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Assessment of surface water pollutant models of estuaries and coastal zone of Quang Ninh – Hai Phong using Spot-5 images

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Abstract: The coastal zone and estuaries of Quang Ninh and Hai Phong have great potential not only for economic development but also for protection and conservation of biodiversity and ecosystem. Nowadays, due to industrial, agricultural and anthropogenic activities signs of water pollution in the region have been found. The level of surface water pollution can be determined by traditional methods through observatory stations. However, a traditional approach to determine water contamination is discontinuous, and thereby makes pollution assessment of the entire estuary very difficult. Nowadays, remote sensing technology has been developed and widely applied in many fields, for instance, in monitoring water environments. Remote sensing data combined with information from in-situ observations allow for extraction of polluted components in water and accurate measurements of pollution level in the large regions ensuring objectivity. According to results obtained from Spot-5 imagery of Quang Ninh and Hai Phong, the extracted pollution components, like BOD, COD and TSS can be determined with the root mean square error, the absolute mean error and the absolute mean percentage error (%): ±4.37(mg/l) 3.86(mg/l), 27%; ±55.32(mg/l), 48.30(mg/l), 14%; and ±32.90(mg/l), 23.38(mg/l), 28%; respectively. Obtained outcomes guarantee objectivity in assessing water contaminant levels in the investigated regions and show the advantages of remote sensing applications in Resource and Environmental Monitoring in relation to Water – Air – Land.

Keywords: Estuarine, Pollution, COD, BOD, TSS.

1. Introduction

Nowadays in the time of industrialization water, air, and soil pollution is a burning issue, especially in developing countries like Vietnam. Water estuaries and the coastal zone of Quang Ninh and Hai Phong are hardly affected by agricultural, industrial, anthropogenic and natural activities. The coefficient of oil pollution in the sediment increased from 0.7 (in 2001) to 2.4 (in 2008). Pollution of water takes the second place after oil pollution. Recently, turbidity level of coastal water increased in the beach zone and badly affected tourism and caused coral bleaching by reducing productivity of phytoplankton photosynthesis. Only for Cam River from 1960 to 1992, the average water flow silt content increased from 1 to 12.9 km^3/year and from 20 g/m^3 to 340 g/m^3, respectively. Moreover the Bio – chemical Oxygen Demand (BOD) is greater (13.6 to 31 mg/l), and the level of the bacteria (coliform) exceeded acceptable standards.

Along with the policy and raise public awareness about protecting the environment, we need to put the scientific advances in environmental remediation; firstly there is a need to strictly monitor the environment using technological innovations. In the field of water environment, Remote Sensing solutions allow for an objective presentation of environmental state on the large- scale. Satellite remote sensing technology has been applied in the World for many years, from the 70's-80's, when Landsat and Spot images appeared on the market (Verdin, 1985; Lathrop and Lillesand, 1989). The beginning of 21^{st} century brought new satellites that could be applicable to water quality monitoring and allowed many countries to use this technology not only for water preservation and management (Pasterkamp et al., 2000; Richie et al., 2003, Yuan – Fong Su et al., 2008; Keiser et al., 2008; Manchino et al., 2009). Optical satellite imagery with a spatial resolution as high as satellite Worldview – 2 (less than 0.5 m for panchromatic and 2.0 m for multispectral) has been studied to monitor water quality in the continent and coastal strip (Liew et al., 2011).

Presented results are part of a project entitled "*The use of remote sensing and GIS technology for establishing a database, mapping the waste water pollution from industrial park, urban to make warning of the risk of pollution in the northern key economic regions*" (by the national remote sensing center (now is National Department of remote sensing), according to the Decision No. 977/QD-BTNMT, June 02, 2011) and showed that with the use of SPOT5 satellite images, as well as in the near future using Vietnam VNREDSat – 1 satellite images, we can actively monitor water surface quality of the river flow, lakes and coastal estuaries. With Spot-5 satellite imagery acquired on 23rd October 2010 of Quang Ninh – Hai Phong area we extracted some pollution components like BOD (Bio-Chemical Oxygen Demand), COD (Chemical Oxygen Demand) and TSS (Total Suspended Solid) with an average relative error and mean square error, respectively, 3.84%, ±4.37 (mg/l); 0.01%, ±55.32 (mg/l); 0.01%, ±32.90 (mg/l). The correlation coefficient R between the components of pollution estimated model BOD, COD and TSS from remote sensing and data of water samples taken from the field are: 0.74, 0.84, 0.91, respectively.

