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DEVELOPMENT OF DECOMPOSING-TYPE BIOSORPTION COMPOSITES FOR PURIFICATION OF SOIL CONTAMINATED WITH PESTICIDES

Introduction. *Reducing soil pollution with pesticides is one of the important environmental issues. One of the ways to solve this is bioremediation of soils, in particular, the creation of biosorption complexes in which microorganisms-destructors are fixed on carriers that are sorption-active against the pollutant.*

Problem Statement. *Environmental pollution with chemical compounds that are used in agriculture is on of the problems of our time. Therefore, it is important to develop and implement the latest technologies for cleaning and restoring soils contaminated with agrochemicals.*

Purpose. *Investigation of the physicochemical, sorption and destructive (with respect to pesticides) properties of biologically modified sorbents based on plant materials for cleaning soils from pesticidal contaminants. Detoxification of accumulated pesticides in soils in order to restore them, increase productivity and increasing productivity and further obtaining high-quality and environmentally friendly agricultural products.*

Materials and Methods. *The amount of pesticides in the soil was determined by high performance liquid chromatography. The selection of microorganisms, potential destructors of pesticides was carried out by the method of accumulative cultures from soils (chernozems) contaminated with pesticides.*

Results. *A destructive biosorption detoxicant based on plant materials was created to neutralize pesticides of various chemical composition. The optimal conditions for the modification of specialized biosorption complexes of destructive action relative to pesticides are determined. The technology of manufacturing and use of biosorptive detoxicant has been developed and the technological process of its production has been worked out.*

Conclusions. *Tests at the pilot industrial site showed the high efficiency of the biosorption composite for cleaning soils from the accumulation of pesticides, which indicates the prospects of its use in the agricultural sector.*

Keywords: pesticides, plant waste, biosorption composite, microorganisms-destructors, and detoxification.

Reducing the level of soil contamination with pesticides of different chemical composition is one of the important problems of environmental protection. The growing use of pesticides, in particular herbicides, worldwide has resulted in an important task for researchers, which is to develop effective measures for preventing the effects of intensive chemicalization in the agro-industrial complex. At all levels of production, transporta-

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tion, use, storage, and disposal, pesticides pollute the environment. Special studies have shown that, in some regions of Ukraine, the risk of soil contamination from chemicals used in agriculture, accumulation of pesticides in the soil and their interaction with soil microflora may be higher than that of the pollution caused by industrial emissions [1—3]. The wide range of pesticides and fertilizers used does not allow for a complete chemical analysis of contaminated soil and surface water. Given the established positive correlation between the mutagenic activity of chemical compounds detected in the test systems of microorganisms and aquatic organisms, the risk of soil contamination is obvious. Soil plays the role of storage of pesticides, where they decompose and from where they constantly move to plants and the environment, where some of them can circulate for a long time. Pesticides in the soil are under the influence of external factors, some of which determine their behavior, transformation, and, finally, mineralization. The type and rate of transformation depend on the chemical structure of the active substance, its stability, composition and chemical properties of soils. Soil contaminated with pesticides is a real danger to the environment and human health.

Environment pollution by chemical compounds used in agriculture is one of the most crucial problems of our time. The problem and recommendations for purifying soils from pesticides and for minimizing their adverse effect on plants are very important.

For purifying the soils contaminated with organophosphorus and methylcarbamate insecticides and phenoxy- and dinitroaniline herbicides at a level not exceeding 20 mg/kg, a method for soil composting together with plant residues, fallen leaves, etc. is promising. In order to restore soils and to detoxify the accumulated pesticides, the use of biotechnological methods that involve the introduction of pesticide-destroying microorganisms into natural ecosystems, is becoming more and more widespread. Many researches [4, 5] emphasize the importance of soil microorganisms in the decomposition of pesticides. It has been proved that almost all chemical compounds used as pesticides are utilized by microorganisms.

Numerous strains of fungi, bacteria, actinobacteria, and algae that convert these substances into non-toxic compounds have been recovered. The advantage of using biological methods for pesticide decontamination over the physicochemical ones is the fact that microorganisms mineralize pesticides and other products of organic synthesis in the natural cycle of substances without adverse effects on the ecosystem.

The ability of a single microorganism to decompose an organic compound is limited by the individual genetic complex. The natural population of bacteria is genetically heterogeneous and in manifest itself with respect to xenobiotics at the level of the strain. The metabolic capacity of natural population is much higher than that of a single microorganism [6, 7]. The joint activity of consortium microorganisms makes it possible to bring about complete mineralization of any organic compounds, while this cannot be done by any population of one species of microorganisms [8—10]. There is information about various biological preparations for pesticide destruction [11—12]. Liquid microbial preparations for pesticide neutralization in soil have been developed and used [9, 10].

