



Assessment of Wastewater in Duhok Valley, Kurdistan Region/Iraq

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ABSTRACT

In order to characterize the waste water in Duhok valley in Duhok governorate, during 25km, seven sites were selected in Duhok valley, to represent their water quality. Monthly samples were collected from the Duhok valley for the period from, April to September, 2015. The qualitative study of Duhok valley water tested, as considered one of the main sources of water pollution for Musol Lake. The physical and chemical test for water samples are taken from different locations in Duhok valley. To know the degree of pollution, and the impact of self-purification processes to improve water quality before arriving to the Mosul Lake, and the indicated results of the study a lack of dissolved oxygen in the water (DO). And high organic load values, (BOD) and most of the bad qualities during water passage within the city of Duhok, while meat a significant improvement in the quality of water downstream before arriving at the dam Lake, is attributed to the effect of operations of self-purification ability of water. In spite of salinity problems and toxicity, the quality of water is suitable for irrigation crops on both sides of the valley. The all samples were tested for conductivity, TDS, pH, total hardness, chloride, alkalinity, sulfate, BOD, and phosphate, according to the standard methods.

1. Introduction

Duhok valley considered as main stream for discharge of different liquid waste of Duhok city and its environs, which is transported by long Stream to Mosul Lake on the Tigris River north of the city of Mosul. After expanding population and evolving social, economic and population growth of the city of Dohuk lead to increase the amount of effluent civil, industrial and agricultural to the valley without making any treatment, as well as increasing environmental pollution and the emergence of problems odor problems, and therefore negative impact on water quality in the Mosul Lake.

Also considered as a source of irrigation of fruits and vegetable located around the valley, which lead to negative events for the plants and production and soil permeability, as well as be used for watering animals and livestock, especially after passing away from the city of Duhok, as being this valley for a distance more than about 25 km before arriving in Mosul Dam, as the spread of Typha and fragment growth on the sides of the valley, which may play

an important role in addition to physical and chemical factors in the incidence of operations demineralization self-water contaminated and improve its quality before it reaches Mosul Dam. Waste disposal of civil, agricultural and industrial liquid, untreated directly into the valley is one of the breaches of environmental water resources and a threat to the lives of people for the possibility of the spread of epidemics and diseases such as cholera, typhoid and dysentery.

Water is the most vital element among the natural resources, and is critical for the survival of all living organisms including human, food production, and economic development. Today there are many cities worldwide facing an acute shortage of water and nearly 40 percent of the world's food supply is grown under irrigation and a wide variety of industrial processes depends on water. The environment, economic growth, and developments are all highly influenced by water-its regional and seasonal availability, and the quality of surface and groundwater. The quality of water is affected by human activities and is declining due to the rise of urbanization, population growth, industrial production, climate change and other factors. The resulting water pollution is a serious threat to the well-being of both the Earth and its population.

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Water Pollution and its Impact on the human health are sinks for wastes. Wastes are most often discharged into the receiving water bodies with little or no regard to their assimilative capacities. The discharge of raw sewage, garbage, as well as oil spills are threats to the diluting capabilities of the lagoons and rivers in the major cities. The natural purification of polluted waters in itself is never fast, while heavily polluted water may traverse long distance in days before a significant degree of purification is achieved. In addition, valley and canals are becoming increasingly polluted from industrial wastewater dumped by factories. The water pollution threatens food production and is raising both environmental and human health concerns.

Because of the lack of the water resources management plan and policies, both the quality and quantity of water in this valley have reached a very critical situation that does not allow its instant use.

Pollution of the water in these valley also include various industrial discharge, domestic waste; indiscriminate throwing of pathological and commercial wastes.

However, the specific objectives of the study were as follows: To show the variations in different water quality parameters along a strip of the Duhok valley due to the disposal of untreated industrial waste and season change (dry and wet); and To analyze the health problems created by the pollution.

