ANALYSIS OF WATER INHERENT OPTICAL PROPERTIES WITH PETROLEUM POLLUTION

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KEY WORDS: Petroleum pollution, inherent optical properties, spectral absorption features, backscattering coefficient, relationship model.

ABSTRACT: Inherent optical properties, including mainly spectral absorption coefficient and water backscattering coefficient, are important parameters on ocean color remote sensing and have a key function on the establishment of sedi-analytical model based on remote data. Petroleum pollution substance exists in water body in the form of float oil, disperse oil, emulsification oil and decompose oil etc. Water spectral absorption features must be influenced by them. Emulsification oil and decompose oil, etc in water can be absorbed by suspended particles. They will influence backscattering coefficient through de-pigment particles. This paper presents a study of water inherent optical properties with petroleum pollution. The results showed that in water body with petroleum pollution, (1) the absorption spectral of yellow substance, de-pigment particles and petroleum pollution substance all follow e-exponential attenuation trend; (2) the spectral absorption coefficient of yellow substance and phytoplankton pigments may be increased; (3) the petroleum mass-specific backscattering coefficients (backscattering coefficients of unit petroleum concentration) decreases with the wavelength increasing and follows power law to petroleum concentration; (4) Petroleum concentration has little effect on the power-law index of backscattering coefficient.

1. INTRODUCTION

It is imperative to have the information about the spatial distribution of the petroleum polluted water body due to the outburst of petroleum pollutions in a timely manner in order to do a better monitor. The remote sensing technology can be used as one of these measurement methods because it has the advantages of large scale, dynamic and low-cost access to regional information, which are not comparable to those through the traditional observation methods. Currently, the remote sensing technology is mainly applied to oil spill detection in the field of oil-contaminated waters. The researches on mechanisms and models of remote sensing have made a great progress, and the operational monitor system of marine oil spill has been established in China, Canada, America, Germany and some other countries [1-4]. However, the related research reports about the case of petroleum-polluted water without forming a visible or detectable film have not been yet seen domestically or internationally. The researches on the detection mechanism and identification models by using Remote sensing technology are of great scientific significance and application value [5].

Petroleum pollutions exist in water body in the forms of float oil, disperse oil, emulsified oil and decomposed oil etc, which influence the apparent optical properties and inherent optical properties of the water. To apply remote sensing semi-analytical models to quantitatively inverse the concentration of petroleum pollution in water, we must firstly ascertain the inherent optical properties of petroleum substance. Presently, researches on this field in China are still blank, and in other countries, just at the beginning [6]. This paper focuses on absorption coefficient properties of petroleum-polluted water in order to provide reference to the establishment of quantitative inversion of the petroleum-polluted concentration in water based on the model of remote sensing semi-analysis.

The experimental field work was conducted in Shuangtaizi River and Raoyang River in Panjin city (the area of Liaohe oil field), Liaoning province of CHINA. Liaohe oil field is the third largest oil field in China, whose products are mainly crude oil and natural gas. The oil exploration activities will inevitably have side effects on the water environment. It becomes a typical experimental field of inherent and apparent optical properties in the petroleum-polluted water.

2. ANALYSIS DISCUSSION

The field work was made at the rivers located in Panjin city, Liaoning province of CHINA from 21st to 26th May 2008. Spectral absorption coefficient data of yellow substance, De-pigment particles and phytoplankton pigments were measured with the U-3010 spectrophotometer. Concurrent water samples for laboratory measurements of chlorophyll, petroleum pollution, and suspended material were collected. Spectral backscattering coefficient data were measured by HydroSca-6 spectral backscattering sensor. The petroleum pollution concentration was analyzed with the infrared spectrophotometer.

2.1 The influences of petroleum substance on absorption feature of yellow substance

Petroleum substances according to the features seen in the water there, in a petroleum contaminated water, the impact of petroleum substances should be mainly reflected in the absorption coefficient of yellow substance on the end use of the ratio of tank experiments to study the different oil concentration of yellow substance absorption coefficient of the material presented by the spectral variation. Take the sewage treatment plant effluent, the same body of water (to ensure that other groups score the same body of water) for the ratio, Figure 1 for the four experimental samples.

