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ӘЛ-ФАРАБИ атындағы ҚАЗАҚ ҰЛТТЫҚ УНИВЕРСИТЕТІ

КАЗАХСКИЙ НАЦИОНАЛЬНЫЙ УНИВЕРСИТЕТ имени АЛЬ-ФАРАБИ

AL-FARABI KAZAKH NATIONAL UNIVERSITY

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Серия экологическая

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және әл-Фараби атындағы ҚазҰУ-дың 80 жылдығы аясында өткізіліп жатқан
«Экологиялық мәдениеттің және қоғамның тұрақты дамуының қазіргі кездегі мәселелері» атты
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*В журнале опубликованы материалы международной научно-практической конференции
«Современные проблемы экологической культуры и устойчивого развития общества»,
проводимой в рамках «Года экологической культуры и охраны окружающей среды в СНГ»
и 80-летия КазНУ имени аль-Фараби.
Тематика докладов освещает актуальные проблемы экологической культуры,
устойчивого развития, теоретические и прикладные аспекты биотехнологии и
экономические механизмы перехода к «зеленой экономике».*

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"Modern problems of ecological culture and sustainable development of society", held within the framework
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80 th anniversary of the al-Farabi KazNU.
Subjects of the reports highlights the ecological culture and sustainable development, theoretical and applied
aspects of biotechnology and economic mechanisms of transition to the «green economy».*

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V.S. Cherednichenko, A.V. Cherednichenko, A.S. Nyssanbayeva, A.R. Zhumalipov, A.S. Madibekov*

Al-Farabi Kazakh National University, Kazakhstan, Almaty
*E-mail: madibekov@mail.ru

Distribution of heavy metals (microelements) in snow Cover in Kazakhstan

The distribution of microelements in the snow cover in northern Kazakhstan has been studied. Also, using the data from previous studies the spatial distribution of microelements for the entire territory of Kazakhstan has been mapped. The areas of local pollution in snow cover in major industrial centers Chromtau, Zhezkazgan, Balkhash, and Shymkent have been identified.
Keywords: snow cover, microelements, lead, cadmium, arsenic, map, pollution.

В.С. Чередниченко, А.В. Чередниченко, А.С. Нысанбаева, А.Р. Жумалипов, А.С. Мадибеков

Распределение тяжелых металлов (микроэлементов) в снежном покрове Северного Казахстана

Рассмотрены распределения концентрации микроэлементов в снежном покрове в северной части Казахстана. Также, используя данные предыдущих исследований, построены карты пространственного распределения микроэлементов для всей территории Казахстана. Выделено локальное загрязнение снежного покрова микроэлементами в районах крупных промышленных центров Хромтау, Жезказган, Балкаша, Шымкента.
Ключевые слова: снежный покров, микроэлементы, свинец, кадмий, мышьяк, карты, загрязнение.

В.С. Чередниченко, А.В. Чередниченко, А.С. Нысанбаева, А.Р. Жумалипов, А.С. Мадибеков

Солтүстік Қазақстан территориясындағы қар жамылғысындағы ауыр металдардың (микроэлементтердің) таралуы

Қар жамылғысындағы микроэлементтердің таралу ерекшеліктері қарастырылады. Зерттеу аймағы ретінде солтүстік Қазақстан алынған. Микроэлементтердің кеңістік таралу ерекшеліктерін бағалау үшін бүкіл Қазақстанның территориясына карталары салынған. Қар жамылғысы микроэлементтермен ластанған аудандар белгіленген (Балқаш, Жезқаған, Хромтау, Шымкент)
Түйін создер: қар жамылғысы, микроэлементтер, қорғасын, кадмий, мышьяк, карта, ластану.

The study of the chemical composition of snow cover (SC) is the most important part of the process of studying the environment pollution. The content of microelements in snow cover varies in wide range depending on the human impact. At first we studied the concentration of microelements in northern Kazakhstan. To do this we considered the observations of the 25 meteorological stations situated on the study area over a five year period. Then, using the results of previous studies of microelements distribution over southern Kazakhstan we mapped the entire Kazakhstan. The chemical analyses were made in a chemical-analytical laboratory of National meteorological service (NMS) "Kazgydromet" branch in Almaty in accordance with the existing requirements and standards [1]. The amount of heavy metal concentration is given in the table below.

