

HEAVY METAL CONCENTRATION IN SOUTH VIETNAM WATERS

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ABSTRACT Data obtained from investigations which had been carried out during 1998-1999 in the waters of South Vietnam indicate that concentrations of Fe and Zn were usually higher than permissible limits. In the East South Vietnam waters, Fe concentration varied from 77 to 4450 $\mu\text{g/l}$ (mean 1045 $\mu\text{g/l}$) and Zn concentration varied from 7.24 to 74.1 $\mu\text{g/l}$ (mean 26.7 $\mu\text{g/l}$). Pollution coefficients of the two metals were 10.4 and 2.7 respectively. In the Gulf of Thailand, variation range of Fe was 133-850 $\mu\text{g/l}$ (mean 318 $\mu\text{g/l}$) and of Zn was 4.8-167.8 $\mu\text{g/l}$ (mean 23.46 $\mu\text{g/l}$); corresponding pollution coefficients were 3.2 and 2.3. Mn, Cu, As had mean concentrations lower than permissible limits. In the East South Vietnam waters, variation range for Mn was 9.0-444.6 $\mu\text{g/l}$ (mean 57.0 $\mu\text{g/l}$), for Cu was 1.0-20.3 $\mu\text{g/l}$ (mean 3.1 $\mu\text{g/l}$) and for As was 1.0-10.5 $\mu\text{g/l}$ (mean 3.7 $\mu\text{g/l}$). In the Gulf of Thailand, Mn concentration varied from 1.2 to 410.5 $\mu\text{g/l}$ (mean 19.1 $\mu\text{g/l}$), Cu concentration varied from 1.2 to 14.7 $\mu\text{g/l}$ (mean 3.7 $\mu\text{g/l}$), variation range of As concentration was 1.0-13.3 $\mu\text{g/l}$ with the mean value was 3.6 $\mu\text{g/l}$. Scarce data relating to Hg, Cd, Pb showed that their concentrations in the East South Vietnam waters were negligible (usually < 1.0 $\mu\text{g/l}$).

HAM LÖÖNG KIM LOẠI NẶNG TRONG CÁC VÖC NÖÖC PHÍA NAM VIỆT NAM

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TÖM TẮT Số liệu thu được qua các chuyến khảo sát nước thực hiện tại vùng biển phía Nam Việt Nam trong 2 năm 1998-1999 cho thấy các kim loại Fe, Zn thường có hàm lượng cao hơn mức cho phép: trong vùng biển Đông Nam Bộ phạm vi dao động của Fe và Zn rất rộng (Fe: 77-4450 $\mu\text{g/l}$, trung bình 1045 $\mu\text{g/l}$; Zn: 7,24-74,1 $\mu\text{g/l}$, trung bình 26,7 $\mu\text{g/l}$). Hệ số ô nhiễm của các kim loại này lần lượt là 10,4 và 2,7. Trong Vịnh Thái Lan hàm lượng Fe dao động từ 133 đến 850 $\mu\text{g/l}$, trung bình 318 $\mu\text{g/l}$ (hệ số ô nhiễm 3,2) và hàm lượng Zn dao động từ 4,8 đến 167,8 $\mu\text{g/l}$, trung bình 23,5 $\mu\text{g/l}$ (hệ số ô nhiễm 2,3). Các kim loại Mn, Cu, As có hàm lượng thấp hơn mức cho phép. Trong khu vực Đông Nam Bộ phạm vi dao động của Mn là 9,0-444,6 $\mu\text{g/l}$ (trung bình 57,0 $\mu\text{g/l}$), của Cu là 1,0-20,3 $\mu\text{g/l}$ (trung bình 3,1 $\mu\text{g/l}$), của As là 1,0-10,5 $\mu\text{g/l}$ (trung bình 3,7 $\mu\text{g/l}$). Trong khu vực Vịnh Thái Lan, hàm lượng của Mn dao động từ 1,2 đến 410,5 $\mu\text{g/l}$ (trung bình 19,14 $\mu\text{g/l}$), của Cu từ 1,2 đến 14,7 $\mu\text{g/l}$ (trung bình 3,7 $\mu\text{g/l}$) và của As từ 1,0 đến 13,3 $\mu\text{g/l}$ (trung bình 3,6 $\mu\text{g/l}$). Ngoài ra, một số ít số liệu về các kim loại Hg, Cd, Pb cho thấy trong khu vực Đông Nam Bộ hàm lượng của chúng không đáng kể (thường < 1,0 $\mu\text{g/l}$).

