

## Usage of Pesticides and PCBs in Çukurova Region, Turkey and Their Impact on the Environment

Mustafa ÜNSAL

Middle East Technical University, Institute of Marine Sciences, Erdemli, İçel-TURKEY

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**Abstract:** Usage of pesticides and PCBs and their effects on the environment of the Çukurova region of Turkey were studied. Ten groups of pesticides, authorized by the Ministry of Agriculture and Rural Affairs, are currently being used in the region for agricultural purposes. Among them insecticides are the most extensively used pesticide group, followed by fungicides and herbicides. Although the usage of pesticides depends on the annual crop, it varies between 6501 and 9691 tons. PCBs-containing materials, e.g., plastics, lubricating oil, etc. are also used in appreciable amounts in the Çukurova region. The concentration of pesticides in the sediments from different areas of the Çukurova region was found to vary from no detectable level to about 21 ng g<sup>-1</sup> dry weight bases.

**Key Words:** Çukurova region, Pesticide, PCBs, Sea water, Marine organisms, Marine sediments

### PCB ve Pesticidlerin Çukurova Bölgesinde Kullanımı ve Çevreye Etkileri

**Özet:** Çukurova bölgesinde kullanılan PCB ve pestisidlerin tür ve miktarları ve bunların yakın çevreye zararları, literatür bilgilerine dayanarak incelenmiştir.

Bölgede, Tarım Orman ve Köyleri Bakanlığı tarafından belirlenmiş 10 pestisid grubu tarım amacıyla kullanılmaktadır. Bu gruplar içerisinde en çok insektisidler kullanılmakta, bunları fungusidler ve herbisidler izlemektedir. Pestisidlerin yıllık kullanım miktarı ürünün türüne bağlı olarak 6501 ile 9691 ton arasında değişmektedir.

PCB içeren maddeler de, örneğin plastikler, motor yağı vb. Çukurova bölgesinde önemli miktarda kullanılmaktadır.

Çukurova bölgesinin değişik yerlerinden alınan sediman örneklerindeki pestisid konsantrasyonları, aletin hassasiyet düzeyinin altındaki seviyelerden başlayarak kuru ağırlık olarak yaklaşık 21 ngr gr<sup>-1</sup> seviyesine kadar ulaşmaktadır.

**Anahtar Kelimeler:** Çukurova bölgesi, Pestisid, PCB, Deniz suyu, Deniz organizmaları, Deniz sedimanları

### Introduction

Pesticides are synthetic organic compounds that have been produced on a large scale for several decades and are used widely all over the world for different purposes. They play a major role in the control of many arthropods of medical importance (e.g., as a biocide against adult mosquitos in malaria control), and they have also been effective in the control of many agricultural pests including insects, nematodes, vertebrates, weeds, fungi and other microorganisms (1).

In Turkey, although pesticide production was begun in the 1950s, some of them are still imported. More than a thousand pesticides were authorized by the

Ministry of Agriculture and Rural Affairs (M.A.R.A.) (2) to be used against pests in Turkey.

These pesticides are classified into ten groups as follows:

Insecticides; Fungicides; Herbicides; Acaricides; Rodenticides; Nematocides and Soil Fumigants; Molluscicides; Winter Spray Pesticides and Summer Oils; Bactericides; and Fumigants.

Of these groups, insecticides are used the most followed by fungicides and herbicides. Only three chlorinated hydrocarbon insecticides (*Diflubenzuron*, *Endosulfan*, *Endosulfan + Parathion Methyl*) and 52 organophosphorus insecticides are registered by M.A.R.A.

to be used for agricultural purposes and for public health. A total number of 65 fungicides and 89 herbicides are currently registered (2).

Çukurova is the littoral plain of Cilicia and is surrounded by the Taurus mountains. The region includes provinces of Adana and İçel (Mersin) and some part of Iskenderun city and covers an area of about 15,000 km<sup>2</sup> (Figure 1). It has high agricultural activity and thus is subjected to a high usage of pesticides and PCBs-containing material.

A wide range of different substances have been used as pesticides in the Çukurova region. It was obtained from reports prepared by the local governmental offices that depending on the year and on the variety of crop, more than one hundred different pesticides, ranging in amount from 6500 to about 9700 tons are being used annually for agricultural purposes (Table 1).

