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MICROBIOLOGICAL ASPECTS OF TECHNICAL DAMAGE OF THE LAND

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Due to the growing trend of industrialization, urbanization, transport and agriculture, before scientists of various specialties, including land microbiologists, there is a problem of optimizing the interaction between man and the natural environment.

Land microorganisms are an important component of terrestrial ecosystems. Their number can reach several 109 / g of land (Zvjagincev, 1987). Therefore, they, like other biological objects, undergo the impact of technogenic pollution (mineral fertilizers, pesticides, heavy metals, liquid manure, polluted waters, pasture, recreational degressions and heavy machinery, oil and its products, nitrification inhibitors, detergents, etc.). We already have a significant experimental material on the influence of chemical agents of anthropogenic origin on microorganisms (Sencova, Maksimov, 1985; Kohlmaier, 1989; Shukla, 1990; Đukić et al., 1999; Đukić, Mandić, 2000; Đukić et al., 2009 , 2014, 2015, 2018a, b, c).

However, the information, which can be found in the literature, does not allow for a sufficiently comprehensive presentation of the changes that occur in the soil microbial system under the influence of pollution.

Therefore, it is not possible, on the one hand, to evaluate the degree of harmful effects of the pollutant, and on the other, to judge the adaptation properties of soil microorganisms to different influences.

Literary data relating to this problem are extremely controversial, and the conclusions are often inconclusive. It is noticed that in a large number of cases one and the same agent can inhibit, stimulate or even show any effect on soil microorganisms (Zvjagincev, 1989). Because of this, different opinions are still given in the scientific literature regarding the possibility of using soil microorganisms for the assessment of the effects of pollutants: from positive ones (Dobrovoljski et al., 1985; Đukić et al., 1994a, b; Đukić, Mandić, 1996; Đukić , Mandic, 1998; Djukic, Mandic, 1999; Djukic et al., 2012; Semenov and Djukic, 2017), to negative (Wainwright, 1980). However, the existing experimental experiences in the field of sanitary and hygienic normative production, which are carried out under strict laboratory conditions, testify to the fact that soil microorganisms react positively to relatively low concentrations of pollutants in the soil (Gončaruk, Sidorenko, 1986; Mandić et al., 1995 Djukic et al., 1999; Djukic and Mandic, 2000; Djukic et al., 2011; Semenov and Djukic, 2019). Due to all this, it is very important to examine the changes of saprotrophic soil microorganisms in technical soil contamination.

The aim of this our work is to elaborate the concept of ecological and microbiological assessment of the state of soil in conditions of technical pollution.

The goal set is achieved by gradually solving the following tasks:

- developed methods of testing saprotrophic microorganisms in contaminated soil;
- generalizing their own experimental data and literary material in the form of a concept,
- which shows the overall legality of changes in the land microbial community in technical pollution;
- proposing ecological and microbiological solutions for some problems of soil protection.

Method of initiated microbial communities

There are objective difficulties that the researcher encounters during the study of the impact of pollution on microbiological processes in the soil. In our opinion, one of the more important is to use the methods of seeding on solid nutrients (borrowed from medical microbiology) that are completely indefinitely characterized by the return reaction of soil microorganisms to technical pollution in solving this problem. These methods are completely suitable for the separation of pure cultures of microorganisms, however, for ecological microbiological soil testing, their application is clearly insufficient. Due to all this, it is still the current search for new methodological approaches, which correspond to the new tasks, which are placed before the land microbiologists.

A practical inclusion of methodological studies is the method of the initiated microbial community (Guzev et al., 1982), intended for laboratory experiments in order to clarify the modifying effects of different factors on the microbial soil system in conditions that resemble the natural ones.

Methodological explanation

The proposed method includes several key operations that require independent explanation. The starting position, which forms its basis, is the opinion of Vinogradski (1952) - that saprophytic microorganisms of the soil should be examined in the conditions of active faction - in the process of mineralization of organic substrates, which arise in the soil. In accordance with this approach, the reaction of soil microorganisms to pollution is studied only after enrichment of the soil with an energy substrate.

Earlier research has found that multi-component substrates, for example, plant residues, initiate the development of a microbial community, which only uses their easy-to-use ingredients (Zajcev etc., 1979). Therefore, for model experiments, the use of individual compounds is more fundamental than substrates. The development of microbial communities initiated with soluble carbohydrate compounds, such as glucose or sucrose, depends to a large extent on their concentration. The same dose of these compounds in different soils can be used in different ways: oxidation, followed by the accumulation of microbial biomass or fermentation, which monitors the enrichment of the soil with toxic products, but without a significant increase in biomass. In the experiment, it is difficult to control the concentration effect (Guzev etc., 1986a, b).

Therefore, it is more advantageous to use insoluble polymers of plant origin. Cellulose is quickly accumulated and broken down by microorganisms in the soil, which can be controlled well. However, the microbial community, initiated by cellulose, has a small biomass and a relatively poor composition of species, which significantly complicates the work. Starch has unique properties for activation. It regularly comes to the soil in the form of plant residues, is quickly colonized and exploited by many land microorganisms. This is evidenced by the practice of application (in soil microbiology) of starch-based substrates, where the development of various systematic groups of microorganisms is always observed.

The significant complexity of the analysis of the impact of technical pollution is conditioned by the large spatial-time variability of the intensity of the microbiological processes in the soil. This phenomenon, firstly, is related to the micro-zonal characteristics of the spread of microorganisms in the soil and the incontinence of nutrient substrates into it (Zvjagincev, 1987). Second, the technogenic change is difficult to distinguish from the natural dynamics of microbiological processes in the soil. Both types of changes are characterized by the shift of one actively functioning microorganism to another. In one case, the change in organisms in the community is conditioned by pollution, and in the other, there is a change in the activity of ecologically-trophic groups of microorganisms with different development strategies (Guzev, Ivanov, 1986, Zvjagincev etc., 1994). At the expense of the natural dynamics of microbiological processes in freshly harvested soil samples, there may be a significant difference in the activity of different groups of microorganisms. In order to compare soil samples with varying degrees of pollution, these differences need to be leveled. By holding soil samples in an air-dry state, with subsequent simultaneous moistening before the experiment, it is possible to selectively synchronize the activation moment of the hydrolytic group of saprophytic microorganisms. In this way, other groups of microorganisms (oligotrophs and cytoropha) are temporarily derived from the active state (Guzev etc., 1986). For this reason, this work presents the research of various soil samples, which were kept in an air-conditioned state until the experiment.

When describing the microbial community, special attention is paid to the populations of microorganisms, which are bulkyly represented in the active group. Three gradations of abundance were used: dominant microorganisms, microorganisms that are often found, and microorganisms that are rarely found. An example is the description of amylolysis microbial communities of a large number of soils (Figure 1). In the picture, a wide variety of bands of different widths highlight the different representation of microorganisms in the land community.

