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Review on DDT and its residues in Turkey's wetlands

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Abstract: *Turkey is a country rich in wetlands (250 wetlands, approximately one million hectares). As it is in many countries, the wetlands in Turkey are threatened by the agricultural activities, loss of habitats due to these activities and by pesticide contamination. After 1940, large quantities of pesticides, especially DDT, were used intensively against mosquitoes and pests in most of the wetlands in Turkey causing considerable contamination. In the beginning of 1980's, production, import and use of DDT was forbidden due to its toxicity on non-target organisms, environmental persistence, and accumulation in food chains. The scientific studies made in Turkey on the level of contamination in various environs and organisms by DDT and its metabolites, are limited. These limited studies, especially the ones made after 1990's, have shown that we still observe DDT contamination in many wetlands (including internationally important ones like Goksu Delta and Meric Delta) and in organisms like birds and fishes. The data on the concentrations of DDT and its metabolites in the organisms and the biological magnification levels are not adequate since in most of the studies only water and sediment samples were analyzed. Besides, in the few studies made on the organisms, standard methods and suitable indicator organisms were not used. Because of these reasons, it is very difficult to make reliable evaluations on the DDT levels and its effects in the wetlands of Turkey. It is interesting that DDT levels are higher than its metabolites in water, sediment and organism samples in some wetlands which imply the possible use of DDT recently. The aim of this review is to summarize the studies made so far on DDT and its residues in the wetlands of Turkey and to shed light on the possible hazardous effects and to propose approaches for future studies.*

Key words: *DDT, Water, Sediment, Fish, Bird, Wetlands, Turkey*
PDF file of full length paper is available with author

Introduction

Turkey is a country rich in wetlands, ranking first in this respect among the Middle Eastern and European countries, with the exception of the Common wealth of Independent States (former USSR). The number of wetlands in the country exceeds 250 with a combined area of approximately one million hectares. Almost 75 wetlands are larger than 100 hectares. In addition to these natural wetlands, Turkey also has a large area of artificial wetlands consisting of dammed lakes and reservoirs (TCV, 1993; Kilic and Eken, 2004; Perktas *et al.*, 2006). Of all the Turkish wetlands, 60 percent has freshwater, 20 percent salt water and 20 percent brackish water. Turkey's wetlands are important because they are concentrated in Anatolia, which is crossed by two major bird migration routes. About 450 different bird species are found in Turkey and 250 of them are migratory birds. Considering the 'Society for Conservation of Natural Life', 61 wetlands comply the criteria of the Important Bird Habitat (Yarar and Magnin, 1997; Kilic and Eken, 2004; Perktas *et al*., 2006). Turkey adopted the Ramsar Convention on Internationally Important Wetlands as a habitat for birds in May 17, 1994 and identified five wetlands as Ramsar Land: Goksu Delta, Manyas Bird Sanctuary, Sultan Marsh, Lake Burdur and Lake Seyfe. Based on international criteria, 18 wetlands that can offer refuge and food to over 25 000 birds at a time, have been classified as first class (Class A). An additional 45 wetlands have been identified as Class B, accommodating 10,000-25,000 birds (TCV, 1993; Kilic and Eken, 2004; Perktas *et al.*, 2006). With the adoption of the 1952 'Environmental Impact Evaluation Regulation', wetlands have been classified as "sensitive regions", and the preparation of an Environmental Impact Assessment (EIA) became compulsory for most activities concerning these wetlands. The most serious unfavorable development encountered in the preservation of wetlands is intentional draining. Swamps and marshes have been drained and reclaimed for agriculture and for malaria control (EFT, 1995). The loss of wetlands in the Mediterranean countries is highly significant. In fact, internationally important sites listed under the Ramsar Convention are threatened. The main causes of the problem are population pressure, lack of public and political awareness, lack of political will, over-centralized planning procedures and financial policies. Although, during the big projects in Turkey, like dam constructions, environmental impact assessments are considered, they tend to be rather narrowly defined and closely linked to the objectives of the agency promoting the project. There seems to be limited knowledge on the wetlands in Turkey, which is a major handicap for both conservation efforts and policy formulations. An important threat to the wetlands is pollution, both directly and indirectly by rivers that feed them. Particularly suspended solids in contaminated rivers accumulate in stagnant wetlands. The heavy metals and pesticides cause mass deaths of fishes, frogs and waterfowl. Another threat to wetlands is the collection of bird eggs and frogs, cutting and burning of grasses, grazing cattle, especially water buffalo, in the shallow areas. Hunting is also a serious problem for wildlife of Turkish wetlands, as is the case in most Mediterranean countries (Finlasyon *et al*., 1992)

