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ENVIRONMENTAL IMPACT OF RUSAFA WATER PROJECT IN BAGHDAD, IRAQ

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Abstract: This study dealt with the assessment of the environmental impact resulting from the construction of the Rusafa water project in Baghdad city, where the evaluation process is one of the necessary steps in the decision-making for the establishment of development projects.This study aims to evaluating the performance of project, the main points will be mentioned by conduct laboratory analyzes of samples of raw water and produced of the project and measurement of some air pollutants dispersion inside and outside the project included measurements of the quality of effluent water which included variables (water temperature, pH, EC, turbidity, TDS, suspended solids TSS, total hardness TH, dissolved oxygen DO, residual chlorine, chlorine, nitrate NO3, Sulphate SO4, calcium Ca, magnesium Mg, sodium Na and potassium K) and some variables of air such as (NO2, CO, CO2, SO2, O3, temperature, relative humidity and wind speed) inside and outside the site, The results of the study showed when compared with Iraqi Standards and the World Health Organization (WHO) that some of them were in the range of limits and the other are outside that range. The study recommended based on the provisions of the Law for the Protection and Improvement of the Environment No. 27 of 2009 in Article 10, the project owner must comply with the preparation of the Environmental Impact Assessment (EIA) study prior to its establishment.

Keywords *EIA, Water measurements, Air measurements*.

الاثار البيئية لمشروع ماء الرصافة في بغداد، العراق

الخلاصة: تناولت هذه الدراسة تقييم الاثار البيئية الناتجة عن انشاء مشروع ماء الرصافة في مدينة بغداد حيث تعتبر عملية التقييم من الخطوات الضرورية في صناعة القرار لانشاء المشاريع التنموية. تهدف الدراسة لتقييم اداء عمل المشروع والنقاط الرئيسية تم تحديدها بواسطة فحوصات مختبرية لنماذج من الماء الخام والماء المنتج للمشروع ونماذج من ملوثات الهواء داخل وخارج المشروع. تضمنت فحوصات الماء المتغيرات (درجة حرارة الماء، ودرجة الحموضة، التوصيل الكهربائي EC، العكارة، المواد الصلبة الذائبة TDS، المواد الصلبة العالقةTSS ، الصلابة الكلية TH، الأوكسجين المذاب DO، الكلور الحر المتبقي، الكلورين، نترات NO3، كبريتات SO4، الكالسيوم Ca، المغنيسيوم Mg، الصوديومNa والبوتاسيوم) اما فحوصات الهواء فشملت المتغيرات مثل(NO2، CO، CO2، SO2، O3، درجة الحرارة، الرطوبة النسبية وسرعة الرياح) داخل وخارج المشروع والتي تبين من خلال الدراسة بعد مقارنتها مع محددات المحلية والعالمية مثل المواصفة العراقية ومنظمة الصحة العالمية WHO بعضها ضمن والبعض الاخر خارجها .اوصت الدراسة استناداً لما نصَ عليه قانون حماية وتحسين البيئة رقم 27 لسنة 2009 في المادة 10 يجب ان يلتزم صاحب المشروع بإعداد دراسة لتقييم الأثر البيئي قبل انشائه.

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1. Introduction

Rusafa Water project is fifth largest project in the world and the first in the Middle East project will make the city Baghdad at the forefront of producing pure water for cities in the world where per capita will reach of water a day is about 500 liters in , Where it would eliminate the most important service problems faced by residents of Rusafa areas that are hardest hit in this area, one of the biggest achievements of the Iraqi governments since 2003 – 2016 , The project will end the water shortage in the capital until 2030 [1].

In Iraq, all water treatment plants are conventional and working on removing of suspended and pathogenic impurities, In These conventional plants, sedimentation and filtration with coagulant aid are used to remove suspended and colloidal particles and chlorine is used for pathogenic removing.

After water passed to treatment, several tests were conducted to measure it's, and comparing these parameters with standards in order to evaluate its quality and to the extent that matches the required standards [2].

2. Objective and Classification of project

The aim is evaluating the performance of Rusafa water plant. Rusafa water project is classified within the white list category (C) according to Article 65 of Law No. 3 of 2011; as such projects characterized by specific environmental effects can be controlled and treated.

But Article 10 of Law No. 27 of 2009 obliges the entrepreneur created before starting to submit a report to the Environmental Impact Assessment.

