

# Influence of forest mangrove on increased deposition rate and wave attenuation in Ngoc Hai area (Hai Phong)

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**Abstract.** Mangrove forests in Hai Phong coastal area are the ecosystem with high productivity. Mangroves forests also have a good role on protection dike and coastal residential area. The extending of alluvial deposition area and development of mangrove forest are two processes occur together.

Base on the results study on the coastal zone of Ngoc Hai (Do Son, Hai Phong) since 2004 to 2011, this paper shown the role of mangrove forest on increased deposition rate, heighten bathymetry, and wave attenuation in Ngoc Hai area (Hai Phong). Deposition rate in the study could be increased about 0.1-0.4cm/year if mangroves age increasing one year age.

## 1. Introduction

Bathymetry in the coastal zone of Hai Phong is relatively flat. Surface alluvium bottom with medium level in almost of alluvial ground under water. Some alluvial ground always are impacted by wave activities such as Tan Thanh (Duong Kinh), Bang La (Do Son), Ngoc Hai (Do Son). These are also places with mangrove forests and evidenced of the role of mangroves on the coastline protect, keep sediment and improve alluvium bottom. Recently researches on this study shown erosion – deposition have four main features (Tran Duc Thanh et. al., 2001):

- Erosion occurred with along time and continues in near future: Cat Hai

- Deposition occurred with along time and now changes to erosion stage: Vinh Quang (Tien Lang), right bank of Van Uc mouth.

- Strong erosion occurred with along time and now changes to deposition stage: Bang La (Do Son), Ngoc Hai (Do Son), Tan Thanh (Duong Kinh), Dai Hop (Kien Thuy).

- Almost deposition occurred with along time, alternate short erosion stage and strong deposition now: coastal zone of Tien Lang.

This paper shows some results of the study on the role of mangrove forest on increased deposition rate and wave attention in Ngoc Hai (Do Son, Hai Phong).

## 2. Materials and methods

### *Materials*

Main materials in this study include measured results on mangrove forest structures

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in Ngoc Hai (Do Son), attitude of the coastal zone in the period of 2004-2011. Moreover, this paper also used data which relative to mangrove ecosystem and coastal dynamics of Vietnamese and international authors.

### Methods

This paper applied some methods [6]:

- Study on mangrove structure and classification of the mangrove structure:

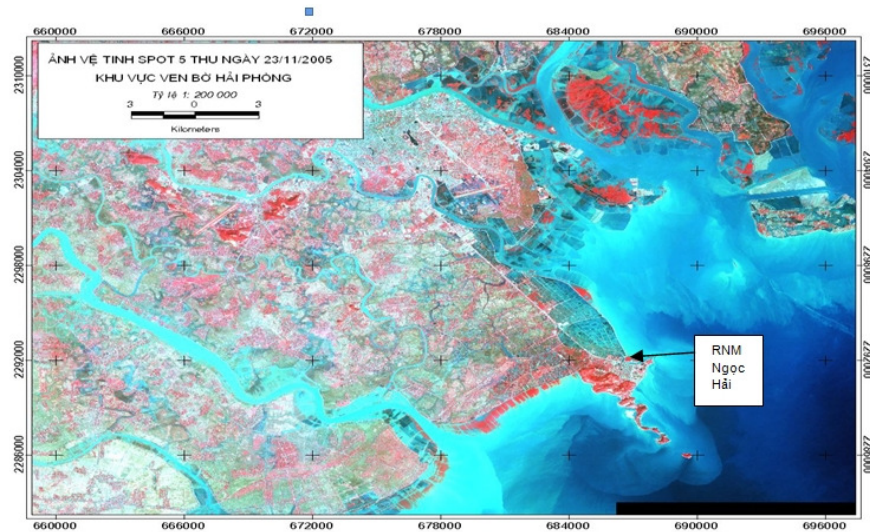


Figure 1. Study Area.

Braun – Blanquet [3], S.Aksornkoe [1] methods applied in order to measure diameter size and number of mangrove. Cells study arranged along cross section perpendicular to the sea dike with the direction from dike edge to the seaward. Depend on bathymetry and mangrove distribution, some others point also measured. *Kandelia obovata* Shuen, Lui and Yong, *Avicennia marina* measured with cell size of 10m x 10 m. *Sonneratia caseolaris* (L.,Engl.) measured with cell size of 25m x 60m (Phan Nguyên Hồng, Hoàng Thị Sản) [4].