2. Material and Methods

The studied area include seven sites were selected according to the types of waste disposal in Duhok valley water with in Duhok governorate, in Kurdistan region (Figure 1) Monthly sample were collected from the Duhok valley during the period April to September, 2015. All water samples were kept in polyethylene bottles [1].

Water samples were tested the electrical conductivity, total dissolved solids, pH, DO, BOD. Total hardness, the tests were measured according to the following methods: Electrical conductivity (EC), conductivity was estimated by electrical conductivity meter [2]. Lonlab EC, TDS level HANNA instrument, (w t w) the prop was calibrated monthly by buffer solution, on the reading the conductivity values were converted to specific conductivity at 25°C and the results were expressed by as µs/cm.

Total Dissolved solid (TDS) the amount of the total dissolved solids in water was estimated by TDS meter lonlab EC, TDS, level HANNA instrument WTW. Hydrogen ion concentration (pH) the pH was measured directly by using portable pH meter lonlab pH level 2, HANNA instrument, WTW pH meter was calibrated with three buffer solution of pH 4, 7 and 9.

Dissolved oxygen (DO) Determination of oxygen was carried out according to the Winklers methods (Azide modification) as describing by [2], the results were expressed in mg/l. Biochemical oxygen Demand (BOD) the water sample saved in incubator 2 during 5 days under 20°C after that determine dissolved oxygen by Winklers method (Azide modification), as describing by [2].

Total hardness, Estimated of total hardness was made by titrating water sample against EDTA disodium salt with Eriochrome black T, indicator at pH 10. (Using ammonium buffer), the results were expressed in mg/l [2].

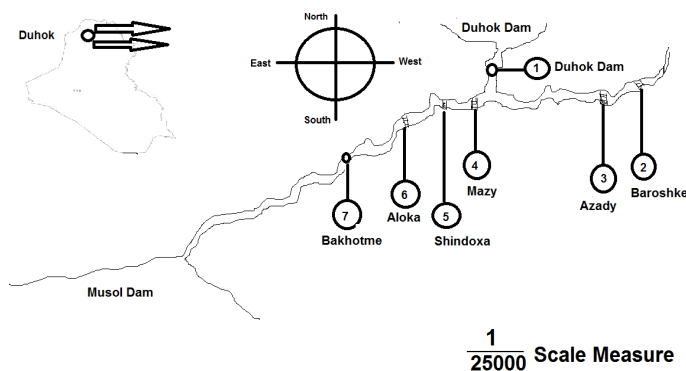


Figure 1: Site location of the studied waste water in Duhok Valley

3. Results and Discussions

Surface water temperature depends largely upon categorize geographic location and climate. results indicate shown in table 1, that the degree of water temperature decrease in temperature especially during the winter and works reduce activity of microbes or microorganisms this increase occurred as a result to the domestic waste discharge to the Duhok valley, this can be solved by rainfalls which will wash the waste from streets and the city's neighborhoods [3].

The temperature of valley water from the table 1, show the lowest value (16.1°C' in site Duhok Dam in March. While the highest value of (32.5°C') in site Baroshke bridge in July.

Table 1: Variation in Temperature of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
		Sites						
1	Duhok dam	16.1	18.2	18.8	20.1	23.2	24.6	24.8
2	Baroshk bridge	19.3	23.4	25.1	31.6	32.5	30.7	28.2
3	Azady bridge	15.2	22.8	24.3	29.2	30.3	31.6	29.6
4	Mazy bridge	18.8	18.6	20.6	27.5	29.2	29.6	29.2
5	Shindoxa	17.1	20.1	21.1	25.6	27.1	26.9	27.0
6	Aloka bridge	19.6	18.8	22.4	24.1	26.6	25.7	26.8
7	Bakhotmy	18.8	19.3	21.6	23.2	22.1	21.9	21.1

