

Microscale atmospheric pollution of Pogranichny settlement (Primorsky region, Russia)

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Abstract. The paper discusses the study of atmospheric particulate matter in the small urban settlement Pogranichny by means of laser granulometry of snow water. The atmosphere of this settlement is polluted with particles under 10 μm (PM_{10}) to a certain extent. We found microparticles potentially hazardous to health in significant quantities (from 176.3% to 24.9%) in 4 sampling points out of 9. Large particles (sized over 400 μm) dominate on the most territory of the settlement reaching 78.1%.

1. Introduction

In Russia the systematic study of the composition and quality of atmospheric particulates is conducted only in select areas, among them are Arctic and Antarctic [1-4], Siberia [5, 6] and the Far East [7-9]. Previously we have studied small settlements of the Amur Region and the Primorsky Region [10]. Microscale atmospheric pollution was found in some small (in terms of the number of population) towns, villages and settlements [11]. Although the percentage of these findings was not big, and the atmosphere of megacities and industrial towns is more vividly contaminated with microparticles, these studies should be continued, because prolonged exposure to particulate matter can cause a variety of diseases in humans [12, 13].

This paper discussed the study of microscale atmospheric pollution of the small urban settlement Pogranichny, located in the Primorsky Region.

2. Materials and methods

Pogranichny is an urban settlement in the South-west of the Primorsky Region, the administrative center of the Pogranichny district. The distance to Vladivostok is 205 km along the highway, and only 15 km to the border with China. As of 2016 the population of the settlement is 10,179 people (Russian Federal State Statistics Service 2016). The climate in Pogranichny is humid continental with cold and dry winters and warm and wet summers. Western winds prevail in the settlement, and the average annual wind speed is 2.9 mps.

There are no major industrial enterprises on the territory of the settlement. One should only note the Grodekovo railway station (cargo traffic of several million tons). The bulk of the enterprises in Pogranichny are engaged in production of crops and livestock products.

The snow sampling points were selected taking into account the main sources of particulate matter emission – close to the railway station, major roads, boiler houses, and a background sampling point on the outskirts of the settlement (Figure 1).



