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ENVIRONMENTAL QUALITY OF COASTAL WATERS IN SOUTHERN CENTRAL AND EAST SOUTH VIETNAM - OCCURRENCE OF RED TIDE PHENOMENA

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ABSTRACT The coastal waters in Southern Central and East South Vietnam are in eutrophicated status. Nitrate and COD were the main factors that determine the eutrophication. Organic substance budget is high. Among the heavy metals zinc usually has the concentrations higher than critical value described in Vietnamese Fishery Water Standard (1995). HAB were sometimes recorded. It usually prevails in hot dry season when the high water temperature and weak dynamic regime can accelerate the mineralization of organic matter and stimulate excystment of dinoflagellate cysts. High concentration of zinc may also contribute to the occurrence of HAB. However, up to now the knowledge on the relation between water quality and red tide phenomenon is not enough and there is no effective approach for the prediction of this phenomenon established. Therefore, comprehensive studies are necessary for the waters that are potentially threaten by HAB in order to prevent this phenomenon and/or to minimize its consequences.

CHAT LÖÔNG CAC VÖC NÖÔC VEN BÔ NAM TRUNG BO VA ÑONG NAM BO SÖ XUAT HIEN CUA HIEN TÖÔNG TRIEU ÑO

Pham Van Thôm, Le Thò Vinh
Vien Hai Döông Hoc

TOM TAT Cac vöc nöôc ven bô Nam Trung Bo va Ñong Nam Bo Viet Nam ñang ô trong tình trang öu döông hoa. Nitrate va COD la nhöng yeu to chính gay nen hien töông öu döông. Dö trö chat höu cô lôn. Trong so cac kim loai nang, Zn thöông co ham löông cao hôn möc tôi han qui ñònh trong Tieu Chuan Nöôc Thuy San Viet Nam (1995). Hien töông nô hoa cua tao gay hai ñöôc ghi nhan le te. Hien töông nay thöông dien ra vao mua kho nong khi nhiet ño cua nöôc cao va che ño thuy ñong löc yeu co the gia toc sö khoang hoa cac chat höu va kích thích sö thoat bao (excystment) cua tao gay hai. Ham löông cao cua Zn cung co the gop phan gay nen trieu ño. Tuy nhien, cho ñen nay sö hieu biet ve moi quan he giöa chat löông nöôc va hien töông trieu ño con qua ít va chöa xay döng ñöôc nhöng phöông phap hieu qua ñe dö bao no. Vì the, rat can cac nghien cöu sau ô cac vöc nöôc co nguy cô xay ra trieu ño ñe co the ngan ngöa va/hoac lam giam thieu cac tac hai cua hien töông nay.

INTRODUCTION

Separate investigations on the environmental quality of coastal waters in Southern Central and East South Vietnam were implemented during 1993-1998 (see Fig.1) through that some HAB were recorded. This phenomenon may become universal in the future due to the rapid development of the coastal regions. For this reason the knowledge on the relation between water quality and red tide phenomenon is very necessary. This paper presents some preliminary results relating to the problem.

MATERIALS AND METHODS

Water samples were collected using plastic bathometer. These samples were measured and analyzed for pH, TSS, DO, COD, nutrients and heavy metals following the manuals described in Standard Methods for Examination of Water and Wastewater (APHA, 1992). Water quality was considered on the basis of Vietnamese Fishery Water Standard (NEA, 1995) and Chinese Fishery Water Standard (Guao Shenquan et al., 1991).

