Environmental monitoring of the Shatt Al-Diwaniyah River water quality using GSM wireless remote sensing technology (WSN)

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Abstract. This study used wireless remote sensing (WSN) technology to monitor river water in the city of Diwaniyah (Iraq). This technique helps to monitor the water quality of the river using the sensors submerged in water to conserve water resources within a specified standard for local use and the ability to take the necessary measures to restore the health of the body. The eight-month study period included four stations in the Shatt al-Diwaniyah River. Eight environmental factors were observed: water temperature, (pH), electrical conductivity (EC), Total dissolved solids (TDS), Turbidity, dissolved oxygen (DO), light penetration and chlorophyll a through wireless sensors. The results of the present study showed that the characteristics of the water quality of the Shatt al-Diwaniyah River were compatible with Iraqi drinking water standards except turbidity and electrical conductivity. The results showed that wireless remote sensing technology in river water monitoring can be considered as an alternative to the traditional manual method used by specialists to monitor river water as a means of shortening effort and time as well as continuous and constant monitoring systems.

Key Words: Wireless sensor networks, environmental monitoring, water quality, Diwaniyah, river

1. Introduction

Water monitoring programs play a critical role in various water uses, such as studying aquatic life, watering livestock, human use, irrigation, recreation, etc. Clean water sources are useful not only for ecosystems and natural habitats but also for public health [1]. The Shatt al-Diwaniyah river has received many studies that dealt with the measurement of factors related to the quality of water traditionally, which was the defect is not to give a visual picture of the nature of water in the stations studied as well as requiring the taking of samples to the laboratory and require the presence of people specializing in physical and chemical analysis[2]. Water quality assessment is a key link in the management and monitoring of water quality only by monitoring water quality in a reasonable time and targeting the planning and management of the aquatic environment. With regard to water quality assessment, traditional methods such as water sampling Analysis of indicators and grade assessment can only provide water quality status at the point of sampling instead of large areas of water, while extensive field sampling will consume a great deal of manpower, materials and water resources [3,4].

Recently with the rapid development of remote sensing techniques, a growing number of researchers have been conducting rapid, continuous and dynamic water monitoring through remote sensing technology. Moreover, this technique has been adopted by many scientists in water quality assessment [5]. Remote sensing techniques offer quick and realistic information on water quality variables that include physical, biological and biochemical properties. WSN technology also offers a greater
opportunity to develop systems that will help monitor water quality and sanitation in order to determine the quality of water by examining the properties of water first and then matching the features in the water with numerical standards to see if the water quality is appropriate or inappropriate for a specific use [6]. The present study aimed to know the values of some important variables in the Shatt al-Diwaniyah River using the wireless sensor network (WSN).

2. Materials and methods:

During the current study, four stations were selected, including wireless sensors to monitor the quality of river water in the city of Diwaniyah, where the first station was north of the city of Diwaniyah within the water purification plant of Diwaniyah project (No. 6) for drinking water (N=31°96'27.5":E=44°94'81.6""). The second station was in the housing complexes for drinking water (N=31°94'82.1": E=44°96'94.8") while the third station was to the South of the city of Diwaniyah near the sewerage station (N=31°72'92.2":E=44°96'80.8") . The fourth station was in the district of Al-Hamzah within the water project of Al-Mansour (N=32°05'18.89":E=44°77'55.28") (figure 1).

![Figure 1. Location of samples in Shatt al-Diwaniyah river (Diwaniyah Environment Directorate / Geographic Information Systems Division)](image)

The wireless sensor was characterized by the fact that the source of energy supplied by the solar panels, where the sensors to monitor the quality of water used in the study are the YSI multi-parameter wireless sensor sonde model 6600V2-S and the system switch circuit data and using communication technology Global System for Mobile communications (GSM).

Eight environmental factors were observed during the study: water temperature, pH, Total suspended solids (TDS), conductivity (E.C), dissolved oxygen (D.O), light penetration, turbidity, and Chlorophyll a. The monthly rate of readings from the monitored stations was taken within 8 months of the study (figure 2). The wireless sensor system consists of the following parts [7]:

**Sensor:**

It is a device that detects and responds to some types of physical changes that occur in the environment to be sensed. These changes may be temperature, acidity, salinity, and other sensors where the signal response is displayed at the sensor station or the signal is transmitted through the networks and displayed on the device Computer. Sensors are usually made up of two types [6]:

- Optical
- ISE is the selection of ions that are consistent with the chemical.
Sonde:
It represents the device to which all the connections are connected to the different sensor types. This part represents the core of the project. The Sonde receives the difference of voltage and wavelength reflected from each connection and converts it to digital data with Timestamp for each read time and date of reading and storing it until called by Datalogger or Third party such as a calculator. In the case of conductivity, it reads and analyzes the voltage of the sensor and converts it to the units of μs / cm, the unit of electrical conductivity measurement.

