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Snow cover studies using the example of Polish cities: Review

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Abstract

The article reviews the studies of snow cover abroad using the example of the cities of Poland. In two cities of Poland (Ostrovets-Swietokrzyskie and Poznan), the chemical composition of snow cover samples was determined using analytical equipment, and the physical parameters of the snow cover for the period 1952-1990 were determined from the data of meteorological stations in Poland (height of snow cover, period of snow cover, the first and the last days of the snow cover). The obtained results on the chemical composition of snow samples were compared with the background values provided by meteorological stations.

Keywords: Snow cover, air quality, dust, atmospheric air;

1. Introduction

Snow cover is a valuable source of information about the state of air quality. Its use as an accumulator of potential pollutants is widely known in Europe and in the world. Heavy metals that enter the air and then the snow cover together with precipitation can come from local sources (home stoves, car exhaust, thermal power plants), and from remote, transported from considerable distances. With the help of snow cover, it is possible to determine the qualitative and quantitative composition of atmospheric emissions, as well as to assume possible sources of their receipt. Accumulation and transformation of chemical elements in a snow cover have an impact on groundwater, terrestrial environment and human health. Russian [1, 2, 3, 5, 8, 9] and foreign [4, 6, 7] scientists are actively engaged in the study of snow cover. This article presents the review of snow cover research from Poland by International scientists.

2. Methods

To study the question of studying snow cover in other countries, three articles were analyzed in which the authors are studying the chemical composition and physical properties of snow cover in several cities in Poland.

In the town of Ostrovets-Swietokrzyskie, on January 31, 2017, 18 snow samples were taken within a radius of 7-9 km from the metallurgical plant. The study area is located in the Kamenna river valley and within the Keleck Upland. Snow samples were transported in polyethylene containers to the Environmental Research Laboratory of the Department of Environmental Protection and Modeling of the Jan Kochanowski University in Kielce. Then, the physicochemical properties and chemical composition of water samples from melted snow were analyzed [7]. In the

snow cover of this territory, a number of indicators were determined, such as chemical composition, electrical conductivity, pH value, and took into account the minimum and maximum air temperature, snow cover thickness, wind direction. An ICP-MS-TOP spectrometer was used to determine the concentrations of heavy metals. The Hach HQ 40d multi-parameter water quality meter with electrodes was used to measure pH and conductivity. To control the quality of the results obtained, certified reference materials were used.

In the city of Poznan, there is a large number of enterprises that can be technogenic sources of emissions of chemical elements. Such enterprises are power plants, domestic coal-fired ovens, landfills for domestic waste, cement plants, industrial enterprises for the production of metals and paints, smelting and incineration of waste, and agriculture [7].

Snow samples were collected in January, February and March 2013 in the city, located on the main campus of Adam Mickiewicz University. The sampling site is an urban area subject to anthropogenic sources such as fuel combustion, industrial processes and the minor role of heavy traffic. In addition, 5-10 km from the sampling site, there are such sources of pollution, such as a metallurgical plant, household boilers, waste incineration, and rail freight transport. Snow cover studies were carried out on a flat surface and away from buildings in order to exclude the influence of particles entering the atmospheric air in winter when heated, as well as soil contamination because of re-weighing. When sampling snow, plastic bags and gloves were used to avoid contamination of samples with extraneous sources [7]. Each snow sample was divided into layers 1, 2 and 3 cm thick. Each sample was placed in a cleaned plastic bag and then taken to the laboratory for analysis. Three snow samples were taken immediately after the snowfall to prevent dust from entering the samples. After the snow melted in closed bags, acid (HNO3) was added to the samples and frozen until analysis. This approach makes it possible to determine the total concentration of chemical elements in snow samples. The dishes for the analysis were thoroughly cleaned: the dishes were kept in nitric acid for two days, washed, dried, and stored in plastic bags.

In the samples of the snow cover, the chemical composition of the snow cover was determined taking into account meteorological factors that can affect the inter-seasonal variability. The depth of the snow cover was measured at the sampling site with a polyethylene stick. The total concentrations of chemical elements (Cd, Pb, Cr, Cu, Ni, As) were determined by atomic absorption spectrometry. Zinc in snow samples was determined based on measurements in a flame [6].

In addition to studying the elemental composition of snow cover samples, studies are being carried out on the variability of the main characteristics of the snow cover, such as the depth of snow cover, the number of days with snow cover, and the dates of the beginning and end of the snow cover. Polish scientists analyzed observations of 43 stations in Poland from 1952 to 2013. This study analyzed the daily snow depth from 43 stations in Poland. The study of the data began on October 1, 1951 (38 meteorological stations) or later (5 stations) and continued until December 31, 2013. Shorter series of observation data relate to stations in: Rzeszow (data starting from 1952), Nowy Sach and Lesko (since 1954), Terespol (since 1955) and Leshno (shortest time series since 1958) [7].

