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Optimizing the Use of Organic Amendments for the Rehabilitation of Degraded Mine Tailings

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Abstract

The soil degradation process is one of the highly pressing environmental issues in the world. This problem has increased significantly with economic and industrial growth. In fact, the ensuing problems of soil degradation could be restored by the rehabilitation process. This approach aimed to recover the soil ecological functions lost by degradation. Phosphate-mine residue (MR) used in this experiment were the waste rocks of the open-pit phosphate mines produced during the excavation process. The need of management of those MR is gaining more interest to develop sustainable alternative methods for the rehabilitation for these areas.

In this study, the objective was to optimize the combination of different amendments for rehabilitation of MR in order to restore their quality and fertility. Response surface methodology was employed to analyze the individual and combined effects of the organic amendments on pH and soil organic matter (OM) of MR. Phosphate MR was mixed with topsoil from the mine in various quantities (0, 25 and 50%) and amended with three distinct amendments: biochar (0%, 2%, and 4%), manure (0%, 5%, and 10%), and vermicompost (0%, 4%, and 8%) following a Box-Behnken design (29 possible combinations).

After one month of incubation, the process modelling confirmed that the 2FI model ($P< 0,0001$) was adequate to explain the behavior of pH. Model refinement revealed that the experimental values are extremely similar to the expected values with an R^2 of 0,97 and a non-significant lack of fits (0.52). The linear model ($P< 0,0001$) was adequate to explain the behavior of OM. The experimental values are considerably similar to the expected values with an R^2 of 0.78 and a non-significant lack of fits (0.63). The numerical equation and analysis of the interactions between the elements revealed that vermicompost, manure and topsoil were the main factors influencing the pH. The optimal combination for optimizing the pH of MR giving the lowest possible value (from 8.9 to 7.91) was the vermicompost at 8%, however, biochar, manure and the topsoil must be at 0%. On the other hand, vermicompost, biochar, manure and topsoil when adjusted to the maximum (8%, 4%, 10% and 50% respectively) enhance the OM content of MR from 0.5 to 1.31%.

The obtained model enable us to improve the quality of phosphate mine residue in term of pH and OM while minimizing the organic amendment inputs.