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A. Zhildikbaeva, A Kaisanova., A. Zhyrgalova, L. Sabirova*

Kazakh National Agrarian Research University, Almaty, Republic of Kazakhstan
*a.zhildikbaeva@mail.ru**

CADASTRAL VALUE OF CONTAMINATED AGRICULTURAL LAND

Abstract.

The article deals with the problem of improving the methodology of assessment and the choice of an effective way to increase the cadastral value of agricultural land. The developed method can be used to assess soil, water and air pollution on land allotment areas located on the territories of the considered areas with mining and metallurgical industries in Kazakhstan. The result of the proposed method is the ability to determine the coefficient of accumulation of hazardous and harmful factors of the industrial and environmental factors, its use will allow to establish the time of emergencies in the industrial and environmental situations. The results of studies on the assessment of crop contamination by heavy metals using the developed methodology and program allow to assess the damage and update land cadastral maps in the areas under consideration. Under these conditions, improvement of methods of assessment and selection of effective way to increase the cadastral value of agricultural land in the Republic of Kazakhstan cannot be implemented without establishing the sources and causes of pollution, organization of measures to reduce emissions, localization or elimination of the source of pollution. Only under such conditions high efficiency of costs for reclamation and involvement of unused and abandoned lands into agricultural turnover can be achieved.

Key words: *soil bonitet, cadastral value, differential rent, capitalization period, cumulative pollution, land reclamation, heavy metals.*

Introduction.

Land as the main basis of all processes of society in the political, economic, social, production, environmental and other spheres has a value, an objective assessment of which is one of the most important conditions for the normal functioning and development of a multiform economy [1].

Under the conditions of formation and development of market economy there is a need to improve the approaches and methods of evaluation of land to obtain reliable information about the cadastral value of agricultural land [2].

Assessment of agricultural lands has a long history in the Republic of Kazakhstan. The development and carrying out of land-evaluation works was connected with the works on creation of the land cadaster and was aimed at obtaining some averaged indicators characterizing the differences in the quality of agricultural lands. Cadastral assessments were to provide comparability of production results depending on the quality of land in different ways of use [3,4].

Pollution of soils with heavy metals leads to loss of nutrients, development of erosion, suppression of vegetation or complete death. The actual situation of agricultural lands does not always meet the requirements of environmental safety of agricultural products. Cumulative accumulation of pollutants in the soil in the vicinity of open fields, in the areas of cultivation of cereals, leads to a decrease not only, its quality, fertility, bonitet, but also deterioration of food safety of the products of plant growing raw materials and products [5].

In many regions of the country there is a difficult water and environmental situation, desertification of territories takes threatening proportions, the depletion of species composition of fauna and flora is progressing, which leads to climate change, reduction of soil fertility and deterioration of public health.

The data shows that the main polluters of the air basin are thermal power plants, non-ferrous and ferrous metallurgy enterprises, oil refineries, petrochemical and oil producing industries, phosphorus and cement factories.

In order to solve the above-mentioned tasks and make an objective assessment of the cadastral value of contaminated lands, a program based on a mathematical method was developed.

Methods and materials.

The developed program makes it possible to approach this problem from the marketing position of taking into account the necessary data both on the capitalization coefficient and on the district and regional appraisal of the contaminated land plots in order to increase the efficiency of cadastral evaluation of contaminated agricultural land.

This methodology allows to analyze the effect of Rd - differential rent of contaminated land, the capitalization factor - K, the average score of the arable land of the district - Bd and the average score of the arable land of the region - Br, as well as - the distance factor $К_{re}$ from the regional center and economic damage from land pollution. The availability of such data will make it possible to forecast the cluster development of processing infrastructures in the vicinity of agricultural lands [6].

The program and its use in the methodology of assessment and selection of effective way to increase the cadastral value of agricultural land will allow to develop a science-based economic mechanism to attract and increase investment in the agricultural sector of Kazakhstan, as well as to forecast the production of environmentally safe agricultural products in the studied areas with simultaneous improvement of the soil.

Results and discussion.

Today the solution of problems of effective land use requires the organization of accounting and assessment of soil fertility according to soil bonitet within the boundaries of land use. It is known that even within the limits of one land use the economic fertility of lands differs from the main group of soils towards low appraisal score, which affects the results of production.

