ваного методу з використанням Хортонівських коефіцієнтів.

Результатом даного дослідження є:

1) доведення можливості застосування законів Хортона до річок Прикарпаття;

2) знаходження значень чотирьох параметрів, що описують особливості структури гідрографічної мережі річок басейну верхнього Дністра;

3) наведено практичний приклад застосування отриманих результатів для інженерних розрахунків;

4) показано на незалежному матеріалі достатню точність розробленого методу.

Завдання подальших досліджень полягає у визначенні коефіцієнтів Хортона для решти річок Карпат, їх типізації та ув'язці з факторами підстилаючої поверхні, визначенні щільностей річкової мережі для трас трубопроводів та місць розташування підприємств нафтодобувного комплексу.

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STUDY CONCERNING ACCUMULATION OF HEAVY METALS IN SPONTANEOUSLY VEGETATION GROWS UP ON THE WALLS OF THE TAILING PONDS

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Статья представляет аспекты, касающиеся нагромождения тяжелых металлов (Pb, Cu, Zn) в отходах, складированных в терриконы и в растениях произвольно выросших на этих терриконах.

Проанализированно 10 грунтовых проб и 8 сортов растений. Опираясь на два параметра (уровень концентрации и фактор отбора, определенного для объективности анализов), мы отобрали нагроможденную серию для изучения тяжелых металлов.

The paper present aspects concerning accumulation of heavy metals (Pb, Cu, Zn) in the solid wastes who made the walls of a tailing pond and in the spontaneously vegetation species who grow up on the walls.

Has been analyzed 10 soil samples and 8 vegetation species samples. Based on two parameters, concentration degree and selectively coefficient, defined for an objective analysis, we set the preferentially accumulation serie for studied heavy metals.

Introduction

Processing ores activity, an important branch of mining industry, presents a major impact on environment because of wastewater and solid wastes resulted from different applied technologies. The ration solid/liquid resulted in the wastewater from wet processing technologies varies in range 113 ÷ 1120.

Considered that in every year are processed thousands tones of ores, the amount of wastewater is very important. The wastewater coming from non-ferrous and golden ores processing plants, who applied flotation technology, contain flotation reagents (xanthates, phenols, simple and complex cyanides), soluble salts of heavy metals (Pb, Cu, Zn, Fe).

Solid suspension contained in the wastewater resulted from processing ores technology are represented by the raw processing particles, contained in range 50 – 96% in the ores sender to processing. For the mostly processing plants, the only solution to clean up the wastewater is a tailing pond. Their take place a decanting of suspensions process, but the clear waters resulted can't be spilled in running waters because they still contain dissolved pollutant agents.

Table 1 - The contains of heavy metals in samples collected from the tailing pond's walls

General symbol of the soil sample	Soil samples				
	Collect depth	Symbol of soil sample	Concentrations of heavy metals, C_1, %		
			Cu	Pb	Zn
1.	Surface	1A	0.007	0.17	0.22
	30 cm	1B	0.03	0.14	0.11
2	Surface	2A	0.01	0.12	0.07
	30 cm	2B	0.01	0.10	0.08
3.	Surface	3A	0.04	0.19	0.15
	30 depth	3B	0.03	0.14	0.11
4.	Surface	4A	0.07	0.20	0.21
	30 depth	4B	0.05	0.19	0.18
5	Surface	5A	0.07	0.11	0.46
	30 cm	5B	0.07	0.12	0.24

Table 2 - The contains of heavy metals in vegetation samples collected from the tailing pond's walls

Vegetation samples					
Name of the plant	Symbol of the soil sample from where the plant has been collected	Symbol of plant sample	Concentration of heavy metals,		
			Cu	Pb	Zn
Reinouttria japonica	1	1C	0.0020	0.0059	0.0185
Arctium lappa	1	1D	0.0043	0.0080	0.0194
Robinia pseudaccacia (accacia – leafs)	2	2C	0.0024	0.0005	0.0187
Typha latifolia (rush)	3	3C	0.0022	0.0033	0.0059
Festuca pratensis (grass)	4	4C	0.0032	0.0065	0.0107
Robinia pseudaccacia (accacia – pods)	4	4D	0.0054	0.0191	0.0196
Chamomilla millefolium (cammomile)	4	4E	0.0312	0.0295	0.2053
Alchemilla millefolium	5	5C	0.0138	0.0175	0.1277

That is why, the mentioned waters should be advanced cleared. Because the cleaning process takes a long time, an important problem shows up, concerning the strong impact of tailings pond on environment.

Their integration in environment is a major problem. The solid wastes, where the chemical analysis show high concentrations of heavy metals, are made by low granularity particles. They are easily transported by the wind and pollute the environment on a wide area. The stability of he tailing ponds can be improved by planting the vegetation on the walls. The paper presents a study about accumulation of heavy metals by different spontaneously vegetation species, accommodated on the walls of a tailing pond.

Collecting the samples

For study has been chosen the tailing pond exploited by REMIN SA Company – Baia Mare – Romania. The activity profile of the company is obtained, by flotation technology, the heavy metals (Pb, Cu, Zn) concentrates. The wastes resulted from the processes are spilled in the mentioned tailing pond. Also, in the same tailing pond are spilled the wastewater coming from golden ores cyanidation process and acid mine waters resulting from the non-ferrous mines that surrounded the town.

The mentioned tailing pond, spreads on 120 hectares and placed near two large villages, presents the entire characteristics of a plain tailing pond.

On the areas where are spilled the flotation waters, having a basic pH, the vegetation is stronger grow-up comparative with the areas were acid mine waters are evacuated. Also, as we claim to the top of the tailing pond, the vegetation is less and on the last level, the newest one, none vegetation species have been present.

