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FLOOD RISK ASSESSMENT OF CHERVONOGRAD MINING-INDUSTRIAL DISTRICT

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ABSTRACT

In the beginning of the century, few desktop review projects were carried out in Ukraine under the Global Water Partnership. In particular, interested in transboundary water research, there are some examples: Environmental Project Water Management of Kakhovka Reservoir and Lower Dnieper River (2000-2001) and Flood Management in Ukraine and Slovakia (2000-2003), and the 16th OSCE Economic and Environmental Forum "Maritime and inland waterways" (2007). The afore-mentioned studies were mostly dedicated to the establishment of a dialog between the governments and stakeholders. So far, basically, there are no applied research in order to perform the risk assessment in particular transboundary areas. For instance, during the past decade, both the Chervonograd coal mining industrial district in the Western Bug river region (the border between Eastern Poland and Western Ukraine) and the mitigating environmental risks for water security have been paid a little attention. The Lviv-Volyn carboniferous basin (Western Ukraine) is one of three major coal mining regions in Ukraine). This paper describes the recent preliminary results of applying GIS technology for simulation of flood risks and associated hazards in the Lviv-Volyn coal basin. The contamination of drinking water (Be, Yb, Co and Pb) was considered as one of main hazards in territory of investigation. Using satellite optical imagery, flood modeling and the prediction of contamination were conducted in the areas of West Bug River and Vistula River. The input parameters were the following: the average water flow velocity 0.45-0.65 m/s, the width of the channel in the meadows 25-70 m, and the depth 1.1-1.7 m. The river runoff is adjusted by the dams of the Dobrotrivska thermal power station and the Sokalsky chemical factory. The water field is 6250 sq. km. The issue of increasing risk of wasting drinking water resources in the region with the estimated population of about 15 million inhabitants is essential.

Keywords: Flooding, modelling, abounded mines, environmental disaster, disaster management, water resources

1. INTRODUCTION

The latest desktop study of literature has identified a need for further investigation of problems and risk assessment which are associated with the Western Bug River and increasing of the technogenic risks[8,9,10,11,12,13,14,15,16,17,18,19,20,21,22]. One of the major concerns is unpredictable underground water discharge from the abounded coal mines. Earlier researches were founded by various international institutions during the period of 2009-2012 before the Revolution of Dignity in the end of 2013. Later this work was almost terminated. The group of experts from the Lviv State University of Life Safety made an attempt to review the state-of-the-art and conduct modeling.

The extraction of coal has a negative impact on the environment, which leads to a violation of the stability of geosystems, and thus to increase the environmental hazard. In Ukraine, coal mining is concentrated in three basins: Donetsk, Lviv-Volyn carboniferous basins and Dniprovsky coal basin. Lviv-Volyn carboniferous basin is located in the western part of Ukraine near the border with Poland. The territory of the coal basin in the Northern direction flows on the Western Bug River (Figure 1) with numerous tributaries, of which the main are Rata and Solokiya. In Ukraine and Poland water from the Bug is used for food and drinking needs. The Western Bug River flows into the Vistula River. The research area has the prospect of being involved in the pan-European waterway, the Baltic Sea - the Black Sea. The research aimed at predicting possible contamination of the territory if flooding occurs of the Western Bug River will occur.

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1.1 Background

The geological environment of the studied territory (Figure 1) is considered as part of the Volyn-Podilsky plate of the Western European platform, where the paleomezo-kainozoic complex of terrigenous-carbonate and fluviogeoglacial deposits of the Lviv-Volyn coal basin forms on the folded epigercy basis. The basin is characterized by a general inclined regional decline of carbon depos-its in the southwest at an angle of 10-20 and the spread of fractures of the sub-latitudinal and North-Eastern stretch associated with disturbances in the crystal-line basement. With the formation of the Carpathians, the easing of the Eastern European platform in Western Europe, the secondary dislocations are associated with the rise of a series of sub-Carpathian syncline and anti-clinnic structures, separated by powerful zones of disturbances. Syncline structures are filled with carbonaceous deposits, some of which are mostly productive on coal[1]. The relief of the territory is basically flat: no significant fluctuations in elevations are observed. Separate elevations that serve watersheds between rivers, have sloping relief; valleys are wide and in the western and northern parts are swampy. Fluvial accumulative erosion relief is developing in river valleys. The flood plains have a flat surface with a slightly noticeable slope towards the channels and in the direction of the course the year is often marshy and strutted. The floodplain terraces in the valleys of the Western Bug River and some of their tributaries are composed of alluvial fine-grained sand with lenses and layers of lake and marsh sediments, mules, soups and loams, with a total capacity of 2-5 m. The flat accumulative relief of the zandarous plains is complicated in the boundary of the Western Bug with denudation forms corresponding to a slightly raised section of the quaternary surface of the upper chalk. Occasionally monotony of the flat relief of the zander plains is disturbed by sandy strands of eolian origin. Absolute markings is at 200-250 m. The Westen Bug River is characterized by a calm flow: the average flow velocity is 0.45-0.65 m/s. The width of the channel in the meadows is 25-70 m, the depth is 1.1-1.7 m, river runoff is regulated by the dams of the Dobrotrivska DRES and the Sokalsky Chemical plant. The water-field for hydrological station in Sokal is 6250 km2, the average slope of the channel is 0.00064. The river is polluted with organic matter and in some areas by heavy metals.

