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BIOINDICATION AND MAIN WAYS OF OPTIMIZING AGRICULTURAL INFLUENCE ON NATURAL ECOSYSTEMS

The article deals with the main aspects of positive and negative influence of agriculture on natural ecosystems.

The positive influence of agriculture on the environment consists in creating reservations of biodiversity in anthropogenic landscape, for example, forest lines protecting fields from erosion of soil. Agricultural activity can stimulate the increase in the number of some species. Most negative influence is felt by natural ecosystems of forests, meadows, rivers, etc. adjacent to agricultural lands. One of the examples of consequences of agricultural negative influence is anthropogenic successive processes in natural ecosystems, structural and functional changes of biota. Research shows that most receptive to pollution are water ecosystems (rivers, streams, lakes, etc.), swamp ecosystems, ecosystems of water-meadows of small rivers.

In the result of contamination of soil and water with different substances (primarily organic) biodiversity is reduced, species and ecological structure of natural ecosystems are changed (the number of highly specialized — stenobiontic species of plants and animals decreases, on the contrary, the number of euribionts, i.e. species tolerant to anthropogenic influence — increases).

In the article the main ways of optimizing agricultural activity influence on natural ecosystems are defined. The efficiency of monitoring of ecological state of natural communities, which are under pressure from agriculture, considerably improves when methods of bioindication are employed.

Different taxonomic groups of organisms can react to direct toxic influence and change in habitat caused by this influence in various ways. To define the level of agricultural influence on natural ecosystems it is possible to use certain species as well as whole taxonomic groups of organisms as bioindicators.

Key words: bioindication, species-bioindicators, agricultural impact, natural ecosystems, environmental monitoring.
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БИОИНДИКАЦИЯ И ОСНОВНЫЕ ПУТИ ОПТИМИЗАЦИИ СЕЛЬСКОХОЗЯЙСТВЕННОГО ВОЗДЕЙСТВИЯ НА ЕСТЕСТВЕННЫЕ ЭКОСИСТЕМЫ

В статье рассматриваются основные аспекты положительного и отрицательного влияния сельского хозяйства на естественные экосистемы.

Положительное влияние сельского хозяйства на окружающую среду заключается в создании резерватов биоразнообразия в антропогенных ландшафтах, например, лесозащитных полос, защищающих поля от эрозии почвы. Сельскохозяйственная деятельность также может стимулировать увеличение количества некоторых видов. На природные экосистемы лесов, лугов, рек и иных объектов, прилегающих к сельскохозяйственным угодьям, ощущается в основном негативное влияние. Одним из примеров последствий отрицательного сельскохозяйственного воздействия являются

антропогенные сукцессионные процессы в природных экосистемах, структурные и функциональные изменения биоты. Исследования показывают, что наиболее восприимчивы к загрязнению водные экосистемы (реки, ручьи, озёра и т. д.), болотные экосистемы и экосистемы пойменных лугов малых рек.

В результате загрязнения почвы и воды различными веществами (в первую очередь органическими) уменьшается биоразнообразие, видовая и экологическая структура природных экосистем изменяется (количество узкоспециализированных стенобионтных видов растений и животных уменьшается, а число эврибионтов, т. е. видов, толерантных к антропогенному воздействию, — увеличивается).

В статье определены основные пути оптимизации влияния сельскохозяйственной деятельности на природные экосистемы. Эффективность мониторинга экологического состояния природных сообществ, находящихся под сельскохозяйственным прессингом, значительно улучшается при использовании методов биоиндикации.

Различные таксономические группы организмов могут реагировать на прямое токсическое воздействие и изменение условий обитания, вызванных этим воздействием, различными способами. Чтобы определить уровень сельскохозяйственного воздействия на природные экосистемы, можно использовать отдельные виды, а также целые таксономические группы организмов в качестве биоиндикаторов.

Ключевые слова: биоиндикация, виды-биоиндикаторы, сельскохозяйственное воздействие, естественные экосистемы, экологический мониторинг.

