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Concentration of Residual Chlorine and Its Health Effects on The Drinking Water of The Kirkuk City

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Abstract: Chlorine is one of the basic sterilizers for the drinking water in most countries due to its wide availability and low cost, which it works to eliminate the causes of diseases in drinking water effectively through the destruction of membranes and attack the basic enzymes of those organisms. The sterilization process of chlorinated drinking water depends on the added chlorine dose and the contact timethe residual chlorine is of great importance in maintaining the quality of drinking water. Therefore, the residual chlorine concentration in the drinking water of the city of Kirkuk was studied by some factors such as water temperature turbidity electrical conductivity total soluble salts and pH of five stations by five samples per station during the study period, which lasted between January and July 2017. The results of the study showed that the concentration of residual chlorine ranged from 0.8 - 3 mg/l where it was higher than the limit allowed within the standards. The results also showed an inverse relationship between residual chlorine concentration and water temperature while the turbidity and concentrations of total dissolved solids, electrical conductivity, and pH were within Iraqi standards.

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1. INTRODUCTION

Water is one of the essential natural resources we need daily and its processed through water treatment stations so that the water for drinking purposes can be free from contaminants and health problems, as well as a good taste and odor-free so a standard calibration of drinking water has been established.

It is known that the process of water treatment is carried out through the transfer units of sedimentation and filtration to remove impurities. The most of the drinking water treatment stations in Iraq use chlorine in the process of purification of drinking water, where it plays an important role in the elimination of many microorganisms. It has to be used because water is a quick way to spread many diseases as well as that the water medium is an important part of the life cycle of some pathogens. 50% of the population in Third World countries are reported to have water-related diseases while about 80% of the total disease in developing countries is due to water pollution and more than 16% of the world's population use polluted water (Ramal, 2010). The World Health Organization (WHO) gives priority to three simple rules, its access to water from the best possible resources. Benefit available means to protect water resources ensure permanent water treatment. The continuous application of these rules ensures the protection of populations from water-borne diseases.

Liquid chlorine is low solubility in water so when chlorine

Chlorine is a toxic gas 2.45 times heavier than air, and its presented in the three cases according to temperature and pressure. The liquid chlorine is a low solubility in water so when water sterilization must to use chlorine gas otherwise, the liquid chlorine does not cause its use effectively in addition to its danger to the workers and corrode the pipes (Abdullah, 2001). Chlorine is widely used in the world to treatment drinking water to distinguish chlorine by its low cost, ease of application, great efficiency and its ability to maintain its efficiency in sterilizing water until it reaches the consumer (Nikolaou, et al, 2004). When chlorine is added to water, part of its consumed in reaction to chemicals that may be present in water is called chlorine demand another part of the water is the so-called residual chlorine (Abdullah, 2001).

The added chlorine dose should be sufficient to eliminate the germs, also to break down and oxidize the organic and inorganic substances present in the waterand then leave a residual amount of free chlorine after 30 minutes of contact time (time to kill microorganisms and interact with other organic matter present in water). The remaining chlorine is very important in maintaining water quality. It should be noted that the amount of organic matter varies from one source of water to another. Accordingly, the chlorine doserequired for disinfection varies according to the characteristics of the water sources (Ubeed, 2011). The main focus of chlorination is to ensure that free amounts of chlorine remain for as long as possible to ensure that bacterial growth is prevented during the transfer, storage and distribution of water, the residual chlorine content in drinking water is evidence of the success of the sterilization process and the disposal of abandoned organisms but the increased concentration on standard determinants poses a risk to human health so these measurements and tests are therefore necessary because there are many sources of contamination of drinking water and for the purpose of ensuring that they are suitable for human use otherwise their effects will be serious and direct on the human and the environment (Zhang, et al, 2007).

The Objective of The Study

The current study aims at measuring the residual chlorine concentration in the drinking water of Kirkuk city and some important characteristics of drinking water such as pH, temperature, turbidity, electrical conductivity (EC) and total soluble solids (TDS) to determine the quality and validity of this water for human consumption, and determine the relationship between and compare them with the limit allowed in the Iraqi Standards.

