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SUITABILITY ANALYSIS OF WASTE ROCK APPLICATION IN HYDRIC RECLAMATION IN THE NATURAL WATER-BEARING SUBSIDENCE TROUGHS IN KARVINSKO, CZECH REPUBLIC

ANALIZA PRIMJENJIVOSTI JALOVINE ZA POBOLJŠANJE SVOJSTAVA VODE U ULEKNUĆIMA ISPUNJENIM VODOM, NASTALIH SLIJEGANJEM U KARVINSKOM OKRUGU, REPUBLIKA ČEŠKA

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Ključne riječi: jalovina, uleknuća nastala slijeganjem ispunjena vodom, kvaliteta vode, hidrokemijski parametri, poboljšanje svojstava vode

Abstract

The paper deals with a suitability analysis of waste rock application in hydric reclamation on the basis of studying its impact on water quality in the natural water-bearing subsidence troughs. The evaluation was carried out in sixteen localities where waste rock had been used in the past for the purposes of bank system improvement. Within the evaluation of waste rock impact on the hydrochemical character of water in the subsidence troughs the values of geochemical background were identified. In order to compare the impact of waste rock on the quality of water, changes in the hydrochemical parameters were monitored in the localities without waste rock banking, with partial (maximum ½ circumference) and complete waste rock banking.

Sažetak

U radu je prikazana analiza mogućnosti primjene jalovine za poboljšanje svojstava vode na temelju promatranja utjecaja jalovine na kvalitetu vode u uleknućima nastalih slijeganjem ispunjenih vodom. Procjena je izvedena na šesnaest lokacija gdje je u prošlosti jalovina korištena za poboljšanje sustava nasipa. Tijekom procjene utjecaja jalovine na hidrokemijski karakter vode u uleknućima, uočen je geokemijski utjecaj. U cilju usporedbe utjecaja jalovine na kvalitetu vode, praćene su promjene hidrokemijskih parametara na lokacijama bez jalovinskih nasipa, s nasipima djelomično izrađenim od jalovine i nasipa izrađenih od jalovine u cijelosti.

Introduction

The Ostrava - Karviná District (OKR) can be evaluated as a region significantly affected by anthropogenic activities. With regard to the fact that coal mining is done by controlled caving without backfilling, changes in the relief occur. Apart from terrain deformations, which often lead up to disrupting the original ecosystems, there are also changes in the regime of ground and surface water, microclimatic conditions, physical-chemical, physical and deformational properties which cause destruction of residences and underground services.

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. During areal improvement waste rock was

predominantly used and thus morphologically very dull areas taking up several hectares were formed with limited chance for revitalization. Improvement with further possible utilization of water areas was not applied as there were mainly efforts to reclaim the devastated land resources.

The process of subsidence trough formation in the Karviná 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 main objective of the study was a suitability evaluation of waste rock in hydric reclamation on the basis of studying its impact on water quality in the natural water-bearing subsidence troughs. The evaluation was carried out in sixteen localities where waste rock had been used in the past for the purposes of bank system improvement. In order to compare the impact of waste rock on the quality of water, changes in the hydrochemical parameters were monitored in the localities without waste rock banking, with partial (maximum ½ circumference) and complete waste rock banking.

With regard to the fact that the legislation ambiguously classified waste rock as waste, its environmental properties were evaluated according to the leach ability tests. Raclavská and Matýsek (in Raclavská, Matýsek, 2002) state that the values of the monitored parameters of waste rock leaching tests, subject to Regulation 383/2001 Coll. as amended, are under limits of class I. Nonetheless, in some cases the analyses of ground and surface water inter-reacting with waste rock show unacceptably high contents of certain components (Raclavská, Grmela, 2006).

Results and Discussion

The main problem is heavily increased mineralization. Water seeping through the heaps mostly have a natrium–sulphate character with mineralization of up to 7 $g \cdot l^{-1}$ with SO_4^{2-} content over 4 000 $mg \cdot l^{-1}$ in extreme cases.

Evaluating the impact of waste rock on the conductivity and dissolved substances, it was discovered that in the localities where there is interaction with waste rock along the overall water areas, the conductivity values are considerably higher. Among localities that were in contact with waste rock only partially (maximum ½ water area) and water areas without any contact with waste rock no statistically significant difference was identified. The scope of conductivity for the localities whose water is in contact with waste rock along its overall circumference is from 74 to 288 $mS \cdot m^{-1}$. Much bigger variances in data (31 – 195 $mS \cdot m^{-1}$) are apparent with water areas which are in contact with waste rock only partially. The most homogenous set of the evaluated parameter data (conductivity, dissolved substances) is demonstrated with the group of localities without the contact with waste rock (34 – 66 $mS \cdot m^{-1}$).

