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Резюме

МОНІТОРИНГ ЯКОСТІ ВОДИ В ЛОКАЛЬНИХ ВОДООЧИСНИХ УСТАНОВКАХ

Петренко Н.Ф., Винницька О.Л., Лагода О.В., Андрейцова Н.И., Дмитрієва Т.Н.

У роботі представлені результати порівняльної ефективності очищення води централізованого господарсько-питного водопостачання м. Одеси в 8 пунктах експлуатації ВОУ за період 2004 р. - перший квартал 2005 р.

Показано, що вживання ВОУ колективного користування, технологія очищення яких включає механічну фільтрацію, адсорбцію на АУ, ін., для додаткового очищення води централізованого господарсько-питного водопостачання дозволяє видаляти з неї залишковий хлор, хлорфеноли і ін. хлорорганічні сполуки (зниження значення ПО), катіони заліза; одержувати питну воду із сприятливими органолептичними властивостями.

Summary

MONITORING OF QUALITY OF WATER IN LOCAL WATER-PURIFYING INSTALLATIONS.

Petrenko N.F., Vinnitskaya E.L., Lagoda O.V., Andrejtsova N.I., Dmitrieva T.N.

In the work they present the results of comparative study of the efficiency of water treating of the centralized economic - drinking water supply of Odessa in 8 points ВОУ operation in 2004 - the first quarter 2005. Application of ВОУ for common use which technology of clearing includes a mechanical filtration, adsorption on АУ, etc. for additional water treating of the centralized economic - drinking water supply allows. To delete from it residual chlorine, chlorphenoles, and other chlororganic substances (decrease of ПО value), iron cations. To receive potable water with favorable organoleptic properties.

УДК 502.57:622.2:625.7/.8

ENVIRONMENTAL IMPACT OF UTILIZING COAL MINING WASTE FOR ROAD CONSTRUCTION

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Introduction

Coal mining waste generation and use

Poland and Ukraine belong to the world's major producers of hard coal, holding in 2004 8th position with 100.4 Mt/yr and 10th position with 56.8 Mt/yr , respectively (WCI, 2004). For every ton of coal output, about 0.35 t waste has been generated (mean value). In these countries, coal mining waste rock comprise thus one of the biggest groups of waste (in Poland, 35.8 Mt of coal mining waste, i.e. 30% of total was generated in 2004) (GUS, 2004). In the EU, waste from the extractive industries amounts to about 29% of total waste generated in the EU each year, with an annual volume over 400 million tons (EEA, 1993-2005). In the EU member states, coal mining waste is considered a valuable construction material widely utilized in civil engineering as fill and earthworks material, also in transport engineering structures: as a road base and sub-base, for highway and railway embankments, leveling of parking lots, harbor constructions etc. Also in Poland, roughly 35 Mt, i.e. 98%, has been utilized for these purposes in 2004 (GUS, 2004).

Legislation on environmental protection aspects of waste management

In the EU Member States, use of industrial waste in civil engineering is standardized and normalized with respect to technical parameters (e.g. British Standards BS882, 1992; BS3797, 1990; BS 1047, 1983; BS6543, 1985; BS 5328, 1991, BS

3892, 1982; BS12, 1991; BS146, 1991; BS4246, 1991; German BAST-E9,1971; FGSV 616/2, 1984; Dutch WKE-N-78163,1965; WKE-R-78156, 1982, SVC Normen en Proefvoorschriften 1992, Bouwstoffenbesluit, Staatscourant 1991).

Adaptation of the EU legislation on the environmental aspects of waste management by the European countries, both by member states and candidates, has greatly contributed to harmonization of national legislation and integration of environment-related waste management policy.

