

## The Level of Soil Pollution in the Aksu River Basin as a Result of Anthropogenic Impact

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### ABSTRACT

As the main purpose of this article, the authors consider the level of soil pollution in the Aksu River basin as a result of anthropogenic impact, in which factors of anthropogenic transformation of soils in different zones play an important role, as well as processes occurring in soils as a result of their impact. This article highlights the research of the main analyses carried out, which showed that the anthropogenic transformation of soils within the surveyed territory is multifactorial and complex. As an assumed result, the validity of which is analyzed in this article, it can be considered that the degree and forms of manifestation of anthropogenic transformation of foothill soils depend on their use, as one criterion of which is considered the use of such soil for arable land, including irrigated arable land, in which the degradation of mountain soils is mainly associated with pasture loads during a certain period. As a research question, it remains to be considered whether this is really the case or whether the present territory is subject to a different anthropological impact.

**Keywords:** soil pollution, heavy metals, Aksu river basin, universal-comparative-geographical method, pasture degradation, phytotoxicity, soil-reclamation conditions, Clark concentrations.

### INTRODUCTION

As an introduction to the research question, it is worth noting that soils play a key role in the mechanisms of maintaining the stability of ecosystems, where they are the habitat for most living organisms, determine the structure of biocenoses and the level of biodiversity (Shamsutdinova, 2011). That is why this study is extremely relevant, the results of which can be important at the national and international levels (Wenyong et al., 2020). As the essence of the topic under study, it can be indicated that the basins of the Karatal, Aksu and Lepsy rivers are a unique region in terms of natural-geological and hydrogeological conditions (Wang et al., 2020) of the Republic of Kazakhstan, united in a single geographical

system (Huan et al., 2020), which has a common paleogeographic, tectonic and geomorphological features, which implies an interconnected symbiotic relationship of their influence on each other, especially given the territorial community, in which the length of the Aksu River today is 316 kilometers.

Narrowing down to the parameters of the zone of direct research, it is worth noting that the level of soil pollution of the Aksu River basin as a result of anthropogenic impact should be studied from the perspective of considering territories at a certain time in the spring-summer period, due to several factors (Huan et al., 2020), which include the location, coordinates and potential sources of pollution, as well as the level of variability of precipitation amounts (Bitemirov, 2019).

Analyzing the objective reasonableness study of this question, it should be noted that the basin of Aksu river due to the singularity at the geological-geomorphological and hydrogeological, soil-Botanical conditions is of great interest due to the prevailing complex environmental conditions of lake Balkhash and Balkhash, in which parameters of the river due to certain factors as one of the main, which carry their waters into the lake, remain the center of attention of the scientific society of the Republic of Kazakhstan, as well as studies from other countries (Godall et al., 2020).

The area under study has long attracted the attention of many outstanding researchers. It was visited by geographers and naturalists: P.P. Semenov (1859), P.S. Pallas, M. Sivers, G.S. Karelin and N.G. Kirillov, botanist A.I. Shrenk (1845), zoologist A.M. Nikolsky (1855), B.V. Sapozhnikov (1905–1907), geologist V.A. Obruchev (1912), V.V. Dokuchaev and S.S. Neustruev (1907). Information about the processes that took place in this territory is available in the fundamental research of several leading scientists and researchers of the Republic. The results of studies regarding changes in the geosystems of the South-Eastern part of Balkhash, which was given to the environmental impact assessment of anthropogenic impacts on biological resources Pribaltic region was described in detail in the thesis PhD, associate Professor T.A. Bazarbaeva regarding the structural organization and dynamics of geosystems of river basins of South-Eastern TRANS-Balkhash area and Timakovoy J.T. on environmental impact assessment of anthropogenic influence on biological resources of the Pribaltic region.

The analysis of the current state of geosystems on the basis of an integrated approach in the conditions of “high-water” hydrological indicators has not yet been carried out (Choel et al., 2019). This is due to the fact that the hydrometeorological indicators obtained in the 60s were not comparable due to the lack of analytical material on other components created on the basis of a single methodological approach. Thus, geobotanists and soil scientists did not take into account the properties of the plastic bed (Bitemirov et al., 2019), and geomorphologists conducted studies of geomorphological processes without taking into account paleogeographic features.

To verify the potential results of this study, the authors put forward primary and secondary

hypotheses. The primary hypothesis. When the accurate determination of the levels of elements in soil in accordance with the gradations in the standards to determine the level of anthropogenic influence in the study area, which can be described statistically as a high impact faux anthropogenic impact and how much impact natural anthropogenic impact. The secondary hypothesis. Regarding the transformation of soils in mountain areas, it can be determined that when considering the content of heavy metals in the studied soil, it is possible to indicate the multiplicity of anthropological influence.

Conducting a data study, a separate type of study design was selected for each part of the study. When considering statistical data of cross-sectional design with elements of cohort studies with randomized sampling and dichotomous coding (Li et al., 2020), it turned out to be the most acceptable due to the large number of confounder factors, which turned out to be perfectly correlated in linear progression with standardized indicators.

The reflection of the results of this study of the level of soil pollution in the Aksu River basin as a result of anthropogenic impact can be determined both from a theoretical and practical point of view (Wang et al., 2020), predicting the expected reflection of that in the future, its level of influence, the scale of influence, possible risks, barriers, etc. As a theoretical reflection of the results of this study of the level of soil pollution in the Aksu River basin as a result of anthropogenic impact, we can suggest a possible alternative to creating specialized disciplines for a separate unified study of the level of soil pollution as a result of anthropogenic impact, as a result of which it will be possible to clearly define detailed mechanisms of the impact of flexibility and methods of prevention.