The method for contaminant biodegradation through the use of microorganism decomposers, both in the free state and immobilized on a porous carrier, is the most appropriate to reduce the level of soil contamination [13]. A preparation for purifying soils from pesticides using a destructive microbial preparation based on a mixture of biologically active soil and straw has been already known [14]. Immobilization of microbial cells that destruct contamination on the surface of the sorption carrier increases the efficiency of biotechnological processes. The method of adsorption on the surface of the sorbent is one of the simplest and most common means of immobilization of microbial cells. Promising sorbents for the use as a carrier of microbial cells are carbon sorbents, both individually and in combination with certain mineral and plant sorption materials. Carrier sorbents shall have high chemical resistance, mechanical strength and sufficient permeability to substrates, biocompatibility, and manufacturability. The creation of broad-spectrum biosorption complexes based on materials of inorganic and plant origin and a natural consortium of microorganism decomposers is relevant for the detoxification of soils contaminated with pesticides of different chemical composition. A promising area is the development of biosorption composites, in which microorganism decomposers are fixed on carriers of sorption-active contaminants and microorganisms. The development of such preparations on the basis of sorbent carriers of different origin and physicochemical properties with immobilized microorganisms destroying pesticides requires a study of the relationship between sorption binding and the destructive capacity of the complex.

Biosorption composites based on plant sorption materials and adapted natural association of microorganism decomposers are effective for neutralization of soil contamination with pesticides. In addition, the reintroduction of the microbial complex to the natural environment gives it selective advantages. Therefore, conducting research on the development and practical application of a biosorption complex to purify the soil from pesticides is extremely important.

The search for optimal methods of pesticide analysis is one of the most important problems of analytical chemistry. These methods primarily include capillary gas chromatography (GC), high performance liquid chromatography (HPLC), thin layer chromatography (TLC), and capillary electrophoresis (CE). These methods have a high resolution, which is necessary for the analysis of multicomponent samples, and a high sensitivity that enables detection of pesticides in small concentrations, up to 1 μg/dm^3 and less. The HPLC method is used as the most effective method of analysis.

The biodestructive capacity of biosorption composite with immobilized pesticide-destroying microorganisms is monitored by reducing the concentration of contaminant (pesticide) and accumulating a biomass in the test system. The crude biomass is measured after cell precipitation by centrifugation, after which the dry biomass of the washed cells is determined.

The microorganisms (potential destructors of pesticides) are recovered by the method of accumulative crops from soils (chernozems) contaminated with pesticides, from samples taken from the field of activity of agricultural firms, where pesticides have been used for a long time. In addition, as noted, the introduction of a microbial complex into the natural environment gives it selective advantages. It is known that in the presence of a contaminant (pesticide) in the soil, only the most resistant populations survive, by selective suppression. The experiments were made using the following mineral composition (g/l): K_2HPO_4 — 0.5; $NaNO_3$ — 0.5; $(NH_4)_2SO_4$ — 0.5; $MgSO_4$ $7H_2O$ — 0.2; $CaCl_2$ $2H_2O$ — 0.01; $FeSO_4$ $7H_20$ — 0.01 in distilled water. Pesticides *Betanes* (Ukraine) (with phenmidifam as active substance); *Caribou* (Ukraine) (with triflusulfuron-methyl as active substance); *Pyramine-turbo* (Sweden) (with chloridazone as active substance); *Nurel-D* (Ukraine) (with chlortephis cypermethrin as active substance); PCB (with polychlorinated biphenyl as active substance) are used as the only source of carbon and energy.

Each sample of contaminated soil is added to a flask containing nutrient medium and pesticide, and microorganisms are grown stirred at a temperature of 25—30 °C. Subsequently, the culture fluid (CF) is subcultured into fresh medium of the same composition and re-cultured in the presence of pesticide. Having been cultivated, the mixture of microbial cells is plated on dense nutrient media (based on agar-agar) used in the further experiments for immobilizing microorganism decomposers (MOD) on the surface of sorbent carrier. Individual members of the microbial consortium have different ability to decompose pesticides at different stages of culture maturation, which ensures a long-term stable effect of the preparation. Experimentally, as a result of the species analysis of the obtained culture of microorganisms (MO), it has been established that the main species are *Sporocytophaga myxococcoides, Sorangium cellulosum, Cellvibrio mixtus genomic, Trichoderma viride*, and accompanying heterotrophic bacteria *Pseudomonas Balousterium*,

The process of pesticide degradation has been studied both in contaminated soils and in the aquatic environment with the introduction of microorganism decomposers in the form of culture fluid and immobilized on the sorbent. The carrier of microorganism decomposers is selected based on the following requirements: the material shall have the same absorption capacity as the contaminant (pesticide), be a favorable environment for the activity of microorganisms, and be a potential source of organic fertilizer for soil.