The framework EU waste legislation in force is based on three major documents with amendments: (1) Directive 75/442/EEC on waste, as amended by Directives 91/156/EEC, 91/692/EEC and Commission Decision 96/350/EC; (2) Directive 91/689/EEC on hazardous waste, as amended; (3) Decision 2000/532/EC establishing a list of waste, as amended, the latest amendment by Council Decision 2001/573/EEC. In addition to these documents, the EU policies on waste comprise numerous regulations concerning specific waste streams, both in force and in preparation. The EU legislation in preparation includes the proposal for a Directive on the management of waste from the extractive industries, in this of coal mining wastes (COM, 2003). Following this proposal, the European Standardization Committee, Technical Committee 292 "Characterization of Waste" has undertaken works on developing standards on environment impact-related testing waste from the extractive industry and established a working group on Mining waste in CEN/TC 292 (2005).

The EU legislation on waste was adopted also by Polish environmental regulations, (e.g. Polish Act on waste, 2001, and other legislative documents), which cover also relevant regulations concerning water protection (Directives of Minister of Environment, 2002, 2004a,b).

Environmental impacts associated with coal mining wastes

According to the EU list of waste (2000), coal mining wastes do not belong to hazardous waste. Though, they are also not environmentally neutral, the major issues being related to water pollution due the formation of leachates, in particular of acid rock drainage (ARD) that occurs as a result of sulfide-rich mining waste material exposure to atmospheric oxygen and water. An extent of adverse environmental impact on the water quality depends upon the content of soluble substances, sulfides, their reactivity, buffering capacity of a rock material, as well as waste granulation that influence the conditions of water percolation and air penetration into waste rock layer.

In the case of mining waste reuse, the major problem consists in the difficulty of a reliable environmental impact assessment (EIA) related to long-term pollutants release from wastes and evaluation of a risk exerted by these wastes in specific constructions such e.g. as railway or highway embankments and other engineering constructions used for transport-related purposes. Long-term EIA became thus the major criterion of coal mining waste management.

The aim of the presented study is to illustrate the temporal transformations occurring in the coal mining waste layer as a result of technological processes of re-extraction, transport and deposition of waste at the place of destination according to the reuse purpose (railway or highway embankment, road sub-base, ground leveling etc), exemplified in coal mining wastes that originate from coal mining waste dumps, and the impact of these processes on ground water quality.

Material and Methods

Characteristics of studied objects

For studies, coal mining wastes from two dumping sites: Anna coal mine in Bukyw and Szczyglowice coal mine in Smolnica comminities (Upper Silesia, Poland) were selected.

At the Bukyw dump (site I) coal mining waste rock from coal seams of 600 and 700 groups of Namurian A carboniferous formation was disposed since 1976. The wastes consisted mainly of coarse-grained washery discards (93.7%) that was a hard material resistant to particle size degradation due to wetting and effect of other atmospheric factors. These waste showed moderate chloride salinity (0.01%)

and were relatively high-buffered: their neutralization capacity exceeded acid generation capacity 2.37 times (in equivalent units).

At the Smolnica dump (site II) coal mining waste from coal seams of 300 and 400 groups that consisted mainly from shale and mudstone of Westphalian A, B and Namurian C carboniferous formations was disposed.

Minor, but environmentally important components of waste are iron sulfides (pyrite, markasite) responsible for ARD generation due to ARD generation as a result of sulfide reaction with oxygen and moisture, and Ca-Mg carbonates (calcite, dolomite), which are buffering agents preventing from the rock acidification provided that they are available in sufficient amount, i.e. that ARD generation potential/ buffering capacity e” 3.0. Another factor of importance with respect to pollution potential of waste rock to water is chloride salinity, fairly high in some coal seams (Szczepacska and Twardowska, 2005). At both dumping sites, residual coal extraction by physical methods was carried out.

Technology of waste rock re-extraction from coal mining dump for obtaining material for road/railways construction comprised excavation of a rock deposited at the dump, its transport, often size reduction and finally deposition at the destination place. As a result, the waste layers were disturbed and exposed to the atmospheric impacts, including water and air. As a result of weathering processes, in the waste rock the pollutants are generated, released and transported with infiltrating water to ground water causing degradation of its quality to the level rendering it unfit to any use.

