

Determination of organochlorine compounds in coastal marine sediments from the southern west of the Mediterranean Sea

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ABSTRACT: Recent evidence suggests that polychlorinated biphenyls might also have adverse reproductive, developmental and endocrine effects. Although, the use of polychlorobiphenyls in Algeria has been banned for more than two decades, large quantities of these compounds containing products remain disseminated, mainly stored in obsolete or damaged equipments. This research describes a study to assess polychlorinated biphenyls distribution in marine sediments collected from the seaside of Tamentfoust touristic resort located in the eastern side of Algiers Bay. After microwave-assisted extraction and purification with both concentrated sulphuric acid and activated silica gel, the extracts were analyzed by gas chromatography with an electron capture detector. Relatively high contamination levels of polychlorinated biphenyls were found in samples collected from the port of Tamentfoust (15 to 70 ng/g d.w.), while the concentrations were lower in the stations located outside the port (0 to 26 ng/g d.w.). Compared with data previously reported by some other researchers, the polychlorobiphenyls concentrations found in this work showed an environmental persistence, but a decrease of approximately 5 times in 30 year i.e since the ban of the use of polychlorinated biphenyls. The predominant polychlorinated biphenyls congeners in all sediment samples were polychlorinated biphenyls 138, 153, 180 and 187. This composition was similar to industrial mixture (Aroclor 1260). This probably indicated that the contamination originated from the port and has a continental source.

Keywords: Environment; Extraction; Gas chromatography; Polychlorinated biphenyls

INTRODUCTION

Polychlorinated biphenyls (PCBs) are persistent organic pollutants with significant bioaccumulation potentials in environmental systems (UNEP, 2003). These compounds are frequently detected in a wide variety of environmental matrices such as sediments, soils, biota, water and air, in both industrial and non-industrial areas (Iwata *et al.*, 1995; Floch *et al.*, 1996; Bodin *et al.*, 2004). The synthesis of PCBs was first described in 1881 (Schmidt and Schultz, 1881). Their wide industrial application started from 1930 because of their chemical stability including nonflammability and heat resistance properties (Erickson, 1997). They have been used as dielectric fluids in capacitors and transformers, hydraulic fluids, lubricating oils,

plasticisers, additives in pesticides, inks and paints (Gervason, 1987; Edward Raja and Selvam, 2009). The presence of PCBs in the environment was first identified in biological samples in 1966 (Jensen, 1966). PCBs have long been identified as harmful substances due to their toxicity (Safe, 1992, Persson *et al.*, 2005, Sporveri *et al.*, 2007; Juang *et al.*, 2009a; b). In the Mediterranean Sea, there have been numerous studies investigating the environmental fate and distribution of PCBs particularly in the northern side (Spain, France, Italy) (Tolosa *et al.*, 1997). However, information on the spatial and temporal distribution of PCBs in the southern Mediterranean countries remains poor. Recently, some papers described investigations on PCBs observed in Egypt (Barakat *et al.*, 2002, Tundo *et al.*, 2004, Said, 2007), Tunisia (Pavoni *et al.*, 2000)

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and Morocco (Pavoni et al., 2001). In Algeria, PCBs were widely used mainly as dielectric fluids in the past 50 years and some still remain in use or in storage (6699 apparatus containing over 3443 tons of Askarel oil have been inventoried) (Ministère de l'Aménagement du Territoire et de l'Environnement, 2006). Although this class of compounds were banned in 1987 (decree 87-182 issued on 18 August 1987), the distribution of PCBs and their effects on environment and human health havenot been widely studied since data published by Elder and Villeneuve (1977) and Cousteau (1979). In the other hand, ISMAL (Institut des Sciences Marines et de l'Aménagement du Littoral) located in Algiers, has contributed to UNEP programs for Mediterranean Sea protection. The aim of this study was to assess the level and distribution of PCBs in marine sediment samples collected from the seaside of Tamentfoust resort (La Perouse) located

in the eastern side of Algiers Bay. In this district, tourist activities take place while the number of inhabitants increases markedly during the summer period. Six sampling campaigns were carried out from July to October 2002 in the Tamentfoust port and in four locations situated outside the port.

MATERIAL AND METHODS

Sample collection

Thirty coastal marine sediment samples were collected from five sites located at the port and on both sides at 3 m (locations 2 and 5) and 10 m depth (locations 3 and 4) as described in Fig. 1. An aerial view of Tamentfoust Port is shown on Fig. 2. Sediments were freeze-dried and stored in sealed containers. All the samples were analyzed at the Laboratory of Physics and Toxicological Chemistry (LPTC), Bordeaux1 University, France.