As an applied reflection of the results of this study of the level of soil pollution in the Aksu River basin as a result of anthropogenic impact, it is possible to assume the creation of specialized author’s mechanisms aimed at identifying the impact factors, the level of pollution and the range of measures taken, to determine how correctly and timely these measures were carried out (Bitemirov et al., 2019). This involves not only the work of specialized environmental agencies of the Republic of Kazakhstan, but also other structures that are closely interrelated with this issue.

## MATERIALS AND METHODS

For the present study, the field method is of great importance, since it examines the factor of the level of soil pollution in the Aksu River basin as a result of anthropogenic impact, which is directly observed in nature. With the help of this method, it became possible for the authors to establish a certain level of soil relationships depending on several external and internal factors, which helps to find out the overall picture of the development and vital activity of bio and chemo systems in the composition of this soil. To identify the problem areas, the route method of ecological research was selected based on the Result No. 1. The universal-comparative-geographical method of research also allowed to identify of changes in soil properties in relation to the main natural factors of soil formation.

Determination of the TM content in the prepared soil samples was carried out by atomic absorption method according to GOST-ST RK ISO 11047–2008 on MGA-915 and AS-1 devices in the laboratory of Physical and chemical research methods in Biology of the Faculty of Biology and Biotechnology of Al-Farabi Kazakh National University. The obtained values of the detected metal concentrations are expressed in mg/kg.

The values of HM concentrations in the samples were compared with the MPC (UEC) of chemicals in the soil (GN 2.1.7.2041–06, 2006; GN 2.1.7.2511–09, 2009). The assessment of changes was carried out on the basis of data from analyses of the following physical and chemical properties of soils: humus, according to I. V. Tyurin; total nitrogen according to GOST 26107–84 I. G. by the method of Kjeldahl, CO<sub>2</sub> of carbonates by volumetric method, pH GOST 26423–85 potentiometric method, exchangeable cations Ca, Mg titrimetric method in the modification Gruberova, Na, K according to the method Karatayev and Mametova in the modification Gruberova, agile (hydrolysis) nitrogen by the method of Tjurin and Kononova, movable phosphorus and potassium according to GOST 26205–91 for Machine; granulometric composition of Kaczynski; the composition of the salts.

Determination of the content of heavy metals. The instrument was calibrated using a calibration form and five series of working standard solutions of each metal for analysis. The concentrations of heavy metals (Fe, Zn Mn, Cu, Co, Ni, Cd,

and Pb) were determined for the split samples using a flame atomic absorption spectrophotometer (FAAS, model: AA-320N, Shanghai, China).

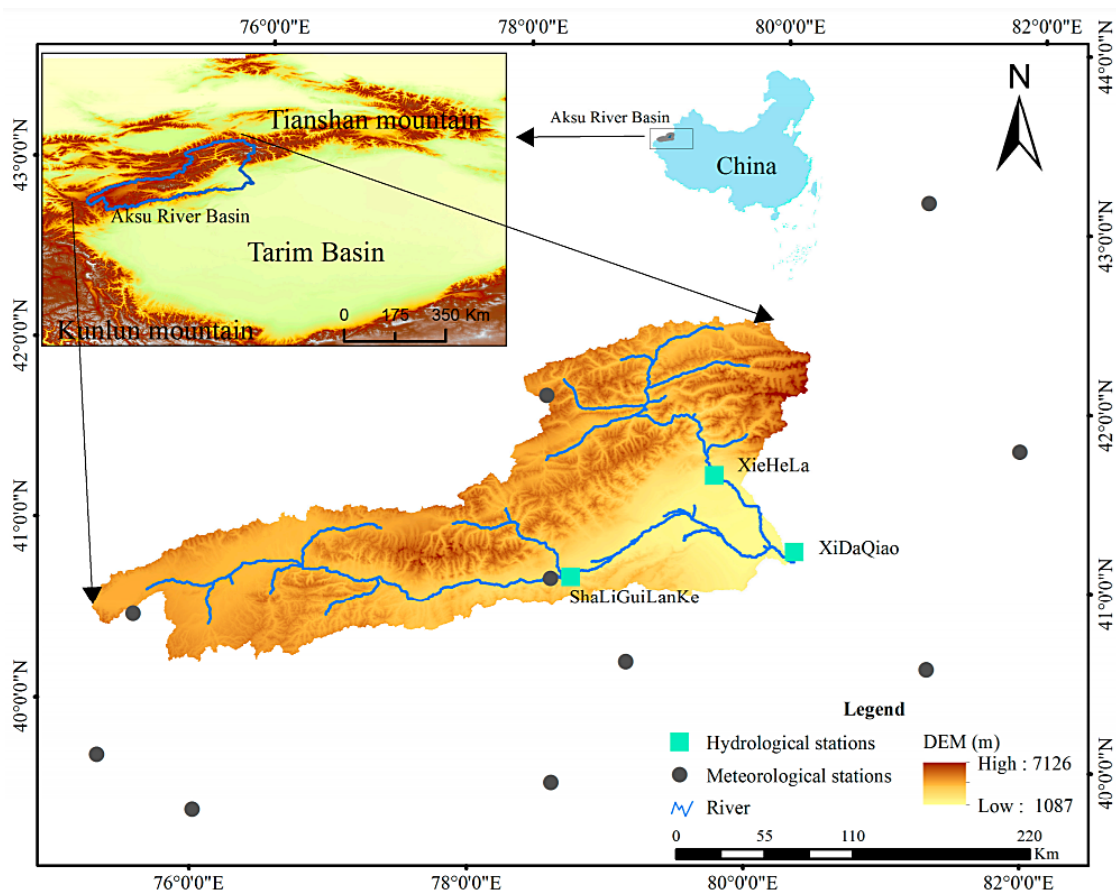
The probability level  $p < 0.05$  was considered statistically significant. The Pearson correlation coefficient was used to determine the relationship between heavy metals. All statistical analyses were performed using SPSS software version 16.0 (IBM Corp., USA) for Windows (Uwah, Gimba, Gwaski, 2012).

