Heavy metals in water and bottom sediments in reservoirs of the Dnipro cascade

Volodymyr Osadchyi, Nataliia Osadcha, Yuriy Nabyvanets, Valery Osypov, Dmytro Kozhemiakin, Volodymyr Kanivets

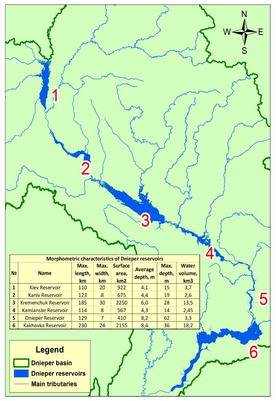
Ukrainian Hydrometeorological Institute , Ukraine (osad@uhmi.org.ua)

EGU 2020-9558

Introduction

Objectives. The purposes of this study were:
- assessment of suspended matter income sources as a basis for the Dnipro reservoir cascade bottom deposits forming;
- study of the main processes of heavy metals transformation in “water-suspended matter-bottom deposits” system;
- study of heavy metals distribution in different types of bottom deposits of the Dnipro reservoirs cascade;
- quantitative assessment of heavy metals remobilization from the Dnipro reservoirs cascade bottom deposits.

Objects and methods. Reservoirs of the Dnipro cascade were the objects of research.



Morphometric characteristics of Dnieper reservoirs

№	Name	Max. length, km	Max. width, km	Surface area, km2	Average depth, m	Max. depth, m	Water volume, km3
1	Kiev Reservoir	110	20	922	4,1	15	3,7
2	Kanis Reservoir	123	8	675	4,4	19	2,6
3	Kremenchuk Reservoir	185	30	2250	6,0	28	13,5
4	Kamianske Reservoir	114	8	567	4,3	14	2,45
5	Dnieper Reservoir	129	7	410	8,2	62	3,3
6	Kakhovka Reservoir	230	24	2155	8,4	36	18,2

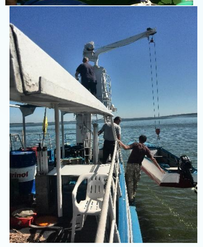


Fig.1. The Dnipro cascade scheme and fields work

Suspended particles of rivers Prypiaty, Dnipro, and Desna (erosion processes taking place at these rivers catchments) are the main sources of the Dnipro reservoirs cascade complex of bottom deposits forming.
Data concerning the daily (for the year 2010) incoming of suspended solids and dissolved organic substances associated with the flow of rivers Dnipro and Prypiaty is presented on Fig. 2.

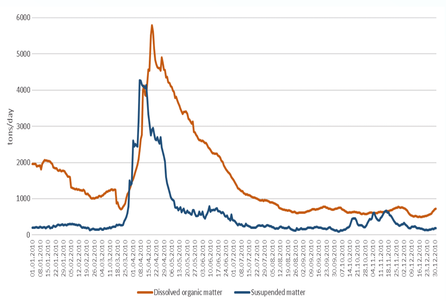


Fig.2. Daily discharged of suspended solids and organic matter

Results

The significant part of suspended matter is formed due to transformation of dissolved organic matter of humus origin (humic and fulvic acids) of the rivers Dnipro, Desna, and in particular of the rifer Prypiaty.

Annual incoming of suspended solids reached 205.9 thousand tones; dissolved organic substances – 553.5 thousand tones.
In soluble phase of the last Kakhovsyke Reservoir the amount of suspended particles remains a bit higher than 190.0 thousand tones; accumulation is equal to 363.5 thousand tones.

Sorption on to suspended particles which are represented by organic substance (humic and fulvic acids) and iron. Fulvic and hydroxo-fulvic complexes of iron form the suspended matter system being the powerful collector for heavy metals removal from solution phase, especially during the spring period when the changes of physicochemical conditions of water media occur (Fig. 3-5).

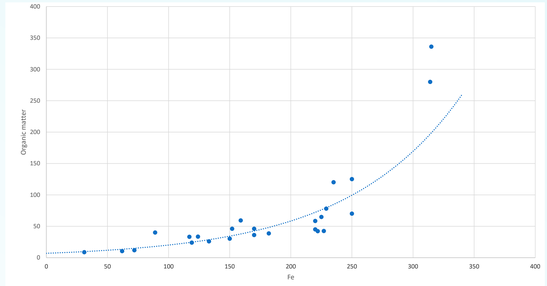


Fig.3. Correlation between suspended forms of Fe and organic matter

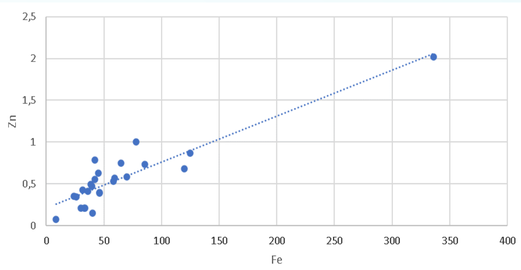


Fig.4 . Correlation between suspended forms of Fe and Pb, mg/kg

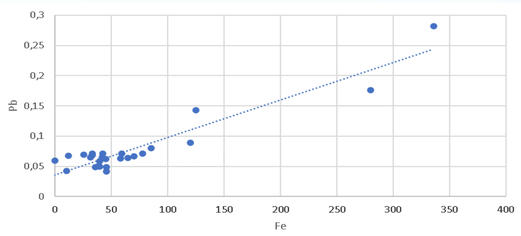


Fig.5 . Correlation between suspended forms of Fe and Zn, mg/kg

Changing of physicochemical conditions of water media leads to polymerization of dissolved high-molecular fraction of humic and fulvic acids and their subsequent transferring to the suspended migration form.

