Bio-Accumulation of chromium in *Raphanus sativus* irrigated with highly chromium contaminated water

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ABSTRACT

Chromium is a heavy metal which leads to environmental hazards. The growth of plant and development is effected by toxicity of Chromium. Now a day the soil and groundwater are getting highly contaminated with chromium (Cr) due to many tannery and chemical industries effluent**.** The soil and groundwater are getting highly contaminated with chromium (Cr) due to many tannery and chemical industries effluent. The indiscriminate disposal of tannery and chemical wastes is the main cause of chromium contamination in soil and groundwater. It has been reported that most (>90%) of the soil samples nearby these industries has high concentration of Cr (>200 mg kg^{-1}) which exceeds the maximum permissible limit prescribed by many Environmental Protection Agencies. The Cr contaminated soil and water has exhibited greater risk in terms of both salinity and solidity hazards and was found unsuitable for both human consumption and irrigation purpose as it will lead to carcinogen & mutagen in human body. In this present study, Radish (*Rapahanus sativus*) plants have been grown in uncontaminated soil and highly Chromium contaminated water has been supplied as irrigation during the growing period. The variation of Bio-accumulated Chromium during initial growth period in different parts of Radish plant (i.e. root and leave) has been analyzed and studied. The morphological study has been done after during this period. The growth rate has been retarded with contaminated water irrigation. The yield of biomass in root and leave has been decreased to 33. 33% and 23.52% respectively. Similarly the width and length of leave and root has been decreased considerably

KEY WORDS: Chromium contaminated, Bio-accumulated Chromium, Growing period, un contaminated soil.

1. INTRODUCTION

Chromium (Cr) is a hard metallic element. Mineral chromites are the only ore of chromium. It is also geologically available on the earth crust of around 20 to 140 mg/kg. Therefore, apart from the natural occurrence, large quantities of chromium are discharged into the waste water from these industries. It is used widely by many industries all over the world such as aircraft painting, pesticide application, leather tanning, textile manufacturing, metal finishing, dyeing, cement industries etc. The chromium contamination in such area would be very high due to release of effluent.

Industrial development may lead to more heavy metal dispose to the environment (Adriano 2001). Due to the bio-accumulation capacity most of the heavy metals are highly toxic, carcinogen & mutagen when ingested by human (Praveena, 2013). The disposed heavy metals lead to the freshwater which used for irrigation for crops (Wajahat, 2006). It has been documented that crop/vegetables irrigated with heavy metal contaminated water may hyper accumulate heavy metal which may pose threat to the human when the crop vegetable is consumed (Arora, 2008). Hence it is up most important to identify the heavy metal accumulation in particular crop/vegetables when irrigated with contaminated water (Gowd, 2005). Though the oxidation state of the chromium can be altered by the soil environment condition & the toxicity depends on the oxidation state, the study of the mobility & bio-ability of the chromium is required to access the risk of contamination status and remedial alternatives (Rangasamy, 2015). Hence, the objective of this study is todetermine the Bio-accumulated chromium in *Rapahanus sativus* during initial growth stages in different parts of Radish (i.e. root and leaves).

2. MATERIALS AND METHODS

Collection and Sampling of soil and seed: Soil samples were collected from the agricultural field, where Radish plant has been grown previously. Radish Seeds have been collected from different stores in Vellore. The textural classification of the collected soil has done through sieve analysis. The particle size distribution curve has been shown in Fig.1. Specific gravity of soil has been determined to know the characteristic of the collected soil. The soil is found to be sandy loam mixed with organic content and uniformly graded, which is very much suitable for radish growth. The chemical properties of the collected soil sample have been analyzed for pH, Electrical Conductivity and Chromium before taking final decision. The test has been done as per ISO 9001:2000 (Irrigation Research and Development, 2009). The concentration of Chromium in soil was found to be 36.89 mg/ kg of dry soil which is less than permissible limit (Table.1). The seed sample were also tested for initial Chromium concentration before sowing and shown in Table.1.