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Introduction. Global ecological problems are crisis ecological situations acute to the whole planet the solution to which can be found only by participation of the whole mankind. These problems are caused by the increasing influence of man on nature, in the first run — on natural ecosystems. Besides other global modern problems this category includes the problem of global atmosphere and water pollution, land pollution and degradation, as well as cutting down of biodiversity and ecosystems' degradation. The cause of these problems is increasing influence of human activity on the biosphere.

The study of human impact on the natural ecosystem presents one of the most important directions in ecology, which is actively being developed in many countries [1—4].

Alongside with industrial sources of negative influence on the environment agriculture also has significant influence on natural ecosystems and agriculture. However the influence of agricultural activity on nature cannot be evaluated as definitely negative.

The positive influence of agriculture on the environment consists in creating agriculture ecosystem as reservations of biodiversity in anthropogenic landscape, creating conditions for increasing the number of some organisms.

The negative influence of agriculture on the environment consists in transformation of natural landscapes and environment pollution.

Transformation of natural landscapes can go in different directions: destruction of natural ecosystems in the result of deforestation, meadows' ploughing, swamps' draining for agricultural needs; producing anthropogenic ecosystems — agroecosystems (ecosystems of fields, vegetable gardens, gardens, etc.); transformation of natural ecosystems under the influence of cattle pasture, hay-mowing, etc.; soil degradation, water and wind erosion.

The use of new agricultural lands has already led to serious consequences in different regions of the Earth. Agriculture is an inherent sphere of social activity which provides for existence of our civilization. That is why under modern conditions of striving for stable development the problem of agricultural activity is raised in order to prevent negative influence on natural communities.

Material and methods. The material for the article present research results of the authors carried out on the territory of Belarus in the period from 2008 to 2014. The standard methods of collection and identification of species used to establish the species structure of organisms living in ecosystems which have been affected by anthropogenic factors of agricultural origin. Invertebrates were collected by cutting entomological net on vegetation and hand-picking. In order to establish the taxonomic structure of invertebrate fauna living in aquatic ecosystems hydrobiological net, hand-picking of invertebrates from the roots of macrophytes, washing in the bath with water and sifting soil sieve sediment and decomposing plant remnants were

used. Species structure of vertebrates was taken into account by visual records on the routes. Higher plants were considered by visual records, manual collection routes and drawing up a herbarium.

To assess the ecological status of aquatic ecosystems bioindication method based on the analysis of the species structure of invertebrates was used [5—7].

Results and discussion. Agricultural activities can have both positive and negative effects on natural ecosystems. The positive influence of agriculture on the environment consists in creating reservations of biodiversity in anthropogenic landscape, for example, forest lines protecting fields from erosion of soil on the territory of Belarus are places of concentrations for many species of insects (bugs Miridae, Nabidae, Reduviidae, Acanthosomatidae), beetles (Carabidae Staphylinidae, Scarabaeidae, Coccinellidae, Cerambycidae, Chrysomelidae, Curculionidae), butterflies (Nymphalidae, Satyridae) etc.), amphibias (Anura), birds (Passeriformes) and mammals (Insectivora, Rodentia). Agricultural activity can stimulate the increase of the amount of some species. Forest-protecting lines make a convenient place of habitation for the long-eared owl (*Asio otus* (Linnaeus)).

Enlargement of cultivation areas encourages increase in number of pests, weeds and several species tending to places of human habitation. Swamps' drainig in Belarus and their use as territories for agricultural activity (growing agricultural plants, pasture of cattle, etc.) stimulated the increase of the white stork (*Ciconia ciconia* Linnaeus) population. At the same time, it is agricultural lands (fields pasture, etc.) that make comfortable places for habitation of such hunting species of birds as the sulfuric partridge (*Perdrix perdix* Linnaeus), quail (*Coturnix coturnix* (Linnaeus)). Different species of geese *(Anser)*, including rare species, in the period of spring migration use fields with winter crops as feeding places. The abundance of invertebrate (in the first run agricultural vermin in the fields and vegetable gardens) leads to the increase in number of some species of amphibians (toad *Bufo bufo* Linnaeus) and birds (starling (*Sturnus vulgaris* Linnaeus), yellow wagtail (*Motacilla flava* Linnaeus) whinchat (*Saxicola rubetra* Linnaeus), black-headed gull (*Larus ridibundus* Linnaeus), rook (*Corvus frugilegus* Linnaeus), jackdaw (*Corvus monedula* Linnaeus)). Some predatory birds (kestrel (*Falco tinnunculus* Linnaeus), marsh harrier (*Circus aeruginosus* Linnaeus) and buzzard (*Buteo buteo* Linnaeus)) eagerly use agrocenoses as hunting areas.