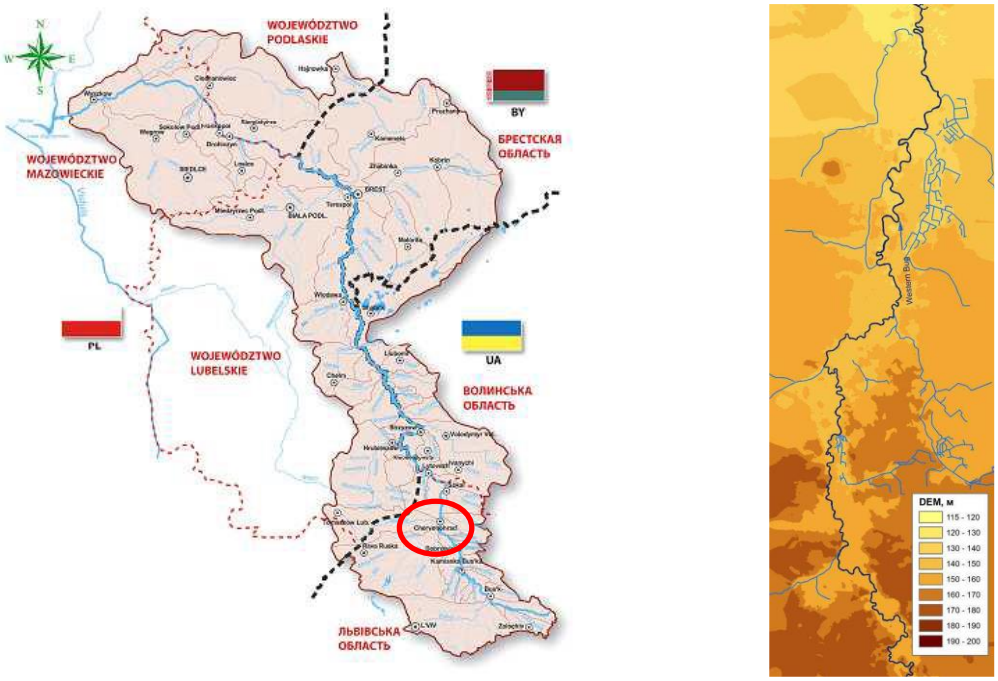

Figure 1. The left picture - Western Bug River, the coal mining area of interest is depicted by the red circle (source: Korneev, A., Pakhomau, A., Flood Risk Mapping in the Bug River Basin. FLOOD-WISE project sub-report phase 2 (February 2012)); the right picture - Digital Elevation Model for the transboundary district (Poland – Ukraine – Belarus).

1.2 Research

Determination of the content of heavy metals is carried out in certain varieties of rocks (sandstones, siltstones, argillites, coal) within the waste heaps of the mines of the Chervonohrad mining region of the Lviv-Volyn Carboniferous Basin (Figure 2). The content of P, Sr, Mn, Ni, Ba, Pb, V, Cu, Zr, Sn, Ga, Cr, Mo, Ti, Y, Yb, Zn, Ge, Co in a mixture of rocks (argillites, aleurolites, occasionally sandstones) was determined with use of spectral photometer in the laboratory of Lviv Geological Prospecting Expedition of the State Enterprise "Zakhidukrheologiya" [3].