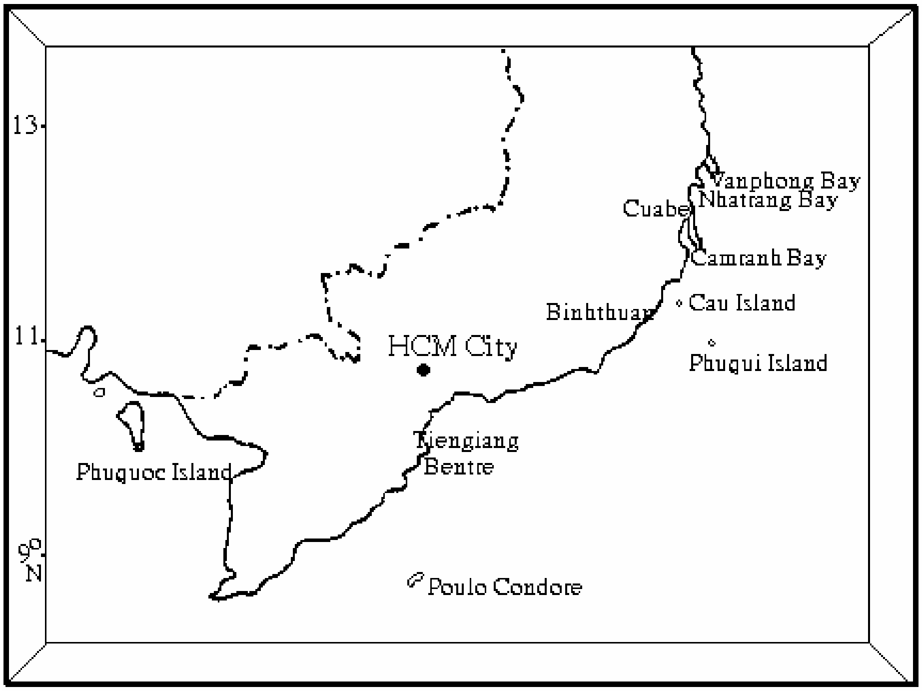


Figure 1: Location of investigated areas

WATER QUALITY OF COASTAL WATERS IN SOUTHERN CENTRAL AND EAST SOUTH VIETNAM

On the basis of Trophic Status Index (Okaichi, 1971, in: Guao Shenquan et al., 1991) the coastal waters in Southern Central and East South Vietnam is obviously eutrophicated. High COD value and high concentration of nitrate are main factors causing the eutrophication of the waters. Environmental characteristics of the studied waters are summarized as below:

- pH values and DO concentrations were in acceptable range;
- TSS concentrations were low in southern central waters (minimum value was recorded nearby Cau island, Binhthuan) and were high in southeastern waters (maximum value was recorded near the Cua Tieu river mouth, Tiengiang);
- Most of COD values were higher than 3mg/l and values greater than 10mg/l were usually recorded;
- Concentrations higher than 100µg/l of nitrate-N were found in several areas except for the area offshore Binhthuan;
- Variation range of phosphate-P was large; concentrations higher than critical value (15µg/l) were usually recorded in East South Vietnam waters;
- Organic matter budget was high; the highest value of organic N was found in Vanphong bay and one of organic P was recorded in the coastal waters of Tiengiang;
- Zinc had the highest concentration in the waters of Southern Central Vietnam;

contrarily, copper had the highest concentration in East South Vietnam waters. All of maximum and minimum values of zinc were found in Phanthiet bay; the lowest mean value was recorded offshore Tiengiang and the highest mean value was found nearby Cau island. Corresponding values of copper were found in Tiengiang and Camranh bay. The highest concentration of arsenic was found in Cuabe. All of these metals are presumably agriculturally derived.

- Phosphorous is the limiting nutrient in most of the cases, mean nitrate/phosphate ratios varied in large range, minimum value was found in Bentre, maximum value was recorded nearby Cau island. Silicate/nitrate ratios were also varied in wide range (from 0.49 nearby Cau island to 23.36 in Nhatrang bay).

Statistic values of principal environmental parameters are presented in Tables 1 & 2.

Spatial variations of important parameters mean values are depicted in Figure 2 (there is a lack of data in some sites). This figure reflexes the abundance of phosphorous containing substances and of copper in East South Vietnam waters. On the other hand, high value of COD, high concentration of nitrate and zinc in the waters nearby Cau island (an island that is less effected by anthropogenic activities) are also noticeable features. It is possible the quality of the waters around the island is ruled by "upwelling" phenomenon.

HAB RECORDED DURING 1993-1998 IN STUDIED AREA

During this period only three red tide phenomena were officially recorded in the waters of Southern Central and Southeastern Vietnam.

1. In April 1993 high density of phytoplankton was found at 16/37 sampling stations in the coastal waters of Binhthuan. Dominant species was Oscillatoria erythraea, highest density was 29 x 10^9 cells/m^3 (Nguyen Ngoc Lam, personal communication). Concentrations of nutrients were relatively high (nitrate: 65-1090μg/l; mean 168μg/l; phosphate: 2.2-37.6μg/l, mean 12.8μ/l).

2. In the same period, bloom of harmful algae was also occurred in the western coast of Vanphong bay (Vangia, Xuantu, Nguyen Ngoc Lam et al., 1997). Maximum density of phytoplankton was 49.35 x 10^3 cells/l. Dominant species was Noctulica scintillans. Concentration of nitrate-N and phosphate-P were 2 180μg/l and 6.5μg/l simultaneously.