Pollution of arable land with heavy metals not only leads to deterioration of soil humus and wheat yield quality, but also sharply reduces the cadastral value of agricultural land in the vicinity of the deposit. Metals exist either as separate objects or in combination with other soil components. These components may include exchangeable ions sorbed on the surfaces of inorganic solids, non-exchangeable ions and insoluble inorganic metal compounds such as carbonates and phosphates, soluble metal compounds or free metal ions in the soil solution, complex metals from organic materials and metals attached to silicate minerals [7].

In matters of buying and selling land, establishing a land share in common land ownership, obtaining a bank loan, donation, or other forms of land circulation, a cost estimate is required not only for environmentally clean but also for land contaminated by industrial and radioactive wastes.

The sizes of solid mineral, including organic soil particles are in the range from micrometer to several millimeters and are packed randomly! This leads to several consequences, namely communicating pores of neighboring layers have labyrinth-like character in which aeration pores are formed, gravitational water penetrates through capillaries, tunnel burrows and passages of zoofauna are formed on loosened layers, with coprolites, and in places inaccessible to above-ground atmosphere and oxygen anaerobic micro zones are formed, pores occupied by pinched water and pinched air are excluded from total porosity [8].

Salts of heavy metals in soil exist in the form of complex compounds. These are stable compounds of the highest order, which in aqueous solution either does not dissolve at all, or disintegrates to a very insignificant extent. Complex compounds consist of a central atom or ion, the complexing agent. Which is bound to the ligands. The complexing agent and the ligands form an inner sphere. The ions that compensate for the charges of the inner sphere form the outer

coordination sphere. The complexing agents can be either neutral or charged particles. Most often these are heavy metal cations. The complexing agents are acceptors of donor ligand pairs. The role of ligands in complex compounds is played by both neutral and charged particles. The most common ligands include molecules of organic compounds and their ions, including H_2O, NH_3, CO, CN^{-1}, OH^{-1}, F^{-1}, CI^{-1} etc., which are present in the form of active centers in the main food material - carbohydrates of grain [9].

Starch molecules in the form of COOH, OH have the most polar groups. They are easily hydrolyzed by water, which have not only a high dipole moment (D = 1.84D), but also a high dielectric permittivity. Therefore, heavy metal salts easily penetrate, surrounded by electrostatic charges, into the nanopores of protein, starch, and other carbohydrates.

Thus, the analysis of physico-chemical aspects of heavy metals and its accumulation in the tissues and the ear of wheat, rice and horticultural products is related to the biological system of crop production as a non-equilibrium system, which provides its stability, growth and development due to the outflow of entropy into the environment. All these processes are either endothermic (photosynthesis) or exothermic, which take place in the soil due to diffusion, phase transitions of the first kind, adsorption and transfer of mineral salts, including salts of heavy metals to vegetative organs and fruits.

At the same time, heavy metal contamination of agricultural land, not only leads to a deterioration in the quality of crop production, but also sharply reduces their cadastral value.

