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An Environmental Study for Assessing the Efficiency of the Drinking Water Purification Plant Supplying Some Areas North of Tikrit

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A B S T R A C T

The current study is conducted to evaluate the efficiency of the drinking water purification plant supplying for some areas north of Tikrit. The study samples were taken monthly, including a sample from the river outlet of raw water, a sample from the sedimentation basin, and the third sample from the drinking water line, starting from August of 2020 until March 2021. The study included, firstly, measuring some environmental factors, including (turbidity, pH, dissolved oxygen, Biochemical oxygen demand , calcium hardness, magnesium hardness , chloride ion) and secondly, microbial factors (total aerobic plate count, total coliform). The study has recorded high values of turbidity in the winter season, reaching (162.4) nephelometric turbidity unit, while the pH values were tending to be basicity, as their levels ranged between (8.3-7.1). As for the dissolved oxygen concentration, it was high in the spring season, reaching (9) mg / Liter and the concentration of the biochemical oxygen demand was high in the summer season due to the high temperatures, as its concentration reached (4. 3) mg / liter. The chloride ion concentration was conformity with compliance with international standards, it ranged between (55.6-32.7) mg / liter. The microbial study, it was found that the water is very polluted, especially in the spring season, as the values of the total number of aerobic bacteria ranged between (17.6-3) × 103 cells / ml, while the values of the total number of coliform bacteria were between (4-4) cells / 100 ml.

1. INTRODUCTION

The quality of the water of the Tigris River has differed from what it was previously, due to the control over the release of water by the neighboring riparian countries on the river that comes to Iraq or locally through water storage in dams and lakes, as well as the large consumption of water for domestic, industrial and agricultural purposes. The increase in the discharge of polluted water from cities, reeds, factories, etc. to the river has led to an increase in the concentration of pollutants in the Tigris River and has affected its quality. Also, the conditions that Iraq went through in previous years has led to the deterioration of the characteristics of drinking water resulting in the projects of liquefaction of water and a decrease in water rates. As in the last decades of the twentieth century, water quality standards and the determinants of its standard properties have become important matters in limiting or reducing the risk of pollutants and impurities in water sources. Regional and international organizations and agencies across the United Nations are actively seeking to encourage research programs aiming at finding minimum determinants of impurities and pollutants ensuring the safety of consumers from diseases [1].

The environmental workers' knowledge of these systems, regulations and specifications related to drinking water greatly influences the selection of raw water sources, the selection of the filtration stages in the project, as well as their influence on the design determinants of each stage and the cost of treatment. Most countries of the world have their formal and informal institutions and scientific societies concerned with matters of the water environment and its protection from the threat of pollution. These bodies work in cooperation with neighboring countries in regional bodies and organizations [2]. Many of these bodies have classified the water quality of rivers and water bodies based on their characteristics and specifications, and have determined the appropriate and necessary method for filtering and treating each type to make it suitable for human use.

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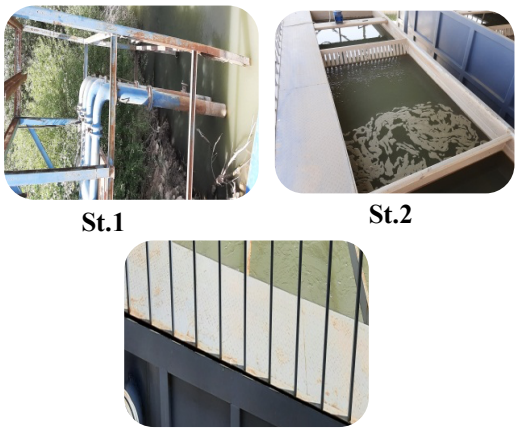
2. MATERIALS and METHODS

2.1. Description of the Study Area

The study included some qualitative and microbial characteristics of the drinking water purification plant feeding some areas north of Tikrit, which specifically Hammad Shihab, Al-Suqoor, Al-Mahzam and Al-Shahama. This plant feeds about three thousand people from those areas with drinking water. The study included three sites that use raw Tigris River water as a source of water. Samples were collected from raw river water, after sedimentation and filtration processes, for the purpose of conducting the above checks in order to find the efficiency of each of the filtering processes with an indication of its effect. In addition to determining the validity of the filtered water for drinking and its conformity with the standard specifications for drinking water. The study took eight months, as shown on the pictures below.