Table 1 – Average concentration of heavy metals (elements) in snow cover (2005-2010)

№	MS	Winter period precipitation, mm	Microelements, мkg/l			
			Pb	Cu	As	Cd
1	Zhalpaktal	59,36	2,4	11,1	0,1	0,1
2	Kamenka	53,63	3,8	19,8	0,2	0,2
3	Taipak	39,10	2,0	8,9	1,0	0,3
4	Zhimpity	30,11	3,2	16,2	0,5	0,8
5	Aktobe	69,60	2,4	23,3	0,4	0,6
6	Novorossiyskoye	92,10	2,2	17,6	0,5	0,1
7	Zhagabulak	41,03	4,7	6,0	0,2	1,0
8	Mygalzhar	69,53	2,4	19,8	0,9	0,7
9	Irgyz	72,92	2,6	17,5	1,0	0,2
10	Tobyl	50,73	1,4	15,1	1,2	0,4
11	Kostanay	49,83	1,0	16,9	0,4	0,3
12	Arkalyk	53,65	0,5	2,8	1,3	0,1
13	Atbasar	65,18	2,0	10,9	0,5	0,3
14	Petropavlovsk	73,95	4,0	16,5	0,6	0,4
15	Kokshetau	66,28	2,1	6,7	1,2	0,2
16	Schuchinsk	51,80	0,0	3,9	1,5	0,0
17	Astana	81,40	5,1	25,0	0,7	3,3
18	Karaganda	73,47	2,6	10,7	0,9	0,2
19	Ertys	45,56	1,7	18,2	1,0	0,1
20	Ekibastuz	41,17	3,8	19,6	1,1	0,2
21	Pavlodar	50,87	3,1	27,0	2,1	0,2
22	Semiyarka	92,44	3,9	14,5	2,0	0,1
23	Semey	58,10	2,9	20,9	2,4	0,4
24	Shemonaikha	89,45	2,0	12,4	1,1	0,1
25	Ridder	132,35	3,9	20,6	0,4	0,5

For the northern part of Kazakhstan the behavior and distribution of heavy metals in all media is of interest to study, especially on the basis of snow cover monitoring. Metals are contained in the majority of industry, power supply and moto transport emissions, and they are indicators of anthropogenic impacts of these emissions on the environment.

Lead. In figure 1 as well as on the table there presented lead concentrations on the snow cover at the region stations. It can be noted that the most lead concentrations occur in the area of Astana – 5.1 mg/l, and the minimum in MS of Schuchinsk – 0.0 mkg/l, Arkalyk – 0.7 mkg/l.

Figure 1 also shows that the lead concentration in snow cover (SC) Schuchinsk in northern Kazakhstan did not exceed the maximum allowable rate (MAR). The concentrations of lead decrease with the bias to the east of the western regions to Arkalyk, and then they grow in the area from Schuchinsk to Semipalatinsk and Ridder.

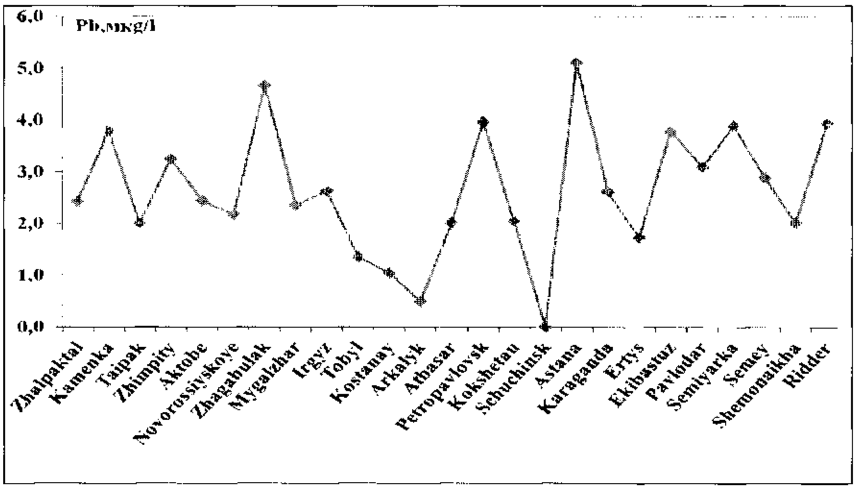

Figure 1 - Long-term average distribution of lead concentration (Pb), mkg/l

Its maximum concentrations in the eastern region occur over Zhagabulak near the industrial area (Chromtau area) and over Astana. Its main peak concentration can be observed over Astana.

