BIOMAGNIFICATION AND METABOLISM OF CHLORINATED ORGANIC POLLUTANTS IN HARP SEAL *(Phoca groenlandica)*

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Introduction

The arctic marine environment is continuously exposed to a variety of chlorinated contaminants, clearly documented by AMAP (1). PCBs and pesticides like the chlordanes, DDTs and toxaphenes (PCCs) have been shown to be relatively persistent in many species, resulting in high concentrations in animals at the top of the food chain (2). These levels are the direct result of both exposure, mainly by the food, and metabolism. Substantial differences in metabolic capacity between species result in different contaminant loads and accumulation patterns.

Many chlorinated contaminants are highly lipophilic and are therefore associated with the fatty tissues in animals. Since many arctic animals selectively feed on the more lipid-rich tissues, there is an effective biomagnification of many contaminants. To determine the accumulation through the food chain and the persistency of different contaminants in particular species several methods are currently in use. The biomagnification factor (BMF) is a frequently used method to assess the bioaccumulation of a particular contaminant from one species to the other. The BMF is usually calculated as the fraction between the contaminant concentration in two consequent trophic levels. For example, the BMF from arctic cod (*Boreogadus saida*) to seals is the fraction between the concentration in seals and their prey on a lipid weight basis (3). However, one of the weak points of the BMF is that its value depends on the contaminant concentration in predator and prey. The contaminant concentration has been shown to be directly dependent on the size of the lipid reserves (4). Consequently, changing lipid cycles result in changing BMF. A possible improvement of the BMF is to use the contaminant per kg body weight as the basis for the calculations.

Another method to assess the persistency of contaminants, and indirectly their bioaccumulation potential, is the metabolic index (MI). The MI expresses the accumulation potential of a certain compound relative to PCB 153 (5) and is therefore independent of the lipid content of the animal.

Only limited information is available about the persistency of different contaminants in seals, although previous studies have indicated that seals are able to metabolise a variety of chlorinated compounds (4, 6). The aim of the present study was to assess the persistency and bioaccumulation potential of some chlorinated hydrocarbons in harp seals using both the BMF and the MI.

Material and Methods

Thirteen sub-adult (≤ 4 years) harp seals were sampled during August 1997 in the northwest Barents Sea along the ice edge. Seal samples were taken as described previously (6). The blubber thickness was measured dorsally, at 60 % of the total body length (7). A tooth was extracted for age determination. Ten g of blubber was sampled and the PCB and pesticide analyses were carried out as described previously (4). The major food items of harp seal i.e. polar cod (*Boreogadus saida*) and a pelagic crustacean (*Themisto libellula*) were also sampled for this purpose. The total amount of blubber in the seals was calculated as described by Ryg et al. (7). The contaminant burden (μg/kg body weight) was calculated, assuming an even distribution of the contaminants in the blubber. The BMF was calculated as the fraction between the amount of contaminants in the seals (μg/kg body weight) and their prey (μg/kg wet weight). In both seal blubber and the two major prey items of harp seals, the relative contribution of each compound, as a fraction of PCB 153 (Compound X/PCB 153), was calculated after logarithmic transformation of the individual data. The ratio between these 2 fractions, the MI (compound X / PCB 153)$_{seal}$ / compound X / PCB 153)$_{food}$ times hundred), was calculated (5).

Results and Discussion

In fig. 1 the BMF and MI are presented for 15 different PCB congeners (A) and several pesticides (B).