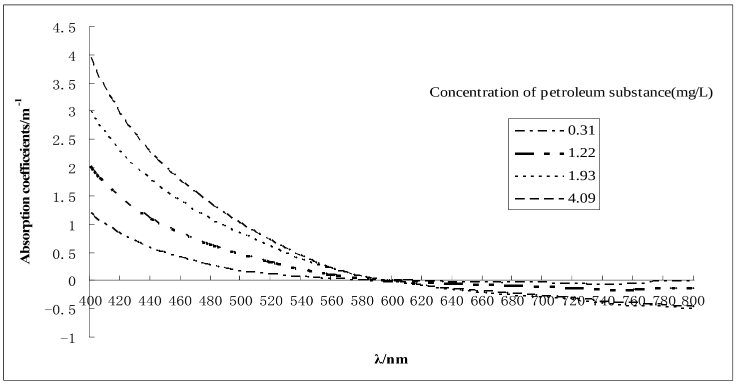

Fig.1 Yellow substance absorption spectra in same water with difference petroleum concentration

Figure 1 shows the absorption spectra of yellow substance, the following conclusions can be drawn: (1) with increasing concentrations of petroleum substances (curves a to d, the concentration of petroleum substances by the 0.31mg / L to 4.09mg / L), yellow substance absorption coefficient value with the increase, indicating that there is petroleum pollution in the water, yellow substance absorption coefficient of determination of optical properties of the material containing the impact of petroleum substance ; (2) there is petroleum substance in the water of material existence with increasing concentration of petroleum substances, yellow substance absorption spectrum shape unchanged, still follow the exponential decay law, but significant change in the slope of the exponential function, the slope of the exponential function of the degree of change are discussed separately in a later section.

2.2 Analysis of Exponential Function Slope of Yellow Substances, Petroleum Substances and De-pigment Particles

From the preceding analysis, the yellow substance, petroleum substances and non-pigmented particulate absorption coefficients follow the e exponential decay equation, increasing the yellow material, petroleum substances and non-pigmented particulate matter absorption coefficient to distinguish the degree of difficulty, but If the slope of the exponential function of these three major differences in the order of magnitude, then it is possible to use optimization methods to distinguish them.

Taking into account: (1) characterization of the exponential slope of the absorption coefficient of the material increases with decreasing wavelength of the parameters: (2) it has nothing to do with concentration, but with the composition and selection of the band; (3) there are two main effects: first, fitting the band selection, and second, and material composition and molecular size of the other factors, for taking reference wavelength λ_0= 440nm, in the 400-600nm band were calculated on the exponential function of the three slope. Using 21 samples, the calculated absorption coefficient of petroleum substances exponential slope of the experience, the minimum is 0.023nm^{-1}, a maximum of 0.089 nm^{-1}; the use of non-petroleum eight samples of water, calculated in this study regional yellow substance of e exponential function exponential function with a slope of 0.016 nm^{-1} ~ 0.023 nm^{-1} between the use of the river of the 26 samples, suspended sediment is calculated e slope of the exponential function exponential function exponential function with a slope of 0.001 nm^{-1} ~ 0.07 nm^{-1} between. According to existing research [7], under normal circumstances, clean ocean water the exponential slope of yellow substance at 0.014 nm^{-1} ~ 0.019 nm^{-1}, between lake yellow substance and non-pigmented particles exponential slope at 0.016 nm^{-1} ~ 0.024 nm^{-1} and

0.07 nm^{-1} ~ 0.46 nm^{-1} between non-pigmented particles Qinghai Lake exponential slope of the average of 0.028 nm^{-1}, the value of Meiliang Bay changes range of 0.014 nm^{-1} ~ 0.018 nm^{-1} between. Obviously the yellow waters of the study area, the slope of the exponential function of material and clean ocean water, lake and Meiliang Bay are similar, non-pigment particles is greater than the average slope of the exponential function in Qinghai Lake, Qinghai Lake, but the range is less than the maximum.

