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TEMPORAL VARIATIONS IN CHEMICAL COMPOSITION OF SNOW COVER IN MOSCOW

ABSTRACT. This article summarizes the data of the chemical composition and the acidity of the seasonal snow precipitation for the cold periods 1999-2006 (n=180), 2010-2013 (n=82) and 2018-2019 (n=18) in different parts of Moscow. Major ions content was measured, such as SO_4^{2-}, HCO_3^-, Cl^-, NO_3^-, Ca^{2+}, Mg^{2+}, Na^+, K^+ and NH_4^+, also pH and sum of ions (mg/L) were measured. During the 2018-2019 season, snowpack samples were taken twice at 4 sites in Moscow: two in the North-East Administrative Okrug (NEAO) near the road and in the park at the distance of 3 km from each other, and two in the South-Western Administrative Okrug (SWAO) and in the Western Administrative Okrug (WAO) near the road and in the park at the distance of 6 km from each other. Samples were taken with a break of 5 days to determine the dynamics of the chemical composition within the beginning of the snow-melting. In each pair of sampling sites there was one that is located in the park and one located near the road. This experiment showed a slight variability of the chemical composition of snow during 5 days under the influence of the new snowfall. In general, there is a trend of changing the composition of snow from calcium carbonate to calcium chloride, which is mainly connected to the use of anti-icing reagents; for the same reason, the areas that are closer to the roads are the most polluted.

KEY WORDS: snow cover chemistry, snow pollution, ionic composition, precipitation acidity, urban ecology

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INTRODUCTION

The study of the chemical composition of snow cover is an important part in the research of the air pollution processes. The study of the pollution of the snow cover is widely used to control atmospheric input. The snow cover is a depositary for pollutants and is an informative object in identifying anthropogenic air pollution. The chemical composition of melting snow is formed as a result of the input of various chemical elements with precipitation, the absorption of gases by the snow, water-soluble aerosols, and the interaction of the dust particles deposited from the atmosphere with the snow cover. Snow cover pollution occurs in two stages. Firstly, it is the pollution of snow during its formation in the cloud and falling on the location which is wet deposition of pollutants with snow, secondly, the pollution of the snow which has already fallen as a result of the dry sedimentation of pollutants from the atmosphere, as well as their input from the underlying soils and rocks (Vasilenko et al. 1985).

The study of the chemistry of snow cover is carried out intensively in Russia as well as in other countries of the world. Yakhnin and his co-workers (2003) provide data of the content of major components and trace elements in the atmospheric precipitation of Leningrad Area and Finland. It is showed that the content of sulfates in the snow in Finland was decreasing, and in Leningrad Area was increasing through the period from 1999 to 2001. Comparison of the composition of samples of snow cover and wet fallout during the winter period provide comparable results. Yakhnin et al (2002) also studied the level of the contamination of snow cover in Estonia and in the west of Leningrad Area near industrial zones considering the connection between the structure of technogenic atmospheric fallout and the main sources of emissions into the atmosphere. Negrobov et al. (2005) proposes to use data on snow cover to determine the level of the pollution and the composition and emission rates of enterprises. Yanchenko (2014) notes an increase of alkalinity of snow in industrial areas of Bratsk. Belozertseva et al. (2017) studied chemical composition of snow in lake Baikal area and showed the difference between contaminating compounds for different hollows in this area: the northern part is contaminated mostly by SO_4^{2-}, HCO_3^-, Cl^-, Ca^{2+}, while the southern receives NO_3^-, NH_4^+ and Na^+. Analysis of the chemical composition of snow cover in Komi (Vasilevich et al. 2011) showed low salinity and acid pH values – EC varies from 9.4 to 10.02 µS/cm that is approximately 6.0 –6.4 mg/L, pH varies from 4.6 to 4.8. Prozhorina et al. (2014) and Prozhorina and Yakunina (2014) studied the snow cover of Voronezh in 2013 and 2014. The authors have shown that nitrates, nitrites, and chlorides predominate in technogenic emissions in Voronezh, and that motor transport and industrial enterprises are the main sources of pollution. Shumilova et al. (2012) investigated the pollution of snow cover in Izhevsk; the authors obtained high values of the snow salinity (up to 1247.5 mg /L) in the industrial zone.

