

Real-Time Water Quality Monitoring System- Analysis Of Pashan Lake, Maharashtra, India

Sujaya Das Gupta, M.S.Zambare, N.M.Kulkarni, A.D.Shaligram



Abstract: Pashan Lake in Pune, Maharashtra, India is one of the ancient man-made lakes constructed during British era majorly as a source of water supply for the neighboring colony. Over a while, the lake has witnessed severe degradation of water quality owing to heavy deforestation on neighboring hills, hyacinth formation, industrial effluents, and various anthropogenic activities. A consistent rise in pollution is reported, making the lake water non-potable. Recently, the monitoring and analysis of the lake's water quality status are under consideration to check the suitability of water for drinking. Further, this can aid in planning suitable measures to reduce pollution levels. To address such need of real-time water quality data aforementioned, this paper proposes an online portable water quality monitoring and notification system. An Internet of things(IoT) based platform has been developed with the ability to sense, record, process and wirelessly transmit water quality data. Such platforms enable remote access to data about quality status of any water resource. Further, the developed system has been deployed in Pashan Lake and the results so obtained have been discussed.

Keywords: Real-time water quality monitoring; Internet of Things (IoT); Pashan Lake

I. INTRODUCTION

Pashan Lake (location as on Google maps as shown in Fig.1 between 18°32'05"N and 73°47'13"E), one of the main lake of Pune city, is one of the oldest artificial lake built in British era for water storage. The source of water for Pashan Lake is small rivulet Ram-Nadi originating in Bavdhan and flowing through the Pune city and finally meeting Mula River. The total catchment area of Pashan Lake is about 40 square kilometers. The lake once upon a time was one of the desirable visiting places for migratory birds and contained various types of fishes.



Figure 1. Pashan lake location [courtesy-Google Maps]

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Rapid deforestation and road construction caused lake silting due to erosion thereby, resulted in a decline in the depth of the lake which further decreased the population of birds and fishes. Moreover, pollution is attributed to the various anthropogenic activities and formation of water hyacinth, resulting in severe degradation of the lake's water quality [1].

A recent report Environmental Status Report (ESR) by the Pune Municipal Corporation has revealed that despite all the earlier efforts taken by them towards lake restoration, the continuous water quality degradation persists with lower levels of dissolved oxygen, higher levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD) [2].

Therefore, to understand the pollutant levels and devising solutions to lessen the pollution, continuous monitoring of water quality parameters is required. In this project, it was proposed to design and develop an online water quality monitoring system for the study of various Physico-chemical water quality parameters like pH, temperature, electrical conductivity, dissolved oxygen of the lake. Further, provision is made in the system to upload the real-time measured data to a cloud server which can allow data access and analysis.

II. EARLIER WORK

State government agencies like Pune Municipal Corporation, Maharashtra Pollution Control Board and research groups from different organizations have studied and analyzed the water quality of Pashan Lake to assess its fitness for human consumption.

According to Environment Status Report (ESR), 2016-2017 published by Pune Municipal Corporation indicate a consistent rise in the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels of Pashan Lake. BOD and COD are considered as measures of organic matter contamination and chemical matter contamination in water bodies respectively. Low BOD and COD values indicate good water quality. It is mentioned in the report that since March 2016 to Feb 2017, BOD of the lake is found to rise from 13mg/l to 18mg/l and COD increased from 42.50mg/l to 58 mg/l. Fluctuation in DO level is observed to be 6.10 mg/l in 2011 and 5.40 mg/l in 2016 [2].

The Physico-chemical characteristics study of lakes in Pune city conducted by various researchers from different organizations revealed the water quality degradation of different lakes like Katraj lake, Pashan lake and highlighted the necessity of restoration of these lakes for achieving water potability to combat the current water scarcity in the city scenario and enriching the aquatic life [1],[9].