To create a complex biosorption material, materials of different types have been studied: kaolin clay, zeolites, bentonites, glauconites, vermiculites, tuffs of various deposits, silica gels, coal and vegetable sorbents (peat, crushed wheat and oat straw, beet pulp, sugar cane trash). Table 1 shows the structural and sorption properties of the carrier for immobilization of microorganism decomposers of pesticides.

According to the obtained data, the mineral silica gel has the best structural characteristics, while the plant-based carriers have the best absorption capacity for pesticides. Such MO sorbent carriers have a target adsorption capacity and are biocompatible. In addition, these materials are environment friendly and technologically simple. Immobilization of microorganism decomposers on the surface of the sorbent makes it possible to obtain a sorbent material of the biodestructive type. The absorption capacity of the carrier sorbent has been tested on a mixture of pesticides in the form of an aqueous emulsion of pesticides at a concentration of 1 mg/l.

For obtaining a biosorption complex it is important not only the ability of material to absorb contaminants by physical and chemical mechanisms, but also the ability to immobilize active microorganism decomposers on its surface. In contrast to the bacterial preparations obtained by fixing microorganisms on neutral sorbents of synthetic or mineral origin, the immobilization of MO decomposers on the surface of materials active against contaminant has certain advantages in terms of their decomposing action. In addition,

Table 1. **Structural and Sorption Properties of Sorption Matrix for Immobilizing Microorganism Decomposers of Pesticides**

Property	Mineral carrier				Carrier based on plant residues			
	silica gel	bentonite	coal	kaolin	wheat straw	peat	bagasse	sorption composite
Hydrophilicity,%	8—10	35—40	10—15	40—50	30—40	20—30	30—45	21—33
Hydrophobicity,%	90—92	60—65	80—90	50—60	60—70	70—80	55—70	59—75
Absorption capacity relative to pesticide, mg / g	0.3—0.4	0.01—0.02	0.01—0.02	0.01—0.02	0.08—0.1	0.08—0.1	0.2—0.6	0.14—0.16
SOE (sorption exchange capacity), mg-eq / g	4.6—5.8	3.8—4.6	3.2—5.0	4.2—5.8	3.1—4.6	2.8—3.0	3.2—4.2	2.2—3.1
Specific surface area, m^2/g	200—220	80—110	80—120	90—130	50—55	60—70	50—60	43—51
Water pore volume, cm^3/g	0.3—0.35	0.12—0.2	0.08—0.1	0.09—0.15	0.05—0.06	0.06—0.09	0.05—0.08	0.02—0.03
Benzene pore volume, cm^3/g	0.35—0.4	0,.09—0.12	0.07—0.09	0.1—0.12	0.07—0.09	0.08—0.12	0.06—0.09	0.03—0.05

the effectiveness of such biosorption complexes depends on the physicochemical parameters of the biotechnological process (pH, temperature, concentration of various ions, pressure), which shall meet the optimal living conditions of immobilized microorganisms.

The relationship between sorption binding and the decomposing capacity of the complex has been studied. The surface or part of the surface holding MO cells is freely "washed" by external environment (liquid or gas), while the consumption of substrates and the release of microorganism waste products are determined mainly by biological factors, namely, the functionality of a particular biocomplex. Between the external environment and the cell, as a result of immobilization of the latter, there appears a layer of carrier material, with the cell and the environment exchanging substances through this layer where there is a diffusion-controlled transport of nutrients, and the metabolites are removed. In this case, the properties of the carrier (e.g., its porosity, charge, hydrophilicity) can significantly affect the properties of the immobilized biocomplex, improving the potential of the microorganism.

The adsorption immobilization is realized through the natural ability of many microorganisms to stick to various media and to continue their life in such a stationary state. The method for artificial immobilization often involves passing a cell suspension through a container with a sorbent.

The adsorption methods of immobilization are among the simplest and the most "natural" ones. In nature, microorganisms and their associates almost always exist not in an isolated (free) form, but in an adsorbed state. This method of immobilization has been chosen for this research. The variety of surface properties of sorbents and cells causes different mechanisms of adsorption interaction and different types of adhesion forces. The adhesion of cells to the sorbent is determined by the following factors:

1) chemical bonds between the cell surfaces and the adsorbent (chemisorption);

