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IoT Based Low-Cost System for Monitoring Water Quality of Karnaphuli River to Save the Ecosystem in Real-Time Environment

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ABSTRACT : *This paper is about preserving the Karnaphuli River ecosystem by controlling the quality of the water. We know an ecosystem is a mechanism that includes interactions between a populations of living and non-living species. The environment comprises producers, primary customers, secondary consumers, third-party consumers and separators. This is a cycle. Every dimension is dependent upon one another. Water is an essential thought for all living things for the river ecosystem. The water quality of the river is also a major concern as it is used for drinking and private uses, agriculture and aquatic life but the water of the river is heavily polluted for modern civilization. The growth of new mills poisoned the river water by factory. The habitat for the polluted water is destroyed. River fishes are dead. Water plants cannot respond to the polluted water. Oxygen levels are decreasing. The water quality depends primarily on some water parameters. The water parameters are Temperature, pH and Dissolve Oxygen etc. They are called smart devices or intelligent things. When we speak of smart devices, we mean capturing and collecting information about any object capable of the environment, transmitting it via the existing network infrastructure, receiving data from the network to which it belongs and operating under certain conditions. Consequently, appropriate steps against such anthropogenic activities should be taken to improve the overall water quality of the Karnaphuli River for its sustainable usage.*

Keywords: Artificial Neural Network (ANN), Water Quality Monitoring, IoT, Sensors, Real Time.

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I. INTRODUCTION

Karnaphuli River is very important river for the Chittagong city. This is one of the most famous rivers in Bangladesh. It is the longest river in Chittagong. It starts at Lusai Hill of Assam, India. After passing about 195 km, near many famous institutions like Chittagong Port, Marine Academy, Chittagong Dry Dock, Naval Academy, International Air Port etc., it reaches to the estuary of Bay of Bengal. This river is surrounded by a dense population and also covered by big shipping activities, which pollutes the Karnaphuli River severely. Many industry established on the bank of the river. Approximately 800 industrial units are building beside the Karnaphuli River in different areas like Kalurghat, Sagorica, Anowara etc. This is very much alarming. Most of the industrial business of Chittagong dependent on this river and river water but the recent analysis shows that water is polluting heavily in the Karnaphuli river due to the ejection of untreated effluent from industrialization, municipality sewage, rubber dam and river bank erosion along with using excessive fertilizer for agricultural production due to which the water quality is polluting.

Minimum six millions of people regularly make 1,800 to 2,000 tons of garbage and also 22 tons of biodegradable and non-biodegradable waste which reach Karnaphuli River by 52 canals and drains. Every day blood from 400 slaughterhouses is dumped into Karnaphuli River. Department of Environment said that more than 350 metric tons of toxic wastes are being drained to the river Karnaphuli in a day. Well known paper mill Karnaphuli Paper and Rayon Mills are produce average 1050 cubic meter of toxic wastes and discharge to the river every day. People use the river water for much purpose as like domestic use, fisheries, irrigation. For the water supply to the city area people WASA directly collect the water from the Karnaphuli River. So it is very important issue to know about the quality of this water. Water plays an important role to maintain the aquatic and terrestrial ecosystem. For this rising water pollution ecosystem of the river water is damaged day by day. Water quality mainly depends on the Temperature, pH and Oxygen level of the water.

The ejection of untreated effluent from industrialization, municipality sewage, fertilizer for agricultural production dangerously damaged the main water quality element. Water Temperature, pH and Oxygen level are not like before. This is affected on the ecosystem which based on the Karnaphuli river water. An ecosystem creates with living things (plants, birds, and fishes) as well as the non-living environments (weather, water flow, earth, sun, soil, oxygen, carbon di-oxide, calcium etc.) that surround the living things. Inorganic ingredients are producer, Primary Consumer, Secondary Consumer, Tertiary Consumer and separator. In an *ecosystem producers* are those organisms that use photosynthesis to capture energy by using sunlight, water and carbon dioxide to create carbohydrates. The plants are called the main producers in an ecosystem. Primary consumers are those who cannot make their own food and depend upon the producer. They eat producer. Some small fishes etc. are called primary consumer. Consumers are called are generally meat-eaters. They eat the primary consumer. Tertiary consumers are eating the secondary consumer. Big fish, eagles etc. are tertiary consumers. Last of all is separator. Separators are those who eat the death fish or eat the dumping things in the water. Separator eat dead plants and fishes in the process the break them down and decompose them when that happen, They release nutrients and mineral back into the water soil which then will be used by plants. Every level of this food chain in important to keep running the ecosystem of the river. But for the pollution of water regularly many of water plants, fish are not found as like before. According to local sources, many fish species like Chitol, Rita, ModhuPabda, Rupchanda and Borguni are not found as before. Fish are poikilothermic animals; their body temperature is the same as, or 0.5 to 1°C above or below, the temperature of the water in which they live. In their natural environment, fish can easily tolerate the seasonal changes in temperature, decrease to 0°C in winter and increase to 20–30°C.

