SOIL INVERTEBRATES AS BIOINDICATORS OF ANTHROPOGENIC IMPACTS ON THE DIFFERENT FUNCTIONAL GROUPS IN THE IRRIGATION AND RAINFED AREAS OF SOUTHEAST OF KAZAKHSTAN

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ABSTRACT

The work is based on the study of influence of anthropogenic impacts on soil biological activity in comparison with its main indicators, which allowed to establish the soil fauna correlative connection with major traditional indicators of soil fertility, and significantly enhances their ecological importance in the assessment of agricultural techniques in agricultural production.

In Kazakhstan such researches have a fragmented character, soil animals and their effects on soil properties have been studied poorly. The reason for the relatively poor knowledge of soil animals is not only the complexity of the conditions for the existence of organisms in the soil, but also the difficulty of observation and study of the soil fauna due to the opacity and density of habitat. And, despite the importance of soil fauna in the soil-forming process, in Kazakhstan it is still poorly understood, especially in the agro-technical influences in irrigation and rainfed areas of south-eastern Kazakhstan. Lack of information on the biological activity in this area, the underestimation of the role of soil invertebrates and their value in the formation and reproduction of soil fertility, lack of methods of biodiagnostics and indication of soil identified the relevance and need for systemic research in this direction.

The title and direction of research on the effect of different systems of application of fertilizers, pesticides and other agricultural methods on living component of soil environment in the long-term stationary experiments, and, based on them, the development of parameters for monitoring of anthropogenic impacts in the system of modern agriculture in irrigation and rainfed areas of south-eastern Kazakhstan were chosen on the basis of above mentions.

Keywords: soil, soil invertebrates, bioindicators, anthropogenic impact

INTRODUCTION

Agricultural production is one of the main polluting factors of the soil cover, which is connected with the means used for crops protection. Unfortunately, many of drugs used in the past and at present have a pronounced negative effect on crops resulted in the

mutagenic, clastogenic [1], gametocidic [2] and general toxic effect, which ultimately leads to a decrease in plant productivity.

It is still little known the effects of fertilizers and pesticides in the soil invertebrates that have a significant impact on soil-forming process, especially in regular use. Fertilizer systems (mineral, organic, organo-mineral) used in agriculture have an impact not only on the productivity of crops and crop quality, but also on the ecological state of the soil and, consequently, the number and diversity of soil biota, which is an indicator of safety in the use of agrochemicals in agriculture.

The value of soil invertebrates as the important components in terrestrial ecosystems is well known. They occupy a leading place on zoomass composed of cenosis, significantly affect the processes of soil formation and biological activity.

Collection of mesofauna was carried out by M.S. Gilyarov method (1965). Soil invertebrates were considered in the samples of the areas of 0.25 m2 (50x50 cm). All the collected invertebrates were counted and fixed for further precise definition. Determination of the insect larvae was carried out using "Determination of soil-inhabiting insect larvae", for insects imago - "Determination of insects." Determination was carried out 3-fold.

Off-site treatment of the material was conducted on the basis of Ecology Biosphere Laboratory of Center of physicochemical methods of research and analysis of al-Farabi Kazakh National University and the Department of Soil Science and Agricultural Chemistry of the Kazakh National Agrarian University.

During processing the material the following indicators of soil macrofauna were studied: species diversity, at the level of collection and the number of soil invertebrates.

It was found that the use of fertilizers, especially organic, improves the vital functions of soil invertebrates (Table 1), which, in turn, depend on the optimization of many basic agrophysical and agrochemical soil properties (density, specific gravity, soil moisture, soil pH , a sufficient amount of root and stubble).

Table 1 - Effect of organic and mineral fertilizers on mesofauna meadow-chestnut soils (arable land)

Variants	Soil invertebrates	
	number of groups	total number of specimens per m^2
Control	3	12
RK estimated rate	4	16
Manure 30 t/ha	5	20
Manure 60 t/ha	6	24

Table 1 shows that the total number of mesofauna on the option with the introduction of manure (30-60 t/ha) was 20-24 specimens per m^2, while in the control sample (without fertilizers) their number was 12 specimens per m^2.

In our view, the higher number in a variant with manure is due to its direct and indirect effects: the direct effect is expressed in additional supply of manure mesofauna of

Scarabeidae family; the indirect effect - nutrients of manure serve as an additional source of food and organic matter, which improves soil structure, its water-physical properties and increase the buffering capacity.

Ultimately, all this creates favorable conditions for the habitat and nutrition of soil macrofauna.