St.1 St.2

St.3

Fig 1: Colonies developing on medium Nutrient agar when calculating the total number of aerobic bacteria

2 .2. PHYSIOCHEMICAL PROPERTIES

2.2.1. Turbidity

Water turbidity was measured by a Turbidity meter device of the type HANNA-LP2000. The device expresses standard solutions in (N.T.U) Nephelometric Turbidity Unit as a turbidity unit, with a rate of two readings per sample, after the device is zeroed.

2.2.2. pH

The pH of the samples was measured using a pH meter made by HANNA type (Microprocessor HI 9321) after calibrating the device with standard buffer solutions with a pH of (4, 7, 9).

2.2.3. Dissolved Oxygen in Water

The modified Winkler method was used to determine the concentration of dissolved oxygen in the water. Oxygen bottles with a volume of (250 ml) were filled by immersing them in water and making sure that there is no air bubble. The oxygen of the sample in the field is fixed by (2 ml) of manganese sulphate, then (2 ml) of base potassium iodide was added. The sample is well shaken where it is stirred twice or more, and then left for about 10 minutes and then adding (2 ml) of concentrated sulfuric acid, and by this the proportion of oxygen in the water was fixed. In the laboratory, (50 ml) was taken from the sample and tittered with sodium thiosulfate of (0.025) to calculate the oxygen concentration with the addition of drops of starch as a reagent and taking a rate of two readings. The results were expressed in the units (mg / liter) method as described in [3].

2.3.4. Biochemical oxygen demand in water

The same method of dissolved oxygen measuring was used the Biochemical oxygen demand opaque bottles (250 ml) were filled for all samples. These opaque bottles were then transferred to the laboratory. After placing the samples in the incubator for five days at a temperature of 25 ° C, the oxygen concentration in these bottles was measured. Using the equal

tion, the Biochemical oxygen demand results were determined by units (mg / liter), depending on the method described in [3].

$$BOD5\ mg/L = DO0 - DO5.$$

2.2.5. Calcium Hardness

The measurement was conducted according to what is stated in [4] by adding (2) ml of a (1) standard concentration of sodium hydroxide solution to (50) ml of water sample with the use of (0.2) g of monoxide dye as a guide to be tittered with the aforementioned sodium salt solution with the same concentration until the solid violet color appears instead of the pink color. Using the following equation, the calcium hardness was calculated in mg / liter: -

Calcium Hardness of $CaCO_3$ (mg/L) = AxBx1000/sample size (ml)

A= size of Ethylene Diamine Tetra Acetic Acid (ml)

B= size of $CaCO_3$ (mg) equaling one ml of standard Na_2EDTA.

2.2.6. Magnesium Hardness

The magnesium ion concentration (Mg^{+2}) was calculated using the mathematical equation mentioned by [4] and the results were expressed in mg / L.

Magnesium Hardness Mg.H (mg/L) = Total Hardness T.H – Calcium Hardness Ca.H.

2.2.7. Chloride

Chloride ions were measured according to what is shown in [4] by taking (50) ml of water sample, then adding a few drops of potassium chromate K2CrO4 and wiping it with a solution of silver nitrate AgNO3 with a concentration of standard (0.0141) until the color turns to meaty red .Through the following equation, the chloride ion concentration was calculated and the results were expressed in mg/L.

Cl(mg/L)= AxBx1000/equivalent weight of Cl/sample size (ml)

A= The volume of silver nitrate.

B= Silver Nitrate Standard.

2.3. Microbial Tests

2.3.1. Enumeration of Bacteria Count

The plate pour method was adopted to estimate the total live number of bacteria. The water sample was shaken vigorously approximately 25 times, then a series of dilutions were prepared up to $^{-5}10$ using a 0.85% physiological normal saline. One (1) ml was transferred using a clean and sterile pipette from each dilution and from the original sample to the sterile Petri dishes. Then, the nutrient agar was poured after reaching a temperature of (45-50) degrees Celsius. The plates were gently rotated in the shape of the number 8 with the nutrient agar. After that, it was left to solidify and then the dishes were incubated upside down at 37 ° C for 24 hour in the incubator. The number of developing colonies was calculated, in which the total live number of aerobic bacteria counted, as shown in Figure 1, by the standard plate count using a colony counter, that the number of colonies in each plate ranging from (30-300) colonies, and then multiplying the number of colonies in the reciprocal of the dilution and expressed as cell / 100 ml [5].

