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Changes in photosynthetic assimilation of $^{14}CO_2$ in Antarctic phytoplankton induced by some selected chlorinated hydrocarbons (Aroclor 1254, Aroclor 1242, pp'DDE, pp'DDT and Lindane)

ABSTRACT: Influence exerted by various concentrations (0.01 to 50 ppm) of some chlorinated hydrocarbons (Aroclor 1254, Aroclor 1242, pp'DDE, pp'DDT and Lindane (γ HCH)) upon the photosynthetic assimilation of $^{14}CO_2$ in Antarctic marine diatom assemblage dominated by *Corethron criophilum* and some species of *Nitzschia* (*Fragilariopsis* group) has been investigated. The photosynthesis was fully inhibited by Lindane (γ HCH) in all applied concentrations. To smaller extent the photosynthetic process was inhibited in turn by Aroclor 1242, pp'DDE and pp'DDT successively. Aroclor 1254 proved to be the least toxic. The possibility of the decrease of the primary production of the Antarctic diatoms caused by the chlorinated hydrocarbons was discussed.

Key words: chlorinated hydrocarbons, Antarctic marine diatoms, $^{14}CO_2$ assimilation.

Introduction

Marine plankton cumulates the chlorinated hydrocarbons (CHs) that occur in the marine ecosystem. The level of cumulation depends on the extent of pollution of water by waste products of those compounds (Jensen, Renberg and Qlson, 1972).

Diatoms (Bacillariophyceae) are basic components of marine phytoplankton in the Antarctic (El-Sayed 1985). High amounts of lipids (up to 35% of the dry matter) that occur in diatoms (Baraškov 1972) cause that they quickly cumulate the lipophilic remnants of the chlorinated hydrocarbons that occur in the sea water. The CHs get into the Antarctic areas mainly by the atmosphere while the chief source of water pollution is the atmospheric rain and snowfall (Tanabe et al. 1982). Studies carried out by Łukowski and Ligowski (1987, 1988) show that diatoms may be regarded as index organisms indicating the rate of pollution in Antarctic waters by CHs. These studies revealed also that the substantial local increase in that rate is determined by the release of CHs deposits from the melting ice of glaciers and icebergs as well as from the bottom deposits brought up to the euphotic zone by the constant mixing of water.

The varying concentrations of CHs in the sea water exert an influence upon the photosynthesis of phytoplankton. Changes in the metabolism of diatoms caused by CHs have so far been studied mainly using DDT and, in some individual cases, an using Aroclor 1242 and Aroclor 1254. Those were experiments based on the material of the laboratory culture, where the influence of DDT and PCBs upon the photosynthetic incorporation of $^{14}CO_2$ by selected diatom species from trophical and temperate zones was examined. It was found that such compounds cause the inhibition of photosynthesis (Wurster 1968, Keil and Priester 1969, Moore and Harriss 1972).

In such laboratory cultures the inhibition of the photosynthesis in phytoplankton has been already noted at the DDT concentrations in water of the ppb rate. A low concentration of Aroclor 1242 in water (0.1 ppm) has inhibited the growth and has lowered the quantity of RNA and of chlorophyll in the cells of marine diatoms (Keil, Priester and Sandifer 1971).

At present no investigations in situ has been carried out on the influence of the chlorinated hydrocarbons upon physiology of phytoplankton in Antarctic waters.

In the present work an attempt has been made at determining the influence of various concentrations of several chlorinated hydrocarbons: Aroclor 1242, Aroclor 1254, pp'DDT, pp'DDE and Lindane (γHCH) upon diatoms occurring in the net marine Antarctic phytoplankton. Our aim was to examine the influence of these compounds upon the photosynthetic assimilation of $^{14}CO_2$ of the diatom assemblages originating directly from the ocean.

Material and methods

In the experiment net phytoplankton was used that had been taken in the South Shetlands area using a Copenhagen-type net with a mesh size of 55 μm from a water column from 100 meters to 0 m. Phytoplankton contained nothing but diatoms dominated by *Corethron criophilum* Castracane (about 52% of cells) as well as some species of the genus *Nitzschia* (Fragilariopsis group). Lots of 50 cm^3 of the diatoms suspension (appr. 4550 cells in 1 cm^3) were put into waterproof, transparent plastic containers placed inside a chamber artificially illuminated. Light intensity inside such a plastic container was 2000 1×. Within the chamber the containers were cooled down to temperature of 2°C by means of a steady flow of sea water.