2. Scientific basis and technology solutions

2.1. Radiation of water body and its inherent optical properties

For field direct measurements of the water surface radiation our investigation team were using a spectrometer. By definition of Mobley (1999), the determination of the remote-sensing reflectance (R_{rs}) is measured as:

$$R_{rs} = \frac{L_w}{E_d} \tag{1}$$

Where:

L_w is the water-leaving radiance signal,
E_d is the downwelling irradiance signal just above the water surface (from the sun, the sky or light radiation to go to the water surface).
The downwelling irradiance E_d is still given by Mobley 1999 as:

$$E_d = \pi \frac{1}{R_p(\lambda)} L_d(\lambda) \tag{2}$$

Where:

L_d is the downwelling radiance signal,
R_p is the reflectance factor, λ is channel image corresponding to a compatible wavelength.
The under-water upwelling radiance signal, L_u, is the total of the water-leaving radiance signal, L_w, and the sky radiance directly reflected by the surface, L_r, i.e.:

$$L_u = L_w(\lambda) + L_r(\lambda) \quad \text{and} \quad L_r(\lambda) = kL_s(\lambda) \tag{3}$$

k is a proportional factor which relates the sky radiance (L_s) to the radiance directly reflected by the surface (L_r). The water-leaving radiance (L_w) is then:

$$L_w(\lambda) = L_u(\lambda) - kL_s(\lambda) \tag{4}$$

The k value depends on many factors of the atmospheric environment. In case of using optical satellite imagery such as SPOT, Landsat, etc. this value depends on the wavelength of each spectral channel of the image. The description of three radiation components coming into the sensor is shown in Figure 1.

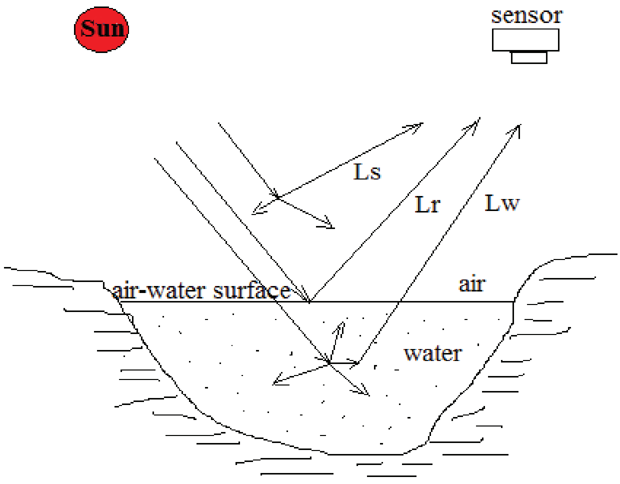


Fig. 1. The three radiation components coming into the sensor: L_s – sky radiance; L_r – sky radiance directly reflected by the surface; L_w – water-leaving radiance

Remote Sensing Reflectance defined by the equation (1) may be associated with internal Fresnel reflectance (ρ), the air – water Fresnel reflection at the interface ($\bar{\rho}$), the refractive index of water (n), the water-air reflection ($\bar{r}$); at the same time is also a function of the absorption coefficient of the water body (*a)* and backscattering coefficient of the water body (b_b), with relative coefficient (*f)*, is described according to (Gordon et al., 1975; Morel and Gentili, 1993):

$$R_{rs} = \frac{(1-\rho)(1-\bar{\rho})}{n^2(1-\bar{r}R)} \frac{f}{Q} \frac{b_b}{a+b_b} \tag{5}$$

Where:

Q = E_u (0-)/L_u (0-), with E_u (0-) is the upwelling irradiance at null depth (denoted 0-) or from the water surface, Lu (0-) – see expression (3) .

