ongoing mining activities. Currently. some landscape sanitation – recultivation projects were suggested. mainly hydrological recultivations. [2].

2 METHODS AND AREA DESCRIPTION

The areas above the cavities decline and large subsidence troughs are formed. The extent and speed of subsidence depends on the mining technology. speed of the advance. seam thickness. the method of packing the mined out areas. the properties of the roof. etc. Water can accumulate in the formed depressions. In the past such drain less basins – subsidence troughs were often the subject of extensive improvement works and served for the foundation of settling basins for flotation tailings and coal slurries. The process of subsidence trough formation in the Karvina partial basin of OKR has not been finished and it will last even past mining termination. The subsidence troughs can even deepen and widen due to mining activities. Currently. certain improvement – reclamation constructions (ARS) are designed as hydric reclamation. The evaluation was carried out in sixteen localities where waste rock had been used in the past for the purposes of bank system improvement. [3],[4]. Figure 1 shows 16 monitored sites in the Karviná district of Ostrava. Table 1 lists the GPS location of these locations.

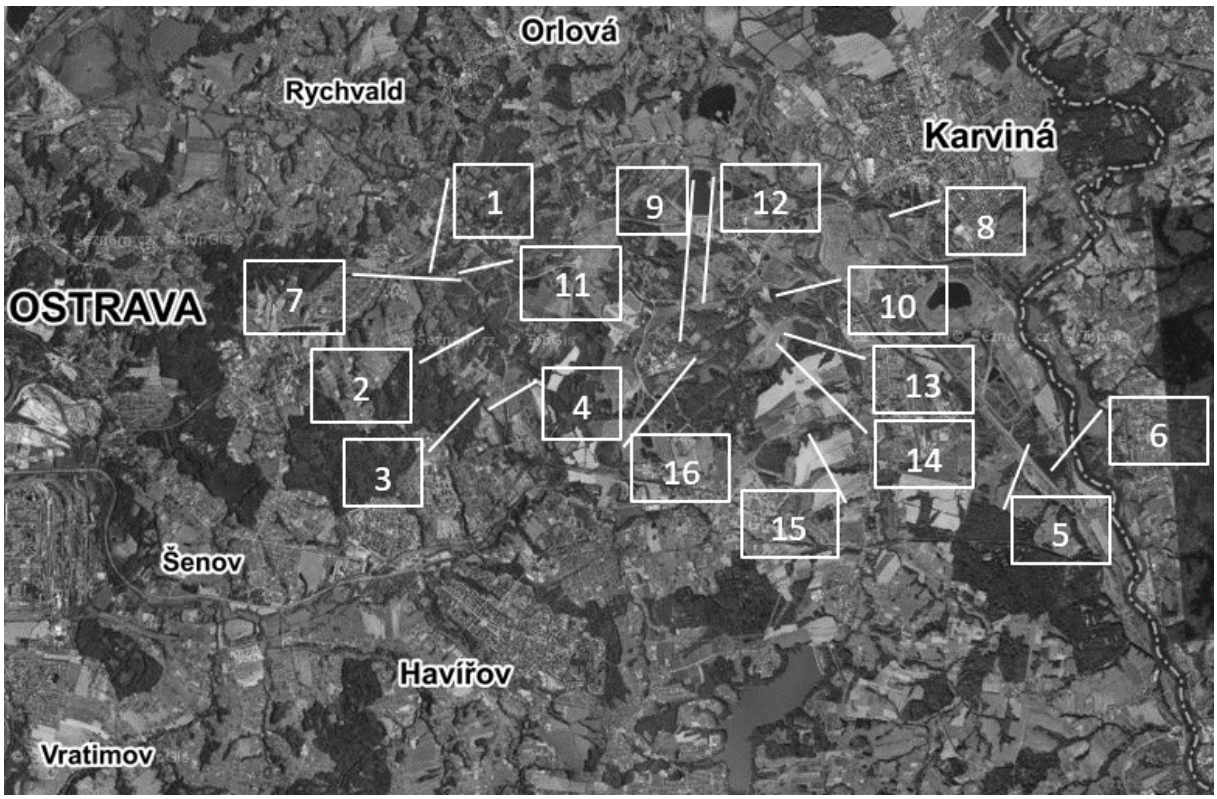

Figure 1. Map with sampling points.

