Poll Res. 40 (3) : 1096-1103 (2021)

ISSN 0257–8050

SPATIAL VARIATION OF THE OPTICAL AND QUALITY PROPERTIES OF THE TIGRIS RIVER IN AL-SHURQAT CITY/ SLAHALDEEN/ IRAQ, USING GEOMATIC TECHNIQUES

AYAD A. AL-DULIAMI, EHAB M. AMEN AND ESSA M. THALLAJ

Natural Resources Research Center (NRRC), Tikrit University, Tikrit, Iraq.

(Received 26 February, 2021; accepted 19 April, 2021)

ABSTRACT

The study aimed at spatial variation in the Optical and qualitative properties of the Tigris River in Al-Sharqat City using geomatic techniques. The path of the study area was determined and water samples were brought to study the chemical and physical tests (Ca, Mg, Na, K, CL, SO4, HCO3 and trace elements Cd, Zn, Cu, and Pb, and tests pH, EC, NTU). WQI, SAR, Na% TSS, and TDS, were calculated, then the results compared with standard criteria dependents by, WHO 2017, IQS 2009 for human drinking and Ayres and Westcot classification to irrigation water for agricultural use. A satellite image at date 7-1-2019 was acquired and it's digitally processed by converting the radiation values to spectral reflectivity and calculated using the ERDAS 15 program and establishment a database and preparing spatial distribution maps of properties and criteria using ArcGIS 10.2. The relationship of Correlation (r) and Regression (R2), was found between the specific properties of water and the spectral reflectivity using the SAS program. The results found that there was no danger of concentration of dissolved ions for the drinking water and irrigation, while there was a risk of concentration of cadmium, zinc, and lead. The Correlation r and R2 coefficient using SAS program between the properties and parameters of the water quality with the spectral reflectivity at the visible wavelengths were positive and very weak at the invisible spectral bands and the best spectral ratio at the band4 / band2.

KEY WORDS: Water pollution, Water quality, Spectral reflectance, ERDAS, WQI.

INTRODUCTION

Water pollutants can be divided into three parts according to their source: inorganic, organic, and biological materials such as viruses and bacteria, which are more present and abundant (Leopold and Freesea, 2009). The main pollutants are organic, inorganic particles, suspended and dissolved solids that lead to water turbidity (Sinclair *et al.*, 2014). Water turbidity is one of the most visible environmental indicators of water purity and plays an important role in protecting the health of the aquatic ecosystem (Dash *et al.*, 2015). The high water turbidity leads to pollution such as heavy metals, Highly turbid water deteriorates drinking water and increases ecosystem risk (Blasi 2013). As well as colored components absorb light energy at certain wavelengths and reflect some outside the water.

Therefore, it controls the optical properties of water, so the scatter and absorption of rays is caused by different sources, including metal ions such as iron and manganese, resulting in a reddish brown color of water, (Wilson 2010). Measuring the turbidity of water using remote sensing methods is based on assessing the effect of water surface reflection by the ratio between the light source and the dispersed light recorded by the sensor (Doxaran *et al.*, 2004). Therefore, it is necessary to use technological development in the field of environmental preservation and study of pollution damage through the digital processors of the satellite images as an alternative method, and prepared of environmental maps that it's become important recently, as these techniques are an effective tool and a means to help build a reliable database by many researchers, which represent

Corresponding author's email: Aiad2017@tu.edu.iq ehabmohammadnrrc@gmail.com

modern and sophisticated tools to build the necessary information. There are many interactions that occur between radiation and water, including Absorption, Reflection, Refraction, and Dispersion. The important part that record by Remote Sensing devises is the reflected part, as there is a certain spectral behavior at visible wavelengths. That ranges from 0.4 to 0.7. Thus, it is important to monitor water resources and identify the impacts and risks that lead to its deterioration. Since surface water is constantly changing and exposed to environmental impacts, it is important to conduct periodic studies to determine the state of the water and its health effects. So, this study aimed to evaluate the water pollution in Al-Shirqat City using geomatic techniques and based on water quality characteristics after comparing them with international standards.

MATERIALS AND METHODS

An exploratory survey of the Tigris River section was conducted in Al-Shirqat City, Salahaldeen, Iraq, and identified the path between the longitude (43 ° 14′ 38.49″ and 43^{o} 25′ 41.57″) E, and latitudes (35^{o} 31′ 47.04″ and 35^{o} 15′ 37.57″) N. The distance which the samples were collected was 45 km, from Al-Shirqat Bridge in the north to Al- Zawiya area in the south (Fig. 1). Populations of the study area suffer from pollution and repeated injuries as a result of drinking water and the spread of diseases and epidemics, especially cancer, kidney and skin diseases, etc. It is known that the population of the study area, depends on the Tigris River water as a source of drinking water, as well as, agriculture uses. The area is located within arid and semi-arid regions that suffer from low rainfall and high temperatures. The reason for choosing the time of sampling and study the water quality of the Tigris River, especially in this region is the result of the large military actions witnessed in the area and the large war debris that ensued, which decompose and sweep away with the valleys and floods thus to reach the Tigris River, as well as the sewage that flows directly downstream.