There is a strong relationship between electrical conductivity and total dissolved solids they reflect the salinity in the water, as noted in Figure 1 that the electrical conductivity rises in the waters of the valley of Duhok during the runoff in the city of Dohuk, which may be due to the effect of waste water effluent as well as the interactions that occur between the acidic compounds, which formed from oxidation and biological decomposition with the basic compound present around the valley water, which increase the EC value. Table 2 shows variation in the electrical conductivity among the studied valley water. The minimum value was recorded in site Duhok dam was (748) µs/cm in September, but the maximum value (1326) microSiemens/cm was recorded in Baroshke bridge in March. This increasing occurred as a result to the domestic wastes discharge to the Duhok valley and the interaction between the acidic compound which form for oxidation decomposition processes with basic compounds that as found as suspended materials [4], [5].

Table 2: Variation in (EC) microSiemens/cm of Dohuk valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	831	768	842	761	752	801	748
2	Baroshk bridge	1326	1061	1125	986	869	938	873
3	Azady bridge	1184	1231	1026	1152	969	1026	963
4	Mazy bridge	438	1010	882	973	898	909	926
5	Shindoxa	858	922	868	963	872	843	857
6	Aloka bridge	892	939	946	871	982	886	892
7	Bakhotmy	984	846	905	973	1020	1089	1105

Total dissolved solid (TDS) is the best individual value representing the salinity of the water. Table 3 shows the minimum value of (478) mg/l was recorded in Duhok dam in September. While the maximum value of (787) mg/l was recorded in site Azady Bridge in April. This increases caused by the effects of liquid waste reach to the Duhok valley. All of the recorded value were above the minimum level of drinking water standard for drinking recommended by (WHO) and (EPA) 500 mg/l [6], [7].

Table 3: Variation in (TDS) (milligram per liter) of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	531	491	538	487	481	512	478
2	Baroshk bridge	784	679	720	631	556	600	558
3	Azady bridge	757	787	656	737	620	656	616
4	Mazy bridge	600	646	564	622	574	581	592
5	Shindoxa	549	590	555	616	558	539	548
6	Aloka bridge	570	600	605	557	628	567	628
7	Bakhotmy	629	573	579	622	652	696	707

The results shown in the table 4 indicate that the pH drop in the values of the Duhok valley may return to the impact of domestic, industrial and agriculture waste discharged in Valley Duhok, and the occurrence of decomposition and oxidation processes, which lead to formation of many compounds of acidic, such as acetic acid and mineral acid.

Continuation of the relative decline of the rate of pH values during the runoff valley within the city, and rise after leaving them up to the average before coming to Lake Mosul Dam, and rise in values may be due to the consumption of dissolved CO₂ gas.

In water, results from the decomposition and oxidation of the vital operations of the water by algae and aquatic plants, for processes of photosynthesis, which leads to raise the values may be due to bicarbonates ions, soluble consumption as a source of organic carbon for aquatic plants, for the manufacture of food [8].

Table 4 shows a variation pH values among the studied valley waste water. the minimum value of (5.7) was recorded in site Azady bridge in March, while the maximum value of (8.2) recorded in site Bakhotme in March, this increase of pH due to nature of pollutions which reach to the Duhok valley, such as

fertilizers and detergents that has alkaline effect on the water [9-10].

Table 4: Variation in pH of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	8.1	8.0	7.8	7.6	8.0	7.9	8.1
2	Baroshk bridge	6.6	6.4	6.3	5.9	7.2	7.1	6.8
3	Azady bridge	5.7	6.1	6.7	6.4	7.2	6.7	6.8
4	Mazy bridge	7.5	7.3	7.1	6.9	7.4	7.3	7.1
5	Shindoxa	7.3	6.9	7.4	7.1	7.3	7.3	7.4
6	Aloka bridge	7.4	7.4	7.6	7.5	7.6	7.4	7.6
7	Bakhotmy	8.2	8.0	8.1	7.8	7.7	7.6	7.8

