MATERIAL BALANCES IN CU MONG LAGOON – PHU YEN PROVINCE

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ABSTRACT Based on data collected from surveys during 1999 – 2001 in Cu Mong lagoon (Phu Yen province) and applying the LOICZ **(Land-Ocean Interactions in the Coastal Zone)** biogeochemical model, the exchange times of water, material balances and net ecosystem metabolism in Cu Mong lagoon were estimated. The results showed that:

- The exchange time of water in system is about 71 days for dry season and 22 days for wet season.

- Cu Mong lagoon system is lightly denitrifying in the dry season (-7.32 μmolN, m^{-2}, day^{-1}) and is rather fixing nitrogen in the wet season (745 mmolN, m^{-2}, day^{-1}).

- In the dry season, Cu Mong lagoon system is autotrophic (0.37 mmol C, m^{-2}, day^{-1}) and heterotrophic in the wet season (-1.43 mmolC, m^{-2}, day^{-1}).

CAN BANG VAT CHAT ÑAM CU MONG – TÆNH PHU YEN

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TOM TAT Tren cô sô dö lieu thu thap ñöôc tö nam 1999 – 2001 ô khu vöc ñam Cu Mong (tænh Phu Yen), van dung mo hình sinh-ñòa-hoa theo quan ñiem cua LOICZ, thôi gian trao ñoi nöôc, nguon vat chat va trang thai ñong hoa cua he thong ña ñöôc öôc tính. Ket qua tính toan cho thay:

- Thôi gian trao ñoi nöôc cua he thong ñam Cu Mong khoang 71 ngay trong mua kho va 22 ngay trong mua möa.

- Ñam Cu Mong la mot he thong khö nitô ô möc ño nhe trong mua he (-7.32μmolN/m^2, ngay) va ñong hoa nitô trong mua möa vôi cöông ño töông ñoi lôn (745mmolN/m^2, ngay).

- Trong mua kho, ñam Cu Mong ô trang thai tö döông, con trong mua möa he thong ô trang thai dò döông (vôi cöông ño 0.37m molC/m^2, ngay trong mua kho va -1.43mmolC/m^2, ngay trong mua möa).

I. INTRODUCTION

The assessment of material balances, especially as balanced state of atoms playing important roles in biogeochemical cycle, is extremely necessary in order to make solutions of management, exploitation and stable utilization for resources of coastal zones. They will be important bases to determine the exploitable bounds of waters.

The material balances of Cu Mong lagoon were estimated from data collected during 1999 – 2001 belonging to the project: **"Assessing and forecasting the effects of economic and social activities to ecological environment in Cu Mong lagoon and Xuan Dai bay – Phu Yen province. Promoting the means for sustainable management and utilization"** (Ñanh gia, dö bao anh hööng cac hoat ñong kinh te-xa hoi ñen ñieu kien sinh thai moi tröông ñam Cu Mong va vònh Xuan Ñai (Phu Yen), ñe xuat cac phöông an quan ly va khai thac sö dung hôp ly) conducted by Dr. Bui Hong Long.

II. MATERIALS AND METHOD

Data: The data from the project: "Assessing and forecasting the effects of economic and social activities to ecological environment in Cu Mong lagoon and Xuan Dai bay – Phu Yen province. Promoting the means for sustainable management and utilization" [3] and data cited from the document: "The characteristics of climate and hydrology in Phu Yen province" [4] were used.

Methodology: The LOICZ Biogeo-chemical Modeling Guidelines [1, 2] were applied.

The map showed location and budgeted area was presented as fig. 1.

III. RESULTS AND DISCUSSION

1. Study area description

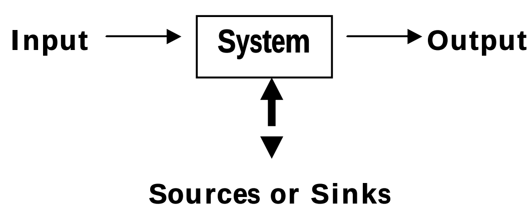
Cu Mong lagoon is located in the northeast of Phu Yen province, between $13^0$30 and $13^0$40N and $109^0$12 and $109^0$18E (Figure 1). With an area of about 2,264 ha and total volume of about $84x10^6m^3$, Cu Mong lagoon is one of coastal zones containing natural potentialities for socio - economic development.

Cu Mong lagoon is governed by a weather regime with two seasons: the dry season from January to August and wet season from September to December. The annual average range of precipitation is 1,650mm with about 76% falling during the wet season. Annual evaporation is between 1,000 to 1,100mm, approximately 2/3 of precipitation (Phan Tam et al., 1994) [4].