2.3 water particle backscattering coefficient spectral model

Figure 2 show the spectral characteristics of the water body particles backscattering coefficient in Shuangtaizi and Raoyang river. In the figure series 1 to 13 measurement points for Shuangtaizi river, Series 14 to 18 for the measurement points around the Raoyang river. Seen from the figure, spectral backscattering coefficient of variation with wavelength is characterized by: the backscattering coefficient from 440 nm to the red band has been gradually decreasing trend was broadly.

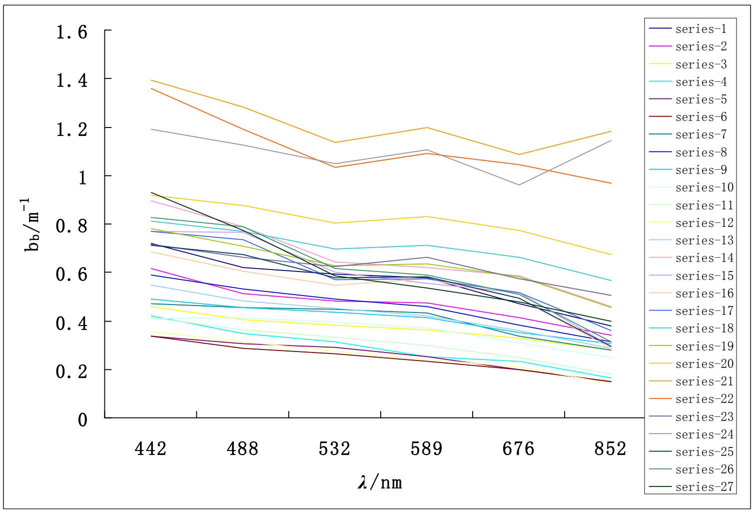

Fig. 2 the particle backscattering coefficient spectra in Shuangtaizi river and the Raoyang river

The correlation analysis of the backscattering coefficient at 442,488,532,589,676 and 852nm wavelength showed that: the wavelength of the backscattering coefficient and backscatter coefficient at 532nm on the whole has a high correlation in above 0.94 (Table 1).

Table 1 the correlation analysis of all the wavelength of the backscattering coefficient and backscatter coefficient at 532nm

	λ/nm				
	442	488	589	676	852
correlation	0.946	0.953	0.98	0.99	0.95

Satyendrannath et al. to study the use of chlorophyll concentration in the spectral characteristics of the scattering coefficient [8], but they used the particle backscattering coefficient of the spectral index model is a kind of relationship that

$$\frac{b_b(\lambda)}{b_b(\lambda_0)} = \left(\frac{\lambda_0}{\lambda}\right)^n \qquad (1)$$

Where, λ_0 is a reference wavelength; n is the scattering index changing with wavelength and with different water change. In order to study the regional water particle backscattering coefficient to simulate the spectral characteristics, the need to determine the particle backscatter coefficient spectral index n of the relationship. After considering the wavelength at 532nm to the scattering coefficient and backscattering coefficient as a whole has a high correlation, the wavelength of 532nm was chosen as a reference wavelength of 532nm. The data normalization was conducted and logarithmic [9] was,

$$\ln\frac{b_b(\lambda)}{b_b(532)} = n\left(\frac{532}{\lambda}\right) \qquad (2)$$

In the satellite data, 852nm wavelength does not participate in color basic algorithm, and more only for atmospheric correction algorithms, so the simulation does not consider 852nm spectral band. The experimental data into equation (2), showed the study area backscattering coefficient of the average spectral index of 0.87, the index of the range of 0.45-1.39. Average is less than the Yellow Sea and East China's sea of 3.064 and Taihu Lake of 1.146, which further reflects the spectral index of the relationship with the different bodies of water change, established a strong regional spectral model.

