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Physico-chemical Properties and Heavy Metal Contents of Soils and Kharif Crops of Punjab, India

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Abstract

Punjab is one of the most fertile regions of India and agriculture is the main occupation of people here. Intensive agriculture is done with the help of agrochemicals throughout the year in Punjab. Sugarcane (Saccharum officinarum L.) and Sorghum (Sorghum bicolour L.) are two important crops of Kharif season in Punjab. Since the soil is under severe risk of heavy metal contamination due to anthropogenic activities in intensively cultivated areas, a study was conducted to analyze the physico-chemical parameters of agricultural soils in different villages situated around rivers of Punjab (Sutlej and Beas). The studied soils were under paddy, sugarcane and fodder plant cultivation. The soil samples were found to be slightly acidic, with sandy texture and low amount of soil organic matter. Soil nutrients such as nitrogen (N), phosphorous (P) and potassium (K) ranged from 0.10 - 0.35 g/kg, 0.033 – 0.084 g/kg and 1.118 – 1.436 g/kg respectively. The contents of heavy metals (Cr, Cu, Cd, Co and Pb) analyzed in soil samples were below the maximum permissible limits, but Cr, Cd and Pb contents were above maximum permissible limits in sugarcane and sorghumm. Soil to plant metal bioaccumulation factor (BAF) was found to be ~1 for Cu in sugarcane and above 1 for Pb in sorghum.

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Keywords: Physico-chemical characteristics, heavy metals, soil nutrients, bioaccumulation;

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1. Introduction

Heavy metal contamination of soil due to various anthropogenic activities has become a major cause of concern throughout the world. The increase in levels of heavy metals such as Cr, Cu, Co, Cd and Pb in arable soils due to application of agrochemicals and contaminated irrigation water led to deterioration of soil health (Rayment et al., 2002; Kaur et al., 2014). From soil, the heavy metals are taken up by food and fodder plants. Although metals such as Cr, Cu and Co etc. are essential for plant metabolism, but at levels exceeding food and fodder safety levels, they pose sever health risk (Wang et al., 2012; Katnoria et al., 2011). Heavy metal contents in soils and crops are dependent on the soil physico-chemical properties, cropping practices, availability and species of metal in soil, solubility of metals in soil and type of plant (Sinha et al., 2006; Dheri et al., 2007).

Punjab is one of the most agriculturally active regions of the India. Due to the availability of irrigation water from perennial rivers (Sutlej and Beas) and fertile soils, intensive cropping is done throughout year. Both groundwater and surface water are used for irrigation. Sugarcane (*Saccharum officinarum* L.) and Sorghum (*Sorghum bicolour* L.) are major crops of Khaif season in Punjab. Sugarcane is a C4 plant with good photosynthetic capability. It is a major raw material for the sugar and fermentation industries of Punjab. Sorghum is a major fodder crop of kharif season. It is a high biomass producing plant with low nitrogen fertilizer requirements and high tolerance to various environmental conditions (Oh et al., 2015). Punjab pioneered in green revolution by adopting agrochemicals and modern techniques for agriculture. But excessive use of these agrochemicals and polluted irrigation sources has resulted in heavy metal contamination of the soils of Punjab. Therefore a study was conducted in intensively cultivated areas around rivers to assess physico-chemical properties of agricultural soils and heavy metal bioaccumulation of in sugarcane and sorghum grown in these areas.

2. Material and Methods

2.1 Study area

The state of Punjab (Lat. 29º30 to 32º32´N and Long. 73º55 and 76º50´E) is located in the north-western part of India bordering Pakistan. . The annual rainfall in Punjab is 435.6 mm and has a continental, semiarid to subhumid climate with two main crop seasons Kharif (fall) and Rabi (spring). Six villages were selected for sampling which are situated on the banks of rivers Beas and Sutlej. The geographical coordinates, codes and studied crops in each village are given in Table 1 and Figure 1 shows the map of studied area.

2.2 Sampling and preparation

Soil sampling was done during the Kharif season (September - October 2013). From each site composite soil samples in triplicates were collected from fields under Sugarcane and Sorghum cultivation. At least five subsamples of soil were pooled to form a composite sample. Soil samples were taken from depths of 0-15 cm. Composite samples of Sugarcane and Sorghum (Shoots) were collected in triplicates from corresponding soil sampling fields from each site for heavy metal analysis. All soil and plant samples were stored in clean polythene bags and were brought to the laboratory. The soil samples were air-dried, ground and passed through 2 mm sieve for physico-chemical and heavy metal analysis. The Sugarcane and Sorghum shoot samples were washed with deionised water, oven dried at 70 °C and then grounded to fine powder with pestle mortar.

2.3 Physico-chemical analysis of soil samples

The soil pH and conductivity were determined determined in 1:5 soil:water suspension using HM digital meter-COM-100 (New Delhi, India) and Equip-tronics EQ-614-A (Mumbai, India), respectively. The mixture was shaken for 2 hours and the supernatant was filtered and used for measurement. Soil texture and organic carbon content were determined by Hydrometer method (Jacob and Clark, 2002) and Walkley Black wet oxidation method (Nelson and Sommers, 1982) respectively. A factor of 1.72 was multiplied with organic carbon content to determine Soil Organic Matter (SOM). EDTA titration method was used for measuring Calcium (Ca) and Magnesium (Mg) (Lanyon and Heald, 1982), acid neutralization method for $CaCO_3$ (Hesse, 1971) and potassium (K) and sodium (Na)