Studies of snow cover in Moscow Area in 2009–2013 (Yermakov et al. 2014) revealed relatively high salinity of snow in several districts (up to 46 mg/L) in comparison to Sergiyevo-Posadsky District (where salinity reaches 9.6 mg/L) and a pH value is close to neutral, indicating the high dust content of the atmosphere.

A study held in the United States (Ingersoll, et all, 2008) compares the composition of snow cover with the results of analysis of the wet deposition samples. Interesting conclusions were obtained that the content of calcium, magnesium and potassium in snow cover is much higher than in wet precipitations, and the concentrations of sulfates and nitrates are comparable in both types of samples and have been decreasing in recent years. Nawrot et al. (2016) studied the chemical composition and the acidity of the snow cover of the Hans Glacier in the South of Svalbard during the season 2005-2006. This season was both the warmest (the mean January temperature was –1.7 ° C in January) and with the highest level of in precipitation since 1988, also, within this season 1.3 m of snow accumulated on the Hans Glacier. The authors noted the high contamination of the snow with sulfates and nitrates, according to their analysis of the reverse trajectories, agricultural fires in Eastern Europe (Stohl et al. 2007) were the source of the contamination.

Jacobi et al. (2012) investigated the snow cover of the coast of Alaska, mainly high contents of sodium, chloride, sulfate and potassium were found due to the influence of sea salts, also high content of magnesium and calcium were found due to the combination of dust and sea salts. Similar studies were conducted in other regions of the United States (Rocky Mountains), as well as for the highlands of Europe and the Himalayas, and were summarized in (Hidy 2003). In the Rocky Mountains thermal power plants are the main source of sulfates and nitrates in the snow cover. Jarzina et al. (2017) investigated physical and chemical properties of melting snow in Poland. The results indicate a significant contribution of pollutants produced by the local metallurgical plant to the chemical composition of snow melt. Kępski et al. (2016) conducted the research on snowmelt snow in the Sudetes and showed that 50-76% of pollutants are added to the soil in first two weeks of snowmelt. Curtis et al. (2018) analyzed the spatial patterns of nitrate distribution in western Greenland and found that nitrate content significantly declined from inland to the coast. Williams et al. (1992) conducted a study of the sources and spatial variations of the chemical composition of snow in eastern Tien Shan, China. According to their data, the average concentration of sulfates in the snow was three times higher than background concentrations in other remote areas of the world.

The relationship between dry and wet deposition depends on many factors, the main of which are: the duration of the cold period, the frequency of snowfalls and their intensity, the physical and chemical properties of pollutants, the size of aerosols.

Due to the high intensity of wet leaching processes the proportion of dry deposition for regional and global pollution in the Northern Hemisphere is usually 10–30%. However, near the local sources with large emissions of coarse aerosols, the picture is reversed, i.e. dry deposition can be from 70 to 90%.

The aim of the research is to determine long-term changes in pH and ionic composition of seasonal snowpack in Moscow within the period from 1999 to 2019. Also, we examined the variability of snow chemical composition within the period of snow melt to be able to find out if the variation during one season is significant.

MATERIALS AND METHODS

The collection and analysis of winter snow samples in Moscow and Moscow Area (Moscow Oblast) were carried out from 1999 to 2006 (Eremina and Grigoriev 2010), as well as in winter in 2010-2011, 2011-2012 and 2012-2013 (Belikov et al. 2012; 2013; 2014), also, sampling took place in 2018-2019 (Fig. 1). In winter season of 2018-2019, samples were taken at 4 sites in the North-East Administrative Okrug (NEAO), South-Western Administrative Okrug (SWAO) and Western Administrative Okrug (WAO) with a break of 5 days to determine the dynamics of the chemical composition within the beginning of the snow-melting period. Also, the sites sampled in 2018-2019 winter season were located in 2 main directions (South-West and North-East), in each direction two sites were sampled: one near the road (88 km MKAD and Stoletova Street) and one in the park (Narodny Park and Kotlovka floodplain) to show the difference between two types of anthropogenic influence. Winter snow samples were also taken in the end of winter and annually analyzed the territory of Meteorological Observatory of Lomonosov Moscow State University (MSU MO). Therefore, it is possible to trace the dynamics of the chemical composition of snow cover over last 20 years.

