RESERVOIR WATER QUALITY MONITORING IN RAWAL LAKE USING GEOINFORMATICS

I. Ahmad, M. D. Anwer and Z. Ahmad*

College of Earth and Environmental Sciences, Punjab University, Lahore
*Department of Earth Sciences, Qaid-e-Azam University, Islamabad
Corresponding author e-mail: hydromod@yahoo.com

ABSTRACT: The objective of this study was to assess the potentials of remotely sensed data for estimation of water quality parameters in the water bodies. The assessment was based on the field measurements, laboratory examination and data analysis of hyper spectral data. The hyper spectral data were integrated into Landsat 7 ETM (Enhance Thematic Mapper). Examination of correlation of simulated Landsat data reveals that multiplicative two band approach by using Band 5 (short wave infrared) and Band 4 (NIR) is best predicator of total dissolved solids (TDS) in water bodies. The ratio Band 5/ Band 4 is also mostly correlated with electrical conductivity. The simple ratio of Band 5 and Band 4 is also used for salinity in water. These three parameters are observed in Band 5 and Band 4 because these three have a strong correlation with each others. For estimation of turbidity multiplicative band approach using (Band1+Band 2/Band 3+ Band 4) was used. The formulas/ algorithms were developed for the study area. The developed algorithms have potential for the estimation of water quality parameters in inland waters. This research work demonstrates an example for the feasibility of remotely sensed data for effective and efficient assessment of total dissolved solids, electrical conductivity, salinity and turbidity in water bodies or reservoirs.

Key word: water quality, electrical conductivity, total dissolved solids, remote sensing.

INTRODUCTION

Synoptic information on water quality is difficult to obtain from a routine in-situ monitoring network. The conventional point sampling campaigns do not give either the spatial or temporal view of water quality needed for accurate assessment and management of water bodies. The conventional method, while accurate for a point in time and space, are time consuming and expensive also therefore, the difficulty of overall and successive water quality sampling becomes a barrier in water quality monitoring, forecasting and management. Remote sensing makes it possible to monitor the water bodies effectively, efficiently, and identifying areas with significant water quality problems. Remote sensing is a tool and technique that provides a platform for large-scale synoptic observations and continuous monitoring of water bodies.

Gordon and Morel (1983) concluded that optical satellite data can present a synoptic monitoring of surface water quality, since oceanic (Case I) waters are optically simple. Gitelson et al. (1993) had developed the empirical regression formulas for the prediction of lake water quality parameters from spectrometer data by employing spectral ratios, typically reflectance ratios, as the independent variables. Cairns et al. (1997) said that the remotely sensed data have widely been used to estimate major water quality variables such as chlorophyll-a, turbidity, suspended sediment concentration, Secchi disk depth, surface water temperature, wave height, and sea surface roughness. Fulk (1999) during a study on a river system in southwest Ohio that included the Great Miami River using Airborne Spectrometer Imager (CASI) suggested that the many bands available in the hyperspectral sensors allow researchers to detect these water quality parameters unlike the few coarse bands of the multispectral sensors. Ahmed (2000) studied to evaluate the potential of using remotely sensed digital data from Landsat satellite (TM sensor), to extract information that help in the monitoring system for Alexandria coastal water quality. Shafique et al. (2001) suggested that the remote sensing could overcome many constraints by providing an alternative means of water quality monitoring over a greater range of temporal and spatial scales. Shafique et al. (2001) resulted that the monitoring of water-quality parameters, such as chlorophyll *a,* turbidity, and suspended sediments, can be done more effectively with hyperspectral data because there are more bands and better spectral resolution. Bhatti (2006) demonstrated the feasibility of remotely sensed data for effective and efficient monitoring of suspended sediments, total suspended sediments; chlorophyll and color dissolved organic matter (CDOM) in water bodies. The band ratioing technique has proven to be advantageous because it tends to allow compensation for variations from atmospheric influences. Jamil and Nazeer (2009) investigated the usability of satellite imagery and Secchi disk data for estimating water quality patterns in Rawal Lake. By predicting the values of SDT (Secchi

Disc Transparency) with the help of regression model they made a retrospective analysis on the past conditions of lake water.

