

Polychlorinated Biphenyls in Sediments from Ghar El Melh lagoon, Tunisia

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Introduction

The polychlorinated biphenyls (PCBs) are a group of persistent organic pollutants (POPs) that have been, for a long-time, focus of great attention by the scientific community due to their impact on public health and the environment.

PCBs have been used as constituents in a variety of products and in several industrial applications. PCBs are hydrophobic compounds that tend to adsorb onto suspended material and sediments. Hence sediments can be considered a pollution reservoir and may be a source of contaminants to aquatic biota. They are carried from terrestrial sources to the aquatic ecosystems through various pathways, such as atmospheric and fluvial transports. PCBs appear to have a potential to biomagnify in both freshwater and marine food webs. Suedel et al¹. reported that in 87% of reviewed data, PCBs showed biomagnification through the aquatic food chain. Therefore, sediment contamination is of great concern.

The Ghar El Melh lagoon is a Mediterranean water body, situated in Northeastern Tunisia, on the Northwestern side of the Gulf of Tunis. This lagoon is 34 km² in size; it extends over a length of 7 km and a width of 4.5 km and limited by the outer geographic coordinates 37°07' N, 10°08' E and 37°11' N, 10°14' E. Due to human activities within the lagoon itself and in the surrounding area, the lagoon ecosystem has suffered a progressive deterioration. This Deterioration has led to a reduction in biodiversity resulting mainly in a decrease in fish resources and production.

A previous study revealed the presence of residual polychlorinated biphenyls in superficial sediment of Bizerte lagoon². To our knowledge, there are no studies of PCBs in sediments in Ghar El Melh Lagoon, and as such, the aim of this study was to elucidate the source and distribution of PCB and to evaluate PCBs contamination in sediments from Ghar El Melh Lagoon.

Material and methods

A total of 12 surface sediments located by GPS were collected in November 2006. 20 PCBs were studied by capillary gas chromatography and electron capture detection, a well established method, described previously².

The whole analytical procedure was validated by analyzing EC-3 sediment reference materials from National Water Research Institute (Canada). The recoveries of studied PCBs in the extract using the same methodology were >90%. The total organic carbon (TOC) contents were measured by means of the method described elsewhere³. The percentage of finer grain size fractions (<63 µm) of each sediment sample was determined gravimetrically after wet sieving.

Results and discussion

The analytical results, based on dry sediment weight, are summarized in Table 1. Total polychlorinated biphenyls concentrations as sum of the 20 congeners ranged from 0.454 ng/g dry wt to 3.940 ng/g dry wt.

Figure 1 shows the geographic distribution of PCB concentrations. In the whole of the lagoon system, the contents of total PCB in the sediment vary from a site to another. This result reflects a zonation of the level of contamination.

The highest PCB concentrations ranged from 2.939 to 3.987 ng/g were detected at the east part of the lagoon site S3 and at site S6. The station S3 is near the fishing harbour. In addition, the station S6 is located in the southwest zone of the lagoon characterized by agricultural activities and water stagnation; this explains the high level of PCB in the sediments of this site.

The stations S2, S9, S10, S11 and S12 were classified as fairly contaminated with total PCB concentrations range from 1.125ng/g to 1.954 ng/g. The stations S11 and S12 were near the old harbour and pollution were affected by fishing harbour associated with artisanal fishing, such as small boats maintenance and painting. The station S9 and S10 were near Ghar El Melh city where there are several local wastewater discharges.

The Stations S4, S7 and S8 were classified as weakly contaminated. S7 and S8 are near the Ghar El Melh city where pollution is affected by agriculture inputs and several municipal waste water discharges.

PCBs were not detected in sediment samples collected from the sites of S1 and S5.

The results of individual PCB congeners showed that greatest number of congeners was found at site S6 with nine congeners and the lowest at sites S2 and S7 with one congener (Table1).

Congeners PCB -8, PCB-18, PCB-66 + 77, PCB-118 + 126, PCB- 170 and PCB-206 were not detected in any station.

Tetra PCBs represented by PCB-52 and PCB-44 were detected only in sediment collected at locations S2, S3 and S6.

The Percentage compositions of low chlorinated congeners (di-, tri- and tetra-PCBs), mid-chlorinated congeners (penta-, hexa- and hepta-PCBs) and high-chlorinated congeners (octa-, nona-, and deca-PCBs) to the total PCB concentrations are given in Figure 2.

Sediment collected at locations S4, S6, S7, S8, S9, S10 and S12 contained penta-, hepta-, octa-, and deca-PCB.

The highest concentration of the individual congeners was detected in site S2 for PCB 44.

For the low chlorinated congeners, PCB 52, and PCB 44 were the most abundant in superficial sediments.

Polychlorinated congeners contribution according to the degree of chlorination to the observed total PCB concentrations, revealed that tetrachlorobiphenyls, pentachlorobiphenyls, hexachlorobiphenyls, heptachlorobiphenyls, octachlorobiphenyls and decachlorobiphenyls accounted respectively for 16%, 25%, 24%, 4%, 2%, and 13%.

The distribution patterns of PCB congeners are, in general, different among the sediments of this study area, which may indicate different input sources and the establishment of a correlation between the congener profiles and the sources is difficult, especially when the source between the distance and the sampling site is large. In addition the usage of PCB in Tunisia is not well established, but the use of PCBs in transformers, electrical and other industries is common.

As regards the results obtained for dioxin-like PCBs (77, 126, 105 and 118) the concentrations for the PCB 105 vary from 0.278 to 0.564 ng/g and PCB 77, PCB 126, PCB 118 were not detected for all sediment samples.

Levels of PCBs in surface sediments in this study were lower than sediments collected from, Italian coast⁴. The concentrations of total PCBs in Ghar El Melh lagoon are generally lower compared to Venice lagoon⁵. The contamination level was similar to Bizerte lagoon² and four order of magnitude higher than Vistula lagoon⁶.