Sampling and laboratory procedure: Water samples were obtained on, January, 2019. They are keep in plastic containers with a capacity of 1 liter. The coordinates of the samples were determined by GPS.

Qualitative analyses were carried out in the laboratory including Electrical conductivity (EC) measurement using Conductivity meter. pH was measured by pH-meter according to the Richard method (Richards, 1954). The dissolved positive ions, calcium and magnesium ions were estimated by titration with EDTA. Sodium and potassium ions were estimated using the Flame photometer (Jackson, 1958). Chloride was estimated with silver nitrate, whereas bicarbonate and carbonate were estimated with sulfuric acid, phenolphthalein index and methyl orange index (Richards, 1954). Heavy elements (Lead, Cadmium, Copper and Zinc) were measured using the ASS-Atomic Absorption

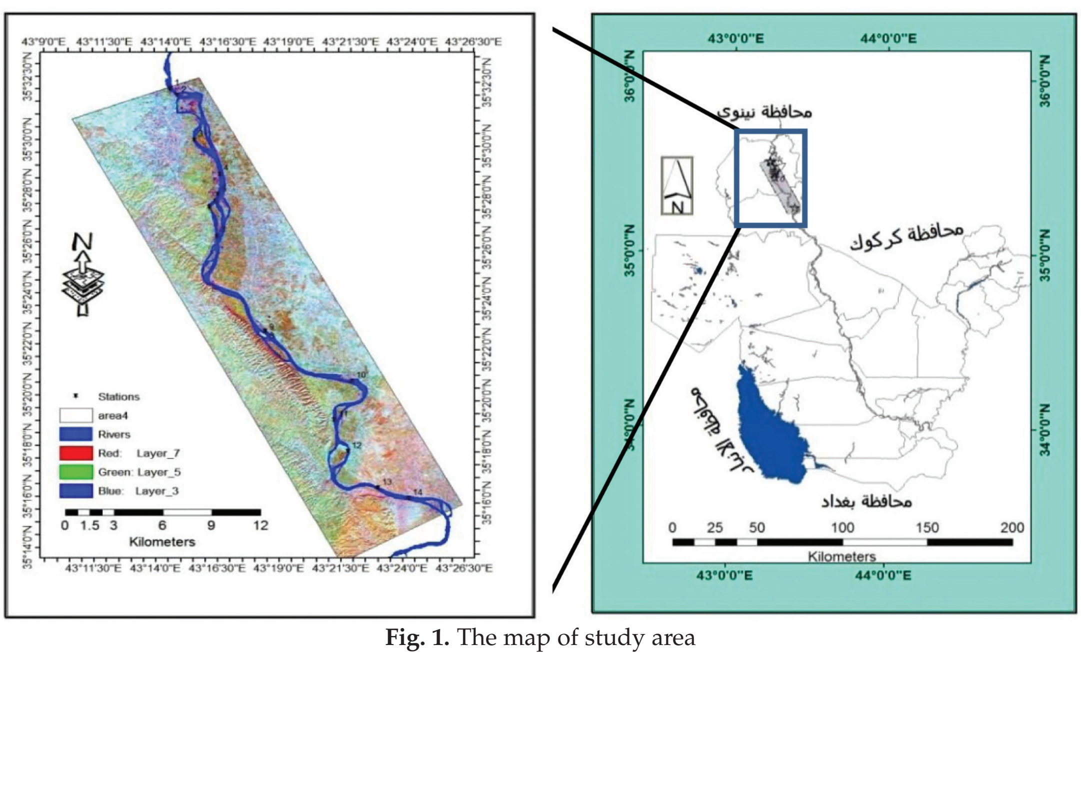

Fig. 1. The map of study area

Spectrometer. World Health Organization (WHO 2017), Canadian standards (Federal, 2017), and Iraqi Quality Standards (IQS 2009) were used to evaluate the Human drinking water, and Ayres and Westcot classification to irrigation water for agricultural use, (Ayres and Westcot, 1989).

