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## Using GIS and Remote Sensing Techniques to Study Water Quality Changes and Spectral Analysis of Tigris River within Mosul City, North of Iraq

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### Abstract

The aim of the study is the measuring of changes in the spectral reflectivity water quality, analyzing the seasonal difference of Tigris River within Mosul City in the north of Iraq using Geographic Information Systems (GIS) and remote sensing techniques during the period (2014-2018). For this paper, Satellite images of the 8 Landsat in 2018 for four seasons have been selected in order to study the seasonal changes on the river they took place during 2018. A total of ten sample datasets were taken at the upstream, midstream and downstream along the Tigris River. This research focuses on analyzing the locational variance of reflectance, analyzing seasonal difference, and finding modeling algal amount change. There are distinctive reflectance differences among the downstream, mid-stream and upstream areas. Red, green, blue and near-infrared reflectance values decreased significantly toward the upstream. Results also showed that reflectance values are significantly associated with the seasonal factor. In the case of long-term trends, reflectance values have slightly increased in the downstream, while decreased slightly in the mid-stream and upstream. The modeling of chlorophyll-a and Secchi disk depth implies that water clarity has decreased over time while chlorophyll-a amounts have decreased. The decreasing water clarity seems to be attributed to other reasons than chlorophyll-a.

**Keywords:** Landsat, spectral reflectivity, water quality, remote sensing, Tigris River.

استخدام تقنيات نظم المعلومات الجغرافية والاستشعار عن بعد لدراسة  
التغيرات في نوعية المياه والتحليل الطيفي لنهر دجلة داخل مدينة الموصل ،  
شمال العراق

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### الخلاصة

ان الهدف من هذه الدراسة هو دراسة تغيرات الانعكاسية الطيفية فصليا لمعرفة وتقييم نوعية المياه في نهر دجلة بالموصل في شمال العراق للاعوام (2014-2018) باستخدام نظم المعلومات الجغرافية(GIS)

والتحسس النائي.تم اختيار(10) مواقع في منطقة الدراسة موزعة في منبع ومصب ووسط النهر وباستخدام صور الاقمار الصناعيه(Landsat8) في الفترة المحددة لدراسة التغيرات الطيفية لمياه انهر دجلة في الموصل.بينتت الدراسة بان قيم الانعكاسية الطيفية لمياه النهر تتغير مع تغير مواقع العينة في منبع ومصب ووسط النهر وبشكل واضح في الحزم الحمراء والزرقاء والخضراء والاشعة القريبة من تحت الحمراء وهذا يدل على ان قيم الانعكاسية ترتبط بالعامل الموسمي بشكل ملحوظ.وكذلك فان قيم الانعكاسية الطيفية زادت بعض الشي في مصب النهر بينما نقصت في منبع ووسط النهر. اما الكلورفيل والعمق فكلما زادت قلت وضوحية الماء بالاضافة الى اسباب اخرى.

## 1. Introduction

Water is the most precious thing Nature provides to humanity. It is the most important in our lives for the preservation of life and is required in all human activities, whether for agriculture, trade, industry, electricity generation or daily use of drinking or whatever [1, 2]. Nevertheless, the quality of water in many large rivers has deteriorated throughout the world by increasing human activity in the past two or three decades [1, 3, 4]. The most common method used to measure the quality of surface water (river, lake, and ocean) is the use of water quality [5, 6]. This is due to the introduction of many pollutants into aquatic ecosystems, in addition to ecological values, which are of high economic importance and their health value is of great importance [5, 7]. The most important aquatic ecosystems are freshwater rivers, so the quantitative and qualitative study of these sources is an important pillar of sustainable development [5, 8]. The study of the characteristics and behavior of the rivers is difficult, complicated and expensive. This is due to the multiplicity of variables affecting the river and its change over time, due to the nature of the sedimentary plane which is the main source of water. Are susceptible to morphological and hydraulic changes that greatly affect the characteristics of the river. Therefore, the researchers attach importance to the study of rivers in all the hydraulic, hydrological, morphological and geological aspects in order to preserve the natural source and its dynamite [9].

This research covers on analyzing reflectance changes on water surfaces using Landsat imagery for Tigris River in Mosul north of Iraq by identifying locations variance of reflectance, analyzing seasonal difference and modeling algal amount variation using Landsat-8.

