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**Title**

THE ASSESSMENT OF SELECTED WASTES AND PLANTS USABILITY FOR RECLAMATION OF  
COPPER INDUSTRY DUMPING SITE

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## INTRODUCTION

In the course of copper ore processing there occur numerous waste products which, apart from chemical compounds emitted to the atmosphere during flotation process, are not suitable for direct utilization and, therefore, are stored on dumping grounds. Investigation proved that these wastes feature extremely disadvantageous properties which effect underground and surface waters pollution, as well as lead to chemical alterations of soil and plants. The account regarding dumping sites data in the region of Lower Silesia reveals that stored wastes amount ranges dozens millions m<sup>3</sup> of organic, mineral and mineral – organic wastes which can be utilized in reclamation of not used dumping sites. This process can involve stabilization of waste dumps surfaces, reduction of erosion processes, then turfing and cultivation of appropriate plants.

The aim of the work was the assessment of selected mineral wastes usability for revitalization of not used copper post-flotation sediment dumps located in Iwiny near Bolesławiec, in the region of Lower Silesia.

## MATERIAL AND METHODS

The first preliminary investigation was conducted in a greenhouse using the method of pot experiment. As a substrate we used a post-flotation sediment mixed with various kind of wastes according to the following pattern:

- A) phosphogypsum 50g + mine sand 50g + quarry overlay 50g
- B) phosphogypsum 100g + mine sand 100g + quarry overlay 100g
- C) phosphogypsum 50g + mine sand 50g + limestone overlay 50g +barren rock 50g + quarry overlay 50g
- D) phosphogypsum 100g +mine sand 100g +limestone overlay 100g +barren rock 100g + quarry overlay 100g
- E) phosphogypsum 50g + mine sand 50g + limestone overlay 50g +barren rock 50g + quarry overlay 50g + beech sawdust 10g + PRP Sol\* 5g
- F) phosphogypsum 50g + mine sand 50g + limestone overlay 50g +barren rock 50g + quarry overlay 50g + beech sawdust 20g + PRP Sol\* 10g
- G) phosphogypsum 25g + mine sand 25g + limestone overlay fine 25g +barren rock 25g + quarry overlay 25g + limestone overlay coarse 50g
- H) phosphogypsum 50g + wheat straw 40g + beech sawdust 40 g PRP Sol\* 15g
- I) phosphogypsum 100g + Ekolator<sup>#</sup> 50g

\*PRP Technologies France

<sup>#</sup>Ekolator- preparation of brown coal and bio fibre (Geo-Trade Poland)

Each object was carried in four replications in 5 kg capacity pots. A post-flotation sediment was thoroughly mixed with wastes and then nitrogen 0.5 g per pot as ammonium nitrate was added. The substrate prepared as above was sown with plants in the following scheme:

PEA *Pisum sativum*

ALFALFA *Medicago sativa*

RED CLOVER *Trifolium pratense*

Mixture A: *Medicago sativa*+*Trifolium pratense* + *Trifolium repens*

Mixture B:*Medicago sativa*+*Trifolium pratense* + *Trifolium repens* + *Festuca rubra* (*Red Fescue*) + *Dactylis glomerata* (*Cock's-foot*) + *Phalaris arundinaceae* (*Reed-grass*)

The second experiment with the same plants was located on the post-flotation sediment dump site in Iwiny near Bolesławiec, in the region of Lower Silesia, Poland. The experiments comprise addition of wastes in amounts listed below:

1. 10 kg mine sand, 10 kg phosphogypsum, 10 kg limestone overlay
2. 20 kg mine sand , 20 kg phosphogypsum , 20 kg limestone overlay

3. 10 kg mine sand , 10 kg phosphogypsum , 10 kg limestone overlay ,10 kg barren rock, 10 kg quarry overlay
4. 20 kg mine sand , 20 kg phosphogypsum , 20 kg limestone overlay ,20 kg barren rock , 20 kg quarry overlay
5. 10 kg mine sand , 10 kg phosphogypsum , 10 kg limestone overlay ,10 kg barren rock , 10 kg quarry overlay, 1 kg PRP Sol
6. 20 kg mine sand , 20 kg phosphogypsum , 20 kg limestone overlay ,20 kg barren rock , 20 kg quarry overlay, 2 kg PRP Sol
7. control- no wastes addition

In the dumping site experiment was carried out on microplots 2 x 2 m size in four replications. With addition of wastes the N fertilizer was placed in the dose of 5 kg N/ha, as ammonium nitrate.

After harvesting (pot experiment) the yield of plants dry mass was evaluated after drying at the temperature of 105°C. The material obtained was subjected to grinding to determine the content of basic macro-components, as well as micro-components like copper, zinc, manganese and iron.

