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City Snow Dumps of a Large Industrial Centre as a Source of Surface Water Pollution (on the Example of Ufa City)

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Abstract: Every year a seasonable snow cover is formed in Russia. The accumulation of snow in urban areas creates the problem of clearing and storage of large amounts of snow. When the snow melts, the entire mass of contaminated substances together with the land runoff enters the surface water bodies. This is the issue of the day for the city of Ufa.

The article deals with the problem of environmental pollution resulting from the storage of large amounts of snow masses scavenged from the territory of Ufa every year. The sampling technique was to mark out the sample area 10×10 size from which snow was collected using the envelope method. The snow collected at five points of the sampling area was used to form a composite sample. This sample was used to test for the presence of organic compounds of different classes, volatile chlorinated hydrocarbons, benzapyrene, petroleum products, heavy metals, and inorganic anions. According to the results of the study of snow dumps in Ufa in the years 1998, 2011, 2013 and 2015 it was found that snow masses taken out from the territory of the city of Ufa and stored in unauthorized dumping grounds are characterized by the excess of almost all controlled substances. Snow dumps must be equipped with special treatment facilities, discharges from which to surface water bodies should be controlled.

Key words: Snow cover, snow pollution, urban snow dumps, surface water pollution, heavy metals, oil products.

Introduction

Snow dumps are now an integral part of the infrastructure of large and medium-sized cities of Russia. Intensive snowfall creates significant difficulties for traffic of Ufa city, especially in 'snow' years, so important city mains are systematically cleared of snow, which is taken to officially permitted snow dumps. In addition, thanks to the cleaning and removal of snow, storm water drainage systems are partially unloaded in spring. At present, the choice of a place for the temporary snow storage is mainly made according to economic criteria (minimum mileage of transport carrying snow, the presence of free areas with convenient supply roads, etc.). Environmental

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aspects remain in the background. Some of the snow dumps are located close to watercourses and reservoirs Snow dumps are not regulated by water legislation, as they do not have marks of organized wastewater discharge. However, snow dumps have become a major source of anthropogenic pollution of soils and water bodies during snow melting, which can be equated with the emergency volley of sewage (Tarasov et al., 2011; Lobkina et al., 2016).

One of the acute problems of the protection of water bodies from pollution is a significant mass of pollutants entering them with surface runoff. The assessment of the degree of pollution of the surface runoff was made on the example of manufacturing sites of the city of St. Petersburg. The increased content of oil products and heavy metals both in rainwater runoff and especially in snowmelt runoff was revealed (Chechevichkin and Vatin, 2014). An example of such a city is Ufa with the population of about 1.2 million people, which has large chemical and petrochemical enterprises, enterprises of energy and of engineering, instrument-making plants and enterprises of other industries.

Surface runoff from the territory of the cities is divided into two streams: the 1st is an organized run-off, which is the storm water sewage of the city and its enterprises; the 2nd is an unorganized one, which flows down the relief into surface water bodies, washing away the city's numerous pollutants without any cleaning. Also, in most cities of Russia, more than half of the storm water sewage systems do not have treatment facilities. As the events of recent years have shown, the existing system of storm water sewage cannot deal with the water flow during heavy snowmelt.

The problem of water bodies pollution with snow melt waters attracts the attention of many researchers. Snow preserves almost the entire volume of precipitation from the atmosphere during the winter period, which allows us to consider it a reliable indicator of pollution (Stepanova et al., 2016). It is noted that the snow that is collected from roadsides and parks, contains hydrocarbons, heavy metals, biogenic compounds (Ociepa et al., 2015), and the quality of the snow changes depending on the distance from the roadside (Vialkova et al., 2017). According to Kuoppomaki (2014), road traffic is one of the main sources of pollution in cities. His analysis of ingredients in snowbags along the roads showed a decrease in pollution levels 5 m from the road. A team of scientists (Kasimov et al., 2017) examined the contamination of soils in the Eastern district of Moscow, benzapyrene, coming from the snow, which is typical for large cities with cold climates.