Dissolved oxygen is an important parameter for water quality as well as the importance of living of aquaculture operation, and self- purification ability of water and prevents the formation and emission of unfavorable odors and harmful compounds for the environment. Low concentration of dissolved oxygen in the water in sites within the City, that due to the large amount of organic materials resulting from the discharge of effluents into the valley, leading to the increase in the number and activity of microorganisms, in the decomposition and oxidation of organic processes thus reducing the dissolved oxygen in the water. And thus is the quality of the waters of the valley. It is considered exceeding the permissible limits of water pollution surface running by Iraqi determinants. And therefore, it's not suitable for aquatic living. Rises dissolved oxygen concentration in the water after the departure of the valley from the city of Duhok, this increase in concentration, may be due to the processes of self-purification occurring in the water and processes of photosynthesis.

The dissolved oxygen value of Duhok valley waste water represented in table 5, the high dissolved oxygen concentration were recorded is site Duhok dam in March was (8.4) mg/l while the lowest value was recorded in site Baroshke bridge and mazy bridge was (0.0) mg/l, this decreasing occurred as a result to the oxidation and decomposition processes for organic materials by bacteria, the increase of domestic and agricultural waste in to the environment helps the growth of bacteria by oxidation processes [11], [8].

Table 5: Variation in DO (mg/l) of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	8.4	8.2	8.0	7.8	7.7	7.6	7.5
2	Baroshk bridge	2.1	2.8	1.5	0.0	0.0	0.0	0.0
3	Azady bridge	3.0	2.5	3.1	2.2	1.8	0.8	0.8
4	Mazy bridge	1.9	2.0	1.6	0.0	0.0	0.0	0.0
5	Shindoxa	2.6	1.8	2.5	1.3	1.8	1.6	1.9
6	Aloka bridge	6.1	5.8	6.9	6.4	7.1	6.8	6.4
7	Bakhotmy	7.3	7.6	7.9	8.1	7.8	7.5	7.8

The values of organic load, the impact reflected on the odor, taste and smell, and notes in field in sampling it is essential to

assess water quality. And results indicate shown in the table 6 to the high organic load values as the water flow into the city to reach the highest concentration to which dates back to the waste put Civil and liquid waste restaurants and hotels to water valley. In addition to rise the organic waste from the city during rainstorms and transported to valley. Water Valley is considered very bad to the values of organic load, (BOD) as classified whence, as well as exceeding the limits of the Iraqi permitted the contamination of water sources ,as unpleasant odors, spreading negative effects, to include aquatic life and the negative impact on the smooth running in this environment,

We observed that there is a significant improvement on the quality of water obtained after valley passes from the city of Duhok, because of its self-purification and of the physical, chemical and biological processes. For Biochemical Oxygen Demand (BOD), in the table 6 shows the highest concentration recorded in site Azady bridge was (147) mg/l in July, while the lowest value was recorded in site Duhok dam outflow stream was (1.8) in August, the increase result in Duhok valley may be due to domestic, industrial and Agriculture waste discharge to the Duhok valley which contain organic matter contain different types pollutants [12].

Table 6: Variation in BOD5(mg/l) of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	3.1	2.8	3.1	1.9	2.1	1.8	2.7
2	Baroshk bridge	111	46	103	124	116	88	121
3	Azady bridge	137	125	93	118	147	48	122
4	Mazy bridge	105	41	86	47	114	83	75
5	Shindoxa	83	71	86	68	63	72	64
6	Aloka bridge	45	52	48	56	47	36	42
7	Bakhotmy	37	29	32	24	19	20	16

The Calcium and magnesium ions often causing total hardening are often common in water. And also notes the relatively high concentrations of total hardness in valley water since entered the city of Duhok, which may be due to the influence of geological factors on spring water nutrients to this valley. As the low concentration notes during the rainy seasons due to the dilution, and higher concentrations during the dry season due to the operations of the Evaporation of water. It observed the low concentration after the water passes the Duhok city, which may be due to sedimentation and uptake of ions and the absorption of these ions by aquatic plants.