Table.1. Preliminary analysis of Chromium concentration in soil and seed sample

Soil sample	Concentration (mg/kg)
Soil 1	36.89
Soil 2	37.84
Seed 1	0.338
Seed 2	0.486
Seed 3	0.480
Seed 4	0.256

It is shown from Table.1 that the chromium content in the soil samples is very less. For this above result we have selected Soil sample 1 as the chromium content in this sample is less compared to soil sample 2 therefore we have chosen the soil sample as per the give data. Similarly, initial chromium concentrations in seed samples were found to be very less. Among the four, sample 4 has the lowest chromium concentration. Hence, it has been selected for germination.

There are many methods available to extract heavy metals from soil, but in this study acid digestion method was chosen to do the analysis as it is the easiest method to conduct.

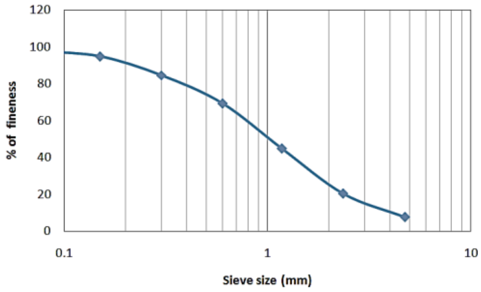

Figure.1. Particle size distribution curve

Experimental Setup: Radish generally grows with 30 cm row spacing and 5 cm plant spacing. Based on this glass aquarium of dimension 60 cm x 30 cm x 40cm has been chosen to grow 6 plants in two rows (Fig. 2). To drain out excess water after saturation from aquarium, 6 holes with 18 mm diameter have made on the bottom surface. The holes are made as such they will lay below the root zone.

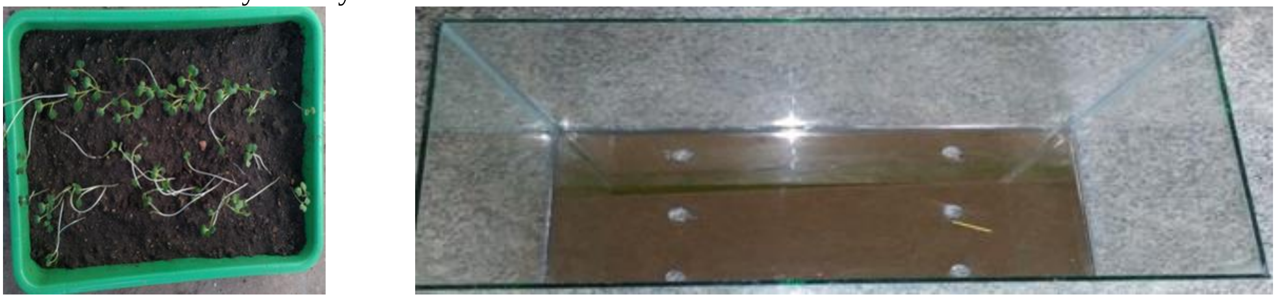

Figure.2. Germinated seeds and glass aquarium used as the experimental set up

Crop Water Requirement: Water required by crop for its survival throughout its growth till maturity. This requirement is fulfilled either in natural way by precipitation or artificially through irrigation. The amount of water required by crop is called as crop water requirement or crop evapotranspiration and can be calculated by:

$$ET_c = ET_0 \times K_c \qquad (1)$$

Where ET_C= Crop Evapotranspiration (mm/day); ET_0 = Reference Evapotranspiration (mm/day); K_c = Crop factor.

The reference evapotranspiration can be estimated by Penman Montieth Equation (FAO 56). The amount of water supplied as irrigation for both contaminated as well as uncontaminated has been decided by crop water requirement.