2.4 Relational model of backscattering coefficient and inorganic suspended solids concentration of water

In order to study the relationship between backscattering coefficients and water bodies with and without petroleum pollution, the relational models of backscattering coefficients in water bodies with and without petroleum pollution and the concentration of particles were established, respectively. From the discussion of 3.3.1 we could know that, inorganic suspended matters influence mainly on the backscattering of water. Therefore, in this section we mainly established the relational models of backscattering coefficient and the inorganic suspended matters. As shown in Fig.3 and 4.

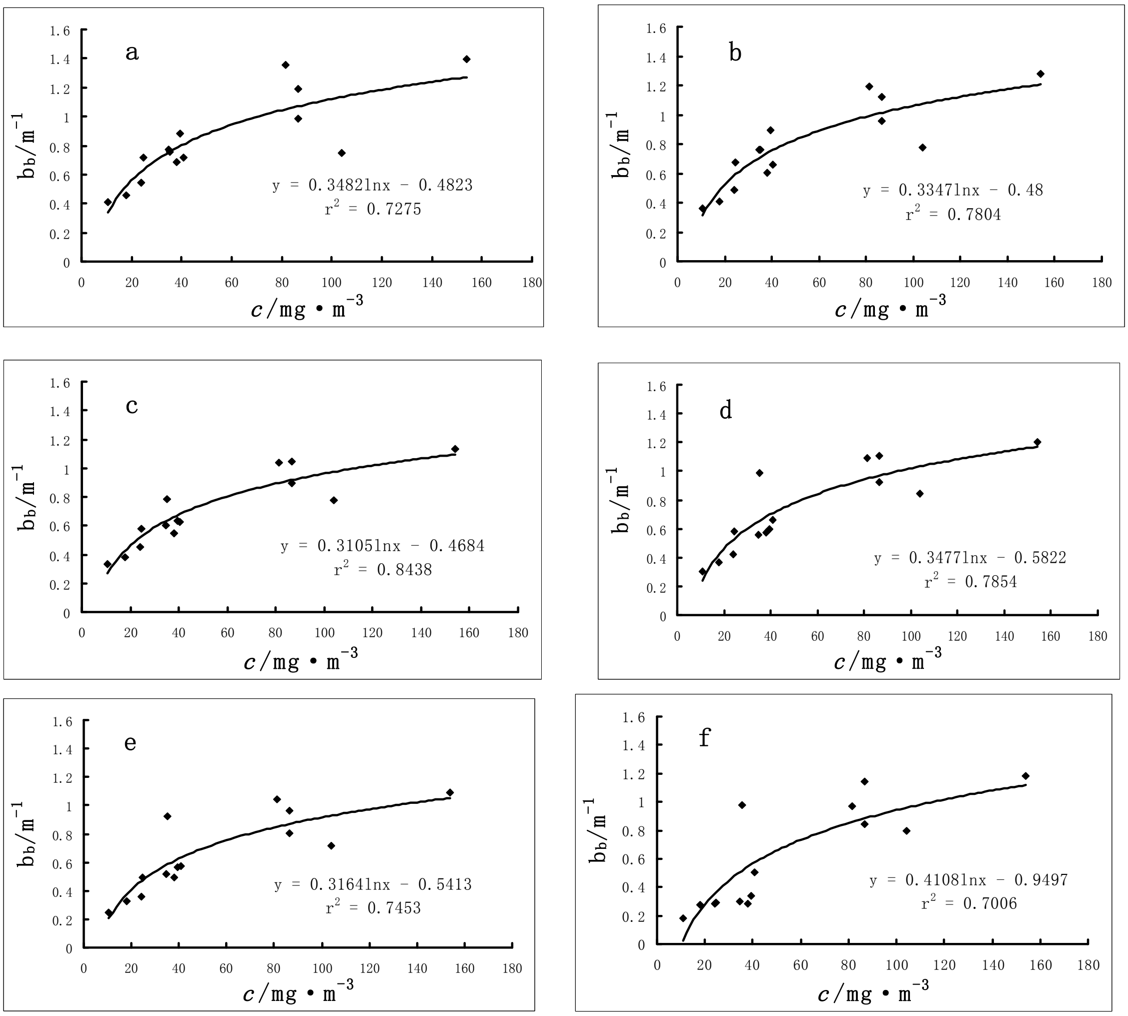

Fig. 3 the relational model of the backscattering coefficient at all wavelength and the concentration of suspended solids in non-petroleum pollution cases(c is the concentration of suspended solids, bb is backscattering coefficient)
a. 442nm，b. 488nm， c. 532nm，d. 589nm，e.676nm，f.852nm

