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Advances in Science, Technology and Engineering Systems Journal (ASTESJ) is an online-only journal dedicated to publishing significant advances covering all aspects of technology relevant to the physical science and engineering communities. The journal regularly publishes articles covering specific topics of interest.

Current Issue features key papers related to multidisciplinary domains involving complex system stemming from numerous disciplines; this is exactly how this journal differs from other interdisciplinary and multidisciplinary engineering journals. This issue contains 2 accepted papers in electrical engineering and environmental sciences domain.

Editor-in-chief
Prof. Passerini Kazmersk

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An Efficient Approach of Load Shifting by Using SCADA

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A B S T R A C T

The consumption of electric power has increased significantly in the past few years, and its demand is still increasing every day. In this regard, its proper distribution is a significant challenge. This paper includes a method not only to improve the existing power distribution by using SCADA but also to reduce the human errors from the system by making the system automated. As a prototype for this paper, a geographical area was divided in to three regions named as A-Islamabad, B-Rawalpindi and C-Attock. These three regions were used as the Remote Terminal Units RTU's and were further divided into four sectors based on different types of consumers. One main control unit was set to handle the whole power system which was referred to as the MTU (master terminal unit). MTU was designed in such a way that not only it was capable to show RTU's readings on Graphical user interface-GUI but also to control them. By establishing such a design, distribution of electric power based on priority was achieved among these regions and thus the load requirements were managed by means of priorities among them. The entire load management task was supervised by an individual who was authorized to control the MTU's GUI. SCADA system enabled the MTU to regulate the electric power in regions and their sectors. All the RTU's were connected with the MTU by means of a wireless network based on an Internet Service Provider (ISP). If the system works accordingly, the MTU would be able to access the RTU's from any part of the world. SCADA provides a platform to manage the overall system with the minimal manpower; hence, the human errors were reduced.

1. Introduction

Smart Grid is a class of technology that is used by people to enhance the electric power distribution system in this century by implementing computerized control and mechanization. The possibility of proper outcome of this technique is based on the two way communication between the MTU and the RTUs [1]. The power distribution network is the last stage in the delivery of electricity. It transfers electric power to the consumers from the huge transmission lines. The distribution of the substations is connected with the transmission system and lowers the output voltage between 2KV and 35KV by using transformers. SCADA system consists of one or more field data interface devices (RTU's), a communication system such as telephone, cable, satellite, etc. A MTU provides a collection of standard and/or custom software Graphical User Interface-GUI, critical infrastructure systems which include critical physical processes. These processes are controlled by automation systems which combine humans, computers, communications, and procedures [2]. The utilization of advanced technologies in the smart grids have improved the energy efficiency by proper management of demand from the consumer side, so that it matches with the availability of electric power. The transmission media used for SCADA system includes copper cable, coaxial cable, fiber optic cable and electromagnetic propagation through the atmosphere [3]. The use of satellites, web based communications, and real-time communications with the improved technologies, are enabling

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utilities to point out problems and faults in the grid faster than before. A variety of median options can be considered for SCADA based new projects or to upgrade obsolete SCADA communication systems. The selection of any of these communication media depends on the technical requirements for the application, geographic considerations of remote facilities to be monitored, controlled, availability of established systems and economic requirements [4]. Implementation of SCADA system minimize the initial cost and provides a complete control over the system, which requires few individuals to control it [5]. The RTU and MTU are the core parts of this system. The RTU of each region, collects information and transfers it to the MTU. The MTU in response, provides a suitable command to the RTU in order to run the system properly. These systems are based on Wireless Local Area Network-WLAN via the Internet Service Provider-ISP for communication between Master Terminal Unit -MTU and the RTU's [6]. The data demonstration is mostly in visual form, the operator can view it on the GUI screen of the RTU's as well as on MTU.

