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Air pollution with sulphur dioxide and fluorine compounds in the vicinity of the Arctowski Station, King George Island, South Shetland Islands *)

ABSTRACT: The measurement of SO₂ and fluorine compounds concentrations in the air at 8 points on the King George Island, South Shetland Islands, were done in January and February 1979. The received values were similar to the ones for regions recognized as the world background areas. The activity of the Polish Antarctic Station did not influence the air pollution status neither in its surroundings, nor in penguins colonies and extinct volcano areas on Penguin Island.

Key words: Antarctic, King George Island, air pollution, SO₂, fluorine compounds

1. Introduction

The Antarctic can be recognized as the most distant area from the world air pollution sources. Therefore, the air pollutant concentrations found there data on the time changes of air pollution in the Antarctic in spite of a numerous research stations in the region. Stern (1976) gives the only values of SO₂ concentrations for the Antarctic area (0.0009 to 0.0029 mg · m⁻³). It is interesting to find how man's activity in this area influence the local air pollution. During the Third Antarctic Expedition of the Polish Academy of Sciences the workers of the Botanical Garden of the Polish Academy of Sciences started the investigations on the above mentioned subject. The control points for the determination of SO₂ and fluorine compounds concentration — some small sources of air pollutants — fuel power station and ships arriving to Admiralty Bay. In the above way we tried to determine the levels of SO₂ and fluorine compounds in the air, resulting from man's activity.

*) Studies were carried out during the Third Antarctic Expedition of the Polish Academy of Sciences in 1978/1979.

2. Area and methods

2. 1. Study area

The localization of control points is presented in Figs. 1 and 2. Their numbers rise with an increasing distance from the Station.

Points No. 1 was fundamental for the studies as it was situated near the meteorological booths and buildings of the Station, including the building housing the engines generating electricity, the main source of air pollution for the area. No. 2 point was situated in the middle of the biggest penguin colony (over 100 000 penguins). Point No. 3 was on a hill 100 m above sea level, a few hundred metres from the Station. No. 4 point was at the highest place near the Station, near to the top of Thomas Hill. No. 5 point was situated few kilometers below Sphinx Hill. No. 6 point was on the top of the Lange Glacier at the altitude of about 600 m above sea level. No. 7 point was on the Keller Peninsula, few kilometers from the Station, near the abandoned British Station. No. 8 point was in the crater of an extinguished volcano on Penguin Island.

2. 2. Measurement of SO₂ concentration

Concentrations of SO₂ in the air was measured by the lead dioxide method. The previously prepared cylinders covered by lead dioxide were