Based on the time series of daily observations of the snow depth, the following characteristics of the snow cover were estimated:

- the average value of the height of snow cover for each month of the cold half-year (from October to April) in cm;
- the average value of the snow cover height for the winter (December, January and February) in cm;
- the maximum value of the height of the snow cover for the winter (December, January and February) in cm;

- the number of days with snow cover each winter (December, January and February) and the average number of days with snow cover in December, January and February;
- the number of days with snow cover during the snow season (from early October to late May);
- the first day with snow cover every winter and the average date of snow cover in winter;
- last day with snow cover in winter and average date of disappearance of snow cover in winter.

Hydrospect 2.0 software (Radziejewski and Kundzewicz 2000) was used to detect existing changes / trends in the snow cover time series.

3. Results

As a result of the study of the physical properties of the snow cover in Ostrovets-Swietokrzyskie, it was revealed that according to the results of the study in the 2016/2017 season, the number of days with snow was 46 days. The first day with snow cover (1 cm thick) was December 3, 2016, and the last day was April 15, 2017. Between these dates the snow cover disappeared several times. Until the day of sampling of the snow cover (January 31, 2017), the snow cover was continuously for 4 weeks. At this time, he was a collector of pollutants that had settled on his upper layer [4]. The maximum thickness of the snow cover was recorded in January 2017 and amounted to 5 cm. According to weather stations, the minimum daytime temperature was below 0 degrees for almost the entire period, which contributed to the strengthening of the snow cover and, probably, increased the emissions of pollutants in the municipal sector. During the period of prolonged snow cover (January 3-31, 2017), winds of the western and south-western directions were observed.

All snow samples had slightly elevated and elevated pH values. Samples with pH> 6.5 accounted for almost 80% of the snow samples. The arithmetic mean of the pH of the analyzed snow samples was 7.38 (with a range from 6.31 to 10.18). The average values of the specific electrical conductivity of the samples were 4.15 MC · M^{-1}. Among the ions found in the snow samples, the highest concentrations were found for the calcium cation Ca^{2+} and the sulfate anion SO_4^{2-} [6].

The chemical composition of snow samples is also different. The increase in Fe and Ni concentrations was clearly visible in the immediate vicinity of the metallurgical plant. In the case of Fe, the concentration of this metal in samples taken in the southern part of the study area was about 50 mg·dm^{-3} and increased to 157.13 mg·dm^{-3} in its central part. In the same profile, the concentrations of Ni and Al increased from 0.15 mg·dm^{-3} to 1.16 mg·dm^{-3} and from 3.15 mg·dm^{-3} to 21.64 mg·dm^{-3}, respectively. The increase in Cr concentration was noticeable between the steel mill and the city center, and in the area south of the steel mill. The spatial distribution of the concentrations of Pb, Cd, Co and Zn showed no clear connection either with the area of the steel plant or with the city center. High concentrations of Pb, Cd and Zn were observed, in particular, in a snow sample collected about 6 km north of the metallurgical plant.

Based on the analysis of the distribution of concentrations and the location of sampling sites, it can be assumed that the dominant source of pollution within these groups was road transport and deposition of pollutants transported from local and regional sources. There are also interesting patterns in comparing the study area with the background areas. Near Ostrowiec Świętokrzyskie, the average concentrations of zinc were 2.6 times lower, copper 11.7 times lower, cadmium 27.3 times lower and lead 266.6 times lower than in Innsbruck. Studies of snow samples collected in Ostrava made it possible to compare the concentrations of Cu, Pb and Fe. Their concentrations were much more diverse. Fe concentrations were twice as low, but Pb and Cu were several hundred times higher (Pb 113 times, Cu 1649 times) than in Ostrava.

In the samples of snow cover taken in the city of Poznan, the minimum pH was 3.93 and the maximum was 6.12. The maximum concentrations of some elements were not observed during the same snow events, which indicates the difference in the conditions for the formation of the snow cover, the influence of industrial emissions and temperature fluctuations. The maximum As

concentrations were found in the samples taken in March, and the minimum concentrations in the samples taken in February. High concentrations of Pb and Zn were found in the snow samples taken in January, but the average Zn value was highest in the snow samples taken in January, in contrast to Pb, indicating the contribution of various emission sources. The maximum concentration of Cr and Pb was measured in the samples during an experiment conducted in January. Cr and Pb concentrations dropped sharply during the second snowfall in January. The lowest concentrations of these chemical elements were recorded in March. An increased Ni content was observed during an experiment conducted in February; the maximum concentration of Ni was found in March. The results show a strong influence from industrial emissions, for example, iron and steel processing, non-ferrous smelting and waste incineration (Cu). Ni and Cu can be released during fuel combustion. As (indicator of sources of ignition) was not associated with any of the main components. The revealed factors point to a strong influence of anthropogenic sources on the chemical composition of snow. High concentrations of Pb, Cr, Cu and Ni can be associated with the transport of air pollutants from remote industrial areas [4].

