

Kazimierz PECHERZEWSKI

Institute of Oceanography, University of Gdańsk
Czołgistów 46, 81-378 Gdynia, POLAND

Air pollution and natural sedimentation from the atmosphere in the region of the Admiralty Bay (South Shetland Islands)

ABSTRACT: The results of studies on the air pollution and on the natural sedimentation from the atmosphere in the South Shetlands (Admiralty Bay) are presented. The amount of dust in the air varied from 0.11 to 10.90 $\mu\text{g}\cdot\text{m}^{-3}$ (the mean being 3.70 $\mu\text{g}\cdot\text{m}^{-3}$). The total amount of substances transported from the atmosphere in the Admiralty Bay region was estimated at 12.7 $\text{t}\cdot\text{km}^{-2}$ per year, whereas the precipitation transports some 2.5 $\text{t}\cdot\text{km}^{-2}$ per year in this region.

Preliminary data on the contents of Cu, Cd, Co, Ni, Pb and Zn in the samples of surface waters, snow and rain in the region of the Admiralty Bay are presented and compared with the results of the authors.

Key words: Antarctic air pollution, trace metals.

1. Introduction

Until recently alarming examples of deterioration taking place in the biosphere, caused by increasing pollution of water, soil and atmosphere, were related mainly to the regions of large urban and industrial agglomerations of highly developed industry. Investigations carried out in recent years supplied us with disturbing data on increasing pollution of the atmosphere (Parkin, Phillips and Sullivan 1970, Juda and Chróściel 1974, Živago and Bogdanov 1974, Stern 1976, Mitra 1979, Perry and Walker 1979, Lisicin 1983, Bezborodov and Eremeev 1984, Pecherzewski 1984 and others), which due to the large-scale circulation of air masses enables the pollution to be quickly distributed throughout the Earth (Žigalovskaja, Machonko and Šilina 1974, Duce and Hoffman 1976, Vilenskii and Miklišanskii 1976, Hodge, Johnson and Goldberg 1978, Sobotovič, Bondarenko and Koromyšičenko

1978, Boutron 1979, Gordeev and Lisicin 1979, Meanhaut et al. 1979, et.c.), as far as to its most distant polar areas.

The so far conducted investigations on the DDT and metabolites contents (Łukowski 1983 a and b), the contents of SO₂ and fluorite compounds (Molski, Bytnerowicz and Dmuchowski 1981), the amounts of trace metals in the suspended matter and waters of the Admiralty Bay, in the samples of Antarctic ice, rain and snow (Brzezińska and Samp 1981, Felkier 1981, Pęcherzewski and Neugebauer, unpubl. data) and krill (Soszka et al. 1981) indicate that the environment of the Admiralty Bay is also situated within the range of influence and occurrence of many harmful and toxic substances of anthropogenic character.

The present study aimed at the estimation of the amount of dust in the air, a basic commonly accepted parameter of the air pollution as well as at the estimation of the total natural sedimentation from the atmosphere in the Admiralty Bay region in the vicinity of Polish Antarctic Station "H. Arctowski".

2. Material and methods

Samples were collected partly during the austral summer 1978/79 (December—February) and partly during the wintering in 1979 (till November).

The measurements of the level of atmospheric pollution and the total natural sedimentation from the atmosphere were carried out using the methods presented, among others, in the papers by Juda and Chróściel (1974) and Bezborodov and Eremeev (1984).

1. Measurements of the air pollution (12 measurements — Table 1) were carried out by the filtering of the air with GF/C Whatman's filters. Sampling was done close to the Hydrological Laboratory of the "H. Arctowski" Polish Antarctic Station. The results are given in $\mu\text{g}\cdot\text{m}^{-3}$.

2. Measurements of the total amount of substances transferred under natural conditions from the atmosphere (8 samples) were conducted using the so called sedimentation traps of the catching surface of 555.4 cm² exposed for the period of 20—30 days close to the station and on the Demay Point. Results are given in $\text{g}\cdot\text{m}^{-2}\cdot\text{month}^{-1}$, and the estimated value of the total sedimentation obtained from recalculations is given in $\text{tons}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$.