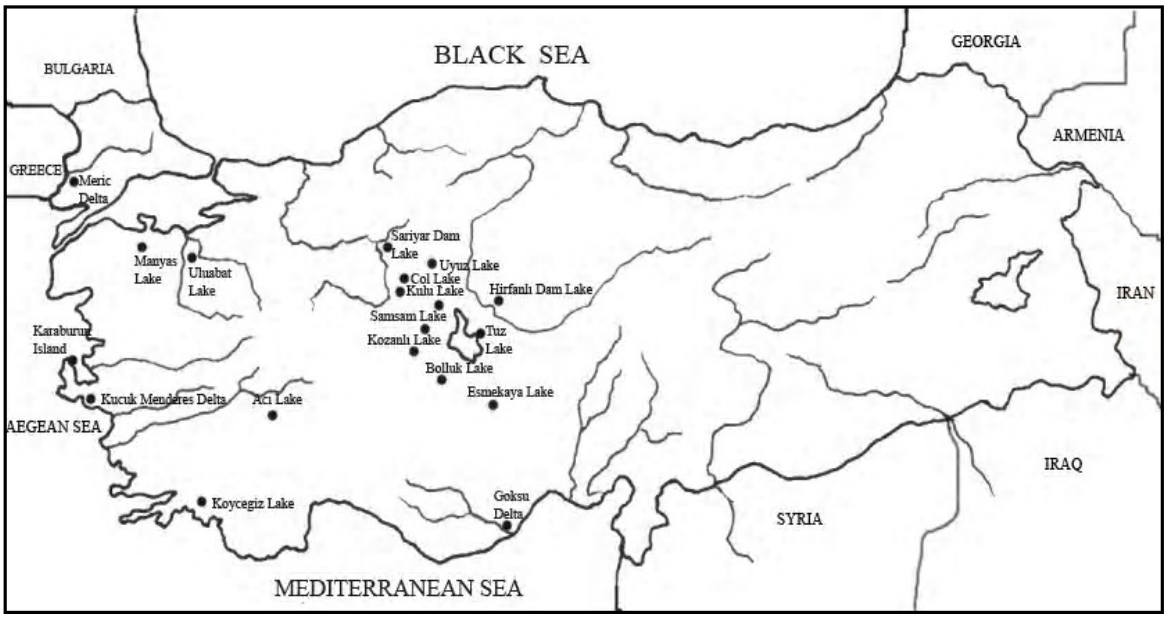

Fig. 1: Wetlands in which DDT residue studies were carried out in Turkey

Use of pesticides in Turkey :

Pesticide usage in Turkey started with the use of DDT against all kinds of pests. A considerable number of synthetic organo-chlorine pesticides have been produced and offered for usage since 1940's. Pesticide production in Turkey has increased over the years. From 1960 to 1994, the number of companies licensed to produce technical pesticide compounds and formulations increased from 17 to 53 and the number of importing firms increased from 10 to 61 (EFT, 1995). The number of active ingredients used in pesticide formulations increased from 105 to 281, while the pesticide consumption per year increased from 23,425 tons to 32,363 tons. As of 1994, 1378 different pesticides, mainly insecticides, herbicides and fungicides, were registered in Turkey. Within the last twenty-five years, the Pesticide Commission of the Ministry of Agriculture and Rural Affairs has cancelled the registration of 32 different pesticides, including DDT, because of their toxic effects, ineffectiveness, or carcinogenic and adverse environmental effects. According to a study done by the 'United Nations Food and Agriculture Organization (FAO) on the use of pesticides in Turkey, the applied amounts of active ingredients are lower than the world average, *i.e.* only 0.6 kg/ha. Over the last few years, the total consumption of pesticides in Turkey has not changed very much. The use of pesticides in Turkey increased by 18 percent from 1982 to 1988, while it decreased by 10 percent between 1988 and 1992. However, more toxic pesticides were used in smaller doses to protect plants from pests and diseases, which increased the hazardous effects and environmental pollution risks (ETF, 1995). The largest amount of pesticides (40% of the total) is used in the Mediterranean region in Adana, Icel and Antalya and 25% is used in Izmir, Manisa and Aydin region (Canyurt, 1997; Delen, 1997,1998; TCV, 1998). The use of 11 organo-chlorine and organo-mercury containing pesticides, including aldrin, dieldrin, BHC, heptachlore, chlordane, lindane and toxophane were prohibited in Turkey between 1971 and 1989. DDT had been used quite intensively in Turkey (553.8 tones in 1978) until 1980s on agricultural fields and swamp areas (those swamp areas were used to be considered only as habitats for mosquitoes). Later, between 1978 and 1985 DDT application, production and importation were officially banned (SPO, 1996, 2001; K olankaya, 2006).

