IoT Based Water Quality Monitoring System Using Wireless Sensor Network

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Abstract-In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time. In this paper we present a design and development of a low cost system for real time monitoring of the water quality in IOT. The system consist of several sensors is used to measuring physical and chemical parameters of the water. The parameters such as temperature, PH, turbidity, conductivity, dissolved oxygen of the water can be measured. The measured values from the sensors can be processed by the core controller. The raspberry PI B+ model can be used as a core controller. Finally, the sensor data can be viewed on internet using cloud computing. Nowadays drinking water is the most precious and valuable for all the human beings, drinking water utilities faces new challenges in real-time operation. This challenge occurred because of limited water resources growing population, ageing infrastructure etc. Hence therefore there is a need of bettermethodologies for monitoring the water quality. The online water monitoring technologies have made a significant progress for source water surveillance and water plant operation. The use of their technologies having high cost associated with installation and calibration of a large distributed array of monitoring sensors. The algorithm proposed on the new technology must be suitable for particular area and for large system is not suitable. By focusing on the above issues our paper design and develop a low cost system for real time monitoring of the water quality in IOT environment.

Keywords-Internet of Things (IoT); Wireless Sensor Network (WSN); Water parameters; Arduino Uno.

I. INTRODUCTION

Water is used in various activities, such as consumption, agriculture and travel, which may affect water quality. Therefore, the water quality monitoring is necessary which includes several chemical parameters. Some of these are: pH, redox potential, conductivity, dissolved oxygen, ammonium and chloride ion amount. There is need to improve existing system for monitoring water bodies, given that laboratory methods are too slow to develop an operational response and does not provide a level of public health protection in real time. Improve and expand monitoring and assessment tools to ensure a statistically robust and comprehensive picture of the status of the aquatic environment for the purpose of further planning. The water quality problems of surface water bodies are predominately caused by organic and nutrient material loads. More than 90% of the River Basin Management Plans (RBMP) assessed indicated that agriculture is a significant pressure in the basin, including diffuse or point source pollution by organic matter, nutrients, pesticides and hydro-morphological impacts. Nowadays Internet of Things (IoT) and Remote Sensing (RS) techniques are used in different area of research for monitoring, collecting and analysis data from remote locations. Due to the vast increase in global industrial output, rural to urban drift and the over-utilization of land and sea resources, the quality of water available to people has deteriorated greatly. The high use of fertilizers in farms and also other chemicals in sectors such as mining and construction have contributed immensely to the overall reduction of water quality globally. Water is an essential need for human survival and therefore there must be mechanisms put in place to vigorously test the quality of water that made available for drinking in town and city articulated supplies and as well as the rivers, creeks and shoreline that surround our towns and cities. The availability of good quality water is paramount in preventing outbreaks of water-borne diseases as well as improving the quality of life. The development of a surface water monitoring network is a critical element in the assessment and protection of water quality. We developed a prototype of easy to install technology by which the different surface water quality indicators can be measured.

This paper presents a smart water quality monitoring system. This project aim is to build IOT project for Smart Water Quality Monitoring System. The development of a surface water monitoring network is a critical element in the assessment and protection of water quality. We developed a prototype of easy to install technology by which the different surface water quality indicators can be measured.Good water quality is essential for the health of our aquatic ecosystems. Continuous water quality monitoring is an important tool for catchment management authorities, providing real-time data for environmental protection and tracking pollution sources. Using GSM we cannot get the updates when there are network problems like rural areas and forest areas.Using Image processing techniques sometimes we didn't get clear images. Any how we cannot judge the purity of the water on image basis. Using zigbee we cannot make this system appropriate for long distances.Here we get water quality conditions through various sensors like temperature, pH, water, turbidity, conductivity and Aurdino board. The information will be uploaded continuously from the WSN through Microcontroller and WiFi. We control and upload this data to cloud and users can access this data through blynk application by installing into their phones. From this system a person from anywhere can monitor the information at any time. An IOT Based system for water quality monitoring is a one stop solution that aims to solve the existing problems, which would not require any manual test of the water quality which is automated in this project. This concept will reduce the man power and mistakes while getting the accurate data. Here end user or concerned person can access the information at any time continuously which is a big advantage. Moreover user need not to have any extra devices for this system, just android phone is enough.

