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Monitoring and Analysis of Water Quality Parameters for Diagnosis of Safe Drinking Purpose using Wireless Sensor Network

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Abstract: ***In the 21st century, the world had advanced through lots of innovations; its parallel impact in the form of pollutions, global warming and climatic change crisis are being raised. These crises create a gap in terms climatic changes, poor air quality, and unsafe drinking water for the population around the world. Among all pollutants, water pollution is a thrust area as it is a prominent parameter in the food chain of living things. There are huge numbers of diseases that are attributed due to polluted water. The water sources are mainly polluted due to untreated sewage and industry discharges. But mainly industrial wastewater discharge contributes to the accelerated pollution in the water bodies. The proposed design focuses on monitoring the water quality parameters like pH, TDS, TOC, and Chlorine content, conductivity etc., using wireless Sensor Nodes around open ponds and wells near tannery units. The data is transmitted to the cloud, and further information is given to the people through GSM. Repository of data is maintained in order to take it for further analysis. Results obtained from the model indicate the values of the above mentioned parameters.***

Keywords: ***microcontroller, pollutants, sensor networks, water parameters, wireless transmission.***

I. INTRODUCTION

A basic healthy living of an individual starts with good quality of air, water, and food to sustain. The sustainability of the individual is getting affected with the basic health issues and finally, chronic. The occurrence of environmental revelations on the current status of health has been increasingly agreed for many diseases. One of the main causes from the industrious hazardous waste that shows adverse effects is in terms of death and sickness.

Water Pollution and its harmful impression on Human health is one of the main essential considerable factors in economic development. A hale and strong labor force is needed for the growth of a family which intern leads to the growth of the society. A strong workforce needs a healthy atmosphere i.e., clean water, air, shelter and food. Significant and direct consequences [1] of environmental deprivation in the developing countries start from the impact of health of human. Additionally, it has been reported in many countries that with three million to five million cases chronicled every year due to the occurrence of diarrhoea.

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Such type of diseases is involving in the sacrificing 3.5 working days aggregating to a loss of nine billion days in a single year for an individual. Thus the survival of the human being and his / her dependents are getting affected.

Approximately there are around 150 dyeing and 20 tanneries units in the storage area of water and expected to discharge the untreated effluents either directly or indirectly in the drain. The discharges from the tanneries resulted in the poor quality and health risks, which were caused owing to the usage of the canal water. Also, the people who are consuming the above mentioned water slowly in the verge of health degradation.

People have to aware of the conditions of the water bodies around the locality. To qualify the above, a model is proposed to observe the water quality with the help of Wireless Sensor Networks (WSN). There are many parameters to be considered, among them the acidic or basic condition of water is determined by its pH value. If pH value is 7 then it is considered to be pure, if below 7 it is acidic. Alkalinity is identified if the pH level is greater than 7. In water which is used for drinking purpose the normal pH range is to be maintained, else it induces eyes irritation, affects the quality of skin and membranes of mucous. The conductivity is identified by the water's ability to pass electric current. Quality of Water gets modified with different mixed solids such as calcium, sodium, chloride, sulfate, and nitrate. The transparency loss is identified by turbidity. It is considered as best measure for defining the quality of water. If larger is the turbidity then higher is the threat of diarrheoa, cholera etc. In the clean water turbidity is low. Customary technique of monitoring the quality of water is done by gathering the water samples manually from different parts and the parameters are tested in centralized laboratories. Few laboratories test for all identified contaminants, but it is quite costly and frequently it is not necessary. In India as per the World Health Organization's estimation, it is found that around 77 lakhs of people are distressed owing to the deficient in getting pure water. In addition, it informs that 21% of sickness is related to poor water facility. Death due to diarrhoea is in order of 1600. Therefore, the various criteria's like pH, ToC, turbidity and conductivity to ensure the water quality has to be a real time monitor as specified in Table 1.

The water used for drinking purpose has to be in the sort of 6.5-8.5 for pH. Then the turbidity and conductivity are to be controlled within the values as specified in table

. The water is not appropriate for drinking purpose when the parameters are beyond the specified values.

