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RESEARCHES ABOUT NICKEL REGIME FROM AGROECOSYSTEMS IMPROVED BY SEWAGE SLUDGE

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Abstract

Lately is deemed nickel (Ni) like a micronutrient (MICROn) essential to the entire food chain: plant-animal-man (Stevenson and Cole, 1999). This is, however, a chemical element in the category of heavy metals (Adriano, 2001). Expression in the agricultural environment of Ni concentrations between deficiency (Alloway, 2008; Bell, 2000) and excess can occur both in nature reserves in the soil, and the contribution of manure. To observe trends of Ni content in soil and plants were used progressive doses of sludge 0:50 t.ha^{-1}, together with chemical fertilizers. We generally mobile forms experienced declining trends between 6 and 4 mg.kg^{-1} d.w. in all four years of culture. It is possible that Ni is detained by forces stronger than the molecules of sludge. Plants have specific concentrations of Ni content in both leaves at flowering and the mature seeds. Correlations obtained in bloom shows increasing concentrations of maize (between 1 and 2 mg) and wheat (4) (3 to 4 mg), and decreasing in wheat (2) (from 3 to 2 mg) and soybean (10 to 6 mg). Mature beans contained Ni inverse relationship with the applied doses: 1 mg in maize, between 3 and 5 mg in wheat (2), between 45-30 mg soybean and between 4 to 3 mg of wheat (4). Such research shows aspects of plant nutrition and highlight the natural cycle of the Ni.

Key words: *luvisoil, Ni, processed sludge, maize, soybean, wheat.*

INTRODUCTION

Nickel (Ni) is the latest essential micronutrient highlighted (Bell and Dell, 2008). Research with specific fertilizers led to obtaining increases of vegetable matter (Brown et al., 1987). IFA studies, as well as other nutrients, Ni was found to be required in food plants (Epstein and Bloom, 2005; Fageria et al., 2002; Maschner, 1995), animals and even humans. It is naturally occurring in the earth's crust, and in soil (Lindsay, 1991), less as single chemical element, but as specific minerals combined: annaberge [$Ni_3(AsO_4)_2.8H_2O$], garnierte [$(Ni,Mg)_6(Si_4O_{10})(OH)_2$], millerite (NiS), nicheline (NiAs), pentlandite [$(Fe,Ni)_9S_8$], skutterudite [$(Co,Ni) As_3$], ullmannite (NiSbS) (Figure 1) and adsorbed by organic matter (OM) and clays. Of mineral deposits, and the enlightenment of soils, Ni continues to exist in cycles and can always be used to support life.

Figure 1. The ullmannite mineral (NiSbS)

The first confirm that micronutrient (MICROn) was made by Brown (1987), who showed that a concentration of 0.05 mg.kg^{-1} in plants is sufficient for normal vegetative cycle. Recently, American researchers (Wood et al., 2004) have demonstrated the harmful effect of Ni deficiency and thus confirmed that it meets the essential criteria in plants. Further research at the cellular level of Ni (Bou et al., 2006) has shown that its absence or deficiency led to impaired metabolism ureidas functionality, the amino acids and organic acids.

Ni sources for agricultural field include both natural mineral form, then the use of chemical fertilizers enriched with chemical elements (some companies produce such fertilizers) and organic sources. Organic sources include residues of crop plants, manure and sludge waste. Ni to be absorbed by plants, it is necessary that organic forms are mineralized by soil microorganisms. Under these conditions that like a culture system in soil, sludge waste that could bring an important contribution to improving it.

MATERIALS AND METHODS

During the four years (2004-2007) field experiment was initiated, and stationary complex. Within its plants were cultivated by the structure: first year maize, winter wheat second year, third year soybean and fourth year winter wheat. In normal cultivation technologies, these plants were fertilized organo-mineral. Thus, processed waste sludge was applied in fractions: 0, 5, 10, 25 and 50 $t.ha^{-1}$. Chemical fertilizers were differentiated into three levels: unfertilized, needs to ½ of normal and normal doses (1/1). Plants have received such $N_{50}P_{50}$/maize, $N_{60}P_{40}$/wheat, $N_{30}P_{30}$/soybean and $N_{40}P_{40}$/wheat for doses ½ and $N_{120}P_{80}$/maize, $N_{120}P_{80}$/wheat, $N_{60}P_{60}$/soybean and $N_{80}P_{80}$/wheat for the 1/1. Sludge doses were applied in the same quantities in the first two years, maize and wheat in the second year following that soybean and wheat in the past year to receive their residual effect.

