

## GEO-ACCUMULATION INDEX AND ENRICHMENT FACTOR OF TRACE METALS IN URBAN SOILS IRRIGATED BY A HIGHLY CONTAMINATED WASTEWATER DRAIN IN CHANDIGARH AND ADJACENT AREAS, INDIA

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### Abstract

Urban wastewater and soil samples from agricultural fields irrigated with wastewater from the storm water drain (commonly known as N-choe) were analyzed for heavy metals. Results reveal that the wastewater contained concentration of Fe, Ni, Mn and Cd which was higher than the permissible limits for irrigation prescribed by FAO, (1985). In this study, geoaccumulation index ( $I_{geo}$ ), enrichment factor (ER), contamination factor (CF) and pollution load index (PLI) have been applied to assess heavy metal distribution in the soils of the study area. Based on geoaccumulation index, soil in the study area is moderately to strongly contaminated with Cd and Ni. According to enrichment factor, samples showed very severe enrichment of Cd and Ni, minor enrichment of Cr, Mn, Pb, Zn. CF values of Cd and Ni were greater than 6 and PLI at 1.75 were observed indicating serious anthropogenic pollution in the study area. Elevated concentrations of Ni and Cd in the soil samples may be attributed to application of wastewater in the agricultural fields as the concentration of these heavy metals were found to be high in the wastewater. Data highlight that long-term practice of wastewater irrigation has resulted in significant buildup of heavy metals in the soil and that such elevated amounts may be transferred to the food chain causing potential health hazard to consumers.

*Keywords:* Geoaccumulation index, enrichment factor, pollution load index, soil contamination, heavy metals.

### 1. Introduction

Rapid urban and industrial developments have contributed to elevated levels of heavy metals in the urban environment of developing countries such as China (Wong, et al., 2003) and India (Tripathi, et al., 1997; Khillare, et al., 2004; Sharma, et al., 2008a, b). There is a gradual decline in the availability of fresh water used for irrigation in India. As a consequence, the use of sewage water and industrial effluents for irrigating agricultural lands is on the rise, particularly in the peri-urban areas of developing countries and there is also an increased concern regarding the exceeding statutory and advisory food standards for trace metals throughout the world. These wastewaters carry appreciable amounts of trace toxic metals (Feigin, et al., 1991; Pescod, 1992; Som, et al., 1994) the concentration of such trace metals in sewage effluents varying from city to city (Rattan, et al., 2002). Crops raised on metal contaminated soils, accumulate metals in excessive quantities enough to cause clinical problems to human beings consuming the metal enriched vegetable products. (Tiller, 1986).

Soil is the most important environmental component because it is not only the geological sink for contaminants, but also acts as a natural buffer by

controlling the transport of chemical elements and substances to the atmosphere, biosphere and hydrosphere (Pendias et al., 2001). Scarcity of water has forced mankind to use alternative, easily available and cheaper water sources. In the present study area farmers are attracted to the use of wastewater for irrigation purposes from N-choe, a water stream carrying domestic and commercial waste from the city. N-choe is highly vulnerable to pollution due to absorption and transportation of domestic and commercial wastewater and the farmers of nearby villages grow various types of vegetables unaware of the harmful effects of consumption of these vegetables grown by the application of wastewater. The present study was carried out to assess the accumulation of heavy metals in the soil around Chandigarh, India where wastewater irrigation is common.

### 2. Study Area

Chandigarh is one of the most densely populated urban centers in India and one of the fastest growing city with a total population of 10,54,686 (Census of India, 2011). It lies between north latitudes 30°40' and 30°46' and east longitudes 76°42' and 76°51'. The city of Chandigarh was declared a Union Territory (UT) in the year 1966 and is the joint capital of both Punjab and Haryana states. The