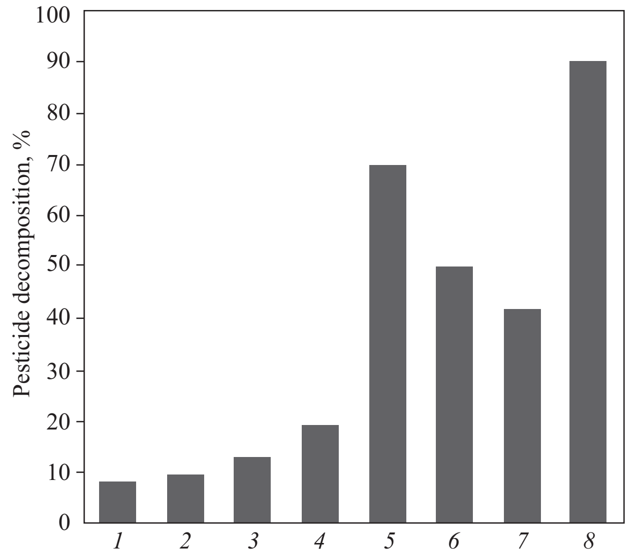

Fig. 1. Effectiveness of pesticide bio-decomposition by biosorption complex in aquatic environment: *1* — microorganism decomposers (MOD) in cultural fluid; *2* — MOD + + silica gel; *3* — MOD + bentonite; *4* — MOD + peat; *5* — MOD + wheat straw; *6* — MOD + oat straw; *7* — MOD + + beet pulp; *8* — MOD + composite of wheat straw, peat, and bagasse

2) ionic interactions, the formation of ionic pairs and triplets;

3) electrostatic (nonionic) interactions of charged cell surfaces and adsorbent;

4) van der Waals forces (dipole-dipole interaction, dipole-induced dipole);

5) the influence of electrolytes, hydration effects, capillary properties;

6) flocculation and coagulation;

7) hydrophobic interaction.

The studies have shown a correlation between the sorption binding of pesticides such as *Chloridazon* and *Chlortefis* by biosorption complexes and the subsequent decomposition of sorbed pesticides by microorganism decomposers immobilized on the carrier surface. The optimal parameters of sorption of MO cells are 20—30 mg of biomass per 1 g of sorbent. Immobilized cells of microorganism decomposers on sorption carrier (composite straw wheat-peat-beet pulp or bagasse) have cell titers within the range from 103 to 107 cells per 1 g. The use of such a biosorption detoxifier

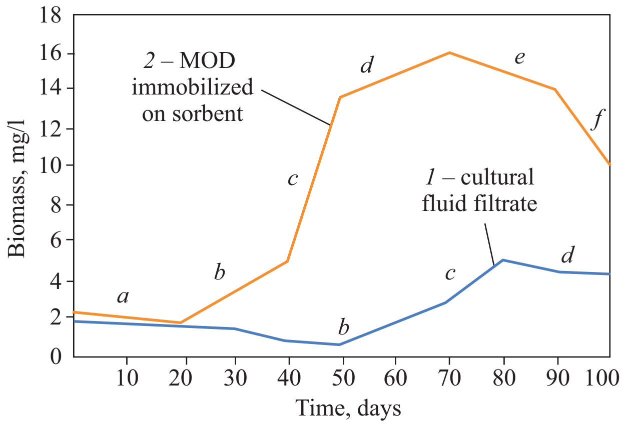

Fig. 2. Growth of microorganisms and bacterial biomass yield in the case of *Chloridazon* pesticide decomposition (t = 30 °C): *1* — cultural fluid filtrate; *2* — MOD immobilized on sorbent; *a* — adaptation phase; *b* — accelerated growth phase; *c* — logarithmic growth phase (exponential phase); *d* — slowdown phase; *e* — steady phase; *f* — extinction phase

accelerates the decomposition of pesticides 8 times in a liquid medium and 4—6 times in chernozem soil. Immobilization of microorganism decomposers on a plant carrier activates the decomposing ability of microorganisms, which several times exceeds that of mineral sorbent carriers (Fig. 1).

The highest biodestructive activity against pesticides has been shown by a combined plant carrier on the basis of crushed wheat straw, peat, and beet pulp or bagasse. Sugar waste (beet pulp or bagasse) contains polysaccharides that stimulate biooxidation processes. Each component of the composite has its function: straw is an active absorber of organic contaminants, yellow laccase is a carrier of MOD and a source of enzyme, it initiates the process of decomposition of the contaminant; peat is MOD preservative and xeroprotector, a source of organic supply; beet pulp or bagasse is a source of polysaccharides and an effective moisture retainer (1/5). The experiments are carried out at the same conditions: at a temperature of 30 °C, initial pH = 8 and initial amount of MOD is 10^7 cells/g.

