Geochemical Characteristics of Solid Atmospheric Precipitations in the Territory of Pavlodar in the Republic of Kazakhstan According to the Study of Snow Cover Pollution

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Abstract

The content of chemical elements in a solid snow cover phase is studied in the territory of Pavlodar, the Republic of Kazakhstan. The main chemical elements that pollute the snow cover and the pollution sources have been revealed. The trends of chemical elements redistribution being removed from the sources of generation are noted.

***The purpose of this paper* is to define heavy metals and micro-elements in the solid snow phase in the territory of Pavlodar, the Republic of Kazakhstan. Then it is required to find out the role of heavy metals and micro-elements, their impact, degree of detrimental effect on the soil. We need to define their number falling along with precipitations and accumulated in snow cover.**

Our research is directed to: define what certain heavy metals are the most dangerous; find out by what factors the environmental impact of heavy metals is defined; clear out what outcomes chemical transformations in the atmosphere may lead to; reveal man-made atmospheric pollution; to understand due to what reasons the chemical composition of filter effluent of thawed snow is generated; to reveal the importance and need of ecological and geochemical assessment of snow cover pollution as a natural absorber of chemical elements in winter time; to see the reasons why heavy metals and micro-elements are chosen for research; to define the main sources of

pollution; to define the main polluting components of the snow cover of Pavlodar; to reveal abnormal zones of very high, high, middle and low levels of pollution; to know what allows to define the most prominent concentrations of the chemical elements in the solid snow cover fraction; to reveal mapping of the distribution of individual chemical elements and their associations across Pavlodar; to know the reasons leading to soils contamination in various zones of the city.

Keywords: chemical elements, solid, pollution, sources, geochemical characteristics, filter effluent, heavy metals, snow cover samples, fluctuation

Introduction

Nowadays, more than half the world's population lives in cities. The part of the urban population keeps steadily growing. Cities have become the centers to concentrate population, industry and, therefore, an intensive environment pollution which represents man-made geochemical and biogeochemical provinces by the area of the toxicants' anomaly. Cities themselves are powerful sources of man-made substances involved in regional migration cycles.

The presence of a large number of various elements in the atmosphere including metals is recently more alarming fact due to industrial activity since they contaminate the soil, vegetation, water, enter into human body and body of other animals being falling on a surface. Here, heavy metals (lead, cadmium, mercury, nickel, cobalt, chromium, vanadium, copper and zinc, as well as arsenic, selenium and antimony) are the most dangerous.

The environmental impact of heavy metals is defined by many factors and, particularly, by their running in the atmosphere. Chemical transformations in the atmosphere may lead to the arising of more or less toxic forms of elements than initially emitted ones, as well as the impact on their flow from the atmosphere. According to the dimensions of aerosol particles, we may define the life-span of heavy metals in the atmosphere and, therefore, the distances where they may be carried from the source of the emission (Yatsenko-Chmielewska M.A., Tsybulskiy V.V., Milyaev V.B., 1994).

It is known that snow cover with a high absorption capacity is the most informative object to reveal man-made atmospheric pollution. If it has not been intensively melting, snow cover actually accumulates and retains all components that contaminate the atmosphere unlike rains, which partially infiltrate in grounds and soil, partially entry runoff waters, and are partially purified by vegetation (during the season). The chemical composition of filter effluent of thawed snow is generated due to various chemical elements to entry with precipitations, gasses absorbed by snow cover, water-soluble aerosols and to solid particles falling from the atmosphere to interact with snow cover. In this case, if a dusty territory is described by the quantity of solid sediment falling snow, the thawed snow filter effluent shows the degree of air pollution in the most soluble forms of elements. That defines the importance and need of ecological and geochemical assessment of snow cover pollution as a natural absorber of chemical elements during winter.

Heavy metals and micro-elements are chosen for research for a good reason. They are known by high toxicity, mutagenic and carcinogenic effects, and are capable of both bioaccumulation and biomagnification. Being highly concentrated in the environment, they adversely impact on ecosystems. In low concentrations, some of them are very important for exchange processes. Also, they are vital for a body as micro-elements.