Table 2 - Influence of treatment methods on the number of soil macrofauna (dry lands)

Predecessor	Methods of soil treatment	Soil invertebrates	
		number of groups	total number of specimens per m^2
Clean steam	Flat carved treatment at 20-22 cm	2	8
	Flat carved treatment at 10-12 cm	4	16
	Direct seeding (zero tillage)	1	4
Chickpeas	Flat carved treatment at 20-22 cm	3	12
	Flat carved treatment at 10-12 cm	5	20
	Direct seeding (zero tillage)	2	16

Table 2 shows that the number in different rotationfields ranged from 8 to 20 specimens per m^2. One of the factors of the change in the number is the crops rotation. The number of scarab (*Scarabaeidae*) and earthworms (*Lumbricidae*) increased after fields fallow. Increased number of these groups is also maintained under the chickpeas. On the field with chickpeas the number of click beetles (*Elateridae*) reduced with simultaneous increase of the larvae from the family of ground beetles (*Carabidae*).

Studies of the effect of tillage methods showed that in the use of flat carving abundance of insects increased by 12%, worms' population decreased by 17% on the contrary.

In direct sowing in the fields of study, there was some reduction in the number of pest insect to 9%.

As a result of studying the effects of chemicals on soil organisms in studied soils, it was found that they have a significant impact on the total number and composition of species.

Sensitivity to different chemical elements differs for various groups of soil organisms. Soil animals are a sensitive indicator of changes in terrestrial ecosystems under the influence of a variety of natural and anthropogenic factors. One of the most important environmental indicators is soil mesofauna. Therefore, in our opinion, this problem should be addressed not only in terms of soil invertebrates in protected areas, but also in soils that are subjected to intense anthropogenic loads. The use of soil macrofauna in bioindicative studies is the most interesting [3]. The complex changes in the composition of pedobionts is not always taken into account, a separate test facility is taken, the state of indicators of which serves as the evaluation of biome changes or the content of heavy metals in the environment by the accumulation in organisms bioindicators. The whole complex of soil animals in general and its individual elements are very sensitive to the most of biotic and abiotic factors, specifically respond to changes in humidity, temperature, soil chemistry that can be successfully used in

diagnostic and indicator purposes. Soil invertebrates under the influence of anthropogenic factors are of particular interest [4].

Studies indicate that pesticide pollution of soils leads to changes in species composition of soil invertebrates. Our findings confirm that there is a significant reduction in species diversity (20%) of the complex soil invertebrates families scarab (*Scarabaidae*), click beetles (*Elateridae*) and an increase in the absolute dominance of a small number of species: earthworms (*Lumbricidae*). Furthermore, the weevils family (*Curculionidae*) unusual for normal conditions appears in contaminated soil, obviously resistant to pesticides.

As a result of studies sensitivity of some types of pesticides mesofauna to various chemical elements was assessed: weevils (*Curculionidae*), leaf beetles (*Chrysomelidae*).

These results give a reason to conclude that, in contrast to the abundance indices, the species composition of soil organisms can be used as a criterion for quality assessment of the impact of pesticides on soil.

Data analysis on mesofauna of the investigated experimental variants helped to conclude that insect larvae from the family of *Carabidae, Scarabaeidae, Elateridae, Formicidae, Lumbricidae, Coccinellidae* are of common types, since these species have plasticity (the ability to inhabit in a wide variety of habitats). The dominant species are insect larvae of *Lumbricidae, Formicidae, Scarabaeida* (Figure 1).

Figure 1 - Common types of insect larvae in the studied experimental variants

It is found that the bulk mesofauna concentrated in the upper soil layers (0-10; 10-20 cm), in further 30 cm it was not found. In our opinion, such a distribution of invertebrates associated with the physical properties and mechanical structure of soil. Particle size is also largely determines the soil porosity and water-, breathability. Porosity affects the supply of oxygen and moisture of the soil. Moisture and aeration conditions, as well as the temperature determine the depth of soil invertebrates penetration. Mechanical and aggregate composition of the soil is also affects the depth of mesofauna holding. Since the large particles at the depth (0-10 cm) are not so dense, it provides minimal resistance for the move of soil animals.

More species were recorded in the variants with fertilizers. There are many types of *Carabida, Scarabaeidae, Coccinellidae, Lumbricidae, Formicidae.*

It was established that the introduction of optimal doses of fertilizers has no significant effect on the overall complex of soil mesofauna. However, it has a positive effect on certain types of soil invertebrates (*Scarabaeidae, Lumbricidae*), as well as the state of

the plant, which leads to an increase in overall agrocenosis productivity and some changes in microclimate conditions.

It was found that the quantitative and qualitative composition of soil macrofauna is associated with a certain soil type.

It should be noted that the genetic characteristics of the studied light-brown soils, according to A.A.Sokolov [5], is the absence of earthworms, which according to studies are a diagnostic indicator of the potential fertility of black earth and dark-brown soils. In terms of our study, it was found that their appearance on light-brown soils indicates an improvement of the soil structure and its physical properties. It is well known that earthworms, being the most effective natural structurants also enrich the soil with organic matter due to their coprolites.

The appearance of earthworms suggests that light-brown soils have favorable physical properties. Thus, our studies have shown that the anthropogenic factor (farming techniques used in the cultivation of various crops, the use of fertilizers and pesticides) has a significant impact on soil mesofauna.