What is considered harmful for the environment when evaluating hazardous properties H13 (Regulation No. 376/2001 Coll.) is the conductivity value of 2 000 $mS \cdot m^{-1}$ (for water leach). Permanent damage – destruction of cells due to deposit pressure arise at values over 3 000 $mS \cdot m^{-1}$. It is apparent from the stated results that the water in subsidence troughs which is in full contact with waste rock has approximately twice higher conductivity than the remaining evaluated groups of localities, but it will not have any significant impact on the water ecosystem.

Also hydrogen carbonates in the subsidence troughs show differences in dependence on the presence of waste rock. It was discovered that the water areas that are in contact with waste rock, either partially or fully, have much higher content of hydrogen carbonates than the localities without any contact with waste rock.

It is known that the ground water in areas where waste rock is applied has a hydrogen carbonate or sulphate character. Percentage representations of hydrogen carbonate and chloride anions were assessed with dissolved substances. In case of three localities (Karvinský les, Ignačok and Panský stav) it can be assumed that hydrogen carbonates are dominant anions.

Evaluating the impact of waste rock on hydrochemical parameters it was identified that the localities with which waste rock had been applied along the overall circumference during reclamation had almost 2.5 times higher concentration of chlorides when compared with water areas which were in contact with waste rock only partially. Compared with localities with no contact with waste rock it was almost 4.5 times higher.

The highest contents of chlorides were identified in the localities of Mokroš and Lanovka I. The Mokroš locality is affected by leaching of chlorides, which are increasingly present in the slurries from coal preparation in the neighbouring locality of Nový York.

With regard to the fact that during weathering of carbonates the liberation of calcium becomes easier, it can be assumed that the localities with waste rock along the overall circumference should have higher content of calcium. The acquired values imply that the saturated subsidence troughs with dominant fraction of waste rock have almost twice higher concentration of calcium than the two remaining evaluated groups.

The situation was similar in case of magnesium. It was not possible to clearly determine that the source of Mg^{2+} is the waste rock, which is apparent from Table 1, calculating the concentration range for the classification of hydrochemical parameters in subsidence troughs affected by the presence of waste rock. The most probably the magnesium content will be of an organic origin and it will enter the water system due to decomposition of biomass (chlorophyll). This is also supported by the identified upward trend of magnesium content towards the end of the summer months and beginning of autumn.

The value of geochemical background (Table 1) is determined as an arithmetic mean adding or subtracting a standard deviation ($\bar{x}_i \pm \delta$). It is clear from Table 1 that the criterion for water quality evaluation in subsidence troughs on the basis of waste rock volume used was correct. The selected parameters show considerable differences between the individual groups, except for the above mentioned magnesium. On the contrary, it is apparent that in case of the monitored parameters no concentration is so high to significantly influence the water ecosystem.

Table 1 Concentration range for the classification of hydrochemical parameters in subsidence troughs affected by the presence of waste rock
Tablica 1. *Interval koncentracije za klasifikaciju hidrokemijskih parametara u uleknućima nastalim slijeganjem uslijed prisustva jalovine*

Hydrochemical parameter	no contact with waste rock	<½ contact with waste rock	full contact with waste rock
conductivity ($mS \cdot m^{-1}$)	33–60	45–112	117–284
dissolved substances ($mg.l^{-1}$)	175–197	232–473	412–1510
$(HCO_3)^-$ ($mg \cdot l^{-1}$)	27–144	110–174	140–292
Cl^- ($mg \cdot l^{-1}$)	11–25	19–39	46–121
Ca^{2+} ($mg \cdot l^{-1}$)	31–70	49–74	68–177
Mg^{2+} ($mg \cdot l^{-1}$)	21–33	20–33	21–97

Conclusion

Within the evaluation of waste rock impact on the hydrochemical character of water in subsidence troughs, values of geochemical background were determined as an arithmetic mean adding or subtracting a standard deviation. It is clear from the concentration ranges for the classification of hydrochemical parameters in subsidence troughs affected by the presence of waste rock that the criterion for water quality evaluation in subsidence troughs on the basis of waste rock volume used was correct. In the selected parameters (conductivity, dissolved substances, chlorides, hydrogen carbonates, calcium and magnesium) except for magnesium, which will most probably be of a biological origin (chlorophyll), the differences between the individual groups are substantial. The acquired correlations and percentage representations of hydrogen carbonates and chlorides in the dissolved substances imply that in all the studied localities there will be more sulphate ions and thus cations Ca^{2+} and Mg^{2+} will prefer the bond onto an anion $(SO_4)^{2-}$ or onto chlorides in case of magnesium.

On the other hand, it was apparent from the hydrochemical data that in no case the concentrations are so high to significantly influence the water ecosystem. With regard to the high adaptability of micro organisms to a certain "tolerable" change in conditions, this issue must be a subject of further hydrobiological or phytosociological research.

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