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USING WATER INDICES (NDWI, MNDWI, NDMI, WRI AND AWEI) TO DETECT PHYSICAL AND CHEMICAL PARAMETERS BY APPLY REMOTE SENSING AND GIS TECHNIQUES

Dr. Mustafa T. Mustafa [*1], Dr. Khalid I. Hassoon [2], Dr. Hussain M. Hussain [3], Modher H. Abd [4]

[*1]Head of building and construction engineering department, College Technical engineering, Iraq
[2]Remote sensing Center, Directorate of space Technology and Communications, Ministry of Science &Technology, Iraq
[3]Remote Sensing Center- University of Kufa, Iraq
[4]Surveying Technical Engineer, Iraq

Abstract

This study was undertaken by analyzing data from satellite image (Landsat-8 OLI) and geographical information system (GIS) to find the relationship between water parameters and water indices of spectral images. The main purpose of this research was to develop a model for the physical and chemical parameters of Gharraf stream in Iraq. The water parameters used in this study included: acidity (PH), Total Dissolved Solids (T.D.S), Alkalinity(ALK), Electrical Conductivity (E.C), Calcium(Ca), Chloride (CL), Sodium (Na), Sulfate (SO4), Potassium (k), Total suspended solid (T.S.S), Total Hardness (TH).Where the samples were taken to seventeen stations with two seasons and at the same time took a satellite image on 4/FEB, 11 / MAY.GIS techniques were used in the beginning to project the coordinates of seventeen stations along the stream in Landsat-8 satellite image for extract data. Then, these data are treated in SPSS software for purpose finding correlation and regression equations. Positive strong correlations between the reflectance of the satellite image and the water parameters in 4/FEB and 11/ MAY with five stations, helped to build six regression models. These models could be used to predict these six water parameters (PH, E.c, CL, SO4, Na and K) at any point along the stream in Iraq from the satellite image directly.

Keywords: Parameters Model; Al-Gharraf Stream; GIS, Remote Sensing; Landsat-8 OLI; Water Indices.

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1. Introduction

Gharraf stream is a necessary resource in thi qar city, especially for drinking and irrigation use. An increase of anthropogenic activities especially in the surrounding area near stream has effects to water bodies, where consider one of the most significant environmental issues in many areas of the world. Therefore, the stream water quality monitoring program is needed in order to raise sensibility of the public by address the consequences of present and future threats of contamination[1].the method in situ measurements of water quality characteristics is ordinarily limited, especially in spatial and temporal range, because of the high cost of data collection and laboratory analysis[2].in recent decades, the advent of increasingly efficient for satellite image (landsat-8 oli) analyses and geographical information system (gis) are significant tools to monitor and predict water quality parameters for rivers and stream[3].spectral indices are combinations of surface reflectance at two or more wavelengths[4]. These twelve parameters are acidity (ph), total dissolved solids (t.d.s), alkalinity(alk), electrical conductivity (e.c), calcium(ca), chloride (cl), sodium (na), sulfate (so4), potassium (k), total suspended solid (t.s.s), total hardness (th) from seventeen stations along the stream. Spectral indices are combinations of surface reflectance at two or more wavelengths. These indices were used in the present study: normalised -difference water index (ndwi), modification of normalised difference water index (mndwi), normalised difference moisture index (ndmi), water ratio index (wri) and automated water extraction index (awei), where these spectra were extracted from the image.

2. Materials and Methods

2.1. Study Area

The present study dealt with the Gharraf stream, which dates back to the Sumerian period (split King Antmina) of the Tigris River near the Dam of Kut. Gharraf stream is the longest branches of the Tigris River and derives its properties from it, Where the population in the areas that pass through the stream (998.729). In addition, the amount of drinking water in these areas is estimated at 6429 m^3 and the cultivated land is estimated at (2151019) acres [5]. It's passing Wasit, Thi-Qar governorates, and ends in the marshes and the length of (230) m leading to Hammar south of Nasiriya City. Nasiriya is located between latitude (30˚36′00″ _ 32˚00′00″ N) and longitude (45˚36′00″ _ 47˚12′00″ E), as shown Figure (1). Stream extends towards the city, which is passes ALfagr, Gala Sikar, Al Rifai and Al Nasr and the (168 km) distance from the beginning branches of the river into two branches Shatt al-Shatra, which passes in Shatrah, Gharraf and ends in the marshes leading to Hammar ,while the second section is the Shatt Al bdai, which ends in the marsh leading to Hammar also.