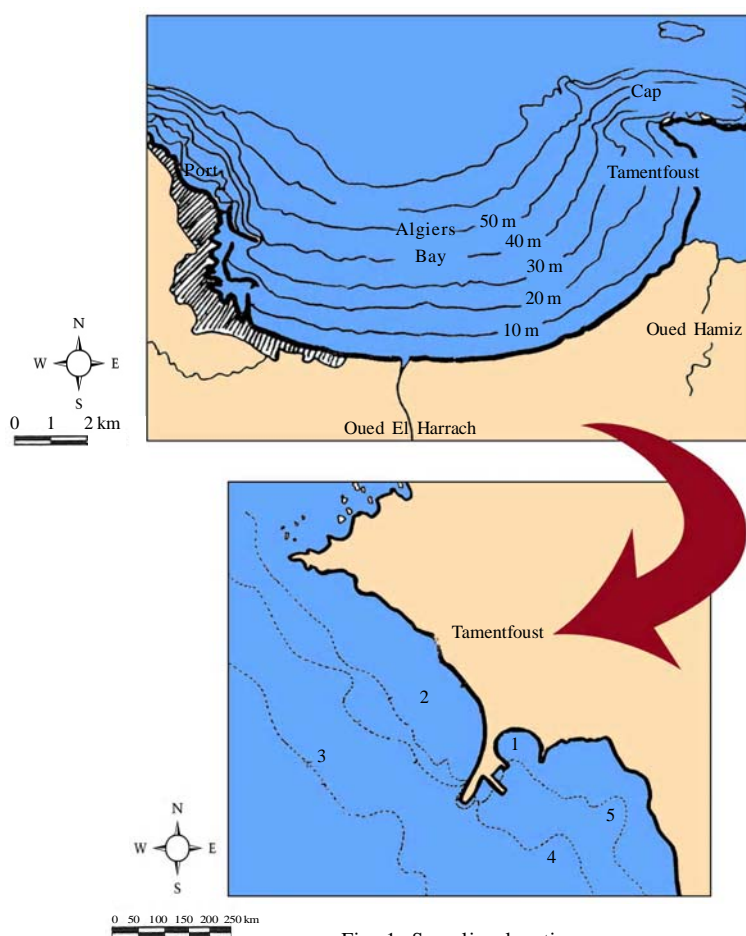


Fig. 1: Sampling locations





Fig. 2: Aerial view of Tamentfoust Port (from Google earth, 2009)

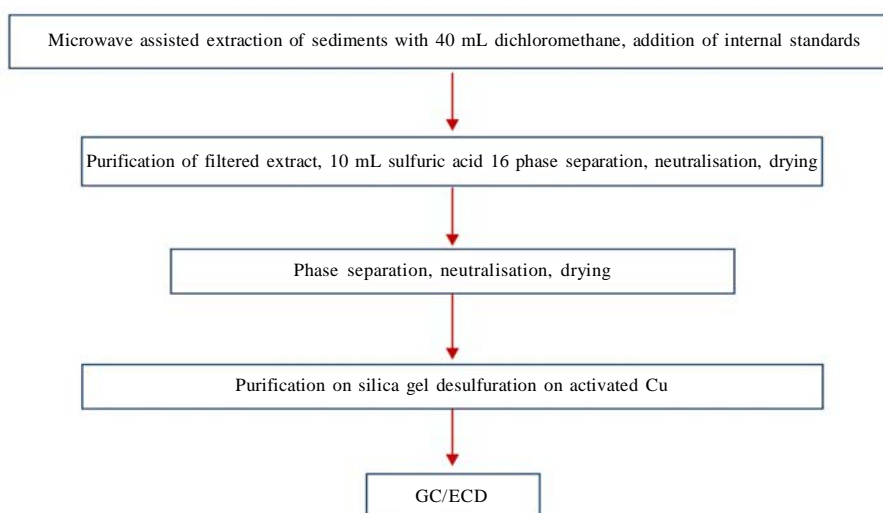


Fig. 3: The procedure of sample preparation

Sample preparation

The experimental procedure is summarized in Fig. 3. All samples were sieved through 2 mm to homogenize sediments prior to the extraction. The surrogate standards PCB30, PCB103, PCB155, PCB198 and octachloronaphthalene (OCN) were added to the sediment before extraction. The sample (5g mass of dry sediment) was extracted by microwave-assisted extraction (Letellier, 1999; Budzinski *et al.*, 2000; Thompson and Budzinski, 2000) with 40 mL of