3. The Study Area

Rusafa water project is located in the Husseiniya area in Northeast of Baghdad in N 34◦6′24.36″, E 44◦24′57.07″ within the limits of Municipality Department plate (1), the project is far on the Tigris River, a distance of 500 meters.

With an area of 420 acres and consists of two stages and the first stage implementing the second is under construction the nature of the areas surrounding the plant, as follows:

1. Abu Tauh village south of the Plant.
2. Al-Basatine neighborhood north of the Plant.
3. Qmirh Village east of the Plant.
4. AL-Thaalbh Bansin Station 120 meters away from the project and Baquba-Baghdad Highway Two Sides street width of 20 meters separating the carrot centrist display 5 meters to the west of the station [3].

Plate 1. Site of Rusafa water project [3]

4. Processing Flow for the project

Al-Rusafa water project is designed to serve the residential area and the future extension of the city according to the Master Plan.

The target year at 2030, with design capacity of (910,000) m^3/d divided at two stages for a construction purpose. The project consists of four main sections first outlet.

Which is located on the Tigris River and includes the elements of the initial filter and pumping station for raw water and the second section carrier lines between the outlet and the treatment plant and the number of five lines of the third treatment plant and section located approximately (3.5) kilometers east of the river it includes (16) basin sedimentation and two pools for the nomination consortium of 14 units nomination.

The other project sections include chemical plant and reservoirs of pure water card (90) thousand cubic meters for each station of pure water pumping and transmission lines reservoir from the pumping station to the points.

Reservoirs distribution beside me Karkh and Rusafa a length of 70 km in diameters ranging from 1400-1800mm. pure water distribution from the project to the neighborhoods of the capital Baghdad will be by seven lines, two of which diameter (1600 mm) track to the embankment and passing through areas the people of Ur and Ithaalbh and seven palaces and granular Obeidi and perfectionism, municipalities and other lines in diameter 1800 mm track to orchards neighborhood and reflect the military channel is then connected by the main network between the areas of Afaq Arabiya and by Muhammad Qasim for quick passage [3].

5. Field Measurement of Water Pollutants

Three water samples were taken from the raw water and produced water, and subjected to a number of physical and chemical tests in laboratories of the Mayoralty of Baghdad. the samples were taken from raw water from side of river Tigris in Baghdad, and produced water form water reservoirs of project during the three months (June, July and August), and all three samples were taking the arithmetic average and standard deviation.

The aim of the tests to determine the proportion of contaminants in the raw water and the processor to assess the efficiency of the plant during the operating period. These physiochemical variables were Temperature water temp °C was measured in situ using portable thermometer, pH, Electrical Conductivity (EC), Turbidity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Hardness (T.H), Dissolve Oxygen (DO), Free Residual chlorine, (Cl-), Nitrate (NO3-2), Sulphate (SO4), Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K) as shown in table (1).

Table 1. Mean values ± standard deviation for measurement of water variables

Variables	Mean ± standard deviation		Iraqi Standard	WHO Standard
	Raw Water	Produced Water		
Water temp. °C	18.9±1.5	18.5±1.5	-	-
Hydrogen ion (PH)	7.44±006	7.32±0.07	7- 8.5	6.5 – 8.5
E.C. µs/cm	913.0±17.0	796.5±10.3	2000	2000
Turbidity (NTU)	161.8±9.2	2.95±0.25	5	5
TDS mg/l	594.0±12.0	502.5±12.0	1000	1000
TSS mg/l	154.5±9.5	2.72±0.12	-	-
TH ($CaCO_3$) mg/l	336.5±4.4	302.0±8.0	500	500
Dissolved Oxygen mg/l	9.11±0.57	3.22±0.14	-	5 - 8
Free Residual chlorine ppm	ND	3.5±0.0	-	-
Chloride (CL) mg/l	47.5±0.5	70.5±5.5	200	600
Nitrate (NO_3) mg/l	1.3±0.0	3.55±0.9	40	50
Sulphate (SO_4) mg/l	222.5±2.5	165.0±1.0	200	400
Calcium (Ca) mg/l	58.0±1.0	65. 5±1.7	75	200
Magnesium (Mg) mg/l	26.0±0.0	27.5±2.2	50	150
Sodium (Na) mg/l	36.0±0.0	43.0±3.8	-	40
Potassium (K) mg/l	2.9±0.0	2.58±0.05	-	-

6. Field Measurement of Air Pollutants

Three air samples were taken from outside and inside the project near the generators during the three months (June, July and August) in 2016, all three samples were taking the arithmetic average and standard deviation goal of these measurements to know whether there are contaminants out of the project and the impact on the surrounding environment during the operating period.