PCBs, which form another group of synthetic compounds, were first introduced in the late 1920s and have been used for a variety of applications (3). The PCBs used in industry probably consist of at least eighty different substances (4). Their usage area is widespread including heat transfer fluids, plasticizers, lubricating and cutting oils, etc. Also, greenhouses occupy an important part of the agriculture in the Çukurova region and a large amount of plastics containing PCBs are used to cover these greenhouses.

In spite of the extensive usage of pesticides and PCBs-containing material in the Çukurova region, there is no information available about the effect of these compounds on the soil and in both marine and land atmosphere. Although there are substantial data concerning the concentrations of pesticides and PCBs in sea water, marine sediments, and in marine organisms, and also concerning their effects on these organisms in the western Mediterranean Sea (5, 6, 7), few

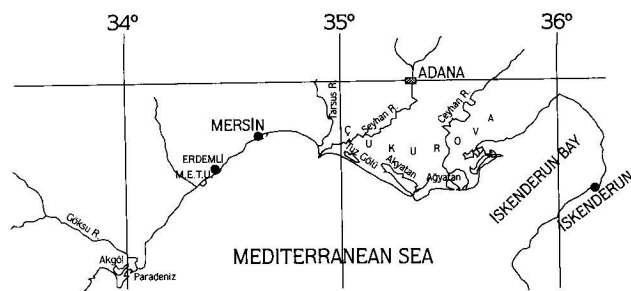


Figure 1. Çukurova Region and its Adjacent Areas

Table 1. Annual Usage of Pesticides in the Çukurova Region During the Ten Years from 1978-1987.

Years	ADANA Region			İÇEL (MERSİN) Region		
1978	Insecticides*	2,515,526	Kg	Insecticides*	1,241,086	Kg
	Fungicides	1,413,708	"	Fungicides	1,553,390	"
	Herbicides	206,770	"	Herbicides	21,239	"
	Oils	712,650	"	Oils	920,250	"
	Fumigants	76,605	"	Fumigants	--	"
1979	Insecticides*	1,968,939	Kg	Insecticides*	571,892	Kg
	Fungicides	1,104,803	"	Fungicides	2,357,769	"
	Herbicides	122,090	"	Fungicides	2,357,769	"
	Oils	400,050	"	Oils	1,288,500	"
	Fumigants	29,580	"	Fumigants	--	"
1980**	Insecticides*	2,621,375	Kg	No data available		
	Fungicides	152,520	"			
	Herbicides	444,297	"			
	Oils	231,647	"			
	Fumigants	--	"			
1981	Insecticides*	2,529,332	Kg	Insecticides*	1,606,733	Kg
	Fungicides	737,155	"	Fungicides	1,308,582	"
	Herbicides	254,791	"	Herbicides	113,965	"
	Oils	485,150	"	Oils	1,008,750	"
	Fumigants	18,743,88	"	Fumigants	--	"
1982	Insecticides*	1,190,343	Kg	Insecticides*	611,747	Kg
	Fungicides	828,368	"	Fungicides	1,661,570	"
	Herbicides	237,796	"	Herbicides	101,152	"
	Oils	306,502	"	Oils	676,688	"
	Fumigants	23,085	"	Fumigants	864,451	"
1983	Insecticides*	2,280,698	Kg	Insecticides*	1,576,461	Kg
	Fungicides	466,753	"	Fungicides	999,516	"
	Herbicides	204,784	"	Herbicides	70,760	"
	Oils	296,237	"	Oils	996,000	"
	Fumigants	29,340,65	"	Fumigants	4,685	"
1994*	Insecticides*	4,295,043	Kg	Insecticides*	1,943,681	Kg
	Fungicides	284,488	"	Fungicides	1,318,767	"
	Herbicides	346,085	"	Herbicides	105,500	"
	Oils	333,479	"	Oils	1,043,250	"
	Fumigants	--	"	Fumigants	21,142	"
1985	Insecticides*	2,978,720	Kg	Insecticides*	1,553,788	Kg
	Fungicides	395,497	"	Fungicides	1,495,855	"
	Herbicides	525,540	"	Herbicides	112,038	"
	Oils	148,775	"	Oils	799,713	"
	Fumigants	26,288,86	"	Fumigants	--	"
1986	Insecticides*	1,598,806	Kg	Insecticides*	1,625,798	Kg
	Fungicides	711,504	"	Fungicides	1,227,889	"
	Herbicides	206,608	"	Herbicides	97,190	"
	Oils	303,579	"	Oils	2,022,711	"
	Fumigants	60,371	"	Fumigants	110,225	"
1987	Insecticides*	2,169,533	Kg	Insecticides*	1,697,612	Kg
	Fungicides	406,716	"	Fungicides	1,075,968	"
	Herbicides	257,500	"	Herbicides	314,150	"
	Oils	338,882	"	Oils	2,069,910	"
	Fumigants	27,020	"	Fumigants	--	"

