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Distribution and ecological risk of DDTs in sediments from Hormozgan Province, south of Iran

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Abstract

Organic pollutants have not been universally studied in Hormozgan Province, in spite of urbanization, industrial and agricultural development in recent years. In this paper, DDT and its isomers DDE and DDD were analyzed in surface sediments collected from fifteen stations of Hormozgan Province coastline. The sediments were sampled in September and March 2010. The concentration of ∑DDTs varied from ND to 45.88 ng/g dry weight. DDT showed the higher levels than its isomers DDD and DDE, offering the new source of DDT in the studied area. ∑DDTs showed homogeneous distribution along the Hormozgan province. Detected concentrations of DDTs exceed the NOAA sediment quality guiltiness.

Keywords: DDTs; Sediment; Ecological risk assessment; Hormozgan Province; Iran.

1. Introduction

DDT is a well-known compound among persistent organic pollutant chemicals. Its popularity is related to its application for the control of vector-borne illness, malaria and typhus during the Second World War. DDT has also been used for disease control in agriculture. DDD has been used as a pest killer, but not as much as DDT. The healthcare application of DDT in controlling malaria is limited in some countries, but DDT residues are found in all environmental matrices and human breast milk Tanabe and Subramanian (2006). After DDT enters sediment, its concentration is lost and the metabolites are produced in mechanisms involving volatilization, water runoff, chemical transformation, and removal through harvest. Chemical transformation causes a change of DDT in its analogs DDE and DDD under abiotic and biotic processes. DDT has the bio-concentration ability in marine food chain.

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Consumption of contaminated fish and seafood could transfer DDT and its analogs to humans (Tanabe *et al.,* 1989; Faroon, 2002; Minh *et al.,* 2006). Some studies have also established the relationship of DDT compounds and diseases, such as lymphoma, breast, prostate and endometrial cancer (Faroon, 2002; Rajendran *et al.,* 2005).

Hormozgan Province with the longest coastline in south of Iran is the primary sailing destination in Southern Iran. Consequently, Hormozgan Province is among the largest supplier of seafood for Iran. Furthermore, this province suffers from malaria as an environmental related illness and needs to healthy activities to control it. Southeastern Iran borders with Afghanistan and Pakistan, sufferin g from malaria Hanafi-Bojd *et al.* (2012). Furthermore, Mehran River runs through Larestan Mountain (Fars Province), enters Hormozgan Province, passes through Jenah and Kookherd cities, and finally reaches the Persian Gulf. On its way, Mehran River receives the wastewater of Sayeh Khosh shrimp farm and passes through an active agricultural area in Hormozgan, particularly in Fars provinces. Regarding to marine ecosystem of Hormozgan Province, some information were reported by neighboring countries which motivated our investigation. De Mora *et al.* (2010) reported that sediments from Bandar Abbas indicated the highest value of ∑DDTs among the boarding countries of Persian Gulf. Therefore, the current study intended to reflect the concentration and distribution pattern of DDTs sediments collected from Hormozgan Province.

2. Materials and methods

The sediment samples were collected from the Hormozgan Province coastline in September and March 2010 at the highest tidal time. The location of sampling stations is presented in Figure1. Whereas, ME station faces to Mehran River input the stations such as SI, QE and GA were selected as references sites in areas far from probable pollution sources. Van Ven sampler was used for collection of sediment samples. The fractions under 2 mm of frizee dried sediments were kept in -20 °C until analysis. Sediment samples were exposed to microwave radiation for extraction of DDTs (De Mora *et al.,* 2010; Mohebbi Nozar *et al.,* 2013). A mixture of hexane and dichloromethane was used as an extraction solvent under microwave power of 1200 watts. The extraction time was 115 °C for 20 min. sulfur interference was removed by active copper. DDT components were separated by silica gel column chromatography prepared in simple 50 ml burette United State Environmental Protection Agency, USEPA (1996). Instrumental analysis of DDTs was performed by GCMS equipped with capillary column (0.25 mm × 30 m × 0.5 μm) of DB-5ms. DDTs components were analyzed based on external standard method and single ion monitoring (SIM) mode at m/z: 246 and 235. Gas chromatography system oven was operated from 80 °C (1.5 min hold) to 160 °C (with 40 °C/min ramp) to 170 °C (with 10 °C/min ramp) to 250 °C (with 4 °C/min ramp) and finally to 300 °C (with 8 °C/min ramp and 10 min hold). The injector was maintained at 290 °C. The Quality control and quality assurance of the analytical methods were evaluated through matrix spike, method blanks and duplications of all experiments. Certified reference material IAEA-417 for sediment homogenate was used to confirm the quality assurance of procedures for DDTs analysis. Calculated method detection limit and recovery coefficient for used procedure were 0.2 ng/g and 80 %, respectively.

