

# SEAWIFS IMAGES USED FOR SUPERVISING ALGAE BLOOM AT VIETNAM SEA

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**Abstract: Seawif images used for supervising of algae-bloom phenomena at Viet Nam sea area.**

The area of Vietnam is a constituent part which accounts for a large area of the East Sea. There has been so far certain limitation and shortage of updating in the study and monitoring of environmental characteristics in general and in-depth study of allocation of Chlorophyll-a . In this report, utility of SEAWIFS for monitoring of the blossoming of alga in the sea of Vietnam by application of the ocean color analysis technology for a three-year study (2002-2004) of temporal and space allocation of Chlorophyll-a in the sea of Vietnam is introduced. SEAWIFS data are collected and analyzed by OC4 (Ocean color 4), which calculates the volume of Chlorophyll-a, in SEADAS. The accuracy of SEAWIFS data is examined by previous research data on the sea of Vietnam, which can determine the areas of the sea of Vietnam where alga blossoms. Through SEAWIFS data, a rule can be determined that the alga blossoming does not mainly stay along the coast but is prone to spreading out to the offshore during such season. Chlorophyll-a is of a very high value ( $> 1 \text{ mg/m}^3$ ) and mainly seen in big river mouth areas, like Red River, Mekong River and the area adjacent to Thai Land bay, in every seasons. It is due to the impact of suspended materials and nutrition flowing from the continent. Alga blossomed in the area of Hoang Sa island ring in August 2002 and Nov. 2003. Appearance of a narrow strip with Chlorophyll-a of high value going along the coast of Ninh Thuan – Binh Thuan in between May and September every years may be in relation to the phenomenon of upwelling in the area. The study contributes to the fundamental examination of the sea environment, especially the application of SEADAS to analysis of typical variants of the ocean, which has opened a new path that is the application of advanced technology to the proper utility and protection of natural resources in the sea of Vietnam.

## **Section : Application**

### **Subsection Titles : environment**

**Keyword:** SEAWIFS images, Ocean color 4 of SEADAS, Chlorophyll-a, Vietnam sea area, proper utility and protection of natural resources in sea areas.

#### **1. Introduction**

Remote sensing development with ability of observing the whole Earth from regional to global scale has become an effective tool for monitoring and supervising issues of sea environment. Research on Chlorophyll-a arrangement in sea water and algae bloom by SEAWIFS images has been made in various countries worldwide; however, it is a new method which is initially paid attention in Vietnam.

There are some remote-sensing applications in researching Vietnam Sea and South China Sea. Tang (1998)[13] analyzed spatial and temporal structures of pigment content received from CZCS at China continent and East sea. Tang, Kawamura, Min An Lee, Tran Van Dien (2002) researched spacial and seasonal arrangement of Chlorophyll-a and sea water condition at Tokin Gulf from SEAWIFS, NOAA-AVHRR and Quikscat datum. Such researches indicate high content of Chlorophyll-a is on the North of the Gulf and algae bloom often occurs in Winter, which relates to operation of Northeast

monsoon. There is not any research on Chlorophyll-a arrangement and algae bloom for the whole of Vietnam sea by using SEAWIFS images.

This article introduces research and use of SEAWIFS images to determine spatial arrangement of Chlorophyll-a value as well as to consider and to detect Vietnam's areas where algae are in blossom in three years from 2002 to 2004.

## 2. Generalization on ocean color and algae bloom remote-sensing

For the ocean, water color change is caused by substances available in ocean water, including phytoplankton, inorganic and mineral dissolvable substances and others which are discharged by human. Phytoplankton in general and algae in particular exist in ocean water and mainly cause changes in ocean color. Alga is unicellular plant with very small size suspending in water, that contents Chlorophyll-a and is capable for synthesizing organic substances. They are the first and the most important chains of ocean ecosystem. Their existence and development take important role for all species of living things in the ocean. Algae bloom is a phenomenon of algae mushrooming in a large scale or sudden development of some algae in suitable temperature and light conditions. The phenomena of Red Tide which happen at some territorial waters in the world, caused by some algae mushrooming, influence significantly on species of living things and environmental pollution at such areas.