2. Background

2.1. SCADA System

SCADA stands for Supervisory Control and Data Acquisition. This system becomes popular in the 1960's in order to monitor and regulate the remote equipment. Mainframe technology was in use in the early times of SCADA systems but that technique requires human operators to make decisions and also to maintain the information system. In 1960, the SCADA system becomes most popular system for the management and distribution of electric power among different areas because it monitors and also controls the distribution [7]. Early SCADA systems were expensive and not efficient because of the increased human labour cost and the manual operations. The SCADA systems of our age are more effective and cost-efficient. SCADA system is the base for the distributed automation networks and systems. For the smooth monitoring and control of the overall power system, the use of SCADA in electrical utility firms started in early 60's. The first SCADA based power system was implemented in the USA in 1962, which includes generation, transmission and distribution. [8]. Now days, almost all of the critical industrial infrastructures and processes are controlled remotely from a centralized location by the implementation of SCADA. The management of electricity, flow of oil and gas through pipes, distribution of water operation of chemical plants and signalling network for the railways are some applications of SCADA [9].

2.2. System Components of SCADA

The SCADA system mainly consists of the following subsystems:

i. GUI or Graphical User Interface to present data to human operator to control the process.
ii. RTU or remote Terminal units which connects sensors and transform signals to digital data.
iii. Microcontrollers to control all the processes within a grid station and to process data.
iv. Terminal system, to interface controllers and RTU's with centralized control system.
v. Data acquisition server is an application service which processes industrial protocols to connect application services.
vi. Supervisory systems (computers), to collect data on processes and send commands to the SCADA system
vii. Communication set-up is used to connect the supervisory system to the RTU's [9].

2.3. Smart Grid

Smart Grid is the result of the desires of worldwide power industry's stakeholders to respond to the designing and building challenges of the power network "the grid" of the future. Different names such as intelligent grid, grid wise, EPRI's Intelligrid, and others. The Smart Grid is integrating the electrical and information technologies in between any point of generation and any point of consumption". EPRI website offers a laconic definition which states "A Smart Grid is one that incorporates information and communications technology in to every aspect of electricity generation, delivery and consumption in order to minimize environmental impact, enhance markets, improve reliability and service, and reduce costs and improve efficiency" [10]. Intelligent monitoring, control, communication and self-handling technologies are the outcomes of smart grid innovative products and services to allow distributors to play their role in optimizing the operation of the system and provide distributors with enhanced information and choice of supply.

The improved reliability, quality of power, reduction in peak demand, reduction in transmission congestion costs, potential for enhanced energy efficiency, benefits gained by increased asset utilization, upgraded security, accommodation ability for renewable energy, improved strength and ease of repair in response to nasty attacks, is the potential promise of the smart grid [10].

3. Design Methodology

In this paper, monitoring and control of three regions A,B & C (RTU's) of the geographical area are analysed. Each of these areas are divided into four sectors named as Industrial Sector, Commercial Sector, Residential Sector and Social Sector. All of these sectors are connected to their RTU's and these three RTU's are further connected with MTU via WLAN over ISP. Often in SCADA systems, the RTU is located at a remote location. This distance can vary from tens of meters to thousands of kilometers. One of the most cost-effective ways of communicating with the RTU over long distances can be by simple internet connection [11]. After establishing an internet connection, a link is created between database and MTU which results in controlling of any RTU anywhere by sending and receiving real time data to the remote database and also the RTU's can access that data and send acknowledgements to MTU.

These three RTU's, are controlling three regions, and their selves are further controlled by a centralized location named as MTU. On the GUI of MTU, every detail about the power, voltages and currents can be viewed and hence the load requirements can be managed and supplied to the distribution zones according to the consumers of RTU's. All this may result in the proper distribution of electric power and also in removal of human errors by making the system automated.

3.1. Distribution Zones/Geographical Regions

A region is divided into four sectors named as industrial, commercial, residential and social sector, as shown in Figure 1. All of these four sectors have different load requirements according to the type of consumers in them.

