WATER QUALITY ASSESSMENT IN LAKES USING REMOTE SENSING

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ABSTRACT

Water quality of the fresh surface water sources like lakes and 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 Hyperspectral images from the remote sensing satellites can be used for assessment of spatial and temporal variation in water quality. Chemical parameters like suspended chlorophyll, suspended minerals, colored dissolved organic carbon, secchi depth and turbidity can be derived.

The paper attempts to give 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 reflectances of the same locations are 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 Hyperspectral 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.

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 lakes or reservoirs. 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 lakes. 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.

REMOTE SENSING THE WATER QUALITY PARAMETERS

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 available, 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.

RADIOMETRIC REFLEXES FROM THE POLLUTANTS

Excessive nutrient contents in the lakes 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 lake.

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 0.65μm 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 0.7μm to 0.705μm and chlorophyll-a absorption range 0.675μm to 0.680μm. So measuring the pollution in broad wavelength region proves to be difficult.

WATER QUALITY ASSESSMENT MODEL

The spectral reflectance of the some locations in the lake 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). Hyper-spectral bands that 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.

CONCLUSION

Monitoring the water quality by sampling the water periodically is not a viable solution. The inland waters are recognised 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 is to be developed after analyzing the sample data and same have to be applied on that specific band to estimate the pollution level.

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