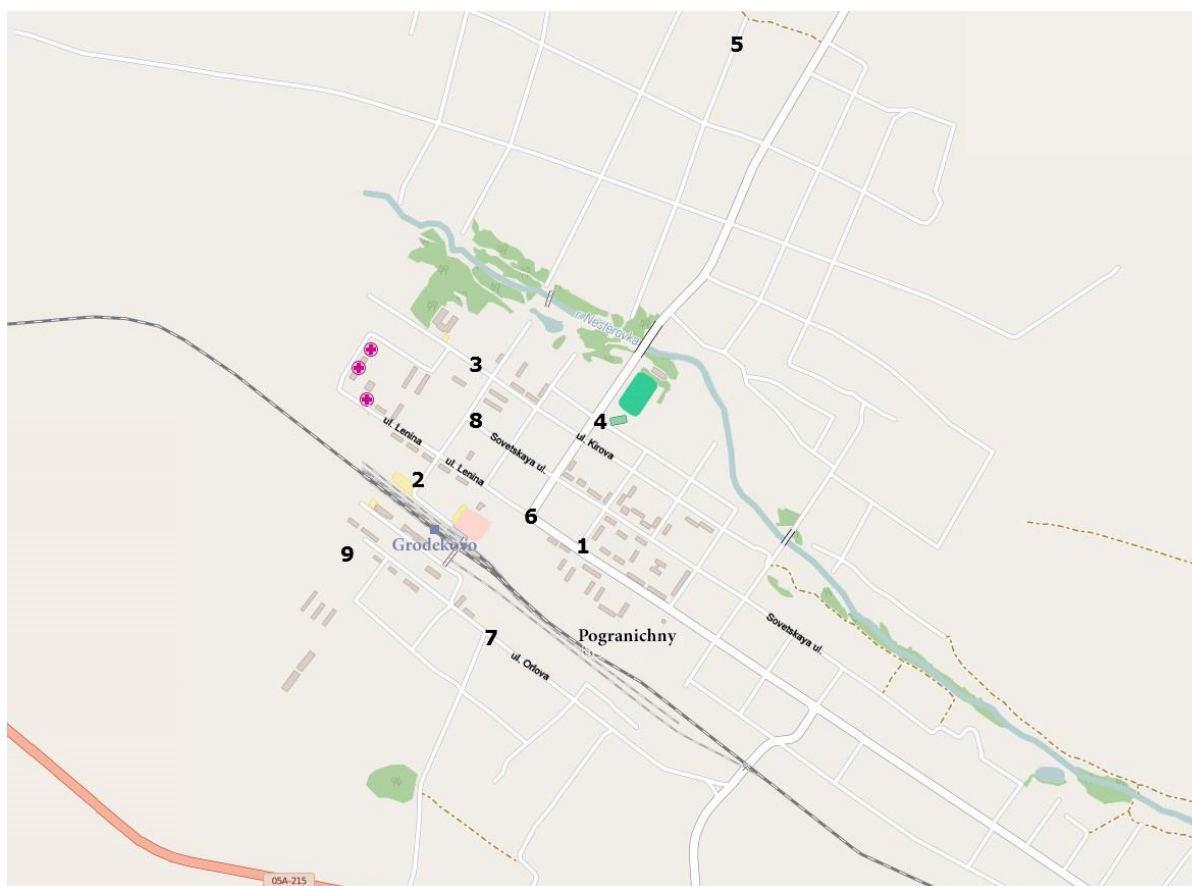


Figure 1. The sampling area in Pogradichny settlement: 1- Budennogo Str., 2 - Gagarina Str., 3 - Kirova Str., 4 - Komsomolskaya Str., 5 - Krasnoarmeyskaya Str., 6 - Lenina Str., 7 - Orlova Str., 8 - Sovetskaya Str., 9 - Shkolnaya Str. OpenStreetMap contributors

The atmospheric precipitation (snow) for the study of the near-ground 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 fresh snow (5-10 cm) from a 1 m² area was collected. It was placed in sterile 2.5-liter plastic containers and transported to the laboratory. After the snow in all containers has melted, each sample amounted to 350-400 milliliters of liquid. The resulting liquid was stirred and a portion 50 ml was taken from each sample for the analysis on the laser particle analyzer Analysette 22 NanoTech plus (Fritsch GmbH, Germany), which can determine the dimensions of the particles and their percentage in a single measurement.

The measurements were carried out using the equipment of the Nanocenter of Far Eastern Federal University (FEFU).

3. Results and Discussion

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

Fine-sized particles (under 1 µm) were found in all the samples, however, their content is negligible. The particles under 10 µm were found in all sampling points in Pogradichny settlement. The content of these particles reaches significant values (from 16.3% to 24.9%) in samples collected at four sampling points: near the railway station, along one of main roads and, interestingly, in the background area. It is most probable that the sources of these particles are small heating enterprises operating on coal and, to a lesser degree, automobiles, which is most common in small settlements with no industrial enterprises [14, 15].

The most pronounced particles size class in all the samples studied is over 400 μm , ranging from 13.7% to 42.3% in various areas of the settlement with the exception of sampling point No. 5, where it constitutes only 4.3%. However, this background sampling point is dominated with particles over 400 μm is size – 49.9%. This trend is observed even at the sampling points located in close proximity to railways and automobile roads, which can be the sources of PM_{10} in the atmosphere in significant quantities [16, 17], and that indicates a relatively favorable ecological situation in these areas.

Table 1. Distribution of particle fractions in snow samples in Pogranichny settlement, %

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	1.7	7.9	6.8	-	20.9	22.2	40.5	566.46	882.46
2	1.8	16.3	17.9	5.6	29.6	28.3	0.5	240.41	431.87
3	2	12.4	8.2	0.9	21.3	17.7	37.5	514.6	882.46
4	2.1	15	11.2	-	16.8	13.7	41.2	516.77	882.46
5	3.4	24.9	13.5	1	3	4.3	49.9	512.45	911.59
6	0.2	0.5	3.2	1.1	31.3	38.7	25	524.54	446.13
7	2.6	17.4	17.2	-	32.7	29.8	0.3	255.41	418.07
8	2.6	23.3	22.9	-	33.3	17.9	-	191.68	367.13
9	0.2	1.5	3.8	1.5	14.9	42.3	35.8	593.66	702.99