The experimental variants were of area of 100 m^2, in three repetitions. Chemical analyses were performed by specialized laboratories, as follows: Ni in soil, total shapes of leaves and grains, according to ISO 11047-99, and Ni mobile forms of soil by Na_2EDTA solution. Plant samples were collected at two vegetation periods and analyzed: leaves during flowering, and mature seeds. Leaves were harvested from the right cobs of maize, appeared last three leaves, including standard wheat leaf and middle flower stems and pods formed at base for soybean. Soil samples were collected from arable horizon with agrochemical special instrument, during the blooming and maturity. The data obtained were processed statistically by variance analysis method, and using correlations and regressions

RESULTS AND DISCUSSIONS

Content of nickel (Ni) in cross-cultural environment. From measurements performed soil Ni contents were demonstrated by both heavy metal total and mobile forms. Total nickel in soil ranged from relatively normal values considered (Table 1). Thus, in the four years ranged from 15-22 $mg.kg^{-1}$ d.w. Ni like minimum and 21-33 $mg.kg^{-1}$ d.w. like maximum values. Recent results recommended that Ni in soil total forms to be around 20 $mg.kg^{-1}$ d.w. (Capatâna and Simionescu, 2007). Ni average of the four years ranged between 18 and 23 $mg.kg^{-1}$ d.w.

Table 1. The nickel (Ni) contents from soil (mg/kg d.w.) total forms

Heavy metal	Maize	Wheat, 2	Soybean	Wheat, 4	Toxic limits
Ni, limits media	20 – 24 22	22 – 26 23	17 – 21 18	15 – 33 21	$30^{EU.2010}$ 50^{344}

$30^{EU.2010}$-proposal; 50^{344}-Ord. 344

Depending on complex doses of sludge waste and chemical fertilizers into the soil, mobile nickel evolved negative in all four cases (Figure 2). In the first two years when sludge expressed direct effect, these trends are statistically well: r =-0.789*** for maize and r =-0.737*** for wheat in year two. The explanation is the nickel (Ni) may be in a state of adsorption something stronger, just on sludge molecules embedded in soil culture. In these circumstances the state proportion of nickel ions (Ni^{2+}) in exchange was to be relatively small. Thus, in the four years analyzed, the absolute values of mobile Ni were within between 6 and 4 $mg.kg^{-1}$ d.w. Literature data less refer to Ni (as Ni^{2+} ions) present in the soil of plant culture. Instead get some input data to us, having regard to farming new insurance supported nickel complex of conditions favorable for plant nutrition.

