

**XVI INTERNATIONAL
ECO-CONFERENCE®
24-27th SEPTEMBER 2014
NOVI SAD, SERBIA**

SAFE FOOD

PROCEEDINGS

2014

Publisher

ECOLOGICAL MOVEMENT OF NOVI SAD

21000 Novi Sad, Vojvođanskih brigada 17/I

Phone/Fax: (+381 21) 529-096

Phone: (+381 21) 420-175

E-mail: ekopokretns@gmail.com

www.ekopokret.org.rs

Editorial Board

Academician Rudolf Kastori, President

Nikola Aleksić,

Prof. Ana Perenić

Prof. dr Desanka Božidarević

Prof.dr Rodoljub Oljača

Prof. dr Olga Najdenovska

Prof. dr Imre Kadar

Project Editor

Nikola Aleksić

Copy Editor

Ana Perenić

Layout and Formatting

Ljubica Aleksić

For the Publisher

Nikola Aleksić, Direktor

Print

„ALBUM” DOO Novi Sad

Circulation

500 copies

Publication year: 2014

THE AUTHORS ARE RESPONSIBLE FOR THE
QUALITY OF ENGLISH TRANSLATIONS

CIP – Каталогизација у публикацији
Библиотека Матице српске, Нови Сад

63:502/504(082)
631.147(082)

INTERNATIONAL Eco-Conference (18 ; 2014 ; Novi Sad)
Safe food : proceedings / XVIII International
Eco-Conference, 24-27th September 2014, Novi Sad ;
[organizer Ecological Movement of Novi Sad ; project editor
Nikola Aleksić]. - Novi Sad : Ecological Movement of Novi
Sad, 2014 (Novi Sad : Album). - 486 str. : ilustr. ; 23 cm

Tiraž 500. - Bibliografija uz svaki rad. - Сажети. -
Registar.

ISBN 978-86-83177-47-9

I. Ecological Movement of Novi Sad. - I. Ekološki pokret
grada Novog Sada v. Ecological Movement of Novi Sad
a) Здрава храна - Производња - Зборници b) Еколошка
пољопривреда - Зборници
COBISS.SR-ID 289561351

Organizer :

- Vojvodina Academy of Sciences and Arts
- Institute for Food Technology, Novi Sad
- Ecological Movement of Novi Sad

Co-organizers :

- University of Novi Sad
- Russian State Agrarian University – MTAA, Moscow, Russia
- Legambiente d'Italia (National environmental organization)
- Institute for Field and Vegetable Crops, Novi Sad, Serbia

Patronage :

- Matica srpska, Novi Sad

Host :

- Institute for Nature Conservation of Vojvodina Province, Novi Sad

Official water of XV International Eco-Conference® 2014

MINAQUA

Honorary Committee :

President :

- **Prof. Dr Dragan Stanić**, President of Matica srpska, Serbia

Vice-Presidents:

- **Academician Pap Endre**, President of the Vojvodina Academy of Art and Science
- **Prof. Dr Miroslav Vesković**, Rector of the University of Novi Sad
- **Prof. Dr Vladimir M. Bautin**, Rector at Russian State University MTAA, Moscow
- **Dr. Jegor Miladinović**, Director of the Institute for Field and Vegetable Crops- Novi Sad, Serbia
- **Dr. Marijana Sakač**, Research Advisor of the Institute for Food Technology, Novi Sad, Serbia
- **Dr. Biljana Panjković**, Director of the Institute for Nature Protection of Vojvodina Province
- **Vittorio Cogliati Dezza**, President of Legambiente d' Italy

Scientific Committee :

President:

- **Academician Rudolf Kastori**, Academy of Science and Art of Vojvodina, Novi Sad, Serbia and Hungarian Academy of Sciences, Budapest, Hungary

Vice-Presidents:

- **Prof. dr Pavle Sekeruš**, Vice-Chancellor for science at the University of Novi Sad
- **Prof. dr Evgenij Ivanovich Koshkin**, Vice-Chancellor for International Co-operation at the Russian State Agrarian University – MTAA, Moscow, Russian Federation
- **Dr. Zvonko Nježić**, Research Associate of the Institute for Food Technology in Novi Sad, Serbia
- **Dr Dragana Miladinović**, Assistant Director for Science at the Institute for Field and Vegetable Crops in Novi Sad, Serbia
- **Stefano Ciafani**, Vice-Presidente of Legambiente d' Italy

