

Limnological Study in Upstream and Downstream Degala Basin Water Body within Erbil City-Iraq

Kwestan Hassan Sdiq¹, Layla Mohamed Aladdin², Bakhtyar Abdullah Othman³, Sewgil Saaduldeen Anwer^{4ab*}

^{1,2}Medical Microbiology Department, College of Health Sciences, Hawler Medical University, Erbil, Iraq.

³Biology Department, College of Science and Health, Koya University, Erbil, Iraq.

^{4a*}Clinical Biochemistry Department, College of Health Sciences, Hawler medical University, Erbil, Iraq.

^{4b*}Nursing Department, Nursing College, Tishk International University, Erbil, Iraq.

*Corresponding author: sewgil.anwar@hmu.edu.krd

Article Information:

History:

Received: 14 September 2021.

Accepted: 12 February 2022.

Published: 31 March 2022.

Keywords:

Physicochemical; biological; algae; Degala Basin; TDS.

DOI:<http://dx.doi.org/10.32894/kujss.2022.131488.1046>

Abstract

The Degala Basin is one of the water reservoirs in the heart of the Degala sub-district, roughly 50 kilometers east of Erbil City. Samples were collected monthly from different sites of Degala Basin during October 2020 to August 2021 to determine physicochemical and biological properties EC, TDS, Chloride, Na, K, Ca hardness, total alkalinity, nitrate, and DO, pH, total hardness, Mg hardness, and Sulfate. The statistical analysis of the data revealed that there were significant differences in physico-chemical parameters between the two sites, with high significant relationships for (EC, TDS, chloride, Na, K, Ca hardness, total alkalinity, nitrate, and DO) and low significant relationships for (pH, total hardness, Mg hardness, and Sulfate) at the ($p \leq 0.05$) for all parameters studied different algal species obtained from all sampling sites in Degala basin revealed the presence of a variety of algal species. There is small change in the pH value during the observation period among upstream, basin and downstream. Different genera of algae found in Degala basin.

1. Introduction:

In various essential activities, water plays a key role and is inevitable for all living things because it has a great social and economic significance that eventually affects human life. Water is widely used for irrigation, industrial production, generation of hydroelectric power, fisheries, the protection of human life and domesticated animals. Physicochemical researches are therefore of primary importance in determining water quality for its best use and also in recognizing the pollution load on receipt [1]. Dams, built to change natural flow regimes, are one of the most significant human interventions in the hydrological cycle and they can result in post-impoundment phenomena that are specific to reservoirs and not natural lakes. The size of the dam, its location in the river system, its geographical location with respect to altitude and latitude, the detention time of the water and the source(s) of the water all influence the water quality [2].

In all major rivers and lakes, water contamination is an acute issue, and water is known to contain a large number of chemical elements, the interactions of both the physical and chemical properties of water play a significant role in composition, distribution, and abundance of aquatic organisms [3].

The Degala Basin is about 35 km to the northeast of Erbil city. The main stream that drained to it is composed of two branches which are intermittent. The watershed has a kidney shape. At the outlet there are several springs which are the sources of the base flow during dry seasons. The inhabitants at the upstream are engaged in raising animals and dry farming. Irrigation farming is practiced to a very low extent. The whole area has an undulating topography. The vegetative cover includes oak trees and some accompanying species such as hawthorn, wild cherry and wild pistachio. The soil of the watershed has a fine textured soil with patches of unconsolidated materials belonging to Kolosh formation. The main aims of this investigation were to assess physico-chemical and phycological parameters among upper stream, Degala basin and lower stream with correlation among them at each station.

Table 1. The physical and chemical properties of studied downstream site during the study period.

	pH	EC	TDS	Chloride	Sodium	Potassium	T. hardness	Ca Hardness	Mg Hardness	T. Alkalinity	Nitrate	Sulfate	DO
10-Jan	8.24	920	505	41	77	4.8	492	340	152	192	30	242	8.4
25-Feb	8.1	820	451	37.1	82	4.9	538	360	178	204	34	248	8.9
10-Apr	8.3	852	467	34.6	84	5.7	528	384	144	218	32	253	9
25-May	8.1	784	431	35.3	76	5.4	516	337	179	209	29	236	8.5
10-Jul	8.4	762	419	32.6	79	6.2	472	320	152	224	27	231	6.8
25-Aug	8.6	832	458	29.2	74	6.7	440	295	145	240	24	21	7.3
10-Oct	8.5	861	474	25	81	7.1	428	306	122	238	29	204	6.8
25-Nov	8.3	912	501	32	68	6.9	466	328	138	232	32	231	6.9
SD	0.178	55.79	30.4	4.89	5.097	0.9	40.48	28.7	19.31	17.1	3.16	15.99	1
Min	8.1	762	419	25	68	4.8	428	295	122	192	24	204	6.8
Max	8.6	920	505	41	84	7.1	538	384	179	240	34	253	9

Table 2. The physical and chemical properties of studied basin site during the study period.

	pH	EC	TDS	Chloride	Sodium	Potassium	T. hardness	Ca Hardness	Mg Hardness	T. Alkalinity	Nitrate	Sulfate	DO
10-Jan	8.21	974	544	48	82	5.1	470	310	160	176	29	247	6.8
25-Feb	8.2	942	518	41	91	7.4	496	320	176	172	24	284	5.1
25-Feb	8.2	942	518	41	91	7.4	496	320	176	172	24	284	5.1
10-Apr	8.4	995	547	39	93	7	509	338	171	163	20	279	6.2
25-May	8.2	916	504	36	97	6.8	504	340	164	170	28	260	6.1
10-Jul	8.5	902	496	35	87	7.1	468	331	137	166	25	216	4.5
25-Aug	8.62	884	486	31	92	7.3	418	320	98	154	26	244	4.8
10-Oct	8.89	864	475	33	95	7.8	454	324	130	151	24	228	4.3
25-Nov	8.48	947	520	39	84	7.34	466	322	144	176	28	258	5.2
SD	0.242	44.74	25.9	5.31	5.303	0.82	29.89	10.1	25.83	9.487	2.93	23.34	0.9
Min	8.2	864	475	31	82	5.1	418	310	98	151	20	216	4.3
Max	8.89	995	547	48.97	7.8	509	340	176	176	29	284	6.8	

**Figure 1.** A. Map of Iraq showing studied area, B. Map of Erbil province, C. Studied area (Degala)

2. Material and methods:

2.1 Description of the study area:

Generally, the hydrology, geology, climate and vegetation cover of Iraqi Kurdistan region area described by [4]. Rocks of this area are in part igneous rocks which are originated from magma, sedimentary rocks that is mainly composed of limestone, mud and sandstone and metamorphic rocks [5]. The present study area covered a distance about 50km east of Erbil City, The Degala basin constitutes of a small water reservoir located in the center of Degala sub- district, the valley drains its water from rain and snow melting water additionally springs located few kilometers to the north will be another important source for accumulating water. The dam is earthy with an elevation of about 30m above ground surface within latitude 36.171586 and longitude 44.38215, and the capacity of the lake reservoir capacity is about 1.06 million cubic meters. Fig. (1; A,B,C).