This study has measured the following ambient air components in two sites where the first site was in project vicinity and the second was close to water producing line using portable devices provided by Environmental Research Center, University of

Technology (NO, NO2, CO, CO2, SO2, O3, Temperature, Relative Humidity (RH) and wind Speed) as shown in table (2).

Table 2. Mean values ± standard deviation of Air variables

Variables	Mean ± standard deviation		Iraqi Standard	WHO Standard
	In side	Out side		
NO ppm	0.14±0.002	0.2±0.004	-	-
NO2 ppm	0.18±0.012	0.3±0.038	0.11	0.25
CO ppm	25.0±3.16	38.0±6.12	9	9
CO2 ppm	100.0±15.0	154.5±19.5	-	250
SO2 ppm	0.07±0.01	0.1±0.018	0.14	0.01
O3 ppm	0.02±0.00	0.03±0.001	0.12	0.11
Temp. ($_o$c)	32.0±3.0	32.0±3.28	-	-
RH. %	38.0±2.4	40.0±2.22	-	-
Wind Speed m/sec	4.6±0.24	4.4±0.62	-	-

7. Measurments Results

7.1. *Water Measurements Results*

The mean of temperature (C°) for the raw water was 18.9 ±1.5, while produced water in the project, it was recorded a mean value of 18.5±1.5 respectively as shown in Figure (1).

The mean of PH for the raw water was 7.44±006, while produced water in the project, it was recorded a mean value of 7.32±0.07 respectively, the result was within the limits of Iraqi standard for drinking water (7-8.5) and WHO (6.5-8.5) as shown in Figure (2).

The mean of EC for the raw water was 913.0±17.0, while produced water in the project, it was recorded a mean value of 796.5±10.3respectively. The permissible limits for all samples matches standard specifications for Iraqi drinking water standards and WHO (2000 µS/cm) as shown in Figure (3).

The mean of Turbidity (NTU) for the raw water was 161.8±9.2, while produced water in the project, it was recorded a mean value of 2.95±0.25 respectively. Turbidity values for raw water exceeded the Iraqi standards (5 NTU) for treated water for WHO was not exceeding 1.5 so the two samples were not in limits Previous study recorded several reasons affected the turbidity of water such as the presence of materials that may be particles or soil or sand or clay, or even organic and non-organic matters or may be microorganisms. These materials cause lack of water transparency, interfere with the efficiency of the chlorine adding process, and help protect the bacteria [4] The highest reading recorded to raw water due to the erosion of large amounts of suspended solids into the river as shown in Figure (4).

The mean of Total Dissolved Solids (TDS) for the raw water was 502.5±12.0, while produced water in the project, it was recorded a mean value of 594.0±12.0 respectively, the permissible limits for all samples matches standard specifications for Iraqi drinking water standards and WHO (1000mg/l) as shown in Figure (5).

The mean of Total suspended solids (TSS) for the raw water was 2.72±0.12. While produced water in the project, it was recorded a mean value of 154.5±9.5 respectively, these results showed an increase in TSS concentration in raw water rains in winter that carry many suspended materials such as dusts and others beside the increase in winds velocity and sand storms in summer as a result of that increase velocity of water in its turbidity [5], as shown in Figure (5).

The mean of Total Hardness (TH) for the raw water was 302.0±8.0. while produced water in the project, it was recorded a mean value of 302.0±8.0 respectively. The results of the current study of drinking water matched the Iraqi standards for safe drinking water (500 mg/l), The total hardness is a digital term of water content of metal especially calcium, magnesium ions, and other alkaloids ions, its counted one of major characteristics that differs as the water quality differs around the world .Hard water is the water which contains these ions and others such as iron, manganese, and aluminum; they are more common than easy water [6] as shown in Figure (5).

The mean of Dissolved Oxygen (DO) for the raw water was 3.22±0.14, while produced water in the project, it was recorded a mean value of 9.11±0.57 respectively as shown in Figure (11). The mean of Free Residual chlorine ppm for the raw water was 3.5±0.0, while produced water in the project, it was recorded a mean value of ND respectively, the results was exceeded the limit for produced water for Iraqi standards for safe drinking water (0.3-1mg/l) and WHO standards (0.5-1.5 mg/l) as shown in Figure (5).