2.2. In Situ Water Quality Data

Water samples were collected from various spatial locations in the Gharraf stream on dates coinciding with Landsat-8 OLI acquisition dates (Table 1) of the study area for 20017. In addition, the physical and chemical parameters for seventeen stations with 4/FEB/, 11/MAY were analysis from the Department of the Environment Water / Najaf Governorate (Table 2 and 3).

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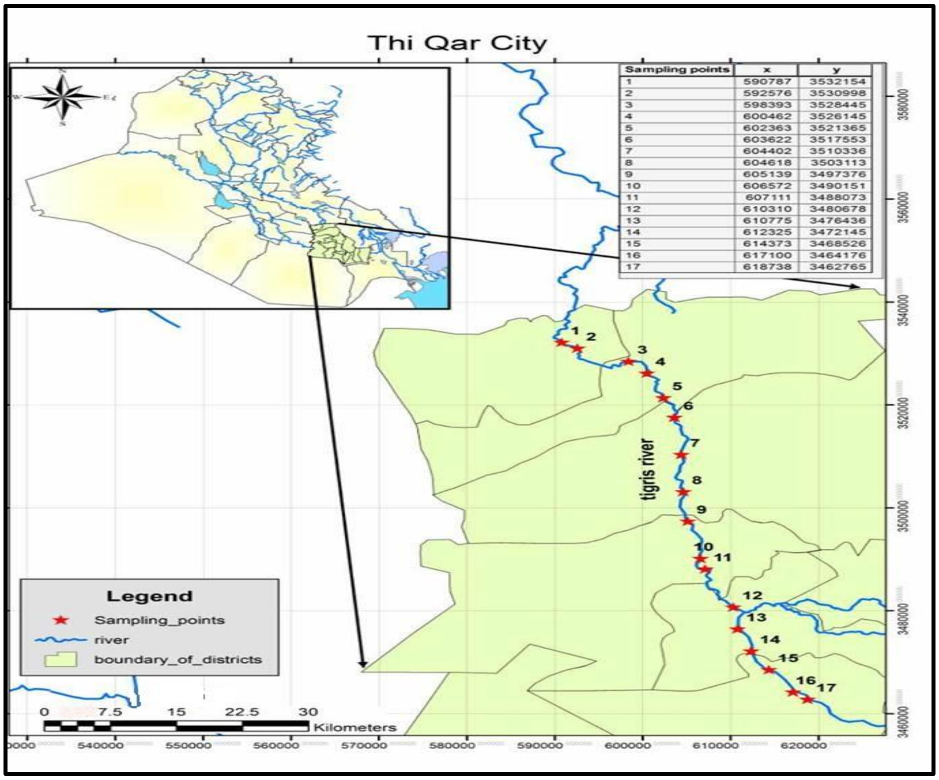

Figure 1: Location of the study area (Al- Gharraf stream)

Table 1: Details of Landsat -8 Data and in Situ Water Quality Sampling Dates.

Year	**Water sample Data**	**Image acquisition data**	**Path/Row**	**Number of water sampling points**
2017	4/FEB	4/FEB	168/38	17
2017	11/MAY	11/MAY	168/38	17

Table2: Test results conducted in the Department of the Environment Water / Najaf Governorate (date: 4/FEB/2017).

