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Assessment the Performance of Al-Nassriya Water Purification Plant, South of Iraq.

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ABSTRACT

In order to ascertain the drinking water quality for human consumptions, water samples were collected from Al-Nassriya Water Purification Plant (WPP) on Al-Gharraf River in Dhi-Qar, Iraq. The following water quality parameters were determined namely; Turbidity, pH, Total Dissolved Solid, Electrical Conductivity, Total Hardness, Cl^-, Na^+, K^+, Ca^{+2}, Mg^{+2}, NO_3^-, SO_4^{-2}, PO_4^{-3} and the concentration of four heavy metals Pb, Zn, Cd, and Ni. The research results showed that the performance of the WPP units was good but the plant in the time of the study works only 60 percent of its designed output because of the lack of reliable power from the national grid, old distribution system afflicted with leakages. Most of the parameters analyzed were within the guidelines given by WHO and Iraqi standards for drinking water while few others were not.

Keywords: water quality, performance, Al-Nassriya Water Purification Plant

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INTRODUCTION

Water quality is a growing global concern. Polluted water and inadequate sanitation kill two children every minute worldwide. Water quality is the physical, chemical and biological characteristics of water in relationship to a set of standards [1][19].

According to the World Health Organization (WHO) guidelines: drinking water must not contain chemicals, inorganic substances or organisms that may be harmful to human health [2].

Drinking water should also be at a reasonable temperature and be free of unappealing odors, taste, and color. The guideline defines drinking water as water which is safe to drink over a lifetime that is and it constitutes no significant risk to health [3].

Water quality investigations have been widely done by researchers [4][5] all over the world with rapid urbanization; the chemical features of water have become a cause of large concern as toxic chemicals in industrial effluents cause a high risk to human health.

In Baghdad, [6] evaluated the performance of Sharq Dijla WPP and found that the supplied water was within the permissible limits.

The study of [7] shows that the quality of the potable water of Al-Karkh WPP was (68%) violated the WHO standards, while (99%) of the samples were compliance with those standards and advanced water treatment units must be added according to the scientific conventional methods with a systematic maintenance for the different stages of water treatment plant is highly recommended.

This study aims to evaluate the quality of Al-Gharraf River water and the efficiency of Al-Nassriya WPP at Al-Bad'ah for drinking purpose by determining the physicochemical parameters, the concentration of some heavy metals in water and compare the values with WHO and Iraqi standards.

MATERIALS AND METHODS

The Study Area

Al-Nassriya Water Purification Plant (WPP) (the largest in the south of Iraq) is located in Al-Bad'ah area, 4 km north of Al-Shatra City, raw intake is from the western shore of Al-Gharraf River which is a branch of Tigris River, **Figure 1**.

The WPP was designed to operate 24 hours per day, with a total capacity output of 240,000 m^3 per day (10,000 m^3 per hour), it provides potable water to five cities in Dhi-Qar governorate south of Iraq: Nassriya, Ad Dawayah, Al-Shatra, Al-Gharraf and Suq Al-Shoyokh. It was built in 2007 [8].

The transmission line is 110 km of piping lines runs two directions, 51 km to the south from the WPP near Al-Shatra to the city of Nassriya, with additional 26 km of pipes to Suq Al Shoyokh; while another northeast transmission line segment of 25 km to Al-Dawayah [8].

Water from the river is screened to remove large objects as it exits the raw intake structure, then it flows by gravity into the raw water pump station and pumped to the rapid mix tanks. Effluent from the rapid mix structure flows by gravity to the flocculate clarifiers for the sedimentation process.

Gaseous chlorine is used for the disinfection and to reduce the risk of disinfection by-products, multiple chlorine injection points are used. The water is chlorinated as it is reached the rapid mix tanks, where alum is added to facilitate the flocculation and coagulation of solids. The effluent is further chlorinated as it flows to the filters which are made of granular media material. The filters remove additional solids, those that did not settle out in the clarifier. After filtration, there is an additional disinfection as water flows to the two 4,000 m^3 capacity for each ground storage tanks, there is a system of six high service pumps with 2,000-m^3/hour capacity for each (one of them serves as a spare) that lift water to the transmission lines [8].

Figure 1. Illustrated overview by Google Earth for Al-Nassriya WPP.

Sampling and Chemical Analysis

Four WPPs were constructed on Al-Gharraf River at Al-Bad'ah area, the fifth is under construction. Al-Nassriya WPP (the largest) was chosen in this study and samples were collected from five locations during April 2015:

1- River (input point). 2- Before sedimentation. 3- After filtration.
4- After chlorination. 5- Output.

Samples were preserved and analyzed according to American Public Health Association [9]. Water electrical conductivity (EC) (uS/cm), and pH were measured *in situ* using a WTW multi-meter model Multi 340i. Turbidity (Tur) (NTU) was determined *in situ* using WTW portable turbidity meter model TURB 355 IR/T.