Table 3. The physical and chemical properties of studied upstream site during the study period.

	pH	EC	TDS	Chloride	Sodium	Potassium	T. hardness	Ca Hardness	Mg Hardness	T. Alkalinity	Nitrate	Sulfate	DO
10-Jan	8.12	918	504	29	22	3.24	470	320	150	204	31	228	7.1
25-Feb	8.3	814	448	26	28	2.5	488	330	158	212	29	238	5.6
10-Apr	8.4	727	400	21	39	2.2	445	325	120	236	25	216	8.5
25-May	8.35	742	408	23	36	2.7	428	296	132	224	23	248	8.3
10-Jul	8.3	720	396	20	33	2.9	440	302	138	244	26	220	6.6
25-Aug	8.5	730	402	18	40	3	432	285	147	260	31	214	8.3
10-Oct	8.54	717	394	17	36	2.66	430	304	126	262	27	209	7.9
25-Nov	8.47	856	470	24	31	2.92	452	318	134	236	36	218	7.3
SD	0.14	75.8	41	4.1	6.01	0.32	21.2	16	12.8	20.9	4.1	13.2	1
Min	8.12	717	394	17	22	2.2	428	285	120	204	23	209	5.6
Max	8.54	918	504	29	40	3.24	488	330	158	262	36	248	8.5

Table 4. The water resource characteristics standards of Kurdistan, Iraq and WHO.

Water resource characteristics	Kurdistan global mean suggested	Iraq standards	WHO
			(international) standards
pH (unit)	7.7	6.5-8.5	6.5-8
Conductivity	400	2000	100-500
Total Dissolved solids (TDS)	842	1000	1000
Chloride (mg.l^{-1})	150	350	250
Na ions (mg.l^{-1})	14	200	200
K ions (mg.l^{-1})		10	200
Total hardness	204	500	100-300
Ca ions (mg.l^{-1})	51	150	75
Mg ions (mg.l^{-1})	22	100	50
Total alkalinity	205	125 -200	100 -200
Total alkalinity	205	125 -200	100 -200
SO ₄ (mg.l^{-1})	184	250	200
DO (mg.l^{-1})	8	5	4.0-6.0

2.2 Physical and Chemical parameters:

Samples were collected monthly from different sites of Degala Basin from October 2020 to August 2021 for physicochemical and biological analysis using sterile plastic bottles then the samples delivered to the laboratory and preserved for further analysis.

2.2.1 pH, Electrical Conductivity (EC), ($\mu\text{S.cm}^{-1}$) and Total Dissolved Solid(TDS),(mg.l^{-1}):

were measured by a portable multimeter pH, EC, TDS meter model (HANNA, instruments, HI9811, 200), the results were expressed as $\mu\text{S.cm}^{-1}$ for EC and (mg.l^{-1}) for measured TDS [6].

2.2.2 Chloride:

was determined by argentometric titration using standard silver nitrate titrant (0.014 N) and potassium chromate indicator solution as described by [6].

2.2.3 Sodium, Calcium and potassium (Na, Ca, K) mg.l^{-1} : were measured by flame Emission photometric method (Sherwood-410).For obtaining the standard curve the instrument calibrated by standard solution as described by [6].

2.2.4 Magnesium ($\text{mg CaCO}_3.\text{l}^{-1}$):

Determined by EDTA (Ethylene-di amine-tetra acetic acid disodium salts) in which 100ml of water was taken .2ml of buffer solution with pH of ammonia %25 was added, and 6 drop of Erich Rome Black T as indicator [6].

2.2.5 Total Alkalinity:

was determined in the lab by titration methods using standard sulfuric acid titrant (0.1N) as described by [6],the results were expressed in $\text{mg CaCO}_3 \text{l}^{-1}$.

2.2.6 Nitrogen – Nitrate (N-NO₃) (mg.l):

Nitrate was determined by Ultraviolet Spectrophotometric Screening Method. After filtration of water sample 50 ml of

Table 5. The water resource characteristics standards of Kurdistan, Iraq and WHO.

	pH	EC	TDS	Chloride	Sodium	Potassium	T. hardness	Ca Hardness	Mg Hardness	T. Alkalinity	Nitrate	Sulfate	DO
pH	1												
EC	-0.597	1											
TDS	-0.598	1.000**	1										
Chloride	-.806*	.885**	.886**	1									
Sodium	.776*	-.880**	-.880**	-.862**	1								
Potassium	-0.316	0.511	0.509	0.261	-0.477	1							
T.hardness	-0.603	.713*	.717*	.787*	-.777*	0.011	1						
Ca.Hardness	-0.409	0.544	0.545	0.637	-0.564	-0.374	.801*	1					
Mg.Hardness	-0.501	0.519	0.524	0.527	-0.601	0.475	0.687	0.106	1				
T.Alkalinity	.852**	-.732*	-.735*	-.963**	.778*	-0.086	-.754*	-0.636	-0.475	1			
Nitrate	0.086	0.658	0.658	0.297	-0.399	0.531	0.38	0.19	0.395	-0.041	1		
Sulfate	-0.545	0.251	0.254	0.603	-0.346	-0.037	0.32	0.13	0.373	-.731*	-0.32	1	
DO	0.485	-0.433	-0.436	-0.501	0.7	-0.137	-.788*	-0.501	-0.694	0.483	-0.27	-0.282	1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

water sample acidified by adding 1ml of hydrochloric acid solution 1N and Ultraviolet Spectrophotometer (model Gen way 1400), with a 1cm quartz cuvette cell at a wavelength of 220 nm for nitrate reading and a wavelength of 275 nm to determine interference due to the dissolved organic matter. Results were expressed in mg l^{-1} [6].

2.2.7 Sulphate (SO_4^{2-}) ($\text{mg SO}_4^{2-} \cdot \text{l}^{-1}$):

Sulfate was determined by Turbid metric method described by [6] (APHA,2012) acetic acid medium with barium Chloride , so as to form barium sulfate. Sulfate values were determined from the calibration curve was measured by spectrophotometre at wavelength 490nm and the results were expressed as $\text{mg SO}_4^{2-} \cdot \text{l}^{-1}$.

2.2.8 Dissolved Oxygen (D.O) ($\text{mg} \cdot \text{l}^{-1}$):

Directly in the field the dissolved oxygen was measured by using special oxygen –sensitive membrane electrode (HANNA instrument, HI 9142 German company) Results were expressed by $\text{mg} \cdot \text{l}^{-1}$ [6].

2.2.9 Total Hardness ($\text{mg CaCO}_3 \cdot \text{l}^{-1}$):

Total hardness was determined by EDTA (0.01 M) titrimetric method as described by [6], using buffer solution of pH 10 and Eriochrome Black T as indicator.

2.3 Phycological study:

Total number count of algae was performed by using sedimentation method [7]. One liter of each sample taken was put in graduated cylinder (1000 ml), samples were preserved by adding drops of Lugol's solution and left in stand place, after ten days, 900 ml were sucked by siphon technique. The rest was transported to another cylinder (100 ml) and left at the same method to seven days, after that 90 ml drawn and the rest (10 ml) put in covered glass vials, adding 2-3 drops of Lugol's solution. Algae were identified using compound

microscope based for morphological characterization such as Filament or Unicellular, Akinet, Heterocyst, Hormogonia, Clour, Chloroplast and cell shape depending on the following references [8][9][10].