		Location		Physical Properties				CatIon (mg/l)				Anion (mg/l)		
	Name	**E**	**N**	**Ph**	**EC(μs/cm)**	**TSS**	**TDS**	**Ca**	**TH**	**Na**	**K**	**Cl**	**So4**	**ALK**
Loc_01	ALfagr	590787	3532154	7.85	1494	60	1016	121	486	142.8	4.0	153	413	128
Loc_02	ALfagr	592576	3530998	8.01	1568	44	1022	127	508	146.0	4.4	148	281	136
Loc_03	ALfagr	598393	3528445	8.18	1471	30	1018	120	482	143.2	4.0	146	405	128
Loc_04	Gala sgar	600462	3526145	8.24	1477	58	1020	120	482	142.4	4.0	148	408	128
Loc_05	Gala sgar	602363	3521365	8.25	1476	60	1026	120	482	145.2	4.0	140	386	128
Loc_06	Gala sgar	603622	3517553	8.31	1474	36	1030	120	482	146.4	4.0	143	395	128
Loc_07	Al-Rifai	604402	3510336	8.31	1472	70	1032	120	482	144.8	4.0	144	392	126
Loc_08	Al-Rifai	604618	3503113	8.39	1467	42	1036	120	482	145.2	4.0	146	497	126
Loc_09	Al-Rifai	605139	3497376	8.43	1497	22	1026	121	486	142.0	4.0	144	397	128
Loc_10	Alnsar	606572	3490151	8.40	1480	56	1030	121	486	145.2	4.0	140	374	128
Loc_11	Alnsar	607111	3488073	8.42	1480	72	1028	121	486	143.2	4.0	143	404	128
Loc_12	Albdai	610310	3480678	8.42	1478	66	1024	120	482	144.4	4.0	144	408	128
Loc_13	Alshatra	610775	3476436	8.43	1481	28	1022	120	482	145.2	4.0	153	408	128

Loc_14	Alshatra	612325	3472145	8.58	1485	36	1018	120	482	144.8	4.0	149	413	128
Loc_15	Alshatra	614373	3468526	8.80	1484	28	1022	120	482	145.6	4.0	144	394	128
Loc_16	Algarraf	617100	3464176	8.67	1502	40	1036	121	486	145.2	4.0	149	398	130
Loc_17	Algarraf	618738	3462765	8.34	1532	56	1040	122	490	146.8	4.4	137	402	132

Table3: Test results conducted in the Department of the Environment Water / Najaf Governorate (date: 11/MAY/2017).

	Name	Location		Physical Properties				CatIon (mg/l)				Anion (mg/l)		
		E	N	Ph	EC(µs/cm)	TSS	TDS	Ca	TH	Na	K	Cl	So4	ALK
Loc_01	ALfagr	590787	3532154	8.4	828	34	564	73	294	74.7	2.4	90	181	74
Loc_02	ALfagr	592576	3530998	8.4	790	58	446	72	290	73.5	2.1	88	186	72
Loc_03	ALfagr	598393	3528445	8.3	808	34	482	73	294	75.6	1.8	89	171	72
Loc_04	Gala sgar	600462	3526145	8.3	808	24	598	73	294	74.7	2.4	89	181	72
Loc_05	Gala sgar	602363	3521365	8.3	818	48	560	73	294	75.6	2.4	88	171	74
Loc_06	Gala sgar	603622	3517553	8.4	816	56	486	73	294	76.2	2.4	88	176	74
Loc_07	Al-Rifai	604402	3510336	8.5	836	52	598	76	304	77.7	2.4	98	217	76
Loc_08	Al-Rifai	604618	3503113	8.4	816	60	562	73	294	77.4	2.4	89	202	74
Loc_09	Al-Rifai	605139	3497376	8.4	816	38	556	73	294	76.8	2.4	89	204	74
Loc_10	Alnsar	606572	3490151	8.4	827	42	494	73	294	76.5	2.1	90	182	76
Loc_11	Alnsar	607111	3488073	8.3	851	68	488	76	304	78.0	2.1	94	208	76
Loc_12	Albdai	610310	3480678	8.6	848	38	680	76	304	79.5	2.4	92	246	76
Loc_13	Alshatra	610775	3476436	8.4	846	36	450	76	304	75.9	2.4	93	205	76
Loc_14	Alshatra	612325	3472145	8.4	855	40	646	76	304	76.5	2.4	94	214	76
Loc_15	Alshatra	614373	3468526	8.6	881	36	602	77	308	89.7	3.9	98	208	78
Loc_16	Algarraf	617100	3464176	8.5	866	54	526	77	308	79.2	2.4	100	214	78
Loc_17	Algarraf	618738	3462765	8.5	872	16	628	77	308	76.5	2.4	102	220	78

2.3. Remote Sensing Data

In this study, Landsat 8 OLI imagery with a spatial resolution of 30*30 m in the optical bands was downloaded from the United States Geological Survey (USGS) Earth Explorer website (www.earthexplorer.usgs.gov). A total of two Landsat images (path 168, row 30) acquired on 04 FEB and 11 MAY in 2017 were used in this study

The methodology consists of the following steps:

1) Conversion of satellite image digital number values to unitless planetary reflectance.
2) Atmospheric and geometric correction of the satellite image.(Landsat-8 correct).
3) Application of water index.
4) Correlation and regression analysis between the pixel reflectance values and the water quality.

