OBSERVATION OF MICROPHYTOBENTHIC BIOMASS IN HAMPYEONG BAY USING LANDSAT TM IMAGERY

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ABSTRACT:

The goal of this study is to investigate the relationship between microphytobenthic biomass and normalized vegetation index obtained from Landsat TM images. Monitoring a seasonal change of microphytobenthic biomass in the sand bar is specifically focused. Since the study area, Hampyeong Bay, was difficult to approach, we failed to obtain ground truths simultaneously on satellite image acquisition. Instead, chlorophyll-a concentration in surface top layer was measured on different dates for microphytobenthic biomass. Although data were acquired on different dates, a correlation between the field and satellite images was calculated for investigating general trends of seasonal change. NDVI and tasseled cap transformed images were also used to review the variation of microphytobenthic biomass by using Landsat TM and ETM+ images. Atmosphere effects were corrected by applying COST model. Seaweeds were also flouring in the same season of microphytobentic blooming. Songseok-ri area was minimally affected by seaweeds from February to May, and selected as a test site. NDVI value was classified into high-, moderate-, and low-grade. It was well developed over fine-grained sediments and rapidly reduced from May to November over sand bar. In this bay, correlation between grain size and microphytobenthic biomass was clearly seen. From the classified NDVI and tasseled cap transformed data, we finally constructed spatial distribution and seasonal variation maps of microphytobenthic biomass.

KEY WORDS: Microphytobenthic biomass, Landsat TM, NDVI, Tasseled cap, COST model

1. INTRODUCTION

The tidal flat has a special environment when compared other ecological systems, and microphytobenthic biomass plays an important part of primary producer because they supply nutrients to the intertidal ecosystem. The microphytobenthic biomass blooms during the optimum environment conditions for them, forming a patch so called the algal mat. This algal mat mainly appears from February to March then its activity relatively decreases from November to December. This algal mat can be detected by satellite image, and shown different reflectance because microphytobenthos has different chlorophyll concentrations for each wavelength. Therefore, the species and the amount of microphytobenthos can be figured out by investigating these properties. General trends of seasonal change also can be estimated by comparing previous and posterior images.

2. STUDY AREA

Songseok-ri area is located at Hampyeong Bay in southwest Korea (Figure 1). Some areas of Hampyeong Bay were affected by seaweeds and halophytes. Seaweeds also bloom during the same blooming season of microphytobentos. Songseok-ri area is selected for study area because it is affected the minimum by seaweeds from February to May. Table 1 shows collected satellite images and in situ data.

Table 1. Collected satellite image to monitor seasonal changes of microphytobenthic biomass in the intertidal

Satellite Images	Acquisition Date	Spatial Resolution
Landsat TM	1999. 05. 05	30×30m
Landsat ETM+	2001. 03. 15	30×30m
	2001. 09. 23	30×30m
	2002. 02. 14	30×30m

Figure 1. Study area.

3. METHOD

3.1 Normalized Difference Vegetation Index

NDVI is calculated from the visible and near-infrared light reflected by vegetation. Nearly all satellite vegetation indices employ this difference formula to quantify the density of plant growth on the Earth (near-infrared radiation minus visible radiation divided by near-infrared radiation plus visible radiation). The result of this formula is called the normalized difference vegetation index (NDVI). Written mathematically, the formula is:

$$NDVI = (NIR - VIS) / (NIR + VIS)$$

Calculations of NDVI for a given pixel always result in a number that ranges from minus one to plus one; however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1(0.8~0.9) indicates the highest possible density of green leaves (Rouse et al., 1974; Deering et al., 1975).

3.2 Tasseled Cap Transformation

Tasseled cap transformation is one of the available methods for enhancing spectral information content of Landsat TM data. Tasseled cap transformation especially optimizes data viewing for vegetation studies. Tasseled cap index was calculated from data of the related six TM bands. Research has produced three data structure axes that define the vegetation information content (Crist et al. 1986, Crist and Kauth, 1986):

- Brightness-a weighted sum of all bands, defined in the direction of the principal variation in soil reflectance.
- Greenness-orthogonal to brightness, a contrast between the near-infrared and visible bands. Strongly related to the amount of green vegetation in the scene.
- Wetness-relates to canopy and soil moisture (Lillesand and Kiefer, 1987).

The tasseled cap transformation for Landsat satellite imagery is calculated with the following coefficients.

