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A Study of Himreen Reservoir Water Quality Using in Situ Measurement and Remote Sensing Techniques

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Abstract
The use of remote sensing and GIS in water monitoring and management has been long recognized. This paper is an application of remote sensing technique and in situ measurement for monitoring water quality parameters of Himreen Dam reservoir water. Himreen dam constructed in 1980 lies in Diyala governorate east part of IRAQ is used mainly for Control Diyala river flood and power generation.

The output results shows that high correlation found between reflectance values were extracted from landsat TM 1989 and ETM+ 2002 images with water depth and its turbidity and there is no sources of thermal pollution in water. Generally, Himreen reservoir water can be classified according to the standard Specification (US Standards) as good medium salt water.
Keywords: Remote sensing, Water quality, Himreen reservoir, Landsat TM and ETM+ images.

Introduction

Water is valuable natural resources that essential to human survive and the ecosystems health. The characteristic of water can be categorized into three namely physical, biological and chemical. These characteristics are used in water monitoring program. *In situ* measurements and collection of water samples for subsequent laboratory analyses are currently used to evaluate
water quality. These measurements are accurate for a point in time and space but do not give the spatial and temporal view of water quality in wide space. Thus, the technologies such as remote sensing and GIS are very useful as a tool in evaluating and monitoring water quality(5).
Although remote sensing has proven useful for water quality monitoring, it will never replace traditional field surveying and sampling. However, when coupled with such techniques, remote sensing can enhance and complement existing approaches to maximize resources and cost effectiveness

The technology of remote sensing can be considered as a fast method for quantifying the suspended solids in surface water in our days, which offers a unique method of data collection and analysis for water resource managers and engineers. This technology, like all others, has its capabilities and limitation. Also this technique is increasing capability of providing precise and updated information on suspended solids in surface water.

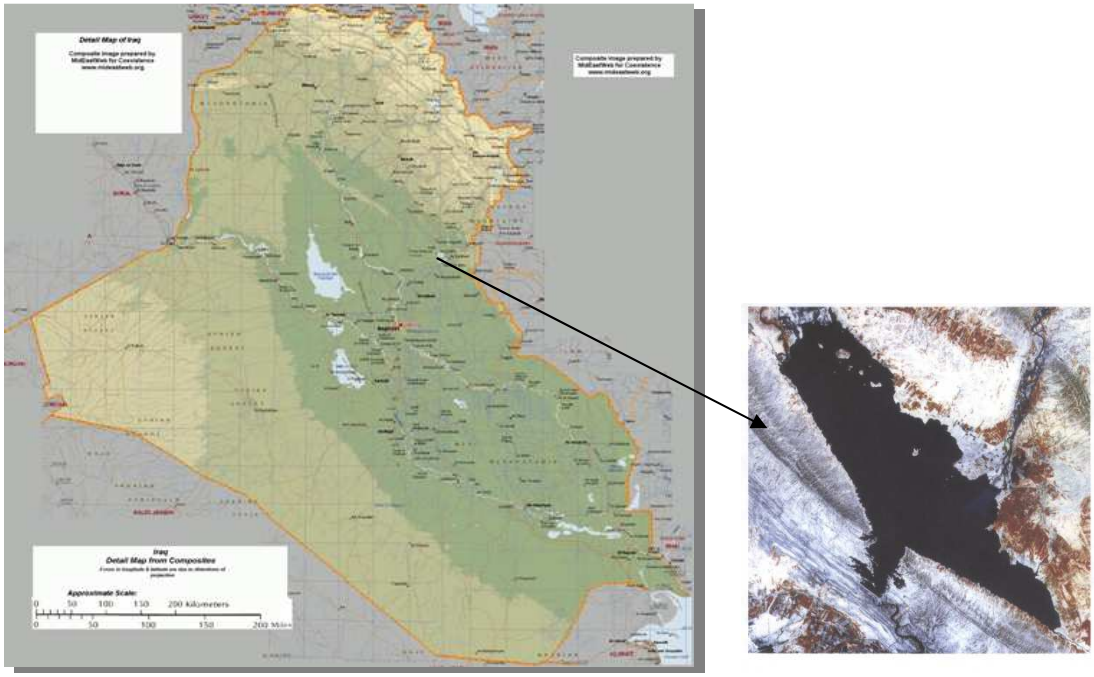
Suspended sediments cause several technical problems in reservoirs, dams, and turbines of electrical energy generation stations which depend on water energy. Therefore it is very important to study suspended sediments in water, its seasonal changes, and the percent of its concentrations.