2.3.2. Enumeration of Fotal Coliform

The most probable number (MPN) method was to determine the total number of coliform bacteria mentioned in [4]. Three groups were inoculated, and each group consisting of three test tubes containing the MacConkey broth in each test tube(Durham's tube) of these groups (for the detection of released gas), as the following is conducted:

2.3.3.1. Presumptive Test

This was conducted by adding 10 ml of single strength MacConkey broth medium in two sets of test tubes and the double strength in a third set. These tubes were inoculated with water samples through sterile pipettes, as the tubes of single strength were inoculated with volumes (0.1,1) ml of water sample while the double strength with a volume of 10 ml of water sample. The inoculated tubes were incubated at 35 ° C for a period of 24 hours. The color of the medium in the test tube changed from pink to yellow, as well as the accumulation of gas in Durham's tube by 10% or more of the test tube volume were an indication of the positive result Figure 2. To confirm that the bacteria which fermented the culture medium (the color of the culture media changed to yellow) and formed gas inside Durham's tube were of intestinal origin, the following was conducted:

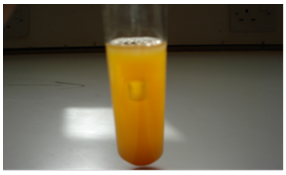


Figure 2: Appositive MPN test result is acid and gas formation in a Durham's tube.

Figure 3: Colonies *E.coli* bacteria developing on medium EMB agar.

2.3.3.2. A Confirmed Test

Isolates were cultured on (EMB agar) medium (Eosine Methylene Blue agar) by the planning technique. Aloop full were transferred from the positive test tubes (acid+gas).The tubes are shaken well and the culture media were inoculated on (EMB agar) (Eosine Methylene Blue agar).The dishes were then incubated upside down at 35 ° C for a period of 24 hours. The appearance of small black circular colonies surrounded by a metallic sheen belt is indicative of the positive colonies returning (depending on their morphological characteristics) from the confirmatory test Figure 3. The coliform bacteria were identified depending on the morphological characteristics through disseminating the loop full of those colonies that were identified as belonging to coliform bacteria on the slide. These were then dried in the air, fixed with flame and stained with a Gram stain [6].

2.4. Statistical Analysis

Using the SPSS 9th edition statistical program, the results were analyzed statistically according to the tests of ANOVA and the calculation of the correlation coefficient.

3. RESULTS AND DISCUSSION

3.1. Turbidity

The turbidity was a measure of the degree of clarity of water since the presence of solid particles leads to blocking part of the light in its water path. These particles may be small-sized minerals that reach the water from the soil or large particles were plant and animal residues and clumps of scraps of organic matter. Water differs in the severity of its turbidity, most of them have turbidity in which the more turbid, the more germs there are in the water.. There was a relationship between turbidity and absorption, as the nutrients present in low concentrations in the water are absorbed on the surface of suspended particles that cause turbidity, and thus these particles become a hotbed for the growth of bacteria [7].

The turbidity values during the current study period show a clear variation, as the values range between (1.4 - 162.4) Nephelometric turbidity unit NTU, where the highest turbidity value was recorded in the first site at the river's intake of raw water in December, and the lowest value in the third site at the sedimentation basin in August as shown in Table (1). The results of the statistical analysis show that

there were significant spatial and temporal differences between the study sites at a significance level of $P \leq 0.01$, and the presence of temporal significant differences at the level of significance $P \leq 0.05$. This indicates an increase in the turbidity values in all study sites in December. This is due to the high level of the river water as a result of the increase in the volume of the flowing water, which leads to the non-sedimentation of suspended materials, as well as the speed of the water currents to excite, mix and lift the sediment materials [8].

Table (1): Monthly and locational changes of turbidity (N.T.U.) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	58.5	20.5	1.4	26.8 a
September	60.8	26.9	1.9	29.866 a
October	68.9	24.8	2.8	32.166 a
Nov	79.2	28.2	3.2	36.866 a
December	162.4	52.4	9.4	74.733 b
Jan	113.5	40.1	7.5	b53.7a
Feb	83.7	32.6	5.7	40.666 ab
March	90.6	30.7	5.1	42.133 ab
Sites rates	89.7 c	32.02 b	4.62 a	

3.2. pH

The pH reflects the activity and effectiveness of the hydrogen ion and its effectiveness in water [9]. Aquatic organisms differ in their need for specific pH ion concentrations [10]. Algae and aquatic plants consume carbon dioxide for the purpose of the photosynthesis process, which leads to an increase in the pH value during the day, while the respiration process carried out by the micro-organisms and the rest of other organisms and aquatic plants at night emits carbon dioxide, which leads to a decrease in the pH value [11].