Methods

At the studied coal mining waste sites, the vertical drillings through the waste dumps were conducted to the depth 10-15 m, and rock material from the subsequent layers was collected and transported to the laboratory in tightly closed plastic bags in order to prevent from the moisture loss. In the laboratory, pore solution from the rock samples was extracted by pressure method and analyzed for chemical composition by ICP-MS (Perkin-Elmer Elan). In parallel, samples of ground water up-gradient and down-gradient of the dumps were also taken and analyzed. Vertical transformation of pore solution due to contaminants leaching and re-distribution of loads in the infiltration water stream in the studied dumps along

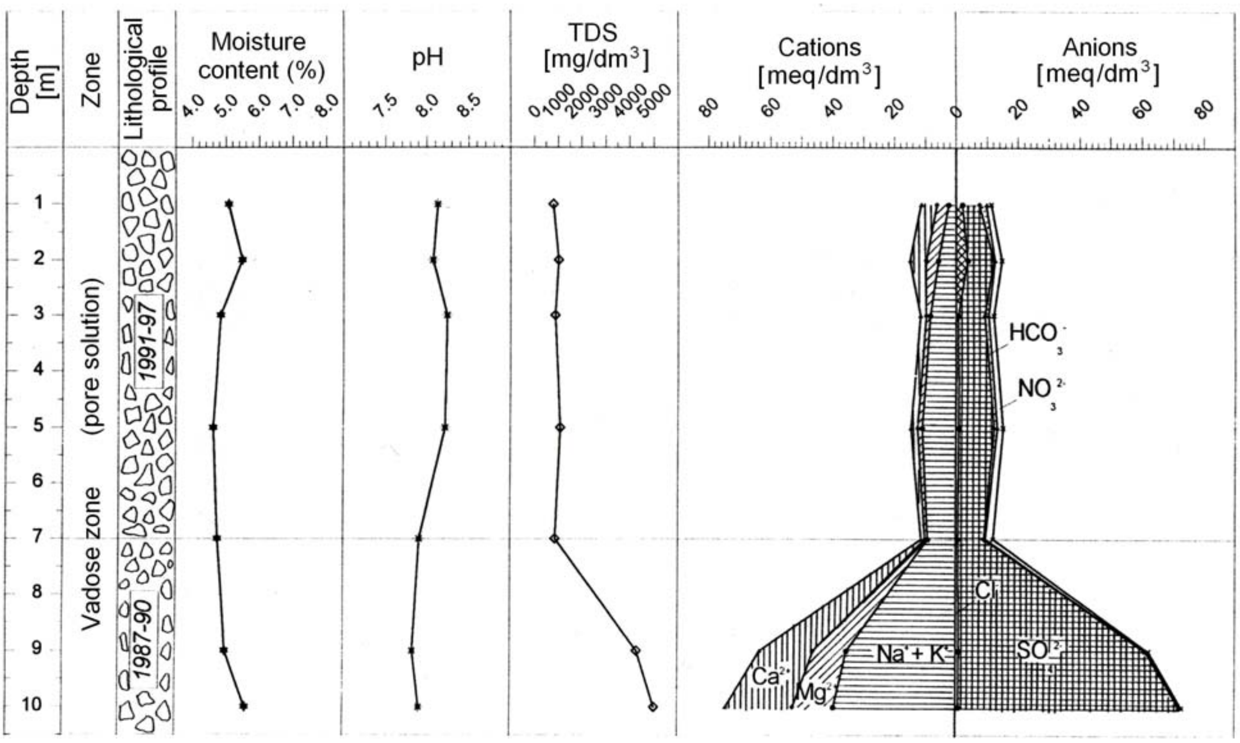

Fig. 1 Hydrogeochemical profile along the borehole A (Buków dump)

with the impact of leached loads on the ground water quality down-gradient of the dump was evaluated. The studies were focused on three major processes: chloride leaching, and ARD generation and buffering, which determine the pollution potential from coal miming waste to ground waters. These studies simulated the processes occurring in the engineering constructions for transport purposes performed with use of coal mining wastes.