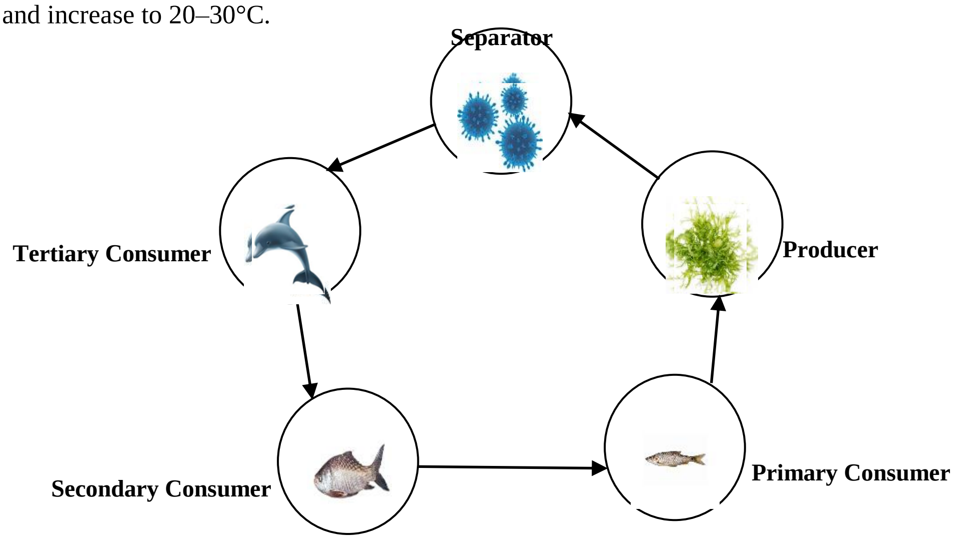


Fig.1. Ecosystem of a river

For the pollution, temperature shock is one of the reason may fish die. For fish live some water parameters are important. The water parameters are BDO, Free CO2, Alkalinity, Calcium, Chloride, pH, Water Temperature etc. For Katal fish BDO, Free CO2, Alkalinity, Calcium, Chloride, pH, Water Temperature is more important parameter. Water pollution changes the water parameter and fish are died. In 2009 to make sure of the precise number of fish species available in river Karnaphuli. Once the Karnaphuli was exist in large number with a total of 140 fish species which include 66 species of freshwater, 59 species of silently salty water and 15 species of migratory fish. However, recently discovered that 20-25 species of freshwater and 10 species of brackish water have already become extinct while the rest fish species are also in peril. Not only the fish affected by the water but also birds are also affected by the pollution. Birds drink water from river and also some bird eat small fish from the river water and they also affected by the water quality. So we see that for the water pollution elements of ecosystem are reduces very badly and ecosystem is not look balanced. The pH level of Karnaphuli river water is very respecting issue for aquatic and human life. The ecosystem is badly damaged by the water quality. It is high time to closely monitor the water quality to save the natural life, ecosystem and save the Karnaphuli river water from the big number of water pollution. We proposed a water quality monitor system which is sensor based work .The sensor placed on the river water and they collect the data like Temperature, pH, Oxygen level from the water .This system is help to monitor the water very closely and also regularly which help to monitor water quality.

II. PROBLEM STATEMENT

The value of the aquatic ecosystem for living fish is infinite. If the environment changes for some reason, that becomes detrimental to the fish. As the fish will die, the fish may therefore vanish. And when the fish is killed, we will be robbed of the nutrients our body needs. Therefore, we need to be conscious of the water cycle and take steps required to save the ecosystem. Algal blooms may also be of concern, as some algae species contain neurotoxins that can kill the environment. Oil spills into water can cause harm to the aquatic environment. Such as impacts on all aspects of the marine food web, including long-term damage to habitats for breeding and migration impacting future generations of marine life. High turbidity will significantly reduce river ecology. By reducing food supplies, decreasing spawning beds and affecting gill function it can damage fish and other aquatic life. It can also reduce the rate of growth of fish and other aquatic plants, resist disease and affect the effectiveness of fish capture methods. Temperature can affect aquatic organisms, metabolic rates and biological activity. As such it impacts the ecosystems chosen for a variety of aquatic life 8. Some species, particularly aquatic plants, improve at warmer temperatures, while some fish like truce or salmon prefer colder streams. There is a direct relation between metabolic rates and temperature of the water. That occurs at higher temperatures, as many cellular enzymes are more active. For most fish, water temperature changes of 10 ° C would approximately double the rate of physiological activity. Many animals can handle this increase in the metabolic rate better than others. In most animals, improved metabolic activity can be seen in respiration levels and digestive responses. Improved breathing rates at higher temperatures result in increased oxygen consumption, which can be detrimental if rates continue to rise over a longer period of time. In addition, temperatures above 35 ° C can start to denature or breakdown enzymes, reducing the role of metabolism. Temperature fluctuations may also influence aquatic organisms, behavioral choices, such as shifting to warmer or cooler water after feeding, predator-prey responses, and rest or migration routines. Many shark and stingray species will even search for warmer waters when they become pregnant. Plants are also influenced by the temperature in the atmosphere. While some aquatic plants tolerate cooler water, warmer temperatures are most favored. In particular, tropical plants may show limited growth and dormancy at water temperatures below 21 ° C. Although dormancy is suitable for surviving a cold winter, most plants need warmer temperatures to flourish.

III. LITERATURE REVIEW

Water quality monitoring in this first twenty-first century has gained more attention among researchers. In this subject, numerous works are either done or are ongoing focusing on different aspects of it. The main theme of all the projects was the design of a secure, cost-effective, real-time water quality monitoring system that incorporates wireless sensor networks and stuff internet. A brief overview is given bellow of previous related works in this area:

Table.1: Previous works on water quality analyzing system

Related Works	Description	Limitations
Li Zhenan, Wang Kai, Liu Bo, “Sensor-Network based Intelligent Water Quality Monitoring and Control”, 2013 International Journal of Advanced Research in Computer Engineering &Technology (IJARCET)[1]	A smart network that combines remote sensing technology with applications for power. In this process, the water quality of the river and lake was monitored and controlled.	Through implementing suitable algorithms for system design, they struggled to address technical challenges such as sensor choice and wireless network control.
N. Nasser, A. Ali, L. Karim and S. Belhaouari, "An efficient Wireless Sensor Network-based water quality monitoring system," *2013 ACS International Conference on Computer Systems and Applications (AICCSA)*, Ifrane, 2013, pp. 1-4. [2]	The system was a WSN-based water quality monitoring system, self-configurable, reusable and energy efficient.	They developed a network model in this case without carrying out any tests to determine the water quality.
F. Ntambi, C. P. Kruger, B. J. Silva and G. P. Hancke, "Design of a water management system," *AFRICON 2015*, Addis Ababa, 2015, pp. 1-5. [3]	The system consists of three sub-system wireless sensors. Both communicate wirelessly with each other and send information to a computer connected to the GUI.	Due to wireless data transmission, data processing is sometimes not assured. There is a risk of data loss.
S. Wadekar, V. Vakare, R. Prajapati, S. Yadav and V. Yadav, "Smart water management using IOT," *2016 5th International Conference on Wireless Networks and Embedded Systems (WECON)*, Rajpura, 2016, pp. 1-4. [4]	The water level sensor will provide the water level in the water tank and, depending on the water level, the water motor will turn on and off automatically. Data will be shown on Android.	The design will only work to detect a tank's water level.
Joy Shah, “An Internet of Things Based Model for Smart Water Distribution with Quality Monitoring” 2017 International Journal of Innovative Research in Science, Engineering and Technology[5]	The paper focuses on the distribution of water using a water flow sensor and a water control valve to help accurately disperse water and provide adequate water.	The design does not use a water level sensor, so it will not be aware of the amount of water in the tank. Citizens won't be aware of the lack of water.
Proposed System: IoT Based Low-Cost System for Monitoring Water Quality of Karnaphuli River to Save the Ecosystem in Real-Time Environment	Our system overcomes the disadvantages by recognizing the weakness of previous water management systems, as it requires cloud use to store sensors data. This will ensure data security and avoid loss of data. We are working on our project to develop an integrated water quality monitoring system based in Arduino. We proposed a design for connecting sensors to Arduino. It shows the sensor values on an LCD. Arduino is also a Wi-Fi system interface to send data from sensors to servers in real-time with live streaming in the webpage.	

IV. SYSTEM DESIGN APPROACH

Here we propose an IoT system with additional capacity to monitor water quality based on the problems confronting it. Water temperature can impact aquatic organisms, metabolism levels and biological activity. For most fish, water temperature changes of 10 ° C would roughly double the rate of physiological activity. It determines the habitats chosen for an aquatic life transition. Alternatively, temperatures above 35 °C can trigger breakdown, enzymes, reducing metabolic activity. Most fish even head for warmer waters when they become pregnant. Plants are also affected by the temperature in the water. Although some aquatic plants tolerate cooler water, the majority prefer warmer temperatures. The pH level and oxygen level of water are also modified for changing the water temperature which affects the river ecosystem. The optimal pH range varies between species; however, the pH range of 6.5-9.0 is generally accepted for fish cultivation but the water temperature change the pH level. So fishes don't feel comfortable in the water. The output of the ANN technique (in terms of root-mean-square error and correlation coefficient) was tested using statistical methods in our proposed system. The module is implemented on Arduino UNO R3 and ESP 8266 Wi-Fi. Arduino UNO R3 is used as this board is able to process low-power sensor data from a computer, and the ESP 8266 Wi-Fi laptop was used to send live streaming data to the Internet. In this chapter we explore the system design methodology for the proposed low-cost IoT-based system to analyze Karnaphuli River's water quality temperature, pH, and turbidity level within a real-time environment.

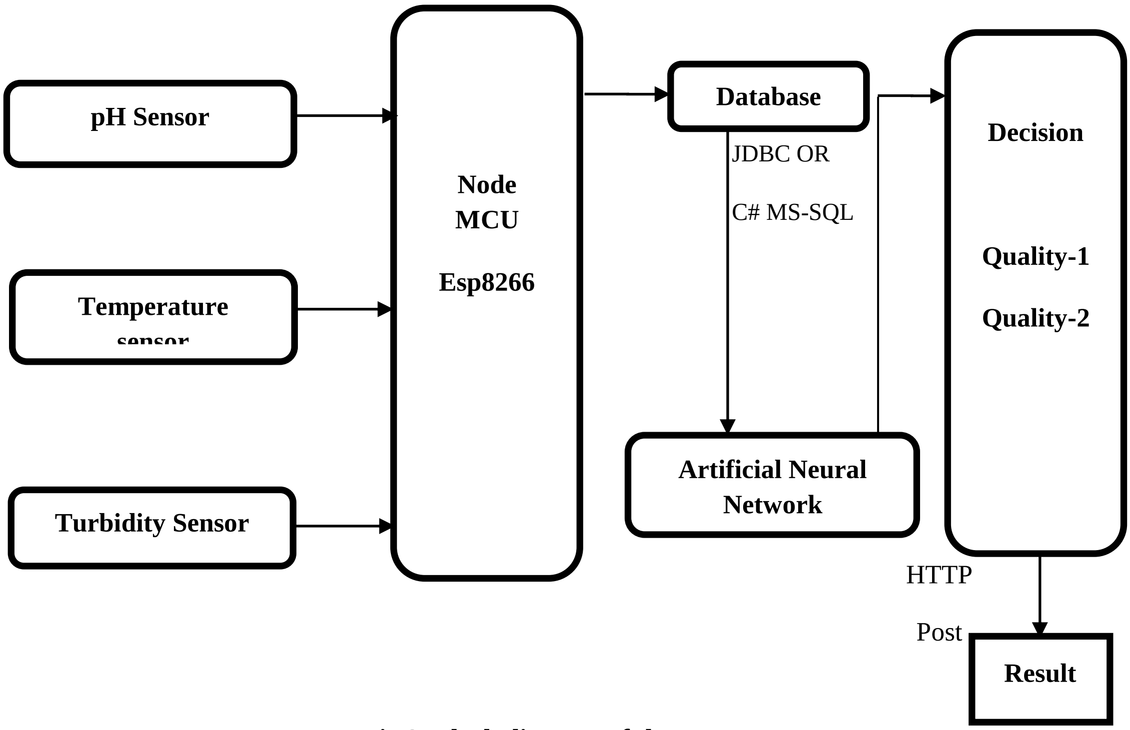


Fig.2. Block diagram of the system

This block diagram is present in the water quality monitoring system. A microcontroller is used as a sensor node offering real-time streaming of data via Wi-Fi. Place the data in a folder. Using the Artificial Neural Network's Back Propagation Algorithm, a decision will be made by machine whether the water is good or bad. The main objective is to develop a system for continuous analysis of the quality of river water at remote locations using wireless sensor networks with low power consumption, low cost and high precision detection. The weaknesses being studied to enhance the water quality are temperature, pH, turbidity level, etc. The goals for implementation of the concept are as follows:

- Using remote sensors to measure water parameters such as pH, temperature, turbidity, etc.