Basic principle of remote sensing is to gather signals reflected or radiated from objects without direct contacting to such objects. Similar to ocean color remote-sensing, changes in ocean color relate to change and arrangement of phytoplankton in the water (if the water contents much phytoplankton, its color is green, if less, its color is deep blue).

The first for ocean water datum receivers is CZCS (Coastal Zone Color Scanner) on Satellite NIMBUS-7. Operated since 1978 to 1986, it comprised of 6 channels researching ocean color. It is followed with an OCTS (ocean color temperature scanner) operated since November 1996 to June 1997. SEAWIFS (Sea-viewing Wide-Field-of-View Sensor) on Seastar satellite operated since September 1997 to the end of 2004 with 8 channels with 1.1km spatial resolution. They are important datum for researching Chlorophyll-a arrangement, biological capacity of oceans, physical and biological processes in ocean. At present there are remote-sensing devices supplying data of ocean color, remarkably MODIS with 36 channels, 8 of which specialize in researching ocean color.

## 3. Materials and methodology :

**Areas to be researched :** Including the whole sea of Vietnam. Territorial waters of Vietnam is a part of South China Sea. This area absolutely lies within equator and tropic. The territorial bottom is characterized with a large hollow in 5000m depth at the centre and directed to Northeast and Southwest. The continent terrace is extended on the North and the South, narrowed and running along the East and West coastal lines.

There are two big gulfs, Tokin Gulf and Thailand Gulf. Vietnam sea is affected with changing monsoon in the year. It is Northeast monsoon in Winter and Southwest wind in Summer. Monsoon is the important element for climatic and flow characters in such region.

### Materials and research method :

Remote sensed Data to be used are SEAWIFS images with 1.1km spacial resolution at image centre, which are selected and down-load from Internet. Totally 408 SEAWIFS images with less cloud at Vietnam sea in three years from 2002 to 2004 are selected and settled. SEAWIFS datum are processed with SEADAS (Sea Data Analysis System) which runs on Linux operation system with OC4 (Ocean Color 4) algorithm to calculate content of Chlorophyll-a from SEAWIFS images. Since SEAWIFS images are not complete for the whole territorial waters of Vietnam in the three years, we have to sum-up



Figure 1. Research area diagram

monthly average value to create monthly average data with 2x2km spatial resolution to indicate rule of Chlorophyll-a arrangement at Vietnam sea.

The OC4 algorithm is developed on the experimental formula of 2800 Chlorophyll-a optical biological measurement stations in the world. The OC4 algorithm is generalized as follows [4]:

$$Cs = 10^{0.366-3.067*R+1.930*R^2+0.649*R^3 - 1.632*R^4}$$

Of which :  $R = \text{Log}_{10} (R_{ys443} > R_{ys490} > R_{ys510})$   
 $R_{ys 550}$

R : Reflex spectrum of objects at different wave-lengths.

Accuracy of Chlorophyll-a value calculated with CO<sub>4</sub> from SEAWIFS has been tested and found rather appropriate with Vietnam sea (Tran Van Dien, 2002). It is different and error at some coastal estuaries due to water opaqueness and suspending substances taken from the continent.

#### 4. Result and discussion :

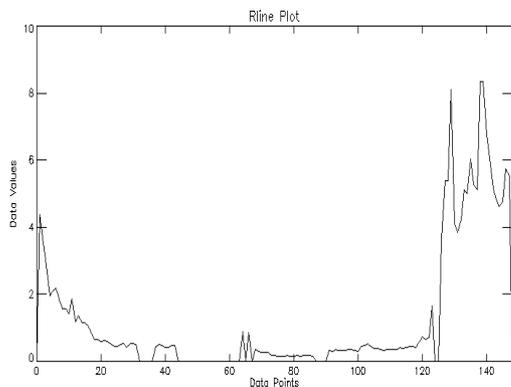
##### 4.1. Spatial arrangement of Chlorophyll-a value and algae bloom in Vietnam sea

High Chlorophyll-a value is often at coastal waters and estuaries where nutritional condition is favor for algae development. Offshore is less convenient for algae development, just specific cases of algae bloom like surrounding Paracel Islands in August 2002 and November 2003 and some Southern offshore areas.