Besides that, the part of the bottom deposits complex is formed due to the removal of calcium carbonate ($CaCO_3^-$) from the water column. This is more characteristic for the Kremenchutsyke Reservoir and Kakhovsyke Reservoir as being the most bioproductive. During the summer time owing to the shift of the carbonate-calcium system toward forming of the high-soluble compounds of $CaCO_3^-$ dozens of thousand tones of calcium carbonate are removed only to the bottom deposits of the Kakhovsyke Reservoir (Fig. 6).

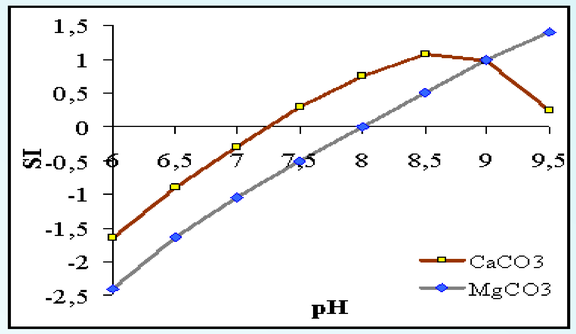


Fig.6 . The dependence of the saturation index (SI) regarding the system calcite and magnesite from the pH value in the Kakhovske reservoir

Heavy metals transformation in “water-suspended solids” system.
The main processes leading to the metals transferring from the solution phase to suspended form are the following:
1. Sorption on to suspended solids entering the reservoirs with the rivers water flow as a result of erosion processes at catchment areas.

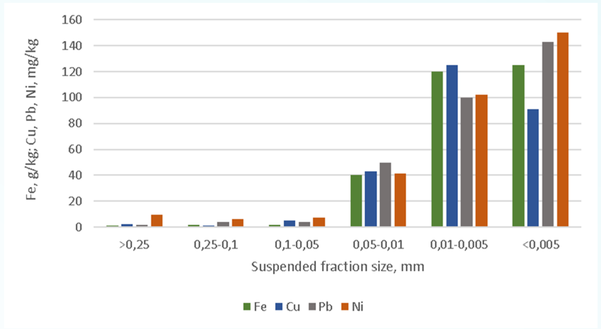


Fig.7 . Content of iron, copper, lead and nickel in the different suspended fraction size

Results

Biological consumption of heavy metals by phytoplankton. The multiannual researches showed that the average Fe concentrations l n phytoplankton of the Dnipro Reservoirs is 271.5 mg/kg dry weight; Mn – 453.3 mg/kg dry weight; Zn – 172.5 mg/kg dry weight; Cu – 15.7 mg/kg dry weight; Pb – 13.1 mg/kg dry weight; Ni – 15.6 mg/kg dry weight; Co – 4.5 mg/kg dry weight; Cd – 3.4 mg/kg dry weight. During the years which are characterized with intensive hydrobiological processes the “reservoirs blooming” can utilize up to 24.8 tons of iron; 41.3 tons of manganese; 15.7 tons of zinc; 1.2 tons of lead; 0.4 tons of cobalt, and 0.3 tons of cadmium.

The content of heavy metals in silty sediments of the Dnipro cascade reservoirs is shown in Fig. 8.

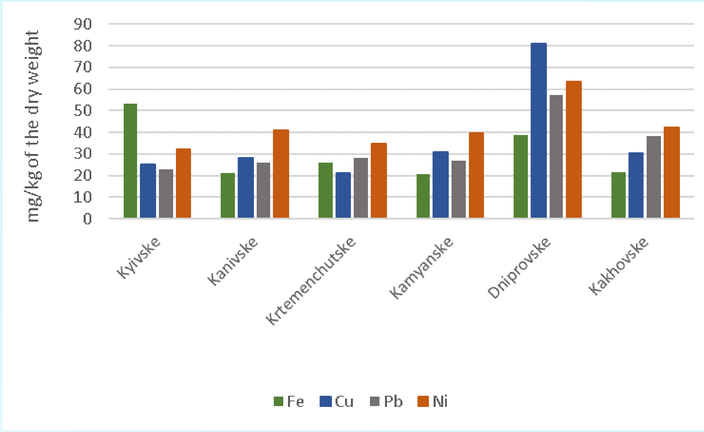


Fig. 8. Content of heavy metals in silty sediments of the Dnipro cascade reservoirs

Conclusion

The Dnipro reservoirs cascade serves as a powerful biogeochemical barrier concerning the heavy metals entering the water media as a result of the different kinds of human activities.

Hydrological factors, physicochemical and biological processes are the leading driving forces in heavy metals transferring from the solution phase to suspended migration form with subsequent sedimentation and accumulation in bottom deposits.

Quantitative assessment and calculation of heavy metals molecular diffusion velocity from interstitial water of bottom deposits have shown that manganese is the most labile. For the other heavy metals, the secondary pollution originated from the bottom deposits under current physicochemical conditions of water media is practically impossible.