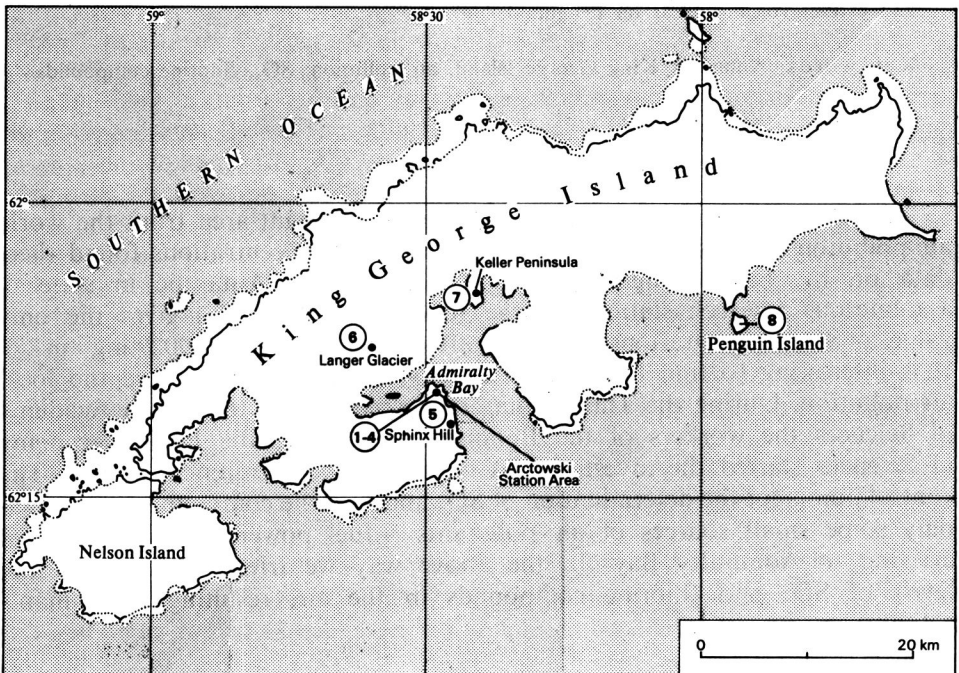


Fig. 1. Locality of the air pollution control points on the King George and Penguin Islands

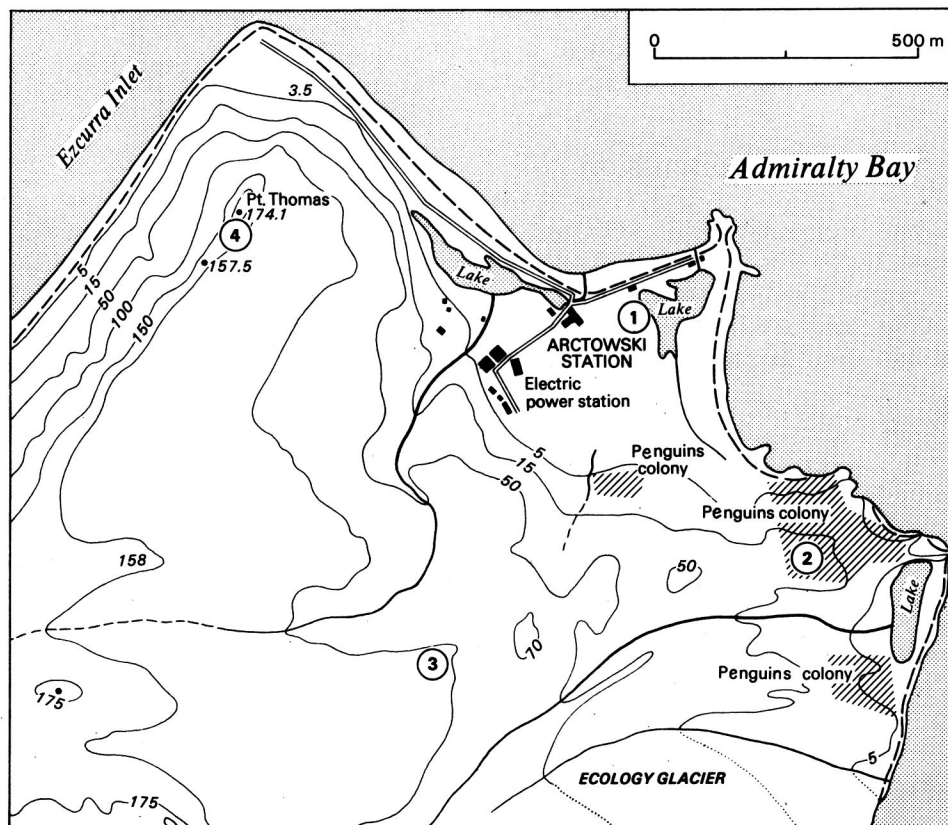


Fig. 2. Locality of the air pollution control points around the Arctowski Station

prepared in the Department of Plant Ecology and taken to King George Island in tightly closed twist-off jars. The cylinders were hung in the meteorological booths in different points of the Island for a period of few weeks. The SO₂ content in the air was determined according to the method described by Just (1968). The SO₂ concentrations are presented in mg · 100 cm⁻² per 24 h and converted into mg · m⁻³ using the multiplication factor 0.09 (Liang, Sterling and Galloway 1973).