Chemical composition of tested plants

<i>Pea Pisum sativum</i>								
Object	K	Ca	Mg	P	Mn	Fe	Zn	Cu
	% dry mass				mg kg <sup>-1</sup> dry mass			
A	2.18	0.78	0.90	0.15	65.8	62.2	12.4	7.9
B	2.04	0.87	1.01	0.18	68.2	65.7	12.4	7.4
C	1.72	0.92	0.9	0.13	52.4	69.7	14.1	7.2
D	1.67	1.10	1.14	0.20	43.8	103.3	11.7	7.3
E	1.93	0.82	0.90	0.13	70.1	60.7	14.8	6.9
F	1.71	1.10	1.21	0.09	75.6	57.9	11.7	6.2
G	1.80	0.88	0.93	0.11	64.8	72.0	18.0	9.3
H	2.22	0.99	1.03	0.07	116.6	57.0	17.1	8.5
I	2.03	1.17	1.26	0.09	62.6	77.1	15.6	10.2
<b>LSD<sub>0.05</sub></b>	<b>0.15</b>	<b>0.13</b>	<b>0.08</b>	<b>0.02</b>	<b>13.0</b>	<b>14.4</b>	<b>3.7</b>	<b>1.7</b>
<i>Alfalfa Medicago sativa</i>								
A	1.66	2.37	1.27	0.10	102.5	59.2	16.3	13.7
B	1.91	2.18	1.08	0.12	101.4	67.7	17.6	14.1
C	1.62	2.49	1.31	0.10	103.6	60.5	22.5	14.2
D	1.90	2.59	0.89	0.10	98.5	73.0	95.0	11.6
E	1.73	2.45	1.25	0.09	97.2	57.1	24.7	13.4
F	1.98	2.38	0.92	0.11	95.5	58.5	15.4	11.5
G	1.71	2.71	1.41	0.07	91.6	58.1	19.2	13.8
H	1.92	2.88	1.18	0.10	114.1	155.1	17.5	16.9
I	1.82	2.39	1.06	0.10	99.5	59.1	17.9	12.7
<b>LSD<sub>0.05</sub></b>	<b>0.14</b>	<b>0.24</b>	<b>0.12</b>	<b>0.02</b>	<b>12.3</b>	<b>13.5</b>	<b>2.7</b>	<b>1.1</b>

<b>Red clover <i>Triforium pratense</i></b>								
Object	<b>K</b>	<b>Ca</b>	<b>Mg</b>	<b>P</b>	<b>Mn</b>	<b>Fe</b>	<b>Zn</b>	<b>Cu</b>
	% dry mass				mg kg <sup>-1</sup> dry mass			
A	2.07	2.02	1.27	0.16	94.3	56.4	12.5	11.7
B	2.02	2.02	1.08	0.24	90.3	63.7	14.9	15.4
C	1.94	1.96	1.31	0.19	83.5	56.0	23.9	11.3
D	2.00	1.92	0.89	0.23	87.8	64.0	53.2	13.5
E	2.28	1.88	1.25	0.18	81.6	53.0	14.5	10.7
F	2.08	2.14	0.92	0.26	84.8	80.3	22.3	13.6
G	2.17	2.39	1.41	0.12	71.2	46.4	11.9	8.6
H	1.98	2.31	1.18	0.17	106.7	101.6	17.9	18.4
I	2.34	2.21	1.06	0.23	64.1	61.7	15.5	13.4
<b>LSD<sub>0.05</sub></b>	<b>0.20</b>	<b>0.16</b>	<b>0.12</b>	<b>0.02</b>	<b>14.1</b>	<b>9.9</b>	<b>3.8</b>	<b>3.6</b>
<b>Mixture A*</b>								
A	1.75	2.12	1.17	0.11	105.3	74.1	16.2	15.9
B	1.92	2.08	0.83	0.09	74.4	55.6	10.2	14.0
C	1.81	2.21	1.00	0.07	66.9	48.3	10.7	14.1
D	2.06	2.13	0.89	0.10	68.3	56.2	21.8	13.5
E	1.73	2.09	1.08	0.09	61.6	39.3	11.3	13.0
F	2.26	1.99	0.86	0.13	63.6	59.4	13.7	13.7
G	1.74	2.3	1.21	0.06	65.9	51.5	12.3	13.9
H	1.96	1.84	1.02	0.08	73.6	87.3	11.0	15.5
I	2.0	2.01	0.97	0.08	60.3	45.3	11.0	13.9
<b>LSD<sub>0.05</sub></b>	<b>0.14</b>	<b>0.16</b>	<b>0.12</b>	<b>0.02</b>	<b>10.63</b>	<b>10.19</b>	<b>3.44</b>	<b>1.27</b>
<b>Mixture B**</b>								
A	1.85	2.29	1.06	0.11	64.4	47.5	14.0	13.4
B	1.81	2.17	0.96	0.10	66.3	49.6	10.1	14.6
C	1.95	2.23	1.02	0.09	55.1	43.3	12.7	13.5
D	1.88	2.29	0.98	0.12	60.3	46.5	12.0	13.8
E	2.06	2.02	1.04	0.11	54.2	37.5	12.6	13.1
F	2.20	2.12	0.99	0.13	63.9	51.1	12.0	14.1
G	1.66	2.26	1.26	0.04	57.2	53.6	9.1	16.5
H	2.29	2.51	1.20	0.04	81.4	90.3	14.7	18.0
I	1.97	2.11	1.10	0.10	60.6	45.8	10.9	14.9
<b>LSD<sub>0.05</sub></b>	<b>0.21</b>	<b>0.21</b>	<b>0.13</b>	<b>0.02</b>	<b>7.2</b>	<b>24.2</b>	<b>4.0</b>	<b>3.1</b>

Yields of tested plants (pot experiment) g/pot

Object	Pea <i>Pisum sativum</i>	Alfalfa <i>Medicago sativa</i>	Red clover <i>Triforium pratense</i>	Mixture A*	Mixture B**
A	11.2	11.2	11.3	8.4	9.4
B	10.4	11.9	13.7	13.6	14.8
C	12.3	8.9	8.2	8.7	8.8
D	8.5	13.0	15.6	11.0	9.0
E	8.9	8.5	7.4	5.8	3.9
F	2.9	12.4	11.9	7.6	7.4
G	8.6	4.0	2.7	4.1	4.0
H	2.8	4.4	3.6	2.5	1.1
I	2.7	13.4	7.5	11.1	10.2
<b>LSD<sub>0.05</sub></b>	<b>1.55</b>	<b>2.35</b>	<b>2.63</b>	<b>1.75</b>	<b>3.53</b>

The result of revitalization at the post-flotation sediment dump site located in Iwiny near Bolesławiec, in the region of Lower Silesia, Poland.