The pH values in the current study range between (7.1-8.3). The results of the statistical analysis show that there were no significant spatial differences between the study sites. This indicates that the rates of the pH values were close in the three sites during the study period, and the presence of temporal significant differences at a significant level of $P \leq 0.05$. Therefore, the highest value was recorded for the pH during the winter season, and the lowest values in the summer season and these results corresponded with [12]. The pH values of the current study were identical to the US Environmental Protection Agency's specification, which determines that the pH of natural water ranges between (6.5-8.5) as it does not cause any problems in natural waters [13].

Table (2): Monthly and locational changes of pH in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	7.1	7.6	7.8	7.5 ab
September	7.2	7.8	7.7	7.566 ab
October	7.5	7.4	7.2	7.366 a
Nov	7.7	7.9	7.3	7.633 ab
December	8.1	7.6	7.5	7.733 ab
Jan	8.3	7.9	7.8	8 b
Feb	7.8	8	7.7	7.833 ab
March	7.6	7.3	7.2	7.366 a
Sites rates	7.66 a	7.68 a	7.52 a	

3.3. Dissolved Oxygen in Water

Dissolved oxygen was important factor in the physio-chemical factors affecting the water quality of any water body, as it helps in the speed of dissolution of organic pollutants [14]. It is regarded an important measure to assess the quality of water and its degree of contamination, as it is very necessary for the breathing and living of aquatic organisms and its importance in the process of natural self-purification of water through microorganisms and preventing the formation of harmful odors [15,2]. The current results shows concentrations of dissolved oxygen ranging between (4-9) mg / liter, Thus, the amount of dissolved oxygen in the spring season was more than that in other seasons which is due to the speed of the water currents as a result of the strong movement of the winds, which leads to good ventilation, the constant mixing of water and the high dissolved oxygen in these water currents [16]. In addition, the reason for the low oxygen values in the summer is due to the inverse relationship between water temperature and dissolved oxygen concentration [17].The results of the statistical analysis shows that there were no significant spatial differences between the study sites, and the presence of temporal significant differences at a significant level of $P \leq 10.0$.

Table (3): Monthly and locational changes of Dissolved Oxygen (mg / liter) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	4	4.3	4.7	4.333 a
September	5.4	5.6	6	5.666 b
October	7.4	7.7	8	7.7 c
Nov	7.6	7.8	8.2	7.866 c
December	7.9	8.3	8.5	8.233 d
Jan	8	8.7	8.9	8.533 d
Feb	8	8.6	8.7	8.433 d
March	8.8	8.7	9	8.833 d
Sites rates	7.13 a	7.46 a	7.75 a	

3.4. Biochemical Oxygen Demand in Water

The results in Table (4) indicate that the values of the Biochemical oxygen demand range between (0.3-4.3) mg / liter, So, the high values of the Biochemical oxygen demand in the summer are due to high temperatures and the flow of organic materials present in industrial waste and sewage into the riverbed. Therefore, when decomposed, dissolved oxygen in water is consumed [18]. It was also observed in the statistical analysis that there was a negative correlation between each of the Biochemical oxygen demand and dissolved oxygen and the correlation coefficient values reached (-0.527 -0.21). The results of the current study matched, in most of its rates, the values of the pro-

posed Biochemical oxygen demand for drinking water within the international standards [19] of < 3 mg / liter.

Table (4): Monthly and locational changes of Biochemical Oxygen Demand (mg / liter) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	4.3	3.1	2	3.133 bc
September	4	2.8	1.7	2.833 b
October	3.7	2.2	1.1	2.333 ab
Nov	2	1.4	0.8	1.4 ab
December	1.5	1.1	0.6	1.066 ab
Jan	0.8	0.5	0.3	0.533 a
Feb	1.6	1	0.7	1.1 ab
March	1.9	1.3	0.4	1.2 ab
Sites rates	2.47 b	1.67 ab	0.95 a	

3.5. Chloride

The chloride ion was considered as one of the important negative ions in natural water, the presence of chloride salts in water bodies in general prevails over other salts [20]. The results shown in Table (5) indicate that the chloride values range between (32.7-55.6) mg / liter, The results of the statistical analysis show that there were no significant spatial differences between the study sites which indicates that the rates of chloride values were close in the three sites during the study period, and the presence of temporal significant differences at a significant level of $P \leq 0.05$. Thus, the high chloride values during the winter season was due to the occurring drifts and soil washing as a result of rain. The results of chlorides in drinking water when measured were in conformity with the international standard specifications for drinking water of 250 mg / liter [1].