## 2. Data and Methods

In this research, to obtain results, we divided our work into the following steps:

Description of a studied area: ten points were selected to study areas and locations of Tigris River in Mosul using spectral reflection properties of contaminated water for different bands seasonally. Also, Interpolation methods are used to obtain maps of a studied area.

### 2.1 Description of a Studied Area

The Tigris River is one of the largest rivers in the Middle East, stretching for over 1900 km, of which 1415 km are within Iraq, the catchment area reaches 235,000 km<sup>2</sup>. Tigris River sharing with Euphrates River the main source for man uses, especially for drinking water since they pass the major cities in the country [10- 13]. The River enters Mosul city at coordinates 42°49'19" E, 36°37'48" N and divides the city into two parts "Left Bank" (east side) and the "Right Bank" (west side). The length of the river along Mosul city is about 21 km. The study area extends from the north of the city of Mosul to the end of the city and a length of 21 km. This part of the river, however, divides the city of Mosul into two halves, the right coast and the left coast where the population gatherings in addition to most of the stations draw water for the stations are located in this section and the five bridges The city of Mosul within this section of the river as well as the existence of facilities and activities of various industrial and urban on both sides of the river in addition to the existence of the river Khoser, which flows in this river from the left bank of the back of the Nineveh bridge. Figure-1 shows the studied area. The following Table-1 clarifies the selected points of location.



Figure 1-Mosul city [14]

Table1-Shows the location of selected points in Mosul city (Unite: meter in WGS\_1984\_UTM\_Zone\_38N)

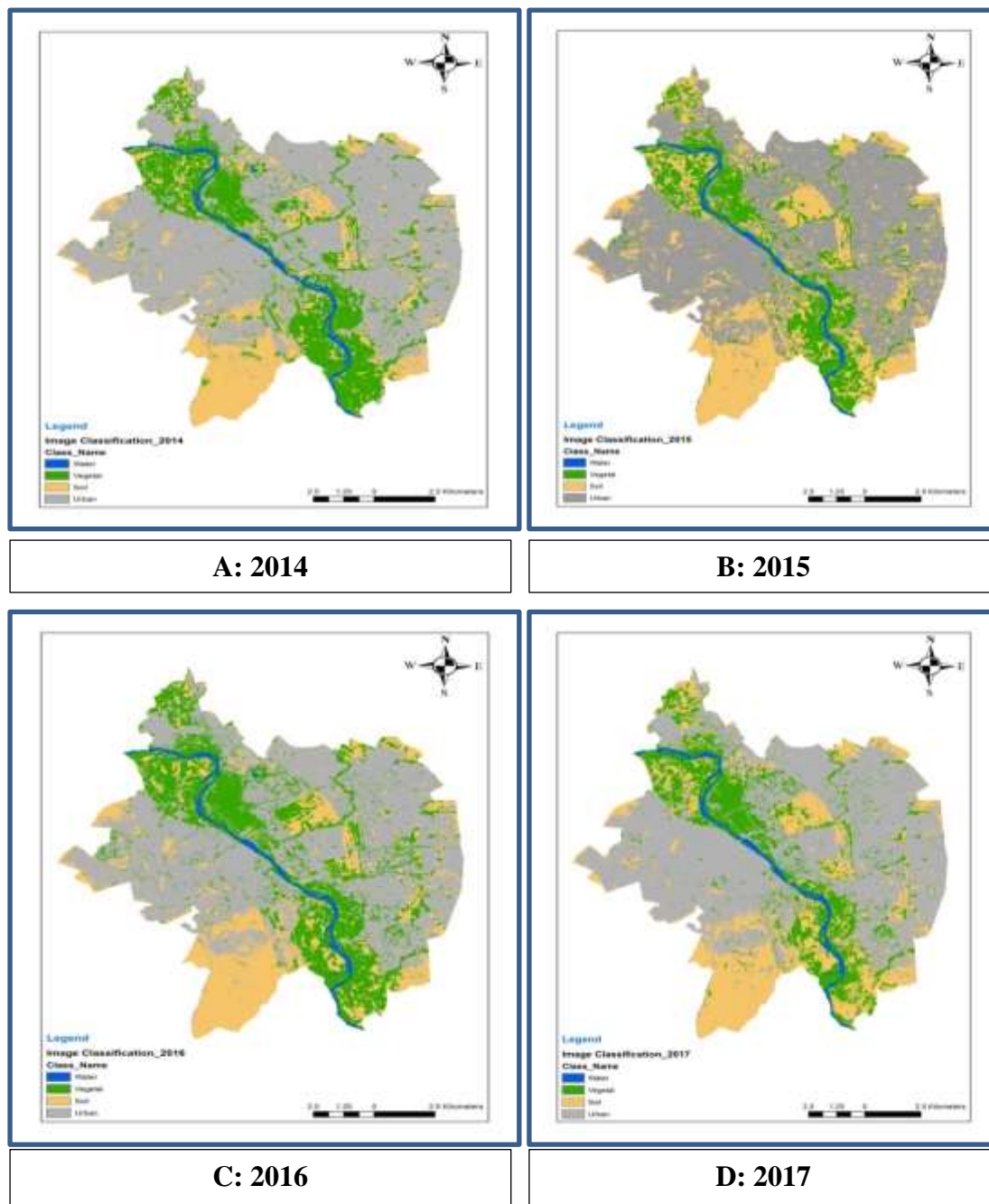
X_coordinate	Y_coordinate
328283	4029740
330612	4029440
330473	4027540
330764	4025790
332810	4023990
334776	4021710
335685	4019910
336273	4018270
335751	4016300
336584	4014440