Studies of the physical properties of the snow cover according to the data of meteorological stations in the cities of Poland showed that the average height of the snow cover in winter in the period 1952–2013 ranges from 2.2 to 11.8 cm (with the exception of mountainous regions, where the depth of the snow cover is much higher). The lowest average snow depth is typical for the western part of lowland Poland, and the highest for the northeastern part (Suwałki region). Comparing the intervals 1952–1990 and 1991–2013, we can conclude that the period 1952–1990 was more snowy (in terms of the average depth of snow cover) at 38 out of 43 analyzed stations.

The maximum height of snow cover in winter 1952–2013 ranges from 34 cm (Poznan, Slubica) to 85 cm (Krakow), excluding mountainous areas. The maximum height of snow cover in winter, recorded in the period 1952–2013. In most cases is equal to the maximum value recorded in the period 1952–1990. If in the period 1952-1990. The maximum value of the depth of snow cover was recorded at 39 stations, then for the period 1991–2013 - only at four stations. 1963 and 1979 are absolute record holders. During these years, the maximum depth of snow cover fell at 13 and 12 stations, respectively.

Average number of days with snow cover over the period 1952–2013 ranges from 29.6 days (Szczecin) to 65.8 days (Suwalki). If we take into account the entire snow period, including the non-winter months (October, November, March, April), the average number of days with snow cover in Poland is 60.6 days (excluding mountain stations).

On the territory of Poland, the average day of appearance of snow cover in winter for the analyzed period 1952–2013 is November 23. The average day for the disappearance of snow cover in Poland is March 26-28. The earliest disappearance of snow cover occurred on 22 November 1989 in Szczecin [4].

4. Conclusion

Thus, in the cities of Poland, research is being carried out to study the snow cover to analyze the chemical composition and physical parameters. In the cities of Ostrovets-Swietokrzyskie and Poznan, the chemical composition of snow cover samples was determined and possible sources of chemical elements were identified. Investigations of physical parameters using weather stations in Poland for the period from 1952 to 1990 showed physical changes in snow cover (height of snow cover, periods of occurrence, first and last days of occurrence of snow cover).

References

1. Alekseeva, M.N., Raputa, V.F., Yaroslavtseva, T.V., Yashchenko I.G. (2020). Estimation of air pollution due to gas glaring from remote observations of flare thermal radiation. *Atmospheric and Oceanic Optics*. Vol .33. Is. 3. pp. 289–284
2. Belan, B., Buchelnikov, V., Lizova, V., Simonenkov, D., Talovskaya, A., Tentyukov, M., Yazikov, Y. (2019). Estimation of the Effect of Meteorological and Orographic Conditions on Aerosol Contamination of the Snow Cover in the South of Tomsk Region. *Atmospheric and Oceanic Optics*. Vol. 31. Is. 6. pp. 656-664.
3. Kasimov, N.S., Kosheleva, N.E., Vlasov, D.V. and Terskaya, E.V. (2012). Geochemistry of snow cover within the eastern district of Moscow. *Vestnik Moskovskogo Unviersiteta*. Seriya Geografiya. 4. pp. 14–24.
4. Małgorzata Szwed, Iwona Pinskwar, Zbigniew W. Kundzewicz, Dariusz Graczyk, Abdelkader Mezghani (2017). Changes of snow cover in Poland. *Acta Geophysica*, pp. 65–76.
5. Osipova, N.A, Filimonenko, K.A., Talovskaya, A.V., Yazikov, E.G. (2015). Geochemical approach to human health risk assessment of inhaled trace elements in the vicinity of industrial enterprises in Tomsk, Russia. *Human and ecological risk assessment*. 21. pp. 1664–1685.
6. Patrycja Siudek, Marcin Frankowski, Jerzy Siepak (2015). Trace element distribution in the snow cover from an urban area in central Poland. *Environmental Monitoring and Assessment*. Vol. March 2015. pp. 187-225.
7. Rafal Koz£Owski, Miroslaw Szwed, Krzysztof Jarzyna (2018). Analysis of snow pollutants in an industrial urban zone near the city of Ostrowiec Swietokrzyski. *Ecological Chemistry and Engineering*. Vol 25 (1), pp. 7-18.
8. Shevchenko, Vladimir P., Vorobyev, Sergey N., Krickov, Ivan V., Boev, Andrey G., Lim, Artyom G., Novigatsky, Alexander N., Starodymova, Dina P., Pokrovsky, Oleg S. (2020). Insoluble particles in the snowpack of the Ob River Basin (Western Siberia) a 2800 km submeridional profile. *Atmosphere*. No. 11. pp. 1184.
9. Yanchenko, N.I., Belykh, L.I., Slutsky, S.L., Lanko, A.V. (2016). Polycyclic aromatic hydrocarbons in solid residue and volatile organic compounds in snow cover filtrate of Bratsk. Bulletin of the Tomsk Polytechnic University. *Geo Assets Engineering*. V. 327. Is. 2. pp. 52–58.