- To collect and send data from different sensor nodes via a wireless channel to the base station.
- Simulating and evaluating quality control parameters.
- pH sensor is using to find the drinkable water or not. That means the water level is 6 to 8.
- The solenoid valve is using water tap open and close. If the pH sensor value is 6 to 8 means the valve is open otherwise it was close only in this project.
- The temperature sensor is using to find the temperature level in the water.
- Turbidity sensor finds the water flowing or not.

V. SYSTEM ARCHITECTURE

The proposed architecture can be seen in the Fig. 3 in which we can see the three different layers: physical, logical, and application.

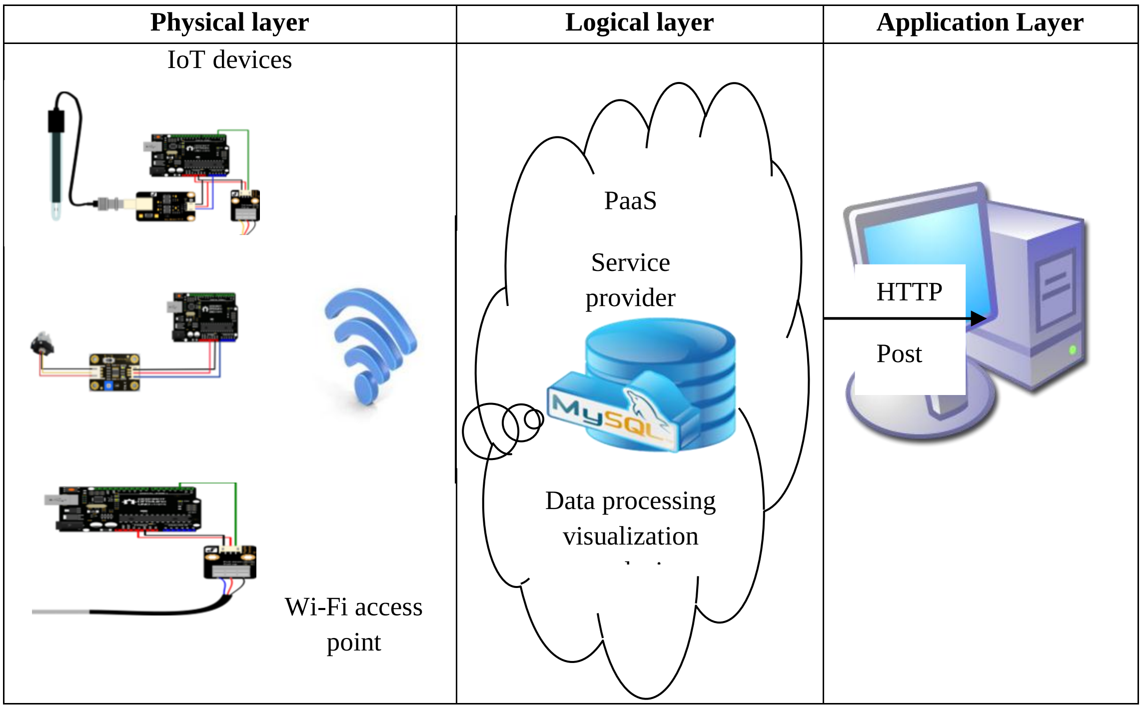


Fig.3. System architecture

5.1 Physical Layer

The physical layer is comprised of a WSN, in charge of capturing water data for normalization processing and sending them to the logic layer responsible for storage and further processing. The basic components of this layer are sensor nodes. They contain sensors and/or actuators. Sensors can measure physical phenomena such as temperature, Turbidity, and pH, and provide a measurable representation of this phenomenon on a scale or specific range.

5.2 Logical Layer

The data generated by the sensors should be processed and stored so that they are persistent and accessible from different networks and for different applications. Given the benefits, the IoT platforms rely on computing environments in the cloud and architectures oriented to a service for storing and processing data, enabling the user to build applications that incorporate these services, forgetting effects on maintenance and how or where they are deployed.

5.3 Application Layer

One of the trends in the world of technology is the connected PC. The device is capable of running applications that use that connection, employing user interfaces adapted to screen size and interactive interfaces through devices such as remote distance or pointing devices.

VI. SYSTEM FLOWCHART

The following flowchart shows our proposed IoT system's complete processing phase. A connection between sensor networks and controllers is established in the first phase. The data is then uploaded to the sensor-reading server. The LCD display also shows these sensor data.