Secretary:

- **Ana Perenić**, Professor of Ecology and Environment Protection, Vice-Director Ecological movement of Novi Sad, Serbia

Members:

- **Academician Srbislav Denčić**, Institute for Field and Vegetable Srops, Novi Sad, Serbia
- **Academician Vaskrsija Janjić**, University of Belgrade, Resident Professor at the Agricultural Faculty, Serbia
- **Marjan Jošt**, JOST Seed-Research, Križevci, Croatia
- **Academician Branka Lazić**, University of Novi Sad, Resident Professor at Agricultural Faculty, Serbia
- **Prof. Dr. Desanka Božidarević**, University of Novi Sad, Resident Professor at Agricultural Faculty, Serbia
- **Prof. Dr. Biserka Dimiskovska**, University "St. Cyril and Methodius", Institute for Earthquake Engineering and Engineering Seismology (IZIIS), Skopje, Republic of Macedonia
- **Prof. Dr. Miodrag Dimitrijević**, University of Novi Sad, Resident Professor at Agricultural Faculty, Serbia
- **Prof. Dr. Ivana Đujić**, University of Belgrade, Resident Professor aof Food Chemistry and Biological Faculty, Serbia
- **Prof. Dr. Slavko Filipović**, University of Novi Sad, Resident Professor at the Technology Faculty, Serbia
- **Prof. Dr. Vladimir Hadžić**, University of Novi Sad, Resident Professor at Agricultural Faculty, Serbia

- **Prof. Dr. Vladan Joldžić**, Institute for Criminological and Sociological Research, University of Belgrade, Resident Professor at the Biological and Chemical Faculty, Serbia
- **Prof. Dr. Kadar Imre**, Research Institute for Soil Science and Agricultural Chemistry, Hungarian Academy of Sciences, Budapest, Hungary
- **Prof. Dr. Borivoj Krstić**, University of Novi Sad, Resident Professor at the Faculty of Science, Serbia
- **Prof. Dr. Ivana Maksimović**, University of Novi Sad, Resident Professor at Agricultural Faculty, Serbia
- **Prof. Dr. Dragutin Mihajlović**, University of Novi Sad, Resident Professor at Agricultural Faculty, Serbia
- **Prof. Dr. Rodoljub Oljača**, University of Banja Luka, Resident Professor at the Faculty of Forestry, Bosnia and Herzegovina
- **Prof. Dr. Mihailo Peruničić**, University of Novi Sad, Resident Professor at the Technology Faculty, Serbia
- **Aleh Rodzkin**, International Sakharov Environmental University, Minsk, R.. Belarus
- **Prof. Dr. Atila Salvai**, University of Novi Sad, Resident Professor at the Agricultural Faculty, Serbia
- **Prof. Dr. Velibor Spalević**, University of Montenegro, Research associate at the Biotechnical Faculty of Podgorica, Montenegro
- **Prof. Dr. Ivan Šimurić**, University of Zagreb, Resident Professor at the Agricultural Faculty, Croatia
- **Prof. Dr. Marija Škrnjar**, University of Novi Sad, Resident Professor at the Technology Faculty, Serbia
- **Prof. Dr. Radmila Šovljanski**, University of Novi Sad, Resident Professor at the Agricultural Faculty
- **Prof. Dr. Ion C. Ungureanu**, Resident Professor at the University of Agricultural Sciences and Veterinary Medicine, Buckarest, Romania
- **Prof. Dr. Ljubo Vračar**, University of Novi Sad, Resident Professor at the Technology Faculty, Serbia
- **Prof. Dr. Momčilo Vukićević**, Faculty of European Legal and Political Studies in Novi Sad, Serbia
- **Prof. Dr. Victor Veniamovič Zakrevskii**, North-Western State Medical University named after I.I. Mechnikov, Resident Professor, Sanct-Petersburg, Russian Federation
- **Prof. Dr. Lu Zhongmei**, Resident Professor at the Wu Han Law University, China
- **Mr. Ivan Lulić**, ing. polimer technology

Organizing Committee :

President:

- **Nikola Aleksić**, Director of the Ecological Movement of Novi Sad

Vice-president:

- **Angelo Mancone**, Co-ordinator Legambiente Veneto, Rovigo, Italy

Secretary:

- **Ljubica Aleksić**, Organizer of the Ecological Movement of Novi Sad

Members:

- **Dr Vera Đekić**, Center for Small Grains, Kragujevac
- **MA Slađana Đuranović**, Professor of English language and literature
- **Zoran Kovačević**, Organizer of the Ecological Movement of Novi Sad
- **Milenko Košutić**, Engineer, Expert Assistant at the Institute for Food Technology (FINS)
- **Slobodan Mišić**, Organizer of the Ecological Movement of Novi Sad
- **Bratimir Nešić**, Translator and Lector of the Ecological Movement of Novi Sa
- **Milanko Nešković**, Organizer of the Ecological Movement of Novi Sad
- **Dr. Đorđ Okanović**, Research Associate of the Institute for Food and Technology in Novi Sad
- **Dr. Vera Popović**, Institute for Field and Vegetable Crops, Novi Sad
- **Marina Samsonov**, Translator and Interpreter of the Ecological Movement of Novi Sad
- **Prof. Dr. Milan Stanulović**, Translator
- **Željko Štrbac**, Student of Faculty of Technical Sciences in Novi Sad
- **Luka Vujasinović**, Organizer of the Ecological Movement of Novi Sad
- **Petar Vukić**, Technical Director of the Ecological Movement of Novi Sad

Official water of the XVIII International Eco-Conference® 2014

- MINAQUA, NOVI SAD

Official host of the XVIII International Eco-Conference® 2014

- Institute for Nature Conservation of Vojvodina Province in Novi Sad



ECO-CONFERENCE® 2014
ECOLOGICAL MOVEMENT OF NOVI SAD

Zoran Dinić¹, Radmila Pivić¹, Dragana Jošić¹, Aleksandar Sebić²,
Aleksandra Stanojković-Sebić¹

¹Institute of Soil Science, 11000 Belgrade, Serbia

²Faculty of Technology and Metallurgy, University of Belgrade, Serbia
soils.dinic@gmail.com

METALLURGICAL SLAG USE EFFECTS ON SOIL CHEMICAL, PHYSICAL AND MICROBIOLOGICAL PROPERTIES

Abstract

The aim of this research was to investigate the effect of Ca - containing metallurgical slag on the changes of basic chemical characteristics, and granulometric composition of Stagnosol, a type of soil with very acid reaction, through the vegetative experiments performed in semi-controlled conditions. The effect of metallurgical slag was compared to those of other commercial lime materials in combination without and with standard fertilizers. The obtained results imposed that all the lime materials, along with metallurgical slag, showed positive effects on the main chemical properties and microbiological activity of experimental acid soil comparing to non-fertilized one, which could not be said for soil granulometric composition, possibly due to a short time period before analyses.

Key words: *metallurgical slag, Stagnosol, chemical properties, granulometric composition, microbiological activity*

INTRODUCTION

The majority of Serbian soils is characterized by high soil acidity and application of only organic and mineral fertilizer is not enough to sustain their productivity. Thus, on these soils it is necessary to apply Ca-containing fertilizers – calcifiers, for improving their physico-chemical and biological properties. The application of traditional alkaline liming materials for the amelioration of soil acidity

consequently improving crop production and it's a common practice (Foth and Ellis, 1997). However, the alkaline nature and the need for sustainable and environmentally acceptable disposal options for metallurgical slag have prompted its use as a liming material on acid agricultural soils. The slag consists primarily of calcium silicate minerals, and has nearly the same ability to neutralize soil acidity as agricultural limestone (Lopez et al., 1995). Therefore, it is particularly important to develop new technologies to utilize metallurgical slag as resource materials in order to decrease the land used for disposal of slag and reducing environmental pollution.

Along with other lime materials (ground slag stone, saturated slag etc.) present in Serbia, metallurgical slag from Steel factory - Smederevo (Serbia) can be of great importance. Thus, these investigations were aimed to define the main parameters for possible wider usage of this secondary raw materials for amelioration and fertilization of acid soils in Serbia.

