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Utilization of Functionalized Biochar from Water Hyacinth (Eichhornia crassipes) as Green Nano-Fertilizers

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Abstract : As the global population steadily approaches the 10billion mark, the world is currently faced with two major challenges among others – accessing sustainable and clean energy, and food security. Accessing cleaner and sustainable energy sources to drive global economy and technological advancement, and feeding the teeming human population require sustainable, innovative, and smart solutions. To solve the food production problem, producers have relied on fertilizers as a way of improving crop productivity. Commercial inorganic fertilizers, which is employed to boost agricultural food production, however, pose significant ecological sustainability and economic problems including soil and water pollution, reduced input efficiency, development of highly resistant weeds, micronutrient deficiency, soil degradation, and increased soil toxicity. These ecological and sustainability concerns have raised uncertainties about the continued effectiveness of conventional fertilizers. With the application of nanotechnology, plant biomass upcycling offers several advantages in greener energy production and sustainable agriculture through reduction of environmental pollution, increasing soil microbial activity, recycling carbon thereby reducing GHG emission, and so forth. This innovative technology has the potential for a circular economy and creating a sustainable agricultural practice. Nanomaterials have the potential to greatly enhance the quality and nutrient composition of organic biomass which in turn, allows for the conversion of biomass into nanofertilizers that are potentially more efficient. Water hyacinth plant harvested from an inland water at Warri, Delta State Nigeria were air-dried and milled into powder form. The dry biomass were used to prepare biochar at a pre-determined temperature in an oxygen deficient atmosphere. Physicochemical analysis of the resulting biochar was carried out to determine its porosity and general morphology using the Scanning Transmission Electron Microscopy (STEM). The functional groups (-COOH, -OH, -NH2, -CN, -C=O) were assessed using the Fourier Transform InfraRed Spectroscopy (FTIR) while the heavy metals (Cr, Cu, Fe, Pb, Mg, Mn) were analyzed using Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES). Impregnation of the biochar with nanonutrients were achieved under varied conditions of pH, temperature, nanonutrient concentrations and resident time to achieve optimum adsorption. Adsorption and desorption studies were carried out on the resulting nanofertilizer to determine kinetics for the potential nutrients' bio-availability to plants when used as green fertilizers. Water hyacinth (Eichhornia crassipes) which is an aggressively invasive aquatic plant known for its rapid growth and profusion is being examined in this research to harness its biomass as a sustainable feedstock to formulate functionalized nano-biochar fertilizers, offering various benefits including water hyacinth biomass upcycling, improved nutrient delivery to crops and aquatic ecosystem remediation. Altogether, this work aims to create output values in the three dimensions of environmental, economic, and social benefits.

Keywords : biochar-based nanofertilizers, eichhornia crassipes, greener agriculture, sustainable ecosystem, water hyacinth
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