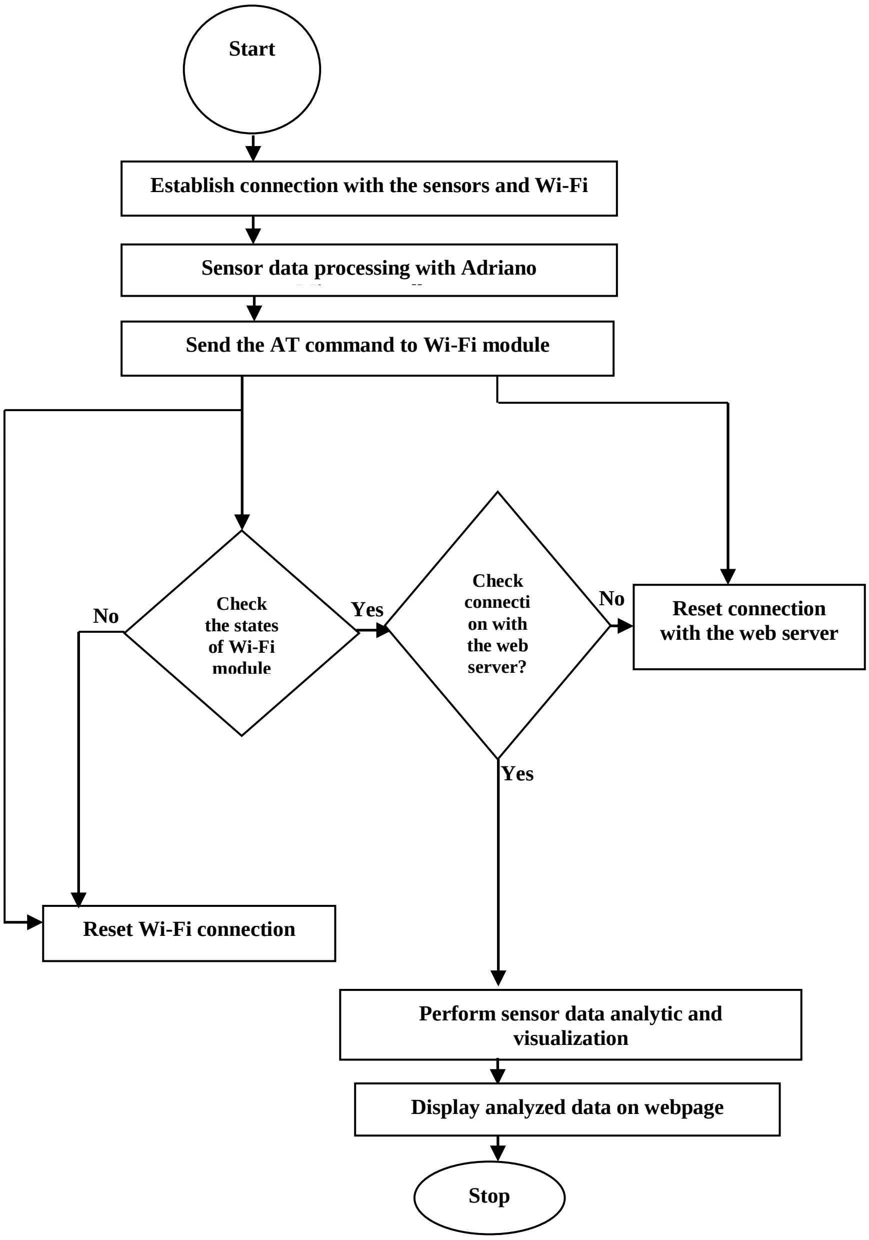


Fig.4. System flowchart

VII. OTHER PARAMETERS OF WATER QUALITY

The following physio-chemical parameters are very important because they have a significant effect on water to ensure water quality. In addition, aquatic life is also impaired by water quality deterioration.

- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)
- Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Oil and Grease
- Color
- Heavy Metals (Pb, Cd, Zn, Hg)

7.1 Total Suspended Solids (TSS)

Total Suspended Solids (TSS) is the dry weight of non-dissolved suspended particles in a water sample that can be obtained by a filter analysed using a filtration system. TSS is measured by filtering the water sample through a specific kind of filter and by calculating the filter weight before and after filtration. Then, the TSS is calculated as:

(Dry Weight of Filter and Trapped Material – Dry Weight of Filter)

((Dry Weight of Filter and Trapped Material-Dry Weight of Filter))/ (Volume of Water Sample)

The resulting value depends on the type of filter used.

7.2 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is a measure of the total dissolved content in a suspended acidic, ionized or micro-granular (colloidal sol) liquid of all inorganic and organic compounds. TDS contains sodium, chlorine, calcium, magnesium, potassium, sulfates and bicarbonates.

Total Suspended Solids = Total suspended solids (TSS) - Total Solids (TS)

7.3 Dissolved Oxygen (DO)

Within water or other liquids, dissolved oxygen (DO) is the amount of natural, non-compound oxygen. It is an important factor in the evaluation of water quality due to its impact 2 on the organisms that live within a body of water. A too high or too low level of dissolved oxygen can harm aquatic life and affect the quality of water.

7.4 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed (i.e. required) by aerobic biological organisms to break down organic material at certain temperatures in a given water sample over a certain period of time. The BOD value is expressed most generally in oxygen milligrams consumed per liter of the sample during 5 days of 20 ° C incubation and is often used as an indicator of the degree of water organic pollution. The higher the price of BOD, the greater the amount of organic matter or ' food ' available for oxygen-consuming bacteria. Domestic wastewater, oil and organic waste can lead to increased BOD, etc.

7.5 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is a measure of water's ability to consume oxygen as organic matter is decomposed and inorganic chemicals such as ammonia and nitrite are oxidized. It is commonly expressed in the mass of oxygen consumed over the volume of solution which in SI units is milligrams per liter (mg/L). COD includes BOD + Oxygen required for other chemical reactions taking place in wastewater. Therefore, COD is always greater than BOD or COD/BOD>1.

7.6 Oil and Grease

Oils, fats, and waxes, including kerosene and lubricating oils, are included. Oil and grease trigger unsightly films on bodies of open water and have a negative impact on aquatic life. They can also interfere with processes of biological treatment and cause maintenance problems because they cover the surfaces of ETP components.

7.7 Color

Although the color is not included in the 1997 Environment Conservation Regulations, it is a concern in the effluent of dye house because it is so visible, unlike other contaminants. Therefore, that color is critical for a factory's public image, and foreign textile buyers are increasingly setting color discharge standards. Nevertheless, color is less of a concern as a health and environmental problem than many other variables, e.g. BOD & pH.

7.8 Metals

A number of heavy metals are listed in the national environmental quality standards for industrial wastewater, including Cd, Cr, Cu, Fe, Pb, Hg, Ni, and Zn. Most metals, which are normally only naturally present in the atmosphere in trace amounts, can be toxic to humans, plants, fish and other aquatic life.

