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*POLLUTION MONITORING OF SNOW COVER DUST AEROSOLS IN TYUMEN**

SUMMARY. The article is devoted to the assessment, characterization and dynamics of dust pollution in the city of Tyumen in winter and based on the study of snow cover.

KEY WORDS. Anthropogenic effects, snow cover, assessment, dustaerosols.

The intense urbanization has led to a number of environmental problems associated with deterioration of the urban environment, the attention to which is increasing every year [1-5]. In recent years, snow cover as an integral indicator of atmospheric pollution of the areas, characterized by its long time presence, is used as an object of air monitoring [6-10]. Snow cover, having a quality to accumulate the contaminants that are adsorbed on the surface of the crystals during their fallout, is used as an indicator of air pollution. Dust aerosols, accumulated in snow cover, remain until snowmelt and thus have significant seasonal geochemical information. The concentration of dust aerosols is usually 2-3 orders of magnitude higher than in the air during the formation and snow fall as a result of dry and wet washing. Therefore, the changes of these substances can be made by relatively simple methods and with high reliability.

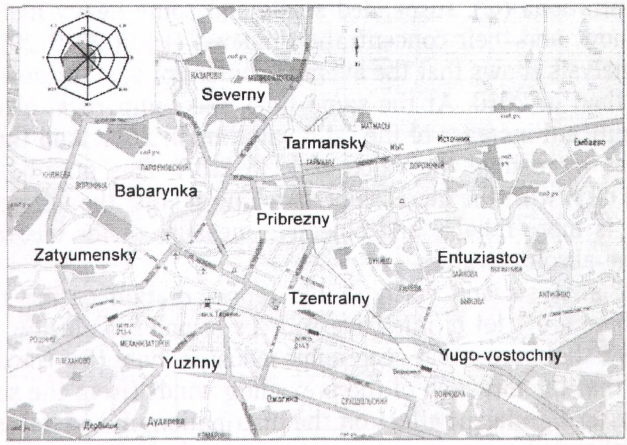

Fig. 1. The layout of Tyumen industrial hubs [3]

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Tyumen can be attributed to the major urban centers, and only in 2010 it was removed from the list of cities with the highest level of air pollution in the Russian Federation [12]. The industrial hubs are located mainly along the borders of residential areas. The city enterprises are geographically grouped into nine industrial sites [3]: Babarynka, Zatyumenka, Centre, South, Southeast, Coastal, Enthusiasts, Tarmany and North (Fig. 1).

The aim of the research was to study the dynamics of the dust distribution in the city in winter, based on the chemical analysis of the snow cover in 2010-2011.

Method. The snow samples from different areas of the city were selected in March 2010-2011 with the weighing snow gauge (VS-43) according to the guidelines for air pollution control [12]. In 2010 the samples were taken in 40 locations across the city, in 2011 — in 57 locations. The background area is located on a representative downwind areas not exposed to dirt or exposed to it in a minimal degree (24 km from the city, in the north-west). All snow samples were analyzed with standard methods for suspended solids (gravimetric method) and some heavy metals in the solid and water phases of snow (with atomic absorption spectroscopy).

In addition to the absolute content of pollutants in geochemical indicator of snow cover pollution, the concentration ratio of the chemical elements (COP) was used. It is the ratio of chemical elements at the point of testing to its content in the background section. The ratio of MPC (maximum permissible concentration) excess of heavy metals can be also a characteristic of snow pollution. Heavy metals can get into the other environmental media when snowmelt. This ratio is calculated as the ratio of metal concentration in the water and solid phases of snow (in mg / l) to its maximum permissible concentration in surface waters [1].

The statistical analysis was performed using the program "Statistica 7". The map-schemes of the examined indicators distribution are constructed with the simulation program Surfer 8.0 based on maps from the site www.geomap.ru.

The results and their discussion. Table 1 shows the change intervals and average concentrations (C), suspended solids and some heavy metals in the solid phase of the snow, and their concentration indexes (I_c) in 2010-2011.

The data analysis shows that the average content of dust in snow is significantly lower in 2011 than in 2010. At the same time, the comparison of the values of I_c indicates a significant increase of the ratio variation in 2011. And the average value of I_c is 10 times more than the value of Ic in 2010. This may be due to general changes in the city, with the increase of sampling points, the difference in weather patterns, i.e. I_c is more reliable and objective measure of the environment quality compared to the absolute values.

