Dynamics of Metal Distribution in Cultivated Soil and Vegetables in Vicinity to Industrial Deposition: An Inference to Chemical Contamination of Food Chain

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ABSTRACT

The present study demonstrates accumulation and distribution of heavy metals (Fe, Cr, Cd, Pb & Cu) in cultivated soil and vegetables, and its potential implication to health risk via consumption of contaminated vegetables. Deposition of atmospheric metals results significant enrichment of metal contents (Pb=1.6, Cu=1.4 & Cd=15.9) in cultivated soil. Elevated metal content in soil facilitate higher metal accumulation in growing vegetables through root uptake and also by leaf absorption. Results show noticeably higher metal translocation (>1) from soil to roots (TF_r) and shoots (TF_s), followed by higher metal accumulation in leafy shoots (except R. sativa). In sampled vegetables, estimated hazard quotient (HQ) for individual metal does not exceed the safe limit, but integrated hazard quotient (IHQ) in L. esculanta is above the safe limit (1.33) and incredibly close in R. sativa (0.97) and S. oleracia (0.93) to cause health hazard.

Keywords: Atmospheric Heavy Metals, Consumable Vegetables, Health Risk, Soil Contamination, Translocation Factor

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1. INTRODUCTION

The accumulation of heavy metals in agricultural soil and plants is of increasing concern due to food safety issues and potential health risk to local inhabitants (khan et al., 2008). Anthropogenic sources of heavy metals are associated with industrial activity and urbanization such as atmospheric deposition, waste disposal, industrial/urban effluents, vehicular exhaust and long term application of wastewater and sewage sludge in agricultural field (Bilos et al., 2001; Cui et al., 2005). Accumulation of heavy metals in consumable vegetables has been well linked with soil heavy metal and irrigation water from long back; atmospheric deposition has now been identified as one of the principal source of heavy metals entering into plants and soil especially around urban-industrial areas (Pandey et al., 2009). Atmospheric heavy metals may deposit by rain and dust, and contributed to elevated metal concentrations in surface layer of soil (Sharma et al., 2008). Heavy metals are extremely persistent in the environment; which in-turn absorbed by plant roots and subsequently mobilized to above ground vegetative parts. Leafy vegetables are known to accumulate sizable amounts of airborne metals (Voutsa et al., 1996; Pandey et al., 2009). Atmospheric metals may be absorbed directly on leafy surface, or entered through stomatal openings and accumulated within plant tissue. Metal accumulation in different plant parts depends on chemical form of metals, their translocation potential, individual species with their stage of maturity (Sinha et al., 2006). Heavy metal contamination in agricultural soil and vegetables through industrial wastewater and atmospheric source are of great concern because of metal translocation in soil-plant system and ultimately to the food chain (khan et al., 2008; Rattan et al., 2005). Thus accumulation of heavy metals in the edible parts of vegetables represents a direct pathway for their incorporation into the human food chain (Florijin et al., 1993); and therefore has drawn the attention of researchers to health risk assessment of population exposed to contaminated foodstuffs.

1.1. Study Area

Present investigation is carried out in Durgapur industrial zone (Lat long) of state West Bengal, India. This industrial region is heavily dense with a number of industries viz. Iron & Steel plants, Thermal power plants, Chemical factory and Sponge iron & Ferro alloy industries. Field sampling has been performed from cultivated fields in vicinity to Durgapur Steel Plants (DSP) and Alloy Steel plants (ASP). Although these cultivated fields are irrigated by ground water (considered the as safest source) through sub-marshar pump, but heavily contaminated by the deposition of atmospheric heavy metals on soil as well as on plant surfaces from surrounding industrial sources. Mostly garden vegetables (viz. tomato, spinach, radish etc) are produced in these contaminated fields by farmers and sell it to local market/residents. This present investigation is seek to satisfy the following objectives: i) accumulation of heavy metals in cultivated soil and vegetables, ii) metal translocation in soil–plant system, iii) and health risk assessment of heavy metals in consumable vegetables.

2. METHODOLOGY

2.1. Sample Collection and Preparation

Atmospheric heavy metal concentrations were estimated by using high volume sampler (NPM-HVS). Monitoring was performed for 12 hr duration, and sampling sites were also free from overhead obstacles which may interfere in deposition of atmospheric metals. High volume sampler was kept at 2m high to avoid ground level particles. Immediately after collection, air particulate matter was acidified with 70% HNO₃ and stored in dark at room temperature (28 ºC).

Cultivated soil and vegetable samples were collected following randomize block design method. Surface soil (0-10 cm) were collected from root zone of cultivated vegetables with the help of plastic spatula, and kept in zipped plastic bag. In laboratory, soil samples were air dried,
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