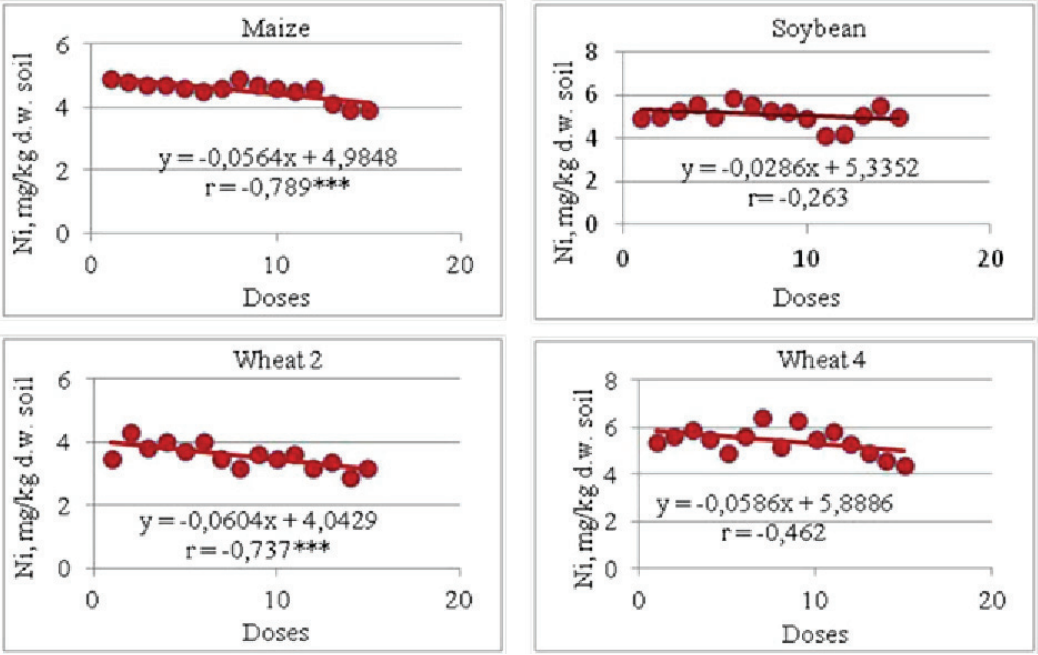

Figure 2. Correlations between Ni concentrations, mobile forms (NiMF) and sludge & chemical doses used

Influence of experimental factors on the content of Ni in leaves and grains. Given the soil conditions of culture, which forms the total Ni were located at relatively normal, and the mobile Ni have shown low concentrations and decreasing trend was expected that absorbtion of Ni^{2+} by plants occur in degrees characterized with great specificity.

And if Ni, high levels of Ni^{2+} ions in the soil can lead to phytotoxicity phenomena, as far other heavy metals have the environmental impact (Lindsay, 1991). In the extreme, of great importance is the analysis of plant, several moments of life. Both Ni and other chemicals, minerals, are selectively absorbed by each species of plant. Ni contents in plant leaves (Ni_{LV}) showed different aspects (Figure 3).

Maize Ni content in its leaves at flowering increased between 1 and 2 $mg.kg^{-1}$ d.w. Very clear experimental factors increased Ni content in leaves, r = 0.974***. The same extent (r = 0.519*), Ni in leaves of wheat have increased year 4 records with the values of the regression between 3 and 4 $mg.kg^{-1}$ d.w. Instead 2nd year wheat leaves were clearly decreasing Ni concentrations between 3 and 2 $mg.kg^{-1}$ d.w., with r =-0.631**. The explanation is that there are richer in heavy weather conditions. Soybean content in leaves was between 10 and 6 $mg.kg^{-1}$ d.w. Ni. Graph of this plant demonstrates the need for this micronutrient ($MICRO_n$) food, nickel (Ni). Concentrations of Ni contained soybean leaves were double and even triple from cereals: wheat and maize.

The correlations obtained between doses of sludge and fertilizer complexes with Ni concentrations in grain (Ni_{GR}) shows characteristic differences, different from leaves due to total negative trends (Figure 4). Thus, statistically decreasing states were obtained from maize in the first year with correlation coefficient r =-0.286, wheat second year, r =-0.327, soybean, r =-0.679** and wheat least year, r =-0.203. Negative states of Ni correlations show that mature grains plants had no need of this micronutrient. Yet exports of nickel (Ni) with grain yield was generally about 1 $mg.kg^{-1}$ in maize kernels, between 3 and 5 $mg.kg^{-1}$ for wheat and 30-40 $mg.kg^{-1}$ in soybean.

Agrochemical indices restricting Ni transfer in the agricultural environment. Recently succeeded in limiting the development of indices (Ord. 344/708/2004) of Ni concentrations in agricultural soil, when applying sludge waste (Table 2).