Cadmium. One of the most toxic metals is cadmium, which was widely used in production of dyes (pigments) and as a stabilizer in plastic (including PVC). Cadmium is contained in power plants', metallurgy and a number of chemical plants' emissions (production of sulfuric acid), lead-zinc plants' emissions and so on.

Figure 2 and the table show that the most concentrated areas of cadmium are locally situated over Astana region where maximum allowable rate increased three-fold (1MAR=1mkg/l), and also at Zhagabulak station where the concentration of cadmium is close to 1 MAR. At the same time the long-term average accumulation of cadmium in the snow cover of northern Kazakhstan is below standard rate. The average concentration of cadmium for the territory of northern Kazakhstan is ranging from 0.1 to 3.3 mkg/l.

Cadmium content in the soils of Pavlodar and in its surroundings is fully considered in the paper /2/. Its authors have found that there are relatively high concentrations of cadmium in the soils. Our research shows that cadmium in Pavlodar region is really coming heavily from atmosphere on the underlying surface in the form of depositions (see the table). At the same time the concentration values of cadmium in snow cover from our data averaged over three years are low.

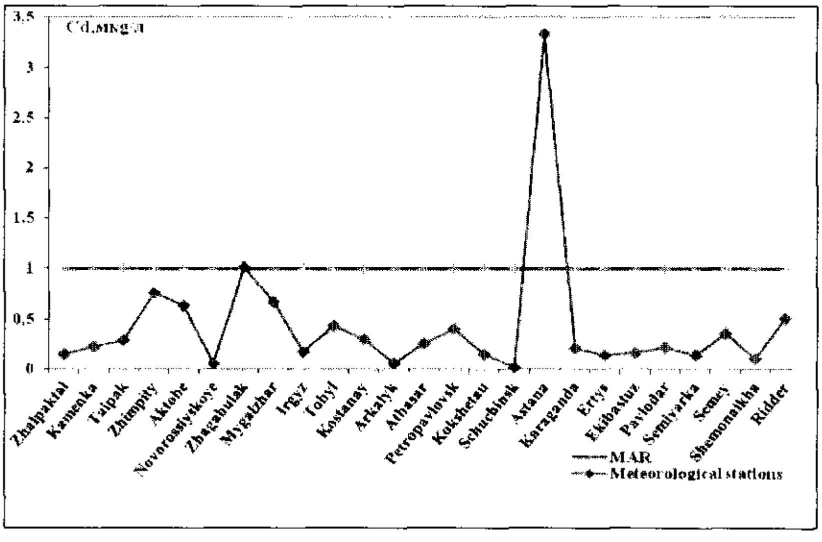

Figure 2 - Long-term average distribution of cadmium concentration (Cd), mkg/l

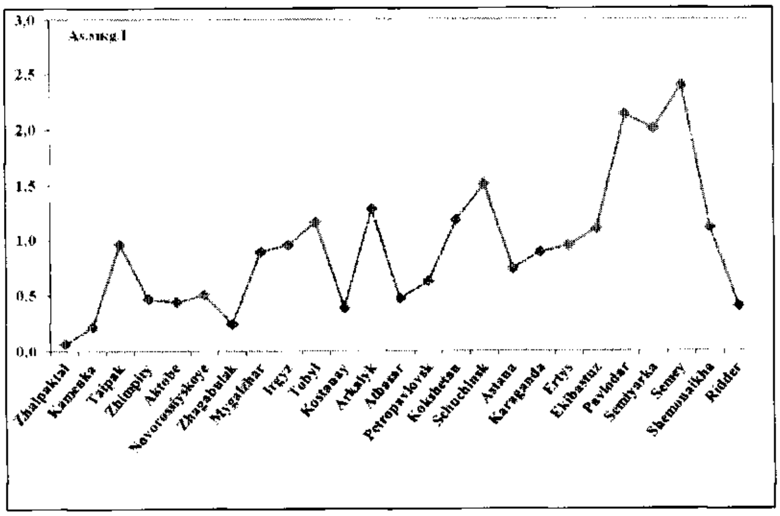