2.2. Indirect radiation of water body from a satellite

Due to atmospheric effects, satellite optical remote sensing in general and therefore Spot imagery need a radiometric correction and particularly an atmospheric correction. First of all, an original image has to be converted from quantized DN values into values of reflectance at the top of atmosphere (TOA), R*. Next, using an atmospheric correction model (Vermote et al., 1997), TOA reflectance values need to be modified into the surface reflectance. TOA reflectance R* associated with the water body, namely the above-water reflectance R_w (4) can be calculated through the relationship:

$$R^* = T_g\left(R_a + R_r + T_d R_w\right) \tag{6}$$

Finally remote sensing reflectance is calculated by the relationship:

$$R_{rs} = \frac{R_w}{\pi(1+S.R_w)} \tag{7}$$

where R_a and R_r are the aerosol and Rayleigh reflectance, T_g and T_d are the gaseous and diffuse transmittances in the atmosphere; S – the total spherical albedo. Remote sensing reflectance can be calculated from the equation (7), (5) and (1).

2.3. Identifying the components of surface water pollution

For the estimating and mapping of the spatial distribution of water quality variables (components of surface water pollution) with usage of remote sensing images, first it is needed to estimate modeling of water quality based on water surface- leaving reflectance. Several regression models are often used [2-6, 10-13, 15], and can be summarized in four basic forms:

$$\log Y = c_o + \sum_{i=1}^{k} c_i.\log X_i \;;\quad \log Y = c_o + \sum_{i=1}^{k} c_i X_i \;;\quad Y = a_o \prod_{i=1}^{k} X_i^{a_i} \;;\quad Y = c_o + \sum_{i=1}^{k} c_i X_i \tag{9}$$

Where: Y – the water quality variables; X_i – water surface-leaving reflectance of a given spectrum.

One of the important steps in analyzing the estimated models of surface water pollutants such as BOD, COD, TSS etc. is validating established models. Firstly, correlation coefficients between field observation and modeled values have been calculated (10a). However, good correlation coefficients do not automatically indicate good model accuracy. Therefore, other statistical parameters were used to assess model performance. In this research (table 2), useful statistical parameters are as follows:

Correlation coefficients, R^2:

$$R^2 = \left[\frac{\sum_{i=1}^{n}(x_i-\bar{x}_i)(y_i-\bar{y}_i)}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x}_i)^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y}_i)^2}}\right]^2 \tag{10a}$$

Root mean square error, RMSE:

$$\text{RMSE} = \sqrt{\frac{1}{n}\left[\sum_{i=1}^{n}(x_i-y_i)^2\right]} \tag{10b}$$

Mean absolute error, MAE:

$$\mathrm{MAE} = \frac{1}{n}\left[\sum_{i=1}^{n}(x_i - y_i)^2\right] \quad \text{and MAE in (\%)} = \frac{MAE}{\bar{x}_i}.100 \tag{10c}$$

Coefficient of modeling efficiency, ME (after Buler and Mayer, 1993):

$$\mathrm{ME} = 1 - \left[\frac{\sum_{i=1}^{n}(x_i - y_i)^2}{\sum_{i=1}^{n}(x_i - \bar{x}_i)^2}\right]. \tag{10c}$$

Where:

x_i are the observed values with mean of $\bar{x}_i$;
y_i are the modeled values with mean of $\bar{y}_i$;
n is the number of observations; i = 1, 2, 3, …n.

When modeling, the key is to present objectively the nature of the phenomenon, it does not depend on the imposition of human consciousness but on the relationship between water quality variables with water surfaces-leaving reflectance, as presented in Section 2.1 and 2.2. Solving this is the essence of the right technology. In order to accomplish that goal, there should be implemented 2 processes:

– Finding the objective relationships between water quality variables and water surface-leaving reflectance.
– Selecting the appropriate model for mapping water quality.

Effective tool to solve the above technology is based on regression theory with image processing and combing images on high level.

3. Results and evaluation

3.1. Input materials

a) Satellite image: Satellite images used in our experiment were two Spot-5 images. Their parameters are presented in table 1.
b) Map data: Map data used was the topographic map with a scale of 1: 25,000 for Quang Ninh, Hai Phong regions.
c) Water quality component data analyzed from field water samples (in-situ measurements).