3. Measurements of the amounts of substances washed out from the atmosphere by atmospheric precipitation (16 samples taken between December 1978 and November 1979) were done using the same sedimentation traps exposed in the course of precipitation. The obtained values are given

in $\text{mg}\cdot\text{dm}^{-3}$. The estimated total value given in $\text{tons}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$ was obtained after recalculation of these data taking into account the yearly total precipitation in this region being about 800 mm* (Spravočnik, 1977). The contents of chosen trace metals in the samples of precipitation and waters of the Admiralty Bay was determined with the method of atomic spectroscopy (Pęcherzewski and Neugebauer, unpubl. data).

Routine analysis of the materials were carried out in the Laboratory of Hydrochemical Research of the Marine Environment of the Institute of Oceanography, University of Gdańsk.

3. Results and discussion

Values of air pollution with dust measured in the region of the Admiralty Bay in the course of the Antarctic summer (December 1978 — February 1979) indicate the occurrence of considerable pollution of these regions (0.1 to $10.9 \mu\text{g}\cdot\text{m}^{-3}$; the mean value about $3.7 \mu\text{g}\cdot\text{m}^{-3}$) in comparison to certain areas of the open ocean (Table 1).

Table 1
Values of air pollution in $\mu\text{g}\cdot\text{m}^{-3}$ according to various investigators

Study area	Number of samples	Value of air pollution in $\mu\text{g}\cdot\text{m}^{-3}$		Source of information
		from — to	mean	
Region of the Admiralty Bay (Dec. 1978 — Feb. 1979)	12	0,11 — 10,90	3,7	present author
Atlantic Ocean	10	0,17 — 11,00	3,0	Parkin et al. 1970
Atlantic Ocean	11	0,13 — 0,96	0,52	Živago and Bogdanov 1974
Pacific Ocean				
— spring	6	0,28 — 0,88	0,52	Živago and
— summer	14	0,19 — 3,10	0,73	Bogdanov 1974
Samoa Islands	—	0,003 — 0,09	0,10	Duce et al. 1976
Gdańsk Bay and Southern Baltic	47	6,20 — 76,9	24,20	Pęcherzewski et al. 1984

The above presented values represent only a momentary condition of the atmosphere, which undergoes constant dynamic changes. The final result of this process is natural sedimentation of dust and also the natural washing off by atmospheric precipitation.

* The author has chosen this many years' average instead of the yearly mean for 1978 (abt. 555 mm) estimated by Nowosielski (1980).

Table 2

Total amount of substances (mg dm^{-3}) and contents of trace metals ($\text{mg dm}^{-3} \cdot 10^{-3}$) in samples of atmospheric precipitation (snow, rain) collected in the region of the Admiralty Bay, Greenland, open ocean and North Sea according to various authors

Type of atmospheric precipitation and region of sampling	Total number of samples	Mean amount of substances in mg dm^{-3}	Mean content of chosen trace metals in $\text{mg dm}^{-3} \cdot 10^{-3}$						
			Cu	Cd	Co	Ni	Pb	Zn	
Snow and rain in the region of the Admiralty Bay (Dec. 1978 — Feb. 1979)	16	3.1	1.40	0.54	0.25	0.40	0.84	2.60	
Atmospheric precipitation — means for the world ocean (Bezborodov and Ereemeev 1984)	91	—	3.20	—	—	1.30	6.20	5.60	
Atmospheric precipitation — North Sea (Cambray et al. 1975)	—	—	30.00	—	—	—	35.00	160.00	
Melted snow from Greenland (Boutron 1979)	17	—	0.05	0.01	—	—	0.27	0.28	
Waters of the Admiralty Bay Oceanic waters (Gordejev and Lisicin 1979)	48	—	1.35	0.38	0.40	0.68	0.68	8.91	
	—	—	1.52	0.07	0.03	0.06	0.53	5.30	

In eight samples collected in the course of the Antarctic summer (December 1978 — February 1979) the total amount of natural sedimentation varied from 0.61 to 2.14 $\text{g}\cdot\text{m}^{-2}\cdot\text{month}^{-1}$; the mean value was about 1.06 $\text{g}\cdot\text{m}^{-2}\cdot\text{month}^{-1}$. After recalculating the estimated value of the yearly 1.06 $\text{g}\cdot\text{m}^{-2}\cdot\text{month}^{-1}$. After recalculating the estimated value of the yearly total amounted in the region of the Admiralty Bay to about 12.7 $\text{tons}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$. Similar investigations carried out in the region of the Gdańsk Bay and Southern Baltic (Pęcherzewski 1984) showed that the total amount of substances transferred from the atmosphere into the waters of the Gdańsk Bay amounted to about 60 $\text{tons}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$.