Nirbhay et al. suggested that if the anthropological activities like washing of animals, clothes, etc. and wastewater disposal into Pashan lake causing a rise in the concentrations of dissolved solids, can be regulated, it can be considered for drinking post-treatment [4]. Each of the research work aforementioned used traditional sample collection and lab testing methods. Moreover, the commercially available multi-parameter in-situ online water quality measurement systems are very expensive and not easily accessible. Our project takes note of all such problems enabling remote wireless access to sensor data.

III. SOME OF THE BASIC WATER QUALITY PARAMETERS AND THEIR IMPORTANCE

A. Temperature

Water temperature has a significant effect on its various physical, chemical and biological processes, which in turn alters the concentration of substances in the water sources. Increase in temperature accelerates the rate of evaporation and chemical reactions of water bodies, also increasing the solubility of gases like O₂, CO₂, and also turbidity leading to the growth of micro-organisms, algal blooms.

B. pH

It is defined as "A negative logarithm of the hydrogen ion activity in a solution and indicates the degree of acidity or alkalinity of the solution". It plays a vital role in various chemical and biological reactions. pH value varies from 0-14. Pure water with a pH of about 7 is considered neutral whereas that having pH value less than 7 is acidic and those with pH more than 7 is alkaline. Low pH values (less than 6) leads to pipe corrosion whereas high pH causes scale formation in water heating apparatus, also reducing the germicidal potential of chlorine and affects the taste. For various industrial applications, neutral to slightly alkaline water is recommended.

C. Conductivity

It is "A measure of the ability of water to conduct an electric current. Conductivity in water is affected by the presence of inorganic dissolved solids (metals, salts, etc.) such as chloride, nitrate, sulphate and phosphate anions or sodium, magnesium, calcium and iron cations". Conductivity measurements can lead to the identification of pollution zone and give an estimate of the influence of effluent discharge and runoff waters.

D. Total dissolved solids (TDS)

TDS is defined as mainly "The measure of Bicarbonates, carbonates, sulphates, nitrates and phosphates of calcium, magnesium, sodium, and potassium with traces of iron, manganese and other minerals dissolved in a liquid". TDS value determines its suitability for various applications like irrigation, drinking, and industrial uses. High dissolved solids make water unfit for human consumption as it is harmful to physiological processes in the human body.

E. Salinity

It is the sum of weights of different salts such as sodium chloride, magnesium, calcium sulphates, and bicarbonates. The presence of salt can restrict the abstraction of water for drinking purposes.

F. Turbidity

Turbidity according to the International Standards Organization (ISO) is defined as "The reduction of liquid transparency due to the presence of undissolved, suspended solid matter, particles not in true solutions such as silt, clay, algae, and other microorganisms; organic matter and other minute particles".

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Turbidity according to the International Standards Organization (ISO) is defined as "The reduction of liquid transparency due to the presence of undissolved, suspended solid matter, particles not in true solutions such as silt, clay, algae, and other microorganisms; organic matter and other minute particles". Turbidity of drinking water accelerates the growth of harmful microorganisms and reduce the effectiveness of disinfection processes like chlorination, UV irradiation treatments, resulting in increased health issues.

H. Dissolved oxygen (DO)

It is defined as "A measure of the amount of free oxygen dissolved in water". It serves as a major indicator of water quality and has a significant effect on aquatic life as well. The amount of dissolved oxygen is a function of temperature, salinity, and pressure. With the rise in temperature and salinity, DO decreases whereas it increases with increase in pressure (atmospheric and hydrostatic) [5].

Table-I indicates the basic water quality parameter standard range for drinking prescribed by Bureau of Indian Standards (BIS).

Table-I: Water quality parameter standards by BIS [10]

Sl.No.	Parameters	BIS(acceptable limits)
1	pH	6.5-8.5
2	Turbidity(NTU)	10
3	Electrical Conductivity(μ S/cm)	400
4	TDS(mg/l)	500
5	Ca(mg/l)	75
6	Mg(mg/l)	30
7	Cl ⁻ (mg/l)	250
8	Iron(mg/l)	0.3
9	Total hardness(CaCO ₃ ,mg/l)	300
10	Dissolved oxygen(mg/l)	5

IV. THE SYSTEM BLOCK DIAGRAM

Fig.2 shows the block diagram of the proposed water quality monitoring system. The main operating units consist of the data acquisition, processing, and transmission circuits. Detailed descriptions of the major blocks are as follows:

A. Sensor types:

Table-II indicates the different types and specifications of sensors used for determining the basic water quality parameters.