Definition of the leaf canopy covers by formula:

$$L = \frac{S}{G} \quad (1)$$

Here:

L- leaf canopy cover of mangrove forest

S- covered area (m<sup>2</sup>)

G- mangrove forest area

Wave measure:

Characteristics of wave were measured in periods of 2004-2010. Equipments are DNW-5M, IVANOP-H10 combined with sighting mechanism (MIA) which set up 2m from the sea dike.

Coefficient of wave attention due to mangrove is calculated by the formula (Mazda (1997) [5]):

$$R = \frac{H_s - H_L}{H_s} \quad (2)$$

With: R- coefficient of wave attention due to mangrove;  $H_s$ - wave height in front of mangrove forest;  $H_L$ - wave height in place with distance L from front of mangrove forest.

#### Measure bottom altitude:

Bottom altitude compared with standard level which same as the lowest low tide (Normalize of Hydrometeorology, 1991 [8]).

$$H = H_1 - h \quad (3)$$

Here: H- bottom altitude;  $H_1$ - water depth; h- water level [2].

Water depth measured by Echosounder Hondex Ps-7 equipment combined with fixed the stakes.

#### Measure deposition rate:

Deposition rates are measured by fixed the stakes. These stakes fixed at place every 50m along section from the dike to the seaward. The stakes are marked and record value initial and checking value at every six month. Measures carried out twice time per year in the period of 2004-2011.

### 3. Results and discussion

#### Structure of mangrove forest in the study area

Component species and subclass of leaf canopy

*Kandelia obovata* Shuen, Lui and Yong mangrove forests in study were grew in 1999, besides to Ngoc Hai fishing port (Do Son) and C1 drain (Cam Cap dike).

In the period of 2004-2006: Wide mangrove forest is about 270m. Main species components are *Kandelia obovata* Shuen, Lui and Yong, some alternate *Sonneratia caseolaris* (L.) Engl., and *Avicennia marina* regenerate. There are very few others species. Tree height varies 22cm to 35cm, and density about 10-13 tree/m<sup>2</sup>.

In the period of 2007-2008: Wide mangrove forest is almost no change. Main species components are *Sonneratia caseolaris*, some alternate *Avicennia marina* in the *Kandelia obovata* forest. Regenerate species are almost *Kandelia obovata* Shuen, Lui and Yong with density about 10-13 tree/m<sup>2</sup>. Tree height varies 45cm to 55cm.

In the period of 2009-2011: Wide mangrove forest is almost no change. Main species components are *Sonneratia caseolaris* (L.) Engl., , some alternate *Avicennia marina* in the *Kandelia obovata* Shuen, Lui and Yong forest. Regenerate species are almost *Kandelia obovata* with density about 10-15 tree/m<sup>2</sup>. Tree height varies 50cm to 55cm.

Since 2010, saplings of *Sonneratia caseolaris* (L.) Engl., have been grown in front of the *Kandelia obovata* Shuen, Lui and Yong forest. Now trees height relatively steady (1.3-1.5m), tree ratio alive about 40 – 45%. These mangrove forests are wide about 150m.

Base on the tree height, it is can be device the mangrove forest in this area as below:

Layer 1: tree layer height over leaf canopy layer: *Sonneratia caseolaris* (L. Engl.)

Layer 2: tree layer height over leaf canopy layer: (*Avicennia marina*);

Layer 3: tree layer height with closed leaf canopy: *Kandelia obovata* Shuen, Lui and Yong

Layer 4: regenerate tree layer: *Kandelia obovata* (Shuen, Lui and Yong) in near coastline.

*Tree density, number and diameter of trees*

Mangrove forest is wide about 420m with sections: tree 12 ages with wide 270m; *Sonneratia caseolaris* trees have just grown in

2010 with wide 150m; regenerate tree 4.5 age and wide 20m. The highest tree and big diameter are *Sonneratia caseolaris*. The *Kandelia obovata* and *Sonneratia caseolaris* (L.) Engl., are grown in same time but *Sonneratia caseolaris* (L.) Engl., growing faster.