\* Insecticides include: Acaricides, Nematocides, Molluscicides and Bactericides

\* The values of 1980 and 1984 are the total pesticides sold in Adana and its counties.

studies have been carried out in the northeastern region of this sea (8, 9, 10). Thus, we review the qualitative and quantitative usage of pesticides in the Çukurova region to evaluate their harmful effects on living organisms, especially on those living in the marine environment.

### Pesticide Usage in the Çukurova Region

As a consequence of agricultural activities, a very wide range of plant species are grown in the Çukurova region. These plants may be classified under the following titles: Field plants: cereal, chick pea, bean; Industrial plants: cotton, tobacco, sesame, anise; Citrus fruits: lemon, orange, mandarin, grapefruit; Olive; Vineyard; and finally, Vegetable.

Due to this variety of cultivated plant species, the number of pests which infest these plants is also very high in the Çukurova region. Therefore, a long pesticide list is available for protecting the crops against these pests (Table 2). About 10% of the total authorized pesticides by M.A.R.A. (2) are being used in the region. According to the reports prepared by the Ministry of Agriculture and Rural Affairs-Plant Protection Office (M.A.R.A.-P.P.O.) (11) in Adana, the quantity of pesticides used annually for only agricultural purposes has ranged from 6501 to 9691 tons during the last decades (Figure 2). These annual changes in the quantity of pesticides are probably due to yearly fluctuations in the area of arable land or may be related to the kind of agricultural products.

Insecticides are the most extensively used group among the pesticides in the Çukurova region. Cotton, being the main agricultural product of the region, is affected by different insect species: *Heliothis armigera*, *Aphis gossypii*, *Tetranychus cinnabarinus*, *T. urticae* and

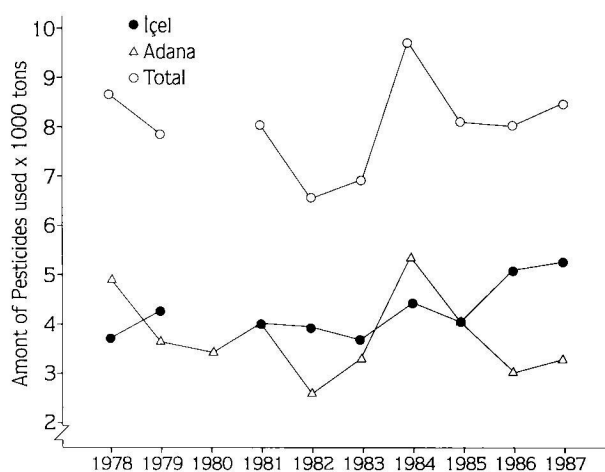


Figure 2. Annual Fluctuations of the Pesticides used in the Çukurova Region

*Bemisia tabaci*, white fly, etc. (11). Therefore, a number of insecticides are applied to protect the cotton crop from these pests. Some of these insecticides are; Temik, Nuvacron, Hucron, Ofunack, Curacron and Azodrin. Additionally Tefralin and Ateflox are also used against the unwanted weeds in the cotton.

Cotton production is followed by citrus fruits production which constitutes about 75% of the total production in Turkey. White Oil is used extensively (1000 to 2500 tons per year) (11) to protect these fruits against the pests, *Aonidella aurantii*, *Ceroplastes floridensis* and *Parabemisia meyricea*. The other pesticides used to protect citrus fruits from *Ceratitis capitata* and from *Phyllocoperata olivera* are Malathion, Zineb and Neoron.

Various vegetables are also grown extensively in the region. Especially greenhouses are widely used for early vegetable production and Malathion, Basudin, Dursban, and Sulphur are the main pesticides applied to protect these vegetables.

