Effect of Wasit Thermal Power Plant on Water Quality of Tigris River Downstream to Al Zubaidiyah City

Hiba Alaa1 and Ali Jwied Jaeel2

1 Civil Engineering Department, M.Sc. Student, University of Wasit, Iraq. Email: hibaaalaa340@gmail.com
2 Civil Engineering Department, PhD, University of Wasit, Iraq. Email: alijwaid@uowasit.edu.iq

Abstract. This study was directed at Wasit Thermal Power Plant (WTPP) to determine the water quality status. Nine sampling stations established along the reach of Tigris River, the first station was 500m upstream (US) to WTPP and it was a reference station, the second station at WTPP and seven stations downstream (DS) to WTPP for collection of water samples. Water samples were prepared for their physico-chemical characteristics at all sampling stations were compared with the reference station. Sampling of all stations (downstream to WTPP) showed higher water pH, total dissolved solids (TDS), electrical conductivity, and chemical oxygen demand (COD) than that of sampling station upstream to WTPP and lower water dissolved oxygen (DO). The results showed increasing of pH, TDS, EC, and COD by 68%, 166%, 60% and 478% respectively, and decreasing the value of DO by 66% indicated that discharge from WTPP increased pollution load in river Tigris.

1. Introduction

Water is a basic and primary need for all vital life processes, and it has now been established that life first arose in the aquatic environment. Since prehistoric times, man has been closely linked to water, and the evidence of the earlier civilization that developed all historical human settlements on inland water resources has proved conclusively, according to the World Water Commission in the twenty-first century, more than half of the world's major rivers are so depleted and contaminated that they endanger human health and toxins surrounding ecosystems. When exhaust water finds its way into any water body that pollutes water, water pollution is primarily related to household and industrial waste. Both types of wastewater pose threats to water quality that can be classified as health risks and health hazards. Many freshwater resources are polluted through human activities. Some 25,000 people (in developing countries) are said to die every day because of their daily use of sewage. Many more millions suffer from recurrent and devastating water-borne diseases, [1]. About half of people living in developing countries do not have access to safe drinking water and 73% do not have sanitation facilities. Some of their waste eventually pollutes drinking water supply, resulting in high levels of suffering. Any human use of water, whether for drinking, irrigation, industrial processes or recreation, has some quality requirements to make it acceptable. This quality standard can be described in terms of the physical, chemical and biological properties of such water [2]. In many places, surface and underground water is exposed to industrial, agricultural and municipal waste. Water is contaminated with organic and inorganic chemicals as it passes through urban settlements, agricultural land and industries. It has been a common practice around the world for waste disposal in streams / rivers. Organic matter disposed of in the river dissolved oxygen is used in water through its aerobic decomposition. DO low levels may
interfere with water uses for a variety of purposes. Water pollution is the contamination of water by natural and foreign matter such as microorganisms, chemicals, industrial wastes or other waste or sewage in quantities that are likely to cause damage to living organism. The US Environmental Protection Agency (EPA) identifies pollution due to the presence of undesirable substances that cause its chemical composition, quantity, inhibiting or obstructing natural processes, and causing undesirable environmental and health effects. Water pollution not only effects on water quality but also it threatens human health, economic development and social prosperity so that it considered as environmental problem that requires an effective and quick solution [3]. Furthermore, assessment of water quality by using accurate techniques such as Water Quality Index (WQI) to estimate the status of water and maps by GIS to represent the spatial distribution of parameters have become an important experimental and practical. Water quality studies have focused on situations where serious pollution problems arise, particularly in densely populated urban areas. For example, the city of Baghdad is populated and produces a large amount of wastewater from different sources disposed of directly in the Tigris River or after treatment. In the past few years, the increase in wastewater discharged directly into the river by pumping stations has caused the storm sewage network to increase pollution levels in the river water [4]. Most of the potential negative environmental impacts of recycled water use in the environment come from the origin of recycled water as liquid water. These impacts include other water resources and potential pollution of surface and groundwater sources. Public health risks and other environmental impacts that may directly or indirectly affect the public. Fortunately, no significant adverse effects have occurred. It is important that all public water systems serve the water with the best possible quality for their customers [5]. Tigris is an important river of the central part of Iraq supplies water to a large command area of Wasit province. Ali 1978 [6] concluded that Tigris River in Baghdad area is highly polluted comparing with Euphrates and Abu- Graib stream. Al-Masri and Ali 1985 [7] confirmed that discharging treated and untreated wastewater into river limited the use of water for different uses as it flows downstream. For evaluating water quality parameters Al-Masri and Ali 1985 [7] were studied some water parameters such as: sulfate, Alkalinity, chloride, calcium, hardness, and magnesium in Tigris River through Baghdad city. Ghadban 1993 [8], concluded that after the war on Iraq in 1991, most water intakes of treatment plants, were heavily polluted by sewage discharges causing ecological damage and public health hazards. Abd-Ali 1993 [1], also concluded that war on Iraq in 1991, affected the bacteriological quality of the Tigris river in Baghdad especially down river at Dora site, as a result of discharging the material sewage to the river. In Wasit Governorate (central Iraq), the Tigris River is facing the impact of conservative pollution due to the continuous discharge of domestic wastewater during the current construction phase (2010-2016) for Wasit Thermal Power Plant (WTPP). The present study aims to study the impact of contaminated industrial wastewater from this plant directly in the river on water quality during the operation period from September 2018 to March 2019.

