The Development of Water Quality Monitoring System and its Application Using Satellite Image Data

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Abstract

In this study, we was measured the radiance reflectance by using multi-spectral image of low resolution camera(LRC) which will be loaded in the multi-purpose satellite(KOMPSAT) to use the data in analyzing water pollution. Also we investigated the possibility of extraction of water quality factors in rivers and water body by using high resolution remote sensing data such as Airborne MSS. Especially, we tried to extract the environmental factors related with eutrophication, and also tried to develop the process technique and the radiance feature of reflectance related with eutrophication. The results were summarized as follows : First, the spectrum of sun's rays which reaches the surface of the earth was consistent with visible rays bands of $0.4\mu m \sim 0.7\mu m$ and about 50% of total quantity of radiation were there. And at around $0.5\mu m$ of green spectral band in visible rays bands, the spectrum was highest. Second, as a result of the radiance reflectance Chlorophyll-a represented high spectral reflectance mainly around $0.52\mu m$ of green spectral band, and suspended sediments and turbidity represented high spectral reflectance at $0.8\mu m$ and at $0.57\mu m$ each. Third, as a result of the water quality analysis by using Airborne MSS, Chlorophyll-a could have a distribution chart when carried out ratio of B3 and B5 to B7. And Band 7 was useful for making the distribution chart of suspended sediments. And when we carried out PCA, suspended sediments and turbidity had distributions at PC 1, PC 4 each similarly to ground truth data. Above results can be changed according to the change of season and time. Therefore, in order to analyze more exactly the environmental factors of water quality by using LRC data, we need to investigate constantly the ground truth data and the radiance feature of reflectance of water body. Afterward in this study, we will constantly analyze the radiance feature of the surface of water in water body by measuring the on-the-spot radiance reflectance and using low resolution satellite image(SeaWiFS). Besides, we will gather the data of water quality analysis in water body and analyze the pattern of water pollution.

1. Introduction

Recently, the range of human activity has become wider with a rapid progress of scientific technique. That caused natural environment destruction and dried up natural resources. Those problems are raising in the world. Especially, water pollution is becoming strained as the modern civilization has industrialized. Several kinds of methods are suggested to solve the problems.

At present, eutrophication in rivers and water body is presented as a serious social problem. Hereupon, in order to manage this problem effectively, a large scale and systematic skill for analyzing the water quality is required. However, the present analysis method of water quality in rivers and water body is difficult to inspect constantly the distribution status, movement and spread of pollutants because the method is being used to analyze some specific chosen spots for their characteristics of water flowing.

The remote sensing by the satellite data can make an alternative plan to solve those problems. Furthermore, by using strong points of remote sensing, the environmental factor in water body can be analyzed faster and more exactly. Therefore, the measuring method by satellite can help us to observe the place of origin and the whole water body at the same time. Also, it has a merit of analyzing the polluted area properly and watching it constantly.

The water quality analysis by the satellite data has been used in Kim Kwang-Eun(1994), Yoshifumi(1982), Forster et al(1985), George, D.G.(1990), Serwan and M.J. Baban(1993)'s studies. Most of these studies analyzed the water quality change by an interrelation analysis between the satellite data and the analyzed data of water quality in rivers and water body. The water quality factors such as Chlorophyll-a, suspended sediments and turbidity which have much optical characteristics, and water temperature which can be sensed exactly by thermal infrared rays spectrality usually used. However, the study with a new analysis method using those factors for the eutrophication of rivers and water body is not sufficient.

In this study, we measured the radiance reflectance by using multi-spectral image of low resolution camera(LRC) which will be loaded in the multi-purpose satellite(KOMPSAT) to use the data in analyzing water pollution. Moreover, we investigated the possibility of abstraction of water quality factors in rivers and water body by using high resolution satellite data such as Airborne MSS. Especially, we tried to extract the environmental factors related with eutrophication, and also tried to develop the process technique and the radiance feature of reflectance related with eutrophication.