Similarly, fungicides are highly used in the Çukurova region for the protection of food crops against fungal diseases. Their annual usage changes from 500 to 3000 tons (11). Of the main group of fungicides, Copper compounds ( $\text{CuSO}_4$ ) and Sulphur are the most favored accompanied by Zineb, Maneb and Quintozene (PCNB) to control the mildews and fungi.

The annual usage of herbicides (200 tons) and acaricides (1000 tons) is less than the other pesticides

Table 2. Some Pesticides Used Frequently in the Çukurova Region (11)

Insecticides*	Fungicides	Herbicides
Azinphos	Captan	2,4-D Amin
Azodrine	$\text{CuSO}_4$	Ateflox
Basudin	Dithane	Diuron
Comit (Miticide)	Maneb	Linuron
Curacron	Quintozone (PCNB)	Tefralin
Diazinon	Sulphur	Trifluralin
Dicofol	Zineb	
Dursban		
Hucron		
Larvin		
Malathion		
Mitac		
Neoron		
Nuvacron		
Ofunack		
Oils		
Phostoxin		
Tamaron		
Tefradon		
Temik		

\* Insecticides include; Acaricides, Rodenticides, Nematocides Molluscicides, Bactericides and Fumigants.

(11). Among the herbicides, *2,4-D Amin*, *Trifluralin*, and *Diuron*, and among the acaricides, *Diazinon*, *Dicofol* and *Azinphos* are the authorized and most-used pesticides. Of the herbicides, *2,4-D Amin* is the favored compound for controlling weed infestations in cereal fields. A number of pesticides are also used for the treatment of seeds, e.g., *Quintozene (PCNB)*, *Dithane*, *Captan*, and to sterilize the storehouses, e.g., *Malathion* and *Phostoxin*.

In summary, the application of insecticides, fungicides, winter spray pesticides and summer oils is very high in the Çukurova region. They constitute more than 90% in weight of all the pesticides used annually in the region. They are followed by acaricides, herbicides, nematocides and fumigants. The quantity of all the pesticides used for agricultural purposes in the Çukurova region exceeds 9500 tons per year (11).

#### Pesticides in the Environment

Pesticide residues are introduced into the environment via different routes including household application, agricultural and industrial usage, public health protection and by some accidental leakage from insecticide production plants. They are distributed within the soil, water, air and biological compartments of the ecosystem (Figure 3).

#### Pesticides in the Atmosphere

Following surface application for agricultural purposes or for public health activities, pesticides are partially degraded to their metabolites through biological or photochemical reactions as, for example, the degradation of *DDT* to *DDE* and *DDD*, and they are then volatilized into the atmosphere (4). The rate of vol-

atilization is related to the vapor pressure of the compound.

PCBs can reach the environment in a number of ways. One way is via burning plastics, resins and other products which may contain *PCBs* in dumps and incinerators (8). *PCBs* also enter the atmosphere via evaporation from products containing these compounds, mainly electrical transformers, capacitors and plastics (10).

The pesticides in the atmosphere can exist in three forms: in the vapor phase, dissolved in rainwater, or adsorbed onto particulate matter. A large proportion of the pesticide residues find their way into the atmosphere via windblown particulates and subsequently remain adsorbed until redeposited at the ground/sea level (12). According to Goldberg (4) the *DDT* residues and *PCBs* exist in the atmosphere mainly as gas molecules, not associated with particulates, and their residence time is 51 and 40 days, respectively.

Although some data are available in the literature about the pesticide and *PCBs* concentrations in the atmosphere of the western Mediterranean Sea (5), no data was found for the Çukurova region and its adjacent areas.

#### Pesticides in the Marine Environment

##### a. In Sea Water

The atmospheric removal processes which result in the deposition of pesticides in the sea include rain, dry or wet fallout and vapor-phase deposition onto the surface. They may also be applied to water as aerial sprays for the control of mosquitos or agricultural pests.

Rainfall can carry the *DDT* and *PCBs* by rinsing it from the atmosphere (5). Woodwell (13) suggested that rainfall is the most important process for removing *DDT* from the atmosphere, and the Natural Academy of Science (NAS) [cited in Kideys (10)] computed that up to 25% of the annual *DDT* production would be rained into the world's oceans.

As was mentioned before, *PCBs* enter first into the atmosphere and then into the oceans following dispersive usage in paints, plastics and paper products (4).