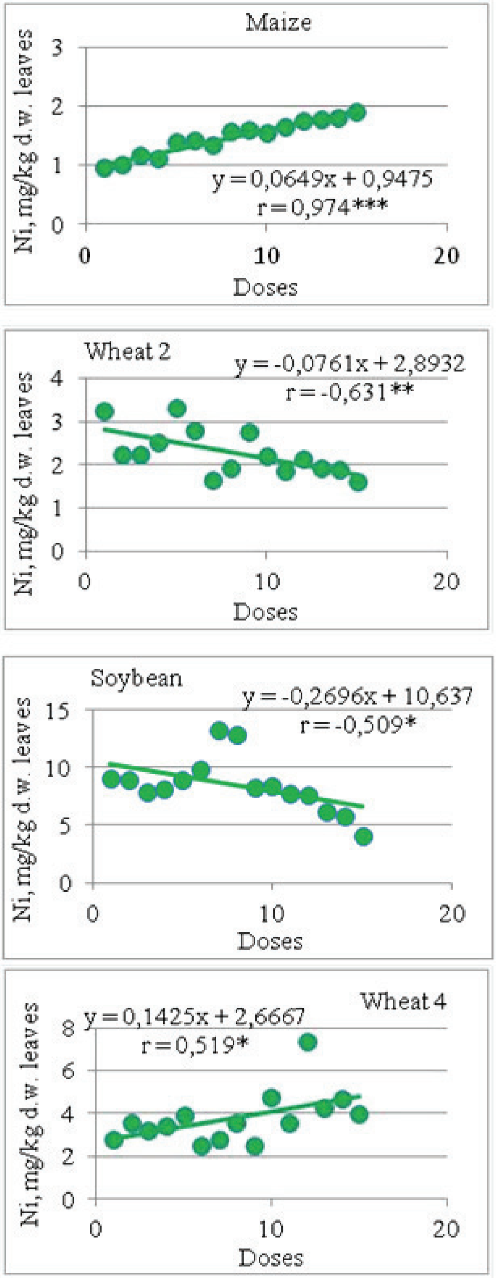

Figure 3. Correlations between Ni concentrations from plant grains (NiGR) and sludge & chemical doses used

Table 2. Ni (mg/kg d.w.) indices, used by the sludge application in the agricultural field (after Pusztai, 1988 quoted by Borlan, 1994)

Indices	Calculation
Level Considered Tolerable, LCT	LCT_{Ni} = 40.CEC/35 = = 13 mg.kg^{-1} d.w.
Maximum Tolerable Intake, MTI	MTI_{Ni} = 400.CEC/35 = = 128 mg.kg^{-1} d.w.
Applicable Annual Dose, AAD	AAD_{Ni} = 400.CEC/35.Ni* = 5 t.ha^{-1}.year^{-1}

CEC, cationic exchange capacity (11,16 me/100 d.w. soil)
*Ni from sludge, 27 mg.kg^{-1} d.w.

At first index, the level considered tolerable total soil Ni (LCT_{Ni}) should be less than 13 mg.kg^{-1}d.w. The data obtained prove slightly increasing from the index. Other index, maximum tolerable intake of nickel from waste sludge (MTI_{Ni}), will ensure that concentrations will be below the 128 mg.kg^{-1} d.w. Ni. Permanent analyzed sludge contained around 50 mg.kg^{-1} d.w. Ni. The third indicator, the annual allowable time waste sludge (AAT_{Ni}) was 5 t.year^{-1}.ha^{-1}. Thus, for a 4-5 year cycle of crop rotation, can be applied between 20-25 t.ha^{-1} sludge waste.

CONCLUSIONS

By using processed sludge (anaerobic digestion and dried) has been an improvement in nickel (Ni) albic luvisol eco-environment of the resort. Average levels of total soil Ni shown in the four years fit around values considered normal for this particular micronutrient with 20 mg.kg^{-1}d.w. Mobile forms of Ni showed annual decreases due to complex dose applied. Mean soil Ni_{MF} ranged between 6 and 4 mg.kg^{-1} d.w. and could be due to a longer Ni pronounced the higher doses of sludge introduced into soil.

Given the negative state of Ni^{2+} concentrations in soil solution (SSol), it was expected that plants absorb both selective and specific to the $MICRO_n$ Ni, of course correlated with the concentrations. Maize and wheat in year 4, Ni contained in the leaves of the flowering period increasing concentrations of between 1 and 2 mg.kg^{-1} d.w. and that between 2 and 4 mg.kg^{-1} d.w. Second year wheat and soybean leaves contained nickel in reports reverse negative between 3 and 2 mg.kg^{-1} d.w. and 10 and 6 mg.kg^{-1} d.w. Explanation of these states by both the specific need of each plant part for Ni and studied by conducting plant physiology.

Correlations obtained with useful production (grains) show that plants have used nickel (Ni) in vegetation, after which they stored by grain in a clear and total opposite. In the maturity stage was not necessary and that the contents: 1 mg.kg^{-1} d.w. maize, 5-4 and 3 mg.kg^{-1} d.w. wheat and 45-30 mg.kg^{-1} d.w. for soybean, and means the real exports of Ni.

Agrochemical indicators which limits the application of waste sludge doses are useful in the agricultural field and can give valuable information for users of agricultural products: sewage sludge. Level considered tolerable soil concentrations must not exceed 13 mg.kg^{-1} d.w. total Ni. Maximum tolerable intake levels of sludge for agricultural field will not exceed 128 mg.kg^{-1} d.w. Applicable annual sludge shall not exceed 5 t.ha^{-1}, which means that a rotation of 4-5 years can apply doses between 20-25 t.ha^{-1} sludge.

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