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Automated IoT based Smart Water Quality Assessment System

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***Abstract*—The aim of this paper is to develop automated Internet of Things (IoT) based Water Quality monitoring System. The different sensors are used to monitor the different parameters of water. The whole System having Arduino to interface the sensors and GSM module for remotely monitoring the data. This complete system is solar powered. The device is useful for accessing the quality of water. It can monitor the different water bodies in real time. We are presenting a design and development of a cost effective system for real time water monitoring. Also the device can measure other physical and chemical properties of the water. The Apparatus consist of modules Turbidity Sensor, pH sensor, Temperature & TDS Sensor. All sensors are connected with Ardurino. Ardurino converts the signal form into system readable form and send it to GSM module. The GSM Module will send the sensed data to Smart devices/ cloud through IOT platform. The result can be accessed daily/weekly or monthly.**

Keywords: Internet of Things, Total Dissolved Solid, Power of Hydrogen (Ph), Global System for Mobile, Liquid Crystal Display

I. Introduction

Water is the most essential element to life on Earth. As per the article 47 of Indian constitution has a prime concern to provide clean drinking water. It also has the important responsibility for the state to improve the standard of public health. The Clean Drinking Water Supply in Rural is a major problem. So safer and Quality water supply is important necessity in that area. Drinking water supply is also one of the six components of Bharat Nirman[1]. Accurate quantification of lake/River water quality is essential for its management and improvement. So there is an urgent requirement for precise and decent water resources planning and management. For this we have to ensure sustainable use of watershed resources. This could be achieved through precise and reliable models.

In this project our objective is to create a low cost automated system to assess the quality of water based on Internet of Thing (IOT)/smart sensor technologies Bhimtal and Nainital Lake.

For achieving this we will make use of information technology. Smart sensing devices gives valuable water quality information very quickly over the other water quality assessment tools.

We can collect different water quality parameter information with slite variation using Internet of Thing through sensor. After that we can do required qualitative comparisons. It has also be a powerful tool to trace the impact of contaminated Water. It is a powerful tool for storage, collection, retrieval and management of a Multitude of spatial and non-spatial data. This model will helps to predict sensitivity and vulnerability analysis.

The overall objectives of using these Information technologies in mountain areas are to bring about an improvement in the quality of water. It is a cost-effective technology for providing water quality of lake. Moreover, this method has become a technological method of choice due to the enhancement of most of the water quality parameters; and it serves as an inexpensive tool to purify water from lake. This system can be implemented on system to continuously monitor the water quality. It can be helpful to monitor the quality of water. In future the ability of this proposed model is also the prediction of water quality of Lake Bhimtal/Nainital.

A. Origin of the Proposal

There are number of lakes in hill area of Uttarakhand. These lakes are big water reservoir of Himalaya and plays very big role for Himalayan ecology. The management of lake water quality is a major environmental challenge. Lake provides multiple services such as water supply, waste assimilation, fisheries[2,3], and spiritual cultural. Indian Government is investing approximately Rs. 8588.2 crore on Himalayan ecology and established separate ministry to clean the Ganga river named as Namami Gangay. Cleaning of water is very important for humanity. Therefore an urgent need to device a low cost automated water quality assessment technique based on computing technology, for Himalayan Lake, So that we can save the health, life of affected society.

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B. Definition of the Problem

In hill area the availability of drinking water is very worst and sources are limited. Existing water sources are going to be polluted day by day due to the increase of population. So it can affect the health of large area of population. Throughout history there have been many instances when large number of people have died due to disease causing germs proliferate via society by a polluted water supply. The low quality of water caused gastrointestinal diseases, typhoid, diarrhea, reproductive problems, neurological disorders, and even cancer disease. The latest water assessment has been indicated about the water quality is very alarming About to 80% of India's surface water is polluted, an international organization working for water sanitation and hygiene. A large number of population of Uttarakhand is drinking polluted water. An estimated 580 people in India die of water pollution related illness every day ("An overview of diarrhea, symptoms, diagnosis and the costs of morbidity" (PDF). CHNRI. 2010. Archived from the original (PDF) on May 12, 2013.). Most of the population is directly consuming the water without any filtration process. Very few people could use/consume the filtered water due to its higher installation and maintenance cost of the water filter unit. A casual investigation has revealed that in Uttarakhand, poor population are not using any scientific method for quality assessment of water. They generally drink water directly from source. No scientific quality assessment method is applied at their level either.

