# A Study on Chlorophyll Estimating Algorithm in Kwangyang bay Using Satellite Images

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**Abstract**

Water pollution is becoming a serious problem in the populous cities and coastal areas near industrial complex. Sometimes, phytoplankton is considered as the most important element in the coastal environment. Phytoplankton is easily estimated by measuring chlorophyll content in the laboratory. In this study, to build up estimating algorithm of the chlorophyll amount related to the monitoring of coastal environments in Kwangyang bay, the correlationship the respective in situ observed data with Landsat TM and SeaWiFS satellite image was analyzed. It showed that Landsat TM band 3 image has the highest correlationship with observed data, and based upon this result the monitoring algorithm of chlorophyll in coastal area was extracted.

This algorithm will be an important for extracting and controlling environment elements in coastal areas in the future. And it has a significant meaning that it has established a spatial data construction in which satellite image alone could monitor the coastal environment.

## I. Introduction

Korea is a peninsula surrounded by sea water which has a continental shelf, three times as large as its own land size, and a long coastal line of 11,542 km. So it has great advantage in developing and using coastal area. This coastal area is not only a source of provisions providing us 3,000,000 tons of marine products a year, but also an important living place as a resort and sightseeing place with 92 beaches and 2,761㎢ marine parks. But because various influx of polluted water from land, uncontrolled reclamations of foreshore, dumped wastes into the sea, other activities, and 300 contaminating accidents at sea a year in 1990s, are deteriorating the quality of the coast, environmental problems have been occurred.

Recently, satellite data are becoming very useful because it can be applied to a larger area and used as reference data to existing research. Go-Hueng coastal area including Kwangyang bay area, a representative city of heavy and chemical industry in Korea, has been developed as a coastal area where Yeochon industrial complex of 3.03 million Criticism and Kwangyang iron foundry are located, and has a great potential for development in the future. It is the most complex and seriously environmentally polluted region due to its population of 800,000 and fishery and aquaculture farm land formed along the coastal area.

COD of Kwangyang bay was less than 4mg/ℓ(III grade) and COD of Yoja bay and Kamak bay was less 2mg/ℓ(II grade). So the chronical eutrophication of Kamak bay and its vicinity has had a serious effect on the fishery industry of the area(Annual Report of Korean Coastal Environment Monitoring, 1998).

The purpose of this study is to extract, compare and evaluate the correlationship between the in situ observed data and satellite images such as Landsat TM high resolution image and SeaWiFS for monitoring the chlorophyll, a important environmental element in the coastal area. In addition, effective coast monitoring algorithm which is appropriate for Kwangyang bay area of Korea is developed on the basis of existing satellite image algorithm.

## II. Research methods and materials

For the coastal environment monitoring of this study, image processing was analyzed using ERDAS IMAGINE 8.3 S/W with Landsat TM image based on the existing algorithm, and geometric correction polynominal model method was carried out using GCP drived from topographic map of 1/50,000.

To measure in situ chlorophyll in Kwangyang bay area(Fig. 1), water of 500mℓ was collected from standard water depth and it was filtered by glass microfiber filter(membrane 0.45μm). To prevent oxidization, just before finishing filtering, it was solidified with 1% carbonate magnesium ($MgCO_3$) solution of 1mℓ and then kept in the freezer Frozen-kept filter paper was dipped into the 90 % acetone of 10mℓ, kept in cold chamber for 24 hours and then chlorophyll was extracted from it. The extracted chlorophyll was centrifuged and then from it, high-quality chlorophyll was obtained and analyzed by Tunner Designs, Model 10-Au-000).

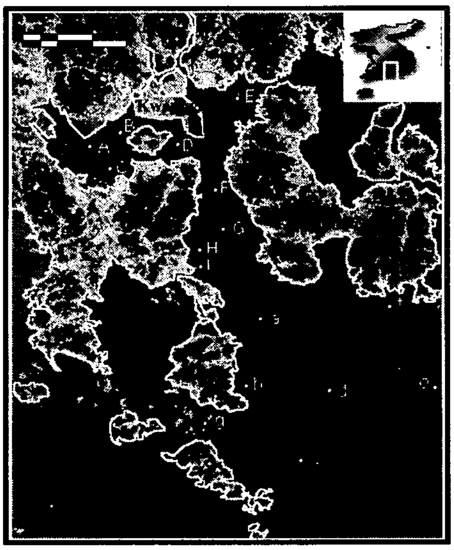

Fig. 1 The study area and sampling points

Specific spectral value for each band from the in situ observed data location was extracted. In addition the value on the regular coordinate points and those of image digital numbers were analyzed and extracted from the images of SeaWiFS detected at the same time with Landsat TM.

