WATER QUALITY MONITORING SYSTEM USING WIRELESS SENSOR NETWORKS

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

In

Computer Science and Engineering

By

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Under the supervision of

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To

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Candidate's Declaration

I hereby declare that the work presented in this report entitled **" Water Quality Monitoring System using Wireless Sensor Networks"** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering** submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2016 to December 2016 under the supervision of **Dr Yashwant Singh**(Associate Professor –CSE department).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Dr Yashwant Singh

Associate Professor

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Dated: 28-4-2017

Acknowledgement

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I extend my gratitude to Jaypee University of Information Technology for giving me this opportunity. I also acknowledge with a deep sense of reverence, my gratitude towards my parents and members of my family, who always supported me morally .

Thanking You,

Akshita Ahluwalia

ABSTRACT

In the traditional times water quality monitoring was a very big issue. People were kept for getting samples from the water bodies and then bringing the samples to the laboratories. This resulted in more cost, more man power requirement and more time. The major issue at that time that resulted due to this problem was that real time data could not be delivered. Traditional methods for Water Quality Monitoring had these disadvantages due to which modern methods are used now. In modern methods wireless sensor network is used which sends data wirelessly to the user from base station. It has far better performance as compared to traditional methods of water quality monitoring .It requires lesser cost, lesser manpower, lesser time and most importantly delivers data in real time. This method of water quality monitoring is far more efficient than traditional method. In this project I have simulated a water monitoring system using the WSN technology for observing water quality with particular emphasis on heavy metals.

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Chapter-1 INTRODUCTION

1. INTRODUCTION

Freshwater is a limited asset which is vital. It is useful for horticulture, industry and furthermore for survival of human beings. If freshwater is not of adequate amount and quality sustained growth is impossible. Water contamination and inefficient utilization of freshwater jeopardize ventures causing development. . Over-pumping of aquifers, Release of unsafe chemicals, long-run air transport of poisons and sullying of water bodies with substances that advance development of algal growth are some of today's extremely real reasons for water quality deterioration. It has been demonstrated that great quality water is crucial for financial advancement also. Sea-animals are being undermined due to pollution and dangerous utilization of water-administration. A large portion of the water quality issues are there from quite a while however they are raising exceptionally now and other issues are evolving at a great pace. Therefore treating polluted water should be the fundamental aim to meet end goal to deliver safe drinking water .Net natural contamination prompts aggravating of the oxygen ratio in water and extreme pathogenic sullying.

Definition of water quality by WHO is as follows - "Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact, and drinking water."

Monitoring is defined by the International Organization for Standardization as follows- "The programmed action of measurement, sampling and subsequent recording or signalling or both of various water characteristics, often with the goal of assessing compliance to specified objectives. Monitoring is of three types - First is long-term, second is short-term and third is continuous monitoring."

Testing of Water quality is a very essential part of monitoring the environmental. When water is of poor quality, it infects both aquatic life and the surrounding ecosystems present. Physical properties of water quality are as follows: temperature and turbidity. Chemical characteristics are: dissolved oxygen and power of hydrogen. Biological indicators of water quality are: phytoplankton and algae. The mentioned parameters are rare not only meant for surface water studies of the lakes, oceans, and rivers, but also for groundwater and industrial processes.

Various reasons can be indicated regarding why water quality should be checked. The data for one cause might be helpful for another. Information of water quality checking might be of handiness in the administration of water assets at various levels i.e. nearby, national and universal. At the point when nations share water bodies then a water quality observing project gives data that helps in establishment of universal understandings between them relating to the utilization of these water bodies. Water quality monitoring is the premise of water quality administration. Checking of Water quality gives the subtle elements that permits intelligent decisions to be made on- issues of water contamination. , Creating and actualizing water quality administration programs, Survey the effectiveness of management activities. [4, 5, 11]

The list of indicators used to measure water quality is as follows:

Alkalinity

Sir Andrew Dickson defined alkalinity as "The total (or titration) alkalinity of a natural water sample can be regarded as a measure of the proton deficit of the solution relative to an arbitrarily defined zero level of protons. The problem of unambiguously incorporating any particular acid-base system into the definition of alkalinity is thus the one of deciding which form to specify as the zero level of protons, and it is proposed that it be defined so that acids with a dissociation constant $K > 10^{-4.5}$ (at 25°C and zero ionic strength) are considered as proton donors, whilst those bases formed from weak acids with $K < 10^{-4.5}$ are considered proton acceptors"

Alkalinity in simpler words is defined as the capability to counteract acidic/Alkaline compounds is natural buffers that can separate excess hydrogen. Extreme level of alkalinity leads to "embrittlement".

pH

The National Bureau of Standards defines pH as**"quantitative** measure of the acidity or basicity of aqueous or other liquid solutions. The term, widely used in chemistry, biology, and agronomy, translates the values of the concentration of the hydrogen ion — which ordinarily ranges between about 1 and 10^{-14} gram – equivalents per litre — into numbers between 0 and 14. In pure water, which is neutral l (neither acidic nor alkaline), concentration of the hydrogen ion is 10^{-7} gram – equivalents per litre which corresponds to a pH of 7. A solution with a pH less than 7 is considered acidic; a solution with a pH greater than 7 is considered basic, or alkaline."
pH i.e power of hydrogen is a numeric scale useful for specifying solution's acidity /basicity. More the value on the scale more basic it is and lesser the value on scale more acidic it is. Value equal to 7 implies solution is neutral; less than 7 implies it is acidic and greater than 7 implies it is basic If species is more sensitive then it is more affected by alteration in ph value.

Dissolved Oxygen

Dissolved oxygen is defined as the level of free non compound oxygen present in water or other liquids". It is a very essential factor for measuring water quality.High and low level of dissolved oxygen affects the organisms immensely. A fish kill/ winterkill occurs due to prolonged reduction in dissolved oxygen due to ice or snow cover on a lake or pond. Not only low dissolved oxygen but also high concentration is harmful. A special type of sensor is used to measure dissolved oxygen (DO) inside water. Solubility of dissolved oxygen increases as temperature increase. Sources of dissolved oxygen in water are – oxygen from photosynthesis process and from the air.

Turbidity

Turbidity is the determination of clarity of water. Turbid water appears cloudy or colored affecting the physical look of the water. An opaque, hazy or muddy appearance is caused by suspended solids and dissolved colored particles. Turbidity can be caused due to suspended sediment like clay or silt, inorganic materials, or organic matter such as algae, plankton and decaying material.

Large amount of turbidity creates difficulty for navigation and increases risks of flooding. As turbidity increases water quality decreases .Higher turbidity prevents light from entering the water body thus causing threat to aquatic life.

Temperature

Temperature is a very important factor which should be considered when evaluating quality of water. Although some of the aquatic plants can bear cooler waters but most prefer warmer temperatures. Below 21°C water temperature tropical plants show restricted growth and dormancy. While dormancy is apt to survive a cold winter, warmer temperatures are needed for most plants to live. Temperature can also prohibit respiration and photosynthesis of plants. Photosynthesis by algae is increased as the temperature of water body gets increased.

Heavy metals

A toxic heavy metal is any thick metal/metalloid that is noted for its toxicity especially in context of environmental. Heavy metals basically refer to cadmium, mercury, copper, silver, selenium, antimony, thallium, chromium, cobalt, nickel, lead, manganese and arsenic. All these heavy metals are present in the World Health Organization's catalogue of heavy metals. Heavy metal is a very important factor which should be considered when evaluating quality of water

Chloride

High concentration of chloride ions causes occurrence of salty taste in water .Chloride is an indicator of water pollution. Higher the amount of chloride more

polluted the water is. Amount of chloride permissible for drinking water is 250 Milligram/litre.

