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Soil nutrients and heavy metal availability under long-term combined application of swine manure and synthetic fertilizers in acidic paddy soil

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Abstract

Purpose Fertilization is a vital approach to increase the crop yield by enhancing soil fertility, but some of the fertilizer sources such as pig manure contain non-essential toxic heavy metals, which can produce the environmental and public health risk. Therefore, the purpose of this study was to investigate the soil fertility and heavy metal pollution risk under long-term fertilization in acidic paddy soil.

Materials and methods Fertilizer treatments that were arranged in randomized complete block design (RCBD) included CK (no fertilization), NK (inorganic nitrogen and potassium fertilization), NPK (inorganic NK and phosphorus fertilization), NPKM1 (70% of NPK and 30% pig manure application), NPKM2 (50% of NPK and 50% of pig manure application), and NPKM3 (30% of NPK and 70% of pig manure application).

Results and discussion The rice grain yield and soil nutrient contents were highest under NPKM3 treatment. Long-term addition of manure significantly ($P \leq 0.05$) increased soil pH and SOC content compared to the NPK fertilization. Soil available and total Cr, Cd, and Hg contents were highest under NPKM3 treatments, while soil total and available Pb content was significantly ($P \leq 0.05$) higher under NPK treatment. Highest ecological risk (IR) was (1904) under NPK treatment and highest pollution load index (PLI) was 1.5 under NPKM3 treatment. Cd concentration in rice grain exceeded the maximum permissible limit of 0.1 mg kg^{-1} under combined application of manure and inorganic fertilization treatments. Grain Cr, Hg, and Pb contents were within safe limits of their concentration in all treatments. Moreover, biological accumulation coefficients of Cr, Cd, Hg, Pb, Zn, and Cu were highest under NPK treatment. Redundancy analysis (RDA) showed that soil pH and nutrient contents showed significant correlation with heavy metal concentrations in soil. Soil pH showed significant ($P \leq 0.05$) positive effect on Cd accumulation in rice grain.

Muhammad Qaswar and Liu Yirena contributed equally.

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