



Potential application of the culture materials of edible fungi to the organic rice fields: assessments of environmental risks

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Factorial cultivation of mushroom develops rapidly in Shanghai in recent years. According to statistics, the outputs of *Agaricus bisporus* (AB) and *Flammulina velutipes* (FV) attained 10,000 tons and 59,000 tons in Shanghai in 2017, respectively. With the outputs increasing, the wastes of culture materials also increase, and the reuse of them has become a headache problem. Field experiments were conducted to evaluate the risks of heavy metal contamination after applying the discarded culture materials of AB and FV to paddy fields as organic fertilizers for the consecutive years 2017-2018. The experiments had six fertilizer treatments: the culture material of AB, that of FV, cow manure, swine manure, chemical fertilizer and control (CK). A plot of the experiments was 25 m² in area, and each treatment was triplicated. The contents of Cu, Zn, Pb, Cd, Ni, Cr and Co in the culture materials of FV are 4.623 mg kg⁻¹, 48.39 mg kg⁻¹, 0.620 mg kg⁻¹, 0.198 mg kg⁻¹, 1.780 mg kg⁻¹, 1.350 mg kg⁻¹ and 0.460 mg kg⁻¹, respectively; those of AB are 9.848 mg kg⁻¹, 97.07 mg kg⁻¹, 1.870 mg kg⁻¹, 0.283 mg kg⁻¹, 9.060 mg kg⁻¹, 13.79 mg kg⁻¹ and 1.288 mg kg⁻¹, respectively. The FV culture material is mainly made of corn cob and wheat straw; while AB, chicken manure and rice straw. Cu, Zn, Ni, and Cr contents in the latter are a little higher than the former. For comparison, Cu, Zn, Pb, Cd, Ni, Cr and Co contents in the swine manure are 117.9 mg kg⁻¹, 412.6 mg kg⁻¹, 2.730 mg kg⁻¹, 0.426 mg kg⁻¹, 11.96 mg kg⁻¹, 8.160 mg kg⁻¹ and 3.080 mg kg⁻¹, respectively; and those in the cow manure are 0.560 mg kg⁻¹, 11.98 mg kg⁻¹, 0.900 mg kg⁻¹, 0.060 mg kg⁻¹, 4.900 mg kg⁻¹, 7.790 mg kg⁻¹ and 0.830 mg kg⁻¹, respectively. Affected by feed additives, the contents of heavy metals in the swine manure are higher than the AB and FV culture materials. The experiments indicated that there are no significant differences in the contents of Cd, Pb, Ni, Cr and Co in the soils for the different fertilizer treatments ($p > 0.05$). However, the contents of Cu and Zn in the soils for the swine manure treatment are significantly higher than the other treatments and CK ($p < 0.05$). Likewise, no significant differences in the heavy metals in the rice for the different treatments were observed ($p > 0.05$). The contents of Pb, Cu and Zn in the rice for the swine manure are a little higher than the other treatments and CK, but do not attain a significant level ($p > 0.05$). In short, the culture materials of AB and FV are generally cleaner than the swine manure, and returning the materials to the fields as organic fertilizers do not pose environmental hazards to the soils and rice. Promisingly, they can be applied as environment-friendly manure to the organic rice fields. This work was supported by the Agriculture Research System of Shanghai, China (Grant no. 201809).