Phosphorus

Phosphorus (P) is present in ammonia, nitrite, and nitrate. Phosphorus comes from yard waste, animal feedlots, fertilizers and wastewater .As the amount of phosphorus in water increases the water quality decreases because algae growth is supported by phosphorous which cuts the oxygen supply in water is mentioned earlier.

Nitrates and Nitrites

Nitrogen is a very essential nutrient for plants and algae. Amount of nitrate permissible for drinking water is 45 mg/l. Nitrate and nitrites are an essential part of fertilizers and organic material. This element enters water mainly from industries. Higher the amount of nitrate lower is the water quality. Excessive nitrates cause "blue baby" syndrome.

Fluoride

Amount of fluoride permissible for drinking water is 1 mg/l.At higher quantity it leads to mottling/ fluorosis of the teeth. Fluoride should be present in the range of 1-1.5 mg/l in water to ensure good quality water.

Sodium

Sodium is an active metal whose occurs in nature. Amount of nitrate permissible for drinking water is 1 mg/l. Large amount of sodium in drinking water causes risk of "heart attack" in human beings.

Sulphate

Amount of sulphate permissible for drinking water is 400 Milligram/litre. If the level of sulphate exceeds this value then it leads dehydration in human beings.

Selenium

Amount of selenium permissible for drinking water is 0.1 Milligram/litre. If the level of selenium exceeds this value then causes damage to the peripheral nervous system; fatigue; irritability; damage to kidney, etc

Ammonia

Amount of ammonia permissible for drinking water is 0.5 Milligram/litre. If the level of ammonia exceeds this value then it might cause acid–base equilibrium disturbance, glucose intolerance and reduction in tissue sensitivity to insulin.

Cyanides

Amount of cyanide permissible for drinking water is 0.5 Milligram/litre. If the level of cyanide exceeds this value then cause depression of the central nervous system that can result in respiratory arrest and death.

Aluminium

Amount of permissible for drinking water is 0.1 Milligram/litre. If the level of aluminium exceeds this value then it can cause Alzheimer disease which destroys the memory and functions of the brain.

Chromium:

Amount of chromium permissible for drinking water is 0.05 Milligram/litre. If the level of chromium exceeds this value then cause allergic reactions , ulceration of the skin, elevated cancer risk.

Iron

Amount of iron permissible for drinking water is 0.3 Milligram/litre. If the level of iron exceeds this value then it can lead to iron deficiency, anemia and fatigue, etc.

Nickel

Amount of nickel permissible for drinking water is 0.02 Milligram/litre. If the level of nickel exceeds this value then can cause lung cancer, cardiovascular disease, neurological deficits, developmental deficits in childhood, and high blood pressure, affect the kidneys and livers.

Copper

Amount of copper permissible for drinking water is 1.5 Milligram/litre. If the level of copper exceeds this value then can cause adverse health effects, including vomiting, diarrhea, stomach cramps, nausea, liver damage and kidney disease.

Zinc

Amount of zinc permissible for drinking water is 15 Milligram/litre. If the level of zinc exceeds this value then cause fever, nausea, vomiting, stomach cramps, and diarrhoea.

Arsenic

Amount of arsenic permissible for drinking water is 1 Milligram/litre. If the level of arsenic exceeds this value then it can cause the following- cancer in the skin, lungs, bladder and kidney; etc

Cadmium

Amount of cadmium permissible for drinking water is 0.003 Milligram/litre. If the level of cadmium exceeds this value then it causes can cause kidney dysfunction, lung impairment, cancer, tracheo-bronchitis, pneumonitis, pulmonary edema, dryness and irritation of the nose and throat, etc.

Mercury

Amount of mercury permissible for drinking water is 0.001 Milligram/litre. If the level of mercury exceeds this value then causes cause tremors, emotional ,insomnia, neuromuscular, headaches, disturbances in sensations, changes in nerve responses ,poor performance on tests of mental function.

Lead

Amount of lead permissible for drinking water is 0.01 Milligram/litre. If the level of lead exceeds this value then it causes damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells.

Other dissolved solids

Amount of other dissolved solids permissible for drinking water is 2000 Milligram/litre. If the level of other dissolved solids exceeds this value then it can cause cancer, coronary heart disease, arteriosclerotic heart disease and cardiovascular disease.

1.1 PROBLEM STATEMENT

In the traditional times water quality monitoring was a very big issue. People were kept for getting samples from the water bodies and then bringing the samples to the laboratories. This resulted in more cost, more man power requirement and more time. The major issue at that time that resulted due to this problem was that real time data could not be delivered. Traditional methods for Water Quality Monitoring had these disadvantages sue to which modern methods are used now.

In modern methods wireless sensor network is used which sends data wirelessly to the user from base station. It has far better performance as compared to traditional methods of water quality monitoring .It requires lesser cost, lesser manpower, lesser time and most importantly delivers data in real time. This method of water quality monitoring is far more efficient than traditional method. [3]

1.2 OBJECTIVES

- To study water quality and importance of water quality monitoring
- To study use of WSN in water quality monitoring systems
- To simulate a water monitoring system using the WSN technology for observing water quality with particular emphasis on heavy metals.

1.3. METHODOLOGY

Water Quality Monitoring system is divided into three main modules-

1.3.1 Sensor Unit:

Sensor unit comprises of several sensors to sense the water quality parameters. In this project sensor used measures only the amount of heavy metals like Ammonia, pH, Chloride, Fluoride, Arsenic, Iron, Nitrate, Sulphate, Selenium, Zinc, Mercury, Cyanide, Copper, Chromium, Nickel, Cadmium, Dissolved solids, Dissolved oxygen present in water. Data in the form of electrical signal is sent to the microcontroller or microprocessor for processesing it into form that is understandable by humans after being sensed/ detected by the sensor nodes. [3, 7, 12]

1.3.2 Wireless Sensor Node:

The WSN sensor is the principle building piece of the created WSN framework model. Behaviour of the WSN sensor is decided by a microcontroller and a software program .It is fitted with sensor and microcontroller units. The information detected by the sensor goes through a molding circuit which conditions it so that it can be processed efficiently in the upcoming stage. At the next point of time after this the information will be given to the controller. The wireless sensor hub in this comprises of sensor unit and a microcontroller .WSN depends on adaptable, simple to-utilize hardware and software. [3, 8, 9]

1.3.3 Base Monitoring Station:

The base station gets the information sent from the sensor hubs/nodes i.e. end gadgets and switches, remotely. Information that is got from the end gadget/device is sent to the PC and information got is shown utilizing the Graphical User Interface on the base observing/monitoring station. From earlier testing, we characterize an edge value (range of quantities) for the observing of the measure of metals inside the water. Contingent upon the value acquired whether it is higher or lower than the characterized limit we become acquainted with whether the water is appropriate or not for the particular reason. The acquired information is checked with the edge values of the predefined water parameters. In the event that the received water parameters don't coordinate with the preset values then SMS will be sent to concerned individual so as to take required measures. [10, 3, 7]