Solid precipitations in the territory of Pavlodar in the Republic of Kazakhstan is very important topic for such branches of science as biology, chemistry, geology, biochemistry, etc. because the content of heavy metals, micro-elements and other substances in precipitations is little studied and researched in Kazakhstan and its regions. The subject of our article is generally little researched in the territory of Kazakhstan, particularly, in Pavlodar. The number of different chemical elements and heavy metals in precipitations, in particular, in snow cover is not reliably observed. The number of heavy metals and chemical elements is the most difficult to find out in a snow cover, since unlike rains, snow tends to accumulate a lot of them. For example, various phosphates, salts, nitrates, sulphides which are absolutely not seen in the snow cover. Also, the certain impact of heavy metals and micro-elements which are contained in precipitations, on the environment of Kazakhstan is not studied and revealed completely. Thus, we decided to research the subject of our paper more thoroughly. To do this, we will trace the frequency of the precipitations falling in the territory of Pavlodar, and measure the number of chemical elements there, using special tools, methods, and techniques, providing an analysis and comparing the obtained results. Then, based on the above listed actions and measures, we will define the adverse effect of all that elements on the environment of Kazakhstan in the territory of Pavlodar.

If we know certainly the number of heavy metals and micro-elements contained in the solid snow phase in the territory of Pavlodar, and clearly find out nature of their impact, adverse effect and outcomes on the environment, we will be able to make contribution to environment protection in Kazakhstan. Thus, the subject of our article is very relevant, actual and important for the environment and its protection.

Atmospheric precipitation is the main, if not the only, source of moisture land. So, the desire to know the most reliable quantity is natural.

The reliability of the determination of the amount of precipitation depends on the accuracy of many theoretical calculations concerning, for example, the water balance equation dry land, thermal and water balance of the active surface, water calculations, including the assessment harvest. Reliable data on rainfall is not less required, and to produce long-term weather forecasts. Precipitation is the most variable in time and space weather event, because of their education and the intensity is influenced by many factors. The most favorable conditions for the formation of heavy precipitation are in areas with high moisture content, and strong upward movements of air. Any research is possible with a reliable source material. Such data in the study of sediments are multiyear average precipitation. The territory of Kazakhstan, except for mountainous areas differs prominent aridity. This is explained by the fact that Kazakhstan is located almost in the center of Eurasia, little accessible and directly exposed to moist Atlantic air masses. Great influence on the distribution of rainfall has terrain. Under the influence of elevation on the redistribution of precipitation areas: increasing their elevated areas on the windward and leeward decrease.

A variety of climatic and orographic conditions of Kazakhstan determines the uneven distribution of precipitation in its territory.

During the year in Kazakhstan in the passage and the formation of cyclonic and anti-cyclonic formations continuously interact air masses coming from the Arctic, from the continental temperate latitudes, from the Atlantic and Central Asia. The interaction and the subsequent transformation of the substantial changes in their hydrothermal features. These processes have a one-year cycles, thereby causing the seasonal pattern in the distribution of species on the territory of Kazakhstan and rainfall.

Sediments are the least well south-western Balkhash (173 mm), south-west Aral Kyzylkum (151 mm). The influence of large bodies of water (the Caspian and Aral seas, lakes. Balkhash, etc.) to wet the adjoining desert is very limited. Thus, the annual rainfall ranges from 150 to 200 mm. As we approach the mountain range could cause the active fronts, rainfall increases dramatically. Highlands of east and south-east of Kazakhstan differ abundant moisture. Depending on the altitude, landforms and slope exposure in eastern and south-eastern mountain systems of Kazakhstan in an average year there is 350-629 (Almaty) mm.

The study of the chemical composition of snow cover 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.

Aerosol sampling in Kazakhstan was performed at a remote astronomical observatory in the Tien Shan mountain region. The background character of the site was considered by comparing the elemental concentrations, obtained by Energy Dispersive X-Ray Fluorescence, with those reported for other remote stations. On the basis of the variability of the elemental concentrations and the source of origin, the elements could be classified into two main groups. These findings, complemented with enrichment factor calculations revealed the first group of elements to be originating mainly from local sources, and the second group to be related to long-range transport of anthropogenic aerosol. Automated individual particle analysis by electron probe X-ray microanalysis and subsequent cluster analysis resulted in the identification of 12 distinct aerosol particle types. Relative particle type abundances were converted to absolute abundances by estimating the particle number concentrations for the detected particles, exploring the seasonal particle variation. Based on the absolute abundances, a strong seasonal pattern was found for Si-Al-Fe-, Si-, Ca-S-Si-, Ca-Si-, Fe-Si- and Ti-Si-rich particles. These particle types can mainly be attributed to the local soil source. For most of the remaining particle types, a completely different seasonal trend was found, which can be related to anthropogenic emissions. Their abundance in winter can be related to long-range transport of anthropogenic aerosols. As a result, these data can be representative for the Tien Shan site and may be useful to climate modellers and environmentalists.