INTRODUCTION

The studied marine areas are the sea from Vungtau to Cua Dinhhan and the Gulf of

Thailand. Wastes from domestic, industrial and agricultural centers were mainly discharged into the sea big rivers (Dongnai - Saigon and Mekong rivers for East South

Vietnam sea; Ongdoc and Bayhap rivers for the Gulf of Thailand). Besides, these marine areas are impacted by oil exploitation, fishery, tourism and transportation, etc.

In order to understand the present environmental conditions in these waters, the Institute of Oceanography carried out some investigations during 1998-1999. Based on the data collected through these investigations, this paper presents preliminary information on the distribution of heavy metals.

MATERIALS AND METHODS

In this paper data of below investigations were used (location of studied areas is shown in Figure 1):

- July 1999 investigation in the area nearby Condao (sponsored by WWF);

- May 1997 investigation in coastal waters of Baria - Vungtau;
- June 1997 investigation in the vicinity of Cua Tieu;
- March and October 1998 investigations in the Gulf of Thailand;

Marine Environment Monitoring Program (1996-1999, fixed stations: Vungtau, Cua Dinhan and Rachgia).

In these investigations the water samples were collected using plastic bathometer. The water samples were treated, preserved, and analyzed following the manuals described in Standard Methods for Examination of Water and Wastewater (APHA, 1992): Fe and Mn were analyzed by colorimetric methods; Zn, Cu and As were analyzed by atomic absorption spectrophotometer methods.

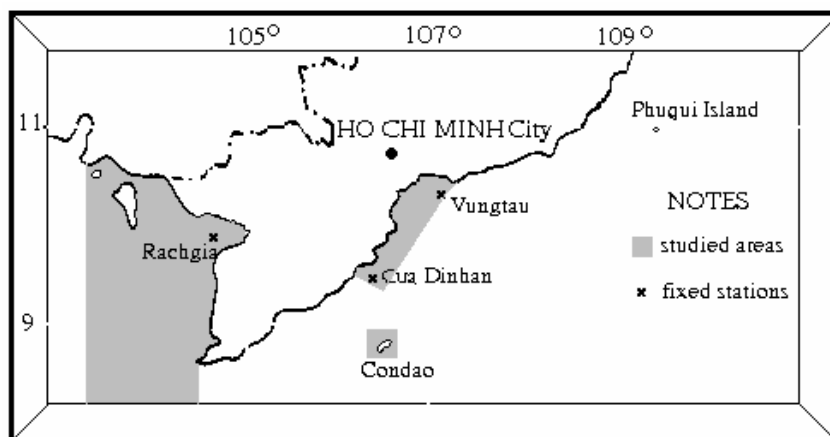


Figure 1: Location of studied areas

DISTRIBUTION OF HEAVY METALS

1. The waters of East South Vietnam

In this waters available data were concentrated in two areas: coastal sea from Vungtau to Cua Dinhan and the sea nearby Condao.

In the first waters, concentrations of Fe, Mn and Zn were highest in Cua Hamluong; Cu distributed regularly whereas the concentration of As was higher in southern part. Variation range and mean value of heavy

metals were presented in Table 1.

Concentrations of Pb, Cd and Hg in a little of analyzed samples were very low (mean concentrations of Pb: $< 1.0 \mu\text{g/l}$, Cd: $< 0.02 \mu\text{g/l}$, Hg: $< 0.02 \mu\text{g/l}$).

In the waters nearby Condao the concentrations of heavy metals were much lower than those in the coastal waters (Table 2). The concentration for Fe was lower 19.9 times; for Mn: 29.2 times; for Cu: 2.5 times and for As: 2.5 times whereas concentration of Zn was similar.

Table 1: Statistics values of heavy metals (coastal waters of East South Vietnam)