Sampling was carried out in the period of maximum liquid water content (LWC) in the snow, in the end of February – beginning of March. All sampling was held mostly in places, that are not influenced by human activity (parks, forests) more than in 100-200 meters from the roads, with exception of two sites sampled in season 2018-2019: at 88 km of MKAD and Stoletova street, that were located near roads. Such sampling was conducted in order to compare sites that are relatively close to each other, but experience different levels of anthropogenic influence. Samples taken from 1999 to 2013 were taken in parks, the sites were chosen in such a way to cover different directions and distance from the center of Moscow (Fig.1). The one column of the entire thickness of snow cover was sampled with a standard snow sampler 60 cm long and with a cross-section area of 50 cm^2. Then the snow was transferred to plastic cuvettes. The sampling protocol used in this study is similar to the sampling standard for ionic composition study used in USA (Snow-survey sampling guide, 1967). A study to determine the representativeness of one sample was conducted in 2010 (Eremina and Grigoriev 2010). For this purpose, 10 seasonal snowpack samples were taken at a site with total area of 100 m^2. After full chemical analysis, it was found that the content of all components, with the exception of the hydrocarbonate ion, differs slightly in these samples (standard deviation S = 0.06–0.10). For the HCO_3^- ion, the scatter was slightly higher, probably due to the plant of building materials, that was close to the sampling site and which gave alkaline emissions (Eremina and Grigoriev 2010).

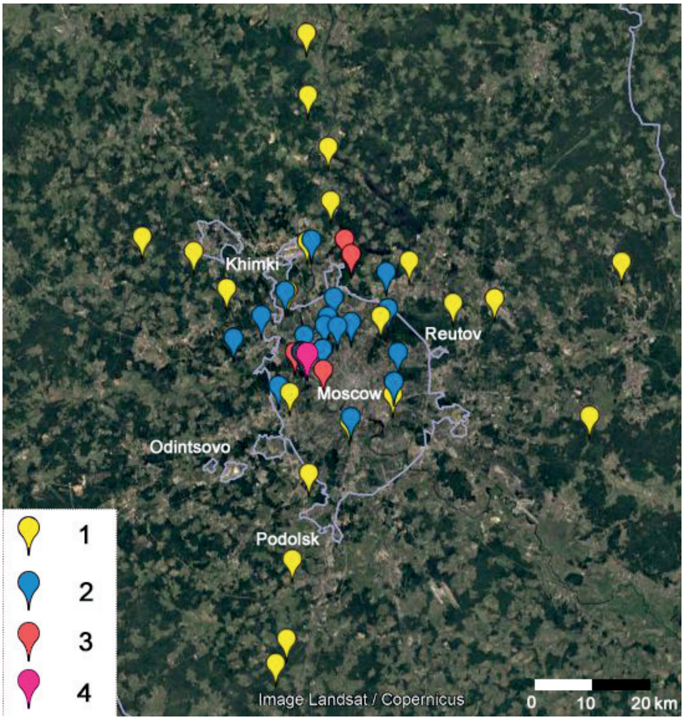

Fig. 1. Sampling points: 1 – 1999 – 2006; 2 – 2011 – 2013; 3 – 2018 – 2019 ; 4 – MSU MO 1999 – 2006, 2011 – 2013, 2018 – 2019

Melting of snow samples was conducted at a temperature of 20°C±2°C (the standard temperature in a laboratory room) without additional heating during 24 hours. The samples were closed in cuvettes during the melting procedure. Chemical analysis of snow samples was carried out in the chemical laboratory of Moscow State University. Preparation for sample analysis included thawing to room temperature and filtration. Major ions content was measured, that are anions: sulfate (SO_4^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), nitrate (NO_3^-): as well as cations: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+) and ammonium (NH_4^+). The ion concentration is expressed in mg /L, microeq/L and %-eq. Concentration of HCO_3^- and the pH of samples were measured immediately after the sample preparation, since the pH value and the concentration of HCO_3^- ions can change quite significantly during long-term storage of the sample. The pH value and the concentration of bicarbonate (by titration with hydrochloric acid) were determined on an Expert -001 ion meter (Ekoniks, RF). The content of cations and anions was determined by ion chromatography on a JetChrom instrument (PortLab, RF). The ionic composition is studied as it the most reliable analysis that can show the contamination of atmosphere air through the dissolved compounds.