Figure 3 - Long-term average distribution arsenic concentration (As), mkg/l

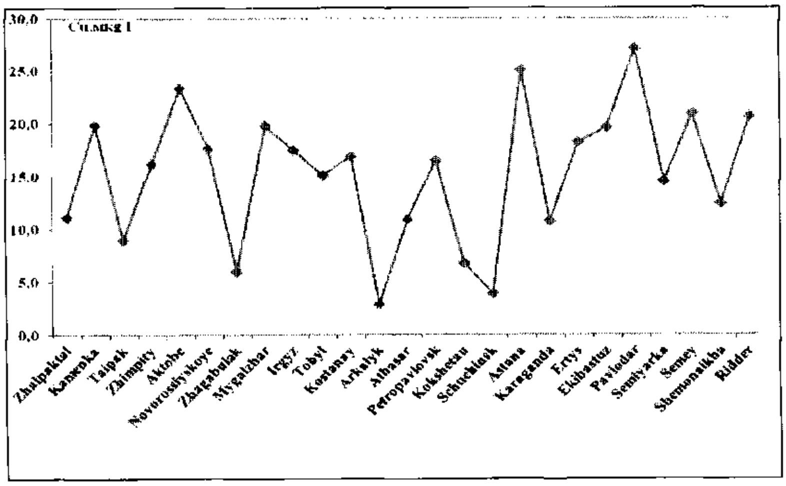

Figure 4 - Long-term average distribution of copper concentration (Cu) mkg/l

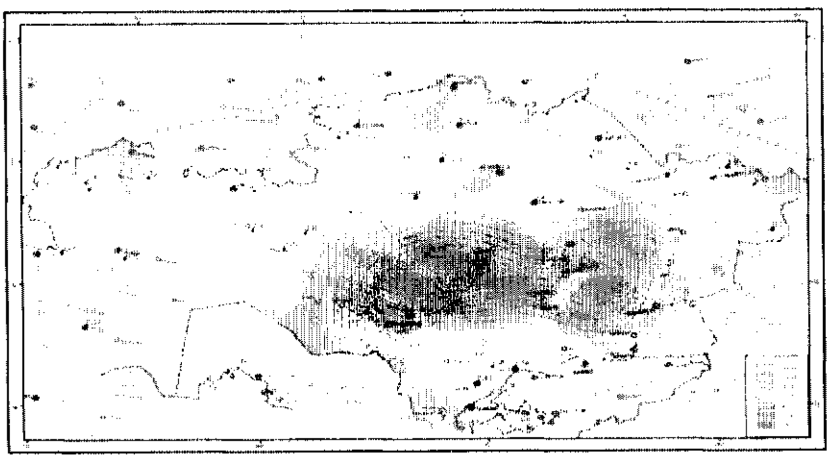

Figure 5 - Average concentrations of lead (Pb) in snow cover through Kazakhstan, mkg/l

Arsenic. Arsenic (fig.3) refers to the second class of danger, it is a high-risk substance, its MAR is 50 mkg/l. The major sources of arsenic emissions in the environment are the products of combustion of coal and petroleum, the emissions of mining and processing and metallurgic plants. It is applied in every day life as a cleaning agent and in agriculture as a pesticide. Some arsenic comes from the soil and as a result of decomposition of plant and animal organisms. In natural waters arsenic compounds are dissolved and suspended.

Five-year average rates of arsenic in snow cover through northern Kazakhstan are on the table and Figure 3.

Figure 3 shows that the average content of arsenic in snow cover on the observed area is significantly below the MAR.

Arsenic concentrations have the marked positive trend when moving from western to eastern part of the area. The lowest content of arsenic is at the station Zhalpaktal, 0,1 mkg/l; its highest content is observed in the eastern part of the territory, in Pavlodar, Semiyarka, the maximum rate is at the station Semey, 2,4 mkg/l.

