Water Quality in Landsat OLI Images

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Abstract: *Remote sensing images are representation of the earth's surface as seen from space without any physical contact. It generally detects the surface feature through reflectance of matter and represents various Digital Number (DN) values. In the context of water it also represent DN values according to reflectance of water properties, whatever it can detect from the space. Landsat Operational Land Image (OLI) is more effective to detect the surface features. It has been used to detect water body. The surface water quality is not same all over the surface so the energy absorption and relaxation is not the same. The DN value of surface water is changed due to the change of chemical properties of water. It will be a fundamental study to explore the relationship between DN value and water quality. This research explores a complete integration of DN values of Landsat OLI satellite image with same surface water quality, which are collected from several points. The chemical properties of collected surface water, which are analyzed through lab and is integrated with DN value of the Landsat OLI satellite images. The variations among the chemical properties of collected surface water and the DN values of the exact Landsat OLI images are categorized within an index. The correlations between surface water quality and DN values of Landsat OLI are investigated in this research.*

Keywords: Remote sensing, Satellite image, Landsat OLI, DN values, Water quality

1. INTRODUCTION

Remote sensing is a technology to acquire data of any object without physical contact. Remote sensing is used to land use pattern and change detection of temporal variations. Remote sensing techniques have widely been used in water body assessment (Alparslan et al., 2007, Brando and Dekker, 2003, Chen et al., 2007, Giardino et al., 2007, Hadjimitsis and Clayton, Kondratye et al., 1998, Koponen et al., 2002, Pozdnyakov et al., 2005, Ritchie et al., 2003, Seyhan and Dekker, 1986, Wang and Ma, 2001). The landsat OLI (operational land image) have high resolution band those are reflected by the water and its substance materials. The water quality depends on the dissolve and substance materials (Dekker et al., 1995). There is a variation between the reflection of fresh water and polluted water. The presence of dissolve materials represents water quality. Water color depends on the absorption and scattering of light by organic and inorganic constituents present in the water (Bukata, 2005). Suspended materials absorb the energy. The absorption and reflection depends on the amount of suspended materials and other components of water. Suspended sediments increase the radiance emergent from surface waters in the visible and near infrared proportion of the electromagnetic spectrum (Ritchie et al., 1976). The water body is more reflected in band 3 (green band) and less reflected in band 5 (NIR band). By using this band, the water depth is detected but the water quality can also be detected by using this band. The reflectance of polluted water and the reflection of depth water are not same, as a result the DN value or signature also not same. The variation of DN value is estimated by the variation of ground water quality.

The main aim of this research is to explore the relation between the surface water quality and Landsat OLI image of different locations. The specific objectives are:

1. To detect the DN value or signature of a particular point from Landsat OLI bands.
2. To identify the surface water quality and
3. To explore the relation between water quality variation and DN value.

2. STUDY AREA

Seven particular locations have been selected for collecting water samples. This area of interest has been selected by satellite image investigation and Google earth observation. The surface locations of these points have been identified by using Global Positioning System (GPS). The Landsat OLI satellite image and locational references of water samples have been shown in Figure 1 and Table 1.

Table 1: Sample references

Satellite Image Reference: LC81370442016351LGN00 / 16 December 2016					
Id	**Longitude**	**Latitude**	**Id**	**Longitude**	**Latitude**
A	90°19'53.466"E	23°54'29.996"N	E	90°14'21.658"E	23°50'43.233"N
B	90°20'34.77"E	23°50'40.622"N	F	90°15'1.721"E	23°54'16.119"N
C	90°20'33.084"E	23°49'36.422"N	G	90°14'29.126"E	23°54'10.053"N
D	90°15'33.169"E	23°47'51.585"N			