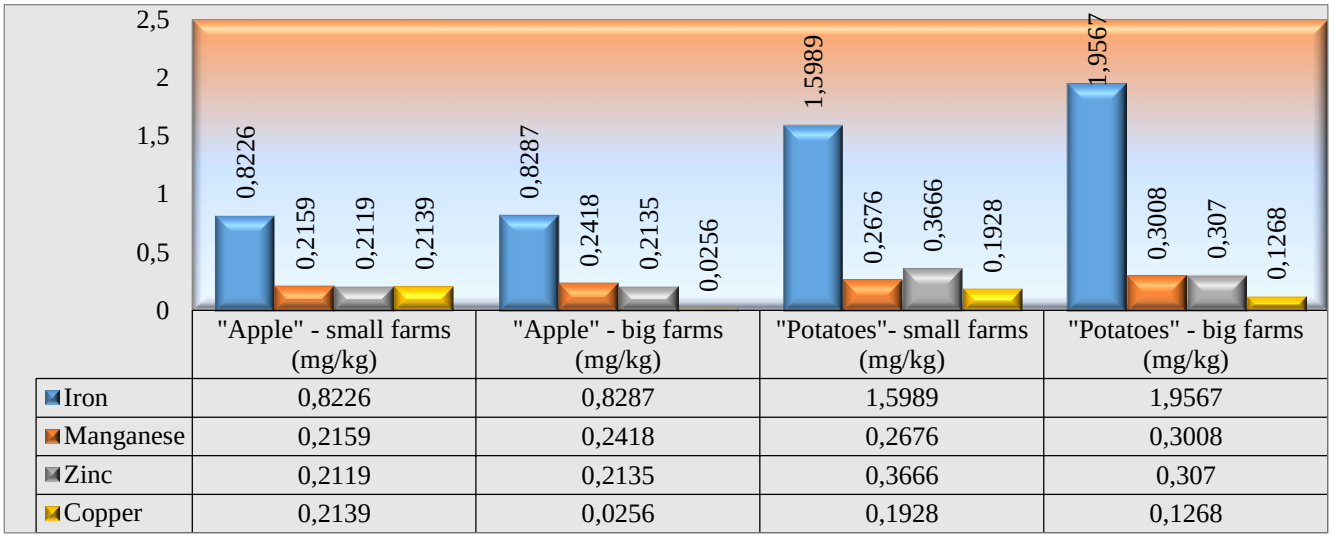
The implementation of these tasks will solve a twofold problem: to include in agricultural turnover abandoned and contaminated areas of land and simultaneously offer ways to reduce environmental pollution in order to obtain a cleaner ecological harvest.

To establish quantitative and qualitative changes in the biological potential of fruits and vegetables and the content of heavy metals in the adjacent fields depending on the distance from the source of pollution, preparatory activities were carried out methodology of field studies in farms of Almaty region.

In our studies, the content of heavy metals - cadmium, lead, arsenic and mercury is determined to monitor the environmental safety of fruit and vegetable products.

The results of laboratory analyses for heavy metals - cadmium, lead, arsenic and mercury) are summarized and their relationship between soil and climatic conditions (temperature, precipitation, air humidity) and agricultural practices of crop cultivation (crop rotations, soil treatment, irrigation, pesticide use, etc.) in conditions of Almaty region is established.

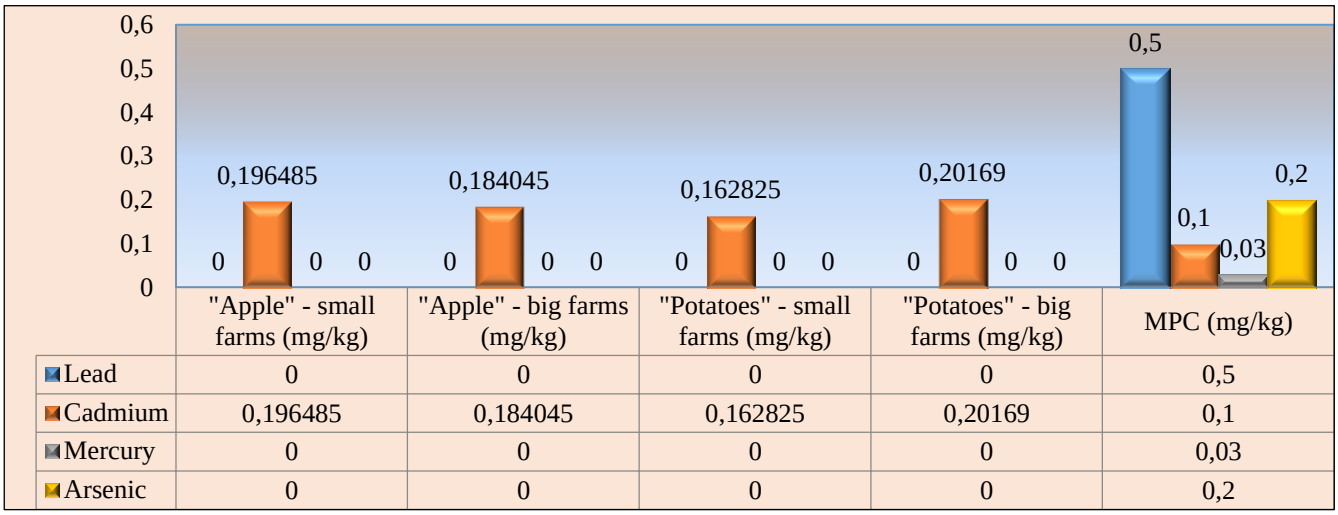
The results of research of fruit and vegetable samples of Karasay and Enbekshikazakh districts of Almaty region are shown in Figure 1.