The scientific project "Structural and functional transformation of small rivers flood lands' biota under anthropogenic influence" was carried out in Baranovichi State University. In the result of the conducted research there have been defined the taxonomic and ecological structure of small rivers flood lands' biota experiencing different degrees of anthropogenic influence. The conception of structural and functional change of small rivers flood lands' biota under anthropogenic influence of different levels has been formulated. There have been worked out practical recommendations on small rivers ecosystems' preserving.

Most negative influence is felt by natural ecosystems of forests, meadows, rivers, etc. adjacent to agricultural lands. One of the examples of consequences of agricultural negative influence is anthropogenic successive processes in natural ecosystems, structural and functional changes of biota. Research shows that most receptive to pollution in Belarus are water ecosystems (rivers, streams, lakes, etc.), swamps ecosystems, ecosystems of water-meadows of small rivers.

In the result of contamination of soil and water with different substances biodiversity is reduced, species and ecological structure of natural ecosystems are changed: the number of stenobiontic species of plants and animals (narrow specializing species related to biotopical preference and food specialization) decreases, on the contrary, the number of euribionts (widely specialized species), i. e. species tolerant to anthropogenic influence, — increases.

Under the influence of a number of factors (cattle pasture, land and water pollution with sewage from cattle-breeding farms, watering off mineral fertilizers and organic substances from fields, spring burning of grass, hay-mowing, etc.) in zoocenoses of rivers, water meadows and flood-lands forests on the territory of Belarus the portion of stenobionts

reduced from 0.09% to 0.05%. Less vivid changes in this case showed the ecological structure of higher plants. The number of stenobionts reduced from 18% to 11—10%. Besides, due to the above mentioned factors there was seen a tendency for decreasing in diversity of plant associations which varied from 50—40 in non-influenced flood-lands ecosystems to 20—30 in influenced ecosystems. The decrease in number of food (trophical) groups, reduction of the number of invertebrate phytophages in comparison with zoophages was also registered. The correlation of phytophages and zoophages in flood-lands ecosystems is 1.6—1.7 when the influence is minimal or absent while it is reduced to 1.0—1.1 in ecosystems with intensive agricultural influence.

Research shows that species structure of animals and plants in flood-lands ecosystems of small rivers vividly illustrates the degree of anthropogenic influence. When anthropogenic influence grows the number of species decreases immensely. Thus, the number of species of invertebrate can decrease by 10—58%, and vertebrate — by 10—37%. This parameter for plants varies from 3 to 27% under different degree of influence. The coefficient of flora and fauna similarity with ecosystems is registered to fall under the increase of influence. This witnesses the process of convergence which is accompanied by gradual disappearance of initial differences between non-influenced communities and communities under anthropogenic pressure.

Melioration of swamp when agricultural technologies are not followed can lead to serious consequences for ecological systems. Land-reclamation which is not scientifically based can result in: decrease in biodiversity of swamps and ecosystems adjacent to them; decrease of subsoil waters level, fir-wood drying; shallowness of water bodies; turning into deserts of territories suffering land-reclamation and degradation of soil (more than 190 000 hectares of drained lands have soil degraded to different degree); pollution of water ecosystems with organic and mineral substances watered from drained swamps, and as a result — their overgrowth with macrophytes, shallowness and upsetting the hydrological conditions [8; 9].

In the course of analysis of anthropogenic transformation of ecosystems (in particular, in the result of agricultural activity) on the basis of literary sources [10; 11] and data of our own research several general theses characterizing the process of anthropogenic change of natural ecosystems were formulated.

1. The identity of parameters indicating the state of ecosystems in the process of transformation under the same type of influence in different geographical zones.

2. Different resistance to influence with different species, groups, types of ecosystems.

3. Anthropogenic influence is felt by the ecological structure of communities. It is unfavourable to stenobionts and favourable to euribionts.