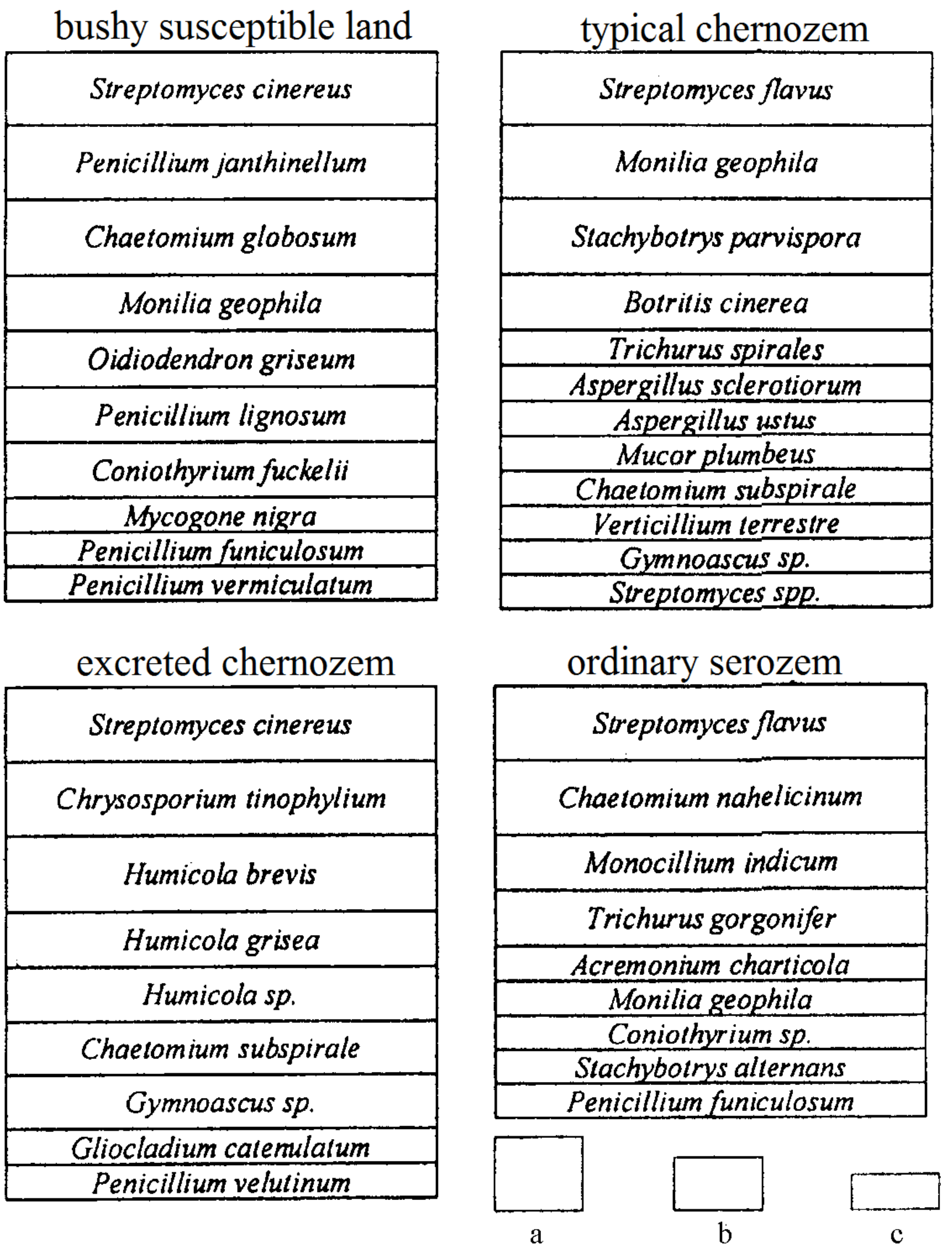
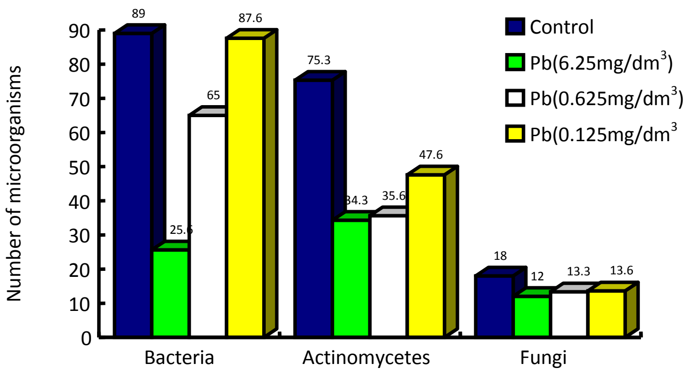
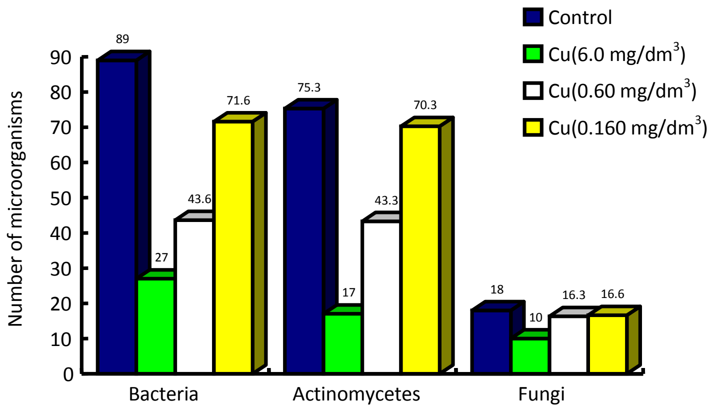


Fig. 1. Composition and organization of amylolytic microbial communities in different soils; a - the dominant level, b - microorganisms that are often found, and c micro-organisms that are rarely found (Guzev, Levin, 2001)

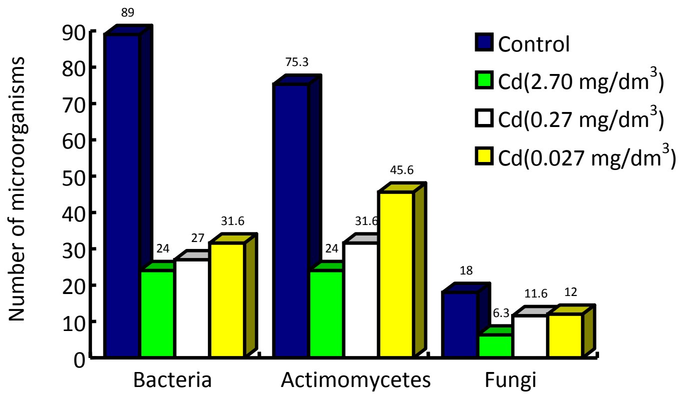
It should be pointed out that using this scale of abundance, very illustrative results are obtained. There are relatively few dominant microorganisms in the communities of different lands, but their composition is significantly different, even in genetically similar soils. The lawfulness of changes occurring in the community of saprotrophic soil microorganisms in technical pollution was studied using the amylolysis microbial community as a real model of the land microbial system. Initially, laboratory experiments determine the tendency of changes in the composition of soil microorganisms under the influence of artificial insemination of pollutants in growing doses. The gradient was the concentration of pollutants from extremely small to extremely large (Đukić, Mandić, 1997; Đukić et al., 1999) - graph. 1,2,3,4. A mandatory requirement for a minimum concentration of any pollutant is the absence of any changes in the microbial community of land compared to control. In addition, during the work on the gradient analysis of biotic communities (Ramenskij, 1938; Witteker, 1980), as a way of presenting test results, a diagnostic diagram is used, with one of the axes representing the concentration of pollutants, and on the other qualitative and quantitative characteristics microbial communities. The reality of legality, expressed in laboratory conditions, is checked by examining samples taken in field trials and in areas that are contaminated due to disasters or chronic disposal of insufficiently purified waste.



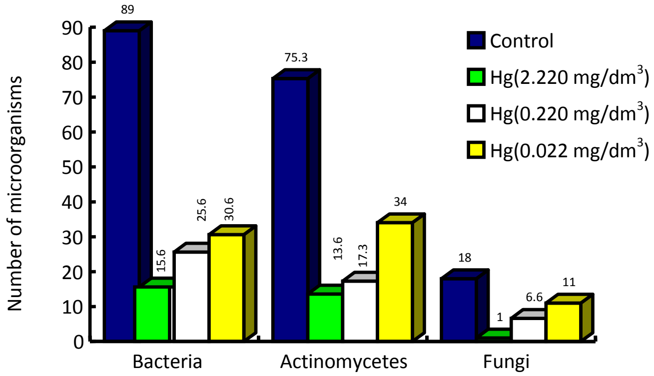
Graph.1. Effect of diverse concentrations of lead on total number bacteria (10^6 g^{-1} abs. dry soil), fungi and actinomycetes (10^5 g^{-1} abs. dry soil)- \uki} i sar., 1999.



Graph. 2. Effect of diverse concentrations of coper on total number bacteria (10^6 g^{-1} abs. dry soil), fungi and actinomycetes (10^5 g^{-1} abs. dry soil)- \uki} i sar., 1999.



Graph. 3. Effect of diverse concentrations of cadmium on total number bacteria (10^6 g^{-1} abs. dry soil), fungi and actinomycetes (10^5 g^{-1} abs. dry soil)- \uki} i sar., 1999.



Graph. 4. Effect of diverse concentrations of mercuty on total number bacteria (10^6 g^{-1} abs. dry soil), fungi and actinomycetes (10^5 g^{-1} abs. dry soil)- \uki} i sar., 1999.

Microorganisms, which colonize a significant part of starch on the surface of the soil, are checked for toxic activity in relation to soil animals and test plants. The selectivity of microbial biomass consumption in soil by microscopic nematodes and ticks is determined, as well as the suppression of germination of seed of the test plant, which is located directly on the biomass of the community. Information on the phytotoxic properties of the dominant microorganisms in the initiated community is used to qualitatively evaluate the changes occurring in the saprotrophic group of soil microorganisms in the pollution process.

It should be pointed out that both the energy substrate, which is used for activation, as well as the conditions for the development of the initiated microbial community, exhibit a certain selective effect. That is, information on the reaction of the microbial community of land to any impact is obtained on the basis of the "answer" of a limited, but rather numerous group of soil microorganisms - amylolithic. Pointing to the existence of a close interaction of microbiological processes in the soil, it can be established that the impact of the technogenic load directly or indirectly involves all parts of the soil microbial system, including the group of amylolysis microorganisms. The experience of experimental work is confirmed by the high indicative properties of this group of microorganisms. This is latter obviously related to the fact that the development of amylolithic, in accordance with the proposed methodology, takes place in non-sterile soil in conditions of natural competition of a large number of populations, capable of using an easily accessible substrate, such as starch.