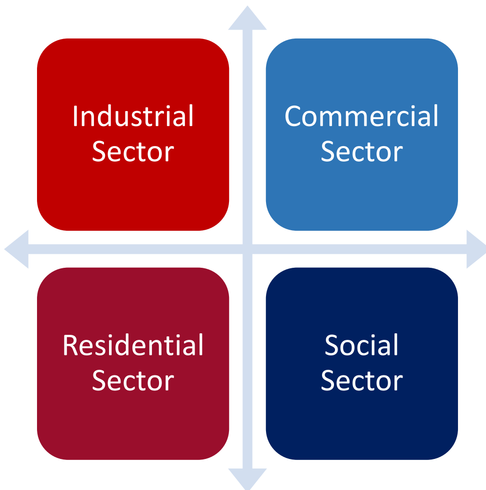

Figure 1: Four sectors of a geographical region

All of the four sectors are connected to the RTU of that region, which in turn provides the information regarding the load requirements among the distribution regions.

3.2. Block Diagram

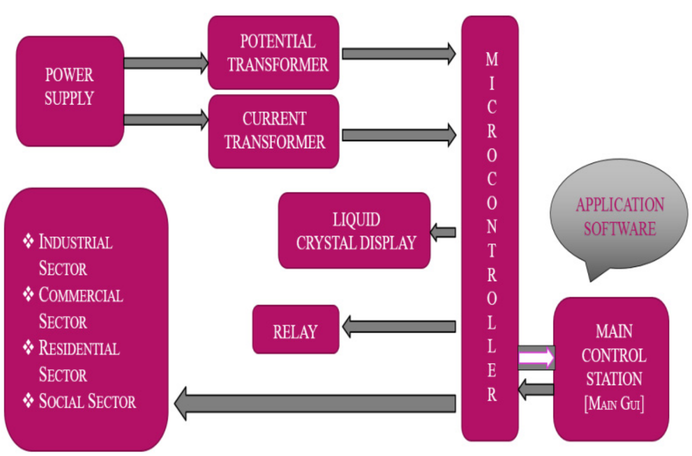

Figure 2: Block diagram

The block diagram of the smart grid system, which is based on SCADA is shown in Figure 2. The potential transformers-PT and current transformers-CT can be worked as the sensors to sense current and voltage ratings in the sectors of RTU. The microcontroller receives the information from the sensors and displays the data on LCD. After that, the relays can be turned ON/OFF according to the load situation. The switching of relays is the main task in the circuitry to supply or cut the load from any region or sector.

3.3. GUI and Communication between MTU and RTU's

GUI's of MTU and RTU's are designed in Microsoft Visual Studio using windows form for the front end and C# for the server side. A remote database is created to store the real time data so that the communication between MTU and RTU's can be done. For this purpose, logics were implemented using C# and their combined execution results in successful communication between MTU and RTU. Priorities have been set on the RTU's and their sectors by implementing conditional statements in the program code. Which in results performs desired power switching, "ON" or "OFF" in the targeted sector of the targeted RTU. Also the MTU receives acknowledgements, on real time regarding changes in status of sectors from On to Off and vice versa.

3.4. Priorities for power distribution

By using SCADA in a smart grid system, the electric power can be distributed in the different regions and sectors according to the requirements. But what could be a solution, if the load increases? Or if the system cannot meets the demand side requirements? The solution could be the priority based power distribution. To avoid the total shutdown of the whole system, a specific shutdown in a certain region could be a better option. To achieve this, a priority based technique can play its role. In priority based power distribution, priorities can be set on the different regions and also on the sectors of the regions according to the importance of that area. In this paper, the priorities regarding regions and sectors are shown in the table 1:

Table 1: Priorities among regions and sectors

Region	**Name of Sector**	**Priorities**	
		Region Based	**Sector Based**
A-Islamabad	Industrial	1st	1st
	Commercial		2nd
	Residential		3rd
	Social		4th
B-Rawalpindi	Industrial	2nd	1st
	Commercial		2nd
	Residential		3rd
	Social		4th
C-Attock	Industrial	3rd	1st
	Commercial		2nd
	Residential		3rd
	Social		4th

In case of increase in the load requirements from the demand side, the least priority sector of the least priority region will be shut down. It means if the load increases than the social sector of third region, Region C, would be shut down. The sectors and regions of top priorities may not blackout. After setting these priorities, the system may run according to the requirements and also can meet the load shifting requirements.

