# HỢP TÁC QUỐC TẾ TRONG ĐIỀU TRA, NGHIÊN CỨU TÀI NGUYÊN VÀ MÔI TRƯỜNG BIỂN

# INTERNATIONAL COOPERATION ON INVESTIGATION AND RESEARCH OF MARINE NATURAL RESOURCE AND ENVIRONMENT

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NHÀ XUẤT BẢN KHOA HỌC TỰ NHIÊN VÀ CÔNG NGHỆ
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# A VIETNAM - RUSSIA FIELD SURVEY FOR STUDYING OF THE NEAR SHORE DYNAMIC AND SEDIMENT PROCESSES AT THE RED RIVER DELTA

**Nguyen Manh Hung[1], Kos'yan R. D.[2], Podymov I.S.[2], Soколов V.A.[3]**

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**Abstract:**

*The Red River Delta (RRD) located in the Northern Vietnam is under constant threat from wave and high water level in the sea (especially during typhoons and severe northeast monsoons). Most of the Red river sediment is discharged into the sea through some different branches. In general, accumulation occurs in the vicinity of the branches, at a rate depending on the local sediment discharge of the branch. The most intensive accumulation is recorded at Day mouth and Balat mouth with the rate of about 10 meter per year. However, simultaneously wit this accumulation, high rates of erosion has occurs at Hai Hau district - Nam Dinh province, threaten the low-lying land behind the sea dike system with the most population density of the RRD. In this context, the execution of a field survey on near shore wave, current and sediment transport in the Hai Hau beach during monsoon season is the main objective of the Vietnam Russian joint project "Study and modeling of the dynamical processes of the Vietnam and Russian southern seas coastal zones for the coastal erosion forecasting".*

*In the report, results of the field survey from 4th to 18th January 2011 at Thinh Long town, Hai Hau district, Nam Dinh province will be presented. During this experiment new system of turbidity and wave measurements equipment from Shirshov Institute of Oceanography - Russian Academy of Sciences and Russian State Institute of Oceanology have been used. The main results of the survey is supporting to the detail study of the near shore dynamic and sediment transport processes and their resulting to the coastline eroding.*

## I. INTRODUCTION

1. The Red River Delta plain has an approximately triangular shape form with the apex near the town Viet Tri, 150km inland. Its base extending about 130km from the port of Hong Gai in the north to southernmost point of Ninh Binh province in the south. The total area of RRD is 16.654km$^2$. In fact, RRD is comprised of two deltas: Red river (Da,Thao, Lo rivers) and Thai Binh river delta.

The mean annual water discharge of the Red river is 137.000 million cubic meters (Thai Binh river discharges 3,000 million cubic meters. The coastal zone of the RRD from the north to the south includes the following provinces: Quang Ninh, Hai Phong, Thai Binh, Nam Dinh, and Ninh Binh. The total sea dyke length of RRD is 1,500km, including the dykes along the rivers and estuaries. Before the construction of the Hoa Binh reservoir the annual sediment discharge at Son Tay was 113,6 million tons (1958 - 1988). After starting to operate the Hoa Binh reservoir the annual sediment discharge at Son Tay was reduced to 57,3 million tons (1989 - 2001). The coastline and river mouths of Red and Thai Binh river systems are shown in the figure 1.


**Fig. 1.** Red and Thai Binh river systems.

2. From the North to the South there are six main river mouths: Cam, Van Uc, Thai Binh, Tra Ly, Ba Lat, Ninh Co, and Day river mouth. All the river mouths show an ongoing growth in the seaward direction because of the huge annual sediment discharge to the sea. The highest seaward growth rate occurs at the Day river mouth (140m/year at Kim Son province - 1995-2001). A river mouth oriented towards the south, being less exposed to the wave attack, is favorable for the accumulation process at the mouth. At Van Uc and Thai Binh river mouths the accumulation is not strong as at Day and Ba Lat mouths. Ba Lat mouth is the main source of water and sediment from the Red river discharge to the gulf of Tong King. About 40 - 45% of the annual Red river water discharge at Ha Noi (before operation of Hoa Binh reservoir), which is estimated to be 107,000 million tons, and 34% of the annual Red river sediment discharge at Ha Noi (81,583 million tons) are conveyed through the Ba Lat mouth.