## RESULTS

The main results of this study were obtained in the spring-summer period, since this period is one of the most favorable for studying the state of soils in the study area in 2019, due to the convenience of conducting field studies and systematization of data on elements in the soil of their changes under a particular impact. In accordance with the above, three results were identified, classified in order from A to C. At the same time, the first result “A” concerns the general characterization of soil sampling samples on a regional basis, the second result “B” concerns the transformation of soils in mountain areas, and the third result “C” considers the soil cover of the Aksu River ecosystem.

**Result A**, concerning the general characterization of soil sampling samples on a regional basis. In this result, 3 soil sampling points were identified, which are located in different rural districts of the study area: in the rural area of Taras 2, 2.5 km. from the highway – No. 1; in the rural area of Abay, 50 m from the highway – No. 2; in the rural area of Abay, a field of soy culture, 100 m from the highway – No. 3. The general characteristics of the location of selected soil samples in the city are presented in Table 1.

In addition to the above table, it is also necessary to consider potential sources of pollution separately in the specified region. This will allow us to analyze which factor is the most influential on the level of soil pollution in the Aksu River basin. The biological factor cannot be excluded due to the need for comparison in order to identify whether the anthropogenic impact is really a key factor in soil pollution in the Aksu River basin. At the same time, the results of heavy metal waste, the results of pulp and paper waste in the form of dumped, discarded and/or accumulated garbage,



**Figure 1.** The geographic location of the Aksu River Basin, hydrological stations (blue squares) and meteorological stations (black dots)

plastic in the garbage, components of burnt rubber that have settled into the soil (Aslam et al., 2020), which often occurs in vulcanization, excessive use of fertilizers, proximity to transport and road, in which the exhaust gases of internal combustion engines also settle on the soil, are highlighted as an anthropogenic factor.

When studying the factors of anthropogenic impact on soils, it is necessary to know their impact throughout the study area. Therefore, to identify changes in soil properties in relation to the main natural factors of soil formation, a universal-comparative-geographical research method was used, in which soil samples (according to

Nos. 1–3) (Bitemirov et al., 2019) were selected according to the standard method. Preparation of soil samples for the determination of metals was performed using standard laboratory procedures.

In addition to contamination with chlordioxins, soil contamination with heavy metals should also be taken into account, including zinc, copper, lead, cadmium, nickel, cobalt and manganese (Schikowski et al., 2020). The present data were examined in accordance with Table 3 (Clark concentrations), which indicated the content of each of them in accordance with the depth of the excavation. In accordance with the present, the main results can be observed in the table below.

**Table 1.** General characteristics of soil samples

| No.                 | Location  | Coordinates                 | Possible sources of solutions           |
|---------------------|---|-----------------------------|---|
| Aksu district       |   |                             |   |
| 1                   | In rural Taras 2, 2.5 km from highway                     | 45°26'27" N<br>79°47'56" E  | In accordance with Table 2 and Scheme 1 |
| Sarkantsky district |   |                             |   |
| 2                   | In the village of Abay, 50 m from highway                 | 45°26'07" N<br>80°04' 40" E | In accordance with Table 2 and Scheme 2 |
| 3                   | In the village of Abay, soy field, 100 m from the highway | 45°29'15" N<br>80°04'44" E  | In accordance with Table 2 and Scheme 3 |