The classification of the image is intended to classify the spatial image into geographic regions according to the numerical values of the image elements. The classification can be based on the numerical values of a single channel or using multichannel information. It is called a single channel, dissecting the density. The human eye may have difficulty interpreting the image in black and white. It consists of a continuous series of grayscale gradients. In order to facilitate the interpretation process, the gray scale is divided into groups according to their density. Each group is given a specific color or symbol, thus obtaining a qualitative map. The classification process can be done in two ways what classification oriented classification is directed and in every style there, especially in training mode, a process that teaches the classification of computer controls such as the number and varieties of statistical criteria for each category [14, 15]. When selecting the training areas, it is necessary to take multiple samples of the same category distributed in different locations on the scene used to collect the largest number of existing differences

For each category as a result of their different locations, and then we can underestimate the effect of these differences on the Rating accuracy. After defining the training areas and drawing their

boundaries, the electronic computer reads the digital value of the units within the limits of the training area for each category. These values are used to find the spectral response for each type of existing earth cover. When using a classification method based on statistical processes such as Maximum Likelihood, we need to collect training samples in which the number of units is equal to the number of channels used plus at least one unit, and using less than this number leads to the inability to calculate the correlation and difference of these spectral response values Samples. In practice, we need ten units more the number of used channels, and generally the calculation of the spectral response rate and the correlation matrix and the difference of each category more accurate than the number of units for training groups. Therefore, the use of more units gives more accurate classification results. The analyst should check whether the units are distributed

systematically (Gaussian) for each category and in each used channel, using a classification method based on a systematic basis [16]. Figures-2 shows the supervised classification of satellite image for years (2014, 2015, 2016 and 2017).