2.3.1. Conversion of (DNS) to Top of Atmosphere Reflectance

This conversion is important for studies regarding reflectance of river surfaces because the raw digital numbers of a Landsat-8 the image is not only dependent on the reflectance characteristics of the specific scene.in addition, its contain noise and digital number value offsets that are a result of the viewing geometry of the satellite, atmospheric depth due to viewing angle, the design characteristics of the sensor and the angle of the sun's incoming radiation [6]. Extracting

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the information from Landsat images, a single pixel (digital numbers, DN) was converted to reflectance according to following equation [7]:

$$\rho\lambda' = M_p * Q_{cal} + A_p \quad ... (1)$$

Where:
$\rho\lambda'$ = Top-of-Atmosphere Planetary Spectral Reflectance, without correction for solar angle.
M_p = Reflectance multiplicative scaling factor for the band (REFLECTANCEW _ MULT_BAND_n from the metadata).

A_p = Reflectance additive scaling factor for the band (REFLECTANCE _ ADD_BAND_N from the metadata).

Qcal = Level -1 pixel value in DN.

Note:
$\rho\lambda'$ is not true TOA Reflectance because it does not contain a correction for the solar elevation angle . The conversion to true TOA Reflectance formula is:

$$P\lambda = \rho\lambda' / \sin(\theta) \quad ... (2)$$

Where:
$P\lambda$ = Top-of-Atmosphere Planetary Reflectance.
θ = Solar Elevation Angle (from the metadata, or calculated).

The Reflectance values for each Landsat-8 OLI band for the water sampling location on each date were extracted, as shown Table (4 and 5).

2.3.2. Atmospheric and Geometric Correction

Landsat-8 OLI data for 0.07 clouds for scene. The images were precision corrected by geometric and radiometric.

Table 4: Satellite image reflectance values in bands 3–7 at seventeen different stations (date: 4/FEB/2017).

	B3	**B4**	**B5**	**B6**	**B7**
Loc_01	0.1188	0.0841	0.0237	0.0105	0.0105
Loc_02	0.1196	0.0853	0.0254	0.0103	0.0091
Loc_03	0.1175	0.0811	0.0264	0.0161	0.0135
Loc_04	0.1215	0.0857	0.0256	0.0115	0.0115
Loc_05	0.1205	0.0844	0.0310	0.0177	0.0137
Loc_06	0.1202	0.0781	0.0134	0.0040	0.0003
Loc_07	0.1215	0.0813	0.0213	0.0010	0.0063
Loc_08	0.1209	0.0822	0.0267	0.0170	0.0185

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Loc_09	0.1216	0.0834	0.0262	0.0160	0.0136
Loc_10	0.1260	0.0870	0.0269	0.0141	0.0139
Loc_11	0.1226	0.0855	0.0348	0.0150	0.0152
Loc_12	0.1241	0.0855	0.0295	0.0091	0.0139
Loc_13	0.1505	0.1471	0.1373	0.1408	0.1218
Loc_14	0.1250	0.1176	0.1530	0.0905	0.0789
Loc_15	0.1179	0.1203	0.1757	0.1789	0.1324
Loc_16	0.1045	0.0960	0.1148	0.0997	0.0818
Loc_17	0.1600	0.1732	0.2020	0.2158	0.2013

B3=Green, B4=Red, B5=NIR, B6=SWIR1, B7=SWIR2

Table 5: Satellite image reflectance values in bands 3–7 at seventeen different stations (date: 11/MAY/2017).