3. In the RRD, the accumulation in general is taking place at the river mouths, whereas the erosion often occurs at downdrift side of the mouths and at some specific stretches located between the river mouths. About 70% of the sediment from the rivers is transported to offshore. The sediment typically found in the RRD consists of sand, silt and clay, mostly of river origin, with grain sizes in the range 0,001mm to 0,025mm. Because of the dominance of fine fractions the sediment is very mobile, requiring fairly low water velocities to initiate motion and net transport. Simultaneously with the intensive accumulation at the river mouths, high rate of erosion has occurred in some stretches and the typical erosion one is the Hai Hau beach, which is located between the Day and Balat mouths. The 30 km along Hai Hau beach has suffered from erosion at least from the beginning of the last century. The coast has been eroded at a rate of 10 - 15 m/year during the last half century

4. The coast line evolution and river mouth change in general and the erosion in Hai Hau beach in particular are the subject of the research of many Vietnamese and international projects [1] - [4], [9], [10]. In the frame of these projects some synthesis marine dynamic, sedimentary measurement have been organized [1], [5] and some results of modeling shoreline and sea bottom changes with state of the art models are obtained. Nevertheless the general situation is the lack of the detailed measurement data especially in the near shore and surf zone during the severe weather as monsoons and typhoons.

5. The Vietnam Russian Joint project "Study and modeling of the dynamical processes of the Vietnam and Russian southern seas coastal zones for the coastal erosion forecasting" was implemented with the main objective of new approaches of sediment transport and coastline evolution. These approaches are based on the researches of physical mechanism of spatial and temporal change of suspended concentration and sediment transport caused by random waves in the near shore zone where in the traditional approach, only the time averaged processes have been studied. The new models for forecasting of spatial and temporal fluctuates of the concentration of suspended sediments and sediment transport under the random waves, turbulent vortex, phased shift between the fluctuation of suspended sediment concentration and current under the ripple and sheet flow regimes. In order to fulfill the objective, new detail dynamic and sedimentary measurement will be execute in the study site. A cross shore profile in Thinh Long town, Hai Hau province has been chosen for experiment. This is a rather gentle slope profile ($\alpha$=0,009) and bottom grain size is rather fine (d=0,01mm) so the experimental profile is typical for delta coastal zone.

## II. EXPERIMENTAL SET-UP AND PROCEDURE

An experiment in the frame of the above mentioned Vietnam - Russian joint project was organized from $4^{th}$ to $18^{th}$ of the January 2011 (called VN-2011). The survey group consists of 4 staffs from the Institute of Mechanics - leading by Assoc. Prof. Dr. Nguyen Manh Hung and 3 staffs from the Institute of Oceanography Shirshov and Russian State Institute of Oceanography leading by Prof. DSc. R. Kos'yan. The experimental apparatus are three turbidity meters and two wave-water level recorders.

### 1. Apparatus and calibrations:

The optical turbidity meter is shown in the figure 2a, the wave - water level recorder is shown in the figure 2b respectively.

As the turbidity meter consists of transducer and receiver sensors it works more stable than the same kind of the apparatus with two sensors in one place (as Optical Back Scatter sensor). In order to convert turbidity to suspended solids concentration the apparatus have to be calibrated with a turbidity standard and suspended matter from the water in the place of the experiment. So by the beginning of the December 2010 a bottom sample at the place with the 0.5m depth (about 150 from the beach wall at mean tide level) has been sent to the Institute of

Oceanography Shirshov for the calibration.