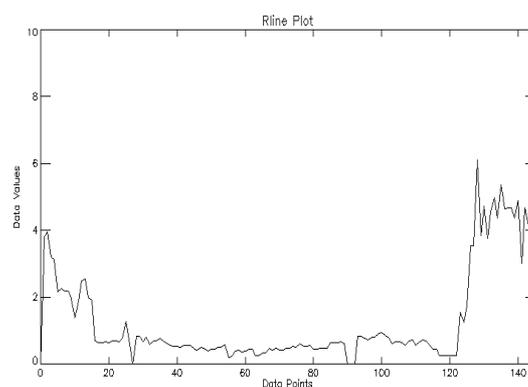
Algae bloom is frequent at Tokin Gulf, specially coastal area of the West, the North of the Gulf and the shallow area surrounding Hai Nam island. Chlorophyll-a value decreases from the coast outward to the Gulf centre. Very high value of Chlorophyll-a is observed in the whole year at the Red River and Thai Binh river estuaries.

Gulf of Thailand, the high value of Chlorophyll-a also concentrate mainly in the bank side area and usually starting from April.

In the pelagic area of our country, the value of chlorophyll-a is often low and equal in the whole year showing that the algae bloom in this area is very little, only observing and seeing that it has the algae bloom but only taking place in a short time around the two archipelagos Hoang Sa and Truong Sa.



*Chlorophyll-a distribution along the cross section parallel of 19° latitude of Tokin Gulf, taken in November 2002.*

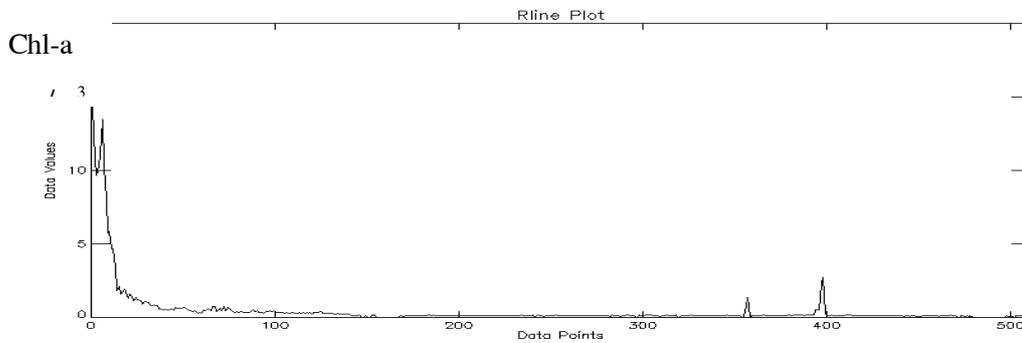


*Chlorophyll-a distribution along the cross section parallel of 19° latitude of Tokin Gulf, taken in November 2003*

**Figure 2. Cross-section at Tokin Gulf, received from SEAWIFS images**

In the Central sea, algae bloom concentrates on coastal area of South-Central sea, from Khanh Hoa to Binh Thuan and from Hue to Da Nang, sometimes they extend to offshore [5,6]. The peak is often observed at Ninh Thuan - Binh Thuan sea.

The Southern sea is a valley gate of big river, Mekong river, thus, algae bloom occurs the whole year around, especially the narrow strip along Ba Ria to Ca Mau Cape (Chlorophyll-a is often  $> 4\text{mg/m}^3$ ). This algae bloom area also extends to offshore [2,7] ( figure 3).



**Figure 3. Chlorophyll-a distribution along the cross section parallel of  $10^{\circ}$  latitude from Mekong river estuary November 2003, received from SEAWIFS photo**

#### **4.2. Distributing seasonally the value of Chlorophyll-a and the phenomenon of algae bloom**

The species of algae often concentrate in the bank side area, they **distribute equally nearly in the year** in these areas. This phenomenon is explained that it is due to the bank side area is the place with the most favorable conditions for the species of alga in particular and the ephemeral plants in general to exist, reproduce and develop (For the factors: nutrition, living condition, temperature, salt and mineral substances). The sea area near the shore is proved that it is the area where concentrated with many ecosystems with high productivity in the world (such as the ecosystem of mangrove forest, ecosystem of sea grass ...). The source of material in these areas is always plentiful and rich because it receives a lot of sources of other nutrition and is regularly supplemented (the material is poured from the continent, form bottom up). It is the first basic material creates condition for the algae to reproduce and develop with large quantity and a wide scale. The ephemeral plants when having condition to develop because they are the first and most important link in the chain of food and are the basic origin to form the primary productivity in ocean. From that the productivity is circulated and transported in the chain of food bringing about the development of all other organisms.