Table (5): Monthly and locational changes of Chloride (mg / liter) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	36.6	39.8	42	39.466 a
September	32.7	36.1	38.2	35.666 a
October	40	42.3	44.4	42.233 ab
Nov	41.8	43.8	45.9	43.833 ab
December	49.4	52.2	55.6	52.4 ab
Jan	53.1	55.8	60.4	56.433 b
Feb	48.5	51.6	53	51.033 ab
March	45	49	50.9	48.3 ab
Sites rates	43.38 a	46.32 a	48.8 a	

3.6. Calcium and Magnesium Hardness

Calcium and magnesium were considered basic positive ions in the freshwater environment due to the presence of these two ions and their dominance in rocks and sediments. They also have a major role in influencing total hardness concentrations [21]. The amount of magnesium was less than calcium in solubility due to its tendency to precipitate in large quantities [22].

The results shown in Table (6) indicate that the calcium hardness values range between (125-184) mg/liter. Table (7) indicates the values of magnesium hardness which range between (85-142) mg / liter. The results of the statistical analysis show that there were no significant spatial differences between the study sites with regard to calcium and magnesium hardness, and the presence of temporal significant differences at a significant level of $P \leq 0.01$, and this indicates the high values of calcium and magnesium hardness in the winter season and their decrease in the summer season. This is due to the geological formation of the land in that water always contains high concentrations of calcium that are higher than those of magnesium [23]. The calcium and magnesium results in this study do not match the United State – Environmental Protection Agency drinking water standards, which range between 25 and 50 mg / liter for calcium and 50 and 125 mg / liter for magnesium [7].

Table (6): Monthly and locational changes of Calcium Hardness (mg / liter) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	125	137	129	130.33 a
September	133	146	142	140.33 ab
October	147	150	153	150 b
Nov	140	149	144	144.3 3 ab
December	167	159	160	162 bc
Jan	175	184	181	180 c
Feb	152	163	157	157.3 3 bc
March	129	135	137	133.6 6 a
Sites rates	146 a	152.87 a	150.37 a	

Table (7): Monthly and locational changes of Magnesium Hardness (mg / liter) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	97	108	103	102.66 ab
September	105	113	107	108.33 ab
October	112	118	115	115 b
Nov	109	110	114	111 ab
December	125	111	116	117.33 b
Jan	136	142	138	138.66 c
Feb	85	95	89	89.66 a
March	90	98	102	96.66 a
Sites rates	107.37 a	111.87 a	110.5 a	

3.7. Bacteriological Tests

3.7.1. Total Plate Count (T.P.C.)

Most bodies of water contain many types of bacteria that can be sourced from the soil drifting into that water or the source of wastewater in large quantities. They may be satisfactory or unsatisfactory stuck in the water column or stable in the bottom sediments and may be characterized by their high stability and long-term survival in the water when they were in the form of spores. They were classified either aerobically or anaerobically depending on their need for

oxygen [24]. The purpose of examining the total number of bacteria was to know the general bacterial content in the water, and not all bacterial species, but only those that have the ability to grow in culture media and form visible colonies under certain conditions of temperature [25]. The results shown in Table (8) indicate that the total plate count of aerobic bacteria range between (17.6-3) x10^3 cells / ml, as the lowest value was recorded at the third site during August and the highest value recorded at the first site during March. This is due to the suitability of temperature degree for growth and the high water levels with the resulting torrents loaded with organic matter and bacteria as a result of fertilization of agricultural lands with animal fertilizers drifting into the river, as well as the presence of large numbers of livestock and cows that graze close to the project at that site, which is a major source of micro-organisms and bacteria access to the river [26]. As for the decrease of bacteria count in summer, this is due to several reasons, including the high temperature of the water, which reduces the amount of dissolved oxygen which may lead to a decrease in the growth rates of aerobic bacteria [27].

The results of the statistical analysis show that there were no significant spatial and no significant temporal differences between the study sites. The US Environmental Protection Agency has determined that the highest permissible concentration is (50) cells / ml, indicating that the project water in general is contaminated with aerobic bacteria [28]. The total count of bacteria are not in conformity with the Iraqi drinking water standards [37] of 10 cells / ml.