In table 7 shows the total hardness in the Duhok valley waste water, the minimum value of total hardness was recorded in the Azady bridge was (428) mg/l in August, while the maximum value was recorded in Bakhotme site was (722) mg/l, in March. This increase occurred as a result to the Agriculture and domestic wastes discharge to Duhok valley and wastes from soil during the rain seasons [5]. The variation of hardness is probably related to the geological formation of the area [13].

Calcium hardness is part of the total hardness. The results in table (8) shows the lowest value was recorded in site (Mazy bridge) was (401) mg/l in August, While the highest value was recorded in site Bakhotme was (632 mg/l) in May. These results reflects the

characteristics of the geological formation rich with calcium and magnesium in contact with water [14].

Table 7: Variation in total hardness of Duhok valley among the studied period.

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	593	611	579	541	561	580	571
2	Baroshk bridge	702	683	663	713	651	505	482
3	Azady bridge	611	572	589	477	436	428	459
4	Mazy bridge	643	634	564	621	548	482	438
5	Shindoxa	634	582	608	487	453	539	411
6	Aloka bridge	603	576	531	486	469	502	527
7	Bakhotmy	722	685	706	612	588	562	559

Table 8: Variation in calcium hardness of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	496	563	493	448	493	498	482
2	Baroshk bridge	593	591	586	623	584	436	389
3	Azady bridge	538	499	493	386	376	346	385
4	Mazy bridge	547	561	483	448	471	401	368
5	Shindoxa	552	485	477	406	396	448	372
6	Aloka bridge	473	489	462	359	387	388	426
7	Bakhotmy	566	601	632	561	502	483	497

For magnesium (Table 9) the lowest concentration were recorded in Shindoxa site was (39) mg/l in September, while the highest value was recorded in site Bakhotme as (136) mg/l in March. These results may be due to waste disposal of civil, Agriculture and Industrial liquid to Duhok valley.

Table 9: Variation in Magnesium hardness of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Sites								
1	Duhok dam	97	48	86	93	68	82	89
2	Baroshk bridge	109	92	77	108	67	69	93
3	Azady bridge	73	73	96	91	60	82	74
4	Mazy bridge	96	78	81	73	77	81	70
5	shindoxa	82	97	131	81	57	91	39
6	Aloka bridge	130	87	69	127	82	114	101
7	Bakhotmy	136	84	74	51	86	79	62

The high concentration of chloride ions with runoff water in the valley within the city of Duhok, result to put the large amount of sewage residential units, restaurants, and hotels, as studies refer the amount of chloride which discharge by one human every day is (6) grams, which leads to high concentration of chloride ions in the waters of the Valley.

As noted in the table 9 a decline of improvement in the quality of the valley after leaving the city of Duhok over the long stream. more than twenty-five kilometers before arriving the Mosul Dam, which may be due to absorbed by aquatic plants, especially sugar cane plant. The chloride of water clarifies from the table 10, that the maximum value of (185.2) mg/l was recorded in site Baroshke bridge in May while the lowest value was recorded in site Duhok dam in July was (31.1) mg/l, All the value are within the recommended levels of 250 mg/l chloride concentration can be used as an indication of sewage agriculture and industrial pollution [15-16].

Table 10: Variation in chloride of Duhok valley water among the studied period.