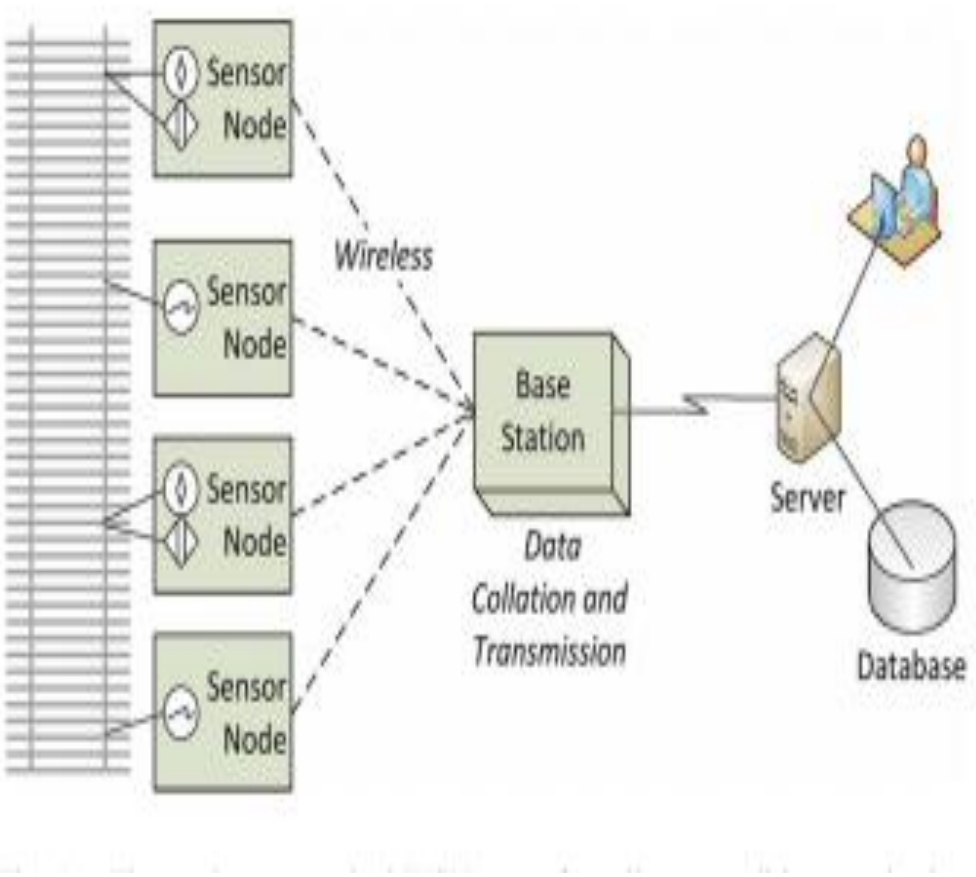

Fig 1: Water Quality Monitoring System Model

Diagram represents water quality monitoring system using wireless sensor network. The different kind of sensors i.e. Heavy metal sensor, ph sensor, DOES sensor sense the different parameters and sends the information to the base monitoring system [4]

1.5 Organization of report

Chapter 2 in this report is the literature survey which explains in detail the components of the water quality monitoring system.

Chapter 3 explains the system development i.e. the inference rules according to which system has been developed.

Chapter 4 describes the system performance and it's working.

Chapter 5 is the conclusion.

Chapter-2 LITRATURE SURVEY

2 BACKGROUND

WSN comprises of “nodes" which can vary from few to a large number. Every “node” is attached to different number sensors. Wireless sensor networks /wireless sensor actuator networks (WSAN) is defined as a collection of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location.

WSN is bi-directional. It checks the functioning of all the other sensors present in a network. Wireless sensor networks applications - to notice animals conduct in remote areas like in a forest, to notice temperature in an area after a fire and then temperature map is created, in smart buildings, in intensive care in hospitals, etc.

The WSN comprises of “nodes". Each “node” has four components which are as follows: a radio transceiver which is connected to an antenna, a microcontroller, which acts as an interface. A battery source and the fourth and main component is the sensor node which can be quiet small or big depending on the need. Extremely small "motes" are not developed till date. [11, 15, 18]

It requires lesser cost, lesser manpower, lesser time, delivers data in real time

And most importantly helps to develop a perfect water status graph. WSNs topology is one of the following - star topology, wireless mesh topology or cross layered topology. [12]

The main attributes of WSN are - It is resistant to failing of node; it is scalable; easy –to –use, has “cross layer” design, has “heterogenous” nodes, is resistant to severe environment conditions and consumes less power comparatively.

Designing of WSN is cross layered now as traditional “layered approach” had many shortcomings that were as follows:

1. It could not pass data among the various layers.
2. It did not assure network optimization

3. It could not modify in response to environment change.
4. It could not be used in wireless network.

Therefore nowdays cross layered approach is preferred for improving the transmission efficiency and the QoS.

Sensor nodes comprise a processing unit; radio transceivers and a power source like battery. Producing lower cost and smaller size sensor. Has not been possible till now. Research is still going on this issue.

WSN performs communication with a Local Area Network or Wide Area Network via gateway. The Gateway behaves like an interface for the Wireless Sensor Network and the network.

Wireless sensor network uses simpler OS as compared to normal OS used in our PC's. OS of WSN is similar to embedded systems. Wireless sensor networks are application specific. They do not have a general platform. Operating system like eCos and uC/OS are used for sensor networks. [2, 4]

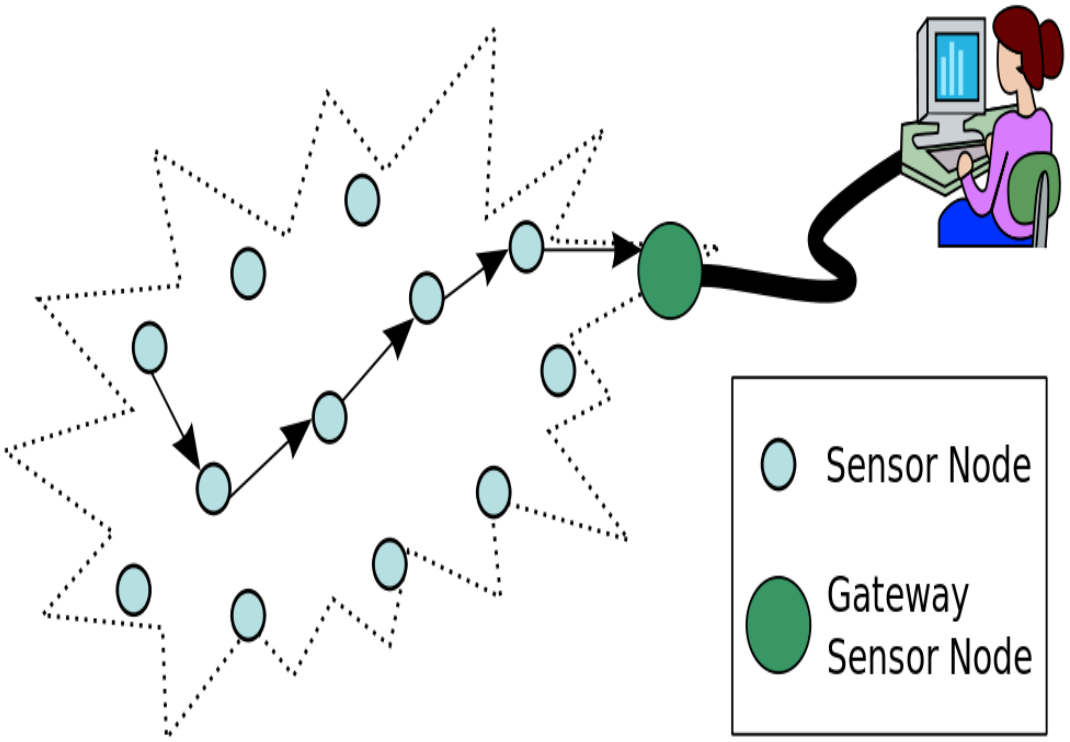

Fig 2: Diagramatic representation of Wireless Sensor Network [7]