Factors influencing PCB concentrations in sediment:

Many important factors, such as organic carbon content, and particle size can control the PCBs levels in the sediments^{7, 8}. The organic carbon values of the sediments given in Table 1 range from 2.01% to 4.78%. The percentage of finer grain size fractions was in the range 5.3-98.9% (Table 1). Neither TOC nor grain size (<63 µm) are correlated with the distribution of either total PCBs. It is suggested, therefore, that the observed distribution of PCBs was not governed by sedimentary characteristics, and may be due to localised sources of inputs.

References :

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Table 1: Levels of PCBs (ng/g dry wt), percentage of total organic carbon (TOC) and percentage of finer grain size fraction (<63 μm) in surface sediments of the Ghar El Melh Lagoon

Chlorinated Congener Group	Site											
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Bi- 8	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Tri- 18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
28	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Tetra 52	n.d.	n.d.	0.672	n.d.	n.d.	0.480	n.d.	n.d.	n.d.	n.d.	n.d.	0.504
44	n.d.	1.206	n.d.	n.d.	n.d.	0.491	n.d.	n.d.	n.d.	n.d.	0.173	n.d.
66	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
77	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Penta- 101	n.d.	n.d.	0.453	n.d.	n.d.	0.733	n.d.	0.179	0.595	0.631	n.d.	0.387
118	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
105	n.d.	n.d.	n.d.	n.d.	n.d.	0.296	n.d.	n.d.	0.278	n.d.	0.564	0.498
126	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Hexa- 153	n.d.	n.d.	1.656	n.d.	n.d.	0.636	0.454	n.d.	n.d.	n.d.	0.239	0.258
138	n.d.	n.d.	0.905	0.282	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
128	n.d.	n.d.	0.047	n.d.	n.d.	0.014	n.d.	0.069	n.d.	n.d.	0.034	0.246
Hepta- 187	n.d.	n.d.	0.140	n.d.	n.d.	0.078	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
180	n.d.	n.d.	0.114	0.136	n.d.	0.159	n.d.	n.d.	n.d.	n.d.	0.115	0.026
170	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Octa- 195	n.d.	n.d.	n.d.	0.019	n.d.	0.052	n.d.	n.d.	n.d.	0.149	n.d.	0.035
Nona- 206	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Deca- 209	n.d.	n.d.	n.d.	0.335	n.d.	n.d.	n.d.	0.210	n.d.	0.410	n.d.	n.d.
∑PCB	n.d.	1.206	3.987	0.772	n.d.	2.939	0.454	0.458	1.225	1.190	1.125	1.954
%TOC	3,10	2,74	2,36	2,01	4,78	3,10	2,35	3,37	3,31	2,74	2,23	3,12
%<63 μm	98.90	65.40	5.30	98.10	95.40	79.10	87.70	68.60	94.20	91.30	92.50	96.70

n.d.: Not determined (below detectable limit).

Figure 1: Spatial distribution of Σ PCB in surface sediment from Ghar El Melh Lagoon

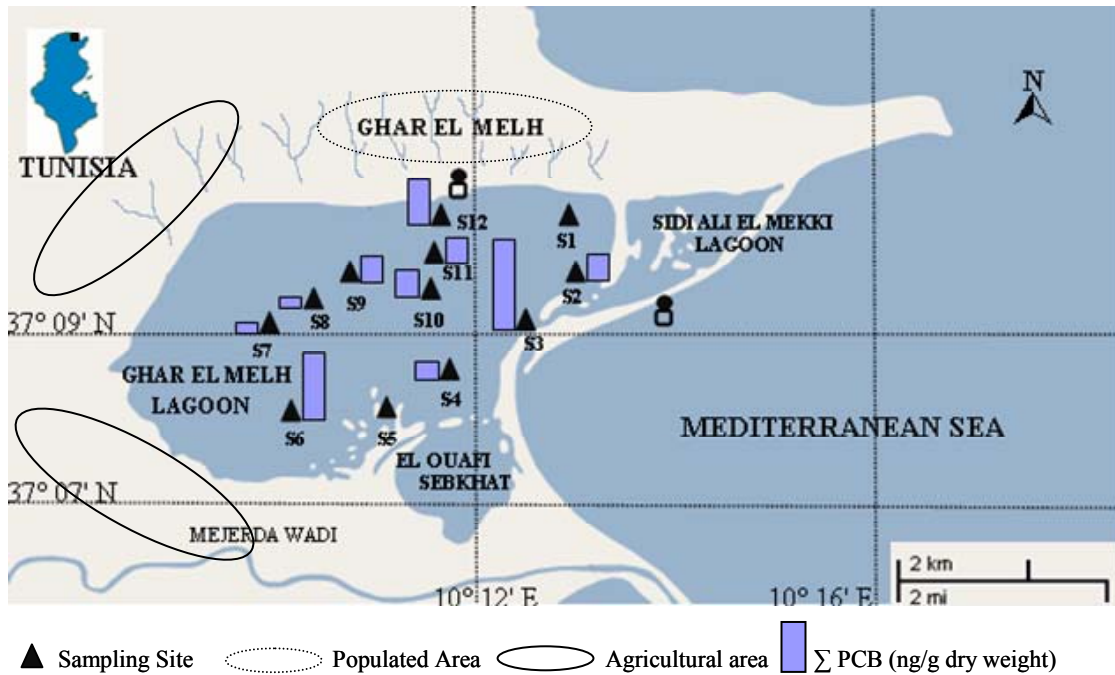


Figure 2: Relative contribution of low-, mid- and high chlorinated PCB congeners to the Σ PCB in Ghar El Melh Lagoon