The purpose of this research is to study some quality parameters of Himreen reservoir water, measured spectral characteristics of water from landsat images data and noticed the effect of suspended sediment on water quality.

Himreen Reservoir Description:

Along the course of Diyala river two major dams exist, these are Derbendikhan dam in the extreme north of the river and Himreen dam in the middle parts of the basin. Both reservoirs is considered as multi-purpose reservoir providing the following:
1. Control of Diyala river flood.
2- Regulation of Diyala River for supplying of water for irrigation.
3- Power generation utilizing regulated outflows for irrigation requirements.
4- Meeting municipal and industrial downstream requirements.

Himreen dam lies in the intersection of Himreen mountain with Diyala river, about 10 km from the position of Diyala fixed dam which is known in the name of Al-Sodor. The dam was constructed in 1980; it is 3360 m long and 40 m in height and it has a spillway of 70 m wide with five gates which gives a maximum discharge of 4000 cubic meter per second (figure-1).



Fig(1) **GPS Coordinates of Himreen reservoir : N 34° 10' 43.58", E 45° 00' 17.17"**

Climate of Himreen Reservoir Area

Climate is considered one of the most important factors that affect environmental components of water, air and soil. The climate of Himreen reservoir area is characterized by large changes throughout the year. Long hot summer with as well as short winter with limited and seasonal rainfall. The maximum mean monthly temperature for the period of study was during July is 44 ^{0} c and the minimum during January is 15^{0} c. Table (1) shows average mean annual values of temperature, rainfall, relative humidity and evaporation for the period of study.

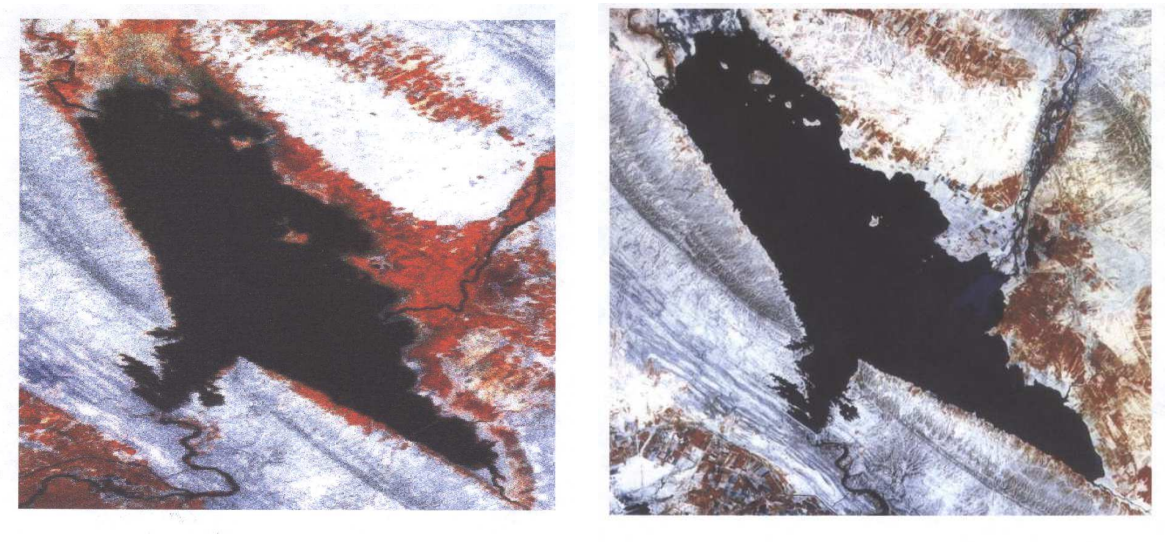
Table(1) Average mean average values of temperature, rainfall, relative humidity and evaporation (6)