The basic legitimacy of changes in the microbial soil system under the influence of technogenic pollution

The study of the reaction of microbial communities, which actively functions in soil, to various technogenic pollution, made it possible to formulate the basic setting for the given study: regardless of the nature of the pollutant, the change in soil microorganisms in response to the increasing load, is manifested alternately by four adaptive zones . Under the adaptive zone (Reuters, 1990), a conditional space is defined, limited by the interval of concentrations of the investigated agent, in which a certain entirety of changes in the microbial community, which actively functions in the soil, is observed. Each of the above zones corresponds to a certain level of technogenic excitation.
It turned out that, in the case of various contaminants, it is worthwhile to examine the reaction of soil microorganisms to different levels of technogenic load. On the one hand, this allows studying situations that are approximate to real, because in typical cases pollutants reach the soil at concentrations corresponding to different load levels: heavy metals - from several grams to several kilograms per 1 ha; fertilizers - from a few kilograms to several tons; oil - from thousands to tens of thousands t. On the other hand, the method of exposure of the subject matter allows to comprehensively examine the principally different ecological and microbiological aspects of the problem of optimizing the interaction of man and the natural environment.

Low load level

The first adaptive zone, characterized by a low load level, is the homeostasis zone of the microbial soil system. In the synocular diagram, a low level of loading is illustrated by the example of the action of cadmium on the initiated microbial community of busy-podzolic soil (Figure 2). In this figure, as well as in all subsequent analogue diagrams, the width of each strip (piece of land) bounded by the broken line, conditionally shows the representation of a particular microorganism in the community, depending on the dose of the pollutant. The homeostasis zone is limited to a diaspense concentration of 0 to 7 mg Cd / kg of soil, in which only the summarized biomass of an actively functioning community of microorganisms changes, and its composition and quantitative relationships of species are practically no different from the same in the control soil. Lead acts on the amylolysis microbial community analogously, but the homeostasis zone parameters are expanding - from 0 to 200 mg / kg (Figure 3).

Changing the composition or quantitative relationships of species in the community, in increasing the burden, testify to the transition to the next adaptive zone.

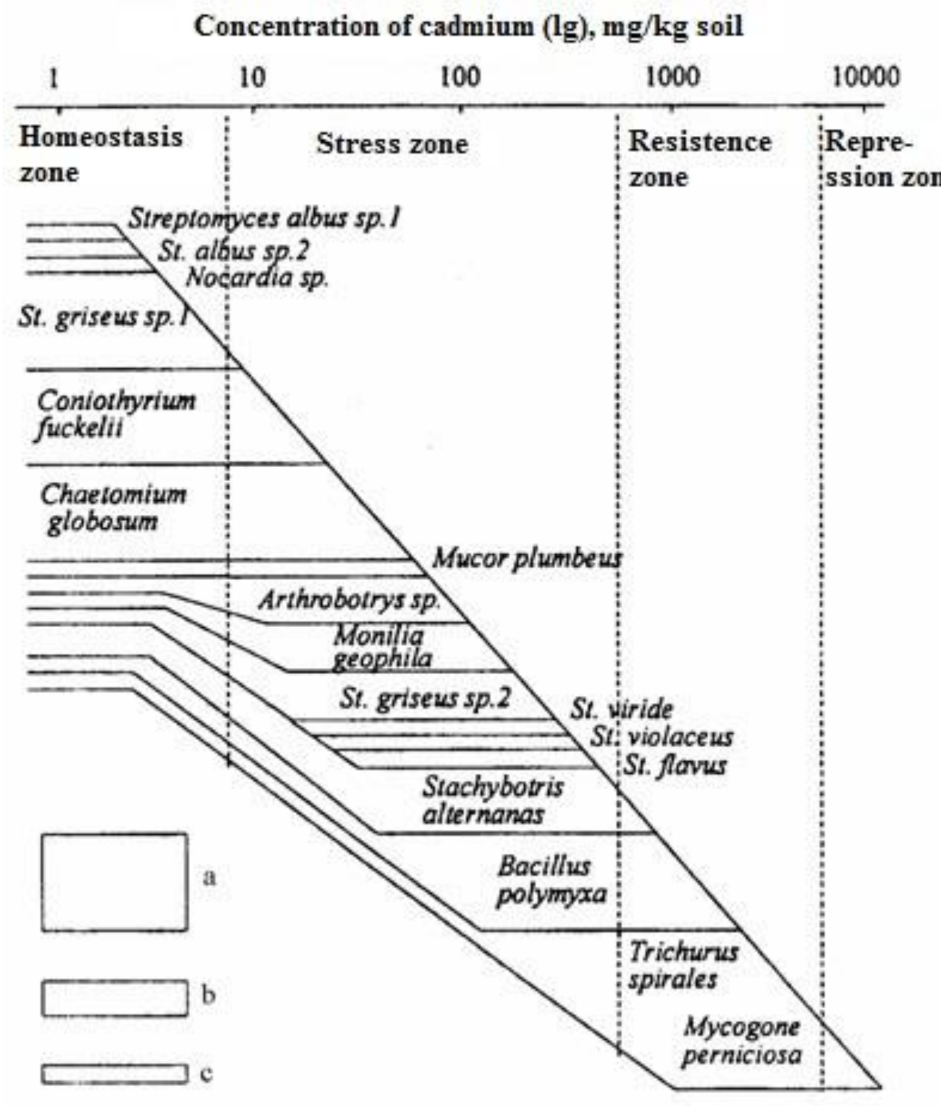


Fig. 2. The influence of the concentration of cadmium (in the form of acetate) on the organization of the amylolytic microbial community of podzolic soil; a- dominant species; b- frequently occurring species; c- rarely occurring species (Guzev., 1985).

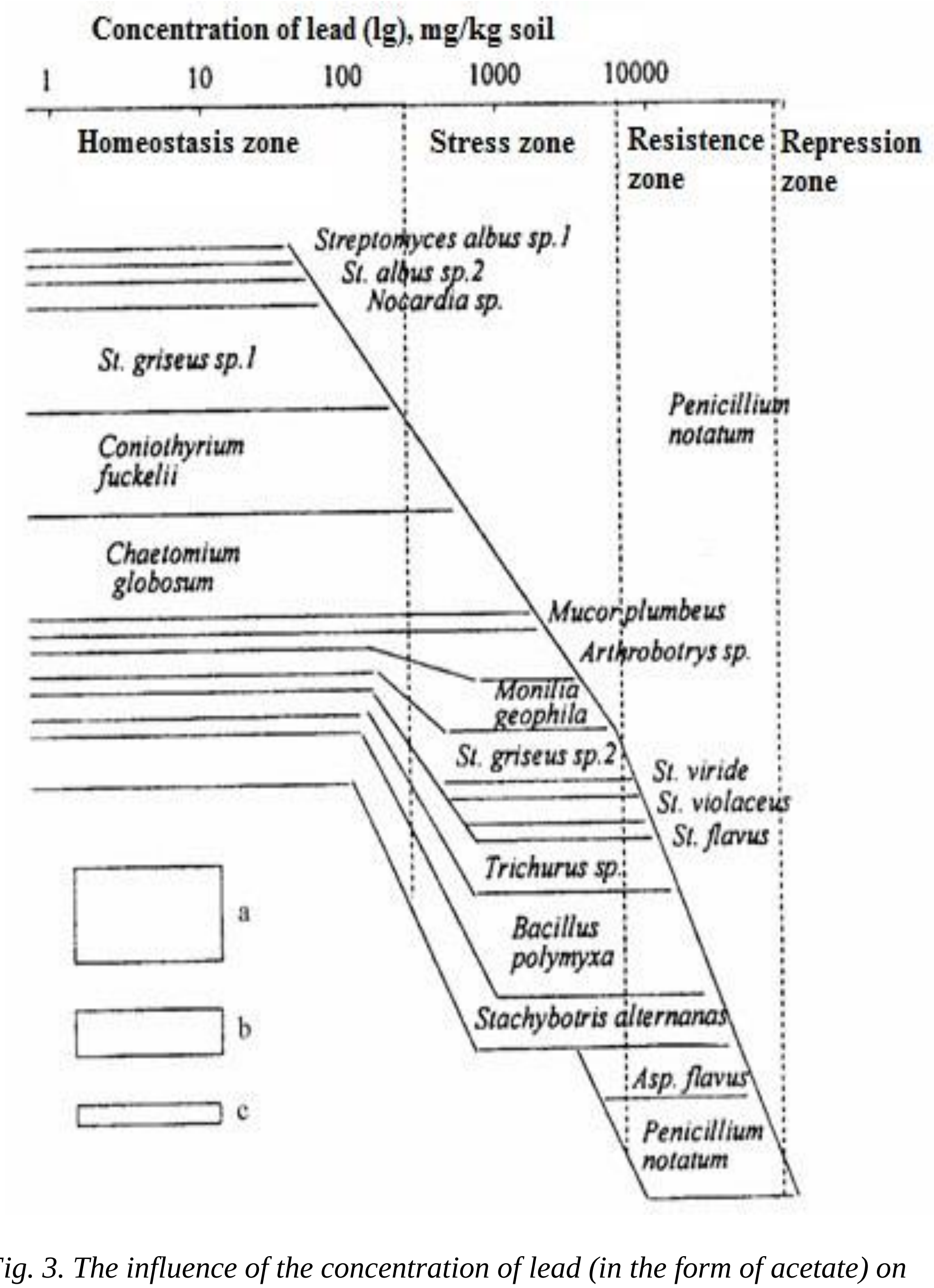


Fig. 3. The influence of the concentration of lead (in the form of acetate) on the organization of the amylolytic microbial community of podzolic soil; a- dominant species; b- frequently occurring species; c- rarely occurring species (Guzev, 1985).

