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Review Article

Statistical estimation of Rosetta branch water quality using multi-spectral data

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Abstract

This research aimed at assessing the approaching of Multi-Spectral Remote Sensing (MS-RS) data for estimating water quality (WQ) of Rosetta branch (RB) using stepwise regression technique. The methodology was based on developing an algorithm for estimating WQ using the Worldview-2 bands reflectance. Results showed that the optical WQ parameters as total suspended solids (TSS) and chlorophyll-*a* (Chl-*a*) were acceptably estimated using MS-RS data with high confident. The optical WQ parameters are the most likely affecting the reflected radiation that sensed by the satellite. However, this research expanded to select non-optical WQ parameters such as pH value and biological demand (BOD) that is less likely affecting the radiation reflectance, nevertheless, still correlated to optical WQ parameters. The determination coefficient showed significant high values for ortho-phosphate (OP), total dissolved solids (TDS), Chl-*a* and pH with different mathematical formulations depending on pollution level. The results showed that, it is promising to perform routine WQ monitoring programs on different water bodies, even for those has relative narrow width as RB, using MS-RS data.

Keywords: Rosetta branch; Water quality; Remote sensing; Worldview-2; Stepwise regression

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1. Introduction

Egypt faces a rapidly increasing deterioration of its surface and groundwater due to heavy discharges of polluted domestic and industrial effluents into its water bodies. In addition, excessive use of pesticides and fertilizers in agriculture also causes water pollution problems (Jahin et al., 2009).

According to Rifaat and Mohamed (2004) the Nile River system receives a large quantity of industrial, agriculture and domestic wastewater; however, it is still able to recover in virtually all the locations, with very little exception. The Rosetta branch (RB), as part of this system, flows downstream Delta Barrage to the north-west about 225 km and ends with Idfina barrage which regulates the excess flow of the branch. It is considered the main source of fresh water for the western side of the Nile Delta. Idfina barrage regularly releases water to the Mediterranean Sea during winter closure period.

Along RB, there are two main causes of pollution which degrade the quality of water. These are agricultural and industrial points discharging directly into the branch. The major agricultural source, further Talla and Sabal drains, is Rahawy drain. The significance of that drain is that, besides agriculture drainage water, it carries sewage effluents of a side of great Cairo (i.e., about 2.2 million m^3/day) besides some industrial effluent. These effluents would conceivably alter the composition of natural environment of the branch and consequently affect the ecological conditions prevailing (El Gammal and El Shazely, 2008).

The traditional measurement of water quality requires in situ sampling, which is a costly and time-consuming effort. Because of these limitations, it is impractical to cover the whole water body or obtain frequent repeat sampling at a site. This difficulty in achieving successive water quality sampling becomes a barrier to water quality monitoring and forecasting (Senay et al., 2001). It would be advantageous to watershed managers to be able to detect, maintain and improve water quality conditions at multiple river and lake sites without being dependent on field measurements (Shafique et al., 2003).

Remote sensing techniques have the potential to overcome these limitations by providing an alternative means of studying and monitoring water quality over a wide range of both temporal and spatial scales. Several studies have confirmed that remote sensing can meet the demand for the large sample sizes required for water quality studies conducted on the watershed scale (Senay et al., 2001). Hence, it is not surprising that a significant amount of research has been conducted to develop remote sensing methods and indices that can aid in obtaining reliable estimates of these important hydrological variables. These methods ranged from semi-empirical techniques to analytical methods for estimating and producing quantitative water quality maps (Dekker, 1997 as cited in Shafique et al., 2001). Several research articles (Gitelson et al., 1993; Dekker et al., 1996, 2002) had developed different prediction models for lake water quality parameters using satellite spectral bands with several ratios or indices. These water quality parameters have included chlorophyll-*a*, suspended matter and turbidity, as they most likely change the water color.

Most satellite remote sensing studies have chosen optical property parameters such as chlorophyll *a*, turbidity or colored dissolved organic matters (Coskun et al., 2008). Recently, there have been some studies advocating for the use of a satellite remote sensing approach to determine nutrient distributions in lakes because of the advantage of synoptic coverage that is not available from traditional sampling methods (Chen and Quan, 2012). Few studies have attempted to monitor and model nutrient data, since these models do not yield results as statistically strong or consistent as constituents that have optical properties (Chen and Quan, 2012; Dewidar and Khedr, 2001; Wu et al., 2010). Dewidar