Mean annual Temperature (c^{o})	Minimum mean annual Temp (c^{o})	Maximum mean annual Temp (c^{o})	Average mean annual Rainfall (mm)	Average mean annual Relative Humidity(RH%)	Mean annual Evaporation (mm)
23	16	30.5	21	47	739

Practical Work

Data sets used in this study are:-

1- Two Landsat images dated 06/9/1989, and 06 sep. 2002 for Himreen reservoir. The two Landsat images are shown in figure (2-a & 2-b) show the region of study which represents Himreen reservoir.



a- Landsat TM 1989 **b- Landsat ETM+ 2002**

Fig(2) Himreen reservoir satellite images

2- Water Laboratory tests: - obtained from General Management of Reservoir and dams. These tests were carried out at the same date of the two of Landsat images. Water tests included, total dissolved solids (TDS), Electricity (EC) and (PH) value.

For temporal analysis of Himreen reservoir water quality , 12 sample locations have selected in Himreen reservoir as shown figure (3).

Fig. (3) 12 Selected locations in Himreen Reservoir

It is well known that there is positive relationship between suspended material and water reflectance, increasing in the concentration of suspended sediments in surface water will cause increasing in the radiant energy reflected from these sediments which are suspended in surface water. This principle is basic principle of digital processing detection of water with high suspended martial from satellite images. The contour values of selected location points is given in table(2).

Table (2) Contour values for 12 selected points (2)

Locations	Contour (m)
1	110
2	90
3	90
4	110
5	105
6	100
7	100
8	105
9	95
10	90
11	105
12	100

Spatial analysis of ARCGIS software is used to produce reflectance distribution maps for 1989 and 2002 landsat image bands, as shown in figuers (4) and (5).