The size of the homeostasis zone quantitatively reflects the comparative toxicity of the various contaminants directly in the soil. Thus, for example, for cadmium (Figure 2) in busy-podzolic soil this characteristic is 30 times smaller than for lead (Figure 3).

Comparison of different heavy metal compounds, according to the size of the homeostasis zone in the particular soil, allows these substances to be placed in a series with decreasing activity: Hg> Cd> Ni> Cu> Pb (tab.1). In the above sequence, the activity of certain compounds, in general, corresponds to their solubility. In this case, practically insoluble oxides of heavy metals in the soil are 2-3 times less toxic than from the well-soluble salts of these elements (Jemcev, Đukić, 2000; Đukić, Mandić, 2000).

Tab. 1. Comparative ecotoxicological activity of a range of heavy metals according to behavior in relation to the microbial system of busy-podzolic soil (Guzev, Levin, 2001)

Active element	**Form of compound**	**Size of the homeostasis zone (mg / kg land)**
mercury	nitrate (well soluble) sulphate (poorly soluble) sulphide (practically insoluble)	2 5 10
Cadmium	acetate (well soluble) oxide (poorly soluble)	7 20
Nikl	nitrate (well soluble)	30
Copper	acetate (well soluble)	70
Lead	acetate (well soluble) oxide (poorly soluble)	200 300

Comparison of the size of the homeostasis zone, as a measure of the potential resistance of soil microorganisms to pollution (tab 1), with other standards accepted in biology and medicine (Table 2), shows that the indicator, proposed by Guzev et al. (1985) in its entirety, corresponds to the concepts of comparative toxicity of heavy metals. It can be seen that, according to each normative, metals form strings that are somewhat different from each other. In doing so, it has been shown that practically in all cases Hg and Cd are the most toxic, while Ni, Cu, and Pb are less toxic. Naturally, the least concentrations accepted as permitted are characteristic of normative nutrients, and the concentrations accepted for the land are the highest. Other norms occupy an intermediate position.

Tab. 2. Comparative toxicity of a range of heavy metals (mg / kg) according to some sanitary and hygienic indicators (Guzev et al., 1985)

Indicator of toxicity	**Hg**	**Cd**	**Ni**	**Cu**	**Pb**	**Literary source**
Background in different land	0.01-1.0	0.01-1.0	5-500	2-100	15-100	*Dobrovoljskij*, 1980 *Rence, Kirstja,* 1986
MDK in the soil	2.1	5.0	35	23	20	*Gončaruk,Sidorenko*,1986 *Ammosova* i dr., 1989
MDK in plants	2.0-5.0	3.0-5.0	100	100	100	*Kloke*, 1979 *Rence,Kirstja*,1986
MDK in food products	0.005-0.7	0.01-0.2	0.4	0.4-30	0.5-3	*Bespamjatnov,Krotov*,1985 *Ribalskij* i dr., 1993
LD_{50}*	18	88	-	43	100	*Bespamjatnov,Krotov*,1985

* lethal dose of reagent, which causes 50% of mortality

The toxic effect of heavy metals on soil microorganisms, determined by the size of the homeostasis zone, is closest to the maximum allowed concentrations (MDKs) of these elements in the soil and is practically always above their minimum basic content. On the basis of all this, it can be considered that the proposed criterion is quite objective.

Medium load level

The second adaptive zone, characterized by the medium load level, is the zone of stress of the microbial soil system. Changes inherent to this zone are observed in experiments with all studied pollutants and are highlighted in all of the above mentioned diagnostic diagrams. The specificities of this zone are considered on the case of the effects of nitrogen fertilizers (Figure 4, Chart 5, 6). Under conditions of laboratory experiment, the stress zone is limited by diapasonic concentration of the agent from 100 to 7000 kg N / ha. In this interval, the concentration of mineral nitrogen, in the active microbial community, comes primarily to the redistribution of populations by the degree of domination. The leading position in the community is gradually occupied by organisms that are rare in the control soil (and in the homeostasis zone), and, on the contrary, the dominant control areas are rarely found. As a result, the composition of the community of stress areas practically does not differ from the control, and the community organization is undergoing significant changes. A further increase in the load leads to a change in the composition of species in the community, which indicates the transition to the next adaptive zone.

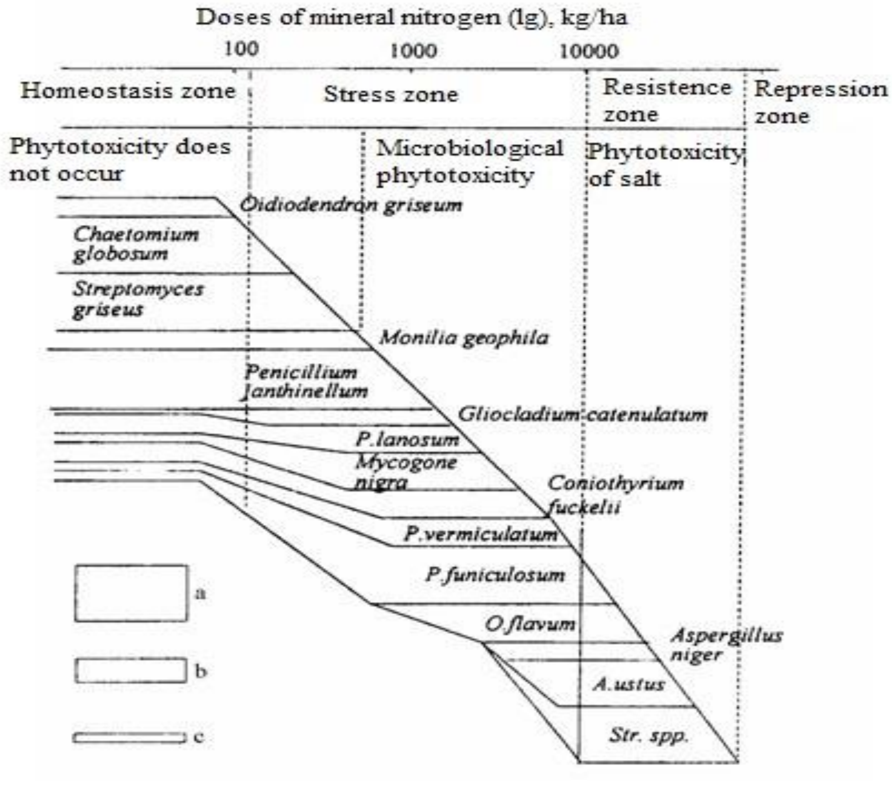
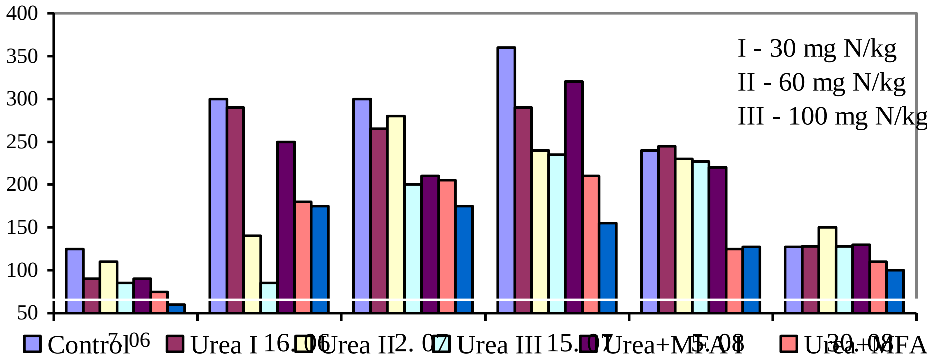
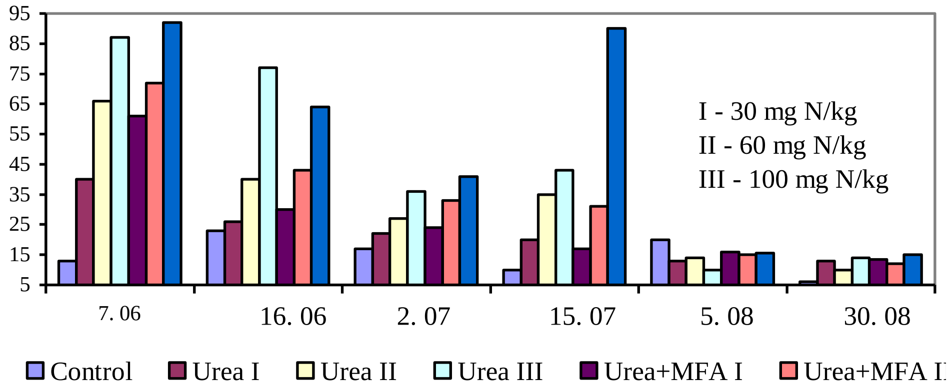