Fig. 1 : Map of Uttarakhand

The present water quality assessment is very tedious and time consuming, because it is manual and judged through lab testing. As per survey of literature and onsite inspection at local level, we found that the companies are installing different water filter but they are very costly sometime they are not very reliable so their use is not widespread. If we are using filtered water for long time it cause the lake of minerals in body. We found that, there is no computer based automatic water quality assessment system applied.

C. Importance of the Proposed Research in the Context of Current Status

As per above review of current status of research and development in the subject at national and international level, we came to this conclusion that the Computing technology based automated water quality assessment technique is a requirement of time, and Nainital and Bhimtal lake is suitable for the study.

Although there are number of lakes in Himalayan region but we have taken Nainital lake for experimenting the pilot study further it can be applied on other lake, river and reservoirs of the state or Himalaya. The Nainital Lake is a famous lake of India situated at kumaun region of Uttarakhand state. It one of the famous tourist place of Inda. This lake having 48 hectares surface area. The maximum depths of the lake is 27.3m.

Springs, rainwater, and many inlet nullahs receive water in this lake. Around 40,000 local inhabitants are dependent on this lake. But sometime back anthropogenic activities such as construction, domestic sewage, agricultural activities and surface runoff have remarkably changed the quality of water of the this Lake. Most of the researcher Nationally and internationally working in same area so this research is very essential for the state.

D. How this Proposal is Beneficial to the State

A huge number of population of Uttarakhand lives in the remote hilly area. Approxmately 90 % of the rural and hill area population depends on the direct and natural water. The topography of the state is high and deep slops. the surface water sources and lakes meets the rising demand of water.

Fig. 2: Satellite Image of Nainital Lake

A large population of the state is below poverty line in Uttarakhand. Therefore this low cost water quality Assessment solution is very acquate for the poor population of the state. All the time the Government agency and other one could know the quality of water on any means of communication. If proposed system sense that the quality of water is not up to the mark, the corrective action could be taken by the local body

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II. Survey of Literature

We have reviewed and analyzed a lots of good quality research paper which has been published by different scientist/researchers internationally and nationally on water quality. Following are some research paper which are very important for our project work.

Panda et al. worked on "ANN Application in Lake Water Quality calculation with the help of Satellite Images". To predict the Cl and SM concentrations of water they have designed Radial basis function neural (RBFN) network models. The model is trained and verified with data from the years 2001 to 2004. The RBFN testing model have resulted in a coefficient of determination (R2). The root mean square error, average testing accuracy and standard error prediction (SEP) indicated the merit of the developed models.

Somvanshi et al. worked on "Integrated remote sensing and GIS approach for water quality analysis of Gomti river, Uttar Pradesh". They have worked in nearby cities of lucknow as. Sitapur, Barabanki districts to do the mapping of water quality parameters of Gomti River, Barabanki and Lucknow districts of Uttar Pradesh, India. IRS LISS III data used and analyze with measured sample points for mapping. The water quality parameters included SS, Chloride, TS, pH, DS, COD and TH.

Balasaheb et al. worked on "Review on Study of Lake Water Using Multi Sensor Remote Sensing Data". They used multi sensor satellite data such as IRS LISS III or OCEANSAT-1(IRS-P4), Landsat TM/ETM+. Significance is given on the analysis of capabilities of IRS LISS III or OCEANSAT-1(IRS-P4), Landsat TM/ETM+ data in monitoring water quality of lakes. A classification scheme regarding various water quality parameters (Turbidity, Chlorophyll –α, Total phosphorus and Secchi depth) is created based on combinations of different bands.

Indrani et al. worked on "Measurement of Water Quality aberration in the Godavari River with the help of Clustering and GIS Techniques". The main focus of their research is to design a tool for planning and management of the Godavari river water quality. This is obtained by classifying the pollution layers of Godavari River into different levels with the help of water quality index and a clustering approach. The results of the separation Analysis revealed that esired parameters i.e. pH, Faecal Coliform (FC), Dissolved Oxygen (DO), and Ammonia Nitrogen (NH3-N) and Total Coliform (TC) were necessary for study in spatial variation.

Sunitha et al. worked on "Water monitoring with the help of Satellite Image analysis Methods and Techniques[4]: A Review". On their work they study satellite image classification methods 1) Automatic classification, 2) manual classification and 3) hybrid and techniques along with their own advantages and disadvantages. The authors have also compared various researchers' comparative results on satellite image analysis techniques from different researcher's results.

