Cloud based analysis of Drinking Water quality parameters

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Abstract. The contamination of water bodies becomes a very big threat to the world. This happens due to pollution, domestic and industry waste and over population. This threat will lead to low rainfall, famines etc. In recent years, the research on monitoring and analyzing water quality is increasing. The water quality has to be examined in people living area, ponds, lakes, rivers and also the water bodies near the industries. People not having safe drinking water will lead to many diseases. The older methods of officials collecting sample from the water bodies, analyzing in labs, providing the results and taking control actions will be costly and takes more time. The main disadvantage is the lack of real time data analysis is not possible in the traditional systems. In this paper, a real time water quality method is analyzed and the results are verified with the traditional methods. This method uses high level processor, sensors, networking and measurement devices to give the real time data. The important parameters of water like temperature, turbidity and pH levels are monitored continuously. The user can verify the data anywhere anytime using the web interface provided in the method. The data analysis is also provided in tabulation and graphical representations. This paper provides an optimal method for monitoring the water quality in an efficient way. Traditional methods that rely on collecting water samples, testing and analyses in water laboratories are not only costly but also lack the capability for real-time data capture, analyses and fast dissemination of information to relevant stakeholders for making timely and informed decisions.

1. Introduction

Nowadays research on water is increasing because water is the very important component for human beings and animals to survive. According the reports of water sanitation and health committee of WHO, around 10% of the world population is not having drinking water and 75% of the world population is not drinking quality water [13]. The water contamination may lead to diseases like transmitting and non-transmitting, produced by virus or bacteria and many more. The impact of water quality will produce an imbalance in ecosystem, human living environment [6]. The sources of water for mankind comes from underground water, water running on the surface and the rain water. This underground water provides water for half of the world and the salinity of the ground water and the availability of water differs from place to place. The water running on surfaces like lakes, ponds, streams and rivers needs a treatment before drinking. The final source is the rain water, which is the purest form of water. All government advises to build rain water harvesting system because of the importance of rain water [17]. The main qualities to consider the safety of water is microbiological, physical and chemical conditions. The factors like virus, bacteria, sediments, precipitate, minerals, temperature, color, odour, taste comes under the above three conditions [3]. As
Rainwater is due to the evaporation of water from surface, it is also not pure due to pollution and presence of dust and smoke in the environment. A safe water must be free from pathogens, less content of toxic chemicals, clear, tasteless and with zero odour. World Health Organization has given limitations for the substances that should be present in the water level for drinking [16].

Human race are the main reason of water pollution. Humans polluting the water bodies for their betterment in infrastructure and technology. The waste from Industries developed by humans will be diverted to the nearby water bodies like rivers and ponds and they make the water contaminated. Other reasons highlighted are human population, industrial and domestic practices. Sewage threatens fresh water and the living aquatic flora and fauna. The flora and fauna are entirely disturbed and leads to death by suffocation [12]. The organizations like American Public Health Association, Indian Statistical Institute, Central Pollution Control Board, Indian Council of Medical Research and World Health Organization are working on fixing the standards for drinking water. According to the above organizations, the following standards and limits are followed [9].

| Name of the parameter      | Accepted levels                           |
|----------------------------|------------------------------------------|
| pH                         | 6.0 to 9.0                               |
| Temperature                | 20°C to 25°C                             |
| Hardness                   | below 75 mg/L                            |
| Alkalinity                 | 20-200 mg/L                              |
| Dissolved oxygen           | less than 1 mg/L to more than 20 mg/L    |
| Nitrate and Nitrite        | Nitrate 10.0 mg/L and for nitrite at 1.0 mg/L |
| Chlorides                  | less than 600 mg/L                       |
| Fluoride                   | 1.5 ppm                                  |
| Arsenic                    | 50 μg/l                                  |
| Lead                       | 0.05 ppm                                 |
| Phosphorus                 | 0.005 to 0.05 mg/L                       |
| Iron                       | 0.3 mg/L                                 |
| Pesticides                 | Less than 1%                             |
| Microfibers                | Less than 0.5%                           |