The cluster analysis and cartographic representation of the results (Fig. 2) indicate that there are a lot of intensive sources of pollution in the city. And there is no link between the sources and geographic industrial hubs [3]. The isoconcentration scheme shows that the direction of the prevailing winds (from the southwest to the northeast) have no significant effect on the distribution of dust aerosols in the city. The architectural and plan structure is a determining factor. In January to September 2009 a similar pattern was observed in the study of the dust aerosols concentration distribution conducted with the sedimentometric method [5].

Table 1

The changing intervals of concentration (C) and concentration indexes (I_c) of the suspended substances and metals in the solid and water phases of the snow cover of Tyumen in 2010-2011

Indicator	Phase	Background concentration, mg/l		2010 (n=40, P=0,95)		2011 (n=57, P=0,95)	
		2010 г.	2011 г.	C, mg/l	I_c	C, mg/l	I_c
Suspended substances	Solid	0,56	0,05	0,02÷1,67* 0,68±0,39**	0÷3,0 1,2±0,2	0,001-0,406 0,085±0,025	0,22-90,24 18,90±0,32
Copper	Solid	0,013	0,079	0,001÷1,51 0,24±0,09	0,001÷113,5 17,9±6,9	0,04÷0,79 0,24±0,05	0,56÷9,99 2,99±0,61
	Water	7,37		0,61÷326,0 34,3±139,0	0,08÷44,2 4,65±4,82	1,35÷52,00 11,39±2,80	0,79÷30,416,66±1,64
Zinc	Solid	0,398	1,316	0,07÷8,20 1,54±0,64	0,2÷20,6 3,9±1,6	0,29÷3,41 1,19±0,15	0,22÷2,60 0,91±0,11
	Water	6,12		1,34÷175,0 27,2±56,9	0,22÷28,6 4,44±9,32	0,06÷168,00 35,42±10,04	0,01÷3,49 0,74±0,21
Lead	Solid	<0,001	0,233	0,001÷5,22 0,57±0,30	0,001ч5224 572±302	0,04÷7,64 0,66±0,37	0,19÷32,81 2,84±1,57
	Water	10,1		0÷50,85 14,9±28,2	0,0÷5,03 1,48±2,79	0,001÷51,30 12,42±3,67	0,01÷14,74 3,57±1,06
Cadmium	Solid	-	-	-	-	-	-
	Water	0,005	0,037	0÷1,50 0,14±0,60	0÷300 27,7±119	0,02÷1,42 0,20±0,08	0,57÷38,80 5,451,64±

Note: * — change interval of values; ** — average value.

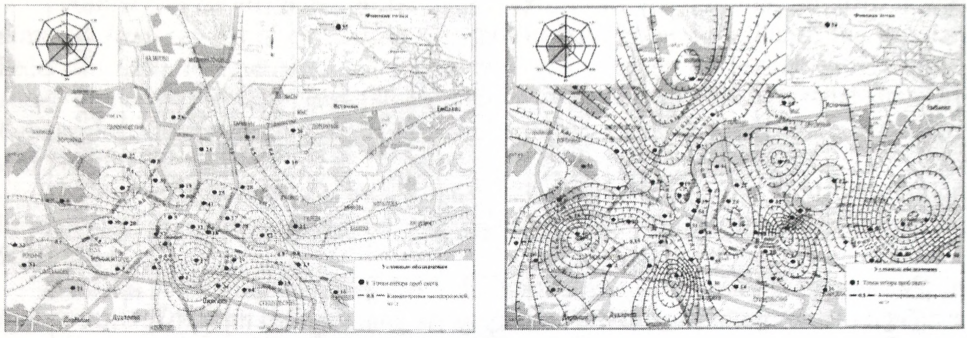

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Fig. 2. The schemes of dust aerosols isoconcentration in the snow cover of Tyumen in 2010 (a) and 2011 (b) respectively

In addition, the samples collected near the main roads of the city, indicate the formation of technological anomalies along them. Thus, it confirms a significant contribution of motor vehicles to the overall pollution in the city. The statistical and cartographic processing of the results confirms this hypothesis. The concentration of dust aerosols in the snow cover near Republic St., Melnikaite St., Chelyuskintsev St., Maurice Thorez St., Herzen St. was 0.8-1.4 mg/l (I_c = 13-23) in 2010 and 0.2-0.4 mg/l (I_c = 20-40) in 2011.

A large proportion (about 30%) of metal-fabricating industries of Zatyumenka industrial hub (OJSC Tyumen Accumulator Plant, OJSC Tyumen Mechanical Plant, OJSC Tyumen Electromechanical Plant, JSC Repair and Engineering Works) predetermine further industrial pollution of the snow cover of the central industrial hub where the prevalence of western and south-western bound winds is fixed. The high levels of dust aerosols concentration of the central industrial hub is provided by LLC Tyumen Construction Machinery Plant, and vehicles: in 2010 I_c = 11.7, in 2011, I_c = 1-10.