Table 2. Tasseled cap coefficients for Landsat TM and ETM+ at satellite reflectance

MSS, TM4 and TM5						
Index	Band1	Band2	Band3	Band4	Band5	Band7
Brightness	0.3037	0.2793	0.4743	0.5585	0.5082	0.1863
Greenness	-0.2848	-0.2435	-0.5436	0.7243	0.0840	-0.1800
Wetness	0.1509	0.1973	0.3279	0.3406	-0.7112	-0.4572
ETM+						
Brightness	0.3561	0.3972	0.3904	0.6966	0.2286	0.1596
Greenness	-0.3344	-0.3544	-0.4556	0.6966	-0.0242	-0.2630
Wetness	0.2626	0.2141	0.0926	0.0656	-0.7629	-0.5388

Tasseled cap results and change in tasseled cap values between images will be used to assess changes to the environment. These changes will be compared and contrasted to changes in radiometric value, NDVI value, and classification.

3.3 Atmospheric Effect Correction by COST Model

The solar radiation is absorbed or scattered by the atmosphere during transmission to the ground surface, while the reflected or emitted radiation from the target is also absorbed or scattered by the atmosphere before it reaches a sensor. The ground surface receives not only the direct solar radiation but also sky light, or scattered radiation from the atmosphere. A sensor will receive not only the direct reflected or emitted radiation from a target, but also the scattered radiation from a target and the scattered radiation from the atmosphere, which is called path radiance. Atmospheric correction is used to remove these effects and COST model is corrected with the following process (Chavez, P.S. Jr., 1996).

- Reading the image header
  - Solar elevation angle
  - Date of image acquisition
- Computing the solar zenith angle
- Computing the earth-sun distance in astronomical units
- Determining minimum DN for each band
- Converting each DN value to spectral radiance value
- Computing dark object for each band (assumed to have a reflectance of 1% by Charvez, 1996)
- Converting radiance value to planetary reflectance value

4. RESULT

Atmospheric effect correction on the Landsat TM and ETM+ included Songsuk-ri area is implemented by using the COST model (Chavez, 1996). It is an essential process to remove atmospheric effects because atmosphere affects to all visual and infrared bands in optical remote sensing. The atmospheric effect correction converts the DN values to the reflectance with 0~1 range.

NDVI was computed by using corrected Landsat TM and ETM+ in Songsuk-ri area. Vegetation indices are defined as dimensionless radiometric value. These functions can be used as indicators of relative abundance, activity of green vegetation, leaf-area-index (LAI), percentage green cover, chlorophyll content, green biomass, and absorbed photosynthetically active radiation (APAR). In this study, spatial distribution of chlorophyll-a was estimated and classified by NDVI into high-, moderate-, and low-grade and shown in red, green, and blue colours, respectively (Figure 2).

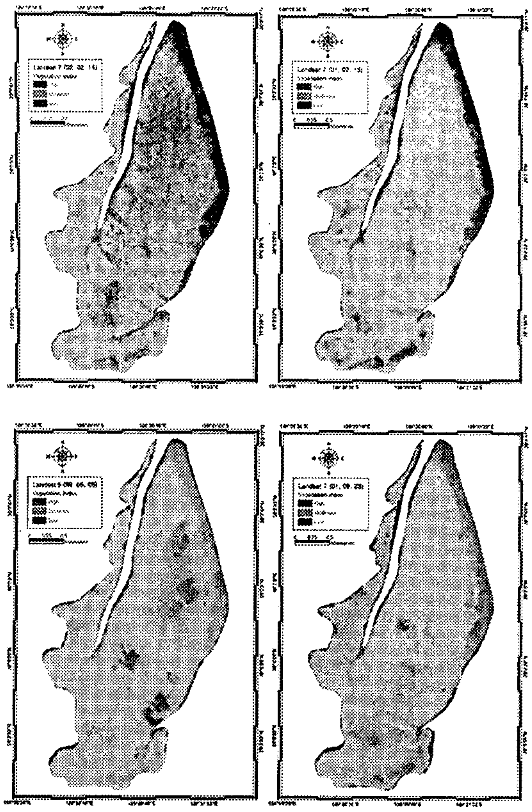
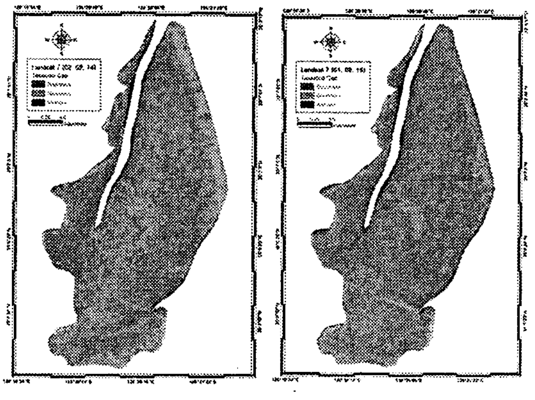


Figure 2. Seasonal change of microphytobenthic biomass (NDVI).

