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DISSOLVED ORGANIG CARBON AS A CONTROLLING FACTOR OF NICKEL AVAILABILITY IN RECLAMATION OF BARREN SOIL

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INTRODUCTION

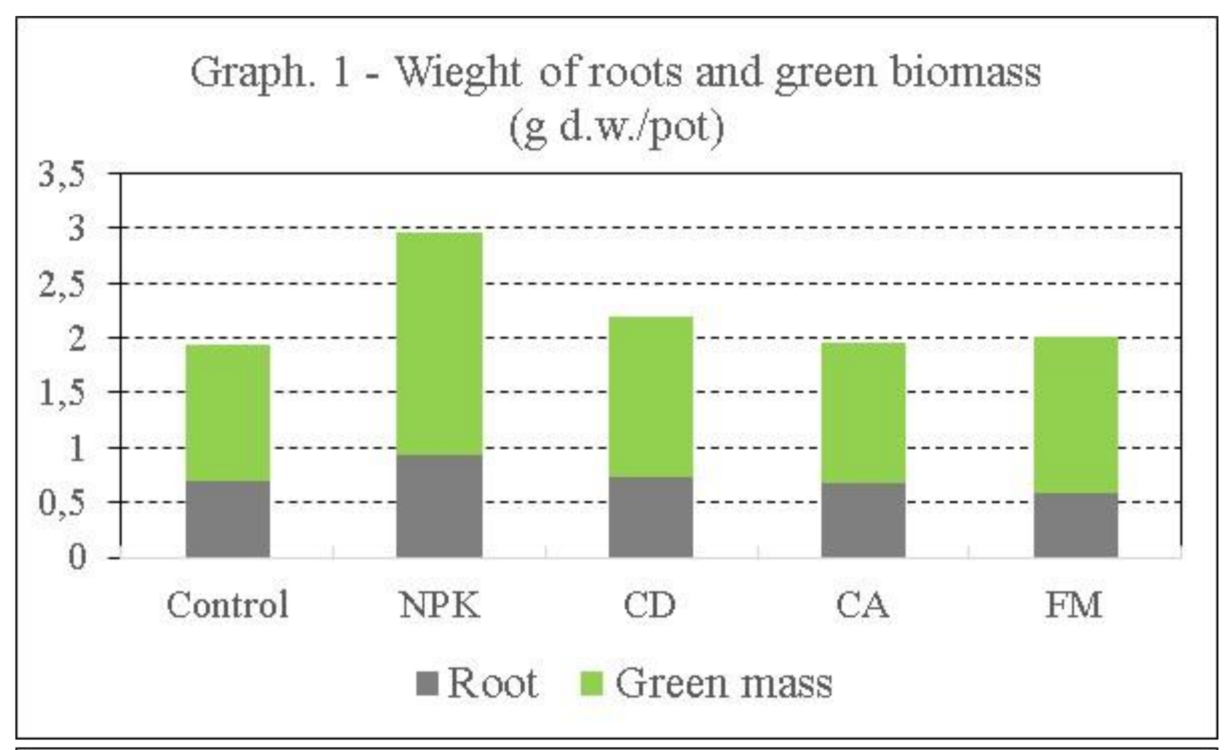
Lignite exploitation at Kostolac basin (Serbia) has generated over 4000ha of surface deposited barren soil, with on-going increasing trend on an annual level. Since such deposits might be connected to numerous environmental treats, such as: leaching of potentially toxic elements or wind erosion, many attempts of their reclamation have been made. The term reclamation today means ecological restoration, i.e. restoring readable biocenoses and parts of ecosystems to their original appearance, structure, diversity and function. Therefore, the objective of our work was to investigate a possibility to reclaim barren soil by growing arable crops, as the closest to an original function of a land. Here, we present the results from growing maize as a test plant.