2. MATERIALS AND METHODS

The Kirkuk Unified Water Project is located in the Kiwan(K1) area, northwest of Kirkuk Which pumps drinking water to all areas in the center of Kirkuk city, the main source of water is the Tigris river (Lower Zab) and the water is treatments in the project by chlorine gas. The design capacity of the project is 75 million gallons / day through five ground tanks spread throughout the city as shown in Figure 1.

The city was divided into five stations according to Table 1 samples from five stations were collected by five samples per month from each station during the months of January-June 2017. The samples were taken from the sites by plastic bottles of 2 liters after they were washed twice with the sample water at each station. The plastic bottles were wellclosedand transferred to the laboratory for the necessary analysis, all the tests were done in the laboratory of the Directorate Water of Kirkuk.

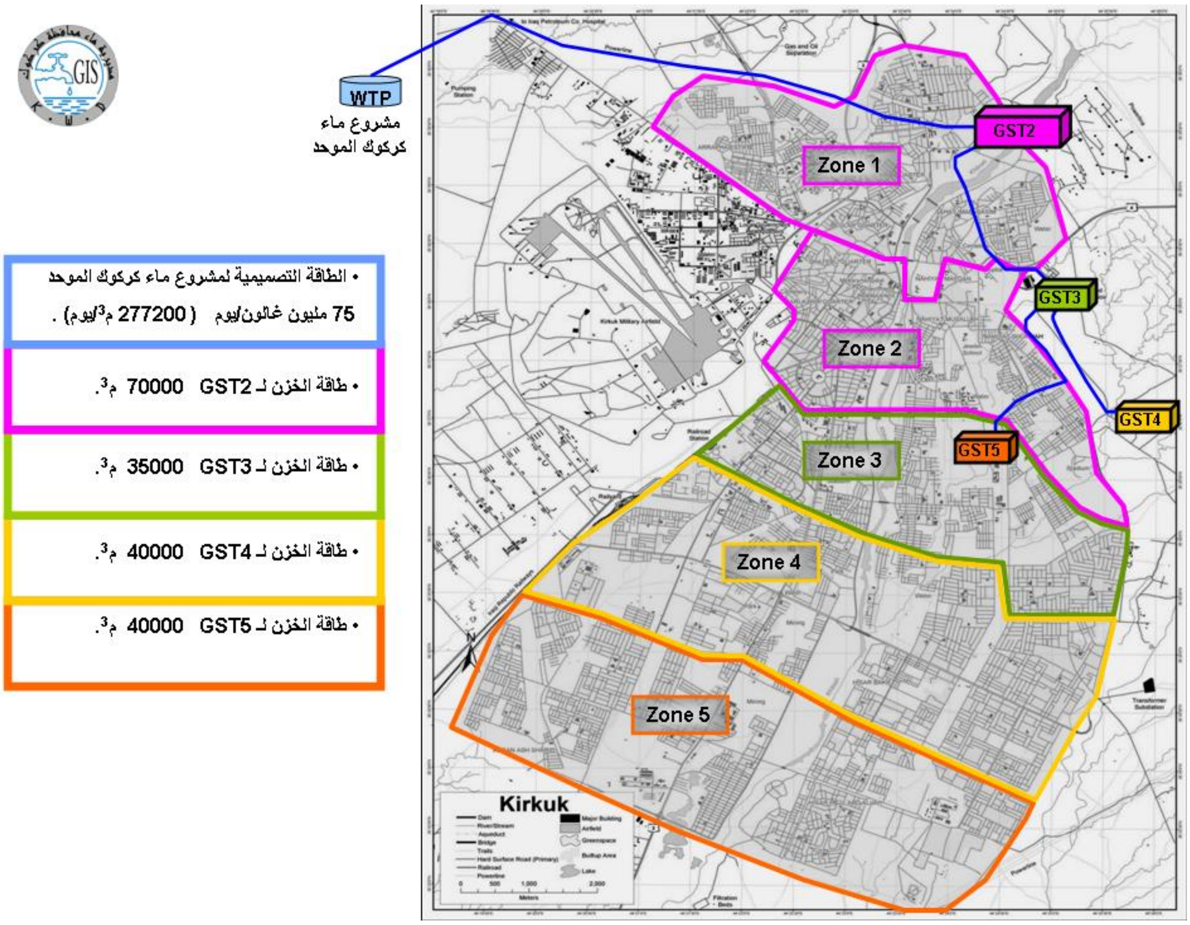

Figure 1. Kirkuk unified water project and distribution areas

Table 1. The geographical location of the stations

Number of stations	Name of stations	The geographical location of the stations
Station No. 1	Tank No. 1	Northwest of Kirkuk
Station No.2	Distribution areas of Tank No. 2	North of Kirkuk
Station No.3	Distribution areas of Tank No.3	Downtown Kirkuk
Station No.4	Distribution areas of Tank No.4	South of Kirkuk
Station No.5	Distribution areas of Tank No.5	South of Kirkuk

Turbidity

Water turbidity was measured using the German Turbidity meter was done after calibrating the device using standard solutions equipped by the manufacturer. The samples are tested in a special tube supplied with the device when the tube is placed in the reading process of machine and through the results in (N.T.U) Nephthelomtric Turbidity Unit.

Electrical Conductivity (E.C.)

The CONSORTC 830 Multi parameter analyzer was used to measure the electrical conductivity of the samples after calibrating the device then reading results process through the unit of microsiemens / cm (μS).

Total Dissolved Solids (TDS)

Total Dissolved Solids was measured using the WTW Digital conductivity model made by the German HANNA and expressed in mg/l units

Measurement of pH

The pH of the samples were measured using a pH meter manufactured by HANNA (Microprocessor HI 9321) after calibrating the device with Buffer Solution with pH (9, 7, 4).