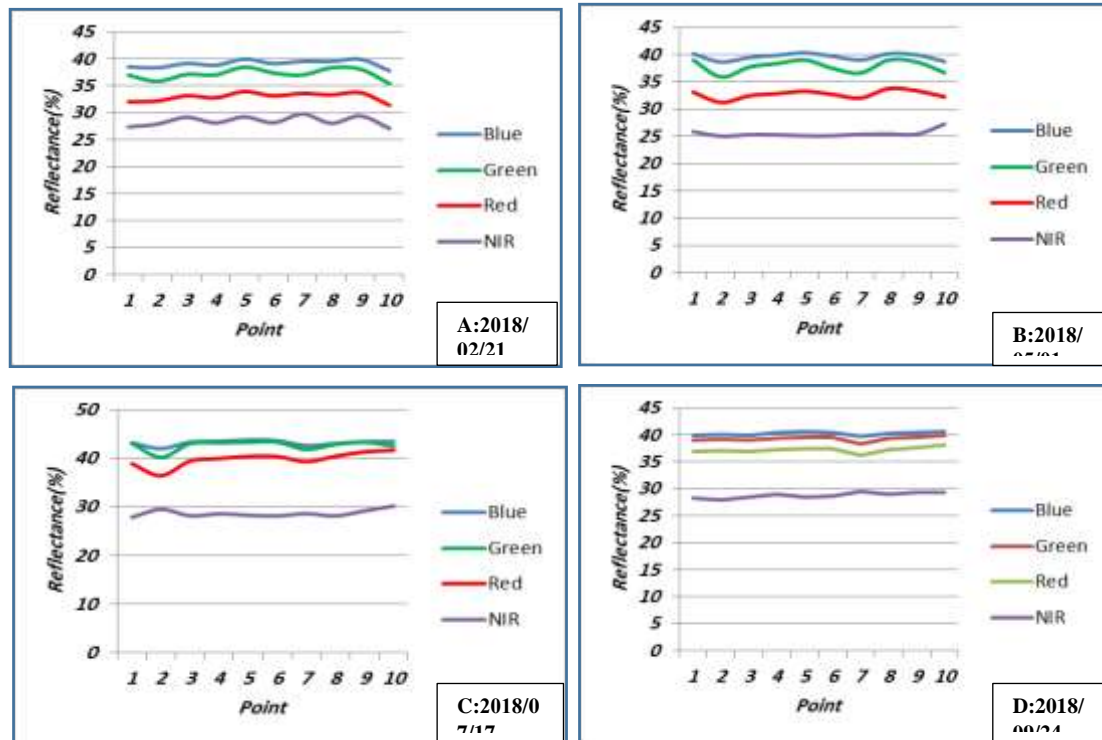


**Figure 2-** shows classification of satellite image for years (2014, 2015, 2016 and 2017)

### 3. Results and Discussion:

#### 3.1 Change of Reflectance along Tigris Rivers

To analyse, the annual change of reflectivity values, data were collected in four seasons in 2018. The satellite images of Landsat 8 were used for city Mosul city. Ten locations were identified using GIS (Geographic Information System), the spectral reflectivity of the water sites created by Erdas imagines. Figure-3 Shows the spectral reflectivity of water for 10 sites, so (p1- p3) represent upstream, (p4-p7) midstream, while (p8-p10) downstream, in each annual and for four bands (Blue, Green, Red and near ).



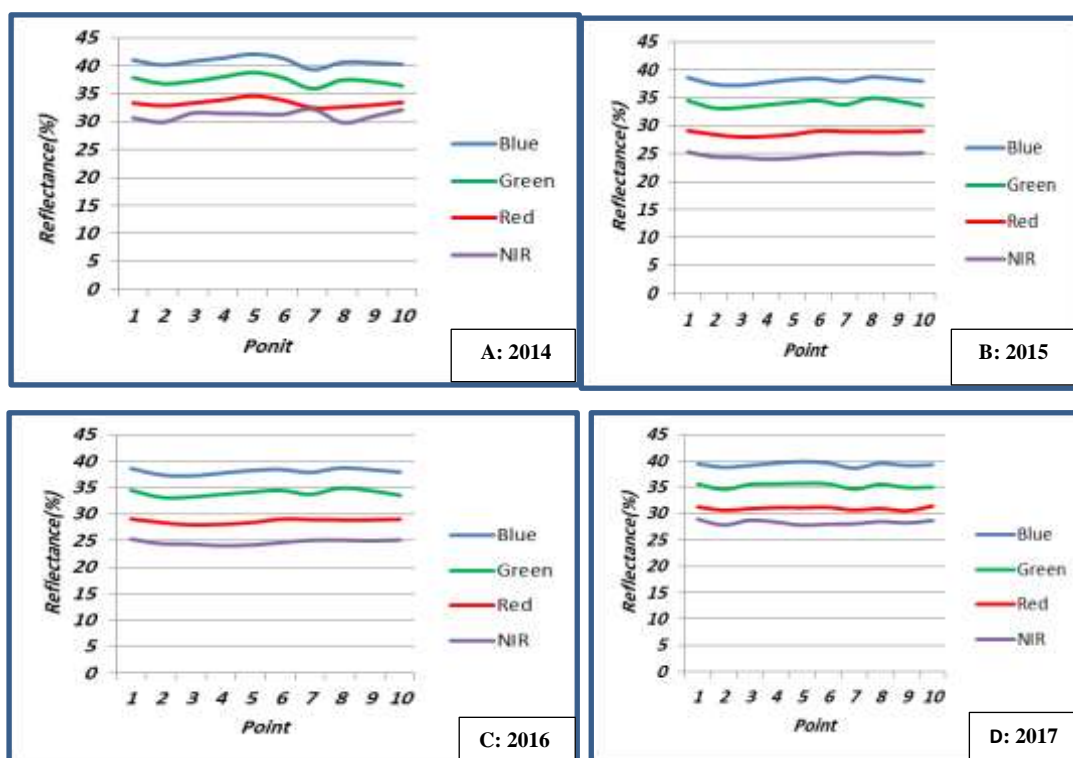
**Figure 3-**A, B, C and D are reflectance values at the sample points from p1 to p10 for (Blue, Green, Red and NIR) in 2018

From Figure-3 it can be seen that the highest values of spectral reflectivity shown in the summer for blue and green bands than the rest of the seasons, this due to increase the releases of water from the of Mosul dam. And for winter and spring, the values of spectral reflectivity of upstream may decrease in the blue, green and red while the increase in NIR. Summer is significantly different in the green and blue bands, while NIR band is significantly different than the rest of the bands in all seasons and were the lowest values.

