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The Content of Heavy Metals in the Alluvial Formations of Mountain Torrent**

1. Introduction

Base deposit gathered in the bottom of rivers and water basins as a result of mineral and organic material sedimentation retains different harmful substances containing heavy metals and durable organic compounds. Some compounds could be return ad to the water in the result of chemical and biochemical processes going on in sediments (it determines the caution to the living organisms), as well as in the result of mechanical movement of earlier deposited contaminated sediments. [2, 3, 10, 16, 22, 26]. Contaminated sediments could be transported to the soil of flood terrace or down with the river during water rising or flooding. Accumulative properties of deposit cause several times higher concentration of contaminants than those in the water. Quality of bed sediments of rivers is the factor of the anthropogenic pollution, as well gives information on potential threads for the ecosystem [9, 15, 17, 21, 23, 25]

The aim of the investigations was description of heavy metal content in the alluvial deposits gathered in the sandbanks of channels of Jalowiecki torrent, with consideration of amount of deposit fraction.

2. Methodic

The object of investigations was part of the basin of Jalowiecki torrent, placed in the grounds of Zawoja district, in the west part of Carpatian Mountains, in the Beskid Makowski region. Basin is limited in the North-West direction by the Jalowieckie mountain range and in the South-East direction by the Babiogórskie

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mountain range. Investigated stream is the mountain torrent with surface area of the basin of 19.33 km^2. Lower part of the torrent basin is built with magura sandstones, more often medium- and fine-grained, which together with quartz contains feldspar, slivers of dark phyllite shist, chlorite-sericite shist and muscovite. It comes from higher part of middle and upper eocene. The bottom of the valley is built with quaternary formation and gravels forming the terraces. It is covered not-bold gravels formed contemporary in the stream channel. The age of the gravel terraces is dated to the early post-glacial period, probably [18].

Intensive transport in the torrent channel of the river rubble is going on, it is gradually sorted and breaking up to smaller grains and its accumulation leads creating a visible channel formation. This formations are less durable, and in the dependence of value of the flow undergo to dynamic changes. It influences directly on torrent flow increasing its roughness and resistance. In the medium part of Jalowiecki torrent, in the longitude of 1.1 km three channel form appears. Meander sandbank, lateral "A", is formed in the higher part of measuring length on the right bank. Next formation is lateral sandbank "B" characterized by the significant size, its length is approx. 30 m. Last formation is lateral sandbank "C" of 12 m length, which state the bank protection of the torrent right side and despite visible erosion of bank slope is particularly stable.

Investigated material is taken from layer down to 20 cm, in the several points of each sandbank. Points are localized along sandbanks proportionally to its length. Fractions of > 6 mm, 6–2 mm, 2–1 mm, 1–0.5 mm, 0.5–0.25 mm, 0.25–0.1 mm, 0.1–0.05 mm, 0.05–0.025, <0.025 mm were derived from the fetched material after drying. In the grains of size under 2 mm content of cadmium, copper, nickel, lead, chromium and zinc were determined by the atomic absorption spectrophotometer method.

3. Results

Sediment contained in river-bed sandbanks is characterized by changeable graining and different content of analyzed heavy metals. Sandbank A is very strong and highly skeletal built, sandbank B is highly skeletal, and sandbank C – medium skeletal [20]. Detailed presentation of grain size distribution of investigated samples is presented on figure 1.

