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ENVIRONMENTAL IMPACTS OF ECONOMIC ACTIVITIES ON QUALITY OF SOUTHWEST PART OF VAN PHONG BAY

Pham Van Thom, Duong Trong Kiem
Nguyen Hong Thu, Pham Huu Tam, Le Thi Vinh
Institute of Oceanography (Nha Trang)

ABSTRACT At present, the water environment of the southwest part of Van Phong bay is relatively good. Pollution of organic matters and heavy metals (Fe, Zn) is fairly. However, the high content of heavy metals was recorded in just settled thin layer of sediment near the sea port of Hyundai-Vinashin Shipyard (April 2000).

It is reasonable to say that the activity of the shipyard is the unique industrial factor that can impact upon the environmental quality of studied waters and its adjacent land. Preliminary impacts of wastes from the shipyard were noted (high contents of heavy metal concentration in water column, sediments, and high bioavailableness). Among the wastes from the shipyard NIX grain (used in cleaning the boat before painting) is the main pollutant source. The negative impacs of the NIX grain become more seriously when the shipyard extends its activity.

The negative impacts of NIX can be eliminated by the recovery and treatment of this solid waste. The best solution may be the replacement of NIX by quartz sand. If this solution is impossible, reuse of solid waste is very necessary.

ANH HÖÔNG CUA CAC HOAT ÑONG KINH TE ÑOI VÔI CHAT LÖÔNG MOI TRÖÔNG PHAN TAY NAM VÒNH VAN PHONG

Pham Van Thôm, Döông Trong Kiem,
Nguyen Hong Thu, Pham Höu Tam, Le Thò Vinh
Vien Hai Döông Hoc (Nha Trang)

TOM TAT Moi tröông nöôc vung tay nam vònh Van Phong hien con kha tot (chæ co hien töông nhiem ban nhe chat höu cô, Fe va Zn). Trong tram tích co luc ña ghi nhan ñöôc sö tap trung kha cao cua Hg trong khu vöc cang cua Xí nghiep ñong tau Hyundai-Vinashin cung vôi sö co mat cua lôp bun mong chöa nhieu kim loai nang dan xuat tö chat thai ran cua xí nghiep (thang 4 nam 2000).

Co the noi la hien nay chæ co hoat ñong cua xí nghiep ñong tau la co kha nang gay tac ñong lôn ñen moi tröông phan tay nam vònh Van Phong; phan lôn cac hoat ñong kinh te khac trong khu vöc lan can khong co kha nang gay anh höông ñang ke ñen chat löông moi tröông. Cac tac ñong ban ñau cua chat thai tö xí nghiep ñong tau (sö tang ham löông cua kim loai nang trong nöôc, trong tram tích - ke ca tram tích ô ñay cac gieng nöôc sinh hoat

- va trong cac sinh vat an loc...) ña ñöôc ghi nhan. Ket qua khao sat cac nguon thai cua xí nghiep cho thay cac hat NIX dung ñe lam sach vo tau) la nguon gay nhiem ban chu yeu. Trong töông lai möc ño tac ñong co the trô nen nghiem trong hôn, ñac biet la trong tröông hôp xí nghiep mô rong hoat ñong.

Co the ngan chan o nhiem bang cac bien phap thu hoi va xö ly cac chat thai ran. Bien phap triet ñe nhat co the la thay the hat NIX bang nguyen lieu sach hôn trong nöôc (thí du cat thach anh).

I. INTRODUCTION

The studied area located in the southwest part of Van Phong bay (long. 109°12'-109°18'E; lat. 12°28'-12°35'N). My Giang island located in the southern end of the area provides the important part of raw materials for Hon Khoi Cement Plant. Small coral reefs distributed around the island. Other economic activities are ship repair and building in Hyundai - Vinashin Shipyard (which was initiating since 1998) and tourism (Doc Lech beach). Ship to ship oil transfer is intended to perform in this area.

Besides, aquaculture is developed in Ben Goi bay.

The sea bottom of studied area is relatively smooth and covered mainly by sand and sandy mud (Pham Van Thom, 1982). Quality of seawater was studied through some investigations (Pham Van Thom, 1997). The results indicate the occurrence of fair pollution (pollutants: nitrate, organic matters and some heavy metals).

Potable water in Hon Khoi peninsula is fairly salty, BOD values are negligible, COD values vary in large range, 5.60 - 41.60mg/l, heavy metal concentrations (Zn, Cu and Pb) are low (unpublished data of the ION).

