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Secondary pollution from sediment and red tide occurrence*

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Abstract—The laboratory simulation study on the micro-bio element (MBE) released from polluted sediment in municipal sewage disposal area in Xiamen Harbor during to the changes of environmental parameters are presented in this paper. The red tide organisms was incubated in the sediment leaching solution. The effect of released MBE from sediment on the growth of phytoplankton was also estimated. The results showed that the MBE released from pollution sediment - secondary pollution would be able to induce red tide to breakout.

Keywords: sediment; secondary pollution; red tide.

1 Introduction

There are multifarious aspects to induce red tide. Besides the hydrographic and meteorological factors, the biological and chemical factors are internal and main factors. In chemical aspect, the control function of contents of MBE (Cu, Cr, Mn,.....) in water is well know, while the promotion function of the contents of MBE released from the polluted sediment into water has been less reported. Study on the kinetics of MBE released from sediment into water and on the effects upon dominant species of alga, grew in different incubation periods, in Xiamen Harbour are presented in this paper.

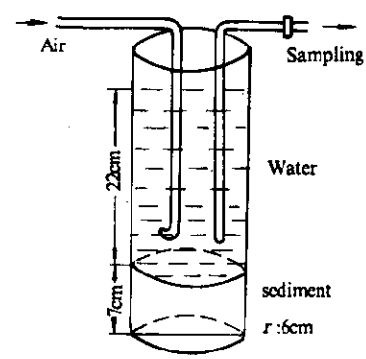

Fig. 1 Apparatus for MBE released

2 Materials and methods

Polluted sediments: sampled from the municipal acceptor area, Yuandang Lake, which connects with Xiamen Harbour.

Phytoplanktons: *Sk. costatum*, *Pr. micans*, *Ch. mulleri*, *Ch. socialis* isolated from harbour water, and incubated under 1560 lux, 14h:10D, 22±1℃.

Determination of MBE and aquatic chemical parameters (ACP): MBE analyzed with AAS and ICP; ACP analysed with standard methods. Apparatus for MBE released (Fig. 1).

Sequent extraction procedure is shown in Fig. 2.

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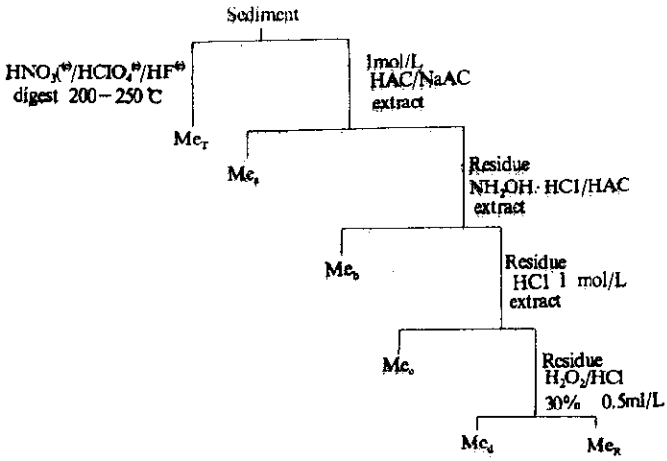

Fig. 2 Sequent extraction procedure

3 Results and discussion

3.1 The MBE was released from sediment within short acting period

Variation of the environmental parameters effected on MBE released. The released experiment was carrying out under the following conditions for 5 days, and the background of MBE contents ($\mu g/L$) in different phases shows as Table 1. The leaching conditions are: pH 6.00—9.00, E_H -0.035-0.299V, NTA 10—40$\mu g/L$ and salinity 0.00—3.00. Then we obtained results as show in Table 1,2 and Fig. 3—5.

Table 1 Background of parameters **Unit: μg/L**

TOC, %	H_2O, %	TP, × 10^{-6}	a			b			c			d			Res		
			Cu	Cr	Mn	Cu	Cr	Mn	Cu	Cr	Mn	Cu	Cr	Mn	Cu	Cr	Mn
0.269	30.8	632	21.5	6.10	569	12.2	8.29	178	41.9	12.9	44.0	17.3	1.63	68.6	22.6	6.15	37.6

Table 2 Effect on MBE released (S 30.0, pH 8.65)

E_H, VC_0	−0.035	0.029	0.078	0.093	0.191	0.299	Relation equation
$\triangle[Me]C_H$	0.137	0.328	0.386	0.393	0.411	0.426	
$\mu g/L$ Cu	0.462	0.533	0.652	0.733	0.519	0.500	$Cu=0.312+1.16\triangle E_H$, $r=0.845$, $\alpha=0.10$
Cr	0.228	0.235	0.208	0.284	0.208	0.290	$Cr=0.249\pm0.041$
Mn	21.4	20.1	10.4	18.1	20.7	31.3	$Mn=37.5-72.4\triangle E_H$, $r=-0.829$, $\alpha=0.05$