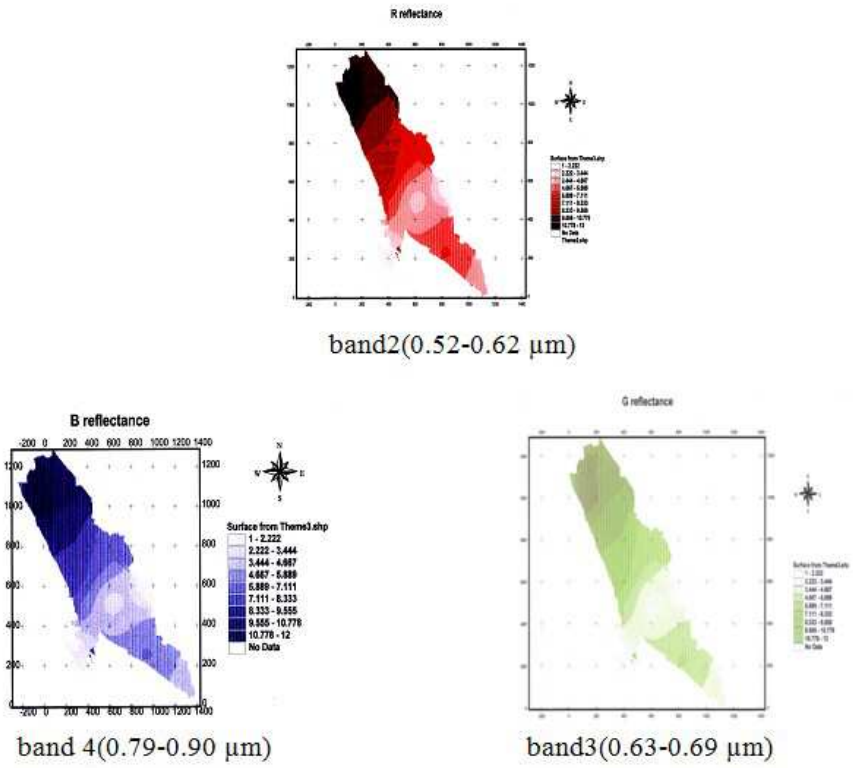


Fig. (4) Reflectance Distribution of Landsat TM, 1989

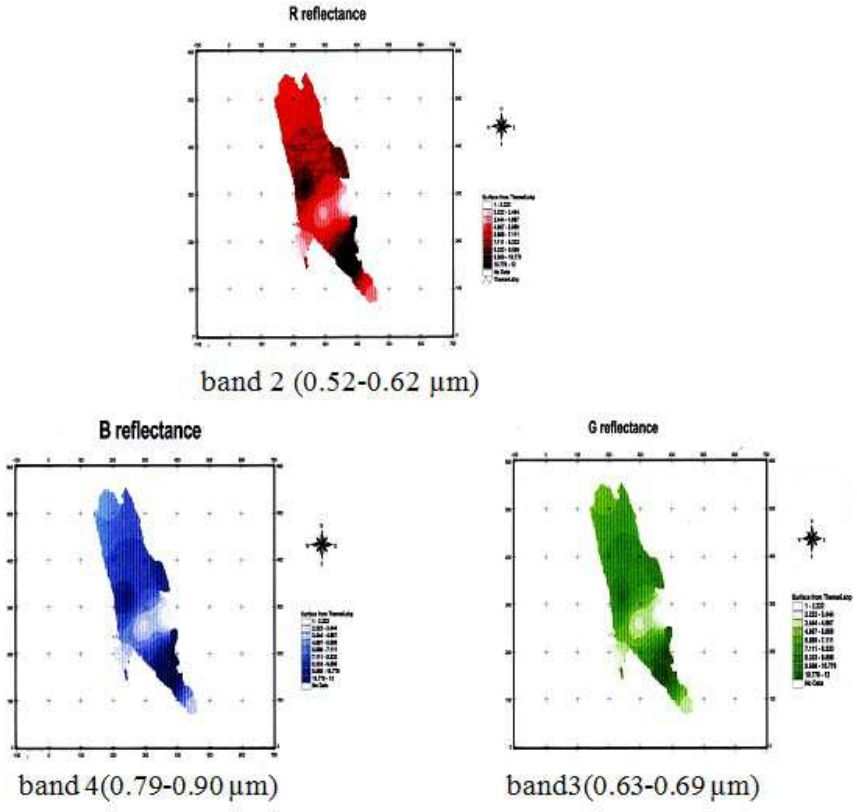


Fig. (5) Reflectance Distribution of Landsat ETM+ 2002

It can be clearly noticed that reflectance values in the meeting region of Diyala river with Himreen reservoir in 1989 image was higher than 2002 image. That means low concentration of suspended sediments carried out in 2002 by Diyala river.

Thermal Detection:

For the surface temperature estimation, the radiation emitted from the target on the surface is measured by using thermal infrared region (10.4-12.5 µm) of landsat image. Surface temperature of wide areas can be extracted under assumption that satellite sensor should have proximity to the black body. In this study we estimated the surface temperature using NASA model. The digital numbers were transformed into absolute radiance (7); Using:

Lλ = GAIN * DN +OFFSET

This can also be expressed as:

Lλ = (Lmax - Lmin)/255 * DN + Lmin

Where: Lλ is the spectral radiance, Lmin and Lmax [mW cm -2sr -1 µm-1] are spectral radiances for each band at digital numbers 0 and 255 respectively.

The spectral radiances (Lλ) were converted into effective at-satellite temperatures T by:

T= K2 / ln (K1 / Lλ +1)

Where: K1 = 666,09 w*m -2 *sr -1 *µm-1 and K2 = 1282.71 K respectively.

From the thermal band of Landsat 1989 and 2002 images, the surface temperature of Himreen water was found to be around (27 C^0) for all regions of reservoir for both dates. The temperature of Himreen reservoir water is homogenous which means that there is no thermal pollution waste thrown in reservoir.

Himreen Reservoir Water Quality

From the results of reservoir water laboratory test (from General Management of Reservoirs and Dams - Ministry of Water Resources) and water temperatures (from landsat images) as shown in table (3).

Table (3) Watery Year 1989 – 1990

Date	PH	EC (µm/CM)	TDS (PPM)	Temp(c)
Sep 1989	**8.18**	**510**	**330**	**27**
Sep 2002	**7.87**	**584**	**391**	**27.3**

The water of Himreen reservoir lake classified as good quality for drink and irrigation with medium salt water according to U.S classification standards of water quality given in tables (4&5) below:-

Table (4) US Standards (4)

WATER CLASS	TDS (mg/L)
Low salt	0 - 160
Medium salt	160 - 480
High salt	480 - 1440
Very high salt	1440 - 3200

Table (5) US Standards (4)

Adequate for agriculture	Water nature	EC (µc/cm)
Excellent	Low salt	100 - 250
Good	Medium salt	250 - 750
Accept	Highly salt	750 - 2250
Bad	v-highly salt	2250 - 5000

Digital Image Classification

Classification is the process of grouping pixels or regions of the image into classes representing different ground-cover types.