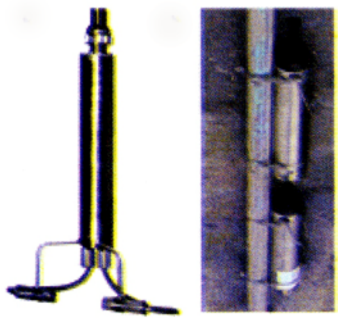

**Fig. 2.** The optical turbidity meter (a) and two Wave and Water level recorder mounted in a steel stake (b).

As the turbidity meter consists of transducer and receiver sensors it works more stable than the same kind of the apparatus with two sensors in one place (as Optical Back Scatter sensor). In order to convert turbidity to suspended solids concentration the apparatus have to be calibrated with a turbidity standard and suspended matter from the water in the place of the experiment. So by the beginning of the December 2010 a bottom sample at the place with the 0.5m depth (about 150 from the beach wall at mean tide level) has been sent to the Institute of Oceanography Shirshov for the calibration.

The grain size analysis of the sample is tabulated in the table 1. The calibration was made using the 20 liters water box where three turbidity sensors were mounted in the level of 7cm from the depth and looking each other by the angle of 120 degrees. In the center of the box equipped a stirring machine with the blades to the level 5cm above the bottom (see the figure 3). The distribution of the grain size is depicted in the figure 4.

After the calibration the correlation equations have been established for each turbidity sensor numbered 3, 4 and 5.

**Tab. 1.** The grain size analysis for the Thinh Long beach sample (December/2010).

| **Grain size [mm]** | **Mean grain diameter $\overline{d}$ [mm]** | **Sample distribution** | | |
|---|---|---|---|---|
| | | **Weight [g]** | **%** | **%x $\overline{d}$** |
| 8-5,0 | 6,25 | 0 | 0 | |
| 5-2,5 | 3,75 | 0 | 0 | |
| 2,5-1,6 | 2,00 | 0 | 0 | |
| 1,6-1,0 | 1,30 | - | - | - |
| 1,0-0,63 | 0,815 | 0,04 | 0,04 | 0,052 |
| 0,63-0,4 | 0,515 | 0,04 | 0,04 | 0,032 |
| 0,4-0,315 | 0,36 | 0,13 | 0,13 | 0,067 |
| 0,315-0,2 | 0,26 | 3,72 | 3,72 | 1,34 |
| 0,2-0,16 | 0,18 | 18,67 | 18,67 | 4,85 |
| 0,16-0,1 | 0,13 | 66,56 | 66,56 | 11,98 |
| 0,1-0,063 | 0,082 | 10,54 | 10,54 | 1,37 |
| 0,063-0,05 | 0,056 | 0,30 | 0,30 | 0,024 |
| 0,05-0,02 | 0,031 | 0 | 0 | 0 |
| Total | | 100,00 | 100 | 19,715 |

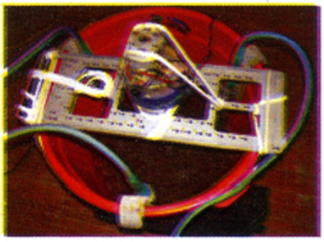

**Fig. 3.** The calibration of the turbidity sensors by the sample from Thinh Long town, December 2010.

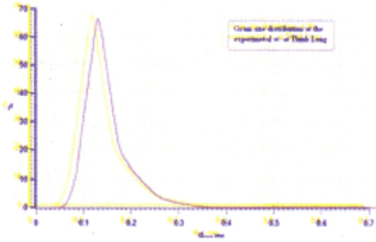

**Fig. 4.** The grain size distribution at Thinh Long beach.

The correlation equation for the turbidity sensor №3:

$$C = -0{,}02243007783 * (-2{,}734957677 * \ln(U_{mv}/3084))^2 + 1{,}2194181236 *(-2{,}734957677 * \ln(U_{mv}/3084)) + 0{,}046445078$$

The correlation equation for the turbidity sensor №4:

$$C = 0{,}013357355 * (-2.745213776 * \ln(U_{mv}/2906))^2 + 0{,}874113622 * (-2.745213776 * \ln(U_{mv}/2906)) + 0{,}030851964$$

The correlation equation for the turbidity sensor №5:

$$C = -0{,}02095384162 * (-2{,}980300149 * \ln(U_{mv}/2803))^2 + 1{,}07265623836 * (-2{,}980300149 * \ln(U_{mv}/2803)) + 0{,}082134275$$

Where: C - Suspended concentration [g/l],
$U_{mv}$ - Out put of the turbidity sensor [mV].