Field data used in this study included: GPS data measured at nine monitoring sites in the current study area, and water sampling at these 9 points for laboratory analyses of water quality components. From the results of water sample analysis, we have used three components COD, BOD, TSS (Table 2, column 2) to build a model for the entire region from SPOT-5 images.

Table 1: The parameters of Spot 5 satellite image

Image parameters	**Image 1:** 272-308	**Image 2:** 272-309
Date receiving pictures	23-10-2010	23-10-2010
Time (GMT)	03:22:47	03:22:55
Angle of incidence	-21.528744°	-21.528984°
Viewing angle	-18.945236°	-18.945236°
Solar azimuth	148.916574°	148.456782°
High angle sun	52.982617°	53.370144°
Resolution	10 m	10 m

Fig. 2. False color SPOT5 images with the observation points (yellow color)

3.2. Concentration distribution of water pollutants extracted from Spot-5 image

The first step is to correct images (radiation) due to atmospheric effects, to eliminate the noise affecting the water-leaving radiance. This issue has been mentioned in Section 2.

To extract the distribution function of surface water quality from Spot-5 images, we built the relationships between radiance values in the reflected image atmospherically corrected and data components pollutants at the field observation stations.

Table 2: The accuracies of estimated components COD, BOD, TSS based on field samples data at the interesting sites (unit: mg/l)

No stadion	*Field samples data* ($M_{TĐ}$)						*Estimated components from models* (M_{AH})			dM = $M_{TĐ} - M_{AH}$		
(1)	(2)						(3)			(4)		
	COD		BOD		TSS		COD	BOD	TSS	COD	BOD	TSS
	A	A-TB	B	B-TB	C	C-TB						
1	420	*84.2*	19.7	*5.4*	23	-61.8	388.97	15.23	61.70	31.03	4.47	-38.69
2	418	*82.2*	12.6	*-1.7*	18	-66.8	425.29	19.72	1.15	-7.28	-7.11	16.84
3	346.5	*10.7*	16.7	*2.4*	16	-68.8	441.44	17.64	27.32	-94.94	-0.94	-11.32
4	125	*-210.8*	16.7	*2.4*	16	-68.8	178.55	18.83	14.50	-53.54	-2.13	1.49
5	504	*168.2*	3.7	*-10.6*	241	156.2	426.04	6.29	235.29	77.96	-2.59	5.70
6	327	*-8.8*	20.8	*6.5*	16	-68.8	339.09	17.67	29.20	-12.08	3.13	-13.19
7	253	*-82.8*	16.7	*2.4*	179	94.2	302.54	10.78	102.60	-49.54	5.92	76.4
8	332	*-3.8*	7.2	*-7.1*	135	50.2	270.62	9.32	130.24	61.37	-2.12	4.76
9	297	-38.8	14.9	*0.6*	119	34.2	250.00	8.56	160.99	46.99	6.34	-41.99
Aver-age	*335.8*		*14.3*		*84.8*		*335.84*	*13.78*	*84.78*	-0.005	0.55	-0.001
	RMSE* MAE** MAE(%)***									55.32 48.30 14%	4.37 3.86 27%	32.90 23.38 28%
	Modelling efficient (ME) Correlation coefficient (R)						*0.733* *0.843*	*0.352* *0.736*	*0.933* *0.914*			

* *Root mean square error*; *** Mean absolute error; *** Mean absolute error in %.*

The concentrations of contaminants have been extracted from the image data based on the data of water samples taken from the field stations and described through the following models:

Pollutants BOD:

Log(BOD)=1.0339*(logFB)-0.0375 with a correlation coefficient (**R = 0.736**); (11a)

Where: $FB = 10^{23.3740-30.4377*b_2-49.5898*b_3+3.0271*b_5-3.7479*b_6}$

Pollutants COD:

COD = 1.0331*FC-11.245 with a correlation coefficient (**R = 0.843**) (11b)

Where: $FC = 14810.934-16557.4828*b_2- 43824.8298*b_3+1610.1745*b_5-1555.2931*b_6$

<u>Pollutants TSS</u>:

TSS = 1.0319*FT-2.6409 with a correlation coefficient (**R = 0.914**) (11c)

Where: $FT = 10^{-14339.5123+12745.9261*b_2+42563.0023*b_3-1160.0887*b_5+1687.3527*b_6}$

Denote b_1=XS1, b_2=XS2, b_3=XS3, b_4=XS3/XS1, b_5=XS3/XS2, b_6=XS2/XS1, where XS_j with j = 1, 2, 3 are the multispectral bands of Spot-5.