Table 1. Number, diameter of the tree in the standard cell in the mangrove in Ngọc Hải (Đồ Sơn)

Year	Classify age	Characteristics				
		Number tree/ha	Maximum tree diameter (mm)	Averaged tree diameter (mm)	Maximum tree height (cm)	Average tree height (cm)
2004	<i>Sonneratia caseolaris</i> 5 age	100	152	124	395	350
	<i>Avicennia marina</i> 5 age	100	72	56	190	152
	<i>Kandelia obovata</i> 5 age	17.700	97	76,7	185	147,9
	Total	17.900				
2006	<i>Sonneratia caseolaris</i> 7 age	100	177	151	421	376
	<i>Avicennia marina</i> 7 age	100	84	65	199	162
	<i>Kandelia obovata</i> 7 age	17.700	110	88,7	194	156,9
	Total	17.900				
2008	<i>Sonneratia caseolaris</i> 9 age	100	187	160	450	410
	<i>Avicennia marina</i> 9 age	100	95	75	209	173
	<i>Kandelia obovata</i> 9 age	17.700	119	99	206	167
	Total	17.900				
2011	Regenerate <i>Kandelia obovata</i> near the dike 1 age	120.000	12	10	55	50
	<i>Sonneratia caseolaris</i> 12 age	99	200	184	530	512
	<i>Avicennia marina</i> 12 age	97	106	97	227	188
	<i>Kandelia obovata</i> 12 age	17.600	142	116	221	184
	Total	17.796				
	Regenerate <i>Kandelia obovata</i> near the dike 4 age	120.000	25	21	115	98

*Wave attenuated by mangroves forest*

Coast of Ngọc Hải (Do Son) is always impacted by wave activities coming from directional Northeast. Wave measure carried out in daily with spring tide in 2004, 2008 and

2011. Bottom altitudes in this area are 2.4m (near the dike) and 1.8m (further the dike). Some measured wave heights in spring tide in November 2004 are shown in table 2.

Table 2. Wave height and coefficient of wave attenuate at the mangrove forest (*Kandelia obovata*) with wide 270m (Ngoc Hai) – directional wave in Northeast (18/11/2004)

Time	Wave height(m)					Attenuate coefficient (%)			
	Front of the forest	100m from outer edge of the forest	200m from outer edge of the forest	Near the dike	Place without mangrove	100m from outer edge of the forest	200m from f outer edge of the forest	Near the dike	Place without mangrove
7:15	0,25	0,18	0,1	0,05	0,2	28	60	80	20
7:30	0,3	0,15	0,15	0,06	0,2	50	50	80	33
7:45	0,3	0,2	0,12	0,08	0,2	33	60	73	33
8:00	0,3	0,18	0,12	0,08	0,19	40	60	73	37
8:15	0,3	0,2	0,1	0,05	0,2	33	67	83	33
8:30	0,3	0,2	0,1	0,05	0,21	33	67	83	30
8:45	0,25	0,18	0,1	0,06	0,2	28	60	76	20
9:00	0,3	0,22	0,14	0,07	0,25	27	53	77	17
9:15	0,35	0,25	0,18	0,09	0,25	29	49	74	29
9:30	0,3	0,22	0,15	0,08	0,23	27	50	73	23
Average	0,3	0,22	0,13	0,07	0,21	33	58	77	28

In front of the forest (100m), averaged wave height is 0.3m. Averaged wave height at place distance 100m from outer edge of the forest is 0.22m to correspond with coefficient of attenuate wave height is 33%. Wave height continues decrease after 100m; mean wave height is 0.13m and coefficient of attenuate wave height is 58%. After the mangrove forest with wide 270m, wave height is about 0.07m

and coefficient of attenuate wave height is 77%. In the place without mangrove tree, mean wave height is 0.21m to correspond with coefficient of attenuate wave height is 28% (Table 2).

The measured wave height results in spring tide in November 2008 in the mangrove forest with wide 270m in Ngoc Hai (Do Son) are shown in Table 3.