Snow cover contamination is assessed in the impact areas of the first stage of the expandable launch system Proton in Central Kazakhstan. It was revealed that the chemical effect of propellants on the snow cover is local. The increase in the content of the following high-toxic substances in the snow was registered: unsymmetrical dimethylhydrazine, nitrosodimethylamine, and nitrate and nitrite ions. The most part of the pollutants is localized in the upper 5-cm snow layer. Nitrogen tetroxide decreases the value of pH, and unsymmetrical dimethylhydrazine increases it. The inflow of calcareous soil particles to the atmosphere and their subsequent fallout result in the alkalization of snow and in the neutralization of acidification by nitrogen tetroxide accompanied by the formation of the salts of nitric acid and nitrous acid.

Material and Methods

The city of Pavlodar is a multidisciplinary industrial center. 87 industrial enterprises were registered in the city during the research. Aluminum, machinery, cardboard-roofing, chemical, petrochemical, shipyard and repairing yard, instrument, industrial rubber plants, steel production and electrical plants, etc. are the major industrial enterprises.

Besides, there are 3 TPP, more than 20 boiler-rooms and 5751 units of private house-building in the city. They burn annually over 4 million tons of coal in total. There are over 60.3 thousand garden-plots and hundreds of gardens of private households within the city of Pavlodar. Here the production of vegetables, potatoes, and small-fruit crops is concentrated.

In the South and South-West of Pavlodar, there are major industrial centers of the Pavlodar region of Aksu and Ekibastuz, which are the part of the Pavlodar-Ekibastuz territorial and production complex. Pavlodar is the center of this region. These centers are located in the main directions of air mass movement. Therefore, they likely to affect Pavlodar.

Snow cover samples were selected in various regions of the city and its industrial zones (north and eastern) according to standard methodological recommendations (*Methodological recommendations to assess the degree of air pollution of localities with metals according to the content in snow cover and soil*, 1990; Vasilenko

V.N., Nazarov I.M., Friedman S.D., et al., 1985; Plokhinskiy N.A., 1970).

The snow cover samples were selected at 1 sample per 1 sq. km. Due to such a network, we may reveal pollution focus related to industrial zones or major individual enterprises (Panin M.S., Geldimammedowa E.A., 2006). The samples were selected during the spring melting in the city area and in the nearest suburb. Baseline samples were taken in the distance 80 km from the city to the opposite side of the wind rose. 456 samples of snow were selected and analyzed.

Filtered solid particles were dried in the air and weighed. The weight of sediment defined the total number of dust falling per unit area in a time unit.

The content of the chemical elements in the solid fraction was determined by an atomic absorption method by the spectrophotometer Perkin Elmer, model 403 with the electro-thermal analyzer HGA-74 and deuterium background corrector.

The data obtained during the research was processed statistically according to Plohinskiy N. A. (Dospekhov B.A., 1979) and Dospehov B.A. (Koroleva G.P., Gorshkov A.G., Vinogradova T.P., et al., 2015) using Microsoft ® Exel. Outline maps were drawn up using the MapInfo Professional Version 5.0.

Results and Discussion

The average content and margins of fluctuation of the chemical elements in the solid snow cover phase in Pavlodar are provided in table 1.

Table 1. Variational and statistical indexes of the content of chemical elements in the solid snow cover phase in the territory of Pavlodar

Element	Kv, mg/kg	M ± m, mg/kg	σ, mg/kg	V,%	Background, mg/kg	Kc
Cu	29.8-392.7	137.4 ± 13.9	95.0	69.1	20.5	6.8
Zn	54.5-785.5	264.3 ± 24.1	164.9	62.4	48.3	5.6
Cd	0.18-7.0	2.1 ± 0.26	1.77	85.5	0.16	13.2
Pb	28.7-198.8	102.5 ± 8.0	54.8	53.5	23.2	4.5
Cr	19.6-101.5	56.2±3.1	21.4	38.0	18.4	3.1
Mn	28.8-575.8	171.2 ± 20.7	141.7	82.8	24.3	7.1
Co	9.3-96.7	41.6±2.9	19.7	47.3	7.9	5.3
Mo	0.38-5.9	2.2 ± 0.22	1.52	70.5	0.29	7.6
Be	0.22-6.8	1.9±0.21	1.47	78.8	0.17	11.1
Ni	27.8-170.8	77.9 ± 5.3	36.1	46.3	21.1	3.7
Sr	39.8-639.5	266.0 ± 23.7	162.5	61.1	29.8	9.1
V	10.9-112.7	55.0 ± 3.4	23.6	42.8	9.8	5.7

Note: Kv is a margin of fluctuations, σ is an average quadratic deviation, V is a coefficient of variation, Kc is a concentration factor

According to the value of average content of an insoluble fraction of the snow, the chemical elements are arranged in descending order: Sr(266)>Zn(264.3)>Mn(171.2)>Cu(137.4)>Pb(102.5)>Ni(77.9)>Cr(56.2)> V(55.0)>Co(41.6)>Mo(2.2)>Cd(2.1)>Be(1.9).