Development of the vegetation on the walls of tailing pond is stopped by the high concentration of heavy metals and acidity in the soil and by the bacterial leaching processes who occur inside of solid layers of the walls. For the study, have been collected 10 soil samples from surface and 30 cm depth and 8 vegetation species samples that grower-up on that soil.

The samples have been chemical analysed in purpose to determine a correlation between contains of heavy metals in plants and in the soil where they developed.

Experimental data

According to standardisation methods [1, 2, 3], the samples were disaggregated and contains of Cu, Pb and Zn were measured using ICP-AES method.

In Tables 1 and 2 are presented the heavy metals contains in soil and vegetation species collected.

Based on the results from Table 2, has been made the chart from Figure 1.

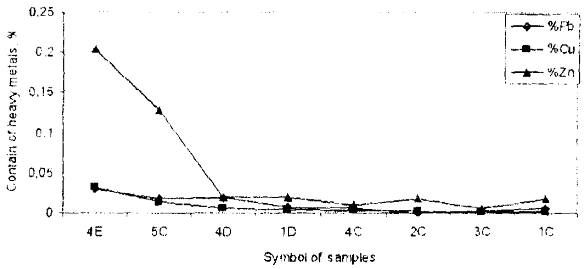

Figure 1 - The variation of heavy metals contained in studied vegetative species

Discussion of the results

For an objective appreciation of the results, we calculate two parameters: concentration degree (CD, %) and selectively coefficient (SC, %) of each heavy metal in plants.

Concentration degree (CD, %) is defined as follow:

$$CD(\%) = \frac{C_2}{C_1} 100\,, \qquad (1)$$

where C_1 and C_2 are the parameters from the Tables 1 and 2.

The resulted values are presented in Table 3.

Selectively coefficient (SC, %) indicate the affinity of each vegetation specie for a heavy metal and he has been calculated as follow:

$$SC(\%) = \frac{CD}{\sum_{i=1}^{n} CD} = 100\,, \qquad (2)$$

where: CD – concentration degree, defined in equation (1), [%]; Σ CD – the sum of concentration degrees of all heavy metals analyzed, [%]; n – the number of vegetative species considered for analysis [adimensional].

In Table 4 are presented the calculated values of SC (%) for studied species. Base on these, were express the preference of each studied species for each analyzed heavy metals.

Table 3 - The values of concentration degree (CD, %) for analysed heavy metals

Symbol of plant sample	Vegetation species	Concentration degree, CD, %		
		Cu	Pb	Zn
1C	*Reinouttria japonica*	2.86	3.47	8.41
2C	*Robinia pseudaccacia* (acacia – leafs)	24.00	0.5	23.38
3C	*Typha latifolia* (rush)	5.50	1.74	3.93
4C	*Festuca pratensis* (grass)	4.57	3.25	5.09
5C	*Achilea millefolium*	19.71	14.58	53.21
1D	*Arctium lappa*	6.14	4.70	8.82
4D	*Robinia pseudaccacia* (acacia – pods)	10.80	10.05	10.89
4E	*Matricaria chamomille* (camomile)	44.57	24.58	85.54

Table 4. The calculated values of selectively coefficient, SC(%), for each studied specie and heavy metal

Name	Selectively coefficient, SC (%)			Preference for heavy metals		
	Cu	Pb	Zn	Maximum	Middle	Low
Reinouttria japonica	19.29	23.57	57.14	Zn	Pb	Cu
Arctium lappa	31.23	23.90	44.87	Zn	Cu	Pb
Robinia pseudaccacia (acacia – leafs)	50.12	1.04	48.84	Cu	Zn	Pb
Festuca pratensis (grass)	35.39	25.17	39.44	Zn	Cu	Pb
Robinia pseudaccacia (acacia - pods)	34.02	31.66	34.32	Zn	Cu	Pb
Matricaria chamomilla (camomile)	28.81	15.88	55.31	Zn	Cu	Pb
Achilea millefolium	22.52	16.67	60.81	Zn	Cu	Pb
Typha latifolia (rush)	49.24	15.58	35.18	Cu	Zn	Pb

Conclusions

Based on experimental data, we can conclude the follows:

1. All analysed species accumulate heavy metals from the walls of the tailing pond;
2. With exceptions of *Typha latifolia* (rush) and *Robinia pseudaccacia* (acacia-leafs), Zn is the heavy metal for which the others analysed species present the higher concentration degrees. These are in range 85.54%, for *Matricaria chamomille* (camomile) and 3.93 for *Typha latifolia* (Table 3). The explanation is connected with high level of Zn in the solid waste where grower up the species mentioned above. The species *Typha latifolia* (rush) and *Robinia pseudaccacia* (acacia – leafs) have a particular behaviour. Thus they were collected from a soil containing 0.15 % Zn and 0.04% Cu *(Typha latifolia)* and 0.07% Zn and 0.01% Cu *(Robinia pseudaccacia)* (Table 1), the analyses of plants show a higher concentration degree for copper than Zn (Table 2).
3. Mostly of vegetative species accumulate a low led amount (Table 3). The maximum concentration degree was realised by *Matricaria chamomilla* (camomile), 24.58%, and the lower, by *Robinia pseudaccacia* (acacia -leafs), 0.5%.
4. Between the studied heavy metals, copper presents the lower concentration in solid waste, in range 0.01 ÷ 0.07% (Table 1), but vegetative species assimilate copper rather than led, although the concentrations of led in soil samples are almost ten times higher (Table 1).

Starting from the presented data, we can concluded that, for analysed vegetation species, the preferentially accumulation serie of studied heavy metals is Zn > Cu > Pb.

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