SEPARATION OF SEWAGE WATER BASED ON WATER QUALITY PARAMETERS FOR SOUTH KARNATAKA COASTAL REGION

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ABSTRACT: Hyperspectral Imagers are used in the spacecraft or aircrafts to get fine characteristics of target element through capturing image in a large number of narrow and contiguous bands. The water quality assessment using hyperspectral image analysis is of new research for Indian continent. In this paper, case study analysis to extract water quality parameters for the South Karnataka Coastal region using AVIRIS-NG dataset is illustrated. The simulation results show that water quality parameters CDOM, SSC, Back scattering coefficient for pure water and suspended sediment concentration for varied as per the ground truth area situation. The spectral characteristic are generated from WASI and experimentation result show mapping of sewage concentration in Netravati river of Manglore region of south Karnataka in Indian continent.

1. INTRODUCTION

Coastal water contaminated with various pollutants, out of which most of are hazards and harmful for the sea animals and pollute the water. In the recent years, hyperspectral remote sensing has proven its promising way of extracting fine details form its imaginary. Sewage and industry wastes are most hazards constituents which pollute the water most. Sewage is the term used for wastewater that contains feces, urine, toilet debris and laundry waste etc. Water pollution is any change or modification in the physical, chemical and biological properties of water that will have a detrimental consequence on living things. Sewage pollution can kill fish and other aquatic life and also affect biodiversity, amenity value and the use of water and land for agricultural purposes. Sewage can be hazardous to the environment, which is why we don't want raw sewage to get into the groundwater or other bodies of water. It can damage every element in the ecosystem.

In situ measurement of river or coastal for water quality measurement parameters is partly useful. The flow of water is very fast so retrieval of water properties such temperature, PH and other concentrations of optically active constituents are changing so spatial correlation is expected in image but accuracy of results with respect to in situ measurements are not correlated. In last decade, various empirical, semi-analytical and analytical ocean color models have been developed to derive the water quality parameters of interest such as total suspended solids (TSS), concentrations of Chl and absorption of colored dissolved organic matter (CDOM). In this paper, four parameters are commonly affect the sewage content of water: sewage spectra form at in situ measurement, back scattering of pure water, color dissolved organic matter (CDOM), suspended sediment concentration. The spectrum shape thus gives information on these water properties and allows their retrieval under some conditions.

2. DATA

In situ measurement campaign and data set collection was by the coauthor within the framework of AVIRIS-AO project. This data set contains hyperspectral images of coastal zones with the limited ground truth data. It also includes a library of reference spectra measured at the ground level, as well as water analyses.

2.1 Study area

The study area was site no. 10 in AVRIS-NG Next Generation Airborne Visible Infrared Imaging Spectrometer (AVIRIS-NG) is considered for high sewage area separation. The data has been prepared especially for the specific needs of the 2015 India campaign. The AVIRIS-NG can take observations over a continuous electromagnetic spectrum spread over 380 – 2510 nm at 5 nm band interval so total 426 band image was captured. The sensor is capable of providing hyperspectral observations at 6 -7 m pixel resolution over a flight swath of 6 km when the flight altitude is about 6 – 7 km. The site id 10 is located at the Mangalore costal region ($12^0 48$`N, $74^0 81$`E). It covered an area of 514 km^2 patch. From this small patch which is more affected by sewage is selected as study area which is shown Figure 1. This zone covered an area of 14.87 km^2 as shown in Figure 1. The spatial resolution of is 7.7m per pixel and spectral resolution is 5 nm. The sewage was coming from the north side of the bridge area and entered into Netravati River. In situ measure was collected location $12^0 50$`N, $74^0 51$`E which was sewage dominated water. Netravati River has high concentration of suspended sediments and sewage water near bridge area.