A coefficient of variation of the chemical elements varies from 38.0% (Cr) to 85.5% (Cd). According to a coefficient of variation of the researched chemical elements in the solid fraction of the city's snow is arranged in the following descending order: Cd (85.5)>Mn(82.8)>Be(78.8)>Mo(70.5)> Cu(69.1)> Zn(62.4)> >Sr(61.1)>Pb(53.5)>Co(47.3)>Ni(46.3)>V(42.8)> Cr(38.0).

In the solid phase of the city's snow cover the maximal number of copper exceeded the minimal one by 13 times, zinc – in 14, cadmium – in 39, lead – in 7, chromium – in 5, manganese – in 20, cobalt – in 10, molybdenum – in 16, beryllium – in

31, nickel – in 6, strontium – in 16, vanadium – in 10 times (Figure 1).

According to the analysis of the solid snow cover fraction, the average concentration of chemical elements in all researched samples exceeds the background by 3.1-12.9 times. The maximal exceed is typical for cadmium (by 12.9 times), beryllium (by 11.0), strontium (by 8.9), molybdenum (by 7.4), manganese (by 7.0); the minimal exceed – for chromium (by 3.1), nickel (by 3.7), lead (by 4.4), cobalt (by 5.3).

The average concentrations of the chemical elements in the solid phase fixed in the snow vary considerably in the zones of the city and show their average saturation with motor vehicles and industrial enterprises (table 2).

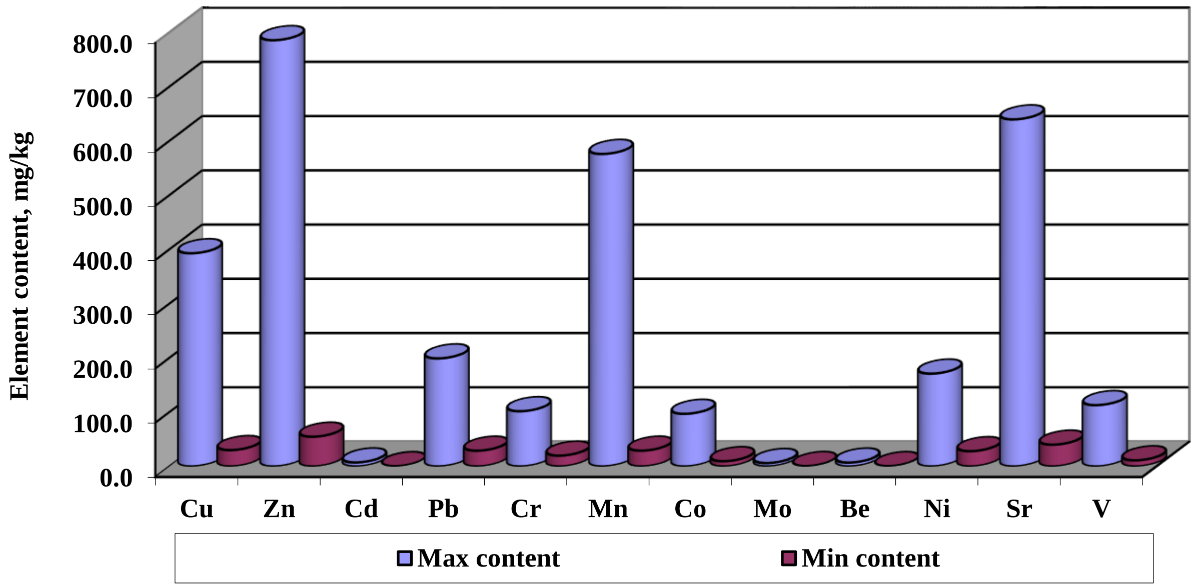

Figure 1. Exceeding of the maximum content of the chemical elements over the minimal one in the solid snow fraction of Pavlodar

It has been established that the average content of Sr, Zn, Cu, Pb, Ni, V, Cr, Co, Be, Mo is maximum in the Northern industrial zone. Average Mn and Cd content is maximum in the samples selected in the Eastern industrial zone. The lowest concentrations of chemical elements in the solid snow cover phase are in the central zone (see table 2, figure 2).

