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Effects of organic and inorganic amendments on bio-accumulation and partitioning of Cd in *Brassica juncea* and *Ricinus communis*

Kuldeep Bauddh [a], Rana Pratap Singh [b,*]

[a] Centre for Environmental Sciences, Central University of Jharkhand, Brambe, Ranchi 835205, India
[b] Department of Environmental Science, B.B. Ambedkar University, Lucknow 226025, India

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ABSTRACT

The effects of different fertilizer amendments on cadmium (Cd) uptake and growth of Indian mustard (*Brassica juncea* L.) and castor bean (*Ricinus communis* L.) were investigated in this experiments. The application of vermicompost, un-entrapped and entrapped forms of inorganic fertilizers (i.e., urea and diammonium phosphate; DAP) and bio-fertilizers (*Basillus subtilis* and *Azotobacter chrocoocum*) to the soil caused significant increase in the fresh and dry biomass of roots and shoots of both the species. Protein and proline content in the plant leaves increased with the application of these fertilizers, however, the level of malondialdehyde (MDA) got decreased. Application of Cd caused decrease in protein content which was found to recover with the amendments of these fertilizers. However, proline content was found increased with application of the fertilizers in both presence and absence of Cd in both the plants. Increased MDA content in Cd treated plants was reduced when these fertilizers were applied to the soil. Application of un-entrapped inorganic fertilizers and bio-fertilizers increased Cd uptake in the roots and shoots of both the species whereas, vermicompost and entrapped forms of these fertilizers decreased the metal accumulation. *R. communis* was found to be more tolerant and extracted higher amount of Cd than that of *B. juncea*. Accumulation of the metal was further increased by the application of fertilizers especially inorganic fertilizers by *R. communis*.

1. Introduction

Cadmium contamination in the soil has steadily increased in last few decades because of mining, smelting, irrigation with industrial wastewater, electroplating, and use of chemical fertilizers and pesticides (Ghosh and Singh, 2005; Zhang et al., 2010). Many physical approaches like electrodialysis, leaching, stabilization and land filling, used for the remediation of heavy metals (Bayat and Sari, 2010) are expensive and does not protect the ecosystem adequately (Ghosh and Singh, 2005). Phytoremediation, a plant based remediation system, has emerged as an economical, eco-friendly and aesthetically acceptable technology in the recent years (Huang et al., 2011; Bauddh and Singh, 2012a,b; Santana et al., 2012; Witters et al., 2012; Olivares et al., 2013; Pandey, 2013; Kumar et al., 2014a). Phytoremediation is a natural and effective technique however, the process has been found to take substantial years. To address this, scientists are using chemical amendments which are found to accelerate the bioaccumulation of heavy metals to some extent (Huang et al., 1997; Liphadzi et al., 2003; Garba et al., 2012a,b). Many chelants such as EDTA (ethylenediaminetetraacetic acid), CDTA (*trans*-1,2-diaminocyclohexane-*N*,*N*,*N*′,*N*′-tetraacetic acid), EDDHA [etylenediamine-di (*o*-hydroxyphenylacetic acid)], etc. have been applied to obtain higher efficiency in accumulating heavy metals in the plant parts (Grčman et al., 2003; Meers et al., 2005; Lin et al., 2009; Wang et al., 2009; Garba et al., 2012a,b). These chemical constituents may alter the physicochemical and biological properties of soil. The *in-situ* application of chelants may pose the potential risk of causing groundwater pollution through uncontrolled metal solubilization and migration (Nowack 2002; Romkens et al., 2002; Madrid et al., 2003; Chen et al., 2004). It has been reported in many studies that the application of these chemical chelants decrease yield of plants (Blaylock et al., 1997; Chen et al., 2001). In this aspect, researchers have suggested the use of fertilizer as chelating material to enhance the bioavailability of heavy metals for their uptake from the soil (Blaylock et al., 1997; Prasad and Freitas, 2003). Application of different inorganic and organic fertilizers in metal contaminated soils improve the soil fertility, physico-chemical and biological properties and increase the biomass of plants which may result higher efficiency in extraction of the toxic metals by plants (Zaccheo

* Corresponding author. Tel.: +91 9889121823.
E-mail addresses: kuldeepenvir0811@gmail.com (K. Bauddh), ranapsingh1@hotmail.com (R.P. Singh).

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