

ABSTRACT

on the thesis of Kurganbekov Zhaneldi Nurumbetovich on theme «The investigation of migration and transformation of heavy metals in the "soil - plant" system in under growing vegetable crops in Turkestan district» presented to receive a doctoral degree of philosophy (PhD) on the specialty 6D060800-Ecology

Relevance of the theme. Quality and environmental safety of agricultural products is one of the most important problems today. Heavy metal soil contamination poses a serious threat to food security and environmental sustainability. The Turkestan region is one of the most agrarian regions of Kazakhstan, where vegetable farming is widespread. However, as a result of anthropogenic and natural factors, heavy metals are accumulated in the soil and enter into plants. This not only reduces the quality of food, but also poses a serious threat to human health. Therefore, the study of patterns of distribution of heavy metals in the soil-plant system and evaluation of their impact on agricultural products under the conditions of the Turkestan region is a current scientific problem.

The purpose of the research is to study the accumulation and distribution processes of heavy metals in agricultural plants grown near highways of Turkestan region and important objects of national economy, as well as the determination of ecological indicators of quality of cultivated agricultural products.

The objectives of the research:

- to study the transformation and migration of common chemical elements in the “soil – plant” system on agricultural fields of Turkestan region;
- to determine the pattern of accumulation and distribution of heavy metals along highways of the region;
- Biotesting of heavy metal concentrations in crops and seeds;
- to determine the influence of phosphorous fertilizers on absorption of heavy metals by plants under laboratory conditions;
- to determine the accumulation dynamics of dry mass and yield of potatoes according to the quantity of heavy metals in soil under agricultural conditions;
- to determine the transformation of heavy metals in soil and crops;
- to develop mathematical model for experimental study of copper ion absorption.

Object and methods of the research.

The objects of the research are heavy metals in the “soil-plant” system on agricultural fields of southern region of Kazakhstan.

The research samples are the migration process of heavy metals in the “soil-plant” system, dependence of productivity of plants on concentration of heavy metals.

Methods of studying the content of heavy metals, migrating in the “soil-plant” system by means of biotesting were adopted as a methodological basis.

Main conclusions proposed for the defence:

- Features of transformation and element migration of heavy metals in the “soil-plant” system of agricultural lands of southern region of Kazakhstan;
- Levels of heavy metal pollution in areas near main highways of the region, their accumulation and distribution patterns;
- Performance indicators for heavy metal biotesting in crops and their seeds;
- Features of influence of phosphorus fertilizers on absorption of heavy metals by various plants in laboratory conditions;
- Dynamics of change in accumulation of dry mass and yield depending on the amount of heavy metals in the soil;
- Transformation indicators of heavy metals in soil and crops.

Main results of the research:

To study the influence of heavy metals CuSO_4 , CdCl_2 and ZnSO_4 on plant viability as research subjects were used seeds of cucumbers, tomatoes and sweet pepper. Germination of plant seeds in laboratory conditions, growth energy of saline solutions with concentration 10^{-3} - 10^{-5} moles/ l, length of stems and roots of plants, accumulation of biomass above and below ground showed a reverse dependence on the reduction of heavy metals concentration.

It was determined that on the 7th day of growing vegetable crops (tomatoes, cucumbers, sweet pepper) viability was increased as the concentration of heavy metals was decreased. It was determined that the growth of pepper stalks and roots is accelerated at concentrations of ZnSO_4 and CdCl_2 10^{-5} , and tomato stalks- at concentrations of CdCl_2 10^{-5} .

An important indicator of the growth of plants and their bodies is the accumulation of biomass in roots and stems. In tomatoes, the concentration of ZnSO_4 and CdCl_2 is increased from 10^{-3} in roots to 10^{-5} in stalks, and CuSO_4 is accumulated in stalks. The biomass accumulation of pepper is CuSO_4 $10^{-3,-4}$, in stem 10^{-5} , ZnSO_4 $10^{-3,-4}$, in stem 10^{-5} , CdCl_2 10^{-3} - 10^{-5} passes from root to stalk and cucumber 10^{-3} - 10^{-5} passes from root to stalk.

The research results are carried out on selected crops in 20 garden plots located in Maktaral district showed that plants belonging to different families differ in their ability to accumulate heavy metals.