Criteria used in assessing water quality for agricultural use

$$TDS\ (\frac{mg}{L}) = \mathrm{EC}(dS.m^{-1}) \times 640 \quad \ldots\ 1$$

$$\mathrm{Na}\% = \frac{\mathrm{Na}}{\mathrm{Ca+Mg+Na+K}} \times 100 \ldots\ldots\ 2$$

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \quad \ldots.3$$

Turbidity (NTU) was measured by Digital Portable Turbidity meter.
Total Suspended Solid was measured by
$TSS=1.09 \times (Turbidity)^{1.077}$ .. 4
Turbidity (NTU) was measured by Digital Portable Turbidity meter.

Total Suspended Solid was measured by

$TSS=1.09\times(Turbidity)^{1.077}$ .. 5

Applications of Remote Sensing to evaluate of Water Quality

The satellite Landsat 8 on 7-01-2019, Landsat 8, OLI- Operational Land Imager Sensor (PATH 169, ROW 35). The digital number- DN was converted from radiation value 0-65536 to reflectance 0-1 using ERDAS Ver.15, as the equation below:

$$P'\lambda = Mp \times Qcal + Ap \quad ..\ 6$$

Pλ = TOA Planetary Spectral Reflectance, without correction for solar angle. (Unit less).
Mp=Reflectance multiplicative scaling factor for the band (REFL_MULT_BAND_n from the metadata).
Qcal.= Level 1 pixel value in DN.

$$P\lambda = \frac{PF\lambda}{Sin(\theta)} \quad ..\ 7$$

$P\lambda$ = TOA planetary reflectance
Sin(θ) = Local sun elevation angle; the scene center sun elevation angle in degrees is provided in the metadata file.

Spectral reflectivity was calculated at each band and a database of water characteristics and criteria was evaluated using ArcGIS Ver.10.2. The data were represented by Interpolation IDW. SAS program, was used to calculate the Regression coefficient (R2) and Correlation coefficient (r) between spectral reflectivity and water quality characteristics.

RESULTS AND DISCUTION

The Figures 2 and 3, show the spatial distribution of trace elements concentration in river water.

Zinc (Zn): Its concentration ranged between (0.54 to 5.18) mg.l^{-1}, and after comparison with international and local standards (WHO, 2017, Canadian standards 2017, and IQS 2009) and classification of irrigation water standards (Ayres and Westcot 1989), all samples were within the acceptable limit of drinking water except samples 14 and 13.

Cadmium, (Cd): Its concentration ranged (0.001 to 0.110) mg.l^{-1}, after comparison with the specification and standards, most of the samples were not suitable for human drinking and irrigation use.

Lead, (Pb): Lead was higher than the acceptable limit for drinking water and irrigation purposes, Its ranged (0.0302 - 0.98) mg.l^{-1}.

Copper, (Cu). Its concentration ranged from (0.05-1.67) mg. l^{-1}, was found that most of the stations at the bottom of the river were above the acceptable limit.

Soluble ions. The Table 1 refer to soluble ions concentration in River section express that ppm(mg L^{-1}) concentration in study area as fallowing:

Calcium ($Ca+_2$): The calcium ion concentration ranged (51.5 - 71.2) mg.l^{-1}, according to the standards of WHO, 2017, Canadian standards 2017, and IQS, 2009 for drinking water, and classification of irrigation water standards (Ayres and Westcot, 1989), its values was within the acceptable limits.

Magnesium (Mg^{+2}): Its ranged (7.47 to 15.40) mg.l-1, according to the standards, its values was within the acceptable limits.

Sodium (Na^+): Sodium concentration ranged (16.0 - 25.8) mg.l^{-1}, after comparison with the standards, its values was within the acceptable limits to drinking water and irrigation purposes.

Potassium (K+): Its values was within the acceptable limits to drinking water and irrigation purposes.

Sulfate (SO_4^{-2}). Its ranged (104-148) mg.l^{-1}, according to the standards of WHO, 2017 and IQS, 2009 for drinking water, and classification of irrigation water