	"Apple" - small farms (mg/kg)	"Apple" - big farms (mg/kg)	"Potatoes"- small farms (mg/kg)	"Potatoes" - big farms (mg/kg)
Iron	0,8226	0,8287	1,5989	1,9567
Manganese	0,2159	0,2418	0,2676	0,3008
Zinc	0,2119	0,2135	0,3666	0,307
Copper	0,2139	0,0256	0,1928	0,1268

Figure 1 - The content of trace elements in fruits and vegetables in apples and potatoes of small and big farms.

The diagram shows that potatoes have twice the iron content of apples.



	"Apple" - small farms (mg/kg)	"Apple" - big farms (mg/kg)	"Potatoes" - small farms (mg/kg)	"Potatoes" - big farms (mg/kg)	MPC (mg/kg)
Lead	0	0	0	0	0,5
Cadmium	0,196485	0,184045	0,162825	0,20169	0,1
Mercury	0	0	0	0	0,03
Arsenic	0	0	0	0	0,2

Figure 2 - Content of heavy metals in apples and potatoes of small and big farms.

Figure 2 shows that all samples contain increased content of cadmium in all samples of fruit and vegetable products. At the same time, the results of cadmium determination in the samples: "Apple" - small farms; 2 "Apple" - big farms; 3 "Potatoes" - small farms; "Potatoes" - big farms showed cadmium content of 0.196485; 0.184045; 0.162825; 0.20169 respectively, which exceeds the MPC(maximum permissible concentration) in 1.5-2.0 times!

The following substantiation of quantitative changes in the cadastral value of contaminated agricultural land is carried out using a mathematical model and equations.

The program for calculating the cadastral value of land works using the changing data on land pollution, differential rent, capitalization period, the coefficient of environmental hazard of land, the average score of arable land of the district, the average score of arable land of Kostanay region and the factor of distance from the regional center by the following formula (1) [6,10]:

$$V_{1\text{pollution}} = Rd \times K \times E_{ehr} \times \frac{Bd}{Br} \times K_{re} \qquad (1)$$

where is,

$V_{1pollution}$- the cost of chemically contaminated land tg/ha;

Rd- differential rent, tn/ha;

K -capitalization period, year;

E_{ehr}- environmental hazard ratio of land;

B_d - average grade of arable land of the district;

B_r - average grade of arable land of the region;

K_{re}- coefficient of remoteness from the regional center.

The coefficient of environmental hazard of land is calculated by the formula(2):

$$E_{ehr} = \frac{MPC_p}{F_{pl}} \qquad (2)$$

where is,

MPCp - maximum permissible concentration of the pollutant or relatively safe level of the substance in the soil mg/kg.

F_{pl} - actual content of the pollutant in the soil, mg/kg;

If there are several pollutants, the total index of pollutants is calculated (I_{pollut}) by the formula(3):

$$I_{pollut} = K_c - (n-1) \quad (3)$$

where is,

$К_c$ - total metal concentration factor determined by the ratio of metal content in the soil to the background (clark) content;

n - number of contaminating ingredients.

The assessed lands are contaminated with the following 5 heavy metals:

Cadmium - 5,0 mg/kg;

Mercury - 2,0 mg/kg;

Lead - 120 mg/kg;

Molybdenum - 44 mg/kg;

Zinc - 172 mg/kg.

The background content of elements in the soil for these elements is 0.5; 0.1; 10.0; 3.0; 5.0 mg/kg, respectively.

The program calculates the coefficient of total metal concentration $К_c$, determined by the ratio of metal content in the soil, to the background (clark) content:

$$К_c = \frac{5,0 + 2,0 + 120 + 44 + 172}{0,5 + 0,1 + 10,0 + 3,0 + 5,0} = 18,4$$

$$К_c = 18,4$$

Calculation of the pollution index I_{pollut}:

$$I_{pollut.} = 18,4 - (5-1) = 14,4$$

The established pollution index was 14.4.