Figure 3 (a) - (f) are the relational model of six-band backscattering coefficient and inorganic suspended solids concentration in non-petroleum contaminated water, respectively. It can be seen from the figure the backscattering coefficient and inorganic suspended solids concentration in the model reflects the logarithmic relationship model. Figure 4 (a) - (f) are the relational model of six-band backscattering coefficient and inorganic suspended solids concentration in petroleum polluted water, respectively. It can be seen from the figure the backscattering coefficient and inorganic suspended solids concentration in the model reflects a linear relationship between the model petroleum pollution on the backscattering coefficient of particles attached. At present, studies have shown that[9], the other two types of water, the backscattering coefficient and total suspended solids concentration in the model are generally expressed as a power mode, with the results of this study are apparently different in this regard reflects the regional, it also shows the interference of oil pollution, making the relationship between the model has changed.

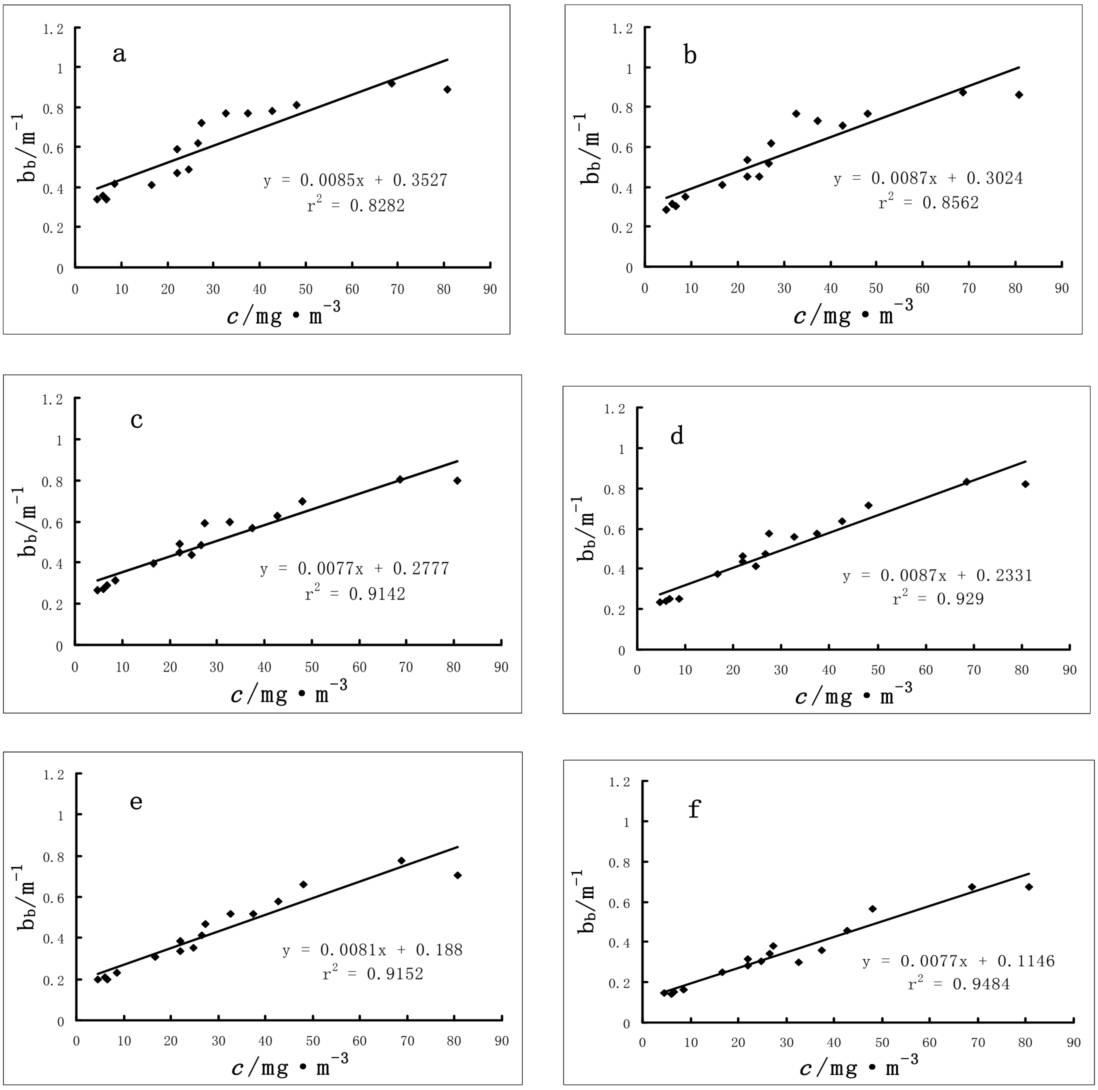

Fig. 4 the relational model of the backscattering coefficient at all wavelength and the concentration of suspended solids in no petroleum pollution cases(c is the concentration of suspended solids, bb is backscattering coefficient)

a. 442nm，b. 488nm， c. 532nm，d. 589nm，e.676nm，f.852nm

3. CONCLUSION

Based on the experimental data, by the absorption coefficient of yellow substances and pigment particles with non-petroleum and petroleum contaminated water, the influence of petroleum contaminated substance on water backscattering properties were discussed. Moreover, the study was done on the backscattering coefficient features of petroleum contaminated water. The petroleum contaminated water backscattering coefficient spectral model was set up between the backscattering coefficient and inorganic suspended solids concentration with petroleum contaminated water and non-petroleum contaminated water.

As the petroleum substance on backscattering coefficient is attached to the inorganic particles in the water body to its backscattering coefficient of a single separate also the need for further research, this is the future need for further work.