2.4 Statistical analysis:

Experimental data in this study was obtained from three replicates, and values were shown as mean \pm standard deviation. Statistical significance of correlations between variables was based on correlation test. It is performed by correlation coefficient and significant effects ($P < 0.05$), which were analyzed based on data obtained under various culture conditions by SPSS statistics vision 27.

2.5 Result and Discussion:

This study involves determining the physical and chemical parameters of surface water, pH is one of the most important parameters. The pH value of aquatic system is an important indicator of the water quality and the extent pollution in the water shed areas [11] due to determining of the alkalinity and acidity of water condition [12](EPA, 2005) because it effects biological life, and all biochemical reactions since they are sensitive to the alternation of pH [13]. At downstream, basin, and upstream of reservoir, the pH ranged between minimum 8.1 to maximum 8.9 that were recorded during January, February, May, and October 2020 respectively in three stations Table (1, 2, and 3) with \pm SD (0.178, 0.242 and 0.14) were recorded from downstream, basin, and upstream respectively Fig.(2). Although, from the results it seems that the pH value shifted toward the alkaline side of neutrality [14] the accumulation of the calcareous soils and consumption of CO_2 through photosynthesis [15]. Mostly, Iraqi inland water was regarded to be on the alkaline side of neutrality Table (5), reflecting geological formations of the area, specially the geology of Kurdistan composed mainly of CaCO_3

Table 6. The physical and chemical properties of studied basin site during the study period.

Algal genera	Division	Upstream	Dam	Down stream	NO.	%
Chlorella	Chlorophyta	4	5	2	11	8.7
Chlamydomonas	Chlorophyta	5	1	0	6	4.8
Stigeoclonium	Chlorophyta	1	0	0	1	0.8
Chara	Chlorophyta	1	0	0	1	0.8
Scendesmus	Chlorophyta	4	5	1	10	7.9
Closterium	Chlorophyta	4	4	1	9	7.1
Spyrogyra	Chlorophyta	8	7	0	15	11.9
Selenastrum	Chlorophyta	12	0	0	12	9.5
Euglena	Euglenophyta	10	4	1	15	11.9
Chroococcus	Cyanophyta	3	2	3	8	6.3
Anabaena	Cyanophyta	4	0	0	4	3.2
Lyngbya	Cyanophyta	1	1	0	2	1.6
Phormidium	Cyanophyta	4	1	1	6	4.8
Oscillatoria	Cyanophyta	3	2	1	6	4.8
Spirulina	Cyanophyta	4	3	1	8	6.3
Nostoc	Cyanophyta	0	1	0	1	0.8
Myxosarcina	Cyanophyta	2	1	1	4	3.2
Navicula	Bacilliarophyta	2	0	0	2	1.6
Anomoeoneis	Bacilliarophyta	2	2	1	5	4.0
Total					126	100

[16],[17]. Similar results were observed in Dukan lake by [18]. Electrical conductivity can be used as an indicator for testing the quality of water thus, an indicator of salinity and osmotic pressure of water, due to its significant correlation with parameters such as temperature, pH value, alkalinity, total hardness [19]. Water conductivity and dissolved solids values measured for the basin were higher than for the other streams due to increased surface area and altered dissolved minerals due to excessive water evaporation from the dam, which may have subsequently increased the concentration of dissolved salts by accumulating them as reflected in the TDS values [20]. The high value of conductivity may be related to high concentration of sodium, chloride and TDS [21]. Usually TDS level is directly correlated to the electrical conductivity, primarily when it is in high concentrations [22]. Similar conclusion was reported by [14],[23]. In current observations, the EC varies between (717 - 995) $\mu\text{s cm}^{-1}$ were recorded during October and April 2020 individually in three stations Table (1, 2 and 3) with \pm SD (55.79, 44.74, and 75.8) were recorded from downstream, basin, and upstream respectively. While the TDS varied between (394 - 547) mg l^{-1} at the same

time Fig.(2). The results showed that downstream, basin, and upstream \pm SD (30.4, 25.9, and 41). According to standard methods due to the close relationship between EC and TDS a significant positive correlation obviously found at sites Table (5). The range of total dissolved solid electrical conductivity of the water were varied due to natural sources, and depended on the solubility of mineral in different geological region, and water containing Table (4). Nearly in all natural waters, chlorides are present. This is the most natural anion that is inorganic and found in water. Large amounts of chloride are removed by humans and animals, so contamination of water is suggested. The variance observed is often associated with basin hydrology [24] in the current study. Although chloride concentration was recorded between (17-48) during October and January 2020 in upstream, and basin Table (1, 2 and 3) with \pm SD (4.89, 5.31, and 4.1) Fig.(2).

The statistical relation among sample stations during study period for Chloride revealed that a significant positively correlated with total hardness and EC while negatively with pH at level 0.05 and 0.01 as shown in Table (5). Chloride is characterized as innocuous particle, it can change to the inoffensive

structure very quickly [25]. The salts of sodium, potassium and calcium contribute to the concentration of chloride inside the water. The large contents of chloride in freshwater are an indicator of pollution, hence the high chloride concentration level in water contributes to deteriorate the domestic plumbing, water heaters and municipal water works equipment [26]. The rocks of high ground and mountain have normally a very low concentration in chloride, therefore running water and ground water often do not have a lot of chloride [27] which is obviously recognized in the area Table (4). Clearly sodium and potassium are two elements eluted during the rainy season followed by rapidly absorbed via dry soil. [28]. The dominance of Na^+ over K^+ , can be explained by the solubility of sodium since it is more soluble than potassium, and K^+ is generally more easily fixed in the rock matrix within clay minerals. Hence K^+ is the least abundant among cations [29]. However sodium and potassium concentrations comes in accordance with the general known levels of these elements in other parts of the world. The concentration recorded was between (22-97) for sodium while potassium recorded (2.2-7.8) during January and May 2020 in upstream, and basin Table(1, 2 and 3) with \pm SD (5.097, 0.82, and 6.01) for sodium, and \pm SD (0.9, 0.82, and 0.32) for potassium Fig.(2).

