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NON - TRADITIONAL SLAG VALORIZATION FOR AGRICULTURE

T. VELEA[1], Ildiko ANGER[1], F. STOICIU[1], Eugenia GAMENT[2], M. MIHALACHE[3], L. ILIE[3], Lavinia POPESCU[4], Fl. ZAMAN[4], Luminita MARA[1], V. PREDICA[1]

[1] National R&D Institute for Nonferrous and Rare Metals, 102 Biruintei Blvd, Pantelimon, Romania

[2] National R&D Institute for Soil Science, Agrochemistry and Environment Protection, 61 Marasti Blvd. sector 1, Bucharest, Romania

[3] University of Agronomic Sciences and Veterinary Medicine of Bucharest, 61 Marasti Blvd. sector 1, Bucharest, Romania

[4] Institute for Metallurgical Research, 39 Mehadiei street, sector 6, Bucharest, Romania

tvelea@imnr.ro, angerildiko@yahoo.com

Introduction

Ensuring the conservation of biodiversity and removing the pollutants that affects human health directly and seriously are necessary to develop an economy in closed circuit, without wastes.[1]

LF slag occurs in ladle furnace processing of steel (secondary metallurgy, refining steel). This idea has been launched to the first time in 1957 by AEA-SKF Company. The ladle furnace (LF) is known as a smaller version of electric arc furnace, having all three graphite electrodes coupled to a transformer for liquid steel heating. The bottom of the ladle furnace is equipped with an argon injection system and with injection lance for desulfurizing agents (Ca, Mg, CaSi, CaC_2, $CaO+CaF_2$) and/or supply system for deoxidizing additives or chemical composition adjustments. The LF slag resulted, has a low content of FeO and high content of Al_2O_3. The most important components of LF slag are: CaO (40-60 wt.%), Al_2O_3, SiO_2 and MgO. Due the high content of free CaO, this slag is very alkaline. The most common applications of LF slag are: reintroduction into the steelmaking unit, as a substitute for clinker or cement, for acid mine water treatment, as a fertilizer in the agriculture, as a possible chemical trap for CO_2.

Soil acidity can influence plant growth and can seriously limit crop production. The low pH of soil has toxic effects upon the plants and produces an unfavorable balance between acid and alkaline elements needed by plants.

The soil acidity can have influence upon soil fertility, decrease the availability of essential elements (nutrients), decrease activity of soil micro-organisms, increase the solubility and negative influence of toxic elements[2] (aluminum, manganese, iron) and prevalence of plant diseases, decrease of plant production, water uses and competitive ability of different plant species. Soil acidity can cause molybdenum, calcium and magnesium deficiency in plants. The high content of hydrogen ion decreases phosphorus availability.[3]

Soil pH is referred to the so called "acidity" of the soil and is a measure of the number of hydrogen ions present in the soil solution.[4]

The classification of acid soils using pH is the following: pH < 5.5 - soil is strongly acid; pH is 5.5 – 5.9 the soil is medium acid; pH is 6.0 – 6.4 the soil is slightly acid; pH is 6.5 – 6.9 the soil is very slightly acid and when pH is 7.0 the soil is neutral.

Concerning the agricultural land, Romania is situated on 6th place in Europe. From the agricultural land in Romania about 17 % is acid soil, having the pH less than 6.0.
Because of the limited land resource, a judicious management practice is necessary to increase the crops. One of the most important and particularly feasible management practices is the use of lime and liming materials to ameliorate the soil acidity,[5] like calcite ($CaCO_3$), but this is an expensive natural material. But for this purpose can be used alkaline waste materials. For this reason we proposed to use for acid soil remediation LF slag with high alkalinity, resulted from the secondary refining of the steel.

The goal of this paper is to present the effect of the presence of LF slag on soil properties and on the crop production.

Materials and Methods

Samples of LF slag were analyzed by Optic Spectrometry with plasma inductively coupled ICP – OES, for chemical composition. The instrument used is a SPECTROFLAME – ICP model P (Germany). For the determination of phases presents in the LF slag was used the diffraction method Bragg – Brentano. The analyses were performed with BRUKER D8 ADVANCE instrument. The optical microscopy was performed with a Zeiss – Jena – Axio IMAGER Alm instrument.

The particle size of soil from the studied area was determined by laser diffraction method using the instrument Laser Particle Size Analysette 22 Compact offering the domain 0.03 µm - 300 µm. The soil chemical characteristics were determined in agreement with Romanian standards.

Results and discussions

LF slag composition

From the results of elemental spectrometry analysis and chemical analysis the slag composition in oxides was calculated.