4. The transformation of ecosystems is digression (i. e. a variant of succession opposite to progression) having the following characteristic features: simplification of species structure of communities (decrease in α-diversity) due to decrease in total number of species; convergence of communities (decrease in β-diversity); in other words, anthropogenic influence equals initial differences between communities, i. e. sequential gradual stages of changes with different ecosystems lead to the same final stages; mirror reflection of the stages of digression and progression (final stages of natural ecosystem's digression, preceding their complete destruction are, to a certain degree, similar to initial stages of progression, i. e. successive process of natural ecosystems' development to conservative community).

5. Absence of monotony of biota's reaction to anthropogenic influence is possible, namely: different vector of the same group reaction (suppression, stimulating) under influence of different level, different vector of various groups' reaction under the influence of the same level.

6. Non-specific biota's reaction to toxic influence. Anthropogenic changes of ecosystems in their activity are analogous with naturally conditioned. In other words, biota reacts the same way to any unfavourable changes no matter what their origin could be.

7. Non-linear biota's reaction to influence can be revealed in: different pace of changes under different levels of influence (i. e. in some places there are traced slow or proportional (according to the

degree of influence) changes; however, there are also places where small increase in influence causes strong reaction of biota; the existence of threshold in reaction, i. e. the effect of light anthropogenic influence is difficult to discover, it is not felt to a certain degree of influence.

To avoid negative consequences is possible with the help of measures aimed at optimization of interaction of man and nature [8; 9].

The optimizing of agricultural activity influence on natural ecosystems includes several ways.

The use of purification buildings at agricultural enterprise and prevention of non-licensed sewage throwing into water and soil. Activity in this direction will make it possible to prevent sewage throwing into the environment and not to put natural ecosystems at risk of degradation, in the first run water and flood-lands. Besides, these measures will positively influence the state of soil in ecosystems because they will prevent soil-building organisms from destruction.

Banning of running agricultural activity in protected zones of rivers, streams and other water bodies, as well as within key natural territories. For agricultural objects which serve as sources of influence on natural ecosystems there have been introduced parameters of sanitation-preventive zones from 50 to 1 000 m depending on: power, conditions of employment, character and number of substances thrown into the environment, noise and vibrations produced by them and other unfavourable ecological factors, as well as their influence on the place of living and health of man.

Economizing of fresh water usage in agriculture, for example, for watering. This will make it possible to lower taking water from rivers and lakes, and thus not to upset the hydrological balance in water bodies. It will also benefit to steadiness of natural ecosystems.

Carrying out science-based melioration. Such melioration benefits rational use of land sources and economic prosperity of the region. First and foremost it concerns the necessity to produce soil-protecting lines consisting of trees and bushes along the shores of land-reclamation canals. This will enable to avoid weathering of soil and washing it off into canals. Moreover, creating such lines will positively influence the hydrological conditions of drained lands and will not allow the lowering of subsoil waters' level in adjacent ecosystems.

Prevention soil from becoming saulty, bogged up and erosed. Conservation of lands as the main means of agricultural production, territorial basis of various management, key environment-building factor is one of the main tasks of agriculture. Ways of land resources' protection are complex and imply holding management, hydro-technical, forest and land-reclamation measures directed at optimizing of land usage in agriculture [8]. To management measures belong: differentiated use of land in agriculture. It is important to evaluate agro-ecological state of soil which differs in genetic componential composition, the level of fertility, degree of moistening, being subject to erosion and other properties. To hydro-technical measures of land resources belong: building adaptation land-reclamation systems instead of land-reclamation based on drainining. Adaptation land-reclamation systems are constructions adapted to natural conditions of the land-reclamation object. This includes producing artificial water-borders in bogged areas presented by land dikes, ponds and wells for collecting water, drain system, forest lines, etc. Forest and land-reclamation measures consist in use of wood-plants for land protection. Planting trees and bushes bordering with agricultural lands, or agro- and forest- land-reclamation, is based on understanding that trees and bushes are one of the most powerful and effective factors of prevention of land from degradation. Agro-technical measures on decrease and stopping soil degradation are aimed at prevention of the possibility of erosive processes to reveal themselves, increase in soil resistance against washing off and weathering, water-absorbing properties of soil. An important measure which enables quality of soil horizon is the correct choice of crop rotation. The choice of crop rotation depends on a concrete situation: it is necessary to take into consideration the type of soil, climate, moisture, relief, the presence of animals, weeds, etc.