MATERIALS AND METHODS

The study was carried out in pot experiments, under semi-controlled condition in the greenhouse of the Institute of Soil Science, Belgrade, from April to July, during 2009. In the experiments the comparisons of the effect of metallurgical slag with other lime materials (ground limestone and hydrated lime) in combination without and with standard fertilizers (organic and mineral) were studied. The experiment was undertaken with Stagnosol (World Reference Base for Soil Resources, 2006), a type of soil that has very low pH. The designed experiments were in three replications: Control – no fertilizer (T1); NPK mineral fertilizer [composite NPK (15:15:15)] + manure – standard fertilization (T2); CaCO₃, no standard fertilization (T3); Ca(OH)₂, no standard fertilization (T4); Metallurgical slag, no standard fertilization (T5); NPK mineral fertilizer [composite NPK (15:15:15)] + manure + CaCO₃ (T6); NPK mineral fertilizer [composite NPK (15:15:15)] + manure + Ca(OH)₂ (T7); NPK mineral fertilizer [composite NPK (15:15:15)] + manure + metallurgical slag (T8). The experiment was performed in plastic pots with 4 kg of homogenized soils. Spring barley was chosen as an experimental crop due to its good response to neutralization of soil acidity. Before planting, the amount of fertilizers and slag was measured according to the experiment design and mixed with soil (calculated as for 1 ha): NPK – 15:15:15 = 500 kg ha⁻¹; Manure = 30 t ha⁻¹; CaCO₃ = 4 t ha⁻¹; Ca(OH)₂ = 2,8 t ha⁻¹; Metallurgical slag = 4 t ha⁻¹ (same as the amount of CaCO₃, in spite of lower amount of slag). All three lime materials with granulation of 0.2 mm were applied in the experiment.

Before industrial homogenizing and standard grinding the chemical composition of five composite samples of metallurgical slag used from different deposition sites was analyzed.

Chemical properties of the study soil were determined using the following chemical analyses: pH in 1M KCl was analyzed potentiometrically with glass electrode

(SRPS ISO 10390: 2007, 2007); total N was analyzed on elemental CNS analyzer Vario EL III (Nelson and Sommers, 1996); available P₂O₅ and K₂O were analyzed by Al-method according to Egner-Riehm (Riehm, 1958), where K was determined by flame emission photometry and P by spectrophotometer after color development with ammonium molybdate and SnCl₂; Ca and Mg were extracted by ammonium acetate followed by determination on atomic adsorption analyzer SensAA Dual - GBC Scientific Equipment Pty Ltd, Victoria, Australia (Wright and Stuczynski, 1996); trace elements (Fe, Mn, Zn, Cu) were determined with an ICAP 6300 ICP optical emission spectrometer, after the samples were digested with concentrated HNO₃ for extraction of total forms, and by DTPA for extraction of soluble forms of the elements (Soltanpour et al., 1996); the total content of CaCO₃ in slag studied was determined using the "rapid titration method" by Piper (van Reeuwijk, 2002).

Soil granulimetric composition was analyzed by determination of particle size distribution in mineral soil material, using the standardized method by sieving and sedimentation (ISO 11277: 2009(E), 2009).

Microbiological activity of the study soil was determined using the following parameters: total number of soil microorganisms was determined using agar plates method on the soil extract nutritive medium; the number of fungi was determined by indirect dilution method on Chapek nutritive medium; the number of *Azotobacter* spp. was determined using Tchan method in the liquid N-free manite nutritive medium (Sarić, 1989); soil dehydrogenase activity (DHA) was assayed under standard conditions (24 hours of incubation at 30°C ± 1) by measuring the intensity of the red-coloured triphenyl formazan extinction, spectrophotometrically (Thalman, 1968). The number of the tested microorganisms was calculated on 1.0 of an absolutely dry soil, while DHA was expressed in µg TPF·10 g⁻¹ of anair dry soil.

Statistical analyses were performed using SPSS/SYSTAT - 16 software. The effects of treatments on all the variables were tested using ANOVA method.