All the industrial hubs of the city (with the exception of South and Zatyumenka) include a significant proportion (16-38%) of construction industry enterprises that predetermine the pollution of urban systems with dust aerosols. The largest number of construction industry enterprises (Vinzili Claydite Gravel Plant, concrete goods plants) is located in Southeast industrial hub. The concentration of dust aerosols varies here from 0.2 to 1 (I_c = 3.3-16.7) in 2010, 0.1-0.2 (I_c = 10-20) in 2011.

Significant concentrations of dust aerosols in the snow cover were observed in North and South industrial hubs: in 2010 — C = 0.7 mg / l (Ic = 11.7) in 2011 — C = 0.3-0.4 mg/l (I_c = 30-40). The average concentration ratio of the chemical elements in Tyumen is 11.7 in 2010 and 12.1 in 2011.

The metals, most of which are related to the first and second classes of danger, are among the specific city pollutants. Their negative impact on a person is manifested not only in the direct effect of high concentrations, but also in the long-term consequences associated with the ability of many metals to accumulate in body. The metals are found in most types of industrial, energy and vehicle emissions, and they are indicators of the industrial impact of these emissions on the environment.

The lead content in the snow cover of Tyumen varies from 0.1 to 7.7 mg/l (3.3 to 256.7 MPC (maximum permissible concentration)). The highest recorded concentration is in Zatyumenka industrial hub (7.7 mg/l, 256.7 MPC). The main source of lead here is OJSC Tyumen Accumulator Plant and the highways (Avtoremontnaya, Yamskaya, Bypass) (Fig. 3). The plume of contamination extends from Zatyumenka industrial hub to the north-east, i.e. in the direction of the prevailing winds. The lead content in the snow cover in other industrial hubs and residential areas is 0.2-0.4 mg/l (6.7-13.3 MPC). The main sources are the motorways (Republic St., Lenin St., Shirotnaya St.) especially during the regular traffic congestions.

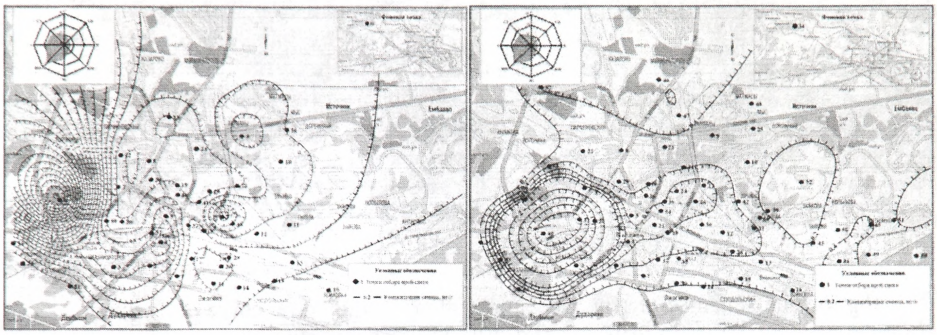

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Fig. 3. The schemes of lead isoconcentration in the snow cover of Tyumen in 2010 (a) and 2011 (b) respectively

The distribution of copper in the snow cover is shown in Fig. 4. The contrast of anomalies in this case appears less obvious; however, the general contour of the geochemical field with an increased pressure is similar to the contours of the lead. The dispersal areas are also oriented in the direction of prevailing winds. Copper is found everywhere, in the range of 0.1 to 0.8 mg/l. Maximum concentrations are observed in Centre, South and Southeast industrial hubs (0.3-0.4 mg/l); Tarmany industrial hub (0.5-0.8 mg/l). The obtained results do not exceed the MPC limit of copper, which is equal to 1 mg/l, in the waters of economic and drinking mains and community water use bodies.