Results and Discussion

Pore solution along the non-disturbed profile of coal mining waste at Bukyw dump 9-19 years' after deposition showed high degree of washing chlorides out from the upper layer of waste 9-15 years after rock deposition and proceeding intensive sulfide oxidation within the waste layer (Fig 1). The older bottom part of the waste rock up to 19 years old due to the lesser water exchange rate and vertical load redistribution displayed characteristic downward increase of SO_4^{2-} concentrations and thus also increase of pollution potential to ground waters. Hydrogeochemical composition of pore solutions changed downward from SO_4-Na-Ca in the upper part of the waste layer profile to SO_4-Ca-Na-Mg, SO_4-Na-Ca-Mg or SO_4-Mg-Na-Ca. Neutral or slightly alkaline pH 7-8 values were an evidence of sufficient buffering properties, thus maximum concentrations of SO_4^{2-} up to 3850 mg dm^{-3} were limited by equilibrium with gypsum. Under these conditions, also trace metal release was low; in the highest concentrations Sr (up to 4 mg dm^{-3}) and Mn (up to 3.52 mg dm^{-3}) occurred; also Fe, Zn, Cu and Li were present in the detectable, but permissible concentrations.

Ion concentration pattern along the BI and BII profiles (Bukow) displayed a significant impact of re-extraction and disturbance of waste material on the hydrogeochemical conditions in the waste body that determined a pattern of contaminant release from the wastes. Compared to waste in non-disturbed layer, increase of hydraulic conductivity, porosity and bulk density of material was observed, along with increase of moisture content and therefore of an infiltration flow rate (Fig 2). Also substantial changes of leaching dynamics occurred that indicated the "re-activation" of contaminant mobilization (intensification of generation and leaching of contaminants from the older waste, mainly sulfates, but also chlorides as a result of rock grain size reduction, re-exposure to atmospheric conditions and material admixing). Besides of significant increase of concentrations and loads of macro-contaminants in pore solutions after re-deposition, the disturbance of the initial pattern of a vertical redistribution downward

