

コーヒー炭およびコーヒー機能炭と *Ipomoea aquatica* を組み合わせた水質浄化の評価

Evaluation of coffee charcoal and functional charcoal combined with water spinach (*Ipomoea aquatica*) for water purification

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Introduction

Water is essential for life and sustainable development, but rapid industrialization, urbanization, and pollution have significantly degraded water quality. Heavy metals from mining, agriculture, and chemical use are especially harmful due to their persistence. While nitrates are necessary for biological functions, excessive levels pose serious environmental and health risks. Coffee (*Coffea arabica* L.) production generated 10.38 million tons in 2022-2023, producing large volumes of waste like husks and grounds. Transforming this waste into charcoal offers an eco-friendly method for nitrate removal and wastewater management. This study explored growing spinach in coffee charcoal, functional charcoal, and glass beads. This integrated approach provides a sustainable, low-energy solution for water treatment and environmental protection.

Materials and method

This study was conducted from August 19 to September 28, 2024, in a net house at the Faculty of Agriculture, Okayama University. It investigated the effects of coffee charcoal and functional charcoal (activated with 10% calcium chloride) made from coffee grounds carbonized under high temperature, in non-oxidizing conditions. A cylindrical metal mesh pot was placed inside a Wagner pot (1/2000 a, 15 L) with a plastic barrier to hold burned akadamatuchi soil, preventing excess inorganic phosphorus. Glass beads were used as a neutral medium for cultivating water spinach. Treatments included functional charcoal (FC), functional charcoal with plant (FCP), coffee charcoal (CC), coffee charcoal with plant (CCP), and glass beads with plant (GBP), each with five replications in a Completely Randomized Design (CRD), totaling 25 pots. Each pot contained 10 liters of water, 1.3 liters of charcoal, and 0.56 liters of burned akadamatuchi soil. Water was exchanged five times using water from the Okayama University livestock farm pond, adjusted to 10 ppm nitrogen using commercial KNO_3 . Spinach seedlings of uniform size were transplanted into the pots.

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Water parameters (pH, EC, salinity, and $\text{NO}_3\text{-N}$) were monitored one day interval, while $\text{PO}_4\text{-P}$ and $\text{NH}_4\text{-N}$ were sampled every three days. Plant dry weight was recorded at the experiment's conclusion.

Result

There was a great significance effect on nitrate-nitrogen adsorption by treatments (Figure 1). At the first exchange of water, FCP showed the maximum adsorption ability (99.00 %) followed by FC. CC and CCP were recorded as lower adsorption result in the first cycle. In the second exchange, the similar results were observed in FCP and FC, however, the CC and CCP has been showed the more adsorption efficiency than first cycle. The adsorption capacity of FC and CC were recorded lower comparatively less

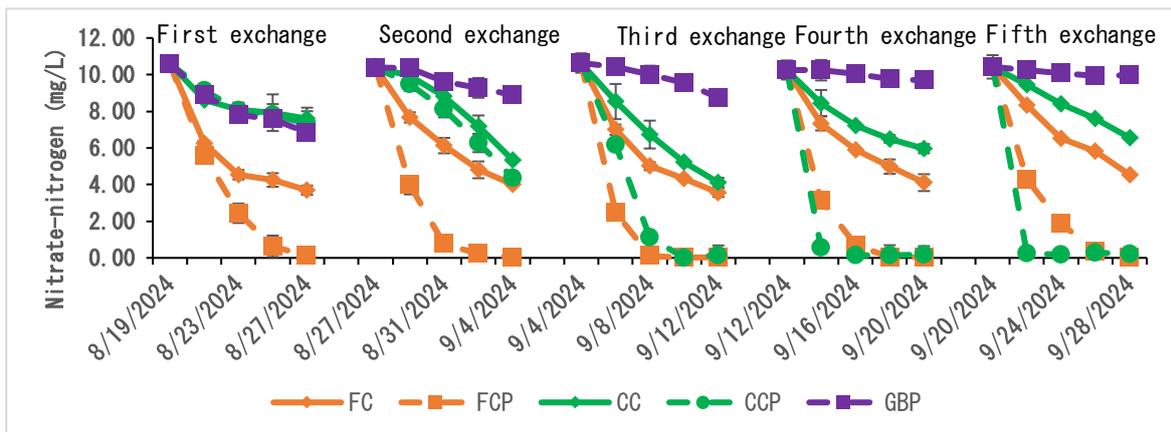


Figure 1 (a) Nitrate-nitrogen adsorption by charcoal and water spinach plant, (b), Error bar indicates the standard deviation

than FCP and CCP due to the combination of spinach plant. Additionally, FC adsorbed more quicker than CC due to the presence of ion exchange group in outer layer resulting quick adsorption whereas CC adsorbed through simple penetration into pore space slowly. From the second to fifth exchange, the lowest adsorption was found in GBP. FCP and CCP were represented the equivalent result in the last three cycle. It may be due the vigorous plant growth (using their root for growing absorption of more $\text{NO}_3\text{-N}$) as well as functional and coffee charcoal combinedly. FC showed good ability to adsorb nitrate-nitrogen compared to CC without plant. The highest dry matter of water spinach plant was recorded in CCP whereas the lowest one in GBP (Figure 2.). Previous research has shown that coffee charcoal has a higher nitrogen content than functional charcoal. It may be due to more growing spinach in CCP. The pH, EC, salinity, $\text{PO}_4\text{-P}$, $\text{NH}_4\text{-N}$ and $\text{NO}_2\text{-N}$ showed no significance variation during study.

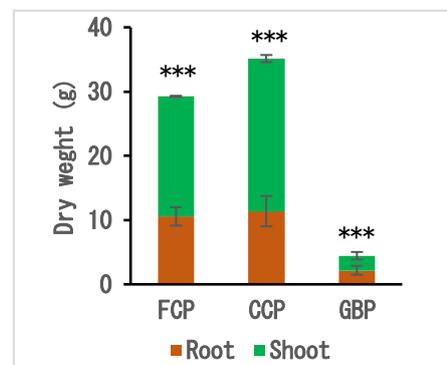


Figure 2. Dry weight of water spinach plant at the end of the experiment,

(b), Error bars indicate the standard deviation,

(c) Tukey's method shows a significant difference at 1 % level

In conclusion, functional charcoal with spinach plant can be recommended for new tools for water purification and sustainable environment.