Fig. 4. Effect of mineral nitrogen (in the form of ammonium nitrate) per organization amylolytic microbial communities of podzolic soil; a- dominant species; b- frequently occurring species; c- rarely occurring species



Graph. 5. Changes in potential nitrogen fixing activity in a podzolic soil in the absence of plants under nitrogen fertilisation, x 10^{-3} mg/kg/ha



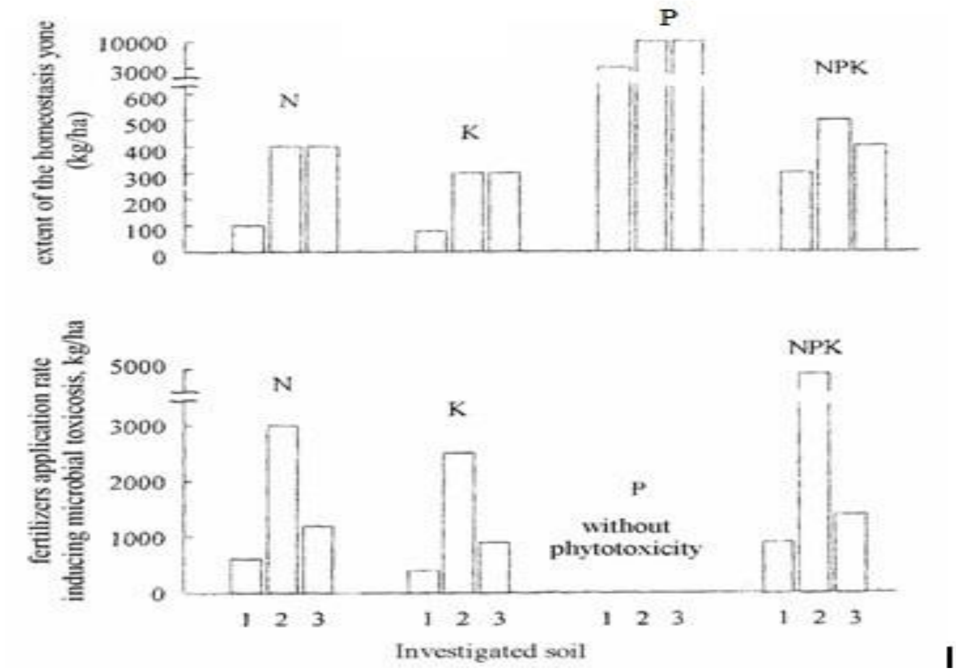
Graph. 6. Changes in potential denitrification activity in a podzolic soil in the absence of plants under nitrogen fertilisation, x 10^{-3}mg/kg/ha

It is very important to emphasize that under the influence of increased doses of nitrogen fertilizers in the community, in addition to structural changes, the physiological activity of soil microorganisms is also changing. For doses of 600 kg N / ha and above, the micromycetes Penicillium funiculosum, P. janthinellum and P. vermiculatum, which dominate the amyloidal community, directly in the soil inhibit seed germination (Figure 4), the development of seed-salad seeds and are not used by microscopic invertebrates - ticks and nematodes.

This phenomenon is called microbial soil toxicity (Guzev et al., 1984a, b). Previously, it was assumed that the leading role in soil toxicity, due to the application of mineral fertilizers, has microorganisms

(Krasiljnikov, 1958, Mandić et al., 2011, 2012; Đukić et al., 2015), however, the soil toxicity is, as a rule, explained by his strong acidification (Mineev, 1990), which directly or indirectly suppresses the plant's activity. However, in the given experiments, the acidity of the soil is slightly changed during the single feeding of mineral nitrogen, within the limits of 0.2-1.0 pH, and only at the highest doses of fertilizer. It should be emphasized that in the doses of mineral fertilizers, which are above the limits of the stress zone, the direct negative effect of these substances on the plants is observed - salt phytotoxicity.

Potassium and a lot of mineral fertilizer in increased doses show the effect of nitrogenous mineral fertilizers on the soil microorganisms (Zvjagincev, 1989; Yemtsev, Djukic, 2000; Djukic et al., 2018a, b), while only various forms of phosphorus fertilizers are not followed by microbial phytotoxicosis of soil Figure 5). In the zonal series, the studied soils differ from one another to the boundary concentrations between the homeostasis zone and the stress, and, in particular, according to the doses of fertilizers that cause microbial phytotoxicity.



Sl. 5. Comparative stability of the microbial systems of busy-podzolic soil (1), derived chernozem (2) and typical serozem (3)) as related to mineral fertilisers (Guzev, Levin, 2001)

The reality of the changes characteristic of the stress zone was shown in field experiments with long-term use of relatively small doses of mineral fertilizers (Figure 6). In the figure of dashed rectangles indicate the composition, and the lines - the quantitative relationship between the species of initiated microbial communities of soil in different variants of the experiment. The amyloidal microbial community of bush-podzolic soil in a variant with thirty years of introduction of 100 kg / ha / year of mineral nitrogen fertilizer is similar to the same in the model experiment with the one-time application of the same fertilizer in the dose range from 600 to 1300 kg / ha (Figure 4). The introduction of nitrogen, potassium and nitrogen - potassium fertilizers has also led to the dominance of the toxinogenic mushrooms of the genus Penicillium (Figure 6). Between the degree of microbial soil toxicity and the yield of agricultural crops, a close correlation was established: in these variants of the Polish experiment yields of all crop cultures decreased by 30-60% of control (Gomonova, 1984). It was further established that, when introducing the nitrification inhibitor (Popov et al., 1990; Đukić et al., 2009), some herbicides and certain heavy metals (Zvjagincev, 1989; Mandić and Đukić, 2010; Đukić et al., 2011) concentrations, corresponding to the stress zone, in the amyloidal community, toxinogenic microorganisms are predominantly developed. This allows for the very wide spread of the occurrence of microbial toxics and is marked as negative (i.e., which deteriorates the natural fertility of the soil) the medium load property.

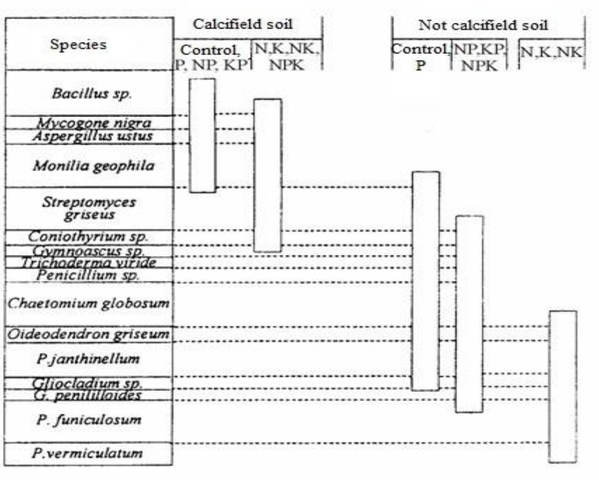


Fig. 6. Organization of the amylolysis microbial union of subsoil soil in field examination in calcium and the application of various mineral fertilizers; dominant level, microorganisms that are often and rarely found are presented with "strips" of different widths (Guzev, Levin, 2001)

The effect of eliminating toxinogenic microorganisms in the community, which is the opposite already described, is determined by the calcium acidification (pH 4.2) of bushy-podzolic soil. In this case, in the conditions of the laboratory experiment, a significant increase in the stability of the microbial soil system is observed on the high doses of mineral fertilizers. This reflects on the increase in the size of the homeostasis zone and the dose of fertilizer, which causes microbial phytotoxicosis (Table 3).