The pesticide decomposition has been studied both on contaminated soils and in the aquatic environment with the introduction of microorganism decomposers in the form of culture fluid and immobilized on the sorbent. Fig. 2 shows the results of the growth of microorganism decomposers by the yield of bacterial biomass over time during the pesticide decomposition under the influence MOD both in the free state (culture fluid) and immobilized on the carrier sorbent.

The MOD growth rates are good both in the case of free bacterial cultures and in the case of those immobilized on the sorbent. Thus, the phase of adaptation and the beginning of growth is longer when in the case of contaminant treatment with culture fluid as compared with the culture on the sorbent surface. The same pattern is found for the exponential growth phase, when the cells are dividing, and for the stationary phase that is characterized by reducing concentration of substrate contaminant consumed by MOD, and by the accumulation of decomposition products. The extinction phase is marked with the loss of MOD viability. On the sorbent, the phase of MOD extinction occurs under much greater accumulation of biomass.

The microbiological activity of the biosorption composite depends on the type of MOD carrier and its sorption capacity with respect to pesticides. Table 2 shows the data on the activity of

Table 2. **Sorption Capacity with Respect to Pesticide of Matrix Sorption Material for Immobilization of Microorganism Decomposers and Microbiologic Activity of Bioactive Sorbent**

Adsorbent	Chloridazon		Chlortefis	
	Sorption capacity, g/g of sorbent	MOD activity, % of decomposition	Sorption capacity, g/g of sorbent	MOD activity, % of decomposition
Kaolin	0.02	No	0.06	No
Vermiculite	0.03	No	0.08	No
Coal sorbent	0.11	0.1	0.24	0.2
Wheat straw	20.1	0.8	28.4	3.10
Peat	13.6	2.09	18.8	5.19
Bagasse	8.6	10.28	6.54	20.09
Beet pulp	9.0	15.02	7.6	20.60
Composite 1	22.9	85.21	36.2	91.32
Composite 2	32.6	90.61	46.2	90.82

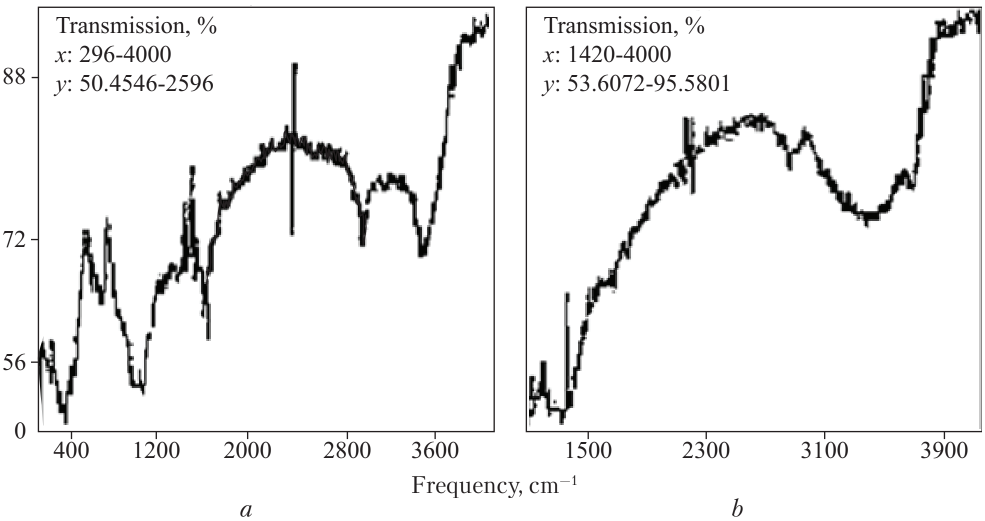

Fig. 3. IR spectra of soils contaminated with pesticides: *a* — before treatment; *b* — after treatment with biosorbent detoxifier

the complex (sorbent-immobilized MOD) with the use of sorbents of mineral and plant origin: composite 1 (crushed wheat straw 50% + peat 20% + beet pulp 30%), composite 2 (crushed wheat straw 50% + peat 20% + bagasse 30%).

The best indicators of microbiological activity are reported for composite 1 and composite 2. The sorption capacity of the matrix sorption material with respect to pesticides affects the decomposing activity of the bioactivated sorbent.