3.5. Circuit diagrams

The controller section of the smart grid consists of a DC power supply, microcontrollers, LCD's, RS 232 port and MAX 232 serial

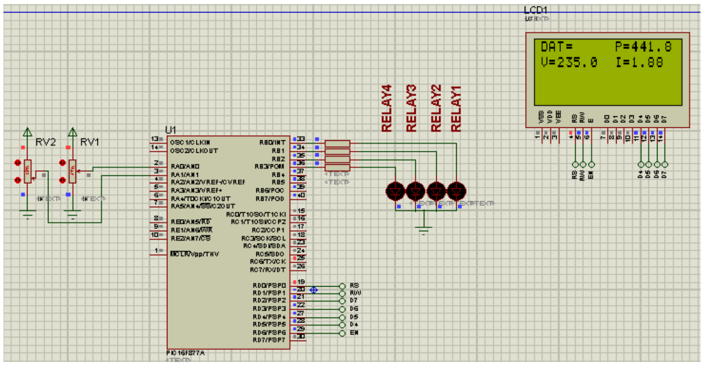

Figure 3: Controller section

communication IC's. Firstly the DC power supply provides the circuit with a sharp 5v input to run the microcontroller. After that the controller reads the data received from the MAX 232 IC to checks the status of the grids, whether ON or OFF. The relays connected in the switching section are operated by the input from this section i.e. controller section, As shown in the figure 3.

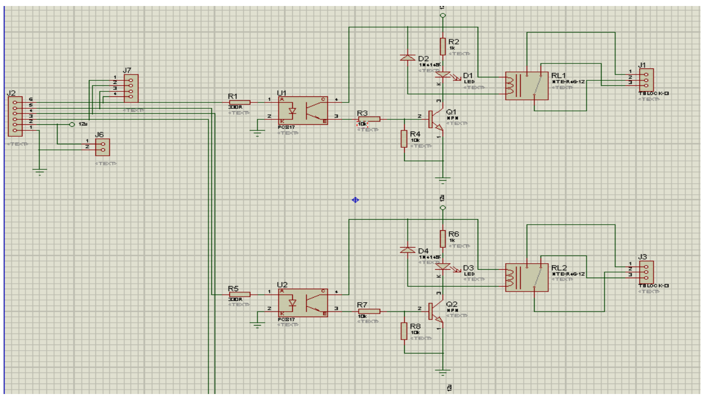

Figure 4: Switching section

Figure 4 shows the relays operation. This is the switching section of the smart grid. The relay operates after receiving the command from microcontroller i.e. ON or OFF. Microcontroller is programmed in such a way that the relays can operates manually by changing the state of the grid ON/OFF on the GUI screen or by the priority based automatic shutdown of the least priority sector of that grid-(RTU), when the load in the highest priority sector would increase.

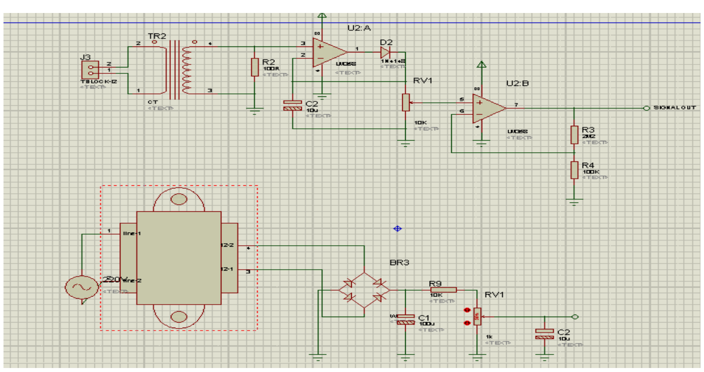

Figure 5: Sensing section

The third section in the smart grid is sensing section, which includes the current transformers and potential transformers, As shown in Figure 5. Both transformers work as sensors in this circuitry. They sense the voltages and currents which are being consumed by the system. After that, they transmit the data of the grid to the microcontroller, which in turn transmits it to the GUI of specific grid via serial communication. Finally, the RTU's transfers this information to the MTU via WLAN over ISP.