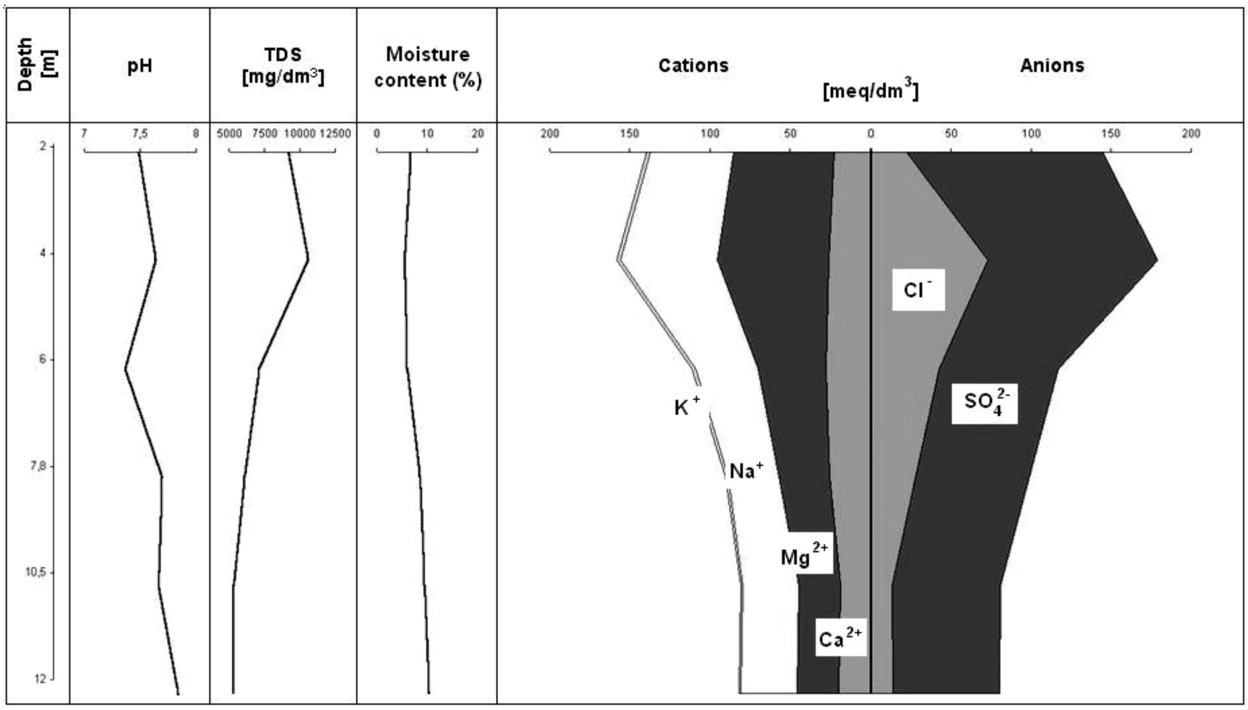

Fig. 2 Hydrogeochemical profile along the borehole BI (Buków dump)

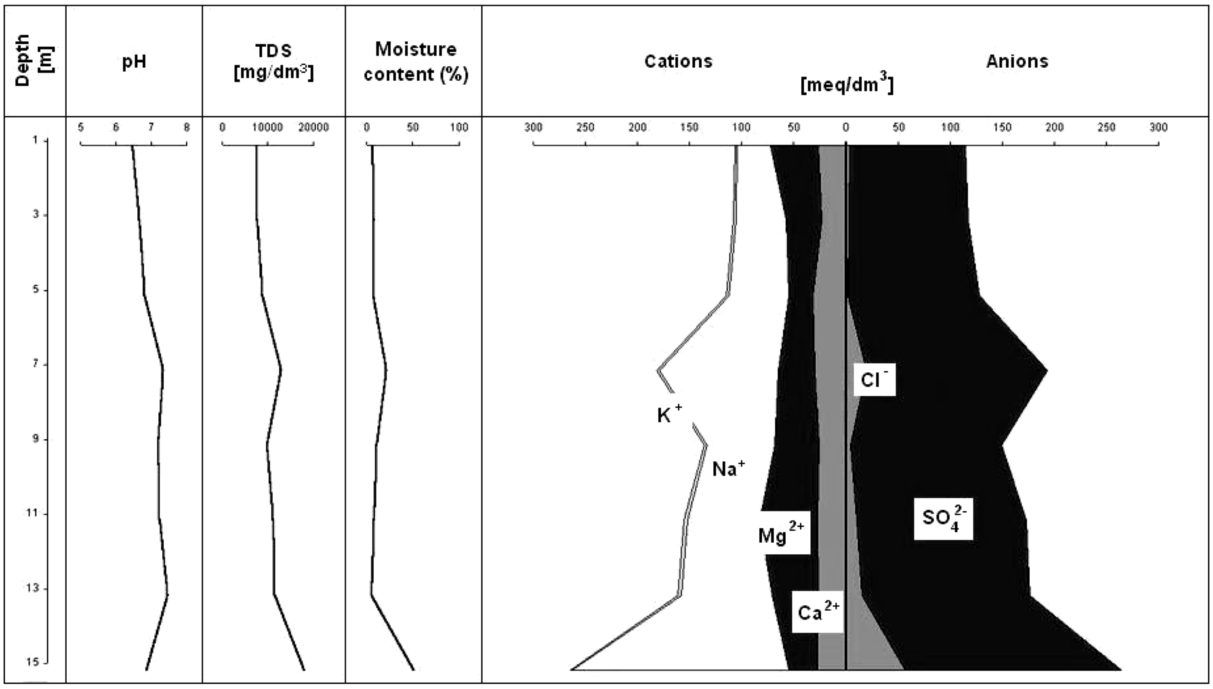

Fig. 3 Hydrogeochemical profile along the borehole SI (Smolnica dump)