The mean of Chloride (CL) mg/l for the raw water was 70.5±5.5. while produced water in the project, it was recorded a mean value of 47.5±0.5respectively, The results of the current study of drinking water matched the Iraqi standards and WHO were with limits for two samples, For the areas to the project the rates of chlorides were higher than the projects supplying them that's might be due to the breaks in the transferring pipes because of the excavations most of times then cause the mixing of drinking water in the pipe with the liquids in the lands that network of pipes pass through it then carrying many materials and salts, or it might be due to the corrosion of the internal substances lining the pipes as shown in Figure (5). The mean of Nitrate (NO_3) mg/l for the raw water was 3.55±0.9. while produced water in the project, it was recorded a mean value of 1.3±0.0respectively, the results of the current study of drinking water matched the Iraqi standards for safe drinking water (40 mg/l) and WHO (50 mg/l) were in limits for two samples as shown in Figure (5).

The mean of Sulphate (SO_4) mg/l for the raw water was 165.0±1.0 while produced water in the project, it was recorded a mean value of 222.5±2.5 respectively. The results of the current study of drinking water matched the Iraqi standards for safe drinking water (200 mg/l) so for raw water was exceeded limits. The increase of SO4 might be due to many reasons, such as, they can't be removed by the traditional processing methods, or adding Alum article in non-regular doses Or the drinking water

contaminated by sewage that contain a high concentration of SO4 in some areas due to the old distribution networks and their corrosion, or the leakage of ground water, and other human industrial activities as shown in Figure (5).

The mean of Calcium (Ca) mg/l for the raw water was 58.0±1.0 while produced water in the project, it was recorded a mean value of 65.5.5±1.7 respectively, the results of the current study of drinking water matched the Iraqi standards for safe drinking water (75 mg/l), Soil erosion and mining of dolomite can be attributed to high values of calcium and magnesium concentration in river water [7]. It has a great importance in water because the hardness and the quality of water depend on its concentration in it as shown in Figure (5).

The mean of Magnesium (Mg) mg/l for the raw water was 27.5±2.2, while produced water in the project, it was recorded a mean value of 26.0±0.0 respectively, the results of the current study of drinking water matched the Iraqi standards for safe drinking water (50 mg/l), In addition to bio adsorption of Mg ions by plants which depend on water characters of temperature, pH, and dissolved Oxygen concentration as shown in Figure (5).

The mean of Sodium (Na+1) mg/l for the raw water was 43.0±3.8, while produced water in the project, it was recorded a mean value of 36.0±0.0respectively, the results of the current study of drinking water matched the WHO (40 mg/l) so for produced water exceeded limits. It's one of the ions responsible of hardness in water, increasing in its concentration leave sediments on the pipes walls [8] as shown in Figure (5). The mean of Potassium (K) mg/l for the raw water was 2.58±0.05, while produced water in the project, it was recorded a mean value of 2.9±0.0 respectively, as shown in Figure (5).

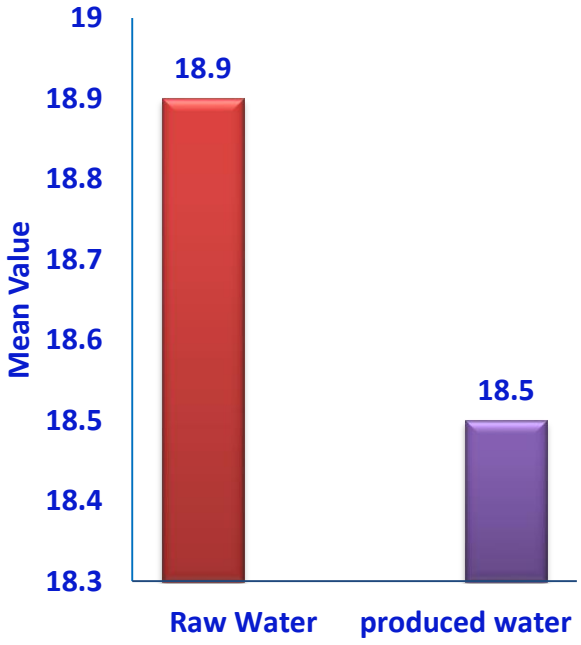

Figure 1. Temperature value of the samples.