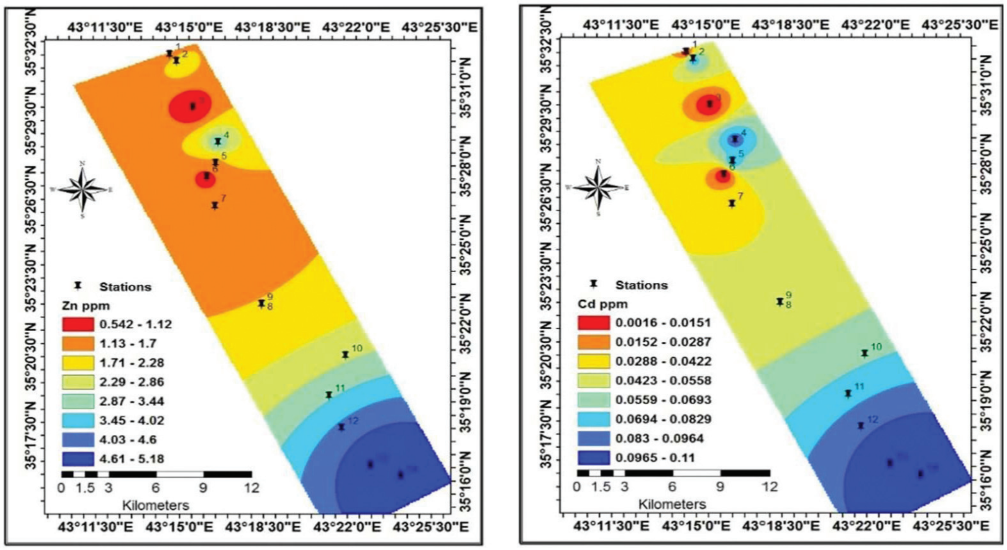

Fig. 2. Distribution maps of cadmium and zinc in water samples

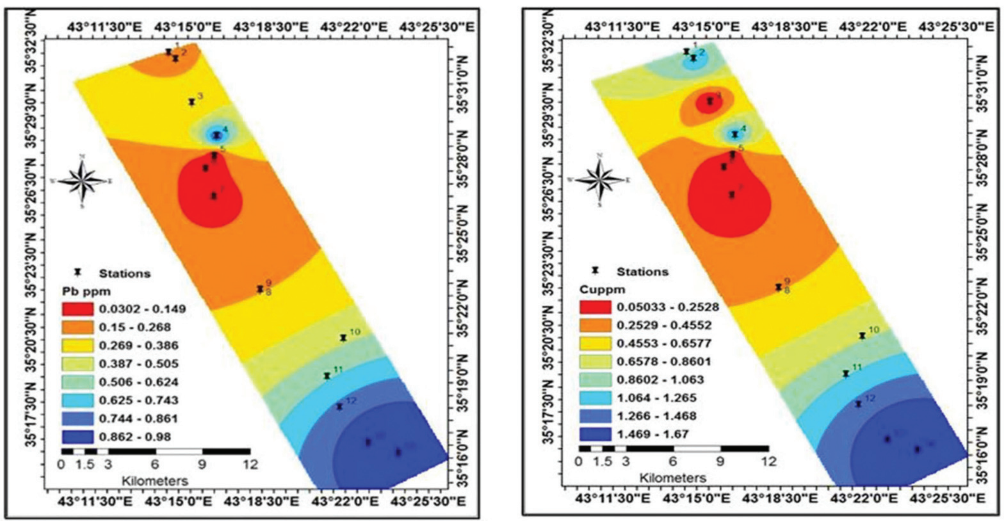

Fig. 3. Distribution Maps of copper and lead in water samples

Table 1. The Cations and Anions concentration in study area

Point	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1} mg l^{-1}	HCO_3^-	CL^{-1}	SO_4^{--}
1	51.80	8.84	16.80	10.14	25.00	61.45	113.20
2	64.70	11.22	21.00	12.09	49.20	58.00	128.16
3	58.00	8.04	19.99	34.32	31.10	59.00	103.68
4	68.74	13.32	23.46	0.78	94.42	68.00	135.00
5	57.00	9.36	19.09	3.51	15.87	58.22	125.60
6	51.50	7.74	16.04	12.09	13.77	46.93	103.68
7	58.00	10.92	19.00	1.17	37.30	65.68	107.45
8	71.20	15.70	25.76	3.12	88.45	66.29	146.02
9	63.00	10.30	21.50	8.20	60.00	62.00	121.00
10	58.70	12.00	20.00	8.20	57.20	57.00	125.00
11	58.40	13.40	18.50	8.50	53.50	54.20	126.00
12	55.20	13.80	17.20	8.70	51.00	51.40	130.00
13	51.80	15.50	16.50	1.50	48.00	47.00	138.00
14	52.80	15.60	16.20	0.78	46.00	46.30	140.00

standards (Ayres and Westcot, 1989), its values was within the acceptable limits.

Chloride (Cl-): Its ranged (46 - 68) mg. l^{-1}, according to the standards, its values was within the acceptable limits.

Bicarbonate (HCO_3-): Its values in water samples ranged (13.8-94.4) mg.l^{-1}, which within the acceptable limits.

Criteria of Water Quality

After comparing Its results (Fig. 4) (with the standards of WHO, 2017 and IQS, 2009 for drinking water, and classification of irrigation water standards (Ayres and Westcot, 1989), its values was within the acceptable limits. The EC range 0.415 – 539 dSm^{-1} and the value high at down flow section and also that SAR, TDS, and Turbidity was ranged between (0.63-1.25), (251-345) and (4.90-12.6) respectively.