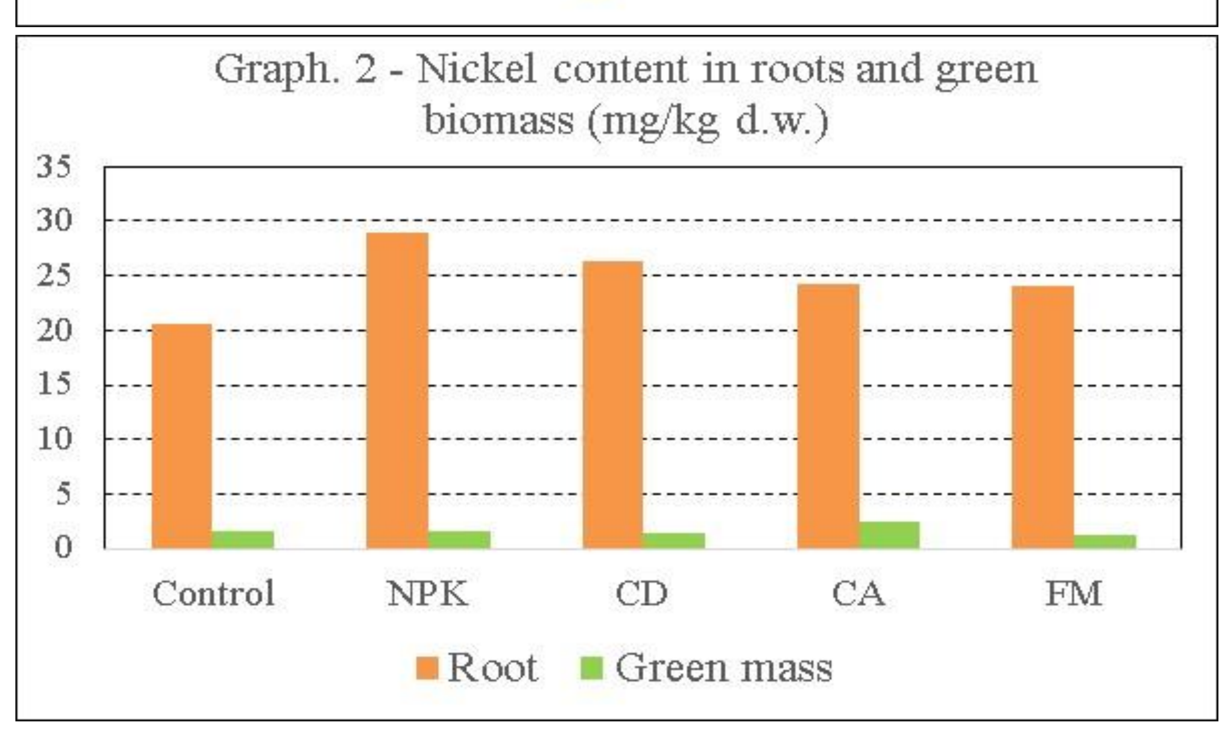
MATERIAL AND METHODS

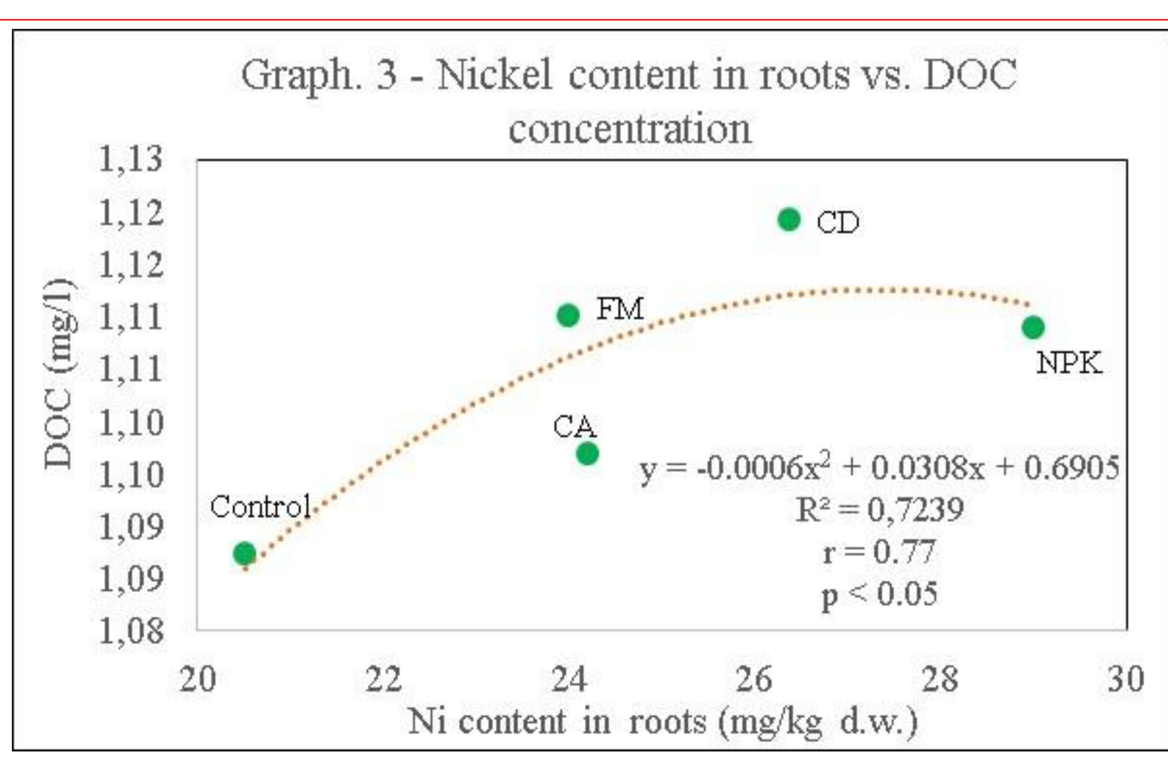
We have conducted a pot experiment under semi-controlled greenhouse conditions, in four replicates and with the following treatments: control, NPK (1000 kg ha^{-1}), farmyard manure (FM) (100 t ha^{-1}), coal dust (CD) (35 t ha^{-1}) and coal ash (CA) (35 t ha^{-1}). Duration of the experiment was 60 days, after which green biomass and roots were separated and their masses were measured. We have also determined contents of trace elements (TEs) (Ni, Cr, Pb, Zn, Cd, Cu) in green biomass and roots (by AAS method, after an acid digestion). Analyses of barren soil used for the the experiment included determination of: (i) basic chemical properties such as pH and organic matter content, (ii) pseudo-total contents of TEs (US EPA 3050B), (iii) 0.005 M DTPA-extractable amount of TEs. After the first results, additional analyses of the barren soil after the experiment were performed: determination of dissolved organic carbon (DOC) and determination of labile Ni by the Diffusive Gradients in Thin Films (DGT) technique. Nickel flux (µg Ni cm-1 h^{-1}) was calculated from the accumulated Ni mass in the DGT resin gel. Further, Specific UltraViolet Absorbance (SUVA254), an indicator of DOC aromaticity, was obtained by dividing UV254 value by the DOC concentration.

