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Optimization of phytoremediation technologies for eliminating manmade pollution

Abstract

Relevance of the research

In recent decades, the pace of industrial activity has accelerated, leading to industrial accidents and significant environmental pollution. The sites of former mining and chemical industrial facilities, along with the surrounding areas, serve as hotspots for environmental contamination by industrial pollutants. Heavy metals figure prominently among these pollutants; they can accumulate in soil horizons and leach into surface and groundwater. This results in gradual changes to chemical composition, the disruption of geochemical environmental integrity, and increased adverse impacts on biotopes.

Various technologies have been proposed to address this problem. However, most of these methods entail limitations associated with the risk of re-contaminating the soil. For instance, the application of physical and chemical techniques can lead to secondary environmental pollution.

Phytoremediation technologies offer the advantage of utilizing biological processes that reduce the concentration and/or bioavailability of pollutants, thereby facilitating the natural recovery of soils and aquatic environments. Research indicates that phytoremediation—classified as a "soft" technology—holds immense potential for environmental remediation.

Phytoremediation technologies represent an environmentally effective, non-invasive, and sustainable approach to removing heavy metals from soils and water bodies, suitable for large-scale application. Based on the ability of plants to hyperaccumulate metals, a phytoremediation technology known as "induced phytoremediation" is being developed; this process involves the intensive uptake of metals by plant roots and above-ground parts through the use of a complex of additives, followed by the processing of the plant biomass. The use of chelating additives can

enhance the efficiency of this process by both converting metals into bioavailable soil fractions and increasing the rate of metal translocation into the plants.

The degree of development of the research

A literature review revealed that research into metal accumulation in plants has reached a certain level, but a number of unresolved issues remain. It has been established that the key problem is that heavy metals are not involved in plant metabolic processes and are not essential for their vital functions. When absorbing high concentrations of these elements, there is an urgent need to support plant growth and development. The solution to this problem lies in the comprehensive use of functional and growth-regulating additives in combination with chelating agents, which specifically enhance the rate and efficiency of metal absorption.

The purpose of the work

Optimization of phytoremediation technologies for treating heavy metal environmental pollution.

The research tasks:

1. Comparative analysis of the effectiveness of plants and chelating additives used in phytoremediation technologies.

2. Development of methods to optimize phytoremediation technologies for the remediation of heavy metal environmental contamination.

3. Development of measures to protect and preserve habitats during the remediation of heavy metal environmental contamination.

4. Optimization of phytoremediation technologies for the protection and preservation of habitats in the Usolye-Sibirskoye urban district.

Scientific novelty of the research

To optimize phytoremediation technologies, the following have been proposed for the first time:

1) complexes of additives—chelating (dipotassium salt of hydroxyethylidenediphosphonic acid, monoethanolamine salt of disubstituted 2,2'-(ethylenedithio)diacetic acid, iron chelate of the ethylenediamine-N,N'-o-hydroxyphenyl-N,N'-diacetic acid salt), growth-regulating (indole-3-butyric and gibberellic acids,

monopotassium phosphate), and functional (potassium humate, diatomite, exogenous phytohormones, trace element concentrate supplemented with CuK_2EDTA, MnK_2EDTA, ZnK_2EDTA)—characterized by high rates of heavy metal uptake (AF > 1) and biomass growth in plants, thereby enabling the protection and preservation of biotopes;

2) the use of carbon fiber applied to plant roots as a carrier for chelating additives (dipotassium salt of hydroxyethylidenediphosphonic acid, disodium salt of ethylenediaminetetraacetic acid) in aquatic environments.

Practical significance of the research

1. New complexes of chelating, growth-regulating, and functional additives have been developed, enabling the effective optimization of phytoremediation technologies for biotopes located within the Russian Federation.

2. Novel methods have been developed to optimize phytoremediation technologies for the remediation of environmental contamination by heavy metals.**Provisions for defense**

The results are submitted for defense:

– methods for optimizing phytoremediation technologies,

– the effectiveness of complexes comprising chelating agents (dipotassium salt of hydroxyethylidene diphosphonic acid; monoethanolamine salt of disubstituted 2,2'-(ethylenedithio)diacetic acid; iron chelates of ethylenediamine-N,N'-o-hydroxyphenyl-N,N'-diacetic acid) and plant growth regulators (indolyl-3-butyric acid, gibberellic acid, monopotassium phosphate), as well as the impact of additives such as potassium humate, diatomite, exogenous phytohormones, and trace elements (CuK_2EDTA, MnK_2EDTA, ZnK_2EDTA) on the relationship between plant characteristics and metal accumulation,

– the effectiveness of using carbon fiber as a carrier for chelating agents (dipotassium salts of hydroxyethylidene diphosphonic acid; disodium salt of ethylenediaminetetraacetic acid) in the remediation of metal-contaminated water bodies,

– proposals for optimizing phytoremediation technologies to address environmental pollution specifically metal contamination and recommendations regarding measures for the protection and preservation of biotopes.