

WATER QUALITY ASSESSMENT FOR OPEN WATER BODIES BY REMOTE SENSING: A REVIEW

B.S. Singhvi¹, Bhardwaj Govind Singh², Arora R.P.³Samdani K.L.⁴

^{1,3,4} Civil Engineering Department, College of Technology and Engineering, Udaipur-313001,

bssop@rediffmail.com

²Department of Mining Engineering, College of Technology and Engineering, Udaipur-313001, India

bhardwaj_gs@rediffmail.com, gshardwaj@mpuat.ac.in

Abstract:

Water quality of the fresh surface water sources like rivers and other reservoirs are degraded by human activities. Industrial effluents and domestic sewage with high organic wastes are the main source for pollution in urban lakes. Monitoring the water quality periodically by field measurements is uneconomical. With recent and planned launches of satellites with improved spectral and spatial resolution sensors, greater application of remote sensing techniques to assess and monitor water quality parameters are possible. Multispectral or Hyper spectral images from the remote sensing satellites can be used for assessment of spatial and temporal variation in water quality. Water quality parameters like suspended chlorophyll, suspended minerals, colored dissolved organic carbon, depth and turbidity can be derived.

This paper gives a conceptual idea of developing a water quality assessment model for a particular satellite sensor. Optical properties of the water and its spectral response pattern in various wavelength regions for different type of pollutants are to be determined. Water sampling should be carried at some fixed points and the spectral reflectance of the same locations is obtained through ground truth radiometer. Quality parameters of the collected samples will be analyzed experimentally to find the pollutant levels. Relationship between the pollutant levels and its spectral response in various wavelength regions will be established. Multispectral or Hyper spectral data obtained from the satellite will be corrected for atmospheric corrections and the same will be calibrated with the radiometric values obtained from the ground truth radiometer.

Key Words: Remote sensing; Radiometer; Pollutant; Chlorophyll.

1. INTRODUCTION:

Precipitation in Indian subcontinent is through monsoons that are unevenly distributed. The excess amount of water during this period is harvested and stored for future use in different water bodies. Urban population is highly dependent on these water sources to satisfy their domestic water demands. Unfortunately, Industrialization and population explosion causes drastic changes in the water quality of these water bodies. Untreated or partially treated industrial effluents, domestic sewage with rich BOD content and fertile sediments reaching the storage structures are the main cause for this pollution. Current techniques for measuring water quality involve in-situ measurements and/or the collection of water samples for subsequent laboratory analyses. While these technologies provide accurate measurements for a point in time and space, they are expensive, and do not provide either the spatial or temporal view of water quality

needed for monitoring, assessing or managing water quality for an individual water body or for multiple water bodies across the landscape.

Remote sensing of indicators of water quality offers the potential of relatively inexpensive, frequent and synoptic measurements using sensors aboard satellites. Remote sensing applications to determine water quality are limited to measuring those substances or conditions that influence and change optical and/or thermal characteristics of the surface water properties. Suspended chlorophyll, suspended minerals, colored dissolved organic carbon, temperature, turbidity are water quality indicators that can change the spectral and thermal properties of surface waters and are most readily measured by remote sensing techniques (George and Malthus, 2001). Pollutants that do not change the optical and/or thermal characteristics of surface waters can only

be inferred by measuring surrogate properties (i.e. algal blooms) that responded to chemical inputs. The remote sensing techniques have the ability to provide both spatial and temporal views of surface water quality parameters that is typically not possible from in-situ measurements. Remote sensing makes it possible to monitor the landscape effectively and efficiently identifying water bodies with significant water quality problems.

2. MEASURABLE WATER QUALITY PARAMETERS BY REMOTE SENSING:

The essential water quality parameters are categorized as physical, chemical and biological. The physical except temperature and biological parameters cannot be quantified using remote sensing techniques. The chemical parameters like suspended sediments, chlorophyll, turbidity, secchi depth are spatially measurable through remote sensing techniques. Even though it is possible to quantify these pollutants with availability, it becomes difficult in the case of urban lakes due to the increased suspended particulate matter (SPM) levels. The poor radiometric and spectral resolution of the present satellites used for remote sensing may not be ideally suited for the quality estimation (Mumby and Edwards, 2002). Airborne hyper-spectral images with high spectral and spatial resolution are best suited for the estimation of pollutants.

3. RADIOMETRIC REFLEXES FROM THE POLLUTANTS:

Excessive nutrient contents in the open water bodies cultured by human activities results in rich algal bloom, the state commonly called as eutrophication. These chlorophyll concentrations can be easily mapped in near infrared band of the spectrum (Schalles *et.al.*, 1997). Suspended sediments concentration is important measure of water quality. These contaminants show good reflexes in visible and infrared bands (Ritchie and Schiebe, 2000). The chlorophyll content and suspended sediments act as surrogate data for the nutrient and other chemical content. The spectral coefficients are inversely, exponentially correlated to the secchi depth. Thermal infrared band is used to assess the surface temperature of the open water bodies.

The temporal and spatial distribution of chlorophyll concentration in the Gulf of Cadiz was analysed by remote sensing data from the Sea-viewing Wide Field-of-view Sensor (Navarro and Ruiz, 2006).

The problem lies in finding the optimum wavelength region to estimate the quantum of pollutants. Though the pollutants are identified by broader wavelength regions, the response shown by the pollutants are not similar within the region. Moreover, the pollutant levels do not show any distinct relationship with the spectral response. In the case of suspended sediment concentration, it is observed from the literature that 0 to 200 mg/l of pollutant has curvilinear relationship with the response and the variation is very high at 0.65 μm wavelength region (Ritchie *et.al.*, 1976). Above 200 mg/l the spectral response gradually saturates (Curran and Novo, 1988). The increased level of chlorophyll content has shown improved reflectance throughout visible and infrared bands. It shows a significant scattering in very narrow range of 0.7 μm to 0.705 μm and chlorophyll α absorption range 0.675 μm to 0.680 μm . So measuring the pollution in broad wavelength region proves to be difficult.

4. WATER QUALITY ASSESSMENT MODEL:

The spectral reflectance of the some locations in the open water bodies should be obtained through ground truth spectro-radiometer for different narrow wavelength regions and the samples are collected at the same points for laboratory analysis of different constituent pollutants. Correlation analysis between the reflexes in different wavelength and the concentration of pollutants are to be carried out. Regression analysis is carried out to model the relationship pattern existing between the concentration and response in particular wavelength region (Whitlock *et.al.*, 1982). Hyperspectral bands those are highly sensitive for the pollutants and their concentration are used to acquire imageries. These imageries were corrected radiometrically for the climatic variations. The regression model is applied on the specific bands to assess the pollution concentration and its spatial variation. Two spectral bands of the visible spectrum viz. [0.45- 0.52 μm (Blue), 0.52-0.60 μm (Green)] of satellite

images obtained by LANDSAT7 ETM. It has been used to follow the contaminated water (Vigonolo *et. al.*, 2006).

5. CONCLUSION:

Monitoring the water quality by sampling the water periodically is not a viable solution. The inland waters are recognized are optically complex and have spectral signatures that are composed of many overlapping spectral components. Remote sensing with its advancements in airborne hyper-spectral images is advantageous in deriving the pollution levels. A regression model could be developed after analyzing the sample data and same have to be applied on that specific ban to estimate the pollution level.

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