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РОЛЬ ОТХОДОВ В ДЕТОКСИКАЦИИ И ПОВЫШЕНИИ УРОЖАЙНОСТИ СЕЛЬСКОХОЗЯЙСТВЕННЫХ КУЛЬТУР

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В работе представлены результаты лабораторных и полевых исследований по изучению детоксикации сероземной почвы от продуктов техногенеза и повышения ее плодородия. Исследования проведены с использованием удобрительно-мелиорирующего состава, включающего сероперлитсодержащий отход сернокислотного производства и вермикомпост. Установлено положительное влияние данного удобрение-мелиоранта на рост и развитие корнеплодных (картофеля, свеклы, моркови, редьки) и кормовых (клевер) культур. Показана возможность применения рассматриваемого состава для получения экологически чистых сельскохозяйственных продуктов. На основе проведенных экспериментальных лабораторных и производственных испытаний найден оптимальный путь применения смеси вермикомпоста и сероперлитсодержащего отхода сернокислотного производства под кратким названием «Вермисер» в качестве удобрения-мелиоранта в сельскохозяйственной практике. При обработке препаратом «Вермисер» семян моркови и свеклы происходило увеличение корневой системы растений, площади листовой поверхности, ускорение процессов фотосинтеза. При этом фотосинтез как основа роста и развития растений, накопления химических соединений и, следовательно, биомассы может быть связана с другими физиологическими показателями, в т.ч. изменением химического состава. «Вермисер» повышает количество, качество и товарный вид продукции, что важно для производства продовольственных корнеплодных культур – картофеля, свеклы, моркови и редьки.

Ключевые слова: удобрение-мелиорант, сероперлитсодержащий отход, детоксикация, плодородия, вермикомпост

ROLE OF WASTE IN DETOXICATION AND INCREASING YIELD OF AGRICULTURAL CROPS

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The paper presents the results of laboratory and field studies on the detoxification of gray soil from the products of technogenesis and increase its fertility. The studies were carried out using a fertilizer and reclamation composition, including sulfur-perlite-containing waste from sulfuric acid production and vermicompost. The positive effect of this fertilizer-meliorant on the growth and development of root crops (potatoes, beets, carrots, radishes) and fodder (clover) crops has been established. The possibility of using the composition in question to obtain environmentally friendly agricultural products is shown. on the basis of experimental laboratory and production tests, the optimal way was found for using a mixture of vermicompost and sulfur-perlite-containing waste of sulfuric acid production under the short name «Vermicer» as an ameliorant fertilizer in agricultural practice. When processing the «Vermiser» preparation with seeds of carrots and beets, an increase in the plant root system, leaf area, and acceleration of photosynthesis took place. At the same time, photosynthesis as the basis for the growth and development of plants, the accumulation of chemical compounds and, therefore, biomass may be associated with other physiological parameters, including change in chemical composition. Vermiser increases the quantity, quality and presentation of products, which is important for the production of food root crops – potatoes, beets, carrots and radishes.

Keywords: fertilizer-ameliorant, seroperlite-containing waste, detoxification, fertility, vermicompost

The disturbance in the ecological balance in ecosystems that has emerged in the last century is caused by the release of a large number of pollutants from anthropogenic sources. This problem is of great concern to all of humanity. Environmental protection is the most important state task for Kazakhstan. Environmental security is one of the strategically fundamental components of national security and an important aspect of protecting the interests and priorities of a country in international integration processes. It is determined by the degree of protection of the individual, society and the state from the consequences of excessive anthropogenic impacts on the environment. Ecologically safe activities of industrial enterprises and economic entities are regulated by the Environmental Code, the laws «On Radiation Safety», «On Subsoil and Subsoil Use» and other legislative documents [1]. Ensuring a normal environmental situation is impossible without the availability of timely and reliable information about the state of the environment.