In this paper, all the commands, to operate or to shut down the sectors, can only be send through the MTU, as the idea behind the design of this system is to reduce human error, labour and overall system cost. To operate such system, only few individuals would be required.

4. Graphical User Interface

To handle the system properly, there is a need of a graphical user interface (GUI) which can provides a variety of information about the RTU's. For this purpose, a GUI was developed using the Microsoft Visual Studio as shown in Figure 6. The GUI of MTU is designed in such a way that it can display the real time information of all the regions and their sectors and control them wirelessly. After every manual operation from the MTU,RTU send the acknowledgements of the tasks, in both cases, done or not done. The GUI of RTU just shows the real time values of the power, currents and voltages.

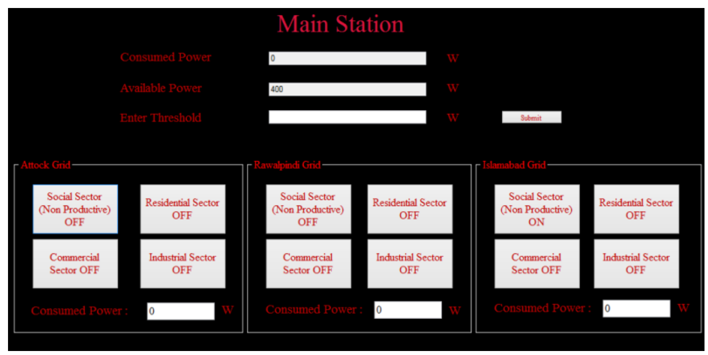

Figure 6: MTU's GUI

The MTU's GUI shows the three geographical regions (RTU'S) and four sub-sections of each section (sectors). All sectors of the three regions are organized by this MTU's GUI. On the bottom of the main GUI screen, there are three blocks below each section which shows the consumed power in each city. On the top of the GUI screen, there are three sections which show the consumed power (across all regions),the available supply capacity, which a system can still holds and the threshold. Threshold is assumed as the maximum supply capacity of the grid e.g. any utility company, which delivers the power to the customers and they consume it according to their needs while having no idea about the maximum capacity of the supplier. In this regard, a threshold is introduced in the prototype of this paper . In the next section of this paper, three different threshold values would be assumed. It would be then analysed that how capable our priority based approach is to shift the load so that load shedding could be avoided.

Also, when different sectors of different regions would turn On or Off, the main GUI and the RTU's GUI will receive the information against those happenings. This feature is the main entity which delivers the information about the status of power supply in the sectors.

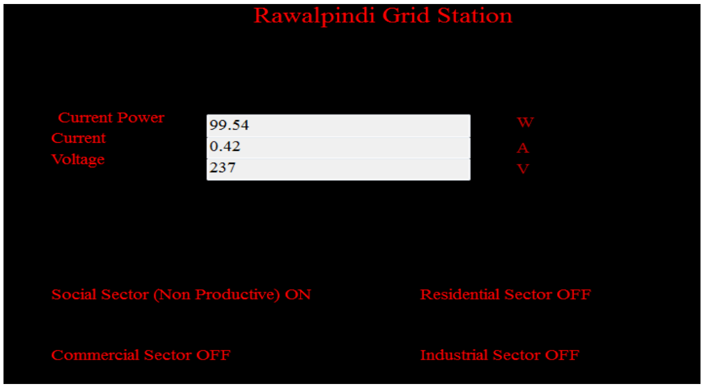

Figure 7: RTU's GUI

The RTU's GUI shows four sectors of a certain region (city). These sections just deliver the information of the status of sector On/Off, As shown in figure 7. On the top, there are three sections, they shows the consumed power, the average current and the average voltage ratings of a region.

5. Results and analysis

The priority based power distribution was successfully achieved and the load shifted according to the requirement.