RESULTS AND DISCUSSION

The results of the laboratory investigations of properties and composition of metallurgical slag studied (Table 1) showed that this material has very alkaline reaction (pH = 12.50), with the content of Ca in oxide forms (CaO) from 33-45 %, of which about 50 % is easily soluble (in 1 M ammonium acetate). Content of total magnesium is about 0.40 % that was mainly in forms of MgO (0.70 %). Total phosphorous contained in the material is about 0.60 % where nearly all the amount was in plant available forms. Content of total iron is expectedly high enough (about 15 %), while the amount of soluble forms is only 0.30 %. The third element (along with Ca and Fe) is Mn, with total amount about 1.8 %, but with low (insignificant) amounts of soluble forms. The studied metallurgical slag contains lower amounts (10-20 mg kg⁻¹) of zinc and a little higher amount of Cu (about 200 mg kg⁻¹).

According to Yusiharni et al. (2007), metallurgical slag stone (ground steel slag) contains 22-38 % CaO and 3,5-6,5 % MgO. Oxides of calcium and magnesium are partially free, and partially bound to carbonates and silicate that are easily hydrolyzed. Upon the neutralization rate this slag stone material is classified between burned (oxide) slag and ground slag stone (calcium carbonate). Together with Ca and Mg the major part of Si (7-15 % as SiO₂), especially free Si acids, can have influence on increasing of SiO₂:R₂O₃ ratio (sesquioxide of Al and Fe) in soil, what reduces the phytotoxic effects of soluble Al and Fe on crops. Besides above mentioned positive effects of Ca, Mg and Si, content of citrate-soluble phosphorus that varies between 0.5-2 % P₂O₅ and other biogenic and microelements in smaller amounts improves its fertilization benefits compared to the other slag materials that are applied for soil neutralization.

Table 1. Properties and composition of metallurgical slag (means ± standard deviation)

Property	Value	Property	Value
pH in H ₂ O	12.48±0.04	Total P ₂ O ₅ (%)	0.61±0.10
Total Ca (%)	26.20±3.48	Total Fe (%)	15.34±0.79
Total CaO (%)	36.60±4.83	Available Fe (in DTPA, mg kg ⁻¹)	3.38±0.96
Total CaCO ₃ (%)	65.80±8.64	Total Mn (%)	1.80±0.15
Available Ca (%)	17.18±1.98	Available Mn (in DTPA, mg kg ⁻¹)	3.12±1.04
Total Mg (%)	0.41±0.04	Total Zn (%)	14.60±5.59
Available Mg (%)	0.07±0.02	Total Cu (%)	228.8±15.4

All above mentioned benefits of metallurgical slag confirm the fact that for the past years the production and application of this material in agricultural areas has increased in many developed countries. In several researches an increase of pH, exchangeable Ca and Mg and decrease of mobile Al in acid soils by using different doses of metallurgical slag was reported (Rodriguez et al., 1994).

In Table 2 the results of soil physical and chemical properties before the experiment was established are given. The results shows that the study soil is medium heavy by mechanical properties, with total technical clay fraction about 69% and colloidal clay fraction of 24%.

Table 2. Physical and chemical properties of Stagnosol before the experiment was established

Granulometric composition	Value (means ± standard deviation)
Bulky sand, 2-0.2 mm	5.0±0.59
Miniature sand, 0.2-0.02 mm	25.9±1.33
Dust, 0.02-0.002 mm	45.1±1.22
Clay, < 0.002 mm	24.0±0.21
Total sand, > 0.02 mm	30.9±1.05
Dust + clay, < 0.02 mm	69.1±1.05
Chemical properties and elementary composition	Value (means ± standard deviation)
pH in 1M KCl	4.45±0.01
Total N (%)	0.24±0.01
Available P ₂ O ₅ (mg 100g ⁻¹)	3.73±0.28
Available K ₂ O (mg 100g ⁻¹)	19.8±1.54
Available Ca (mg 100g ⁻¹)	240±19
Available Mg (mg 100g ⁻¹)	35±3.89

The optimum pH range for growth of most crops in soil is between 5.5 and 7.0, within which most plant nutritives are available (Prasad and Power, 1997). The studied Stagnosol had very acid soil reaction, with pH in KCl 4.45, then, low content of readily available phosphorus and soluble calcium and is well supplied with available potassium. Content of available Mg is generally within the range of optimal supply.