**Table 2.** Gradations of soil pollution level

|       | Territory                          | Aksu district                          |     |     |     |     | Sarkandskiy district                |     |     |     |     |   |     |     |     |     |
|-------|------------------------------------|--|-----|-----|-----|-----|-------------------------------------|-----|-----|-----|-----|---|-----|-----|-----|-----|
|       |                                    | rural Taras 2, 2.5 km from the highway |     |     |     |     | in Abai village, 50 m from the road |     |     |     |     | in the village of Abai, soybean field, 100 m from highway |     |     |     |     |
|       |                                    | 45°26'27" N<br>79°47'56" E             |     |     |     |     | 45°26'07" N<br>80°04'40" E          |     |     |     |     | 45°29'15" N<br>80°04'44" E                                |     |     |     |     |
| 1     | Biological pollutant (natural)     |  |     |     |     |     |                                     |     |     |     |     |   |     |     |     |     |
| 1.1.  | Pathogens of infectious diseases   | A1                                     | A2  | A3  | A4  | A5  | A1                                  | A2  | A3  | A4  | A5  | A1  | A2  | A3  | A4  | A5  |
| 1.1.1 | Insects                            | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.1.2 | Ticks                              | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.1.3 | Mold                               | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.1.4 | Wool                               | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.1.5 | Pollen                             | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.2.  | Pathogens of infectious diseases   | A1                                     | A2  | A3  | A4  | A5  | A1                                  | A2  | A3  | A4  | A5  | A1  | A2  | A3  | A4  | A5  |
| 1.2.1 | Insects                            | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.2.2 | Arthropods                         | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.2.3 | Worms                              | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 1.2.4 | Fungi                              | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2     | Chemical pollutant (anthropogenic) |  |     |     |     |     |                                     |     |     |     |     |   |     |     |     |     |
| 2.1   | Heavy metal                        | A1                                     | A2  | A3  | A4  | A5  | A1                                  | A2  | A3  | A4  | A5  | A1  | Aa2 | A3  | A4  | A5  |
| 2.1.1 | Zinc                               | Aa1<br>Aa2<br>Aa3<br>AA4<br>AA5<br>Aa1 | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2.1.2 | Copper                             | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
|       | Lead                               | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
|       | Cadmium                            | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
|       | Nickel                             | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
|       | Cobalt                             | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
|       | Manganese                          | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2.2   | Chlordioxide                       | A1                                     | A2  | A3  | A4  | A5  | A1                                  | A2  | A3  | A4  | A5  | A1  | A2  | A3  | A4  | A5  |
| 2.2.1 | Pulp and paper                     | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2.2.2 | Rubber                             | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2.2.3 | Plastics                           | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2.2.4 | Fertilizer                         | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |
| 2.2.5 | Exhaust                            | Aa1                                    | Aa2 | Aa3 | AA4 | AA5 | Aa1                                 | Aa2 | Aa3 | AA4 | AA5 | Aa1   | Aa2 | Aa3 | AA4 | AA5 |

**Result B, concerning the transformation of soils in mountainous areas**

Sources of toxic substances entering the lithosphere, especially in its upper layer-the soil, can be divided into two groups: natural and man-made. From natural sources, the greatest contribution is

made by: weathering of rocks and minerals, erosion, volcanic activity, dust, fog, gases of volcanic origin (Meléndez-Jiménez, 2020).

The main factor of degradation of the soil and vegetation cover of mountain territories is pasture depression. Overgrazing manifests itself, first of all, in the violation of vegetation cover, in some

**Table 3.** Clark concentrations

| Sections   | Depth, cm | Zn  | Cu  | Pb  | Cd (0.5) | Ni (4.0) | Co (5.0) | Mn (1500) |
|--|-----------|-----|-----|-----|----------|----------|----------|-----------|
| R-1, rural area, Taras village 2, 2.5 m from the highway, mg/kg  | 0–10 cm   | 1.2 | 0.7 | 1.3 | 3.6      | 0.5      | 0.5      | 0.5       |
|  | 11–29 cm  | 1.4 | 0.4 | 1.4 | 3.1      | 0.5      | 0.7      | 0.7       |
| R-2, Abaya village, 50 m from the high way, mg/kg                | 0–40 cm   | 1.5 | 0.9 | 1.3 | 6.2      | 0.5      | 0.7      | 0.7       |
|  | 0–7 cm    | 1.4 | 1.0 | 2.0 | 4.6      | 0.4      | 0.6      | 0.7       |
| R-2, Abaya village, soybean field, 100 m from the highway, mg/kg | 7–17 cm   | 1.3 | 1.0 | 1.3 | 4.6      | 0.4      | 0.7      | 0.7       |
|  | 17–28 cm  | 1.2 | 0.9 | 1.6 | 5.1      | 0.3      | 0.8      | 0.7       |



places to its complete destruction, accompanied by over-compaction and destruction of surface soil horizons (Feng et al., 2020). This leads to long-term preservation of soil mobility on slopes, burial under clastic material of soils, changes in their temperature and water regimes. A sharp increase in liquid and solid surface runoff causes the formation of landslides and scree, the exposure of underlying rocks, and sometimes even causes destructive storm surges (Zheng, 2020).

The peculiarities of the formation of the soil cover of mountain territories allow us to assess mountains as a special type of natural environment, where the dynamics of exogenous processes cause a high vulnerability of ecosystems under anthropogenic influence.

### Result C, concerning the soil cover of the Aksu River ecosystem

The object of the study is the soil cover of the Aksu River ecosystem, located in the South-East of the Balkhash basin. To study the physical and chemical properties of soils, the procedure of digging soybean fields in 2.5 km from the village of Taras was carried out, the results of which are described in detail in Table 4.

The mechanical and granulometric composition, physical and chemical properties of foothill

light chestnut and gray soils located on the foothills of the Dzungarian Alatau were studied. Serozems are distributed in different ways. Sagebrush-oatmeal vegetation, projective design 65–75%. Plant height 30–45 cm. Based on this, we propose that the mobile form of nickel be included in the list of priority elements for the array that are subject to constant monitoring.

It should be noted that despite the great diversity of the soil cover of the irrigated massifs of the republic, the problem of establishing regional background levels of heavy metals in irrigated soils remains unresolved (Liu, 2020). In the context of ever-increasing technogenic pressure on the environment, including on the soil cover, the study and systematization of data on the background content of heavy metals in irrigated soils at the regional level is very relevant and necessary for assessing the stability and stability of irrigated ecosystems to global and regional anthropogenic impacts.

Based on the analysis of the content and distribution of heavy metals in the background areas, it is possible to identify the features of the formation of the regional level of the background of heavy metals and classify the range of concentrations of the studied metals (Jin, 2020).