The pH or potential of Hydrogen represents the acid or alkaline (base) levels of any solution. The solution hardness can be measured using the pH value. It is also used to check the toxic and corrosive effects of water. According to standards, pH value of 7 is the neutral. Any values above the neutral value is considered as either acidic or alkaline. In general, the surface water has a pH of 6.5 to 8.5 and in ground water, the range is 6 to 8.5. Measuring pH is very important as it affects the aquatic living and it changes the state of water bodies. Cu and NH3 present in water will not have any effect, when the pH level is in neutral. Changes in pH will change copper and Ammonia to toxic [5]. The temperature effects on the water bodies should also be monitored, as it creates a large impact on them. All the flora and fauna will undergo some metabolic activities in their life span. In the normal temperature, the time span of the activities will not be delayed or increased. But the increase or decrease in temperature will either delay or increase the span of the metabolic activities. Some good algae and protozoa will lose their lives due to the change in temperature. Temperature changes also decrease the dissolved oxygen content and increase the carbon dioxide content in the water bodies, making them not suitable for drinking [18].

Water’s conductivity is also an important parameter in water quality. Conductivity defines the current passing capability. It is directly proportional to the ions present in the water. The conductivity varies from place to place. Pure water has very low conductivity but the sea water has more conductivity. The aquatic living like fish can withstand certain amount of electrical conductivity and increase in EC will lead to the death of aquatic living. Measuring conductivity in water bodies is needed as it represents the amount of dissolved substances, chemicals, and minerals. If the impurities are more, conductivity will be more. Potassium (K+), Magnesium (Mg+), Sodium (Na+), Carbonate (CO2−), Chloride (Cl-) and sulfate (SO2−) are the different positive and negative ions affect the quality of water [19]. Another important parameter which defines the water quality is turbidity. Turbidity is directly proportional to the amount of suspended solids in water. The amount of light reflected, absorbed, scattered can be found using the turbidity. The aquatic plants like algae needs sunlight for their photosynthesis. If the sunlight is scattered by the suspended particles, then the light required for photosynthesis will not be available. So the degradation of aquatic
plants and animals will happen and there is a disturbance in the water ecosystem. Turbidity causes severe effects on humans by producing allergies and headaches. It changes the taste and odour of the water [4]. The paper is structured in the following way. The related works are listed in the literature work. The very important parameters like pH, Temperature, Conductivity and turbidity are measured in real time using this model. The proposed model is defined in terms of block diagram, hardware components used and the results. The results can be verified in the web portal designed for this system. The user can use his login credentials for login. The user can get real time data anywhere and any place.

2. Literature Survey

M O Faruq et al. [10] designed a low cost microcontroller based system for monitoring the water quality. He used a basic microcontroller with some sensors and produced the output in the LCD. The author monitored temperature, pH and the turbidity and the results are displayed. The system designed is portable. This system provides data which cannot be stored for further analysis. Moreover the user has to be available near to the system for getting the values. Zexin Lin et al. [20] provided a wireless sensor networks based rural drinking water monitoring system. As WSN is involved, the author created nodes for all modules like water quality monitoring, pathways, collecting hubs, processing units and the deliverable parts. All the modules are activated on collection of sample. This system provides a greater reduction in human intervention. The author also used a high end GPS system for finding out the highly impacted places.

