Study on Plastics Detection Technique using Terra/ASTER Data

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abstract: In this study, plastic detection technique was developed, applying remote sensing technology as a method to extract plastic wastes, which is one of the big causes of concern contributing to environmental destruction.

It is possible to extract areas where plastic (including polypropylene and polyethylene) wastes are prominent, using ASTER data by taking advantage of its absorptive characteristics of ASTER/SWIR bands. The algorithm is applicable to define large industrial wastes disposal sites and areas where plastic greenhouses are concentrated.

However, the detection technique with ASTER/SWIR data has some research tasks to be tackled, which includes a partial secretion of reference spectral, depending on some conditions of plastic wastes and a detection error in a region mixed with vegetations and waters. Following results were obtained after making comparisons between several detection methods and plastic wastes in different conditions;

(a)"spectral extraction method" was suitable for areas where plastic wastes exist separated from other objects, such as coastal areas where plastic wastes drifted ashore. (single plastic spectral was used as a reference for the “spectral extraction method”)

(b)On the other hand, the "spectral extraction method" was not suitable for sites where plastic wastes are mixed with vegetation and soil.

After making comparison of the processing results of a mixed area, it was found that applying both "separation method" using un-mixing and "spectral extraction method" with NDVI masked is the most appropriate method to extract plastic wastes.

Also, we have investigated the possibility of reducing the influence of vegetation and water, using ASTER/TIR, and successfully extracted some places with plastics. As a conclusion, we have summarized the relationship between detection techniques and conditions of plastic wastes and propose the practical application of remote sensing technology to the extraction of plastic wastes.

Keyword: ASTER, plastic,

1. Introduction

Conventionally, satellite remote sensing performed rock classification, alteration zone extraction, geological structure extraction, etc., and came the big role as a tool of resources exploration. In recent years, the environmental destruction has become hot topics by abandonment of life waste and industrial waste greatly with development of industrial activity, and has become one of the big problems in a local government. Moreover, it is known that the plastics waste which account for a big rate in industrial waste. The plastics have a characteristic spectrum pattern like alteration minerals due to contained OH basis in a short wavelength infrared region. In this research we considers utilization of satellite remote sensing data using this feature, while we try to develop the detection technology of the plastics waste.

2. Characteristics of Plastic Spectrum

A plastic is the general term of the high polymer substance which compounded oil and coal chemically as materials, and the synthetic resin is also used in the almost same meaning. Moreover, although a synthetic fiber is a high polymer substance, the synthetic fiber consist of the molecule arranged to the liner structure unlike the plastic which consists of the three dimensions structure. The strong point as a material of a plastic is "easy to process", "light and strong", "not rotting and rusting", "electric insulation being good", etc.

However, due to not rotting properties plastics are not included in substance circulation of an ecosystem and existing semi permanently. These strong points are the demerit as wrack waste, illegal abandonment waste, and general/industrial waste. According to URL (http://www.pwmi.or.jp) of Plastic Waste Management Institute in Japan, the amount of gross plastics products and the amount of discharge of plastics are 14,740,000t and 9,970,000t in 2000. and as for the quantity of production and the amount of discharge of plastics, the amount of discharge amounts to 9,970,000t. Among these, although 4,940,000t of the plastics discharged is reused, it destroys by fire or disposes about 5,240,000t more than a half of total discharge.

To get the characteristics of plastic spectrum, the cluster analysis and principal component analysis are carried out using the existing spectra collapsed in the ASTER band with the response function of ASTER sensor. The spectra samples are plastics, minerals and vegetations. The spectra of the vegetations are collected from in situ plants at Unakamimachi, Kaijo-gun, Chiba-ken in Japan, and the spectra of minerals are quoted from the spectrum library of U.S. Geological Survey. The spectrum of polyethylene and polyvinyl chloride are shown in Fig. 1. There is the distinctive absorption in the ASTER SWIR band 5-9 region. The collapsed spectrum are shown un Fig. 2. The principal component analysis result is shown in Table 1. In the principal component analysis PC-1 -PC-3 can explain 98.087% of the whole change of reflectance. Furthermore, it is thought that PC-1 is the factor representing change of all bands, PC-2 is the factor of band 8-9 and PC-3 is the factor of band7. The vegetations spectra and the plastics spectra are similar in that characteristics of short wave infrared region. From these analysis it will be possible to separate the soil and the plastics for the spectrum pattern characteristic of a short wavelength infrared region using ASTER data and be classified several plastics type.