The statistical analysis revealed that there were a significant positively correlated with pH and negatively with EC, TDS, chloride at level 0.05 and 0.01 as shown in Table (5). The values of sodium were found to be always higher than potassium and much less than that of calcium, similar conclusion made by Shekha 1994. The differences between sodium and potassium values in this survey may possibly relate to soil formation [28] The amount of sodium recorded in all water samples was below the maximum permissible limit of WHO and EPA for drinking water, 200mg l^{-1} [30],[31]. The variation of total hardness may be due to source, type and origin of water source, geological and soil properties of the catchments area, various human activities and effect various pollutant as well as the climate conditions have been shown to influence on the hardness value in any water system [32]. Generally the sites recorded between (418-538) during August and February 2020 in basin and downstream, Table (1, 2 and 3) with \pm SD (40.48, 29.89, and 21.2). Total hardness is primarily imparted by calcium and magnesium ions in most of the fresh water, which apart from sulphate, chloride and nitrates, are present in combination with river carbonates and bicarbonates, resulting in greater erosion of the coastal river level [33]. Our study value is slightly higher than WHO 1996 [34] recommend value which is 100-300 $\text{mg CaCO}_3 \cdot \text{l}^{-1}$. Hardness depends on the amount of calcium or magnesium salts or both [35](Singh and Singh, 2003). In general, the hardness caused by the presence of calcium and magnesium originated from the sedimentary rocks, the most common being limestone and chalk [36]. In the present study, the values of total hardness exceeded those of total alkalinity which indicates that hard-

ness in studied area is caused by other ions rather than $Ca + 2$ and $Mg + 2$ ions that participate in formation of non-carbonic hardness [37]. Although hard water has no known health effects, it is not suitable for domestic use [38]. In an aquatic environment, calcium is an essential micronutrient and this environment is affected by the metallic oxide adsorption of calcium ions. In addition, microorganisms that play an important role in the calcium exchange between sediments and overlapping water have an impact. Magnesium is an essential for chlorophyll and acts as a limiting factor for phytoplankton growth. Thus, magnesium loss decreases the phytoplankton. Calcium and Magnesium are essential for all the organisms. They are required as micronutrient for algae and important nutrient for the metabolism of plants [39].

Ca and Mg reported values ranging from minimum concentrations of ($285\text{mgCaCO}_3\text{l}^{-1}$) at upstream water in August and ($98\text{mgCaCO}_3\text{l}^{-1}$) in basin water in August to maximum concentrations ($384\text{mgCaCO}_3\text{l}^{-1}$) at basin water in April and ($179\text{mgCaCO}_3\text{l}^{-1}$) in downstream river in May, respectively with \pm SD (28.7, 10.1 and 16) and (19.31, 25.83 and 12.8) were recorded at upstream, basin and downstream respectively. In all sampling sites and dates the level of Ca concentration were higher than Mg concentration and the results shown that a significant positive correlation between sites was found with total hardness at level 0.05 and 0.01 as shown in Table (5). Calcium and magnesium are considered to be the main constitute of hardness property [40]. The presence of calcium in water supplies results from passage over deposits of limestone and dolomite. While the average abundance of magnesium ion $Mg + 2$ in the earth's crust is %2.1; in soils it is 0.03 to %0.84 and in surface waters it is 4 $\text{mg} \cdot \text{l}^{-1}$ [6] (APHA, 2012) Since these minerals contribute mostly to the dissolved cations in the natural system, an increased rate of weathering does not alter the relative abundance of calcium and magnesium, but increases their concentrations [41]. In the present study, the concentration of calcium was less than that of magnesium. Similar, results have been reported by [42]. This may be attributed to the geological formation of the area which can be related to the nature of soil and rock [43]. The total alkalinity value were ranged between ($151 - 262\text{mg l}^{-1}$), the highest value was recorded in upstream in August and the lowest value was recorded in basin dam during January with \pm SD (17.1, 9.48 and 20.87) from upstream, basin water body and downstream separately Fig.(2)

with significant correlation among sites during studied period a significant positive correlation between sites was found with pH, sodium and negatively with EC, TDS, chloride, and total hardness at level 0.05 as shown in Table (5). Alkalinity in general, was in the range of Kurdistan and Iraqi standards Table (5) beside its depending on the rock and soil properties caused by the existence of calcium and magnesium carbonate, bicarbonates and possibly hydroxide ions [44]. Alkalinity of water has increased in the rainy months. When rainfall

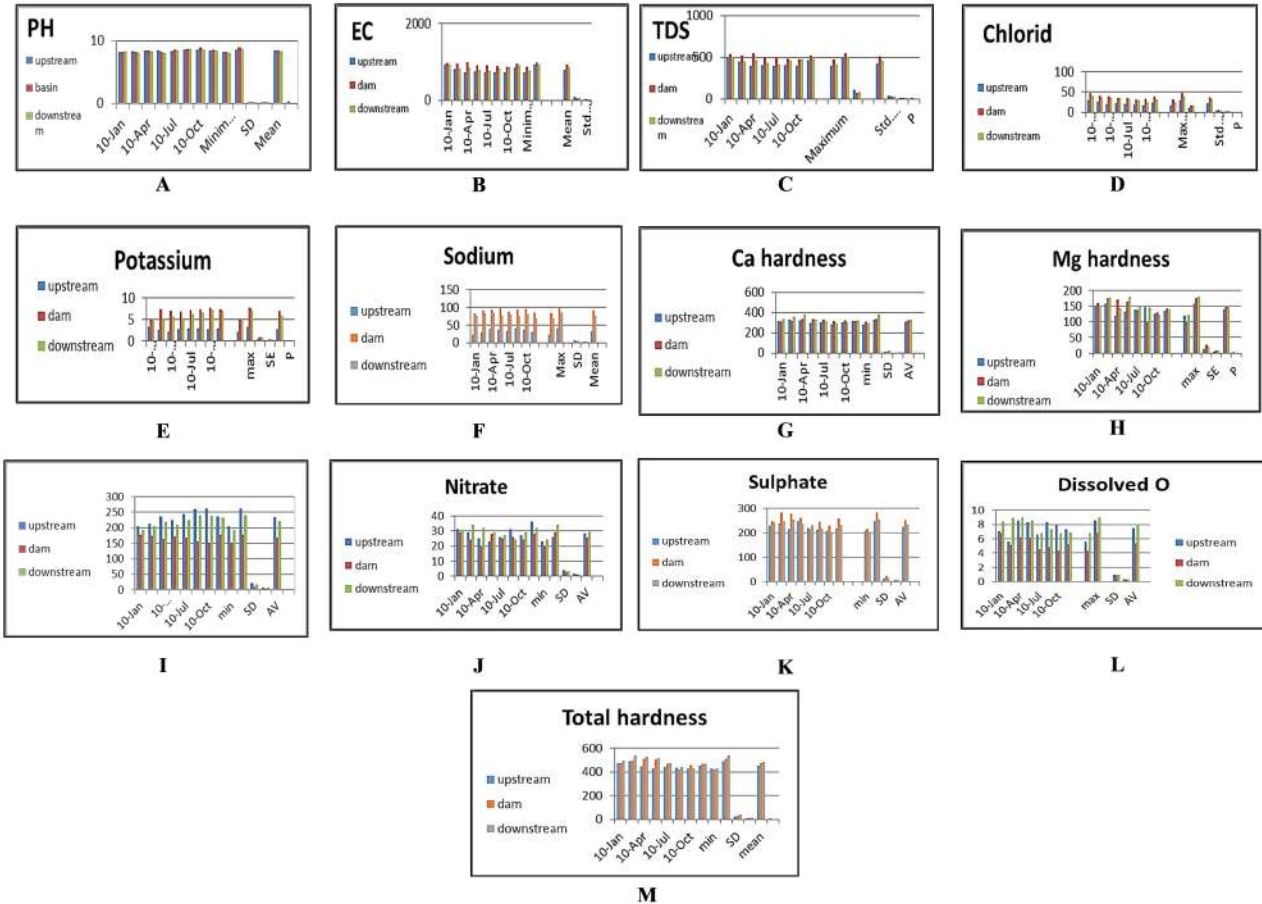


Figure 2. Physicochemical characters of upstream and downstream Degala Basin water (A: PH, B: EC, C: TDS, D: Chloride, E: Potassium, F: Sodium, G: Ca hardness, H: Mg hardness, I: Total alkalinity, J: Nitrate, K: Sulphate, L: Dissolved Oxygen, M: Total Hardness).

passes through the soil layers, it reacts with carbon dioxide to form carbonic acid, the later react with limestone to produce dissolved calcium and bicarbonate (HCO_3) [45].