According to calculations, the content of benzapyrene in the solid fraction of snow is 11.5 times higher than the background and almost 100 times higher than MPC. The study of the precipitation processes of pollutants entering the surface water during snowmelt was carried out by Blecken et al. (2012) for the area of Lulea (Sweden). At the same time, an increase in the concentration of polluting ingredients in sediments accumulated in the reservoir was revealed. Snow cover plays an important role in the absorption of heavy metals entering the environment during its melting (Pilecka et al., 2017). In the city of Jelgava (Latvia), three areas with different concentrations of pollutants in snow were identified: 1st – railway and industrial area; 2nd – transit roads with intensive urbanization area; 3rd – forest and open areas.

According to Onuchin (2014), the state of the snow cover enables the zoning of the territories according to the degree of pollution, and allows to explain the processes taking place in the technogenic landscapes. The study of the snow cover of Longyir and Barentsburg areas (the Spitsnergen archipelago, Arctic) are of great interest (Abramova et al., 2012). High concentrations of polycyclic aromatic hydrocarbons, macro-ions and other components are due to the functioning of local combustion sources and industrial activities. In general, researchers have similar view on the topic, which can be expressed by a single thesis: the state of snow cover is the main indicator of environmental pollution.

The purpose of the study is to determine the qualitative and quantitative composition of snow pollutants taken out of the city of Ufa, and to make an assessment of the consequences arising in the places of snow storage.

The snow collected from the territory of the city is heavily polluted, and the combination of elements in it is very different from that which is formed outside. When clearing the streets, snow is mixed with trash, paving slabs, sand etc. Thus this snow mass should be treated as municipal waste. However, snow is not mentioned as waste neither in all-Union State Standard 25-916-83 'Material secondary resources' nor in the Federal Classificatory Catalogue of Wastes (No. 786 from 02.12.2002). In this regard, the choice of places for polygons and their equipping are hard tasks that are not regulated by existing legislation (Lobkina et al., 2016).

Every year in Ufa about ten regional snow dumps are organized, but their location does not always meet environmental requirements. They are often located near water bodies or on their watershed areas, which can be a serious hazard for surface waters (Konashova et al.,

2018). Due to its adsorption properties, as well as rather long formation period characteristic for our climatic zone, snow cover is a natural accumulator of pollutants, coming during long winter from the atmosphere in the form of wet and dry fallouts (Asylbaev et al., 2018). This is especially noticeable within the city limits, where there are plenty of low and medium emission sources (motor vehicles, small boilers, etc.), and where the conditions of atmospheric dispersion of pollutants are worse. The problem of snow dumps for the city of Ufa comes into sharp focus due to the fact that the city is located on the rivers watershed, on the so-called Ufa Peninsula. The topography of the city is the key for the "fast" runoff of melting snow into surface water bodies (Mustafin et al., 2018). Even undisturbed snow areas in the city (lawns, parks) contain high concentrations of pollutants in comparison with undeveloped areas. The work (Minigazimov, 2017) shows that exhaust gases of cars contain the entire spectrum of heavy metals and other highly toxic combustion products of hydrocarbon fuels.

Methods

For the first time the survey of snow dumps in Ufa was conducted in March-April, 1998 in Sovetskiy, Oktyabrskiy and Ordzhonikidzevskiy boroughs.

Inspection of snow dumps in Ufa is connected with their location: the dump of Ordzhonikidzevsky borough is located on the bank of the Belaya river near the Northern bus station, that of Oktyabrsky borough is near the Sipaylovo 100 m from the Ufa river, the dump of the Soviet borough is about 300 m from the left bank of the Belaya river. In this regard, it was necessary to assess the level of the risk of water pollution in the river during the snowmelt.

The baseline showed that the snow on the dumps is a frozen mass which is densely compacted. The guide values of the snow layer height on dumps are 2-2.5 m, and area occupied by dumps is 1-2 hectares.