3. In April 1997 bloom of Gonyaulax sp. prevailed in Cuabe (Nhatrang). Density of phytoplankton was decided by cells of this species (maximum density was recorded in 22nd April - 407.2 x 10^6 cells/l). In this period concentration of nitrate was relatively high whereas concentration of phosphate was lower than critical value.

Actually, the number of red tide events may be more numerous. There is an ignorance on the occurrence of this phenomenon because of the lack of essential monitoring activities. In 1998 a large quantity of Peridinium quinquecorne (determined by Ho Van The) drifted onshore in the vicinity of Nhatrang Port. The observations were further carried out along the west side of Nhatrang bay. Moreover, there was no bloom recorded.

DISCUSSION

The above mentioned data are not enough for the discussion about the relation between the environmental quality and the occurrence of HAB. However, they may help us to recognize some basic features of this problem.

The first feature is related to the trophic level of the waters. Data just presented above indicate that the studied waters were evidently in eutrophic status. However, HAB had been recorded only in some area. As above mentioned, in April 1997 bloom of Gonyaulax sp. occurred in Cuabe where the eutrophication index was the highest in studied waters (Trophic Status Index TSI = 7.75 in comparison with 5.90 in Camranh bay and 3.35

in Bengoi bay). Before, in April 1993, bloom of Oscillatoria erythraea was prevailed in coastal waters of Binhthuan when concentration of phosphate (limiting nutrient in the waters) was noticeably increased. Another interesting aspect is the absence of HAB in strongly eutrophicated waters where concentration of TSS is very high (southeastern waters for example).

The second feature is the characteristics of the elements that can influence the development process of phytoplankton

Table 1: Statistic values of studied elements in various areas
1a: basic parameters and nutrients

Area	**Value**	**pH**	**DO** (mg/l)	**TSS** (mg/l)	**BOD** (mg/l)	**COD** (mg/l)	**NO_3-N** ($\mu g/l$)	**Org N** ($\mu g/l$)	**Org P** ($\mu g/l$)	**PO_4-P** (μg/l)	**SiO_3-Si** ($\mu g/l$)
Vanphong bay	Mean	8.07	6.24	22.7	1.30	11.25	354	902	46.6	7.0	392
	Max	8.37	7.14	44.0	2.11	13.20	2590	1845	122.0	40.8	3379
	Min	7.55	5.32	9.0	0.34	8.10	15	260	20.0	0.5	20
	n	50	28	32	12	6	38	38	38	50	50
Cuabe	Mean	7.95	-	-	-	15.34	205	638	55.2	14.5	1009
	Max	8.15	-	-	-	52.50	310	784	95.0	37.5	1820
	Min	7.44	-	-	-	5.30	145	510	17.3	1.0	255
	n	35	-	-	-	35	35	35	35	35	35
Nhatrang bay	Mean	8.13	6.19	-	0.95	10.20	170	621	28.9	22.4	1986
	Max	8.20	6.80	-	2.24	17.89	345	816	43.0	32.6	8235
	Min	8.04	5.53	-	0.41	4.97	95	336	18.5	1.0	145
	n	12	12	-	11	20	20	20	20	32	12
Camranh bay	Mean	8.15	6.24	44.6	1.09	-	105	692	47.9	7.0	321
	Max	8.26	6.80	380	1.68	-	295	890	223.8	31.5	767
	Min	7.90	5.29	11	0.57	-	35	495	24.3	0.5	60
	n	18	12	44	12	-	44	44	44	44	44
BINHTHUAN	Mean	-	-	-	-	12.68	91	551	36.5	11.0	265
	Max	-	-	-	-	16.50	102	610	55.5	14.5	462
	Min	-	-	-	-	7.90	82	495	22.8	8.3	96
	n	-	-	-	-	13	13	13	13	13	13
Phanthiet bay	Mean	8.06	-	-	-	8.87	101	572	42.9	8.8	401
	Max	8.17	-	-	-	17.60	195	710	74.5	14.5	2353
	Min	7.73	-	-	-	2.90	53	425	28.0	5.0	122
	n	34	-	-	-	34	34	34	34	34	34
Cau Island	Mean	8.08	6.18	18.3	1.60	19.8	669	591	36.8	6.3	165
	Max	8.24	7.92	36.7	3.83	29.0	13040	1000	62.5	17.2	565
	Min	7.70	4.85	5.0	0.76	12.0	47	325	6.0	0.5	10
	n	96	62	69	14	6	125	98	98	125	98
TIENGIANG	Mean	7.81	8.41	228.9	-	-	365	798	179.4	39.2	1992
	Max	7.93	8.78	412.0	-	-	740	1025	424.0	75.5	6600
	Min	7.63	7.93	72.9	-	-	111	543	67.0	10.3	380
	n	4	12	12	-	-	27	27	27	27	27
BENTRE	Mean	-	-	-	-	14.5	206	881	158.4	45.2	-
	Max	-	-	-	-	11.3	55	640	44.5	12.0	-
	Min	-	-	-	-	17.5	422	1080	450.0	98.0	-
	n	-	-	-	-	20	20	20	20	20	-

