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НЕРАСТВОРИМЫЕ ЧАСТИЦЫ В СНЕГЕ ШПИЦБЕРГЕНА (ВЕСЕННИЙ СЕЗОН, 2008–2014)

PARTICULATE MATTER IN SNOW ON SVALBARD (SPRING SEASONS, 2008–2014)

Аннотация. *В программе представлен анализ результатов полевых исследований на Шпицбергене, выполненных в период с 2008 по 2014 годы в рамках Норвежско-Российского сотрудничества по проектам NorthPOP, SvalPOP и при поддержке РФФИ (14–05–21382 мол_а).*

Ключевые слова: *состав снега, нерастворимые частицы, концентрации нерастворимых частиц, поток нерастворимых частиц, Шпицберген, Арктика.*

Summary. *Results of field studies on Svalbard performed in 2008–2014 during Norwegian-Russian collaboration in the frame of NorthPOP, SvalPOP projects and with support of Russian Foundation for Basic Research (RFBR), project mol_a 14–05–21382, are discussed.*

Key words: *composition of snow, particulate matter (PM), concentration of PM, fluxes of PM, Svalbard, Arctic.*

Introduction

The vulnerable Arctic environment makes the local nature highly susceptible even for minor climatic changes. Studies of snow cover in Svalbard are essential for getting better understanding of the climatic and environmental change in the Arctic and also provide detailed studies on modern processes of snow and ice [3; 7]. Snow and ice cover large area of the Arctic (approximately 60% of Svalbard is year around covered by snow and ice) and act like a mirror reflecting most of incoming solar energy back to space. Melting of snow and ice thus enhance the temperature and leads to increased melting. This self induced continued warming can result in very rapid climatic changes when approaching a threshold or tipping point. Recent repots clearly indicate that large changes in ecosystem compositions with tremendous implications for the human populations of the North must be expected in the Arctic [1; 9; 10; 12]. Particulate matter (PM) in snow is extremely important and can change characteristics and properties of snow, such as changing of albedo and the resulting radiation balance [8].

Snow pits contain all-the-winter accumulation of PM trapped with snow. Dating these particles relatively to the pit stratigraphy doesn't give clear understanding because of changing of weather conditions (melting and freezing the snow pit layers) during the entire period of nine months from September till May [16], but gives precise information of winter atmosphere composition.

The major anthropogenic emission sources at Svalbard are coal mining, energy production and transportation. The coal mining activities in Svea and Barentsburg include in addition to the coal production, transportation with heavy duty vehicles, stationary machinery, as well as transportation of coal related products on marine vessels. Svea, Longyearbyen (Gruve 7) and Barentsburg produce commercial coal mining. Piramiden (the second largest coal mine at Svalbard) was closed in 1998. Natural emissions of pollutants from coal transportation and storage in uncovered piles are substantial [11; 21]. Coal is the primary fuel for the local production of electricity and heat at Svalbard. The power plants are located in Longyearbyen and Barentsburg. These plants supply energy mainly for electricity, the mining activities, as well as local households and official buildings including the airport in Longyearbyen. Transportation is divided in land based transportation (private cars, heavy duty vehicles and snowmobile), shipping (cruise, research vessels, goods, coal) and aviation (domestic, international and local).

Local emissions of anthropogenic pollutants contribute significantly to the total deposition on Svalbard. Pollutants such as soot and black carbon are important for global warming both as the compound that heats the atmosphere, and as a contributor to accelerated melting when deposited on snow and ice. Preventing snow and ice melting on Svalbard and in the rest of Arctic region is a key factor to ensure a sustainable future. In this context it is important not only to abate global emissions of short-lived climate pollutions, but to prevent increase in emissions of them also from local sources within the Arctic itself.

The main purpose of the paper is to get and expand new data on particulate matter and in Svalbard snow in the vicinities of living centers, to understand their main sources and environmental implication.

Materials and methods

Research is focused on the area in the vicinities of living centers on Svalbard archipelago (Longyearbyen and Barentsburg) and the main tourist attracted snowmobile track close to these settlements: vicinity of Grumantbyen abandoned settlement, glacier Grønfjordbreen, Adventdalen valley and vicinity of Gruve 7 (Fig. 1).

All snow samples were collected, stored and melted in clean polyethylene bottles. Each collection was done in the up-wind conditions on the 200 m distance from the snow mobile. Samples were melted and filtrated in University Centre on Svalbard (UNIS) using pre-weighted nuclear-pore lavsan (polyester) filters (47 mm in diameter, 0.45 μm pore size). Melted samples were filtrated on 3 parallel filters to minimize the random error of filtration.