Table (8): Monthly and locational changes of Total plate count (cell x 10^3/ ml) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	5.8	4.7	3	4.5 a
September	7.8	5.5	3.6	5.63 a
October	6.9	7	4	5.96a
Nov	9.8	8.5	5.3	7.86 a
December	14.1	9.6	9.2	10.96a
Jan	15	12.3	8.5	11.93 a
Feb	9.9	9.4	4.4	7.9a
March	17.6	11	9.8	12.8 a
Sites rates	10.86 a	8.5 a	5.97 a	

3.7.2. Total Coliform

The results shown in Table (9) indicate that the values of the total count of coliform bacteria in the current study range between (4-42) cells / 100 ml. The lowest value was recorded in the third site in September and February, while the highest value is recorded in the first site in March. The recording of high values in the current study is due to the high water levels in the spring season, which increases the quality of the organic nutrients. One of reasons for the increase in the number of coliform bacteria was also the suitability of the temperature, as the correlation coefficient recorded a positive significant relationship between the numbers of coliform bacteria and turbidity of (r = 0.411) at a significant level P ≤ 0.01. The results of the statistical analysis show that there were significant spatial differences between the study sites at a significant level of P ≤0.05 , and the lack of temporal differences. The correlation coefficient recorded a positive significant relationship between the number of coliform bacteria and turbidity of (r = 0.400) at the P ≤ 0.01 level of significance. The project waters within the study area for all sites and in all the months of the study concerning the total number of coliform bacteria as being in conformity with the Iraqi standard specifications for drinking water [29] which specified that the total number of coliform germs should not exceed (10) cells / 100 ml.

Table (9): Monthly and locational changes of Total Coliform (cell /100 ml) in the study sites.

Sites / Months	St1	St2	St3	Months rates
August	24	35	5	21.333 a
September	19	27	4	16.666 a
October	30	32	8	23.333 a
Nov	29	26	8	21 a
December	37	34	7	26 a
Jan	38	42	9	29.666 a
Feb	33	23	4	20 a
March	42	30	9	27 a
Sites rates	31.5 b	31.125 b	6.75 a	

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دراسة بيئية لتقيم كفاءة محطة تنقية مياه الشرب المغذية لبعض مناطق شمال مدينة تكريت .

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الخلاصة:
أجريت الدراسة الحالية لتقيم كفاءة محطة تنقية مياه الشرب المغذية لبعض مناطق شمال مدينة تكريت ، تم أخذ عينات الدراسة شهرياً تضم عينة من مأخذ النهر للماء الخام وعينة من حوض الترسيب والعينة الثالثة من الخط الناقل لماء الشرب بدءاً من شهر أب لعام 2020 ولغاية شهر أذار عام 2021 . شملت الدراسة أولاً قياس بعض العوامل البيئية منها (الكدرة ، الاس الهيدروجيني ، الاوكسجين الذائب ، المتطلب الحيوي الكيميائي للأوكسجين، عسرة الكالسيوم ، عسرة المغنسيوم ، أيون الكلورايد) وثانياً العوامل المايكروبية (العدد الكلي للبكتريا الهوائية Total Plate Count، العدد الكلي لبكتريا القولونTotal Coliform) ، سجلت الدراسة قيم عالية للكدرة في فصل الشتاء حيث وصلت الى (162.4) وحدة كدرة نفثالين بينما قيم الأس الهيدروجيني كانت تميل الى القاعدية اذ تراوحت مستوياتها ما بين(7.1-8.3) أما تركيز الأوكسجين الذائب كان عالياً في فصل الربيع حيث وصل الى (9) ملغم/لتر وتركيز المتطلب الحيوي الكيميائي للأوكسجين كان عالياً في فصل الصيف نتيجة إرتفاع درجات الحرارة حيث وصل تركيزه الى (4.3) ملغم/لتر أما تركيز أيون الكلورايد كان مطابقاً للمواصفات القياسية العالمية فقد تراوح ما بين (32.7-55.6) ملغم / لتر . بالنسبة للدراسة المايكروبية فقد وجدت ان المياه ملوثة جدا خصوصاً في فصل الربيع ، اذ تراوحت قيم العدد الكلي للبكتريا الهوائية بين (3-17.6) $\times 10^3$ خلية/مل، في حين كانت قيم العدد الكلي لبكتريا القولون ما بين (4-42) خلية/100مل.
الكلمات الدالة :المايكروبية , عسرة الكالسيوم ، أيون الكلورايد، البكتريا الهوائية ، بكتريا القولون .