Table 3. Wave height and coefficient of wave attenuate at the mangrove forest (*Kandelia obovata*) with wide 270m (Ngoc Hai) – directional wave in Northeast (19/11/2008)

Time	Wave height(m)					Attenuate coefficient (%)			
	Front of the forest	100m from outer edge of the forest	Front of the forest	100m from outer edge of the forest	Near the dike	100m from outer edge of the forest	Front of the forest	100m from outer edge of the forest	Near the dike
7:30	0,30	0,20	0,12	0,06	0,20	33	60	80	33
7:45	0,32	0,21	0,13	0,07	0,21	34	59	78	34
8:00	0,32	0,22	0,12	0,07	0,21	31	63	78	34

8:15	0,31	0,22	0,11	0,08	0,22	29	65	74	29
8:30	0,34	0,26	0,16	0,09	0,23	24	53	74	32
8:45	0,40	0,30	0,18	0,11	0,30	25	55	73	25
9:00	0,39	0,28	0,17	0,09	0,26	28	56	77	33
9:15	0,40	0,28	0,17	0,10	0,28	30	58	75	30
9:30	0,38	0,24	0,14	0,09	0,23	37	63	76	39
9:45	0,38	0,22	0,13	0,07	0,23	42	66	82	39
10:00	0,36	0,20	0,12	0,08	0,22	44	67	78	39
10:15	0,34	0,19	0,10	0,08	0,21	44	71	76	38
10:30	0,32	0,18	0,11	0,09	0,18	44	66	72	44
Average	0,35	0,23	0,14	0,08	0,23	34	62	76	35

In front of the forest (100m), averaged wave height is 0.35m. Averaged wave height at place distance 100m from outer edge of the forest is 0.23m to correspond with coefficient of attenuate wave height is 34%. Wave height continues decrease after 100m; mean wave height in that place is 0.14m and coefficient of attenuate wave height is 62%. After the mangrove forest with wide 270m, wave height

is about 0.08m and coefficient of attenuate wave height is 76%. In the place without mangroves tree, mean wave height is 0.23m to correspond with coefficient of attenuate wave height is 35% (Table 3).

The measured wave height results in spring tide in November 2011 in the mangrove forest with wide 440m in Ngoc Hai (Do Son) are shown in Table 4.

Table 4. Wave height and coefficient of wave attenuate at the mangrove forest with wide 440m (150m mangrove of small *Sonneratia caseolaris* and 20m mangrove of regenerate *Kandelia obovata* and 270m older mangrove forest) in Ngoc Hai) – directional wave in Northeast (19/11/2011)

Time	Wave height(m)				Attenuate coefficient (%)				
	Front of the forest	250m from outer edge of the forest	350m from outer edge of the forest	Near the dike	Place without mangrove	250m from outer edge of the forest	350m from outer edge of the forest	Near the dike	Place without mangrove
6:00	0,36	0,22	0,13	0,06	0,23	39	64	83	36
6:15	0,37	0,22	0,12	0,07	0,22	41	68	81	41
6:30	0,39	0,24	0,14	0,07	0,24	38	64	82	38
6:45	0,42	0,27	0,16	0,08	0,26	36	62	81	38
7:00	0,42	0,27	0,15	0,07	0,28	36	64	83	33
7:15	0,41	0,25	0,15	0,08	0,26	39	63	80	37
7:30	0,40	0,24	0,14	0,06	0,25	40	65	85	38
7:45	0,38	0,23	0,13	0,06	0,23	39	66	84	39
8:00	0,37	0,23	0,14	0,06	0,23	38	62	84	38
8:15	0,36	0,22	0,13	0,05	0,22	39	64	86	39
8:30	0,35	0,21	0,12	0,05	0,22	40	66	86	37
Average	0,38	0,24	0,14	0,06	0,24	39	64	83	38

The analysis in the table 4 (November 19, 2011) shows in front of the forest (100m), averaged wave height is 0.38m. Averaged wave height at place distance 250m from outer edge of the forest is 0.24m to correspond with coefficient of attenuate wave height is 39%. Wave height continues decrease after 350m; mean wave height in that place is 0.14m and coefficient of attenuate wave height is 64%. After the mangrove forest with wide 440m, wave height is about 0.06m and coefficient of attenuate wave height is 83%. In the place without mangroves tree, mean wave height is 0.24m to correspond with coefficient of

attenuate wave height is 38% (Table 3). Although mangrove tree still small and regenerate *Kandelia obovata*, high tree density in this area decreased significantly wave height.