Using the materials of **Table** , the calculation of the differential rent.

The differential rent ($Rd_{ec.c}$) on ecologically clean land in this area is 60,880 c.u./ha.

The differential rent ($Rd_{pollut.}$) on contaminated land is calculated taking into account the pollution coefficient - $К_c$:

$$Rd_{pollut.} = 60\ 880\ \text{c.u.} \times\ 0,60 = 36528\ \text{c.u./ha}$$

The capitalization period on clean land $К_{ec.c}$ is 39 years.

Capitalization period ($К_{c\ pollut}$) on contaminated land is calculated according to the formula (4):

$$К_{c\ pollut} = 0,60 \times\ К_{ec.c}\ \text{year} \quad (4)$$

Table

Table of soil categories by degree of contamination

Category of soils by degree of contamination	Cumulative concentration factor of pollutants ($I_{pollut.}$)	Correction factor of differential rent reduction and capitalization term ($К_c$)
1	Till 16	0,60
2	16-35	0,50
3	32-128	0,40
4	>128	0,30

Consequently: $К_{c\ pollut} = 0,60$ x $39 = 23,4$ years

According to the public register of the cadastral value of agricultural land, the district appraisal score is B_d- 36 points, which corresponds to class IV - the worst land. - regional - B_r- 41 points, which corresponds to the V class - average soil quality characteristic.

When calculating the value of contaminated land, the remoteness factor is also taken into account K_{re}:

K_{re} =1,4

a) Calculation of the value of contaminated land ($V_{Lpollut*}$):

$V_{Lpollut* = Rd} \times K_{c\ pollut} \times \frac{Bd}{Br} \times K_{re} = 36528 \times 23,4 \times \frac{36}{41} \times 1,4 = 105072365$ c.u./ha

b) Calculation of the cost of green land (V_{Lec}):

$$V_{Lec} = Rd \times K_{ec.c} \times \frac{Bd}{Br} \times K_{re} = 60\ 880 \times 39 \times \frac{36}{41} \times 1,4 = 2\ 918676,3 \text{ c.u./ha}$$

c) The calculation of economic damage is calculated as the difference between the value of ecologically clean land and contaminated:

2 918676,3 c.u. – 1 050 723,5 c.u. = 1 867 952,8 c.u./ha

If the soil is contaminated with one chemical element, the correction is made only for the period of capitalization, the rest of the sequence of calculating the value of the land is similar to the above. So, the evaluated land is contaminated with one chemical element, benz(a)transfer of the 3rd degree (K_c= 0,4).

In this case, the correction is made, only for the period of capitalization, the rest of the sequence of calculating the value of the land is similar to the above.

$$V_{\text{Lpollut}*} = \text{Rd} \times \text{K}_{\text{c pollut}} \times \frac{Bd}{Br} \times K_{re}$$

$$V_{\text{Lpollut}*} = 60\ 880 \times (39 \times 0,4) \times \frac{36}{41} \times 1,4 = 1167405 \text{ c.u./ha}$$

The economic damage from benz(a)transfer contamination of the 3rd degree is:

2 918 676,3 – 1 167 405 = 1 751 271,3 c.u./ha.

The ecological condition of land is related to its economic characteristics, so increasing the ecological efficiency can be seen as improving the quality of land, which allows to obtain additional products and increase the economic performance of agricultural production in general by preventing damage to the natural environment. Damage to the natural environment is first measured by the amount of deterioration of natural indicators, which are given a subsequent economic assessment.

Conclusion.

Heavy metals lead, cadmium, mercury, arsenic are toxic even at very low concentrations. The presence of trace elements and content of heavy metals in the areas under consideration have been established.

The results of the research on the assessment of crop contamination by heavy metals using the developed methodology and program allow us to assess the damage and update the land cadastral maps in the considered areas of Almaty and Kostanay regions.

At the same time, with the ability to choose a plot for agricultural production online, the publicity of the cadastral value of agricultural land is achieved using the developed methodology, which will be an additional incentive to attract investment in the agricultural sector.