On the other hand, Connell & Miller (14) indicated that chlorinated hydrocarbons may enter into the hydrosphere via many pathways including: (a) direct application for pest and disease vector control; (b) urban and industrial waste-water discharge; (c) runoff from non-point sources; (d) leaching through soil; (e) aero-

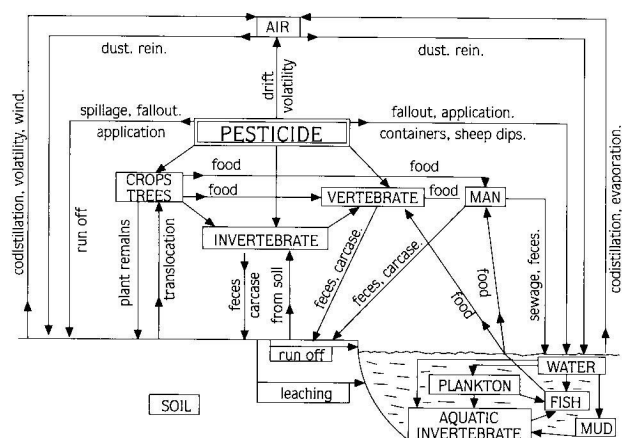


Figure 3. Pesticide Cycling in the Environment [From Edwards (15)].



sol and particulate deposition, rainfall; and, (f) absorption from the vapor phase at the air-sea interface.

It is suggested that there are some ways by which the pesticides and PCBs reach the marine environment from the Çukurova region; rain, river discharge, erosion of soil and direct application for pest control and disease vector control. But the relative importance of these sources is unknown since there is no study done in the region on the relative contribution of these sources to the sea water concentrations of pesticides and PCBs.

In spite of the intensive usage of pesticides and PCBs in the Çukurova region, data on the sea water concentrations of these compounds are very scarce. The only existing study has been carried out by Kideys (10), where the time series of certain chlorinated hydrocarbons, e.g., DDT and its metabolites, BHC and PCBs in sea water and in plankton off Erdemli were investigated. A significant positive correlation was observed between rainfall and BHC and PCBs concentrations in sea water. This author states that after agricultural usage of these compounds in the Çukurova region, they are washed up and drained from the soil via rainwater and from there either directly reach the marine environment or are discharged into the sea via rivers.

In the Çukurova region and its adjacent areas, there are three large rivers: Seyhan, Ceyhan and

Göksu and some small streams. They flow across agricultural land and reach the Mediterranean Sea (Figure 1). There are also many drainage canals used for agricultural purposes. The pesticides contained both in and on the soil are washed up and carried by these canals into the Akgöl, Paradeniz, Tuz Gölü, Akyatan and Ağyatan lagoons (Figure 1).

#### b. In Marine Sediments

Because pesticides exhibit low solubility in the water, they remain adsorbed onto the particulate matter suspended in the water column. After a certain period, a large proportion of these disappear from the water by settling down and reaching the mud and/or sediment at the bottom. Thus, pesticide residues are unlikely to occur in large quantities in standing water; only the turbulence of moving water can keep the particulate matter in suspension. There are some data available in the literature about the PCBs and pesticide content of marine sediments from areas adjacent to the Çukurova region (8, 9). Baştürk (8) obtained high pesticide concentrations in the sediments collected from river mouths which proves their transport by rivers (Table 3). He also found that near-shore sediments of the southeastern coasts of Turkey contain minute amounts of PCBs, but some high values were obtained from the samples collected from industrial discharge regions. According to this study, *t*-DDT and PCBs concentrations exhibited variations between sta-

Table 3. Concentrations of Organochlorine Residues in the Near-shore Sediments of the Southeastern Mediterranean Coast of Turkey [from Baştürk (8)]