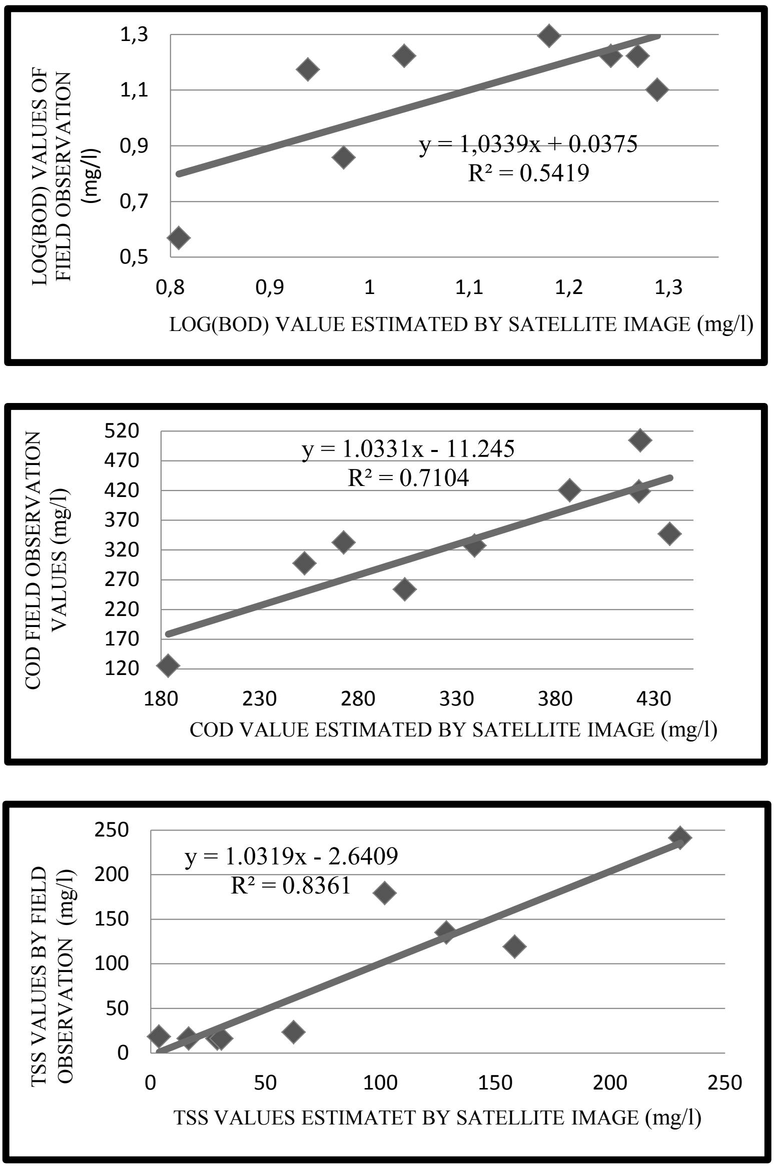


Fig. 3. Correlation between BOD, COD and TSS estimated by model and field observation

The relationships (11a), (11b), (11c) have been determined based on the values estimated from satellite imagery and field observation (figure 3).

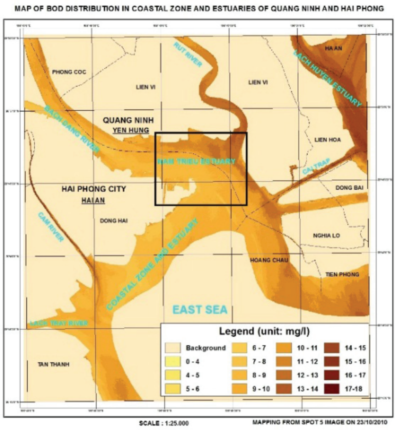
In order to evaluate the three models built in this study, we determined the root mean square error (RMSE), mean absolute error (MAE), the correlation between field data and data extracted from the model and Modelling Efficiency ME. Assessment results are presented in Table 2.