Method of selection included planning of a 10×10 m sampling area in target points, where snow was selected by the envelope method. Selection was made by means of an ice auger with a diameter of 12 cm which at its deepest point reaches as deep as 90 cm. The snow collected at five points of the sampling area was used to form a composite sample to be tested for the presence in it of organic compounds of different classes, volatile chlorinated hydrocarbons, benzapyrene, petroleum products, heavy metals and inorganic anions. The main methods used in the analysis of the samples are chromatography-mass spectrometry (HMS), gas-liquid chromatography (GC), high-performance liquid chromatography (HPLC), atomic absorption spectrometry (AAS), IR and UV spectrophotometry.

Results

The results of the study of snow in the surveyed dumps in 1998 on the content of heavy metals (HM) are shown in Figure 1. The migration capacity of heavy metals during the snowmelt period is due to their soluble form contained in filtered snow water. When snow melts in landfills and around landfills, it will form water contaminated with soluble forms of copper, zinc, manganese, nickel and vanadium. In comparison with the natural background, the snow in the dumps of Oktyabrsky and Soviet boroughs is enriched with a soluble form of iron, and the snow in the dumps of Oktyabrsky and Ordzhonikidzevsky boroughs is enriched with a soluble form of vanadium. But iron does not belong to toxic elements, and the level of pollution with vanadium is not high and does not exceed 5 $MAC_{fish\ farm}$ (maximum admissible concentration of a fish farm water bodies), that's why we don't consider these elements further.

The content of benzapyrene in snow samples from snow dumps and in background samples is shown in Figure 2. The main part of benzapyrene is undissolved in the composition of suspended particles of snow water. All snow samples exceeded the standards for Benz(a) pyrene in water. The level of benzapyrene in all the snow samples is higher than the standard level. The highest level of pollution of snow water was noted in the dumps of the Soviet (10.28 $MAC_{fish\ farm}$) and October (8.4 $MAC_{fish\ farm}$) boroughs.

The results of the tests of snow samples for the content of volatile and semivolatile organic compounds are presented in Figures 3, 4 and 5.

If we compare the data on the pollution of snow dumps, we can see that the list of polluting compounds and their content are approximately the same for all the tested objects. The liquid phase of the snow cover contains phenol, alkylphenols, alkyl phthalates and carboxylic acids, the concentrations of which exceed the $MAC_{fish\ farm.}$ In comparison with the natural background snow water contains higher concentrations of alkyl naphthalenes, alkyl benzene and phenanthrene. In some samples of snow water, small amounts of volatile organochlorine compounds were found.

The liquid phase of the snow cover was tested for the content of inorganic ions (chlorides, sulfates,

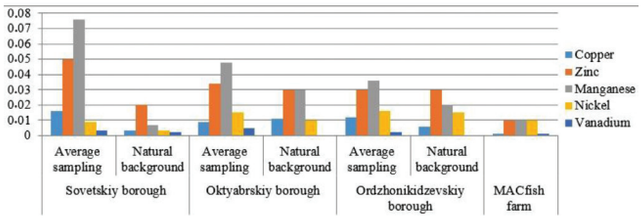

Figure 1: Concentration of HM (heavy metals) in snow samples stored at snow dumps (mg/dm^3). Remarks: $MAC_{fish\ farm}$ (maximum admissible concentration of a fish farm).

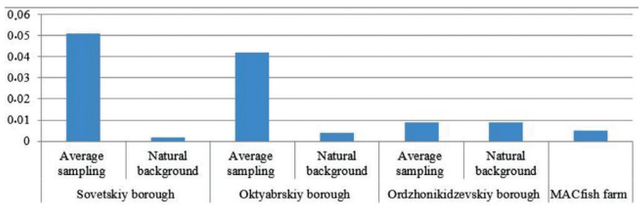

Figure 2: Benzapyrene content in snow samples taken from Ufasnow dumps in 1998 (μg/dm^3).