The wave and water level recorders GMU-2M is the standard operational equipment product of the Russian Hydro meteorological Service (see figure 2b) and the last calibration was made in November 2010.

**2. Experiment set-up:**

The turbidity meters and the wave recorders have been mounted in two steel stakes. The first stake is equipped with two wave recorders at the level 30cm and the second one at the level 80 cm from the bottom (see figure 2b). The second stake had 3 turbidity meters № 3; № 4 and № 5 at the levels 30cm, 65cm and 100 cm from the sea bottom (see figure 5). Two steel stakes with the apparatus have been mounted in the wooden stake at the distance 150m from the coast. Because each turbidity sensor have two electricity lines connected to a computer in the station by the regulator system E-140 (150Hz), two supporting stakes in the distance of 50m and 100m from the beach wall have been established (see figure 6).

**Fig. 5.** The turbidity meters mounted in the stake before experiment.

**Fig. 6.** The experiment profile.

The experiment was executed during the Northeast severe monsoon with high wave and very could weather so the building three wooden stakes and taking them out were done during the low tide phase with the water depth not more than 0,5m (see figure 7). So the turbidity sensor №5 and even №4 and higher wave recorder often emerged in the air (see figure 8).

**Fig. 7.** Equipment set-up (during the low tide).

**Fig. 8.** A moment when two turbidity meters and one wave recorder were in the air.

## III. EXPERIMENT RESULTS AND DISCUSSION

### 1. Data format:

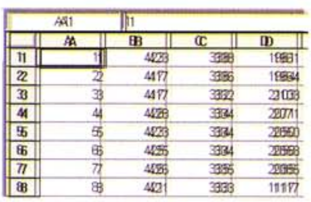

**Fig. 9.** Turbidity data output.

**Fig. 10.** ASP E-140 connected to a personal computer during the experiment.

**Fig. 11.** Settings interface for turbidity measurement.

Data format of the turbidity meters output is shown in the figure 9.

Where: Column A - Number of records; Column B - Out put data of turbidity sensor №3, mV- (30cm from the sea bed); Column C - Out put data of turbidity sensor №4, mV- (65cm from the sea bed); Column D - Out put data of turbidity sensor №5, mV- (100cm from the sea bed).

The Number of recording period is calculated by the formula: A = (A - 1)/50.

A data analyzed program for data analyzed system ASP E-140 was established in the Southern Institute of Shirshov was used for turbidity data analyzed (http://coruna.coastdyn.ru/longinov/pres/156_158p.pdf). The Data analyzed system ASP E-140 with personal computer and an example of data setting are shown in the figure 10 and figure 11.

For the wave and water level data analyzing a data analyzed software of the wave recorder established by the equipment factory have been used to convert the out put signal (wave pressure in the measurement layer) to the wave parameter (wave heights and period) using the real wave attenuation coefficient at the gauge.

**2. Data analyzed:**

In the table 2 tabulated the data of sediment concentration measurement and the wave, water level and temperature data are shown in the table 3.

**Tab. 2.** Sediment concentration data obtain by turbidity measurement.

| Turbidity data files | Filtra -tion | Time (Hanoi) | | Notes |
|---|---|---|---|---|
| | | Start | End | |
| **12/1/ 2011** | | | | |
| adc_data_01.dat | No | 05h02' | 05h30' | Some time the highest turbidity sensor emerged from the water. |
| adc_data_02.dat | No | 05h33' | 06h04' | Some time the highest turbidity sensor emerged from the water. |
| adc_data_03.dat | No | 06h32' | 7h02' | Some time the highest turbidity sensor emerged from the water. |
| adc_data_04.dat | No | 7h55' | 08h30' | The highest turbidity sensor emerged fully from the water. |
| adc_data_05.dat | No | 10h56' | 11h30' | The highest turbidity sensor emerged fully from the water, the middle sensor start emerging from the water. |
| adc_data_06.dat | No | 13h57' | 14h30' | The highest turbidity sensor emerged fully from the water, the middle sensor some time emerged from the water. |
| adc_data_07.dat | No | 16h55' | 17h30' | The highest turbidity sensor emerged fully from the water, the middle sensor some time |