RESULTS AND DISCUSSION

Studies of snow samples on the territory of MSU MO showed no significant change in their acidity (Table 1). The average value of pH for all 20 years of observations at MSU MO is around 6.3. A slight increase in the acidity of seasonal snow was observed during the cold periods of 2006–2007, 2008–2009, and 2009–2010 (average values from 5.5 to 5.8). In other years, the pH of seasonal snow samples varied in the range of 6.2 - 7.1.

To observe the trends in the ionic composition, we divided the entire study period into 2 parts,10 years each. Concentrations of some ions in recent years have decreased the comparing with the first period, while others have increased. Thus, the decrease in the content of the following ions: HCO_3^-, SO_4^{2-} and Ca^{2+} in the second period (Table 1) is noted. The total sum of ions (mineralization, salinity) of the samples also decreased. The HCO_3^-

content decreased by 2 times from 4.7 mg /L to 2.3 mg /L. The lowest value of bicarbonate ion was obtained in the winter of 2009-2010 (1.1 mg/L), and the maximum in 2007-2008. (12.0 mg/L). The content of SO_4^{2-} also decreased from 2.0 to 1.2 mg/L, and the highest average content of sulphate ion 3.6 mg/L was noted in 2005-2006. In the second observation period, the content of the main cation calcium (Ca^{2+}) decreased slightly from 2.6 to 1.8 mg /L.

The concentrations of the other ions in the second period have increased. Comparing with the first period, the content of chloride and sodium ions increased remarkably. In the snow of the first period from 1999 to 2008 the mean content of Cl^- was 1.4 mg/L, and in 2009-2018 2.4 mg/L. The maximum amount of chloride obtained in the winter season 2012-2013 (3.8 mg/L). In the second period, the content of sodium ion increased from 0.4 to 0.9 mg /L. Apparently, this is due to the active use of anti-icing reagents, the main components of which are chloride and sodium ions (Eremina et al. 2015). Anti-icing reagents in Moscow are used not only on the roads, but also in parks, so the short distance aeolian transport of their components is possible. The content of the other ions has not changed significantly. The values of confidence interval show that the increase of contamination is not significant, only Cl^- and Na^+ content increase significantly.

In Table 1 the concentrations are presented not only in mg/L, but also in the %-eq. From these data, the contribution of each ion to the total mineralization of the sample can be estimated. Among the cations, calcium is the predominant ion (in all the years of observation), and the share of sodium has greatly increased in the second period (12.3%-eq). In the first period, the bicarbonate was the predominant anion (21.3 %-eq.) and in the last decade the chloride ion became the predominant one. So, if in the first period the seasonal samples of snow cover belonged to the bicarbonate-calcium class, now it is the chloride-calcium one. Chloride prevails not only in seasonal snow samples, but also in daily samples. (Eremina 2013, 2019).

Considering general data for Moscow sampling sites, the ion content is significantly higher here, because the MSU MO is located on the territory of the Botanical Garden of Moscow State University and is protected by trees from major highways, and there are no industrial enterprises close to it.

Results of snow study for 1999 - 2006 are presented in (Eremina and Grigoriev 2010). However, during these years, samples were taken mainly in the park zone near Moscow Ring Road (MKAD) and there were practically no samples in the center of Moscow. And in winter seasons 2010-2011, 2011-2012 and 2012-2013 samples were taken in the center of Moscow (Fig. 1).

Table 1. Chemical composition and pH of snow samples from the territory of MSU MO in different years, CI – confidence interval

MSU MO, sampling period	pH	HCO_3^-	SO_4^{2-}	Cl^-	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+	NH_4^+	Sum of ions
		Concentration, mg/L									
1999-2008 n=23	6.30	4.7	2.0	1.4	1.3	2.6	0.1	0.4	0.1	0.4	13.0
2009-2018 n=22	6.25	2.3	1.2	2.4	1.2	1.8	0.1	0.9	0.2	0.3	10.4
CI	±0.12	±0.8	±0.3	±0.3	±0.1	±0.3	±0.01	±0.2	±0.03	±0.1	±1.2
		Concentration, %-eq..									
1999-2008		21.3	11.9	11.5	5.8	35.8	2.5	4.7	0.7	5.7	
2009-2018		12.4	8.4	21.7	6.5	28.7	2.5	12.3	1.5	5.8	

All collected samples of the snow cover of these three seasons can be divided into 4 groups by the sampling site: 1) Moscow Center (approximately within the third transport ring (TTK); 2) Parks (squares, forest parks, etc. near MKAD); 3) Moscow Area - suburbs (4 samples at a distance of 5, 15, 25, and 40 km from MKAD in 4 main directions); 4) MO MSU (for comparison).