1b: heavy metals

Area	Value	Zn ($\mu g/l$)	Cu ($\mu g/l$)	As ($\mu g/l$)	Area	Value	Zn ($\mu g/l$)	Cu ($\mu g/l$)	As ($\mu g/l$)
Vanphong bay	Mean	13.9	4.7	7.5	BINHTHUAN	Mean	14.5	6.1	4.2
	Max	28.9	11.8	48.0		Max	28.6	15.5	12.5
	Min	1.6	1.1	1.9		Min	5.3	2.7	2.3
	n	35	31	23		n	13	13	13
Cuabe	Mean	22.3	6.0	12.2	Phanthiet bay	Mean	29.8	4.8	0.8
	Max	76.9	14.8	40.5		Max	106.6	17.1	1.3
	Min	3.5	1.0	1.4		Min	1.6	1.6	0.2
	n	39	39	39		n	34	34	34
Nhatrang bay	Mean	11.9	5.1	7.8	Cau island	Mean	47.5	6.1	1.4
	Max	39.8	13.8	26.1		Max	106.3	12.7	2.7
	Min	2.0	1.0	2.5		Min	1.7	0.6	0.2
	n	36	16	16		n	18	18	18
Camranh bay	Mean	18.8	4.4	4.2	TIENGIANG	Mean	5.6	23.1	-
	Max	59.5	20.1	16.5		Max	10.3	60.0	-
	Min	3.0	1.0	1.5		Min	2.8	5.1	-
	n	28	28	28		n	17	17	-