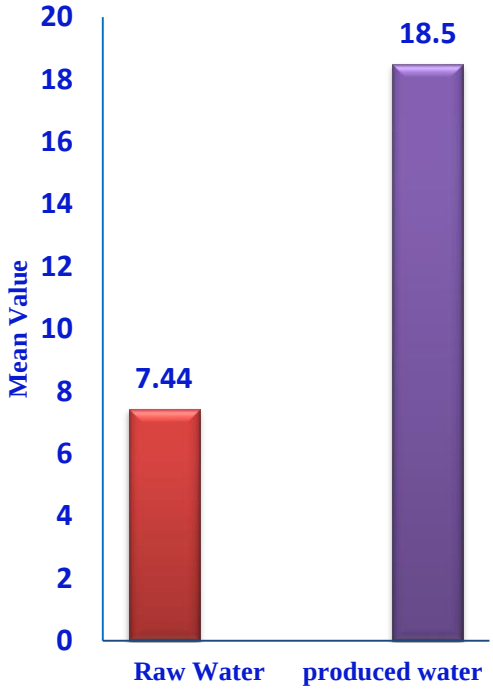

Figure 2. PH value of the samples

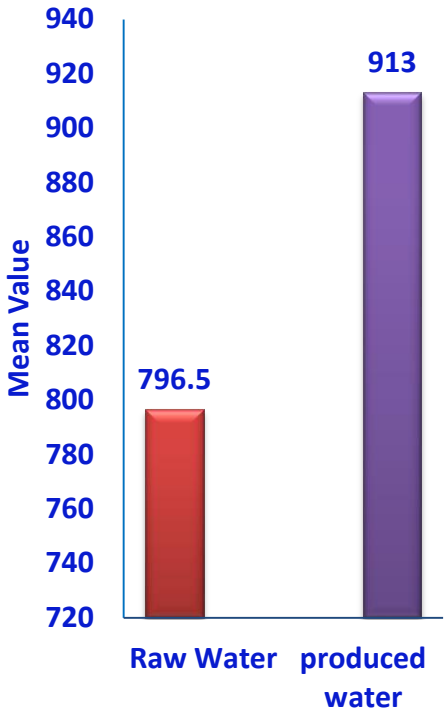

Figure 3. EC value of the samples.