II. MATERIALS AND METHODS

Two investigations had been performed in April 2000 (dry season) and October 2001 (rainy season). Water samples had been collected at 12 stations and sediment samples at 6 stations (sampling sites were illustrated in Figure 1). Besides, waste from the shipyard (waste water and solid waste) and potable water had been also collected.

Totally, 48 sea water samples, 02 potable water samples, 15 sediment samples and 04 waste water samples were analyzed for pH, DO, BOD, COD, TSS, ammonia, nitrite, nitrate, phosphate, silicate, organic N , organic P, oil and grease, Fe, Mn, Zn, Cu, As, Cd, Co, Ni, Cr and Hg (following the methods described in APHA, 1995 and FAO, 1975).

III. QUALITY OF WATER AND SEDIMENT ENVIRONMENT

1. Water environment

Dry season: The data from April 2000 (Tables 1a, 1b, 1c) suggest a fair pollution of organic matters, Zn and Fe (TCVN, 1995, NEA, 1995). Ammonia concentration was sometimes high. Molar ratios N/P were usually greater than Redfield index. Molar ratio Si/N was usually smaller than 1.

Rainy season: The data presented in Tables 2a, 2b and 2c (from October 2001 investigation) indicate that the pollutions of organic matters and Fe were more noticeable in comparison

with dry season. Ammonia existed in smaller concentration. Molar ratios N/P and Si/N were higher than in dry season, there was no Si/N value lower than 1 recorded.

In two above mentioned investigations, the environmental quality of area around Hyundai port was similar to the other parts of the studied waters.

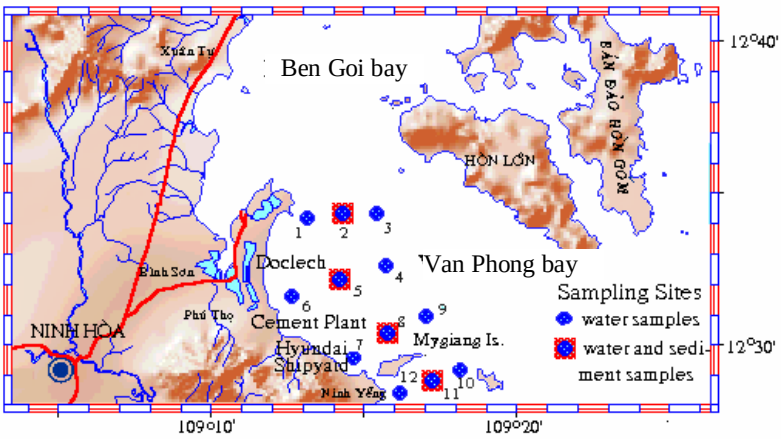

Fig. 1: Location of sampling sites

Table 1: Quality of seawater (April 2000)

1a. Basic parameters:

Area	Value	pH	Temperature (°C)	Salinity (‰)	DO (mg/l)	BOD (mg/l)	TSS (mg/l)	COD (mg/l)	N/P	Si/N
Whole	Mean	8.1	29.2	33.4	6.7	0.9	16.6	6.8	48.8	0.7
	Max.	8.2	30.8	33.8	7.2	1.5	26.3	10.8	86.3	2.3
	Min.	8.0	24.9	33.2	6.2	0.2	10.5	1.7	19.6	0.2
	n	24	24	24	24	24	24	24	24	24
Hyundai Port	Mean	8.1	29.4	33.4	6.7	1.0	18.4	7.0	54.6	0.6
	Max.	8.1	30.8	33.8	7.2	1.5	23.1	8.8	83.5	1.2
	Min.	8.0	26.7	33.2	6.3	0.7	15.0	5.7	26.2	0.2
	n	6	6	6	6	6	6	6	6	6

1b. Nutritive elements:

Area	Area	Value	NO_2-N	NO_3-N	SiO_3-Si	PO_4-P	Org. N	Org. P
		(µg/l)	*(µg/l)*	*(µg/l)*	*(µg/l)*	*(µg/l)*	*(µg/l)*	*(µg/l)*
Whole	Mean	4.1	0.3	63	105	3.3	517	27.8
	Max.	46.0	3.7	78	233	8.0	620	43.5
	Min.	0.0	0.0	43	44	1.8	425	21.5
	n	24	24	24	24	24	24	24
Hyundai Port	Mean	8.9	0.8	67	109	3.3	516	26.6
	Max.	46.0	3.7	70	152	5.8	540	32.0
	Min.	0.0	0.0	64	51	1.8	485	21.5
	n	6	6	6	6	6	6	6

