Assessment the performance of water treatment plants in Baghdad governorate using GIS

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ABSTRACT

Water is essential to a solid society and feasible growth. Water demand is increasing due to increasing population density, fast urbanization, industrialization, and agriculture. The Tigris River supplies drinking water to nine water treatment plants in Baghdad, therefore monitoring their chemical and physical properties is important. 15 parameters (pH, Tur., TDS, EC, TH, Alk., Ca⁺², Mg⁺², Fe⁺², Cl⁻, SO₄²⁻, NH₃, NO₃⁻, NO₂⁻, PO₄³⁻) from treated water were measured in 2009 and 2019 and compared their values to Iraqi and WHO findings. The results show that the value of turbidity in 2009 at center 8 was 11.2 which is exceeded the allowable limits this is might be absent the coagulation process, as well as the high concentration of the turbidity in the Tigris river at that time, meanwhile the value of alkalinity, was 159.75 (mg/l) in 2019 at center 2. however the remaining results were inside as far as possible.

Keywords: Water treatment, water quality parameters, WHO standards, GIS

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1. Introduction

For the whole human race, water is considered one of the most essential natural resources. The increasing population and economic activity have led to huge demands of water. The decline in surface water supply quantity and quality is due to water contamination and improper water resources management [1]. Water treatment plant studies are handled with every aspect, like physical, chemical & bacteriological of water characteristics, that gives the first indication to assess the water treatment plant and best method to treat the water [2].

Water, the principle constituent of biological system is a valuable public resource and a great normal asset might be as rain water, ground water, surface water (for example streams, lakes, oceans, etc.), and ice sheets. The surface water is the main types of water for human exercises like drinking water, agribusiness, industry, hydropower age and other different areas of the economy. On the planet, perhaps the most essential ecological issue is water quality weakening that came about because of the climatic change and expanded contamination [3]. Developing consideration had been seen during the last a very long time in, water quality evaluation of various streams by dissecting the physicochemical and organic boundaries of water and observing the spatial and fleeting varieties.

The water content can be quantified by some mixture of physical, chemical, and biological properties and measurements. When THESE certain parameters exceed a certain level, they may have adverse consequences on human wellbeing [4][5]. River tributaries can have a direct effect on characteristics physical-chemicals of river due to the discharging huge quantities of domestic and Industrial water without treatment [6]. Climate change, population increase, rising water shortages, demographic shifts, minimal environmental understanding, water and land-use disputes and urbanization put on demonstrate raising water challenges[7].
Remote sensing is the method of collecting photographs and details at a distance, somebody do not have to get in contact. This is done by data processing bodies [8], and then applying them in our everyday life. In this way, it allows numerous technological endeavors to thrive [9].

GIS has many applications on water source and sewage treatment services are identified, Groundwater simulation and hydrology, water and drainage networks and inventories, Flooding modeling, hydraulic modeling for surface layer and settlements in river [10][11]. GIS (Geographic Information System) has various category of such as Mathematical, Spatial, Spatial monitoring. Analyzing spatial trends by Integration of the technology allowed this to be feasible. Databases is another factor which provide the opportunity to evaluate and simulate this model [10].

2. Case study

Tigris Stream is the fundamental wellspring of savoring water Baghdad city, as well as the water of the Tigris Waterway, is using for agricultural and industrial purposes. The Tigris enters north of Bagdad near the Al-Karkh water treatment plant, the length of the stretch of the river is around 65 kilometers [12].

The data of the physical and chemical of the supply water from nine water treatment plant centers have been collected from the Baghdad Mayorlty, Ministries of Health and Water Resources for two years 2009 and 2019. These data reflect the composite monthly values of 15 indicators in figure 1. The satellite image of Baghdad is taken from the Landsat 8 satellite on 2/12/2019.

Table 1. shows the name and coordinate of the water treatment plants centers

| Centers | Names       | X       | Y       | Elevation (m.a.s.l.) |
|---------|-------------|---------|---------|---------------------|
| S1      | Al-Karkh    | 438563.6| 3718466 | 32                  |
| S2      | East Tigris | 439014  | 3697737 | 30.12               |
| S3      | Al-Sader    | 437899  | 3694420 | 29.71               |
| S4      | Al-Karama   | 440037.2| 3691317.8| 29                 |
| S5      | Al-Wathba   | 441611  | 3690418 | 28.36               |
| S6      | Al-Qadisiyah| 441483.4| 3682765.8| 27.65              |
| S7      | Al-Dora     | 442461.8| 3680584.3| 27                 |
| S8      | Al-Wahda    | 448222.5| 3683676 | 26.1                |
| S9      | Al-Rashed   | 449174.6| 3683082.8| 26                 |

Figure 1. The audit area map for the centers along the Tigris Stream in Baghdad city (Source: Landsat 8)
3. Results and discussion

**Hydrogen Ion Concentration (pH):** For 2009, the most extreme pH value was recorded at 7.67, while the base value was 7.39. In 2019, the most extreme pH was recorded at 7.79, while the base value of pH was 7.25. For the two years, pH estimates were within the suitable principles as shown in figure 2.

![Spatial distribution of pH](image)

**Turbidity (Tur.):** The maximum concentration of turbidity in 2009 was 11.7 NTU at center 8, exceeding the allowable standards. The minimum value was 1.48 NTU at center 3. In 2019, the maximum value of turbidity was 3.15 NTU at center 2, and the base value was 1.17 NTU at center 3, both values within the allowable standards as shown in figure.

![Spatial distribution of Turbidity](image)
Figure 3. Spatial distribution of turbidity

**Total solids (TD):** the maximum concentration of total solid in 2009 was 593.24 (mg/l) at center 9 and smaller worth was 423.08 at center 1. In 2019 the most extreme worth was 610 (mg/l) at center 3 and smaller worth was 455.18(mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.