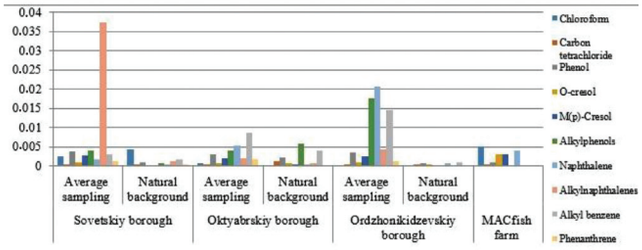

Figure 3: Concentration of organic compounds in snow samples stored at snow dumps in the range from 0 to 0.04 mg/dm^3.

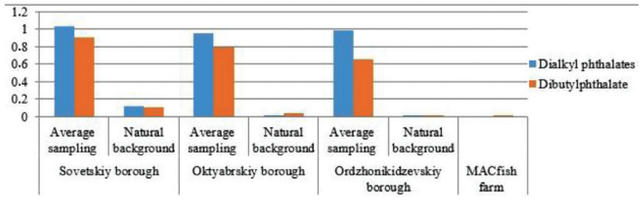

Figure 4: Concentration of organic compounds in snow samples stored at snow dumps in the range 0-1.2 mg/dm^3.

phosphates, nitrates, nitrites, ammonium ion, calcium and magnesium). The results are presented in Figures 6 and 7; the filtrate of all snow water samples meets all the indicators of sanitary standards by the content of inorganic ions in them. There is an excess of $MAC_{fish\ farm.}$ for ammonium ions – from 1.2 to 1.8$MAC_{fish\ farm.}$ and for nitrates from 5 to 8 $MAC_{fish\ farm.}$

In contrast to other indicators, the content of oil products was found in unfiltered melt water. Snow

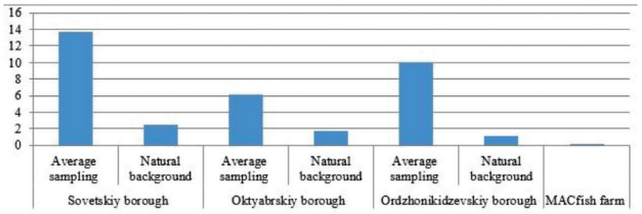

Figure 5: Concentration of carboxylic acids in snow samples, stored at snow dumps (mg/dm^3).

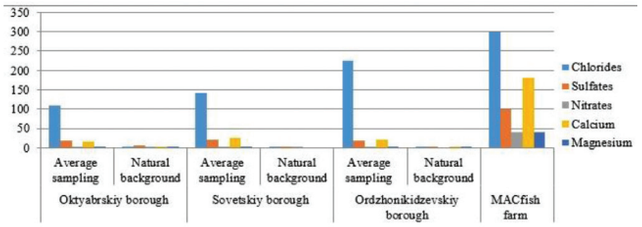

Figure 6: Concentration of inorganic ions in snow samples, stored at snow dumps (mg/dm^3)

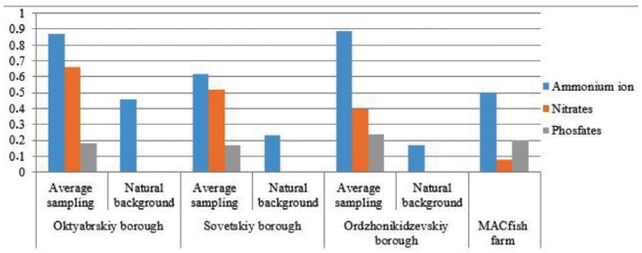

Figure 7. Concentration of inorganic ions in snow samples, stored at snow dumps (mg/dm^3).

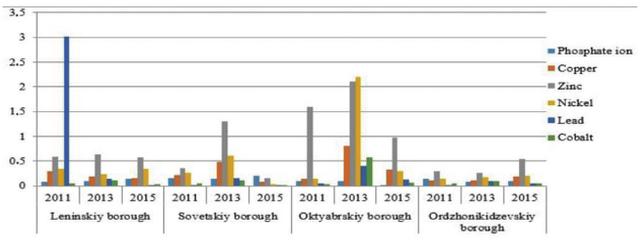

Figure 8: Concentration of pollutants in snow samples, stored at a snow dump in range from 0 to 3.5 mg/dm^3.