dichloromethane using a Magidigest 350 Prolabo apparatus at a 15W power and for 10 min. After extraction, the sample was filtered and purified with concentrated sulphuric acid. The organic and acid phases were separated and the organic extract was diluted with pure water and dried over anhydrous sodium sulfate. The extract was concentrated under a gentle flow of nitrogen then purified a second time on a column packed with activated silica (2 g) and 1cm of activated copper on top for elimination of elemental



sulfur. The PCBs were eluted from this column with 3 × 5 mL 10:90 dichloromethane-pentane. The extract was concentrated under nitrogen and transferred to 0.5 mL iso-octane. The solution was further re-concentrated to 0.05 mL in a conical injection vial. The same procedure was used for the blank sample which was run with every set of five samples to check for secondary contamination.

Chemical reagents

The PCBs standards were purchased from Promochem (Promochem, Molsheim, France) in solution at 99 % + purity. The surrogate standards PCB 30, 103, 155 and 198 and OCN were also obtained from Promochem (Promochem, Molsheim, France) as crystals of 99 % + purity. A certified solution of PCB, SRM 2262 was obtained from NIST (Gaithersburg, MD, USA). Dichloromethane was purchased from Prolabo (Prolabo, Fontenay sous Bois, France, pesticide grade). The anhydrous sodium sulfate and the concentrated acid were from Fluka Chemie (Buchs, Switzerland), and the silica gel (particle size 0.063-0.2 mm) from Merck (Darmstadt, Germany). The copper (40 meshes, 95.5 % purity) was purchased from Aldrich (Aldrich,

Strasbourg, France). Iso-octane of spectroscopy grade quality and HPLC grade pentane were from Scharlau, ICS (St. Médard en Jalles, France).

Gas chromatography

The extract was analyzed by GC-ECD on a Hewlett-Packard 5890 Series II gas chromatograph equipped with a ⁶³Ni electron-capture detector using a HP5 capillary column (60 m × 0,25 mm i.d. × 0,25 μm film thickness). The GC conditions were as follows: splitless injection (1 μL); injector temperature: 280 °C; detector temperature: 290 °C; initial oven temperature: 60 °C held for 2 min, heated to 120 °C at 6 °C/min and held for 5 min, then heated to 280 °C at 2 °C/min and held for 20 min. Helium was used as the carrier gas. The PCB congeners were analyzed individually when possible, though in some cases the concentrations are reported as the sum of overlapping congeners due to coelution on the GC column. The relative response factors of different compounds were determined after each six samples by injecting a standard solution of PCBs (Table 1) spiked with the same solution of internal standards (PCB30, PCB103, PCB155, PCB198 and OCN)

Table 1: List of the studied PCBs and their corresponding internal standards

Internal standards	Chemical name	IUPAC nomenclature
PCB30	2,4'-dichlorobiphenyl	PCB 8
PCB30	2,2',5'-trichlorobiphenyl	PCB 18
PCB30	2, 4,5-trichlorobiphenyl	PCB 29
PCB30	2, 4,4'-trichlorobiphenyl	PCB 28
PCB30	2,2',4,6-tetrachlorobiphenyl	PCB 50
PCB103	2,2',5,5'-tetrachlorobiphenyl	PCB 52
PCB103	2,2',4,6,6'-pentachlorobiphenyl	PCB 104
PCB103	2,2',3,5'-tetrachlorobiphenyl	PCB 44
PCB155	2,3',4,4'-tetrachlorobiphenyl	PCB 66
PCB155	2,2',4,5,5'-pentachlorobiphenyl	PCB 101
PCB155	2,2',3,4,5'-pentachlorobiphenyl	PCB 87
PCB155	3,3',4,4'-tetrachlorobiphenyl	PCB 77
PCB155	2,2',4,4',5,6-hexachlorobiphenyl	PCB 154
PCB198	2,3',4,4',5-pentachlorobiphenyl	PCB 118
PCB198	2,2',3,4',5,6,6'-heptachlorobiphenyl	PCB 188
PCB198	2,2',4,4',5,5'-hexachlorobiphenyl	PCB 153
PCB198	2,3,3',4,4'-pentachlorobiphenyl	PCB 105
PCB198	2,2',3,4,4',5',6-hexachlorobiphenyl	PCB 138
PCB198	3,3',4,4',5-pentachlorobiphenyl	PCB 126
PCB198	2,2',3,4',5,5',6-heptachlorobiphenyl	PCB 187
PCB198	2,2',3,3',4,4'-hexachlorobiphenyl	PCB 128
PCB198	2,2',3,3',4,5,6,6'-octachlorobiphenyl	PCB 200
PCB198	2,2',3,4,4',5,5'-heptachlorobiphenyl	PCB 180
PCB198	2,2', 3,3',4,4',5-heptachlorobiphenyl	PCB 170
PCB198	2,2', 3,3',4,4',5,6-octachlorobiphenyl	PCB 195
PCB198	2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	PCB 206
PCB198	2,2', 3,3', 4,4',5,5', 6,6'-decachlorobiphenyl	PCB 209