3. RESULTS AND DISCUSSION

Crop water requirement for radish crop: The crop coefficient for different growth stage is different and it is 0.7, 0.85, 0.9 and 0.7 during initial, development, mid and late stage in Radish (Richard, 1998). Based on this crop factor the crop water requirements for different stages were calculated by using Eq.1. The required amount of water was given to the both the aquarium i.e. one with contaminated water and another without contaminated water as daily irrigation requirement. After 30 days of transplanting the radish plants were uprooted and the study of biomass accumulated and bioaccumulation of chromium in roots and (leaf + Stem) have been done and presented in Fig.3 and Table.2 respectively.

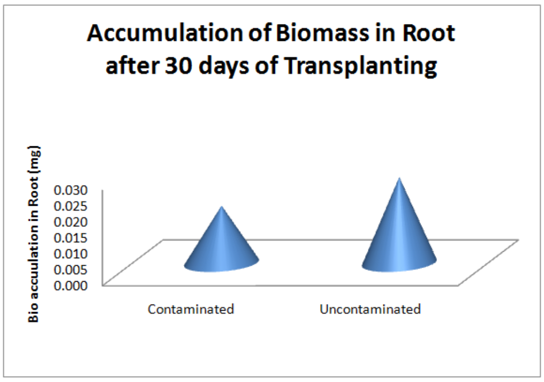

Figure.3. Accumulation of Biomass in Root

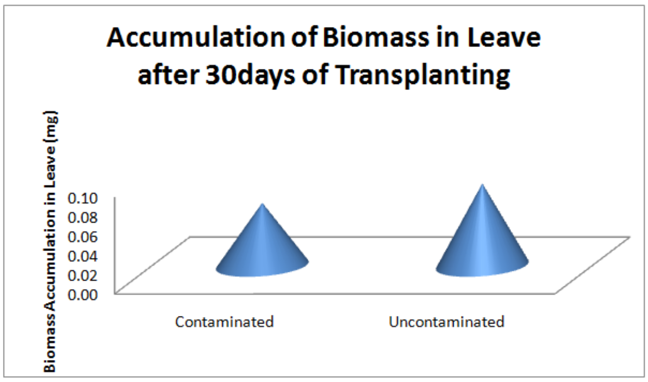

Figure.4. Accumulation of Biomass in Leave

Table.2. Bioaccumulation of chromium in radish plant

Plant tissues	Chromium Concentration (mg/Kg dry weight)	
	Irrigated with contaminated water	Irrigated with Uncontaminated water
Root	279.17	31.79
Stem + Leave	71.77	4.17

To know the effect of chromium in radish plant growth a morphological study has been done and presented in Table.3.

Table.3. Morphological study of the Radish plant

Parts of the Radish plant	Contaminated	Uncontaminated
Length of Root (cm)	5	7
Length of leaves (cm)	3	6
Diameter of Leave (cm)	1	2

From these results it shows that the growth rate of Radish is getting deteriorated both in root as well as leaves, if the Chromium contaminated water is given as irrigation at the rate of 0.0831mg/L. The decrease rate in yield of biomass in root is 33.33% and in leaves it is 23.52%. Similarly foliage decrease in leave is 48.3% and 50% in length and diameter respectively. In case of length of root it decreased to 33.33%.

Bio-accumulation of Chromium in different parts of wheat has been studied (Marius, 2009). The accumulation rate was more in root and less in leaves as it is found in case of radish (Table.2). In literature in different plants in different growth stages Chromium accumulation has been studied (Habib, 2011). It has shown that Chromium accumulation is more during the mid-stage. In this study as radish has been uprooted before maturity. Hence, the complete study of bio-accumulation in different stage has not been done so far. But, it can be anticipated as the literature said as it has seen for different parts of radish.

4. CONCLUSION

From this study it can be conclude that the growth rate of the root and leaves is getting retardation by applying contaminated water as follow:

- The yield of biomass in root and leaves decreased by 33.33% and 23.52% respectively till 30 days after transplanting.
- The aerial parts i.e. length and width of leaves have decreased by 48.3% and 50% respectively, till 30 days after transplanting and length of root has decreased by 33.33%.
- The bio accumulation of Chromium in Radish plant in different stage can be anticipated as previous studies have done for other crops.

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