High alkalinity value in the hot months may be due to the phytoplankton activity, photosynthesis and respiration processes while the low value which recorded at cold month as shown Fig.(2, this may be due to the dilution phenomena by rain or snow which cause the reduction in alkalinity value [46]. Increasing in alkalinity values may be due to decreases in the water level. Bicarbonate increases with the decrease of water levels, accumulation of carbonate during summer results the liberation of free CO_3 during decomposition of bottom deposits, which possibly converts insoluble $CaCO_3$ in to soluble $Ca(HCO_3)_2$ have also been reported by [47](Al-Naqishbandy 2020). According to WHO standards Table (4) the high desirable level of alkalinity concentration is $125\text{mg-CaCO}_3/\text{L}$ and the high permissible level is $200\text{mgCaCO}_3/\text{L}^{-1}$ [48].

Nitrates are very important nutrient factor in aquatic ecosystems, generally, water bodies polluted by organic matter exhibit higher values of nitrates [49]. The nitrate concentration in surface water is normally low ($8 - 10\text{mg}/\text{L}^{-1}$), but can reach high level as a result of agriculture run-off, contamination with human and animal wastes. The concentrations often fluctuate with the season and may increase when the river is fed by nitrate-rich aquifers. The sites recorded between (20-36) during April and November 2020 in basin and downstream, Table (1,2 and 3) with \pm SD (3.16, 2.93, and 4.1) were recorded from upstream, basin and downstream respectively Fig.(2). The statistical shown that there is no correlation between sites as shown in Table (5). The sources of nitrate in water are flowing from agricultural regions which contain chemical fertilizer or from the effluents of factories and sewage wastewater which were discharged without any treatment [50]. This may be due to the nitrate importance in the final phase in oxidation of ammonia and other nitrogen compounds [51]. Also the highest value of nitrate reflects the direct effect of the agriculture runoff [11]. The results of the Nitrate present revealed that the higher values recorded during rainy season. This may be attributed to the oxidation of ammonia by nitrifying bacteria, and the presence of nitrate concentration in indicated level due to presence of many villages and crop farms on upstream river that most of them use fertilizers and it erosion to nearby water during rainy or windy days. The lower values recorded during semi rainy month April may be related to the denitrifying bacteria in basin water body [52]. And mixing of waste water bodies with downstream river due to close contact between Degala sub-district and downstream basin and drain Degala Sewer system through downstream.

Commonly, sulfate concentration is an abundant ion in the earth crust and its concentrations of water range from few milligrams to several thousand milligrams per liter, according to water quality criteria in 1989, a guideline value of APHA, $400\text{mg}/\text{L}^{-1}$ for sulfate was established. As for sulfate, the values ranging from Minimum value of ($204\text{mg}/\text{L}^{-1}$) were recorded in downstream river in October to maximum

concentration($284\text{mg}/\text{L}^{-1}$) during February in basin water body due to weathering and runoff surface water from the study area [53],[54] (Fattah,2010 and Kurunc et al.,2005) and \pm SD (15.99,23.34 ,and 13.2) were recorded from upstream ,basin and downstream individually Fig.(2). According to statistical relations there were a significant negative correlation with total alkalinity at level 0.05 and 0.01 as shown in Table (5). Sulfate is one of the primary particles present in the water in different obsessions going from a couple to a few thousand milligrams for each liter [6] (APHA., 2012). In general, Iraqi Kurdistan Region inland water usually contain significant amount of sulfate [55] as shown in Table (5).

Dissolve oxygen DO is an important limnological parameter indicating the level of water quality in the water body and the level of organic contamination. When assessing the water quality requirements of an aquatic environment, the determine of DO is remarkably important. The DO values typically remain lower than those of the system where the rate of respiration and organic decomposition is high, and the rate of photosynthesis is high [56]. So dissolved oxygen, may be influenced by water temperature, composition, treatment and any chemical or biological processes taking place in the distribution system [57]. Dissolved oxygen concentration in this study was highly depended on air and water temperature. The maximum value of DO was recorded as $9\text{mg}/\text{L}^{-1}$ in April at downstream (2).

This is due to the inverse relationship between oxygen concentration and temperature [58]. and minimum recorded as 4.3 in Degala basin at October and \pm SD (1, 0.9 and 1) were recorded from upstream, basin water body and downstream correspondingly. The low oxygen-retaining capacity of water due to the increase in organism respiratory demand at high temperature may also be the reason for low values of dissolved oxygen [59],[60]. A significant negatively correlation with total hardness at level 0.05 and 0.01 as shown in Table (5). During the study period, the maximum DO value was recorded in downstream due to low water temperature and higher atmospheric influences due to its position and heavy water flow and lower temperature at this station and also in the running season compared to other sampling sites [1]. The primary environmental factors directly affect some of the chemical reactions in aquatic ecosystems throughout different seasons of the year [61]. In addition to the biological activities, the solubility of gases also has an effect [62] Meanwhile it can be considered as the dominant factor because of its effect on the rate constant that predict the reaction rate that lead to incomplete insight by ignoring the changes in solute changes and reaction zone areas [63].

3. Phycological study:

The total results of the present study showed that a total of 126 algal genera were recorded. The greatest bulk of identified algal species (65) belonged to Chlorophyta followed

by Cyanophyta (35) , Euglenophyta (15) and diatom (11) as shown in Table (6). A total of 126 of algae were identified from the site on the base of their morphological study and the Chlorophyte were dominated over all taxa then Cyanophyta and Diatoms, the isolated strains of algae ranged from unicellular to filamentous in form Fig. (3). Isolates included Cyanophyta, Chlorophyta and Bacillariophyta (Diatom). The color of the cultures ranged from blue-green to green and yellow-brown for Myxosarcina. Toma and Bahram [63] listed and recorded 244 blue-green algae species in the province of Erbil. Aziz and Muhammed [64] recorded a total of 151 algal species in some springs around the Safeen Mountain Area. The majority of the species obtained by Aziz and Muhammed were Chlorophyta with 68 species, followed by Cyanophyta with 46 species, Euglenophyta with 18 species, Chrysophyta with 12 species, Charophyta with 3 species, Rhodophyta with 2 species and Cryptophyta and Pyrrophyta with one species [65]. In five artificial ponds in the main parks within Erbil city, A total of 163 species were recorded which belonged to 69 genera. Furthermore, Aziz and Yasin [66] in 2019 recorded a total of 116 species belonging to 58 genera, 31 families, 19 orders, 9 class, and 8 divisions in eight artificial fish ponds in Erbil.