After studying the above research paper we come to the conclusion that the most of scientist/researcher has done their research work for water quality assessment using multi-model soft sensing method/GIS/ Hyper spectral Remote Sensing/Satellite Imaging. Very few researcher has done water quality assessment using smart sensor. Smart sensor/ Internet of Thing is a newer technology, normally this method is not frequently used by majority of the researcher. Therefore we worked on "**development of Automated Internet of Thing (IOT) based smart water quality assessment system for Bhimtal/Nainital Lake".**

III. Objective

The Major objective of the research work:

1. To extract the water quality parameter through Smart Technologies/ Internet of Things/ smart imaging technique or other relevant method.
2. To device an analysis technique, for low cost automated water quality assessment system based on computing technology.
3. To implement the developed system in Bhimtal/ Nainital Lake or various water bodies of Uttarakhand.

IV. Methodology

In the first phase of the project we had reviewed the state of the art in water quality assessment devices/ technologies. We have also reviewed the different study of water quality monitoring techniques which is done in India and other country. By this study we have finalized the standard parameters and equipment which will be used in our system.

In the Second phase we have developed a technique to input the standard parameter. A sensor platform was designed to collect remotely the required parameter information of lake water. The recorded or captured sensor value will be pre-processed. After pre-processing we will extract the required parameter information in appropriate or required format. For this pre-processing we need to develop a computer vision sub-system for extracting the information. The water quality parameter information that has to be extracted may be chemical[5, 12] and biological parameters and have been identified as turbidity, TDS, pH, calcium, dissolved solids, copper, coliform bacteria, magnesium, sulfate,manganese, nitrate, fluoride, zinc, phenolic compound, alkalinity, cadmium, arsenic, lead, chromium, pesticides, aluminium. But in our system we have selected some major and common parameters that have included in our study.

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Image interpretation system can also be used [6]. This system can be designed to input water quality data from the high spatial resolution imagery (for example digitized photograph) and/or through compatively coarse spatial and spectral resolution sensor data (for example Landsat Thematic Mapper) otherwise through installing sensors in the water reservoir as needed.

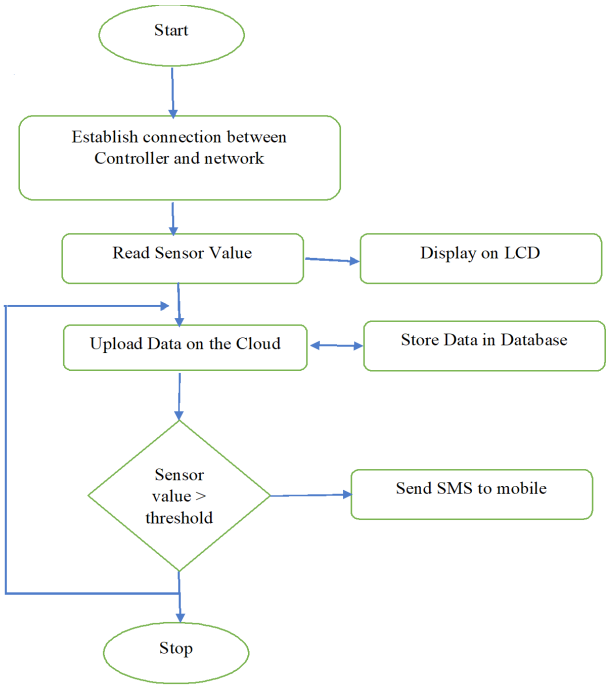

Fig. 4: Flowchart for Device Work

Either we will develop an automated software to collect the required parameter or we can use some readymade software which fulfill the same requirement, as per availability in software market. The selected sensor will be directly connected with the Arduino[7] board and GSM[8] shield, finally all the sensor will be assembled as a single unit. The GSM shield will send all sensor information in central server. The software in the server will identify the water quality considering national and international parameter. N number of devices can be connected with the central server. This way the server can identify and alarm the polluted water source or reservoir. We can also display the polluted area in the Google map.

Artificial Neural Network can also be used for water quality forcasting. Through the collected parameter and Artificial Neural Network (ANN) we can also develop a system to classify the water as per their quality[9] . For this we to develop appropriate type/architecture, activation functions of various stages and learning strategy, rate etc. of Artificial Nural Network. We will develop appropriate training methodology and post training learning strategies. So this will be the future plan or extension of our research project.