Estimating algorithm was extracted not only by comparing and analyzing specific spectral values of the in situ observed data and each band of Landsat TM but also by comparing chlorophyll value extracted from SeaWiFS.

## III. Chlorophyll estimating algorithm by satellite image.

Estimation of the chlorophyll content in water is important due to its indication of phytoplankton, which are the basis of the marine food chain. A high level of accuracy can be obtained for the direct estimation of phytoplankton using the colour change from blue to green as chlorophyll pigments in the water become more abundant.

For satellites not specifically designed for marine applications such as Landsat and SPOT the sensors are calibrated for both land and water viewing thus the digital values received over water areas tend to be very low due to small reflective band gains(Tassan, 1987, 1988; Cracknell and Hayes. 1991). This adversely affects image quality in two ways. First, a large proportion of the total sensor received radiance is attributable to atmospheric scattering. Second, sensor noise accounts for a further large proportion of the total signal, particularly the horizontal or vertical striping caused by imprecise calibration of the individual detector heads of multi-spectral scanners. This striping is often only detectable over water because the weaker signal varies much less, and over longer length scales than over land. Thus, for quantitative estimation of water quality parameters, atmospheric correction and destriping should be carried out(Janet and Kim, 1995).

Among the current satellite sensors operating in the visible wavelength region only Landsat's Thematic Mapper appears to be suitable for the quantitative estimation of sediment, chlorophyll and yellow substance concentrations in water bodies(Tassan, 1987). These applications have been investigated by numerous authors including Lathrop and Lillesand(1986), Rimmer and others(1987), Tassan(1987), Ekstrand(1992) and Lathrop Jr. (1992).

Janet and Kim(1995) applied the algorithms known th enhance the detection of water quality variables, suspended sediment(Tassan, 1987) and chlorophyll(Esfrand, 1992) to the TM data: The Equation of chlorophyll is as follows; $C = 116.78-31.19(TM1/\log TM3 + 1)$.

For this study, this equation was applied for Kwagyang bay area, but the result showed much errors with in situ observed chlorophyll data.

Jilong Li et al(1991) researched the applying remote sensing to evaluate, both qualitatively and quantitatively, water chlorophyll and lake weed concentrations and their spatial distribution and to build a model for calculating chlorophyll and lake weed concentrations with Landsat TM data.

The research results show that correlations between the in situ observed chlorophyll concentration data and the TM data. Through statistical analysis it was found that algorithm correlation represented the relationships between chlorophyll concentration and the results (TM band 2 normalized with band 1 and band 5 data). The coefficients rise to 0.869 with the following calculation model.

$$Ch\ 1 = A + B * Ln(Nom(TM\ band\ 2\ with\ band\ 1) \div band\ 5)$$

where A and B are constants and Nom (TM band 2 with band 1)equals (TM band 2 - band 1)/(band 2 + band 1).

Besides of above algorithms, there are some monitoring algorithms for chlorophyll as follows;

i ) NASDA OCTS ALGORITHM (OCTS-C)

Chl = 10^(-0.55006 + 3.497 * R)

where R = log10((nLw(520) + nLw(565))/nLw(490))

and nLw = normalized water-leaving radiance

ii ) OC2 (SEAWIFS) ALGORITHM TUNED TO OCTS (O'REILLY ALGORITHM)

Chl= 10^( 0.3164 - 2.132*R + 0.6303*$R^2$ + 0.004*$R^3$ ) - 0.0708

where R = Log(Rrs(490)/Rrs(565))

iii ) NDPI PIGMENT (FROUIN ALGORITHM) AND CHLOROPHYLL DERIVATION

Pigment Concentration = 10^(0.32277 - 1.08741*NDPI)

where NDPI = R(443)/R(490) - R(565)/R(490)

and R = below-surface reflectance

NDPI Chlorophyll in this study is derived from NDPI Pigment Concentration using the inverse of the formula which the SeaWiFS Project uses to derive pigment from Chlorophyll-a:

NDPI Chlorophyll = (NDPI Pigment/1.34)^1.0204081

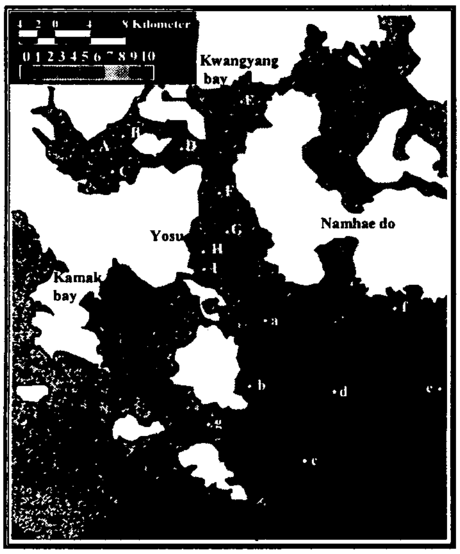


Fig. 2 Extracted image of chlorophyll by Landsat TM band 3

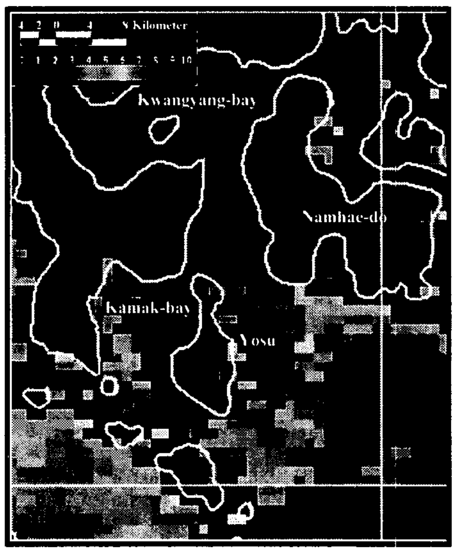


Fig. 3 Extracted image of chlorophyll by SeaWiFS data

In this study, chlorophyll estimating algorithm was derived from the calculation of correlationship by using 6 bands of Landsat TM, SeaWiFS and in situ observed chlorophyll.

## IV. Results and discussion

### 1. Landsat TM image analysis

The result analyzed for each band of Landsat TM is that Landsat TM band 3 is presented as high relationship value(Fig. 4). As the fact that chlorophyll has high reflectance of between 0.45μm and 0.65μm of spectrometer in case of plant plankton is generally known, so did it have the highest correlationship at the spectral range of Landsat TM band 3(0.60~0.69μm) in this study. But on the whole, the coefficients of correlation were low, and it was thought as a reason that the activities of the factors of atmospheric scattering light, water scattering light and bottom reflecting light affected the results. According to the coefficients of correlation, band 3($R^2$ = 0.9073) of visible had the highest value, and band 4($R^2$ = 0.4698) and band 5($R^2$ = 0.341) of near infrared had relatively high values.

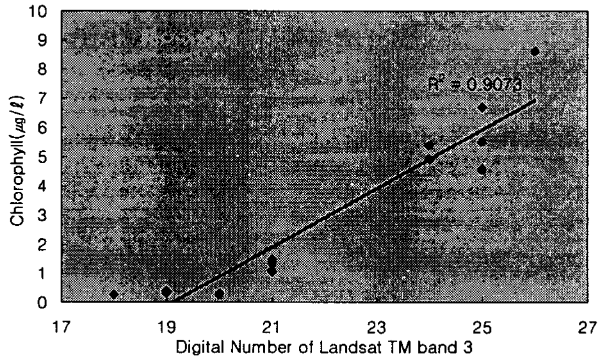


Fig. 4 Relationship between observed Chlorophyll and Lnadsat TM band 3

### 2. SeaWiFS image analysis

Because SeaWiFS has low resolution, data about narrow coastal areas such as Kwangyang bay area could not be obtained. But the results in Fig. 5 were prepared by extracting data of some parts (a~g) of South Sea area and comparing them with in situ observed chlorophyll.

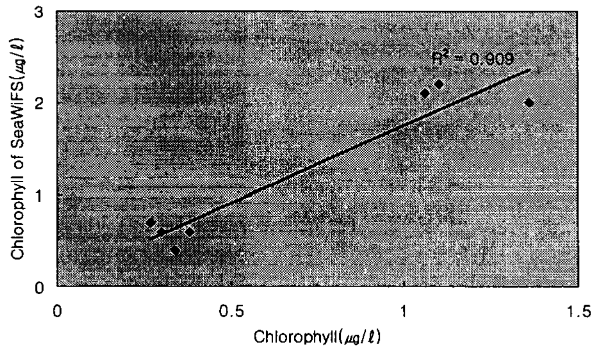


Fig. 5 Relationship between observed chlorophyll and SeaWiFS chlorophyll

According to Fig. 5, observed chlorophyll and SeaWiFS had relatively high correlationship. Therefore, more precise environment monitoring of coastal area could be carried out using Landsat image of high resolution and SeaWiFS image which has low resolution but shows sub real time image.

### 3. Analysis of correlationship between Landsat TM and SeaWiFS

The values of band 3 and band 4 which showed the most approximate values to the measurements in situ among SeaWiFS and TM band are shown in Fig. 6. From this result, band 3 has the most approximate values to in situ observed chlorophyll.