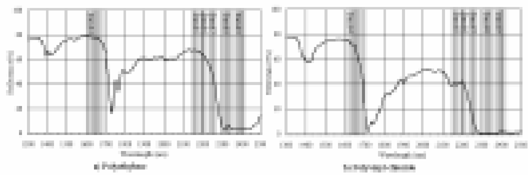

Fig. 1. The spectrum of polyethylene (left) and polyvinyl chloride (right).

In addition, the short wavelength infrared region spectra collected the plastics samples as the polyethylene, polypropylene and polystyrene which are typical plastic in industrial waste, and the other plastics which are 12 kinds of general plastics.

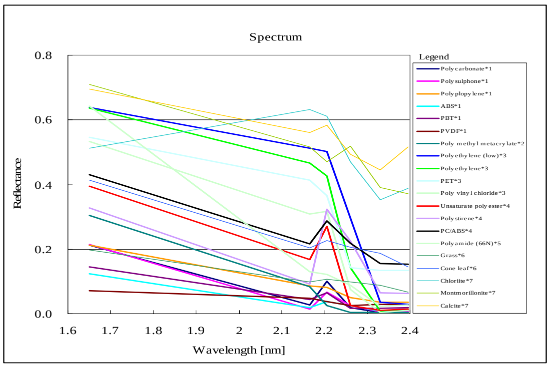

Fig. 2. Collapsed spectrum of plastics, plant and minerals. The midium values of caliculated wavelength are 1650nm (band4), 2165nm (band5), 2205nm (band6), 2260 (band7), 2330nm (band8) and 2395nm (band9), respectivity.

Table 1. Result of principal component analysis about collapsed spectrum of the plastic materials.

PC	Eigen Value	Contribution	Cumulative Contribution
PC-1	0.149515	81.678	81.678
PC-2	0.020863	11.397	93.075
PC-3	0.009176	5.013	98.087
PC-4	0.002176	1.189	99.276
PC-5	0.001202	0.657	99.932
PC-6	0.000124	0.068	100.000

3. Methodology and Result

How to extract various plastics was examined by the method used for geologic alteration zone extraction. The data used for examination is the ASTER data in Tokyo. The experimental techniques are a ratioing, the maximum likelihood method classification, principal component analysis, plastic index, and GSLR-SPI analysis. The outline, the strong point and the demerit of the technique are indicated below. In addition, it assumed that there was no influence of Raleigh dispersion by the air molecule in band 9 with long wavelength, and the simple air compensation using the spraying figure of band 1-8 to band 9 was carried out.

1) Ratioing

Outline: The spectrum pattern of general plastics has the high brightness value of band4, and the brightness of band5 is low. Plastics can extract as a bright point by performing operation processing of bnad4/band5 using this.

Strong point: It is possible to obtain a result by comparatively simple processing.

Demerit: It is difficult to use the pattern of a detailed spectrum.

2) Maximum likelihood method

Outline: The classification method by likelihood. The pixel is belonged to the classification class from which the degree of likelihood as the maximum. The artificial lawn ground was used for election of the classification class of plastics.
Strong point: it is possible to processing an individual image.
Demerit: Unsuitable as a general-purpose method in several images.

3) Principal component analysis

Outline: Although ASTER data is multi-band data, it is possible to express only three components in RGB simultaneously. It becomes possible to compress multi-band data by using the principal component analysis.
Strong point: It is possible to compress multi-band data.
Demerit: Explanation of each main ingredients is difficult.

4) Plastic index

Outline: It is the technique of having applied the spectrum index which Jackson (1983)[1] proposed to plastics. A spectrum index is a kind of rectangular conversion, and it calculates as alignment combination of a pixel value in which each band carried out reflectance conversion.
Strong point: Processing is easy by using a conversion factor.
Demerit: Much spectrum data is required for calculation of an exact conversion factor.

5) GSLR-SPI analysis

Outline: Perform matching processing between the image that is changed into false reflectance by the GSLR method and the spectrum pattern of the plastic collapsed in the ASTER band by the SPI method (Tsuchida et al. and 1993[2]).
Strong point: The classification which employed the feature of a fine spectrum efficiently is possible.
Demerit: Processing is complicated.