| Turbidity data files | Filtration | Time (Hanoi) | | Notes |
|---|---|---|---|---|
| | | | | emerged from the water. |
| | | Start | End | |
| adc_data_08.dat | No | 19h58' | 20h30' | The highest turbidity sensor emerged fully from the water, the middle sensor some time emerged from the water. |
| adc_data_09.dat | No | 23h02' | 23h32' | The highest turbidity sensor emerged fully from the water, the middle sensor some time emerged from the water. |
| **13/1/2011** | | | | |
| adc_data_10.dat | No | 06h07' | 06h37' | The middle sensor was submerged in the water the highest sensor some time emerged from the water. The maximum water level observed from the beginning of the experiment. |
| adc_data_11.dat | No | 08h55' | 11h05' | The middle sensor was submerged in the water the highest sensor fully emerged from the water. The water level lower than one in the last observation period about 30 cm. Start ebb time period. In the moment of the end of the observation period the second sensor almost emerged from the water, the gauge was in the breaker line. |

**Tab. 3.** Water level (h), averaged wave height ($\zeta_{cp}$), maximum wave height ($\zeta_{max}$) and temperature (T) obtained by recorder SUM-2M

| N Obs. | Date (Hanoi) | h [cm] | $\zeta_{cp}$ [cm] | $\zeta_{max}$ [cm] | $T^0C$ |
|---|---|---|---|---|---|
| 1 | 22: 00 - 11/1/2011 | - 47 | 17 | 33 | 13. 5 |
| 2 | 01: 00 - 12/1/2011 | - 12 | 22 | 59 | 13. 3 |
| 3 | 4: 00 - 12/1/2011 | 26 | 30 | 72 | 13. 5 |
| Interp. | 5: 30 - 12/1/2011 | 43 | 37 | 79 | 13. 4 |
| 4 | 7: 00 - 12/1/2011 | 33 | 39 | 77 | 13. 4 |
| 5 | 10: 00 - 12/1/2011 | 5 | 32 | 73 | 13. 5 |
| 6 | 13 : 00 - 12/1/2011 | - 5 | 31 | 65 | 13. 8 |
| 7 | 16 : 00 - 12/1/2011 | - 3 | 30 | 59 | 13. 9 |
| 8 | 19 : 00 - 12/1/2011 | - 6 | 30 | 58 | 13. 8 |
| 9 | 22 : 00 - 12/1/2011 | - 10 | 23 | 46 | 14. 1 |
| 10 | 01 : 00 - 13/1/2011 | 8 | 24 | 54 | 14. 3 |
| 11 | 04 : 00 - 13/1/2011 | 34 | 25 | 53 | 14. 3 |
| Interp. | 05 : 30 - 13/1/2011 | 46 | 27 | 56 | 14. 3 |
| 12 | 07 : 00 - 13/1/2011 | 36 | 25 | 53 | 14. 4 |
| 13 | 10: 00 - 13/1/2011 | - 25 | 18 | 36 | 14. 2 |
| 14 | 13: 00 - 13/1/2011 | - 39 | 17 | 40 | 15. 3 |
| | | | | | |

In the figure 12 depicts the temporal distribution of suspended sediment concentration at the horizons of 30 and 65 cm above the sea bottom for the whole measurement period and a fragment of the period for all three horizons (data for all three horizons could not display for all the measuring period because the highest sensor often emerged from the water) is shown in the figure 13. Temporal distribution of mean sea water elevation and wave heights is showed in the figure 14.