Residual Chlorine

The tests are done using a LOVIBOND disk with a (DPD) detector, a powder prepared in special containers used for each test. The measurement process is done by taking 10 ml of the water sample and then adding a (DPD) as a result, a pink solution of varying color is produced according to the remaining chlorine concentration in the sample,the cell is then placed on a disc (LOVIBOND) and the color of the test sample is compared with the color grades on the disc (LeChevallier et al., 1981).

RESULTS AND DISCUSSION

Water Temperature

The temperature of the water samples was measured as shown in Table 2 which shows the variation in temperature values between the months of January, February and the months of May, June which confirms that there is a wide impact of seasonal variation on water temperature change which affects a large part of the physiological system, metabolic and geochemical processes in the river water (Barakat, 2007).

Table 2 shows the water temperature in the stations, which ranged between the highest recorded in the first station in June at 28.7 °C and the lowest recorded in the second station in February at 16.8 °C. A gradual rise in water temperature can be observed from January to June. The fluctuating results of the temperature between the stations in this study is due to the extent of these stations affected by the temperature of the periphery derived from the sun (Fatalawi, 2007)

pH

Natural water tends to the base side because of the presence of carbonates and bicarbonates (Lind, 1979). Therefore, the pH values were within a narrow range and did not change much. This is observed in the current study that there are no significant differences between stations. The result was consistent with (Samurai, 2009).The pH values of the water samples did not change significantly during the considered months. The pH measurement results shown in Table 3 are within the range (7.2-7.7). These percentages indicate that the water has a weak base because the calcareous nature of the Tigris River that passes through many of the mountainous highlands (Al-Shuwani, 2009). These percentages of pH concentration are acceptable for drinking water quality according to the World Health Organization (WHO) and Iraqi standard that ranging from 6.5 <pH> 8.5.