In this regard, the establishment of reliable background levels of heavy metals in soils is one

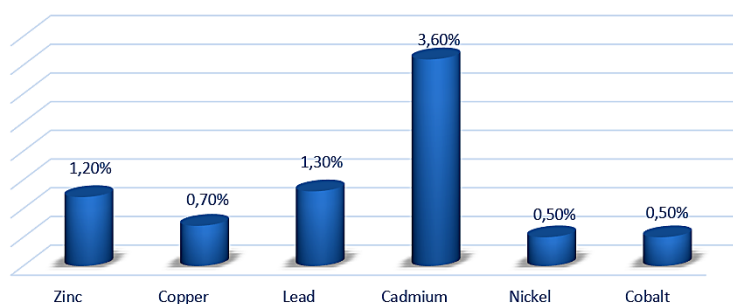


Figure 2. Element content at a depth of 0–10 cm, mg/kg. Section 1, rural area; 2, 2.5 m from the highway

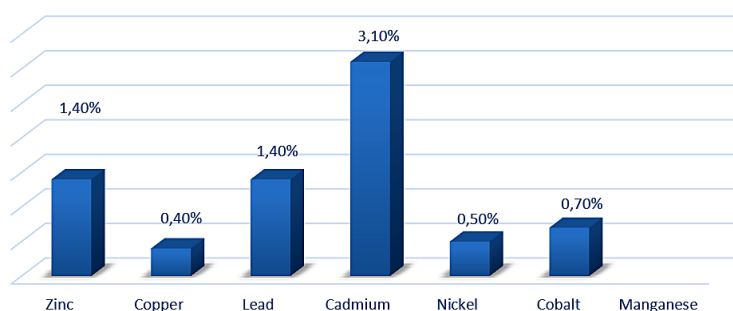
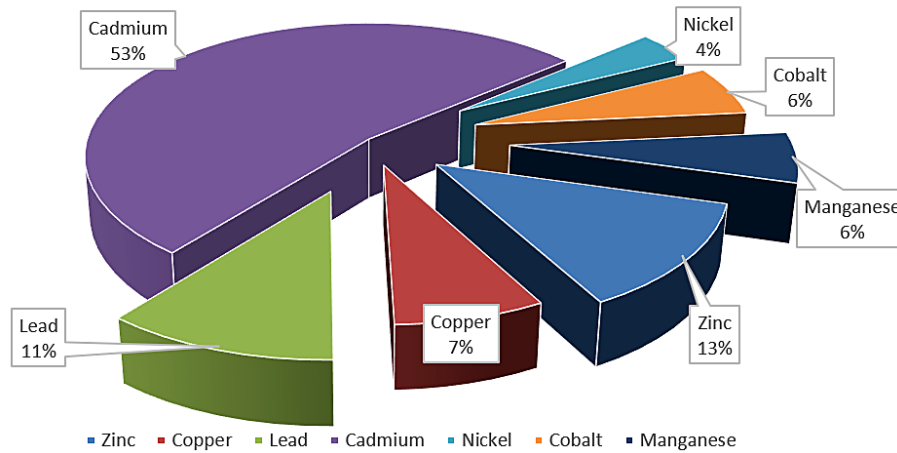


Figure 3. The content of elements at a depth of 11–29 cm, mg/kg. Section 1, rural area; 2, 2.5 m from the highway



**Figure 4.** The content of elements at a depth of 0–40 cm, mg/kg. Section 2, Abay village, 50 m from the highway

of the urgent tasks that have both scientific and applied significance (Ta Long, 2020).

When studying the features of the content and spatial variation of soil properties or the average content of certain elements in certain types of soils or in their totality, the use of statistical data analysis methods is of great importance to increase the reliability of the obtained data and conclusions on them. In addition, the use of statistical analysis also increases the interpretative capabilities of the data. It should be recognized that all conclusions on the absolute values of soil properties made for one or more typical sections without statistical processing can often be unreliable and can lead to incorrect interpretation of the data obtained.

Among the constants that characterize the distribution of certain elements in soils, a special place is occupied by the arithmetic mean, which characterizes the average level of their content and, in fact, the study of characteristics, the establishment of the true value of the average, i.e. the true background content, is the main goal of most works.

Based on this, we subjected the obtained analytical data on the content of heavy metals in the soils of the object of study to variational and statistical processing (Zhou, 2020). As can be seen

from the obtained data, the calculated values of the Student’s t-test for all the studied soils at 95% significance level are significantly higher than the t-test. (table 5). Analysis of the degree of variability of heavy metals content in soils object of research shows that the established average values of metal contents in the soils are statistically stable, as evidenced by the size of their coefficients of variation, which on a scale gradation corresponds to the limit from small to medium.

Based on the analysis of the obtained statistical constants, it can be concluded that the calculated values of the average correctly reflect the statistically significant true values of the average content of the studied metals in the soils of the upper part of the irrigation massif. Based on this, we propose to take the average values of heavy metals in soils given in Table 5 as their background content in the soils of the ancient alluvial terraced upper part of the irrigation massif.

Further, using the obtained average background data, the contribution of each metal to the total “metallic” background of the soils of the object of study was calculated (Figure 5).