Despite the regular flow of environmental information from numerous scientific studies, as well as the presence of a number of practi-

cal measures in the field of environmental protection, its condition often continues to remain unsatisfactory [2-4]. Thereby, our republic still maintains the status of a state with an ecologically vulnerable territory and unresolved environmental problems. Therefore, the country pays special attention to the development of scientific research on the most important problems of environmental safety, sustainable nature management and other issues related to environmental protection and rational use of natural resources. Soil conservation and rational use are of paramount importance for the economic and social development of the country. Compared with other objects of the biosphere, the soil cover is a medium that takes on the pressure of the flow of industrial, agricultural, municipal, including landfills of solid waste, emissions, various wastes and plays the most important role as a buffer and detoxifier [5-7]. The soil accumulates heavy metals, pesticides, oil products and many other pollutants, protecting and purifying them from water systems and atmospheric air. Most of the toxicants in the soil system can be mineralized or transformed into substances that do not have toxic effects on soil, microorganisms, plants, animals and humans, or, conversely, converted into more toxic forms [8-9]. The natural stability, resistance and buffering of soils to the effects of chemical pollutants are not unlimited, in connection with this, for various reasons, large areas of land are lost annually. Therefore, maintaining and restoring the soil cover, reducing the negative impact of pollutants further on plant and animal organisms and creating conditions for obtaining high and high-quality crop yields, even in areas where large industrial enterprises, large cities, and transport arteries are located, are necessary to solve a number of urgent problems in the field of ecology.

Due to the high technogenic pollution and the intensive development of erosion processes, an important theoretical and practical task is also to study the bioaccumulation of chemical elements by various crops. The selection of highly effective fertilizer and land reclamation agents that have accumulating pollutant properties, as well as crops and varieties that are able to concentrate toxic substances in the least valuable part of the crop, will make it possible to obtain environmentally friendly products in technologically polluted territories.

Thus, the analysis of literary sources [10–12], especially the results of the assessment and comparison of known methods indicate that at present there is no ideal way to neutralize (detoxify) lands. Thereby, the issue of developing effective methods and technologies for improving and increasing soil productivity that meet modern requirements in environmental, technological and economic aspects is relevant.

The aim of this work is to establish the possibility of obtaining environmentally friendly crops on anthropogenically modified gray soil by creating conditions for detoxification and reproduction of its fertility.

Objects, methods and results of the study

Research work was carried out on the basis of the Ecological Control and Chemical Analysis laboratory of the Ecology Research Institute using updated guidelines for conducting analytical and testing work, certified methods for performing measurements, updated GOSTs, and other regulatory documents necessary for experiments and software complexes ERA-Air-Waste-Class-Climate.

For the rehabilitation of gray earth soils contaminated with heavy metals, we previously used ameliorant fertilizer, which included solid vermicompost and sulfur perlite-containing waste from sulfuric acid production [13-15]. Elemental sulfur accounts for 50-60% of sulfur-perlite-containing waste, perlite accounts for 15-25%, sulfides, polysulfides, thiourea, lime, gypsum represent the rest. When used, these complex formulations play the role of both fertilizers and ameliorant [16-18].

In this work, we used the gray earth soils of the Turkestan region of the Republic of Kazakhstan with the total humus content in the layer (0-40 cm) – 1.0-1.2%, total nitrogen – 0.09-0.18%, mobile phosphorus – 9 , 1-26.0 mg / kg, the amount of exchange bases is 23.6-26.9 mEq / 100 g of soil, the pH of the aqueous extract is 6.5. It is characterized by unfavorable physical properties, namely, the low structure of the arable layer; when it dries, rather dense crusts form on its surface.

Field studies were carried out on plots with a total area of 45 m^2, with an accounting area of 27.5 m^2. The repetition of the experiments is fourfold. The laying of experiments, observations and biometric measurements were carried out during the growing season according to the well-known methodology for conducting experiments with fertilizers. Scheme of experience, options: 1 – without making vermicompost and mineral fertilizers (control); 2 – with the introduction of vermicompost, 4 ton / ha; 3 – with the introduction of vermicompost, 8 ton / ha; 4 – sulfur-perlite-containing waste, 15 ton / ha; 5 – camel manure, 20 ton / ha; 6 – a mixture of sulfur-perlite-containing waste and vermicompost (1.7: 1) 20 ton / ha Fertilizer – ameliorating agent is introduced locally in the form of a nest, as well as scatter, followed by mixing with a soil layer of 0-20 cm.