The population density along the coast of the lagoon is low. The standard of living is relatively low in this area. Economic activities in and around Cu Mong lagoon include: aquaculture, marine exploitation, agriculture and salt production (Phan Tam et al., 1994; Bui Hong Long et al., 2001) [3, 4].

2. Water and salt balances

As the conceptual model of LOICZ [1], the transport of materials in a system is:



Following that, we can describe this process by:

$$dM/dt = \sum Input - \sum Output + \sum (Sources - Sinks) \quad (1)$$

Where: dM/dt is a change of mass of material of interest. Assuming that the system of interest is at steady state (dM / dt = 0), water and salt budgets for Cu Mong lagoon are calculated.

Based on the collected data on salt and topography of Cu Mong lagoon, this system could be divided into 2 boxes called as: upper and lower. Following that, the water and salt balances in this system were presented in figures 2a and 2b.

Using data from table 1 to figures 2a and 2b, the water and salt budgets were calculated as following:

2.1. In dry season

Table 1: The water, salt and nutrient fluxes in Cu Mong lagoon [3, 4]

N_0	Factors	Dry season		Wet season	
		Upper	Lower	Upper	Lower
1	V_P ($x10^4$ $m^{3,}.month^{-1}$)	47	77	383	628
2	V_E ($x10^4$ $m^{3,}.month^{-1}$)	123	201	83	136
3	V_Q, V_G	≅ 0	≅ 0	≅ 0	≅ 0
4	S_{system} ($x10^4m^2$)	995	1629	995	1629
5	V_{system} ($x10^4m^3$)	2368	6027	2368	6027
6	$S^0/_{00}$ (psu)	26.53	32.25	30.40	31.16
7	DIN (μgl^{-1})	144.01	80.16	174.2	95.5
8	DIP (μgl^{-1})	11.88	7.77	11.5	10.27

(V_P, V_E, V_R, V_X defined in figs 2a & 2b; System: the area of the system)

V_{R1} = - (V_P + V_E) = - (47 -123) x104 = $76x10^4m^{3,}.month^{-1}$

V_{X1} = $-V_{R1}xS_{R1}$ / (S_2 - S_1) = - 76x29.39 / (32.25 - 26.53) = $-391x10^4$ $m^{3,}.month^{-1}$

V_{R2} = - (V_{P2} + V_{E2}+V_{R1}) = - (77 - 201 - 76) x104 = $200x10^4$ $m^{3,}.month^{-1}$

V_{X2} = $-V_{R2}xS_0$ / (S_0 - S_2) = - 200x34.30 / (34.30 - 32.25) = $-3346x10^4$ $m^{3,}.month^{-1}$

2.2. In wet season

$V_{R'1}$ = - ($V_{P'}$ + $V_{E'}$) = - (383-83) x104 = - $300x10^4$ $m^{3,}.month^{-1}$

$V_{X'1}$ = $-V_{R'1}xS_{R'1}$ / ($S_{2'}$ - $S_{1'}$) = 300x30.78 / (31.16 - 30.40) = $12150x10^4$ $m^{3,}.month^{-1}$

$V_{R'2}$ = - ($V_{P'2}$ + $V_{E'2}$+$V_{R'1}$) = - (628 - 136 + 300) x104 = $-792x10^4$ $m^{3,}.month^{-1}$

$V_{X'2}$ = $-V_{R'2}xS_{0'}$ / ($S_{0'}$ - $S_{2'}$) = 792x33.70 / (33.70 - 31.16) = $-10508x10^4$ $m^{3,}.month^{-1}$

The water change time in the system (τ) can be calculated as the total water volume of the system **($V_{sys.}$)** divided by the sum of the absolute value of residual flow **($/V_R/$)** and mixing volume **(V_X)**:

$$\tau = V_{sys.}/(/V_R/+V_X) \quad (2)$$

Therefore:

- The water change time of system in the dry season:

τ_1 = (6027+2368) / (200+3346) ≅ 2.37 (months) or 71 days.

- Similarly, the water change time of system in the wet season:

τ_2 = (6027+2368) / (10508+792) ≅ 0.74 (months) or 22 days.

The difference of the water change time between two seasons in Cu Mong system is relatively high even if V_Q source is not worth mentioning. It proves that the water change time of system was highly affected by the precipitation and evaporation.

3. The budgets for nonconservative materials

Based on the balances of salt and water fluxes and nutrient concentration measured, the budgets for nutrient materials (N and P) in season were estimated and presented in figures: 3a, 3b, 4a and 4b. The results showed:

- In the dry season, ΔDIN and ΔDIP in both regions were negative. That means, this system is a sink for N and P.