Copper. In the emissions of solids copper is contained mainly in the form of compounds, mainly copper oxide. The Table and Fig 4 show the distribution of copper in the North Kazakhstan.

As a result of the research we obtained the data on the concentrations of various microelements in snow cover in northern Kazakhstan. During the same period of time and using the same methodology the authors /3,4/ obtained similar data for southern Kazakhstan.

As a result we have the opportunity to map the distribution of concentration of investigated elements through the Republic. We made such maps of distribution of concentrations of microelements. Fig. 5 shows the map of distribution of lead through Kazakhstan. It can be seen that most extensive area of high concentrations of lead is located above the central, southern and some eastern regions.

Maximum concentrations, more than 36 mkg/l, are above Zhezkazgan and above Balkhash, more than 29 mkg/l. The area stretches east to the area of Kalbin Mountains. Another ridge of high concentrations oriented from Zhezkazgan region towards north-east to Pavlodar. This corresponds to the prevailing wind direction in winter in the absence of atmospheric fronts.

The second area of high concentrations of lead is in the west being extended from Uralsk region to the south-east. Maximum concentrations in this area are 3.8-2.6 mkg/l, i.e. they are an order of magnitude lower than in the core area of the central regions. Another area of increased concentrations of lead is above northern regions where the concentrations reach 4.0-2.8 mkg/l.

Ile Alatau foothills and west of the Altai are characterized by low concentrations of lead, less than 2 mkg/l. At the same time in the south in Schimkent region and in Ust-Kamenogorsk region locally they rise to 3.5-4.0 mkg/l. There are a lot in common in the territory distribution of cadmium and lead (Figure 6,7). The highest concentrations of cadmium are also located in a vast area of high concentrations in Zhezkazgan-Balkhash region where average concentrations are 5.32 mkg/l, 5 or more times exceed MAR (Figure 6).

The ridge of high concentrations of cadmium of about 3 mkg/l is oriented from an extensive area of high concentrations of cadmium over the central regions to the north-east, Astana region. In this case, the snow cover in Karaganda and Pavlodar regions has low cadmium, less than 0.5 mkg/l.

Another area of high concentrations of cadmium, but they are lower than 1 MAR, is located in the west in Uralsk-Atyrau regions. Local areas of higher concentrations which are lower than 1 MAR are in the Shymkent and Ust-Kamenogorsk regions. Ile Alatau foothills, the north-west and north-east of Kazakhstan, as well as Aktau region, have low or very low levels of cadmium.

The area of high concentrations of arsenic is shifted to the east of the central regions of Kazakhstan, which are characterized by high concentrations of lead and cadmium (Fig.7).

The central area of concentration is located in Balkhash region, it is 41.07 mkg/l, and from here the ridge extends to the east and is easily visible to the border with China. The second ridge is oriented through Zhezkazgan (19.66 mkg/l) to the north-west to Kostanay, but the concentrations in this direction rapidly decrease. In Kostanay the arsenic content is only 1.17 mkg/l.

In the west of the Republic, not very vast area of increased concentrations of arsenic is located in the middle stream of the Ural River, and it is focused on the latitude. Arsenic concentrations are about 1.2 mkg/l.