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	Duhok dam	46.6	38.3	43.8	32.6	31.1	40.2	38.6
2	Baroshk bridge	171.1	168.1	185.2	160.3	138.5	122.6	135.6
3	Azady bridge	80.8	96.1	111	93.5	109.1	107.2	93.8
4	Mazy bridge	77.3	80.5	71.6	60.8	68.5	70.2	60.3
5	Shindoxa	63.2	54.1	60.8	55.7	63.2	71.2	65.9
6	Aloka bridge	51.9	34.6	40.0	36.7	49.1	44.3	51.7
7	Bakhotmy	37.2	28.6	46.1	55.6	62.6	67.8	64.2

Cause baseline water for the presence of ions bicarbonates and carbonate and hydroxide, Since water valley values did not reach 8.3 pH, this means that base in the cause of bicarbonates ions, and notes from the table 11 that the high concentrations may be due to formation of acidic compounds from the decomposition of organic materials, such as carbonic acid which acts solubility of calcium carbonate sediment and benthic.

And suspended solids and converted into bicarbonate calcium. As can be seen from the table 11 lower total basal concentrations of ions bicarbonates the waters of the valley out of the city, and could be due to the dioxide carbon consumption and ions bicarbonates as a source of organic carbon processes of photosynthesis of plants percent and algae, which leads to the low concentration of ions bicarbonates and basal due to sedimentation. Table 11 shows significant differences in alkalinity of Duhok valley water among the studied period. The highest values were recorded in site Baroshke bridge was (388) mg/l in August, while the lowest value were recorded in site Duhok dam was (31.1) mg/l in July. As Alkalinity is naturally occurring in water, it is variation can be related to geological formation of the sites as well as the discharge of pollutants to Duhok valley [17].

Table 11: Variation in total Alkalinity of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	Duhok dam	153	137	123	141	136	127	117
2	Baroshk bridge	382	368	371	373	365	388	372
3	Azady bridge	284	315	326	281	311	326	288
4	Mazy bridge	329	369	361	416	374	355	323
5	Shindoxa	281	305	286	281	315	299	266
6	Aloka bridge	217	223	237	211	197	200	244
7	Bakhotmy	264	253	269	256	246	239	228

Table 12 shows sulfate concentration in the studied Duhok valley along the Study period. It's range between (67-237) mg/l. With significant difference among the Duhok valley within Duhok city. The highest concentration was recorded in site Shindoxa was (237) mg/l in May, while the lowest concentration was recorded in Aloka bridge was (67) mg/l, in August, this increasing occurred as result to Agriculture and runoff transport sulfate from sewage and fertilizer to Duhok valley [3].

Table 12: Variation in sulfate of Duhok valley water among the studied period.

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	Duhok dam	83	104	96	100	125	188	113
2	Baroshk bridge	154	149	166	203	182	175	162
3	Azady bridge	134	158	119	94	133	115	137
4	Mazy bridge	171	188	143	105	141	138	127
5	Shindoxa	206	195	237	204	173	165	177
6	Aloka bridge	93	88	101	76	89	67	78
7	Bakhotmy	121	113	93	127	108	126	105

Table 13 shows a significant variation in phosphate value among the studied Duhok valley water included in the study with a range from (4.9 to 23.2) mg/l, the highest concentration was recorded in mazy bridge was (23.2) mg/l, This increasing occurred as a result of domestic and Agriculture wastes [18]. While the lowest concentration was recorded in site Duhok dam was (4.9) mg/l, in September.

Table 13: Variation in phosphate of Duhok valley water among the studied period

Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1	Duhok dam	8.1	6.5	7.2	9.3	8.6	5.7	4.9
2	Baroshk bridge	12.6	20.3	18.1	20.4	23.1	19.9	20.6
3	Azady bridge	15.3	17.1	10.2	11.6	21.9	17.6	19.3
4	Mazy bridge	17.3	15.2	20.6	18.4	23.2	18.8	21.4
5	Shindoxa	21.1	19.6	21.5	16.7	24.5	23.1	21.6
6	Aloka bridge	13.3	14.7	10.2	12.8	8.9	11.7	12.3
7	Bakhotmy	16.2	18.4	20.5	21.3	19.8	21.7	22.3