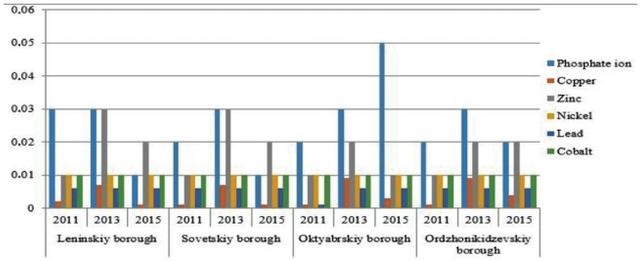

Figure 9: Concentrations of pollutants in the background snow sample in the range from 0 to 0.06 mg/dm^3.

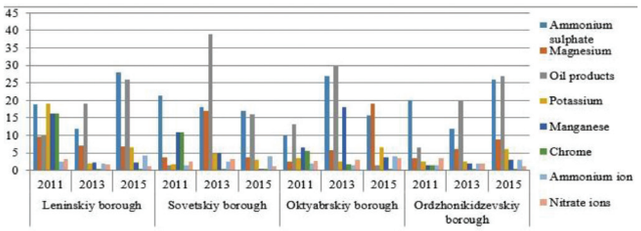

Figure 10: Concentration of pollutants in snow samples, stored at a snow dump in the range from 0 to 45.0 mg/dm^3.

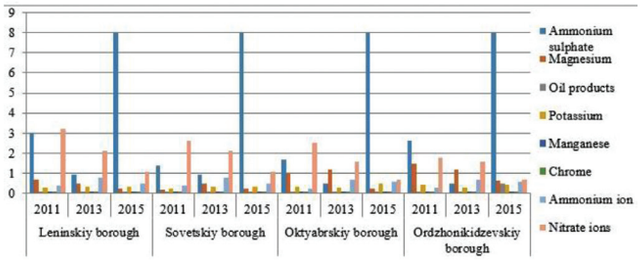

Figure 11: Concentrations of pollutants in the background snow sample in the range from 0 to 9.0 mg/dm^3.

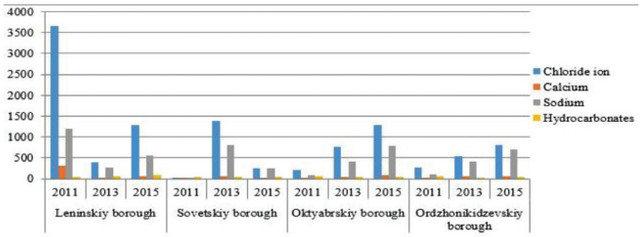

Figure 12: Concentration of pollutants in snow samples, stored at a snow dump in the range from 0 to 4000 mg/dm^3.

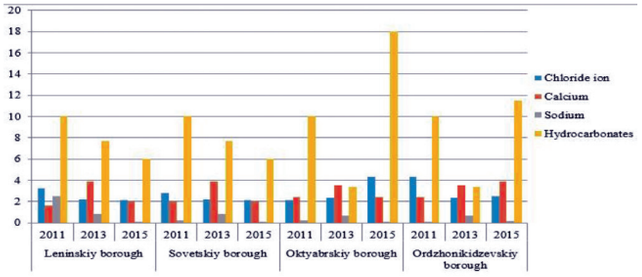

Figure 13: Concentrations of pollutants in the background snow sample in the range from 0 to 20.0 mg/dm^3.

dumps are extremely contaminated with petroleum products. The average level of snow polluted by oil products at the dump of Oktyabrsky borough was 1548 $MAC_{fish\ farm}$, of Soviet borough – 1128 MACfish farm and Ordzhonikidzevsky – 652 MACfish farm. The maximum levels reached 3600 $MAC_{fish\ farm}$.

In February and March 2011, 2013 and 2015 sampling of snow masses stored at snow dumps in the Soviet, Lenin, Ordzhonikidzevsky and October boroughs of Ufa was carried out. The locations of snow dumps and snow sampling points are shown in Table 1.