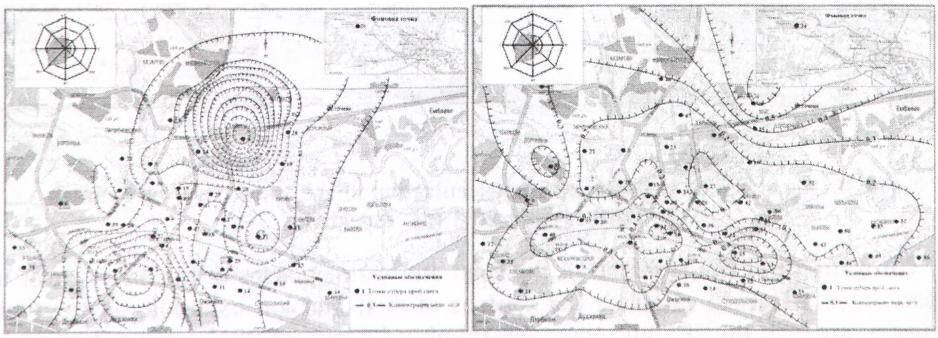

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Fig. 4. The schemes of copper isoconcentration in the snow cover of Tyumen in 2010 (a) and 2011 (b) respectively

The research results of zinc content in the snow cover of Tyumen indicated (Fig. 5) that the maximum recorded concentration in Southeast industrial hub is 3.4 mg/l (3.4 MPC). Significant hot spots are located in Zatyumenka, South, Tarmany, North, and Centre industrial hub (1.2-1.6 mg/l, 1.2-1.6 MPC). High concentration of zinc is fixed near industrial plants and along the major highways of the city.

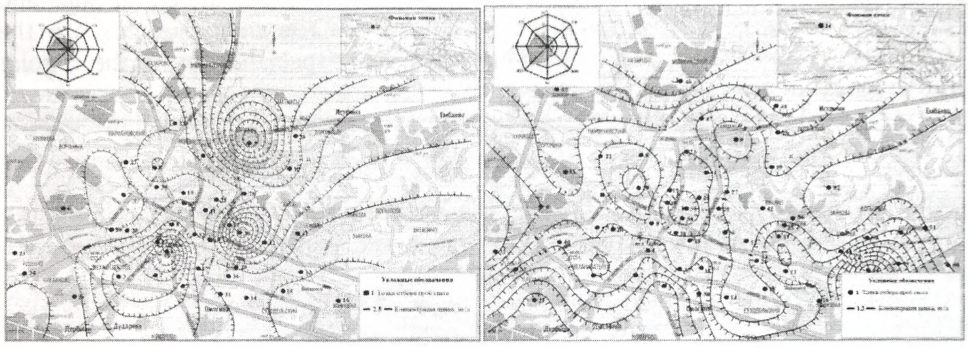

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Fig. 5. The schemes of zinc isoconcentration in the snow cover of Tyumen in 2010 (a) and 2011 (b) respectively

The distribution of cadmium concentrations is shown in Fig. 6. Snow cover contains cadmium only in a water phase, which indicates its high migratory ability and high toxicity. The obtained results are below the limits of cadmium MPC in the waters of economic and drinking mains and community water use bodies.

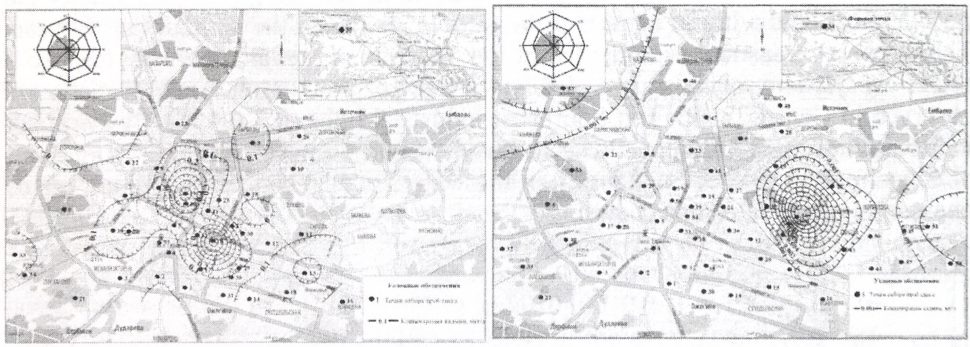

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Fig. 6. The schemes of cadmium isoconcentration in the snow cover of Tyumen in 2010 (a) and 2011 (b) respectively

Conclusions. The research of the solid and water phases of the snow cover in urban areas allows to establish the sources of dust and ion pollution, assess their dispersal areas in the city and their determining factors. In 2011 some reduction in the absolute concentrations of dust aerosols in snow cover of the researched area is fixed, and the concentration indexes increased more than tenfold. This discrepancy

indicates a significant difference between the conditions for the formation of precipitation (snowless winter of 2011 and rainfall in a short period of time). Thus, the most reliable results are obtained by using relative values. All Tyumen industrial zones are the areas of high dust aerosols and heavy metals pollution. The areas of the highest man-caused impact are oriented in the direction of the prevailing winds in certain regions only. The city architectural and planning structure is the determining factor. Significant contribution to the snow cover and air pollution is made by the highways location.

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