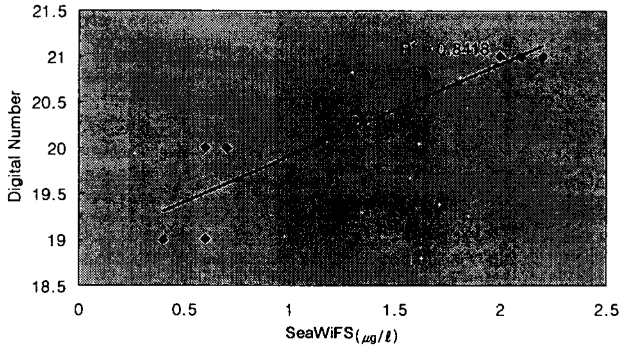


Fig. 6 Relationship of chlorophyll between Landsat TM and SeaWiFS

### 4. Extraction of chlorophyll estimating algorithm in Kwangyang bay area

On the basis of the correlationship between Landsat TM band 3 image and in situ observed chlorophyll, estimating algorithm of chlorophyll in Kwangyang bay area in Southern Sea of Korea was extracted as follows;

$$\text{Chlorophyll}(\mu g/\ell) = 0.9958 \times \text{DN3} - 18.929$$

## V. Conclusion

To Extract chlorophyll estimating algorithm in Kwangyang bay area, the correlationship with the respective in situ observed data was analyzed using Landsat TM and SeaWiFS satellite image. It showed that Landsat TM band 3 image has the highest correlationship whit in situ observed data, and the monitoring algorithm of chlorophyll in coastal area was produced based upon this result.

This method will be an important one for extracting and controlling environment elements in coastal areas in the future. And it has a significant meaning in that it has established a spatial data construction in which satellite image alone could monitor the coastal environment. Therefore, it is considered to be desirable to establish more effective information management infrastructure on coastal environment by extraction of monitoring algorithm for each coastal area of Korea.

## References


Kim Y. S, Suh A. S, Jo M. H, 1998. Introduction to Remote Sensing, *DongHwa Technology Publishing Co*, 373p.

National Fisheries Research and Development Institute Republic of Korea, 1998. Recent Red Tides in Korean Coastal Waters, *National Fisheries Research & Development Agency*, 292p.

National Fisheries Research and Development Institute Republic of Korea, 1998. Annual Report of Korean Coastal Environment Monitoring, *National Fisheries Research & Development Agency*, 3, 105p.

Cracknell, A. P. and Hayes, L. W. B., 1991, *Introduction of Remote Sensing*, Taylor and Francis London.

Ekstrand S., 1992. "LANDSAT TM based quantification of chlorophyll-a during algae blooms in coastal waters.", *Int. J. Remote Sens*, 13(10), pp. 1,913-1,926.

Janet N. and Kim C. G., 1995. "Remote Sensing for Marine Environmental Monitoring: A SINGAPORE CASE STUDY." *Asian-Pacific Remote Sensing Journal* , 7(2), pp. 27-36.

J. C. Jeong and S. J. Yoo, 1999. "The Analysis Errors of Surface Water Temperature Using Landsat TM", *Journal of the Korean Society of Remote Sensing*, 15(1), pp.1-18.

Jilong L., Lin Z., Jin M., Qiquan H. and Jing J., 1991. "The Use of Landsat TM Data to Quantify Chlorophyll and Lake Weed", *Asian-Pacific Remote Sensing Journal,* 4(1), pp. 1-14.

Lathrop JR., R. G., "Landsat Thematic Mapping monitoring of turbid inland water quality", *Photogrammetric Engineering and Remote Sensing*, 58(4), 1986, pp. 465-470.

Lathrop JR., R. G. and Lillesand, "T.M. Utility of Thematic mapper data to asses water quality in southern Green Bay and west-central Lake Michigan", *Photogrammetric Engineering and Remote Sensing*, 52, 1986, pp. 671-680.

Novo, E. M., J. D. Hansom, and P. J. Curran, 1989. "The effect of sediment type on the relationship between reflectivities and suspended sediment concentration", *Int. J. Remote Sens.*, 10(7): pp. 1283-1289.

Rimmer J., Collins, C. and Pattiaratchi C.B., "Mapping of water quality in coastal waters using airbome Thematic mapper data". *Int. J. Remote Sens.*, 8(1), pp. 85-102.

Sanae M. and Kazuo N., 1999. "Inverse Estimation of Multi-Substance Concentration Based on a Radiative Transfer Theory for Remote-Sensing Analysis of Coastal and Ocean Environments", *Journal of the Japan Society of Remote Sensing*, 19(2), pp. 50-63.

Tassan, S., 1987. "Evaluation of the potential of the Thematic Mapper for marine application", *Int. J. Remote Sens.*, 8(10), pp. 1455-1478.

Tassan, S., 1988. "The effect of dissolved 'yellow substance' on the quantitative retrieval of chlorophyll and total suspended sediment concentrations from remote measurements of water color", *Int. J. Remote Sens.*, 9(4): pp. 787-797.