CONTAMINATION OF SEDIMENT DEPOSITS AT THE BACKWATER LEVEL ENDS IN WATERWORK RUŽÍN I BY SOME HEAVY METALS

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Abstract

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The major part of sediment deposits is situated in the localities, where Hnilec, Hornád, Belá and Opátka rivers flow into the water reservoir of Waterwork Ružín I. The analysis of sediment deposits for heavy metals (HM) showed the following results.

Except for Cu, Co and Ni, the small tributary Belá creates sediment deposits with a low content of HM compared with the requirements of the Methodical Instruction of the Ministry of the Environment of the Slovak Republic No. 549/1998-2. The sediment deposits of the second small tributary Opátka have a similar composition, only the content of Cu exceeds the admissible concentration specified by the Instruction. The analyses of sediment deposits in the Hnilec river proved a high content of Cu and the increased content of Co and Ni. The sediment deposits of the Hornád river are heavily contaminated by HM, especially by Hg.

Introduction

Since its completion in 1969, the water reservoir of Waterwork (WW) Ružín I has had a multifunctional relevance in the management, environment and anti-flood protection and it has had a significant role of accumulator of erosion products from the catchment areas of the rivers, which flow into it. The rivers discharging into the water reservoir (Fig. 1) flow through the Slovenské Rudohorie with a lot of geological ore deposit structures of utility metals, which were intensively mined and processed in the past. That is why there are different minerals in the weathering products, which have primary but mostly secondary forms and often soluble forms which get into brooks and rivers due to the wash-out. These minerals can be the originators of the majority of heavy metals in the water reservoir sediment deposits, which represent the subject of our team's research.

The literature (Holubová et al., 1996) states that the quantity of sediment deposits in the reservoir is estimated to 7 million m^3. The annual inflow of the sediment into the water reservoir, where they form sediment deposits, is about 260 thousand m^3. Their distribution on the water reservoir bed is uneven and represents the subject of hydrological research.

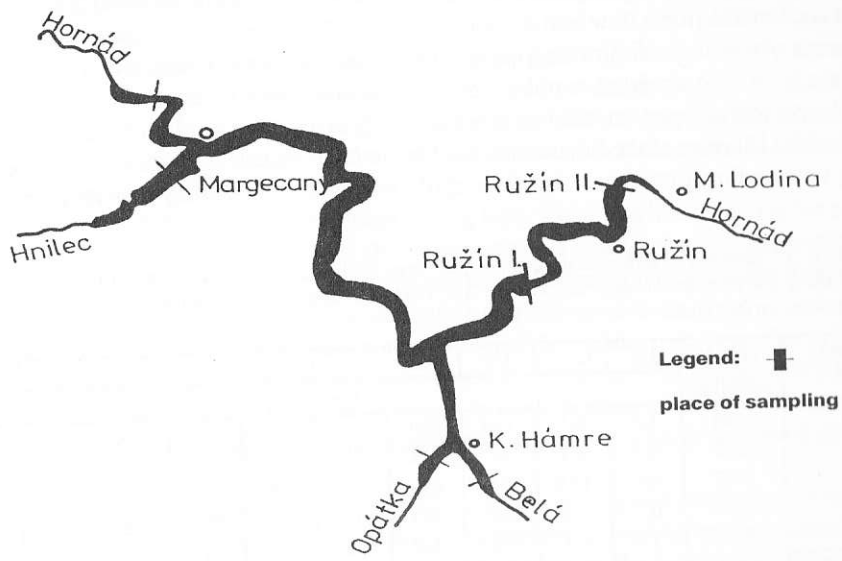

Fig. 1. Lay-out of the water reservoirs Ružín I, II and main tributaries.

The highest quantity of sediment deposits is at the backwater level ends of the rivers Hnilec, Hornád, Belá and Opátka (Fig. 1), where the thickness achieves several meters. . In the deeper sections of the water reservoir, in the direction towards the WW dam, the thickness of sediment deposits diminishes considerably and becomes irregular. They consists of very fine (pelitic) material which takes almost "the rocky" form after being dried. The water reservoir sides are mostly very steep, so the sediment deposits flow down them into the streamline of original watercourse. The sediment deposits are in the depth of 15 m and more, so in the future this may complicate their excavation from the water reservoir. The places more suitable for excavation are situated in the vicinity of the mouth of the rivers Hnilec, Hornád, Belá and Opátka (Fig.1), where the sediment deposits form a several meter thick layers the surface of which is currently less than 10 m under the maximum water level.