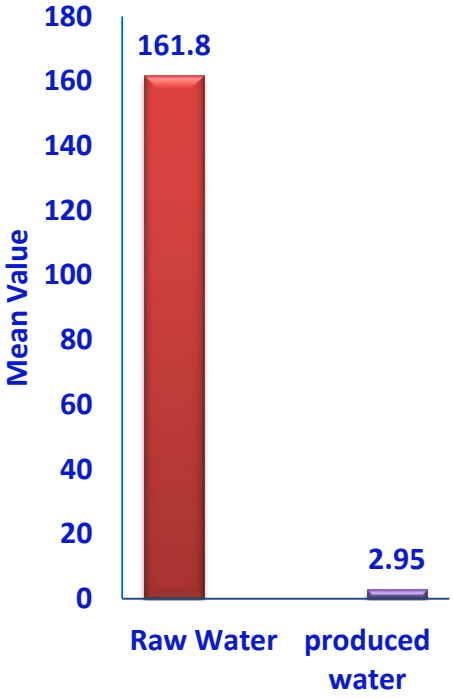

Figure 4. Turbidity value of the sample

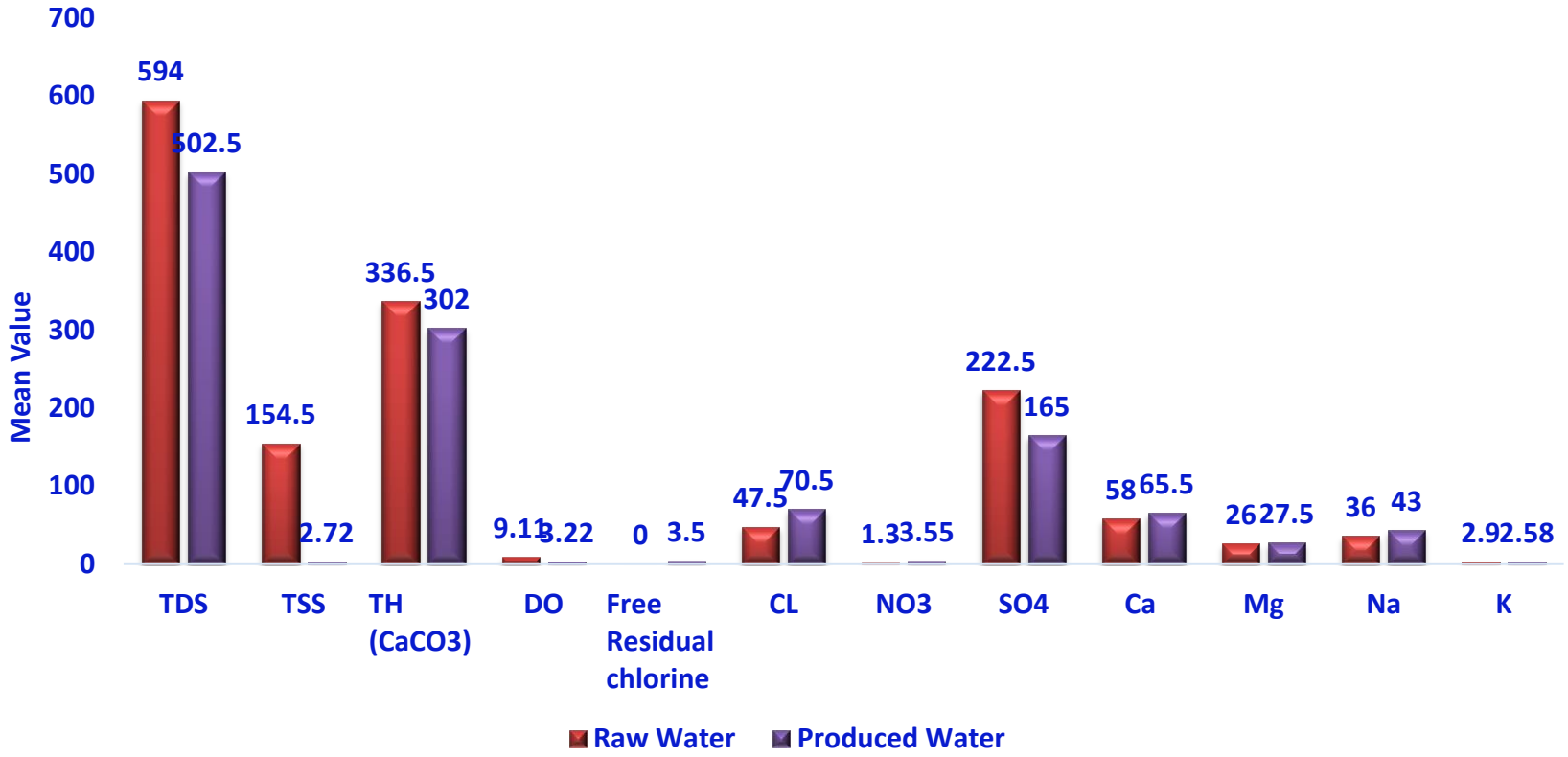

Figure 5. TDS, TSS, T.H, DO, Free Residual chlorine, (Cl-), NO3, SO4, Ca, Mg, Na and K value of the samples

7.2. *Air measurement Results*

The mean of air NO ppm content outside the project was 0.2±0.004 ppm, while inside the project, it was recorded a mean value of 0.14±0.012 ppm respectively as shown in Figure (6)**.** The mean of air NO2 ppm content outside the project was 0.3±0.038ppm, while inside the project, it was recorded a mean value of 0.18±0.012 ppm respectively, when compared with the limits of the Iraqi specification (0.11 ppm) and WHO (o.25 ppm), which the two samples were higher than for the specified parameters as shown in Figure (6)**.**

The mean of air SO_2 ppm content outside the project was 0.1±0.018 ppm. While inside the project, it was recorded a mean value of 0.07±0.01ppm respectively.When compared with the limits of the Iraqi specification (0.14 ppm) and WHO (0.01 ppm), within the limits of the Iraqi standard of the two samples but outside the limit standard for WHO as shown in Figure (6)**.** The mean of air O_3 ppm content outside the project was 0.03±0.001 ppm, while inside the project, it was recorded a mean value of 0.02±0.00ppm respectively, when compared with the limits of the Iraqi specification (0.12ppm) and WHO were (0.11ppm), which the two samples were in limits as shown in Figure (6).

The mean of air CO ppm content outside the project was 38.0±6.12ppm, while inside the project, it was recorded a mean value of 25.0±3.16 ppm respectively, when compared with the limits of the Iraqi specification and WHO were (9ppm), which the two samples is higher than for the specified parameters as shown in Figure (7) The mean of air CO_2 ppm content outside the project was 154.5±19.5 ppm, while inside the project, it was recorded a mean value of 100.0±15.0ppm respectively, when compared with the limits of WHO (250 ppm), which the two samples was in limits for the specified parameters as shown in Figure (7).

