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ECOTOXICOLOGICAL EVALUATION OF GRAIN PRODUCTS OF AGROCENOSIS FOR THE CONTENT OF NITRATES IN THE CONDITIONS OF THE PRAVOBEZHNAYA FOREST STEPPE

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Abstract

The article presents materials on the nitrate pollution of grain products of the agrocenosis in the forest-steppe of the right bank. The aim of the research was to establish the ecotoxicological assessment of grain products of the agrocenosis by the content of nitrates in the conditions of the forest-steppe of the right bank. The studies were carried out during 2017−2019 years with grain and seeds of field crops grown in conditions of intensive chemicalization of agriculture in the forest-steppe of the right bank.

It was found that the actual content of nitrates in winter wheat grain for the period of harvest, grown under conditions of intensive chemicalization of agriculture, was 51.30 mg / kg, which is 5.8 times less than the MPC, in winter rape seeds − 88.30 mg / kg, which is 3.4 times less than the MPC, in the grain of furious barley − 91.20 mg / kg, which is 3.3 times less than the MPC, in wet corn grain − 10.23 mg / kg, which is 29.3 times less than the MPC , in dried grain of corn − 9.12 mg / kg, which is 32.9 times less than the MPC, in sunflower seeds − 131.80 mg / kg, which is 2.3 times less than the MPC.

The lowest accumulation coefficient and hazard coefficient of nitrates was in corn grain grown in conditions of intensive chemicalization of agriculture.

The research results showed that when using intensive chemicalization of agriculture in grain and seeds of agricultural crops, no excess of the content of nitrates was found. According to environmental indicators, regarding the content of nitrates, such crops are recommended to be used for food needs.

Keywords: ecotoxicological assessment, nitrates; grain products; agrocenoses, pollution.

Human health is mainly determined by the influence of environmental factors, including the quality of food. The careless, selfish attitude of man to the biosphere has led to the fact that the plant world has also become dangerous for humans. In the process of processing plant materials, more and more environmental problems arise, the solution of which is due to food safety.

Food safety – no threat of harmful effects of food, food raw materials and related materials on the human body. Ensuring food safety every year becomes more and more urgent and urgent task of scientists, food manufacturers, sanitary and epidemiological stations, and other government agencies. Food safety is the absence of harmful effects on human health when consumed, namely, toxic, carcinogenic, mutagenic and teratogenic effects of all components [1].

The intensive development of industry, widespread urbanization, chemicalization of agriculture leads to the flow of foreign substances into food raw materials and food products, which negatively affect the health of the population. In this regard, the safety and quality of food products is one of the main factors that determine the health of the population of Ukraine.

The environment is a potential source of emissions of harmful substances into food raw materials and food products. Exhaust gases from automobiles, emissions from industrial enterprises, waste from livestock complexes, aerosols, pesticides, nitrates, fertilizers, detergents, food preservatives and dyes - this is a far from complete spectrum of sources of all organic and inorganic substances that pollute the environment. Trace amounts of these and similar substances are stored in plants and end up in milk and animal meat. That is, a lot of chemicals penetrate into the human body with food, water and air, which are completely unnecessary for him, and often very harmful [1].

Every year, the problem of pollution of the natural soil environment with harmful substances that have the ability to accumulate in the soil and subsequently be transferred to grain products is becoming more acute. One of these harmful substances is nitrates, which will enter the soil when mineral fertilizers are applied to replenish the soil nutrients. And this negatively affects the ecology of the environment and agrocenoses, including [2].

Recently, there has been a great deal of interest in the content of nitrates in food and in those disorders in human health that can be caused by nitrate pollution. Essentially important in solving the problem of nitrates is the identification of sources of pollution with nitrates, their elimination and the introduction of constant strict control at all stages of production, processing, storage and consumption of food products [2].

Until recently, nitrates were considered low-toxic chemical compounds that do not cause significant deviations in human health even in high doses. Moreover, nitrates have been used in medicine as diuretics.

Excessive nitrate content in crops, raw materials and products is a lack of understanding of the current situation, which has already led to the threshold of criminal carelessness and the use of unreasonably high doses of nitrogen fertilizers, unsatisfactory quality of nitrogen fertilizers; uneven distribution of nitrogen fertilizers over the field surface during their application; excessive enthusiasm for late fertilizing of crops with nitrogen; violation of the balance of the ratio between nitrogen and other nutrients (primarily phosphorus and potassium); low level of farming culture and technolog-

ical discipline during work; disregard for the introduction of scientifically grounded crop rotations on huge sown areas and the predominance of monoculture is unacceptable; low level of knowledge of leading specialists in farms; lack of varietal policy when breeding and growing varieties with a low level of nitrates in the crop; lack of proper effective control over both the progress of the work performed and the quality of the final product − for the content of nitrates and other substances; weak efficiency of the introduction of scientific developments into the practice of obtaining a high-quality crop [3].