Morphology of particles, qualitative estimation of composition and proportion of biogenic, mineral and anthropogenic particles in insoluble aerosols was carried out using a segment of a filter by scanning electron microscopy in P. P. Shirshov Institute of Oceanology RAS, Moscow, using JSM-U3 microscope (Jeol Inc., Japan) with magnification from 100 to 10000 times and in Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow.

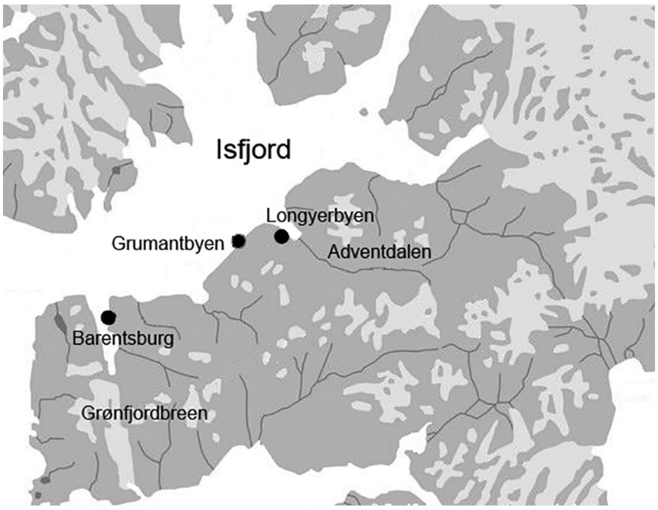

Fig. 1. Location of the snow sampling sites

Fluxes of PM were calculated using data on PM from integrated snow samples from snow pits [13; 14].

Results

Fresh snow samples were collected in Barentsburg each week from January to April in 2008 and 2014. Concentration of PM in these samples varied from 2.4 to 158.5 mg/l. Average concentration of PM in fresh snow during this period was 34.7 mg/l in 2008 and 57.8 in 2014. In 2009 concentration of PM in the same area varied from 7.0 to 44.9 mg/l, in average 25.9 mg/l, in 2010 and 2011 it was in average 21.7 and 27.0 mg/l. Such high concentration of PM in the Barentsburg area are comparable with concentration of PM in samples, collected in the vicinity of Gruve 7, on average they were 16.8 mg/l in 2009. In April 2009 concentration of PM in the samples from the Grumantbyen and Longyearbyen, also Grønfjordbreen and Adventdalen areas are on the background level (from 0.9 to 4.2 mg/l), comparable to the Arctic region with concentration on average from 0.36 to 5.8 mg/l [3; 5; 6; 19]. In 2014 average concentration of PM in fresh snow in the vicinity of Barentsburg was 2 times less than in Longyearbyen (Table 1).

In April, 2008, 2009, 2011 and 2014 integrated snow samples from snow pits were collected. Using PM concentration data from integrated samples from snow pits, fluxes of PM on the land surface were calculated for the areas with high anthropogenic impact: from 33.7 to 24.4 mg/m^2 per day in the vicinity of Gruve 7 and from 41.3 to 61 mg/m^2 per day in Barentsburg. Maximum flux of PM from atmosphere to the surface was found in 2011 in the vicinity of Barentsburg — 216 mg/m^2 per day. Such high concentration of PM in melted snow can be typical

Table 1

Concentration of PM in 0.45-μm-filtered melt water from snow in the vicinities of Barentsburg and Longyearbyen, Svalbard

Date of snow sampling	Area of snow sampling	Concentration of PM, mg/l	Fluxes of PM, mg/(m^2 per day)
winter 2008	Barentsburg	2.4–158.5 **34.7**	36.0
April 2009	Barentsburg	7.0–44.9 **25.9**	61.0
	Gruve 7	15.0–18.7 **16.8**	no data
	Adventdalen	0.9–8.6 **4.2**	
	Grønfjordbreen glacier	2.3–3.2 **2.7**	
	Longyearbyen	1.8–2.8 **2.3**	
	Grumantbyen	0.7–1.2 **0.9**	
February — March 2010	Barentsburg	4.6–31.9 **21.7**	130.2
	Longyearbyen	1.8–18 **10.8**	64.8
April 2011	Barentsburg	15.0–45.9 **27.0**	216.0
	Gruve 7	5.2–18.7 **15.9**	no data
	Longyearbyen	2.0–30.1 **13.2**	105.6
March — April 2014	Barentsburg	30.2–108.9 **57.8**	29.3–170.9 **68.8**
	Longyearbyen	81.8–123.9 (1775.1*) **102.9**	112.5

* sample with the highest concentration of PM in snow, that is not considered in calculating of mean value

for industrial cities in the North and they are connected with local manmade emissions and weathering of the coal containing sediments. Airborne effect is found and clearly visible as the darkest snow that is found in the downwind from the processing plant, in the vicinities of the mines and along the snowmobile tcracks.