Table 2. Temperature values ºC

Stations	January	February	March	April	May	June
1	18	17.2	20.7	22.8	28	28.7
2	18.2	16.8	21	22.9	27.8	27
3	18.4	17.4	20.9	23	28	27.9
4	18.3	17.3	21	22.9	28.1	28
5	18.2	17.2	20.7	22.9	28	27.6

Table 3. Values of pH

Stations	January	February	March	April	May	June
1	7.7	7.3	7.3	7.2	7.2	7.6
2	7.5	7.2	7.2	7.3	7.2	7.5
3	7.4	7.4	7.2	7.2	7.2	7.5
4	7.6	7.6	7.2	7.4	7.3	7.6
5	7.6	7.5	7.3	7.4	7.3	7.5

Table 4. Turbidity values mg/l

Stations	January	February	March	April	May	June
1	4.1	3.9	4.4	4.5	3.5	3.5
2	4	4.2	4.2	4.4	3.8	3.6
3	4.2	4	4.5	4.2	4	3.7
4	4	4.5	4	4.6	3.9	3.8
5	4.3	4.3	4.3	4.4	3.7	3.6

Turbidity

The cause of the turbidity is the presence of materials that may be minutes of soil, sand, Organic and Inorganic matter, or microorganisms, can be expressed by the visual property that makes light spread or absorbed instead of moving in a straight line (Mufriji, et al, 1991).Turbidity is the measurement of water transparency of suspended solids and high ratios of pathogenic organisms. The high rates of turbidity can protect living organisms from the effect of disinfection so the process of treatment and disinfection should be successful enough to keep water turbidity at the lowest level (Azzawi, 2010). The results showed an approximation of the turbidity values ranging between 3.5-4.6 NTU as shown in Table 4. It is within the international standards for drinking water. The high rate of turbidity of river water in rainy seasons is due to the erosion of soil, mud, and suspended matter with rain, such as algae and organic matter downstream (Al-Misleh, 1988), As the increased turbidity in the winter occur as a result of increasing water levels and movement, which leads to the non-deposition of the suspended materials (Al-Saadi et al, 1986).

Electrical Conductivity (E.C.)

Electrical conductivity is a numerical expression of positive and negative ions found in water (APHA, 2003). The electrical conductivity of water depends on the soluble matter (mainly electrolytes) and its values are influenced by concentrations of salts found in the form of ions (Al-Shwani, 2001). The electrical conductivity ranged from 340 - 431 μs/cm as shown in Table 5. The increase in the rate of soluble salts in the river water coincides with seasonal changes, as it increases in the winter from the summer due to rainfall, and

Table 5. Electrical conductivity values µs / cm

Stations	January	February	March	April	May	June
1	412	417	418	425	351	321
2	416	420	416	430	340	327
3	417	416	419	426	362	331
4	414	423	422	425	341	329
5	413	416	421	429	344	326

increase the amount of dissolved salts in the water. The abundance of highly soluble carbon dioxide causes the increase of negative carbon ions that combine with positive ions that form heterogeneous salts (Al-Haidari, 2003). The results for all samples during the study period were match with Iraqi Standard No. 417 of 1989 and the World Health Organization (WHO, 1993), which determined the validity of drinking water of electrical conductivity value does not exceed 2000 µs / cm.

Total Dissolved **Solids (T.D.S.) mg/l**

Soluble solids represent the measurement of inorganic salts, organic matter and other soluble substances in water, either naturally occurring in water or as a result of industrial and household wastes produced by anthropogenic or from the atmosphere or due to evaporation due to high temperatures or falling rain. It also depends on geology of earth (Wetze, 1983), containing organic particles or metals that are useful when they are present in the water as nutrients or lead to water pollution by containing toxic substances (Hassan et al, 2012). The variation in concentrations of dissolved solids during the months of the year may be due to the fact that the months with high concentrations of dissolved solids in rainy months (Table 6). Rainfall, particularly in densely populated cities and industrial areas, carries with it pollutants present in the atmosphere and solubility. When these rains reach the rivers, they increase concentrations of substances in water (Al-Sadani, 2009). A positive correlation was found between the concentrations of total dissolved solids and turbidity, The reason for the increase in total dissolved solids concentrations in the waters of the Tigris River is the increase in flow rates during the winter and spring due to rainfall which leads to high turbidity rates (Samurai, 2009).