Table 1: Drinking Water quality limit as per WHO standards

Parameters considered	Units	Quality limits
Turbidity	NTU	5–10
Conductivity	microS/cm	300–800
pH	pH	6.5–8.5
chloride	mg/L	0.5-2.0

Early from the late 2000s, there were new technologies that have been discussed by many researchers [3], [4],[6],[9],[10] which is to discourse some of these limitations. In specific, fiber optic bio sensors, MEMS based sensors that work on surface mount design. New sensors were developed to identify the presence of various substances in water is through Internet based architectures. Monitoring for the measured data was done with computer assisted tools. Likewise, methods were discussed to examine the quality of water parameters in water bodies like river, basin, and lakes. Design of a system that is to monitor the criteria's for quality of water using Internet of Things in actual time is conversed [2]. Sensors are placed along with the Pi using ZigBee. Data from the sensor are monitored using a cloud based data server. It is just a portable device but used only one measuring sample at a time.

The above system requires to remove the manual process and to go for automatic monitoring and controlling. They also provide the basic survey of the works carried in wireless sensor networks; that laboratory based testing the collected samples is still followed in most of the countries to detect chemicals and microbial contaminants.

The burst detection and localization [4] structure, combines lightweight compression and incongruity detection by graph topology for water circulation systems. It considerably minimizes the communications that is taking place among the sensors and the storage servers.

Monitoring methods of water quality parameters, required sensors, embedded based design, and information dissemination process, government policy, and ensuring proper information dissemination to villagers is given in [5]. They also explored the Sensor data in Cloud domain. Efficient utilization of technology like solar, GSM, and economic exercises to improve water quality and its alertness amongst people is addressed [8],[9],[10].

From the survey and report it is found that though many researchers have touched on the monitoring, analysis of the water quality parameters. There is a necessity in distributed Wireless sensor nodes that collects the information from various network topologies, and data is collected in a common cloud server where data analytics is done to identify the water is safe or impure for drinking and other purposes.

II. MATERIALS AND METHODS

A. Overview of the Wireless Sensor Network and design

By considering the discussed issues, a water quality system that monitors the quality of water in actual-time through wireless sensor network is proposed. In this the criteria are considered like pH, conductivity, turbidity and total dissolved salts and they are measured with the help of sensors. The Analog values from these sensor output are converted to Digital. The measured digital values are posted to the controller for decision. In this proposed system, GSM (Global System for Mobile) unit is used to move the handled information from the microcontroller to the cloud. The gathered information is able to be studied in an android application using a unique IP (Internet Protocol) address in anywhere in the world. The information is sent to the people to have better understanding of the essential water quality parameters to prevent them from chronic diseases.

To develop a wireless sensor network, the sensor output from the water reservoir is sensed using modern sensors, which is further processed for determining its applications. Finally, it can give a water quality report to the concern authority. The information about the quality of water is also given to the individual people through the mobile app.

The block diagram for Quality of water monitoring using Wireless Sensor Network is in Fig. 1, quite a few sensors like Conductivity, Turbidity, ToC, pH, Total Dissolved Salts are coupled to the microcontroller. The sensor values are accessed by the microcontroller and the data is transferred through the internet. A PIC or raspberry pi can be used as a core controller. Here PIC is used. The result is also viewed on the Application developed in Android.

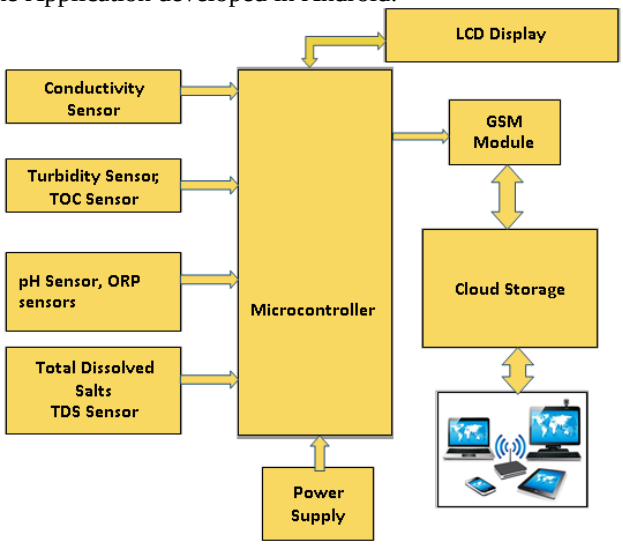

Fig. 1 Block Diagram of Monitoring of water Quality using Wireless Sensor Network