Spectral reflectivity as an indicator of water quality

The results of Table 2, show that the spectral reflectivity were increased at the band 2 and band 4, whereas, and decreased at other wavelengths. The reflectivity values at the band 2 (blue wavelength 0.45- 0.51) m, ranged from 0.1510 - 0.1709, while it decreased in the band 3 at the green wavelength (0.53-0.59) m, ranged from 0.0125-0.0243 μm. The band 4 (red wavelength 0.64-0.67) ranged between 0.1330-0.1559. The band 5 (near-infrared NIR 0.85-0.88) m ranged from 0.0402 to 0.0975 m, Consequently. Water reflectivity decreases at wavelength of 0.85 m and its more than 0.85, water absorbs band at the reflected NIR wavelengths was it appears in darkness. So, there is no reflectivity at these wavelengths due to suspended impurities in

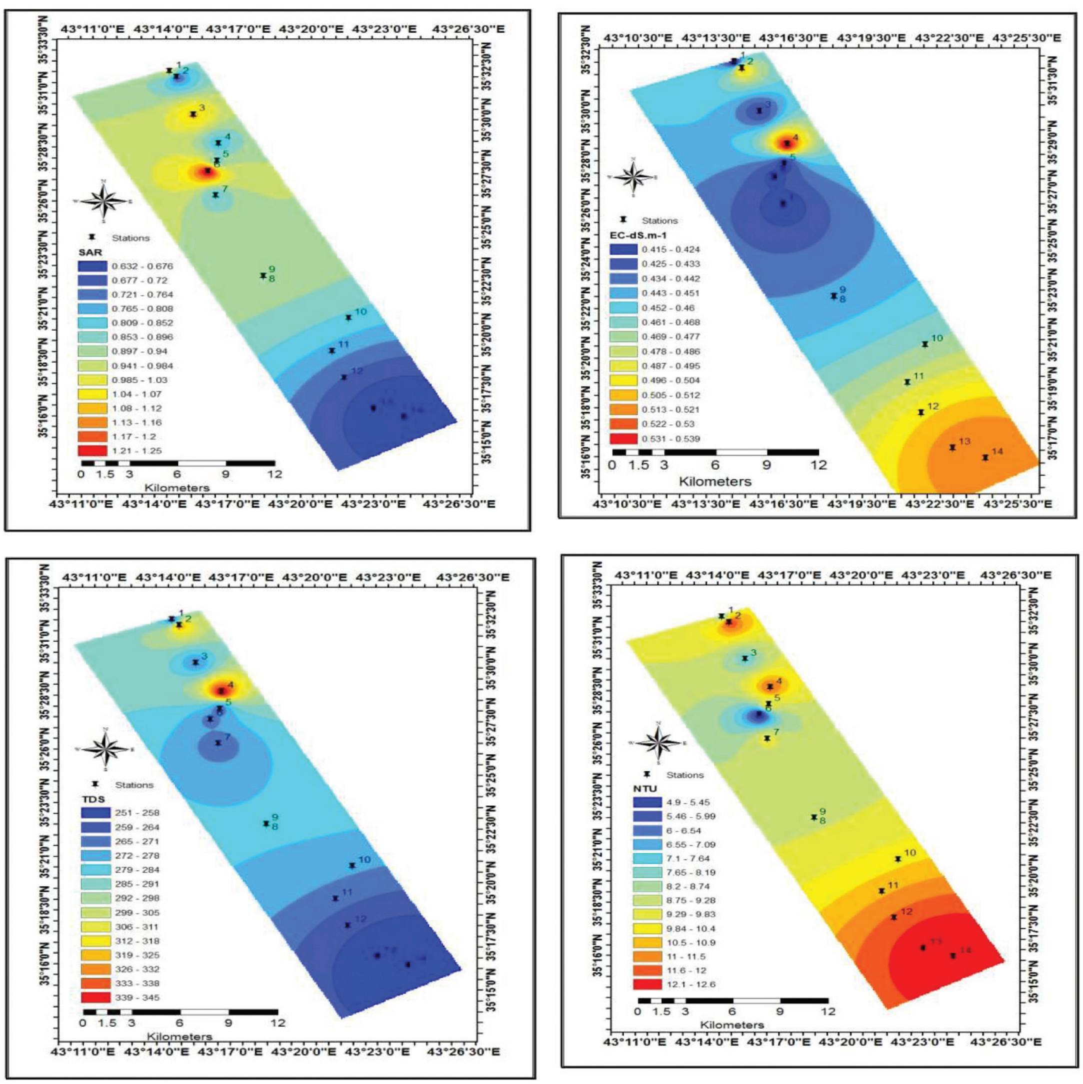

Fig. 4. Distribution map of EC, SAR, TDS, and Turbidity

the water. Therefore, the spectral reflectivity of water is the result of different factors that together or individually change the spectral behavior of water bodies, including the depth of water, turbidity, dissolved substances, flow rate, etc.