In the case of mid-stream, it is noted that the reflectivity values are unstable values and differences in all band than the rest of the seasons, the spectral reflectance and a variation can be used to distinguish between shallow and deep water, clear and turbid waters, as well as rough and smooth water's bodies. Autumn and summer reflectance is similar in the green and blue bands. NIR reflectance is particularly the lowest value during the spring season. In the downstream, winter reflectance is significantly decreased in the four bands and summer and autumn are similar in most bands.

#### 3.2 Time-series change of reflectance values along Tigris Rivers

The time-series changes of reflectance values were analyzed in the Downstream, Mid-stream, and Upstream. To Analyse the annual change of reflectivity values, data were collected in summer for four years (2014, 2015, 2016, and 2017). Figure-4 shows the spectral reflectivity of water for 10 sites, so (p1- p3) represent upstream, (p4-p7) midstream, while p8-p10 downstream in each annual and for four bands (Blue, Green, Red and NIR).



**Figure 4-**A, B, C and D reflectance values for the sample point's from p1 to p10 of (Blue, Green, Red and NIR) in 2014, 2015, 2016 and 2017

In the Figure-4, each point indicates a reflectance value for a sample of a Landsat scene and for four bands (i.e. Blue, Green, Red and NIR bands). For the upstream area, decreases appear in the all bands and all years (2014, 2015, 2016 and 2017). While for mid-stream, the decreases and increases appear for the green and blue bands for all years, but the red and NIR bands reflectance values are rather constant. A significant increase of NIR reflectance values appears during the 2014s. In the case of the downstream, the red and NIR band reflectance values increase in all years, but the other bands decrease of reflectance values during the studied period.

**4.2. Modeling Chlorophyll-a Quantities and Secchi Depths**

Chlorophyll-a (Chl-a) and Secchi depth (SD) is calculated to estimate the changes over annual for 10 sites in section (4.1) of water in Mosul city:

$$SD(m) = 26.07 - 23.26 \left(\frac{G}{B}\right) - 17.19 \left(\frac{R}{B}\right) \text{-----} (5)$$

$$Chl-a \left(\frac{\mu g}{L}\right) = -46.51 + 105.30 \left(\frac{G}{B}\right) - 40.39 \left(\frac{R}{B}\right) \text{-----} (4)$$

Where are represented by B, G and R the blue, green and red band reflectance values, respectively. Secchi depth (SD) is a measure of the transparency of the water in the meter. Secchi depth can be affected by the color of the water, algae, and suspended sediments. Transparency decreases as color, suspended sediments, or algal abundance increases.

Chlorophyll-a is a green aquatic plant whose abundance is related to the number of plant nutrients, especially phosphorus and nitrogen.

Figure-5 and Figure-6 show the changes in estimated amounts. In general, the models show decrease in trends of chlorophyll-a quantities and an increasing of Secchi disk depth. In the case of sample points P7 and P10, decreasing amounts of chlorophyll-a appear at 2016 and 2017 and the Secchi disk depths decrease too, the opposite results as shown in Figures-(5,6) and Table-(2,3) can be related to the dissolved organic compo funds that change water color and non-algal particulates such as clay or sand [17]. In 2018 the amounts of chlorophyll-a increasing than the rest of the years and the

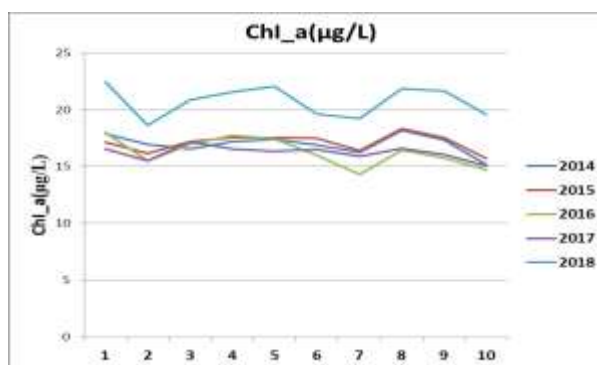
Secchi disk depth decreases due to amount of plant nutrients, especially phosphorus and nitrogen. Secchi depth can, therefore, be affected by the number of plant nutrients coming into the river from sources such as sewage treatment plants, septic tanks, and lawn and agricultural fertilizer. Suspended sediments often come from sources such as resuspension from the river bottom, construction sites, agricultural fields, and urban storm runoff.