Four types of loads are attached to the system which are controlled by the microcontroller and relays. The industrial sector was controlled by heavy duty relay, which could pass 20 amp of current. All other sectors were controlled by simple electromechanical relays which had passed 5 amp of currents As shown in Figure 8.

Figure 8: Hardware design of RTU

5.1. Scenario 1

In Scenario 1, the load demand was 10100 watts and the supply capacity (threshold) of the system was 8500 watts. According to the priorities, the sectors with the least priorities would shut down and the load would distribute among the high priority sectors. In this way the system may work according to the requirements. In the table 2, the scenario 1 is summarized in which the load demand exceeds the maximum supply capacity. As a result, the sectors with least priority were shutdown and the load is transferred to the high priority sectors.

Thus a total shutdown of the whole system was avoided.

Table 2: Scenario 1- priority based distribution

	Name of Sector	Scenario 1			Result
		Thresh hold	Required Power	Over load	ON/ OFF
			10100W		
A	Industrial		1500w		ON
	Commercial		1300w		ON
	Residential		750w		ON
	Social		500w		**OFF**
B	Industrial		1350w		ON
	Commercial		1100w		ON
	Residential	8500w	600w	1600 w	ON
	Social		350w		**OFF**
C	Industrial		1000w		ON
	Commercial		900w		ON
	Residential		500w		**OFF**
	Social		250w		**OFF**

5.2. Scenario 2

In Scenario 2, the load requirement was 18300 watts and the threshold in the system was 15000 watts. The results were summarized in the table as shown in the table 3.

Table 3: Scenario 2- priority based distribution

	Name of Sector	Scenario 2			Result
		Thresho ld (W)	Require d Power	Over load	ON/ OFF
			18300W		
A	Industrial		4000w		ON
	Commercial		2000w		ON
	Residential		1000w		**OFF**
	Social		500w		**OFF**
B	Industrial		3000w		ON
	Commercial		2000w		ON
	Residential	15000	1000w	3300 w	**OFF**
	Social		500w		**OFF**
C	Industrial		2000w		ON
	Commercial		1500w		ON
	Residential		500w		**ON**
	Social		300w		**OFF**

5.3. Scenario 3

In Scenario 3, the load requirement was 13900 watts and the threshold in the system was 5100 watts. The results were summarized in the table 4:

Table 4: Scenario 3- priority based distribution

	Name of Sector	Scenario 3			Result
		Thresh hold	Required Power	Overl load	ON/ OFF
			18900W		
A	Industrial		4900w		ON
	Commercial		2000w		**OFF**
	Residential		1000w		**OFF**
	Social		200w		ON
B	Industrial		3000w		**OFF**
	Commercial		2000w		**OFF**
	Residential	5100w	1000w	13900 w	**OFF**
	Social		500w		**OFF**
C	Industrial		2000w		**OFF**
	Commercial		1500w		**OFF**
	Residential		500w		**OFF**
	Social		300w		**OFF**

All of the above scenarios have proved that our approach of shifting load on a priority arrangement was successful in avoiding a situation where whole system shuts down, because demand exceeds the supply.

6. Conclusion and further work

After the successful assembly of components, several tests on the hardware, by varying the load conditions on each of the grids, the prototype of project was working according to the requirements and by using the Graphical User Interface-GUI, it became very easy to operate and control the whole system for the proper and efficient distribution of electric power among different sectors of different regions. The manual operation of power system requires significant manpower, which increases the overall system cost, it is necessary to implement SCADA to control and monitor the system [6]. To tackle the variation of load requirements along with the priority based distribution to avoid a total shutdown was the main achieved task of this project. Some of the advancements, which could be implemented in this system are; (a) Strong database to keep all the record of previous and real time data (b) Strong interactive GUI for the RTU's so they can send requests to the MTU (c) A manual control button in the main GUI to shut down a whole city at once.

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Conflict of Interest

The authors declare no conflict of interest.

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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^{o}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].