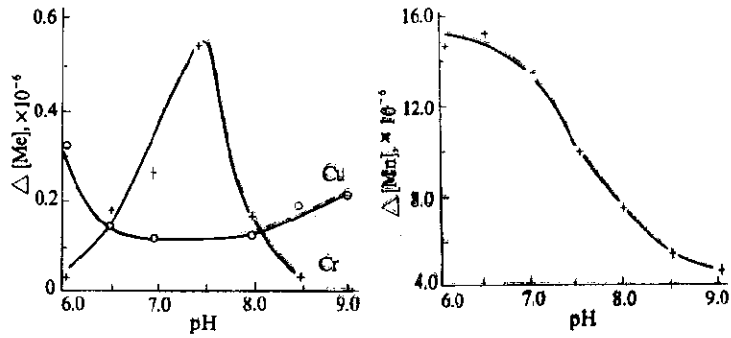

Fig. 3 pH effect

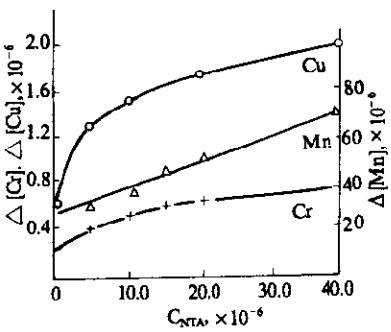

Fig. 4 NTA effect

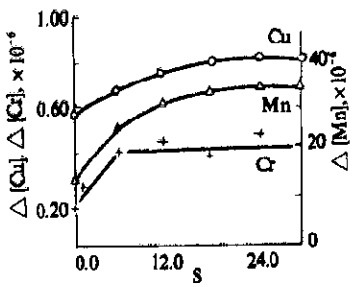

Fig. 5 S effect

The parameters of aquatic environment are effected significantly on MBE released especially E_H and pH.

As Fig. 6 shows the transformation of geochemical phases during the extraction period, such as Mn, from phase a to b, c and d, when the pH raise, Cr from phase c to b and d, Cu from phase c to a.

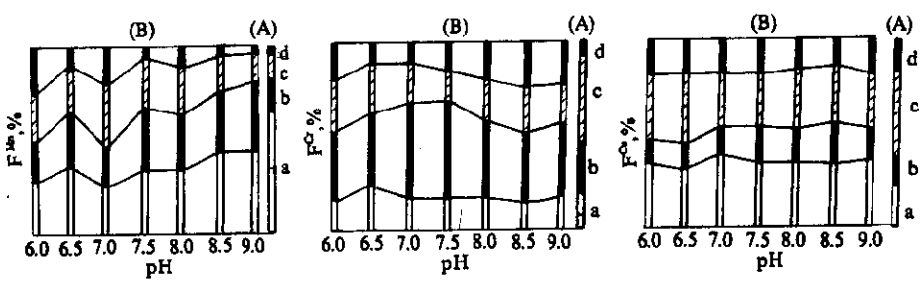

Fig. 6 Transformation of geochemical phases

The relationship between net amount of MBE released [MBE], and amount of transformation $\triangle F_i^{Me}(\%)$ is as follows:

$\triangle[Cr] = -0.822 + 0.0498\ \triangle F_c^{Cr}$, $r = 0.840$, $\alpha = 0.02$

$\triangle[Mn] = -3.15 + 0.438\ \triangle F_a^{Mn}$, $r = 0.840$, $\alpha = 0.05$

3.2 The MBE was released from sediment within long extraction period

The leaching solution was prepared with sewage and sea water. Then extracted polluted sediment for 29 days. The original state of the sediment - water systems are shown in Table 3.

Table 3 The chemical parameters of sediment - water systems

Geochemical	a			b			c			d			Res		
phases,	Cu	Cr	Mn	Cu	Cr	Mn	Cu	Cr	Mn	Cu	Cr	Mn	Cu	Cr	Mn
μg/L	77.10	6.22	301.2	27.44	9.18	92.0	55.83	10.35	52.10	32.18	3.36	61.50	25.80	18.86	158.0
Leaching solution, μg/L	Sewage /sea water = 1:4 S=22.5 pH=7.99 COD=4.18mg/L Cu=8.5 Cr=13.9 Mn=44.5														

The value of chemical parameters and the amount of MBE were analysed in the supernatant at certain time interval. We obtained the released amount of MBE described as the following equations:

$$\triangle[MBE]_x = \sum_{i=1}^{n} [V_o - V_s(i-1)][C_i - C_{i-1}]$$

Where, V_0/V_s present the initial sth sampling extraction solution's volume in liter; C_i is the MBE concentration in the ith leaching solution.