"Water quality monitoring system using WSN" consists of the following components:

2.1 Sensor Unit

Sensor senses the input data and then sends the sensed information is further sent for processing. Input can be temperature, light, heavy metals, gases, vapour, pressure, etc. Output is an electronic signal which is further changed to human-readable form. There are many varities of sensor each of which has a different cost and size. In water quality monitoring system sensors used are – "inductive proximity sensors" to sense the amount of heavy metals like Ammonia, pH, Chloride, Fluoride, Arsenic, Iron, Nitrate, Sulphate, Selenium, Zinc, Mercury, Cyanide, Copper, Chromium, Nickel, Cadmium, Dissolved solids, Dissolved oxygen present in water;

“temperature sensor” to sense water temperature, “pH sensor” to sense power of hydrogen , “turbidity sensor” to sense how turbid the water is and “oxygen sensor” to sense amount of water present in water .[3, 13,19]

2.2 Wireless Sensor Node:

A sensor node called “mote” is a node that performs collecting, processing, and communication with all the nodes present in the network. A fact about a mote is that - “A mote is a node but a node is not always a mote”.

The sensor node consists of:

- A microcontroller,
- A transceiver,
- External memory,
- A power source,
- Sensors.[2]

2.2.1 Controller

Controller processes the input information and checks functioning of all the other parts in the node. Examples of controllers that can be used are microcontroller, digital signal processors, Field Programming Gate Array, etc. A microcontroller is used due to its lesser cost.It is also very flexibile in connecting to another device.It is easily programmable. It even consumes less power.

Microprocessor uses high power in comparison to microcontroller, so a microcontroller is used most of the times. [15, 17]

2.2.2 Transceiver

It does the work of receiver as well as of a receiver. It is defined as a device that can both transmit and receive communications, in particular a combined radio transmitter and receiver. Examples of transceivers that can be used for water quality monitoring system using WSN are “radio frequency” transceivers, “optical communication”

transceivers and "infrared" transceivers. Infrared, transceiver does not require any antenna. It can transmit to a lesser distance. Radio frequency transceiver is the most commonly used transceiver in WSN. WSNs work on following frequencies: 174, 434, 867 and 916 MHz and 2.5 GHz. Transceivers do not have different identifiers that are one issue with it. It has the following states -- transmit, receive, idle, and sleep.

Transceiver should be switched off when not in use as it consumes a lot of power even when it is not working. When a packet is to be transmitted by the transceiver a large amount of power is used. [6, 11, 12]

.

2.2.3 External memory

Sensors make use of flash memory or memory on chip because they are most energy efficient. Flash memory costs less and even has high storing capability. Memory required depends on the application being developed. [13]

2.2.4 Power source

Sensor node needs power supply for detecting data, communicating and then processing it. If it is not provided with required amount of power supply then it will stop working.

Mostly the wireless sensor node is present in a far away location so using battery as a power source for it is not a good option as battery has to be changed on regular basis. Battery (e.g-- nickel-cadmium battery, nickel-zinc, nickel-metal hydride battery) or capacitor is used as a power source for it .It could or could not require charging. Power in battery is saved in following ways – By switching off part of nodes that are presently not in use .This is called "Dynamic Power Management" or by changing amount of power supplied to nodes depending on situation This is called "Dynamic Voltage Scaling" .[12]

2.3 Sensors

Each senor has covers some are area in WSN and senses the input data and then sends the sensed information to microcontroller for further processing. Input for a sensor can be temperature, light, heavy metals, gases, vapour, pressure, etc. Output is an analog signal which is further converted into digital signal using ADC convertor changed to human-readable form so that humans can read it. There are many varities of sensor each of which has a different cost and size.Wireless sensor nodes are small in size so they are supplied power which is lesser than 0.6-2 ampere-hour and 1.3-3.8 volts.Sensors are of three types –"passive, omnidirectional sensors; passive, narrow-beam sensors; and active sensors". Passive sensors are self – powered. Active sensors are not self powered. Theoratical working on WSNs like in this project assumes using passive, omnidirectional sensors. [17, 19]

2.4 Base Monitoring Station

A base station is defined as a fixed point of communication for customer cellular phones on a carrier network.

The base station connects with an antenna which does the task of receiving and transmitting the signals in concerned person.

The base station receives the data sent from the sensor nodes i.e. end devices and routers, wirelessly. Data received from the end device nodes is sent to the computer and data received is displayed using the built GUI on the screen base monitoring station. From prior testing, have set a threshold value/edge value for the monitoring of the amount of heavy metals in water. Depending on whether the obtained value is less than or greater than the threshold, we get to know whether the water is suitable or not for the specific purpose. The obtained data is compared with the standard values of the water parameters. If the obtained water parameters do not match the preset values then SMS will be sending to concerned person in order to take preventive measures. [10, 3, 7].

Chapter-3 SYSTEM DEVELOPMENT

The following is a list of parameters which affect the quality of water immensely if not present in the mentioned range.The system will send an SMS to concerned person if threshold value is not met. The system is developed using Java to achieve the task of water quality monitoring.

Table 1: PARAMETERS AFFECTING QUALITY OF DRINKING WATER

No.	Parameter	Unit	Acceptable Limit
1	Turbidity	NTU	1
2	Ammonia	Milligram/litre	0.5
3	pH	--	6.5-8.5
4	Chloride	Milligram/litre	250
5	Fluoride	Milligram/litre	1.0
6	Arsenic	Milligram/litre	0.01
7	Iron	Milligram/litre	0.3
8	Nitrate	Milligram/litre	45
9	Sulphate	Milligram/litre	200
10	Selenium	Milligram/litre	0.01
11	Zinc	Milligram/litre	5.0
12	Mercury	Milligram/litre	0.001
13	Lead	Milligram/litre	0.01
14	Cyanide	Milligram/litre	0.05
15	Copper	Milligram/litre	0.05
16	Chromium	Milligram/litre	0.05
17	Nickel	Milligram/litre	0.02
18	Cadmium	Milligram/litre	0.003
19	Dissolved solids	Milligram/litre	500
20	Dissolved oxygen	Milligram/litre	1

3.1 Software Components used for WQM system development:

- NetbeansIDE 8.1
- Wampserver
- Java programming language used

Table 2: DISEASES CAUSED BY IMBALANCE OF ABOVE MENTIONED PARAMETERS

S.No.	Characteristic	Disease Caused by the parameter
1	Turbidity	turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis
2	Ammonia	ammonium chloride influences metabolism by shifting the acid–base equilibrium, disturbing the glucose tolerance, and reducing the tissue sensitivity to insulin
3	pH	Metallic or sour taste, alkali taste to the water that makes coffee taste bitter.
4	Chloride	salty taste
5	Fluoride	The most obvious health effect of excess fluoride exposure is dental fluorosis, which when mild includes white streaks, and when severe can include brown stains, pits and broken enamel.
6	Arsenic	Cancer in the skin, lungs, bladder and kidney. It can cause other skin changes such as thickening and pigmentation, developmental effects, neurotoxicity, diabetes, pulmonary disease and cardiovascular disease. Arsenic-induced myocardial infarction, in particular, can be a significant cause of excess mortality
7	Iron	Low iron stores in the body can lead to iron deficiency, anemia and fatigue and can make you more susceptible to infections.
8	Nitrate	Excess levels can cause methemoglobinemia, or "blue baby" disease. High nitrate levels in surface water contribute to algae blooms and may result in elevated levels of disinfection by-