It turned out that the compositions of mobile and gross forms of heavy metals in the soils of the object of study differ significantly (Chen et al., 2020). Among the gross forms of the studied

**Table 4.** The breakdown of the soil No. 1. Results of digging up owl beans in 2.5 km from the village of Taras

|          |   |
|----------|---|
| 0–10 cm  | A plowed Plowed soil layer, the color of the soil is light gray, loose and granular, there is a large number of roots, dusty structure, gradually passing into the next layer, the transition layer is unclear.                         |
| 11–29 cm | The lower part of the plowed layer is light gray, the color of the soil is light gray, loose, sandy; in places: plant roots, metal oxides.  |
| 30–50 cm | The color of the soil is yellowish-brown, moist, the top layer is compacted, rare plant roots. The transition to the next layer is unclear. The color of the soil is light yellowish, moist, finely grained, sandy, slightly compacted. |
| 68–80 cm | Light yellowish, sandy, moist, slightly compacted.  |

**Table 5.** The breakdown of the soil No. 2. Samples were taken at a distance of 50 m from the Abay village

|             |  |
|-------------|--|
| 0–30 cm     | In the upper layer of the soil, the association of mixed plants is concentrated. The color of the soil is gray-brown. Mechanical granulometric composition of stone-heavy clay, compacted. |
| 30–55 cm    | The color is brown, crumbly, clear transition to the next layer.   |
| below 55 cm | It consists of rocks and hard stones.  |

metals, the largest share (48.0%) is occupied by zinc, followed by nickel (28.0%). And copper and lead occupy 15.3% and 7.5%, respectively. The share of cadmium accounted for only 1.2%. And among the mobile forms of the studied metals, nickel occupies the largest share (43.1%), followed by lead (20.0%) and zinc (20.0%). And copper and cadmium occupy 10.0% and 6.9%, respectively.

Consequently, the process of irrigation of the soils of the massif as a whole leads to an increase in the proportion of mobile forms of cadmium, lead and especially nickel, and the proportion of mobile forms of copper and zinc, on the contrary, decreases.

## DISCUSSION

The process of redistribution of heavy metals in the Earth's crust is a direct result of the process of soil formation, which in turn depends on the characteristics of the bioclimatological conditions of natural zones. The mobility of heavy metals in soils, their accumulation or removal and availability to plants are influenced by the physical and chemical properties of the soil, temperature, humidity, agricultural conditions, etc. In addition, the availability to plants and the migration ability of heavy metals depends on their form of presence in the soil. It is known that the more their mobile forms, the higher the migration ability and availability to plants (Li, 2020).

Heavy metals can accumulate in certain soil horizons, thus creating a kind of “reservoir” of elements toxic to soil fertility. The mobility and availability of heavy metals for plants depends on

their level of phytotoxicity for certain crops. In this regard, the results of earlier studies conducted by scientists of the Uspanov Institute of Soil Science showed an increased content of heavy metals in the soils of irrigated massifs of the republic, in particular lead, nickel and copper (Rehman et al., 2020). Deterioration of soil-reclamation and ecological conditions of irrigated massifs also leads to a decrease in the protective capabilities of soils in relation to heavy metals. The waters of irrigation rivers are becoming increasingly polluted due to the ever-increasing anthropogenic pressure on the environment. These factors, along with a decrease in the level of technological discipline, the general culture of agriculture, the degree of cultivation of soils, lead to a deterioration in the quality of the products obtained.

In this regard, the study of migration and accumulation of heavy metals in irrigated soils is relevant and has scientific and practical significance (Uwah, 2012).

Under the influence of metal-rich emissions, areas of landscape pollution are formed mainly at the regional and local levels. The impact of energy companies on environmental pollution is not due to the concentration of metals in waste, but their huge amount. The mass of waste, for example, in industrial centers, exceeds their total amount coming from all other sources of pollution. With the exhaust gases of cars, a significant amount of Pb is released into the environment, which exceeds its intake with the waste of metallurgical enterprises. Arable soils are contaminated with elements such as Hg, As, Pb, Cu, Sn, Bi, which enter the soil as part of pesticides, biocides, plant growth stimulants, and structure-forming agents. Non-traditional fertilizers made

**Table 6.** The breakdown of the soil No. 3. Samples were taken in the Abay village, 100 meters from the road. The vegetation cover consists of alfalfa and various weeds

|          |   |
|----------|---|
| 0–7 cm   | The plowed layer. The color of the soil is light grayish. Plant roots are common, loose, dry. The transition to the next layer is clear.                                    |
| 7–17 cm  | Light brown. Dense, moist, there are plant roots, compared with the upper layer of medium compacted, there are metal oxides. The transition to the next layer is not clear. |
| 17–28 cm | Light brown Compacted, moist, there are plant roots, high metal oxides. The transition to the next layer is not clear.  |
| 28–39 cm | The color is light yellow-brown, compacted, sparse plant roots, the transition to the next layer is unclear.  |
| 39–50 cm | Yellowish-brown, loose-porous, medium-dense.  |