Chemical compositions or solids or surrogates available in the water are measured directly with sensors. Chemical absorptions of solid that might point out the existence of unexpected impurities in the water are known as surrogates. Common sensors used in the water quality monitoring are given as below:

Chlorine Residual Sensor – Chlorine content in drinking water measurement is required in water parameters, as it is the primary disinfectant which is available commonly for its cost affordability. Chlorine sensors are used in the identification of free chlorine, total chlorine and mono chloramines. Total chlorine calculation is also needed in treated waste water, which includes cultivated wastewater also. TOC Sensor - Total organic carbon is a significant factor for analysis of quality of water. It is implemented by a direct indicator and a substitute for numerous water property indications.

Turbidity Sensor -Turbidity sensors give information about the number of suspended solids in water. Naturally, this is done by computing the quantity of light transmitted through the water.

Conductivity Sensor- Conductivity based measurements are executed mainly in processes that are handled in industries, mainly to get details on total ionic compounds presented in water. It finds its application such as water purification, clean water discharge management and the measurement of absorption levels in liquids.

pH Sensor- Another essential parameter to be measured and controlled is pH. The acidic or basic (alkaline) content in a liquid is determined by its pH value. pH sensor along with conditioning circuits are typically shared into single mechanism named as a combination pH electrode.

ORP Sensor - The Oxygen-Reduction Potential of a liquid is measured with the help of ORP sensors. It is used in combined with pH sensor; the measurement of ORP offers insight in the amount of oxidation/reduction reactions happening in the solution. Proper Interface is needed for the sensor to collect the data. These sensors give a warning of water quality conditions.

The implementation of the proposed model is given in Fig. 2.

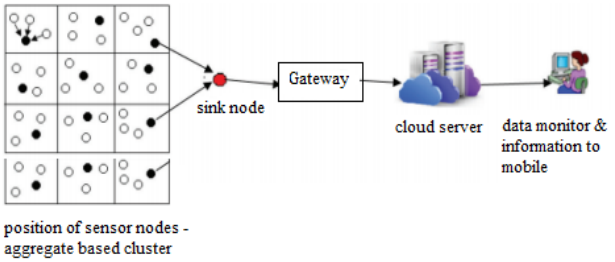

Fig. 2 The implementation structure of the proposed system

The planned model for water quality monitoring system assembles the required pollutant parameters. The sensors nodes positioned outside the region of interest are categorized to various clusters where there is one cluster head and many member heads for every cluster The member nodes broadcast the data to their particular clusters through the cluster heads (CHs). The CHs then put forth the collective data to the sink node. The data from the WSN is sent over to the gateway, from the gateway it is posted to the cloud server for repository purpose. It is also sent to the user to monitor the status. In order to manage the multimedia transportation in the graded and heterogeneous networks with a cost function a routing protocol with cross layer is addressed [13-15]. The needed cost for routing process and requirements to handle multimedia working is determined by the routing protocol which in turn decides the soft quality of service (Soft QoS). In [12],[16], the survey for monitoring the wireless sensor network is discussed. Among the several algorithms, it is found that the attribute-based clustering seems to be effective, which satisfies the properties like Node mobility of nodes, Convergence time, Energy efficient, Balanced clustering, Cluster overlapping, Location awareness, Failure recovery and Cluster stability. Hence the algorithm used here is attributed based clustering for the sensor parameters taken to be pH, conductivity, TDS, TOC, Chlorine etc.,

Attribute-based clustering: the scheme of grouping the WSN is based on the requirements and features of the facts to be measured. This is done to achieve well-organized distribution of data in the network to be given to the gateway. The idea looks like the data driven policy form of WSNs. The clustering is created by aligning the measured parameters of data attributes to the network structure. This technique is based on the leader election algorithm. Since here the measured data is to be propelled to the cloud server for identifying the water quality, there is no need to go for leader based election of the cluster. Thus the collected data from sensor nodes is sent to the cloud. Also it is given to the gateway for further identification of drinking water.