Tab. 3. The influence of calcium on the stability of the microbial system of busen-podzolic soil according to different doses of full mineral fertilizer (Guzev et al., 1985)

Dose of lime, hydrolytic acidity	**Doses of full mineral fertilizer, kg / ha**	
	Homeostasis zone	**Microbial toxicology**
0	300	1000
0.5	400	1300
1.0	500	1500
2.0	500	2500
4.0	600	3000

High load level

Resistance zone (zone of development of resistant forms of microorganisms) is the third adaptive zone of microbial soil system. It is characterized by a high level of loading and is exhibited at high doses of all studied pollutants, regardless of their nature. The characteristics of this zone are demonstrated in the case of oil effects (Figure 7). In the conditions of the laboratory experiment, the resistance zone is approximately "bounded" by the oil concentration range from 10 to 100 dm3 / m2 of soil. In this diapason, the dose of oil revealed radical changes in the composition of the amylolysis microbial community. Its variety of species is rapidly decreasing, but predominantly they do not develop for typical soil, but rather on the given factor of the highly resistant population of microorganisms. In bushy-podzolic soil such microorganisms are presented to the species of micellar mushrooms Aspergillus Ustus and Penicillium Tardum. These micromycetes are not characteristic of the land of a given type, but are more often adapted to the soil, enriched with organic matter. The composition of the amyloidal community, established in the zone of resistance, has nothing in common with the same in unpolluted soil. The total biomass of microorganisms in the community, in this interval, concentration of oil, as well as other pollutants, is, as a rule, stable, though its characteristic is not the same in the action of different reagents. A further increase in the load leads to the complete elimination of growth and the development of microorganisms in the soil. This testifies to the transition to the next (fourth) zone - the zone of repression of the microbial system of land, which is characterized by a catastrophic level of technogenic pollution.

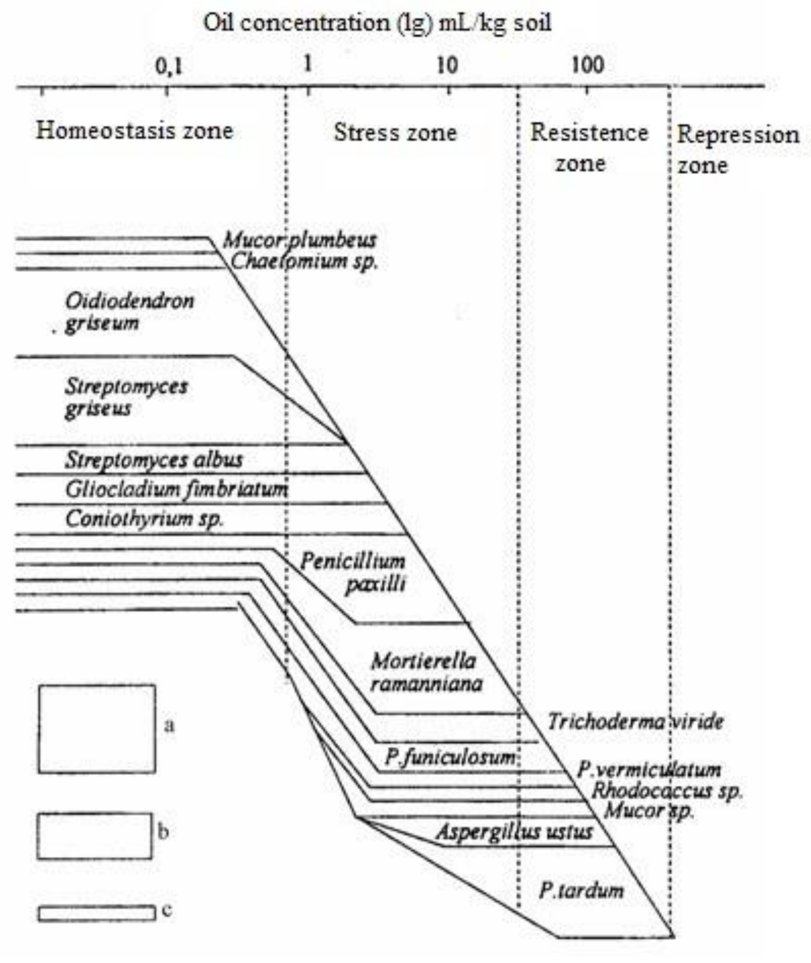


Fig. 7. Influence of the crude oil concentration on the organization of the amylolysis microbial substance of bushy-podzolic soil; a-dominant level, b-micro-organisms that are often found and c-microorganisms that are rarely found)

Gradient analysis of changes in the microbial soil system under the influence of technogenic load

The fundamental feedback of the community to increase doses of pollutants is to gradually inhibit the sensitivity and natural selection of resistant populations. Keeping in the framework of the given scheme Guzev etc. (1985) have been devoted to changing the given model. Their concept consists in the following: the return reaction of the soil microbial system to pollution can be in the basic form characterized by four types of changes in the community of microorganisms, which in the soil function actively. With the gradual increase in the technogenic load, these changes alternate, forming four adaptive zones.

The zone of homeostasis of the microbial soil system comprises a range of active agent concentrations, in which the composition and quantitative relationship of species in the community are unchanged. The total biomass of microorganisms in the community, as well as their activity, can grow somewhat, testifying to the basic stimulative effect of low concentrations of contaminants on microbiological processes in the soil.

The stress zone is a range of concentrations of the active agent, in which the composition of the active microbial community in the soil remains virtually unchanged, while the quantitative relationships of species are subject to significant changes. This is reflected in the redistribution of populations in the community according to degree of domination. The total biomass of microorganisms in the community, which expresses the intensity of microbiological processes, varies greatly in this adaptive zone. In the stress zone, the microbial system responds to changed environmental conditions, through the modification of its organization, in virtually unchanged composition.

The resistance zone is determined by the diapasonic concentration of the acting agent, in which there is a sudden decrease in the variety of species and the change in the composition of the microorganisms that actively function in the soil. Populations of microorganisms that are resistant to high doses of the given substance are developed. The stability of the overall biomass of the community is typical for this zone. The functioning of the microbial system in a given technogenic load interval is shown to be possible only at the expense of the realization of the maximum capabilities of some highly resistant populations, which were previously found in soil in limited quantities.

The zone of repression of the microbial soil system is characterized by complete suppression of growth and development of microorganisms in the soil. This type of change testifies to the complete exhaustion of the reserves of resistance of the living world of the land to the active burden and the inability to function microorganisms in the given conditions.

DIAGNOSTIC PROPERTIES OF DIFFERENT LEVELS OF SOIL CONTAMINATION

The specific properties of the adaptive zones of the microbial soil system, which were singled out by Guzev et al. (1985), have been determined by the action of different pollutants and are experimentally well described. On this basis, they can be proposed for the diagnostic properties of different levels of soil contamination. For the reference point, the basic content of contaminants in virgin lands, land of a specific geochemical region can be taken (Zirin etc., 1985). Such land may be considered unpolluted.

In the concentration of pollutants, which exceed the pollution base several times, only quantitative changes of the intensities of the microbiological processes in the soil can be determined (Panikova, Percovskaja, 1982; Jemcev, Đukić, 2000; Đukić et al., 2018 b, c), without any what qualitative disturbance of the state of the living world in the soil. However, significant spatial and temporal variability of these indicators greatly complicates their use for the diagnosis of pollution (Cairns, 1984; 1986, Zvjagincev, 1989). In addition, the continual character of the change in quantitative parameters does not allow to determine the boundaries between contaminated and unpolluted land. Bearing in mind this and taking into account that the concentration of pollutants in the soil is above the basic, it is suggested that the given load is considered a low level of pollution, which does not exceed allowed. Such a level of pollution has no subsequent effect, so the system easily returns to the starting state in case of elimination of the operation.

With the further increase in pollutant content, microorganisms are redistributed according to degree of domination, as a result of which negative phenomena can develop in soil. On the basis of this last one, one can speak of overcoming the norm, and on this basis, isolate the average level of pollution. As a diagnostic feature of a given level, a certain reduction in the diversity of species of microorganisms in contaminated soil and the increase in the participation of toxinogenic organisms in it can be called (Jevdokimova et al., 1984; Mirčink, 1988). As a supplementary property of this level of pollution, a sharp decrease in the variability of the indicators, characterizing the biological activity of the soil (Zvjagincev, 1989), and the increase in the participation of pigmented forms of microorganisms in soil

(Levin, Babjeva, 1985; Richardson et al., 1985) can be highlighted. These changes are characterized by a clearly expressed subsequent effect after removal of the load.