The results of Tables 3 indicate the relation of Regression R2 and Correlation (r) coefficient, between water quality characteristics and spectral reflectivity. The spectral reflectivity values and its relationship to the water quality properties of showed a Regression (R2) and Correlation (r)relationship at visible wavelengths (0.4- 0.7) m, while there was no clear relationship at invisible wavelengths, this was compatible with Dash *et al.*, 2012. Absorption prevails after wavelength 0.7 m, and water reflectivity decreases, the highest positive relationship was observed at the spectral band 2, 4 (blue and red wavelengths), studies show that water reflectivity decreases with increasing wavelength, but the turbidity and its relationship and its effect on the concentration of suspended and dissolved materials, significantly affected water reflectivity at the red wavelength (0.6-0.7) m. The results of Table 4, showed the correlation between water qualitative characteristics and spectral ratios, the best correlation coefficient It was found that when band 2/band 4 (blue band/ red band), and ranged R2 between 0.47 - 0.91, while the relationship was weak at other spectral ratios, this is probably due to the fact that the water absorbs invisible rays from the electromagnetic spectroscopy and low water content of algae that reflect the rays outside the visible range

Table 2. Spectral reflectivity obtained from Landsat at (OLI) at 7/1/2019

Bands Stations	b2	b3	b4	b5	b6	b7
1	0.1593	0.0136	0.1440	0.0487	0.0172	0.0124
2	0.1651	0.0186	0.1499	0.0651	0.0235	0.0234
3	0.1709	0.0237	0.1559	0.0816	0.0299	0.0344
4	0.1636	0.0185	0.1489	0.0771	0.0329	0.0302
5	0.1562	0.0132	0.1419	0.0725	0.0360	0.0260
6	0.1622	0.0183	0.1471	0.0816	0.0320	0.0292
7	0.1681	0.0234	0.1524	0.0907	0.0279	0.0325
8	0.1642	0.0186	0.1493	0.0717	0.0235	0.0280
9	0.1603	0.0137	0.1462	0.0526	0.0191	0.0235
10	0.1556	0.0131	0.1396	0.0464	0.0224	0.0168
11	0.1510	0.0125	0.1330	0.0402	0.0257	0.0102
12	0.1588	0.0136	0.1445	0.0500	0.0174	0.0120
13	0.1636	0.0189	0.1501	0.0737	0.0326	0.0281
14	0.1684	0.0243	0.1558	0.0975	0.0478	0.0442

*Mean of three point at all station

Table 3. The regression (R2) between spectral reflectivity and water qualitative properties

Proper Bands	EC dS/m^{-1}	Ca^{++}	Mg^{++}	Na^{+}	HCO^{-}	CL- Mg l^{-1}	SO_4^{-}	Ca^{++}	Zn^{++}	Cu^{++}	Pb^{++}	SAR	NA%	NTU
							Regression-R^2							
Band-2	0.46	0.81	0.75	0.90	0.63	0.45	0.52	0.79	0.79	0.20	0.52	0.91	0.40	0.72
Band-3	0.42	0.80	0.70	0.88	0.65	0.49	0.43	0.70	0.76	0.22	0.54	0.88	0.40	0.74
Band-4	0.41	0.78	0.74	0.87	0.59	0.46	0.50	0.78	0.68	0.17	0.47	0.88	0.44	0.73
Band-5	0.01	0.02	0.15	0.09	0.05	0.22	0.22	0.22	0.63	0.34	0.24	0.16	0.14	0.14
Band-6	0.01	0.01	0.25	0.00	0.00	0.00	0.10	0.03	0.44	0.22	0.09	0.02	0.03	0.03
Band-7	0.00	0.00	0.09	0.05	0.03	0.03	0.15	0.08	0.72	0.29	0.16	0.08	0.08	0.05
							Correlation- r							
Band-2	0.68	0.90	0.87	0.95	0.81	0.67	0.71	0.68	0.82	0.55	0.80	0.95	0.62	0.85
Band-3	0.52	0.66	0.80	0.66	0.77	0.77	0.48	0.63	0.65	0.39	0.66	0.61	0.70	0.55
Band-4	0.64	0.88	0.87	0.93	0.78	0.69	0.71	0.72	0.81	0.51	0.76	0.93	0.67	0.84
Band-5	0.12	0.17	0.40	0.28	0.24	0.43	0.48	0.41	0.50	0.59	0.46	0.29	0.39	0.32
Band-6	-0.03	-0.07	0.19	0.03	0.06	0.13	0.30	0.15	0.35	0.46	0.31	0.03	0.19	0.02
Band-7	0.03	0.05	0.28	0.16	0.15	0.33	0.38	0.27	0.40	0.53	0.39	0.17	0.27	0.2