2. 3. Measurement of fluorine compounds concentration

Content of fluorine compounds in the air was determined by exposing to the air the papers saturated by calcium formate, made by Corning Laboratories Inc. The papers, were exposed in meteorological booths similarly as the lead dioxide cylinders for SO₂ measurements during a period of few weeks, under special shelters covering them from very strong winds. The by the specific fluoride electrode Orion 94—09A. Before the measurement papers were cut into 1 cm² pieces and put into a polyethylene beaker with 25 ml of distilled water and 25 ml TISAB II solution were added. The fluoride content in the solution was measured by the known addition method

according to Fluorides in ambient air (1970) and Instruction Manual-Fluoride Electrode (1976) and presented in $\mu\text{g} \cdot 100 \text{ cm}^{-2}$ per 24 h. Using the multiplication factor 7.6 (Adams 1961), the results were converted to $\mu\text{g} \cdot \text{m}^{-3}$.

3. Results and discussion

The accumulation of SO_2 and fluorine compounds took place at all measuring points during few weeks in January and February 1979. Although the received results were very low, near the detection limits of the applied method, there were found differences of SO_2 and fluorine compounds accumulation at particular measuring points (Table I).

Table I
Concentrations of SO_2 and fluorine compounds
at different control points on the King George
and Penguin Islands

Measuring point	SO_2 *) ($\text{mg} \cdot \text{m}^{-3}$)	F^- **) ($\mu\text{g} \cdot \text{m}^{-3}$)
1. The Station	0.0025	0.0699
2. Penguin colony	0.0014	0.1094
3. Hill	0.0017	—
4. Thomas Mountain	—	0.1345
5. Sphinx Hill	0.0014	—
6. Lange Glacier	0.0033	0.0319
7. Keller Peninsula	0.0014	0.0266
8. Penguin Island	0.0014	—

*) Calculated from the results obtained by the lead dioxide method (Just 1968) using multiplication factor: $1 \text{ mg SO}_2 \cdot 100 \text{ cm}^{-2}$ per 24 h = $0.09 \text{ mg SO}_2 \cdot \text{m}^{-3}$ (Liang, Sterling and Galloway 1973).

**) Calculated from the results obtained by the calcium formate papers method (Fluorides in ambient air 1970, Instruction Manual-Fluoride Electrode 1976) using multiplication factor: $1 \mu\text{g F}^- \cdot 100 \text{ cm}^{-2}$ per 24 h = $7.6 \mu\text{g F}^- \cdot \text{m}^{-3}$ (Adams 1961).

The levels of SO_2 and fluorine compounds at No. 1 points were rather low, but their accumulation was higher than at other neighbouring points. At No. 2 point, the accumulation of fluorine compounds was relatively high, but SO_2 concentration was one of the smallest. At No. 3 point, only SO_2 analysis was carried out — the obtained value was very low. At No. 4 point the analysis of SO_2 was spoiled, but the fluorine compounds level was relatively high, the highest value found on King George Island. The SO_2 content at No. 5 point was very low, and it was not possible to determine the fluorine compounds level, because of the very strong winds damaging the accumulation papers. At No. 6 point the SO_2 accumulation was the greatest and the fluorine compounds accumulation was near to average. If these values really represent the amount of air pollutants, and are not errors of the method, this phenomenon can be explained by greater accumulation of pollution caused by a swifter flow of air. At No. 7 point relatively low levels of air pollution were found. At No. 8 point, in the crater of an extinguished volcano we wanted to find if some

sulphurous compounds were still evaporating — the area of the crater was still a little bit warmer than its surroundings. However, the accumulation of SO₂ there was relatively low, and we did not determine the fluorine compounds accumulation because of the damage done to the exposed papers. The comparison of analysed data with ones for other areas of high and low air pollution (Table II) shows the similarity of concentrations found

Table II
Concentrations of SO₂ and fluorine compounds in the air different world localities

Measuring point	SO ₂ (mg · m ⁻³)	F ⁻ (μg · m ⁻³)	Source of information
1. Hawaii	0.0009		Stern 1976
2. Northern Atlantic	0.0099		Stern 1976
3. Antarctic	0.0009—0.0029		Stern 1976
4. King George Island	0.0014—0.0033	0.0266— 0.1345	own data
5. N-E Florida	0.0029		Stern 1976
6. Białowieża Primeval Forest (Poland)	0.0045—0.0225	0.2280— 1.2920	own data
7. Forest Arboretum in Rogów (Poland)	0.0063—0.104		own data
8. Big cities in USA	0.0144—0.3600	0.1600— 0.5200	Warner 1976
9. Warsaw (1978)	0.0198—0.1316		own data
10. Panewnik Forest Distric (Poland)	0.0405—0.5085	4.028—16.416	own data
11. "Polchem" Toruń (Poland)	0.0858—0.5250		own data
12. Aluminium smelter in Skawina (Poland)	0.5040—1.0440	20.21—96.22	Świeboda and Kalemba 1978