The effect of the applied treatments on the changes of soil chemical properties is presented in Table 3. The results show significant decrease in soil acidity both comparing to the control and to the treatments with classical fertilization (NPK + manure). Regarding the content of the main available biogenic macroelements (P, K, Ca, Mg) after fertilization by lime materials, it could be noticed that all the fertilizers and lime materials resulted in increased availability of these elements. Application of slag materials, especially of metallurgical slag, resulted in increased amount of available phosphorous and magnesium comparing to the classical lime materials.

Table 3. Effect of metallurgical slag and selected lime materials on the changes of soil acidity and content of available macroelements (means \pm standard deviation)

Treatment	pH in 1MKCl	Available biogenic macroelements (mg kg ⁻¹)			
		P ₂ O ₅	K ₂ O	Ca	Mg
T1	4.46 \pm 0.01	2.63 \pm 0.33	11.82 \pm 1.64	214.67 \pm 18.90	35.03 \pm 3.92
T2	4.67 \pm 0.03	5.55 \pm 1.20	19.93 \pm 2.85	215.00 \pm 8.54	35.60 \pm 2.52
T3	5.41 \pm 0.04	3.23 \pm 0.67	13.85 \pm 0.62	290.67 \pm 20.55	33.80 \pm 3.44
T4	5.35 \pm 0.14	2.86 \pm 0.80	12.36 \pm 1.46	265.67 \pm 5.51	29.17 \pm 3.40
T5	4.98 \pm 0.02	4.08 \pm 1.30	11.82 \pm 2.08	267.67 \pm 11.59	34.23 \pm 3.79
T6	5.35 \pm 0.11	6.93 \pm 0.80	23.17 \pm 2.04	323.33 \pm 19.43	38.00 \pm 0.85
T7	5.22 \pm 0.16	6.78 \pm 0.03	22.23 \pm 1.69	272.00 \pm 12.53	31.70 \pm 3.16
T8	4.93 \pm 0.02	8.29 \pm 1.05	21.96 \pm 2.07	260.33 \pm 10.97	34.67 \pm 1.42
P value	***	***	***	***	NSD
LSD (0.05)	0.15	1.50	3.46	25.02	5.20
LSD (0.01)	0.21	2.07	4.76	34.48	7.17

LSD - least significant differences; NSD - no significant difference at the P=0.05 level of significance whereas *, ** and *** indicates statistical significant differences at the P<0.05, P<0.01 and P<0.001 levels, respectively.

Experiments in several European countries have demonstrated the ability of metallurgical slag to raise the pH of acid soils, increasing at the same time the Ca and Mg contents of the soils exchange complex (Adriano, 2001), and it has been shown that the slag modified the physical and chemical properties of the soil and lead to an increase in production of between 15 and 40% when 1.6 t ha⁻¹ of metallurgical slag was applied to soils with pH 4-5.

The data on granulometric composition of studied soil after application of fertilizers and lime materials could not give an information about significant changes both of initial status and after application of lime materials (Table 4). Although the lime treated soils show generally a deep modification of the physical and mechanical properties (Russo et al., 2007), in this study the opposite effects are expected probably due to a short time period before analyses.

Table 4. Effect of metallurgical slag and selected lime materials on the changes of main soil physical properties (means \pm standard deviation)

Treatment	Granulometric composition (mm)					
	Bulky sand 2-0.2	Miniature sand 0.2-0.02	Dust 0.02-0.002	Clay <0.002	Total sand >0.02	Dust+clay <0.02
T1	4.6 \pm 0.6	26.6 \pm 1.3	44.9 \pm 1.2	23.9 \pm 0.2	31.2 \pm 1.1	68.8 \pm 1.1
T2	4.9 \pm 0.7	25.7 \pm 0.8	45.1 \pm 0.5	24.3 \pm 1.8	30.7 \pm 1.4	69.3 \pm 1.4
T3	4.9 \pm 0.2	26.1 \pm 0.3	44.1 \pm 0.9	24.9 \pm 0.8	31.0 \pm 0.2	69.0 \pm 0.2
T4	4.8 \pm 0.7	26.9 \pm 1.4	45.2 \pm 0.2	23.8 \pm 0.8	31.1 \pm 0.9	68.9 \pm 0.9
T5	4.5 \pm 0.6	26.0 \pm 0.7	44.6 \pm 0.7	24.8 \pm 1.0	30.5 \pm 0.5	69.5 \pm 0.5
T6	4.9 \pm 0.5	25.8 \pm 0.8	44.5 \pm 0.7	24.8 \pm 1.0	30.7 \pm 0.3	69.3 \pm 0.3
T7	4.8 \pm 0.6	26.0 \pm 0.2	45.2 \pm 0.1	24.0 \pm 0.4	30.8 \pm 0.4	69.2 \pm 0.4
T8	4.9 \pm 0.7	26.6 \pm 1.3	44.3 \pm 1.1	24.2 \pm 1.1	31.5 \pm 0.7	68.5 \pm 0.7