Table 1. GPS location of supply points.

Place of Subscription	Marking in the map	GPS (N. E)
Kozi Becirk	1	49.829394. 18.429266
Dablik	2	49.813483. 18.450727
U lesa nad Bartosuvkou	3	49.817250. 18.429194
Bartosuvka	4	49.815215. 18.431985
Myskovec	5	49.810321. 18.570831
Velky Loucky Rybnik	6	49.806750. 18.575916
Ignacok	7	49.826261. 18.439870
Karvinsky les	8	49.848190. 18.534495
Barbora	9	49.826982. 18.476496
Vetrna jama	10	49.819050. 18.522066
Pansky stav	11	49.828123. 18.441854
Kostel	12	49.834559. 18.490648
Lanovka I.	13	49.826965. 18.506242
Lanovka II.	14	49.824293. 18.504498
Kateřina	15	49.810389. 18.510262
Mokroš	16	49.822115. 18.490232

Hydrochemical and hydrobiological processes in water-bearing subside areas are similar to the ones that occur in small water reservoirs. Therefore literature-based knowledge concerning small water reservoirs can be here also applied. There are no national standards (legislation) for this kind of water reservoirs in the Czech Republic yet. [3]. [5]. [6]

The influence of water flow systems and precipitation on each hydrochemical parameter was studied in sixteen different localities. The main water management problem (concerning small water reservoirs) is the high water level fluctuation during the year. Subside areas that are supplied only with the precipitation water can also be characterized by high water volume fluctuation. This can result in water quality and biological changes. [2]. [7] The linear correlation relation between precipitation and hydrological parameters was studied for the evaluation of precipitation influence on water quality. [7]

3 RESULTS AND DISCUSSION

Although dissolved solid substances do significantly influent water quality. no dependence between the content of dissolved solid substances and precipitation amount was determined. Significant correlation coefficient values for precipitation amount and hydrochemical parameters are shown in the table 1. Highlighted are both-sides increases of studied parameters.

Table 2. Significant coefficient values between precipitation amount and hydro chemical parameters Explanatory note.

Locality	pH	Cl^-	Ca^{2+}	Mg^{2+}	P_{total}	$P\text{-}PO_4$	$(HCO_3)^-$	BOD_5
Kozi Bezirk	*	0.56	*	*	*	*	*	*
Dablik	*	*	0.54	*	0.67	0.64	*	0.51
U lesa nad Bartosuvkou	0.65	*	*	*	0.49	0.52	*	*
Bartosuvka	*	0.56	*	*	0.71	0.66	*	*
Myskovec	*	*	*	*	0.51	0.59	*	*
Velky Loucky Rybnik	*	*	*	*	0.48	0.63	*	*
Ignacov	*	*	0.51	*	*	*	*	*
Karvinsky les	*	0.48	*	*	*	*	*	*
Barbora	0.56	*	0.57	*	*	*	*	*
Vetrna jama	0.50	*	*	0.52	*	*	*	*
Pansky stav	0.65	*	*	*	*	*	*	*
Kostel	*	*	0.65	*	*	*	*	*
Lanovka I.	*	0.50	0.74	*	*	*	*	*
Lanovka II.	*	0.56	*	*	*	*	0.57	0.53
Kateřina	*	*	*	*	*	*	*	*
Mokroš	*	*	0.58	*	*	0.69	*	*

Explanatory note:
Increasing or decreasing trend; * not significant coefficients (below the coefficient of 0.5)