	B3	**B4**	**B5**	**B6**	**B7**
Loc_01	0.1617	0.1630	0.1297	0.0996	0.0710
Loc_02	0.1686	0.1714	0.1352	0.1023	0.0737
Loc_03	0.1642	0.1655	0.1355	0.1011	0.0713
Loc_04	0.1610	0.1622	0.1211	0.0903	0.0650
Loc_05	0.1576	0.1567	0.1305	0.0935	0.0640
Loc_06	0.1680	0.1678	0.1137	0.0835	0.0620
Loc_07	0.1665	0.1698	0.1218	0.0943	0.0714
Loc_08	0.1592	0.1593	0.1230	0.0839	0.0631
Loc_09	0.1493	0.1446	0.1671	0.0786	0.0506
Loc_10	0.1598	0.1559	0.0912	0.0669	0.0537
Loc_11	0.1509	0.1480	0.1396	0.0879	0.0560
Loc_12	0.1468	0.1422	0.1804	0.0916	0.0607
Loc_13	0.1907	0.2064	0.2089	0.1804	0.1563
Loc_14	0.1660	0.1705	0.2220	0.1949	0.1494
Loc_15	0.1688	0.1793	0.2670	0.1797	0.1274
Loc_16	0.1706	0.1815	0.2425	0.2019	0.1545
Loc_17	0.2107	0.2333	0.2783	0.2732	0.2362

B3=Green, B4=Red, B5=NIR, B6=SWIR1, B7=SWIR2
This process is done using (Arc GIS 10.2).

2.3.3. Application of Water Index

After the geo-referenced image data should be converted into top-of-atmosphere (TOA) spectral reflectance using procedures detailed by the image metadata. All output files should be formatted as 32-bit. The water index is then calculated using Equations, as shown Table (6).

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Table 6: Water indices

Index	Formula	Reference
Normalized Difference water Index (NDWI)	NDWI=$\frac{GREEN-NIR}{GREEN+NIR}$	8
Modification Of Normalized Difference Water Index (MNDWI)	MNDWI=$\frac{GREEN-SWIR2}{GREEN+SWIR2}$	9
Normalized Difference Moisture Index (NDMI)	NDMI=$\frac{RED-NIR}{RED+NIR}$	10
Automated Water Extraction Index(AWEI)	AWEI= 4*(GREEN-SWIR2)-(0.25*NIR+2.75*SWIR1)	11
Water Ratio Index(WRI)	WRI=$\frac{GREEN+RED}{NIR+SWIR2}$	12

This process is done using (Arc GIS 10.2).

2.3.4. Correlation and Regression Analysis

To assess the nature and strength of the relationships, the reflectance index values of the image, that are the NDWI, MNDWI, NDMI, WRI, and AWEI were separately against eleven parameters. The coefficient of determination (R2) was used as a statistical measure of how successful the fitted regression model was in explaining the variation of the observed data. R2 values range from 0 to 1, with values close to 1 indicating good model fit. A statistical analysis was performed on the extracted from Arc GIS 10.2 as excel data .Then, this data input to spss software for find the strength of the linear relationship between the two variables is the correlation coefficient(R), as shown Table (7a,b) and Table (8a,b).in addition, application of regression equations Table (9a,b).

The seventeen stations were separated into two sets due to the two reaches of the stream, where the first twelve stations represented the first reach of the stream (50-60) m width. This reach was equivalent to 2 pixels of the satellite image, which these pixels could not mix only water. While, the five other stations represented the second reach of the stream (15-20) m width. This second reach was equivalent to less than one pixel due to the pixels were a mixture of water, vegetation and soil.

3. Results and Discussion

In this study, regression analysis was used to determine the physical and chemical parameters that were considered important explain water quality of Gharraf stream. Situ measurements and the satellite image acquisition time of the stream at seventeen stations at various parts of the stream were input into regression formulae. R Square values revealed that except for (E.c, ALK, T.H, Ca, T.D.s and T.S.S), very high accuracy will be obtained for (PH, CL,SO4, Na, and k) with five stations with date:4/FEB/2017 have respectively 0.752, 0.918, 0.982,0.915 and 0.820 R square values, while R Square values revealed that except for (ALK, T.H, Ca, T.D.s and T.S.S), very high accuracy will be obtained for (PH, E.c, CL, SO4, Na, and k) with five stations with date:11/MAY/2017 have respectively 0.904, 0.983, 0.712,0.999,0.974 and 0.873.