The research work was performed on Rawal Lake (Islamabad/Rawalpindi, Pakistan); a large artificial reservoir catering for the water needs of Islamabad/ Rawalpindi. This glistening man-made lake covers an area of 8.8 sq. km (Figure 1). Water supply from Rawal lake to Rawalpindi and Islamabad is 19.5 million gallons/day and 2.5 million gallons/day respectively.

Basic objective of the study was to determine whether remote sensing technology along with the conventional methods can prove to be a better water quality monitoring tool or not. Present work was carried out to develop simple formulas/ algorithms and to create maps which show the spatial distribution of the water quality parameters in Rawal lake.

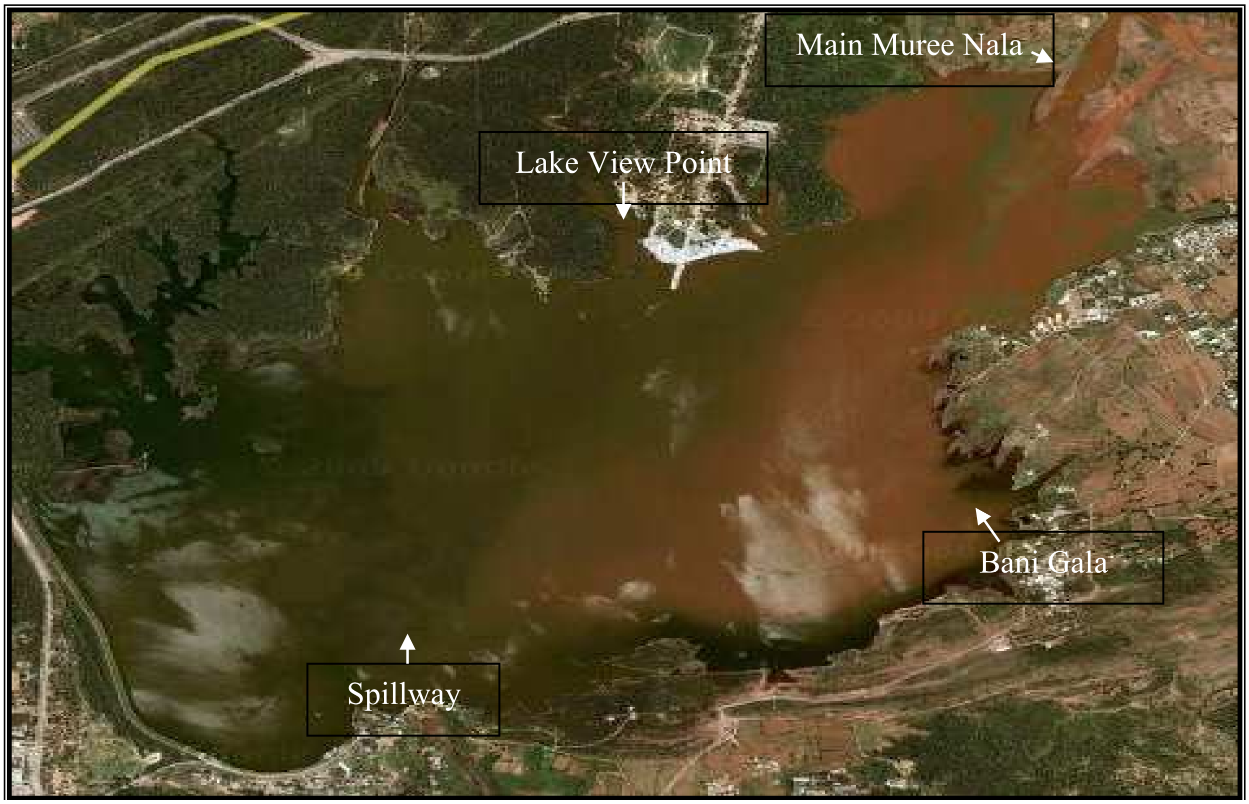

Figure 1: Study area (Source: Google Earth, 2011).