The results of quantitative chemical analysis of snow samples are presented in Figures 8-13 on 18 indicators.

Discussion

In 2011, it was established that snow masses, stored at unauthorized dumps on Derevenskaya pereprava street, Salavat Yulaev avenue, Zhukov street and Zapadnaya street are characterized by the content of all tested substances, and by significantly exceeding content of the same pollutants in the snow sample, selected in an area which is close to an unauthorized dump (background sample).

In 2013 it was established that the following: the snow mass, selected at the snow dump on Blagovarsky street (Leninsky borough of Ufa) and on Sipaylovskaya street (Oktyabrsky borough of Ufa) is characterized by a content of all controlled substances (except mercury and cadmium), which is much higher than in the background sample; the snow mass that was stored at the snow dump on Sobinov street (the Soviet borough of Ufa), is characterized by the content of all controlled substances (except phenol and cadmium), significantly exceeding their content in the background snow sample; and the snow mass stored at the snow dump on L. Chaikina street (Ordzhonikidzevsky borough of Ufa), is characterized by the content of all controlled substances (except mercury, lead, cobalt), significantly exceeding their content in the background snow sample.

In 2015 it was established that in the snow samples collected at the snow dumps of Ufa, the concentrations of controlled substances is much higher than the content of pollutants in the background snow sample.

At the dumps of Soviet and October boroughs the snow is most polluted with benzapyrene ($MAC_{fish\ farm}$ is by 8.4 to 10.4 times higher), the least snow pollution with $MAC_{fish\ farm}$ of 1.8 is observed in Ordzhonikidzevsky borough. Soluble benzapyrene is a more dangerous pollutant for reservoirs.

The content of phenanthrene is much higher than the content of benzapyrene which proves the existence of natural factors, connected with air pollution by biogenic material. The high degree of air pollution with nutrients is proved by the content of carboxylic acids which are degradation products of lipid and protein structures.

The pollution of snow with phthalates both on the streets and in the background samples is quite high

Table 1: Location of snow dumps and snow sampling collection point

Administrative area	*2011*		*2013*		*2015*	
	Sampling	*Natural background*	*Sampling*	*Natural background*	*Sampling*	*Natural background*
Leninskiy	Derevenskaya ferry street	snow from the area close to the dump	Blagovarskaya street	50 m North-West of the snow dump on Blagovarskaya street	Area of Bashkir Republican Training centre	Area of 8 Marta village
Sovetskiy	Salavat Yulayevavenue	snow from the area close to the dump	Sobinova street	50 m North-West of the snow dump on Blagovarskaya street	Area of Bashkir Republican Training centre	Area of 8 Marta village
Oktyabrskiy	Marshal Zhukova street	snow from the area close to the dump	Sipaylovskaya street	120 m South of the snow dump on L. Chaykinoy street	Area of Planeta mall	1 km north of the snow dump
Ordzhonikidzevskiy	Zapadnaya street	snow from the area close to the dump	L. Chaykinoy street	120 m South of the snow dump on L. Chaykinoy street	Novoaleksandrovkaya street	Forest land in the area of Novoaleksandrovkaya street

Remarks: Snow masses of the Soviet district were exported to the snow dump of Leninsky district (2015).

(the content of dibutyl phthalate the $MAC_{fish\ farm}$ in the background samples of snow and varies from 18 to 105 $MAC_{fish\ farm,}$ its content at snow dumps ranges from 385 to 1164 $MAC_{fish\ farm).}$ The degree of contamination of snow with phthalates is approximately the same for the streets of the city of all boroughs. The average content of phthalates at snow dumps is 0.952-1.036 mg/dm^3. The background content of phthalates in the snow of different boroughs is different. Their average concentration in Oktyabrsky borough is 0.056 mg/dm^3, in Ordzhonikidzevsky – 0.022 mg/dm^3, and in Sovetskiy – 0.123 mg/dm^3. A group of phenolic compounds (phenol, cresols, alkylphenols) is one of the rarely detected pollutants. They are also found in small concentrations in snow samples. The level of phenol contamination of the snow dump of the Soviet borough made 0.004 mg/dm^3, of Ordzhonikidzevsky borough – 0.004 mg/dm^3 and Oktyabrsky borough – 0.003 mg/dm^3.