Results of the chemical analysis of sediment samples are presented in the table 1. Content of cadmium oscillate in the range 0.01–0.95 $mg \cdot kg^{-1}$, but the lowest values are stated in the fraction 1–0.5 mm. Lead contains in the range of 8.2–98.50 $mg \cdot kg^{-1}$ and maximal values are denoted in the finest fractions < 0.025 mm. Amount of chromium contains in the range from 21.10 $mg \cdot kg^{-1}$ to

144.80 mg·kg^{-1}. Concentration of the chromium decreases gradually reaching minimal values in the fractions 0.5–0.25 mm and consecutively increases reaching the highest value for diameter < 0.025 mm. Copper content contains in the range of 12.3–62.5 mg·kg^{-1}. The lowest amount of this metal was stated in the fraction 0.5–0.25 mm, and highest one for the grains diameter < 0.025 mm. Manganese concentration oscillates in the wide range from 142 mg·kg^{-1} to 1233 mg·kg^{-1}, the highest one are denoted in the fraction 0.05–0.025 mm. The amount of nickel is in the range 14.3–222.4 mg·kg^{-1}. This metal was highly cumulated in the fraction < 0.025 mm. Zinc level oscillates from 33 mg·kg^{-1} to 149.6 mg·kg^{-1}, the lowest amounts are denoted in the fraction 0.5–0.025 mm, and highest one in the grains < 0.025 mm.

Investigated sediments contains trace elements with the different amount. The highest concentration of copper, chromium, nickel, lead, cadmium and zinc are denoted in the finest fraction (Fig. 2). Similar tendencies presented in the publications of different authors [1, 11, 13, 15, 24, 25].

Deposit sieved by the sieve of mesh diameter 2 mm should be taken into account under the analysis of taken material in the quality point of view [12]. Exceeded content of nickel in the 50% of samples are stated. Over normative amount appears mostly in the fraction < 0.1 mm and sporadically in some samples of higher mesh diameter. Remain elements concentration is significantly under official regulations.

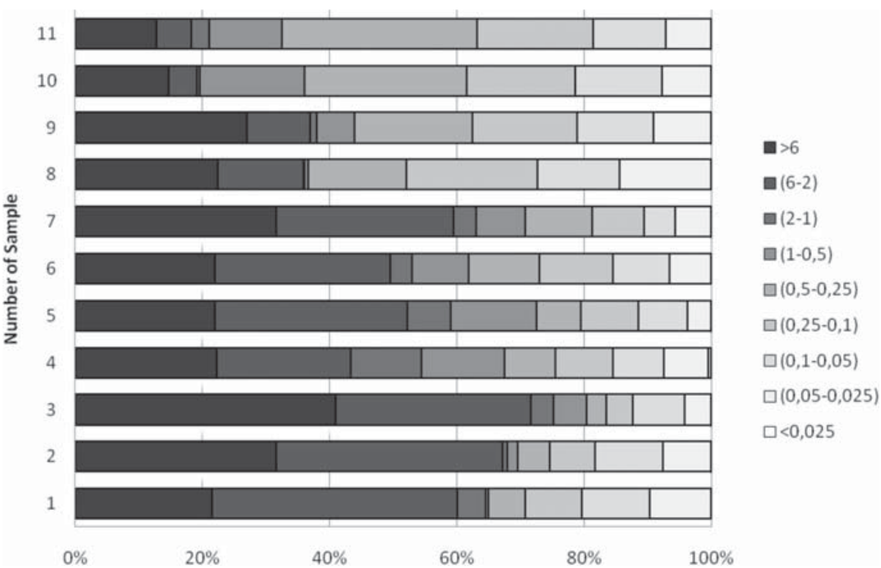

Fig. 1. Percentage contribution of derived fractions in the investigated river-bed sandbanks

Table 1. The content of chosen heavy metals in investigated fractions of sediments

