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СОДЕРЖАНИЕ И РАСПРЕДЕЛЕНИЯ ОКСИДОВ ЖЕЛЕЗА В ЗАВИСИМОСТИ ОТ ГРАНУЛОМЕТРИЧЕСКОГО СОСТАВА ДОННЫХ ОСАДКОВ РЕК УКРАИНЫ

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Представлены результаты исследований содержания и распределения оксидов железа в донных осадках рек Днепр, Южный Буг, Ингулец и Ингул. Проанализирована зависимость содержания и распределения оксидов железа от гранулометрического состава осадков рек. Содержание оксидов железа имеет высокие позитивные коэффициенты корреляции с пелитовой фракцией осадков для всех исследованных рек, за исключением Ингульца. Показано, что изменения в соотношении Fe_2O_3 / FeO позволяют раскрыть наличие восстановительных условий в донных осадках. Предложено использовать этот показатель как абиотический индикатор экологического состояния рек.

Ключевые слова: донные осадки рек; оксиды железа; гранулометрический состав осадков.

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CONTENT AND DISTRIBUTION OF OXIDES OF THE GENERATION DEPENDING ON THE GRANULOMETRIC COMPOSITION OF THE DONAL SEDIMENTS OF THE RIVERS OF UKRAINE

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The article presents the results of studies of the content and distribution of iron oxides in the bottom sediments of the Dnieper, Yuzhny Bug, Ingulets and Ingul rivers. The dependence of the content and distribution of iron oxides on the granulometric composition of river sediments is analyzed. The iron oxide content has high positive correlation coefficients with the pelitic precipitation fraction for all the studied rivers, with the exception of Ingulz. It is shown that changes in the Fe2O3 / FeO ratio make it possible to reveal the presence of reducing conditions in bottom sediments.

Key words: bottom sediments of rivers, iron oxides, granulometric composition of sediments.

Introduction

Bottom sediments of rivers in the modern era increasingly turn to waste depository technological activity. On the one hand, this is due to the growing flow of industrial and domestic discharges, on the other hand – biodegradation rates of decreasing ability of rivers to cleanse themselves, which plays a significant role in their overregulation.

Processes formation of watercourse and delta, sedimentation, transporting distribution streams and reservoirs are largely dependent on particle size that are suspended and transferred by water flow in the form of suspension and those who sinked and moved down.

Researching grain size (structural frame) bottom sediments can better understand the physical and chemical processes that occur in them and their ecological role. However, the chemical composition of bottom sediment geochemical characteristics reflects both the catchment area and the coastal landscape and the intensity and magnitude of anthropogenic pollution [1–3].

Search for cheap, but informative indicators of ecological state of ponds and watercourses, numerical analysis of the literature resources and long independent research allowed us to form our own approach of understanding and forecast of pond's ecological condition, based on studies of bottom sediments as more conservative, in comparison to the water system. Determination and the ratio of iron oxides (FeO and Fe_2O_3) in bottom sediments to some extent characterizes the redox processes occurring in the pond and makes it possible to use these figures as indicators of an abiotic environmental state of the pond.

The aim of our study was to determine the concentration and the ratio (k) of Fe_2O_3 and FeO, and their dependence on grain size distribution of bottom sediments of a number of rivers in Ukraine.

Material and Methods

There have been large-scale studies of bottom sediments lower reaches of the Dnipro and Southern Bugh, and their lower tributaries – Inhulets and Inhul respectively. The basis of the presented research is results of the analysis of samples of bottom sediments, which were selected in expeditions during 2010–2016 years. The choice of the research area is due to considerable anthropogenic pressure on the hydro ecosystems, owing to the location of significant industrial and agricultural capacities in this region. The sampling points were located along profiles that crossed the investigation objects (fig. 1). The Dnipro river research area is the lower reaches, from vil. L`vove (below the Kakhovska hydroelectric station) and to the estuary; 3 profiles were laid, 56 samples were selected. The research area of the Southern Bugh – from 143 km above the delta and before falling into the Dnipro-Bugh estuary; 4 profiles were laid, 50 samples were selected. Inhulets and Inhul were investigated from the headwaters and to the delta, and 72 samples from Inhulets and 68 from Inhul were selected. Overall analyzed 246 samples of bottom sediments.

Samples were taken with the special equipment by submerged or drilling. The thickness of the deposited layer selected for analysis is 0,1–0,65 m. The selected samples after drying were subjected to averaging at the points of selection.