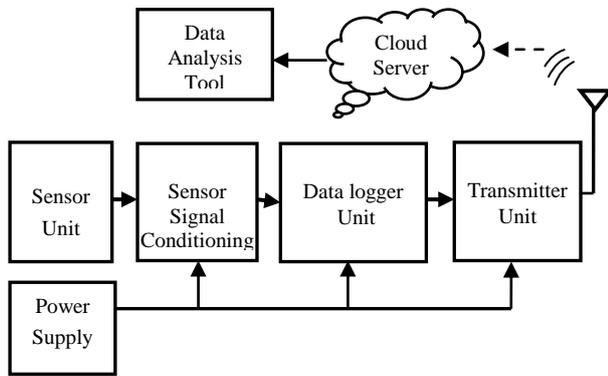


Figure 2. Block Diagram of the System [8]

Table II: Types and specifications of sensors used in the project

Sl. No	Make and Model	Description	Range
1	MicroSet	Temperature Sensor – Waterproof Type: Pt -100 Simplex -3 wire	0 to 100°C
2	MicroSet MS CD 04	Electrical Conductivity Sensor MOC of Electrodes : Glass / Platinum Cell Constant : K =1.0 Max Pressure: 2.5 Bar, Max Temp: 60°C	0 to 10,000 μS/cm
3	MicroSet MS pH 02	pH Sensor Body : CPVC Max Temp : 0 to 80°C Operating Pressure : 0 to 6 Bar Junction : Four Ceramic Ref: Ag / AgCl Process	0 to 14
4	MicroSet MS DO 714	Maintenance Free Dissolved Oxygen Temp. Range : 0 to 40°C Max Operating Pressure: 1 Bar Linearity: This is a straight line ATC: Pt-100	0 to 200%

B. Sensor Data Signal Conditioning:

The magnitudes of the sensor outputs are relatively small therefore special signal conditioning circuits are needed to process these signals by performing functions like amplification, filtering, linearization, level shifting, impedance transformation, etc. The data acquisition system developed in this project was calibrated for the input voltage range of 0-5V. In this project, the observed output voltage variation 0V to 1 V of the temperature measuring circuit (using the sensor- pt100) was calibrated to 0°C to 100°C. Output voltage variation of 10mV of the circuit produced approximately 1°C change in temperature.

The pH sensor used was a combination type housing H⁺ ion-sensitive electrode and reference electrode together. Sensor range: 0 to 14pH as seen from table-II. At 25°C, the sensor displayed output voltage of 0 mV for 7pH and changed by 59.2mV per pH variation. The pH measuring unit had voltage variation of approximately 0.2 V per pH change at the output.

Electrical Conductivity (EC) sensor comprised of two

conductive electrodes made up of glass or platinum separated by some distance (d) in a body. The body was made up of CPVC material. For conductivity measurement, voltage (a low amplitude AC sine wave signal of low kHz frequency) was applied to the sensor probes and the resulting current was measured [7].

Conductivity sensors used in the project had standardized specific cell constant (K) = 1 cm⁻¹ which was directly proportional to the distance (d) separating the two conductive electrodes and inversely proportional to their surface area (A) and therefore K = d/A.

Conductivity C (Siemens/cm) was given by (1):

$$C = G \times K \tag{1}$$

Where G was the conductance (in Siemens)

K is the cell constant

The conductivity range measured by the EC sensor in this project was between 0-3300μS/cm with a resolution of 10μS/cm. The conductivity measuring unit had voltage variation of approximately 66mV per 10μS/cm change at the output.