The basis for the development of methods for soil neutralization and restoration of its fer-

tility was the new results that we obtained earlier in studying the processes of translocation, migration and accumulation of heavy metals, oil products and other eco toxicants in the soil ecosystem, in the soil-plant system. The revealed regularities made it possible to control the behavior of heavy metals and other pollutants in the soil ecosystem and adjacent to it in other objects of the biosphere.

In this work, the rehabilitation of contaminated gray soils with heavy metals, oil products is based on the use of a fertilizer and reclamation mixture composed of vermicompost and waste from sulfuric acid production, including perlite, elemental sulfur and its salts in the form of thiosulfate, sulfide and polysulfides, gypsum, slaked lime. The use of this organic-mineral mixture is advantageous in that its components are not only affordable and cheap, but also environmentally friendly. As an inactivator-sorbent of heavy metals, oil products and other pollutants, the developed composition was used for the first time to detoxify contaminated unproductive soils. This mixture is characterized not only by the transfer of eco toxicants into a difficultly soluble sorbed state, but also by the creation of physicochemical conditions for the development of soil microorganisms.

The indicators characterizing soil fertility were a high concentration of microorganisms and water-resistant aggregates. To establish water resistance, fresh soil samples were selected by the square method. Then, soil aggregates were taken from them and placed in cells with holes of similar size aggregates. To maintain soil aggregates, pins coated with a phosphor were placed below the cells. The system was irradiated with UV radiation and the number of aggregates disintegrated in water was recorded by the number of luminous points. As the results of our experiments show, the introduction of vermicompost into the soil increases the water resistance of soil particles. The value of water resistance for the control experiment is 15 ± 3%, for soil with vermicompost it was 57 ± 5% (for 5 ton / ha) and 74 ± 2% (for 10 ton / ha). When applying vermicompost, there was a significant increase in the number of water-resistant aggregates with a diameter of 0.25-1.00 mm, close to fertile black soil.

As shown by the results of laboratory and field studies, the introduction of the studied fertilizer and reclamation mixture into the soil significantly reduces the mobility of lead, copper, zinc and, accordingly, they become inaccessible or inaccessible to plants. This allows you to get healthy products on contaminated soil. The content of HM in potato, beet, carrot, and radish plants on the soil with the application of the developed organo-mineral sorbent did not exceed the MPC, while in plants grown without our mixture, their amount was 1.3-2.5 times higher than the norm. In experiments, the introduced content of heavy metals ranged from 0.5 to 5 MAC.

During this work, we paid special attention to the influence of the proposed complex fertilizer-reclamation mixture as a whole and separately of the main components of inorganic and organic nature, for example, vermicompost, various HM, and petroleum products on the biological activity of the used gray earth soils. This is due to the fact that the degree of change in a number of indicators of biological activity serves as a measure of the impact of harmful and non-harmful foreign substances artificially entering the soil system. As follows from the results of our work and the work of other researchers, it is precisely the indicators of soil biological activity that are widely used in monitoring and diagnosing the state of the soil system. The results of both laboratory and field experiments showed a smaller accumulation of nitrogen in the green mass of clover when applying a fertilizer and reclamation agent than in clover grown in a control experiment without applying this agent. The low nitrogen content in plants is apparently due to the immobilization of its microorganisms, as more organic carbon was introduced into the soil with vermicompost.