Table 2. Variational and statistical indexes of the content of chemical elements in the solid snow cover phase in the territory of Pavlodar

Element	Northern industrial zone (n=261)	Eastern industrial zone (n=125)	Central (building) zone (n=70)
Cu	$\frac{161,7 \pm 19,11}{30,6 - 392,7}$	$\frac{135,2 \pm 27,6}{29,8 - 293,3}$	$\frac{65,3 \pm 4,6}{48,4 - 80,7}$
Zn	$\frac{290,1 \pm 36,19}{87,9 - 785,5}$	$\frac{260,4 \pm 46,8}{54,5 - 545,7}$	$\frac{190,1 \pm 11,1}{150 - 235}$
Cd	$\frac{2,4 \pm 0,30}{0,25 - 6,0}$	$\frac{2,3 \pm 0,63}{1,2 - 7,0}$	$\frac{0,7 \pm 0,11}{0,35 - 1,3}$
Pb	$\frac{110,7 \pm 10,7}{28,9 - 198,7}$	$\frac{107,0 \pm 17,5}{28,7 - 198,9}$	$\frac{69,1 \pm 7,24}{42,3 - 95,6}$
Cr	$\frac{62,9 \pm 4,02}{28,6 - 101,5}$	$\frac{49,5 \pm 6,37}{19,6 - 90,3}$	$\frac{46,7 \pm 5,0}{29,6 - 67,8}$
Mn	$\frac{176,6 \pm 21,2}{59,6 - 483,3}$	$\frac{213,5 \pm 55,3}{28,8 - 575,8}$	$\frac{80,0 \pm 10,7}{37,8 - 124,3}$

Co	$\frac{48,8 \pm 4,02}{18,8 - 96,7}$	$\frac{31,2 \pm 4,51}{9,3 - 58,2}$	$\frac{36,9 \pm 5,02}{18,6 - 63,5}$
Mo	$\frac{2,3 \pm 0,27}{0,48 - 5,3}$	$\frac{2,5 \pm 0,53}{0,38 - 5,9}$	$\frac{1,1 \pm 0,15}{0,6 - 1,8}$
Be	$\frac{2,4 \pm 0,35}{0,40 - 6,8}$	$\frac{1,4 \pm 0,23}{0,22 - 2,9}$	$\frac{1,2 \pm 0,13}{0,75 - 1,6}$
Ni	$\frac{92,5 \pm 8,34}{30,3 - 170,8}$	$\frac{59,4 \pm 5,8}{27,8 - 96,5}$	$\frac{64,8 \pm 3,2}{52,1 - 80,1}$
Sr	$\frac{338,3 \pm 30,6}{87,6 - 639,5}$	$\frac{215,1 \pm 42,41}{39,8 - 483,5}$	$\frac{129,0 \pm 6,4}{98,7 - 148,8}$
V	$\frac{64,5 \pm 4,56}{28,1 - 112,7}$	$\frac{43,4 \pm 6,36}{10,9 - 83,9}$	$\frac{45,7 \pm 3,9}{28,9 - 58,4}$

Note: The numerator provides the arithmetic mean and its error, mg/kg; the denominator provides the margin of fluctuation, mg/kg