The level of cresols contamination for all the boroughs made 0.004 mg/dm^3. The content of alkylphenols in snow samples collected in Ordzhonikidzevsky is slightly higher. Around the dump of Oktyabrsky borough background snow is enriched in phenolic compounds: their overall amount makes 0.009 mg/dm^3, while in Sovetsky and Ordzhonikidzevsky boroughs it is 0.001 mg/dm^3. Alkyl benzenes, naphthalene and alkyl naphthalenes are air pollutants on the streets of Ufa. Their content is much higher than the sanitary standards. These substances enter the air with the exhaust gases of vehicles. An average content of alkyl benzenes in the snow from the dump of Ordzhonikidzevsky borough is 0.031 mg/dm^3; the content of naphthalene makes 0.004 mg/dm^3 and of alkyl naphthalines – 0.014 mg/dm^3. The content of the same substances in Sovetsky borough is 0.003, 0.002 and 0.037 mg/dm^3 respectively; in Oktyabrsky borough – 0.005, 0.002, and 0.009 mg/dm^3 respectively. Background snow samples of Ordzhonikidzevsky borough contain 0.0006 mg/dm^3 of alkyl benzenes; 0.001 mg/dm^3 of alkyl naphthalines. In Sovetsky borough – 0.0018 mg/dm^3 respectively; 0.0012 mg/dm^3; in Octobrsky – 0.0001 mg/dm^3; 0.0006 mg/dm^3. Naphthalene in background snow samples was present in trace amounts.

Conclusion

The results of the inspection of snow dumps in Ufa

from 1998 to 2015 established that snow masses taken out from the territory of the city are and characterized by the excess of almost all the controlled substances.

In 2011 the most significant excess of the following substances was observed: chloride ion – up to 1141 times, calcium – up to 190 times, sodium – up to 488 times in Leninsky borough. In 2013: chloride ion – up to 628 times, sodium – up to 997 times in the Sovetsky borough. In 2015: chloride ion - up to 609 times in Leninsky borough.

Snow is heavily polluted with benzapyrene. Snow is contaminated with alkyl naphthalenes and alkyl benzenes which is a result of vehicle emissions. Background snow is not contaminated with these compounds. Snow was noticed to be highly contaminated with biogenic compounds on dumps (carboxylic acids, phthalates, ammonium ions and nitrites, alkyl phenols). Excess of sanitary and hygienic standards in water for household use in carboxylic acids was up to 130 times, phthalates up to 1100 times. Background snow is also enriched with biogenic compounds, but to a smaller extent than snow from the street. Standards are exceeded in water for household use in the content of carboxylic acids up to 25 times, the content of phthalates up to 105 times. Snow is heavily polluted by oil products, the main pollution of which occurs during the collection and compaction of snow on dumps.

During melting of snow masses which are stored at the snow dumps of Ufa, a negative impact on the soil cover of land on the site of snow dumps and the surrounding area, including chloride salinization was established. With long-term effect (over a number of years) of melting snow dumps and the excess in the sorption capacity of the soil at the place of waste storage, it is possible to pollute groundwater with melt waters. Based on the above, we believe that snow dumps must be equipped with special treatment facilities, discharges of which to surface water bodies must be controlled.

References

Abramova, A., Chernianskii, S., Marchenko, N. and E. Terskaya (2016). Distribution of polycyclic aromatic hydrocarbons in snow particulates around Longyearbyen and Barentsburg settlements, Spitsbergen. *Polar Record*, **52(6):** 645-659.

Asylbaev, I., Gabbasova, I., Khabirov, I., Garipov, T., Lukmanov, N., Rafikov, B., Kiseleva, A., Khuzhakhmetova, G., Mukhamedyanova, A. and R. Mustafin (2018). Bioaccumulation of Chemical Elements by Old-Aged Pine Trees in the Southern Urals. *Journal of Engineering and Applied Sciences*, **13:** 8746-8751.