Table.2: Health effects due to water contamination (Courtesy of Water Research Center)

No.	Parameters	Permissible limits (by WHO, 2011)	Health Effects
1.	Turbidity	0-5 NTU	Nausea, headaches and muscle cramps
2.	Oxidation Reduction Potential (ORP)	650-800 mV	Goiter, hypertension, ischemic heart disease, gastric and duodenal ulcers
3.	Temperature	20°C-40°C	Metals of sediments have been equilibrated at temperature ranging from 4 to 25 °C
4.	pH	6.5-8.5 pH	pH > 11: Eye irritations, exacerbation of skin disorders pH 10-12.5: Hair fibers to swell, gastrointestinal irritation pH < 4: Redness and irritation of the eyes pH < 2.5: Damage to the epithelium
5.	Conductivity	500-1000 μS/cm	Disturbance of salt and water balance in infants, heart patients, individuals with heart patients, individuals with blood pressure and renal diseases

Table.3: Range of sensor parameters

No.	Sensors	Red	Yellow	Green
1.	Temperature (^oC)	40-50	30-40	20-30
2.	pH (point)	0-5; 9-14	5-6; 8-9	6-8
3.	Turbidity (NTU)	25-40	10-25	0-10

VIII. COLLECTION OF SAMPLES

All the water samples were collected scientific way following a cross-sectional descriptive method. Six Surface water samples were collected from six different estuaries of Karnaphuli River for better results with a small change of geographical position. The surface water samples from the water surface are obtained below one meter. Before and after the sample collection, the cap was locked sufficiently so that no air space can remain inside. Samples were collected early in the morning and in the afternoon during high tide and low tide. Water samples were collected from the Karnaphuli River and tested for physical and chemical parameters. The important water quality parameters, such as temperature, pH, and turbidity were analyzed.

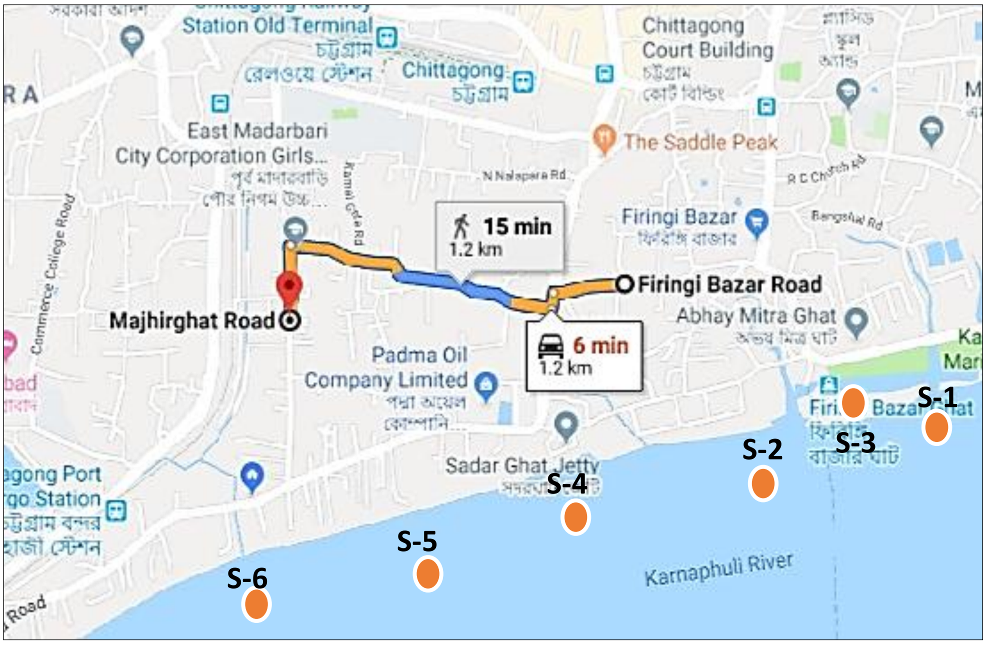


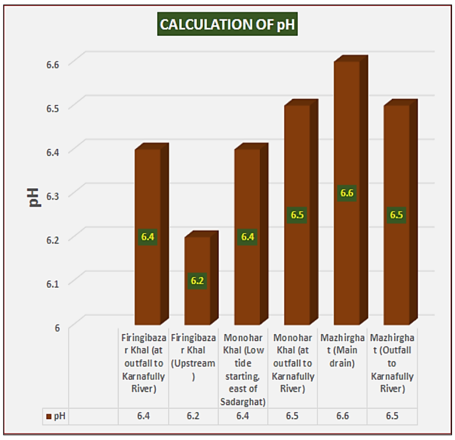
Fig.5. Study area and sampling points of Karnaphuli River

Table.4: The Sampling locations and its tidal condition

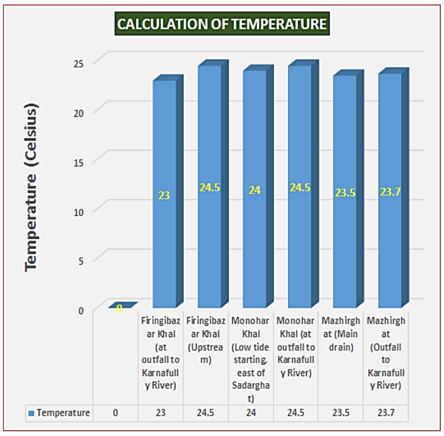
Sl.No	Sampling Sites / Sources	Sample ID	Condition
1	Firingi bazaar Khal(at outfall to Karnaphuli River)	S-1	Low tide
2	Firingi bazaar Khal(Upstream)	S-2	Low tide
3	MonoharKhal(Low tide starting, east of Sadarghat)	S-3	High tide
4	MonoharKhal(at outfall to Karnaphuli River)	S-4	High tide
5	Mazhirghat (Main drain)	S-5	Low tide
6	Mazhirghat (Outfall to Karnaphuli River)	S-6	Low tide