2. Experimental Works

2.1. Wasit Thermal Power Plant (WTPP)

Wasit Thermal Power Station (WTPP) is located in Wasit Governorate. The station is 120 km southeast of Baghdad as shown in figure 1. The source of water upon which the project is the Tigris River, which is located on the right bank of the river about 100 meters from the project power station is one of the projects that have significant environmental impacts on the region began to work the first unit of this station in 2012 and a production capacity of 3301 MW and the station AL Zubaydiyah one of the largest electrical stations in Iraq, where the site was selected on the right side of the Tigris River area (800) and in 2015 the total units 6 units card output of 2550 MW The station works with natural gas, crude oil and heavy fuel [9].
2.2. Wastewater sampling
Prior to sampling, first, the sampling stations were established on the water resource map in Wasit. Sampling stations were selected in the study area at a distance slightly equal to each other. Second, the GPS receiver (Garmin 62S) was used to identify each station and take the station coordinates in the study area to collect water samples as shown in table 1. Water samples were collected in the morning between 9 am and 10 am. The samples were collected using the Grab method according to the [10]; samples were collected in 2 liters’ plastic bottles and stored in an ice box of 4°C and transferred to the laboratory within twenty-four hours for analysis. Water samples were collected by lowering the plastic bottles before cleaning them at the bottom of the water body, and a depth of 30 cm, allowed for excessive flow before pulling out. Ten sampling and sampling points were used 500 meters from each other. The first station was up stream of 500 meters; the second was at the drainage point (WTPP point source). The third location was to the eighth sites at 500m, 1000m, 1500m, 2000m, 2500m, 3000m downstream. The study was conducted within six months.

Table 1. Samples location.

| Distance (Km) | Station (#) | Longitude  | Latitude  |
|---------------|-------------|------------|-----------|
| -500          | 1           | 45.08803   | 32.78939  |
| 0 (WTPP)      | 2           | 45.0876    | 32.77943  |
| 500           | 3           | 45.09476   | 32.77386  |
| 1000          | 4           | 45.10042   | 32.77261  |
| 1500          | 5           | 45.10546   | 32.77105  |
| 2000          | 6           | 45.10942   | 32.7695   |
| 2500          | 7           | 45.11427   | 32.76878  |
| 3000          | 8           | 45.11899   | 32.76915  |
| 3500          | 9           | 45.1291    | 32.77269  |

2.3. Experimental Works
For each collected sample, the following parameters as shown in (table 2) were investigated.
Table 2. Physical-chemical parameters analyzed to assess water quality of Tigris River

| Parameter                        | Symbol | Unit      | Method            |
|----------------------------------|--------|-----------|-------------------|
| Acidity function                 | pH     | -         | pH-meter          |
| Dissolved Oxygen                 | DO     | mg/l      | Winkler’s Method  |
| Total Dissolved Solid            | TDS    | mg/l      | Filtration papers |
| Electrical Conductivity          | EC     | µs/cm     | EC-meter          |
| Chemical Oxygen Demand           | COD    | mg/l      | SpectroDirect     |

2.3.1. Acidity Function (pH)
pH is a crucial issue that affects the survival of aquatic organisms, solubility and toxicity of the many metals within the waters. The acidity of waters will increase the solubility of the many metals that cause adverse effects on aquatic organisms. pH was measured with the help of a pH meter. Decreasing pH scale price throughout heat months is also due to elevation of temperature and water temperature due to increase the biological activity of microorganisms and rise the amount of CO$_2$ in the water, whereas augmented level of pH scale throughout cold months is also due to increase the density of plant and augmented level of dissolved oxygen within the water and consumption of CO$_2$ that cause elevating the pH scale.

2.3.2. Dissolved Oxygen (DO)
Dissolved oxygen level of the samples was measured with the D.O meter. The electrode was dipped into each sample, after it had been rinsed, then readings were taken and the description was given in [11].

2.3.3. Total Dissolved Solids (TDS)
The amount of solids that pass through the filter paper when filtering a certain volume of water is the total dissolved solids, so TDS can be measured as a concentration (mg/l). Total soluble solids consist of inorganic salts (calcium, magnesium, sodium, chloride, and potassium) and small amounts of organic substances dissolved in water. Total soluble solids in drinking water come from natural sources, sewage and runoff to rural and urban areas. The high dissolved solids are considered to be unpalatable to the consumer so 500 mg / l can be acceptable. But more than its, it becomes less palatability, especially for drinking purposes and less dependent on some industries. Concentration of dissolved solids greater than 1200 mg / L causes taste and salinity. TDS test by filtration followed by oven drying 200 ml (V) of sample was filtered by filter paper to separate the suspended solid, then the beaker was weighted (A) and filled by the filtered sample. The sample was dried in the oven at 105°C for 5 hours, the beaker with the dissolved solid was weighted again (B), then TDS was calculated by:

$$TDS = \frac{(B-A)}{V}$$

A=weight of beaker filled by filtered sample, (mg).
B= weight of beaker with the dissolved solid, (mg).
V= volume of sample (L)