The dissolved oxygen sensor probe used an electrode system where the oxygen dissolved reacted with the cathode and produced a current. It measured oxygen saturation from 0 to 200% within a temperature range of 0 to 40°C as seen in table-II. The sensor could also measure the dissolved oxygen concentration from 0-20mg/l. The sensor voltage output varied from 0 mV in Zero solution to 35-55mV in air.

The entire sensor assembly was immersed into the various locations of Pashan Lake and measurements were recorded. The calibration of these sensors with respect to standard instruments and buffer solutions was established in the laboratory. All the needed sensor interfacing circuits were designed, developed and tested in the laboratory before final assembly and field measurement.

C. Data logger unit:

A data logger unit for data processing and storage comprised of Atmega 328 as the central main processor, data multiplexers and decoders, memory card slot for SD memory storage and wireless data communication interfaces for GSM module. The sensor data were given as an input to the processor. The measured temperature, conductivity, dissolved oxygen and pH value of water was acquired, processed and further stored in the SD card memory. The processor board acted as a central controller for all the internal operations of the system proposed. The sensor sampling time was 10s.

D. Transmitter unit:

It enabled the wireless transmission of data from the developed sensor nodes to any remote cloud server. All the processed data was collected and information was uploaded to a cloud server using the GPRS network connection. Separate data channels for each parameter measured were created in "Thingspeak" cloud server and acquired in-situ data were plotted in real-time. SIM 800C based GSM module developed by Rhydo Labz was used for data communication.

V. PROGRAM FLOW

- Read the temperature, pH, electrical conductivity, and dissolved oxygen sensor data one after the other with a sampling interval of 10secs.
- Perform data processing.
- Store the data read in the internal memory card.
- Initialize the wireless communication module.
- Transfer and record the data to the cloud system.

VI. RESULT AND DISCUSSION

Fig. 3-4 shows the experimental field setup for the continuous measurement of the lake's water temperature, pH, dissolved oxygen and conductivity.



Figure 3. Developed System



Figure 4. Real-time deployment of the sensor assembly

Surface water from various locations of Pashan Lake was measured in real-time for their quality analysis using the developed system. Table III displays the values of the several water quality parameters measured by the designed system. The experiment conducted on Pashan lake in summer season indicates that the pH of the lake water varied between 7.19 to 7.45 and was found to be in the acceptable limit prescribed by BIS (6.5 – 8.5). The high value of Electrical conductivity 769 $\mu\text{S}/\text{cm}$ to 814 $\mu\text{S}/\text{cm}$, more than the acceptable limit (300 $\mu\text{S}/\text{cm}$) of potable water was observed. The present investigation indicated that the concentration of dissolved oxygen DO fluctuate between 3.6-4.48 mg/l indicating low dissolved oxygen content making it non-potable. The overall water quality was assessed to be poor owing to the mixing of sewage, industrial effluents from the villages located at the upstream of Ram Nadi and formation of water hyacinth, resulting in severe degradation of lake's water quality. Fig.5 displays the real-time plots for measured temperature, pH, electrical conductivity, dissolved oxygen of Pashan Lake on thingspeak cloud server.