The decomposition of pesticides under the action of MOD in the free state (culture fluid), MOD immobilized on contaminated soil (sorption composite), and MOD aquatic samples (Table 3) has been studied. Immobilization of MODs on functional sorption material increases their

Table 3. **Decomposing Activity of Biosorption Complex and MOD in the Free State Against Pesticides in Aquatic Solution and in Soil (Model Systems)**

Value	Content of pesticides in water, mg /100 g water, in soil, mg/100 g soil							
	MOD introduction option							
	MOD in the free state (cultural fluid)				MOD immobilized on sorption material (composite)			
	Chloridazon		Chlortefis		Chloridazon		Chlortefis	
	water	soil	water	soil	water	soil	water	soil
Introduction after:	50.0	50	50	50.0	50.0	50.0	50.0	50.0
10 days	49.2	25	25	28.0	44.0	18.0	21.0	16.0
20 days	44.0	21	21	15.0	35.0	15.0	18.0	13.0
30 days	42.0	19	19	11.0	32.0	11.0	12.0	11.0
40 days	38.0	18	18	10.0	24.0	10.0	8.0	10.0
50 days	36.5	12.4	17.4	9.0	21.0	9.0	4.0	9.0
60 days	34.5	6.2	16.2	8.1	18.1	8.1	2.0	8.1
80 days	25.0	5.4	15.4	7.2	10.2	5.2	1.5	5.2
100 days	4.0	15.0	15.0	4.1	4.2	2.1	0.9	2.1
120 days	1.0	1.9	2.9	0.8	0.8	0.9	0.4	0.9

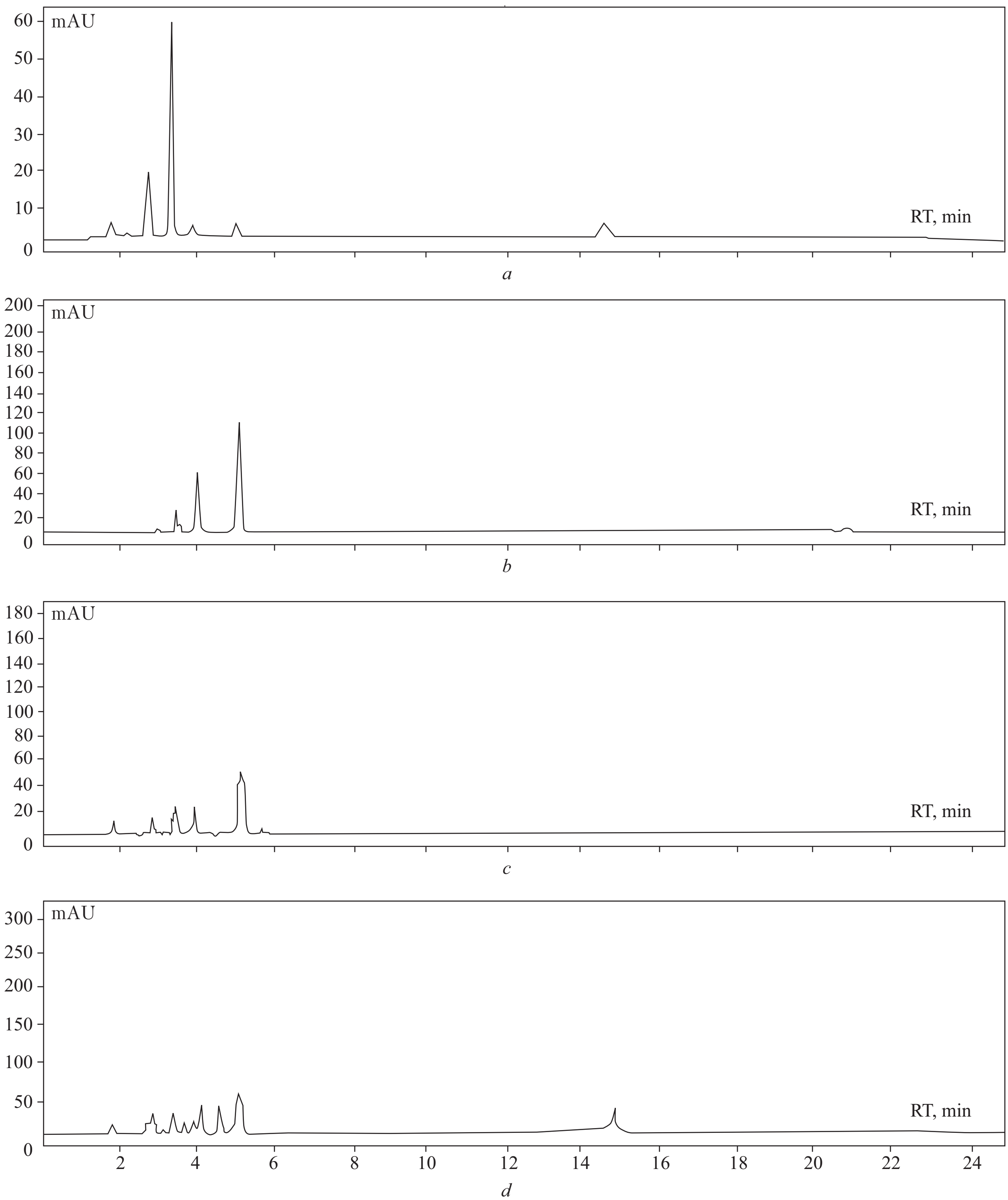

Fig. 4. HPLC tests of soils contaminated with pesticides before treatment (*a*) and after treatment with biosorbent detoxifier (*b, c, d*)