Changes in the living world in the soil, observed when the concentration of the pollutant exceeds the basic content several times, testifies to the high level of pollution. The diagnostic properties of this level are a sudden decrease in the microbiological activity of the soil, according to many indicators, and the development of a very limited number of resistant forms of microorganism. Land with such concentrations of pollutants is characterized by high total toxicity not only in relation to microorganisms, but also more organisms (Zvjagincev, 1989). And, in the end, practically completely suppressing the activity of soil microorganisms can be emphasized as a diagnostic feature of a catastrophic pollution level.

MICROBIOLOGICAL INDICATION OF SOIL CONTAMINATION WITH EXOGENOUS CHEMICAL COMPOUNDS

For the purpose of bioindication of different levels of soil contamination in real terms, the following is proposed. Low level can be determined on the basis of exceeding the basic concentrations of pollutants, which is determined using chemical analysis methods (Dobrovolsky, 1980; Zirin et al., 1985).

Microbiological indicators are the most appropriate for the indication of the mean level of pollution, among which it is considered the most important - the change of the dominoes between the microorganisms, which are active in the soil. It is therefore necessary to experimentally determine the given phenomenon, as well as its immediate connection with the operation of the investigated pollutant. In order to solve this problem, a method of indication was developed based on the reaction of the amylolysis microbial community to the soil of the "stress" dose of the pollutant. This latter equals approximately the doubled concentration, which determines the homeostasis zone. Injecting such a dose is necessary for the microbial community of unpolluted soil to be translated from the homeostasis zone to the stress zone. If there is no change in the domains in the initiated community after the dosing of the stress dose, then their redistribution should be considered in real conditions. Thus, it can be considered that the soil studied is characterized by a medium load level.

This method was examined in field and vegetation trials and enabled the realization of (biosecurity) of the medium level of soil contamination by heavy metals and pesticides. We consider that adequate graphical presentation of the results obtained by the given method is presented in

Figures 9 and 10. In the first case, the pollution of the soil by the mercury is registered (Figure 9), and in the second - different combinations of three pesticides: simazine, SSS and benomy). As an additional indicator of the medium pollution level, the reduction in the variability of soil biochemical process indicators, the reduction in the richness of species and the diversity of soil microorganism complexes, and the increase in the proportion of toxinogenic microorganisms in it.

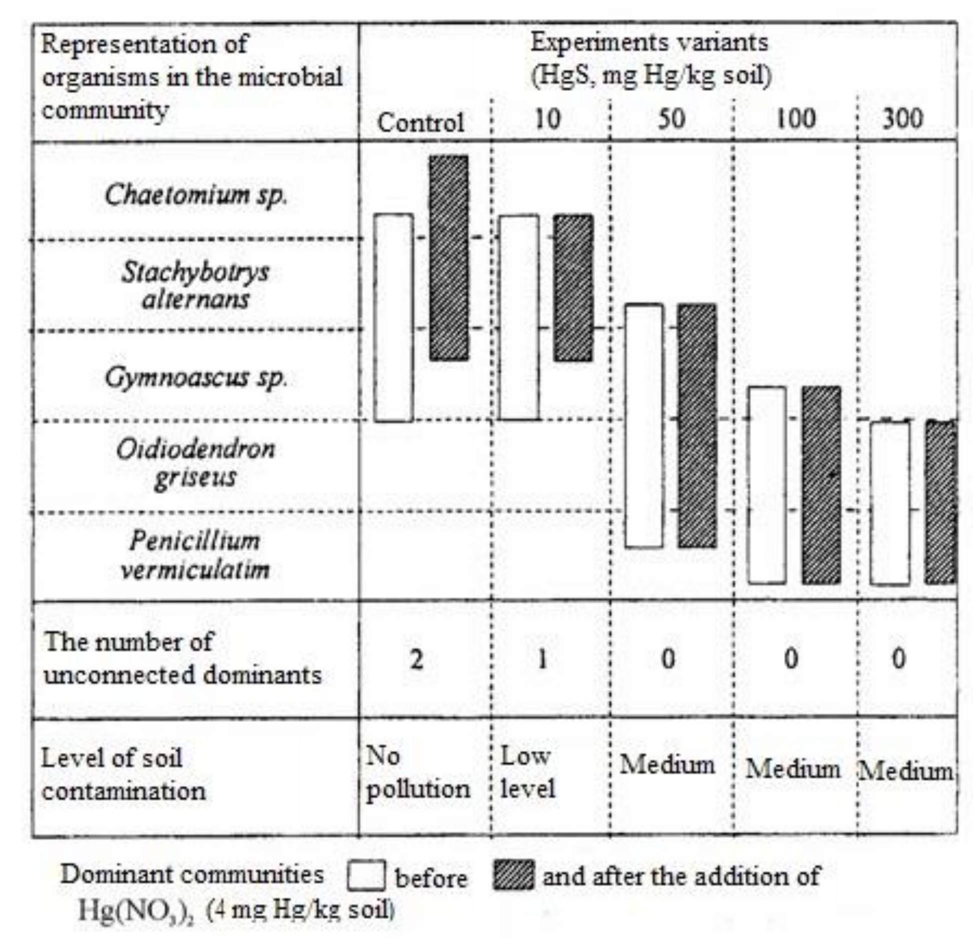


Fig. 9. Change of the dominant composition of the amylolysis microbial joint of bushy-podzolic soil in response to the supplemental introduction of HgS into the soil (Guzev etc., 1985)

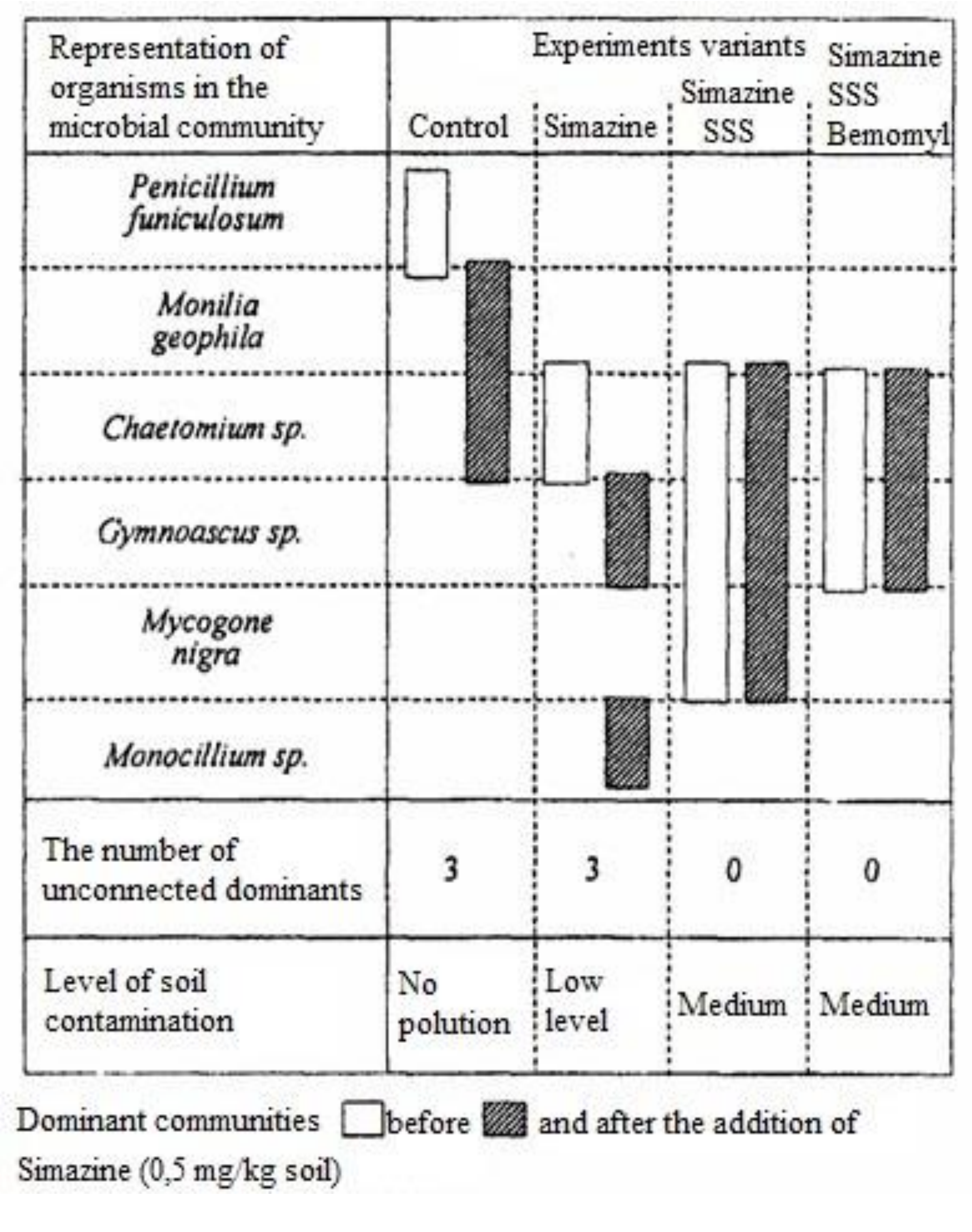


Fig. 10. Modification of the dominant composition of the amylolysis microbial joint of bushy-podzolic soil in response to the additional introduction of simazines into the soil (Guzev etc., 1985)