The following chemical analysis was performed in the laboratories of the Technical Institute of Shatra and the Circulation of Water and Environment, Ministry of Science and Technology, Baghdad by these methods:

Total dissolved solids (TDS) (mg/L) by the temperature controlled oven. Total hardness (TH), Ca^{+2} and Mg^{+2} (mg/L) were measured by EDTA complex metric titration. Na^{+} and K^{+} (mg/L) concentration was measured by flame photometer model M410, UK, and Cl^{-} (mg/L) concentration was measured by silver nitrate titration method. Sulfate (SO_4^{-2}) (mg/L) concentration was determined spectrophotometrically using the barium sulfate turbidity method. Nitrate (NO_3) and phosphate (PO_4) concentrations (mg/L) were measured by cadmium reduction and molybdate-ascorbic acid methods, respectively.

Pb, Cd, Ni, and Zn were measured by Atomic Absorption Spectrophotometer model Phoenix – 986 AAS.

RESULTS AND DISCUSSION

Field observations and engineers who are working in the plant explained that the plant in the time of this study produces only about 144,000 m^3 of potable water per day (6,000 m^3per hour) (60 percent of its designed output). This was due to the: lack of reliable power from the national grid, old distribution system afflicted with leakages. The citizens in the cities of Ad Dawayah and Suq Al-Shoyokh have not accessed to the enough finished water because of illegal taps into the transmission lines and poor distribution systems.

The average of the physical and chemical properties of water samples from Al-Gharraf River and the WPP were given in Table 1 and Table 2.

Turbidity (Tur.)

Comparing the level of turbidity before and after treatment (20 and 3.8 NTU) at the WPP indicates that the efficiency of the filtration units was good and below the Iraqi standards of 5 NTU. Although Turbidity has no health effect it can interfere with disinfection and provide a medium for microbial growth and it may indicate the presence of microbes [10].

Total Dissolved Solids (TDS)

Water can dissolve a wide range of inorganic, some organic minerals, and salts that produce unwanted taste and color. No agreement has been developed on negative or positive effects of water that exceeds the 500 mg/L WHO standard limit. TDS in drinking water comes from sewage and urban industrial wastewater etc. So, TDS test is considered a sign to know the general quality of water [3].

Table 1 clear that in the study area, values were ranges from 515-545 mg/L which are lower than the Iraqi standards and above the WHO limits.

Electrical Conductivity (EC)

When water is pure, it is not a good conductor of electricity and not a good insulator and increase in ions concentration increases the conductivity of water. Therefore, the amount of dissolved solids (ions) determines the electrical conductivity of water [10].

EC value, according to WHO standards should not exceed 400 µS/cm.

In the study areas, EC values were 1010-1015 µS/cm and this clearly indicates that water in the study areas was too ionized and has a high ionic concentration comes from the excessive dissolved solids.

pH of water

The pH of pure water means the measure of hydrogen ions concentration in water which ranges from 0 to 14. Generally, water with a pH of 7 is neutral, lower than 7 is acidic and greater than 7 is basic. Freshwater pH ranges from 6 to 8.5 and water with low pH is tending to be toxic and water with high pH has a bitter taste [2]. According to WHO and Iraqi standards pH of the water should be 6.5 to 8.5. In this study, it ranges from 7.7-8.2. Hence, in the study area the pH values were not exceeded the standard limit, however, these were falling in basic or alkaline range.

Chloride (Cl^-)

It comes from the hydrochloric acid salts as table salt (NaCl) in water and it is important for the metabolism activity and the main physiological processes in human body, it is not of health concern at levels found in drinking water [2].

The high chloride concentration damage water metallic pipes and harms growing plants. According to WHO and Iraqi standards concentration of chloride should not exceed 250 mg/L. In this study, the chloride value ranges from 150-175 mg/L. Thus, all the samples have chloride concentration lower than the standards, **Table2**.

Table 1: Some physic-chemical properties of water samples, Tur. By NTU, EC by µScm and the others by mg/L unit.

	Tur.	pH	EC	TDS	T.H	NO_3^{-1}	SO_4^{-2}	PO_4^{-3}
WHO limits	-	-	400	500	-	50	500	0.1
Iraqi standards	5	6.5-8.5	-	1000	500	10	250	-
Location								
River	20	8.2	1010	545	290	5.9	144	0.08
Before sedimentation	11	8.1	1150	555	285	4.9	131	0.09
After filtration	3.2	7.9	1020	540	290	2.1	120	0.09
After chlorination	3.6	7.7	1030	505	290	2.3	115	0.09
Output	3.8	7.7	1015	515	295	2.3	105	0.09

Table 2: Concentration of, Cl^-, Na^+, K^+, Ca^{+2}, Mg^{+2}, Pb, Zn, Cd, and Ni of water samples in selected sites by mg/L unit.