		Products in treated drinking water. Disinfection byproducts have been linked to increased cancer and reproductive health risks in humans as well as liver, kidney and central nervous system problems.
9	Sulphate	Sulfate may have a laxative effect that can lead to dehydration and is of special concern for infants.
10	Selenium	Short periods of time: hair and fingernail changes; damage to the peripheral nervous system; fatigue and irritability. Long-term, selenium has the potential to cause the following effects from a lifetime exposure at levels above the MCL: hair and fingernail loss; damage to kidney and liver tissue, and problems with the nervous and circulatory systems.
11	Zinc	Fever, nausea, vomiting, stomach cramps, and diarrhoea occurred 3–12 h after ingestion, food poisoning,etc.
12	Mercury	Tremors, emotional changes (such as mood swings, irritability, nervousness, excessive shyness), insomnia, neuromuscular changes (such as weakness, muscle atrophy, twitching), headaches, disturbances in sensations, changes in nerve responses, poor performance on tests of mental function.
13	Lead	Damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells.
14	Cyanide	Depression of the central nervous system that can result in respiratory arrest and death. At higher lethal concentrations, cyanide poisoning also affects other organs and systems in the body, including the heart.
15	Copper	Adverse health effects, including vomiting, diarrhea, stomach cramps, and nausea. It has also been associated with liver damage and kidney disease.
16	Chromium	Allergic reactions in some people, ulceration of the skin, elevated cancer risk
17	Nickel	Lung cancer, cardiovascular disease, neurological deficits, developmental deficits in childhood, and high blood pressure, affect the kidneys and livers

18	Cadmium	Kidney dysfunction and lung impairment , Cancer, tracheo-bronchitis, pneumonitis, and pulmonary edema. Symptoms of inflammation may start hours after the exposure and include cough, dryness and irritation of the nose and throat, headache, dizziness, weakness, fever, chills, and chest pain.
19	Dissolved solids	Cancer , coronary heart disease , arteriosclerotic heart disease and cardiovascular disease
20	Dissolved oxygen	Gas Bubble Disease,eutrophication

3.1 INFERENCE RULES

1. IF turbidity >5NTU

   THEN disease caused is Gastroenteritis

2. IF ammonia>0.5 mg/L

   THEN it might cause acid–base equilibrium disturbance, glucose intolerance and reduction in tissue sensitivity to insulin

3. IF pH>8.5

   THEN water will taste bitter

4. IF pH<6.5

   THEN water will have metallic or sour taste

5. IF chloride>1000 mg/L

   THEN water will have salty taste

6. IF fluoride>1.5 mg/L

THEN it can cause dental fluorosis, which when mild includes white streaks, and when severe can include brown stains, pits and broken enamel.

7. IF arsenic>0.05 mg/L

   THEN it can cause cancer in the skin, lungs, bladder and kidney; thickening and pigmentation, developmental effects, neurotoxicity, diabetes, pulmonary disease and cardiovascular disease

8. IF iron<0.3 mg/L

   THEN it can cause iron deficiency, anemia and fatigue and can make one more susceptible to infections.

9. IF nitrate>45 mg/L

   THEN it can cause methemoglobinemia or blue baby disease; cancer in liver, kidney; and central nervous system problems.

10. IF sulphate>400 mg/L

    THEN it can cause dehydration.

11. IF selenium>0.01 mg/L

    THEN it can cause hair and fingernail changes; damage to the peripheral nervous system; fatigue; irritability; damage to kidney and liver tissue; and problems with the nervous and circulatory systems.

12. IF zinc>15.0 mg/L

    THEN it can cause fever, nausea, vomiting, stomach cramps, and diarrhoea

13 IF mercury>0.001 mg/L

THEN it can cause tremors, emotional, insomnia, neuromuscular, headaches, disturbances in sensations, changes in nerve responses, poor performance on tests of mental function.

14. IF lead>0.01 mg/L

THEN it can cause damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells.

15. IF cyanide>0.05 mg/L

THEN it can cause depression of the central nervous system that can result in respiratory arrest and death.

16. IF copper>1.5 mg/L

THEN it can cause adverse health effects, including vomiting, diarrhea, stomach cramps, nausea, liver damage and kidney disease.

17. IF chromium>0.05 mg/L

THEN it can causes allergic reactions , ulceration of the skin, elevated cancer risk

18. IF nickel>0.02 mg/L

THEN it can cause lung cancer, cardiovascular disease, neurological deficits, developmental deficits in childhood, and high blood pressure, affect the kidneys and livers

19. IF cadmium>0.003 mg/L

THEN it can cause kidney dysfunction, lung impairment, cancer, tracheo-bronchitis, pneumonitis, pulmonary edema, dryness and irritation of the nose and throat, headache, dizziness, weakness, fever, chills, and chest pain.

20. IF dissolved solids>2000 mg/L
THEN it can cause cancer, coronary heart disease, arteriosclerotic heart disease and cardiovascular disease

21. IF dissolved oxygen>15 mg/L
THEN it can cause Gas Bubble Disease, eutrophication

Based on these inference rules the water quality monitoring system developed by me in this project will generate results for the concerned parameters. If these rules are not met then an SMS will be sent to the concerned person indicating that water is unfit for drinking.

Chapter-4 PERFORMANCE ANALYSIS

In the traditional times water quality monitoring was a very big issue. People were kept for getting samples from the water bodies and then bringing the samples to the laboratories. This resulted in more cost, more man power requirement and more time. The major issue at that time that resulted due to this problem was that real time data could not be delivered. Traditional methods for Water Quality Monitoring had these disadvantages sue to which modern methods are used now. In modern methods wireless sensor network is used which sends data wirelessly to the user from base station. It has far better performance as compared to traditional methods of water quality monitoring .It requires lesser cost, lesser manpower, lesser time and most importantly delivers data in real time. This method of water quality monitoring is far more efficient than traditional method.

The system simulated by me takes around five second to send an SMS to the concerned person regarding the content of heavy metals present in water.