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The reflectance in water surface depends upon the sun elevation, where the sun elevation affects the amount of radiation received by the surface of the water, as shown Table (4) and Table (5). Sun elevation in 4 /FEB /2017 was (36.32951258º) and 11 /MAY/ 2017 was (66.52810785º).
Using TOA reflectance with different features of the Landsat 8 OLI sensor obtained higher classification results compared to the TM and ETM+ sensors. This was because the Landsat 8 OLI sensor provides higher SNR imagery than the other sensors [9]. The reflectance five stations were mentioned earlier that the pixels are a mixture of water, vegetation (high due to leaf development and free water leaf) and soil (moisture content is low) that is caused increasing in reflectivity.

Finally, the reflectance in water surface depends upon the sky reflection, the color of the chemical contents disbanded in the water or plants and animals at the bottom of the stream.

4. Conclusions

Some physical and chemical parameters can be calculated using water index form Landsat-8 (OLI) images.

Table (7a): Pearson correlation between spectral water index and water parameters for 4/FEB/2017 with twelve stations

		PH	E.C	ALK	T.H	Ca	CL	SO4	Na	K+	T.D.S	T.S.S
NDWI	Pearson Correlation	-.150	-.033	-.051	-.071	-.066	.123	-.059	.388	-.002	.158	-.328
	Sig. (1tailed)	.320	.459	.438	.414	.420	.351	.428	.106	.497	.312	.149
	N	12	12	12	12	12	12	12	12	12	12	12
WRI	Pearson Correlation	-.045	-.064	-.008	-.086	-.081	-.062	-.113	.470	-.018	.192	-.242
	Sig. (1tailed)	.444	.422	.491	.396	.401	.424	.364	.062	.477	.275	.224
	N	12	12	12	12	12	12	12	12	12	12	12
AWEI	Pearson Correlation	-.017	.020	.033	-.004	.000	-.076	-.290	.442	.050	.184	.106
	Sig. (1tailed)	.479	.476	.459	.495	.500	.407	.180	.075	.439	.283	.372
	N	12	12	12	12	12	12	12	12	12	12	12
NDMI	Pearson Correlation	-.215	.021	.007	-.021	-.016	.169	-.106	.380	.044	.099	-.322
	Sig. (1tailed)	.251	.475	.492	.474	.480	.300	.372	.112	.446	.380	.154
	N	12	12	12	12	12	12	12	12	12	12	12
MNDWI	Pearson Correlation	-.209	.116	.147	.077	.082	.020	-.370	.417	.140	.031	-.071
	Sig. (1tailed)	.257	.360	.324	.406	.400	.475	.119	.089	.332	.462	.414
	N	12	12	12	12	12	12	12	12	12	12	12

**. Correlation is significant at the 0.01 level (1-tailed).*. Correlation is significant at the 0.05 level (1-tailed).

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Table (7b): Pearson correlation between spectral water index and water parameters for 4/FEB/2017 with five stations

		PH	E.C	ALK	T.H	Ca	CL	SO4	Na	K+	T.D.S	T.S.S
NDWI	Pearson Correlation	-.503	-.175	-.093	-.093	-.093	.670	.491	-.329	-.205	-.006	-.154
	Sig. (1tailed)	.194	.389	.441	.441	.441	.108	.200	.294	.370	.496	.403
	N	5	5	5	5	5	5	5	5	5	5	5
WRI	Pearson Correlation	-.274	-.446	-.383	-.383	-.383	.859*	.691	-.675	-.484	-.324	-.340
	Sig. (1tailed)	.328	.226	.262	.262	.262	.031	.098	.106	.204	.297	.288
	N	5	5	5	5	5	5	5	5	5	5	5
AWEI	Pearson Correlation	.271	-.643	-.593	-.593	-.593	.867*	.527	.944**	-.778	-.512	-.492
	Sig. (1tailed)	.330	.121	.146	.146	.146	.029	.181	.008	.061	.189	.200
	N	5	5	5	5	5	5	5	5	5	5	5
NDMI	Pearson Correlation	-.717	.034	.093	.093	.093	.410	.429	-.005	.090	.130	.013
	Sig. (1tailed)	.087	.479	.441	.441	.441	.246	.236	.497	.443	.418	.491
	N	5	5	5	5	5	5	5	5	5	5	5
MNDWI	Pearson Correlation	.139	-.587	-.552	-.552	-.552	.821*	.664	.901-*	-.684	-.522	-.409
	Sig. (1tailed)	.412	.149	.167	.167	.167	.044	.111	.018	.102	.184	.247
	N	5	5	5	5	5	5	5	5	5	5	5