According to the data of scanning electron microscopy PM in snow consist largely of mineral and anthropogenic particles (soot and fly ash). In the vicinity of Barentsburg and Mine 7 ratio between anthropogenic and mineral particles is 90/10, in Longyearbyen area — 70/30. In these regions anthropogenic particles are presented by porous fly

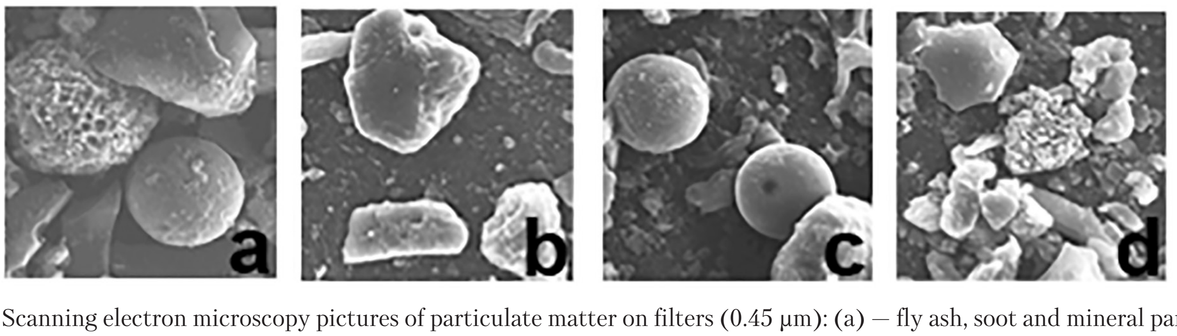

Fig. 2. Scanning electron microscopy pictures of particulate matter on filters (0.45 μm): (a) — fly ash, soot and mineral particles (Barentsburg, 2009); (b) — mineral particles (Barentsburg, 2009); (c) — soot (Longyearbyen, 2010); (d) — mineral and fly ash particles (Adventdalen valley, 2010); size of each picture — 50*50 μm.

ash particles from 7 to 30 μm in size consisting mostly of carbon and smooth spheres from 0.5 to 10 μm in diameter are present. As it was pointed out earlier, anthropogenic particles are deposited locally with the largest particles closest to the source and flocculation of particles of high concentration [2]. In the areas with background level of concentration of PM, anthropogenic/mineral ratio varies from 60/40 to 30/70 in different samples. These areas are not affected by mining activities and soot, fly ashes came from incomplete combustion of fuel of snowmobiles. These areas are the major snowmobile tracks attracting by tourists on Svalbard [15]. Biogenic particles were not found in the samples.

Conclusions

Snow samples were collected in the period 2008–2014 in the Isfjord and Grønfjord areas. Analyses of PM in melted snow samples showed that inter-continental pollution transport cannot be detected because of the big amount of local pollution. The local mining industry is the predominant source of pollutants with respect to emissions of coal dust during storage in unprotected opened piles. In the remote areas from mining activities and power plants areas (Adventdalen valley, Grumantbyen abandoned settlement, Grønfjordbreen glacier), where concentrations of PM in melted snow are on the background level, snow scooters are the main source of pollution.

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СТАТИСТИЧНА ОБРОБКА ГІДРОГЕОЛОГІЧНИХ ДАНИХ З ПРОПУСКАМИ

ОБРАБОТКА ГИДРОГЕОЛОГИЧЕСКИХ ДАННЫХ С ПРОПУСКАМИ

STATISTICAL ANALYSIS OF GEOLOGICAL DATA SPACES

Анотація. *Проведено статистичну обробку даних з пропусками для коректного відображення даних та точної побудови карт.*
Ключові слова. *Пропуски, підземні води, вихідні дані.*

Аннотация. *Проведено статистическую обработку данных с пропусками для корректного отображения данных и точного построения карт.*
Ключевые слова. *Пропуски, подземные воды, выходные данные.*

Abstract. *A statistical analysis of data from a space to display the correct data and accurate mapping.*
Keywords. *Gaps, underground water output.*

Постановка проблеми. У зв'язку зі зростанням значення підземних вод у водопостачанні України, виникає необхідність постійного моніторингу підземних вод, аналізу та оцінки гідрогеологічних процесів, прогнозу можливих змін підземної гідросфери. Вивчення та прогнозування режиму рівнів підземних вод займають провідне положення в комплексі гідрогеологічних досліджень, оскільки дозволяють кількісно охарактеризувати процес формування підземних вод і прослідкувати зміни гідрогеологічних умов