Area	Value	Fe ($\mu\text{g/l}$)	Mn ($\mu\text{g/l}$)	Zn ($\mu\text{g/l}$)	Cu ($\mu\text{g/l}$)	As ($\mu\text{g/l}$)
Vungtau	Min	-	-	7.2	1.2	1.0
	Max	-	-	59.4	20.3	6.4
	Mean	-	-	23.4	6.0	3.0
	n	-	-	10	10	10
Cua Soairap	Min	863	25.9	15.8	1.8	1.5
	Max	4450	221.4	28.8	3.1	4.8
	Mean	2656	123.6	22.3	2.4	3.1
	n	2	2	2	2	2
Cua Tieu	Min	195	9.0	18.2	1.0	2.4
	Max	229	10.8	46.8	5.3	3.3
	Mean	212	9.9	32.4	3.0	2.8
	n	2	2	4	4	2
Cua Dai	Min	-	-	12.1	2.8	-
	Max	-	-	51.3	8.2	-
	Mean	-	-	32.5	5.4	-
	n	-	-	4	4	-
Cua Balai	Min	1175	32.9	10.3	2.3	4.3
	Max	1825	74.9	53.4	7.6	10.5
	Mean	1500	53.9	23.9	3.8	7.4
	n	2	2	4	4	2
Cua Hamluong	Min	1815	62.3	10.5	3.5	8.4
	Max	5370	444.6	14.8	7.9	9.2
	Mean	3592	253.5	12.7	5.7	8.8
	n	2	2	2	2	2
Cua Dinhan	Min	-	-	11.9	2.0	3.5
	Max	-	-	74.1	9.9	7.1
	Mean	-	-	39.8	5.7	5.8
	n	-	-	10	10	10
East South Waters	Min	195	9.0	7.2	1.0	1.0
	Max	5370	444.6	74.1	20.3	10.5
	Mean	1990	110.2	26.7	4.6	5.2
	n	8	8	36	36	28

Table 2: Statistic values of heavy metals (the vicinity of Conson island)

Value	Fe ($\mu\text{g/l}$)	Mn ($\mu\text{g/l}$)	Zn ($\mu\text{g/l}$)	Cu ($\mu\text{g/l}$)	As ($\mu\text{g/l}$)
Min	77	1.7	10.2	1.0	1.5
Max	134	6.8	56.8	2.6	4.0
Mean	100	3.9	26.6	1.7	2.3
n	12	12	12	12	12

2. Gulf of Thailand

Riverine area: The concentrations of heavy metals Fe and Mn were high from

Rachsoi to Khanhhoi while the concentrations of metals Zn and Cu were highest from T5 canal to Xeoro; the As concentration was highest in Bahon (Table 3).

Coastal waters:

In dry season sampling stations were limited by Rachgia, Phuquoc island and Namdu islands. Analysis results showed that variation range of Mn was the highest, maximum values of this element and Fe were found near Rai and Tre islands. Generally, in nearshore zone the concentrations of Fe, Mn, Zn and Cu were higher than the others were (except for Zn, its maximum concentration was found in offshore station). The values higher than 5µg/l of As were found in the area limited

by Rachgia, Phuquoc island, Rai island, and Nghe island. The variation ranges and mean values of heavy metals are shown in Table 4. In serial stations I & II, variation ranges and mean values of all heavy metals are lower in comparison with corresponding values recorded in the nearshore waters. Mean concentrations of Fe, Mn and Cu in the station II were higher than those in station I while the mean concentrations of Zn and As were lower. However, the differences were not noticeable (Table 5).

Table 3: Statistic values of heavy metals in rivers (dry season)

Location	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	As (µg/l)
Vinhte Canal n=4	588 (253-905)	157.6 (69.0-224.2)	38.9 (24.9-50.4)	3.9 (2.2-4.8)	4.2 (1.7-7.0)
Bahon River n=4	579 (408-675)	89.9 (8.5-182.0)	49.8 (4.2-73.5)	5.0 (1.7-9.0)	8.4 (1.6-17.2)
T5 Canal n=4	718 (498-950)	124.6 (66.3-254.4)	56.6 (35.7-71.6)	5.1 (2.4-9.5)	1.6 (1.0-2.1)
Rachsoi River n=4	1791 (1060-2280)	341.3 (235.8-427.8)	62.4 (50.4-72.7)	12.2 (4.1-19.5)	5.0 (1.1-9.0)
Rachgia-Longxuyen n=4	1637 (760-3125)	307.5 (266.0-342.0)	65.5 (42.5-93.1)	11.8 (9.5-13.1)	5.3 (2.5-10.4)
Xeoro River n=4	926 (408-675)	264.1 (75.2-549.4)	57.4 (39.9-73.5)	5.9 (2.7-9.4)	2.0 (1.6-3.0)
Khanhhoi River n=4	1071 (488-2025)	206.5 (135.2-395.9)	34.2 (14.6-71.9)	5.0 (2.2-8.0)	4.7 (1.0-10.4)
Ongdoc River n=4	763 (350-1710)	70.6 (3.0-272.7)	28.4 (11.2-44.8)	4.8 (1.4-6.9)	3.2 (1.7-6.2)
Bayhap River n=4	739 (363-1080)	307.2 (206.5-554.4)	31.1 (13.3-61.5)	4.3 (2.2-6.8)	2.7 (1.5-4.3)
Cailon River n=4	1840 (600-3160)	105.5 (2.4-203.0)	26.9 (20.0-36.5)	4.4 (1.0-10.8)	4.8 (2.8-7.2)
Whole riverine area n=40	1062 (253-3160)	197.48 (2.2-554.4)	45.5 (4.2-73.5)	6.24 (1-19.5)	4.19 (1.0-17.2)

