Article id: jae.2017.1.2.3
Journal of Agriculture and Environment, 2017, 1-2
doi: 10.23649/jae.2017.1.2.3
Advance Access Publication Date: 05 April 2017

POLLUTION

CHELATE-ASSISTED PHYTOEXTRATION OF HEAVY METALS FROM SUBSTRATUM, COMPOSED ON THE BASIS OF SEWAGE SLUDGE

Conflict of Interest

None declared.

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Abstract
The three-year field experiment was conducted on treatment facilities of town Istra to test chelate-assisted phytoextraction of Cd, Cu and Zn using EDTA and safflower dyeing (Carthamus tinctorius L.) on substratum, composed on the basis of sewage sludge. Chelating agent EDTA applied in rates accordingly 1; 3 and 6 mmol/kg onve and annually according to the scheme of experiment. EDTA, applied in rates 1 and 3 mmol/kg of substratum improves parameters of plants' productivity. In all investigated application rates EDTA increases bioavailability of metals in the substratum and raises accumulation and uptake of pollutants by plants from substratum. In variants with annual application of EDTA in rates 1 and 3 mmol/kg the highest accumulation and removal of pollutants by plants are registered.

Keywords: *sewage sludge, heavy metals, EDTA, phytoextraction, plants, rhizosphere, substratum (ground)*

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1 Introduction

Large quantity of sewage sludge is being amassed inside treatment facilities in Russia and the CIS countries. This liquid concentrated waste at overflow of sludge lagoon, drying bed and sludge pond is dumped in the nearest lowlands and is source of pollution for water reservoirs (Zubko et all, 2010).

Sewage sludge is expedient for applying in agriculture and forestry, in gardening and other spheres of human activity as cheap agrochemical filling agent and as a nutritious substratum when mixing with soil. However, the maximum use of sewage sludge by increase its share as a part of a substratum is hindered due to high concentrations of heavy metals.

Phytoextraction is innovative, novel and potentially inexpensive technology using higher plants for *in situ* decontamination of metal-polluted soils, sludge and sediments. By adding a chelating agent, e.g. EDTA, into the soil (substratum) under the plants with well developed biomass, the bioavailability of the heavy metals in soil (substratum) as well as their uptake by plants can be enhanced considerably (Wenzel, 2003).

2 Material and Methods

In 2010-2012 on a field site of Treatment Facilities of town Istra, Moscow region, the method of induced phytoextraction with application of chelate-forming agent EDTA was applied.

As a plant-accumulator of heavy metals was used Safflower dyeing *(Carthamus tinctorius L.),* which forms high biomass.

Chelating agent – *(Na_2EDTA),* disodium compound of *ethylenediaminetetraacetic acid* (further EDTA) - was applied in various rates according to the experiment scheme.

In experiment the vessels containing 6 kg of dry substratum (ground) were used, which were buried into the ground.

The investigated substratum was a sewage sludge mixed with wood sawdust (2:1). Properties of the substratum were as follows: total: N - 2,35%, P – 0,48% and K – 0,25%; pH=6,2; total: Pb – 19,30, Cd – 3,45, Co – 1,56, Cu – 164,6, Zn – 587,0, Al – 6260 and As – 1,57mg/kg.

The experiment consisted of 14 variants with four-multiple replication. EDTA in variants III - VIII, in rates accordingly 1; 3 and 6mmol/kg was applied once in summer 2010. In variants IX - XIV EDTA was applied in the same rates - annually (summer 2010, 2011 and 2012) according to the scheme of experiment. In 2012 the scheme of the experiment was: I – non-planted control 0 EDTA; II – planted control 0 EDTA; III – non-planted 1 EDTA; IV – planted 1 EDTA; V – non-planted 3 EDTA; VI – planted 3 EDTA; VII – non-planted 6 EDTA; VIII – planted 6 EDTA; IX – non-planted 1+1+1 EDTA; X – planted 1+1+1 EDTA; XI – non-planted 3+3+3 EDTA; XII – planted 3+3+3 EDTA; XIII – non-planted 6+6+6 EDTA; XIV – planted 6+6+6 EDTA.

Annually ground and plant's (shoots and roots) samples were collected from the vessels after harvest and analyzed for concentrations of metals Cd, Cu and Zn using atomic absorption spectrophotometer «Perkin-Elmer».

Statistical analyses of experimental results were carried out using MS Excel.

3 Results and discussions

3.1 Influence of EDTA on productivity of plants

EDTA in small rates 1 and 3 mmol/kg of ground (variants IV and VI) rendered stimulating effect on the plants.

Decrease in weight of plants and chlorosis on leaves of plants were registered at the EDTA rate 6mmol/kg of ground, especially at its annual application (variant XIV).

3.2 Influence of EDTA on metal mobilization in ground and on phytoextraction capability

The analysis of ground has shown that phytoavailability of metals Cd, Cu and Zn in substratum increases at increase in rates of EDTA and multiplicity of its applications. The concentrations of plant-available metals in rhizosphere-ground were higher than in bulk-ground. The EDTA stimulates root exudation and enhances accumulation of metal-EDTA complexes in rhizosphere (Wenzel, 2003).

Increasing application rates and multiplicity of applications of EDTA considerably enhance accumulation of all investigated metals by plants. Increase of metals' accumulation by plants under the influence of EDTA confirmed by (Wenzel, 2003, Avtukhovich, 2010).

In conditions of our experiment Cd and Zn accumulated mainly in shoots, while Cu – in roots of safflower plants (Figure 1).

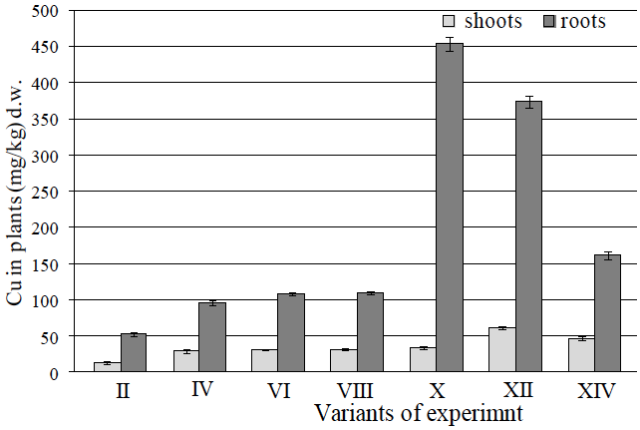

Fig. 1 – Influence of EDTA application to ground on Cu concentrations in shoots and roots of *(Carthamus tinctorius L.)* in 2012.

Variants X and XII - with annual application of EDTA in rates 1 and 3 mmol/kg of ground appeared the most effective considering phytoextraction capacity of safflower plants. In these variants the highest uptake and accumulation by plants of Cd, Cu (Figure 1) and Zn were registered.

Conclusion.

EDTA increases bioavailability of metals in the ground, considerably raises accumulation and uptake of pollutants by plants as well as improves parameters of plants' productivity in certain application rates.

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