MATERIALS AND METHODS

i. **In-Situ Measurements:** In in-situ measurements, 50 samples were collected from selected sites which were recorded by GPS and brought back to lab where these were analyzed for total dissolved solids,(TDS) (mg/l), Electrical Conductivity, (EC) (µS/cm), Salinity and Turbidity (NTU). The results were obtained and used for further study.

ii. **Satellite Imagery Analysis:** In this phase Landsat-7 ETM data was used and spectral signatures were formed for the selected sampling sites which were interpreted and used in the formation of simple algorithms/ formulas for different parameters. The formulas are:

TDS (mg/l) = (Band 4/Band 5)*T
[T=150 for Rawal lake]

EC (µS/cm) = 2*[(Band 4 /Band 5)*T]
[T=150 for Rawal Lake

Salinity = (Band 4 /Band 5)/S
[S =10 for Rawal Lake]

Turbidity (NTU) = [(Band1+Band2)/ (Band3+Band4)]*N
[N= 5 for Rawal Lake]

iii. **Development of GIS layers:** In this phase the results obtained from in-situ measurements and satellite image were used and maps of study area developed which show the spatial distribution of specific parameters. Maps for spatial distribution of TDS, EC, turbidity and salinity were prepared.

RESULTS AND DISCUSSION

From the results it is evident that the values calculated from remote sensing data for the water quality parameters concide closely with the lab observed results. However a minor variation does exist in the values. If we look at the graph for TDS values, there is a difference of ± 20 between the observed and computed values (Figure 2).

So it can be said that remote sensing is an effective technique to monitor the water quality with an error of ± 25% without field validations. But the field validations are necessary. This error could be minimized by using high resolution data with up-to-date recording. Map showing TDS distribution in Rawal lake is presented in Figure 3. Maps showing EC, turbidity and salinity distribution are not shown to conserve space.