Table 4. The regression (R2)between spectral ratio and water qualitative properties

Proper. Bands	EC $dS.m^{-1}$	Ca_{++}	Mg_{++}	Na_{+}	HCO_{-}	CL- Ppm	SO_4^{--}	Cd^{++}	Zn^{++}	Cu^{++}	Pb^{++}	SAR	Na%	NTU
						Person Correlation (r)								
b3/b2	0.22	0.27	0.33	0.21	0.42	0.59	0.03	0.32	0.09	-0.02	0.19	0.15	0.41	0.23
b4/b2	0.62	0.87	0.87	0.91	0.77	0.72	0.70	0.76	0.79	0.47	0.72	0.90	0.73	0.83
b5/b2	0.01	0.02	0.26	0.12	0.11	0.34	0.37	0.30	0.36	0.52	0.33	0.13	0.28	0.19
b6/b2	-0.10	-0.16	0.11	-0.06	-0.02	0.08	0.22	0.08	0.26	0.42	0.23	-0.06	0.11	-0.05
b7/b2	-0.02	-0.04	0.20	0.07	0.08	0.28	0.32	0.22	0.31	0.50	0.31	0.08	0.22	0.14
b2/b3	-0.48	-0.72	-0.58	-0.71	-0.58	-0.68	-0.40	-0.59	-0.40	-0.17	-0.41	-0.72	-0.51	-0.76
b4/b3	0.38	0.56	0.71	0.66	0.51	0.36	0.67	0.56	0.82	0.51	0.67	0.66	0.63	0.53
b5/b3	-0.01	0.00	0.23	0.10	0.09	0.32	0.35	0.28	0.34	0.50	0.31	0.11	0.26	0.18
b6/b3	-0.12	-0.18	0.08	-0.09	-0.04	0.07	0.20	0.06	0.24	0.40	0.21	-0.09	0.10	-0.08
b7/b3	-0.03	-0.04	0.19	0.06	0.07	0.28	0.31	0.21	0.31	0.49	0.31	0.07	0.22	0.13
b2/b4	-0.60	-0.86	-0.82	-0.90	-0.73	-0.71	-0.67	-0.75	-0.73	-0.42	-0.67	-0.90	-0.70	-0.85
b5/b4	-0.05	-0.04	0.20	0.06	0.06	0.31	0.32	0.25	0.30	0.48	0.28	0.08	0.24	0.16
b6/b4	-0.11	-0.18	0.08	-0.09	-0.03	0.07	0.20	0.06	0.23	0.40	0.21	-0.09	0.10	-0.08
b7/b4	-0.06	-0.07	0.17	0.03	0.06	0.27	0.27	0.18	0.28	0.47	0.29	0.04	0.19	0.11
b2/b5	-0.07	-0.14	-0.35	-0.24	-0.18	-0.45	-0.48	-0.44	-0.43	-0.54	-0.38	-0.26	-0.42	-0.34
b3/b5	-0.05	-0.11	-0.32	-0.21	-0.15	-0.39	-0.46	-0.40	-0.42	-0.53	-0.37	-0.23	-0.39	-0.29
B4/b5	-0.04	-0.09	-0.30	-0.19	-0.14	-0.40	-0.45	-0.40	-0.40	-0.52	-0.35	-0.21	-0.38	-0.29
b6/b5	-0.24	-0.40	-0.17	-0.34	-0.25	-0.44	-0.04	-0.27	0.06	0.10	-0.01	-0.35	-0.13	-0.48
b7/b5	0.02	0.02	0.24	0.13	0.13	0.28	0.38	0.24	0.38	0.50	0.39	0.15	0.29	0.20
b2/b6	0.08	0.14	-0.10	0.05	0.04	0.06	-0.29	-0.10	-0.31	-0.35	-0.23	-0.21	0.05	0.10
b43b6	0.09	0.16	-0.09	0.06	0.06	0.08	-0.28	-0.08	-0.30	-0.34	-0.21	-0.20	0.07	0.12
b4/b6	0.09	0.16	-0.08	0.07	0.06	0.09	-0.28	-0.07	-0.30	-0.34	-0.21	-0.19	0.07	0.13
b5/b6	0.18	0.32	0.10	0.25	0.19	0.38	-0.06	0.19	-0.14	-0.14	-0.07	0.02	0.26	0.38
b7/b6	0.33	0.51	0.44	0.55	0.44	0.82	0.46	0.58	0.32	0.41	0.42	0.45	0.60	0.80
b2/b7	-0.09	-0.13	-0.32	-0.25	-0.19	-0.38	-0.50	-0.39	-0.45	-0.53	-0.42	-0.43	-0.27	-0.33
b3/b7	-0.08	-0.11	-0.31	-0.23	-0.17	-0.35	-0.49	-0.37	-0.44	-0.52	-0.41	-0.41	-0.25	-0.30
b4/b7	-0.08	-0.11	-0.30	-0.22	-0.17	-0.35	-0.49	-0.37	-0.43	-0.52	-0.41	-0.41	-0.25	-0.30
b5/b7	-0.05	-0.04	-0.23	-0.16	-0.14	-0.24	-0.43	-0.25	-0.40	-0.48	-0.41	-0.34	-0.19	-0.22
b6/b7	-0.29	-0.48	-0.42	-0.53	-0.41	-0.82	-0.43	-0.57	-0.30	-0.39	-0.39	-0.44	-0.57	-0.78