The determination of granulometric composition of bottom sediments was carried out on the basis of standard technique by a sieve method [4]. From the average, by the method of the «ring of the cone», samples of the primary weight of 1,0–1,5 kg were selected mass 100–200 g. After the sifting with the laundering, 12 fractions were allocated: +10 mm; 10÷5; 5÷3; 3÷2; 2÷1; 1÷0,5; 0,5÷0,315; 0,315÷0,25; 0,25÷0,1; 0,1÷0,07; 0,07÷0,05 and <0,05 mm, which were then divided into 4 fractions.

The determination of iron oxides (FeO and Fe_2O_3) was carried out titrimetrically according to standard methods [5, 6]. For chemical analysis the dry averaged weight of the sample of bottom sediments weighing 100g was selected.

The results were statistically analyzed using correlation study.

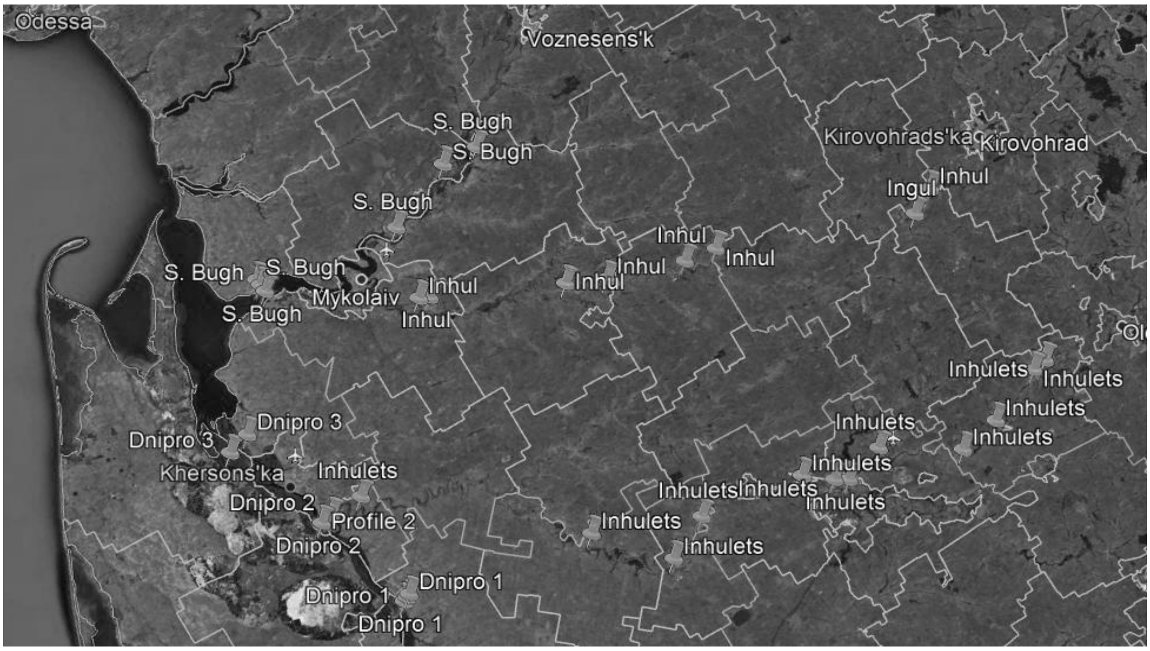

Рис. 1. Район исследования (карты Google Earth)

Fig. 1. The research area (Google Earth)

Results and Discussion

A significant slowdown of flow Ukraine major rivers (the Dnipro and the Southern Bugh), which is a consequence of global regulation clearly reflected in such indicators as size distribution of bottom sediments. According to [7], the number of reservoirs within the river basins is: for the Southern Bugh – 186, for the Dnipro within Ukraine and without taking into account the Dnipro cascade – 498. Of course, this has affected the flow speed, which according to various estimates decreased to 30 times for the Dnipro and 10–15 times for the Southern Bugh.

After examining and analyzing what has been done, the recounting of relative content of sediment particle size to 4 major particle size fractions has happened: psephite, psammite, silts and pelity (table 1).