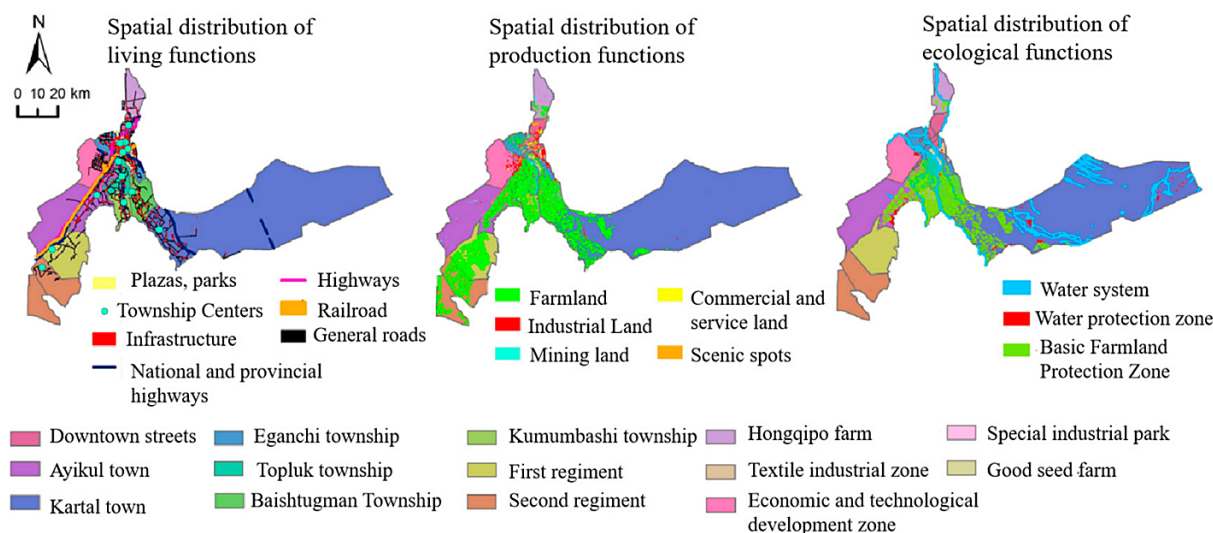


Figure 5. Production–life–ecology spatial function zoning of Aksu city

from various wastes often contain a large set of pollutants with high concentrations. From traditional mineral fertilizers, phosphorous fertilizers contain impurities of Mn, Zn, Ni, Cr, Pb, Cu, Cd (Juvelikyan et al., 2009).

## CONCLUSIONS

The highest level of soil contamination with metals was registered in 2–3 rural areas of Abay. In these samples, the highest values of gross concentrations in the city were noted for more than half of the detected metals (Ni, Co, Zn, Cd) (Table 2). Near sampling point No. 3, there is a soybean field where organic fertilizers are used. Sampling point No. 2 is located near the highway, where it can notice the influence of motor vehicles, which can act as an additional source of soil pollution. It is noted that when burning various types of fuel by boiler plants, near boiler stations in the soils there are increased concentrations of cobalt, lead, zinc, nickel, copper, to lesser extent manganese. The total contribution in soil contamination as a result of the activities of the TPP is estimated at 27%. In addition, enterprises of the real sector (in particular, mechanical engineering, chemical and construction industries) work in the district, and motor transport is developed, which can act as an additional source of soil contamination with TM. The contribution to soil pollution from the construction industry and transport is estimated at 8 and 13%, respectively. A high level of soil contamination with metals was observed in samples from sampling points Nos. 2–3, near the highway. Of the 7 identified metals in soil samples, four metals (Ni, Co, Zn, Cd) have the maximum values of gross concentrations. The source of soil

pollution here is motor transport and soybean crops. TM is released into the environment during the operation of the vehicle itself, as well as a result of tire wear, abrasion of road surfaces or the use of asphalt concrete. The source of cadmium can be lubricating and diesel oils, some engine parts, chassis, etc. The product of deterioration of the coverings of the body is nickel.

## REFERENCES

1. Abdul Rehman, Gujian Liu, Balal Yousaf, Muhammad Zia-ur-Rehman, Zeeshan Javed. 2020. Characterizing pollution indices and children health risk assessment of potentially toxic metal(oid)s in school dust of Lahore, Pakistan, *Ecotoxicology and Environmental Safety*, 1901, Article 110059.
2. Bitemirov, K., Shalkharov, Y., Berdibaev, N. 2019. Protection of honor dignity and business reputation in the system of modern civil law. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22 (4), 01–12.
3. Bitemirov, K., Shalkharov, Y., Kalmyrzaev, B. 2019. Legal nature of religious extremism from the position of contemporary Kazakhstan legislation. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22 (4), 01–12.
4. Bitemirov, K., Shalkharov, Y., Kalmyrzaev, B. 2019. Problems and prospect of countering religious extremism in the Kazakhstan Republic. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22(4), 01–12.
5. Bitemirov, K., Shalkharov, Y., Kozhambekov, D. 2019. Main principles and features of consideration legal characteristics of secular state. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22(4), 01–12.
6. Bitemirov, K., Shalkharov, Y., Nartai, A. 2019. Legal genomics: some aspects of modern jurisprudence and conflictology. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22(4), 01–12.