1c. Heavy metals and Hydrocarbon:

Area	Value	Fe (μg/l)	Mn (μg/l)	Zn (μg/l)	Cu (μg/l)	Pb (μg/l)	Cd (μg/l)	As (μg/l)	HC (μg/l)
Whole	Mean	61.2	3.5	16.5	2.0	1.3	0.1	4.1	195
	Max.	340.0	23.4	41.6	7.0	2.7	0.3	7.2	278
	Min.	14.0	0.6	9.0	1.0	0.3	0.1	2.0	145
	n	24	24	24	24	24	6	24	12
Hyundai Port	Mean	41.3	2.4	14.6	1.7	1.0	0.1	4.1	209
	Max.	120.0	6.0	16.3	3.0	1.9	0.3	5.7	278
	Min.	15.0	1.2	10.8	1.0	0.3	0.1	3.1	146
	n	6	6	6	6	6	6	6	3

Table 2: Quality of seawater (October 2001)

2a. Basic parameters:

Area	Value	pH	Temperature (°C)	Salinity (‰)	DO (mg/l)	BOD (mg/l)	TSS (mg/l)	COD (mg/l)	N/P	Si/N
Whole	Mean	8.14	30.82	32.02	6.34	0.91	35.34	15.51	56.9	2.1
	Max.	8.27	32.20	32.97	7.25	1.73	44.00	19.00	93.0	4.2
	Min.	8.03	29.40	30.73	5.21	0.41	26.00	12.30	21.7	1.2
	n	24	24	24	24	24	24	24	24	24
Hyundai Port	Mean	8.17	30.97	32.32	6.31	0.88	33.52	14.47	61.1	2.2
	Max.	8.20	32.20	32.97	6.72	1.30	39.00	16.70	93.0	3.1
	Min.	8.13	30.10	31.65	5.21	0.46	26.00	12.30	29.0	1.5
	n	6	6	6	6	6	6	6	6	6

2b. Nutritive element:

Area	Value	NH_3-N (μg/l)	NO_2-N (μg/l)	NO_3-N (μg/l)	SiO_3-Si (μg/l)	PO_4-P (μg/l)	Org. N (μg/l)	Org. P (μg/l)
Whole	Mean	13	2.4	56	232	2.6	500	30.2
	Max.	28	3.3	68	411	5.0	577	38.0
	Min.	4	1.3	49	135	1.3	417	23.3
	n	24	24	24	24	24	24	24
Hyundai Port	Mean	4	2.2	64	282	2.8	535	30.1
	Max.	4	2.9	68	411	4.5	576	36.3
	Min.	4	1.3	59	203	1.5	515	23.3
	n	6	6	6	6	6	6	6

2c. Heavy metals and Hydrocarbon:

Area	Value	Fe (µg/l)	Mn (µg/l)	Zn (µg/l)	Cu (µg/l)	Pb (µg/l)	Cd (µg/l)	As (µg/l)	HC (µg/l)
Whole	Mean	167	2	16.4	3.4	1.6	0.6	2.5	299
	Max.	275	13	27.1	7.6	3.7	1.9	3.4	448
	Min.	105	1	7.9	0.5	0.1	0.2	1.4	136
	n	24	24	24	24	24	6	24	12
Hyundai Port	Mean	155	4	16.1	2.9	1.1	0.3	2.7	354
	Max.	178	13	23.1	6.2	2.1	0.6	3.4	448
	Min.	105	1	12.9	0.5	0.1	0.2	1.4	275
	n	6	6	6	6	6	6	6	3

2. Sediment environment

Generally, the granulometry of collected sediments was relatively coarse. As a consequence their contents of organic matters and heavy metals were not high especially in the cases of Cd and Hg (Table 3). However, the occurrence of thin layer of just settled sediment which is rich in heavy metals (especially Co, Ni and Cr) was recorded in the vicinity of Hyundai port.

IV. WASTES FROM ECONOMIC ACTIVITIES

As mentioned above, the economic activities in the vicinity of the studied waters are:

- Cement production (Hon Khoi Cement Plant): there is no wastewater from this activity; dead coral exploitation (from recent marine terraces in My Giang island) had not important environmental impact.