Comparing obtained correlation coefficient values, it is possible to state that even though the elements come from the same source. their ability to migrate depends on other factors (solubility). The biggest correlation dependances were obtained when studying calcium and chloride. with the exception of one locality (Lanovka I). always in different localities which demonstrates their different migration ability. The dependance on precipitation when studying acid carbonate and also calcium was not determined. It can therefore be assumed that calcium released from the waste rock is bound mainly in the form of gypsum or basanit. which has a different solubility than chloride or leaches out of surrounding soils. Key study results were significant correlation coefficient values obtained from the precipitation amount and the occurrence of total phosphorus and phosphates. In this case. it was confirmed that the content of total phosphorus and phosphates decreases with increasing precipitation. This excludes the anthropogenic influence and on the other hand proves the influence of dilution in the case of flow areas (a decrease of phosphor concentrations in affluents).

In the whole set of studied subsident areas there are localities with and without affluents and reservoir outflows. The main aim of this study was to evaluate the influence of affluents on water quality in water reservoirs. Considering the fact that affluents can have a low water content, the affluents can have a negative impact on the water quality in reservoirs (supply of nutrients and suspended solids). In the case of relatively clean streams. water from affluents can have a significantly positive impact on the reservoir water (dilution). Sixteen localities were divided into two groups: water reservoirs with or without affluents and outflows.

One would expect that the reservoirs without affluents and outflows will have a much higher water temperature (considering significant water volume fluctuations during the year). Comparing statistical temperature parameters. there are no significant differences between the forementioned localities. Each locality is very individual and we can mention these main influencing factors: depth. local weather conditions. the development of the surrounding vegetation. etc. We also should not forget to mention that the water volume in affluents and outflows is low.

The influence of dilution with increased precipitation was demonstrated when studying some of the parametres (phosphor) for both types of localities. Phosphor is not brought into the water reservoir through anthropogenic activities which was demonstrated by obtained relations even for observed affluents.

In terms of water pollution control in ecosystems the most significant relation is the one between precipitation amount and dissolved oxygen content (for affluents and also for outflows). This dependance was not demonstrated in the other type of localities – water reservoirs without affluents nor outflows.

Another important parameter that affects the hydrochemical characteristics is the depth. The average depth was 0.7-5 m in all sixteen localities. Therefore, the stratification. which is typical for deeper water reservoirs. was not taken into account.

Another decisive mechanical force. which participates in mixing layers of water in reservoirs. is the wind. In water reservoirs. that are deep enough and their area is large enough. these so called spring and summer mixing of upper water layers occur and a thermal upper layer originates (so called termoklina) where the conventional and drift flow cannot influence the stability of a cold water layer in the reservoir. This year cycle creates specific physico-chemical conditions in aquatic ecosystems. It is very important and not only for the cycle of biogenic elements (N. P. C. S. etc.) but also for the entire biotic part of ecosystems. from plankton and benthos to fish stock (Bartram. Balance. 1996). Hypolimnia volume in relation to the epilimnion volume can be regarded as one of the major criterias of expected future water quality. The higher the ratio is. the more promising are the conditions for optimal water quality. Therefore. in terms of future trophic conditions of water reservoir. deeper reservoirs should be preferred to the shallow ones. A similar case can occur if a so-called thermocline originates. which is actually a chemical “jump layer” that may arise from the increased content of dissolved salts in hypolimnia

In the case of decomposition of organic matter to CO_2 and H_2O. a relation between CO_2 and COD and CO_2 and BOD_5 should also be shown. This dependence has been demonstrated in five localities. The content of dissolved oxygen in water reservoirs was during the entire monitoring period (five years) sufficient. To the contribution of oxygen also helps the very well developed littoral. This is an important finding given the fact that there was a hydrological recultivation.