Table. 2 shows the mean salinity values for all groups of sampling sites for each of the 3 seasons. The trend of decreasing of snow contamination from the center to the suburbs of Moscow is stable over years. Therefore, it is possible to average all values for each group (more than 100 samples in total), and the mean and range of salinity values are also shown in table 2. The most polluted samples of snow were collected in the center of Moscow (average salinity 61.2 mg/L), the less polluted in Moscow Area and MSU MO. Moreover, in Moscow parks near MKAD, seasonal snow mineralization is 3 times less, and in Moscow Area and MSU MO - almost 5 times less than in the center of Moscow. MSU MO may be considered as "background" station compared with other sampling sites in the city.

Figure 2 shows the average content of the main anions and cations for the same 4 sampling sites. A decrease in the concentrations of all ions from Moscow Center to Moscow Area is observed. High concentrations of chloride, calcium and sodium ions in the city center is noted. These are the main components of anti-icing agents, which in recent years have been used in large quantities on the roads of Moscow. In large parks and in outskirts of Moscow this influence is not significant, however, in small parks, surrounded by roads this influence is obvious.

Table 2. Salinity of snow in different sampling sites in 2011-2013 (n=82)

	Salinity, mg/L			
	Moscow Center	Parks near MKAD	Moscow Oblast	MSU MO
2010-2011	60.2	19.6	16.1	12.8
2011-2012	71.1	18.8	15.1	13.4
2012-2013	46.8	24.0	12.4	13.9
Mean	61.2	20.6	14.5	13.4
Min.	24.3	5.6	4.7	5.6
Max.	199.1	53.3	41.8	25.3

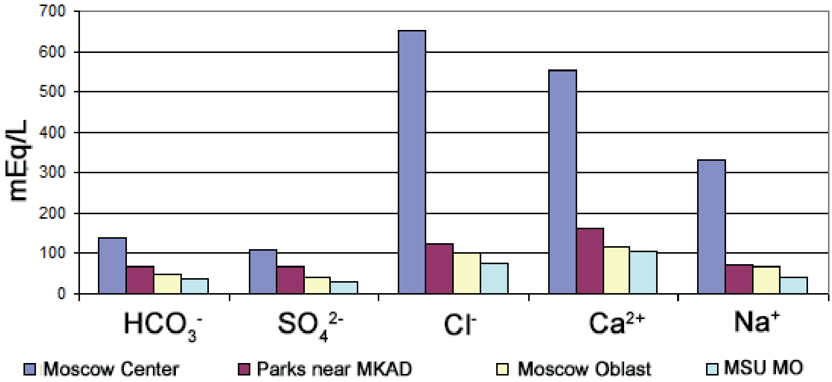

Fig. 2. Ionic composition of snow in different sampling sites

Table 3 shows the average values and the range of pH of snow in 4 sites. The acidity of all collected samples of snow cover varied from 5.1 to 7.9 i.e. there no acidic samples (pH <5.0).

However single (daily) snowfalls are sometimes acidic, especially in winter of 2009-2010 (more than 20%). Usually there are 60-80 single samples during the winter, each sample is taken and analyzed as it falls. However, our analysis of seasonal snow includes all the snow that accumulates from the beginning of the formation of snow cover to the beginning of its melting. Deposition of alkaline particles on the surface of an urban aerosol neutralizes the acidity of individual samples, so seasonal snow has a pH> 5. The lack of acidity is an important environmental indicator, since it means that acid does not enter the soil and rivers with the snow melt.