2.3.4. Electrical Conductivity (EC)
The solution’s capacity to carry an electrical charge is called electrical conductivity. This capacity influenced by the presence of ions, their total concentration, mobility, valence, and liquid’s temperature. Conductivity measurement is very important for identifying certain water properties such as alkalinity, total dissolved solids, hardness and salinity. It is important to note that there is a reciprocal relationship between conductivity and temperature, where the conductivity increases with increasing temperature. The conductivity is the opposite of the electrical resistance. Most inorganic acids, inorganic bases and
inorganic salts have a very good conductivity in their solutions. When the water is ongoing to be purer, its conductivity will be decreased.

2.3.5. Chemical Oxygen Demand (COD)
In environmental chemistry, the chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per liter (mg/l). A COD test can be used to easily quantify the amount of organics in water. The most common application of COD is in quantifying the amount of oxidizable pollutants found in wastewater. COD is useful in terms of water quality by providing a metric to determine the effect an effluent will have on the receiving body. The test was done using SpectroDirect which is a modern single-beam spectrophotometer with an excellent performance that is specifically designed for water and wastewater testing. The instrument is equipped with a wide range of pre-programmed methods based on the proven range of Lovibond® tube tests, liquid reagents.

3. Results and Discussion

3.1. Impact of WTPP on pH value
As shown in figure 2 the pH value of water was within the standard and acceptable value of river water at station #1 (500m before WTPP), then after that at the mixing point (station #2 at WTPP) which is considered the point source of pollution, the value of pH jumped to 10.6 yielding increasing about 68% from original normal value (7.2) before reaching WTPP. The obtained result indicated the notable impact of this power plant on the water quality of the river concerning this important parameter.

3.2. Impact of WTPP on DO concentrations
As shown in figure 3 the DO concentration (7.5 mg/l) of water was within the standard and acceptable value of river water at station #1 (500m before WTPP), then after that at the mixing point source of pollution, the value of DO lowered to its minimum value 2.55 mg/l yielding decreasing about 66% from original normal value (7.5 mg/l) before reaching WTPP. The obtained result indicated the notable impact of this power plant on the water quality of the river concerning dissolved oxygen parameter.

3.3. Impact of WTPP on TDS concentrations
As shown in figure 4 the TDS concentration (750 mg/l) of water was at station #1 (500m before WTPP), then after that at the mixing point source of pollution, the value of TDS increased to a maximum value of 2000 mg/l yielding decreasing about 166% from original normal value (750 mg/l) before reaching WTPP. The obtained result indicated the notable impact of this power plant on the water quality of the river concerning total dissolved solids.

3.4. Impact of WTPP on EC values
As shown in figure 5 the EC values (1500 µs/cm) of water was at station #1 (500m before WTPP), then after that at the mixing point source of pollution, the value of EC increased to 2410 µs/cm yielding increasing about 60% from original normal value (1500 µs/cm) before reaching WTPP. The obtained result indicated the notable impact of this power plant on the water quality of the river concerning electrical conductivity.

3.5. Impact of WTPP on COD concentrations
As shown in figure 6 the COD concentration (55 mg/l) of water was within the standard and acceptable value of river water at station #1 (500m before WTPP), then after that at the mixing point source of pollution, the value of COD increased to its maximum value 318 mg/l yielding increasing about 4.78 times its original normal value (55 mg/l) before reaching WTPP. The obtained result indicated the notable impact of this power plant on the water quality of the river concerning dissolved oxygen parameter.
**Figure 2.** Impact of WTPP on pH values

**Figure 3.** Impact of WTPP on DO concentrations

**Figure 4.** Impact of WTPP on TDS values
4. Conclusions

Tigris is an important river in Iraq it provides water to a huge land of Wasit province. The present study was intended to assess of water quality and so that an evaluation of pollution masses on the river just close to its origin. The study imparted that the water quality is deficient and contaminants of both organic and inorganic origin are coming into the river, thereby spoiling its water quality. The high concentrations of pH, TDS, EC, and COD are due to high concentration of organic and inorganic matter in the industrial wastewater flowing from the WTPP. The high concentration of TDS generates high concentration of dissolved inorganic solids. Also the discharged water from WTPP has a very low dissolved oxygen and that makes an adverse effect on the dissolved oxygen of water in the river at the mixing point and downstream of WTPP. The severely pollution of water of Tigris river has rendered its water unfit for human consumption especially there are many villages downstream about 1km away from the project. Advanced treatment of industrial wastewater before drain in the river is the lone aims by which the problematic of water pollution could be diminished. During the present investigation, the water quality of Tigris river in the upstream of WTPP was observed quite well in comparison to downstream of the river, which was found to be highly polluted due to discharge of industrial wastewater through surface drains.
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