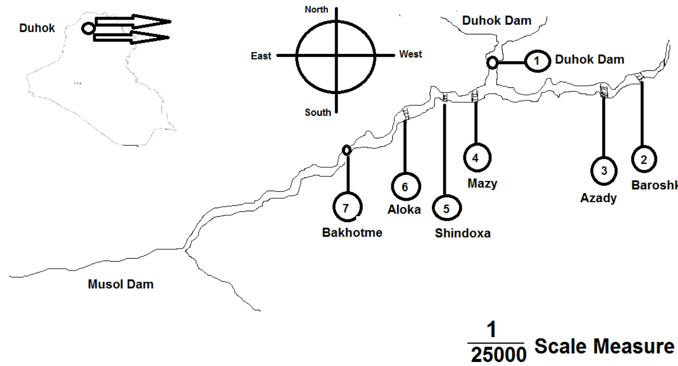

Figure 1: Site location of the studied waste water in Duhok Valley

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 microbs 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^{o}C' in site Duhok Dam in March. While the highest value of (32-5^{o}C') in site Baroshke bridge in July.

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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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 CO_2 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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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.

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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

Sites \ Months		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
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 / Sites	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 / Sites	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 / Sites	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 / Sites	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

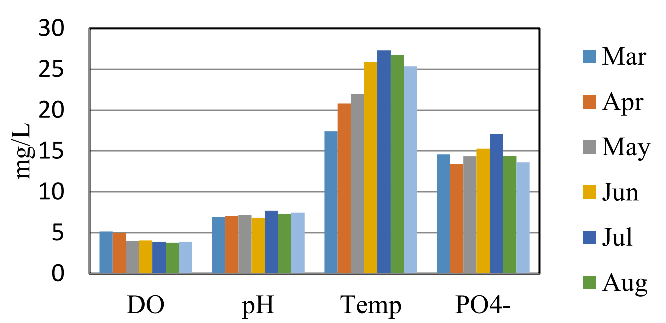

Figure 2: Comparison of some Physico-Chemical parameters variation in seven sampling stations (Mar, Apr, May, Jun, Jul, Aug and Sep) at Duhok valley. Units of DO and Po4- are (mg/L).

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.

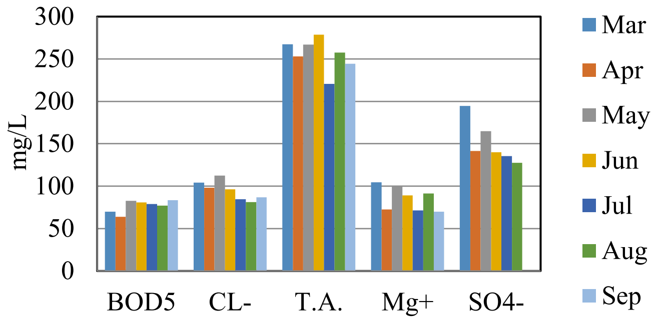

Figure 3: Comparison of some Physico-Chemical parameters variation in seven sampling stations (Mar, Apr,. May, Jun, Jul, Aug and Sep) at Duhok valley. Units of BOD5, CL-, T.A., Mg^+ and SO_4^- are (mg/l).

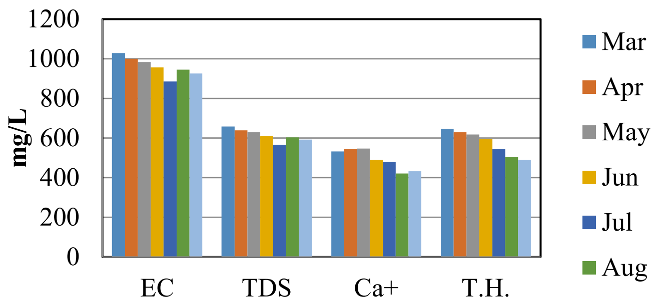

Figure 4: Comparison of other Physico-Chemical parameters variation in seven sampling stations (Mar, Apr, May, Jun, Jul, Aug and Sep) at Duhok valley. Units of EC µs/cm, TDS, Ca^+ and T.H. are (mg/l).

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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