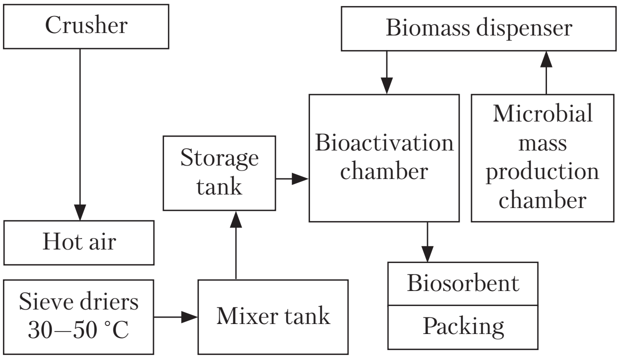

Fig. 5. Flowchart of production of biosorbent detoxifier

metabolic action and the level of contaminant degradation. The decomposing activity of such a complex against pesticides reaches up to 90% in water and soil systems.

Modification changes in the structure of pesticides present in the soil under the action of microorganism decomposers have been evaluated based on the characteristic IR spectra. Qualitative and quantitative changes in the IR spectra have shown transformations of the pesticide structure (Fig. 3).

The study of samples (ethanol extracts) by high performance liquid chromatography (Fig. 4) has shown a decrease in the initial concentration of pesticide in the soil to 30% within 30 days and a complete transformation of the contaminant over a longer period of time.

A complex of natural microorganisms extracted from soils contaminated with pesticides is able to effectively decompose pesticides of different chemical composition and resistance to decomposition. The presence of several pesticide metabolites in the decomposition has been established. The comparison of their spectra with the spectra of known metabolites has shown their ecological inertness.

The *pH* is monitored throughout the whole period after soil treatment with the biosorption detoxifier. During the first three weeks of the study, the *pH* of the medium varies towards alkalinity (as a result of the contaminant decomposition), thereafter no significant changes are reported.

To summarize, the research has confirmed good prospects for the use of plant media to develop a biosorption technology for purification of soils contaminated with pesticides. The biosorption complex based on the composite of wheat straw + peat + beet pulp or bagasse with immobilized microorganism decomposers of natural origin has significant decomposing activity for pesticide detoxification. Laboratory vegetation experiments have shown that the introduction of biosorption detoxifier into soil contaminated with pesticides reduces the inhibitory effect of pesticides and results in increasing green mass of plants.

Based on the obtained results the technological principles for manufacturing the biosorption composite preparation have been developed (fig. 5). The technology of its production consists of the following stages:

The first stage: the production of matrix sorption material. The raw material (wheat straw, beet pulp or bagasse, peat) is crushed in a cam mill, dried with hot air on sieve dryers at a temperature of 30 — 50 ° C. Following this, the material enters the tank where the components are stirred up and then goes to the next tank where the unfinished product is stored.

The second stage: the obtainment of microbial biomass for bioactivation of matrix sorption material. The samples are taken from a field where pesticides of different chemical classes have been used for a long time and the natural biocenosis contains microorganisms reacting on contamination. Having mixed the biologically active soil with water (1:1), nutrient medium for the cultivation of microorganisms, and with pesticide, the microorganisms are cultivated while stirring the resulting mixture at a temperature of 25—30 °C. The culture fluid is subcultured into fresh medium of the same composition and re-cultured in the presence of pesticide. Having grown, the mixture of microbial cells is plated on dense nutrient media (based on agar-agar) that further is used to immobilize MOD on the surface of sorbent carrier.

The third stage: the production of bioactive sorption composite. The sorption carrier surface is biologically activated in the bioactivation chamber, where the microbial biomass is mixed with the sorption composite in the proportion: composite / microbial mass = 90—95 / 5—10 weight parts and dries to a moisture content of 10—15%. Having dried and been powdered by crushers to a particle size of 0.3 – 0.7 mm, the product is weighed and packaged. The biosorption composite is a crumbly powder or granular product of gray color with different shades.

In the course of this research, the instructional technique and methodical recommendations (instructions) concerning application of biosorption detoxifying composite for purifying soils from pesticides have been developed. They are listed below.