Nitrogen is an essential element for all life forms. In the course of the nitrogen cycle in nature, ammonia is released during the breakdown of proteins and other nitrogen-containing substances.

Nitrifying bacteria oxidize it to nitrates, and these, in turn, convert to nitrites. Under the action of denitrifying bacteria, the latter are again converted into nitrogen, again entering the atmosphere.

Nitrogen enters the soil with various types of fertilizers, plant residues, ammonium and nitric acid salts, which are contained in rainwater [4].

Nitrates are natural metabolic products of all plants. They are vital for plants − without them, their normal growth and development is impossible. However, the uncontrolled use of nitrogen fertilizers has led to the accumulation of unlimited levels in plant products [5].

The main cause of nitrate-related physiological problems is nitrate metabolites - nitrites. Nitrite, interacting with hemoglobin, form methemoglobin, which is unable to carry oxygen, which leads to oxygen starvation and, as a result, anemia.

In the soil, under the influence of microorganisms from ammonium and amide nitrogen, from organic nitrogen fertilizers, nitrates are formed (nitrification). In the roots and leaves of plants, ammonium nitrogen is formed from nitrates, which is necessary for the synthesis of amino acids and other nitrogen-containing compounds [6]. The intensity of the synthesis of nitrogen-containing compounds in plants depends on a sufficient amount of carbohydrates that are formed in the process of photosynthesis, on the balance between K, Mg, P and a sufficient amount of trace elements. In the case of an excess of nitrates, the rate of photosynthesis exceeds the rate of intake of nitrates and nitrates accumulate in various plant organs. In addition to an excessive amount of nitrogen fertilizers, the accumulation of nitrates in plant products is facilitated by: violation of the optimal agrotechnical terms of soil cultivation; using plants that can accumulate nitrates; lack of light; great heat and drought; cold periods during the growing season of plants; constant soil moisture; excess or lack of batteries; an increase in the amount of humus, calcium salts; mechanical injury to plants; the use of chemicals that accelerate plant growth; types and varieties of plants; harvest preservation time [7−9].

An increased accumulation of nitrates in plants can occur not only under the influence of high rates of nitrogen fertilizers, but also on high-humus soils, if there are favorable conditions for the mineralization of organic matter and mobilization of soil nitrogen, that is, if there is an excess of it in the nutrient medium [8].

During the day, the dynamics of nitrate accumulation changes. On sunny, but not hot days, their accumulation is much less, and vice versa. In the second half of the day, nitrates are 1.6−2 times less than in the morning [8].

Reducing the amount of nitrates in products is possible in the following ways:

- selection of varieties, less accumulation of nitrates, the use of slow-acting granular fertilizers, fertilization 1−2 months before harvesting;
- safety of products in sealed plastic bags at a temperature of 0−10 C;
- thermal and culinary treatment (cooking, salting, fermentation)
- washing with soaking;
- control of agricultural products with a frequency of 10 days − 120 days, depending on how well the products are used.

To reduce the toxicity of nitrates in case of their excessive intake into the body, it is considered advisable to increase the consumption of foods containing vitamin C, since it binds nitrates in the body and does not allow them to turn into more toxic nitrite or nitrosamines. The fiber contained in vegetables and fruits delays the absorption of nitrosoamines into the blood.

According to the standards of the World Health Organization, the maximum permissible dose of nitrates, which is not harmful to human health, is 3.5 mg per kilogram of body weight, that is, on average, 200−220 mg of nitrates per day. With prolonged consumption of products with a high content of nitrates in the human body, metabolism can be disrupted, causing various diseases.

Therefore, the problem of nitrates for mankind is urgent, and in the future it will become aggravated, especially in certain agricultural regions with the intensive use of mineral (nitrogen) fertilizers. In this regard, the issue of observation and control over the content of nitrates in grain products of agrocenoses is extremely relevant.

Analysis of domestic and foreign literature shows that at present, the level of pollution of plant materials with nitrates is quite high. Mainly, nitrates enter the human body with vegetables, fruits and berries. In the case of a balanced diet, they account for about 70% of the daily dose, the rest is ingested with water, meat and other products [10].