The data listed in tabl. 1 shows a significant variation in grain size and at the same time make it possible to identify a tendency to increase pelitic fraction in sediments and arrange on this indicator rivers in the following row: Dnipro < Inhulets < Inhul < Southern Bugh. However, despite the tendency to silting, in general, has preserved natural facial distribution of sediment, except there are areas within a border of large industrial cities (eg Inhulets within Kriviy Righ).

An important factor influencing the process of forming a chemogenic and biogenic complex of bottom sediments is the saturation of the water object with oxygen. Bottom sediments of natural water flow relate to the balanced aerobic-anaerobic system type. However, there are the shifts of aerobic-anaerobic balance toward anaerobic, which in turn leads to the formation of another chemogenic complex and partial or total destruction of conventional ecotypes [8]. One of the indicators of aerobic-anaerobic shift in balance toward reduction can be displacement the ratio in the bottom sediments of iron oxides, namely the predominance of FeO over Fe_2O_3 [9]. Recently, more attention is devoted to this issue. It was analyzed, the dynamics of accumulation and the features of the distribution of a number of metals, including iron oxides, in bottom sediments of rivers as a result of the development of anaerobic conditions, depending on the volumes of organic matter flow, whose rate of biodegradation does not keep pace with the rate of its receipt [10; 11].

Таблица 1

Гранулометрический состав донных осадков исследованных рек

Table 1

Granulometric composition of bottom sediments

Investigated indicators, particle size fractions		Investigated rivers, (n – number of sample)			
		Dnipro, n=56	Inhulets, n=72	Southern Bugh, n=50	Inhul, n=68
Psephite, % (>2 мм)	min-max	0–80,53	0–11,8	1,1–59,7	0,47–29,5
	M±m	23,07±26,32	3,19±3,52	17,52±19,73	14,98±9,43
Psammite, % (2–0,1 мм)	min-max	7,62–93,56	0–46,4	3,9–59	7,8–79,87
	M±m	47,54±27,12	9,50±10,54	25,49±17,96	43,83±21,07
Silts, % (0,1–0,05 мм)	min-max	2,76–28,39	0,1–5,4	0–8,1	0–3,53
	M±m	10,52±7,38	1,59±1,47	1,61±2,72	1,76±1,08
Pelity, % (<0,05 мм)	min-max	0–62,58	2,9–97,1	3,7–88,1	8,3–89,6
	M±m	18,85±20,92	36,53±32,93	55,37±30,35	48,95±26,12

We have analyzed the concentration and ratio (k) of iron oxides in the upper layer of bottom sediments (table 2, fig. 2) rivers of Ukraine. Comparing the average values of the content of iron oxides (fig. 2) can be noted that the largest concentration determined in r. Inhulets, and the lowest in the Dnipro (Inhulets > Inhul > Southern Bugh > Dnipro). The content of iron oxides in the river Inhulets is relatively high in comparison to other rivers and is conditioned by the metallogenic specialization catchment area that significantly increases by allothigenic material of industrial origin of overburden dumps, tailings and reservoir of enterprises of Kriviy Righ [12].

Таблица 2

Содержание и соотношение (k) оксидов железа (FeO и Fe2O3 в донных осадках)

Table 2

The content and the ratio (k) of iron oxides in bottom sediments

Investigated indicators		Investigated rivers, (n – number of sample)			
		Dnipro, n=56	Inhulets, n=72	Southern Bugh, n=50	Inhul, n=68
FeO, %	min-max M±m	0,1–1,9 0,62±0,16	0,1–6,12 1,24±0,61	0,1–1,1 0,71±0,19	0,5–1,9 1,2±0,06
Fe_2O_3,%	min-max M±m	0,1–1,1 0,4±0,09	0,3–11,31 2,58±0,95	0,3–2,3 0,64±0,12	0,57–3,67 2,12±0,45
k (Fe_2O_3 / FeO)		0,64	2,08	0,90	1,77