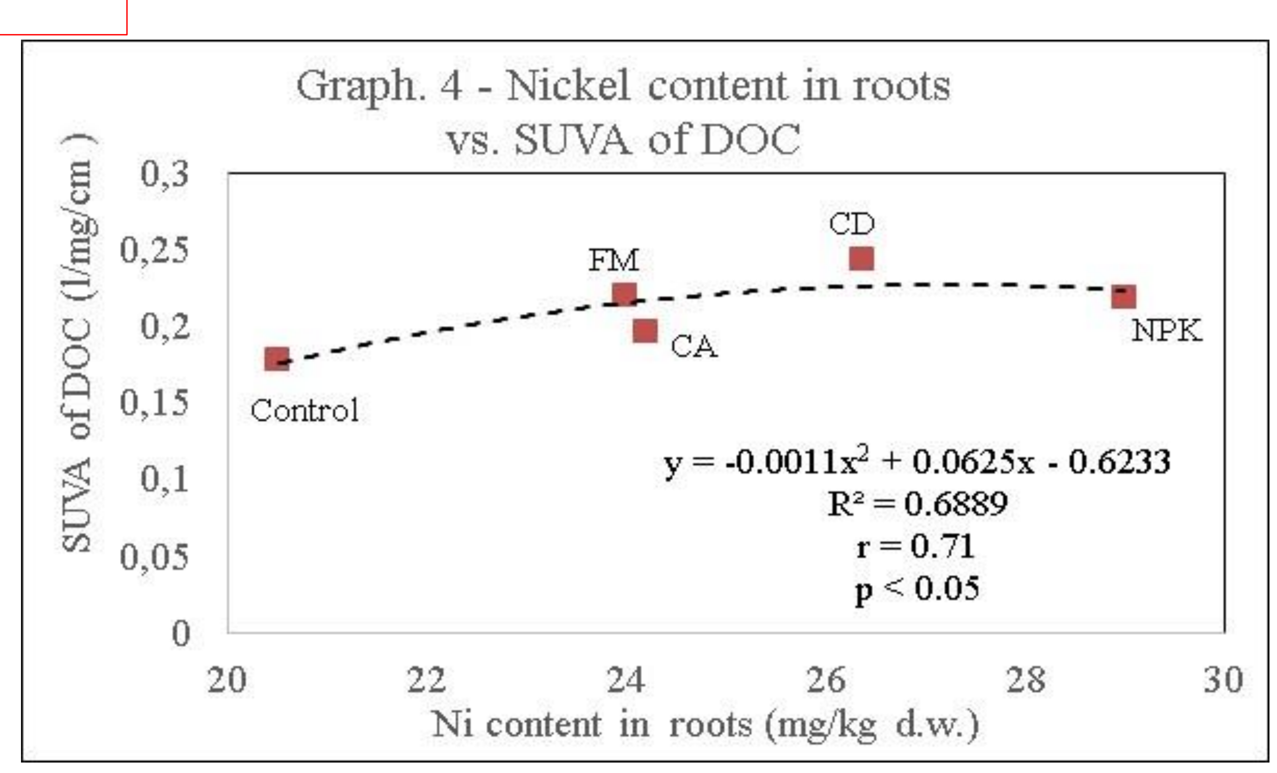
RESULTS AND DISCUSSION

The barren soil was slightly alkaline (pH - 7.39), with low organic carbon content (0.228%). Compared to the control, green biomass of maize was significantly higher in the treatments: NPK, FM and CD, indicating that optimisation of plant nutrition, along with an improvement of barren soil chemical, physical and biological properties, might lead to successful cultivation of arable crops. Pseudo-total contents of all TEs were below legislative threshold, whereas their 0.005 M DTPA-extractable amount were low. However, high Ni contents were recorded in the roots from all treatments (Graph. 2), although such scenario could not be predicted from the pseudo-total and DTPA-extractable Ni. This indicated that a reservoir of labile Ni might existed in the soil. Significant correlation between Ni contents in the roots and nickel fluxes ($r = 0.77$, $p < 0.05$) confirmed that the solid phase was capable to resupply dissolved Ni. In addition, Ni contents in the roots correlated with DOC (Graph. 3), which indicated that DOC might be an important factor controlling Ni plant-availability. Aromatic DOC, indicated by high SUVA254, is highly reactive and is more prone to complex metals compared with aliphatic DOC, indicated by low SUVA254 (Weishaar et al., 2003). In our experiment, SUVA of DOC decreased in the order: CD > FM > NPK > CA > control, showing that organic amendments generated DOC susceptible to complex metals, thus enhance their availability (Antoniadis and Alloway, 2002). This corroborated with significant correlation between Ni contents in the roots and SUVA of DOC (Graph. 4). Therefore, our results indicate that Ni availability in the barren soil might be equally controlled by DOC quantity and DOC quality, both resulted from organic amendments.









CONCLUSION

Our results imply that optimisation of plant nutrition, along with an improvement of barren soil chemical, physical and biological properties, might lead to a successful reclamation of such areas by cultivation of arable crops. However, utilization of organic amendments in reclamation might lead to an enhance availability of TEs, by, among others, formation of their complexes with DOC. Thus, amendments used for reclamation of barren soil should be carefully combined with reclamation goal and detailed analyses of both soil and plants, in order to avoid any undesired outcome either on the goal itself or broader in the environment. The results obtained should be further evaluated with different arable crops and in field conditions.

References

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