as that used for spiking the samples. Blank injections of isooctane were performed before each sample injection to ensure the cleanliness of the injector. A certified solution of PCB, SRM 2262 obtained from NIST (MD, USA) was used. The limit detection was 0.01 ng.

RESULTS AND DISCUSSION

The concentrations of the PCBs in sediments are reported in Table 2 for the location 1, in Table 3 for the locations 2 and 5 and in Table 4 for the locations 3 and 4. All concentrations data are based on dry weight. The mean recovery of PCBs from three replicate sediment samples was 95 %. Twenty PCB congeners were detected at the port, sixteen in the locations two (2) and five (5) and fourteen in the locations 3 and 4. As example, two chromatograms of the PCBs extracts obtained in 30th day at locations 1 and 5 are shown in Fig. 4.

PCB8, PCB66, PCB126, PCB188 and PCB209 were not detected in any of the samples. Individual PCB concentrations of samples collected from the port were higher for congeners substituted with 5, 6 and 7 chlorine atoms (Table 2). In the same station, a 12 ng/g maximum concentration value was found for PCB138 (60th day),

and this extract corresponded to the most contaminated sample with a total PCB content of 70 ng/g. It has been also focused on the seven priority congeners which are known for their persistence in environment samples: PCBs 28, 52, 101, 118, 138, 153 and 180. In this study, the total seven PCBs priority concentrations ranged from 0.11 to 38 ng/g as shown in Fig. 5. They represented 50 % to 62 % of total PCBs in location 1 (the port) and 50 % to 100 % in the other locations.

Among the collected samples, the 12 sediments collected from the locations 2 and 3 were bulky. The particle size distribution of the 18 others was determined by laser. For the locations 4 and 5, the size of sediments was 63 % to 98 % below 650 µm. The sediment samples collected from the location 1 (the port) were fine, with particle sizes below 125µm.

PCBs levels in sediments

The sum of total PCBs concentrations in marine sediments samples collected from Tamentfoust basin ranged from 0 to 70 ng/g dry weight (Tables 2, 3 and 4) were lowest compared to some data collected during the last years in Mediterranean coast (Table 5). Indeed,

Table 2: Concentrations (ng/g d.w.) of PCBs for samples collected from location one (1) (the port at 2.5m depth)

Days	0 day	15 th . day	30 th . day	45 th . day	60 th . day	85 th . day
PCB 8	ND	ND	ND	ND	ND	ND
PCB 18	0.11	0.01	0.20	0.17	0.01	0.17
PCB 29	0.25	0.01	0.01	0.17	0.01	0.01
PCB 50+28	0.01	0.01	0.30	0.01	0.37	0.50
PCB 52	0.33	3.21	1.72	3.33	2.68	1.22
PCB 104	0.01	0.01	0.01	nd	0.21	0.01
PCB 44	0.19	1.03	0.44	1.29	0.67	0.36
PCB 66	ND	ND	ND	ND	ND	ND
PCB 101	1.15	4.20	4.24	6.77	5.81	3.41
PCB 87	1.28	1.62	3.74	2.87	3.84	4.83
PCB 154+77	1.35	6.54	5.53	10.63	7.95	4.89
PCB 118	0.99	4.65	3.75	7.32	5.37	3.16
PCB 188	ND	ND	ND	ND	ND	ND
PCB 153	2.67	3.25	8.67	4.84	10.56	4.01
PCB 105	0.01	0.01	1.41	4.55	0.01	0.01
PCB 138	2.23	1.32	8.30	6.63	11.69	6.32
PCB 126	ND	ND	ND	ND	ND	ND
PCB 187	0.90	4.48	3.08	0.71	6.37	3.23
PCB 128	0.43	3.68	1.63	1.74	4.81	1.57
PCB 200	0.01	0.01	0.44	nd	1.61	0.30
PCB 180	1.62	4.12	5.32	1.29	1.83	4.76
PCB 170	0.90	3.92	2.67	0.74	5.59	3.11
PCB 195	0.13	1.27	0.41	ND	0.50	0.37
PCB 206	0.06	0.40	0.20	ND	0.63	0.15
PCB 209	ND	ND	ND	ND	ND	ND
Total PCBs	15	46	54	53	70	42
Σ7 PCBs	9	20	32	30	38	23