Table.5: Physical and chemical parameters of Karnaphuli River water

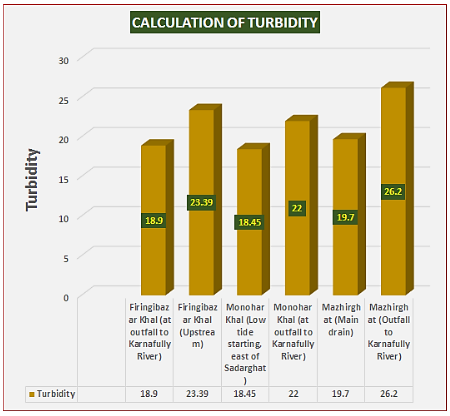
Sample ID	Color	Odor	Temperature (^{O}C)	Turbidity (FTU)	pH
S-1	Light green	High pungent	23	18.9	6.4
S-2	Oily & Black	High pungent	24.5	23.39	6.2
S-3	Turbid color	Odorless	24	18.45	6.4
S-4	Nearly colorless	Odorless	24.5	22.00	6.5
S-5	Light green	Shortly pungent	23.5	19.70	6.6
S-6	Turbid color	Shortly pungent	23.7	26.20	6.5



(b) pH Measurement



(c) Temperature Measurement



(c) Turbidity Measurement

Fig.6. Graph charts (Data measurement of through sensors)

Here, the figures (a), (b) and (c) are the values of pH, Temperature and Turbidity of six points in Karnaphuli River.

The surface of the river should be colorless. 1 specimen was almost colorless, 2 turbid colors, 2 light green and 1 oily and black color, as shown in Table 5. The analysis revealed that the closer the estuary to being colorless was the greater the acceptability. The air of the river should be odorless. Four water samples are odorless, four strongly pungent, two shortly pungent, as shown in Table 5. The finding revealed that the closer the estuary to being odorless was the greater the acceptability. In the case of temperature, the standard for preserving aquatic life is 20-30 (^{o}C) and since it was summer, the entire sample met the national standard as the sample was collected during the summer.PH is an indicator of water state, acidic and alkaline. The norm for any reason in terms of pH is 6.5-8.5; the quality of Karnaphuli River water is between 6.2 and 6.5 in that regard.

A field survey from this study found that around 713 factories directly or indirectly throw their untreated waste or wastewater into Karnaphuli River from Kalurghat to the Chattogram Port. Around 156 of that are really similar to the Karnaphuli. Table 6 and Table 7, respectively, list of such industrial locations and forms of industries.

Table.6: The location of the water pollution responsible industries (Source: Field survey, 2008)

SL	Location	Numbers
1	Kaloorghat	98
2	Mohra	85
3	Chandraghona	10
4	Chaktai	76
5	Sadarghat	71
6	Firingibazar	60
7	Fisheryghat	69
8	Dry-dock	89
9	Katgore	40
10	Jaldia	30
11	Gohira	20
12	Port	65
	Total	**713**

Table.7: The type and number of industries close to Karnaphuli River (Source: Field survey, 2008)

SL No	Industry	Number
1.	Tannery	11
2.	Textile	26
3.	Oil refinery	01
4.	T.S.P plant	01
5.	Urea plant	02
6.	D.D.T plant	01
7.	Chemical industry	01
8.	Fish processing plant	20
9.	Asphalt bitumen plant	01
10.	Steel Mill	01
11.	Paper and rayon mill	01
12.	Soft drinks industry	03
13.	Cement factory	03
14.	Soap and detergent	02
15.	Insect killer production plant	02
16.	Paint and X-ray production unit	04
17.	Others industry	75
	Total	**156**

IX. RESULTS AND DISCUSSION

9.1 Artificial Neural Network-Based Water Quality Analysis

ANN's are used in a wide range of applications effectively. For example, some of them are a prediction, trajectory tracking, control of various systems, and so on. ANNs are parallel networks of information processing. The information flows from the inputs to the outputs through a network structure; it is composed of interconnected node layers. These nodes are elementary processing units called neurons; each receives the information from various inputs and produces an output based on the value its activation function takes when the argument is the weighted sum of its inputs. An ANN is specified by network architecture and a number of parameters. The structure refers to the number of interconnected neuron layers, the number of neurons per layer, the connection topology between neurons (the network) and the form of activation (transfer) process per neuron, whereas the parameters are the weights used in each neuron for the aforementioned weighted sums. In addition, ANNs usually have a network structure set a priori by the designer and then their weights are trained automatically using an optimization algorithm, such as the very popular back-propagation (BP) algorithm (a gradient descent type algorithm) and the Levenberg-Marquardt optimization (an approximation of the Gauss-Newton method). Apart from this common approach, the robust neural back-propagation network can be used with confidence to predict parameters. On the other hand, as has been shown, an adaptive neuro-fuzzy inference model may be more effective in certain specific cases than single-layer feed for artificial neural networks). The following set of equations describes the operation of the BP algorithm.

oj=*f*(net*j*)=*f*(*x*) then net*j*=∑*ijwjioi*+*θj*,oj=f(netj)=f(x) then netj=∑jiwjioi+θj,**(1)**
Ep=12∑*j*∈out(*tpj*−*opj*)2,Ep=12∑j∈out(tpj-opj)2,**(2)**

δpj=(*tpj*−*opj*),**(3)**
Δpwji=−*ε*(∂*Ep*∂*wji*),
Δpθj=−*ε*(∂*Ep*∂*θj*),

Where *j* is the layer number and *i* is neuron number, *oj*oj is neuron output, net*j*netj is weighted sum, *θj*θj is bias, *wji*wji is weight, *ε* is learning rate, *δpj*δpj represents error value in layer *j*, *tpj*tpj is target output, and *opj*opj is actual output. Equation (2) is used to root mean square (RMS) of the errors in the output layer for the *p*th sample pattern.