The relationship between the net released amount of MBE, $\triangle[MBE]$, and the aquatic chemical parameter was as the following multiclement regressive equations:

$\triangle[Mn] = 62.2 - 1.82DO + 8.35COD + 0.0582pH$, $r = 0.986$, $\alpha = 0.1$

$\triangle[Cu] = -257 + 22.8pH + 23.2COD - 170DO$, $r = 0.999$, $\alpha = 0.05$

$\triangle[Cr] = 48.3 - 1.17pH + 9.79DO - 8.41COD$, $r = 0.999$, $\alpha = 0.01$

It shows that the environmental parameters DO. pH played an important role for the release process of Cu, Cr, Mn as the same as in the extraction process.

3.3 The effect of released MBE from sediment on the growth of alga

The effect of MBE remigrated from sediment to water on *Sk. costatum* growth. The *Sk. costatum* was isolated from Xiamen Harbour, incubated in the two different culture media A and B(Table 4) for 5 days. The growth potential was described as Fig. 7.

Table 4 The tropic level and aquatic chemical parameters

	Parameters											
	NH_3-N	NO_3-N	NO_2-N	DIP	DOP	Mn^{2+}	Cu^{2+}	Cr^{3+}	COD	pH	DO	S
Culture media												
A	377	705	369	144	14.7	15.7	9.5	11.6	0	8.67	7.28	22.5
B	9.87	252	8.47	65.2	17.2	46.5	7.0	14.6	2.73	8.72	6.75	22.5

Fig. 7 shows that the released MBE may promote the growth algae and further the inducement of red tide brokeout.

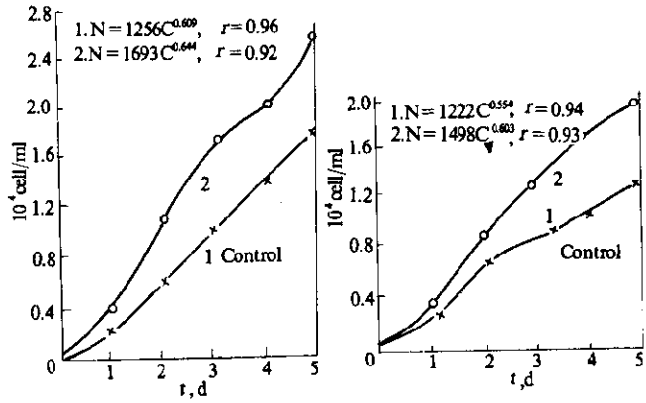

Fig. 7 The effect of culture medium on the growth of *Sk. costatum*

To incubate the mixed algae in the synthetic systems and to be examined its the growth effect, the synthetic systems are; A, natural sea water (NSW as reference system); B, NSW+Mn^{2+} 10(μg/L); c, NSW+Mn^{2+}+10+Cu^{2+} 20μg/L; D, NSW+Mn^{2+} 10+Cu^{2+} 20+EDTA20μg/L; E, NSW +Mn^{2+} 10+Fe^{3+} 10μg/L, and F, NSW+Mn^{2+} 10+Cu^{2+} 20 +Fe^{3+} 10 (μg/L). Mixed algae are ; *Pr. mican* 10^3, *Ch. mulleri* 10^3 and *Ch. costatum* 10^4 (cells/ml). These algae were incubated in above media for 5 days respectively and counted the number of cells day by day. And plotted the growth curves with the resultant data as Fig. 7. Then calculated the division rate (μ) within the logarithmic growth phase. Fig. 8 shows obviously that the Mn^{2+} has significant affect for algae growth, especially for *Ch. costatus* sp. It might induce from 0.20 to 0.66. The *Ch. costatus* drived into the dominant species, while the *Pr micans* sp. become minor one. EDTA made decrease of the content of dissolved free Cu and increase of the growth of alga. The mutual effects of Fe^{3+} and Mn^{2+} are larger than that of Mn^{2+} effect and promote the *Ch. socialic* to be dominant sp.

4 Conclusions

There is a close relationship between the net amount of released MBE and the range of variation of environmental parameters.

The kinetics of MBE released is related to the transformation of geochemical phases of sediment.

The leaching solution from polluted sediment exists in the inducement factor to promote growth of alga.

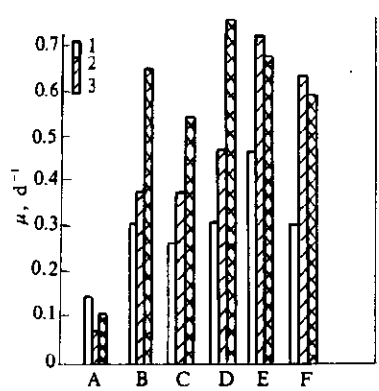

Fig. 8 Division rate of different alga

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