It is able to affirm that the source of nutrition is the first and basis factor to decide the growth and development of the ephemeral plants, the evidence is that in the sea areas it has the stability of the regime of salt heat and sunlight but the value of Chlorophyll-a analyzed is often at the low level ( $< 0.2\text{ mg/m}^3$ ), and equally in the areas. At the big estuaries such as Red river, Mekong river every year it receives the volume of material from the continent pouring out very large, therefore this area always concentrates the very high value of Chlorophyll-a (often  $>5\text{ mg/m}^3$ ), and often very high in the flood season. The results of analyzing TSM (Total weight of suspend material in water) received from SEAWIFT shows that these areas concentrated with high content of TSM, thus the result of calculating Chlorophyll-a needs to be re-corrected due to the impact of the suspend materials in the water at this area.

The area of Gulf of Tonkin, a closed gulf in the Northwest of the East sea. The analyzed value of Chlorophyll-a shows that this are always has the concentration of algae with large quantity. The very high value of Chlorophyll-a concentrates in the estuary of Red river and the Northern coastal areas of the gulf, Loi Chau peninsula, the shallow water area around the Hai Nam island. This value reduces clearly from the shore side to the centre of the gulf. With the observation of three years, we find that the value of Chlorophyll-a concentrated highly and equally in the whole Gulf of Tonkin starting from November to April of next year (often  $> 0.4\text{ mg/m}^3$  in the whole gulf). The bloom of alga flower observing and seeing that mainly at this time. This phenomenon can be described as follows: Starting to appear from the end of October is intensified in the two months December and January to April it reduces gradually and disappears. The phenomenon of blooming alga flower takes place not only in the sea area near the shore but also in the centre of the gulf.

The high value of Chlorophyll-a from November to April coincides with the strong period of operation of the Northeastern monsoon. In the area of Gulf of Tonkin the nutrition condition is often plentiful and help the ephemeral plants to develop almost in the year, but the change of temperature in the winter is the basis favorable condition to stimulate alga to develop with large quantity at this time.

The coastal area of south central part, found that the strongest operation of blooming alga flower is at the end of April and ended at the end of September. The algae bloom the most in July, the area of blooming spreading out with the scope to the area of Truong Sa archipelago. What reason causes the phenomenon of blooming on large scale in the coastal area of south central part, and what maintained them to be able to exist in the time of four months.

At the beginning of April when material and nutrients concentrate very highly at the river estuaries, especially the system of Mekong river at that time is the operation period of Southwest monsoon when the monsoon blows parallel with the seashore road causing the phenomenon of emerging water as mentioned above for the sea area of south central part. It is the condition that makes algae bloom and develop strongly in this area.

The phenomenon of Algae bloom at this area can be explained in connection with water emergence due to topographical factors caused by impact of the sea current when crossing continental slope, and the expansion of the sea current carrying materials from the Southern Central part[figure4], the current named as *Ekman current* [5].



Figure 4. Schema for the Ekman current for explaining the phenomena of Chlorophyll-a concentration at Viet Nam sea

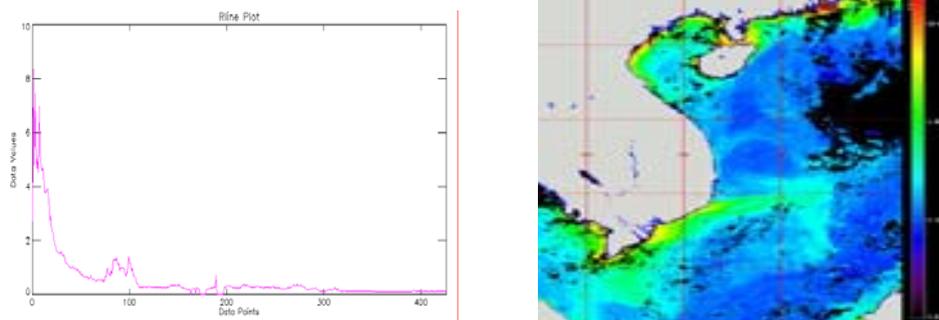


Figure 5. Section of value of Chlorophyll-a at the sea area of south central part July 2002