DDT in Turkey's wetlands:

Considering the application, duration and intensity of DDT in Turkey, the richness of the country in wetlands and the biodiversity in these wetlands, it can be said that studies on DDT and its metabolites (hereinafter will be call as DDTs) are quite inadequate with regard to number and scope. Data on DDTs for various environments and organisms have been collected from 5 of Turkey's 18 "Class A" wetlands (Goksu Delta, Meric Delta, Tuz Lake, Manyas Bird Lake, Uluabat Lake) until today. Residue studies were carried out in 12 of 61 internationally important wetlands (Kulu, Samsam, Kozanli Saz, Bolluk, Esmekaya, Hirfanli Dam, Sariyar Dam, Aci, Col, Uyuz, Koycegiz Lakes and Kuçuk Menderes Delta) (Fig. 1). Especially a more comprehensive identification and observation of the contaminants that threat "Class A" wetlands are required for wetland management and protection studies**.** The findings obtained from the researches are summarized below.

Soil: The analyses were carried out for samples of various soils from different parts in the Goksu Delta (Table 1). Residues were analyzed by gas chromatography using a Ni-electron capture detector. As a result of the study, DDTs were detected in various parts of the Goksu Delta (5.416 $mgkg^{-1}$ of pp'-DDE in agricultural soils). DDTs concentrations in soil samples from agricultural areas were generally higher than water and sediments. op'-DDT, op'-DDD and pp'-DDE were detected at high levels in agricultural soil samples (Ayas *et al.*, 1997; Kolankaya, 2006).

Table - 1: Levels of DDT and its residues (ppb) in different soil types from Goksu delta

Region	Location (province)	Sampling area	Σ DDT	p,p' DDT	o,p' DDD	p,p' DDD	o,p' DDE	References
South Anatolia	Goksu Delta-Silifke	Agricultural	3365	537	2713	2624	5416	Ayas *et al.* (1997)
Coast of	Taiucu	Nonagricultural	320	444	572	90	174	
Mediterranean Sea	Mersin	Dunes	203	148	279	70	48	

Water and sediment: Data for water and sediments are from the published papers related to 21 of 81 internationally important wetlands in Turkey. DDTs residues in water and sediments are shown in Table 2 and Table 3, respectively. Since the areas that were studied have a wide range of water quality (salty, brackish, and fresh) and capacity, it is quite difficult to make comparison between the levels and interactions of contamination with DDTs.

It can be seen that the residue level is higher in the wetlands with freshwater systems (lakes), especially in the ones around agricultural fields. It can be stated that Goksu and Meric Deltas, Sakarya River and Sariyar Dam Reservoir are more contaminated with DDTs compared to other wetlands**.** We should not be misled by the fact that the level of residue in water and sediments is below the toxic effect threshold for organisms. Since permanent contaminants like DDT may form accumulation in organisms through the food chain and through biological magnification, even this level of residues may cause acute and toxic effects on the organisms at the top of the food chain (Fisk *et al.*, 2001; Boon *et al.*, 2002).

Invertebrates: The analyses of DDTs residues in invertebrates (blue crab; *Callinectes sapidus*) are only limited to Goksu Delta (Ayas *et al.*, 1997) and Koycegiz Lagoon (Caliskan and Yerli, 2000) (Table 4). In Goksu Delta, level of DDT was found to be 47 ppb in blue crabs. There is no more data on the invertebrates besides this.

Fishes: The data about the levels of DDTs in fish in Turkey's wetland are relatively small in number. In many of the studies carried out in Turkey's wetlands, only water and sediment samples were taken; but the analysis of residue in fish was not performed**.** As a consequence, the data about the level of DDTs residues in fish and the rate of biological magnification are limited to only a small number of wetlands. However, fish is a suitable indicator for the environmental pollution monitoring because they concentrate pollutants in their tissues directly from water, and also through their diet, thus enabling the assessment of transfer of pollutants through the food web (Fisk *et al.*, 2001; Boon *et al.*, 2002; Joshi *et al.,* 2007; Parma *et al.,* 2007). The data about the DDT residues in fish taken from 6 wetlands (Goksu Delta, Meric Delta, Gala Lake, Sakarya River, Sariyar Reservoir and Koycegiz Lagoon) are shown on Table 5.