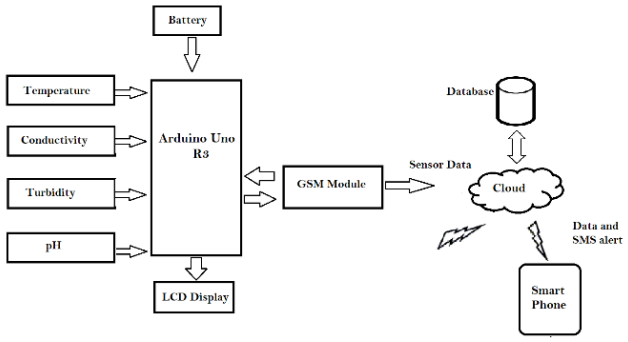

Fig. 5: Block Diagram of Water Monitoring System

The ANN is a data driven modeling technique. This technique can be proposed to forecost the water quality any water reservoir. Several ANN models can be designed for this extension model but best one will be finalized for forecasting or classification.

Some sample of water was taken for lab testing or chemical analysis and that was also compared with the water Quality sensed by proposed device. Finally we have combined all phases. This way we have developed complete automated system and device has been installed in Nainital/Bhimtal lake to monitor the quality of water. During the project time the USERC has run and take care whole system.

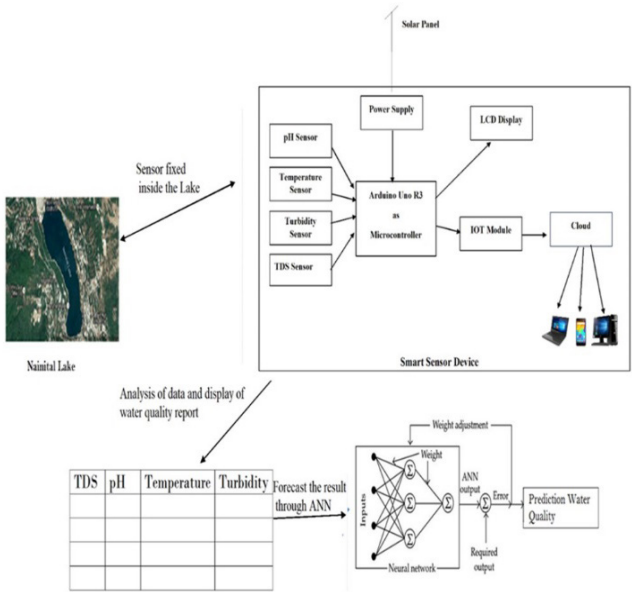

Fig. 6: Proposed Water Quality Model

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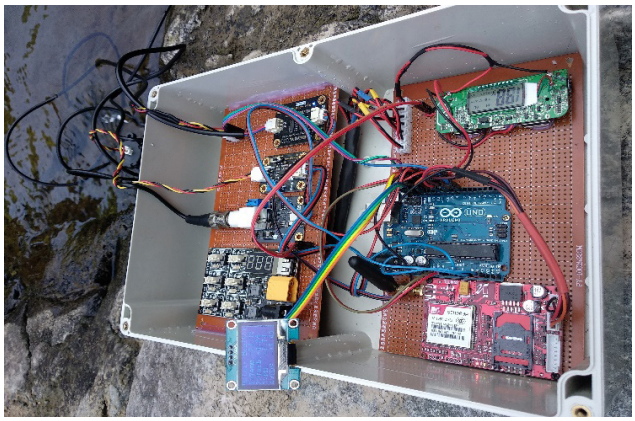