The terms of use are as follows:

- April: sowing of agricultural crops;
- May: treatment of seedlings with pesticides (herbicides);
- June, 10^{th} – 20^{th} days; treatment of crops with pesticides (fungicides, insecticides, etc.); the 20^{th} – 30^{th} days: treatment with biosorption detoxifier;
- July – August: retreatment with biosorption detoxifier, if necessary.

Methods of application. The detoxifying effect of the biosorption detoxifier depends on the method of its application. The main part of the dose is put into rows. It is advisable to abundantly water the soil after the introduction. Watering is not necessary in very humid conditions and in irrigated areas. When introducing the main dose of biosorption detoxifier, it is important to choose the right depth. The preparation shall be introduced into the layer of soil where the roots are concentrated. It is possible to use the biosorption detoxifier with various fertilizers. Additional portion of biosorption detoxifier is used in the case of an insufficient first dose and for soils with heavy pesticide contamination.

Dosage. The biosorption detoxifier is introduced to the contaminated soil at a dose of 0.1—0.2 kg per 1 m^2 of area. In the case of its use on fertile soils, soil mineralization does not occur, as the detoxifier is environment friendly. The application requires the use of special agricultural machinery for loose mineral fertilizers.

Subsequently, industrial tests of biosorption material have been carried out in an experimental field with sugar beet and corn crops. For several years, the land has been treated with pesticides such as *Norwood*, *Zolon*, and *Semi-alpha*, which are very difficult to decompose in the soil. The biosorption preparation is introduced into the soil after a certain period of time when pesticides have performed their function. By the end of the vegetation season, the biomass of the aerial part and the root system of sugar beets growing in the contaminated soil of the reference field and in the experimental plot is monitored. The positive effect of the biosorption detoxifier and the effectiveness of the biosorption technology of soil purification from pesticide residues have been established. During the vegetation season, the green mass increases by 20—30%; the weight of the roots in the experimental plot exceeds 1.5 times that of the roots in the reference field; the total content of pesticides in the soil decreases by 90%. The biosorption preparation is ecologically safe because it contains natural plant materials and microorganisms of natural origin. As the field tests have shown, neutralizing the accumulation of pesticides by using the decomposing biosorption composite helps to restore soil fertility.

Thus, the studies have confirmed the effectiveness of bioactive sorption composites of decomposing type to clean the environment from agrochemicals (pesticides). Given the cheapness and availability of raw materials, the obtained results have given a reasonable approach to solving specific practical problems related to the development of modified bioactive sorption complexes and their use to clean soils from accumulated pesticides of various types.

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РОЗРОБКА БІОСОРБЦІЙНИХ КОМПОЗИТІВ ДЕСТРУКТИВНОГО ТИПУ ДЛЯ ОЧИЩЕННЯ ҐРУНТІВ, ЗАБРУДНЕНИХ ПЕСТИЦИДАМИ

Вступ. Зниження рівня забруднення ґрунту пестицидами є однією з важливих проблем захисту навколишнього середовища, одним зі шляхів вирішення якої є біоремедіація ґрунтів, зокрема створення біосорбційних комплексів, в яких мікроорганізми-деструктори закріплюються на сорбційно активних щодо забруднювача носіях.

Проблематика. Зважаючи на інтенсивність ведення господарювання в Україні та наявний рівень забруднення ґрунтів, важливими є розробка та впровадження новітніх технологій очищення й відновлення забруднених агрохімікатами ґрунтів.

Мета. Дослідження фізико-хімічних, сорбційних та деструктивних (щодо пестицидів) властивостей біологічно модифікованих сорбентів на основі рослинних матеріалів для очищення ґрунтів від забруднення пестицидами. Детоксикація накопичених пестицидів у ґрунтах з метою їх відновлення, підвищення продуктивності та подальшого отримання високоякісної та екологічно безпечної аграрної продукції.

Матеріали та методи. Визначення кількості пестицидів у ґрунті здійснювали методом високоефективної рідинної хроматографії; виділення мікроорганізмів, потенційних деструкторів пестицидів, виконували методом накопичувальних культур з ґрунтів (чорноземів), забруднених пестицидами.

Результати. Створено біосорбційний детоксикант деструктивного типу на основі рослинних матеріалів для знешкодження пестицидів різного хімічного складу. Визначено оптимальні умови модифікування спеціалізованих біосорбційних комплексів деструктивної дії щодо пестицидів. Розроблено технологію виготовлення та застосування біосорбційного препарату-детоксиканту та відпрацьовано технологічний процес його виготовлення.

Висновки. Випробування на дослідно-промисловій ділянці показали високу ефективність дії біосорбційного композиту для очищення ґрунтів від накопичення пестицидів, що вказує на перспективність його застосування в аграрному секторі.

Ключові слова: пестициди, рослинні відходи, біосорбційний композит, мікроорганізми-деструктори, знешкодження.