Element		Fraction [mm]						
		2.00–1.00	1.00–0.50	0.50–0.25	0.25–0.01	0.10–0.05	0.05–0.025	<0.025
Chro-mium [mg·kg^{-1}]	Average*	32.22	29.68	25.75	49.52	58.52	53.95	103.21
	Stand.Dev.	5.36	8.12	3.76	15.02	12.20	16.94	29.20
	Quartile 25%	29.93	25.00	23.75	38.65	50.35	41.40	76.55
	Quartile 75%	34.50	33.10	27.00	56.60	62.50	66.55	132.50
Manganes [mg·kg^{-1}]	Average	559.6	635.0	570.8	648.1	818.0	948.6	698.5
	Stand.Dev.	283.4	196.9	85.9	59.1	47.6	69.9	293.0
	Quartile 25%	451.5	527.0	521.5	614.5	795.5	928.5	491.0
	Quartile 75%	612.5	718.5	598.0	682.5	827.0	974.0	971.0
Nickiel [mg·kg^{-1}]	Average	70.00	59.90	60.68	60.17	78.60	101.10	130.20
	Stand.Dev.	24.87	19.01	9.38	7.54	15.52	13.16	67.69
	Quartile 25%	67.15	53.00	59.50	54.65	65.20	90.30	69.43
	Quartile 75%	82.85	74.40	63.70	66.00	91.50	112.45	199.50
Copper [mg·kg^{-1}]	Average	24.71	23.88	20.18	21.14	29.15	33.61	43.30
	Stand.Dev.	5.44	4.63	1.96	2.51	2.96	8.30	10.83
	Quartile 25%	22.38	23.25	19.45	19.45	26.70	32.40	38.70
	Quartile 75%	28.60	26.45	21.95	22.95	31.65	37.05	51.00
Zinc [mg·kg^{-1}]	Average	65.63	67.11	55.44	62.14	90.14	108.8	119.72
	Stand.Dev.	8.34	15.16	5.32	6.34	6.96	7.88	15.92
	Quartile 25%	65.78	59.75	52.25	58.65	84.95	103.40	108.50
	Quartile 75%	70.65	77.10	60.05	64.25	93.15	111.55	130.60
Cadmium [mg·kg^{-1}]	Average	0.32	0.27	0.28	0.36	0.41	0.44	0.46
	Stand.Dev.	0.19	0.13	0.26	0.30	0.29	0.24	0.19
	Quartile 25%	0.15	0.23	0.15	0.20	0.23	0.25	0.30
	Quartile 75%	0.44	0.35	0.35	0.45	0.68	0.58	0.60
Lead [mg·kg^{-1}]	Average	20.54	18.96	23.01	16.05	20.15	30.61	52.96
	Stand.Dev.	9.74	14.05	25.42	3.45	2.58	18.53	11.08
	Quartile 25%	12.73	12.75	11.85	13.35	18.30	23.90	48.20
	Quartile 75%	22.80	18.60	17.05	18.45	21.80	26.90	56.90

* Average content of each metal was obtained on the basis of 11 samples.