the profile was observed: re-deposited waste displayed either inverse pattern, i.e. occurrence of the highest concentrations of constituents at the upper part of the profile, which was characteristic for the freshly deposited material (Fig.2), or generally uniform concentrations of constituents along the profile.

Due to satisfactory level of waste buffering and slightly alkaline pH value of pore solutions, trace metals were not susceptible to release, nevertheless in pore solutions of re-extracted wastes the concentrations of some trace elements appeared to be elevated (Tl, Li, Ba, Al, Mn), up to the values exceeding standards for drinking water (Ni), along with mobilization of toxic elements occurring in the anionic form (B, Mo).

Low buffering ratio of waste from Smolnica coal mining waste dump (buffering capacity to ARD generation ratio of 0.68-0.71), opposite to relatively well-buffered material from Bukow dumping site, results in a gradual acidification of the rock material. Reactivity of sulfides in this material is characterized by half- period of sulfide decomposition t_{05} = 1440 days. The acidification of a material, in particular in the surface layers, has been observed already in 10 years after waste deposition. Process of acidification along with the vertical redistribution of contaminant concentrations downward the profile causes adverse temporal transformations of waste and pore solutions lasting for decades (Szczepacska and Twardowska, 2005).

Acidification process in the studied waste profile was characterized by the domination of sulfate anions equilibrated mainly by Na^+ and Mg^{2+} cations (Fig. 3). Additional threat to the aquatic environment, besides high sulfate concentrations in this phase, exerted mobilization of trace elements at pH<5 from waste matrix and the underlying soil in the vadose zone.

The local monitoring of ground waters in the vicinity of coal mining waste dumps illustrates changes of water quality down-gradient of the dump. Re-extraction and re-disposal of waste exerted the strongest impact on the sulfate mineralization level due to “activation” of waste in a technological process. Generation and leaching of dissolved constituents from coal mining waste resulted in multiple increase in ground waters of dissolved substances (conductivity), sulfates, chlorides and in acid waters also of heavy metals, in particular Zn, Ni and Cd that made these waters unfit to any use and in the reported cases caused closing the local wells and forsed a need of a distant water supply for the affected communities (Table 1).

Table 1

Selected ground water quality parameters down-gradient of coal mining waste dumps. (P2,…P5B, S-3 – monitoring wells)

	SMOLNICA coal mining waste dump											
	pH			**Conductivity [μS/cm]**			**SO_4 [mg/dm^3]**			**Cl [mg/dm^3]**		
	P2	**P3**	**P4**	**P2**	**P3**	**P4**	**P2**	**P3**	**P4**	**P2**	**P3**	**P4**
1994	**4.70**	**5.52**	**7.10**	**4620**	**3270**	**15080**	**1738**	**1013**	**2329**	**636**	**754**	**3498**
2004	**2.49**	**5.09**	**6.45**	**5460**	**5690**	**12230**	**2320**	**1873**	**6647**	**598**	**833**	**637**
	BUKÓW coal mining waste dump											
	pH			**Conductivity [μS/cm]**			**SO_4 [mg/dm^3]**			**Cl [mg/dm^3]**		
	P4B	**P5B**	**S-3**	**P4B**	**P5B**	**S-3**	**P4B**	**P5B**	**S-3**	**P4B**	**P5B**	**S-3**
1998	**7.06**	**6.98**	**6.56**	**4180**	**7573**	**3505**	**318**	**6427**	**2449**	**184**	**2020**	**617**
2004	**6.57**	**6.82**	**6.79**	**4000**	**4007**	**4190**	**1221**	**3386**	**2159**	**549**	**588**	**163**

