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The role of phytoremediation strategies of ion-adsorption rare earth elements mine tailings highlighted by macroaggregate typology

Guo Meina[1,2,5], Huot Hermine[1,2,3], Liu Chang[1,2], Liu Ye[1], Liu Wenshen[1], Yuan Ming[1], Zhu Shichen[1], Chen Yingyan[1], Chao Yuan-Qing[1], Morel Jean Louis[2], Qiu Rong-Liang[1,4], Watteau Françoise[2], Séré Geoffroy[2], Tang Ye-Tao[1]

[1]School of Environmental Science and Engineering, Sun Yat-sen University, Guangzhou, China
[2]Laboratoire Sols et Environnement, INRAE-Université de Lorraine, Vandœuvre-lès-Nancy, France
[3]Laboratoire Interdisciplinaire des Ecosystèmes Environnementaux, CNRS-Université de Lorraine, Vandœuvre-lès-Nancy, France
[4]Guangdong Provincial Key Laboratory of Agricultural & Rural Pollution Abatement and Environmental Safety, College of Natural Resources and Environment, South China Agricultural University, Guangzhou, China
5 Ganjiang Innovation Academy, Chinese Academy of Sciences, Ganzhou, China

Email of corresponding author: eestyt@mail.sysu.edu.cn; geoffroy.sere@univ-lorraine.fr

Ion-adsorption rare earth element (REE) deposits are one of the main reservoirs of REEs worldwide, mainly located in Jiangxi, Guangdong and other provinces in the south of China. Over the past couple of decades, the most popular mining process to recover REEs was heap leaching by using ammonium sulfate solution. The production of REEs has generated lots of environmental damages, such as water pollution, erosion and landslides. The main soil issues that affect revegetation in the REE mining area can be summarized as: 1) physical problems (*e.g*. compaction, lack of structure, coarse texture, instability), 2) problems of nutrition (e.g. lack of organic matter and nutrients), 3) toxicity problems (*e.g*. low pH, relatively high concentration of REEs). Considering the huge soil erosion in mining area, how to restore a stable structure of the soil should become a major issue. We set up experimental plots to study the various reclamation strategies.

As a basic unit of soil structure, stability and the characteristic of the aggregates are often considered as crucial indicators for evaluating soil structure. Reclamation practices (*i.e.* amendments, planting) were shown to promote and accelerate the formation of organo-mineral associations and the OM accumulation. By the observation of macroaggregates, we defined 4 types of macroaggregates in REE mine tailings, 1) macroaggregates with crusts (Agg_crust), 2) macroaggregates with roots (Agg_root), 3) macroaggregates with weathered rocks (Agg_rock), 4) macroaggregates only with minerals (Agg_unknown). Different types of macroaggregates may suggest different aggregation processes. From the relative abundance of total aggregates, the total aggregate content of the plots with amendments was obviously higher than that of bare tailings, and the total aggregate abundance of T3 was higher than that of T2 in all treatments. The relative proportion of Agg_rock showed good consistency under different treatment and reclaimed time. Agg_unknown abundance is the highest in BA. The proportion of Agg_crust had no significant difference among different treatments, and the highest was 20% in BAG. The effect of time on Agg_crust was not significant, but only increases in the BAG, which was similar to the trajectory of crust coverage. The addition of amendments promoted the growth of plants and the formation of Agg_root. The results of PCA show that the reclamation project can effectively promote the formation of macroaggregates and improve the properties of tailings soil.