6) Results

As a result of performing a field survey using these processing results, it has checked that the processing picture is extracting well plastics, such as a wood covering sheet of a wharf, and an artificial lawn ground, and incorrect-extracting the roof of blue - green. Furthermore, with waste detection technology, it became clear that the method of detecting the characteristics of spectrum pattern to plastics directly is required, and that the GSLR-SPI analysis is selected as the classification method in which the feature of a fine spectrum efficiently is detectable.

The air-photo image and plastic extraction image at Unakamimachi, Kaijo-gun, Chiba-ken - Hasakimachi, Kashima-gun, Ibaraki-ken are shown in Fig. 3. In an extraction image, the illegal abandonment and the waste disposal place which were checked by the field survey did not appear as a high anomaly value. Since the disposed plastics in waste were mixed with soil in this cause, the spectrum pattern of the plastics is not clear. Moreover, the plastic hot house (green house) is widely distributed in Hasakimachi area, and a part of range extracted as plastics corresponded to this green house. In generally the VCM/PVC (PVC) which is used for the green house. Furthermore, as a result of checking a spot, there is also an example which incorrect-extracts a vegetation region with plastics, and it should be necessary to separate vegetation and plastics masking vegetation indices, such as NDVI, etc.

The Tsushima ocean current carry the driftwood and waste washed up on the Sea of Japan coast with a winter monsoon. Many plastics are contained in these driftwood, and since it is washed in sea water, it is distributed alone. The SWIR data (band 5-9) of ASTER L1B observed on September 24, 2001 is used for the plastic detection in northern Nagasaki Tsushima. In the extraction result in northern Nagasaki Tsushima, plastic waste was extracted on the coast of the northeast - north - northwest in northern Tsushima by raising a threshold value until disappearing the incorrect detection pixel for the vegetation distributed along stream (Fig. 4). The field survey carry out on August 8, 2002, the coast of the northern Tsushima island where plastic waste was extracted. Based on the distribution of the plastic waste checked by the field survey, it classified into the part (red) where the spectrum extraction processing result of a plastic answered correctly, the incorrect-detected part (blue), and the non-detected part (green). Since there was much wood etc. and there were few plastics in this non-detected par, the distribution of plastic waste are detected successfully in northern Nagasaki Tsushima. The pixel detected accidentally is a paddy field etc. and it became clear that distinction with vegetation and a plastic is imperfect.

Fig. 3 The air-photo image and plastic extraction image at Unakamimachi, Kaijo-gun, Chiba-ken - Hasakimachi, Kashima-gun, Ibaraki-ken

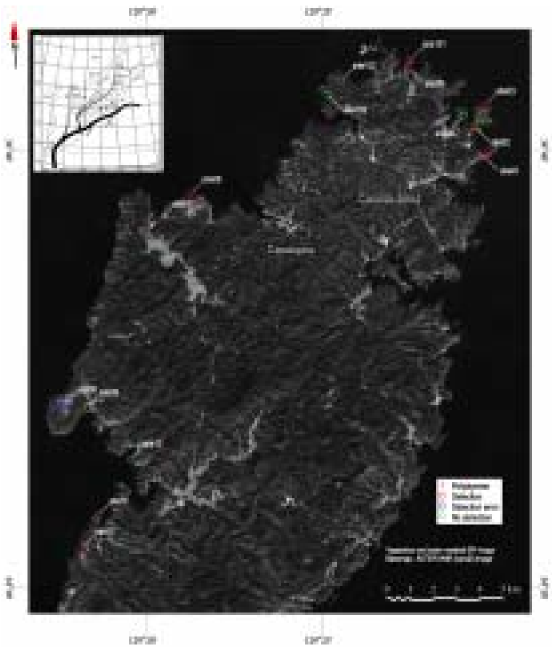

Fig. 4 Result of extracted plastic waste on Tsushima island

4. Conclusion

Some plastic waste are detected on ASTER data as satellite remote sensing data. The inner illegal abandonment spot extracts vegetation in some cases at the area with much vegetation accidentally. Since the spectrum feature is not clear in the case of the plastic mixed soil together, it is undetectable in some cases. For this reason, it is necessary to perform extraction processing by using as teacher data the un-mixing processing and the soil and plastic mixture which separate a vegetation soil plastic, and to heighten detection capability.

References

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