A T Demetillo et al. [1] suggested a water quality monitoring buoy or floating object for large water bodies like rivers and oceans. He used different sensors interfaced in the buoy and wireless sensor networks for getting the data from the sensors. There is a predefined time duration at which the fixed sensors will collect the data from the water bodies. Data collected will be send to the registered mobile number through GSM. If the mobile used has no network, the data will be stored in the RTS and when the network resembles, data will be sent. Jungsu Park et al. [7] presented the advancements happening in the water quality monitoring systems. The information and communication technology ICT is combined with sensors technology for monitoring and controlling the water quality. Various sensors types for measuring different parameters like pH value, DO Concentration, Temperature, Nitrate, Ammonium, dangerous algae, water level and velocity are available currently in the market. He suggested the current methods must be combined with hi-tech analysis like machine learning to achieve the accurate measuring of the water quality.

M H Gholizadeh et al. [11] used remote sensing techniques for measuring the water quality parameters like unwanted deposits, dissolved organic matter in different colors, chlorophyll content and different pollutants. Remote sensing along with Geographic Information systems with different sensors provides the most accurate, cost effective and best tools for analyzing the water quality in various water bodies like ground water, lakes, ponds and oceans. Another major advantage of this method is the collection and analyzing of large amount of data. Arivoli Appavu et al. [2] demonstrated the basic water quality assessment methods. The author had used belts of Cauvery River for their research. The traditional method is the site inspection and sample collection is done from the highly polluted areas. The pollution is mainly from the tanning industries located near to the river banks. Collected samples are subjected to various Physico-chemical methods. Evaporation methods are used to find the TDS (Total dissolved Solid) and residues. By using sodium thiosulphate titration method, the water BOD (Biochemical oxygen demand) is measured. By titration of potassium dichromate and sodium thiosulphate, the water COD (Chemical oxygen demand) is measured. The titrations are carried out in the laboratory and the values are tabulated.

Poonam Prasad et al. [14] developed a Web approach for water quality analysis. The Web based system provides easy analysis of data. The analyzed data can be expressed in different formats like charts, graphs and tabulations. The author analyzed the basic four parameters like pH, Dissolved oxygen, BCD and the non-sporulation bacterium. The data stored in MS-Excel can be changed into MySQL or Oracle data and can be analyzed. The main advantage of the method is the possibility of the various calculations, statistics, grade analysis and the graphical representation. This method is mainly a user graphical interface using Internet web technology where the user can access data regarding the water quality. The hypertext based approach is used for publishing and displaying data to the web browser. Satyam Srivastava et al. [15] used a smart phone based water quality monitoring method. This system can be used in places where human intervention is not possible. The main parameters pH, TDS and temperature are given as input from the sensors to the microcontroller. These three values are sufficient to find other water quality parameters like salinity, dissolved oxygen and conductivity. They developed an application which runs
in Android and iOS, which gives the data collected, analysis and storing. Google Maps is interfaced with
the application which gives the exact location of the water bodies getting polluted. The author developed
the application which is cheap, easy to carry and even an unskilled person can use this application. B H
Lee et al. [8] gives the idea about the location of the water collecting. The monitoring system can be
developed by any technology. Each method has its own advantages and disadvantages. But for all
methods, the input is the water from any sources. This author proposing different methods for finding
the suitable place in the water bodies to get the sample. The author uses a computer based integer
programming code for spotting the perfect location of water sample collection.

3. Proposed Methodology
This section provides the proposed optimal, cost efficient method for monitoring the water quality. The
existing system methodology disadvantages are listed and the overcoming is explained in the proposed
method. The proposed method is developed as hardware and the simulations are done in software and the
results are validated.

3.1. Existing Model
The very basic method is the direct collection of samples from the water bodies. After the collection, it
has to be carefully transported to the laboratories. In the labs, the water sample are analyzed by different
titration methods, formulas and bacterial growth. The main disadvantages of the above method is the
vulnerable to human errors, quality and accuracy of data produced, efficiency and training of the people
employed. The advanced existing system is the use of sensors, microcontroller and the web services.
Arduino is used a core processor and ESP8266 Serial WIFI Wireless Transceiver Module is used as an
interface between the processor and the web services. This method provides the data to the user from the
remote locations. The main disadvantage is the data will be available alone in the web server and the user
has no control on the application.