**. Correlation is significant at the 0.01 level (1-tailed).*. Correlation is significant at the 0.05 level (1-tailed).

Table (8a): Pearson correlation between spectral water index and water parameters for 11/MAY/2017 with twelve stations

		PH	E.C	ALK	T.H	Ca	CL	SO4	Na	K+	T.D.S	T.S.S
NDWI	Pearson Correlation	-.106	.188	.384	-.028	-.042	-.128	.011	.304	.078	-.176	.123
	Sig. (1tailed)	.372	.280	.109	.465	.448	.346	.487	.168	.404	.292	.352
	N	12	12	12	12	12	12	12	12	12	12	12
WRI	Pearson Correlation	-.279	-.237	.016	-.358	-.364	-.106	.573	-.327	-.147	-.468	.112
	Sig. (1tailed)	.190	.229	.480	.127	.122	.372	.026	.150	.324	.063	.365
	N	12	12	12	12	12	12	12	12	12	12	12
AWEI	Pearson Correlation	-.127	-.015	.284	-.211	-.225	-.145	-.234	.087	.049	-.315	.147
	Sig. (1tailed)	.347	.482	.186	.255	.241	.326	.232	.394	.439	.160	.324
	N	12	12	12	12	12	12	12	12	12	12	12
NDMI	Pearson Correlation	-.324	-.335	-.131	-.390	-.393	-.083	.636	-.460	-.163	-.472	.109
	Sig. (1tailed)	.152	.144	.342	.105	.103	.399	.013	.066	.306	.061	.368
	N	12	12	12	12	12	12	12	12	12	12	12
MNDWI	Pearson Correlation	-.106	.188	.384	-.028	-.042	-.128	.011	.304	.078	-.176	.123

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	Sig. (1tailed)	.372	.280	.109	.465	.448	.346	.487	.168	.404	.292	.352
	N	12	12	12	12	12	12	12	12	12	12	12

**. Correlation is significant at the 0.01 level (1-tailed).*. Correlation is significant at the 0.05 level (1-tailed).

Table (8b): Pearson correlation between spectral water index and water parameters for 11/MAY/2017 with five stations

		PH	E.C	ALK	T.H	Ca	CL	SO4	Na	K+	T.D.S	T.S.S
NDWI	Pearson Correlation	-.824*	-.874*	-0.704	-0.704	-0.704	-0.528	-0.246	-0.780	-0.679	-0.598	-0.184
	Sig. (1tailed)	0.043	0.026	0.092	0.092	0.092	0.180	0.345	0.060	0.104	0.143	0.384
	N	5	5	5	5	5	5	5	5	5	5	5
WRI	Pearson Correlation	-0.604	-0.797	-0.711	-0.711	-0.711	-0.750	-0.734	-0.357	-0.259	-.808*	0.095
	Sig. (1tailed)	0.140	0.053	0.089	0.089	0.089	0.072	0.079	0.278	0.337	0.049	0.439
	N	5	5	5	5	5	5	5	5	5	5	5
AWEI	Pearson Correlation	-0.029	-0.262	-0.398	-0.398	-0.398	-0.707	-.905*	0.428	0.434	0.452	0.651
	Sig. (1tailed)	0.482	0.335	0.253	0.253	0.253	0.091	0.017	0.236	0.233	0.223	0.117
	N	5	5	5	5	5	5	5	5	5	5	5
NDMI	Pearson Correlation	-0.723	-0.774	-0.571	-0.571	-0.571	-0.388	-0.187	-0.753	-0.654	-0.606	-0.292
	Sig. (1tailed)	0.084	0.062	0.157	0.157	0.157	0.260	0.381	0.071	0.116	0.139	0.317
	N	5	5	5	5	5	5	5	5	5	5	5
MNDWI	Pearson Correlation	0.181	-0.059	-0.237	-0.237	-0.237	-0.587	-.906*	0.613	0.629	0.376	0.532
	Sig. (1tailed)	0.385	0.462	0.351	0.351	0.351	0.149	0.017	0.136	0.128	0.266	0.178
	N	5	5	5	5	5	5	5	5	5	5	5