B. Schematic and implementation structure of sensor nodes in areas of monitoring

The schematic diagram and the structure of implementation of the sensor network nodes in wireless mode in the area of monitoring the quality of water is given in Fig. 3. It consists of the aggregate based clustering sensor nodes on the water storage area. The data is collected through the microcontroller unit through the sensor nodes; it is directed to the cloud for data storage. The stored data is used for the identification of quality of water parameters. The decision of the water, which is good for drinking purposes, is selected based on the standards. This information can be sent to the public with the help of the android app developed in the mobile environment.

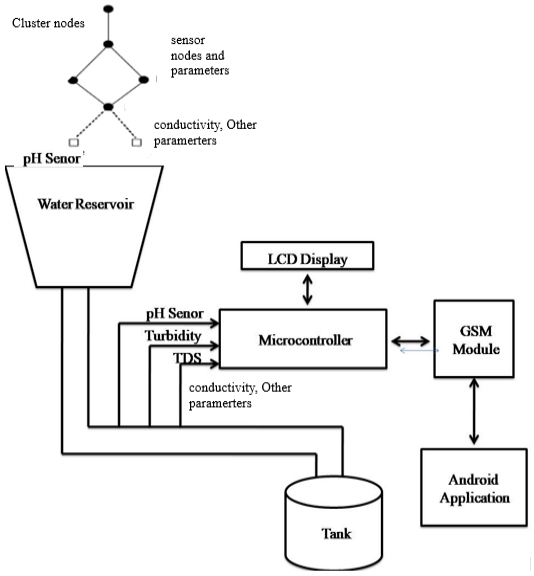

Fig. 3 Schematic and Implementation details of the water quality monitoring

C. Circuit diagram and implementation of the proposed work

The circuit diagram of Wireless Sensor Network based monitoring of Water Quality is given in Fig. 4. The sensors are associated to the analog pins RA0, RA1 RA2 and RA3 of the microcontroller. The resolution for a 10 bit of Analog to Digital converter is 1024. The converter scales the measured input analog value among 0v - 5v to 2 powers of 10 levels, which is obtained as1024 levels. The ADC value is sent to the LCD with the help of D4, D5, D6, and D7 pins. PIC Microcontroller The transmitter pin RC6 of microcontroller is patterned to the receiver pin of GSMs SIM 900. By means of suitable AT (Attention) instructions GSM has to transport the data to the relevant IP address. Hence the quality of water parameters are observed from anywhere in the world.

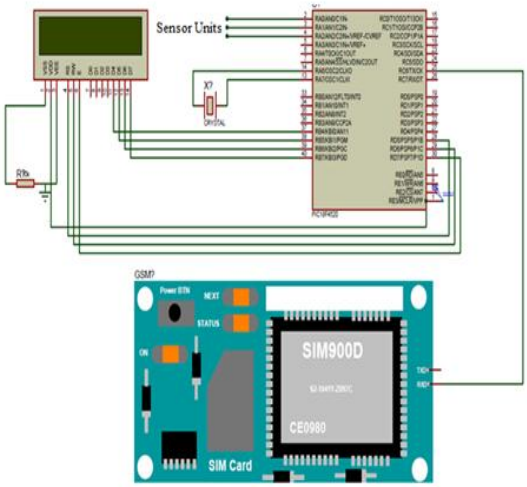

Fig. 4 Circuit Diagram of Monitoring the Quality of Water parameters using Wireless Sensor Network

D. Results and Discussion

The preliminary model Wireless Sensor Network based water quality monitoring system is shown in Fig. 5 and 6. The aim is to provide the necessary information about the water quality parameters in quick accessing time to the people residing at polluted water bodies. The measured information is issued to the cloud for cache purpose. The result is viewed and obtained for processing at any required time. The monitoring of water quality parameters is made online quickly using this system. This work provides a clear idea on monitoring quality of water in authentic time in a city or rustic area to eventually develop the attributes of water for urban resident. For the proposed idea, work has been carried out using a pH sensor, TDS sensor, ORS sensor etc., and it is interfaced with PIC microcontroller. The results of the sensors are discussed with the few contaminated water samples like household wastewater, NaOH, water near tanneries, canal water, and bore water.

pH sensor specifies the range of voltage of 1-5V relating to 1-14pH. The analog signal is from the sensor is sensed by the microcontroller unit, and status of water is displayed in the LCD. The microcontroller delivers the data packets to the cloud space.

