土壤與廢棄物

磷化生物探創新合成與應用於降低汙染土壤中重金屬移動性與農夫健康風險

Synthesis of novel phosphorylated biochar for reducing heavy metals mobility and farmers health risk in the contaminated soil

Nathan Thadeo Yoashi[1], Ying-Lin Wang[1 3], Zeng-Yei Hseu[2], Ling-Chu Chien[3 *], Hsing-Cheng Hsi[1 *]

[1] Graduate Institute of Environmental Engineering, National Taiwan University, Taipei, Taiwan (nathanthadeo@gmail.com, hchsi@ntu.edu.tw)
[2] Department of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan
[3] School of Public Health, College of Public Health, Taipei Medical University, Taipei, Taiwan (lcchien@tmu.edu.tw)

Abstract

Climate change altered heavy metals transformation and mobility in the soil, limiting productivity and nutrient availability, hence elevating health risks. Nevertheless, effective immobilization techniques are scarce and characterized by low efficiency, limited long-term stability, and competitive interference as a result of difficulty in mitigating the subsequent risks. To accommodate the imminences, a novel biochar impregnated with phosphorous and nitrogen was successfully synthesized. Thereafter, an incubation experiment was employed to showcase the impacts of pristine (BC) and modified biochar (PBC) on the heavy metals' immobilization, nutrient accessibility, and farmers' health risks. Results confirmed that impregnation increased the materials' stability, surface area, available nutrients, and ox-phosphonitrogenated function groups compared to BC. Specifically, the elemental analysis revealed an increase in nitrogen and oxygen from 0.47% and 9.47% to 3.01% and 21.4%, respectively. Microcosm experiment indicated the effectiveness of PBC in immobilizing soil heavy metals, compared to the control and biochar without any modification, reducing the labile quantity of heavy metals in the contaminated soil. Notably, the soil available nutrients under the PBC amendment were the highest, followed by BC and the control group endorsing exceptional impregnation potential to climate change adaptation and nutrient bioavailability. Furthermore, the heavy metal bioaccessible fraction exhibited a notably higher level in the control group than the BC group, with a further reduction observed under the PBC treatment. Concomitantly, the PBC treatment demonstrated a diminished non-carcinogenic health risk for farmers, through oral soil ingestion, and dermal contact exposure routes. Considering PBC's multifaceted capabilities, including reducing available heavy metals fractions, enhancing soil physicochemical properties, supplementing soil nutrients, and mitigating human health risks, this innovative material emerges as a viable alternative to conventional amendments. Importantly, PBC not only offers a practical solution for mitigating the impacts of climate change associated with heavy metal pollution in agricultural farmland but also exemplifies a green, sustainable remediation technology currently demanded and feasible.

關鍵字：銀合歡生物炭、重金屬、可利用營養物質、健康風險、氣候變適
Keywords: phosphorylated biochar, heavy metals, available nutrients, health risk, climate change adaptation.