- Contrary to the dry season, ΔDIN, ΔDIP in both regions in the wet season were positive. That means, this system is a source for N and P.

Therefore, although there isn't water flux from river (that also means there aren't nutrient fluxes from river), nutrient fluxes from neighbor lagoon had an important role for this system in the wet season.

4. Stoichiometric calculation of aspects of net system metabolism

If it is assumed that the inorganic reactions in system aren't considerable and all the behaviors of nonconservative materials are biological processes, then the value of ΔDIP can be a measure of the net productivity of the system.

The net ecosystem metabolism (NEM = {p-r]) is calculated as the negative ΔDIP multiplied by the C: P ratio of the reacting organic matter. Assuming that the bulk of the reacting organic matter is phytoplankton, the C: P ratio is 106:1. Thus,

$$\mathbf{(p - r) = -106x\Delta DIP_{obs}} \qquad (3)$$

Moreover, based on the Redfield ratio (C: N: P = 106:16:1), expected nonconservative DIN (ΔDIN_{obs}) can be calculated to be 16xΔDIP. On the other hand, the ΔDIN estimated from the water and salt balances presents the ΔDIN_{obs}. Therefore, the difference between ΔDIN_{exp} and ΔDIN_{obs} represents the difference between nitrogen fixation and denitrification, that is:

$$\mathbf{(nfix - denit) = \Delta DIN_{obs} - \Delta DIN_{expect} = \Delta DIN_{obs} - 16x\Delta DIP_{obs}.} \qquad (4)$$

The results calculated were presented in table 2.

Table 2: Estimated value of (nfix – denit) and net ecosystem metabolism (NEM: p – r) in Cu Mong lagoon

N_0	Factors	Dry season		Wet season	
		Upper	Lower	Upper	Lower
1	ΔDIP_{obs} (x10^4mmolP month^{-1})	-75	-201	591	471
2	ΔDIN_{expect} (x10^4mmolN month^{-1})	-1200	-3216	9456	7536
3	ΔDIN_{obs} (x10^4mmol N month^{-1})	-2373	-2610	71172	532053
4	nfix-denit (x10^4mmolN month^{-1})	-1173	606	61716	524517
5	Nfix-denit (whole system)	-7.32μmolN m^{-2}day^{-1}		7.45m molN m^{-2}day^{-1}	
6	p-r (x10^4mmolC month^{-1})	7950	21306	-62646	-49926
7	p-r (whole system)	0.37mmolC m^{-2}day^{-1}		- 1.43mmolC m^{-2}day^{-1}	

IV. CONCLUSIONS

The estimated results of material balances in Cu Mong lagoon by applying LOICZ model showed:

1. The exchange time of water in system is about 71 days for dry season and 22 days for wet season. They are quite slow, especially in dry season. Thus, they must be deeply noted for exploiting it's ecological capacity as well as making plans of socio-economic development in neighbor areas. To avoid causing the eutrophication easily for the lagoons in the processes of exploitation and economic development, it should develop the natural purified capacity for Cu Mong lagoon.

2. Cu Mong lagoon system is lightly denitrifying in the dry season (-7.32 μmolN, m^{-2}, day^{-1}) and relatively fixing nitrogen in the wet season (745 mmolN, m^{-2}, day^{-1}).

3. In the dry season, Cu Mong lagoon system is autotrophic (0.37 mmol C, m^{-2}, day^{1}), and in the wet season, this system is heterotrophic (-1.43 mmolC, m^{-2}, day^{-1}).