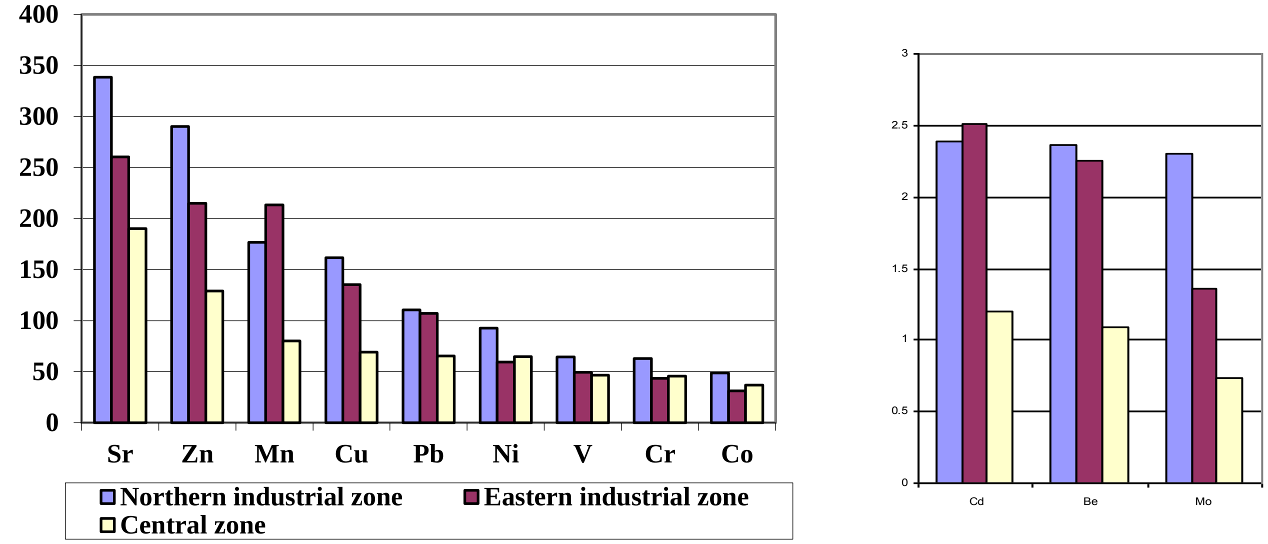

Figure 2. Comparative analysis of the content of the chemical elements in the solid snow fraction of the various zones of Pavlodar

According to the value of the coefficient of variation the researched chemical elements are arranged in the following descending order:

The North industrial zone – Sr>Zn>Mn>Cu> Pb>Ni> >V>Cr>Co>Cd>Be>Mo;

Eastern industrial zone – Zn>Sr>Mn>Cu>Pb>Ni> >Cr>V>Co>Mo>Cd>Be;

Central zone – Zn>Sr>Mn>Pb>Cu>Ni> >Cr>V>Co>Be>Mo>Cd.

According to the solid fraction, the state of the various zones of the city is assessed regarding the total content of the pollutants (Zc) (table 3, figure 3).

Table 3. Comparative analysis of the individual areas of pollution of solid snow fraction in Pavlodar (according to Z_c)

Area of pollution	Value Z_c		Formula of geochemical specialization
	Margins of fluctuation	Average in the area	
North industrial zone	18.5-184.1	83.6	$Cd_{14.9}Be_{13.9}Sr_{11.4}Mo{=}Cu_{7.9}Mn_{7.3}V_{6.6}Co_{6.2}Zn_{6.0}Pb_{4.8}Ni_{4.4}Cr_{3.4}$
Eastern industrial zone	3.8-163.7	66.2	$Cd_{14.1}Mn_{8.8}Mo_{8.6}Be_{8.0}Sr_{7.2}Cu_{6.6}Zn_{5.4}Pb_{4.6}V_{4.4}Co_{4.0}Ni_{2.8}Cr_{2.7}$
Central (building)	41.3-71.0	58.5	$Zn_{25.3}Be_{7.1}Co{=}V_{4.7}Cd_{4.6}Sr_{4.3}Mo_{3.8}Mn_{3.3}Cu_{3.2}Ni_{3.1}Pb_{3.0}Cr_{2.5}$

zone			
General through the city	3.8-184.1	69.4	Cd $_{13.2}$Be$_{11.1}$Sr$_{9.1}$Mo$_{7.6}$Mn$_{7.1}$Cu$_{6.8}$V$_{5.7}$Zn$_{5.6}$Co$_{5.3}$Pb$_{4.5}$ Ni$_{3.7}$Cr$_{3.1}$