Selection of organisms, the occurrence of which in the soil may be an indicator of soil conditions, causes essential issue of food relations, since this factor can be decisive in the distribution of soil invertebrates, but it is not significant in characterizing the soil.

An analysis of number and composition of mesofauna in these soils shows that the their division by the type of nutrition has not only a positive global-ecological, but also agronomic value. Our observations revealed that the larvae of *Pyrrhocoridae*, *Chrisomelidae, Geophilidae* associated with more humus, moisture soils (meadow-brown soils) that are not found in light-brown. In the light-brown soils larvae of *Curculionidae, Juliformidae* families are mainly found, but are not found on meadow-brown soils.

We also conducted a comparative analysis of the studied soils mesofauna by nutritional type.

The composition of soil fauna can be divided into three main groups according to the type of food (Gilyarov M.S., 1965).

1. Phytophages - animals that eat the underground parts of living higher plants.

2. Zoophages - animals that eat the other animals.

3. Saprophages - animals that eat decaying organisms, mostly plants (Table 3).

The data in Table 3 indicate that among saprophages earthworms (*Lumbricidae*), bedbugs (*Pyrhocoridae*) and millipedes (*Juliformidae*) are revealed in studied soils.

Scarabs (*Scarabaidae*), click beetles (*Elateridae*), comb-clawed beetles (*Alleculidae*); darkling beetles (*Tenebrionidae*); leaf beetles (*Chrisomelidae*); weevils (*Curculionidae*) are prominent representatives of phytophages in these soils, and ground beetles (*Carabidae*); ladybugs (*Coccinellidae*); ants (*Formicidae*); geofilidy (*Geophilidae*) - of zoophages.

Table 3 - Zoological biodiagnostics of studied soil by nutrition type

Soil type	Nutrition type		
	Saprophages, specimens per m^2	Phytophages, specimens per m^2	Zoophages, specimens per m^2
Meadow-brown	Earthworms (*Lumbricidae*) – 16.2 Bedbugs (*Pyrrhocoridae*) – 8.0	Scarabs (*Scarabaidae*) – 8.6 Click beetles (*Elateridae*) – 7.1 Comb-clawed beetles (*Alleculidae*) -5.2 Darkling beetles (*Tenebrionidae*) – 4 Leaf beetles (*Chrisomelidae*) – 4.3	Ground beetles (*Carabidae*) – 5.7 Ladybugs (*Coccinellidae*) – 3.2 Ants (*Formicidae*) – 8.7 Geophilidae (*Geophilidae*) -3.2
Light-brown	Earthworms (*Lumbricidae*) – 7.2 Millipedes (*Juliformidae*) – 4,0	Scarabs (*Scarabaidae*) – 6.6 Click beetles (*Elateridae*) – 6.1 Darkling beetles (*Tenebrionidae*) –3.5 Weevils (*Curculionidae*) – 4.4	Ground beetles (*Carabidae*) – 4.2 Ladybugs (*Coccinellidae*) – 5.5 Ants (*Formicidae*) – 7.2

Classification by food type is of great practical importance, since it can be used in the prediction of the decline in yields of cultivated crops.

Mesofauna, along with the other soil characteristics, may be used as a biological indicator. Biodiagnostics of investigated soils was carried out by the classification based on the food chain and habitat of soil invertebrates (Table 4).

Table 4 – Bioindicators of studied soils

Type, subtype of soil	Type	Class	Troop	Family
Meadow-brown soils	*Arthropoda*	*Insecta* *Chilopoda*	*Coleoptera* *Geophilomorha*	*Pyrrhocoridae* *Chrisomelidae* *Geophilidae*
Light-brown soils	*Arthropoda*	Insecta *Diplopoda*	*Coleoptera* *Julida*	*Curculionidae* *Juliformidae*

CONCLUSION

Bioindicator species studied are present regardless of the use of fertilizers and accordingly the level of pesticides. Light-brown soils are characterized by the lack of soil invertebrates belonging to the families *Chrisomelidae*, *Geophilidae*, which are also present in meadow-brown soils, whereas the larvae of soil mesofauna - *Curculionidae*, *Juliformidae* are typical representatives of light-brown soils. Representatives of these families can be used as bio-indicators in the studied soils.

It was found that the maximum toxic effects of pesticides on soil organisms in the studied soils appears in the summer, when the number of soil macrofauna is decreased significantly from 24 to 12 specimens per m2. These include representatives of *Carabidae* ground beetles and *Tenebrionidae* darkling beetles. It was also found that the number of such organisms as the larvae of *Scarabeidae* family – scarabs and Lumbricidae - earthworms increases, exceeding the reference values, sometimes by 2-3 orders.

These groups of soil organisms are tolerant to contamination by pesticides. These include representatives of *Curculionidae* family - weevils, *Scarabeidae* – scarabs and *Lumbricidae* - earthworms.

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