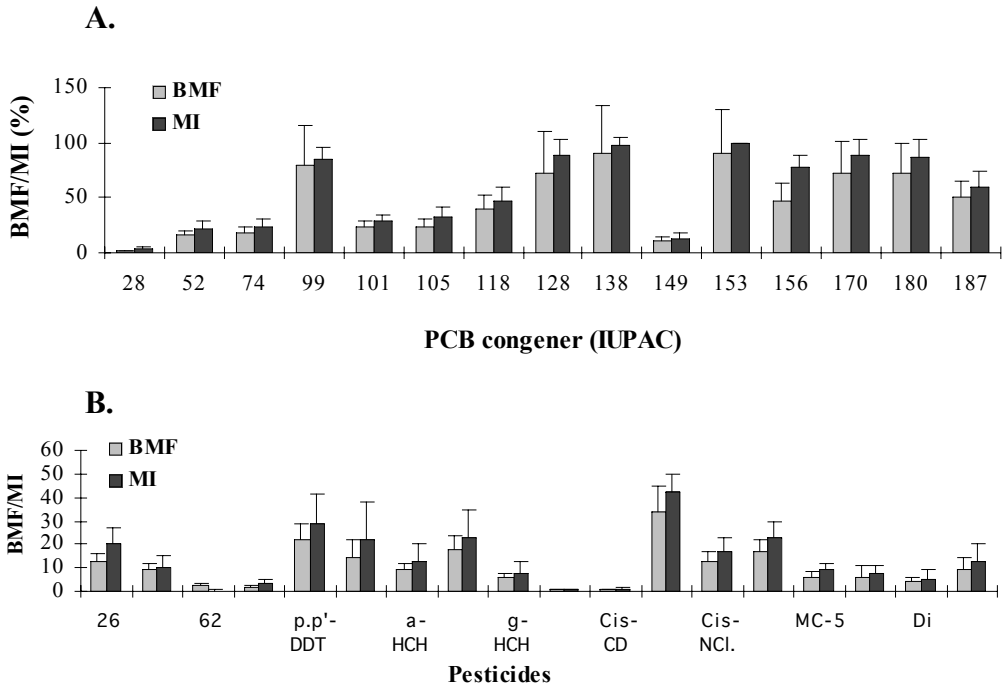

Fig. 1. Biomagnification factor, BMF, from polar cod and *T. Libellula* (1:1 mixture) to seals, were calculated as the *(amount of the contaminant per kg seal) / (amount of the contaminant per kg prey)*. In addition the metabolic index, MI, expressed as the ratio between the concentration relative to PCB 153 in seals and their prey i.e. $(contaminant\ X / PCB\ 153)_{seal} / (contaminant\ X / PCB\ 153)_{prey}$ times hundred, was calculated. **A**: PCBs, **B**: different pesticides: toxaphenes Parlar 26, 50, and 62, DDTs, alpha, beta, and gamma hexachlorocyclohexane (HCH), *trans* and *cis* chlordane (CD), *trans* and *cis* nonachlor (NCl), and U82, MC5 and MC7 from the chlordane group, as well as dieldrin (Di) and endrin (En).

The BMF shows the increase in contaminant concentration from prey to predator based on the total amount of the compound per unit of body mass. Therefore it is independent of the lipid concentration of both predator and prey. This is an advantage of the more commonly used BMF where the calculation is based on the concentration per unit of lipid. Due to large lipid cycles in arctic animals, in seals the lipid content may change with more than a factor 2, also the contaminant concentrations are influenced (4). In addition, different methods of lipid extraction influence on the lipid amount and hence the BMF. The MI, showing the bioaccumulation potential of certain compounds relative to the persistent PCB congener PCB153, is also independent of the lipid concentrations. Values below 100 indicate less bioaccumulation or even metabolism as compared to PCB 153. However, it has been shown previously that the MI of a certain compound changes with the age of the animal (4), making it an age-dependent unit. Further, neither the BMF nor the MI accounts for differences in absorption between contaminants.

For both the PCBs and the pesticides the BMF and the MI harmonised well. Both factors revealed the same behaviour for most contaminants. Based on the CYP isoforms present in harp seals (6) both the BMF and MI showed lower values for the PCBs which theoretically should be non-persistent (PCBs 28, 52, 74, 101, 105, 118, and 149) and high values for most of the higher chlorinated PCBs, considered persistent (PCBs 99, 128, 138, 153, 170, 180, 187).

Both BMF and MI indicated a slower rate of accumulation of the pesticides than PCB 153. Relatively large differences were found between the pesticide groups. The highest MIs were found for the DDTs and chlordanes, followed by β-HCH, and the PCCs. Within the pesticide groups also large differences were found. In accordance with previous studies (8) the MI suggested that β-HCH was the most persistent of the HCHs. The chlordanes showed large differences in persistency with the nonachlors being much more persistent than the chlordanes. Further, the results indicate that the toxaphenes with limits, are metabolised in harp seals. Tox 62 was obviously not very persistent in seals, while Tox 26 and 50, although considred persistent, may be metabolised in harp seals. This is supported by the relatively low occurrence of these two congeners in seals and polar bears (9) as compared to beluga (*Delphinapterus leucas*) (10).

References

1. AMAP, *AMAP Assessment Report: Arctic pollution issues*, Arctic Monitoring and Assessment programme, Oslo, Norway, **1998**; ISBN 82-7655-061-4
2. Muir DCG, Wagemann R, Hargrave BT, Thomas DJ, Peakall DB and Norstrom RJ; *Sci. Tot. Environ.* **1992**, 122, 75
3. Muir DCG, Norstrom RJ and Simon M; *Environ. Sci. Techol.* **1988**, 22, 1071
4. Wolkers J, Burkow IC, Lydersen C, Dahle S, Monshouwer M and Witkamp RF; *Sci. Tot. Environ.* **1998**, 216, 1
5. Bruhn R, Kannan N, Petrick G, Schultz-Bull DE and Duinker JC; *Chemosphere* **1995**, 31, 3721
6. Wolkers J, Burkow IC, Monshouwer M, Lydersen C, Dahle S and Witkamp RF; *Mar. Environ. Res.* **1999**, 48, 59
7. Ryg M, Lydersen CL, Markussen MH, Smith T, Øritsland NA; *Can. J. Fish. Aquat. Sci.* **1990**, 47, 1223
8. Willett KL, Ulrich EM and Hites RA; *Environ. Sci. Technol.* **1998**, 32, 2197
9. Zhu J. and Norstrom R.J. *Chemosphere* **1993**, 27, 1923
10. Stern GA, Muir DCG, Ford CA, Grift NP, Dewailly E, Bidleman TF and Walla MD; *Environ Sci Technol.* **1992**, 26, 1838