Degradation processes in which oxygen is used are documented by dependences found for BOD_5. COD and dissolved oxygen. From the observed dependence between the value of dissolved oxygen and BOD_5 in some locations. it can be stated that in these water reservoirs the oxygen will be used for a degradation of organic matter. This is then reflected negatively on the average annual amount of dissolved oxygen (6.4 $mg \cdot L^{-1}$). Given that the locality is still being studied and will remain the same. it is possible to avoid negative climatic conditions. If the situation continued. there would be an oxygen deficit.

4 CONCLUSION

Preservation of water reservoirs lead to the improvement of environmental quality. that is connected with better aesthetic and hygienic conditions of Karvina region. If an adequate sanitation is chosen. e.g. Kozi Berlik. the water reservoir could be used by the local inhabitants for a short-term recreation. The hydrologic revitalization of the water-bearing subsident areas seems to be the most economically profitable and effective option. Nature development of the water quality in water-bearing subsidence areas will always be affected by the action of a large number of internal and external factors. whose gravity is in particular cases very different and is the result of physical. chemical and biological processes which will be in progress and already are. The hydrogeochemical background (increased content of bicarbonates. chlorides and sulphates) seems to be important and proves the influence of anthropogenic backfill on the water chemism in water-bearing subsident areas. The conclusion of this study on water hydrochemistry is following: "relatively clean watercourses” can have a very positive impact on waters in subsident areas and can contribute to dilution. On the basis of assessing the importance of morphology in the water-bearing subsident areas on water quality it's clear that the volume of hypolimnia in relation to the volume of epilimnia could be regarded as one of the major criterias for the expected future water quality. The bigger is the proportion. the more positive are conditions for optimum water quality. That's why. in term of future trophy of water reservoirs. it's necessary to prefer deeper water tanks to shallower ones.

The appropriate solution for further use of water reservoirs in Karvina region could be to prefer fishing to fish breeding. which would be a big charge on the development of studied localities. Use of water reservoirs for intensive fish breeding purposes could lead to a deterioration in water quality. Highly productive (eutrophic and hypertrophic) ponds with a lot of fish stocks are distinguished by a number of adverse physico-chemical and biological properties. such as excessive concentration of nitrogen. phosphorus and organic matter. high biomass of phytoplankton. small zooplankton long-term presence and absence of larger species. small transparency and submerged vegetation. loss of coastal growth. noticeably small number of water birds. and generally low species diversity of the pond ecosystem.

REFERENCES

[1] SKALOŠ, J. and I. KAŠPAROVÁ. Landscape memory and landscape change in relation to mining. *Ecological Engineering*. 2012. vol. 43. pp. 60-69. DOI: 10.1016/j.ecoleng.2011.07.001.

[2] MENEGAKI, M.E. and D.C. KALIAMPAKOS. Evaluating mining landscape: A step forward. *Ecological Engineering*. 2012. vol. 43. pp. 26-33. DOI: 10.1016/j.ecoleng.2011.02.011.

[3] PERTILE, Eva. *Instrumental methods of analysis*. Ostrava: Vysoká škola báňská -- Technical university Ostrava. 2012. ISBN 978-80-248-2925-8.

[4] BARTRAM, J. and R. BALANCE (EDS.). *A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. Water Quality Monitoring*. E and FN Spon. London. 1996. 383 p.

[5] MOLINOVÁ, B., E. PERTILE and M. NOVÁČKOVÁ. Water and Sediment Quality Assessment in the Wetland Pateria de Fermentelos (Portugal). *Carpathian Journal of Earth and Environmental Sciences* [online]. RO: North University of BAIA MARE. 2013. pp. 133-142. ISSN 1842-4090.

[6] SUROVKA, D. *Application of Low-Cost Sorbents for Removing Sulphates and Selected Metals from Water Matrix*. 2014. Košice: BERG Faculty TU Košice. ISBN 978-80-553-1843-1.

[7] PERTILE, E. *Using Low Cost Materials for Removal of Cr (VI) from Aqueous Environment*. 2014. Košice: BERG Faculty TU Košice. ISBN 978-80-553-1844-8.