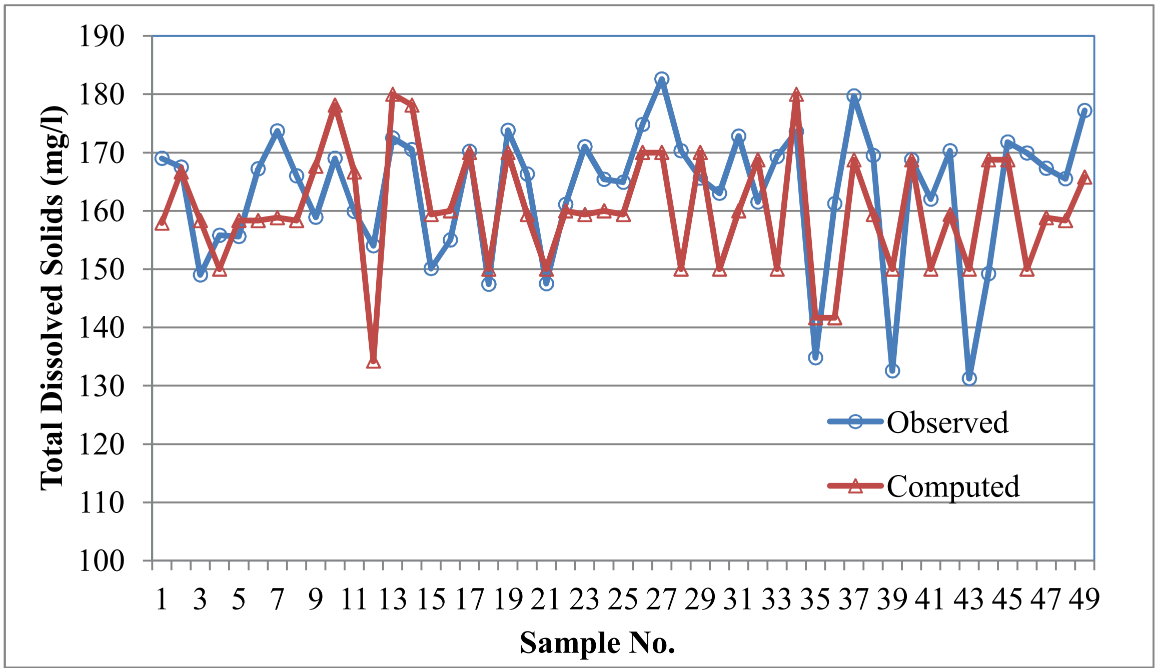

Figure 2 Comparison of Observed and computed Total Dissolved Solids values.

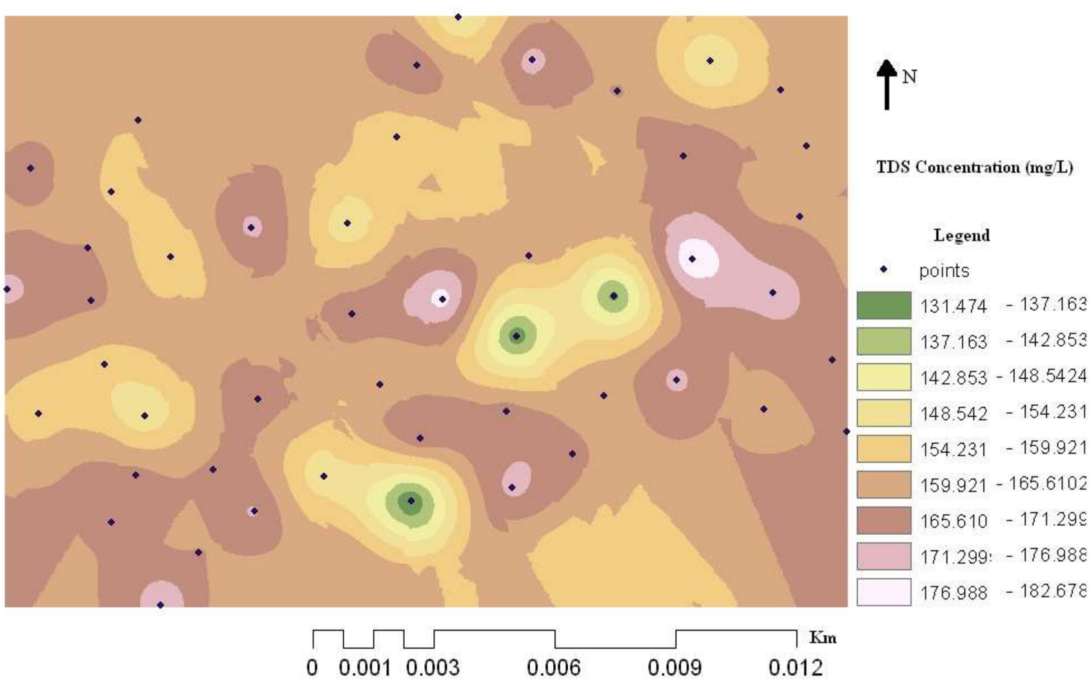

Figure 3 Map showing TDS distribution (mg/l) in Rawal lake

Conclusions and Recommendations: Remote sensing in couple with in-situ measurements is an effective tool and technique for monitoring water quality parameters. The ratio of Band 4/ Band 5 is the best predicator of TDS, EC and salinity. Turbidity was found to be correlated with (Band1+Band2)/ (Band3+Band4). More frequent and regular analysis should be done and a high resolution remote sensing data like ALOS etc should be used for more accurate results. Thus remote sensing along-with the conventional method indicated better performance for the spatial estimation of water quality in Rawal Lake.

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