II. RELATED WORK

The related works forIoT based water quality monitoring system using wireless sensor network are as given below.

*1) Sewer Spill :*It is often assumed that the frequency or volume of Combined Sewer Overflow (CSO) spill is a good indicator of receiving water pollution impact. Whilst this assumption would *appear* to be true, recently there have been challenges to its veracity. To test this basic premise, an integrated model has been applied to the urban waste water system of a semi-hypothetical catchment. By increasing the storage volume at a single downstream tank in the drainage system, the CSO spill frequency and volume was reduced. River water quality criteria, based on UPM standards, were calculated and related to spill frequency and volume over a series of long-term simulation runs. It was found that, up to certain storage volume levels, decreasing overflow frequency improved river DO and BOD and total ammonia. Beyond these volumes, however, there was no further improvement in DO/BOD and an increase in total ammonia. It is concluded that overflow frequency/volume can be used as a performance indicator for receiving water quality, provided its significant limitations are understood.

2) Water Quality Monitoring in Europe's Largest Fluvial Aquarium: Nowadays Geographic Information System (GIS) and Remote Sensing (RS) techniques are used in different area of research for monitoring, collecting and analysis of data from various geographical locations. Due to the vast increase in global industrial output, rural to urban drift and the over-utilization of land and sea resources, the quality of water available to people has deteriorated greatly. The high use of fertilizers in farms and also other chemicals in sectors such as mining and construction have contributed immensely to the overall reduction of water quality globally. Water is an essential need for human survival and therefore there must be mechanisms put in place to vigorously test the quality of water that made available for drinking in town and city articulated supplies and as well as the rivers, creeks and shoreline that surround our towns and cities. The availability of good quality water is paramount in preventing outbreaks of water-borne diseases as well as improving the quality of life. Fiji Islands are located in the vast Pacific Ocean which requires a data collecting network for the water quality monitoring where GIS system can be applicable. This Paper presents a case study of water quality monitoring system with Key Performance Indicators (KPI) for Suva city, using GIS and RS technology.

*3) Sea Water Monitoring For Chemical Parameters :*The application of different multivariate statistical approaches for the interpretation of a large and complex data matrix obtained during a monitoring program of surface waters in Northern Greece is presented in this study. The dataset consists of analytical results from a 3-yr survey conducted in the major river systems (Aliakmon, Axios, Gallikos, Loudias and Strymon) as well as streams, tributaries and ditches. Twenty-seven parameters have been monitored on 25 key sampling sites on monthly basis total of 22,350 observations. The dataset was treated using cluster analysis (CA), principal component analysis and multiple regression analysis on principal components. CA showed four different groups of similarity between the sampling sites reflecting the different physicochemical characteristics and pollution levels of the studied water systems. Six latent factors were identified as responsible for the data structure explaining 90% of the total variance of the dataset and are conditionally named organic, nutrient, physicochemical, weathering, soil-leaching and toxic-anthropogenic factors. A multivariate receptor model was also applied for source apportionment estimating the contribution of identified sources to the concentration of the physicochemical parameters. This study presents the necessity and usefulness of multivariate statistical assessment of large and complex databases in order to get better information about the quality of surface water, the design of sampling and analytical protocols and the effective pollution control/management of the surface waters.

III. HARDWARE COMPONENTS

In the proposed smart Water Quality Monitoring system, a reconfigurable smart sensor interface device that integrates data collection, data processing, and wireless transmission is designed. The hardware of wireless water quality monitoring system comprises the following components.

A. Temperature Sensor

An analog temperature sensor is pretty easy to explain, it's a chip that tells you what the ambient temperature is. These sensors use a solid-state technique to determine the temperature. That is to say, they don't use mercury like old thermometers, bimetallic strips like in some home thermometers or stoves, nor do they use thermistors temperature sensitive resistors. Instead, they use the fact as temperature increases, the voltage across a diode increases at a known rate. Technically, this is actually the voltage drop between the base and emitter. By precisely amplifying the voltage change, it is easy to generate an analog signal that is directly proportional to temperature. There have been some improvements on the technique but, essentially that is how temperature is measured. Because these sensors have no moving parts, they are precise, never wear out, don't need calibration, work under many environmental conditions, and are consistent between sensors and readings. Moreover they are very inexpensive and quite easy to use.