Explanations see Table I.

near the Arctowski Station with data for regions recognized as the world background areas. The values of SO₂ near the Station were 1.5—16 times lower than the Polish base level (Białowieża Primeval Forest with the lowest air pollution level) and much lower (up to 745 fold) than in the industrial areas of high SO₂ pollution. Also, the levels of fluorine compounds in the air at the King George Island were lower than the Polish base level (2—5 fold) and much lower than in the polluted areas (up to 3600 fold). The lack of any significant differentiation of analysed pollution indices at various distances and various directions from the Arctowski Station suggests that the Station has no polluting effect in the area. The observed differences, presumably not related with analytical error, can be assumed as existing spatial differences of studies indices. On the basis of this assumption the following conclusions on the air pollution in the studied region of the Antarctic can be drawn:

1. The operation of the engines generating electricity and the total Station activity does not influence local SO₂ and fluorine compounds air pollution.
2. The crater of the recently extinguished volcano does not emit SO₂, though it is still a little bit warmer than its surroundings.

3. The highest situated point (about 600 m above sea level on the Lange Glacier), where the flow of air masses is the greatest (strong winds), has the greatest accumulation of SO_2 .

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4. Summary

The measurements of concentrations at SO_2 and fluorine compounds in the air at 8 points on the King George and Penguin Islands (South Shetland Islands) were done in January and February 1979 (Figs. 1 and 2). SO_2 concentrations were measured by the lead dioxide method. The content of fluorine compounds was determined by using papers saturated by calcium formate and fluoride selective electrode Orion 94—09A.

The received values of the air pollutants concentrations found on the islands (Table I) showed the similarity with the data for regions recognized as the world background areas (Table II). The values of the air pollution concentrations are similar; no dependence of air pollution on the control points position in relation to the Station, penguin colonies and the extinct volcano was found (Table I).

5. Резюме

Проведено измерения SO_2 и соединений фтора в воздухе в 8 пунктах на Кинг Джордж Исланд и Пингвин Исланд (Южные Шетланды), (рис. 1 и 2). Сгущение SO_2 измерено контактным методом. Содержание соединений фтора в воздухе исследовано применяя экспозиционные бумажки насыщенные муравийным кальцием, а также селективную фторовую электроду Орион 94-09А.

Полученные результаты указывают на сходство сгущений констатированных на островах (таблица I) с результатами полученными в районах определяемых как мировой фон загрязнений воздуха (таблица II). Величины сгущений загрязнения воздуха похожи, не замечено зависимости этих сгущений от расположения измерительных пунктов по отношению к станции, колонии пингвинов и погасшего вулкана (таблица I).

6. Streszczenie

Wykonano pomiary zawartości SO_2 i związków fluoru w powietrzu w 8 punktach na Wyspie Króla Jerzego i Wyspie Pingwina (Południowe Szetlandy) (rys. 1 i 2). Stężenia SO_2 mierzono metodą kontaktową. Zawartość związków fluoru w powietrzu badano stosując papierki ekspozycyjne nasycone mrówczanem wapnia oraz selektywną elektrodę fluorokową Orion 94—09A.

Uzyskane wyniki wskazują na podobieństwo stężeń stwierdzonych na wyspach (tabela I) z wynikami uzyskanymi dla rejonów określanych jako światowe tło zanieczyszczeń powietrza (tabela II). Wartości stężeń zanieczyszczenia powietrza są zbliżone; nie stwierdzono zależności tych stężeń od usytuowania punktów pomiarowych względem Stacji, jak również względem kolonii pingwinów i wygasłego wulkanu (tabela I).

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