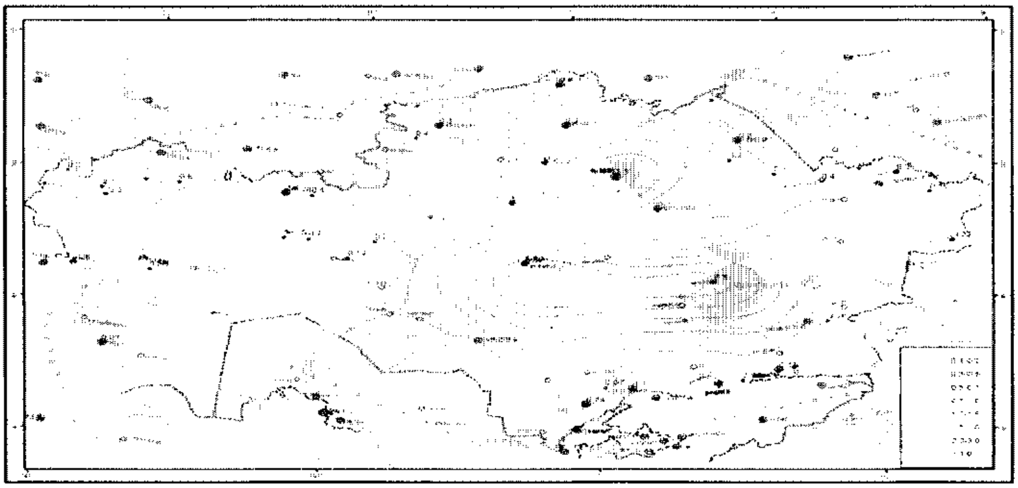

Figure 6 – Average concentrations of cadmium (Cd) in snow cover in Kazakhstan, mkg/l

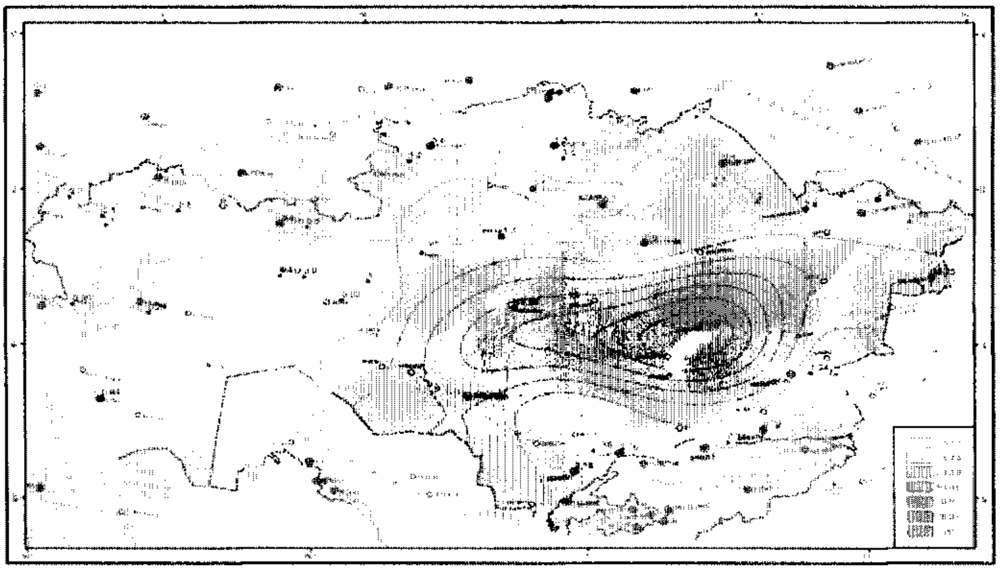

Figure 7 - Average concentrations of arsenic (As) in snow cover through Kazakhstan, mkg/l

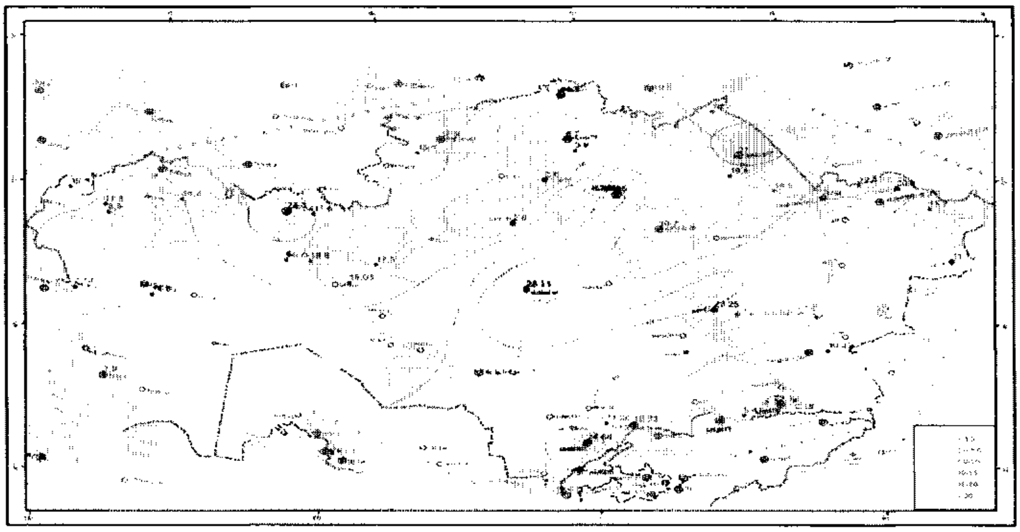

Figure 8 - Average concentrations of copper (Cu) in snow cover in Kazakhstan (mg/l)