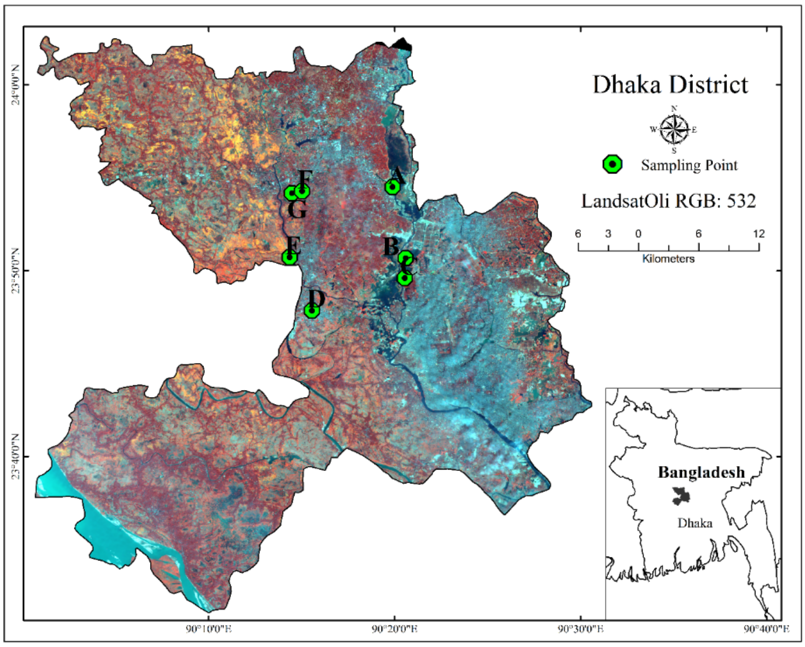

Figure 1. The locational of water sample

3. DATA AND METHODS

The water quality data has been collected from area of interest at the same time and the fixed selected coordinates. This collected water sample has been processed by lab analysis. The DN value of Landsat OLI has been collected by using normal band detection and NDWI (Normalized Deference of Water Index) model. The DN values of Landsat OLI have been created by the reflection and absorption intensity of water. The green band is more reflected by water and dissolved materials in water. The NIR infrared band is more absorbed in water and dissolved materials (McFeeters 1993). A model stands on (Green band -NIR band) / (Green band + NIR band), that is known as NDWI model. This equation has been used to identify the water quality in this research. The collected DN values and parameters of the water quality have been analyzed by statistical analysis (Figure 2).

4. RESULTS AND DISCUSSION

The integration of DN values with the water quality of the selected water samples are the focus of this research. Several parameters of water have been identified in laboratory analysis, such as pH, TDS, DO, Turbidity and EC. The parameters of different types of water depend on the sources of water such as sea water, ground water and surface water.

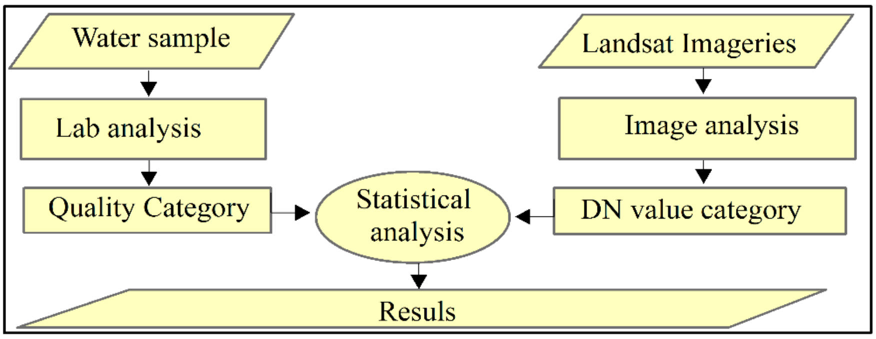

Figure 2: Data processing approach

Optimum reflectance: Water quality is affected by dissolved materials and substances in water body (Dekker et al., 1995). Suspended sediments and materials increase the radiance of surface water in the electromagnetic spectrum (Ritchie et al., 1976). Satellite sensor creates the DN value according to the electromagnetic spectrum or surface water radiance. The results of DN value depend on the target objective and band of satellite image. The reflectance of each band is not equal or optimum. The DN value of particular band has been distinguished by target. The blue, green, red and NIR bands of Landsat OLI reflectance are minimum for water body, but NDVI reflectance is optimum for quality exploration (Table 2).

Table 2: Satellite image properties

Id	Blue Band	Green Band	Red Band	Mean of True Color	NIR	NDWI	Temperature (°C)
A	75	47	59	60	15	214	20.12
B	69	71	52	64	28	192	20.2
C	4	21	33	19	18	224	20.32
D	7	57	47	37	26	187	20.91
E	29	25	49	34	28	184	20.45
F	66	77	75	73	92	142	20.98
G	4	8	15	9	11	229	20.11

Water Quality: The water quality of the collected samples is determined in lab analysis. The pH, TDS, DO, Turbidity, EC and temperature have been used to determine physical properties of water. The temperature has been detected by using band 10 and DN value is converted to radiance value. The radiance value represents the kelvin and centigrade (Table 3).