It stands out that DDT residue is higher in deep (benthic) fish like carps and wells. In the studies carried out in Sariyar Reservoir, the DDTs levels were measured to be 941.16 and 24.57 ppb in wels and carps respectively (Ekmekci *et al.*, 2000). This situation can be explained by the fact that DDT accumulation is higher in the piscivorous and benthic organisms such as wels and carps due to their feeding habits and habitats. In addition, DDTs have a high affinity for the un-dissolved organic matter in the benthic zone and the organisms living in the benthos are more exposed to these contaminants (Larsson *et al.,* 1992; Svobodova *et al.,* 1995).

In Table 5, it can be seen that the DDTs level of fish in Meric and Goksu Deltas are higher when compared with the fish of other wetlands. These Deltas are the ones in which agricultural activities and uses of pesticides are more intense. Agricultural activities in these regions are important economically for the local people. Unfortunately these areas are ecologically very important (also known as "Ramsar Site") due to their location being on a bird-migration route and richness in terms of biological resources. The DDTs level of fish in both wetlands is found to be higher than its metabolites. Some similar results can be seen in carps in the Sariyar Reservoir (Table 5). In Goksu Delta, the DDT and its metabolite (o, p'DDE) levels in carps were found to be 4217 and 615 ppb, respectively (Ayas *et al.*, 1997). Similarly, the DDT level in carps in Gala Lake (5538 ppb) was found to be higher than its metabolite, o, p'DDE (4005 ppb) (Erkmen and Kolankaya, 2006) (Table 5). This situation suggests that, although it was banned, the illegal use of DDT still continues. The studies on the effects of DDTs on human and on fish are small in number. Barlas (1999b) and Ekmekci *et al.* (2000) stated that DDTs might be the reason of the histopathological changes observed in the gills, kidneys and livers of the fish in Sakarya River and Sariyar Reservoir. Ozmen *et al.* (1999) worked on the detoxification enzymes in the livers of carps in Sariyar Reservoir. These researchers underlined that there might be a relation between the enzyme activities and the organo-chlorine pesticide contamination. Furthermore, in this study, it has been emphasized that these liver enzymes are very useful biomarkers for the monitoring of pollution in Sariyar Reservoir.

Birds: Turkey's wetlands are suitable feeding, sheltering and breeding areas for many bird species (especially water birds) that are categorized as threatened species according to European and Global Red List Categories. For example, Dalmatian pelican (*Pelecanus crispus)*, pygmy cormorant (*Phalacrocorax pygmeus),* lesser white-fronted goose *(Anser erythropus),* ruddy shelduck *(Tadorna ferruginea),* white-headed duck *(Oxyura leucocephala,* marbled teal *(Marmorenetta angustriostris),* ferruginous duck *(Aythya nyroca),* Audouin's gull *(Larus audouinii)* are evaluated as globally "Threatened" and "Vulnerable - Endangered" in Turkey

Table - 2: Levels of DDT and its residues (ppb) in water from some wetlands in Turkey