Resdual Clorine

The main goal of adding chlorine to water in water treatment plants is sterilization to eliminate microorganisms that cause disease. To ensure good sterilization, chlorine is added in enough quantities, part of which remains in the form of residual chlorine, which prevents water from biological contamination during storage and transport of drinking water at network. The permissible limits of free chlorine concentrations are 0.2-0.5 mg/l. If this percentage is reduced, the probability of contamination of water by microorganisms is increased, especially when leaks or breakdowns occur in the water network. If chlorine increases, this is dangerous because of the chlorine union with organic compounds that produce compounds that have a health effect.

The addition of chlorine in the Kirkuk unified water project is carried out after filtration so after the completion of the filter operations to be disposed of the largest amount of organic compounds that may be associated with chlorine to be toxic and carcinogenic substances. The free residual chlorine after the disinfection process, it ranges between (0.8 - 3.0) mg/l in drinking water samples as shown in Table 7. The results showed that the highest concentration of residual chlorine was during the month of January at the first station, which is (3) mg/l and the lowest concentration of residual chlorine was in the month of May the

Table 6. Total dissolved solids values mg/l

Stations	January	February	March	April	May	June
1	300	310	312	328	260	256
2	302	316	308	326	238	260
3	303	312	310	322	298	258
4	302	316	316	326	226	260
5	308	314	318	326	235	264

Table 7. Residual chlorine values mg/l

Stations	January	February	March	April	May	June
1	3	2.8	2.9	2.8	2.7	2.6
2	2.3	2.3	2.2	2.3	2	1.9
3	2.1	2.1	2	2	1.7	1.5
4	2	1.9	1.8	1.7	1.5	1.3
5	2	1.8	1.9	1.8	0.9	0.8

fifth station is (0.8) mg/l, due to the different amounts of chlorine added during the disinfection processaccording to the months and seasons of the year and the efficiency of chlorine pumps may affect differences in residual chlorine concentrations (Barakat, 2007).

Chlorine is a toxic chemical, although it is a disinfectant that is easy to use and control its effectiveness. However, recent research has shown that serious damage to human health because of its use. Therefore, when using chlorine and its manufacturing materials, gloves and protective masks should be used in well-ventilated areas but most people use chlorine in the wrong way, especially in cleaning, dish washing and clothing. This cheap chemical is also used extensively in the sterilization of drinking water, chlorine producers have made huge profits although scientific research has shown that chlorine is the leading carcinogen and can be fatal. Chlorine is weak in resistance to inorganic pollutants such as heavy metals such as zinc and iron, which contribute significantly to the injury of the body kidney failure and cirrhosis. Prolonged exposure to chlorinated water, whether by drinking or swimming, can lead to tooth damage, leading to tooth calcification and weakness. There is evidence of a relationshipcolon, bladder and rectum cancerwith chlorinated water. The exposure to chlorine during bathing is greater and more dangerous than the risk of drinking the same water, because when we drink water takes its way to the digestive system and then to the output system and only part of it goes to blood circulation while during showering hot water opens the pores of the skin and thus take chlorine and other pollutants into the body through the pores of the skin, on the other hand, there is another serious problem is the inhalation of dangerous substances during bathing, as the bathroom is usually small and therefore hot water is evaporation with chlorine, easy to inhalation, the vapor-loaded carcinogen and the problem is not only in its absorption across the skin but also in the inhalation of its spray during bathing, The inhalation of chlorine vapor during bathing increases the problems of asthma, allergies and sinuses by adding to skin problems and hair loss. Short-term exposure to these conditions may cause eyesight, coughing, phlegm, nasal bleeding, chest pain, redness of the skinand makingthe head hair dry and difficult to lay off.More-term exposure may cause fluid accumulation in the lungs, pneumonia, bronchitis, hard breathing and increase the problems of cortex in hair, the research has shown that the body absorbs chlorine during bathing, and that the amount of chlorine entering the body during a bath of 10 minutes equivalent to the amount of drinking 8 cups of the same water (Abdel-Latif, 2014).

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