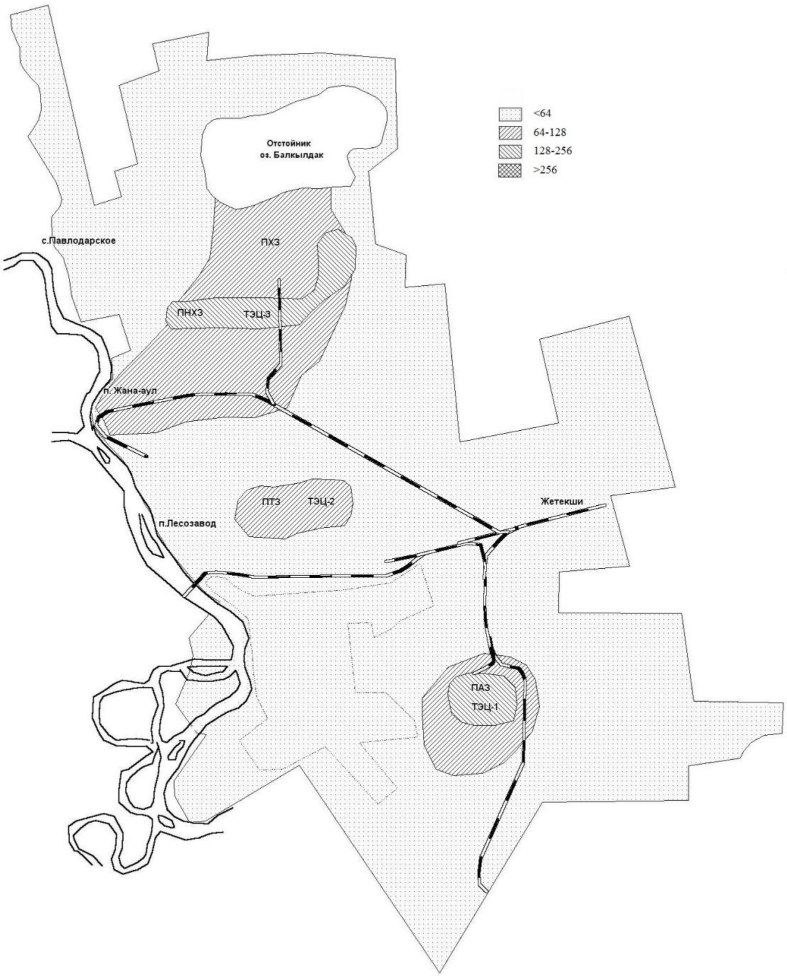

Figure 3. Outline map to arrange the total coefficient (Zc) of pollution in the solid snow cover fraction in Pavlodar

The most prominent concentrations of the chemical elements in the solid snow cover phase are arranged in the direction of the prevailing winds (southwest, southeast, western). The concentration of the chemical elements in the solid fraction of the snow is gradually reduced as far it is from the enterprise (table 4).

If the concentration of Cu was 232.8 mg/kg in the distance 500 meters, then at a distance 10 km the concentration is 29.8 mg/kg, i.e. it is reduced by 8 times. The concentration of Zn is reduced by 8 times, Cd – by 25, Pb – by 4, Cr – by 3, Mn – by 15, Co – by 5, Mo – by 11, Be – by 10, Ni – by 3, Sr – by 9, V – by 6 times respectively.

The content of Cu in the distance 5 km from the petrochemical plant is reduced by 9 times comparing to the concentration in a distance of 100 m, Zn – by 6 times, Cd – by 24, Pb – by 5, Cr – by 2, Mn – by 4, Co – by 3, Mo – by 8, Be – by 5, Ni – by 3, Sr – by 6, V – by 3 times respectively (table 5).

A similar situation is also regarding the content of the chemical elements, depending on the distance from the enterprise “Chemical plant” (table 6).

Table 4. Contents of the chemical elements in the solid snow cover fraction depending on the distance from the enterprise “Aluminum plant” (southwest direction), mg/kg

Element	Distance from the enterprise				
	500 m	**1 km**	**3 km**	**5 km**	**10 km**
Zn	440.3	320.6	87.9	60.7	54.5
Cd	4.9	3.9	0.4	0.3	0.2
Pb	120.3	175.6	48.7	38.7	28.7
Be	2.0	1.6	0.6	0.4	0.2
Cu	232.8	215.6	42.2	38.7	29.8
Cr	62.3	75.5	32.3	28.7	20.6
Co	50.1	43.3	11.7	10.8	9.3
Ni	96.5	80.1	42.3	32.1	27.8
Mn	425.4	210.5	42.5	35.6	28.8
Sr	358.9	320.8	78.6	58.9	39.8
Mo	4.2	3.2	0.9	0.5	0.4
V	65.5	52.9	18.9	13.5	10.9

Table 5. Content of the chemical elements in the solid snow cover fraction, depending on the distance from the enterprise "Pavlodar petrochemical plant" (south direction), mg/kg

Element	Distance from the enterprise				
	100 m	**500 m**	**1 km**	**3 km**	**5 km**
Zn	669.7	413.3	398.7	120.8	106.8
Cd	5.98	3.25	2.77	1.95	0.25
Pb	189.5	143.4	126.8	50.2	38.7
Be	5.89	4.74	3.82	1.77	1.2
Cu	392.7	188.7	169.8	80.5	42.8
Cr	101.5	75.6	69.7	45.6	43.3
Co	68.7	41.5	72.6	36.3	25.6
Mo	5.27	3.32	2.56	0.86	0.68
Ni	156.7	150.9	118.4	62.1	58.8
Mn	372.4	285.6	210.6	108.6	87.6
Sr	506.4	420.5	398.7	265.7	87.6
V	95.5	79.8	62.2	36.2	38.2