ND: Non detected



Table 3: Concentrations (ng/g d.w.) of PCBs for samples collected from locations 2 and 5 (at 3 m depth)

Dates	0 day		15 th . day		30 th . day		45 th . day		60 th . day		85 th . day	
	2	5	2	5	2	5	2	5	2	5	2	5
Locations	2	5	2	5	2	5	2	5	2	5	2	5
PCB8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 29	0.31	0.01	0.01	0.01	0.01	0.50	0.01	0.01	0.01	0.01	0.01	0.01
PCB 50+28	0.01	0.10	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.07	0.01	0.06
PCB 52	0.09	0.33	0.03	0.02	0.01	0.09	0.06	0.14	0.47	0.49	0.05	0.10
PCB 104	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.08
PCB 44	0.01	0.07	0.15	0.01	0.01	0.01	0.01	0.06	0.12	0.10	0.03	0.10
PCB 66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 101	0.37	0.30	0.96	0.04	0.06	0.14	0.16	0.28	0.73	0.49	0.12	0.26
PCB 87	0.26	0.03	0.54	0.30	0.04	0.23	0.05	0.20	0.32	0.25	0.04	0.16
PCB 154+77	0.01	0.01	0.45	0.01	0.01	0.08	0.23	0.30	0.73	0.54	0.38	0.21
PCB 118	0.04	0.66	0.66	0.01	0.01	0.01	0.04	0.12	0.28	0.01	0.07	0.01
PCB 188	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 153	0.34	0.92	0.91	0.37	0.19	0.60	0.21	0.52	0.73	0.43	0.11	0.52
PCB 105	0.19	0.15	0.70	0.04	0.06	0.63	0.01	0.21	0.20	0.01	0.14	0.01
PCB 138	0.29	0.90	0.87	0.33	0.13	0.49	0.18	0.32	0.75	0.29	0.18	0.32
PCB 126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 187	0.10	0.44	0.31	0.23	0.09	0.27	0.10	0.18	0.25	0.16	0.03	0.17
PCB 128	0.07	0.01	0.23	0.01	0.01	0.07	0.06	0.01	0.16	0.02	0.07	0.08
PCB 200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 180	0.10	0.33	0.31	0.34	0.20	0.34	0.16	0.27	0.33	0.27	0.10	0.24
PCB 170	0.05	0.09	0.33	0.18	0.10	0.30	0.11	0.17	0.28	0.11	0.09	0.20
PCB 195	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 206	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 209	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs	2	4	6	2	1	4	1	3	5	3	1	3
Σ7 PCBs	1	4	4	1	1	2	1	2	3	2	1	1

ND: Non detected

Table 4: Concentrations (ng/g d.w.) of PCBs for samples collected from locations 3 and 4 (at 10 m depth)