**. Correlation is significant at the 0.01 level (1-tailed).*. Correlation is significant at the 0.05 level (1-tailed).

Table (9a): Models of WQPs and water index, for five stations (date: 4/FEB/2017)

Parameters	**Model**	**R^2**
PH	PH= 8.396+2.622NDWI-4.295NDMI	0.752
CL	CL=153.835+18.353AWEI	0.751
	CL=133.327+18.030WRI+10.578AWEI	0.830
	CL=144.824+25.024WRI+44.690AWEI-78.621MNDWI	0.918
SO_4	SO_4=333.784+15.013WRI-102.857AWEI+233.350MNDWI	0.982
Na	Na=144.507-2.500AWEI	0.890
	Na=143.293-4.819AWEI+4.908MNDWI	0.915
K	K=3.053-2.068AWEI+3.365MNDWI	0.820

Table (9b): Models of WQPs and water index, for five stations (date: 11/MAY/2017)

Parameters	Model	R^2
PH	PH=8.327-1.050NDWI	0.678
	PH=8.197-4.321NDWI+3.061NDMI	0.904
E.c	E.c=837.273-183.706NDWI	0.763
	E.c=811.255-726.316NDWI+4.273WRI-503.116NDMI	0.983
CL	CL=113.400-22.163WRI-8.024AWEI	0.712
SO_4	SO_4=216.278-71.909MNDWI	0.821
	SO_4=255.878-32.477WRI+14.521AWEI-96.632MNDWI	0.999
Na	Na=68.266-62.126NDWI+39.756MNDWI	0.856
	Na=60.495-244.237NDWI+172.750NDMI+53.981MNDWI	0.974
K	K=0.590-28.279NDWI+21.050NDMI+6.621MNDWI	0.873

الفيزيائية والكيميائية من خلال تطبيق الاستشعار عن بعد وتقنيات نظم المعلومات الجغرافية

الخلاصة: هذه الدراسة قد أجريت بواسطه تحليل البيانات من صورة القمر الصناعي (لاندسات-8) ونظام المعلومات الجغرافية (GIS) للإيجاد العلاقة بين المتغيرات المياه ومؤشرات المياه من الصور الطيفية. الغرض الرئيسي من هذا البحث كان لتطوير نموذج للمتغيرات الفيزيائية والكيميائية لجدول الغراف في العراق. متغيرات المياه المستخدمة في هذه الدراسة تتضمن: الحموضة ، المواد الذائبة الكلية ، القلوية ، الموصلية الكهربائية ، الكالسيوم، الكلوريد ، الصوديوم ، كبريتات ، البوتاسيوم ، المواد العالقة الكلية ، الصلابة الكلية ، حيث العينات كانت مأخوذة لسبعة عشر محطة بموسمين، وفي نفس وقت أخذ صورة القمر الصناعي في **4 / فبراير** ، **11 / مايو** .تقنيات نظم المعلومات الجغرافية (GIS) كانت تستخدم في البداية لتسقيط احداثيات سبعه عشر محطه على طول الجدول في صوره القمر الصناعي (لاندسات-8) لاستخراج البيانات. ثم، هذه البيانات تعامل في برنامج (SPSS) لغرض ايجاد معامل الارتباط ومعادلات الانحدار. الارتباطات القوية الإيجابية بين انعكاس صوره القمر ومتغيرات المياه في **4 / فبراير و 11 / مايو** مع خمس محطات، ساعدت على بناء ستة نماذج انحدار. هذه النماذج يمكن استخدامها للتنبؤ بمتغيرات المياه الستة (**PH, E.c, CL, SO4, Na and K**) في أي نقطة على طول الجدول في العراق من صوره القمر مباشرة.

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*Corresponding author.
E-mail address: sonlargeiraq@ yahoo.com