Blecken, G.-T., Rentz, R., Malmgren, C., Öhlander, B. and M. Viklander (2012). Stormwater impact on urban waterways in a cold climate: Variations in sediment metal concentrations due to untreated snowmelt discharge. *Journal of Soils and Sediments*, **12(5):** 758-773.

Chechevichkin, V.N. and N.I. Vatin (2014). Specifics of surface runoff contents and treatment in large cities. *Magazine of Civil Engineering*, **50(6):** 67-74.

Kasimov, N.S., Kosheleva, N.E., Nikiforova, E.M. and D.V. Vlasov (2017). Benzo[a]pyrene in urban environments of eastern Moscow: Pollution levels and critical loads. *Atmospheric Chemistry and Physics*, **17(3):** 2217-2227.

Konashova, S.I., Sultanova, R.R., Khayretdinov, A.F., Gabdrakhimov, K.M., Konovalov, V.F., Rakhmatullin, Z.Z., Isyanyulova, R.R., Nasyrova, E.R., Gubydullin, A.F. and S.I. Muftakhova (2018). Forestry and Ecological Aspects of the Broad-Leaved Forest Formation. *Journal of Engineering and Applied Sciences*, **13:** 8789-8795.

Kuoppamaki, K., Setala, H., Rantalainen, A.L. and D.J. Kotze (2014). Urban snow indicates pollution originating from road traffic. *Environmental Pollution*, **195:** 56-63.

Lobkina, V.A., Gensiorovskiy, Yu.V. and N.N. Ukhova (2016). Eco-geology. Engineering geology. Groundwater hydrology. Geocryology. *Yuzhno-Sakhalinsk*, **6:** 510-552.

Minigazimov, N.S. (2017). Microelements of petroleum in the environment. Bashkir Encyclopedia. Ufa, 152.

Mustafin, R., Ryzhkov, I., Sultanova, R., Khabirov, I., Khasanova, L., Zagitova, L., Asylbaev, I., Kutliyarov, D., Zubairov, R. and A. Rajanova (2018). Assessment of Slope Stability in Coastal Water Protection Zones. *Journal of Engineering and Applied Sciences*, **13:** 8331-8337.

Ociepa, E., Mrowiec, M., Deska, I. and E. Okoniewska (2015). Snow cover as a medium for deposition of pollution. *Rocznik Ochrona Srodowiska*, **17(1):** 560-575.

Onuchin, A.A., Burenina, T.A., Zubareva, O.N., Trefilova, O.V. and I.V. Danilova (2014). Pollution of snow cover in the impact zone of enterprises in Norilsk Industrial Area. *Contemporary Problems of Ecology*, **7(6):** 714-722.

Pilecka, J., Grīnfelde, I., Valujeva, K., Straupe, I. and O. Purmalis (2017). Heavy metal concentration and distribution of snow and Lichea samples in urban area: Case study of Jelgava. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM. 17th International Multidisciplinary Scientific Geoconference, SGEM 2017; Albena; Bulgaria, **17(41):** 459-466.

Stepanova, N.V., Fomina, S.F. and E.R. Valeeva (2016). Assessment and zoning of the urban area according to the level of heavy metal pollution. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, **7(6):** 1148-1157.

Tarasov, O.Yu., Shagidullin, R.R., Yuranets-Luzhayeva, R.Ch. and N.Yu. Krapivina (2011). Georesources. *Kazan*, **2(38):** 31-33.

Vialkova, E., Zemlyanova, M., Vorotnikova, A., Cherkashin, D., Voronov, A. and L. Maksimov (2017). The protection of urban areas from surface wastewater pollutions. MATEC Web of Conferences. International Science Conference on SMART City, SPbWOSCE 2016; Peter the Great Saint-Petersburg Polytechnic University, Institute of Civil Engineering Saint-Petersburg; Russian Federation.