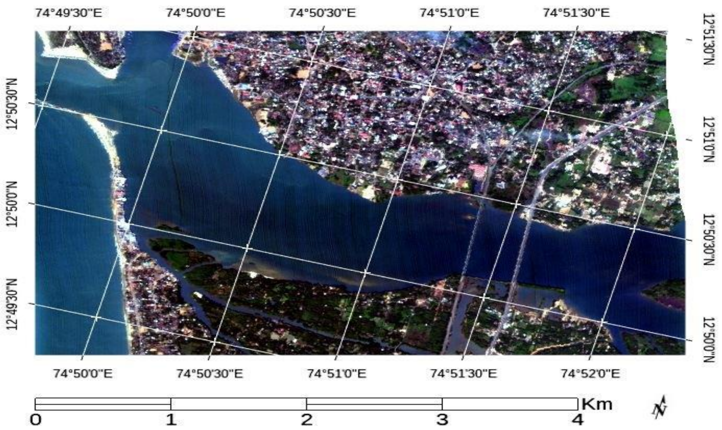

Fig 1. Example case study site of true color composite image.

3. LITERATURE SURVEY

Many authors have proposed solutions for the retrieval of water column properties and comparison of most methods has been presented in (Dekkar, 2011). In the following study, we used the WASI tool to study the organic properties of the water and to generate the spectral library for the required bio-optical model like CDOM and suspended particles present on the water and more details is described in section 3.1. The paper addresses study conducted for the separation of sewage water with clean water or low pollute water.

Recently novel statistical method for mapping water column properties from hyperspectral remote sensing data was proposed by (Sylvain, 2014). In this paper novel maximum likelihood based method is proposed. The usual method do not consider the spatial correlation between neighboring pixels where such pixels are often affected by the same water column if the spatial resolution is high enough. Using local information provided by neighboring pixels makes this method robust to noise. The simulated results show mapping of clear concentration variation of water quality over the small Patuxent River area. The spatial distribution of water quality for Mississippi River is assessed using hyperspectral remote sensing images (Leif, 2013). It is also noted that dynamic nature of river the sample collection in Situ measurement is challenging as rapid temporal and spatial changes expected in river. In this paper, water quality impairment issues occur in the Mississippi River due to urban and agricultural runoff and inputs of treated municipal wastewater is studied.

2.1 WASI tool

The Water Colour Simulator (WASI) is a software tool for analyzing and simulating the most common types of spectra that are measured by ship-borne optical instruments. The term 'WASI' is used for the complete software, while 'WASI-2D' refers specifically to the image processing module (Peter, 2001a, 2014b).

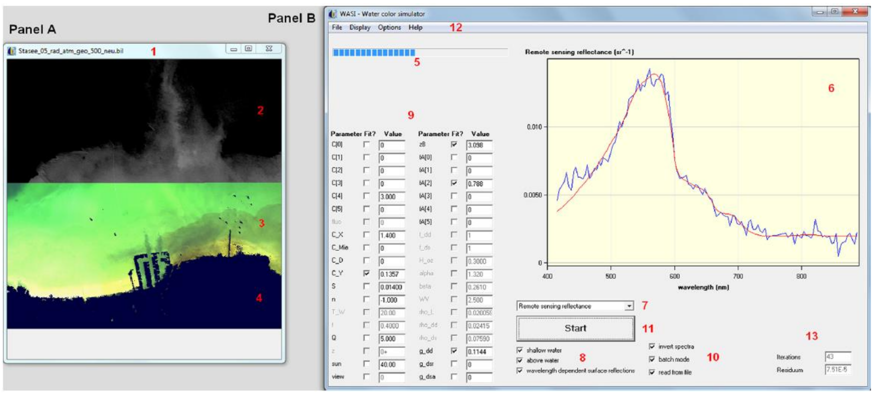

Figure 2. Graphical user interface. Panel A: Image Preview of 2D-Module, Panel B: Main Window of WASI. (1) Filename of image;(2) Processed pixels;(3) Original image; (4) Masked pixels;(5) Progress bar;(6) Spectrum of actually processed pixel(blue: measurement, red: fit curve);(7) Spectrum type;(8) Model options; (9) Parameter list; (10) Operation mode;(11) Start button;(12) Menu bar and (13) Fit quality measure. (Peter 2005c).

WASI can be used to generate the spectra of Table 1.1 as shown below and described in detail (Peter 2005c). Both forward and reverse modes can be combined to perform sensitivity studies. The forward mode can be used to determine the information bearing wavelength ranges by simulating measurements for the expected parameter ranges. WASI-2D is a new image processing software for multi and hyperspectral data from deep and shallow waters. It has been developed for inverse modelling of atmospherically corrected data from airborne sensors and satellite instruments and supports radiance as well as reflectance spectra.