7. Bitemirov, K., Shalkharov, Y., Shukenova, Z. 2019. Problems and prospects of the formation and reform of the judicial system and the justice system in the Republic of Kazakhstan. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22(4), 01–12.
8. Bitemirov, K., Shalkharov, Y., Zhaltyrbayeva, R. 2019. The legal status of the designation of artificial intelligence in the system of modern law. *Res. Journal of Legal, Ethical and Regulatory Issues*, 22(4), 01–12.
9. Bui Ta Long. 2020. Inverse algorithm for Streeter-Phelps equation in water pollution control problem, *Mathematics and Computers in Simulation*, 171, 119–126.
10. Godall Rohi, O'tega Ejofodomi, Godswill Ofualagba. 2020. Autonomous monitoring, analysis, and countering of air pollution using environmental drones, *Heliyon*, 6(1), Article e03252.
11. He Li, Juan Lu, Bin Li. 2020. Does pollution-intensive industrial agglomeration increase residents' health expenditure? *Sustainable Cities and Society*, 56, Article 102092.
12. Huan Huan, Litang Hu, Yu Yang, Yongfeng Jia, Beidou Xi. 2020. Groundwater nitrate pollution risk assessment of the groundwater source field based on the integrated numerical simulations in the unsaturated zone and saturated aquifer, *Environment International*, 137, Article 105532.
13. Huan Huan, Xiang Li, Jun Zhou, Weijiang Liu, Yonghai Jiang. 2020. Groundwater pollution early warning based on QTR model for regional risk management: A case study in Luoyang city, China, *Environmental Pollution*, 259, Article 113900.
14. Juan Feng, Susana Cavallero, Tzung Hsiai, Rongsong Li. 2020. Impact of air pollution on intestinal redox lipidome and microbiome, *Free Radical Biology and Medicine*, 11(2).
15. Juvelikyan H.A., Shcheglov D.I., Gorbunova N.S. 2009. Methods of control and regulation of soil pollution. Educational and methodological guide for universities. Voronezh: Publishing and Printing Center of Voronezh State University. 14(2), 88–94.
16. Kruzhilin, S., Baranova, T., Mishenina, M., & Zaitseva, M. 2020. Regional specificity creation of protective afforestations along highways. *World Ecology Journal*, 8(2), 22–32. <https://doi.org/https://doi.org/10.25726/NM.2018.2.2.003>.
17. M. Choël, N. Visez. 2019. Altérations du grain de pollen par la pollution atmosphérique, *Revue Française d'Allergologie*, 59(8), 555–562.
18. Miguel A. Meléndez-Jiménez, Arnold Polanski. 2020. Dirty neighbors – Pollution in an interlinked world, *Energy Economics*, 6, Article 104636.
19. Mingge Li, Lili Wang, Jingda Liu, Wenkang Gao, Yuesi Wang. 2020. Exploring the regional pollution characteristics and meteorological formation mechanism of PM2.5 in North China during 2013–2017, *Environment International*, 134(6), Article 105283.
20. Qi Wang, Dongmei Hao, Fangbai Li, Xiaoying Guan, Pengcheng Chen. 2020. Development of a new framework to identify pathways from socio-economic development to environmental pollution. *Journal of Cleaner Production*, 25320, Article 119962.
21. Qian Zhou, Xiaoling Zhang, Jie Chen, Yanyan Zhang. 2020. Do double-edged swords cut both ways? Housing inequality and haze pollution in Chinese cities, *Science of The Total Environment*, 7191, Article 137404.
22. Sadar Aslam, Malik Wajid Hussain Chan, Ghazala Siddiqui, Grzegorz Boczkaj, Mohib Reza Kazmi. 2020. A comprehensive assessment of environmental pollution by means of heavy metal analysis for oysters' reefs at Hab River Delta, Balochistan, Pakistan, *Marine Pollution Bulletin*, 15(3), Article 110970.
23. Shamsutdinova et al. 2011. Assessment of the risk level of soil pollution on the example of the territory of Ufakhimprom, *JSC. Ecology of industrial production*, 3, 19–22.
24. Siyu Chen, Teng Li. 2020. The effect of air pollution on criminal activities: Evidence from the NOx Budget Trading Program, *Regional Science and Urban Economics*, In press, Article 103528.
25. Sufeng Wang, Ling Xu, Shijian Ge, Jianling Jiao, Ying Shu. 2020. Driving force heterogeneity of urban PM2.5 pollution: Evidence from the Yangtze River Delta, China, *Ecological Indicators*, 11, Article 106210.
26. Tamara Schikowski, Hicran Altug. 2020. The role of air pollution in cognitive impairment and decline, *Neurochemistry International*, In press, Article 104708.
27. Uwah, E.I., Gimba, M.S., Gwaski, P.A. 2012. Determination of Zn, Mn, Fe and Cu in Spinach and Lettuce Cultivated in Potiskum, Yobe State, Nigeria. *J. Agri. Econo. Develo.* 1(4), 69–74.
28. Wenyong Wu, Renkuan Liao, Yaqi Hu, Hao Wang, Shiyang Yin. 2020. Quantitative assessment of groundwater pollution risk in reclaimed water irrigation areas of northern China, *Environmental Pollution*, 261, Article 114173.
29. Xiaotian Liu, Runqi Tu, Dou Qiao, Miaomiao Niu, Chongjian Wang. 2020. Association between long-term exposure to ambient air pollution and obesity in a Chinese rural population: The Henan Rural Cohort Study, *Environmental Pollution*, 260, Article 114077.
30. Xipeng Jin, Xuhui Cai, Mingyuan Yu, Yu Song, Hongsheng Zhang. 2020. Diagnostic analysis of wintertime PM2.5 pollution in the North China Plain: The impacts of regional transport and atmospheric boundary layer variation, *Atmospheric Environment*, 2241, Article 117346.
31. You Zheng, Jiachao Peng, Jianzhong Xiao, Panda Su, Siyao Li. 2020. Industrial structure transformation and provincial heterogeneity characteristics evolution of air pollution: Evidence of a threshold effect from China., *Atmospheric Pollution Research*, 11(3), 598–609.