The properties of sediment deposits, mainly its expressive toxicity (Bobro et al., 2003 and Seszták, 1998) rank them among wastes (Act No. 606/92 Coll.) and the quantity (Holubová et al., 1996) among the materials with potential use in the future.

Experiments

The separate methodology have been worked out and applied in the sampling of sediment deposits from the part under the water level according to the sampling locality and in consent with operative standards specified in detail in the literature (Bobro et al., 1996). The first vertical profile sampling was carried out in 1994 in the sections where Hnilec, Hornád, Belá and Opátka rivers flow into the water reservoir. The sampling was carried out again on the same places in the following years (Table 1), but the samples were taken only from the surface layer. The air-dried samples were analysed for heavy metals using AAS method.

The content of heavy metals was assessed using a new standard – Methodical Instruction (MI) of the Ministry of the Environment of the Slovak Republic. This MI was also applied to carry out sampling from the surface (10 cm) of a newly-accumulated layer, starting from 1999.

Table 1. Analysis of sediment deposit samples from the branches of water reservoir of WW Ružín I in 1994–2002 and comparison with the MI ME SR. 1994 – average values (vertical profiles); 1995–2002 – values from surface layers

Locality	Year of sampling	Hg	As	Cu	Mn	Cd	Co	Ni	Pb	Zn	Cr
		[mg.kg^{-1}]									
Belá	1994	1.0	6.1	130	700	5	77	96	20.0	139	82
	1995	0.7	3.8	52	654	5	72	106	28.5	110	82
	1997	0.9	17.9	66	686	1	20	44	15.8	127	137
	1999	0.7	7.2	80	897	0.7	37.5	20.6	4.8	90	37
	2002	1.4	6.1	78	800	0.5	28.2	111	49.8	160	78.1
Opátka	1994	1.1	5.8	497	830	5	84	118	20.0	162	89
	1995	2.0	4.4	400	650	5	79	124	20.0	188	99
	1997	1.4	18.9	38	235	1	19	22	15.0	91	53
	1999	0.6	7.2	230	1 041	1.1	98.9	286	3.1	140	77
	2002	2.6	3.8	93	400	0.9	24.9	60.3	64.7	210	63.6
Hnilec	1994	2.2	11.1	1 154	1 160	17	68	89	0.0	852	89
	1995	3.2	12.8	640	1 110	4	99	103	19.0	478	64
	1997	3.4	16.0	438	786	2	35	53	10.0	786	78
	1999	0.9	10.6	440	993	2.2	8.0	33	3.0	520	36
	2002	2.7	9.1	465	1000	0.8	78.8	89.4	134	580	98.8
Hornád	1994	71.7	12.1	396	1 220	20	49	137	0.0	357	94
	1995	21.4	10.8	246	930	3	77	149	20.0	338	111
	1997	11.3	21.5	221	1 045	2	28	62	8.1	308	171
	1999	2.0	16.0	350	1 668	0.5	18.8	59	3.1	120	35
	2002	9.6	7.8	249	1 100	1.4	30.7	171	112	380	236
MI ME SR – TV		0.3	29	36	–	0.8	9	35	8.5	140	100
MI ME SR – MPC		10	55	73	–	12	19	44	530	620	380
MI ME SR – IV		10	55	190	–	12	–	210	530	720	380

TV – testing value, MPC – maximum permissible concentration
IV – intervention value

Results and discussion

The results of the analyses given in Table 1 show that each of watercourses has its characteristic content of metal elements in sediment deposits. These elements partly come from geological background through which the rivers flow. The local sources of iron ores and non-ferrous metals were mined out in the past and processed in the places of their occurrence and winning.

The old technologies formed places (heaps, dumps, landfills, sludge beds, etc.) which are currently the sources of the increased water pollution by elements, which penetrate into the water reservoir sediment deposits. These elements include mercury, copper, zinc, chromium, arsenic and manganese. These elements even allow us to characterise the individual rivers and their sediments.

The Belá river flows through the former mining area, which has been inactive for a long time. Four out of 10 analysed elements show their contents close to maximum permissible concetration (Cu, Cd, Co, Ni) which means that the contamination of sediment deposits is around or slightly above the maximum admissible concentration limit.