Also at this time, the sea area of south central part, a strong sea current (wind current of summer far from the Southwest shore of Vietnam), (Fang et al. 2002) this current has the counterclockwise direction and it is that current that is the main cause to bring the nutrients from the shore and offshore. Creating condition for algae to bloom not only near the shore but also spreading out offshore. The existence of this wide and large region of this alga depends on the source of nutrition and the factor of sea current. To the end of September when this sea current is replaced by the sea current from the North and

the operation of the Northeastern monsoon, the region of algae bloom backs gradually to the South and starts to disappear [8].

In the sea area of central part (from Ha Tinh to Da Nang), it is found that the phenomenon of algae bloom appears a lot in from the beginning of May to September, maybe the phenomenon of algae bloom in this area is related to the operation of coastal small sea current with the counterclockwise direction from May.

The area of Gulf of Thailand is found that it has the algae bloom concentrating in the sea area near the shore, and also found that the strong development at the beginning of April to September coinciding with the operation period of Southwestern monsoon.

During the process of analyzing and studying, we discover that it has the algae bloom in the sea area around Hoang Sa archipelago, observing and seeing in August 2002 and November 2003 ( figure 6).

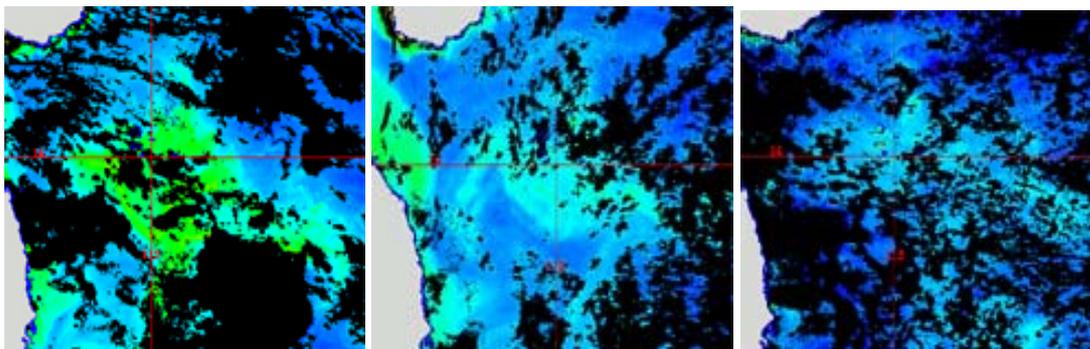


Figure6. algae bloom in the sea area around Hoang Sa archipelago

## 5. Conclusion:

Remote sensing image data SEAWIFS is very significant in researching physical, chemical and biological processes of the ocean. SEADAS software via OC4 algorithm analyzing Chlorophyll-a value received from remote sensing image SEAWIFS is used to study the spatial and seasonal distribution of sea weed. The result showed that some area with highly-concentrated Chlorophyll-a such as river mouths and swallow waters near the shore and open sea area, Chlorophyll-a value always stay at the low level ( $< 0,2 \text{ mg/m}^3$ ). The research has defined the relationship between Algae bloom and: nutritional source, operation of monsoon and emerging waters at some areas of Vietnam territorial waters. In Tonkin Gulf, high concentration of Chlorophyll-a is often seen in winter (from November to April) coinciding with the operation time of Northeastern monsoon. In the South Central Part territorial waters, Algae bloom usually occurs vigorously from April till the end of September, coinciding with the vigor operation time of Southwestern monsoon. They develop powerfully on a broad scale and have location shift caused by the monsoon and sea current on the sea. The result discovered that Algae bloom is also seen at the Parcel Island in August, 2002 and November 2003, which has not been mentioned by previous research works.

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