#### *Influences of mangrove forest on the accumulative deposition*

In places, which exist mangrove forest such as Ngoc Hai (Do Son), due to advantage influences of mangroves so this place are continue deposition. The ground layers in upper bottom (40cm) are almost mud and silt (Table 5).

Table 5. Characteristics of bottom sediment in the study area (analyzed in Institute of Marine Environment and Resources)

Number	Place	Parameters			Type
		$M_d$ (mm)	$S_o$	$S_k$	
1	Ngoc Hai (Do Son): without mangrove, upper bottom	0,168	1,373	1,094	Fine sand
2	Ngoc Hai (Do Son): without mangrove, 40cm from upper bottom	0,142	1,248	1,000	Coarse sand
3	Ngoc Hai (Do Son): in mangrove forest, upper bottom	0,005	3,294	2,348	Fine silk
4	Ngoc Hai (Do Son): in mangrove forest, 40cm from upper bottom	0,100	6,525	0,056	Coarse mud

As a result, in the place, which have mangrove, sediments were kept in the upper bottom. This is advantage factor increasing bottom altitude in the mangrove area. This is results of integrated role of trunk, root and

branch of the tree, which caused wave attenuation.

Table 6 shows deposition rate in mangroves area (Ngoc Hai, Do Son) vary between 3.3-4.1cm/year (rainy season) and 1.8-2.1cm (dry season).

Table 6. Alluvial accretion rate at Ngoc Hai (Đò Son) (unit: cm)

year	Rainy season	Dry season	Annual total
2004	3,3	1,8	5,1
2005	3,4	1,9	5,3
2006	3,4	1,9	5,3
2008	3,5	2,0	5,5
2009	3,6	2,0	5,6
2010	3,8	2,0	5,8
2011	4,1	2,1	6,2

Above table shows in 2004, mangroves tree with lower ages (5-6 year age) so that it is limited wave attenuation, alluvial rate is 5.1cm/year.

In 2005, mangroves tree more developed with both tree height and tree diameter so that capacity of wave attenuation increased with alluvial rate is 5.3cm/year.

In 2008, mangroves tree more developed with both tree height and tree diameter so that capacity of wave attenuation increased with alluvial rate is 5.5cm/year. Regenerate trees appeared in near the sea dike and growing up quickly (Table 1).

In 2011, mangroves trees went on develop with both tree height and tree diameter so that capacity of wave attenuation increased with alluvial rate is 6.2cm/year. Regenerate trees appeared in near the sea dike and growing up quickly.

The alluvial deposition also advantage response to the mangroves. Analyzed results shown the mangroves developed well and the deposition made increase bottom altitude year by year. At present this area are accretion with faster rate, especially in area between 100-150m from outer edge of the forest. Presently, bottom of the mangrove forest are rising significantly. The drain is filling up by sediments (Figure 1).



Figure 1.





Figure 2. Mangrove forest in Ngoc Hai (Do Son).

#### 4. Conclusions

Since 1999, mangrove in Ngoc Hai (Do Son) due to grown with standard specification so that they growing and development quite good. Base on measured data and analyzed results, it is giving some conclusions:

- Alluvial accretion rate in the study area depend closely on tree age and type of mangrove structure forest (2004; 2006; 2008; 2011 with the age in succession 5 age; 7 age; 9 age; 12 age corresponding with alluvial accretion rate 5.1cm; 5.3cm; 5.5cm and 6.2cm)

- The role of mangrove forest on wave attenuation, wind attenuation and increase alluvial accretion rate are going up with mangroves tree development.

- With mangrove forest, which combined *Avicennia marina* and *Sonneratia caseolaris* (L.Engl.) alternated *Kandelia obovata* Shuen, Lui and Yong) older one year age, alluvial

accretion rate increased 0.2cm/year. The mangrove forest older (below growing limit), the alluvial accretion rate more increase in the year after.

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