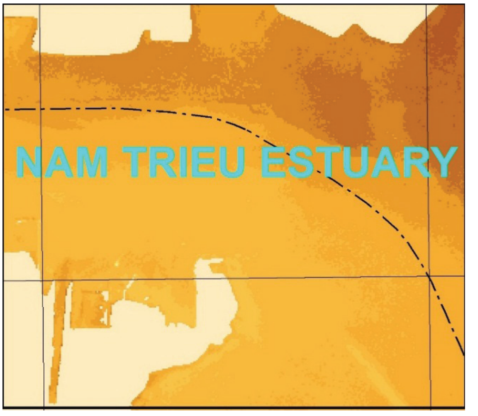
Image pollutants BOD, COD, TSS have been exported to ArcGIS for stratification of pollutants and mapping. Six maps in 1:25000 of three components of BOD, COD and TSS have been established. Figure 4 presents 3 maps of pollution components with their parts, that were magnified.

4. Discussion

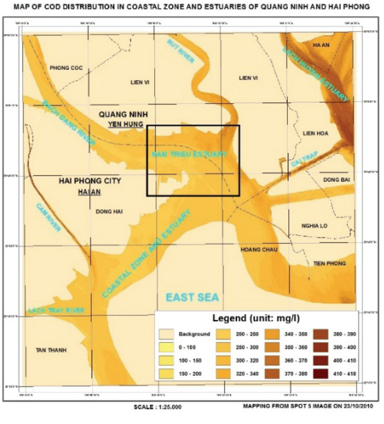
Here are some comments from analyzing results from Table 2:

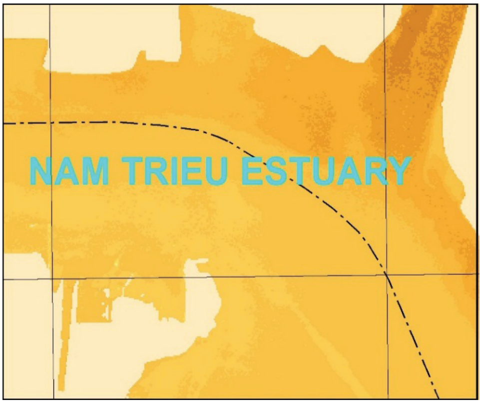
- The correlation coefficient between the built models of COD, BOD, TSS and field sample data has the corresponding values of 0.84, 0.74 and 0.91. This represents: the built models presents the actual values, that have reliability at level: 84%, 74% and 91%, respecively: it also can be said: models for determining water pollution components COD, BOD, TSS from Spot-5 images with only a few field samples can replace a substantial portion of in- situ professional measurements to determine water pollution in investigated estuary with reliability that reaches 84%, 74% and 91%.
- According to analyzed field samples the COD component has been in a high amount of 125-504 mg/l, while the BOD fluctuated slightly from 3.7-20.8 mg/l, but the variability of TSS relatively is large from 16 to 241mg/l.
- From differences between model and in- situ data (Table 2, column 4), the root mean square error (RMSE) and the mean absolute error (MAE) of BOD, COD and TSS were calculated, with values of ±4.37 (mg/l), 3.84 (mg/l); ±55.32 (mg/l), 48.30 (mg/l), and ±32.90 (mg/l), 23.38 (mg/l), respectively. The variation range between these two types of errors of BOD and COD are relatively small, whereas the TSS is great. This presents the sustainability of the TSS model slightly less than the sustainability of the model BOD, COD.
- Mean absolute deviation in % (compared with the average field values) of COD, BOD, TSS is 14%, 27%, 28%, respectively. Through this, the models show the determination of COD, BOD and TSS for achieving accuracy from 72% to 86% compared with field monitoring.
- The model effectiveness (ME) of BOD, COD, TSS, respectively are in values of 0.352, 0.733 and 0.933, that showed BOD model is in low effectiveness. This might explain that the real value of BOD is too small, ranging between 3.7 (mg/l) to 20.8 (mg/l).