B. PH Meter

A pH Meter is a scientific instrument that measures the hydrogen-ion concentration in water-based solutions, indicating its acidity or alkalinity expressed as pH. The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter". The difference in electrical potential relates to the acidity or pH of the solution. The pH meter is used in many applications ranging from laboratory experimentation to quality control. Potentiometric pH meters measure the voltage between two electrodes and display the result converted into the corresponding pH value. They comprise a simple electronic amplifier and a pair of electrodes, or alternatively a combination electrode, and some form of display calibrated in pH units. It usually has a glass electrode and a calomelreference electrode, or a combination electrode. The electrodes, or probes, are inserted into the solution to be tested.

C. Conductivity Sensor

Conductivity sensors are compact, fully integrated sensors for measuring the electrical conductivity of seawater. Conductivity is a key parameter for in-situ measurements of several fundamental physical properties of seawater. For seawater, the ability to conduct electrical current is mostly dependent on temperature and the amount of inorganic dissolved solids. Salinity is defined as the concentration of dissolved solids. This means that, together with temperature and depth information, a good estimate of the salinity may be determined. By using the inductive principle, stable measurement can be obtained without utilizing electrodes that are easily fouled and may wear out in the field.

D. Water Level Sensor

Wide spectrum of sensors is available in the market and commonly, they are classified based on the specific application of the sensor. Sensor used for measuring humidity is termed as humidity sensor, the one used for measurement of pressure is called pressure sensor, sensor used for measurement of displacement is called position sensor and so on though all of them may be using the similar sensing principle. In a similar fashion, the sensor used for measurement of fluid levels is called a level sensor. Quite obvious from its name, level sensors are used to measure the level of the free-flowing substances. Such substances include liquids like water, oil, slurries, etc as well as solids in granular/powder form (solids which can flow). These substances tend to get settled in the container tanks due to gravity and maintain their level in rest state. Level sensors measure their level against a pre-set reference.

E. Turbidity Sensor

Turbidity is the quantitative measure of suspended particles in a fluid. It can be soil in water or chocolate flakes in your favorite milk shake. While chocolate is something we so want in our drinks, soil particles are totally undesired. Keeping aside the potable purposes, there are several industrial and household solutions that make use of water in some or other manner for instance, a car uses water to clean the windshield, a power plant needs it to cool the reactors, washing machines and dish washers depend on water like fish. Turbidity Sensor, which along with a micro controller unit, takes care of turbidity measurements. Crafted with plastic and some metal-alloy traces, turbidity sensor uses light to convey information about turbidity in water. The turbidity sensor appears like an Android bot. Two horn like structure, a top to bottom mono material body.

F. Arduino

Arduino is a computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The project's board designs use a variety of microprocessors and controllers. These systems provide sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. The microcontrollers are mainly programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

IV. SYSTEM DESIGN

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development. Design is the creation of a plan or convention for the construction of an object or a system as in architectural blueprints, engineering drawings, business processes, circuit diagrams and sewing patterns. Design has different connotations in different fields. In some cases the direct construction of an object as in pottery, engineering, management, and cowboy coding and graphic design is also considered to be design. Designing often necessitates considering the aesthetic, functional, economic and socio-political dimensions of both the design object and design process. It may involve considerable research, thought, modeling, interactive adjustment, and re-design.

A. System Architecture

System architecture is the conceptual model that defines the structure, behaviour, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviours of the system. System architecture can comprise system components, the externally visible properties of those components, the relationships between them. It can provide a plan from which products can be procured, and systems developed, that will work together to implement the overall system. There have been efforts to formalize languages to describe system architecture; collectively these are called Architecture Description Languages (ADL). The system architecture is shown in the figure 1.

Figure 1 : System architecture

The system architecture of IoT based water quality monitoringsystem using wireless sensor network has following 3 levels.