Chlorinated hydrocarbons dissolved in acetone were added to the containers with diatoms suspension. After 24 hrs (including 12 hrs of exposition to light and 12 hrs of darkness) 5 μCi ^{14}C (37000 Bq) each were added to the samples and they were exposed to light for 4 hrs. The assimilation process was interrupted by addition of formaline. The samples were filtered through Millipore membrane filters of 1.2 um pore diameter. The radioactivity was determined in diatom cells remaining on the filters. The level of the incorpotated ^{14}C was determined by means of a Geiger-Müller counter. Radioactivity of the samples was expressed in Bq. For control samples were used with acetone only (100 μl) added as well as samples without acetone. All samples were diluted with sea water taken from the depth of 10 meters by a Van Dorn bathometer. Sea water was filtered through a Sartorius membrane filters of 0.3 μm pore diameter.

The following chlorinated hydrocarbons were used: Aroclor 1254, Aroclor 1242, pp'DDT, pp'DDE and Lindane (γHCH) in concentrations in water of: 0.01, 0.1, 1.0, 10 and 50 ppm.

Results and discussion

Addition of chlorinated hydrocarbons (CHs) to the suspension of diatoms resulted in decrease of assimilation of $^{14}CO_2$ in the photosynthetic process in comparison with the control samples (Table 1).

Comparison of the influence exerted by different CHs upon the photosynthetic assimilation of $^{14}CO_2$ in Antarctic marine diatoms (Fig. 1) has shown that the strongest inhibiting effect was due to Lindane (γHCH).

Table 1

Changes in photosynthetic assimilation of $^{14}CO_2$ in Antarctic marine diatoms caused by different concentations of some chlorinated hydrocarbons; N — number of samples, S — standard deviation (%)

Compound	Concentration in water (ppm)	N	Activity of ^{14}C (Bq)	±S
Aroclor 1254	0.01	3	1571	5.2
	0.10	3	1454	4.6
	1.0	3	1593	3.5
	10.0	3	1359	7.2
	50.0	3	1480	6.2
Aroclor 1242	0.01	3	1400	3.9
	0.10	3	1495	1.7
	1.0	3	1406	1.2
	10.0	3	1114	9.9
	500	3	263	2.5
pp'DDE	0.01	3	1521	4.0
	0.10	3	1457	5.1
	1.0	3	1568	4.8
	10.0	3	1281	2.8
	50.0	3	315	8.1
pp'DDT	0.01	3	1456	4.1
	0.10	3	1506	7.1
	1.0	3	1389	4.3
	10.0	3	997	5.2
	500	3	750	3.6
Lindane	0.01	3	1347	5.5
	0.10	3	1340	9.5
	1.0	3	1220	0.2
	10.0	3	400	8.6
	50.0	3	37	9.7
Control sample without acetone		6	1674	3.6
Control sample with acetone		6	1618	3.9

The diatoms showed a diminished photosynthesis already at the concentration of 0.01 ppm of the compound in water. The remaining CHs examined brought about a weaker effect. Aroclor 1242, pp'DDE and pp'DDT clearly inhibited the photosynthesis of diatoms at concentrations higher than 1 ppm. The Aroclor 1254 proved to be the least toxic; it caused fairly small inhibition (12 to 19%) of photosynthetic assimilation of $^{14}CO_2$ only at high concentrations (10 to 50 ppm). Other investigations on CHs toxicity carried out on the marine diatoms under laboratory conditions have shown that the pp'DDT and PCBs distinctly inhibited the photo-

