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Opinion

Assessment of the Impact of Suspended Sediment Load in the Rivers of Mining Areas on the Ecological Status of the Kama Reservoir

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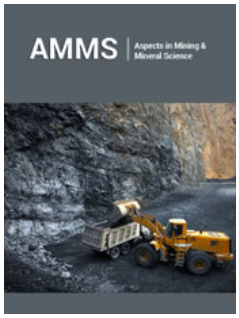
ISSN: 2578-0255



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Submission: January 18, 2022

Published: January 24, 2022

Volume 8 - Issue 3

How to cite this article: Elena Menshikova, Boris Osovetsky, Sergey Blinov. Assessment of the Impact of Suspended Sediment Load in the Rivers of Mining Areas on the Ecological Status of the Kama Reservoir. Aspects Min Miner Sci. 8(3). AMMS. 000690. 2022.
DOI: 10.31031/AMMS.2022.08.000690

Opinion

The aim of the scientific project is to develop directions for optimisation of nature management in the impact area of past mining sites in the Kizel Coal Basin based on revealing regularities of modern alluvial sedimentation processes in river basins and final water bodies of river runoff using the rivers of the Yaiva, Chusovaya, Kosva basins (Perm region, Russia) as examples (Figure 1). The carried-out research has shown that in zones of intensive technogenic influence modern alluvial deposits are the complex natural-technogenic formation. They are formed under the influence of both natural and anthropogenic factors [1]. The study of their composition and forms of presence of chemical elements in them allows to reveal migration flows of substances and identify zones with different intensity of technogenic impact on river water and sediments. The greatest danger is posed by anthropogenic deposits formed in river valleys up to 1km downstream of my self-discharges. The technogenic sediments produced by mixing mine and river water migrate downstream in the form of suspended matter. Flooding occurs most intensively during the flood season. The most contaminated sediments are in river sections downstream of my spills: the Vilva River-downstream of the town of Gremyachinsk to the mouth (the Usva and Chusovaya Rivers are further contaminated), the Kosva Riverdownstream of the town of Gubakha to the mouth, the Kizel and Vilva (northern) Rivers - downstream of the town of Kizel to the mouth (the Yayva River is further polluted). Under current conditions, the impact of development effects has been noted on the longer river parts than during the period of active coal field development. Most of the silty-clay material of the rivers studied in the anthropogenic impact areas is bright orange and rust coloured due to the high content of iron compounds. It is deposited in the channel areas and covers the coarse clastic sediments of the rivers (Figure 2). There composition is presented first by amorphous phases. Experimental data have confirmed that it is the amorphous Fe compounds that can provide sedimentation of toxic metals from the river water. When physical and chemical conditions change, they can be a source of toxic elements in river water due to their high reactivity. This very finely dispersed sediment phase, adsorbing toxic elements, on the one hand, provides processes of self-purification of water, on the other hand, is a source of secondary water pollution in areas of active accumulation. These processes are confirmed for a number of other mining areas (coal areas in Pennsylvania, USA [2], Libiola copper mines in Italy [3], coal deposits in India [4], deposits in the Iberian pyrite belt [5], sulfide mines in Finland [6], etc.).

Figure 1: Location of the study area.

Figure 2: Ochre in river sediments in the Kizel Coal Basin.

The results obtained on the material composition of the fine fraction of river sediments and bottom sediments have shown that the technogenic component plays a significant role in the composition of channel and floodplain sediments of the territory under consideration. Solid technogenic products represented by coal debris, slag particles, magnetic spherules form a technogenic association of river sediment components, the presence of which leads to changes in their mineral and chemical composition, physical and mechanical properties and, consequently, conditions of substance migration and sedimentation [1]. Concentrators of toxic elements are amorphous iron-ore compounds (ochres), which are widespread in the composition of bottom and suspended sediments of the rivers studied in the Kizel Coal Basin. These compounds are characterised by such specific properties as stability and high migration capacity due to their low density, small size and flat form. Their transport in a suspended state during floods occurs in practically the entire mass of the watercourse. In addition, large ochre aggregates migrate as part of the bottom sediment. A detailed assessment of natural-technogenic sedimentation processes in river estuaries and final runoff reservoirs poses the task of investigating the potential toxicity of anthropogenic components. As a methodological approach, recommendations for the ecological assessment of ore deposits were used, which were developed at the All-Russian Scientific-research Institute of Mineral Resources named after N M Fedorovsky [7] using the indicator of potential ecological hazard of minerals (Peh), which along with the chemical composition considers the lithotoxicity of elements included in the mineral and its stability in the environment:

$$Peh = \left(\frac{1}{s}\right) \cdot \sum_{i=1}^{n} (Tl \cdot X/Q)1 + \ldots\ldots\ldots\ldots (Tl \cdot X/Q)n ,$$

where Peh - is an indicator of the potential environmental hazard of the elements comprising the mineral; s - is the stability of the mineral; Tl - is the lithotoxicity of the elements comprising the mineral; X - is the content of toxic elements in the mineral; Q - is the average content of elements in the environment. The results obtained demonstrate that of the identified types of technogenic components, ochres (aggregates of amorphous iron hydroxide phases) pose the greatest danger. This is caused by high concentrations of a wide range of toxic elements in combination with low abrasive strength. Ochres, along with silicate slag particles, are in the same group with Cd, Hg, Pb, As, Ni, Zn, Co, Fe according to the value of indicator of potential ecological hazard of minerals. Association of potentially toxic elements taking into account concentration clarks is represented in ochres by geochemical row of elements Cd>Sb>As>Co, Cu>Zn>Ni>Fe>V. As part of the task of identifying the sources of trace element in river sediments, the study of mine dumps in the territory of Gubakha (catchment area of the Kosva River and its tributaries) was carried out. The results of research of dump substance in comparison with global concentrations of elements in sedimentary rocks show their enrichment with lithium, scandium and germanium [8]. For some studied waste dumps high content of gallium was noted. At the same time the content of yttrium and lanthanides in the studied dumps is significantly lower than average concentrations in sedimentary rocks. Thus, the results obtained in the framework of the project develop ideas about sedimentation processes of anthropogenic substance in the composition of modern bottom sediments of rivers, are devoted to applied aspects of natural and technogenic sedimentation, construction of models of modern sedimentogenesis in areas of technogenic impact, which, first, are the areas of mining. The received results lie in a key of development of technologies of monitoring and forecasting of a condition of environment, prevention and liquidation of its pollution [9]. They will form the basis for the development of additions to the programme of environmental monitoring in influence of the objects of past mining activity in the Kizel Coal Basin.

Acknowledgment

The authors would like to thank the staff of the Nano mineralogy Sector of the «Center for Collective Use of Perm State National Research University» for their assistance in conducting research.

Funding

The reported study was funded by RFBR, project number 19-05-50071.

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