Table 1.1: Spectrum types and major model options (Peter 2005c).

Spectrum Type	Absorption Model
Absorption	Of water constituents Of natural water bodies
Attenuation	For downwelling irradiance
Specular reflectance	Wavelength dependent Constant
Irradiance reflectance	For deep water For shallow water
Remote sensing reflectance	Below surface for deep water Below surface for shallow water Above surface for deep water Above surface for shallow water
Bottom reflectance	For irradiance sensors For radiance sensors
Downwelling irradiance	Below surface and Above surface
Upwelling radiance	Below surface and Above surface

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The single spectrum inverse mode can be applied to in situ measurements of reflectance, irradiance, absorption or attenuation to determine optical properties and concentrations of water constituents, bottom reflectance and parameters of the atmosphere. The reconstruction mode allows sensitivity analysis and can be helpful to determine which parameters to fit and which to keep constant during inverse modelling. The graphical user interface (GUI) is consists of an image preview window (Panel A), and the main WASI window. The image preview window opens automatically upon loading a hyperspectral image. The components of the main WASI window are designated in the legend of Figure 2. A major component is the parameter list (9). It comprises the potential fit parameters of all models implemented in WASI. The image specific settings are made in the popup window shown in Figure 2. WASI can alternately import the image parameters from an ENVI header file (ENVI, 2004), which is widely used as file format descriptor in the remote sensing community. WASI-2D supports as input five data types (8-bit byte, 16-bit unsigned integer, 16-bit signed integer,32-bit signed long integer, 32-bit floating point) and two interleave types (BIL¼band interleaved per line, BSQ ¼ band sequential), output is 32-bit floating point BIL or BSQ. Wavelengths are expressed in units of nm.
BOMBER (Bio-Optical Model Based tool for Estimating water quality and bottom properties from Remote sensing images) is another software package for simultaneous retrieval of the optical properties of water column and bottom from remotely sensed imagery, which makes use of bio-optical models for optically deep and optically shallow waters. Several menus allow the user to choose the model type, to specify the input and output files, and to set all of the variables involved in the model parameterization and inversion (Claudia 2012). The software requires atmospherically corrected input data. It is fully programmed in IDL. More details of this software can be found in (Claudia 2012).

3. Methodology

Imagery was provided by the SAC, ISRO and as detailed descried in section 2 and shown in Figure 1. The imaginary acquired on 30th Dec., 2015. In this paper from the mentioned site, sewage parameter variation should be identified to understand present situation of Natravati River sewage at Manglore region of south Karnataka region. The water quality can be decided by the parameters like total suspended solids (TSS), chlorophyll (Chl a) and CDOM, suspended sediment concentration (SSC), Back scattering coefficient of pure water (bbw) etc. In this paper WASI tool is used to compute spectra of SSC, bbw, CDOM. The spectra is shown in Figure 3 which is computed from the VASI tool. For the endmember target detection Spectral angle mapper (SAM) method is used to see the variation of SAM values for each spectra. The result is described in following section. WASI tool is used for 160 band image between 380nm to 1180nm. The following spectral was computed from it. The spectra shown in Figure 3(c) is taken form the acquired image where during in Situ measurement maximum sewage sample was collected. Due to river dynamic nature, it is expected to change so spectra collected for that location is considered as sewage is coming from that area.