The following elements are accumulated on the ability of fruits and vegetables to absorb heavy metals in relatively large quantities: Zn and Cu in melons, peaches, watermelons and apples; in strawberry - Cu, Ni; in grapes - Pb, Cu. $\text{KP} > \text{Zn}$, Cd , $\text{KP} < \text{Cu}$ in watermelon, Co in peach, Ni in strawberry, Pb in grape, strawberry and apple. Vegetables and fruit trees (surface) absorb high concentrations of heavy metals Zn and Cu. The order of activity Zn is as follows: cucumber > tomato > broccoli > cabbage. The order of activity of Cu is as follows: cucumber > green pepper > tomato > broccoli > cabbage. Concentrations of other heavy metals are similar to MAC. Vegetables and fruits are well assimilated Zn and Cu. Pb in large quantities is digested in beet and potatoes, Co in potatoes, and Ni in onions, potatoes and beets.

Accumulation patterns and distribution of heavy metals along highways were studied, vegetation and soil samples at distances of 2, 5, 10, 150, 200 and 300 meters in the 0-25 cm layer were investigated. No clear pattern of change in the

bioaccumulation coefficient (Bc) of heavy metals in soil and plants as a function of anthropogenic load level was detected, but on the basis of calculation of Bc were predicted levels of danger to agricultural land and plants. Compounds in adsorbed form from the atmosphere may play an important role in the accumulation of heavy metals in above-ground parts of plants.

No clear pattern of change in the biological accumulation coefficient (Bc) of heavy metals in soil and plants as a function of anthropogenic load was identified, but crop and crop hazard levels were predicted based on calculation of Bc. Compounds in adsorbed form from the atmosphere may play an important role in the accumulation of heavy metals in above-ground parts of plants.

The decreasing trend in bacterial numbers as they are concentrated in the soil were shown as a result of experiments on the effect of heavy metal concentrations on soil microorganisms. High concentrations of heavy metal salts (10^{-3}) inhibit soil microflora, while low concentrations do not affect the microflora and have no stimulating effect;

According to the results of laboratory experiments, the application of phosphorus fertilizers in the soil has a significant influence on the growth and development of parsley plants. Despite the small amount of microelement in its mobile form, parsley is highly sensitive to elevated phosphorus concentrations in soil. The mass of plants was increased proportionally to the dose of phosphorous fertilizer.

The effect of manure quantity (small cattle, large cattle, poultry) on the amount of heavy metals in tubers and stalks of cucumbers, mg/kg (2019-2020). When increasing the amount of manure (by three times) in small cattle manure, Zn is not found, Pb is not found in all kinds of manure.

It was found that the soil contamination with lead had no effect on the potato tubers in determining the dynamics of dry mass accumulation and yield of potatoes according to the amount of heavy metals in the soil in the conditions of the valley. The amount of Zn was increased due to the influence of lead. The content of Pb in the roots was increased under the influence of zinc. Even in cases of contamination with the minimum amount of Zn, the root crops obtained comply with the requirements of the MAC;

The amount of heavy metals in the tubers and potato peels was affected as follows: the amount of Zn in the tubers was decreased by 18%, while it remained unchanged in the peeling; the amount of lead in the tuber was increased by 13% and the stem was decreased by 25%; The amount of copper remained the same as in the unmarked version. During the experiment, heavy metals were not accumulated to the same extent as heavy metals without adding an indicator.

Tomato fields were taken from Akdala, Dermene and the surroundings of Arys city, Arys district, as well as from Zhartytobe, Sholakkorgan and Taukkent of the Sozak district, near the highways on the border of Sozak to calculate bioaccumulation (bioaccumulation coefficient) as the ratio of average amount of heavy metals in plants and tomatoes to average quantity in soil. The hazard level was determined by calculating bioaccumulation of heavy metals in soil and plants.

Substantiation of novelty and relevance of obtained results:

Important innovation, resulting from scientific research, aims to develop and adapt the methodology of assessment of environmental risks for public health to the specific conditions of South Kazakhstan region.

- For the first time, the level of accumulation of heavy metals in vegetable crops of various regions of Turkestan region was comprehensively studied;

- The main factors influencing the transformation and migration of heavy metals in soil-plant system were analyzed;

- The pathways of heavy metals to vegetable crops and their potential risks to human health have been systematically studied;

- The migration properties of heavy metals in soil composition according to timing and climatic changes during the year, starting from the border of Sozak district with a unique climate and hot dry wind and road node, settlements of Jartytobe, Sholakkorgan and Taukkent were studied, their quantitative and qualitative indicators were identified.

- The features of plant power belonging to different families, accumulated heavy metals were revealed in our studies conducted with selected crops on 20 garden plots located in the Maktaaral district, home of vegetables and fruits that receive abundant solar energy.