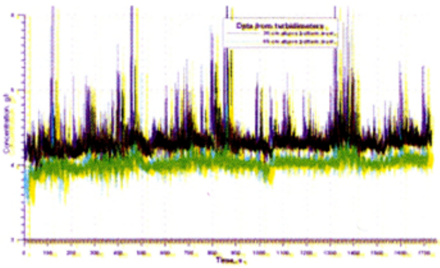

**Fig. 12.** Temporal distribution of suspended concentration (from file adc_data_10.dat in the table 2).

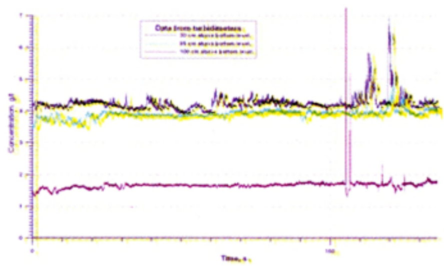

**Fig. 13.** A fragment of the measuring period as shown in the figure 12 where all three sensors were in the water (at the moment 105s the sensor at 100cm was emerged in the air caused some picks).

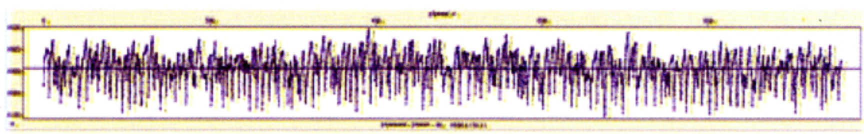

**Fig. 14.** Temporal distribution of mean sea water elevation and wave heights recorded by the wave recorder GUM-2M at 13h00 12/1/2011 (Hanoi).

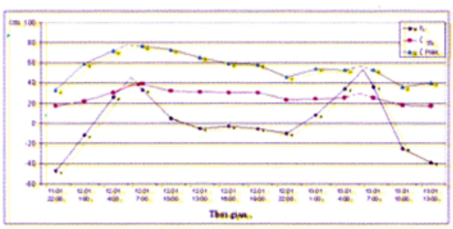

**Fig. 15.** Temporal distribution of $h_{cp}$, $\zeta_{tb}$, $\zeta_{max}$ (cm) during the experiment.

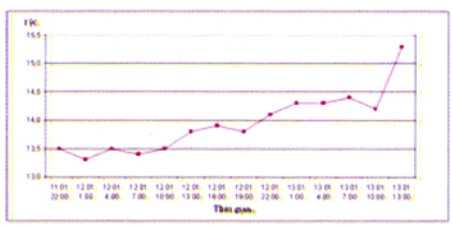

**Fig 16.** Variation of water temperature $T^0C$ during the experiment.

The water level, averaged wave heights, maximum wave heights and sea water temperature for all the measuring duration are shown in the figures 15 and 16 respectively.

### 3. Discussion:

- The data of suspended sediment concentration is the utmost important parameters for sediment transport and successively coastal evolution computations. In general, the sediment concentration is determined averaged for each wave, but in our expedition the sediment concentration is recorded detailed in order to determine the spatial and temporal fluctuates of the concentration of suspended sediment and sediment transport under the random waves, turbulent vortex (see figures 12 and 13). It is clear that the suspended sediment concentration is very sensitive to wave attack.

- The averaged and maximum suspended sediment concentration for the whole period of experiment at the horizons of 30cm, 65cm and 100cm above the bottom is 6g/l - 9,7 g/l; 5,7 g/l - 8,8 g/l; and 1,8 g/l - 2.4 g/l respectively.

- Up to now, one wave recorder often used to measure the wave pressure in the specific layer above the sea bottom. Based on the recorded wave pressure and the distance from the wave sensor to the bottom, the depth of the gauge, the linear wave theory is used to determine the wave attenuation coefficient by depth for converting to the wave parameters in the sea surface. In the small depth, especially in the surf zone, the linear wave theory is inadequate to used and may cause big discrepancy from the measurement and the real wave parameters. By using two wave recorder equipped in the same vertical at different horizons (see figure 2b) in order to get the real coefficient of wave attenuation at the site. The accuracy of the wave data will increase significantly.

- The experiment was executed during the severe Northeast monsoon with very low temperature (the averaged sea temperature about $14^0$C for the whole period of the experiment). In spite of the severe weather, the field survey group - joint collective between Vietnamese and Russian scientists have successfully constructed the station and measurements (although the depth is not quite satisfy for deployment all the equipment at all time). The authors hope that in the future by using a permanent station with the turbidity meters and wave recorders equipped already before the passage of monsoons or typhoons the useful data will be collected.

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