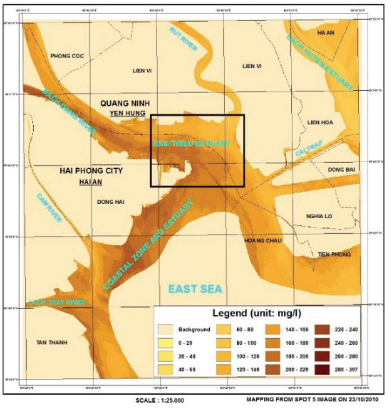


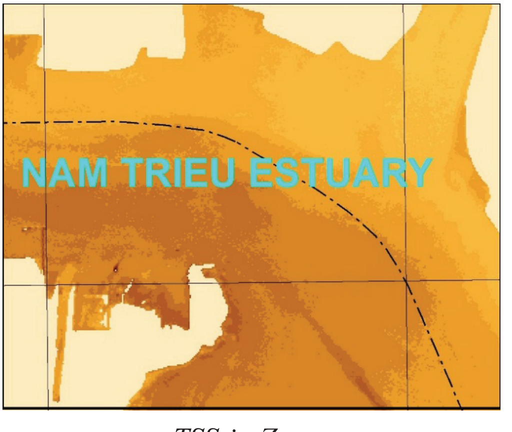
BOD in Zoom





COD in Zoom





TSS in Zoom

Fig. 4. Maps of BOD, COD, TSS components and their parts in zoom for estuary area Quang Ninh – Hai Phong

From the distribution maps of levels of BOD, COD and TSS in estuarine coastal areas of Quang Ninh and Hai Phong in Vietnam presented according to standard TCVN 5945-2005, we find:

- BOD component concentration lowly ranged only between 3.7 (mg/l) – 28 (mg/l). It shows that in general the area is unpolluted by BOD.
- COD component concentration is relatively high, especially more than 500 (mg/l), exceeding the permitted standards. Some local places are of the high concentration as in Lach Huyen, estuaries Hon Dau.
- TSS pollution composition is also relatively high, more than 260 (mg/l), exceeding the acceptable levels in some areas like at the mouth of River Nam Trieu, Lach Tray, TSS pollution component of the high concentration.

5. Conclusion

Results derived with applications of Spot-5 images shows the superiority of satellite technology for monitoring water quality in the wide scale of the area of interest. The models of water quality components, i.e. COD, BOD, TSS built from Spot-5 and data from in-situ measurements allowed for obtaining results with correlation coefficients for parameters at levels: 0.74, 0.84 and 0.91, respectively. Root mean square error (RMSE) and mean absolute error (MAE) of BOD, COD and TSS were calculated, with corresponding values of ±4.37 (mg/l), 14% ±55.32 (mg/l), 27% ± 32.90 (mg/l), 28%.

The method presented above can be applied to multi- temporal monitoring of rivers, lakes and coastal regions, and not only provide objectivity but also economic benefits. To build an accurate model there is one most important and strict requirement: the synchronicity of taking field observations (taking water samples) and acquisition of satellite images.

References

Buler, D. G. and Mayer, D. G. (1993). *Statistical validation*. Ecol. Model, 68:21-32.

Gordon, H. R., Brown, O. B., & Jacobs, M. M. (1975). Computed relations between the inherent and apparent optical properties of a flat homogeneous ocean. *Applied Optics*, 14, 417-427.

Hans van der Woerd & Pasterkamp R., 2000. *A rigorous method to retrieve TSM concentration from multi-temporal SPOT image in highly turbid coastal water. Institute for Environmental Studies (IVM)*, Vrije Universiteit, Amsterdam, Netherlands.

Keiser M. and Aboulela H. (2008). *Spectral enhancement of the SPOT imagery data to assess marine pollution near port Said, Egypt*. PIERS proceedings, July 2-6, 2008, Cambridge, USA.