Table 5. Effect of metallurgical slag and selected lime materials on the changes of soil microbiological properties

Treatment	Average number of microorganisms (number.g ⁻¹ of absolute dry soil)			DHA (μ g TPF-10 g ⁻¹ of air dry soil)
	Total number of microorganisms (x10 ⁶)	Fungi (x10 ⁴)	<i>Azotobacter</i> spp.*	
Initially stage (NV)	4.00	4.33	20	866.7
T1	16.78	8.67	32	371.8
T2	8.34	11.57	22	1042.3
T3	5.89	6.67	39	1033.5
T4	13.89	14.22	62	1366.9
T5	6.56	5.33	22	655.5
T6	11.11	9.33	20	1101.2
T7	16.00	7.67	39	790.8
T8	23.22	10.45	72	1267.3
LSD (0.05)	6.29	3.76	29	230.54

The effect of the applied treatments on the changes of soil microbiological properties is presented in Table 5. In the control treatment the number of microorganisms is significantly increased due to the presence of plants in relation to the treatment with no vegetation (initially stage, NV), thus confirming the influence of the rhizosphere root on increase of the number of microflora (Mandić, 2001). Metallurgical slag and selected lime materials did not show a significant effect on the number of microorganisms in study soil. The number of microorganisms was the lowest in the treatment with slag, and the highest - in the control and the treatment with the NPK and manure in combination with slag. The number of *Azotobacter* spp. indicates that the soil biogenity is not disturbed by using the reclamation measures in the studied treatments. Higher values of dehydrogenase in all the treatments compared to the control indicates that the use of the reclamation measures and slag increased its activity, which is most pronounced in the following treatments: NPK+manure+Ca(OH)₂ and CaCO₃. High dehydrogenase activity indicates a higher rate of respiration and increased mineralization of fresh organic matter and humus (Cvijanović et al., 2008).

CONCLUSION

The results of the paper indicate that the studied metallurgical slag showed positive effects on basic chemical properties and microbiological activity of Stagnosol comparing to non-fertilized one, which could not be said for the soil granulometric composition, possibly due to a short time period before analyses. In general, it was estimated that the studied metallurgical slag of the standardized chemical composition can be added to the acid soils toward amelioration the fertility without adverse effects.