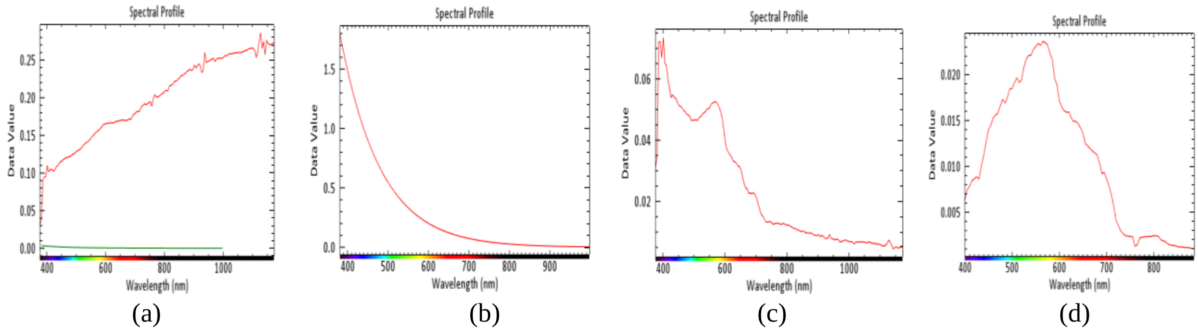

Figure 3. Spectra plot of (a) backscattering coefficient of water (b) CDOM (c) Sewage (d) Suspended sediment concentration

4. RESULTS

Hyperspectral imaginary can provide sufficient information for water quality identification. The spectral characteristics that distinguish waters are computed and mapped for mentioned case study are as shown in Figure 1. Above mentioned four spectra is considered for experimentation and Figure 4 is generated using ENVI 5.4.1. The results show the capability of hyperspectral imagery to capture fine scale variations in water quality condition by the maps shown in Figure 4 (a)-(d) which show the transition of water quality form east side to waste side.