Table 6. Contents of the chemical elements in the solid snow cover fraction, depending on the distance from the enterprise "Chemical plant" (west direction), mg/kg

Element	Distance from the enterprise			
	100 m	**500 m**	**1 km**	**5 km**
Zn	308.4	296.8	270.5	148.3
Cd	1.98	1.63	1.32	0.78
Pb	98.7	87.9	75.3	64.2
Be	1.6	1.0	0.6	0.5
Cu	124.1	110.7	94.3	64.2
Cr	67.7	58.8	42.3	38.4
Co	67.8	52.4	29.8	38.2
Mo	2.8	2.4	2.0	1.1
Ni	72.6	63.8	52.2	30.3
Mn	167.9	121.3	98.7	87.9
Sr	301.7	275.6	210.8	120.7
V	69.7	61.3	52.5	28.1

Conclusion

1. According to a statistical data analysis of territorial directorate of the environment protection and the regional statistical agency in Pavlodar,

stationary sources (the main are petrochemical, tractor and aluminum plants, as well as heat-generating enterprises – TPP 1, 2, 3 in Pavlodar) and auto vehicles are the main sources of pollution. They annually emit 109.8 thousand tons of pollutants into the atmosphere.

2. The pollution of the solid snow cover fraction in Pavlodar has multi-metal nature and is distributed across the territory of the city, making focuses depending on the sources of emissions. The main polluting components of the snow cover of Pavlodar are cadmium, copper, lead, strontium, beryllium, vanadium, molybdenum, nickel.

3. According to the data received, there are abnormal zones of very high (Zc > 256), high (Zc = 128-256), middle (Zc = 64-128) and low levels of pollution (Zc = 32-64). According to the average total pollution's coefficient, the areas of the city are arranged in the following descending order: North> Eastern> Central industrial (building) zones. The zones are described in detail in terms of the prevailing sources of pollution, geochemical spectra and the targeting of the most contaminated sites.

4. The most prominent concentrations of the chemical elements in the solid snow cover fraction are defined by the direction of the prevailing winds and the distance from the industrial centers. The dustiness of the researched territories ranged from 8.2 to 5919 kg/km^2 * per day, and reduced as a whole, as they were further from the industrial sites.

5. The received experimental material was a basis for the mapping of the distribution of individual chemical elements and their associations across Pavlodar.

6. The high content of the chemical elements in the snow cover components in various zones of the city leads to soils contamination in these sites.

In the territory of Pavlodar, the Republic of Kazakhstan, the content of chemical elements in a solid snow cover phase was studied. We have revealed the main chemical elements that pollute the snow cover and the pollution sources. We have noted the trends of chemical elements redistribution being removed from the sources of generation. Man-made substances, heavy metals and micro-elements in the solid snow phase in the territory of Pavlodar, the Republic of Kazakhstan, were defined.

The role of heavy metals and micro-elements, their impact, degree of detrimental effect on the soil were found out. We have defined their number accumulated in snow cover and falling together with precipitations.

We have defined what certain heavy metals are the most dangerous. Then we found out what factors define the environmental impact of heavy metals. It is cleared out what results chemical transformations in the atmosphere may lead to. Man-made atmospheric pollution was revealed. We have revealed and studied what are the reasons to generate the chemical composition of filter effluent of thawed snow. The importance and need of ecological and geochemical assessment of snow cover pollution as a natural absorber of chemical elements in winter time was revealed. We have found out the reasons why heavy metals and micro-elements are chosen for research. The main sources of pollution were defined. The main polluting components of the snow cover of Pavlodar were defined. We have revealed abnormal zones of very high, high, middle and low levels of pollution. It is known what allows to define the most prominent concentrations of the chemical elements in the solid snow cover fraction. We revealed mapping of the distribution of individual chemical elements and their associations across Pavlodar. We have found out the reasons leading to soils contamination in various zones of the city.

According to the previous examinations, studies, analyses, comparisons, diagnostics, we may firmly say that the main idea and purpose of our article was to assess the current state of environment in Pavlodar and the situation of its pollution with different chemical elements, man-made substances, micro-substances and heavy metals which are contained in precipitations and snow cover in large quantity. We have studied the subject that previously little researched in Kazakhstan. The results obtained from our research, may help to solve the problem of environment pollution with chemical elements, heavy metals and man-made substances contained in precipitations and snow in the Republic of Kazakhstan. Since the subject is revealed and studied, new tools, methods, and techniques may be developed and applied in prospect to remove all heavy metals and pollutant elements from the atmosphere, rain and snow.

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