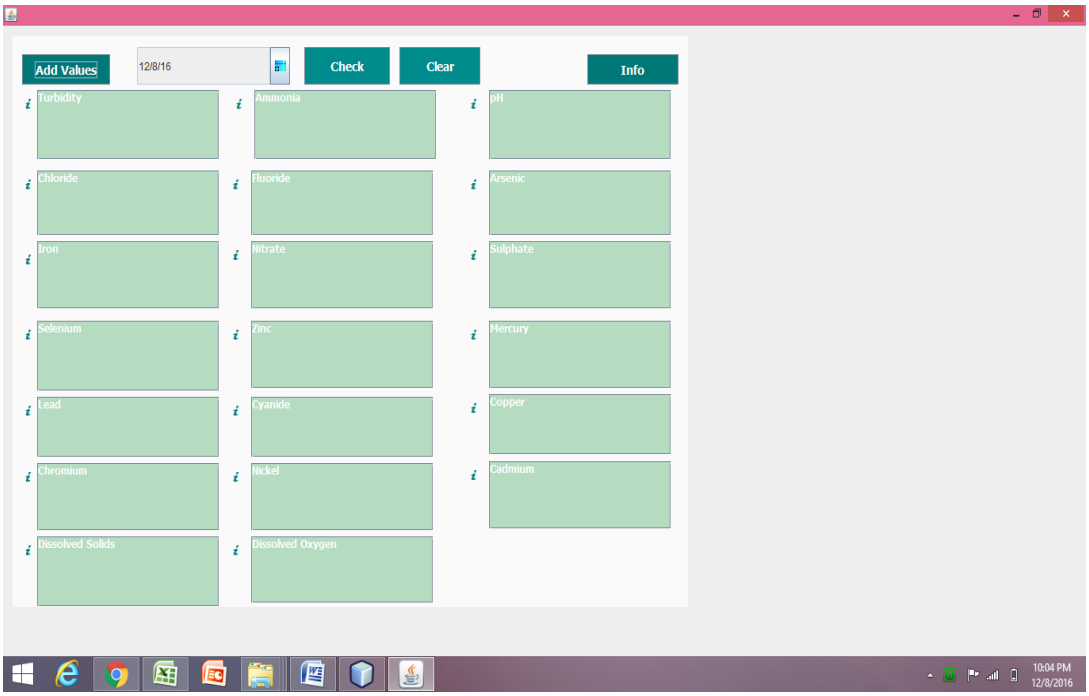

Fig 3: Front end of Water Quality Monitoring System

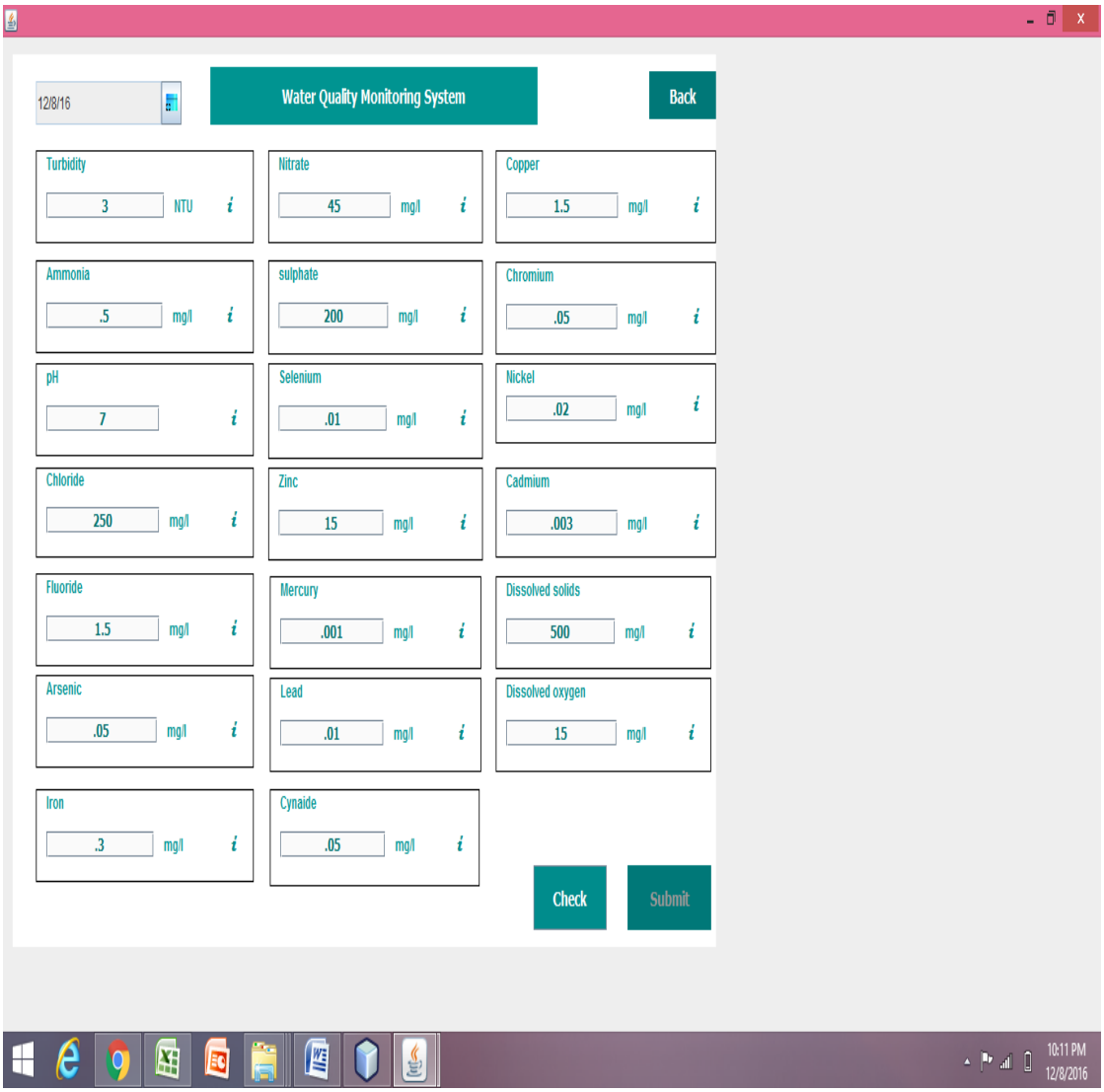

Fig 4: Page displayed on selecting a date on which we want to enter the value

Shows values being entered of different water quality parameters like ammonia, pH, chloride, arsenic, lead, Iron, etc. on the specified date to check whether they meet the given threshold value .After entering values Submit Button is pressed.