1062: mean value

(253-3160): variation range

Generally, it may be said that in the dry season the mean concentrations of heavy metals in the riverine area were obviously higher than those in nearshore sea (Fe is higher 2.25 times, Mn: 8.37 times; Zn: 1.38 times; Cu: 1.54 times and As: 1.21 times). Distribution of Fe and Zn is illustrated in Figure 2.

In rainy season sampling stations were elongated from Rachgia to Camau Cap with

the eastern limit was Phuquoc island. In the vicinity of Tre island (Rachgia bay), the concentrations of heavy metals were higher than other stations. Fe was concentrated in the northern part. The great part of Mn concentration was lower than 10 µg/l except in the case of very high value recorded near Tre island (388 µg/l); values 10-20µg/l were found near Rai, Chuoi and Khoai islands. The spatial variation ranges of Cu and As concentrations

were negligible except in the river mouth areas. Mean concentrations and variation ranges of heavy metals in rainy season are presented in Table 6.

In serial stations A and B the concentrations of heavy metals were not high

(Table 7) and their values were similar except for the Zn concentration (mean concentration of Zn in station B was three times higher than that in station A because of very high concentration of this element in bottom layer). Distribution of Fe and Zn is shown in Figure 2.

Table 4: Statistic values of heavy metals in the eastern part of the Gulf of Thailand (dry season)

Value	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	As (µg/l)
Min	165	2.2	15.3	1.2	1.0
Max	850	410.5	61.3	13.0	13.3
Mean	433	23.6	33.0	4.04	3.45
n	32	32	34	34	34

Table 5: Statistic values of heavy metals at serial stations I & II (dry season)

Station	Value	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	As (µg/l)
I	Min	150	2.0	23.0	1.3	1.2
	Max	403	20.5	41.0	6.0	4.5
	Mean	288	8.7	32.2	2.6	2.6
	n	8	8	8	8	8
II	Min	230	2.6	16.9	2.2	1.0
	Max	463	51.7	43.9	5.0	4.7
	Mean	342	10.1	29.2	3.2	2.4
	n	8	8	8	8	8

Table 6: Statistic values of heavy metals in the eastern part of the Gulf of Thailand (rainy season)

Value	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	As (µg/l)
Min	133	1.2	4.8	1.6	1.5
Max	433	387.6	167.8	14.7	11.9
Mean	211	14.68	14.71	3.38	3.75
n	34	34	37	37	37

Table 7: Statistic values of heavy metals at serial stations A & B (rainy season)

Station	Value	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	As (µg/l)
A	Min	160	1.6	3.2	2.7	1.9
	Max	338	10.5	22.1	5.8	8.8
	Mean	252	3.7	8.6	3.7	4.0
	n	12	12	12	12	12
B	Min	133	1.4	6.8	2.2	2.1
	Max	580	3.0	99.6	11.7	8.8
	Mean	247	2.2	27.7	4.0	3.7
	n	18	18	18	18	18