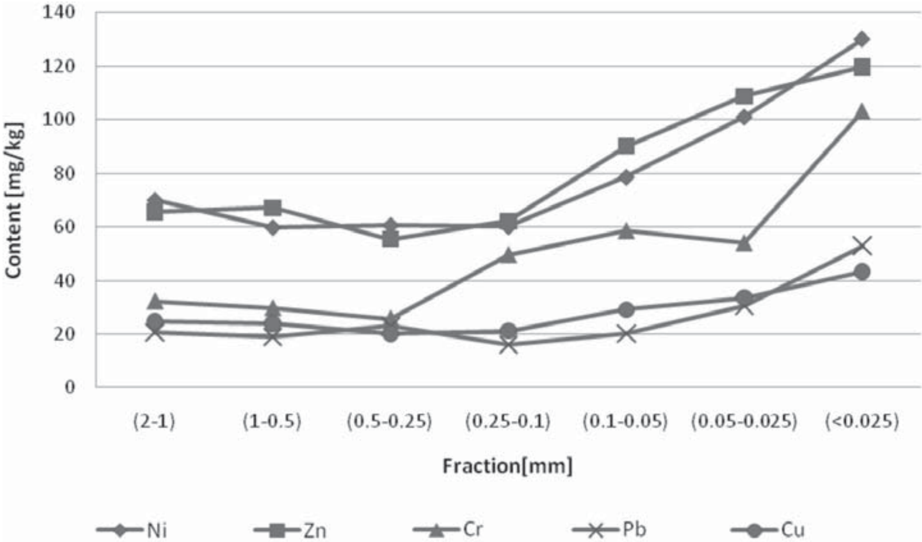

Fig. 2. Average content of chosen heavy metals in the several sediment fractions

National Geological Institute in Poland apply quality classification of bottom sediments based on trace elements content in the fraction ≤ 0.2 mm [3, 5–8]. This fraction represent the content of the heavy metals in the environment in view of the adhesive properties point. Finer fractions are characterized by higher content of of heavy metal in comparison to thicker fraction of the same sample [7]. In the geochemical researches of water sediments incomplete distribution of samples is applied, because for the estimation of the pollution level of the environment the amount of an element which easily moves to the surface water is interested. Total content of an element in the deposit is less essential because remains of its content constitutes the mineral resistant to decay is not important for quality of the environment [4]

Established quality classification of bottom deposits describes threshold values taking lethal influence of accumulated pollutants on water organisms into account (I class – sediments weakly polluted, II class – sediments averagely polluted, III class – sediments polluted). Exceeding of at least one lethal component defines the quality of the deposit. Concentration of investigated metals significantly exceeds values of geochemical background. Especially amounts of nickel are on the high level (all samples of diameter < 0.025 mm), it cause the assignment of the deposit to the III class (Fig. 3).

Several sandbanks not differ each-other by the concentration of investigated metals, only approximately 10% lower content of lead and nickel is stated in the sandbank C in comparison to the others.

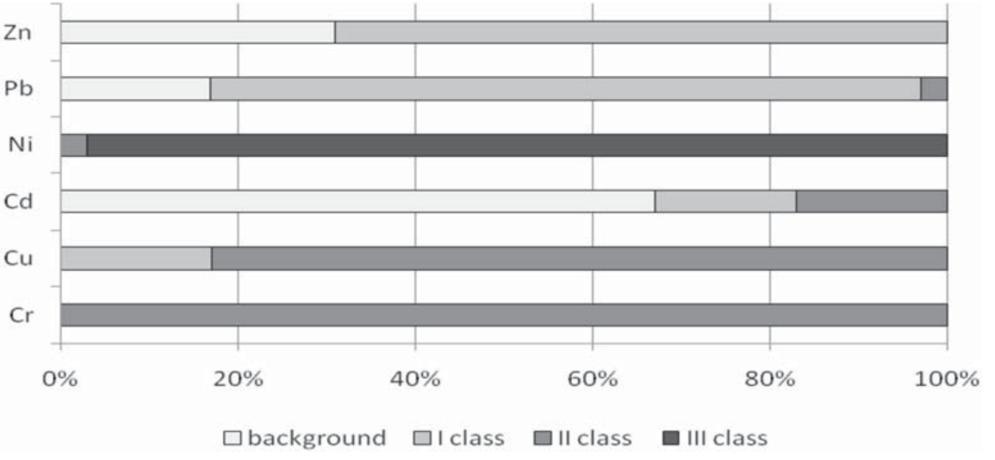

Fig. 3. Percentage contribution of metals In the investigated deposits according to geochemical classification

Source: [6]

4. Conclusions

1. Sediment collected in the River-bed sandbanks of Jalowiecki torrent divers in respect of graining from formation of highly skeletal to medium skeletal structure.
2. Content of analyzed heavy metals in the alluvial materials oscillates in the wide range. The highest content of chromium, copper, cadmium, nickel, lead and zinc are denoted in the finest fractions (< 0.025 mm), while the lowest amount of zinc, chromium and copper contains an alluvial materials with diameter 0.5–0.25 mm.
3. Studied base materials are assigned to the III class, accordingly to the geochemical criteria, in the effect of exceeded concentration of Ni.

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