Geophysical Research Abstracts
Vol. 16, EGU2014-16619, 2014
EGU General Assembly 2014

Heavy metal accumulation in soils and grains, and health risks associated with use of treated municipal wastewater in subsurface drip irrigation

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Constant use of treated wastewater for irrigation over long periods may cause buildup of heavy metals up to toxic levels for plants, animals, and entails environmental hazards in different aspects. However, application of treated wastewater on agricultural land might be an effective and sustainable strategy in arid and semi-arid countries where fresh water resources are under great pressure, as long as potential harmful effects on the environment including soil, plants, and fresh water resources, and health risks to humans are minimized. The aim of this study was to assess the effect of using a deep emitter installation on lowering the potential heavy metal accumulation in soils and grains, and health risk under drip irrigation with treated municipal wastewater. A field experiment was conducted according to a split block design with two treatments (fresh and wastewater) and three sub treatments (0, 15 and 30 cm depth of emitters) in four replicates on a sandy loam soil, in Esfahan, Iran. The annual rainfall is about 123 mm, mean annual ETo is 1457 mm, and the elevation is 1590 m a.s.l.. A two-crop rotation of wheat [Triticum spp.] and corn [Zea mays]) was established on each plot with wheat growing from February to June and corn from July to September. Soil samples were collected before planting (initial value) and after harvesting (final value) for each crop in each year. Edible grain samples of corn and wheat were also collected. Elemental concentrations (Cu, Zn, Cd, Pb, Cr, Ni) in soil and grains were determined using an atomic absorption spectrophotometer. The concentrations of heavy metals in the wastewater-irrigated soils were not significantly different ($P>0.05$) compared with the freshwater-irrigated soils. The results showed no significant difference ($P>0.05$) of soil heavy metal content between different depths of emitters. A pollution load index PLI showed that there was not substantial buildup of heavy metals in the wastewater-irrigated soils compared to the freshwater-irrigated soils. Cu, Pb and Zn concentrations in wheat and corn grains were within permissible EPA limits, but concentrations of Cd (in wheat and corn) and Cr (in corn) were above the safe limits of EPA. In addition, concentrations of Ni in wheat and corn seeds were several folds higher than EPA standards. A health risk index (HRI) which is usually adopted to assess the health risk to hazard materials in foods showed values higher than 1 for Cd, particularly for wheat grain (HRI>2.5). Results also showed that intake of a Cu through consumption of edible wheat grains posed a relatively high potential health risk to children (HRI>1.4), whereas children might also be exposed to health risk from Cd and Cr from corn grains (HRI>1.4). Based on aforementioned results, it can be concluded that the of emitter depth in drip irrigation does not play a significant role in the accumulation of heavy metals from treated wastewater in our sandy loam soil. Although their accumulation in the soil was limited and similar to using fresh water, uptake of Cd and Cr by wheat and corn was relatively large hence resulting in health risk. The results suggest that more attention should be directed towards cultivation of other crops with drip irrigation system for a safe and more productive use of wastewater for irrigation. Alternatively, methods that filter the wastewater before it enters the soil environment might be an option that needs further investigation.