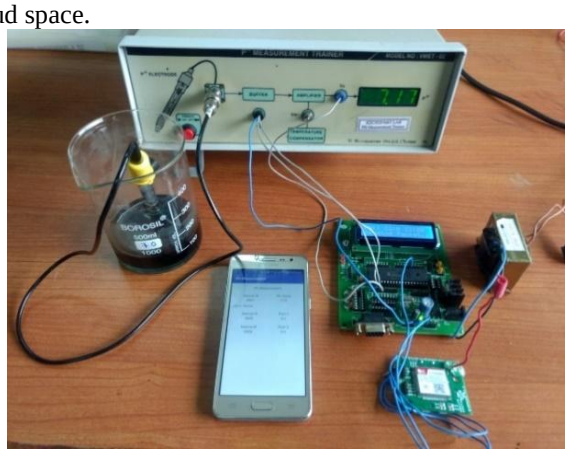

Fig. 5 Hardware Configuration of Wireless Sensor Network based monitoring of Water Quality

Through GPRS (General Packet Radio Service) Network, the developed Android Application collects the data from cloud space.

Fig.6 Software Configuration of Wireless Sensor Network based monitoring of Water Quality

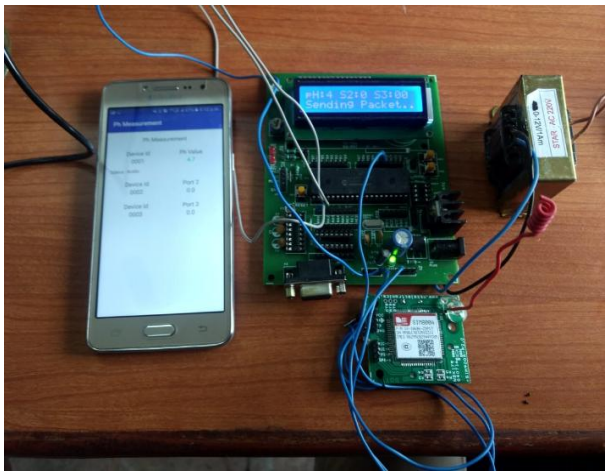

Fig.7 Data Sent to the Mobile through GSM

Fig. 8. Possible Measurements with Different Liquids.

Table II shows various kinds of water quality reports. The developed model is experienced with various solutions like Sodium Hydroxide, Drinking Water, Hydrochloric Acid, and bore water, waste water. To discuss about the sensors, the pH range of the solution is sensed by a pH meter. The output of the pH meter is in Volts. Acidic, alkaline and neutral solution is obtained from the range of pH. According to Indian Standards: 10500 (Drinking water specifications),

the maximum value of turbidity should be 5 NTU. But here, it is much more. If TDS gets reduced, the value of conductivity has to reduce. Similarly, the sensors discussed in the block diagram do the same function and results are indicated in Table II.

Table II: Result Analysis of Water Quality using Wireless Sensor Networks

Solution	pH	Turbidity	Conductivity
HCL	1.35	15 NTU	306 mS/cm
Drinking-Water	2.59	3 NTU	308 mS/cm
NaoH	3.9	19 NTU	482 mS/cm
Household waste	4	45 NTU	306 mS/cm
Waste water (Tanneries)	6	60 NTU	308mS/cm
Bore water	3	3 NTU00	306 mS/cm

III. CONCLUSION

It is the order of the day to ensure water quality with the help of recent technologies. The idea for implementing a low-cost, capable water monitoring system using wireless sensor network is described. Sensor networks comprising of low-priced components such as tiny sensor nodes, microcontrollers, and wireless modules have established their usefulness and competence in many areas. The proposed working scheme additionally confirms the potential of making it probable for the common community to have entrée to the water quality monitoring results in real-time, by IoT devices attached to the internet. The water quality system thus enables a module for predicting the water contamination so that the people can be addressed about their safety before the occurrence of any severe threats to their health.

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