	Cl^-	Na^+	K^+	Ca^{+2}	Mg^{+2}	Pb	Zn	Cd	Ni
WHO limits	250	200	12	150	-	0.01	3	0.003	0.02
Iraqi standards	250	200	-	50	50	0.01	3	0.003	0.02
Location									
River	175	90	47	77	24	0.0106	0.0388	0.00043	0.0021
Before sedim.	185	100	47	77	25	0.0061	0.0367	0.00041	0.002
After filtration	190	140	31	85	22	0.0101	0.0332	0.00042	0.0031
After chlorination	205	100	35	81	21	0.0084	0.0351	0.00038	0.0021
Output	150	85	25	78	24	0.0092	0.0383	0.00036	0.0024

Sulfate (SO_4)

It is derived from the salts of sulfuric acid (H_2SO_4) found in water bodies. The presence of sulfate in drinking water cause noticeable taste and contribute to the corrosion of distribution systems. No large negative impact of sulfate on health is reported and sulfate concentration in natural water ranges from a few to a several hundred mg/L. The WHO standards are 500 mg/L and the Iraqi standards are 400 mg/L as the highest desirable limit in drinking water. In the study area, the concentration of sulfate ranges from 105-144 mg/L. The results exhibit that concentration of sulfate is within the standard limit and not harmful to human health.

Phosphate (PO_4^{-3})

Phosphate concentrations in samples were from 0.08 to 0.09 mg/L which are within WHO and Iraqi standards. Natural water rarely contains more than 0.1 mg/L PO_4^{-3} unless they have passed through soil containing phosphate or have polluted by organic matter [11].

Magnesium (Mg)

Magnesium is the eighth most abundant element in earth crust and naturally found in the water. It is an essential for the proper physiological functions of living organisms. The human body contains about 25g of Mg [12]. According to WHO standards the permissible range of Mg in water should be 150 mg/L and Iraqi standards is 50 mg/L. In study areas, magnesium ranged from 21-24 mg/L, **Table 2**. Such a low concentration effects health as it is essential for human body.

Calcium (Ca)

Calcium is very important for human cell physiology and it is the fifth most abundant element in the earth crust, about 95% is stored in bones and teeth and an adult requires 1,000 mg/ day to work properly [5].

According to [13], the permissible range in drinking water is 150 mg/L whereas [14] established the limit of 50 mg/L. In the study area, results show that the concentration of calcium is 78 mg/L in finished water which is below the limits of WHO and above the Iraqi standards.

Total Hardness

Hard water has high mineral contents that are not harmful to humans. It is measured as calcium carbonate ($CaCO_3$) [10]. According to WHO and Iraqi standards, total hardness of water should be 500 mg/L. In this study, hardness ranges from 285-295 mg/L. These results show that water hardness is not harmful and it is according to the standards.

Sodium (Na)

Sodium is found in less quantity in water. The Proper quantity of this metallic element in the human body prevents diseases like kidney damages, hypertension, and headache etc. The majority of water supply have less than 20 mg/L while in some others the sodium quantity exceeded from 250 mg/L [15].

According to WHO and Iraqi standards, the concentration of sodium in drinking water is 200 mg/L. In the study area, results show that sodium concentration ranges from 85-140 mg/L which could be not harmful to health.

Potassium (K)

This silvery-white alkali metal is highly reactive with water and necessary for living organism functions. It occurs in drinking water at concentrations well below those of health concern [2].

The permissible limit of potassium according to WHO standards are 12 mg/L. The finding of this study shows that the concentration ranges from 25-47 mg/L.These results meet the WHO standards and may prevent the diseases caused by potassium deficiency.

Nitrate (NO_3)

Nitrate is an important parameter of water quality because it causes the blue baby syndrome in infants. In drinking water, the maximum permissible limit of nitrate allowed is 50 mg/L by WHO as nitrate ion (or 11 mg/L as nitrate-nitrogen) to protect against methemoglobinemia in bottle-fed infants [2]. Maximum contaminant level of NO^{-3} according to WHO [15] is 10 mg/L. Source of nitrate in surface water is runoff from fertilizer use, leaching from septic tanks, sewage, and erosion of natural deposits.

In this study area, results show that the concentration ranges from 2.3-5.9 which indicates that the quantity of nitrate is acceptable and not posing threat to the health of inhabitants.

Heavy Metals

The metals studied were: Zinc which is known as an essential metal for metabolism in organisms, Lead which have no known function in biota, Nickel, and Cadmium which are micronutrients needed in a few organisms [13] [16] [17] [18].

The WHO and Iraqi standards for Pb, Zn, Cd, and Ni are 0.01, 3, 0.003, and 0.02 mg/L respectively. Results showed that the average of Pb, Cd, and Ni in finished water were 0.0092, 0.00036 and 0.0024 mg/L respectively. These values were not higher than the Iraqi and WHO standards, Zn concentration was 0.038 mg/L and it is below the standards, such low concentration effects health as it is essential for human body.

CONCLUSIONS

The WPP units were good but the plant wasn't working in its designed output because of the lack of reliable power from the national grid, old distribution system afflicted with leakages. Most of the parameters analyzed were within the guidelines standards for drinking water while few others were not.

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