Tasseled cap transformation was calculated by using corrected Landsat TM and ETM+ in Songsuk-ri area. Tasseled cap transformation is widely used for vegetation index like NDVI. Computed tasseled cap values were classified into soil brightness index, greenness vegetation index and wetness index. As the result of tasseled cap, spatial distribution of chlorophyll-a was estimated and classified into three grade by using greenness vegetation index. Brightness index, greenness vegetation index and wetness index is shown in red, green and blue colours, respectively (Figure 3).



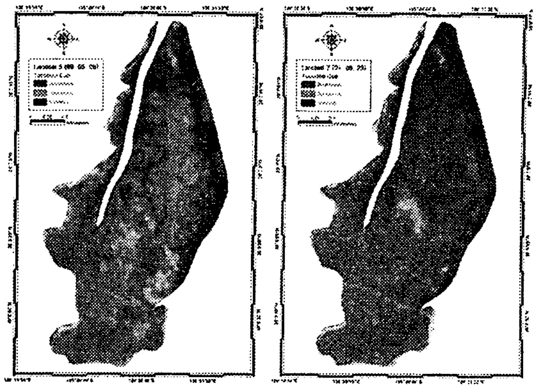


Figure 3. Seasonal change about microphytobenthic biomass (tasselled cap).

The chlorophyll-a concentration of surface top layer was measured by samples collected during field survey, and was computed by using Lorenzen equation (1967). As the result, chlorophyll-a concentration is 37.3~54.3mg m^{-2}, and the mean concentration is 43.8 mg m^{-2}. It was also shown a trend that chlorophyll-a concentration increased on February, and decreased on April and May (Table 3).

Table 3. Chlorophyll-a concentration in surface top layer

Lat / Long (DD)	Date	Chlorophyll-a (mg m^{-2})		
		Site A	Site B	Site C
35.1473 / 126.3468	05. 02. 28	43.6	57.3	61.9
35.1471 / 126.3468	05. 04. 18	29.3	32.6	50.1
35.1468 / 126.3470	05. 05 28	29.5	41.7	21.3

Simple correlation analysis was implemented by using computed vegetation index and greenness index, and satellite images and in situ data on February and May were used to analysis. As the result, correlation coefficients between using vegetation, greenness index and chlorophyll-a concentration were computed, and they are 0.7429 and 0.8674. Coefficients of determination are 0.5519 and 0.7523, and coefficients of alienation are 0.6694 and 0.4977, respectively (Figure 4).

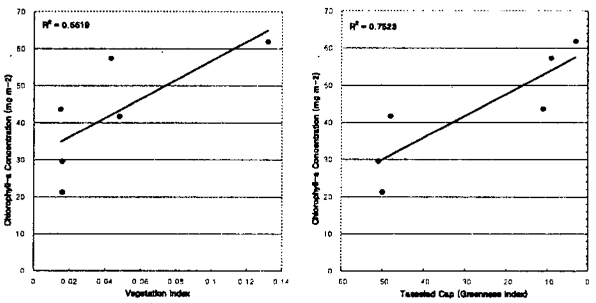


Figure 4. Correlation relationship between vegetation, greenness index and chlorophyll-a concentration.

5. DISCUSSIONS AND CONCLUSIONS

In this study, in order to observe seasonal change about microphytobenthic biomass, atmospheric effect correction, NDVI and tasseled cap using Landsat TM and ETM+ images were computed and compared with in-situ chlorophyll-a concentration at Songseok-ri, Hampyeong Bay in southwest Korea. The effects atmosphere and land were removed by using COST model and masking in order to accurate quantitative analysis. As the result, microphytobenthic blooming rapidly increases on February and vegetation and greenness index of all images, and gradually decreased on March. Due to seaweeds, indices show concentrated trend at some parts on May, and all of microphytobenthic biomass and seaweeds rapidly decreased on September. These results show good coherence with seasonal change of measured chlorophyll-a concentration in field. And we analyzed simple correlation coefficient between computed vegetation, greenness index and in-situ chlorophyll-a concentration. As the result, although the difficulties of approach and data acquisition at the foreshore, analyzed simple correlation coefficients show high correlation relationship and has 0.7429 and 0.8674, respectively.

Seasonal change of microphytobenthic biomass can be observed by using multi spectral images. However, low spatial resolution has variety spectral information in one pixel. Therefore, to get a better quantitative and qualitative analysis, we will be required not only additional data collection and cross verification about other area, but also spectral mixture analysis.

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