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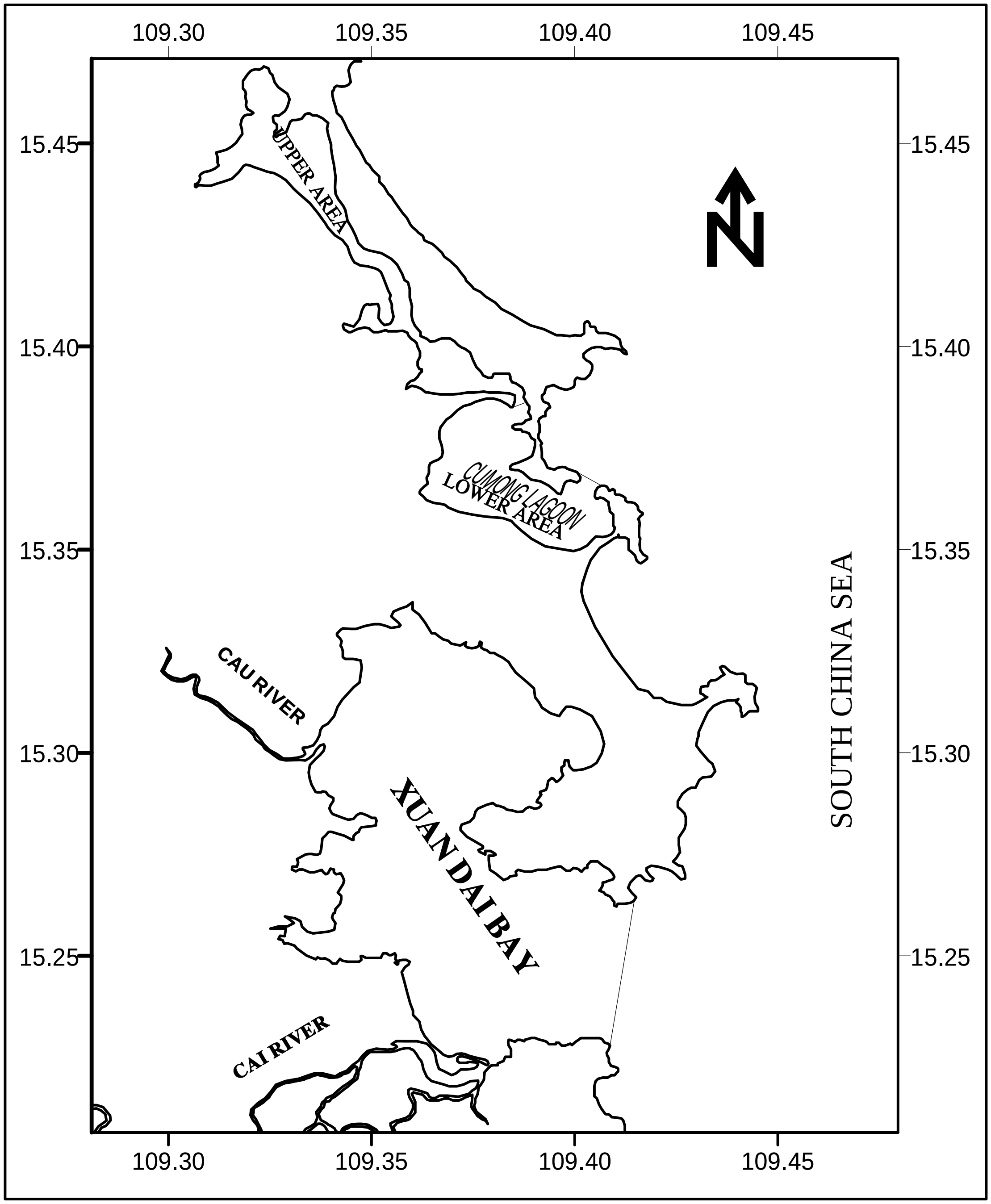

Fig. 1: The map of location and budgeted area of Cu Mong lagoon

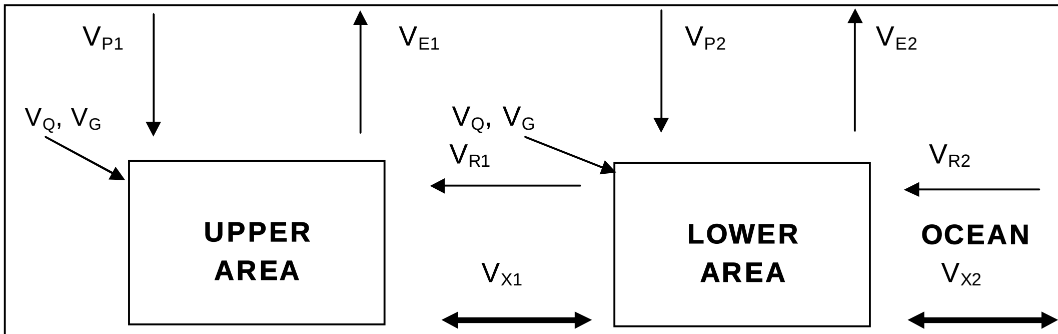

Fig. 2a: The budget of water in Cu Mong lagoon

Notes: V_E: Precipitation V_P: Evaporation V_Q: Runoff
V_R: Residual flux V_X: Mixing flux V_G: Groundwater

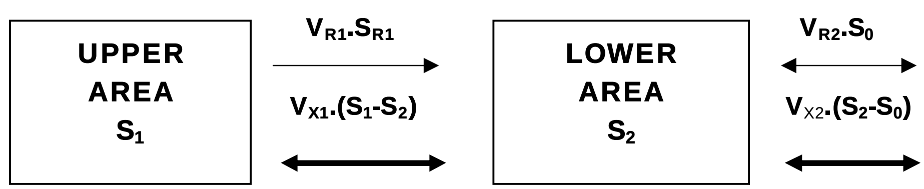

Fig. 2b: The budget of salt in Cu Mong lagoon

Notes: S_1: The salinity of upper area, S_2: The salinity of lower area,
S_0: The salinity of ocean, S_{R1}: The average salinity of system.