Fig.7: Device Photograph during the Live Testing

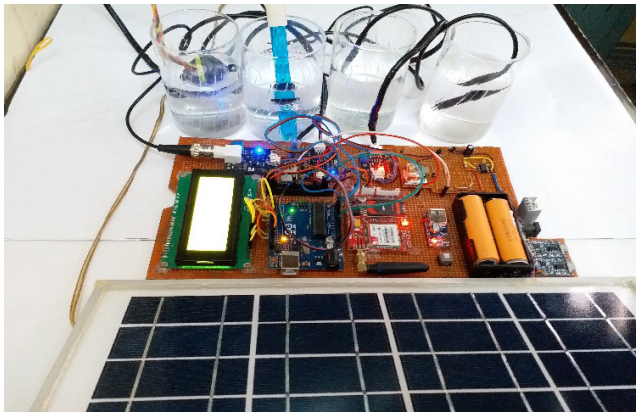

Fig. 8: Complete Photograph of Prototype Device with Power Source

V. Working Principle

In the above block diagram of the proposed system we are using Arduino Uno R3 as controller. this forms the main or core part of the Internet of Thing based water quality monitoring system. Various Sensors are directly connected or interfaced with the controller. Battery will provide power to whole system. The sensor data i.e. TDS, temperature, turbidity, pH are measured or estimated by using the sensor into different water bodies such as lake, river, water tank etc.. The measured data of water by sensors can be displayed through LCD panel[10]. This measured data will be sent to the cloud with help of GSM module [13, 14]. We have developed a mobile application where values obtained by the sensors will be displayed. Same time the collected data will be stored in database[11] (ORACLE/ SQL/MS Excel)for future use or reference for the water management authorities, researcher as well as users. The collected data from the database can be used for forecasting and classification of the water Quality.

VI. Result & Discussion

After the integration of all the hardware components and sensors the prototype was tested with various water samples and the statistics were recorded for analysis. The following table 01 is showing the recorded data from water bodies, which seems that prototype is working perfectly, after that we have tried to optimize the size and efficiency. We have also tried reduce physical size and spacing of the device. For the pH sensor, samples are taken and compared with the pH standards. The digital temperature sensor reading was recorded and compared with the mercury thermometer and other temperature measuring devices. The TDS and the turbidity were cross checked with the readings of Jal Sansthan's Data. The testing phase was carried out in a span of about six months in which the devices were placed at various locations of water bodies around in Uttarakhand.

Table 01: Results from Different Samples

S. N.	Temperature	Turbidity	PH	TDS
1	19.5	.91	8.36	293.66
2	19.5	1.16	8.13	293.66
3	19.5	1.37	8.2	293.66
4	19.5	1.48	8.31	293.66
5	19.5	1.49	8.32	295.59
6	19.5	1.41	8.34	293.66
7	19.5	1.4	8.12	295.59
8	19.5	1.38	8.22	293.66
9	19.44	1.43	8.12	294.05
10	19.44	1.43	8.12	294.05
11	19.44	1.42	8.17	292.12
12	19.44	1.32	8.13	294.05
13	19.44	1.25	8.29	294.05
14	19.44	1.23	8.31	292.12
15	19.44	1.18	8.31	294.05
16	19.44	1.2	8.12	294.05
17	19.38	1.13	8.15	294.45
18	19.38	1.14	8.27	294.45
19	19.38	1.11	8.13	292.51

Following four graphs are representing the output of four different sensors e.g. Fig. 9 of Temperature, Fig. 10 of Turbidity, Fig. 11 of PH and fig. 12 of TDS results. These results were recorded on December 21st 2018, however the device is in active mode 24x7. The device gives continuous reading. These results are taken from running water. Therefor it seems slit variation in the result of following graph.

We are using cloud base IOT frame work namely as Things Speak. So, we can monitor our result remotely in different terminals/computer/smart devices. We have managed the data in excel form and in a oracle/SQL data base. The data can be viewed in a waveform or in a android platform. These results can be used for future forecasting and planning of water issues and regulation.

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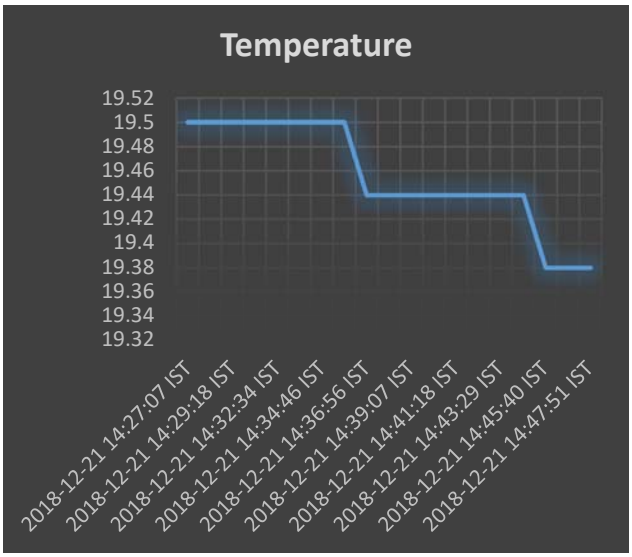