Regulating of pesticide and mineral fertilizers usage; occur to be strong factors negatively

influencing some animal groups (in the first run, soil invertebrates and birds) and plants (grassy flowering plants) not only in agrocenoses but also in natural ecosystems. These substances present major threat for meadow and water ecosystems. It is very important in this process to follow rules of transportation and storage of fertilizers and pesticides, maintenance of uniformity in fertilizers' employment, use of new fertilizers, for instance, with prolonged effect etc., rigid maintenance of portions, forms, periods and ways of fertilizers' employment.

Prevention from negative influence of domestic animals on natural ecosystems, whose non-controlled pasture leads to degradation of plants and soil. The presence of a great number of domestic animals eating plants troubles wild animals especially in the period of reproduction. Wild animals which are not adapted to defend are threatened by swine, cats and dogs. Their habitat in natural ecosystems must be controlled by man.

Monitoring of ecosystems' state. The efficiency of monitoring of natural communities' ecological state considerably improves when methods of bioindication are employed. Different taxonomic groups of organisms can react to direct toxic influence and change in life conditions caused by this influence in various ways. The same is true with different types of natural ecosystems. To define the level of agricultural influence on natural ecosystems it is possible to use separate species as well as whole taxonomic groups of organisms as bioindicators.

One of the factors that have the strongest impact from agricultural activities, is an organic water pollution. Bioindicators can determine the presence of this factor and the degree of water pollution. In this regard, the biological indication is effective attribute of monitoring of ecosystems' state (environmental monitoring) in determining the ecological status of water bodies which are subject to agricultural impact.

The most sensitive to anthropogenic influence intensity are invertebrates [12]. As bioindicators of anthropogenic (including agricultural) water pollution different crustaceans (Crustacea), larvae of caddisfly (Trichoptera), stoneflies (Plecoptera), mayflies (Ephemeroptera), dragonflies (Odontata), etc. can be used, which react to pollution in a very sensible way. Pollution with sewage from cattle-breeding farms causes destruction of individual species of organisms changing species structure of land and water zoocenoses.

According to our observation, in places where sewage from cattle-breeding farms comes into canals and small rivers the reduction in the number of species of water beetles (*Laccobius, Haliplus* etc.) and water bugs Corixidae; larvae of dragonflies *Aeshna* and *Lestes* and mayflies, except most plastic species of mayflies Caenis practically minimized. At the same time the number of worms *Tubifex tubifex* (Müller), larvae of *Chironomus* increased, there appeared larvae of flies *Eristalis* and *Stratiomyia*, some species of water beetles (*Hydrobius fuscipes* (Linnaeus)) — indicators of organic pollution [9].

Sewage from cattle-breeding farms, containing great amount of organic substances, stimulates intensive growth of water plants, leads to overgrowth of the water body and the bottom's silting up, which finally results in shallowness of water ecosystems. The same consequences can be caused by spring-autumn water from land-reclamation canals in lands drained for cultivation. The fact of organic pollution and shallowness is proved by the presence of the species-indicators of organic pollution and shallowness — *Hydrobius fuscipes* and species indicating shallowness and overgrowth — *Helophorus granularis* (Linnaeus), *Anacaena lutescens* (Stephens).

Conclusion. The use of a combination of above mentioned measures combined with the leading agricultural technologies will enable to avoid man's negative influence on nature in the course of agricultural activity. Bioindication is an effective attribute of environmental monitoring in determining the ecological status of different types of natural ecosystems which are subject to agricultural impact. To define the ecological condition of ecosystems separate indicator species as well as taxonomic groups and common indices of biological diversity can be used.

References

1. Bioindication pollution of terrestrial ecosystems. Under the total. ed. R. Schubert. M.: Mir, 1988, 350 p. (In Russian).

