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Original Article

Valorising South-West Banat Copper Mine Tailings in Agriculture

LENESCHI Florin*, Gheorghe DAVID

University of Agricultural Sciences and Veterinary Medicine from Banat "King Michael the Ist of Romania" Timişoara, Calea Aradului 119, 300645,Timişoara, Romania

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Abstract

The paper presents data regarding the chemical material of the material from the Sasca Montana mining in Caras-Severin County (South-West Romania). The mine tailings are stored in thousands of tonnes in landfills that are a source of pollution for the locality and the environment. This residual material contains important amounts of micro-elements (copper, zinc, cobalt, boron, manganese, molybdenum, magnesium, etc.) and macro-elements (calcium, magnesium, sulphur) and is not radioactive. The high content of calcium as well as the fact that flotation was made with basic elements support the idea of using this alkaline material in agriculture. The paper presents harvesting results obtained through the application of different rates of mine tailings on winter wheat and grain maize. Results show that in winter wheat applying the mine tailings on a soil fertilised with $N_{50-150}P_{80}K_{80}$ produced harvesting growths of 23% in the variant treated with 1 t/ha mine tailings, 36% in the variant treated with 2 t/ha mine tailings and 43% in the variant treated with 3 t/ha mine tailings. In grain maize, after applying mine tailings on a soil fertilised with $N_{50-150}P_{80}K_{80}$ the harvesting growth was 23% in the variant treated with 1 t/ha mine tailings, 37% in the variant treated with 2 t/ha mine tailings and 51% in the variant treated with 3 t/ha mine tailings. Research was carried out on a moderately gleyed brown eumesobasic soil on medium fine, clayish-dusty/clayish limey fluvial deposits with basic reaction in the arable horizon with a pH 5.78 and humus 2.37%.

Keywords: copper, mine, tailings, fertilisers, crop ,harvesting, calcium, wheat, impact, acid, soil.

1. Introduction

The goal of the research was to contribute to the reduction of pollution caused by mine tailings from the Sasca Montana copper mining. Stored in landfills, mine tailings are carried away by the wind polluting the soil, the water, the flora, the fauna, and the humans.

* Corresponding author.
Tel: +40-256-277-009
Fax: +40-256-277-122
e-mail:florinleneschi@gmail.com

Data regarding the chemical composition of the material show that mine tailings contain numerous micro- and macro-elements necessary for the plants to grow; it also has an alkaline reaction due to the high content of calcium, which allows its sue on acid soils to neutralise acidity and increase fertility [4,5,6].

Results of chemical analysis regarding the composition of the studied material are shown in Table 1 [3].

Results point out the fact that the material has an alkaline reaction due to both high calcium content and basic flotation. From this point of view, mine tailings can be sued with good results to correct the reaction of acid soils in Western Romania. The main issue is the heavy metal content. [2].

The results of the analysis confirmed that the material can be used in agriculture, as the metal content is within acceptable limits [8].

Silica and calcium compounds predominate, followed by iron and aluminium oxides.

The granulometric composition of the landfill material is:

- gravel 10%;
- coarse sand 25%;

Because of the fine fraction of mine tailings carried away by the air currents, mine tailings also have a negative impact on crops and spontaneous flora: they damage the dermis thus reducing the chlorophyll assimilation area.

As for their negative impact on fauna and the humans, mine tailings affect the mucous of the digestive tract and of the respiratory tract.

Table 1. Content of some samples of mine tailings from Western Romania (oxides or chemical elements)

Oxide or chemical element	Landfill content of mine tailings (%)			
	Sample number			
	1	2	3	4
Si	32	43	51	47
Al	2	1	13	13
Fe	2.0	1.5	6	3
Ti	0.3	0.1	0.27	0.1
P	0.07	0.03	0.05	0.05
Ca	27	15.2	33	18
Mg	2.3	1.5	1.8	2.2
Mn	0.10	0.05	0.12	0.09
S	0.32	0.81	0.53	0.33
Co	Traces	Traces	Traces	0.001
B	Traces	0.001	Traces	Traces
As	0.001	Traces	0.005	0.004
Bi	0.02	0.005	0.006	0.006
Mo	0.003	0.005	0.004	0.005
Pb	Traces	Traces	Traces	0.001
Cu	0.1	0.07	0.09	0.09
Zn	0.06	0.03	0.01	0.05
Cd	Traces	Traces	0.001	Traces
Cr	0.002	0.005	0.003	0.006
Ni	0.001	0.001	0.002	0.001
Se	Traces	Traces	Traces	Traces
Ag	Traces	Traces	Traces	Traces
H_2O (105 °C)	7.0	8.3	10.0	9.3

2. Material and Method

The chemical composition of the material allows mine tailings to be used with no restrictions in agriculture because the heavy metal content is below the one admitted at European level.

In winter wheat, we organised a bifactorial trial in which Factor A was the mine tailings rate (a_1 – no mine tailings; a_2 – 1 t/ha; a_3 – 2 t/ha; a_4 – 3 t/ha), and Factor B was the fertiliser rate (a_1 – $N_0P_{80}K_{80}$; a_2 – $N5_0P_{80}K_{80}$; a_3 – $N_{100}P_{80}K_{80}$; a_4 – $N_{150}P_{80}K_{80}$).