Dates	0 day		15 th . day		30 th . day		45 th . day		60 th . day		85 th . day	
	3	4	3	4	3	4	2	5	2	5	2	5
Locations	3	4	3	4	3	4	2	5	2	5	2	5
PCB 8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 29	ND	ND	ND	ND	ND	ND	0.01	0.01	0.01	0.01	0.01	0.01
PCB 50+28	0.26	0.32	0.05	0.01	0.01	0.20	0.01	0.02	0.01	0.07	0.01	0.06
PCB 52	0.18	0.21	0.01	0.28	0.06	0.54	0.06	0.14	0.47	0.49	0.05	0.10
PCB 104	ND	ND	ND	ND	ND	ND	0.01	0.01	0.01	0.01	0.01	0.08
PCB 44	0.01	0.01	0.01	0.06	0.01	0.08	0.01	0.06	0.12	0.10	0.03	0.10
PCB 66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 101	0.01	0.01	0.03	0.71	0.10	0.92	0.16	0.28	0.73	0.49	0.12	0.26
PCB 87	0.16	0.01	0.11	0.69	0.07	1.03	0.05	0.20	0.32	0.25	0.04	0.16
PCB 154+77	1.64	0.57	0.06	1.00	0.01	1.06	0.23	0.30	0.73	0.54	0.38	0.21
PCB 118	0.01	0.11	0.11	0.82	0.03	0.72	0.04	0.12	0.28	0.01	0.07	0.01
PCB 188	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 153	0.30	0.43	0.29	0.85	0.30	2.46	0.21	0.52	0.73	0.43	0.11	0.52
PCB 105	0.01	0.14	0.02	0.60	0.10	0.01	0.01	0.21	0.20	0.01	0.14	0.01
PCB 138	0.43	0.85	0.05	0.62	0.07	2.15	0.18	0.32	0.75	0.29	0.18	0.32
PCB 126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 187	0.16	0.15	0.07	0.18	0.08	1.24	0.10	0.18	0.25	0.16	0.03	0.17
PCB 128	0.01	0.01	0.05	0.14	0.06	0.37	0.06	0.01	0.16	0.02	0.07	0.08
PCB 200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 180	0.14	0.05	0.19	0.27	0.10	0.96	0.16	0.27	0.33	0.27	0.10	0.24
PCB 170	0.01	0.01	0.21	0.17	0.06	0.54	0.11	0.17	0.28	0.11	0.09	0.20
PCB 195	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 206	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 209	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs	3	3	1	6	1	12	1	3	5	3	1	3
Σ7 PCBs	1	2	1	4	1	8	1	2	3	2	1	1