**Table 2-**Shows the annual values of chlorophyll-a

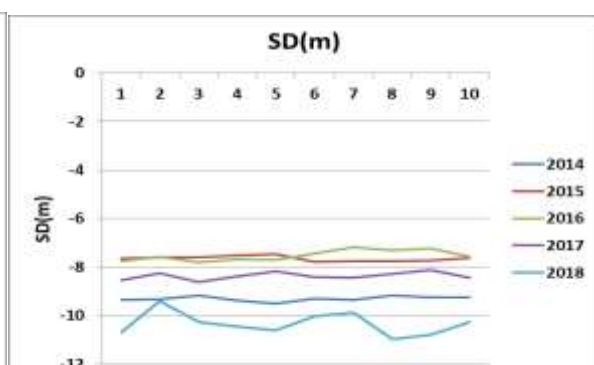
point	2014	2015	2016	2017	2018
1	17.85489	17.13812	17.98506	16.51473	22.42321
2	16.93848	16.12868	15.49627	15.51585	18.61058
3	16.52479	17.16291	16.9375	17.1752	20.86044
4	17.18243	17.55034	17.70146	16.53806	21.54487
5	17.36138	17.53565	17.40531	16.34407	22.04142
6	16.90252	17.49963	16.01022	16.48816	19.6156
7	16.23761	16.37224	14.31623	15.89562	19.18901
8	18.18818	18.30678	16.43907	16.57118	21.82026
9	17.31253	17.53725	15.7273	16.03579	21.65213
10	15.13356	15.69464	14.70789	15.05813	19.56569

**Table 3-**Shows the annual values of Secchi disk depth

point	2014	2015	2016	2017	2018
1	-9.36144	-7.65914	-7.76766	-8.55959	-10.6867
2	-9.31856	-7.61209	-7.57721	-8.25537	-9.4116
3	-9.17773	-7.61166	-7.80339	-8.63472	-10.2734
4	-9.38966	-7.52638	-7.67854	-8.3978	-10.4669
5	-9.51251	-7.47764	-7.70996	-8.18463	-10.6072
6	-9.31327	-7.7958	-7.44274	-8.41366	-10.0297
7	-9.36363	-7.77497	-7.19281	-8.44749	-9.87894
8	-9.17916	-7.75502	-7.32093	-8.29696	-10.9774
9	-9.24145	-7.73185	-7.24558	-8.12761	-10.7915
10	-9.24655	-7.62801	-7.56689	-8.44386	-10.2644



**Figure 5 -** Temporal change of the estimated chlorophyll-a amount for the ten sample points.



**Figure 6-** Temporal change of the estimated Secchi disk depth amount for the sample

## 5. Conclusions

Landsat 8 images were analyzed in this research to identify the locational variance of reflectance along Tigris River in Mosul city, north of Iraq since 2014 to 2018. The temporal changes in chlorophyll-a and Secchi disk depth were also examined to estimate algal variation amount.

The results are summarized as the following:

1. The results showed that there were distinctive reflectance differences among the upstream of the Tigris River. The green and blue values decreased significantly toward the upstream. It was also found that the reflectance values were significantly associated with seasons, the reflectance values in the

green and red bands were constant in autumn compared to the rest of the year and a similar difference was found in the NIR band for summer and winter.

2. In the mid-stream, blue, green, red and NIR reflectance values were similar in the all stable seasons except in the winter when the variation for all bands.

3. In the downstream, most of the bands exhibited much higher reflectance values in summer than in other seasons due to increases the releases of water from the dam of Mosul, while there were relatively little differences between the rest seasons.

4. The modeling of chlorophyll-a and Secchi disk depth implies that water clarity has decreased over the years, and chlorophyll-a amounts have also decreased. The decreasing water clarity seems to be attributed to other reasons than chlorophyll-a such as dissolved organic substances or compounds that change water color and non-algal particulates like clay or sand.

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