The total amount of substances transferred from the atmosphere in the region of the Admiralty Bay, by the atmospheric precipitation (16 samples) ranged from 0.1 to 12.6 $\text{mg}\cdot\text{dm}^{-3}$; the mean value being about 3.1 $\text{mg}\cdot\text{dm}^{-3}$. Assuming the obtained mean value as representative for this region and taking into account that the mean yearly total precipitation in the region of the Admiralty Bay is about 800 mm, the value obtained was 2.5 $\text{tons}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$ of various substances which are transferred from the atmosphere with atmospheric precipitation. The respective value for the Southern Baltic and the Gdańsk Bay amounted to about 20 $\text{tons}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$ (Pęcherzewski, Neugebauer and Bolałek 1984).

The contents of chosen trace metals: Cu, Cd, Co, Ni, Pb and Zn in the samples of precipitation water (snow, rain) collected in the region of the Admiralty Bay, Greenland, North Sea and the open ocean are presented in Table 2. These data indicate a high variability and high contents of the above mentioned trace metals in the investigated precipitation waters; the contents of these metals in precipitation waters frequently exceeded considerably their contents in the sea water, including the investigated surface waters of the Admiralty Bay (Pęcherzewski and Neugebauer, unpubl. data).

The scarcity of data concerning this problem for the World Ocean and Antarctic regions makes it impossible to gain deeper understanding of its range and consequences. However, bearing in mind the permanent increase in atmospheric pollution in highly and even slightly urbanized areas, it is easy to imagine the danger for the whole biosphere, including oceanic waters and polar regions.

The above presented data should be a signal prompting to further research in the field of atmospheric pollution in the Antarctic region that was hitherto commonly regarded as an unpolluted area.

Thanks are due to Mr M. Lipski, M.Sc. for his kindness in collecting the samples during his year-round stay at "Arctowski" Station.

4. References

- Bezborodov A. A. and W. H. Eremeev. 1984. Fiziko-chimičeskije aspekty vzaimodejstvija okeana i atmosfery. — Izd. "Naukova Dumka", Kijev. 190 pp.
- Boutron C. 1979. Trace element content of Greenland snows along an east-west transect. — *Geochim. Cosmochim. Acta*, 43: 1253—1258.
- Brzezińska A. and R. Samp. 1981. Wstępne badania nad występowaniem metali śladowych w Zatoce Admiralty. — *Stud. Mat. Oceanolog.*, 34: 113—126.
- Duce R. A. and E. J. Hoffman. 1976. Chemical fractionation at air/sea "interface". — In: *Annual Rev. of Earth and Planetary Science*. Wiley, New York. 4: 45—61.
- Felkier R. 1981. Studies of microstructural characteristics of an exchange of an iodine and mercury between the sea and atmosphere in natural antarctic condition. — *Pol. Polar Res.*, 2: 7—15.
- Gordeev W. W. and A. P. Lisicin. 1979. Mikroelementy. — In: A. S. Monin (ed.), *Chimia vod okeana, Okeanologija*. Izd "Nauka", Moskva. 337—375.
- Hodge V., S. R. Johnson and E. D. Goldberg. 1978. Influence of atmospherically transported aerosols on surface ocean water composition. — *Geochim. Cosmochim. Acta*, 42:
- Juda J. and S. Chróściel. 1974. *Ochrona powietrza atmosferycznego*. — Wyd. Nauk.-Techn., Warszawa. 448 pp.
- Lisicin A. P. 1978. *Processy okeanskoj sedimentacii*. — Izd. "Nauka", Moskva. 391 pp.
- Łukowski A. B. 1983a. DDT residues in tissues and eggs of three species of penguins from breeding colonies at Admiralty Bay. — *Pol. Polar Res.*, 4: 129—134.
- Łukowski A. B. 1983b. DDT and its metabolites in the tissues and eggs of migrating Antarctic seabirds from the region of the South Shetland Islands. — *Pol. Polar Res.*, 4: 135—141.
- Meanhaut W., W. Zoller, R. A. Duce and G. L. Hoffman. 1979. Concentration and size distribution of particulate trace elements in the South polar atmosphere. — *J. Geophys. Res.*, 84: 2421—2431.
- Mitra A. P. 1979. *Human influence on atmospheric environment*. — Monogr. National Physical Labor., New Delhi. 400 pp.
- Molski B., A. Bytnerowicz and W. Dmuchowski. 1981. Air pollution with sulphur dioxide and fluorine compounds in the vicinity of the Arctowski Station, King George Island, South Shetland Islands. — *Pol. Polar Res.*, 2: 87—93.
- Nowosielski L. 1980. Meteorological conditions at Arctowski Station in 1978 (King George Island, South Shetland Islands). — *Pol. Polar Res.*, 1: 83—93.
- Parkin D. W., D. R. Phillips and R. A. Sullivan. 1970. Airborne dust collections over the North Atlantic. — *J. Geophys. Res.*, 75:
- Perry A. H. and J. M. Walker. 1977. *The ocean-atmosphere system*. — Longman, London, New York. 267 pp.
- Pęcherzewski K. 1984. O stanie zapylenia powietrza w rejonie Zatoki Gdańskiej i Południowego Bałtyku. — *Prace MIR*
- Pęcherzewski K., E. Neugebauer and J. Bolałek. 1984. Predvaritelnyje rezultaty ekspedicionnyh issledowanij postuplenija veščestv iz atmosfery v more (na primere Gdanskogo Zaliva). — *Inf. Biull. AN SSSR*. Moskva. 17: 26—33.
- Sobotovič E. W., G. H. Bondarenko and T. I. Koromyšličenko. 1978. Kosmičeskoe veščestvo v okeaničeskich i lednikovyh pokrovah. — Izd. "Naukova Dumka", Kijev. 117 pp.
- Soszka G. J., M. M. Suplińska, A. Barańska, D. Grzybowska and A. Pietruszewska. 1981. Trace metals, fluorine and radionuclides in Antarctic krill *Euphausia superba*. — *Pol. Polar Res.*, 2: 109—117.