- Oil transfer: until now this activity is not important in the studied waters.

- Tourism (Doc Lech beach): wastes were mainly from domestic; its quantity was not important.

- Marine culture in Ben Goi bay: this activity caused some environmental risks in Ben Goi bay (Pham Van Thom, 1997). However, its impact is not apparently extended to Van Phong bay.

- Huyndai - Vinashin Shipyard: wastes from shipyard are divided into 4 groups:

+ Organic matters (and coliform?);
+ Hydrocarbon
+ Dust
+ Heavy metals (Fe, Zn, Cu, Pb, Cr, Ni, As, Co, Ni, Cr, Cd, Ba, Hg....)

Table 3: Chemical content and granulometry of sediments

a. Nutritive elements:

Value	Organic C (ppm)	Organic N (ppm)	Total P (ppm)	Pelite percentage
Mean	4731	484	1412	12.44
Max.	8700	913	3124	52.21
Min.	11212	204	11	0.12
n	12	12	12	12

b. Heavy metals:

Value	Fe	Mn	Zn	Cu	Pb	Cd	Co	Ni	Cr	Hg	As
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean	12738	110.82	8.03	3.03	4.74	0.03	0.78	2.43	2.27	0.29	4.120
Max.	301250	179.13	112.00	14.71	7.79	0.14	1.72	3.79	2.98	1.08	8.28
Min.	1200	30.89	1.13	0.53	1.95	0.00	0.00	0.84	0.98	0.05	1.27
n	12	12	12	12	12	12	12	12	12	12	12

Some of these waste compositions are presented in Table 4. The wastes causing instantly impact to the health of people living in the vicinity of the shipyard. Besides, they have potentially negative impacts upon the environment of Van Phong bay. The most noticeable feature in the activity of the shipyard is the use of NIX grains in cleaning ship crust (other factories use quartz grains for this purpose). The grains mainly constituted by heavy metals (Table 5). Cleaning process produces many dusts that are distributed by wind. As a consequence, the quality of ambient air and potable water was decreased. Used NIX grains were discarded inside the shipyard and become the main source of heavy metals poured into Van Phong bay.

V. ENVIRONMENTAL IMPACTS OF HYUNDAI - VINASHINE SHIPYARD

The above - mentioned data suggest that, at present, Hyundai-Vinashin shipyard may be the unique enterprise causing the degradation of environmental quality of Van Phong bay.

1. Impacts of wastewater

Daily discharge of industrial wastewater is about 50m^3. Discharge of domestic wastewater is estimated as the same volume. Their environmental impacts may be negligible.

2. Impacts of solid waste

Hyundai - Vinashin has began their activities since 1999. The quantity of imported NIX grains is about 100,000 tons. That means the demand of this material is about 50,000 tons/year. The used NIX grains were accumulated inside the shipyard. A large quantity of heavy metals in the grains are dissolved and carried to the sea by raining water. Bleaching of heavy metals in NIX grains by raining water is proved by some experiments. Data presented in table 6 is an example. Besides, NIX dust (generated in cleaning ship crust) distributed by wind is also an important source of heavy metals.

Up to now, the environmental impacts of ship repair activities are not seriously yet because the quantity of dissolved heavy metals in water column is not very high. However, the concentrations of them are predicted to increase rapidly in the future (higher concentration of Cd in water column and Hg, Cu, As, Co, Ni, Cr in surface sediment nearby the shipyard port may be considered as initial signs). Monitoring activities in this area indicated that the concentrations of Zn, hydrocarbon and coliform were tendentiously increased (Table 7). Higher contents of heavy metals in some mollusks were also recorded in the vicinity of Mygiang island (Vo Si

Tuan, personal communication). High concentration of heavy metals and coliform will be harmful for marine organisms and human health (by means of seafood consumption).