Conclusions

An observation of hydrogeochemical transformations occurring in the vertical profile of coal mining waste resulting from their re-extraction and re-deposition showed significant changes of infiltration water parameters in a waste layer. Re-extraction appears to have the strongest effect on the increase of hydraulic conductivity, porosity and bulk density of the material, and on the contact of material with the environmental factors (atmospheric air, water) that favor the generation and mobilization of contaminants. Due to these changes, the "activation" of generation and leaching of contaminants from the older wastes has been observed. As a result of disturbance of the initial positioning of waste along the waste profile, pore solution in re-deposited wastes display the pattern inverse to that in undisturbed old waste layers, i.e. occurrence of the highest concentrations of constituents in the upper part of the profile. These waste, which due to occurrence of sulfides display a long-term pollution potential lasting for decades and often show the time-delayed maximum adverse effect to the aquatic environment, are sensitive to the impact of both natural and anthropogenic factors that should be taken into consideration at using this material for road, highways and railway embankments construction and other engineering constructions for transport needs. In particular, adequate compaction, drainage and insulation against air penetration should be provided (Twardowska et al., 2005).

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Резюме

ВЛИЯНИЕ ПРИМЕНЕНИЯ ОТХОДОВ УГЛЕДОБЫВАЮЩЕЙ ПРОМЫШЛЕННОСТИ В ДОРОЖНОМ СТРОИТЕЛЬСТВЕ НА ОКРУЖАЮЩУЮ СРЕДУ

Себастьян Стефаньяк, Ирена Твардовская

Польша и Украина являются крупнейшими мировыми производителями каменного угля. В среднем на каждую тонну добытого угля образуется приблизительно 0,35 т отходов. Хотя отходы каменноугольной промышленности не принадлежат к опасным отходам, они способны долгое время загрязнять окружающую среду вследствие высокого содержания сульфидов и хлоридов; в то же самое время, они — ценный строительный материал, широко используемый в гражданском строительстве. Из 35,8 Мт отходов, образующихся в Польше ежегодно, примерно 35 Мт, то есть 98 %, использовались как материал в строительных и дорожных работах. В то же время, широкое использование отходов каменноугольной промышленности приводит к загрязнению значительных территорий, а также воды и атмосферного воздуха. Статья посвящена рассмотрению взаимосвязи использования отходов каменноугольной промышленности в дорожном строительстве и качества природных вод, а также профилактическим мероприятиям, направленным на исправление складывающейся экологической ситуации.

Резюме

ВПЛИВ ВИКОРИСТАННЯ ВІДХОДІВ КАМ'ЯНОВУГІЛЬНОЇ ПРОМИСЛОВОСТІ В ДОРОЖНЬОМУ БУДІВНИЦТВІ НА ОТОЧУЮЧЕ СЕРЕДОВИЩЕ

Себастіан Стефаніак, Ірена Твардовська

Польща і Україна є найбільшими світовими виробниками кам'яного вугілля. В середньому на кожну тонну здобутого вугілля утворюється приблизно 0,35 т відходів. Хоча відходи кам'яновугільної промисловості не належать до небезпечних відходів, вони здатні довгий час забруднювати оточуюче середовище внаслідок високого вмісту сульфідів і хлоридів; в той же самий час, вони — цінний будівельний матеріал, що широко використовується в громадському будівництві. З 35,8 Мт відходів, що утворюються в Польщі щорічно, приблизно 35 Мт, тобто 98 %, використовувалися як матеріал в будівельних і дорожніх роботах. В той же час, широке використання відходів кам'яновугільної промисловості приводить до забруднення значних територій, а також води і атмосферного повітря. Стаття присвячена розгляду взаємозв'язку використовування відходів кам'яновугільної промисловості в дорожньому будівництві і якості природних вод, а також профілактичним заходам, спрямованим на виправлення екологічної ситуації.