Lathrop R. G., Lillesand T. M. (1989). Monitoring water quality and river plume transport in Grren Bay, Lake Mchigan with SPOT-1 imagery. *Photogrammetric engineering and remote sensing*. Vol. 55, No 3, pp. 349-354.

Liew S. C., Saengtuksin B., Kwoh L. K. (2011). *Mapping Water Quality of Coastal and Inland Waters Using High Resolution Worldview-2 Satellite Imagery*. Proc. 34th. International Symposium on Remote Sensing of Environment, 10-15 April 2011, Sydney, Australia.

Manchino G., Nole A., et al. (2009). Assessing water quality by remote sensing in small lake: the case study of Monticchio lakes in Southern Italy. *Biosciences and Forestry*, pp. 154-164.

Mobley, C. D. (1999). *Estimation of the remote-sensing reflectance from above-surface measurements*. Applied Optics, 38, 7442–7455.

Morel, A., & Gentili, B. (1993). Diffuse reflectance of oceanic waters: II. Bidirectional aspects. *Applied Optics*, 32, 6864– 6879.

Morel, A., & Gentili, B. (1996). Diffuse reflectance of oceanic waters: II. Implication of bidirectionality for the remote-sensing problem. *Applied Optics*, 35, 4850– 4861.

Pasterkamp, R., Peters, S.W.M. and Dekker, A.G. 2000. *Environmental Baseline Mapping of Total Suspended Matter Concentrations in the Western Scheldt Estuary Supported by the se of SPOT Images*. 6th International Conference on Remote Sensing for Marine and Coastal Environments, Charleston, SC, USA, p. 260-267.

Richie J. C., Zimba P. V. and Everitt J. H. (2003). Remote sensing techniques to assess water quality. *Photogrammetric engineering and remote sensing*. Vol.69, No 6, pp. 695-704.

Verdin, J. (1985). Monitoring water quality conditions in a Large Western reservoir with LANDSAT imagery. *Photogrammetric engineering and remote sensing*. Vol. 51, No 3, pp. 343-353.

Vermote, E. F., Tanre, D., Deuze, J. L., Herman, M. and Morcrette, J. J. (1997). Second simulation of the satellite signal in the solar spectrum: an overview. *IEEE Transactions on Geoscience and Remote Sensing*, 35(3), 675–686.

Yuan-Fong Su, Jun-Jih Liou, Ju-Chen Hou, Wei-Chun Hung, Shu-Mei Hsu, Yi-Ting Lien, Ming-Daw Su, Ke-Sheng Cheng and Yeng-Fung Wang. (2008). A multivariate model for coastal water quality mapping using satellite remote sensing images. *Sensors*, 8, 6321-6339.

Ocena modeli zanieczyszczeń wód powierzchniowych w ujściach rzek i strefy przybrzeżnej Quang Ninh – Hai Phong przy wykorzystaniu obrazów Spot-5

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Streszczenie

Strefa przybrzeżna i ujścia rzek w Quang Ninh – Hai Phong ma potencjał do rozwoju gospodarczego i ochrony różnorodności biologicznej i ekosystemu. Ostatnio stwierdzono tam wiele oznak zanieczyszczenia wody. Poziom zanieczyszczenia wód powierzchniowych może być określany na stacjach obserwacyjnych metodami tradycyjnymi, jednak znacznie szybsze i dokładniejsze jest wykorzystanie metod teledetekcyjnych.

Analiza obrazów Spot-5 w Quang Ninh – Hai Phong umożliwiła stwierdzenie obecności różnych zanieczyszczeń, w tym BOD, COD i TSS ze średnim błędem kwadratowym, średnim błędem absolutnym

i średnim błędem względnym odpowiednio: ± 4.37 (mg/l), 3.86 (mg/l), 27%; ± 55.32 (mg/l), 48.30 (mg/l), 14%; ± 32.90 (mg/l), 23.38 (mg/l), 28%. Otrzymane wyniki gwarantują obiektywizm przy ocenie poziomu zanieczyszczeń w badanych regionach i pokazują korzyści zastosowań teledetekcji w monitoringu zasobów i środowiska w odniesieniu do wody – powietrza – terenu.