The composition of the snow in 2018-2019 was also studied at 4 points in different parts of Moscow: Narodny Park and 88 km of the Moscow Ring Road - MKAD in the north-eastern part of Moscow, Nakhimovsky Av. near the floodplain of Kotlovka River in the south-western part of Moscow and Stoletova Str. in western part of Moscow. Samples were taken twice with a break of 5 days at the beginning of the period of snow melt (Fig. 3.). Samples taken at 88 km of MKAD show the highest salinity of 41.8-57.4 mg /L and the most alkaline pH values of 6.75-7.10. Calcium chlorides predominate in these samples. In Narodny Park, located in the same part of Moscow, calcium and bicarbonate ions predominate, pH varies in range of 6.55-6.70. Salinity here is 2 times lower than in snow from Moscow Ring Road and varies in range of 19.4-21.1 mg/L. In samples near Stoletova Street in the west of Moscow, the pH is 7.05-7.15, and salinity is 18.6-28.4 mg/L. On the floodplain of the Kotlovka River near Nakhimov Avenue in the south-west of Moscow, the pH is 6.35-6.75, the salinity is 11.1-19.1 mg /L, and snow samples had of calcium - chloride composition. In general, the comparison of the sites located in the parks (Narodny Park and floodplain of Kotlovka river) with the sites in 3-6 km, but located near the roads (88 km MKAD and Stoletova street), show not only the obvious higher mineralization of samples and higher pH due to the influence of the roads, but also more intensive change in an ionic composition. Near the roads the increase of HCO_3^- content in 5 days is higher from 9%-eq. to 19%-eq. in NEAO and from 18%-eq. to 25%-eq.in WAO, while in parks the difference in HCO_3^-content within 5 days is not higher than 2-3%-eq. (Fig. 3).

The predominantly calcium and chloride composition of snow indicates pollution with anti-icing agents (Gladkov et al. 2016)

The samples were taken twice: on 3 March and 8 March 2019. An increase in pH, an increase in the concentration of Ca^{2+} is observed in samples, that were taken later. At the sites in the West and South-West, an increase in salinity, and decrease in the content of Cl^- is observed.

Comparing the composition snow of 2018-2019 (Table 4) to the results of previous years shows, in the last season, slightly higher values of salinity, pH, as well as concentrations of some ions (HCO_3^-, Cl^-, Ca^{2+} and Na^+) were obtained. These samples were collected in other sites, then in previous years, thus the influence of other sources of pollution could have an effect.

Table 3. pH values of snow

	pH			
	Moscow Center	Parks near MKAD	Moscow Oblast	MSU MO
Mean	6.96	6.46	6.00	6.56
Min.	6.70	6.00	5.10	5.45
Max.	7.55	7.85	6.85	7.20
Δ	0.85	1.85	1.75	1.75

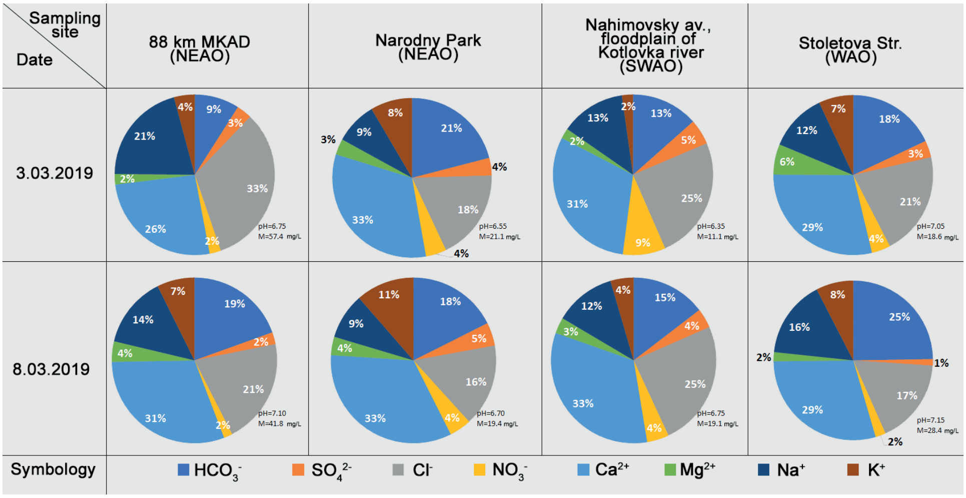

Fig. 3. Chemical composition of snow in 4 sampling sites for 3.03.19 and 8.03.19

In recent years, there is a decrease in sulfates in the snow cover (Table 4), and a noticeable increase in chlorides and sodium. Concentrations of other ions do not change significantly.