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А. Жилдикбаева*, А. Кайсанова, Ә. Жырғалова, Л. Сабирова
Қазақ ұлттық аграрлық зерттеу университеті, Алматы қ., Қазақстан,
*a.zhildikbaeva@mail.ru**

АУЫЛ ШАРУАШЫЛЫҒЫ МАҚСАТЫНДАҒЫ ЛАСТАНҒАН ЖЕРЛЕРДІҢ КАДАСТРЛЫҚ ҚҰНЫ

Аңдатпа.

Мақалада бағалау әдістемесін жетілдіру және ауыл шаруашылығы мақсатындағы жерлердің кадастрлық құнын арттырудың тиімді тәсілін таңдау мәселесі қарастырылады. Әзірленген тәсіл Қазақстанда тау - кен металлургия салалары бар қарастырылып отырған облыстардың аумақтарында орналасқан жер учаскелерінде топырақтың, судың және ауаның ластануын бағалау үшін пайдаланылуы мүмкін. Ұсынылған тәсілдің нәтижесі өндірістік және қоршаған ортаның қауіпті және зиянды факторларының жинақталу коэффициентін анықтау мүмкіндігі болып табылады, оны пайдалану өндірістік және қоршаған ортада төтенше жағдайлардың туындау уақытын белгілеуге мүмкіндік береді. Өсімдік шаруашылығы шикізатының ауыр металдармен ластануын бағалау бойынша жүргізілген зерттеулердің нәтижелері әзірленген әдістеме мен бағдарламаны пайдалана отырып, залалды бағалауға және қарастырылған салалардағы жер-кадастрлық карталарды жаңартуға мүмкіндік береді. Мұндай жағдайларда Қазақстан Республикасында ауыл шаруашылығы мақсатындағы жерлердің кадастрлық құнын арттырудың тиімді тәсілін бағалау және таңдау әдістемесін жетілдіру ластау көздері мен себептерін анықтамай, шығарындыларды азайту, ластау көзін оқшаулау немесе жою жөніндегі іс-шараларды ұйымдастырусыз іске асырыла алмайды. Тек осындай жағдайларда ғана пайдаланылмайтын және қараусыз қалған жерлерді ауыл шаруашылығы айналымына рекультивациялауға және тартуға арналған шығындардың жоғары тиімділігіне қол жеткізуге болады.

Кілт сөздер: топырақ бонитеті, кадастрлық құны, дифференциалды рента, капиталдандыру мерзімі, кумулятивтік ластану, жерді қалпына келтіру, ауыр металдар.

А. Жилдикбаева*, А. Кайсанова, Ә. Жырғалова, Л. Сабирова
*Казахский национальный аграрный исследовательский университет, г. Алматы, Казахстан, a.zhildikbaeva@mail.ru**

КАДАСТРОВАЯ СТОИМОСТЬ ЗАГРЯЗНЕННЫХ ЗЕМЕЛЬ СЕЛЬСКОХОЗЯЙСТВЕННОГО НАЗНАЧЕНИЯ

Аннотация.

В статье рассматривается проблема совершенствования методики оценки и выбора эффективного способа повышения кадастровой стоимости земель сельскохозяйственного назначения. Разработанный способ может быть использован для оценки загрязнения почвы, воды и воздуха на участках земельных отводов, расположенных на территориях рассматриваемых областей, где имеются горно- металлургические отрасли в Казахстане. Результатом предложенного способа является возможность определения коэффициента накопления опасных и вредных факторов производственной и окружающей среды, использование его позволит установить время возникновения чрезвычайных ситуаций в производственной и окружающей среде. Результаты проведенных исследований по оценке загрязнения растениеводческого сырья тяжелыми металлами с использованием разработанной методики и программы позволяют оценить ущерб и обновить земельно-кадастровые карты в рассмотренных областях. В этих условиях совершенствование методики оценки и выбора эффективного способа повышения кадастровой стоимости земель сельскохозяйственного назначения в Республике Казахстан не может быть реализован без установление источников и причин загрязнения, организации мероприятий по снижению выбросов, локализации или ликвидации источника загрязнения. Только при таких условиях может быть достигнута высокая эффективность затрат на рекультивацию и вовлечение неиспользуемых и заброшенных земель в сельскохозяйственный оборот.

Ключевые слова: бонитет почвы, кадастровая стоимость, дифференциальная рента, срока капитализации, кумулятивное загрязнение, рекультивация земель, тяжелые металлы.