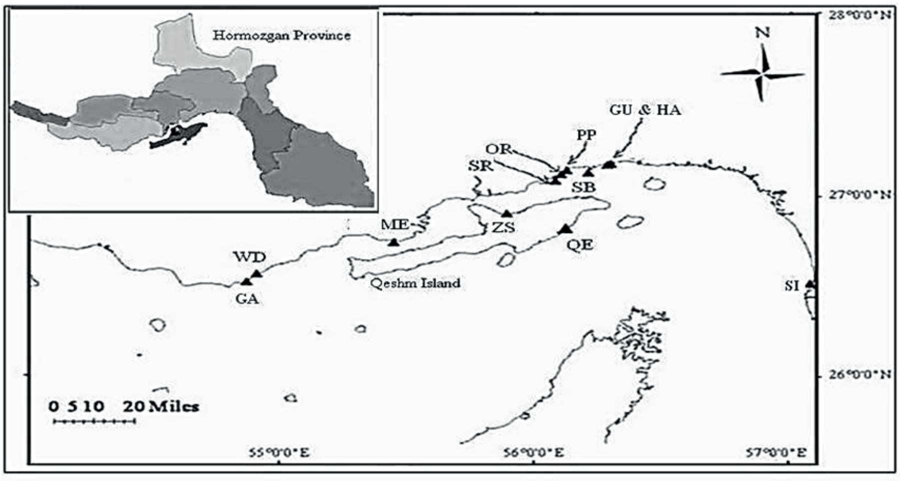

Figure 1. Sediment sampling stations in coastline of Hormozgan Province

All statistical analyses were performed with SPSS 18.0 for Windows. The significance level in all analyses was 0.05. Non-parametric tests were used to compare the significant differences between data sets.

3. Results

The ∑DDTs concentrations (average ± SD) in sediments of Hormozgan Province are shown in Table 1. Collected samples contained the wide ranges of ∑DDTs. These values varied from ND (non-detected) to 45.88 ng/g dry weight. No differences were observed in ∑DDTs between marine stations. They showed a homogenized distribution in the study area, with an average value of 16.87±9.2. DDT hot spots showed that the highest values were related to PP and SB following by ZS. Detected concentrations in wet season was higher than dry season ($p<0.05$), in spite of low amounts of rainfall in Hormozgan Province Hormozgan Meteorology, HormozganMet (2013). Figure 2 shows that DDT dominated over DDD and DDE in collected sediments and the DDT/∑DDTs ratio was estimated at 0.76.

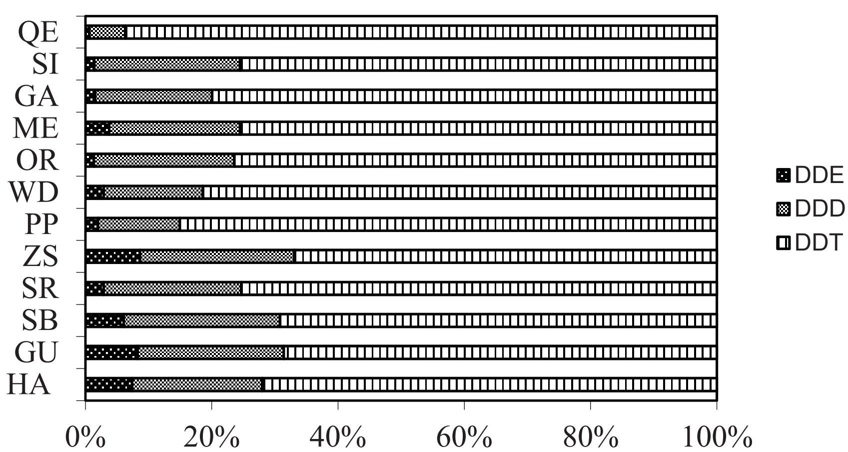

Figure2. Distribution of DDT, DDE and DDD in Hormozgan coastal sediments

Table 1. ∑DDTs concentrations (ng/g dry weight) in Hormozgan Province sediment

	Dry Season		Wet Season	
Station Name	Average	Range	Average	Range
HA	14.66 ± 4.61	15.74 - 18.64	19.48 ± 5.16	15.37- 26.98
GU	14.03 ± 4.11	10.57 - 18.84	15.64 ± 2.9	13.52 - 19.8
SB	22.97 ± 12.1	14.79-40.83	23.57 ± 14.57	15.13 - 45.36
SR	15.42 ± 0.42	15.1-16.05	16.27 ± 0.1.2	14.74- 17.62
ZS	22.07 ± 14.14	13.6- 43.23	25.19 ± 12.9	16.18- 44.24
WD	9.93 ± 3.8	5.88-13.2	13.81 ± 1.91	12 - 15.94
PP	25.39 ± 17.74	15.13- 45.88	22.03 ± 10.43	15.84 - 34.08
OR	17.4 ± 1.3	15.02 -15.79	14.05 ± 3.9	9.6 - 16.86
ME	18.74 ± 10.04	9.77- 33.12	9.5 ± 7.07	ND - 15.43
GA	9.21 ± 5.9	9.17-14.83	15.76 ± 2.29	13.29 - 17.83
SI	10.53 ± 3.92	7.44 - 14.95	17.3 ± 3.92	14.89 - 21.82
QE	8.41 ± 7.47	ND - 14.26	23.74 ± 6.52	16.33 - 28.62