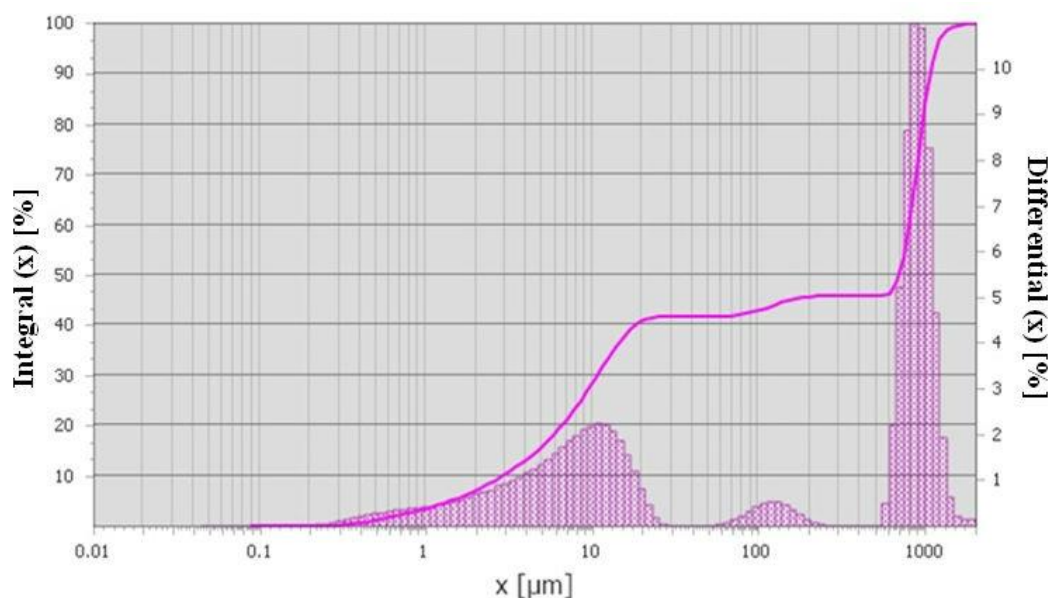


Figure 2. A typical bar graph of particulate matter distribution in the snow water sample collected at Krasnoarmeyskaya Str. (sampling point No.5). The percentage of particles under 10 μm is 24.9%

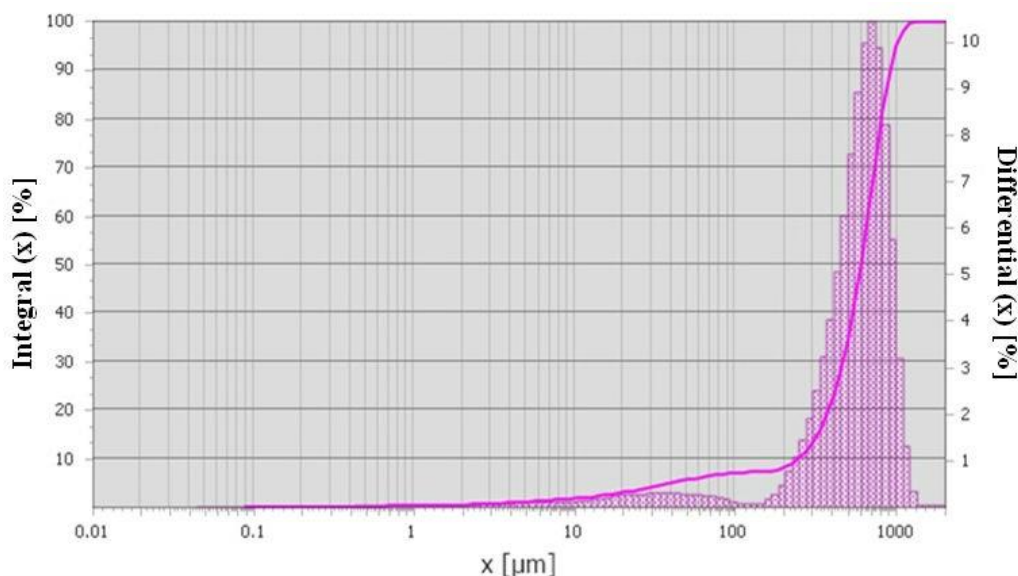


Figure 3. A typical bar graph of particulate matter distribution in the snow water sample collected at Shkolnaya Str. (sampling point No.9). The percentage of particles over 400 μm is 78.1%

As is seen from the above, the railway station and coal-heating have a certain practical influence on the microscale atmospheric pollution of Pogranichny settlement. The general ecological condition is favorable, as the mean diameter of most particles in the samples is above 500 μm .

4. Conclusion

We can conclude that, judging from the sample analysis, Pogranichny settlement can be considered a settlement with low levels of atmospheric pollution. Only in few snow samples from the settlement micro-sized particles were found in significant proportions. This fact is certainly due to the absence of large enterprises, rather low number of population and, consequently, small quantity of vehicles.

One should note that there should be continuous monitoring of the composition of the atmospheric particulate matter in small settlements such as Pogranichny, as there is a trend of increasing man-caused ecological press on natural territories [18]. This study will provide new data for the global system of monitoring over the environmentally important particles (under 10 μm).

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