The winter wheat cultivar cultivated was Alex, and oil rape was the pre-emergent crop.In grain maize, the trial was a bifactorial one with three replicates with the following factor graduation:

Factor A, mine tailings rate: a_1 – no mine tailings; a_2 – 1 t/ha; a_3 – 2 t/ha; a_4 – 3 t/ha), and Factor, fertiliser rate (b_1 – $N_0P_{80}K_{80;}$ b_2 – $N5_0P_{80}K_{80}$; b_3 – $N_{100}P_{80}K_{80}$; b_4 – $N_{150}P_{80}K_{80}$).

The cultivated hybrid was HSZP278 from the FAO 300 group. Winter wheat was the pre-emergent crop. In both crops, the cultivation technology was the one practiced in the reference area.

3. Results and Discussions

Table 2 below presents the resulting winter wheat harvest in 2015-2016.

Results in winter wheat

Table 2. Resulting winter wheat harvest (2015-2016)

Factor A – mine tailings rate	Factor B – N rate				Means of Factor A			
	N_0	N_{50}	N_{100}	N_{150}	Harvesting (kg/ha)	%	Difference (kg/ha)	Significance
S 0$P_{80}K_{80}$	2685	3169	3690	4055	3399	100		
S 1 t/ha $P_{80}K_{80}$	3146	3776	4234	4686	3960	123	561	XXX
S 2 t/ha $P_{80}K_{80}$	3457	4103	4461	5069	4275	136	876	XXX
S 3 t/ha $P_{80}K_{80}$	3697	4234	4732	5064	4433	143	1034	XXX

DL 5% = 106 kg/ha, DL 1% = 161 kg/ha, DL 0.1% = 259 kg/ha

Means of Factor B				
Harvesting (kg/ha)	3248	3320	4279	4711
%	100	125	146	165
Difference (kg/ha)		572	1031	1463
Significance		XXX	XXX	XXX

DL 5% = 71 kg/ha, DL 1% = 96 kg/ha, DL 0.1% = 129 kg/ha

In table 2. there is no significant statistical Mine tailings applied in rates of 1 t/ha on a soil fertilised with $P_{80}K_{80}$ increased the harvest on the average for the four nitrogen levels with 23%. Doubling the rate of mine tailings to 2 t/ha increased the harvest with 36%. T

The highest harvesting growth was in the variant treated with 3 t/ha mine tailings (43%).

These harvesting growths are due to the cumulated effect of mine tailings – correction of acid soil reaction and supply of micro- and macro-elements.

Nitrogen fertilisers were very well valorised: the harvesting growth was, on the average for the four soils, 25% in the variant fertilised with N_{50}, 46% in the variant fertilised with N_{100} and 65% in the variant fertilised with N_{150}.Table 3 below the resulting grain maize harvest in 2015-2016.

Table 3. Resulting grain maize harvest (2015-2016)

Factor A – mine tailings rate	Factor B – N rate				Means of Factor A			
	N_0	N_{50}	N_{100}	N_{150}	Harvesting (kg/ha)	%	Difference (kg/ha)	Significance
S 0 $P_{80}K_{80}$	2610	3284	3837	4227	3489	100		
S 1 t/ha $P_{80}K_{80}$	3178	3866	4362	4885	4073	123	584	XXX
S 2 t/ha $P_{80}K_{80}$	3556	4093	4765	5258	4418	137	929	XXX
S 3 t/ha $P_{80}K_{80}$	3790	4504	5085	5701	4770	151	1281	XXX

DL 5% = 159 kg/ha, DL 1% = 241 kg/ha, DL 0.1% = 387 kg/ha

Means of Factor B				
Harvesting (kg/ha)	3283	3936	4512	5018
%	100	129	154	176
Difference (kg/ha)		653	1229	1735
Significance		XXX	XXX	XXX

DL 5% = 121 kg/ha, DL 1% = 165 kg/ha, DL 0.1% = 221 kg/ha

The effect of applying mine tailings on grain maize is a positive one: the crop valorises effectively both the supply of micro- and macro-elements and the neutralising of acid soil reaction.

Thus, applying 1 t/ha mine tailings on the average for the four nitrogen fertilised soil variants and on soil treated with $P_{80}K_{80}$ the harvesting growth was 23%.

Doubling the mine tailings rate produced a harvesting growth of 37%.

The highest harvesting growth was when applying a rate of 3 t/ha (51%).On the average for the four treatments with mine tailings and on a constant soil treatment of $P_{80}K_{80}$, the supply was well valorised: there was a harvesting growth of 29% for a nitrogen rate of N_{50}, a harvesting growth of 54% for a nitrogen rate of N_{100} and a harvesting growth of 76% for a nitrogen rate of N_{150}.

4. Conclusions

Research regarding the use of mine tailings from copper mining in Western Banat as a source of micro- and macro-elements for crops allows important conclusions for both the reference area level and national level.

The material reaction is alkaline due to the high content of calcium, and to the fact that flotation was made with basic elements. The material is not radioactive and heavy metal content is below maximum admitted limits in the European Union.

Harvesting growths in winter wheat and grain maize after applying mine tailings in rates of 1-3 t/ha, as well as their remanence in crop rotation, motivates economically transport and application expenses.

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