REFERENCES

1. Adriano D. C.: *Trace elements in terrestrial environments*, 2nd edition. Springer-Verlag, New York, USA, 2001.
2. Cvijanović G., Milošević N., Živanović Lj.: *Importance of diazotrophs in conventional production of maize and soybean*. 43rd Croatian and 3rd International Symposium on Agriculture, 96-99, Opatija, Croatia, 2008.
3. Foth H. D., Ellis B. G.: *Soil fertility, 2nd edition*. Lewis Publishers, Boca Raton, Florida, USA, 1997.
4. ISO 11277: 2009(E): *Soil quality - determination of particle size distribution in mineral soil material - method by sieving and sedimentation*. International Organization for Standardization, Geneva, Switzerland, 2009.
5. Lopez F. A., Balcazar N., Formoso A., Pinto M., Rodriguez M.: *The recycling of Linz-Donawitz (LD) converter slag by use as a liming agent on pastureland*. Waste Management Research, 13, 555-568, 1995.
6. Mandić L.: *Microbiological activity and productivity of smonitza under maize in the conditions of different fertilizers application*. PhD Thesis, University of Kragujevac, Faculty of Agronomy, Čačak, Serbia, 2002 (In Serbian).
7. Nelson D. W., Sommers L. E.: *Total carbon, organic carbon, and organic matter*. Methods of Soil Analysis, part 3, SSSA, 961-1010, Madison, Wisconsin, USA, 1996.
8. Prasad R., Power J. F.: *Soil fertility management for sustainable agriculture*. CRC Press, Lewis Publishers, Florida, USA, 1997.
9. Riehm H.: *Die Ammoniumlaktatessigsäure-Methode zur Bestimmung der leichtlöslichen Phosphorsäure in Karbonathaltigen Böden*. Agrochimica, 3, 49-65, 1958 (In German).
10. Rodriguez M., Lopez F. A., Pinto M., Balcazar N., Besga G.: *Basic Linz-Donawitz slag as a liming agent for pastureland*. Agronomy Journal, 86, 904-909, 1994.
11. Russo G., Dal Vecchio S., Mascolo G.: *Microstructure of a lime stabilised compacted silt*. Experimental Unsaturated Soil Mechanics (Springer Proceedings in Physics), 112, 49-56, 2007.
12. Sarić Z.: *Practicum in microbiology*. Academic Book, Belgrade, Serbia, 1989 (in Serbian).
13. Soltanpour P. N., Johnson G. W., Workman S. M., Bentonjones J. J., Miller R. O.: *Inductively coupled plasma emission spectrometry and inductively coupled plasma mass spectrometry*. Methods of Soil Analysis, part 3, SSSA, 91-139, Madison, Wisconsin, USA, 1996.
14. SRPS ISO 10390: 2007: *Soil quality - determination of pH*. Institute for Standardization of Serbia, Belgrade, Serbia, 2007.
15. Thalmann A.: *Zur Methodik der Bestimmung der Dehydrogenaseaktivität im Boden mittels Triphenyltetrazoliumchlorid (TTC)*. Landwirtschaftliche Forschung, 21, 249-258, 1968 (In German).
16. Van Reeuwijk L. P.: *Carbonate*. Procedures for Soil Analysis, 6th edition, International Soil Reference and Information Centre, 7-8, Wageningen, The Netherlands, 2002.
17. World Reference Base for Soil Resources: Food and Agriculture Organization of the United Nations, Rome, <ftp://ftp.fao.org/agl/agll/docs/wsr103e.pdf>, 2006.
18. Wright R. J., Stuczynski T.: *Atomic absorption and flame emission spectrometry*. Methods of Soil Analysis, part 3, SSSA, 65-90, Madison, Wisconsin, USA, 1996.
19. Yusiharni B. E., Ziadi H., Gilkes R. J.: *A laboratory and glasshouse evaluation of chicken litter ash, wood ash, and iron smelting slag as liming agents and P fertiliser*. Australian Journal of Soil Research, 45, 374-389, 2007.

**Zoran Dinić¹, Radmila Pivić¹, Dragana Jošić¹, Aleksandar Sebić²,
Aleksandra Stanojković-Sebić¹**

¹Institut za zemljište, 11000 Beograd, Srbija

²Tehnološko-metalurški fakultet Univerziteta u Beogradu, Srbija

solis.dinic@gmail.com

UTICAJ PRIMENE METALURŠKE ŠLJAKE NA HEMIJSKA, FIZIČKA I MIKROBIOLOŠKA SVOJSTVA ZEMLJIŠTA

Apstrakt

Cilj ovog istraživanja bio je da se ispita uticaj primene Ca – metalurške đšljake na promene osnovnih hemijskih karakteristika kao i granulometrijskog sastava stagnosola. tipa zemljišta veoma kisele reakcije, kroz vegetativne eksperimente izvršene u polukontrolisanim uslovima. Ispitivan je efekat primene metalurške šljake u odnosu na komercijalne krečne materijale u kombinaciji sa i bez standardnih đubriva. Na osnovu dobijenih rezultata može se konstatovati da su svi ispitivani krečni materijali, uključujući metaluršku šljaku, imali pozitivne efekte na osnovne hemijske osobine i mikrobiološku aktivnost ispitivanog kiselog zemljišta u odnosu na kontrolu, što se ne može reći za granulometrijski sastav zemljišta, verovatno zbog kratkog vremenskog perioda između analiza.

Ključne reči: *metalurška šljaka, stagnosol, hemijska svojstva, granulometrijski sastav, mikrobiološka aktivnost*