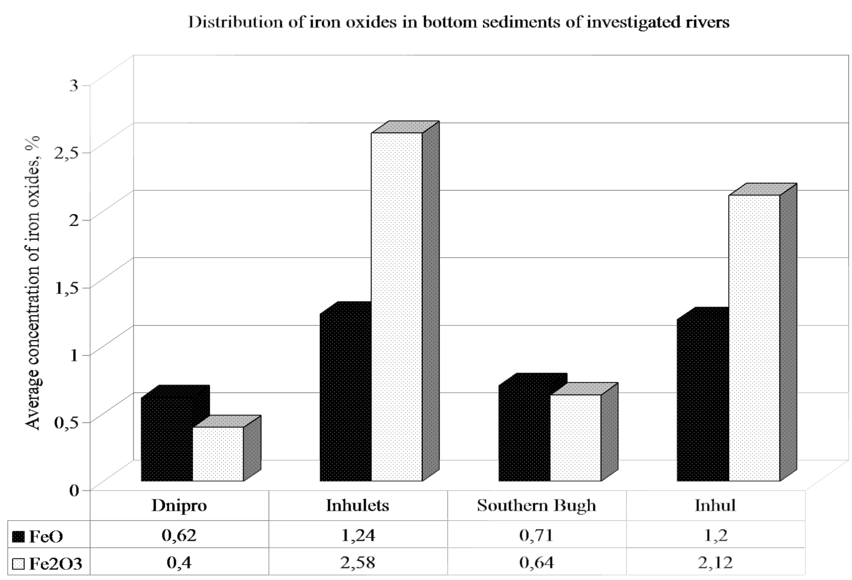

Рис. 2. Среднее содержание оксидов железа в исследованных реках, (%)

Fig. 2. The average content of iron oxides in the investigated rivers (%)

However, determining the ratio k (Fe_2O_3/ FeO) shows fluctuations in rivers redox conditions. In the bottom layer Inhul and Inhulets k $_{(Fe_2O_3 / FeO)}$ > 1, therefore the oxidation-reduction conditions can be defined as transient with a non-constant aerobic-anaerobic balance or oxidative. While in the lower reaches of the Dnipro and the Southern Bugh in the bottom layer k $_{(Fe_2O_3 / FeO)}$ <1, indicating the formation reducing conditions.

Definition of links between particle of different granulometric fractions of bottom sediments and iron oxides has been conducted on the basis of correlation analysis (table 3). The analysis demonstrated as multidirectional and so similar trends. For three out of four surveyed rivers determined high positive correlation coefficients between FeO and pelitic fraction. The correlating dependency, between the indicators considered, for the Dnipro and Inhul rivers looks the most natural. Instead, examined indicators for Inhulets almost do not correlate with each other.

Probably the assumption of transformation and/or disturbance of natural sediment-genesis is caused by technogenic and anthropogenic impact.

Таблица 3

Парные коэффициенты корреляций между размером частиц осадка и содержанием оксидов железа

Table 3

Coupling coefficients of correlation between particle size of sediment and content of iron oxides

Iron oxides	Granulometric fractions			
	Psephite, (>2 мм)	Psammite, (2–0,1 мм)	Silts, (0,1–0,05 мм)	Pelity, (<0,05 мм)
r. Dnipro				
FeO	–0,214	–0,481	–0,118	0,931
Fe_2O_3	–0,182	–0,497	–0,119	0,916
r. Inhulets				
FeO	0,254	–0,160	0,099	0,081
Fe_2O_3	0,273	–0,172	0,135	0,078
r. Southern Bugh				
FeO	–0,805	–0,646	0,124	0,895
Fe_2O_3	0,072	0,013	0,279	–0,065
r. Inhul				
FeO	–0,209	–0,738	0,168	0,762
Fe_2O_3	–0,472	–0,669	0,060	0,762

Thus, studies have shown that there is recently being a general tendency to silting rivers, especially in their lower reaches. This leads to a shift in the natural aerobic-anaerobic balance to the reducing side, which negatively affects the hydroecosystem in general. An indicator of this process can be the ratio of iron oxides (k $_{Fe_2O_3 / FeO}$) with the value <1.

Conclusion

Have been studied the content and the ratio of oxides (Fe_2O_3 and FeO) in sediments Inhul, Inhulets, lower reaches of Dnipro and the Southern Bugh, and has determined their dependence on grain size distribution.

Investigated rivers iron oxide content varies relatively much (except Inhulets of its geochemical anomaly). The ratio of Fe_2O_3 / FeO reveals the presence of reducing conditions of formation of bottom sediments in the lower reaches of major rivers – the Dnipro and Southern Bugh.

The content of iron oxides has high positive correlation coefficients with pelitic fraction of sediment for all rivers except Inhulets. Determination of the concentration and the ratio (k) of iron oxides in bottom sediments is proposed to use as an indicator of abiotic environmental state of the watercourses and ponds.

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