ND: Non detected



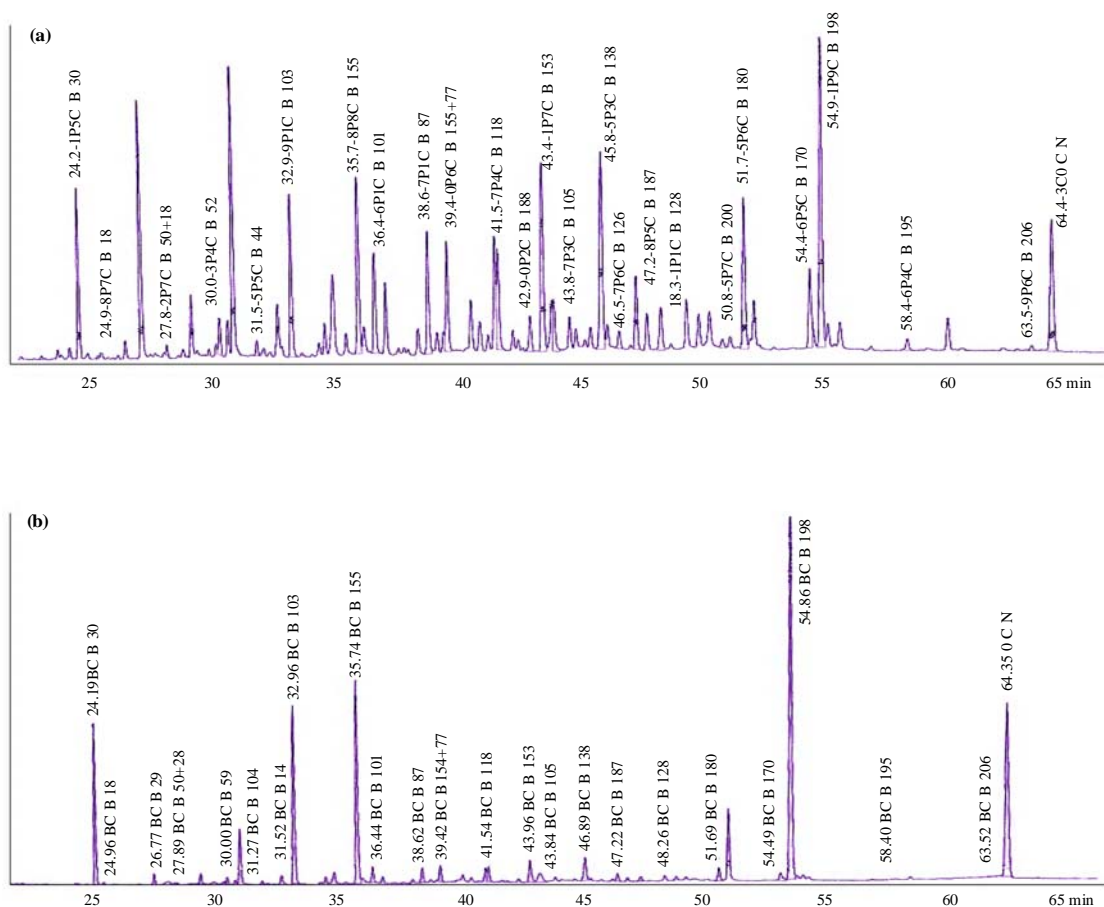


Fig. 4: Chromatograms of the PCBs extract obtained at 30th day (a: Location 1; b: Location 5)

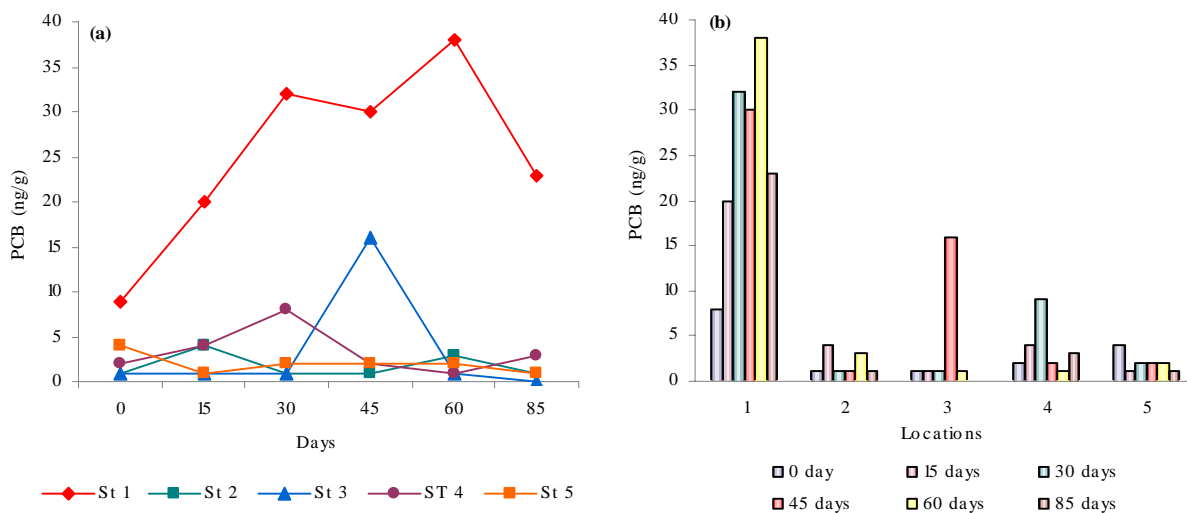


Fig. 5: Concentrations of the seven priority PCBs (a: Over the studied period; b: At the five locations)



Table 5: Comparison of PCB levels determined in sediments from different Mediterranean regions

Location	ng/g d.w.	Reference
Tamentfoust port, Algiers Bay, Algeria	0.31-70	The present work
Algerian coast	9	Elder et Villeneuve, 1975
Algerian coast	7-323	Cousteau, 1979
Arrone River, central Italy	10-200	Bazzanti et al., 1997
Sousse, Tunisian coast	40	Pavoni et al., 2000
Alexandria Harbour, Egypt ^a	0.9-1210	Barakat et al., 2002
Temsah Lake, Suez Canal, Egypt ^b	0.039-43.201	Tundo et al., 2004
Port of Bagnoli, Gulf of Naples, south Italy	4-100	Romano et al., 2005
Keratsini Harbour, Saronikos Gulf, Greece	47.8-351.8	Galanopoulou et al., 2005
Cortiou, Marseille, France	12.68-1559.3	Wafo et al., 2006
Naple Harbour, south Italy ^c	1-889	Sprovieri et al., 2007
Western Coast of Alexandria, Egypt	0.79-64.9	Said, 2007
Coastal Barcelona, Spain	2.33-44	Castells et al., 2008
Near submarine emissary, Barcelona	22.34-37.74	Castells et al., 2008

