Microdimensional pollution of the atmosphere of small settlements of the Far East of the Russian Federation

K.S. Golokhvast, V.V. Chaika, P.A. Nikiforov, Yu.S. Doroshev, N.V. Zemlyanaya, A.A. Fatkulin, V.P. Lushpey, Yu.A. Vasyanovich, A.M. Vasyanovich, A.I. Agoshkov

Far Eastern Federal University, 8 Sukhanova street, Vladivostok, 690950, Russian Federation

corresponding author: droopy@mail.ru

Abstract. Paper is devoted to research of atmospheric suspensions of the small cities and settlements of the Far East with the population to 100 thousand persons: Magadan, Belogorsk, Partizansk, Solovyevsk, Orotukan by means of methods of a laser granulometry and scanning electronic microscopy. Atmospheric suspensions were studied in the dropped-out snow which gathered in the different cities at the time of snowfalls from March, 2010 to January, 2013. It is shown that the studied settlements, considering dimension of fractions of atmospheric suspensions and their morphometric characteristics, it is possible to place in the following order on extent of increase of potential health hazard: Orotukan, Solovyevsk, Partizansk, Belogorsk, Magadan.

1. Introduction

The Far East is among the most interesting regions of Russia from the point of view of studying weighed in the atmosphere nano- and microparticles which, undoubtedly, have essential impact on quality of air, climate, people and animals. This interest is caused by a unique geographical arrangement of the cities, their remoteness from each other, low industrial activity and powerful seasonal transfers of air masses in ocean continent system.

Also long distances between the cities, a small amount of the large industrial enterprises and small number of the population are among interesting features of the Far East.

Earlier we investigated the large cities of the Far East: Vladivostok, Khabarovsk, Blagoveshchensk, Biropolizhan, Ussuriisk with the population from 100 to 700 thousand people [1].

This work is devoted to atmospheric suspensions of the small cities and settlements of the Far East with the population to 100 thousand persons: Magadan, Belogorsk, Partizansk, Solovyevsk, Orotukan.

2. Materials and methods

2.1. Samples area

Magadan - the city (an administrative center of the Magadan region) with the population of 95,9 thousand persons. It is located in the permafrost region, round hills on the bank of the Tauysky Bay.
Sea of Okhotsk, on the isthmus connecting the peninsula to the continent between bays of Nagayev and Gertner. For Magadan the subarctic climate with lines of the sea is characteristic. Winter long, summer short and cool. The industry is founded on an energy drink and fishery. Selection was made in the downtown, near the highway.

Belogorsk - the city in the Amur region with the population of 75,16 thousand people. The city is located on the Tom River (inflow of Zeya). In Belogorsk sharp and continental climate with monsoonal lines and sharp prevalence of a summer precipitation. Winter cold, dry, with low-power snow cover. In the city of 7 boiler rooms (the downtown, to the area Amurselmash, to Gore's region) and Belogorsky shinoremonnty plant. Selection at station was made around school No. 200 to Lenin St. address, 16. Nearby there is a highway and at distance about 1 km – the boiler room supplying with heat the downtown.

Partizansk - the city in Primorsky Krai with the population of 38,6 thousand people. It is located in a valley of the river Guerrilla. The city is surrounded by hills, their height generally 250 meters, some reach height of 500 meters. Climate of monsoonal type with warm damp summer and in the cold low-snow winter. Prior to the beginning of the end of the 1990th years Partizansk was the diversified industrial center, with prevalence of the coal industry. In 2008 coal mining in the village of Uglekamensk is stopped. In 10 km to the South from Partizansk, there is the Partizansky state district power station supplying with electricity all southeast of Primorye. The large railway station and locomotive depot Partizansk work. Tests of snow gathered in one point in the downtown.

Solovyevsk – the village (earlier the settlement) in the Amur region with the population of 3 thousand people. The large enterprises of the industry and others, except a boiler room, aren't present sources of dusting. Selection was made in the settlement center, near the highway.

Orotukan - the settlement of city type in the Magadan region with the population of 2,1 thousand people. Orotukan between medium- to-high hills is located on the right river bank. Orotukan's city-forming enterprise was the plant of the mountain equipment (OZGO) which existed from 1930th to 2005. Till 2002 in Orotukan there was an Orotukansky Mining and Processing Works (OMPW). For today large sources of dusting, except a boiler room, aren't available (www.orotukan.ru). Sampling was made in the settlement center, near the highway.

2.2. Methods

Atmospheric suspensions were studied in the dropped-out snow which gathered in the different cities at the time of snowfalls from March, 2010 to January, 2013. To exclude secondary pollution by anthropogenous aerosols, the top layer (5-10 cm) just dropped out snow was built. It placed in the 3 litre sterile containers. Through a couple of hours when snow in containers thawed, liquid shook up and from each sample gained 60 ml of liquid and analyzed on the laser analyzer of particles Fritsch Analysette 22 NanoTech (Germany). The analysis of samples carried out on a scanning microscope Hitachi S-3400N (Japan). Samples become covered by platinum.