Fig. 9: Temperature Results on Graph

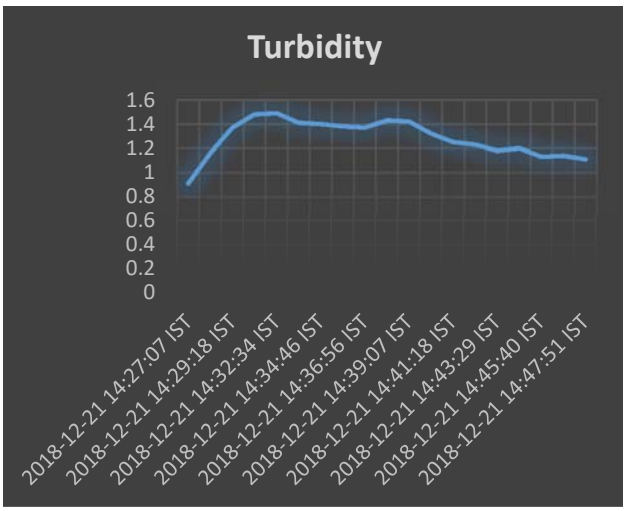

Fig. 10: Turbidity Results on Graph

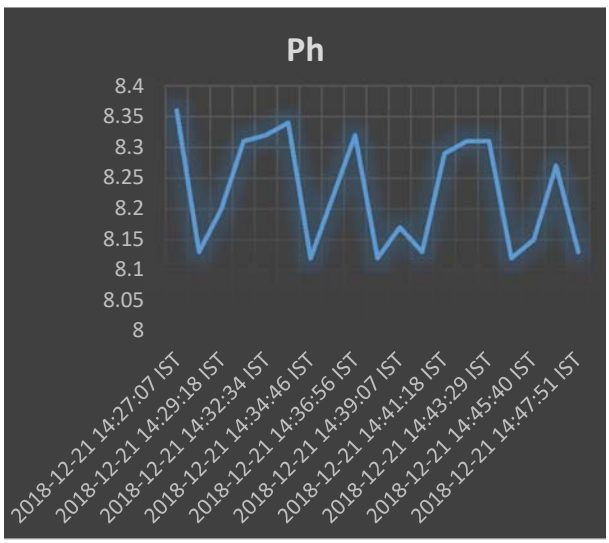

Fig. 11: PH Results on Graph

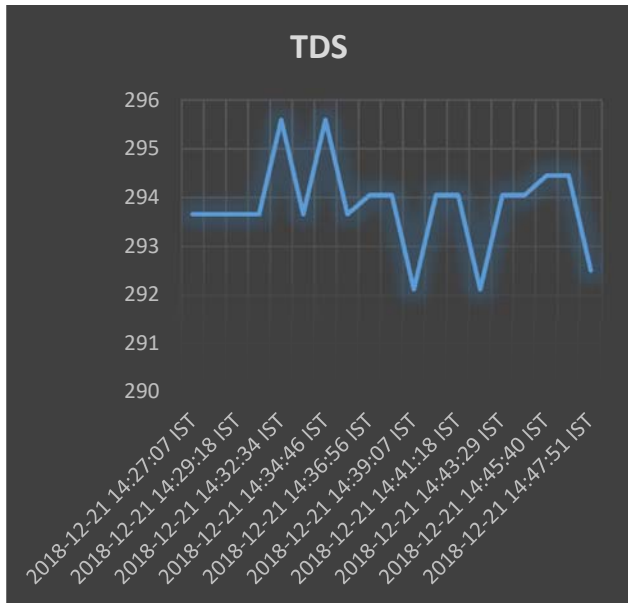

Fig. 12: TDS results on graph

VII. Conclusion & Future Scope

As we have developed an Automated IoT Based Smart Water Quality Assessment System. In This system, we can access real time or live water quality from remotely located lake or river. We can install various nodes in different location, which can be controlled from one base station. A group of sensor are connected with one nodes. The Collected data through sensors is sent to the base station with the help of Wireless Sensor Network technology.

In future we can established a system which is having more sensor nodes as per requirement. More base stations can also be included as the whole system needs. The Ethernet can be one more option to access the internet so that users can locate and get the real time water quality data remotely. The device can be prepared more sophisticated, reliable and optimized. The shape and design of the device can be more fine-tuned. As the device collects data in the tabular form in MS Excel or ORACLE. In future a method can be devised that can forecast the water quality from the data gathered by our system and different machine learning techniques can be used to forecast the data. This way we can forecast, classify or clustering of the water. We can also prepare the water atalas of clean water by using this system.

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