Region	Location (province)	Medium	Water type	N	∑ DDT	p,p' DDT	p,p' DDD	p,p' DDD	p,p' DDE	References
South Anatolia	Goksu delta-Mersin	Delta, lake, wetland	Brackish water	24	50	24	46	57	25	Ayas *et al.* (1997)
Mediterranean Sea	Koycegiz-Mugla	Lagoon lake, wetland	Brackish water	55	BD	(-)	(-)	(-)	(-)	Caliskan and Yerli (2000)
Central Anatolia	Sakarya river-Eskisehir	Riverine	Freshwater	8	1013	1879	1065	1676	825	Barlas (1999a)
	Sakarya river-Ankara	Riverine, dam lake	Freshwater	32	24	13	26	10	3	Ekmekci *et al.* (2000)
	Tuz lake-Konya	Lake, wetland	Salt water	10	BD	831	1236	682	283	Barlas (2002)
	Hirfanli Dam-Kirsehir	Riverine, dam lake	Freshwater	10	BD	98	793	132	212	
	Esmekaya lake-Konya	Lake, wetland	Freshwater	10	284	633	391	273	881	
	Tersakan lake-Konya	Lake, wetland	Freshwater	10	BD	226	193	290	265	
	Bolluk lake-Konya	Lake, wetland	Freshwater	10	26	80	BD	BD	BD	
	Kulu lake-Konya	Lake, wetland	Freshwater	10	26	80	BD	BD	BD	
	Kozanli lake-Konya	Lake, wetland	Freshwater	10	BD	1039	750	BD	BD	
	Samsam lake-Konya	Lake, wetland	Freshwater	10	BD	BD	154	587	BD	
	Col lake-Konya	Lake, wetland	Freshwater	10	BD	254	BD	BD	BD	
	Uyuz lake-Konya	Lake, wetland	Freshwater	10	342	530	289	195	519	
West Anatolia (Aegean)	Menderes-Izmir	Riverine, delta	Freshwater		(-)	355	(-)	375	BD	Turgut (2003)
Marmara (Thrace)	Meric river-Edirne	Riverine	Freshwater	4	358,6	181	(-)	177	BD	Erkmen and Kolankaya (2006)
	Ergene River-Edirne	Riverine	Freshwater	4	527	267	(-)	260	BD	
	Gala lake-Edirne	Delta, lake, wetland	Freshwater	4	910	291,5	(-)	531,5	87	
	Meric delta-Edirne	Lagoon lakewetland	Brackish water	4	181	224	(-)	140	BD	
	Uluabat lake-Bursa	Lake, wetland	Freshwater	30	(-)	34,2	(-)	(-)	39,5	Barlas (2006)

BD = Below detection limit, (-) = Not given, N = Number of sample

Table - 3: Levels of DDT and its residues (ppb) in sediments from some wetlands in Turkey

Region	Location (province)	Aguatic system	N	∑ DDT	p,p' DDT	p,p' DDD	p,p' DDD	p,p' DDE	References
South Anatolia Mediterranean Coast	Goksu Delta - Mersin	Lake- wetland	24	553	220	195	579	57	Ayas *et al.* (1997)
	Koycegiz - Mugla	Lagoon - wetland	55	BD	(-)	(-)	(-)	(-)	Caliskan and Yerli (2000)
Central Anatolia	Sakarya river Ankara	Riverine-dam lake	32	1092	819	1015	573	886	Ekmekci *et al.* (2000)
	Sakarya river-Eskisehir	Riverine	8	703	1228	1142	992	1925	Barlas (1999a)
	Tuz lake-Konya	Lake, wetland	10	2244	1307	527	969	1421	Barlas (2002)
	Hirfanli dam -Kirsehir	Riverine - dam lake	10	BD	254	1389	296	677	
	Esmekaya lake-Konya	Lake, wetland	10	251	550	BD	470	110	
	Tersakan lake - Konya	Lake, wetland	10	BD	370	BD	152	BD	
	Bolluk lake - Konya	Lake, wetland	10	BD	384	70	360	BD	
	Kulu lake - Konya	Lake, wetland	10	BD	828	1115	147	282	
	Kozanli lake - Konya	Lake, wetland	10	BD	245	118	156	760	
	Samsam lake - Konya	Lake, wetland	10	BD	1152	BD	967	BD	
	Col lake - Konya	Lake, wetland	10	BD	BD	826	311	BD	
	Uyuz lake - Konya	Lake, wetland	10	BD	482	226	599	90	
Marmara (Northwest Anatolia)	Meric River - Edirne	Riverine	4	1374,6	681,5	(-)	353,3	803,3	Erkmen and Kolankaya (2006)
	Ergene River - Edirne	Riverine	4	1786	663	(-)	290	833	
	Gala Lake - Edirne	Lake, wetland	4	1418,5	202	(-)	1185	666,5	
	Meric Delta - Edirne	Lagoon - wetland	4	2443,5	1265	(-)	600	587	
	Manyas Lake-Balikesir	Lake, wetland	14	200,14	925	324	203	378,57	Kolankaya *et al.* (1997)
	Uluabat Lake - Bursa	Lake, wetland	30	(-)	333,26	(-)	(-)	401	Barlas (2006)

BD= Below detection limit, (-) = Not given, N = Sample number

Table - 4: Levels of DDT and its residues (ppb) in invertabrates from Turkey's wetlands