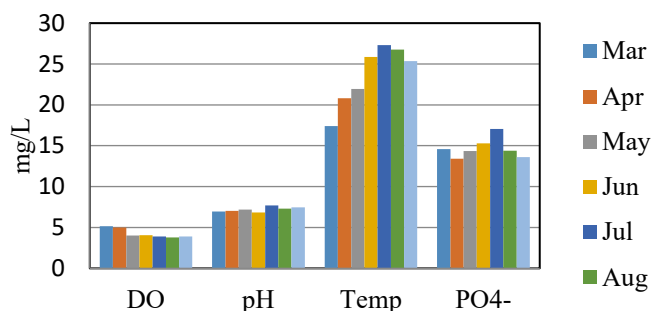


Figure 2: Comparison of some Physico-Chemical parameters variation in seven sampling stations (Mar, Apr, May, Jun, Jul, Aug and Sep) at Duhok valley. Units of DO and Po4- are (mg/L).

Table 14: Demonstrate the minimum, maximum and mean values of study sites.

Physio-Chemical Parameters		Date of Sampling						
		Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature	Min	15.2	18.2	18.8	20.1	22.1	21.9	21.1
	Max	19.6	23.4	25.1	31.6	32.5	31.6	29.6
	Mean	17.84	20.17	21.99	25.9	27.3	27.3	26.67
PH	Min	5.7	6.1	6.3	5.9	7.2	6.7	6.8
	Max	8.2	8.0	8.1	7.8	8.2	7.9	8.1
	Mean	7.26	7.16	7.29	7.03	7.49	7.33	7.37
DO	Min	1.9	1.8	0.00	0.00	0.00	0.00	0.00
	Max	8.4	8.2	8.00	8.1	7.8	7.6	7.8
	Mean	4.49	4.39	4.39	3.69	3.74	3.47	3.49
BOD5	Min	3.1	2.8	3.1	1.9	2.1	1.8	2.7
	Max	137	125	103	124	147	88	122
	Mean	74.44	52.4	64.44	62.7	72.59	49.83	63.24
EC	Min	438	768	842	761	752	801	748
	Max	1326	1231	1125	1152	1020	1089	1105
	Mean	930.4	968.1	942	954.1	908.9	927.4	909.1
TDS	Min	531	491	538	487	481	512	478
	Max	784	787	720	737	652	696	707
	Mean	631.4	623.7	602.4	610.3	581.3	593	589.6
CL-	Min	37.2	28.6	40.00	32.6	31.1	40.2	38.6
	Max	171.1	168.1	185.2	160.3	138.5	122.6	135.6
	Mean	75.44	71.47	79.79	70.74	74.59	74.79	72.87
Total alkalinity	Min	153	137	123	141	136	127	117
	Max	382	369	371	416	374	388	372
	Mean	272.9	281.4	281.9	279.9	277.7	276.3	262.6
Total hardness	Min	593	572	531	477	436	428	411
	Max	722	685	706	713	651	580	582
	Mean	644	620.4	605.7	562.4	529.4	514	506.7
Ca+ hardness	Min	473	485	462	359	376	346	368
	Max	593	601	632	623	584	498	497
	Mean	537.9	527	518	461.6	458.4	428.6	417
Mg+ hardness	Min	73	48	69	51	57	69	39
	Max	136	97	131	127	86	114	101
	Mean	103.3	79.86	87.71	89.14	71	85.43	75.43
SO4-	Min	83	88	93	76	89	67	78
	Max	206	195	237	204	182	188	177
	Mean	137.4	142.1	136.4	129.9	135.9	139.1	128.4
PO4-	Min	8.1	6.5	7.2	9.3	8.6	5.7	4.9
	Max	21.1	20.3	21.5	21.3	24.5	23.1	22.3
	Mean	15.22	15.78	15.47	15.79	18.57	16.93	17.49