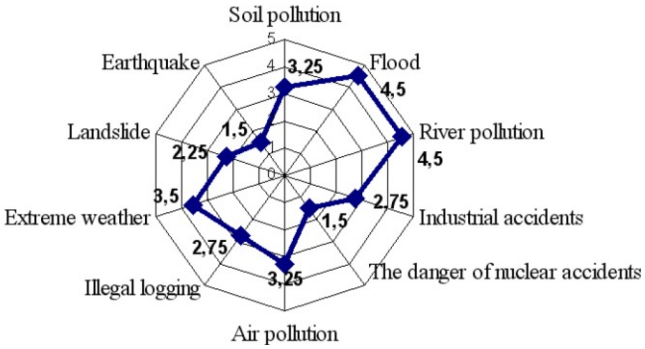

Figure 2. Risk contributions to transboundary Western Bug River environment (adopted from Dobák Imre).

Experts of the State Enterprise "Zakhidkurgeologiya" have determined the geochemical concentration of heavy metals in the coal ash of the Buzhan svita of the Lviv-Volyn Carboniferous Basin (exceeding the maximum over aver-age contents for a coal formation): Mo68-Ag50-V-47-Cu29-Ba-28-Co18- Be17-Sr17-Ga9.5-Ni-8.5-Yb-7.9-P7-Pb7-Zn6.8-Y5.9-U5.7-Ge5.7-Sc5.0-Mn5.0-Ti3, 5-C3.0-As2.9 [3].

More detailed investigation of flooding mines was carried out for the Viseyska and Chervonogradska mines (Figure 2). Mine Viseyska has been operating since 1960 until 2009. The slagheap of mine Viseyska, with a basement area of 225 000 m2, with a height of 10-40 m, con-tains over 5 million m3 of rock. The mixture of rocks is dominated by argillites - 59%. Tericon consists of two parts - Western and Eastern. The Western part of the slagheap is composed mainly of burned rocks in the form of a truncated cone, eastern - non- burnt, formed in a flat dump. Compared with clark, for sedimen-tary pellets of coal, the mine Visejska concentrates beryllium, molybdenum, strontium and ytterbium. The mines are rich in manganese, ytterbium and cop-per. The concentration of manganese is highest in argillites - 2061.6 g/t, less in sandstones - 1607.6 g/t and siltstone - 1088.6 g/t. The highest concentration of Yb was detected in siltstones - 5.3 g/t, less in argillites - 3.9 g/t and sandstones - 3.1 g/t. Cuprum is most concentrated in siltstones (136.7 g/t) and argillites (128.4 g/t), and in very low concentrations it is found in sandstones (27.02 g/t). The Chervonogradska mine has been operating since 1971. 2.9 million m3 of rock have been piled up in the mine Chervonogradska, in the mine tericon, with a base area of 142 000 m2. Every year, the tericon is replenished with fresh breed in the volume of 40 thousand m3. On the slopes, the tericon is partially recultivated by pouring a layer of sand and loam in a thickness of 0.5-0.7 m, which is grown with grass. The coal from mining Chervonogradska is not rich in molybdenum, cuprum, beryllium and scandium in comparison with clark for sedimentary pelite rocks. Elements are concentrated in the grains (concentration coefficient for co-balt: Cc=5.4%; plumbum – Cc=2.1%, manganese - Cc=1.9%, yttrium - Cc=1. 7%, cuprum - Cc=1.2%, ytterbium and beryllium - Cc=1.1%). Reduction of the content of Co, Cu, and Be occurs in the series of siltstone - argillite - sandstone; Pb, Yb the series of siltstone - sandstone - argillite; Mn in the series of sandstone - siltstone - argillite; Y in the series of sandstone - argillite – siltstone. The most dangerous chemical elements are consider those metals that exceed the clark for sedimentary rocks in both of the grains we analyzed: Be, Yb and elements that exceed the mentioned clark in one of the heaps in more than 2 times: Co, Pb.

2. CONCLUSIONS

The Chervonograd mining region is one of the major contributors of pollution and the contamination of heavy metals to the Western Bug River. The following obstacles have been identified, which prevent the efficient harmonization of flood risk mapping and joint flood risk mapping in the cross-border region:

- Absence of high-quality maps of the Western Bug River Basin with the required scales
- Absence of the interoperable flood scenarios
- Absence of the common model with the same or similar legend, lay-out, flood scenario's and depth classes, of the border countries
- Absence of data for good continuity in hydraulic modeling.

Application of modern open source remote sensing data would significantly improve the current situation in Ukraine. It is proposed to establish a network of GPS-based 24/7 water monitoring stations along the river. Also, modern satellite-borne technologies are capable of imaging (SAR, multispectral) of changes in terrain high and flood prediction. Future work will focus on analyses of open-source remote sensing data, which will be gathered from the Western Bug River basin. The study has reviled that presently the highest risk of contamination can be caused by Be, Yb, Co and Pb.

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