- Possibility of accumulation and distribution of heavy metals in the “soil-plant” system on agricultural land (farm field, gardens, vegetable greenhouses, field farms system gradually moving away from the road) along the highway Shymkent-Saryagash-Mahtaral in the Turkestan region of South Kazakhstan oblast were studied, and the transformation of heavy metals in soil and agricultural products were identified. This can be widely used by agricultural and environmental professionals in their work to improve the quality of the environment and prevent negative effects of environmental factors on public health.

- As one of the priority principles of the country’s development strategy until 2050, recommendations to reduce environmental risks to health and social well-being caused by environmental factors, can be used to achieve specific goals for improving living conditions of the population of South Kazakhstan region.

- Based on the study of migration and transformation of common chemical elements in the “soil-plant” system on agricultural fields of Turkestan region, the causes of soil degradation were identified, the possibilities of preventing soil degradation were examined and recommendations were made to farmers.

- Biotesting of heavy metals in crops and seeds was carried out to determine their effect on the plant, i.e. product quality and quantity.

- The influence of different fertilizers on the uptake of heavy metals by plants were determined in laboratory conditions.

- The dynamics of accumulation of dry mass and yield of agricultural products depending on the amount of heavy metals in soil were determined under farming conditions.

- The transformation of heavy metals in soil and agricultural crops were identified;

-The risk level of agricultural land was estimated by calculating the bioaccumulation coefficient B_c of heavy metals in soil and plants.

- Mathematical modelling of experimental studies on copper ion absorption was developed.

- The main structure of the thesis work is to study the properties of plant resistance to heavy metals and climatic conditions in general, by continuous monitoring of changes in soil cover of environmentally unfavorable areas, changes in soil over time and climatic conditions.

-The research results were mathematically processed and calculated economic efficiency. The composition of agrolandscape soils of southern region of Kazakhstan, distribution of elements in farm fields and the value of its migration properties were scientifically studied in depth, and the practical significance of its contamination level and crop quality indicators was substantiated in the thesis.

Theoretical and practical significance of the work.

There is no significant information on the quality of environmentally friendly products, scientifically studied by quantitative and qualitative indicators of chemical elements in plants and composition of soils of agricultural lands of Turkestan region. When writing the thesis, the composition of the soil of agricultural fields in the southern region of Kazakhstan, the importance of its accumulation and the migration properties of elements in the territories under consideration are scientifically studied, the level of soil contamination by heavy metals and the quality of the products produced are of great practical importance.

Correspondence of the thesis to the directions of development of science or state programs.

The thesis work is related to the theme of the plan of research works of NJSC of M. Auezov South Kazakhstan University SRW B-11-04-07 «New environmentally friendly technologies and monitoring in transport and production» and the research work MB-16-04-08: Sustainable development and green technologies of the southern region of Kazakhstan until 2025.

The personal contribution of the PhD student to the preparation of each publication.

The main provisions, results, conclusions and decisions of thesis are represented in 17 published works, 2 articles published in journals included in the international database Scopus, 2 articles published in publications of the Committee for Monitoring Education and Science of the Republic of Kazakhstan, 13 articles were published in international conference publications.

1. Journal of Environmental Accounting and Management. Review was made and data were analyzed, results were obtained and processed in the article «Accumulation of Heavy Metals in Soil and Cultivated Crops».

2. Polish Journal of Environmental Studies. Review was made and data were analyzed, results were obtained and processed in the article «Assessment of Soil Contamination by Heavy Metals: A Case of Turkistan Region».

3. Bulletin of the National Academy of Sciences of the Republic of Kazakhstan. An overview and data analysis were prepared, results were obtained

and processed in the article «Biotesting of heavy metals in vegetable crops» in the magazine «Series «Chemistry and technology».

4.The Bulletin of NAS RK. Series of chemistry and technology. The review and analysis of data was prepared, results were obtained and processed in the article «Accumulation and distribution of heavy metals in the “soil-plant” system.

5.Experimental data were collected and discussed in the article «Accumulation of heavy metals in soil and agricultural crops» in scientific works of M. Auzov SKU.

The author's contribution to each publication is indicated in the thesis.

Structure and scope of the thesis.

The thesis consists of an introduction, six chapters, conclusions, list of literature and appendices. The work is represented in 189 pages, 16 pages of appendices, 51 tables and 54 figures. The list of used literature includes 212 references.