2. Methods of this study and Data Used

In this study, we measured the radiance reflectance of water body to analyze the radiance feature of reflectance of the water body in low resolution spectral band and tried to analyze the water quality factors in rivers and water body by using radiance feature from another remote sensing data. Airborne MSS was used as the remote sensing data.

As the method of this study, first, we measured the reflectance of the surface of water by using SFOV to measure the radiance reflectance of every item of water quality analysis in LRC spectral band($0.4 \sim 0.9\mu m$).

Second, we investigated the usefulness of ground truth data and the LRC data from by measuring every radiance reflectance of water quality factors.

Third, we analyzed water quality factors by using the radiance feature from another data of remote sensing which is similar to the LRC spectral band. By using Airborne MSS, we carried out ratio process and principal component analysis(PCA).

Fourth, we analyzed Chlorophyll-a, suspended sediments and turbidity from the remote sensing data among the water quality factors related with the eutrophication of rivers and water body.

3. Analysis of radiance feature of reflectance in water body

The practical measures of water quality factor among LRC spectral bands are four visible rays bands which are all short spectral bands. Also spectral bands from B1 to B3 are mostly suitable for analyzing both Chlorophyll and eutrophication. Besides, spectral band B4 is suitable for analyzing turbidity and for abstraction the environmental factor related with eutrophication. The rest tow spectral bands are important as the previous process in abstraction the environmental factor of the water quality.

In this study, we measured the radiance reflectance in water body to analyze the water surface radiance feature of reflectance from LRC sensor. As a spectroradiometer which was used to collect data was SFOV(Single Field of View) of GER(Geophysical Environmental Research), an American company,

which has 875 channels at 0.31～2.50㎛ spectral bands.

From the beginning, we found out the quantity of optical energy by measuring the white plate of approximately 25㎝×25㎝ which was spread of Barium sulfate. Then, by using that as a standard, we changed the quantity of the reflected energy from the water body into a percentage to use as a reflectance.

As the subject area of this study, we selected Sang-sam lake which locates at Yong-gwang County, Chon-nam Province(Fig. 1). Sampling was carried out at around 10 A.M., 29 March 1998, according to the measuring time of the Airborne MSS. Analysis items were Chlorophyll-a, suspended sediments and turbidity among the water quality factors related with eutrophication. And the method of this study was Standard Method.

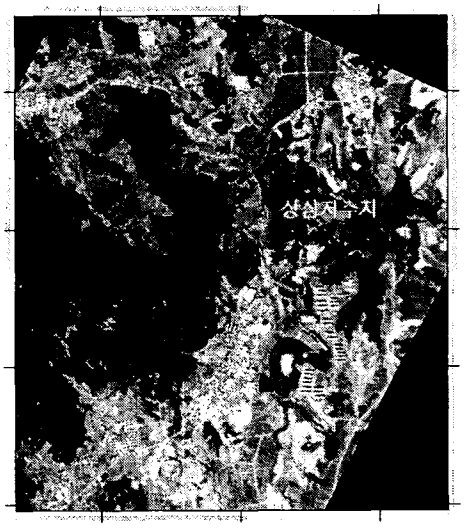


Fig. 1 False color composite image of Sang-sam lake site

Generally, the spectrum of sun's rays which reaches the surface of earth is known as 0.3㎛～3.0㎛. Among them, 0.4㎛～0.7㎛ was consistent with visible rays bands and about 50% of total quantity of radiation were there. And at around 0.5㎛ of green spectral band in visible rays bands, the spectrum was the highest(Fig 2).

The radiance reflectance chart of water body differs according to mainly the flux and the speed of a current, Chlorophyll-a, suspended sediments and turbidity. As a result of the radiance reflectance analysis of every factors of the water quality in water body, among the surface of water, where the density of Chlorophyll-a is high the spectral reflectance was high mainly around the 0.52㎛ of green spectral band. When comparing the surface of the highly dense water and the surface of the lowly dense water of suspended sediments, the reflectance of suspended sediments was relatively high at 0.8 ㎛. Then Band 6 which is mainly infrared rays was in there. The infrared rays are used usefully in plants or agriculture for its strong characteristic of reflection. Besides, they are used in dividing water and land for its strong absorption in water. Turbidity changes according to the water quality factors such as suspended sediments and Chlorophyll-a in water. In this study, by increasing the density of the turbidity artificially, we compared the reflectance of that with clear water. Then the reflectance was high at 0.57㎛(Fig. 3).