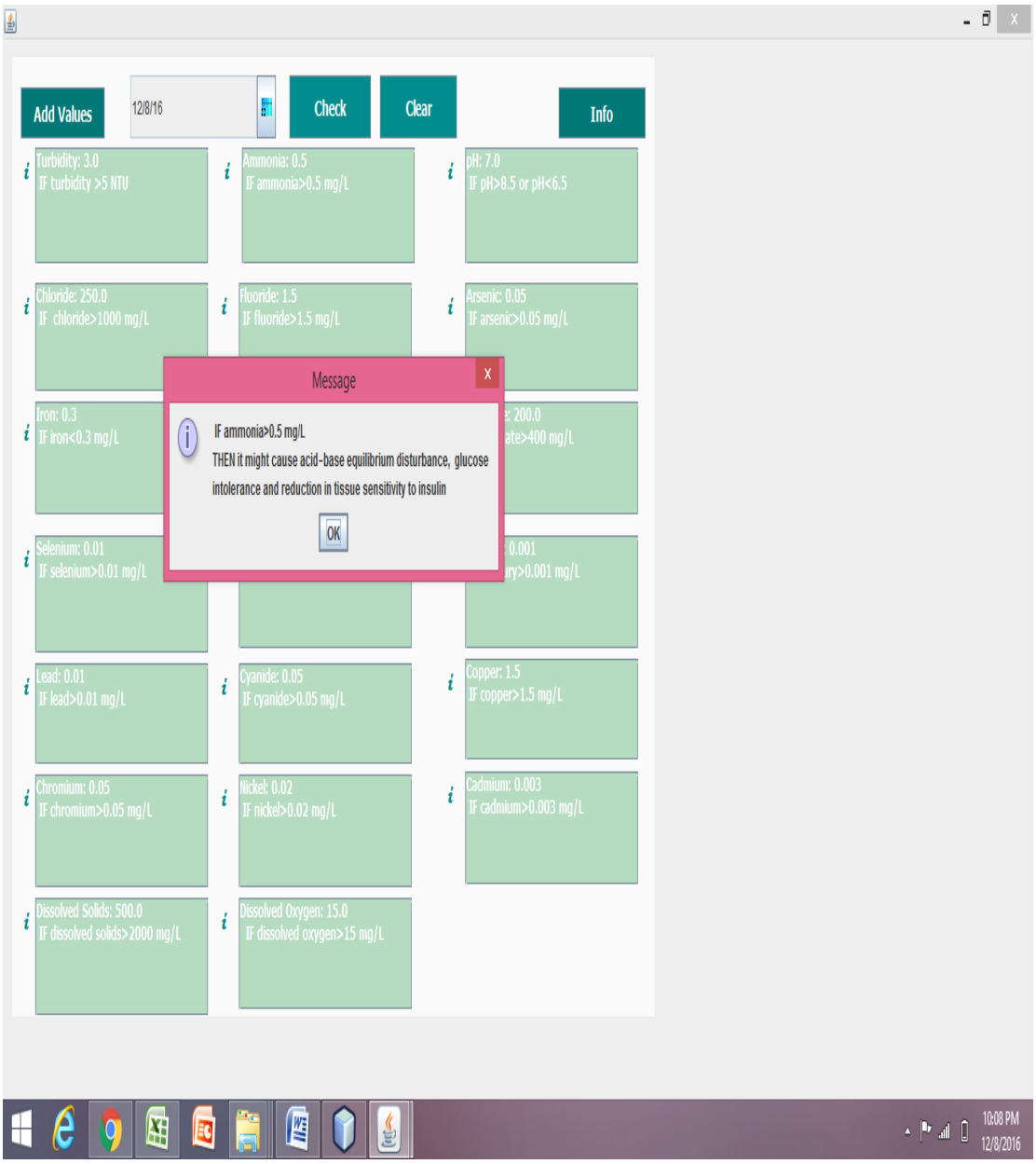

Fig 5: Message displayed.

When information button is pressed it shows the disease caused by increase in threshold value of the specific parameter.In this diagram it shows the effect on humans of increase in ammonia above the edge value.

Fig 6: Sensors turned red.

After entering values of all the parameters we click the check and submit button .After submitting the values the parameters whose value exceed threshold value they Turn red in colour to indicate the rise in value

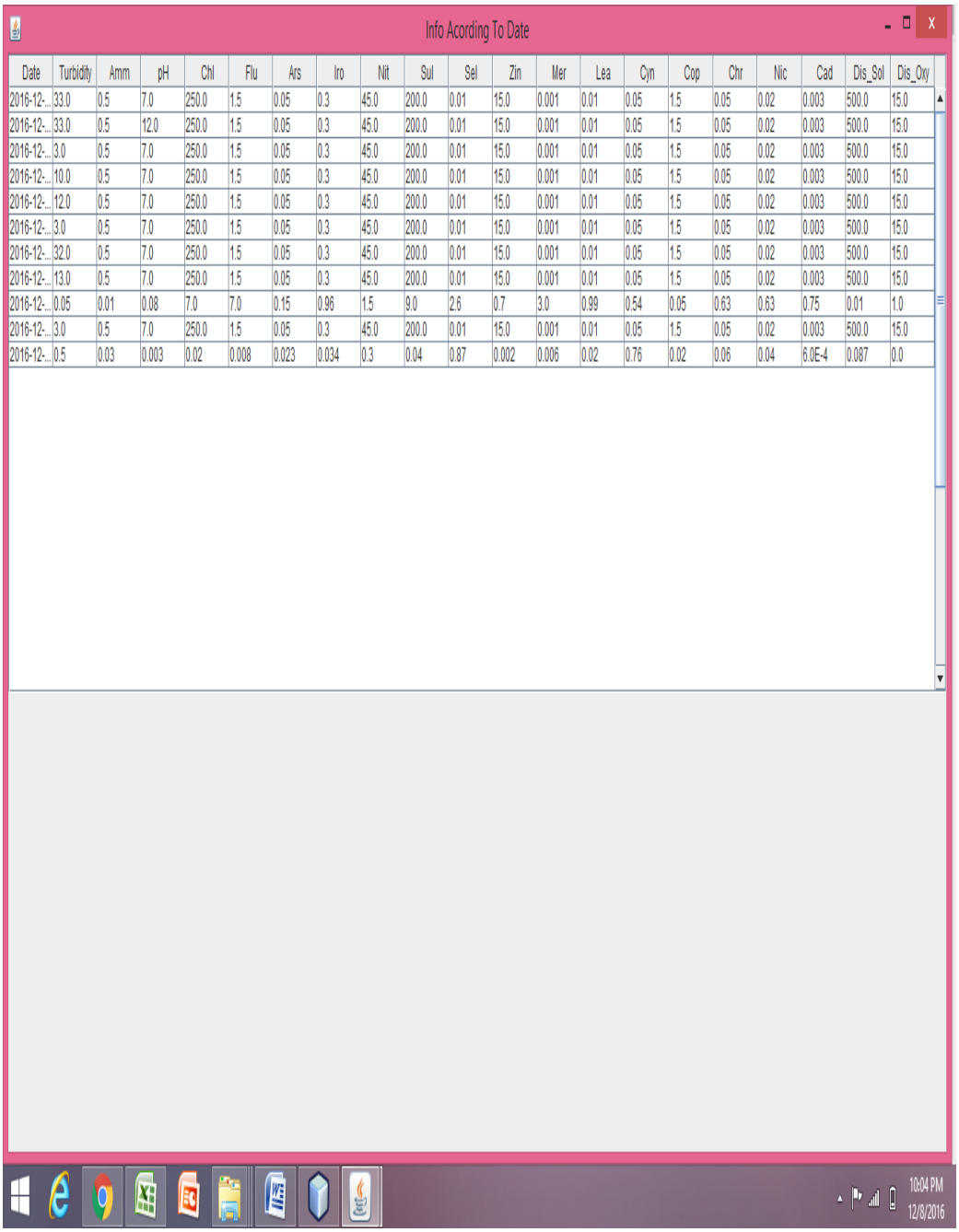

Fig 7: Water Quality Monitoring system database.

After entering the values when Submit button is clicked then values are added to the database for checking the quality of water.