Datalogger:
This device is considered as the brain for the wireless sensor system. It receives the digital data from the Sonde and stores it in its internal memory in the form of tables in addition to receiving many readings from several other exits such as the temperature of the cab, humidity, and voltages installed on the machines and stores the error messages and events that appear during the periods of work. In addition, Datalogger instructs all connected devices to take readings every quarter of an hour (15 minutes) and has a large memory to store readings all the time.

Modem:
The modem is device used to transfer the signal from the station where the subsystems (sensors) to any other station and works in the form of the slide of the mobile after the activation of the service (CDS) (Circuit Switch Data) data system this service exists in all communications companies and any location where the mobile network where. The data is transmitted in ASCII format and the type of modem used is Sierra wireless.

Statistical analysis: Least significant difference (LSD) were applied for data analysis by using Statistical Package for the Social Science (SPSS).

Results and Discussion:
The results showed that the temperature recorded the highest value of 31.9°C, which was recorded in June at the fourth station, while lowest in the temperature was January 11°C at the first station (figure 3). This is due to the climate of Iraq is characterized by large differences in temperature because of seasonality impact on the results of the current study which showed clear monthly fluctuations in temperature [8]. The electrical conductivity recorded the highest
value in August, with 2033 μS/cm for the fourth station, whereas 850.3 μS/cm in February at the first station (figure 4). The electrical conductivity has been increased as we move south, particularly in the hot months, due to the salinity of the soils which are becoming saltier as we move south, as well as the addition of a river of residues [9]. Resulting from precipitation with increased flow velocity and thus mitigation of concentration [10], The high results in the electrical conductivity values recorded in the study exceeded the Iraqi standards of drinking water, 2000 μS/cm [11]. The results of the TDS show highest value in June at the fourth station was 833 mg/l and the value of 512 mg/l in March for the first station (figure 5). The increment in the values of TDS in the winter months may be due to the rainy season in the study area as the rainfall in crowded cities and industrial areas cause high pollution in the atmosphere and these pollutants melt in the rainwater and up to rivers, which lead to increased total dissolve solids in water [12].

The highest value of pH was recorded the 8.3 in August at the third station while the lowest value was 6.07 in February at the fourth station, (figure 6). It was noted that the increase of pH values in summer accompanied by high temperatures that lead to evaporation of water and concentration of salts [13]. The results of dissolved oxygen in water showed the highest increase in the second station, 10.3 mg /l in February, while the third station recorded the lowest value 2.06 in July, (figure 7). This is because of the rise. The dissolved oxygen in the winter may be due to lower temperatures and increased solubility of gases with good water ventilation and increased water levels [14]. The highest value of light penetration in river was 2.12 m at the first station in January while the lowest value was 0.29 m at the second station in August (figure 8). The increase in light permeability in winter may be correlated with increasing water levels and the low numbers of phytoplankton and the low turbidity [15], but the decline in the summer may be due to increase turbidity and the abundance of outstanding materials as well as the presence of planktons [16]. As for the turbidity, the highest value was recorded in July, reaching 50.2 NTU at the third station, and the lowest in January of the first station was 3.2 NTU (figure 9). The turbidity of the third station is due to the large quantity of sewage. It contains a large amount of organic and inorganic materials, soil dust, sand and microorganisms may increase turbidity as the turbidity may increase due to the presence of many substances that are either already present in the river or dumped from the outside [17]. In the current study, high values of turbidity have surpassed the Iraqi standards 5-25NTU[11].While the values of chlorophyll recorded the highest value in April for the third station as it was 21.2 mg / l, whereas the lowest value of chlorophyll was 1.06 mg / l in the first station in January (figure 10) as the increase of chlorophyll in water in Spring may be after rainfall due to nutrient drift. Chlorophyll may increase when light and heat increase or it decreases due to diatoms dominance compared with other algal aggregates [18].
Figure 3. Monthly variations of water temperature in the study stations

Figure 4. Monthly variations of the electrical conductivity rates at the study stations

Figure 5. Monthly variations of the total dissolved solids at the study stations
**Figure 5.** Monthly variations of Total dissolved solids rates at study stations

**Figure 6.** Monthly variations of pH rates at the study stations.

**Figure 7.** Monthly variations of dissolved oxygen rates (mg/l) at study stations.
Figure 8. Monthly variations of light penetration at study stations.

Figure 9. Monthly variations of Turbidity values in the study stations.
Conclusions:
The importance of clean and safe water makes monitoring water quality an important issue. Because the current water quality control procedures in Iraq are manual, costly and time-consuming, the study used a remote sensing system for water quality using the Wireless Sensor Network (WSN) by sending ASCII data to the GSM monitoring center where the system can monitor Water temperature, pH, total suspended solids (TDS), conductivity (EC), dissolved oxygen (DO), light penetration, turbidity and chlorophyll a. This technology is a great choice for use in the monitoring system being low cost and easy to use and consumes little energy as such the data received from the remote sensing contract can be stored in the form of graphs or spreadsheets or can be considered as a value for the parameters specified in real time and thus provides complete coverage and full understanding of the observing ecosystem.

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