4. Discussion

4.1. Concentration and Distribution Patterns of DDTs

Detected DDT/∑DDTs ratio was similar to chemical composition of technical DDT Zhao *et al.* (2010). The presence of DDTs may be related to agricultural usage or anti-malaria hygienic activities Sarkar *et al.* (2008). ME station that receive the Mehran River input showed no signicant differences with refrence areas. In our study, the high value of DDT / ∑DDTs ratio may be related to slow rate degradation of DDTs or recent input of DDT. Malaria is one of the health difficulties in the southeastern provinces in Iran, including Sistan & Baluchistan, Hormozgan and Kerman. Bashagard district in Hormozgan province is known as an important malaria endemic area in Iran. Furthermore, Iran is bordered with countries such as Afghanistan and Pakistan that suffer from prevalent disease of malaria (Vatandoost *et al.,* 2004; Hanafi-Bojd *et al.,* 2011; Hanafi-Bojd *et al.,* 2012). The dominance of DDT against DDE and DDD isomers was reported by Sakar *et al.* (2008); Pandit *et al.* (2001); Guruge and Tanabe (2001) for sediments from different parts of India and also by Booij *et al.* (2001) for sediment collected from Java, Indonesia. Also, the obtained results confirmed the new input of DDT to Daya Bay, China Zhou *et al.* (2001).

Very limited studies on DDTs have been published in southern parts of Iran (Table 2). Detected values in current study were much more than levels reported by De Mora *et al.* (2010). Their values was detected in only one station was selected in Hormozgan Province. In that study Hormozgan Hormozgan, contained the highest amount of DDTs among the countries neighboring Persian Gulf and Oman Sea. Sediment of Masan Bay contained DDTs with an average dry weight of 3.45 ± 3.38ng/g. The average value for sum of DDT and its metabolites in sediment from China detected at 18.5 ng/g Zhao *et al.* (2010) that was similar to our studied area. While many of researches showed the presence of DDT pollutants in the

Table 2. World distribution of ∑DDTs in sediment (ng/g dry weight)

Study area	∑DDTs	Reference
Shadegan wetland, Iran	-	Zahed *et al.* (2009)
Hormozgan Province, Iran	0.312	De Mora *et al.* (2010)
Masan Bay , Korea	0.4 - 12.5	Khim *et al.* (1999)
Haihe area, China	ND - 155	Zhao *et al.* (2010)
Daya Bay, China	0.14 - 20.27	Zhou *et al.* (2001)
Bengal Bay, India	0.04 - 4.79	Rajendran *et al.* (2005)
Xiamen Harbor	4.45 - 311	Sarkar *et al.* (2008)
Hormozgan Province, Iran	ND - 45.88	Current study

marine ecosystem at levels much lower than ours, an enormous value of 311 ng/g dry weight reported for sediment of Xiamen Harbor Sarkar *et al.* (2008).

4.2. Ecotoxicological Assessment

In comparison with the international sediment quality guidelines (SQGs), the detected ∑DDTs exceed the threshold effect concentration (Table 3). DDT pollutants showed a homogenous distribution in studied area and 95.6% of sites contained more than ERL, and no area exceeded the ERM. This finding offers that Hormozgan Province suffers from chlorinated hydrocarbons such as DDTs and is known as one of the major alarm pollutants in the aquatic environment of Hormozgan Province.

Presence of high concentrations of DDTs showed that DDTs pollution in Hormozgan Province coastal is considerable. Officially, DDT has been forbidden in Iran, but the obtained results suggested the recently input of DDT in the studied area.

More investigations should be performed in order to identify the new origin of DDT in marine ecosystem of Hormozgan Province. Survey on presence of DDTs in matrices such as foods and mother milks are suggested to achieve enough information for ecological and health risk management of DDTs. Studies on other

Table 3. Comparison the detected ∑DDTs with NOAA SQGs and reference values

	∑DDTs	Reference
Threshold effect concentration		
ERL[a]	1.6	Gómez-Gutiérrez *et al.* (2007)
Probable effect concentration		
ERM[b]	46.1	Gómez-Gutiérrez *et al.* (2007)
Detected value in reference site	14.18	Current study
Obtained average for facing areas to pollution source	17.99	Current study

[a] ERL: effects range low that refer to concentration below that undesirable effect would seldom occur
[b] ERM: effects range median that refer to concentration above that undesirable effect would frequently occur

categories of pollutants in Hormozgan Province aquatic ecosystems seem necessary.

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