4. Conclusion:

The statistical analysis of the data revealed that there were significant differences in physico-chemical parameters between the two sites, with high significant relationships for (EC, TDS, chloride, Na, K, Ca hardness, total alkalinity, nitrate, and DO) and low significant relationships for (pH, total hardness, Mg hardness, and Sulfate) at the (p0.05 level) for all parameters studied. Due to open areas and the drainage of many waste disposals through stream branches that drain their water to an upstream river, as well as the drainage of municipal waste water from Degala town through basins and downstream water bodies, all water samples from all sampling sites revealed the presence of a variety of algal species thus it is recommended to study the use of algae as an indicator in water pollution and study their role to remove of polluted substances in present water There is small change in the pH value during the observation period among upstream, basin and downstream. Different genera of algae found in Degala basin.

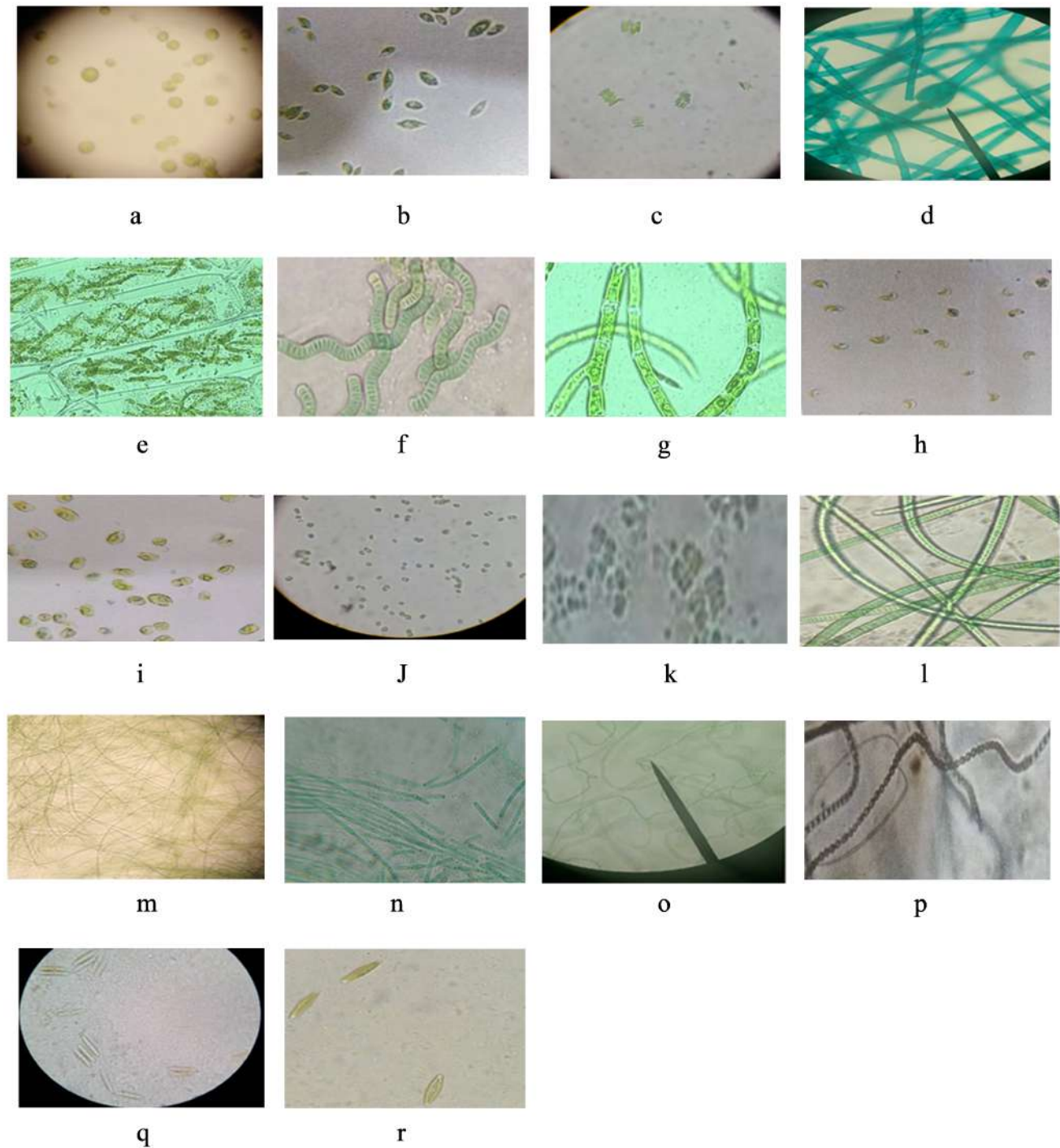


Figure 3. Different algal species from Degala Basin water, a: *Chlorella* 90X, b: *Euglena* 200, c: *Scenedesmus* 58X, d: *Chara* 25X, e: *Spirogyra* 90 X, f: *Spirulina* 200X, g: *Stigeoclonium* 58X, h: *Selenastrum* 66X, i: *Chlamydomonas* 300X, j: *Chroococcus* 140X, k: *Oscillatoria* 2000X, m: *Phormidium* 2500X, n: *Lyngbya* 500X, o: *Anabaena* 2000X, p: *Nostoc* 500X, q: *Myxosarcina* 500X, r: *Navicula* 700X.

Declarations:

Funding: None.

Conflict of interest: The authors declare that they have no conflict of interest.

Data Availability Statement: All of the data supporting the findings of the presented study are available from corresponding author on request.