2. Burdin K.S. Basics of biological monitoring. M.: MGU, 1985, 158 p. (In Russian).

3. Shitikov V.K., Rozenberg G.S., Zinchenko T.D. Quantitative hydroecology: system identification methods. Tolyatti: IEVB RAN, 2003, 463 p. (In Russian).

4. Rozenberg G.S., Krestin S.V. System of analytical models of processes of eutrophication in the reservoir (block approach). Programme and Abstracts 3rd International Conference on Reservoir Limnology and Water Quality. Ceske Budejovice (Czech Republic), 1997, p. 151.

5. Ryndevich S.K. The use of biodiversity indicators to assess the anthropogenic influence on natural water and ecosystem. Materials III International scientific-practical. conf. ''Eco- and agro-tourism: prospects for development in local areas''. Baranovichi: RIO BarGU, 2011, pp. 202-206. (In Russian).

6. Ryndevich S.K. The use of invertebrates for bioindication of ecological status of aquatic ecosystems. Materials International scientific-practical. conf. ''Ecology at the present stage of development of society''. Baranovichi: RIO BarGU, 2014, pp. 189-197. (In Russian).

7. Semenchenko V.P. Principles and system of bioindication flowing waters. Minsk: Orekh, 2004, 125 p. (In Russian).

8. Kochurko V.I., Zuev V.N., Ryndevich S.K. Rational nature employment and environment-protective technologies in production: manual. Baranovichi: RIO BarGU, 2010, 245 p. (In Russian).

9. Ryndevich S.K. The basics of ecology: manual. Baranovichi: RIO BarGU, 2009, 304 p. (In Russian).

10. Vorobeychik E.L. Ecology of impact regions: perspectives of fundamental research. Theses of VI All-Russia population seminar. Nizhny Tagil: Nizhnetagilsk state social-educational academy, 2004, pp. 36-45. (In Russian).

11. Vorobeychik E.L., Sadykov O.F., Farafontov M.G. Ecological norms of techno-pollution of land ecosystems (local level). Ekaterinburg: Nauka, 1994, 280 p. (In Russian).

12. Ryndevich S.K. Determination of the ecological status of aquatic ecosystems based on an analysis of the species composition of invertebrates: practical guide. Baranovichi, 2015, 27 p. (In Russian).

Список цитируемых источников

1. Биоиндикация загрязнений наземных экосистем / под общей ред. Р. Шуберт. М.: Мир, 1988. 350 с.

2. Бурдин К.С. Основы биологического мониторинга. М.: МГУ, 1985. 158 с.

3. Шитиков В.К., Розенберг Г.С., Зинченко Т.Д. Количественная гидроэкология: методы системной идентификации. Тольятти: ИЭВБ РАН, 2003. 463 с.

4. Rozenberg G.S., Krestin S.V. System of analytical models of processes of eutrophication in the reservoir (block approach). Programme and Abstracts 3rd International Conference on Reservoir Limnology and Water Quality. Ceske Budejovice (Czech Republic), 1997. P. 151.

5. Рындевич С.К. Использование показателей биоразнообразия для оценки антропогенного воздействия на естественные водные и околоводные экосистемы // Эко- и агротуризм: перспективы развития на локальных территориях: материалы III Междунар. науч.-практ. конф. (18-19 мая 2011 г., Барановичи, Респ. Беларусь) / редкол.: В.Н. Зуев (гл. ред.) [и др.]. Барановичи: РИО БарГУ, 2011. С. 202-206.

6. Рындевич С.К. Использование беспозвоночных для биоиндикации экологического состояния водных экосистем // Экология на современном этапе развития общества: материалы Междунар. науч.-практ. конф. (25-26 нояб. 2014 г., Барановичи, Респ. Беларусь) / редкол.: В.И. Кочурко (гл. ред.) В.Н. Зуев (отв. ред.) [и др.]. Барановичи: РИО БарГУ, 2014. С. 189-197.

7. Семенченко В. П. Принципы и системы биоиндикации текучих вод. Минск: Орех, 2004. 125 с.

8. Кочурко В.И., Зуев В.Н., Рындевич С.К. Рациональное природопользование и природоохранные технологии на производстве. Барановичи: РИО БарГУ, 2010. 245 с.