Scientists of the Institute of Ecohygiene and Toxicology named after L.I. Medved and the National Medical University. A.A. Bogomolets investigated the content of nitrates, nitrites and nitrosamines in food and diets, their toxicity to humans [11]. They confirmed that the technological processing of plant products helps to reduce nitrates in them. Washing and mechanical cleaning of vegetables reduces the content of nitrates by 3−10%, soaking − by 20-30%, cooking − by 20−80%, frying − by 10%, pickling, canning and pickling − by 50−70%. Researchers at Zaporizhzhya National University used photoelectrocolorimetric, chromatographic methods, and a continuous flow method after nitrate reduction with cadmium for laboratory

monitoring of the content of nitrate ions in food of plant origin [12]. As a result of the conducted studies, it was found that the content of nitrate ions exceeds the maximum permissible norms (MAC) by 2.5 times in radish roots, and 2 times in strawberries, which indicates the unsuitability of these products for consumption.

Depending on the level of chemicalization, the specifics of the farm and the purpose of the research, agrochemical soil research is carried out in Ukraine once every 4−5 years, by agreement with the farm, by the state regional design and technological center for the protection of soil fertility and product quality. The choice of priority metals, the content of which should be controlled, is based on the following factors: the level of metal toxicity, which is characterized by the MPC value, the physicochemical properties of the metal that determine its behavior in soils, migration into natural waters and plants, the ratio between the regional background metal content in soil and its entry into the soil as a result of anthropogenic activities [13−15].

The aim of the research was to establish an ecotoxicological assessment of the grain production of agrocenoses by the content of nitrates in the conditions of the forest-steppe of the right bank.

The studies were carried out during 2017−2019 years. With grain and seeds of field crops grown in the conditions of intensive cultivation technology of the forest-steppe of the right bank.

Laboratory analyzes of grain and seeds were carried out in a certified laboratory of the testing center of the Vinnitsa branch of the State Institution «Institute of Soil Protection of Ukraine».

The results of the study showed that with an intensive level of chemicalization during the cultivation of agricultural crops, on average, the humus content in the soils of the agroecosystems of the Right-Bank Forest-Steppe was 2.3−4.4%, nitrogen, easily hydrolyzed in this range − 63.0−98.0 mg/ kg of soil, mobile phosphorus −159−319 mg / kg, exchangeable potassium − 100−239 mg/kg, while the hydrolytic acidity was 0.28−1.60 mg equivalent/100 g of soil and pH (saline) − 5.8−6.8.The actual content of nitrates in winter wheat grain during the harvesting period, grown under conditions of intensive chemicalization of agriculture, was 51.30 mg/kg, which is 5.8 times less than the MPC, in winter rape seeds − 88.30 mg/kg, which is 3 4 times less MPC, in spring barley grain − 91.20 mg/kg, which is 3.3 times less than MPC, in wet corn grain − 10.23 mg/kg, which is 29.3 times less than MPC, in dried grain corn − 9.12 mg/kg, which is 32.9 times less than the MPC, in sunflower seeds − 131.80 mg/kg, which is 2.3 times less than the MPC (Table 1) [16].

Among the studied grain and seeds, a high content of nitrates was found in sunflower seeds − 131.80 mg/kg. The content of nitrates in spring barley grain was 30.8% less, in winter rape seeds − by 33.1%, in winter wheat grain − by 61.1%, in wet corn grain − by 92.2% and dried corn grain −by 93.1% than in sunflower seeds.

Table 1

Nitrate content in grain and seeds of agrocenoses during intensive chemicalization of agriculture, mg/kg (average for 2017−2019)

Culture name	Nitrate content	
	fact.	MPC
Winter wheat	51,30±1,1	300
Winter rape	88,30±0,5	300
Spring barley	91,20±0,4	300
Corn (wet)	10,23±0,8	300
Corn (dried)	9,12±0,6	300
Sunflower	131,80±3,0	300

So, it was found that in the conditions of intensive chemicalization of agriculture in grain and seeds of field crops, no excess of the MPC content was found.

The main indicator of the intensity of the accumulation of nitrates in grain and seeds is the accumulation coefficient, which is determined by the ratio of the content of nitrates in grain and seeds to the content of easily hydrolyzed nitrogen in the soil on which field crops were grown. The lower the accumulation coefficient, the less nitrates in plants [16].

The coefficient of accumulation of nitrates in the seeds of winter rape, grown under conditions of intensive chemicalization of agriculture was 1.4, in sunflower seeds − 7.2% less, in spring barley grain − 14.3% less (Table 2).

Table 2.

Coefficient of accumulation of nitrates in grain and seeds of agrocenoses during intensive chemicalization of agriculture, mg/ g (average for 2017−2019)

Culture name	Nitrate accumulation coefficient
Winter wheat	0,7±0,02
Winter rape	1,4±0,1
Spring barley	1,2±0,1
Corn	0,1±0,01
Sunflower	1,3±0,1

The lowest accumulation coefficient of nitrates was in corn grain − 0.1, which is less than in winter rape seeds by 92.8%.

