Data on microscale atmospheric pollution of Bolshoy Kamen town (Primorsky region, Russia)

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Abstract. The paper discusses the study of atmospheric particulate matter of Bolshoy Kamen town by means of laser granulometry of snow water samples. Snow sampling points were selected close to major enterprises, along the main streets and roads of the town and in the residential area. The near-ground layer of atmospheric air of the town contains particulate matter of three main size classes: under 10 microns, 10-50 microns and over 700 microns. It is shown that the atmosphere of this town is lightly polluted with particles under 10 μm (PM_{10}). Only in 5 sampling points out of 11 we found microparticles potentially hazardous to human health in significant quantities – from 16.2% to 34.6%. On the most territory of the town large particles (over 400 μm) dominate reaching 79.2%. We can conclude that judging by the particle size analysis of snow water samples Bolshoy Kamen town can be considered safe in terms of presence of particles under 10 μm (PM_{10}) in the atmosphere.

1. Introduction

At the present time the continuous environmental and hygienic monitoring of atmospheric particulate matter in Russia is usually conducted in large cities (Moscow, St. Petersburg, Vladivostok, etc.) [1-4], on territories contaminated in the course of man-caused activities [5, 6] and in wildlife reserves [7, 8]. Primorsky Region is one of the most interesting regions of Russia in terms of the study of microscale atmospheric pollution. The territory is well understudied in this aspect, yet nano- and microparticles of atmospheric particulate matter undoubtedly have a significant impact on air quality, climate, people and animals [9, 10].

The features of the Primorsky Region include long distances between cities and towns (about 100-150 km on average), small number of large industrial enterprises and relatively low population. Previously we studied the major cities of Primorsky Region with the population of 100 thousand to 700 thousand people: Vladivostok, Ussuriysk and Nakhodka [11].

This paper discussed the study of atmospheric pollution with microscale particulate matter of the small town in Primorsky Region (with the population under 100 thousand people) – Bolshoy Kamen.

Bolshoy Kamen is a monotown specialized in shipbuilding and repair works, food industry and construction; it the center of the urban district of the same name in Primorsky Region, Russia. The town is located 20 km east of Vladivostok on the opposite bank of the Ussuri Bay, Sea of Japan. As of 2016 the population of the town is 38,718 people (Russian Federal State Statistics Service 2016). It is a medium-sized town in terms of the number of population and the 7th biggest town in Russia's Primorsky Region. During the cold season northerly winds prevail in the town, during the warm season – southwest winds. The average annual wind speed is 3.4 mps.

The town was originally a naval based and it had a closed status. Due to the closed status of the town it has not seen many ecological studies.

Several large enterprises operate in Bolshoy Kamen: ship-repair yard "Zvezda" (town-forming shipbuilding and repairing enterprise building civilian vessels, remodeling and disposing of nuclear submarines), shipyard "Vostok", fish factory (harvesting and processing of fish and seafood) and bakery plant.

2. Materials and methods

Snow sampling points were selected close to these enterprises, along the main streets and roads of the town and in the residential area (Figure 1).

Figure 1. Snow sampling points in Bolshoy Kamen town: 1 - Alleya Truda, 2 - Korabelnaya Ploschad, 3 - Akademika Krylova Str., 4 - Akademika Kurchatova Str., 5 - Blukhera Str., 6 - Gagarina Str., 7 - Gorkogo Str., 8 - Karla Marksa Str., 9 - Maslakova Str., 10 - Primorskogo Komsomola Str., 11 - Pushkinskiy Per. © OpenStreetMap contributors

The snow for the study of atmospheric particulate matter was collected during the snowfall in January 2015. In order to exclude the secondary pollution with anthropogenic aerosols, only the top layer of freshly fallen snow was collected. It was placed in sterile 3 liter plastic containers and transported to the laboratory. After several hours when the snow melted in the container, the liquid was stirred and 60 ml portion was taken from each sample and analyzed on the laser particle analyzer Analysette 22 NanoTech plus (Fritsch GmbH, Germany). The measurement was carried with the settings of the measured system "quartz/water 20°C", the measurement range was 0.008-2000 μm.

These results allow us to determine the dimensions of the particles and their percentage, with the recalculation according to the transparency of the material. The method makes it possible to determine the distribution of particles by their sizes and fractions, identify their shape and a number of morphometric parameters (mean diameter, mode, median, deviation, deviation coefficient) during a single measurement [12].

3. Results and Discussion

The sizes of particles and percentage ratio of fractions in samples of particulate matter at all sampling stations are presented in Table 1.

After comparing the granulometric parameters of the particulate matter in different areas of Bolshoy Kamen several conclusions can be made. First, according to the snow samples collected, the atmosphere of the town is practically not contaminated with particles under 10 µm (PM_{10}). Only in five areas of Bolshoy Kamen (sampling points No. 1, 5, 8, 9, 11) particles of this size class were found in significant proportions - from 16.2 to 34.6% (Figure 2.).

It is worth mentioning that two of 5 sampling points with the predominance of PM_{10} particles were located near shipyards "Zvezda" and "Vostok", which can be the sources of pollution with particles sized under 10 µm. By contrast, a very little content of PM_{10} particles was found at the nearby sampling point No. 3.