Table 1: The LF slag composition in oxides (wt.%)

LF slag	**SiO_2**	**CaO**	**Al_2O_3**	**Fe_2O_3**	**MnO**	**MgO**	**TiO_2**
	19.85	55.12	6.01	1.18	0.89	9.42	0.22
	K_2O	**Cr_2O_3**	**F**	**P_2O_5**	**V_2O_5**	**SO_3**	**Others**
	0.031	0.055	4.31	0.034	0.062	1.11	1.89

The main components of LF slag are: calcium oxide, silicon dioxide, aluminium dioxide, magnesium oxide. Small quantities of iron oxide are present. The XRD analysis identified the following phases: Calcio-olivine, Mayenite, Periclase, Calcite, Fluorite and Calcium Fluoride Silicate. The optical microscopy analysis shows that the slag is composed from microcrystalline and vitreous phases (Figure 2).

Acid soil texture and chemical characteristics

The experimental studies were carried out in an agricultural area, Moara Domneasca, situated in the East side of Bucharest, Romania. This area is situated in Vlasia Plain. In this area the soil is Chromic luvisol. The pH of the soil has decreased due the use of mineral fertilizers with nitrogen content.

Some physical and chemical characteristics of acid soil from the experimental area were determined. In Table 2 the physical and chemical characteristics of acid soil from Moara Domneasca area are presented (depth: 0-20 and 20-40 cm).

Table 2: Some physical and chemical characteristics of Chromic luvisol

Depth (cm)	Bulk density (g/cm^3)	Total Porosity (%)	Degree of settling (%)	pH (H_2O)	C_{org} (%)	Humus (%)	Nt (%)	P_{Al} (mg/kg)	K_{Al} (mg/kg)
0-20	1.48	42.42	15.28	5.51	1.21	2.08	0.147	74	230
20-40	1.63	37.19	26.39	5.55	1.23	2.12	0.158	87	235

From the data presented in Table 2 is evident that the soil from selected area has pH= 5,51 (medium acid), has no good fertility and is not able to offer good conditions for crops.

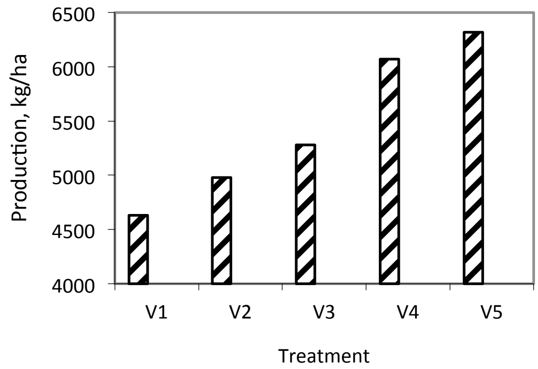

Figure 1: The influence of LF slag on wheat production

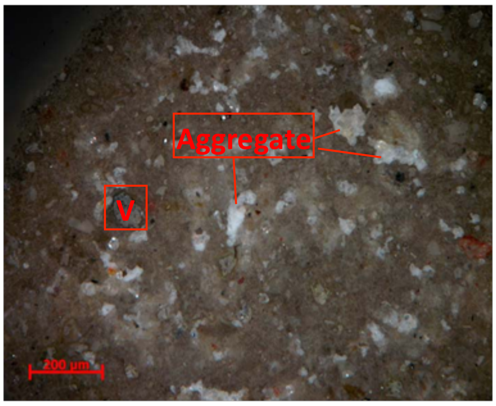

Figure 2: Optical microscopy .N+. Reflected light. V- vitreous phase

The field experiments were carried out with different quantities of LF slag. The influence of presence of LF slag on soil chemical properties is presented in Table 3 for two depths and different LF slag quantities.

Table 3: The influence of LF slag on soil chemical properties

Treatment	pH H_2O		C_{org} %		N_t %		P mg/kg		K mg/kg	
Depth (cm)	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
V1 (soil 0 trm.)	5.51	5.55	1.21	1.23	0.147	0.158	74	87	230	235
V2(1t LF slag/ha)	5.68	5.77	1.35	1.31	0.157	0.153	106	108	225	270
V3 (2t LF slag/ha)	5.80	5.92	1.28	1.23	0.153	0.155	97	105	298	287
V4 (3t LF slag/ha)	5.78	5.95	1.25	1.21	0.151	0.157	85	87	299	326
V5 (5t LF slag/ha)	6.01	6.35	1.32	1.25	0.157	0.132	78	89	311	317

The data from this table show that the increase of the LF slag quantities increases the values of soil chemical characteristics. On the treated soil was cultivated wheat. The influence of presence of LF slag in soil on the wheat production is presented in Figure 1. The heavy metal concentration in wheat grains is presented in Table 4.

Table 4: The heavy metal content of the wheat grains (ppm)

Treatment	Lead	Copper	Zinc
V1 (soil 0 trm.)	0	0	36
V2(1t LF slag/ha)	0	0	40
V3 (2t LF slag/ha)	0	0	34
V4 (3t LF slag/ha)	0	0	41
V5 (5t LF slag/ha)	0	0	41

Conclusions

The LF slag from the steel refining can be used for acid soil remediation. The presence of LF slag in soil improves the chemical characteristics of the soil and increases the crop production. The wheat grain contains zinc, which is very important for human health.

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