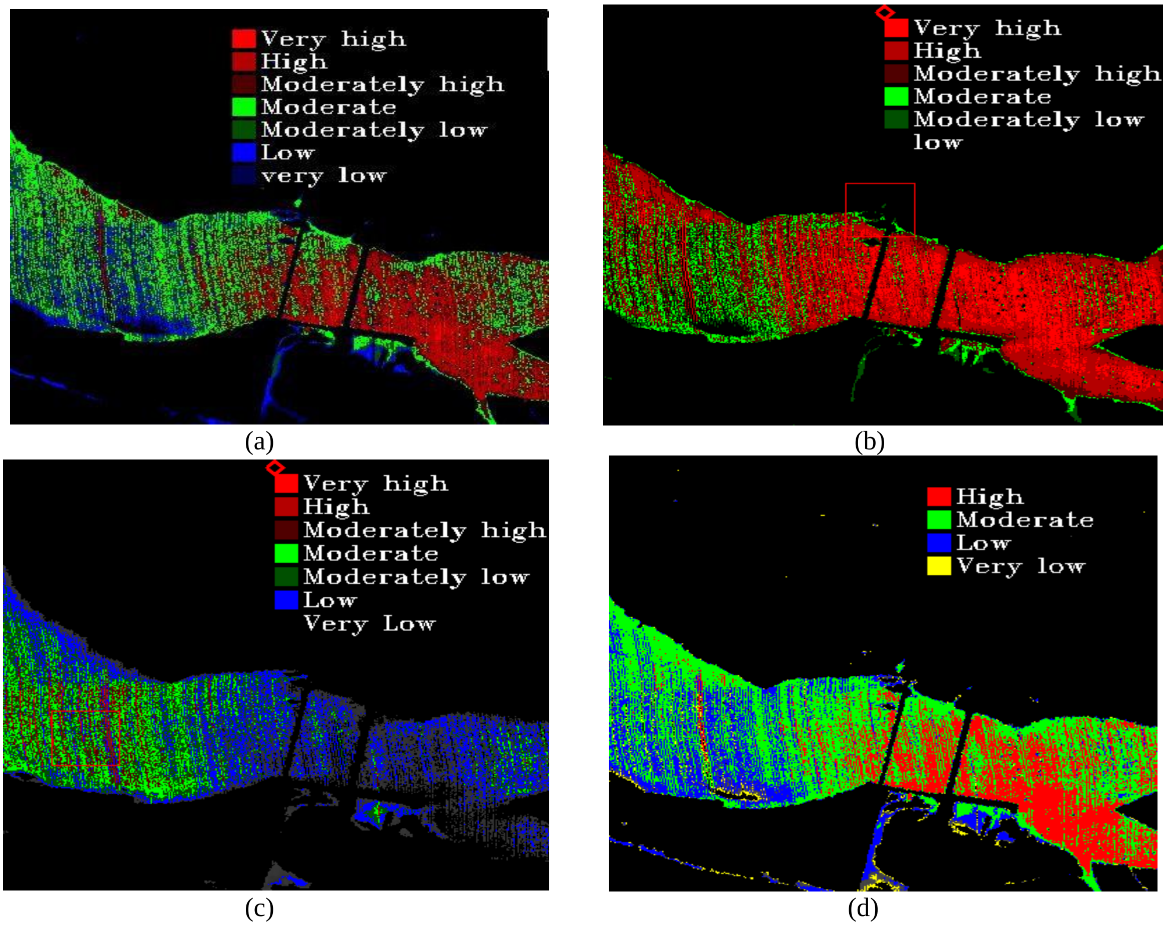

Figure 4. Maps of Natravati River for the site shown in Figure 1 (a) Normalized Gelbstoff absorption (1/m) (CDOM) (b) Sewage (c) Backscattering of pure water (1/m)(bbw) (d) Specific backscattering coefficient of suspended particles Type II (SSC) (m^2/g)

As sewage water intake is north-east side near bridge area at location $12^0$50`N, $74^0$51`E, this area is more dominant for sewage water. Figure 4 (a) – (d) show variation of all four parameter from South-East part to North-West part of Netravati River. It is evident from the results that moving from South-East part to North-West part sewage concentration will change from higher to lower as expected. All the four parameters CDOM, Sewage, Back scattering coefficient of pure water and Specific backscattering coefficient of suspended particles type II is showing (Figure 4 (a),(b),(d)) variations of high to low in the map and for the pure water it showing (Figure 4 (c)) low to high variation as pure water is less in sewage dominant area. The results show some stipes in the images so appropriate destripping algorithms and filters are required to apply to show smooth variation of the water quality parameters.

5. CONCLUSION

Rivers and underground waters are main source of our drinking water. To measure the accurate water quality for river is challenging without remote sensing imaginary. To understand the scenario of drinkable and non-drinkable water in river, the separation of high sewage and low sewage areas are very important so government can plan their drainage or waste water discharge policy. In this paper, for the site area 10 of AVRIS-NG project, case study for sewage water separation is presented. The simulation results show that water quality variations measured by CDOM, Sewage, Back scattering for pure water and SSC are varied as per expectation. More water quality parameters and different target detection algorithms can be used to show robustness of the approach.

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7. REFERENCES

Chunlei 2014. Spectral Analysis of water reflectance for Hyperspectral remote sensing of water quality in Estuarine water, Journal of Geoscience and Environment protection, (2), pp. 19-27.

Claudia 2012. BOMBER: A tool for estimating water quality and bottom properties from remote sensing images, In Computers & Geosciences, Vol. (45), 2012, pp. 313-318.

Dekker 2011. Intercomparison of shallow water bathymetry, hydro-optics, and benthos mapping techniques in Australian and Caribbean coastal environments. Limnology and Oceanography: Methods, pp. 396–425.

ENVI, 2004. ENVI User’s Guide: ENVI Header Format, from http://aviris.gl.fcen.uba.ar/Curso_SR/biblio_sr/ENVI_userguid.pdf

Gitelson 1993. Quantitative remote sensing methods for real-time monitoring of inland waters quality. International Journal of Remote Sensing, (14), pp. 1269–1295.

Leif 2013. Airborne hyperspectral remote sensing to assess spatial distribution of water quality characteristics in large rivers: The Mississippi River and its tributaries in Minnesota, In Remote Sensing of Environment, Volume 130, 2013, pp. 254-265.

Peter 2001a. "The water colour simulator WASI: A software tool for forward and inverse modeling of optical in-situ spectra," International Geoscience and Remote Sensing Symposium, Sydney, NSW, (6), pp. 2743-2745.

Peter 2014b. WASI-2D: A software tool for regionally optimized analysis of imaging spectrometer data from deep and shallow waters, In Computers & Geosciences, Vol (16), 2014, pp 208-215.

Peter 2005c. The Water Colour Simulator WASI. User manual for version 3, pp. 1-*83*

Sylvain 2014. A novel maximum likelihood based method for mapping depth and water quality from hyperspectral remote-sensing data, in Remote Sensing of Environment, Volume 147, 2014, pp. 121-132.