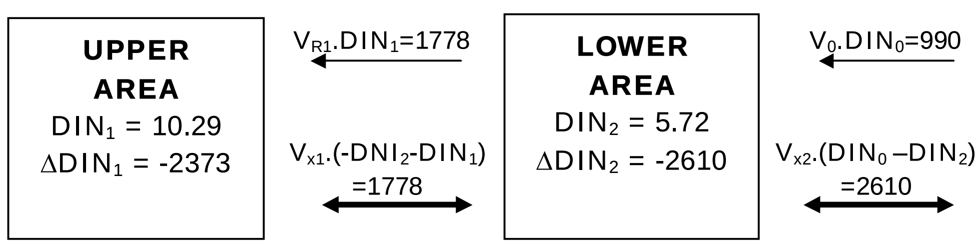

Fig 3a: Dissolved inorganic nitrogen (DIn) budgets
in Cu Mong lagoon in dry season
(Unit DIN flux: $x10^4$mmolN.$month^{-1}$ - DIN concentration: mmolN.m^{-3})

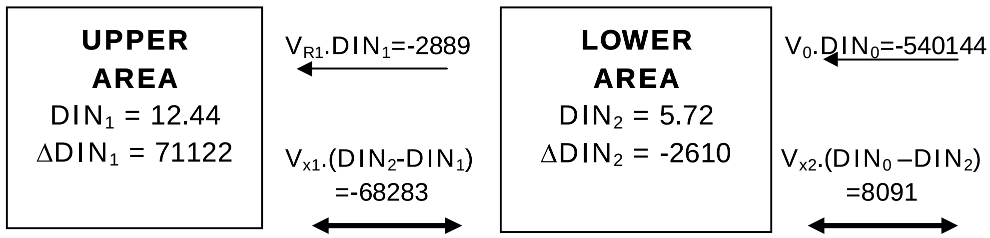

Fig 3b: Dissolved inorganic nitrogen (DIn) budgets
in Cu Mong lagoon in wet season
(Unit DIN flux: x10^4mmolN.month^{-1} - DIN concentration: mmolN.m^{-3})

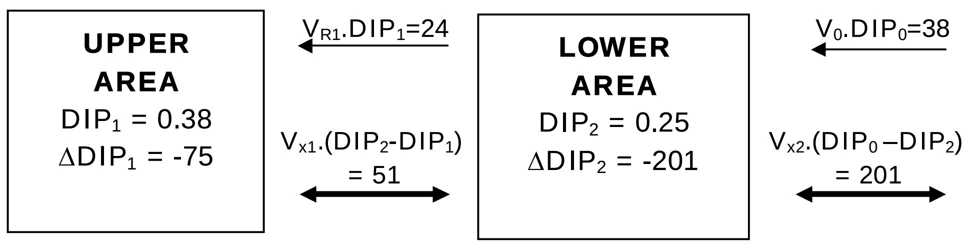

Fig. 4a: Dissolved inorganic phosphorus (DIP) budgets
in Cu Mong lagoon in dry season
(Unit DIP flux: x10^4mmolP.month^{-1} - DIP concentration: mmolP.m^{-3})

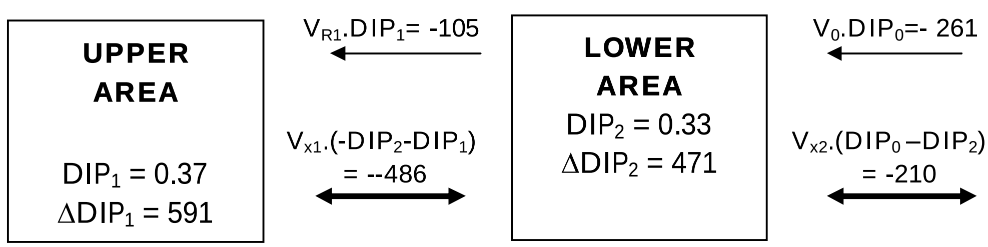

Fig. 4b: Dissolved inorganic phosphorus (DIP) budgets
in Cu Mong lagoon in wet season
(Unit DIP flux: x10^4mmolP.month^{-1} - DIP concentration: mmolP.m^{-3})