Maximum Likelihood classification (MLC) technique is used to classify 1989 and 2002 landsat images .The study area images were classified to five classes represent deep water, shallow water, barren land, rocks and vegetation. Figures (6 &7) and tables (6 &7) shows the result of supervised classification for 1989 and 2002 images.

Classified 1989 landsat image shows the distribution of deep and shallow water through reservoir. The meeting region of Diyala river and Himreen reservoir, shows shallow water region (high concentration of suspended sediments) , it can be easily noticed that the region near the Dam appears as a deep clear water region(low concentration of suspended sediments) .

Also it shows that Diyala river before meeting Himreen reservoir appears with a cyan color which refers to shallow water region with high concentration of suspended sediments. The high concentration of suspended sediments in Diyala river results from soil erosion process which occurs on both sides of Diyala basin and also from sedimentation process.

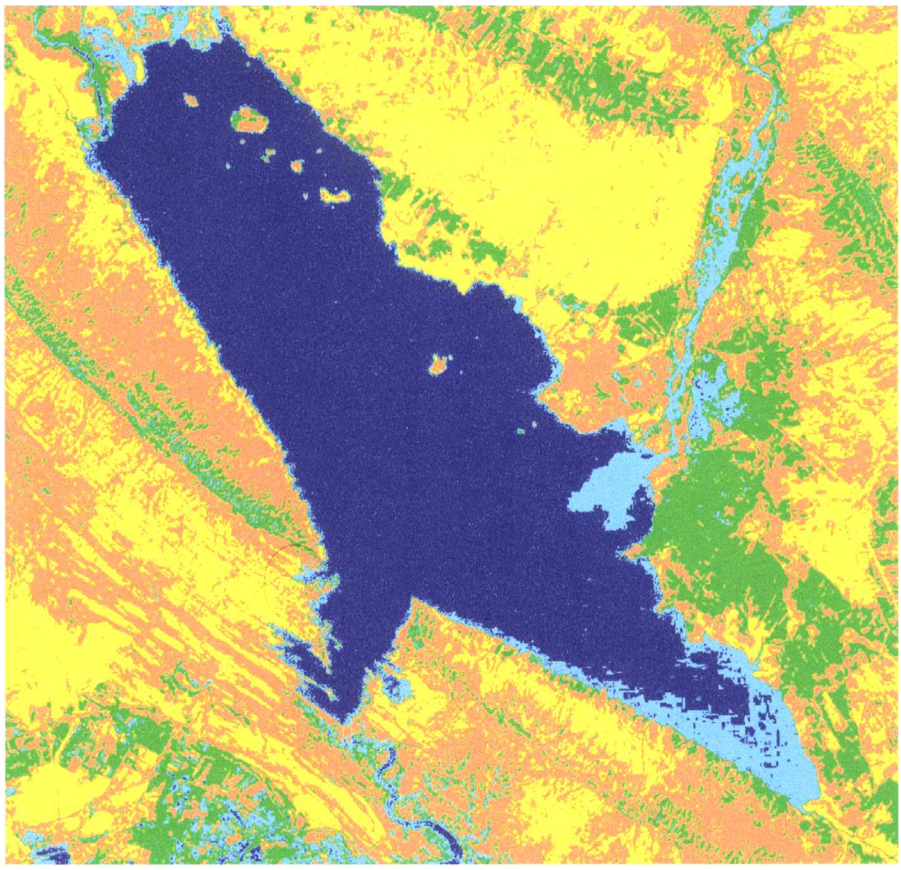


Fig. (6) Classified Landsat ™ Image, 06 Sep. 1989

Table (6) Statistical Information of the (1989) classes.