9. Рындевич С.К. Основы экологии: учеб.-метод. пособие. Барановичи: РИО БарГУ, 2009. 304 с.

10. Воробейчик Е.Л. Экология импактных регионов: перспективы фундаментальных исследований // Фундаментальные и прикладные проблемы популяционной биологии: материалы VI Всерос. популяцион. семинара. Нижний Тагил: Нижнетагил. гос. социал.-пед. акад., 2004. С. 36-45.

11. Воробейчик Е.Л., Садыков О.Ф., Фарафонтов М.Г. Экологическое нормирование техногенных загрязнений наземных экосистем (локальный уровень). Екатеринбург: Наука, 1994. 280 с.

12. Рындевич С.К. Определение экологического состояния водных экосистем на основе анализа видового состава беспозвоночных. Барановичи, 2015. 27 с.

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БИОИНДИКАЦИЯ И ОСНОВНЫЕ ПУТИ ОПТИМИЗАЦИИ СЕЛЬСКОХОЗЯЙСТВЕННОГО ВОЗДЕЙСТВИЯ НА ЕСТЕСТВЕННЫЕ ЭКОСИСТЕМЫ

В статье рассматриваются основные аспекты положительного и отрицательного влияния сельского хозяйства на естественные экосистемы. Положительное влияние сельского хозяйства на окружающую среду заключается в создании резерватов биоразнообразия в антропогенных ландшафтах, например лесозащитных полос, защищающих поля от эрозии почвы. Сельскохозяйственная деятельность также может стимулировать увеличение количества некоторых видов.

На природные экосистемы лесов, лугов, рек и иных объектов, прилегающих к сельскохозяйственным угодьям, ощущается в основном негативное влияние. Одним из примеров последствий отрицательного сельскохозяйственного воздействия являются антропогенные сукцессионные процессы в природных экосистемах, структурные и функциональные изменения биоты. Исследования показывают, что наиболее восприимчивы к загрязнению водные экосистемы (реки, ручьи, озёра и т. д.), болотные экосистемы и экосистемы пойменных лугов малых рек. В результате загрязнения почвы и воды различными веществами (в первую очередь органическими) уменьшается биоразнообразие, изменяется видовая и экологическая структура природных экосистем (количество узкоспециализированных стенобионтных видов растений и животных уменьшается, а число эврибионтов, т. е. видов, толерантных к антропогенному воздействию, увеличивается).

В статье определены основные пути оптимизации влияния сельскохозяйственной деятельности на природные экосистемы. Эффективность мониторинга экологического состояния природных сообществ, находящихся под сельскохозяйственным прессингом, значительно улучшается при использовании методов биоиндикации.

Различные таксономические группы организмов могут реагировать на прямое токсическое влияние и изменение в условиях жизни, вызванных этим воздействием, различными способами. Наиболее чувствительны к интенсивности антропогенного воздействия беспозвоночные. В качестве биоиндикаторов антропогенного (в том числе сельскохозяйственного) загрязнения используются различные ракообразные (Crustacea), личинки ручейников (Trichoptera), веснянок (Plecoptera), поденок (Ephemeroptera), стрекоз (Odontata) и другие насекомые. Загрязнение сточными водами животноводческих ферм вызывает исчезновение отдельных видов организмов и изменение видового состава наземных и водных зооценозов. Так, в этом случае происходит сокращение числа видов водных жуков (*Laccobius, Haliplus* и др.) и водяных клопов гребляков (Corixidae); число личинок стрекоз *Aeshna* и *Lestes* и поденок, за исключением пластичных видов поденок *Caenis*, при сбросе сточных вод животноводческих ферм в водные объекты сводится к минимуму. В то же время количество трубочника обыкновенного *(Tubifex tubifex)*, личинок *Chironomus* увеличивается, появляются личинки мух *Eristalis* и *Stratiomyia*, некоторые виды водных жуков *(Hydrobius fuscipes)* — индикаторов органического загрязнения.

Исследования показывают, что для определения уровня сельскохозяйственного воздействия на природные экосистемы можно использовать отдельные виды, а также целые таксономические группы организмов.