a: Surface sediments, b: Concentration of PCB118, c: Sum of 38 congeners

in some cases these levels could reach 1559,3 ng/g dry weight in Marseille (Wafo et al., 2006), 1210 ng/g in Alexandria (Barakat et al., 2002) and 889 ng/g in Naples (Sprovieri et al., 2007). In the past (1977), high levels of contamination with PCBs were found close to Algiers. Thus, 323 ng/g of Aroclor were found in marine sediments within an area of 10 km from Algiers (Cousteau, 1979). Compared with this data, the PCBs concentrations found in this work showed an environmental persistence but a decrease of approximately 5 times in 30 y, *i.e.* since the ban of the use of PCBs. These data did not reach the threshold concentrations established by some governments as France (Brunet et al., 2007).

Composition of PCBs

The composition of the different extracts was very similar to a slight fluctuation of the total PCBs content over the studied period, except for the sample collected at location three in September which corresponded to a total concentration of 26 ng/g. It was probably due to an accidental spill. The highest PCBs concentrations (70 ng/g) were recorded in sediment samples collected from the port (location 1). These PCBs have been probably emitted from a continental source in addition to the port activities. Off shore, PCBs high levels were 12 ng/g (location 4, 10 m depth) and 26 ng/g (location 3, 10 m depth). This let us to suppose that the contamination of locations situated off shore was originated from the port. This hypothesis was supported by the similar PCBs profile found at all locations and throughout the studied period. The PCBs congeners constituting this profile were ranged from trichloro to nonachlorobiphenyl. The most concentrated contaminants were PCBs 153, 138, 187 and 180 which are either hexa or heptasubstituted. This composition of individual PCBs in the sediments

was most similar to the industrial mixture Aroclor 1260 as it was previously reported by some authors (Schultz, 1989; Bazzanti et al., 1997). Indeed, it is thought that PCBs congeners in sediments closely resemble parent industrial mixture unless modified by bacterial mediated degradation (Brown and Wager, 1990). Compared to the reference matrix, light PCBs such as PCB8 in location 1, PCB8 and PCB18 in locations two and five, PCB8, PCB18 and PCB29 in locations three and four were not detected. This could be explained by their probable volatilization during storage and during analytical procedure. Indeed, the less chlorinated congeners are more volatile than the higher chlorinated congeners (Thompson et al., 2002). Furthermore, PCBs with a higher number of chlorine atoms are more stable in the marine environment since they undergo less readily enzymatic oxidation by bacteria (Abramowicz et al., 1993). Moreover, because of their lower solubility in water, highly chlorinated PCBs are preferentially associated to the sediments (Mangani et al., 1991). On the other hand, PCB195 (heptachloro-substituted) and PCB200 (octachloro-substituted) were only detected at the port. This could be related to the influence of the different sediment grain size fractions in sorbing and releasing PCBs as reported by Thompson et al. (1996), Edgar et al. (2003). According to Pierard et al. (1996), high chlorinated PCBs are preferentially associated with finer particle sizes of sediment fractions, while less chlorinated congeners are found with the bulky ones. As data shows, the particles sediment samples collected from the port were finer (< 125 µm) than those collected from the other locations.

CONCLUSION

The results of this study demonstrate that the PCBs concentrations remains still persistent in the marine



environment despite the ban of their production and use. These concentrations did not show significant fluctuations throughout the short studied period. Compared to the previous results reported for other Mediterranean industrial and urban concentrations, the levels of polychlorobiphenyls determined in the sediments in this region of Algiers Bay can be considered as moderate. The profile of the PCBs was very close to that of Aroclor 1260 mixture formerly used in electrical transformers, hydraulic fluids, plasticizer in synthetic resins and dedusting agents. Although the production and sale in Algeria was discontinued in late 1987, it is still present in many of the transformers and capacitors now in use. Relatively, high contamination levels of PCBs were found in samples collected from the port of Tamentfoust while the concentrations were much lower in the stations located outside the port. In addition, the chromatographic profiles of the different extracts showed a similar composition which probably indicates that the contamination originates from the port. However, it is necessary to implement measures to control industrial waste discharge and to avoid dispersal of these persistent toxic contaminants into the environment (Nouri *et al.*, 2008). Additional, since the very few investigations realized on PCBs in Algeria, further research work should be performed in order to establish a more detailed assessment of the target compounds levels in this area.

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