3. Results and discussion

Analyzing earlier received results [1], it is possible to divide aerosol particles by the sizes into seven classes: 1) from 0,1 to 1 micron (there corresponds PM1), 2) from 1 to 10 (there corresponds PM10), 3) from 10 to 50 microns, 4) from 50 to 100 microns, 5) from 100 to 400 microns, 6) from 400 to 700 microns and 7) more than 700 microns. The sizes of particles and percentage ratio of fractions in suspension tests in all settlements are specified in Table 1.
Distribution of particles in snow on fractions in different settlements

Table 1

| Ø, mkm | Magadan | Belogorsk | Partizansk | Solovyevsk | Orotukan |
|--------|---------|-----------|------------|------------|---------|
| less than 1 | - | - | - | - | - |
| 1 - 10 | 2-3 | 2-3 | 2-3 | 2-3 | 7-9 |
| 13% | 1% | 2% | 1% | 3% |
| 4-5 | 4-6 | 4-7 | 7% | |
| 9% | 7% | 7% | | |
| 8-12 | 5-7 | 4-10 | 7-12 | 9-12 |
| 26% | 6% | 33% | 13% | 9% |
| 7-10 | 11% | | | |
| 10 - 50 | 12-20 | 20-40 | 25-30 | 15-18 |
| 52% | 33% | 30% | 8% | 13% |
| 12-15 | | | | |
| 50 - 100 | | | | | |
| 50-100 | 50-100 | 50-80 | 70-100 | 3% |
| 35% | 13% | | | |
| 100 – 400 | | | | | |
| 100-400 | | | | 300-400 | 3% |
| 400 - 700 | | | | | |
| 400-700 | | | | | |
| more than 700 | | | | | |
| more than 700 | | | | | |

More detailed morphometric characteristics of particles of the suspension found in snow, are given below (table 2).

Table 2

| Parameters | Magadan | Belogorsk | Partizansk | Solovyevsk | Orotukan |
|------------|---------|-----------|------------|------------|---------|
| Arithmetic Mean Diameter [µm] | 9,68 | 18,84 | 34,12 | 28,98 | 607,93 |
| Mode [µm] | 12,56 | 26,39 | 66,76 | 39,71 | 1003,37 |
| Median [µm] | 11,01 | 17,50 | 27,45 | 27,88 | 920,10 |
| Variance [µm²] | 13,61 | 67,26 | 729,08 | 289,96 | 195739,65 |
| Mean Square Deviation [µm] | 3,69 | 8,20 | 27,00 | 17,03 | 442,42 |
| Coefficient of Variation [%] | 38,12 | 43,54 | 79,14 | 58,75 | 72,77 |
| Spec.Surface Area [cm²/cm³] | 8405,72 | 4326,28 | 4400,28 | 3462,35 | 1621,01 |

If to compare granulometric characteristics of suspensions in the studied settlements, it is possible to make some conclusions.

First, the qualitative structure of suspensions of all studied settlements is rather similar, and, judging by scanning electronic microscopy, for 80-90% consists of particles of natural minerals. It can do, is explained by that all these settlements are mainly on plains and in formation of suspensions in these territories the soil erosion is of great importance. Also It should be noted lack of large sources of...
dusting - combined heat and power plant and industrial facilities. The picture of qualitative structure of atmospheric suspensions typical for the small cities, on the example of Belogorsk, is given in figure 1.

Fig. 1. Typical suspension of small settlements (Belogorsk, winter 2011-2012). Scanning electronic microscopy in secondary electrons. Magnification x470.

Except natural components of suspensions, is, judging by morphology, and technogenic microparticles which condemn close attention of experts in the field of environmental protection. In tests practically all settlements in soot and a coal dust (according to the power dispersive analysis) microparticles of metals - Fe, by Zn, Cr, Cu, Ba are often found.

To be necessary to note rather enough high maintenance of suspensions belonging to the class PM10 in the studied cities and settlements (from 12% in Orotukan to 48% in Magadan). These particles from the point of view of environmental monitoring are considered dangerous, but considering their natural genesis (by results of scanning electronic microscopy), it should be taken into account them rather safe for health of the person.

It is important that despite the small sizes of particles (2 and the 3rd classes on our classification), they possess rather small area of a specific surface that besides testifies to rather safe ecological situation as it is considered that on a surface of particles various toxic substances are occluded. Therefore, the specific surface is higher, the danger of particles is higher.

4. Conclusions

As a result, the studied cities can be placed in the following order on extent of increase of microdimensional pollution of the atmosphere, according to morphometric and qualitative characteristics of particles of suspensions: Orotukan, Solovyevsk, Partizansk, Belogorsk, Magadan.

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References
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