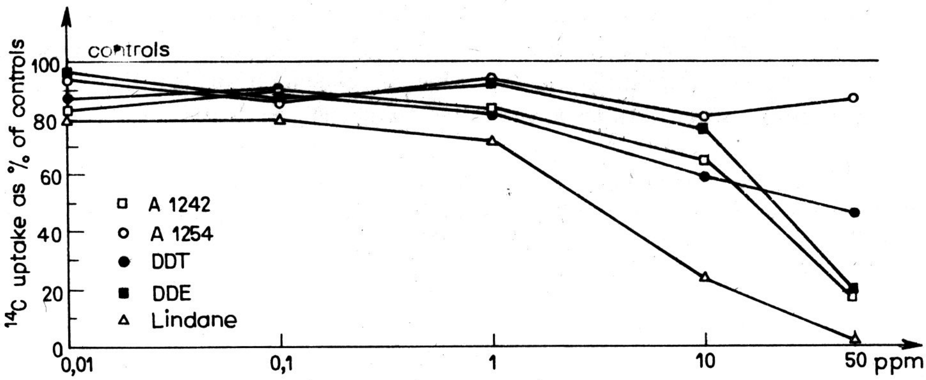

Fig. 1. The influence of chlorinated hydrocarbons upon the photosynthetic incorporation of ^{14}C by Antarctic marine diatoms

synthesis in concentrations as low as a few ppb in water (Wurster 1968, Moore and Harriss 1972).

Thus, the obtained results may imply that diatoms occurring in the Antarctic plankton are less susceptible to the effects of remnants of DDT and the PCBs. Since the presence of these compounds has been discovered in the Antarctic ecosystems for a long time (Sladen, Menzie and Reichel 1966, Tatton and Ruzicka 1967, Riesebrough et al. 1976) it seems likely that diatoms might have adapted to life in conditions of some fairly small concentrations in water and this could be the reason why the inhibition of photosynthesis at low concentrations of DDT and PCs within the environment was not observed.

The high toxicity of the now widely-used Lindane (γ HCH) may cause a decrease of primary production of diatoms that constitute an important producer of organic matter in Antarctic waters (Voronina 1984). The HCH isomers (α and γ) are nowadays the dominant ones within the group of chloroorganic pesticides in the atmosphere and the hydrosphere of the Antarctic (Tanabe et al. 1982).

The possible decrease of the primary production caused by Lindane and, to some lesser extent, by Aroclor 1242 and pp'DDE in Antarctic waters can be locally higher during the Antarctic summer. In comparatively short time due to the melting snow, surface layers of glaciers and drifting icebergs the water is supplied with CHs deposited on the snow and ice surface in winter. Due to the upwellings the CHs deposited at the bottom may penetrate to the euphotic layer of shallow shelf waters. A possibility of such'respective'pollution of Antarctic waters by the CHs has been pointed out by Łukowski and Ligowski (1987, 1988). The hypothesis that the release of CHs deposits from snow and ice may cause the local limitation of the primary production seems to be supported by the results of Tanabe, Hidaka and Tatsukawa (1983) who have discovered a distinctly lower amount of CHs in Antarctic waters below the ice surface than the amount of such compounds at the edge of the melting ice fields; snow and ice contain several times more CHs than the sea water itself.

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Streszczenie

Zbadano wpływ różnych stężeń (0,01—50 ppm) chlorowanych węglowodorów (CHs) w wodzie (Aroclor 1242, Aroclor 1254, pp'DDT, pp'DDE oraz lindan (γ HCH)) na fotosyntetyczną asymilację $^{14}CO_2$ przez zbiorowisko morskich okrzemek antarktycznych występujących w planktonie sieciowym. Okrzemkami dominującymi w zbiorowisku były: *Corethron criophilum* (52%) i *Nitzschia* sp. (Fragilariopsis) (32%). Związkiem najsilniej ograniczającym asymilację $^{14}CO_2$ przez okrzemki okazał się lindan (γ HCH) przy wszystkich stosowanych stężeniach. Słabiej, głównie w stężeniach od 10 pp wzwyż, fotosyntezę hamowały w kolejności: Aroclor 1242, pp'DDE i pp'DDT. Najsłabsze hamowanie fotosyntezy okrzemek powodował Aroclor 1254. Rozważono możliwość ograniczania produkcji pierwotnej okrzemek w wodach antarktycznych w wyniku powszechnej w nich obecności izomerów HCH. Możliwość „wtórnego" zanieczyszczania wód antarktycznych przez CHs, w wyniku uwalniania depozytu tych związków ze śniegu, lodowców i osadów dennych w okresie antarktycznego lata może mieć wpływ na lokalne ograniczenie produkcji pierwotnej w wodach antarktycznych.