The hazard ratio of nitrates is found by dividing the amount of nitrates in grain and seeds by the maximum allowable amount of nitrates in grain and seeds [16].

The hazard coefficient of nitrates in sunflower seeds grown under conditions of intensive chemicalization of agriculture was 0.4, in winter rapeseed and spring barley − 25.0% less, winter wheat − 50% less (Table 3).

Table 3.

The hazard coefficient of nitrates in grain and seeds of agrocenoses during intensive chemicalization of agriculture, mg/kg (average for 2017−2019)

Culture name	Nitrate accumulation coefficient
Winter wheat	0,2±0,01
Winter rape	0,3±0,01
Spring barley	0,3±0,01
Corn	0,03±0,01
Sunflower	0,4±0,01

The lowest nitrate hazard ratio was found in corn at 0.03, which is 92.5% less than in sunflower seeds.

So, the lowest accumulation rate and hazard rate of nitrates was in corn grain grown under conditions of intensive chemicalization of agriculture.

3 months after harvesting winter wheat grain grown under conditions of intensive chemicalization of agriculture, the nitrate content decreased by 55.4% and amounted to 22.90 mg/kg, after 6 months − by 79.1%, after 12 months − by 85. 8% compared with the period of grain harvest and after 24 months − by 87.7% and amounted to 6.29 mg/kg. (Table 4).

Table 4.

Dynamics of the content of nitrates in grain and seeds of agrocenoses under conditions of an intensive level of chemicalization of agriculture, depending on the duration of the post-harvest period, mg / kg (average for 2017−2019)

Culture name	Duration of the post-harvest period of storage of grain and seeds, months				
	After cleaning	3	6	12	24
	nitrate content *, mg/kg				
Winter wheat	51,30±1,1	22,90±0,1	10,72±0,8	7,31±0,4	6,29±0,2
Winter rape	88,30±0,5	45,74±0,9	24,55±1,1	18,54±0,6	18,00±0,5
Spring barley	91,20±0,4	76,52±1,4	37,10±1,2	23,95±1,1	21,38±1,1
Corn (dried)	9,12±0,6	7,07±0,4	4,80±0,3	3,70±0,2	3,65±0,2
Sunflower	131,80±3,0	46,77±0,9	4,20±0,3	4,00±0,3	3,88±0,2

* maximum permissible nitrate content − 300 mg/kg

3 months after harvesting and artificial drying of corn grain, the nitrate content decreased by 22.5% and amounted to 7.07 mg/kg, after 6 months − by 47.4%, after 12 months − by 59.4% compared to the period of grain collection and after 24 months − by 60.0% and amounted to 3.65 mg/kg.

So, the content of nitrates for 24 months of storage of winter wheat grain grown under conditions of intensive chemicalization of agriculture showed a decrease in their content by 87.7%, to the level of 6.29 mg / kg, storage of spring barley grain showed a decrease in the content of nitrates by 76.6% to the level of 21.38 mg/kg.

According to the research results, it was found that the humus content in the soils of the agroecosystem of the Right-Bank Forest-Steppe, where crops were grown, was 2.3−4.4%, nitrogen, easily hydrolyzed − 63.0−98.0 mg/kg, mobile phosphorus − 159−319 mg/kg, exchangeable potassium − 100−239 mg/kg, while the hydrolytic acidity was 0.28−1.60 mg equivalent/100 g of soil and pH (saline) − 5.8−6 8.

It was revealed that the actual content of nitrates in grain and seeds during the harvesting period, grown under conditions of intensive chemicalization of agriculture, was 5.8, 3.4, 3.3, 29.3, 32.9 and 2.3 times less than the MPC, respectively.

As a result of the studies, it was found that when using intensive chemicalization of agriculture in grain and seeds of agricultural crops, no excess of the content of nitrates was found. In terms of environmental indicators, nitrate content, such crops are recommended to be used for food needs.

The main natural factors that distribute the amount of nitrates in the soil are geomorphological features, type of vegetation, climatic conditions, as well as the characteristics of the soil itself - pH and Eh indicators, the mechanical composition of the soil.

To reduce the level of environmental hazard of environmental pollution with nitrates, it is proposed to optimize the processes of application, storage, transportation of fertilizers, the use of organic fertilizers, siderite.

Taking into account natural factors determining migration, distribution and accumulation of nitrates in the soil will contribute to improving the state of the environment. The study of the level of nitrate pollution of soils and agricultural products, the introduction of the proposed environmental measures will allow for the ecological zoning of contaminated areas, improve the

quality of the environment, ensure the environmental safety of the study area and optimally organize a service for monitoring the population health indicators.

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