As the dissolved and dispersed substances in the water of petroleum, the absorption coefficient of yellow substance was measured mixing with them. The separation method used in this study is: choose no petroleum contaminated water body, as the background value, then there is oil pollution of water absorption coefficient of yellow substance minus the pollution of water absorption coefficient of yellow substance, the resulting is the absorption coefficient of the petroleum substance, and further access to petroleum for the absorption coefficient, he establishment of exponential decay equation. In fact, if in the laboratory, the normal petroleum-contaminated water and by water were placed in two light path spectrophotometer, by measuring the optical density of petroleum substances, and then calculate the petroleum substance contaminated water absorption coefficient is the most effective absorption coefficient for petroleum substances method. But for the petroleum to get contaminated water samples, typically using water samples collected in the field, then the method of extraction with carbon tetrachloride, carbon tetrachloride volatile as strong, not conducive to the samples stored for long periods, plus four CFCs are organic solvents, making the normal water and petroleum-contaminated water by spectrophotometer were placed in the way the direct determination of two light absorption coefficient of oil pollution in a way not realized, this is the future to conduct experimental research.

Further research will focus on the more in-depth analysis of petroleum pollution of the absorption features, and ultimately determine the petroleum contamination of water inherent optical parameters for the establishment of quantitative remote sensing inversion of oil contamination of the water body semi-analytic model provides the basic data.

ACKNOWLEDGMENTS

This work was funded by National Natural Science Foundation of China (Grant No. 40771196), National Oceanic Public Good Project (Grant No. 201005025-04) and Key Projects in the National Science & Technology Pillar Program during the Eleventh Five-Year Plan Period (Grant No. 2008BAC34B05-5).

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