Figure 4: Spatial distribution of total dissolved solids

**Electrical Conductivity (EC):** the maximum concentration of Electrical Conductivity in 2009 was 886.33 μS/cm at center 9 and minimum value was 657 μS/cm at center 1. In 2019 the maximum value was 882.89 μS/cm at center 3 and minimum value was 455.18(mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.
**Figure 5: Spatial distribution of electrical conductivity**

**Total Hardness (TH):** the greatest convergence of all out hardness in 2009 was 334.25 (mg/l) at center 4 and smaller worth was 256.22 (mg/l) at center 3. In 2019 the greatest worth was 326.91 (mg/l) at center 2 and smaller worth was 289.3 (mg/l) at center 1. For the two years the qualities were inside as far as possible as displayed in figure.

**Figure 6: Spatial distribution of total hardness**

**Total Alkalinity (Alk.):** the most extreme centralization of all out Alkalinity in 2009 was 144.75 (mg/l) at center 6 and smaller worth was 125.25 (mg/l) at center 1 the qualities were inside as far as
possible. In 2019 the most extreme worth was 159.75 (mg/l) at center 2 this worth somewhat surpass as far as possible, and smaller worth was 130.64 (mg/l) at center 1, as displayed in figure.

**Figure 7. Spatial Distribution of total alkalinity**

**Calcium (Ca**\(^{2+}\)**): the maximum concentration of Calcium in 2009 was 87.03 (mg/l) at center 4 and smaller worth was 63.78 (mg/l) at center 3. In 2019 the most extreme worth was 89.36 (mg/l) at center 9 and smaller worth was 66.18 (mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.

**Figure 8. Spatial distribution of calcium**

**Magnesium (Mg**\(^{2+}\)**): the maximum concentration of magnesium in 2009 was 33.17 (mg/l) at center 6 and minimum value was 23.44 (mg/l) at center 3. In 2019 the maximum value was 32.3 (mg/l) at
center 3 and minimum value was 21.18 (mg/l) at center 9. For the two years the values were within the allowable limits as shown in figure.

Figure 9. Spatial distribution of magnesium

Iron (Fe^{2+}): the maximum concentration of iron in 2009 was 0.23 (mg/l) at center 8 and smaller worth was 0.04 (mg/l) at center 7. In 2019 the greatest worth was 0.18 (mg/l) at center 5 and smaller worth was 0.04 (mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.

Figure 10. Spatial distribution of iron
Chloride ($\text{Cl}^{-}$): the maximum concentration of chloride in 2009 was 72.5 (mg/l) at center 9 and smaller worth was 45.7 (mg/l) at center 1. In 2019 the greatest worth was 70.5 (mg/l) at center 5 and smaller worth was 45 (mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.

![Figure 11. Spatial distribution of chloride](image1)

Sulfate ($\text{SO}_4^{2-}$): the maximum concentration of sulfate in 2009 was 224.75 (mg/l) at center 4 and smaller worth was 131.67 (mg/l) at center 1. In 2019 the greatest worth was 222.36 (mg/l) at center 6 and smaller worth was 124 (mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.

![Figure 12. Spatial distribution of sulfate](image2)
Ammonia (NH₃): the maximum concentration of ammonia in 2009 was 0.02 (mg/l) at center 4 and smaller was 0.01 (mg/l) at center 2. In 2019 the most extreme was 0.065 (mg/l) at center 8 and smaller was 0.01 (mg/l) at center 1. For the two years the values were within the allowable limits as shown in figure.

Nitrate (NO₃): the most extreme convergence of nitrate in 2009 was 0.90 (mg/l) at center 4 and smaller was 0.72 (mg/l) at center 5. In 2019 the best was 1.46 (mg/l) at center 7 and smaller was 0.65 (mg/l) at center 3. For the two years the qualities were inside as far as possible as displayed in figure.
Nitrite (NO$_2^-$): the maximum concentration of nitrite in 2009 was 0.003 (mg/l) at center 9 and minimum value was 0.001 (mg/l) at centers 1, 2 and 3. In 2019 the maximum value was 0.005 (mg/l) at centers 8 and 9 and minimum value was 0.001 (mg/l) at centers 1, 3, 4, 5 and 7. For the two years the values were within the allowable limits as shown in figure.

Phosphate (PO$_4^{3-}$): the maximum concentration of phosphate in 2009 was 0.067 (mg/l) at center 7 and smaller worth was 0.01 (mg/l) at center 2. In 2019 the greatest worth was 0.08 (mg/l) at center 8 and smaller worth was 0.01 (mg/l) at centers 2, 3 and 4. For the two years the values were within the allowable limits as shown in figure.
4. Conclusion

In this study Evaluation has been made by using the spatial distribution of GIS for fifteen physical and chemical parameters of nine water treatment plants in Baghdad take their water from Tigris River in the two years 2009 and 2019 and compare their results with WHO standards These parameters are (‘pH’, ‘Tur’, ‘TDS’, ‘EC’, ‘TH’, ‘Alk’, ‘Ca+2’, ‘Mg+2’, ‘Fe+2’, ‘Cl’-, ‘SO4’-2, ‘NH3’, ‘NO3’-, ‘NO2’-, ‘PO4’-3). The value of turbidity in 2009 at center 8 was 11.2 which is exceeded the allowable limits this is might be absent the coagulation process, as well as the high concentration of the turbidity in the Tigris river at that time, meanwhile the value of alkalinity, was 159.75(mg/l) in 2019 at center 2. however, the remaining results were within the allowable limits.

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