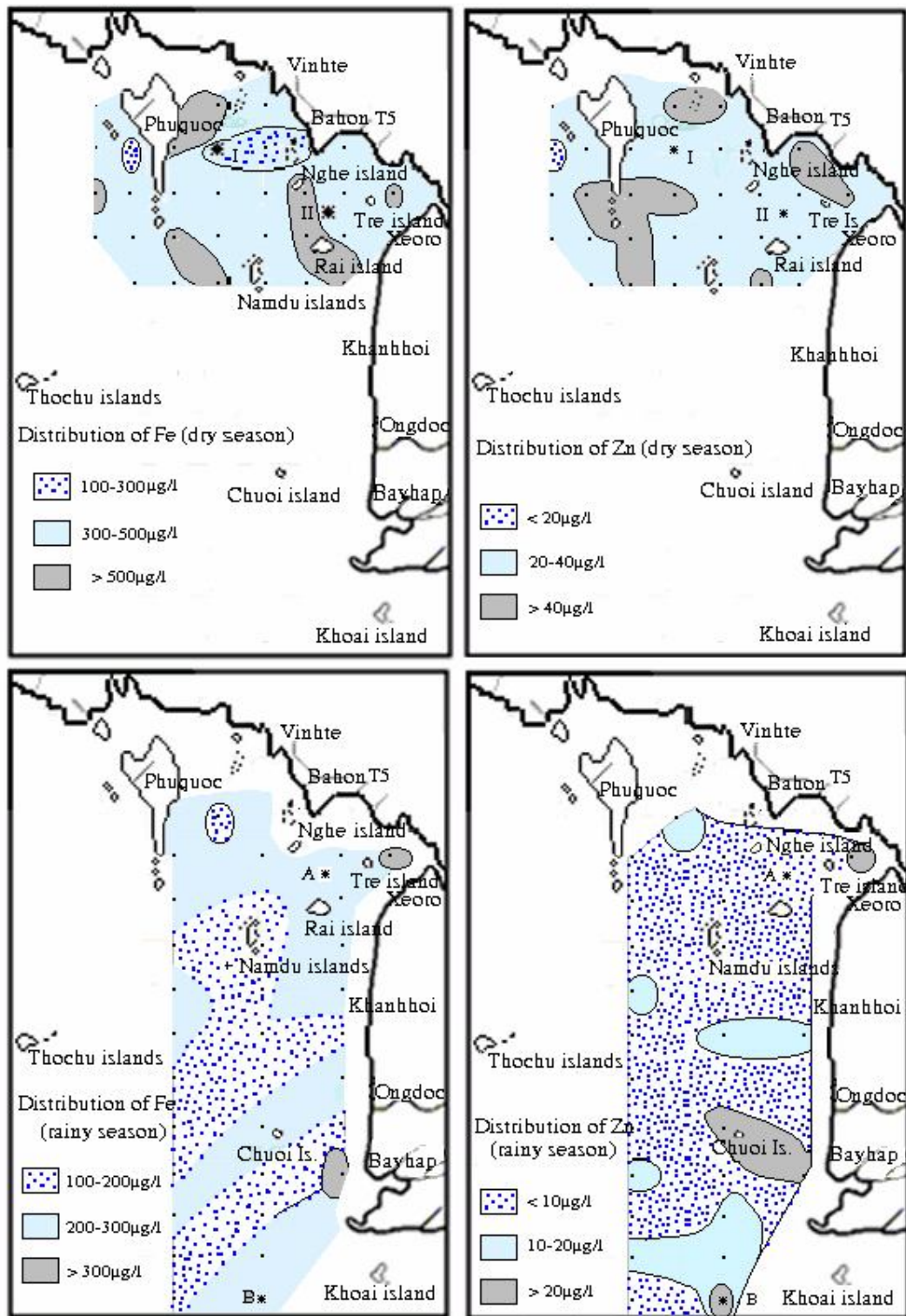


Figure 2: Distribution of iron and zinc

DISCUSSION

1. In the East South Vietnam sea and the Gulf of Thailand the concentrations of heavy metals varied in large ranges (especially Fe, Mn and Zn). Mean concentrations of natural derived metals such as Fe and Mn in East South Vietnam sea were higher than those in the Gulf of Thailand for three times (Table 8). This phenomenon could be explained by the greater discharges of Dongnai – Saigon and Mekong Rivers.

2. In the Gulf of Thailand heavy metals were concentrated in Rachgia bay. This phenomenon suggested that the metals were

mainly taken by rivers flowing from the continent. About temporal variation, in dry season mean concentrations of Fe and Mn were higher than those in rainy season (1.86 and 1.68 times respectively). Whereas, mean concentrations of Mn, Cu and As were similar.

3. Fe and Zn polluted all of the studied waters; pollution coefficients were 10 and 2.7 in the East South Vietnam Sea; 3.2 and 2.3 in the Gulf of Thailand. In addition, preliminary data of Hg, Cd, Pb showed that their concentrations in the waters of East South Vietnam were much lower than critical values. There was no corresponding data in the Gulf of Thailand.

Table 8: Comparison of mean concentrations of heavy metals in East South Vietnam coastal sea and the Gulf of Thailand

Waters	Value	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	As (µg/l)
South East Sea	Min	77.0	9.0	7.24	1.0	1.0
	Max	5370	444.6	74.1	20.31	10.52
	Mean	1045	57.05	26.7	3.14	3.73
Gulf of Thailand	Min	133	1.2	4.8	1.2	1.0
	Max	850	410.5	167.8	14.7	13.3
	Mean	319	19.14	23.5	3.69	3.61

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