The content of Cd and Ni in the sediment deposits of the Opátka river is similar to that in the Belá river, only Cu exceeds intervention value 1.3–2.5 times. The content of Co in one of the samples reaches the MPC limit, however, in other four samples MPC has been exceeded 1.5–4.2 times. The applied methodical instruction does not know intervention value for Co.

The Hnilec river contains sediment deposits of characteristic composition with significant content of Cu. The content of Cu in this branch exceeds the intervention value 2.5 to 5 times. There is a slight increase observed in the content of Hg in the area of the rivers Hnilec and Hornád confluence and in the content of As, Cd, Pb and Cr in relation to testing value, however, they do not exceed MPC. The content of Co, Ni and Zn in samples taken in 1999 is close to testing value, but the content of these elements in samples taken in the previous years exceeds this value, as well as maximum permissible concentration and in one case the content of Zn exceeds also intervention value. The catchment area of the Hnilec is much larger than that of the Opátka and Belá. The rock complexes are similar and formed by Gelnická and Rakovecká series. Also ultrabasic rocks (serpentines – Jaklovce), which are carriers of increased contents of some elements, appear on the surface. The past and recent industrial activities connected with the mining and processing of ores and metallurgic industry (Žakarovce, Gelnica, Prakovce, Smolník, etc.) have their share, too. The numerous and larger residential units situated in this area can also have an effect on the fluctuating content of heavy metals in individual samples.

From the geological point of view the most complicated is the catchment area of the Hornád river with known deposits of iron ores and non-ferrous metals. Due to these deposits the mining industry flourished in this region in the past and this area was noted for big processing complexes producing intensive sources of metal elements which accumulated in the water reservoir of WW. This region includes the cities like Rudňany, Slovinky, Novoveská Huta, Štefanská Huta, Krompachy and some other cities. The significant producers of con-

taminating elements were probably agricultural production complexes 10-30 years ago, which used seeds soaked in solutions containing e.g. Hg. The municipal sphere also represents an important source of contamination.

Table 1 shows the increased share of metal elements in sediment deposits from the Hornád branch of WW. These are mainly Hg, Cu, Cd, Co, Ni and Zn. The content of Hg exceeds both maximum permissible concentration and intervention value in the three of five samplings and testing value has been exceeded in the remaining two samplings. For Cu, intervention value has been exceeded 1.3-3.1 times. For Co, maximum permissible concentration limit has been exceeded 1.5-4 times, for Ni 1.3-3.8 times. Only the content of As is lower than testing value, the concentrations of Pb and Cr are under maximum permissible concentration.

The above-listed facts undoubtedly manifest such a contamination of sediment deposits in this branch of water reservoir of WW Ružín I which requires the environmental intervention. This means that these sediment deposits should be excavated from the water reservoir and processed using the most adequate method.

Conclusion

The analyses of the sediment deposits from the water reservoir of WW Ružín I carried out in 1994-2002 show that the contamination by heavy metals continues in spite of the attenuated or minimal activity of mining-processing and industrial plants situated up the water reservoir.

The volume of sediment deposits accumulated in the water reservoir, their contamination by heavy metals and the methodical instructions used to compare the content of individual elements allow us to recommend to continue in a careful monitoring of qualitative and quantitative indicators of sediment deposits in the water reservoir and to speed up the implementation of the excavation of sediments from the most contaminated localities procuring further use or liquidation of these sediments.

Translated by J. Čechovská

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Brehuv J., Bobro M., Hančuľák J.: **Kontaminácia nánosov z koncov vzdutia v nádrži Vodného diela Ružín I niektorými ťažkými kovmi.**

Najväčšia časť nánosov je usadená v lokalitách, kde rieky Hnilec, Hornád, Belá a Opátka ústia do nádrže Vodného diela Ružín I. Analýzy nánosov zamerané na ťažké kovy poukázali na nasledujúce výsledky. Menší prítok Belá, s výnimkou prvkov Cu, Co a Ni, tvorí nánosy s nízkym obsahom ťažkých kovov vzhľadom na požiadavky Metodického pokynu Ministerstva životného prostredia Slovenskej republiky č.549/1998-2. Druhý z menších prítokov Opátka má nánosy podobného zloženia, len obsah Cu výraznejšie prekračuje prípustnú koncentráciu podľa spomenutého pokynu. Analýzy nánosov rieky Hnilec svedčia o vysokom obsahu Cu a zvýšenom obsahu Co a Ni. Nánosy ricky Hornád sú veľmi kontaminované ťažkými kovmi, podľa spomenutého pokynu.