4.1 Flow of information in water quality monitoring system.

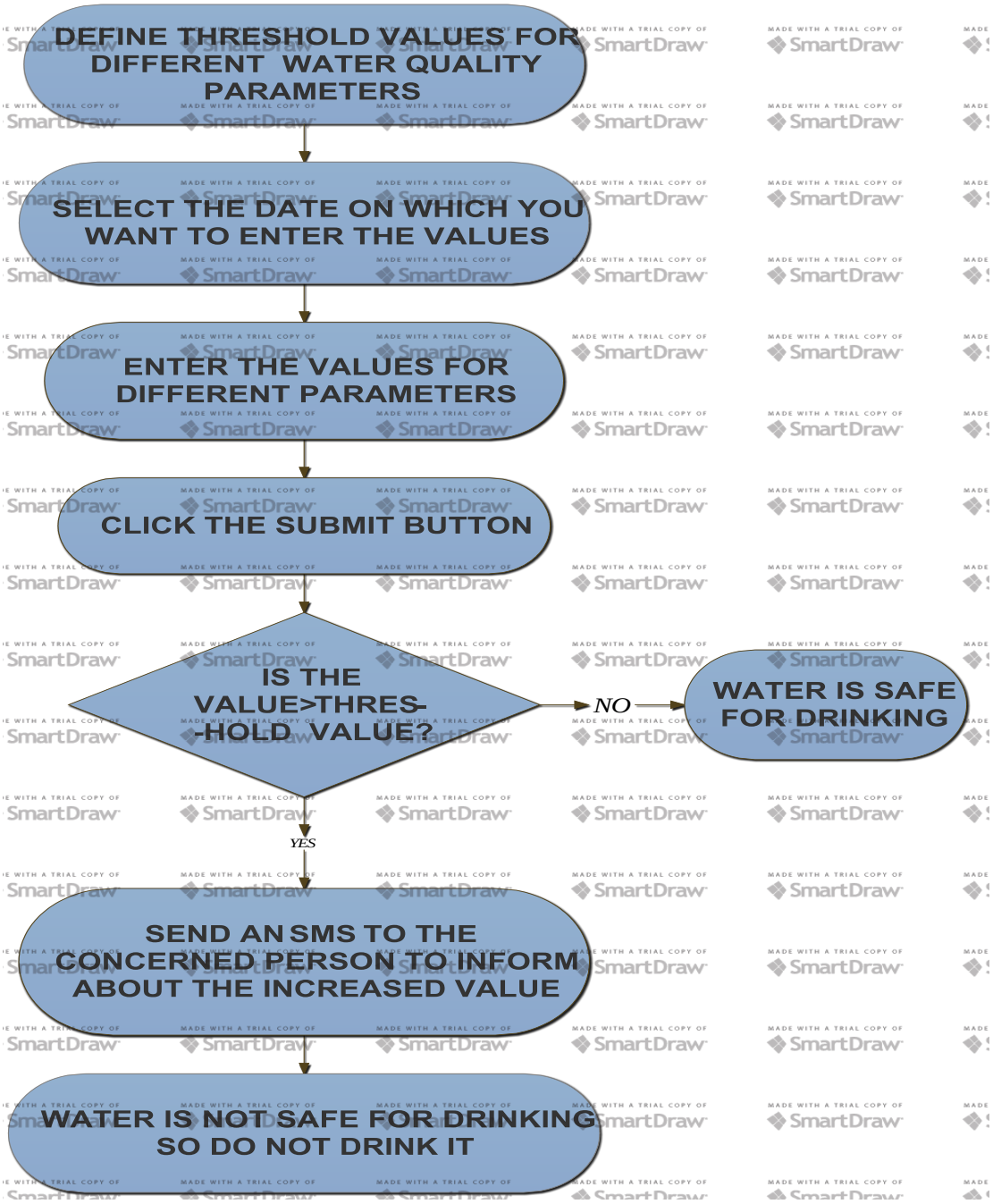

Fig8 : Flowchart representing the working of the water quality monitoring system.

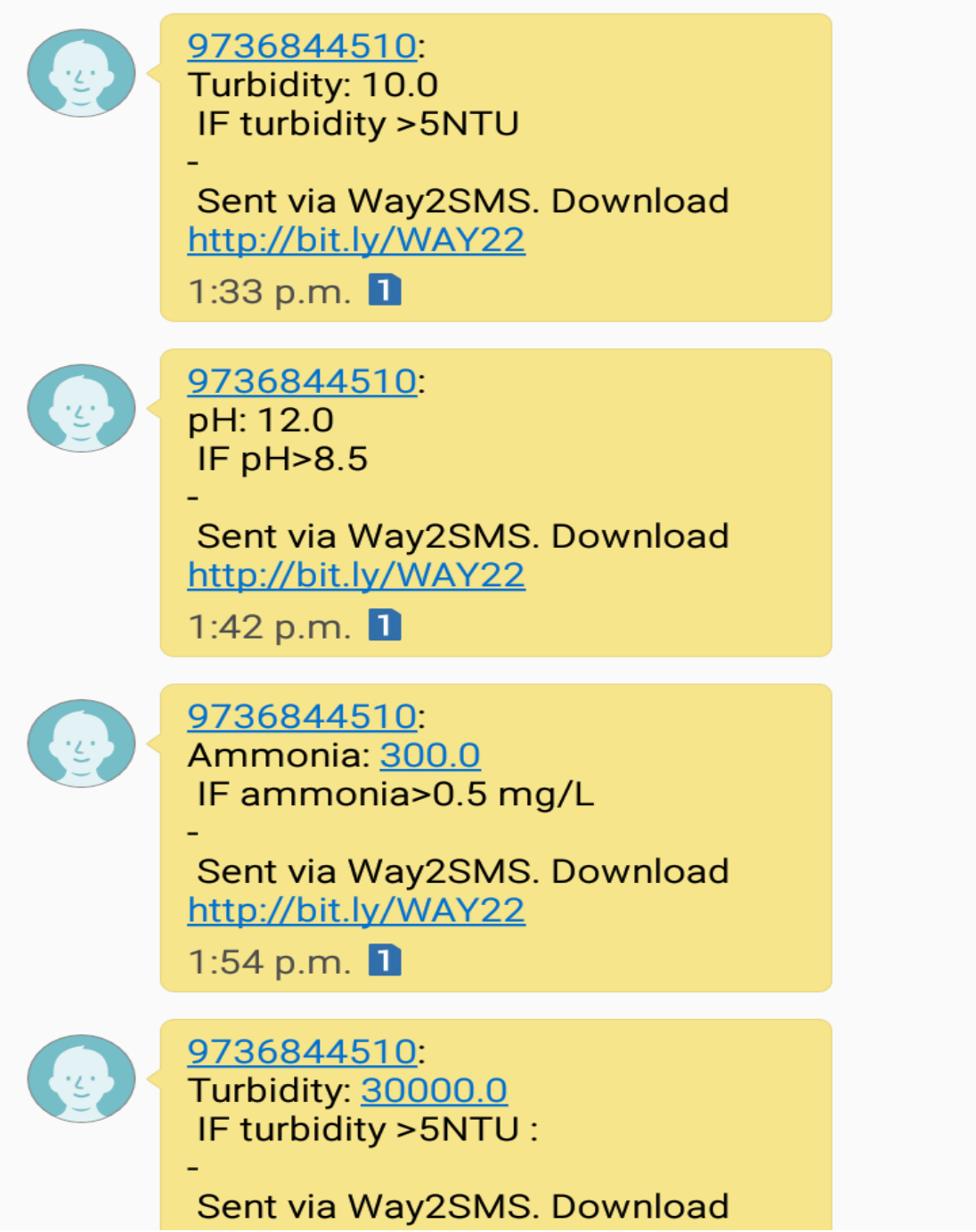

Fig 9: SMS showing that value of water quality parameter has crossed the threshold value of these parameter water quality parameters pH, Ammonia and Turbidity.

Chapter-5 CONCLUSIONS

Observing water quality in the 21st century is a very big challenge in view of the expansive number of chemicals utilized as a part of our regular daily existences .Techniques for water examination is available for very few thousand of chemicals i.e. around '8000'. Water-quality obsering is utilized to caution about the rising water quality issues; to decide consistence with drinking water principles and to protect water from becoming polluted by heavy metsals. Water quality monitoring results help the administrators to decide whether water quality is showing signs of improvement or not.

I got the motivation to do this project after jaundice hit Solan district which is near our college.A large number of people died to this disease.These deaths could have been prevented if the checking of drinking water which was supplied to Solan town would have been done properly beforehand by the concerned authority.In this project I have simulated the water quality monitoring system.This was really a very interesting project to work on.

Future Scope

Improvement in earlier proposed solutions for water quality monitoring that requires lesser power, energy and cost and is much more efficient in terms of performance as compared to the systems which are evolved till date.

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