The area of increased concentrations of arsenic is also in the north-east of the Republic along the Ertys River from Semipalatnsk to Pavlodar and a little further to the north-west. Between this area and the main area of increased concentrations the central area being in Balkhash region there is an area of low concentrations (less than 0.5 mkg/l) from Kostanay to Karagandy.

The spatial distribution of copper in snow cover is extremely mixed (fig.8). There are two areas of maximum concentrations of copper – in Zhezkazgan-Balkhash region (28.3-22.0 mkg/l) and in

Aktobe region (23.3 mkg/l). The first area is very vast; it includes not only the central regions, but also the south of the Republic, including Shimkent and southern Pribalkhashiye. One of the ridges of high concentrations stretches to Ust-Kamenogorsk (20.6 mkg/l), and the second - to Astana (25.0 mkg/l). The second area, located west of Aktobe is oriented to the south-east, Aral Sea region. The areas of low concentrations of copper are not vast. One of them is in the Karagandy-Semiyarka region, (10.0-15.0 mkg/l), the second one is in Kokshetau and Aralsk regions, and it is the deepest one (less than 4 mkg/l) .The third is in Atyrau region (11.0-15.0 mkg/l).). Along the foothills of Ile Alatau lower concentrations of copper (9.0-12.0 mkg/l) are also observed. When comparing the concentration of microelements in snow cover with their concentrations in precipitation /4/, we can see that the concentration of lead in snow cover exceeds the concentration of lead in precipitation on average three times, and as for the other microelements – two times. Therefore, in the intervals between rainfalls the number of microelements falling onto the underlying surface is not less than twice the number of microelements dropping down with precipitation.

The importance of snow cover as a medium for depositing the pollutants is specified in many studies, including /6/. It is also shown that according to the analysis of contaminants in the snow cover in Ust-Kamenogorsk the high concentrations of lead, copper, zinc and some other metals have been found. We did not analyze zinc concentration, but the high concentrations of lead and copper are confirmed by our research. In contrast to /6/ our studies were performed on the long-term data and they show that the concentrations of microelements in the snow cover in Pavlodar exceed 1-2 MAR.

As a result of the analysis of the spatial distribution of microelements in the snow cover in northern Kazakhstan and the whole territory of Republic in general, the following results have been got:

The concentrations of microelements in snow cover are not dependent on the amount of rainfall. There are two areas of distribution of higher concentrations of microelements: in the west and in the east of the territory;

1) The maximum concentrations of lead and cadmium are in the west at Zhagabulak station, and in the east – in Astana, and the values of lead in Astana are the main peak and the concentrations of cadmium exceed 3 MAR, at 1 MAR in Zhagabulak;

2) When moving from west to east the concentrations of arsenic increase by more than 2-fold, from 1 mkg/l at the maximum in Taipak to 2.4 mkg/l in the city of Semey. There are local maxima over northern Kazakhstan;

3) The concentrations of copper have a large spatial variability. The main maximum concentration is in Zhezkazgan region (28.13 mkg/l), where it can be seen in the form of a ridge focused on Astana (25.0 mkg/l), and the second ridge– on the Balkhash (23.26 mkg/l);

4) In the Republic there are a few areas of high anthropogenic contamination of microelements. These are the central regions of Zhezkazgan – Balkhash, and also, but to a less extent in the west – Chromtau region, in the south – Shimkent, in the north – Pavlodar, in the east – Kazakhstani Altai;

5) The number of microelements in snow cover is more than twice the number of microelements in precipitation. This indicates that in the intervals between precipitations microelements fall onto the underlying surface is sufficiently intense.

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СОДЕРЖАНИЕ

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Section 1

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