- Spravočnik po klimatu Antarktidi, (Eds. J. A. Dolgin and L. S. Petrov), 2. Izd. Hidrometeoizdat, Leningrad, 1977, 492 pp.
- Stern A. S. 1976. Air pollution. — Academic Press, New York. San Francisco. London, 684 pp.
- Vilenskij W. D. and A. Z. Miklišanskij. 1976. Chimičeskij sostav snežnogo pokrova Vostočnoj Antarktidi. — *Geochimia*, 11:
- Žigalovskaja T. N., E. P. Machonko and A. I. Šilina. 1974. Mikroelementy v priridnyh vodah i atmosfere. — *Trudy Inst. Eksper. Meteorol.*, 41: 1—183.
- Živago W. N. and J. A. Bogdanov. 1974. Eolovaja vzves nad Atlantičeskim i Tichom okeanami. — In: A. P. Lisicin (ed.), *Gidrofiz. i Gidroopt. issled. v Atlantičeskim i Tichom okeanach*. Izd. "Nauka", Moskva, 259—273.

Received August 10, 1985

Revised and accepted November 15, 1986

5. Streszczenie

W opracowaniu przedstawiono dane ilustrujące stan zapylenia powietrza w rejonie Zatoki Admiralicji (od 0,11 do 10,90 $\mu\text{g}/\text{m}^3$ przy średniej 3,7 $\mu\text{g}/\text{m}^3$; tab. 1). Ogólną ilość substancji, w tym i zanieczyszczeń wynoszonych w warunkach naturalnej sedymentacji z atmosfery ocenia się na około 12,7 ton/ km^2 /rok. Opady atmosferyczne (śnieg, deszcz, mżawka) wymywają substancje znajdujące się w powietrzu atmosferycznym rejonu Zatoki Admiralicji w ilościach około 2,5 tony/ km^2 /rok.

Podano również wstępne dane o zawartości Cu, Cd, Co, Ni, Pb i Zn w pobranych próbkach wód opadowych i śniegu z rejonu Zatoki Admiralicji i porównano otrzymane dane z odpowiednimi wynikami uzyskanymi z rejonu Grenlandii, Morza Północnego i dla otwartych rejonów oceanicznych, a także z zawartością tych pierwiastków w wodach Zatoki Admiralicji i wodach oceanicznych (Tab. 2).