References

- [1] D.R. Khanna G. Matta V. Kesre, L.K. Mudgal and D. Kumar. Study of physico-chemical parameters for a reservoir at khandwa district, m.p. *India. Waste and Water Management*, (2):201–207, 2011.
- [2] M.K. Bhatnagar, Prachi., Tripathi, Ashok., Singh, and Mukesh. Physicochemical analysis of some water samples in Rewa city (m.p.), *India. Poll. Res.*, 31(2):213–215, 2012.
- [3] M.K. Mustapha and J.S. Omotosho. An assessment of the physico-chemical properties of Moro Lake, Kwara State, Nigeria. *African J. of App. Zoo. and Envntl. Bio.*, 7:3–77, 2005.
- [4] E. Guest. Flora of Iraq. *Ministry of Agriculture, Baghdad*, 1:213, 1988.
- [5] K. Karim and I. Ghafor. Updated stratigraphy, tectonics and boundary conditions of the Mawat and Bulfat ophiolite complexes, Kurdistan region, NE-Iraq. In *The Second International the Fourth Scientific Conference of College of Science*, page 149, Tikrit University, 2020.
- [6] I. Ponnuswamy, S. Madhavan, and S. Shabudeen. Isolation and characterization of green microalgae for carbon sequestration, waste water treatment and bio-fuel production. *International Journal of Bio-Science and Bio-Technology*, 5:2, 2013.
- [7] I. Ponnuswamy, S. Madhavan, and S. Shabudeen. Isolation and characterization of green microalgae for carbon sequestration, waste water treatment and bio-fuel production. *International Journal of Bio-Science and Bio-Technology*, 5:2, 2013.
- [8] K. Krammer. Diatoms of Europe. Diatoms of the European inland waters and comparable habitats. *Cymbella*. ARG Gantner Verlag KG, Ruggell, 3:584, 2002.
- [9] K. Krammer. *Cymbella*, *delicata*, *navicymbella*, *gomphocymbellopsis*, *afrocymbella*: ARG Gantner Verlag KG, Ruggell, *Liechtenstein. Diatoms of Europe*, 4:529, 2003.
- [10] D. M. John, B. A. Whittton, and A. J. Brook. *The Freshwater Algal Flora of The British Isles: An Identification Guide To Freshwater And Terrestrial Algae*. Cambridge University Press, Cambridge, 2nd edition, 2011.
- [11] L. Al-Naqshbandy. *Phycolimnological Study with Particular References to Algal Natural Products from Springs and Streams Within Akri District, Duhok*. PhD thesis, Salahaddin University. Erbil. Iraq, 2020.
- [12] U. Epa. Water quality report. Garden Grove. Water Service Division., 2005.
- [13] J. Srinivas, A. V. Purushotham, and K. V. S. G. M. Krishna. Determination of water quality index in industrial areas of Kakinada, Andhra Pradesh, India. *Int. Res. J. Environment Sci.*, 2(5):37–45, 2013.
- [14] A.H.A. Bilbas. *Ecosystem Health Assessment of Dukan Lake, Sulaimani, Kurdistan Region of Iraq*. PhD thesis, Higher Education Coll., University of Salahaddin-Hawler, Iraq, 2014.
- [15] A. A. Al-Lami and H. H. Al-Jaberi. Heavy metals in water, suspended particles and sediment of the upper-mid region of Tigris River, Iraq. In *Proceedings of international symposium on environmental pollution control and waste management*, 4(12):97–102, 2002.
- [16] MA. Alanbari, SS. Alquzweeni, and RA. Aldaher. Spatial distribution mapping for various pollutants of Al-Kufa River using geographical information system (GIS). *International Journal of Civil Engineering and Technology (IJCIET)*, 6(10):1–14, 2015.
- [17] A. M. Kalwale and P. A. Savale. Determination of physico-chemical parameters of Deoli Bhorus Dam water. *Advances in Applied Science Research*, 3(1):273–279, 2013.
- [18] K.H. Sidiq. Ecological and physiological studies on some algae species growth in Dukan Lake, Kurdistan region of Iraq. Master's thesis, the Faculty of Science and Science Education School of Science at the University of Sulaimani, Iraq, 2014.
- [19] P. N. Patil, D. V. Sawant, and R. N. Deshmukh. Physico-chemical parameters for testing of water – a review. *International journal of environmental sciences*, 3(3):1194–1207, 2012.
- [20] O. G. Irenosen, A. A. Festus, and A. F. Coolborn. Water quality assessment of the Owena multi-purposed dam, Ondo State, southwestern Nigeria. *Journal of Environmental Protection*, 3:14–25, 2012.
- [21] R. O. Rasheed. A limnological study on some water systems in Erbil province. Master's thesis, Univ. of Salahaddin, Erbil, 1994.
- [22] K. Leggett, J. Fennessy, and S. Schneider. Hoanib River Catchment Study, Northwestern Namibia: Soil, Water, Fauna, Vegetation, 2001.
- [23] A. R. Hamadamen. Phycological study of the Qandil Mountain Streams/ Sulaimani. Master's thesis, Univ. of Salahaddin-Erbil, 2015.

- [24] Sangal R. R., Kulkarni U. D., and Nandurkar Y.M. An assessment of the physico-chemical properties to study the pollution potential of Ujjani reservoir, Solapur district, India. *ARPN Journal of Agricultural and Biological Science*, 6(3):1–5, 2011.
- [25] C. R. Goldman and A. Horn. *J. Limnology*, 1983.
- [26] J. Mallick. Hydrogeochemical characteristics and assessment of water quality in the Al-Saad Lake, Abha Saudi Arabia. *Applied Water Science*, 7(6):2869–2882, 2017.
- [27] C. N. Sawyer and P. L. McCarty. *Chemistry for Environmental Engineering*. McGraw-Hill Book Company, U.S.A., 3rd edition, 2003.
- [28] M. Al-Sahaf. The water resources in Iraq, "in Arabic", 1976.
- [29] N. Tadesse, K. Bhicemalingeswara, and M. Abdulaziz. Hydrological investigation and groundwater potential assessment in Haromaya watershed, Eastern. *Journal of MEJS*, 2(1):26–48, 2010.
- [30] W.H.O. Nitrate nitrite in drinking water, 2003.
- [31] U. Epa. Water quality report. drinking water report, 2013.
- [32] P.S. Cwelch. *Limnology*. McGraw-Hill Book Company Inc. USA, 2nd edition, 1952.
- [33] C. Chatterjee and M. RAZIUDDIN. Determination of water quality index of a degraded river in Asansol industrial area. *West Bengal. J. Environ. Pollut*, 1(2):181–189, 2002.
- [34] W.H.O. Total dissolved solids in drinking-water, guidelines for drinking water quality, 1996.
- [35] G. Singh and J. Singh. *Water Supply and Sanitary Engineering*. New Chand Jain. Delhi, India, 6th edition, 2003.
- [36] G. Singh and J. Singh. *Guideline for Drinking Water Quality*. World Health Organization, Guidelines for Drinking Water Quality, World Health Organization, Geneva, Switzerland, World Health Organization, Geneva., 3rd edition, 2008.
- [37] O. T. Lind. *Hand Book Of Common Methods In Limnology*. London, 2nd edition, 1979.
- [38] C. Lamurugan and L. Hebsibai. Studies on the pollution potential of Vaigai river at Madurai, India. *Asian J. Research Chem*, 5(9):1108–1112, 2012.
- [39] M. Dubey, A. K. Tiwari, and N.C. Ujjania. The study of physico-chemical properties of Sahapura Lake, Bhopal (India). *International Journal of Advanced Research*, 1(8):158–164, 2013.
- [40] M. G. Hammer. *HWater And Waste Water Technology*. Wiley and Sons. New York, 2nd edition, 1986.
- [41] A. Kiroliiaa, R.N. Bishnoia, and N. Singh. Salinity as a factor affecting the physiological and biochemical traits of *Scenedesmus quadricauda*. *Journal of Algal Biomass Utilization*, 2(4):28–34, 2011.
- [42] F. A. Q. Zewayee. A phycolimnological study on some springs and streams within Erbil province. Master's thesis, Univ. of Salahaddin-Erbil, Iraq, 2011.
- [43] K. M. Champion and R. Starks. The hydrology and water quality of select springs in the southwest Florida water management district, 2011.
- [44] C. N. Sawyer. *Chemistry for environmental engineering and science*, 2003.
- [45] Y.O.M. AL-Barzingy, S.M. Goran, and J.J. Toma. An ecological study on water to some thermal springs in Koya-Erbil province, Iraq. *Journal of Education and Science*, 22(3):36–48, 2009.
- [46] M. Mohammed and K. Kareem. Environmental study of physical and chemical properties for lower Zaab river water in both Debis and Alton Kobri stations in Kirkuk province for year 2013. *Kirkuk University Journal /Scientific Studies (KUJSS)*, 10(2):296–317, 2015.
- [47] L. M. Al-Naqishbandy. *Phycolimnological and physiological study in spring and streams within Akri District Duhok in Kurdistan Region of Iraq*. PhD thesis, Salahaddin University- biology department. Erbil/Iraq, 2020.
- [48] L. M. Al-Naqishbandy. Limnological study on the water treatment plant in Ifraz, Erbil, and Kurdistan region of Iraq. Master's thesis, Univ of Salahaddin, 2001.
- [49] K.K. Shanthi, Ramasamy, and P. Lakshmanaperumalsamy. Hydrobiological study of Siganallur lake at Coimbatore. *India. Journal of Nature Environment and Pollution Technology*, 1(2):97–101, 2002.
- [50] Z. Z. Al-Janabi. Application of water quality indices for Tigris river within Baghdad city- Iraq. Master's thesis, Univ. of Baghdad, 2011.
- [51] J. Bartram and R. Balance. *Water quality monitoring (a practical guide to the design and implementation of freshwater quality studies and monitoring programme)*, 1996.
- [52] Y.J. Seike, K. Kondo, H. Hashihitani, M. Okumura, K. Fujinaga, and Y. Date. Nitrogen metabolism in the brackish lake Nakanoum. *Seasonal Of Nitrate Nitrogen. Jpn. J. Limnol*, 51(3):137–147, 1990.
- [53] A. O. Fattah. Phycological study on Khabour river. Master's thesis, University of Duhok-Iraq, 2010.
- [54] A. Kurunc, K. Yurekli, and O. Cevik. Performance of two stochastic approaches for forecasting water quality and stream flow data from Yesilirmak river, Turkey. *Environmental Modeling Software*, 20:1195–1200, 2005.