The mean of air Wind Speed m/sec content outside the project was 4.4±0.62ppm, while inside the project, it was recorded a mean value of 4.6±0.24 ppm respectively as shown in Figure (8)**.** The mean of air Temp (c°) content outside the project was 32.0±3.28 ppm, while inside the project, it was recorded a mean value of 32.0±3.0 ppm respectively, as shown in Figure (9)**.** The mean of air RH % content outside the project was 40.0±2.22 ppm, while inside the project, it was recorded a mean value of 38.0±2.4 ppm respectively, as shown in Figure (10).

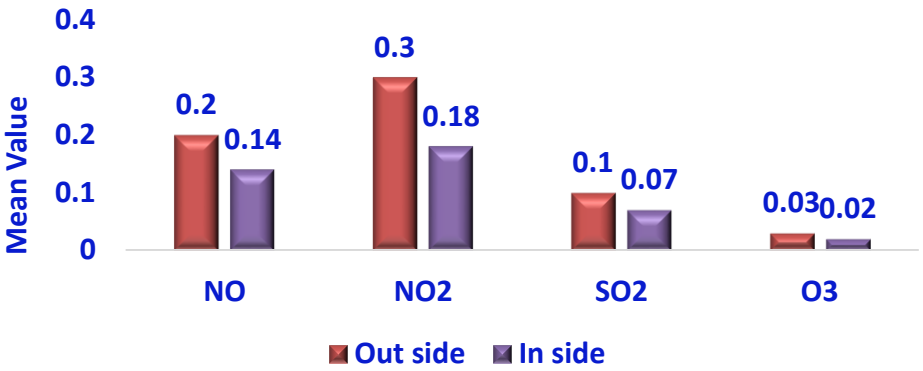

Figure 6. NO, NO2, SO2 and O3 value of the samples.

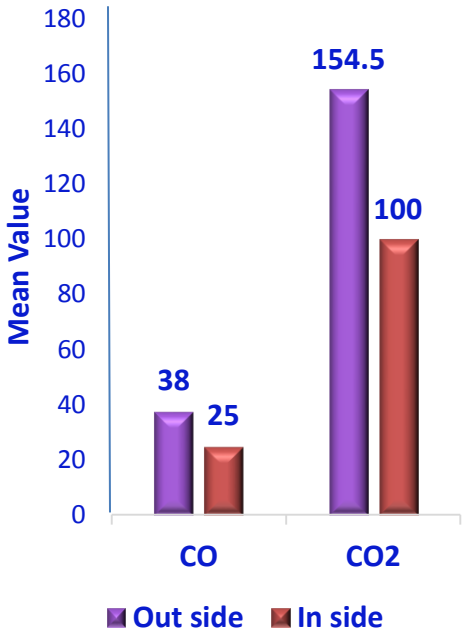

Figure 7. CO and CO2 value of the samples

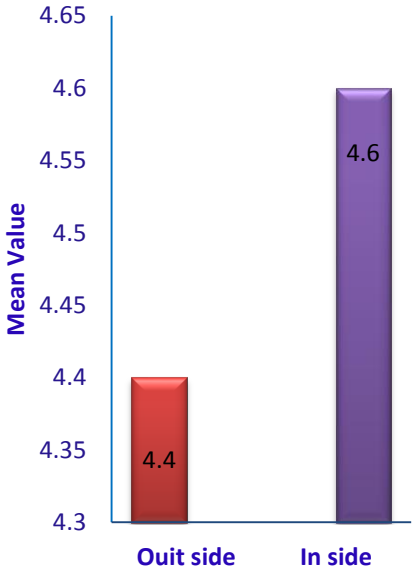

Figure 8. Wind Speed m/sec value of the sample

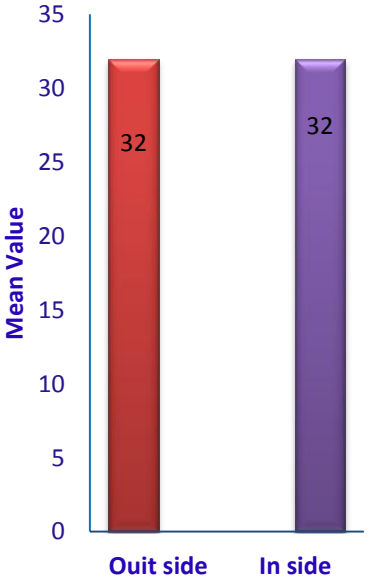

Figure 9. Temp. ($_o$c) value of the samples.