Samples	Concentrations in ng g <sup>-1</sup> (dry bases)								
	Aldrin	op-DDE	pp-DDE	op-DDD	pp-DDD	op-DDT	pp-DDT	t-DDT	t-PCBs
Göksu river	3.8	n.d.	1.8	n.d.	n.d.	n.d.	1.4	3.2	n.d.
Lamas river	0.6	1.3	3.3	n.d.	n.d.	n.d.	16.3	20.9	0.1
Zone of river (*) and seawater mixes	0.5	n.d.	3.6	n.d.	4.5	n.d.	n.d.	8.1	n.d.
500 m away from Lamas River	1.0	0.7	2.1	T	0.6	1.6	3.9	8.9	1.5
1000 m away from Lamas River	0.4	1.1	1.5	n.d.	n.d.	n.d.	4.3	6.9	0.3
Mersin Harbour	0.9	2.2	6.1	2.5	n.d.	n.d.	n.d.	10.8	n.d.
Vicinity of Petroleum Refinery	1.1	2.2	2.2	1.2	0.6	4.1	5.9	16.9	3.6
Vicinity of Fertilizer Industry	0.9	0.5	2.2	1.4	1.3	3.1	3.2	11.7	2.5

(\*): Contains appreciable quantity of sulphur

n.d.: Not detected

T: Trace

tions depending on the sediment texture and organic matter content (8).

### c. In Marine Organisms

When the pesticides reach the marine environment, they are rapidly adsorbed by the sediment, plankton, algae; aquatic invertebrates, aquatic vegetation and fish. Some of these organisms may take up the pesticides directly from the water or they may accumulate them from food (5, 16). Similarly, Livingston [cited in Kideyş (10)] indicated that, for aquatic organisms, intake of pesticides can result from (i) ingestion of contaminated food, (ii) uptake from water passing over gill membranes, (iii) cuticular diffusion, and (iv) direct absorption from sediments.

As was previously mentioned, pesticides and PCBs are insoluble in the water but highly soluble in lipids. Following absorption, they are distributed to the organs and tissues of the body by the circulatory system. Lipophilic compounds, such as organochlorinated insecticides, tend to bind reversibly to plasma proteins as part of an internal transport mechanism and are readily stored in depot fat (14).

Accumulation of pesticides by plankton, especially by phytoplankton, takes place in two steps: first adsorption on the cell surface and then absorption into the cell. Kideyş (10) observed that the concentration factor of *t-DDT*, *BHC* and *PCBs* in plankton collected from offshore Erdemli depended on the compound itself and on the time of year. The concentration factors were found to be ranged from 130 to 1,851,000. These results lead us to suggest that the transfer of these compounds within the food chain will be important since the plankton form the first step in the marine food chain.

The results of Baştürk (8) and Baştürk et al., (9) show that the *DDT* and *PCBs* concentrations in different marine organisms from the eastern Mediterranean were species dependent and that carnivorous fish, e. g., *Pomatomus saltatrix*, contained more *DDT* and *Aldrin* than the other fish species analyzed.

Kideyş (10) also observed an increase in the *PCBs* and *t-DDT* concentrations of plankton between March and October which was most likely due to the high application of these compounds during this period of the year. Thus, the usage of pesticides is well reflected in marine organisms.

Although considerable data are available in the literature concerning the toxicity of pesticides and *PCBs* in marine organisms (5, 6, 14, 16, 17, 18), very lit-

tle information is available about the effects of the pesticides which are actually used in the Çukurova region. The only existing study has been done by Ünsal Kideyş (19) to evaluate the effect of *Dieldrin* on the growth of two marine phytoplankton species. They observed the inhibiting effect of this compound on the growth rate (cell division per day) of *Dunaliella tertiolecta* and *Platymonas suecica*. Experiments of this kind should be extended to studying different marine organisms in order to evaluate the effects of other pesticides, especially those which are used in high amounts either for agricultural purposes or for public health in the Çukurova region.

### Conclusion

The usage of pesticides and especially of insecticides, fungicides, winter spray pesticides and summer oils is extreme in the Çukurova region. They constitute more than 90% in weight of all the pesticides used annually in the region. The quantity of all pesticides used for agricultural purposes in the Çukurova region exceeds 9500 tons per year.

The names of *DDT* and *BHC* were gathered from the reports prepared by the Ministry of Agriculture and Rural Affairs-Plant Protection Office (M.A.R.A.-P.P.O.) in the region until 1983, although their usage was limited previously for agricultural purposes.

A significant positive correlation has been found between the rainfall and *BHC* and *PCBs* concentrations in seawater. However, in spite of their intensive usage, there is no information concerning the concentrations of these compounds in land and marine environments, the atmosphere, and in rainwater. Although a few studies have been carried out on the pesticide and *PCBs* concentrations in seawater, sediments, and in marine organisms, these are far from being conclusive.

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