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Preliminary Assessment of Mixed Plants for Phytoremediation of Chromium Contaminated Soil

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Abstract

This study determined the ability of mixed plants of *Helianthus annuus*, *Zinnia elegans*, and *Impatiens balsamine* to remove chromium (Cr) from soil. This research used respirometer to measure the respiration rate of microorganisms in soil media and Atomic Absorption Spectophotometry to measure Cr content on soil and plants. The results of the study showed that the plants were able to remove Cr from the soil as much as 74%. However, the removal enhanced by microbial activity on the rootzone.

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Keywords

Chromium removal, Contaminated soil, Mixed plants.

Introduction

Heavy metals enter into the environment through natural and anthropogenic sources such as mining, smelting, electroplating, mud disposal, industrial disposal, and others.[1] One of the heavy metals produced by an anthropogenic source and can contaminate the soil is chromium (Cr). Cr pollution may result from leather tanning, steel industry, and fly ash.[2] Although Cr in low concentrations can increase plant growth, the excess concentration of Cr in animals and plants is highly toxic and can cause cancer and teratism.[3] A possible method to overcome the problem of Cr pollution is to use a plant that is phytoremediation. The phytoremediation method has more potential because it has advantages as an economical and environmentally friendly method.[4] Plants that can be used in phytoremediation should be easy to obtain and easy to grow. Local plants can have the ability as a hyperaccumulator plant. In this study used local plants that are easy to grow and obtain in Surabaya, namely *Helianthus annuus* L., *Zinnia elegans* L., and *Impatiens balsamina* L. either with individual or mixed planting arrangements.

Microorganisms found in the soil have a major influence on plant growth. Carbon dioxide results from the respiration of microorganisms as one of the photosynthetic material of plants. The activity

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of microorganisms in the soil is also capable of producing growth hormones namely auxin, gibberellins, and cytokinins that are capable of spurring growth and root culture so that food search areas are wider.[5] With the addition of organic matter, the biomass of microorganisms increases so as to stimulate the increase of microorganism activity. This study also tested the effect of adding organic materials to microbial activity in the soil media used. Given this research, it is expected to determine the ability of plant mixture to remove Cr in the soil.

Methods

General

The idea of research is obtained from literature studies related to the amount of heavy metal waste pollution on the ground. From the problem obtained the research idea that this study discusses the ability of mixed *H. annuus*, *Z. elegans*, and *I. balsamina* in removing Cr, the presence of Cr pollutants in the soil, and the addition of glucose ($C_6H_{12}O_6$) in the soil. *H. annuus*, *Z. elegans*, and *I. balsamina* are used; variation of plants in 1 reactor; addition of glucose ($C_6H_{12}O_6$) to the soil media. While the parameters tested is the respiration of microorganisms in the soil in the form of CO_2 concentration (ppmV) by using CO_2 meter. Chromium concentrations of pollutants in soil, and in each plant.

Preliminary Research

Range finding test is performed to establish the maximum concentration range of heavy metals that remediation can be processed by plants. Range Finding Test is done by planting the seeds of each plant on cotton that has been previously given Cr pollutants. Contaminants are given at 5 different concentrations with a maximum concentration of 30 mg/kg, for each type of plant. Selected concentrations with a higher percentage of plant life.

Main Research

The study was conducted by planting three plants according to the planned variation of planting arrangement. In each variation of planting, repetition is done 3 times. In this study also made a control reactor to measure the removal of Cr pollutants by microorganisms in the soil. In addition, the purpose of providing a control reactor is to know the balance sheet of pollutant.

Each reactor contains 8 kg of garden soil and organic fertilizer in a 3: 1 ratio that has been mixed to homogeneous. Cr concentrations are added in accordance with the results of the range finding test previously performed.

Results and Discussion

Maximum Concentration of Pollutant for Phytotreatment

Range finding test (RFT) was conducted to determine the concentration of contaminants on planting medium that can be used by plants to live.[5,6,7] In this study, RFT was performed by planting seeds of each plant on sterile cotton media that has been given pollutants. The reactor used in the form of 50 ml beaker glass that has been filled with cotton media as much as 3 grams. The concentrations of contaminants added to the cotton medium are $K_2Cr_2O_7$ 0 mg/L (aquadest), 5 mg/L, 10 mg/L, 20 mg/L, and 30 mg/L. It contains the seeds of three plants on separate reactors. In the reactor for the plant *H. annuus* is filled with seeds of 3 seeds, for *Z. elegans* plants filled with seeds of 5 seeds, and for plants *I. balsamina* filled seeds of 7 seeds Observations for RFT were performed for 7 days, with physical observation data and for the number of live seeds in each reactor. From the observation result obtained live percentage of each plant and each pollution concentration.

The average live percentage is calculated for each concentration by averaging the percentage of plant life with the same pollutant concentration. The average life percentage calculation was performed to obtain a somewhat used percentage in the main study, ie concentration with the highest percentage. This study found 30 mg/L concentration as $K_2Cr_2O_7$ contaminant concentration for the main research.

Microbiological Processes

There is an influence on CO_2 production (which shows the microbial activity on the soil) by the presence of Cr pollutants on the soil media. CO_2 concentration is influenced by soil organic matter content, soil temperature, oxygen availability, and nutrient availability as external factor, while influencing internal factors are root biomass and microorganism population.[8]

After the third week of microbiological activity studies on the roots or on the reactor medium decreases and the chemical processes are more influential. Microbiological processes that occur in the root zone reduced contaminants on the soil through microbial activity. The chemical process indicated in the form of rhizofiltration is the contaminant adsorption at the root through the difference in ion charge between the ionic soil and the root ion.[9]

Chromium Removal by Mixed Plants

The highest Cr removal capability is present in the reactor with a mixture of two *H. annuus* plants and *I. balsamine* in a reactor with a glucose-enhanced medium of 74%. Glucose as a supply of organic carbon sources in plants affects the microbes that live on the roots, thus supporting the rhizodegradation process.[9] In addition, the density factor in the plant is also indicated as one of the factors causing the difference of Cr pollination removal ability at the reactor. The density of the plant has an effect on the decrease of Cr concentration on the tannery leather waste.[10] The decrease of Cr with optimum result that is at plant density with mixture of 2 plants (4 individuals) yield higher percentage of removal.

Conclusion

The capability of Cr removal by plant at the highest is 74%, present in reactor with mixture of *H. annuus* and *I. balsamina*. There is an effect of Cr content on media on different CO_2 concentrations, i.e, reactor with scratchy media Cr measured CO_2 concentration has a higher tendency than reactor with non-pollutant media. There is an influence on the addition of glucose to the media, ie the biological activity of the media is higher until the third week of the study.

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