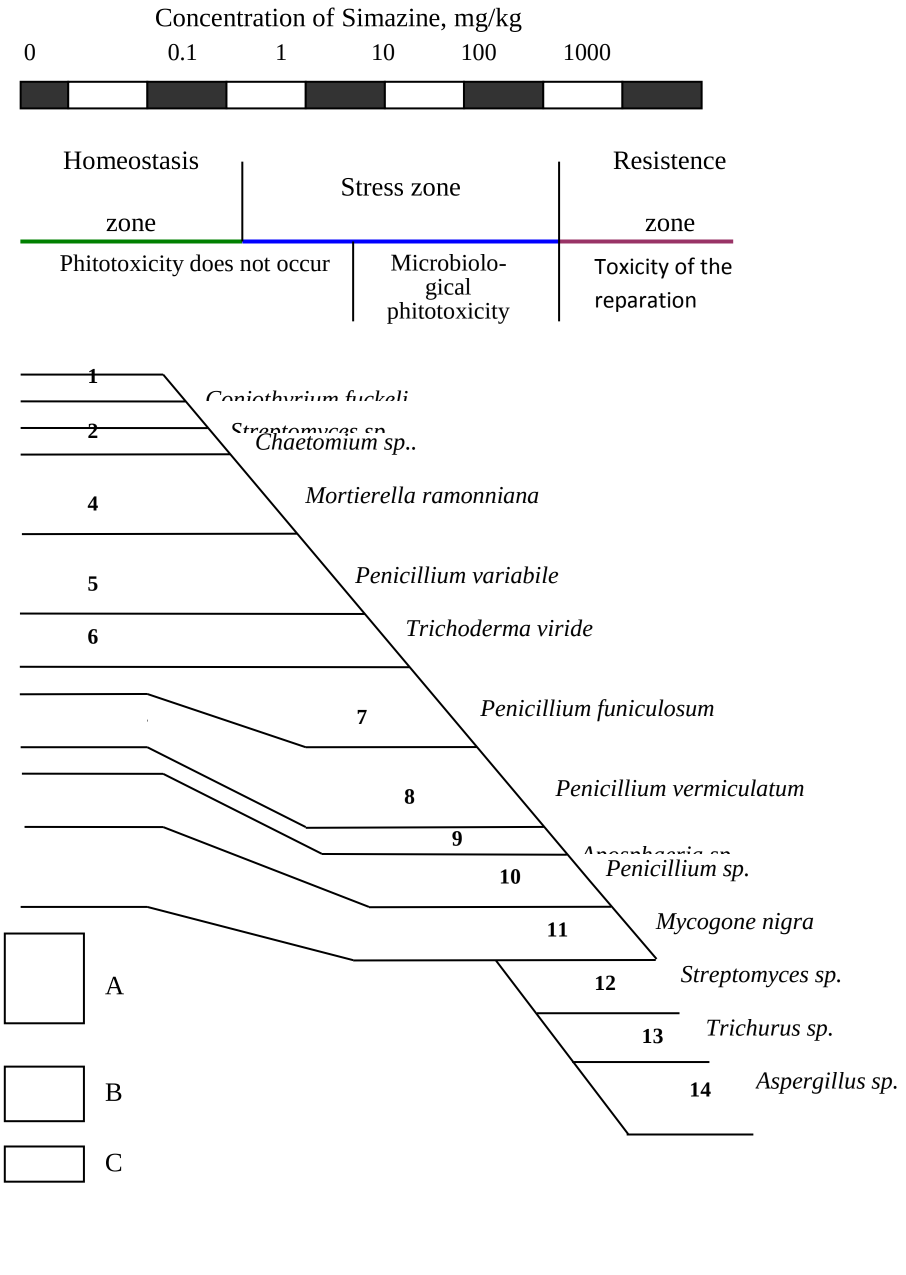


Fig. 11. The effect of the simasin on the composition and organization of the amylolysis microbial community
A-dominant species; B - species that are often found; C - a rare type

For the indication of a high level of soil contamination, many microbiological indicators are appropriate, for example, the widespread distribution of highly resistant microorganisms in the microbial soil community (Marfenina, 1981). However, we believe it is more appropriate to use other tests for it. Since soil at a given level of pollution is characterized by high toxicity, it is easier to determine the existence of that level using the reaction of higher organisms, for example, plants (Dobrovolsky, 1980; Zirin et al., 1985; Ilyin, 1986).

In this way, the proposed microbiological method of indicating contamination allows for a fairly reasonable determination of the mean level of burden of the living world in the soil, whereby the concealed negative consequences of the technical impacts on the soil can be determined.

CONCLUSION

Constant control of the state of the environment must rely on fundamental law, but in real conditions it is necessary to use, first of all, simple procedures and met . This latest request corresponds to today's most developed concept of maximum permissible concentrations (MDK) of pollutants in the soil. This norm is applied in the following way: one of the modern expression methods measures the content of the pollutant in real land, then it is compared with the value of MDK and on the basis of this comparison, a conclusion is drawn on the degree of contamination of the given land. In such a maximally formalized approach, the assessment of the state of the soil consists of its obvious advantage. However, it seems to be apparent (Dobrovolsky etc., 1985).

On the one hand, MDK pollutants in the soil are being developed, modeling experimental conditions and using a large group of different indicators and test objects, and then the strength of the law is added to that norm. However, for its application in real conditions it is necessary to introduce corrective coefficients, which take into account the properties of concrete land (Goncharuk, Sidorenko, 1986). Determining these coefficients requires a lot of severe regional irradiation, which, obviously, are not less extensive and versatile than in determining the MDK itself. In addition, the need to determine the impact of the plethora of exogenous substances that enter the soil, and which interact in different land-climatic zones, significantly complicates both the process of standardization and control.

On the other hand, the concept of MDK causes serious criticism and essence. From the aspect of global (basic) monitoring, it seems that this norm is unreasonably overestimated, since the concentrations corresponding to them often approach the threshold and sometimes critical values of pollution

(Ausmus, 1984; Krivoluckij etc., 1987; Stepanov, 1988). In this case, the basic MDK function is not fulfilled: to guarantee an acceptable (allowed) entry into the surrounding environment of a certain amount of exogenous matter, without any negative consequences for the biosphere. From the point of view of local monitoring, MDK is, to the contrary, too low, because on this basis it can be considered that most of the modern land is overcrowded (Zirin etc., 1985). This significantly impedes the focus of efforts on the implementation of concrete measures for nature protection and the prevention of local critical situations, as the abandonment of any kind of production appears as a uniquely acceptable alternative to any technical impact.

For local monitoring, it seems that a more constructive idea is the comparative expertise of several alternative technologies in order to choose the one that best preserves nature (SCOPE 5, 1979; Smathers et al., 1983). It is assumed that ecological expertise will be performed by specialists of different profiles who are obliged to evaluate the impact of different factors on the environment, health and well-being of people, and also predict the possible consequences of technogenic load by prince of analogous situations. In doing so, each specialist expert will evaluate the reaction of "your" object to a certain effect, with the help of government structures to make a qualified choice between proposed technological variants.

The proposed concept of ecological and microbiological assessment of the state of the land, on the one hand, was elaborated on the basis of the examination of the fundamental laws of changing the living world in soil under conditions of technogenic pollution (Guzev etc., 1985); on the other, contrary to the methodical characteristics of its realization, it can be used for the expertise of the state of the land. The proposed method of microbiological indication does not imply sharp requirements in relation to control samples, since the absolute, but relative, differences in the feedback reaction of the microbial community to the supplementary introduction of the pollutant are not compared. To perform the indication, there is no need for a high level of qualification in the field of the microorganism systematics, because in the microbial community it is sufficient to distinguish the dominant forms, which have clear morphological features. In addition, their identification to a species is often not needed: for practical purposes, it can be operated with mofrological types, which, as a rule, appear as different types. Based on this, it can be concluded that the proposed approach and the ways of its realization are quite simple, accessible for practical application, and therefore can be used in solving the basic task - optimizing the interaction between man and the natural environment.

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