Table 4: Waste water from Hyundai-Vinashin Shipyard

Order N°	Parameters (unit)	Industrial waste water		Domestic waste water	
		(11/10/2000)	(6/10/2001)	(11/10/2000)	(6/10/2001)
1	pH	-	5.2	-	7.3
2	TSS (mg/l)	-	54	-	230
3	BOD (mg/l)	18.64	1.73	203.14	115
4	COD (mg/l)	34.91	45.8	271.18	97.3
5	Ammonia-N (μg/l)	94	630	1520	780
6	Nitrite-N (μg/l)	11.1	6.4	76.2	15.6
7	Nitrate-N (μg/l)	63	125	550	282
8	Phosphate-P (μg/l)	11.0	12.5	147.5	77.5
9	Fe (μg/l)	380	245	1840	4300
10	Mn (μg/l)	361	120	353	43.2
11	Zn (μg/l)	45.3	50.5	169.1	83.8
12	Cu (μg/l)	22.6	20.9	8.4	17.4
13	Pb (μg/l)	13.2	9.9	3.9	14.9
14	Oil and Grease (μg/l)	2215	357	32620	1200
15	Coliform (cell/100ml)	-	-	-	24540000

Table 5: Chemical content of used NIX grains (Data from DOSTE, Khanh Hoa province)

Elements	Bleaching in solvent		Total
	HNO_3 10%	Aqua Regia	
Paint and HC (%)	-	-	0.12, 0.54, **1.20**
Organic C (%)	-	-	0.56, 2.45, **1.73**
Fe (%)	11.35, 30.68, **11.30**	27.21	38.56
Mn (ppm)	190, 691, **440**	259	449
Zn (ppm)	2 631, 7399, **3855**	4 644	7 275
Cu (ppm)	4 322, 7042, **5759**	4 227	8 549
Pb (ppm)	531, 401, **386**	582	1 113
As (ppm)	26, 253, **106**	42	68
Cd (ppm)	0.8, 6.7, **14.4**	0.7	1.5
Cr (ppm)	56.0, 166.8, **28.4**	280	336
Ni (ppm)	30.0, **13.7**	64	94
Co (ppm)	50.0, **42.4**	107	157
Hg (ppm)	0.45, 0.42, **0.59**	0.26	0.71
SiO_2 (%)			**32.92**
Ca (%)			**3.80**
Mg (%)			**1.09**

11.35: 1999; 30.128: 2/2000 (NIX dust); **11.30: 10/2000**; **32.92: 6/10/2001**

VI. CONCLUSIONS

1. Up to now, ship repair (Hyundai - Vinashin Shipyard) is the unique activity that can make noticeable environmental impacts upon southwest part of Van Phong bay. The quantity of heavy metals carried into the sea (by wind and raining water) is estimated to be relatively high. Besides, the

hydrocarbon and bacteria pollution of the waters may be caused by the shipyard activities.

Table 6: Continuously dissolution of heavy metals from used NIX grains by rain water

Metals		Dissolution level (µg/gNIX)		
	1st 24h	2nd 24h	3rd 24h	Sum
Fe	1.187	7.697	0.643	9.527
Mn	0.363	0.500	0.418	1.280
Zn	0.407	0.536	0.554	1.497
Cu	0.386	0.467	0.171	1.024
Pb	0.025	0.053	0.074	0.152
As	0.032	0.041	0.046	0.119
Cd	0.079	0.089	0.030	0.198
Cr	0.089	0.114	0.134	0.336
Ni	0.031	0.101	0.104	0.235
Hg	0.003	0.006	0.008	0.017

Table 7: Pollution coefficient of Zn, hydrocarbon and coliform in waters nearby the shipyard (data from DOSTE, Khanh Hoa province)

Month	Zn		Hydrocarbon		Coliform	
	Year 2000	Year 2001	Year 2000	Year 2001	Year 2000	Year 2001
Feb.	1.85	2.51	X	2.11	5.20	X
May	1.40	1.70	1.03	1.68	7.00	102.00
Aug.	X	3.24	X	1.36	X	X
Nov.	1	1.63	X	1.56	7.00	X

X: not polluted

2. The environmental impacts of the Hyundai - Vinashin Shipyard were expressed by higher concentration of heavy metals in the water column, sediment and some mollusk species. These impacts can threaten human health and become more seriously in the future, especially in the case that the shipyard expands its activities.

Therefore, it is necessary to design and perform some effective measures in order to protect the marine resources and human health. These can be summarized as below:

- Restraining the dispersion of NIX grains and dust as well as the dissolution of heavy metals (cleaning up thoroughly the dry dock, collecting the dispersed NIX dust surrounding the dock and covering carefully the NIX grains).

- Extending the buffer zone of the shipyard.

- Studying the safety measures for treating the solid waste. The best solution may be the replacement of NIX grains by quartz sand.

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