Species	N	∑ DDT	p,p' "DDT	o,p' "DDD	p,p' DDD	o,p' DDE	Location (province)	Region	References
Blue crab *(Callinectes sapidus)*	13	47	BD	BD	BD	BD	Goksu Delta-Silifke, Tasucu"Mersin	South Anatolia"Mediterranean Sea Coast	Ayas *et al.* (1997)
	5	BD	(-)	(-)	(-)	(-)	Koycegiz Lagoon System"Mugla	South Anatolia"Mediterranean Sea Coast	Caliskan and Yerli (2000)

BD = Below detection limit, (-) = Not given, N = sample number

Table - 5: Levels of DDT and its residues (ppb) in some fishes from Turkey's wetlands

Species	Sample	N	Σ DDT	p,p' DDT	o,p' DDD	p,p' DDD	o,p' DDE	Location (province)	Region	References
Carp	Liver	27	1765	102	BD	BD	197	Goksu Delta-Mersin	South Anatolia"Mediterranean Sea Coast	Ayas *et al.* (1997)
(Cyprinus carpio)	Fat	27	4217	446	294	342	615			
	Fat	22	2	(-)	(-)	(-)	(-)	Koycegiz Lagoon -Mugla	South Anatolia"Mediterranean Sea Coast	Caliskan and Yerli (2000)
	Fat	13	24,57	13,42	26,57	10,57	3,71	Sariyar Reservoir -Ankara	Central Anatolia	Ekmekci *et al.* (2000)
	Fat	20	1298	2104	1199	1202	2454	Sakarya River-Eskisehir	Central Anatolia	Barlas (1999a)
	Fat	37	2172	3279	(-)	3363,3	7626,6	Meric River-Edirne	Marmara"Thrace	Erkmen and Kolankaya (2006)
	Fat	16	5538	4694	(-)	4440	4005	Gala Lake-Edirne		
	Fat	11	6225	5245	(-)	BD	9800	Meric Delta-Edirne		
Striped mullet	Liver	16	962	148	BD	BD	66,12	Göksu Delta-Mersin	South AnatoliaMediterranean Sea Coast	Ayas *et al.* (1997)
(Mugil cephalus)	Fat	16	912	346	113	127	243			
Wels *(Silurus glanis)*	Fat	15	941,16	510	1241,6	861,3	886,3	Sariyar Dam-Ankara	Central Anatolia	Ekmekci *et al.* (2000)
Bleak *(Alburnus orontis)*	Fat	22	9,25	44,5	8,25	BD	93,5			
Transcaucasian barb *(Capoeta capoeta)*	Fat	41	BD	(-)	(-)	(-)	(-)			
Mosquito fish *(Gambusia affinis)*	Fat	5	4,8	(-)	(-)	(-)	(-)			
Oreochromis *(Oreochromis mossambica)*	Fat	27	30	(-)	(-)	(-)	(-)			
Eel *(Anguilla anguilla)*	Fat	6	2	(-)	(-)	(-)	(-)	Koycegiz Lagoon-Mugla	South Anatolia Mediterranean Sea Coast	Caliskan and Yerli (2000)
Grey mullet *(Liza saliens)*	Fat	5	BD	(-)	(-)	(-)	(-)			
Thilipped mullet *(Liza ramada)*	Fat	14	10	(-)	(-)	(-)	(-)			
Mullet *(Chelon labrasus)*	Fat	8	BD	(-)	(-)	(-)	(-)			

BD = Below detection limit, (-) = Not given, N = Sample number

Table - 6: Levels of DDT and its residues (ppb) in some birds from Turkey's wetlands

Species	Sample	N	Σ DDT	p,p' DDT	o,p' DDD	p,p' DDD	o,p' DDE	Location (province)	Region	References
Coot *(Fulica atra)*	Liver	21	BD	BD	BD	BD	0,127	Goksu Delta-Silifke,	South Anatolia	Ayas *et al.* (1997)
	Fat	21	517	789	347	253	316	Tasucu Mersin	Mediterranean Coast	
	Egg content	11	65	196	184	184	BD			
Mallard	Liver	23	BD	313	BD	BD	414			
(Anas plathyrynchos)	Fat	23	718	908	231	46	1231			
	Egg content	16	213	113	BD	BD	108			
Purple gallinula	Liver	2	BD	73	BD	BD	BD			
(Porphyrio porphyrio)	Fat	2	BD	564	123	BD	131			
Little egret *(Egretta garzetta)*	Fgg content	7	250	1254	564	85	787			
Audouin's gull *(Larus audouinii)*	Eggshell	8	30	31,3	46,3	24,6	23,3	Aydincik IslandMersin		Ayas (2004)
Audouin's gull *(Larus audouinii)*	Eggshell	10	27	BD	16	BD	BD	Karaburun Island Izmir	West Anatolia"Aegean Cost	