3.2. Proposed Model
The proposed method overcomes the disadvantages of the existing methods. Various sensors are deployed
for measuring different water quality parameters like pH, temperature, conductivity and turbidity. The
Arduino used in existing systems are replaced by Raspberry Pi3 processor. The ESP module is replaced by
an IoT module and the results are demonstrated and tabulated in the IoT analytics Things speak webpage.
The delay in getting the water quality error report is made real time and the present system is sophisti
cated and compact.

3.2.1 Prerequisites of the proposed Method
The proposed method needs the following prerequisites for collecting the data, processing, analyzing and
displaying over the internet.

- Important Sensors- Calibrated and tested in laboratories.
- Processor- Raspberry Pi3 in good condition and properly wired.
- Power requirements.
- Data collected from Standards, PC or any handheld devices with Proper Internet connection

3.2.2 Block diagram and specifications of the proposed Method
The block diagram represents the flow of data from the water sources to the web server. It has different
types of sensors interfaced with the processor and the output is displayed in the website with login. This
section has the specifications of all the hardware components used in the proposed method. We have used
a reliable microcontroller raspberry pi, turbidity sensors, temperature and pH sensors and a cloud platform

Figure 1: Representation of advanced existing technology
for proactive data collection and we have developed a website to keep track of data and a graph is plotted to show the deviation from standard values. We have set the following standards for pH, turbidity and temperature.

| Name of the parameter | Used standard level |
|-----------------------|---------------------|
| pH                    | 6.5 to 8.5          |
| Temperature           | 15°C to 30°C        |
| Turbidity             | >100 NTU (Nephelometric Turbidity Units) |

Figure 2: Block diagram of proposed model

The proposed model uses the following hardware components with specifications and the results may vary for various manufacturers of sensors. These results can be used as a reference while using other sensors and processors.

- **Raspberry Pi3**
  - 3rd Generation
  - Compact size
  - Wireless LAN and Bluetooth connectivity
  - 64 bit CPU
  - 1 GB Ram

- **Turbidity Sensor**
  - Uses light transmittance and scattering rate
  - 5V DC and 30 mA, Response time: <500ms
  - Ratio Range (NTU): 0-1000±30

- **Temperature Sensor DS18B20**
  - Usable temperature range: -55 to 125°C (-67°F to +257°F)
  - 9 to 12-bit selectable resolution
  - Uses 1-Wire interface
  - Multiple sensors can share one pin

- **pH Sensor**
  - Measuring Range: 0 – 14 pH
  - Accuracy: ± 0.1pH (25 °C)
  - Response Time: ≤ 1min
  - Gain Adjustment Potentiometer

- **Analog to Digital Converter (MCP3008)**
  - 10 bit-Uses SAR conversion
  - SPI serial interface
  - Can be added with any microcontroller

### 3.2.2 Hardware Setup

The sensors are interfaced to the Raspberry Pi3 processor and the entire hardware is fabricated.
4. Results and Discussions
This section provides the results and the graphs produced by the proposed model. The results are displayed in the Things Work platform. The User will be provided with username and password.

To view individual parameter log, graph also plotted with timely datum of parameters and thus historical trends are collected. For example, it can be seen in the below graph shows pH, turbidity and temperature graphs are plotted.
5. Conclusion
This work focusses on developing a cost effective water quality monitoring system. The disadvantages of the existing system are overcome by using the proposed system. A complete water surveillance report can be produced to the pollution control board and the necessary actions can be proposed for stopping pollution. This works removes the overall human intervention. In Future, many sensors can be added to find out dissolved oxygen, bacterial growth can be carried on.

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7. Compliance with Ethical Standards

7.1 Funding
The authors declare that they have no conflicts of interest to report regarding the present study.

7.2 Ethical Conduct
This chapter does not contain any studies with human participants or animals performed by any of the authors.

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