- [55] L. M. AL-Naqishabandi, J. Toma, and B. K. Mauloud. A study on water quality in makhmur area, kurdistan, iraq. zanco. *Journal of pure and Applied Sciences/Salahaddin University -Erbil*, 20(1):41–44, 2008.
- [56] S.M. Yeole and G.P. PaTil. Physico - chemical status of yedshi lake in :relation to water pollution, 2005.
- [57] Ridgeway and J. W.H.O. Drinking water quality guideline revision: Organoleptic aspects of drinking water quality. medmenham, 1981.
- [58] T. K. J. Farkha. *A Study Of The Distribution Of Phytoplankton Aquatic Fungi In The Lotic Water In Baghdad District The Effect Of Environmental Factors*. PhD thesis, Dissertation, Al-Mustansiryia Univ., Iraq, 2006.
- [59] S. Goran. Limnological study non-diatom phytoplankton composition of dilope spring and kasnazan impoundment. Master's thesis, Salahaddin University. Erbil.Iraq, 2006.
- [60] R. Sharma, GP. Singh, and VK. Sharma. Effects of culture conditions on growth and biochemical profile of chlorella vulgaris. *Journal of Plant Pathology andMicrobiology*, 3(5):131, 2012.
- [61] M.J. Mohammed, P.V. Krishna, O.A. Lamma, and S. Khan. Analysis of water quality using limnological studies of wyra reservior,khamman district,telnagana. *International journal of current microbiology and Applied Sciences*, 4(2):880–895, 2015.
- [62] L. Zheng, M.B. Cardenas, and Wang. Temperature effects on nitrogen cycling and nitrate removal –production efficiency in bed form induced hyporheic zones. *zonesJournal of Geophysical research Biogeosciences*, 121(4):1086–1103, 2016.
- [63] J.J. Toma and K. Bahram. Cyanophyta recorded in erbil, kuedistan region of iraq. *Current world environment*, 8(1):61, 2013.
- [64] F.H. Aziz and A.Q.A. Muhammed. Twenty new records of algae in some springs around safeen mountain area. *Journal of Advanced Laboratory Research in Biology*, 7(3):17–23, 2016.
- [65] F.H. Aziz, U.H. Bapeer, and S.K. Najmadden. Fourteen algae new records reported in five artificial ponds in the main parks within erbil city, kurdistan region, iraq. *Mesopotamia Environmental Journal*, 4(1):12–22, 2017.
- [66] F.H. Aziz and S.A. Yasin. Twenty-five new records of algae in eight artificial fish ponds in erbil. zanco. *Journal of Pure and Applied Sciences*, 31(4):153–166, 2019.

- دراسة فيزيائية وكيميائية في حوض ديكةلة عند المنبع والمصب داخل مدينة أربيل العراق
 كويستان حسن صديق¹ ، ليلي محمد علاء الدين² ، بختيار عبدالله عثمان³ ، سيوكل سعد الدين انور^{4ab*}
¹ ، ² قسم الاحياء المجهرية، كلية العلوم الصحية، جامعة هه و لير الطبية، أربيل، العراق.
³ قسم علوم الحياة، كلية العلوم والصحة، جامعة كويه، أربيل، العراق.
^{4a*} قسم الكيمياء الحياتية السريرية، كلية العلوم الصحية، جامعة هه و لير الطبية ، أربيل، العراق.
^{4b*} قسم التمريض، كلية التمريض، جامعة تيشك الدولية، أربيل، العراق.

الخلاصة

حوض ديكةلة هو أحد خزانات المياه في قلب منطقة ديكةلة ، على بعد حوالي 50 كيلومترًا شرق مدينة أربيل. تم جمع العينات شهرياً من مواقع مختلفة من حوض ديكةلة خلال الفترة من أكتوبر 2020 إلى أغسطس 2021 لتحديد الخواص الفيزيائية والكيميائية والبيولوجية *EC* و *TDS* و *Chloride* و *Na* و *C* و *Ka* صلابة والقلوية الكلية والنترات و *Do* ودرجة الحموضة ، والصلابة الكلية ، صلابة *Mg* ، وكبريتات. اظهر التحاليل الإحصائي للبيانات وجود فروق ذات دلالة إحصائية في المتغيرات الفيزيائية والكيميائية بين الموقعين ، مع وجود علاقات معنوية عالية لكل من (*TDS* ، *EC*) ، الكلوريد ، *NaKCa* صلابة ، القلوية الكلية ، النترات و *Do* (صلابة ، القلوية الكلية ، النترات و (*pH* ، الصلابة الكلية ، صلابة *Mg* ، والكبريتات) عند ($p \leq 0.05$) لجميع العوامل المدروسة أنواع الطحالب المختلفة التي تم الحصول عليها من جميع مواقع أخذ العينات في حوض دجلة ، وجود مجموعة متنوعة من الطحالب. هناك تغيير طفيف في قيمة الأس الهيدروجيني خلال فترة المراقبة بين المنبع والحوض والمصب. أجناس مختلفة من الطحالب الموجودة في حوض ديكةلة.

الكلمات الدالة: فيزيائي - كيميائي ، بيولوجي ، طحالب ، حوض ديكةلة ، المواد الصلبة الذائبة.