Table 3: Water quality

ID	pH	TDS (mg/l)	DO (ppm)	Turbidity (FTU)	EC (μs/cm)	Temperature (°C)
A	8.3	656	3.6	21.16	95.3	20.12
B	7.81	209	3.56	18.35	65	20.2
C	7.41	742	0.1	28.04	92.7	20.32
D	7.43	303	0.21	8.28	51.2	20.91
E	7.36	498	2.11	35.58	64.7	20.45
F	7.13	223	3.7	6.09	64.3	20.98
G	7.24	1183	3.42	27.82	131.8	20.11

Water Quality and DN value: The DN values are affected by sediments, physical properties and dissolve materials (Potes et al., 2012). The electromagnetic energy is influenced by water quality.

There is a relation between DN values and the physical properties of water. The NDWI values and water parameters have been categorized according to minimum to mean-1σ, mean-1σ to mean, and mean to maximum. The A, B, C, D, E, F and G geospatial points are represented by the frequency of occurrence (Table 4). The frequency of occurrence has focused the relation between water quality and Satellite Image.

Table 4: Category of water parameter

Parameter	Minimum to Mean-1σ	Mean-1σ to Mean	Mean to Maximum
NDWI	F	B,D,F	A,C,G
pH	E,F,G	C,D	A,B
TDS	D,F	E	A,C,G
DO	E,D	F,G	A,B,C
Turbidity	B,D,F	A	C,E,G
EC	D,F	B,E,F	A,C,G
Temperature	Detected by band 10 of Landsat OLI		

The NDWI is more fruitful in TDS, EC and Turbidity, here the correlations are always strongly positive. The NDWI and pH have positive correlation and DO have negative correlation (Table 5).

Table 5: Correlation of NDWI and water parameter

Parameter	**TDS**	**pH**	**DO**	**Turbidity**	**EC**
NDWI	0.8	0.34	-0.13	0.43	0.77

The trend analysis of NDWI and others parameters have shown that the NDWI values have more optimum results for TDS, Turbidity and EC. The temperatures of satellite image have thermal band (Band 10 or 11 of Landsat OLI). In this analysis, the pH and temperature is interrelated so the thermal band of Landsat OLI is more effective for pH (Figure 3).

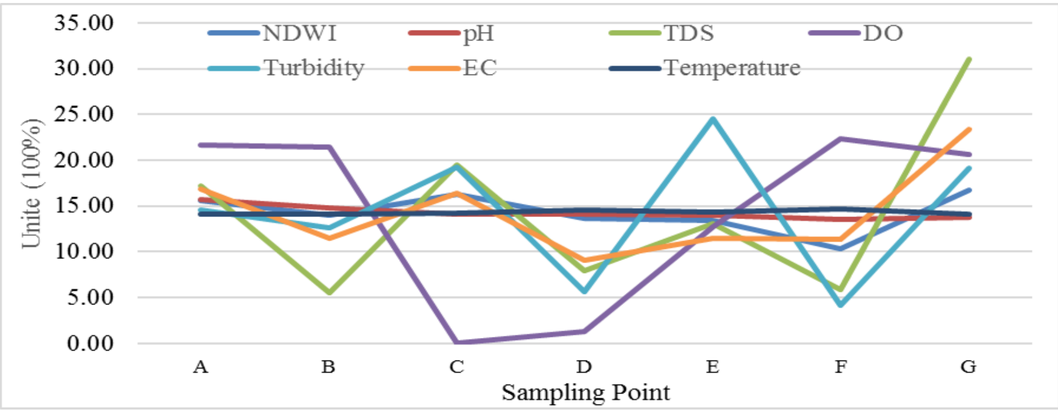

Figure 3: NDWI and water parameter

5. CONCLUSIONS

We have found very strong relations between water quality and satellite image. The water quality parameters are categorized into three types and they are highly related with the DN values of Landsat OLI images. The strong positive correlations have been found among the DN values of NDWI, TDS, Turbidity and EC. The pH is related with thermal band of Landsat OLI. The temperature is related with the radiance value of thermal band. This research indicates that some parameter of water quality is highly interrelated with the reflected sensors of Landsat OLI. Mainly TDS and Turbidity of water serve as major factors for the interpretation of Landsat OLI imageries.

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