Table 15: Summary of Basic Statistics

Physio-Chemical Parameters	Range	25% Percentile	75% Percentile	Mean	Standard deviation	% Coefficient of Variation	Standard Error
Temperature	15.2 – 32.5	20.17	27.3	23.88	3.853	16.13%	1.456
PH	5.7 – 8.2	7.16	7.37	7.28	0.148	2.4%	0.056
DO	00.0 – 8.4	3.49	4.39	3.95	0.453	11.47%	0.171
BOD5	1.8 - 147	52.4	72.59	62.81	9.225	14.69%	3.487
EC	438 - 1326	909.1	954.1	934.3	22.12	2.37%	8.362
TDS	478 - 787	589.6	623.7	604.5	18.36	3.04%	6.94
CL-	28.6 – 185.2	71.47	75.44	74.24	3.013	4.06%	1.139
Total alkalinity	117 - 416	272.9	281.4	276.1	6.724	2.44%	2.541
Total hardness	411 - 722	514	620.4	568.9	54.97	9.66%	20.78
Ca+ hardness	346 - 632	428.6	527	478.4	48.99	10.24%	18.52
Mg+ hardness	39 - 136	75.43	89.14	84.55	10.58	12.52%	4
SO4-	67 - 237	129.9	139.1	135.6	4.879	3.60%	1.844
PO4-	4.9 – 24.5	15.47	17.49	16.46	1.236	7.51%	0.467

Demonstrate the minimum, maximum and mean values of study sites and summery are listed in table 14 and 15. Comparison of some Physico-Chemical parameters variation in seven sampling stations are shown in figure 2, 3 and 4.

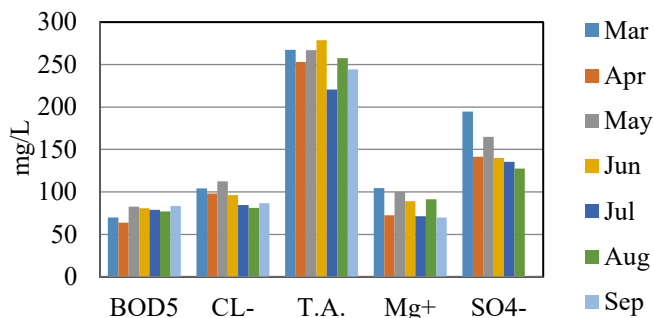


Figure 3: Comparison of some Physico-Chemical parameters variation in seven sampling stations (Mar, Apr., May, Jun, Jul, Aug and Sep) at Duhok valley. Units of BOD₅, CL⁻, T.A., Mg⁺ and SO₄⁻ are (mg/l).

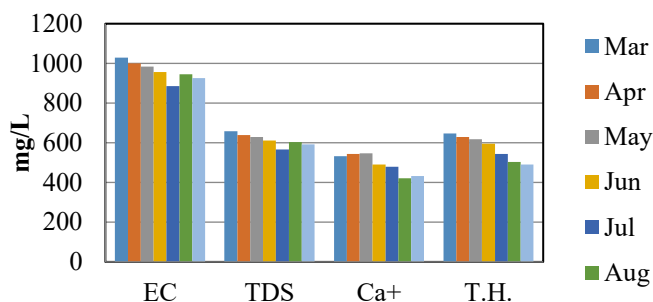


Figure 4: Comparison of other Physico-Chemical parameters variation in seven sampling stations (Mar, Apr, May, Jun, Jul, Aug and Sep) at Duhok valley. Units of EC $\mu\text{s}/\text{cm}$, TDS, Ca⁺ and T.H. are (mg/l).

4. Conclusion

After complete survey, the waste water of Duhok valley is founded as contains high value of electrical conductivity as a result of domestic waste discharge. Similarly, it is classified as hard water. The absence of dissolved oxygen in some sites was zero as a result of high load of organic material. Decrease of pH value in Duhok valley is found due to domestic pollutant.

Conflict of Interest

The authors declare no conflict of interest.

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