Table 1. Distribution of particle fractions in snow samples in Bolshoy Kamen, %

Sampling points	Fraction, µm							Mean diameter, µm	Mode, µm
	under 1	1–10	10–50	50–100	100–400	400–700	Over 700		
	Quantity, %								
1	3.1	24.8	27.5	0.2	24.4	20	-	179.24	404.7
2	0.1	0.6	1.8	0.5	21.9	41.9	33.2	590.77	726.2
3	2.1	15	19.3	6.5	24.8	29.8	2.5	255.77	460.85
4	0.2	1.4	3.5	1.3	19.8	44	29.8	561.95	658.77
5	2	18.7	17.9	-	-	5.4	56	568.94	911.59
6	1.6	11.8	13.6	3.9	66.3	32.5	0.3	281.1	418.07
7	0.6	3.9	7.9	2.8	23.8	31.7	29.3	513.59	800.52
8	3.7	30	29.6	0.1	0.8	4	31.8	328.99	882.46
9	3.4	34.6	17.8	-	-	-	-	361.76	800.52
10	0.3	6.9	12	-	-	1.5	79.2	801.02	972.78
11	1	16.2	9.6	-	-	6.6	66.6	667.84	882.46

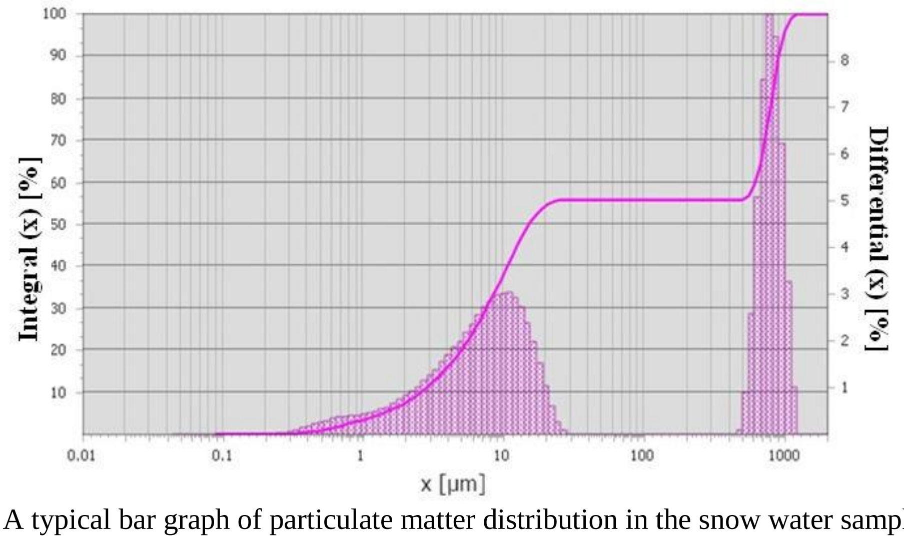

Figure 2. A typical bar graph of particulate matter distribution in the snow water sample collected at Maslakova Str. The percentage of particles under 10 µm is 34.6%.

Another sampling point with a high PM_{10} content (sampling point No. 8) is located near the town's most busy road. It is estimated that vehicle emissions can provide from 50 to 90% of air pollutants in a modern city [13-17], so we can assume that it is the proximity of this sampling station to the road with a busy automobile traffic that produces a high PM_{10} content in the particle size analysis of snow water. The particles of larger size classes (6 and 7 – over 400 μm) prevail in the air of the most area of the town (see Figure 3).

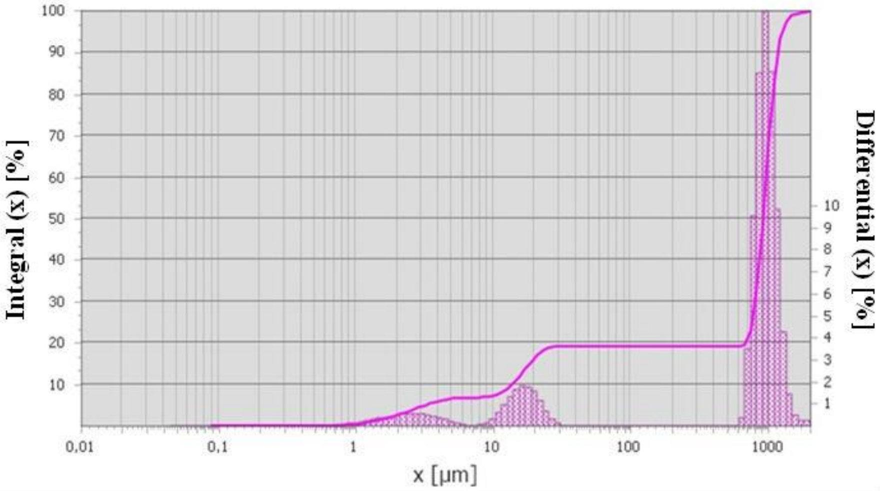

Figure 3. A typical bar graph of particulate matter distribution in the snow water sample collected at Primorskogo Komsomola Str. The percentage of particles over 700 μm is 79.2%.

As we can see, production enterprises and vehicles have little effect on the microscale atmospheric pollution of Bolshoy Kamen at the time of our study. Perhaps one of the reasons for this is the previously closed status of the town (revoked in 2015), restricting the access of large numbers of vehicles to the town, which in modern cities are the major cause of microscale atmospheric pollution [18]. Prolonged exposure to microparticles may have an impact on human and animal health, so periodical monitoring will allow to determine whether the background of microparticles is natural, accidental, or caused by a permanent man-made source.

4. Conclusion

We can conclude that, judging from the sample analysis, that the near-ground layer of atmospheric air of the town contains particulate matter of three main size classes: under 10 microns, 10-50 microns and over 700 microns, as expected. Bolshoy Kamen town can be considered safe in terms of presence of particles under 10 μm (PM_{10}) in the atmosphere. However, the impact of shipyards "Zvezda" and "Vostok" on the microscale atmospheric pollution can not be excluded – two of 5 sampling points with the predominance of PM_{10} particles were located near the shipyards.

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