BD = Below detection limit, (-) = Not given, N = Sample number

(BirdLife International, 2004; Kilic and Eken, 2004). Birds are the dominant and indicator organisms of wetlands (Burger and Peakall, 1995). The birds are exposed to permanent contaminants mostly. It is known that permanent contaminants biologically accumulate/ magnify in birds and cause acute-chronic effects in birds more than fish and invertebrates (Hollamby *et al*., 2006). Data on the DDTs in birds are available only from Goksu Delta for different species (coot, mallard, purple gallinule, and little egret) and the eggshells of Audouin's gulls at Karaburun and Aydincik Islands (Table 6). In Goksu Delta (Ayas *et al*., 1997), the DDTs were detected in livers (mean concentrations ranging from 0.127 ppb- op'DDE in coot to 414 ppb- op'DDE in mallards), adipose tissues (mean concentrations ranging from 123 ppb- op'DDD in purple gallinule to 1231 ppb- op'DDE in mallards) and eggs (mean concentrations ranging from 65 ppb- total DDT in mallard to 1254 ppb- pp'DDT in little egret). Also, DDTs residues have been detected in the eggshells of Audouin's gulls at Karaburun and Aydincik Islands (mean concentrations ranging from 16 to 46.3 ppb-op'DDD) by Ayas (2004).

In this review, the previous studies on the DDTs in Turkey's wetlands and the effects of DDTs on the wildlife are summarized and evaluated. Studies have shown that the wetlands in Turkey and related rivers and delta systems are contaminated with DDTs in high levels (water-sediment; Meric River 358.6-1374, Ergene River 527-1786; Sakarya River 1013-1092; as ppb) and DDT levels in some wetlands are much higher than its metabolites (*e.g.* Meric Delta in sediment DDT: 2443.5 and DDE: 378.57 ppb). On the other hand, due to the microbial degradation in the agriculture lands, DDT level (3365 ppb) of the Goksu Delta is less than the DDE (5415 ppb). Although DDT level is low in invertebrates, it was found higher in the fatty tissues of the carps (in Meric Delta DDT-DDE level, 5225-9800 ppb). In addition, it has been found that DDT has accumulated in the fatty tissues of the water birds (in coots, 517 ppb; in mallards, 718 ppb), and that it has transferred to their eggs (in coots, 65 ppb; in mallards, 213 ppb and little egrets, 250 ppb). We can conclude:

1. There are 81 internationally important wetlands in Turkey and considering the richness of species in these wetlands, the studies on DDTs and their toxic effects are quite insufficient in number and scope.
2. Although it is forbidden to use DDT since 1980s, DDT is still in use today due to weak law enforcement.
3. DDT levels are higher in the wetlands near the agricultural areas.
4. While the identified residue levels do not have acute toxic effects, it should be kept in mind that there shall be long-term chronic effects (especially reproductive success) on the organisms in these wetlands. Under these circumstances, it is unavoidable that endangered bird species will become extinct in Turkey in the long run.

Recommendations :

The recommendations are:

1. In previous studies in Turkey, DDTs have been examined in water and sediment environments, rather than organisms. Therefore, it is not possible to make reliable eco-toxicological assessments (except a few of them) about the accumulation level, biological magnification rate and toxic effects of DDTs on organisms (especially fishes and birds). The choice of organisms and organs is important for the future studies. Focusing on indicator species that live in the areas throughout the year (resident) and the organs where accumulation occurs, will lead to a better eco-toxicological assessment (Mackay and Fraser, 2000). Researchers should consider this fact in future studies.
2. The official and authorized organizations in Turkey (Ministry of Environment and Forest, TUB0TAK-Scientific and Technical Research Council of Turkey) should support the studies on the determination and monitoring of permanent contaminants in the wetlands for the purpose of protecting and developing our biological diversity.
3. The researchers should have more cooperation and communication and use similar and standard methods and should collaborate with foreign researchers and organizations.
4. Turkish Government should take more effective actions to stop the use of forbidden pesticides, inform the farmers on the hazardous results and increase the controls.

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