Assessing environmental impacts of ash as an agricultural amendment

The sustainable management of ash as an agricultural amendment requires a comprehensive understanding of its flow through the system and its environmental impacts. This study integrates Material Flow Analysis (MFA) and Life Cycle Analysis (LCA) to evaluate the large-scale use of ash in agriculture. MFA will quantify the movement of ash and its elemental compositions throughout the system, considering inputs, outputs, and transformations. The key components of the MFA include: ash generation rates, energy consumption, elemental composition, "losses" in elements from the soil system (e.g., leached out), and any "gains" (e.g., elemental uptake by crops calculated using soil-to-plant translocation factors). The final MFA output will provide a comprehensive mass balance, illustrating ash applied to soil, available nutrients contributing to soil fertility, and potentially harmful elements that may accumulate in soil and affect both ecosystem and human health.

LCA will be used to evaluate the climate and health impacts of ash generation and application. Data collection will cover the following stages: ash production, energy use, transportation, water usage. After compiling inventory data, the environmental impacts will be assessed across multiple categories, including Global Warming Potential (GWP) by quantifying CO2 and other greenhouse gas (e.g., CH4, and N2O) emissions from biomass, coal, waste combustion, and transportation using IPCC guidelines or LCA tools such as SimaPro. Human Toxicity will be assessed through human health risks from contaminated water or crops using toxicity databases such as TRACI (Tool for the Reduction and Assessment of Chemical and Environmental Impacts). Resource depletion will evaluate ash as a resource versus traditional fertilizers.

The results of LCA will be analyzed to identify stages or processes in the ash lifecycle that contribute most to environmental impacts. Sensitivity analysis will be conducted using Monte Carlo simulation to assess how variations in key parameters (e.g., transportation distance, energy sources) influence the overall environmental impacts and health impacts. By integrating MFA and LCA, the study will provide a comprehensive assessment of both material flows and environmental impacts.