of the electromagnetic spectrum.

CONCLUSION

The results of the concentration of heavy elements for water samples (cadmium, lead, copper and zinc), exceeded the acceptable limit. The concentration of dissolved ions, EC, SAR, and TDS, was within the acceptable limits, except the Turbidity. Also, the results showed, a Regression (R^2) relationship and Correlation (r) between spectral reflectivity, and water quality characteristics and parameters at visible wavelengths, while it was very weak at invisible wavelengths. Therefor to conduct periodic monitoring of surface water and know the changes that occur in seasonally to determine the relationship between spectral reflectivity with water characteristics is important as there is a difference in spectral reflectivity with the change in water characteristics in different seasons and time periods.

AKNOWLEDGEMENT

We are thankful the staff of central laboratories in Tikrit University and Baghdad. Also We are thankful the staff of central laboratories in Tikrit University and Baghdad and also Mr. Mohamed to help in achievement of trace element analysis.

REFERENCES

Ayres, R.S. and Westcot, D. W. 1989. Water quality for Agriculture. Irrigation and Drainage paper 29, Rev. 1, FAO, Rome, Italy, 174p.

Dash, P., Silwal, S. J. O., Ikenga, J. L., Pinckney, Z., Arslan and Lizottew, R. E. 2015. Water quality of four major lakes in Mississippi, USA: Impacts on human and aquatic ecosystem health. *Water.* 7 : 4999-5030.

Di Blasi J. P., Torres, J. M., Nieto, P. G., Fernandes, J. A., Muniz, C. D. and Taboada, J. 2013. Analysis and detection of outliers in water quality parameters from different automated monitoring stations in the

Miño river basin (NW Spain). *Ecological Engineering.* 60 : 60-66.

Doxaran, D., Cherukuru, R. N. and Lavender, S. 2004. Estimation of surface reflection effects on upwelling radiance field measurements in turbid water. *Journal of Optics A: Pure and Applied Optics*. 6 : 690.

Ellison, C. A., Kiesling, R. L. and Fallon, J. D. 2010. Correlating stream flow, turbidity and suspended sediment concentration in Minnesotas wild rice river. *2nd Joint Federal Interagency Conference.* 10.

Federal-Provincial-Territorial Committee on Drinking Water. 2017. Guidelines for Canadian Drinking Water Quality Summary Table. *Health Canada.* 22p.

Fewtrel, L. and Bartram, J. 2013. Water quality: guidelines, standards and health: assessment of risk and risk management for water-related infectious disease. *Water Intelligence Online.* 12 : 9781780405889.

Iraqi Quality Standard, (IQS). 2009. Iraq Standard of Drinking Water No.417, Second Modification.

Jackson, M. L. 1958. Soil chemical analysis hall, Inc. Engle wood cliffs, N. J.USA.

Leopold, P. and Freesea, S. D. 2009. *Simple Guide to the Chemistry, Selection and Use of Chemicals for Water and Wastewater Treatment, Water Research Commission.* TT, 405.

Richards, A. 1954. Diagnosis and improvement of saline and alkali soils. Agric. hand book No. 60, USDA. Washington, USA.

Sinclair, A., Tayler, K., Van Dam, R. and Hogan, A. 2014. Site-specific water quality guidelines: 2. Development of a water quality regulation framework for pulse exposures of mine water discharges at a uranium mine in northern Australia. *Environmental Science and Pollution Research.* 21: 131-140.

Wilson, P.C. 2010. Water quality notes: Water clarity (turbidity, suspended solids, and color)", University of Florida, Institute of Food and Agricultural Sciences (IFAS) and the Florida Cooperation Extension Service, Gainesville, FL, 32611.

World Health Organization (WHO). 2017. *Guidelines for Drinking-water Quality.* 4th ed, incorporating the first addendum. Brazil, World Health Organization, 518 p.