The neural network is used for water quality monitoring systems. For various input combinations the performance parameters are called datasets with desired outputs. The neural network will contribute to the rating of water quality as good or bad. The benefits of using neural content-assisted analytics are like falsified neuronal networks (ANNs) that are good for acquiring and modeling non-linear relationships, and strong dynamic aggregation. Although the neural networks are prone to overfitting, the neural network model used in water quality monitoring is not complex enough to cause fitting problems. There's also a lot of countermeasures to prevent overfitting. Also, computation overload will not delay the device response, as there are only a few parameters of water quality. The multi-layer neural network model is shown below and has three inputs In 1, In 2, In 3 in the input layer, a hidden layer with four neurons and two output neurons. There is two bias input neuron connected to hidden layer neurons and output layer neurons.

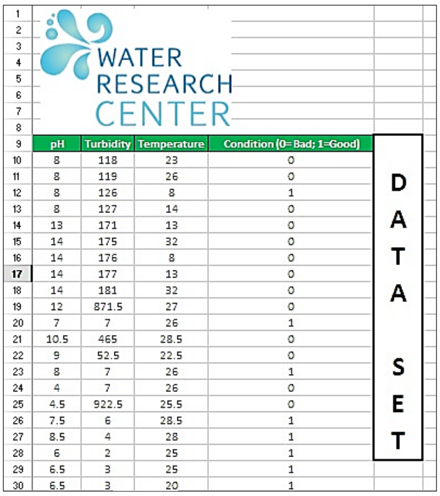
In the neural network model, 3 inputs can be pH value, temperature and turbidity and 2 outputs will be good and bad. Before training the neural network model few other parameters need to be set; as for example:

Learning rate=0.01
Learning algorithm=Back Propagation
Bias input=1
Connection weights=randomly assigned
Activation function=sigmoid function

The output of sigmoid function neuron with inputs x1, x2…weights w1, w2… and bias b is

$$F(X) = 1/\left(1+\exp^{(-\sum_j wjxj-b)}\right)$$

9.2 Data Sets



WATER RESEARCH CENTER

pH	Turbidity	Temperature	Condition (0= Bad; 1=Good)
8	118	23	0
8	119	26	0
8	126	8	1
8	127	14	0
13	171	13	0
14	175	32	0
14	176	8	0
14	177	13	0
14	181	32	0
12	871.5	27	0
7	7	26	1
10.5	465	28.5	0
9	52.5	22.5	0
8	7	26	1
4	7	26	0
4.5	922.5	25.5	0
7.5	6	28.5	1
8.5	4	28	1
6	2	25	1
6.5	3	25	1
6.5	3	20	1

DATA SET

Fig.7. Data sets (Courtesy: https://www.water-research.net)

9.3 Sample Result in Web

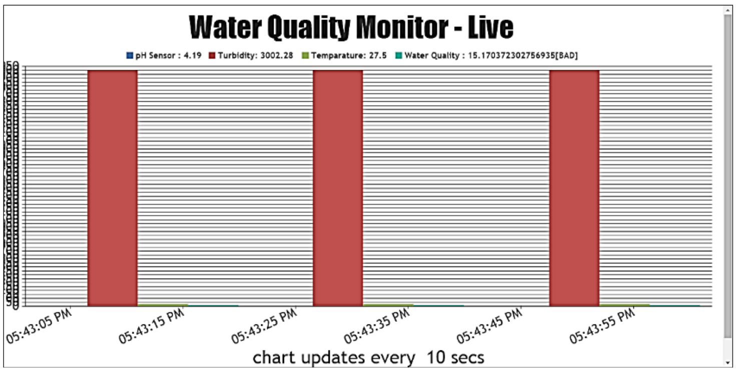


Fig.8. Live streaming snapshot of water quality monitor

A wireless water quality network was used to collect water quality parameters on a regular basis and an artificial neural network prediction approach was proposed to estimate water quality. Estimating the monitoring of water quality enables authorities to take immediate action. The proposed method has the advantage of giving authorities prior knowledge of the importance of their water resources compared to traditional methods of evaluating water quality. Through assessing quality measures for genetic, chemical and physical categories, water quality is determined. A global water quality standard was chosen to assess the water quality of Karnaphuli River. For this reason, we used the Water Research Center's eligible data to consider as a global norm. Furthermore, simulation results are provided here to demonstrate the efficacy and accuracy of the proposed method.

X. CONCLUSION

Water Quality monitoring system is a challenging task. Our system can easily monitor the water quality at low cost and does not require people on duty. The system is advanced from the traditional water quality monitoring system. It is very easy to install and it's easily placed at any kind of water surface. This system efficiently acquires water parameters (Temperature, pH and Turbidity Level) in real time operation at base station without data loss which can help to monitor the water quality in real time and help to maintain the ecosystem beside the

Karnaphuli River. Karnaphuli is the largest and most important river in Chittagong. It is the main source of water and the creator of the fertile land of riverside of Chittagong city. It has sustained its existence and supported early civilization in this region. As a result, the growth of the industrial activities has subjected to the continuous discharge of different types of wastewater without adequate treatment. There are many Mills, Factories, and Industries on the bank of Karnaphuli River. All the wastes of these mills, factories, and industries are as well as municipal wastes drained through the Karnaphuli River and are deposited on the riverbed. There are also some local ship-breaking yards present at the river site. As a result, the probability of non-radioactive toxic as well as radioactive contamination of water, soil, sediment and hence the whole environment is increasing day by day. On the other hand, oil and other wastes from floating boats, lunches and water from cultivated lands containing fertilizers near the river are also responsible for water pollution Karnaphuli River. Since the people of the country are not conscious about the health effects of environmental pollution, so from all the perspective, it is important to measure the water quality of the Karnaphuli River.

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