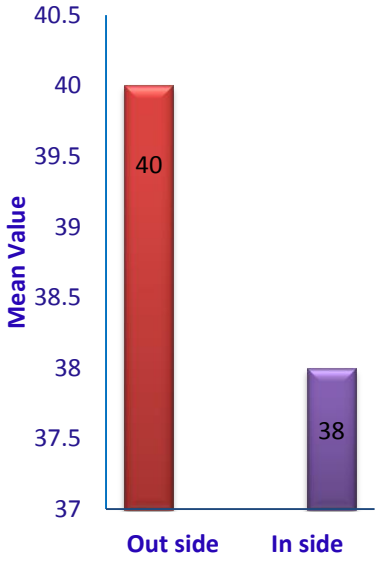

Figure 10. RH. % value of the samples.

8. Analysis of Environmental Impacts

Table (3) as shown below summarizes the impacts for each activity related to the project and presents the magnitude, frequency, likelihood and consequence of each impact.

Table 3. Summary of Impacts

Activity	Type of Impact	Magnitude	Frequency / Duration	Likelihood	Consequence (+ / -)
Water extraction from the river	1-Water drawdown	Significant	Permanent	Low	Negative
	2-Unsustainable water use	Medium	Permanent	Low	Negative
	3-Decrease in water available for existing flora and fauna in the river	Minimal	Permanent	Low	Negative
	4-Effects on the sensitive ecosystem	Minimal	Permanent	Low	Negative
	5-Increase of water supply to population	Significant	Permanent	High	Positive
Treatment of water by chlorination	1-Supply of improved drinking water quality to population	Significant	Permanent	High	Positive
	2- Risk of wrong dosage	Significant	Single event	Low	Negative
	3- Potential hazard from the use of chlorine	Significant	Permanent	Low	Negative
Waste generation	Chemicals coagulation, settled water from pre-sedimentation	Minimal	Permanent	Low	Negative
Installation of electric cables to connect pumps with the power source	Use of potentially harmful materials (e.g. PCB)	Significant	Permanent	Low	Negative
Pump room operation	1- Halted operation due to electricity cuts	Medium	Permanent	Low	Negative
	2- Pollution in case generators are needed	Minimal	Permanent	Medium	Negative
	3- Contamination of water due to spills and propagation of chemical elements (e.g. PCB, oil, etc.)	Significant	Permanent	Medium	Negative
	4- Risk of leakage from fuel storage tanks	Significant	Permanent	Medium	Negative
	5- Noise pollution	Minimal	Permanent	High	Negative

9. Conclusion

1. The project is conventional and working on removing of suspended and pathogenic impurities. In These conventional project, sedimentation and filtration with coagulant aid are used to remove suspended and colloidal particles and chlorine is used for pathogenic removing.
2. The project works within modern techniques for each stage and within the parameters of the Iraqi and environmental determinants and the Iraqi standard for drinking water. The scientific and technical development of modern in many of the joints of the project allows for adjustments in the technological path to the station all units.
3. When compare with the Iraqi limitations and the World Health Organization (WHO) for water measurements were within the limitations and the other were not within the limitations, for Water results that were higher than the limitations were the mean of The mean of Turbidity for the raw water was 161.8±9.2. The mean of Sulphate (SO4) mg/l for the raw water was 165.0±1.0 while produced

water was 222.5±2.5. The mean of Sodium (Na+1) mg/l for the raw water was 43.0±3.8.

4. When compare with the Iraqi limitations and the World Health Organization (WHO) for water measurements for air results that were higher than the limitations were the mean of air NO2 ppm for outside was 0.3±0.038ppm, while inside the project, was 0.18±0.012 ppm. The mean of air CO ppm for outside was 38.0±6.12ppm, while inside the project was 25.0±3.16 ppm.

10. Recommendation

1. The study recommended based on the provisions of the Law for the Protection and Improvement of the Environment No. 27 of 2009 in Article 10, the project owner must comply with the preparation of the Environmental Impact Assessment (EIA) study prior to its establishment.
2. In this project, water usage and water source conservation should observe the “Environmental Protection Law” and “Water Pollution Control Law” and other relevant laws and regulations, and make relevant water resource conservation measures to meet the aim of water and soil conservation, water pollution prevention, water saving and water environment protection.
3. To strengthen protection of water supply and distribution network, they should be avoided overlap with sewage network as far as possible. If the overlaps are inevitable, then precaution for sewage pipeline rupture is required in engineering design to reduce the risk of drinking water contamination incidents.

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