Increasing soil organic matter after application of mineral-organic mixture as an action to prevent climate change

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Greenhouse gas (GHG) emissions come mainly from large-area, monoculture agri-food farms that use large amounts of mineral fertilizers and pesticides. On the other hand, deforestation of land for agricultural land and burning of crop residues leads to the release of carbon dioxide (Gorte and Sheikh, 2010; Viglione, 2022). Agricultural activity leads to many changes in the environment, often negative, but on the other hand, it can play an important role in reversing environmental problems by trapping carbon dioxide, increasing water infiltration and preserving rural landscapes and biodiversity (Haverkamp and Marshall, 2009). Thus, it is important to fully explore the relationship between climate change and fertilizer use. Inexpensive, environmentally friendly fertilizer management techniques are desirable in modern agriculture (Erbas and Solakoglu, 2017). The use of zeolite as a fertilizer additive can have a positive effect on both soil properties and the quantity and quality of crops (Jarosz et al. 2022; Mondal et al. 2021). The depletion of soil organic matter directly affects the ecological processes in the soil, therefore the preservation and enrichment of soil organic carbon is crucial to ensure the long-term stability of agricultural and environmental ecosystems. Therefore, the restoration of soil organic matter is a common goal of soil science research (Kim Thi Tran et al. 2015).

The aim of this study was to investigate the effect of the applied mineral-organic mixtures with the addition of zeolite composites (NaX-Vermiculite - MV and NaX-Carbon - MC) and lignite - L or leonardite - Leo on the transformation of organic matter in contaminated loamy sand soil. A two-year pot experiment was carried out in a vegetation hall using testing plant – maize. The paper compare the changes in soil organic matter as well as organic carbon stocks (CS) after the use of innovative fertilizer mixtures.

The soil carbon content (SOC) was determined by Tiurin method. Humus compounds were determined using Kononowa and Bielczikowa method (1961).

The highest contents of soil organic carbon (SOC) after the 1st year of experiment were observed in soil with addition 9% zeolite-vermiculite composite and 6% leonardite as well as in soil with addition 9% zeolite-carbon composite and 6% leonardite (Fig. 1). After the 2nd year of experiment SOC contents in objects MF, MV9%L6%, MV3%Leo3%, MV9%Leo6%, MC3%L3%, MC9%L6% and MC3%Leo3% were higher compared to control soil – C. In general, the content of fulvic acids carbon (CFA) obtained both after the first and second year of the study was higher than the content of humic acids carbon (CHA). The increase in the content of non-hydrolyzing carbon in the soil (on average by 15%) after application of the mixtures may indicate a greater stabilization of humus compounds and, at the same time, lower CO_2 release. After second year of experiment the highest carbon stocks value was observed in soil with addition 3% zeolite-carbon composite and 3% leonardite, this was an increase of approx. 32% compared to the value obtained after the first year. Research on changes in the quantity and quality of organic matter in the soil is important not only from a cognitive point of view, but also due to the issue of assessing its fertility and productivity. Moreover, on the basis of the changing content of carbon fractions, it is possible to assess the degree of changes in humus compounds as well as soil carbon stocks. Enhancement of C-benefits could contribute to reduction in vulnerability to climate risks and adaptation to climate change risks through enhanced and stabilized crop yields (through soil fertility enhancement and conservation) (World Bank, 2012).

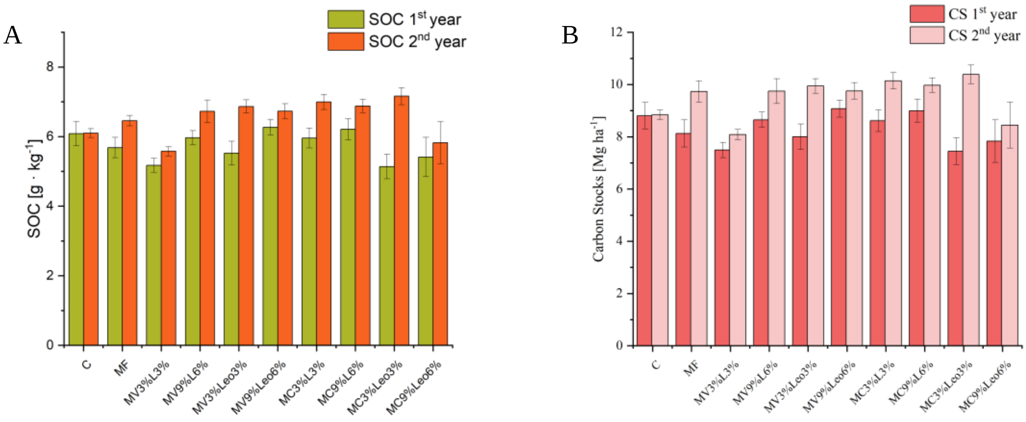

Figure 1 Soil organic carbon (SOC) content – A and Carbon Stocks (CS) – B in soil after the 1st and 2nd year of experiment. Treatments: control (C), mineral fertilization (MF), zeolite/vermiculite composite (MV), zeolite/carbon composite (MC), lignite (Lig), and leonardite (Leo).

References

1. Erbas, B.C., Solakoglu, E.G., 2017. In the Presence of Climate Change, the Use of Fertilizers and the Effect of Income on Agricultural Emissions. Sustain. 2017, Vol. 9, Page 1989 9, 1989. https://doi.org/10.3390/SU9111989
2. Gorte, R.W., Sheikh, P.A., 2010. Deforestation and Climate Change, in: Congressional Research Srevice. p. ss. 41.
3. Haverkamp, R.G., Marshall, A.T., 2009. The mechanism of metal nanoparticle formation in plants: Limits on accumulation. J. Nanoparticle Res. 11, 1453–1463. https://doi.org/10.1007/s11051-008-9533-6
4. Jarosz, R., Szerement, J., Gondek, K., Mierzwa-Hersztek, M., 2022. The use of zeolites as an addition to fertilisers – A review. Catena. https://doi.org/10.1016/j.catena.2022.106125
5. Kim Thi Tran, C., Rose, M.T., Cavagnaro, T.R., Patti, A.F., 2015. Lignite amendment has limited impacts on soil microbial communities and mineral nitrogen availability. Appl. Soil Ecol. 95, 140–150. https://doi.org/10.1016/j.apsoil.2015.06.020
6. Mondal, M., Biswas, B., Garai, S., Sarkar, S., Banerjee, H., Brahmachari, K., Bandyopadhyay, P.K., Maitra, S., Brestic, M., Skalicky, M., Ondrisik, P., Hossain, A., 2021. Zeolites Enhance Soil Health, Crop Productivity and Environmental Safety. Agronomy 11, 448. https://doi.org/10.3390/agronomy11030448
7. Viglione, G., 2022. What does the world's reliance on fertilisers mean for climate change? [WWW Document]. Carbon Br. URL https://www.carbonbrief.org/qa-what-does-the-worlds-reliance-on-fertilisers-mean-for-climate-change/
8. World Bank, 2012. Enhancing Carbon Stocks and Reducing CO_2 Emissions in Agriculture and Natural Resource Management Projects, World Bank. https://doi.org/10.1596/27117

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