Chapter 57
Water Quality Mapping of Yamuna River Stretch Passing Through Delhi State Using High Resolution Geoeye-2 Imagery

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ABSTRACT

The present article utilizes high resolution Geoeye 2 imagery for mapping and monitoring pollution concentrations of 22 km stretch of river Yamuna passing through Delhi state, by developing regression models between water quality parameters (WQP's) and the corresponding spectral reflectance values. Water samples collected from the sampling locations were analysed for 20 WQP's and grouped into four classes namely; $(WQP)_{organic}$, $(WQP)_{inorganic}$, $(WQP)_{anion}$ and $(WQP)_{cation}$. Several spectral band combinations as well as single bands were probed for performing multiple linear regression (MLR) analysis with the four WQP classes. Results reveal relatively strong positive correlations for band combination viz. [mean RGB × √B/R] with all four WQP classes yielding high R^2 value (~0.85) and RMSE (~1.03) amongst other selected band combinations. Spatial distribution maps were generated that substantiates to the actual in-situ pollution concentration levels thereby evidences the potential of high resolution Geoeye-2 imagery for monitoring and mapping pollution concentrations in the water bodies.

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INTRODUCTION

River Yamuna, the largest tributary of river Ganges originates from Yamunotri glacier at an elevation of 6387 m, at the Bander poonch peak in the Uttarkashi district of Uttarakhand. It serves as the primary source of drinking water for Delhi and other neighboring states of Uttar Pradesh, Haryana and Uttarakhand. Last few decades have witnessed severe deterioration in its water quality especially within the 22 km long stretch passing through Delhi state wherein significant water abstraction at Wazirabad barrage (entry point), ITO barrage (midway) and Okhla barrage (exit point) reduces the dilution capacity of the segment. The Delhi segment of river Yamuna is considered as the most polluted stretch since it receives wastewater from seventeen sewage drains of Delhi besides Najafgarh drain.

Determination of water parameters is used for description of the quality of water. Tests for physical/chemical parameters monitor the characteristics that affect the appearance, taste and odor of water but generally do not cause a health risk, while microbiological tests are for water borne organisms that could potentially cause disease. The quality of water is defined by its physical, biological and chemical compositions where chemical composition includes the organic and inorganic substances such as heavy metals, pesticides, detergents and petroleum. The physical composition comprises of turbidity, color and temperature, whereas the biological composition includes plankton and pigment (Allee and Jhonson, 1999).

In addition, some of the parameters that defines the criteria for healthy river water and are widely being analyzed in water quality based studies include pH, turbidity, dissolved oxygen (DO), total suspended solids (TSS), total dissolved solids (TDS), turbidity, total hardness as $CaCO_3$, biochemical oxygen demand (BOD), chemical oxygen demand (COD), calcium (Ca), magnesium (Mg), alkalinity, phosphate (PO_4), sodium (Na), potassium (K), sulphate (SO_4) and nitrate (NO_3) to name a few. Monitoring and assessment of these water quality parameters requires sampling from widely distributed locations which is time consuming and requires a lot of field and laboratory efforts to present statistical results (Singh, et al., 2013; Duong N. Dinh, 2012; Amandeep V., 2011; Kazi et al., 2009; Ekercin, 2007; Icaga, 2007; Wang et al., 2004; Silvert, 1998; Pattiaratchi et al., 1994). However, remote sensing in conjunction with Geographic Information System (GIS) provide better estimates and synoptic coverage of spatial distribution of pollution concentration in rivers and water bodies at a relatively less field efforts and at a cheaper cost (Choubey, 1998; Lindell et al., 1999).

Numerous studies have accounted for the scope of optical remote sensing based analysis towards monitoring and mapping the quality of water bodies using high resolution images (Usaliand Hasmadi, 2010; Dekker et al., 2002; Schalles et al., 1998; and Ritchie and Charles, 1996). Remote sensing satellites quantifies the amount of solar radiation at several wavelength sreflected by the surface water and are capable of providing spatial and temporal data that aids the analysis of changes in the water quality necessary for adopting the strategies for better management practices (Girgin et al., 2010; Zhang et al., 2003; Jensen 2000; Ellis, 1999; Fraser,1998; Kondratyev et al., 1998; Pattiaratchi et al., 1994).

Traditional methods for monitoring river pollutants in terms of water quality parameters (WQP's) by optical satellite data mainly rely on the spectral response of pollutants from the water body (Chavez, 1996). The spectral response towards WQP's can therefore be related by combining certain spectral bands and to generate pollution maps through regression models. The present study undertakes an attempt to monitor and map the spatial distribution of pollution concentrations corroborated by in-situ samplings at selected locations along 22 km Yamuna river stretch passing through Delhi while utilizing high resolutionGeoeye2 imagery. WQP's were grouped into four classes in accordance to their chemical