1) Sensor Part : It consists of the sensors which are connected to the microcontroller. Temperature sensor which measures the analog values of the environment, PH sensor which measures the PH value of the water and conductivity and water level and turbidity are also used to measure the different parameters of the water.

*2) Cloud Part :*Cloud computing is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling on demand access to a shared pool of configurable computing resources like computer networks, servers, storage, applications and services, which can be rapidly provisioned and released with minimal management effort. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in either privately owned, or third-party data centers that may be located far from the user ranging in distance from across a city to across the world. Cloud computing relies on sharing of resources to achieve coherence and economy of scale, similar to a utility like the electricity grid over an electricity network.

3) User Part : It is an android phone which in which a blynk app should be downloaded from the play store. Blynk is a Platform with iOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet.

B. Dataflow diagrams

A data flow diagram is a graphical representation of the flow of data through an information system, modelling its process aspects. A dataflow diagram is often used as a preliminary step to create an overview of the system, which can later be elaborated. Dataflow diagram can also be used for the visualization of data processing. A dataflow diagram shows what kind of information will be input to and output from the system, where the data will come from and go to, and where the data will be stored. It does not show information about the timing of process or information about whether processes will operate in sequence or in parallel.

The dataflow diagram ofIoT based water quality monitoringsystem using wireless sensor network has following 3 levels.

1) Level 0 : The level 0 is one of the dataflow diagrams of the IoT based water quality monitoringsystem using wireless sensor network. This level represents the basic flow of data connecting the user to the sensors and monitoring the water quality. The level 0 dataflow diagram is as shown in the following figure 2.

Figure 2 : Dataflow level 0 diagram

2) Level 1: The level 1 is one of the dataflow diagrams of the IoT based water quality monitoringsystem using wireless sensor network. This provides a detailed of all the sensors connected. The level 1 dataflow diagram is as shown in the following figure 3.

Figure 3 : Dataflow level 1 diagram

3) Level 2 : The level 2 is one of the dataflow diagrams of the IoT based water quality monitoringsystem using wireless sensor network. Detailed structure of the Blynk app is given in level 2. The level 2 dataflow diagram is as shown in the following figure 4.

Figure 4 : Dataflow level 2 diagram

C. System Implementation

The iot water quality monitoring system consists of three main parts that are mentioned below. There are 3 modules in the system implementation of IoT based water quality monitoring system using wireless sensor network.

1) Accessing the Sensor Value : Accessing the sensor values is one of the modules in the system implementation of IoT based water quality monitoring system using wireless sensor network. Accessing the sensor values is given as the algorithm as shown in the following figure 5.

Figure 5 : Accessing the sensor values

2) Cloud : The cloud is one of the modules in the system implementation of IoT based water quality monitoring system using wireless sensor network. The cloud is given as the algorithm as shown in the following figure 6.

Figure 6 : Cloud

3) Blynk App : The blynk app is one of the modules in the system implementation of IoT based water quality monitoring system using wireless sensor network. The blynk app is also referred as user. The blynk app is given as the algorithm as shown in the following figure 7.

Figure 7 : Blynk app

V. CONCLUSION

The proposed smart water quality monitoring system of single chip solution to interface transducers to sensor network using arduino uno is presented by using a wireless sensor network. The results of the five parameters of water quality are verified that the system achieved the reliability and feasibility of using it for the actual monitoring purposes. The water temperature may vary from 0 to 0.4 Degree Celsius depending on the speed of the ambient air temperature cycles. The time interval of monitoring can be changed depending on the need.

By introducing the arduino uno board, the proposed system inherits high execution speed and reusable Intellectual Property (IP) design. The proposed system will assist in protecting the ecological environment of water resources. The smart water quality monitoring system minimizes the time and costs in detecting water quality of a reservoir as part of the environmental management. The wireless sensor network will be developed in the future comprising of more number of nodes to extend the coverage range.

VI. FUTURE SCOPE

The proposed work has a lot of scope interms of maintaining the purity of water.The overall project scope includes city-specific water quality monitoring.To address the water quality in all the industrial areas water monitoring stations will be installed at locations such as residential, industrial areas.

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