Table 2: nitrate/phosphate and silicate/nitrate mean ratios in various areas

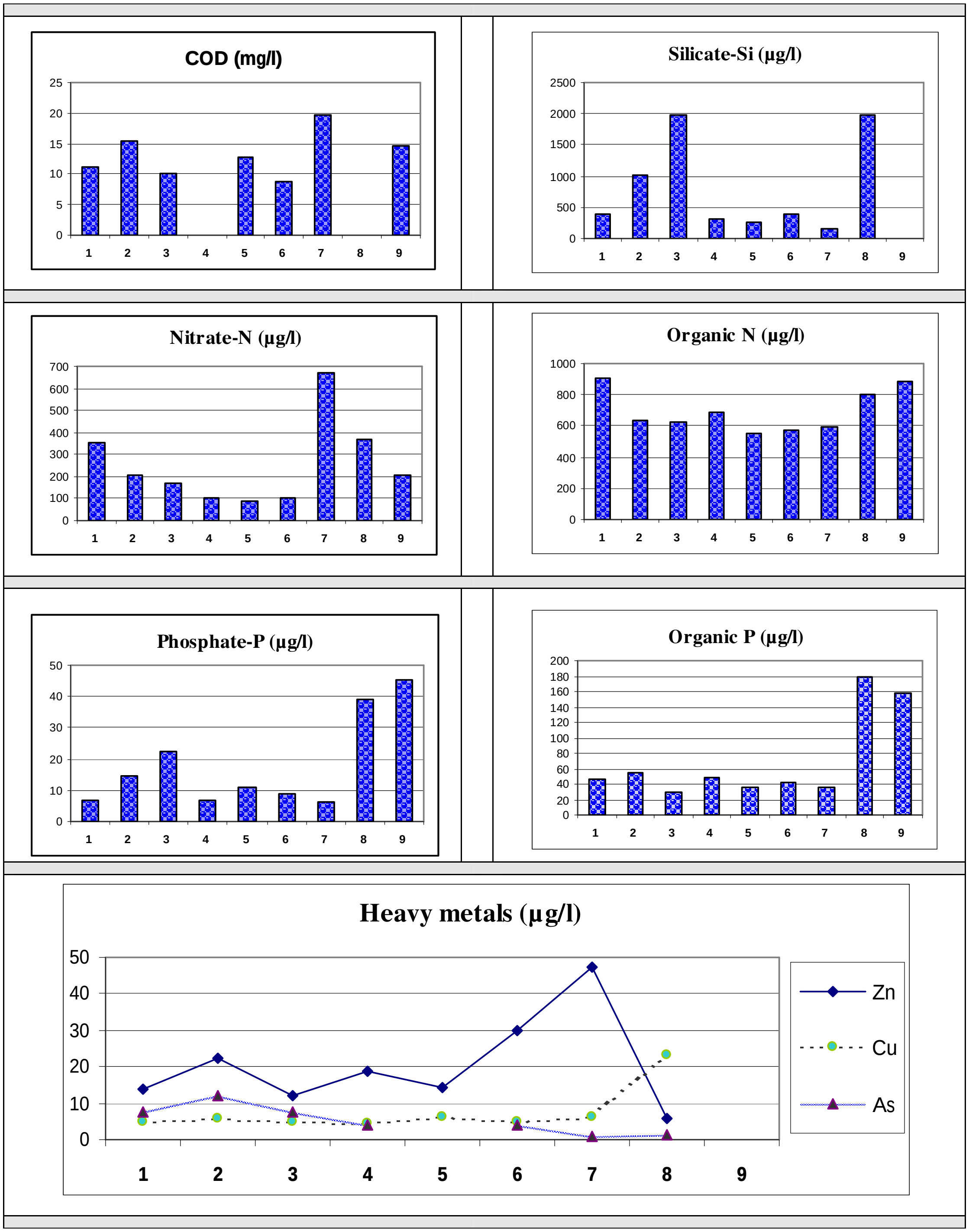
Area	nitrate/phosphate ratio	silicate/ nitrate ratio
Vanphong bay	111.98	2.21
Cuabe	31.31	9.84
Nhatrang bay	25.61	23.36
Camranh bay	19.06	11.22
BINHTHUAN	18.32	5.82
Phanthiet bay	25.41	7.94
Cau island	235.14	0.49
TIENGIANG	20.62	10.92
BENTRE	10.09	-

community. As we known, the increase of N/Si or P/Si can stimulate the growing of harmful algae (Rosa Flos, 1998). High concentration of organic matters may also effect in the same manner. In the other hand, the presence of toxic substances such as heavy metals, pesticides etc. can kill diatom and let harmful algae develop. In studied waters, the toxic substances (zinc for example) may be the important factor controlling the selected growth of phytoplankton because the lack of dissolved silicate is rarely found.

Finally, some physical parameters such as current and water temperature were also important factor controlling the occurrence of red tide. After Ho Kin-chung and I. J. Hodgkiss, 1991, suitable water temperature can stimulate the excystment of some dinoflagellates and initiate red tide phenomenon. Unfortunately, up to now there is no long term record of this parameter.

CONCLUSION

For conclusion can say that despite the available preliminary data indicating the eutrophication, the red tide phenomenon has not been seriously yet in the coastal waters of Southern Central and Southeastern Vietnam. However, the coastal zone of Vietnam is in the development. The rapid development of urbanization, industry, agriculture, aquaculture... will make the strongly eutrophication in coastal waters. Therefore, it is very necessary to design and to implement comprehensive studies as soon as possible in the waters where the HAB potentially exists. These studies should include many



Note: 1:Vanphong bay; 2: Cuabe; 3: Nhatrang bay; 4: Camranh bay; 5: Binhthuan; 6: Phanthiet bay; 7: Cau island; 8: Tiengiang; 9: Bentre

Figure 2: Spatial variation of COD, nutrients and heavy metals mean values

sciences (physic, chemistry, biology, ecology, etc.) and should be divided into simultaneous phases as below:

1. To assess comprehensively the eutrophication status in the waters where HAB were recorded in the basic of available data (applying the most suitable approach for each waters);

2. To prevail long term studies in these waters. The main purposes of them are: (a) to recognize the dynamic of red tide phenomenon in each of waters; (b) to determine a more reasonable critical value for COD; (c) to establish the effective methods for the red tide prediction;

3. To establish monitoring plan for each eutrophicated waters in order to regulate the inputs of pollutants and to prevent HAB and/or to minimize its consequences.

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