The composition of the snow cover in Moscow can be compared to one in Izhevsk in the same winter season of 2010-2011 (Shumilova et al. 2012). The pH of snow in Izhevsk varied from 6.63 to 7.25, in Moscow in the same period pH was 6.30-6.70. The content of chlorides in Izhevsk varied from 1.78 to 40.12 mg /L, in Moscow suburbs according to our data during this period the chloride concentrations were in a range of 1.6-6.1 mg /L, and in the center

Table 4. Comparison of mean values in snow in Moscow over 20 years, CI – confidence interval

Sampling period	pH	Ion concentration, mg/L									Sum of ions, mg/L
		HCO_3^-	SO_4^{2-}	Cl^-	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+	NH_4^+	
1999-2006 (Eremina and Grigoriev 2010) n=84	6.1	3.9	3.0	2.7	1.7	2.6	0.2	0.8	0.3	0.6	15.8
CI	±0.02	±0.6	±0.6	±0.7	±0.2	±0.4	±0.04	±0.4	±0.1	±0.1	±2.4
2010-2011 (Belikov et al. 2012) n=9	6.5	4.4	4.3	2.9	2.2	2.8	0.4	0.9	0.8	0.9	19.6
CI	±0.1	±1.6	±1.3	±0.9	±0.5	±0.7	±0.1	±0.2	±0.6	±0.2	±4.7
2011-2012 (Belikov et al.. 2013) n=9	6.4	4.1	2.4	3.7	3.1	3.4	0.3	1.2	0.2	0.4	18.8
CI	±0.1	±1.2	±1.0	±1.0	±1.3	±0.9	±0.1	±0.4	±0.02	±0.3	±4.5
2012-2013 (Belikov et al. 2014) n=11	6.6	3.8	2.7	7.5	2.0	3.5	0.3	3.1	0.7	0.4	24.0
CI	±0.1	±0.8	±0.6	±1.9	±0.2	±0.8	±0.1	±0.7	±0.2	±0.1	±5.1
2018-2019 (this study) n=18	6.7	6.2	2.2	8.6	1.5	4.7	0.3	3.4	0.8	0.5	28.2
CI	±0.1	±1.6	±0.6	±2.9	±0.3	±1.2	±0.1	±1.2	±0.3	±0.2	±7.1

of Moscow from 6.8 to 75.0 mg/L. Sulfate ion in Izhevsk was detected with a concentration of 3.37-5.55 mg/ L, in Moscow the range is slightly wider from 2.2 to 7.7 mg/L, and in the center of Moscow values reach 19.5 mg /L. Snow in Izhevsk contains nitrate ion in amount of 0.5-5 mg/L, in Moscow the average content was 2.38 mg /L (the range is 0.7-4.7 mg /L). The snow in Moscow is more polluted than in Izhevsk, but the patterns are the same. High content of chlorides is also associated with anti-icing reagents, since the main pollution with chlorides is associated with large highways, which are regularly influenced by reagents in winter. The concentration of sulfate in the snow of Izhevsk is marked as relatively low, as in Moscow. (Shumilova et al. 2012).

CONCLUSIONS

1. In the snow cover in the MSU MO, there is a tendency of a change of snow chemical composition from 1999 to 2019 from bicarbonate-calcium to chloride-calcium, which is associated with the use of anti-icing reagents.

2. For mean values in Moscow the significant increase of sodium and chloride ions content as well as the increase of mineralization in general is shown for the period of 20 years, pH values of snow increased by 0.6 from 1999 to 2019.

3. The comparison of snow samples in the center of Moscow and Moscow suburbs showed a decrease in pollution in this sequence, but the least polluted samples are collected at MSU MO.

4. The ionic composition and the pH of snow samples at 4 sites in Moscow, twice taken in the interval of 5 days, showed significant difference and, therefore, high sensitivity to single events of rain and snow. In general, the comparison of the sites located in the parks (Narodny Park and floodplain of Kotlovka river) with the sites in 3-6 km, but located near the roads (88 km MKAD and Stoletova street) show not only the obvious higher mineralization of samples and higher pH due to the influence of the roads, but also a more intensive change in an ionic composition. Near the roads the increase of HCO_3^- content in 5 days is higher from 9%-eq. to 19%-eq. in NEAO and from 18%-eq. to 25%-eq.in WAO, while in parks the difference in HCO_3^- content within 5 days is not higher than 2-3%-eq. It can be assumed that with the regular snow sampling during one winter, the result of the analysis of the entire snow layer will differ significantly.

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