As the results of the 1st year (2018) of the study showed, the introduction of a fertilizer and reclamation agent into the soil contaminated with HM, consisting of vermicompost and sulfur-perlite-containing waste from sulfuric acid production, is a technique that reduces the mobility of lead, zinc, copper and other HM, as well as reduces them receipt in plants. But, however, how long the observed immobilization effect will manifest itself is not known. Heavy metals, entering the soil, enter into various chemical reactions, are adsorbed by organic matter – vermicompost and others, interact with sulfide, thiosulfate, sulfate anions that are part of the sulfur-perlite-containing waste, clay minerals, oxides contained in the soil itself, in connection with this it is necessary to find out the behavior of toxicants with the prolonged action of the fertilizer-reclamation agent used. Observations must be carried out over several years to establish how changes in the forms of both the organic and inorganic parts of the mixture affect the final result over time. Thereby, field studies to establish the effect of the organo-mineral composition on the mobility of HM and on the state of the resospheric bacteria continue.

Thus, on the basis of experimental laboratory and production tests, the optimal way was found for using a mixture of vermicompost and

sulfur-perlite-containing waste of sulfuric acid production under the short name «Vermicer» as an ameliorant fertilizer in agricultural practice. When processing the «Vermiser» preparation with seeds of carrots and beets, an increase in the plant root system, leaf area, and acceleration of photosynthesis took place. At the same time, photosynthesis as the basis for the growth and development of plants, the accumulation of chemical compounds and, therefore, biomass may be associated with other physiological parameters, including change in chemical composition. An increase in the volume and mass of roots and root crops intensifies their absorption capacity and synthetic activity, intensifies the processes of mass transfer of ions and nutrients throughout the plant, which contributes to the intensive growth of shoots and the formation of new organs. During visual observation, accelerated flowering and ripening of crops, stimulating the development of root systems. The absence of pathogenic microflora, eggs and helminth larvae introduced into the soil makes it possible to increase the ecological safety of the crop. Vermiser increases the quantity, quality and presentation of products, which is important for the production of food root crops – potatoes, beets, carrots and radishes.

In the case of soil contamination with oil products, the detoxifying effect of the Vermiser biological product was manifested in an increase of almost two orders of magnitude in the number of hydrocarbon-oxidizing microorganisms. Due to the presence of these microorganisms in the soil, hydrocarbons were destroyed under crops and, as shown by the results of experimental studies at the end of the growing season, under crops of studied root crops, the decomposition of hydrocarbon compounds accelerated under beets and carrots by 2 times, under potatoes and radishes, respectively 2.5 and 3 times. The data of production trials of 2018-2019 conducted on the lands of the Zebo farm showed an increase in the yield of root crops, for example, when 20 ton / ha of the preparation was applied, the yield of Bordeaux beet varieties averaged 28.8 ton / ha (control 20, 5 ton / ha); for Chantane Red carrots – 30.4 ton / ha (control 25.0 ton / ha). Research in this farm is ongoing.

An increase in yield and an improvement in the palatability of the studied crops are associated with the enrichment of the soil with humic acids (the main components of vermicompost) and other nutrients, as well as the improvement of the soil structure (elimination of the formation of a dry dense cortical layer), which allows creating favorable conditions for optimal aeration and moisture capacity. The improvement in the availability of water to plant tissues can also be explained by the presence of a sufficient amount of silicon compounds in the sulfur-perlite-containing material used. It is known that silicon in plants is deposited in epidermal cells in the form of a double cuticular-silicon layer, while the cellulose-silicon membrane formed in this case creates conditions for a more economical expenditure of moisture. In addition, mono-silicic acids, undergoing polymerization in plants, release water, which can also be an additional source of moisture necessary for the growth and development of plants.

Conclusion

1. The developed technological method for the preparation of fertilizer and reclamation mixtures will make it possible to obtain new environmentally friendly organic-mineral fertilizers on the basis of readily available agricultural and industrial waste utilization products.

2. The use of the developed fertilizer and reclamation composition is an agro-reclamation measure and helps to restore degraded soils, increase their productivity, improve the ecological situation and return agricultural land to economic use.

3. The resulting material can also serve as an informational basis in the preparation of environmental projects and will be used in the educational process during lectures and laboratory classes.

4. Highly humified vermicompost and organic organic agricultural products (vegetables, etc.) will find implementation in the markets, and the potential consumer will be agriculture and the population.

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