CLASSES	COLOR	DESCRIPTION	AREA %
1	Blue	Deep water	22.667
2	Cyan	Shallow water	6.0646
3	Yellow	Barren land	23.3394
4	Coral	Rocks	35.0713
5	Green	Vegetation	12.8580

Classified 2002 landsat image shows that some shallow highly concentration of suspended sediments water regions disappeared, except some regions in the north edges at Himreen reservoir. Diyala river appears as a shallow water region with high suspended sediment concentration, which results from soil erosion and sedimentation.

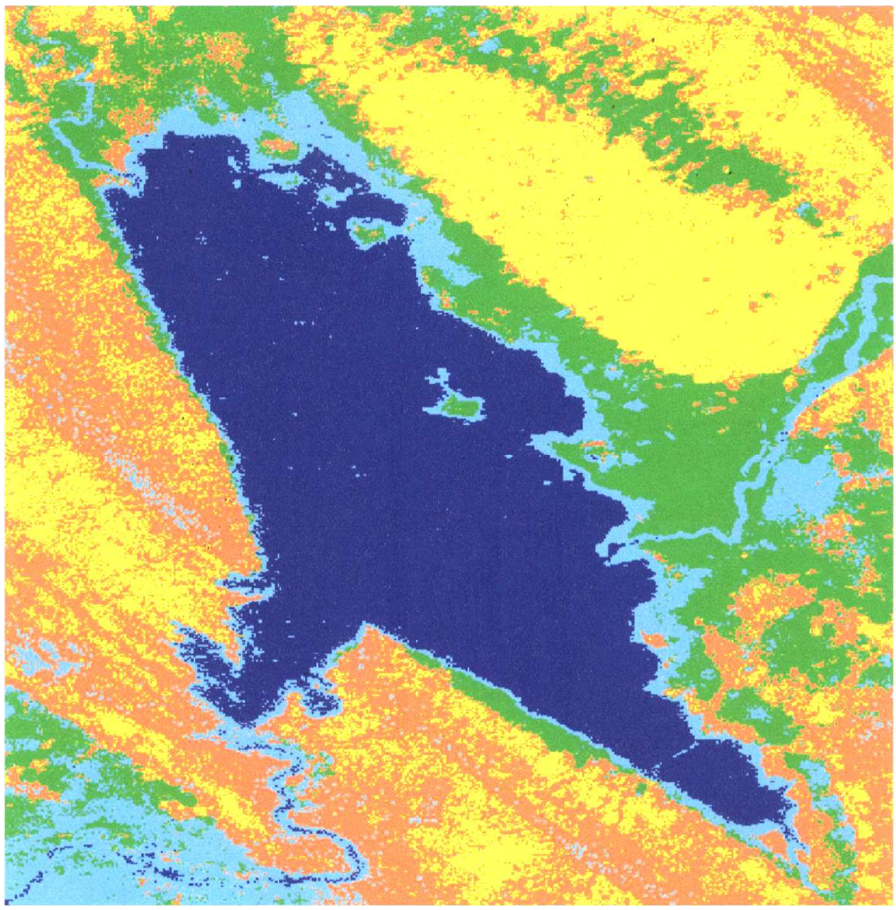


Fig. (7) Classified Landsat ETM+ Image, 06 Sep. 2002

Table (7) Statistical Information of the (2002) classes.

CLASSES	COLOR	DESCRIPTION	AREA %
1	Blue	Deep water	23.2124
2	Cyan	Shallow water	11.6486
3	Yellow	Barren land	20.6984
4	Coral	Rocks	28.5775
5	Green	Vegetation	15.8631

Conclusion

The results are summarized as

1) Suspended Sediments are the most common pollutants (in terms of volume and mass) in surface water. Increase in concentration of suspended sediments lead to increasing in reflectance of water, or (water reflectance).
2) Incapability of determining the type of suspended materials in water by using remote sensing techniques, unless connected to field measurements with image numerical density and performing a comparison.
3) Surface area of 2002 reservoir was less than area of 1989 year that due to the fluctuation in rainfall, shortage of water supply from Diyala river and increase of temperature with time in the study area which indicate the effect of regional climate changes.
4) Himreen reservoir Water can be classified according to the range of the standard Specification (US Standards) as good medium salt water.

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