Table III: Measured water quality parameters

Date and time	Temperature in °C	pH	Electrical Conductivity in $\mu\text{S}/\text{cm}$	Dissolved oxygen in mg/l
2019-05-06 12:44:52 IST	32.26	7.3	791.83	4.38
2019-05-06 12:49:55 IST	31.33	7.36	799.96	4.13
2019-05-06 12:54:57 IST	31.72	7.45	802.54	4.04
2019-05-06 13:00:00 IST	31.52	7.29	811.4	4.48
2019-05-06 13:05:03 IST	32.01	7.38	811.94	4.3
2019-05-06 13:10:06 IST	32.36	7.36	805.66	4.23
2019-05-06 13:15:08 IST	32.36	7.31	805.42	4.63
2019-05-06 13:20:11 IST	32.8	7.31	793.05	4.11
2019-05-06 13:25:14 IST	32.01	7.33	780.74	4.23
2019-05-06 13:30:17 IST	32.4	7.3	793.93	4.28
2019-05-06 13:35:19 IST	32.6	7.33	776.35	4.16
2019-05-06 13:40:22 IST	32.21	7.34	773.73	4.28
2019-05-06 13:45:24 IST	32.11	7.26	773.58	4.15
2019-05-06 13:50:27 IST	31.62	7.35	791.01	4.22
2019-05-06 13:55:30 IST	31.72	7.19	782	4.03
2019-05-06 14:00:32 IST	31.96	7.33	784.43	4.06
2019-05-06 14:05:35 IST	31.67	7.33	772.26	4.25
2019-05-06 14:10:38 IST	31.82	7.39	774.26	4.17
2019-05-06 14:15:40 IST	32.65	7.26	787.21	4.02
2019-05-06 14:20:43 IST	32.99	7.24	787.6	3.99
2019-05-06 14:25:46 IST	33.09	7.36	785.56	3.96
2019-05-06 14:30:48 IST	32.99	7.27	784.14	3.92
2019-05-06 14:35:51 IST	33.14	7.29	785.8	3.96
2019-05-06 14:40:54 IST	33.04	7.34	769.88	3.94
2019-05-06 14:45:56 IST	33.53	7.36	779.27	3.94
2019-05-06 14:51:00 IST	33.33	7.34	778.2	3.9
2019-05-06 14:56:02 IST	32.99	7.27	779.71	3.94
2019-05-06 15:01:04 IST	32.89	7.31	776.5	3.94
2019-05-06 15:11:10 IST	34.65	7.22	789.94	3.79
2019-05-06 15:16:12 IST	35	7.29	778.64	3.82
2019-05-06 15:21:15 IST	34.31	7.22	784.09	3.75
2019-05-06 15:26:18 IST	34.07	7.2	814.08	3.69

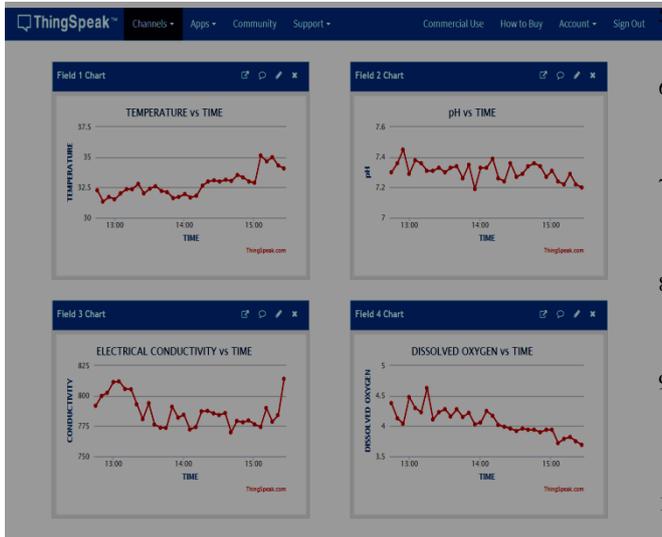


Figure 5. Real-time plots at thingspeak channel

VII. CONCLUSION

The water quality of Pashan Lake deteriorates due to the formation of hyacinth, disposal of domestic sewage, effluents from factories into the lake. The system developed was a wireless sensor node which could measure the water quality parameters using the sensor assembly, process, record and wirelessly transfer data to a cloud server. The sensor node was battery-powered and it was observed that the more power was consumed in wireless data transmission rather than sampling and processing the data. The sensor node presented in this paper allows measuring and reporting the basic quality parameters of water bodies in real-time thereby, giving an understanding about their pollution levels. The IoT based platform successfully enabled remote access to quality parameters of water resources for detailed analysis and reporting. The information so sent to the concerned authorities could aid in devising early solutions under critical conditions. The main objective of this research is to design and develop an efficient and cost-effective measurement system for water resources.

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