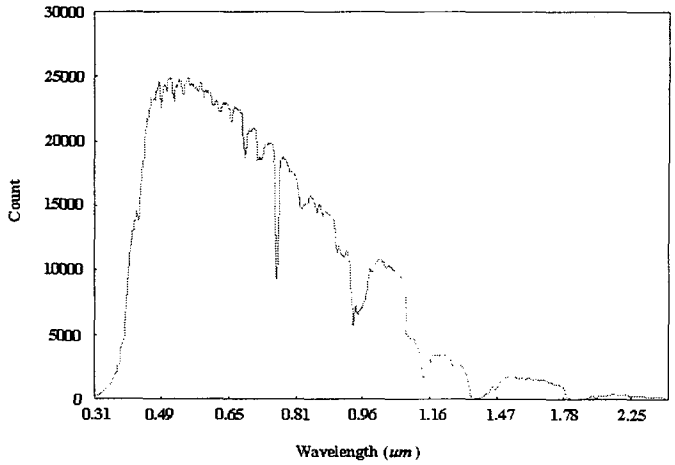
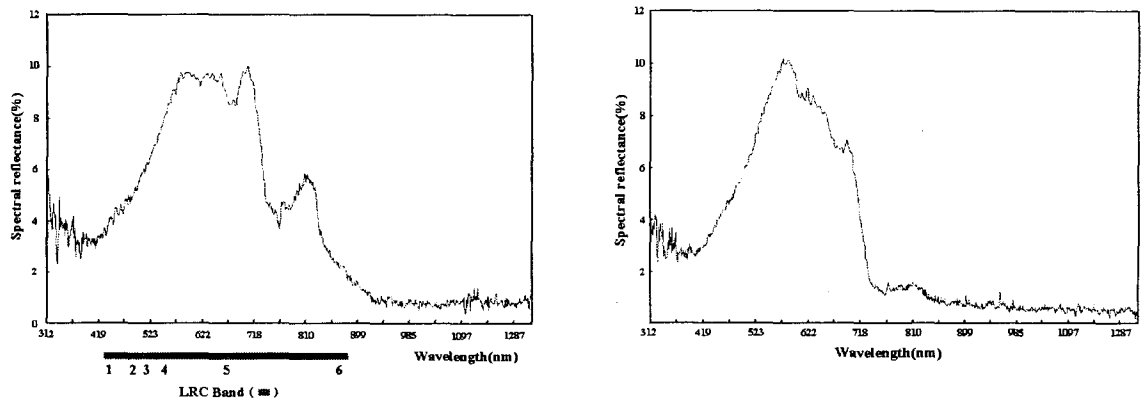


Fig. 2 Spectral distribution of sun's rays by the white plate



(a) Low Density (b) High Density

Fig. 3 Spectral response characteristic of suspended sediments

4. Analysis of the water quality factors by using Airborne MSS data

Airborne MSS is the data which can inspect and analyze water pollution effectively. In this study, we tried to find out the radiance feature of reflectance in water body, and to analyze the water quality by using remote sensing data and the every on-the-spot measured data related with water pollution. Sampling was carried out at around 10 A.M., 29 March 1998, according to the measuring time of the Airborne MSS. Analysis items were Chlorophyll-a, suspended sediments and turbidity.

Generally, water represents as a blue color, however, when water contains Chlorophyll-a represents as a green color in satellite image. So, we analyzed the distribution pattern of Chlorophyll-a by using the green band and the near infrared rays band. In this way, we carried out ratio of Band 3(0.52~0.60 ㎛) and Band 5(0.63~0.69㎛) which is useful for analyzing Chlorophyll-a to Band 7 of near infrared rays bands. We processed again non-operated image to be ratioing. That is like formula 1.

Chlorophyll-a = [(Band 3) - (Band 7)] - [(Band 5) - (Band 7)]

When we compared this result of image process with the real measured distribution of Chlorophyll-a, we obtained a relatively similar result(Fig. 4).

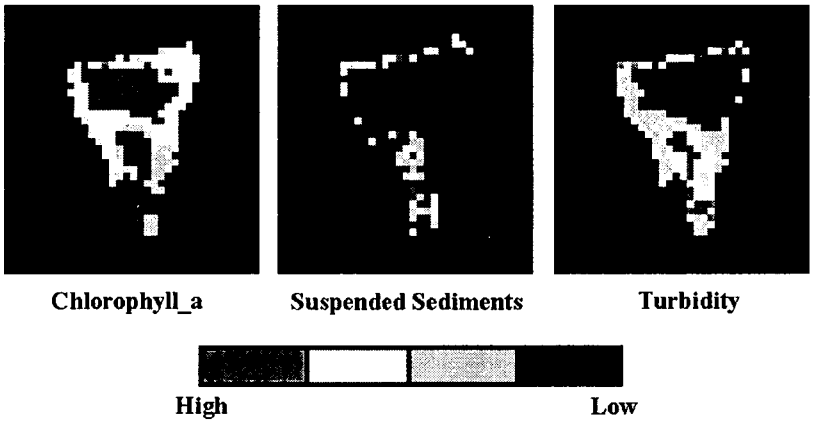


Fig. 4 Distribution chart of water quality factors in the Sang-sam lake

Band 7 among ten bands of Airborne MSS is suitable for investigating the distribution of suspended sediments which exist in the surface layer of water because Band 7 is sensitive at the density change of suspended sediment. In this study, we analyzed the density distribution of suspended sediments in two methods. First, we made a distribution map by using Band 7. As a result, the distribution pattern was similar to the ground truth data. Second, we carried out PCA(Principal Component Analysis) by using Band 1, Band 2, Band 3, Band 5 and Band 7. As a result of PCA, we found out PC 1 is suitable for making a distribution map of suspended sediments(Fig. 4).

Turbidity depends on more suspended sediments than Chlorophyll-a, and the water of high turbidity has a high reflectance at 0.55㎛. So, we made a distribution map by using Band 3. As a result of that, when we compared it with the ground truth data, there was no relativity. So, in this study, we carried out PCA and as a result of that we could made a distribution chart of turbidity at PC 4 which is similar to the ground truth data(Fig. 4)

5. Results and Discussion

In this study, we measured the water quality radiance reflectance of rivers and water body to practically apply the water quality analysis spectral band of LRC sensor. And we analyzed the water quality factors by using Airborne MSS data. The results are below.

First, the spectrum of sun's rays which reaches the surface of earth was consistent with visible rays bands of 0.4㎛~0.7㎛ and about 50% of total quantity of radiation were there. And at around 0.5㎛ of green spectral band in visible rays bands, the spectrum was the highest.

Second, as a result of the radiance reflectance Chlorophyll-a represented high spectral reflectance mainly around 0.52㎛ of green spectral band, and suspended sediments and turbidity represented high spectral reflectance at 0.8㎛ and at 0.55㎛ each.

Third, as a result of the water quality analysis by using Airborne MSS, Chlorophyll-a could have a distribution chart when carried out ratio of B3(0.52～0.60㎛) and B5(0.63～0.69㎛) to B7(0.76～0.90 ㎛). And Band 7 was useful for making the distribution chart of suspended sediments. As a result of PCA, PC 1 is suitable for making a distribution map of suspended sediments. And we could made a distribution chart of turbidity at PC 4 which is similar to the ground truth data.

Afterwards, we will constantly analyze the radiance feature of the surface of water in water body by measuring the on-the-spot radiance reflectance and using low resolution satellite image. Besides, we will gather the data of the water quality analysis in water body and analyze the pattern of water pollution. Also, we will survey the usefulness of the ground measurement data and the LRC data. And we will carry out the study related with data correction about the air because we had many problems in analyzing exactly the radiance feature of the surface of water for noises like cloud and fog.

7. References

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