# Smart Turbidity Monitoring and Data Acquisition using LabVIEW

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*Abstract* — **Availability of Pure drinkable Water is a severe problem in all over the world. So this contamination of water should be under continuous monitoring. The developed system monitor parameter of water like turbidity. The system uses Arduino UNO used for data acquisition with LabVIEW, which enables continuous monitoring and analysis with developed GUI.**

*Keywords* — **Water quality parameter, turbidity sensor, LabVIEW, Arduino UNO.**

## I. INTRODUCTION

Water is the most precious thing on the earth, and it is vital for survival for life, and the same amount of water available on the earth for millions of years ago is still present today. The total area of water on the earth is occupied by about 326 million cubic miles, and from that, about 70% is trapped in glaciers [1]. Of this 70%, near about 1 % of the world's fresh water is readily accessible.

India has 4% of the world's freshwater resources, ranking it among the top ten water-rich countries. However, still Intergovernmental Panel on Climate Change, India stated that India would become a 'Water Stressed Region' with current utilizable freshwater. Water demand is on a high due to fast development and industrialization along with the traditional demand for agriculture. One of the essential components in every item that we use in our daily life is water. Moreover, the amount of freshwater utilized in the production or supply of goods and services is called Water Footprint. As per available data, an Indian adult requires about 135 liters of water every day.

India is facing a freshwater crisis. India has 4% of the world's freshwater but 16% of the global population. In India, 76 million are without access to safe drinking water. In 21% of the country's diseases are water-related. In our country, over 329, 000 children under the age of five years die due to diarrhea in India in 2015[2].

Due to an increase in the human population, and the changes in land use increases the turbidity level of water increases. Turbidity refers to the cloudiness of water, and it causes due to suspended particles. These particles may be organic & inorganic. The inorganic substances are composed of sediments, while the organic substances are mainly algae, microorganisms, etc. Turbidity is an essential parameter for water quality monitoring; high turbidity harms the ecosystem, so monitoring turbidity is essential for drinking water, irrigation water, fish farming & daily activities.

Speaking about intensive water quality monitoring practices, it gives an urgent call to develop a system, where one can know whether available water is safe for drinking or not. For this, a smart approach to designing and developing a smart turbidity water monitoring system.

Moreover, it is essential to check the water repeatedly, and its quality should inform to Central Pollution Control Board(CPCB) stations of a city so that the quality of water is maintained to the desired level. It is checked by two methods manual or automatic. The drawback in manual checking that it is very time-consuming, and human error may be added in readings; due to this, automatic water quality monitoring is preferred. Which continuously, very accurately and without human involvement, monitor the water. The existing system uses a turbidity sensor, Arduino Uno, with LabVIEW for an online turbidity monitoring system.

Various techniques can measure turbidity in a solution. The turbidity meter uses nephelometry (90 degrees dispersion) or other optical scattering detection techniques for low turbidity measurements. In this method, a detecting angle at $90^0$ between the incident light and photon detector is considered to be standard for particle scattering measurement. This meter, according to different methods, uses various light radiations of wavelength greater than 500 nm.

There are many nephelometric water quality standards like the Environmental Protection Agency (EPA) Method 180.1, ISO 7027, the Hach Method 10133, and Standard Methods 2130 B. Fig. 1 shows the nephelometric principle method. [3]

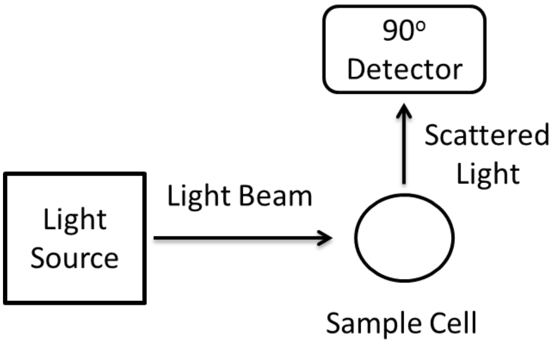


Fig 1: Nephelometric Method (90° detector)

However, the nephelometric method is more expensive, so for, turbidity monitoring system, we use the Light attenuation method standard. The sensor uses in this method is used in the washing machine & dishwasher system. In this measurement system, turbidity sensors used optical technologies that can be placed directly into the investigated water to monitor water continuously. In this method, a detecting angle at 1800 between the incident light and photon detector is considered to be standard for particle scattering measurement. Fig. 2 shows the light attenuation method.

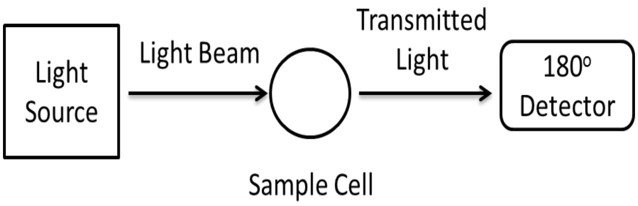


Fig 2: Light Attenuation Method (180° detector)

## II. LITERATURE REVIEW

M.Urs et al. proposed Real-time Water Quality Monitoring using WSN, which measures parameters, temperature, turbidity & pH by the microcontroller. Data sensed by sensors & Arduino microcontroller. GUI developed for fetching data, and Wi-Fi is used to send data on the cloud to make available for the public.[4]

C. Myint et al. developed MICROCONTROLLER-BASED pH AND TURBIDITY MEASUREMENT SYSTEM; the system uses PIC 16F877 microcontroller, LCD module & sensors pH and turbidity, the different liquid values are sensed, and LabVIEW is used for further analyzing.[5].

Bhupen lonkar et al. developed a water quality control & monitoring system using Arduino microcontroller, Wi-Fi & Sensors( Temperature, turbidity, pH & ultrasonic sensor). Sensing data send to the Wi-Fi module for public access. [6]

M.Onibonoje et al. developed water quality controlling using Arduino microcontroller, Xbee transceiver & grove sensors. Sensed parameter data send by Xbee module to sink node consisting Xbee and Arduino connected to PC & monitoring is done through LabVIEW [7]

M. Kumar Jha et al. developed water quality monitoring & flow monitoring using Raspberry Pi, Arduino & sensors ( pH, Temperature, turbidity, Conductivity & water flow sensor). Sensed parameter data send by Arduino controller to raspberry pi & send this data on a web portal to public access.[8]

M. Adzuan et al. developed infrared turbidity meter using Arduino mega microcontroller, IR LED &

photodiode. Sensed parameter data send to PC having MATLAB where analog values are converted to digital values.[9]

A. Faroqi et al. developed a water clarity monitoring & filtration system using Arduino LDR, water pump filtration system & relay, sensed parameter data send to the controller according to the clarity of water filtration pump would on or off.[10]

S. Raghvan et al. developed a water contamination detection system using Arduino UNO, GSM SIM 900A & sensors( pH, temperature & turbidity) sensed parameter data send to a web server by GSM module to user check.[11]

K.A. Menon et al. developed water quality monitoring using PIC16F1877 & pH sensor sensed parameter data send to a base station using Zigbee & user PC. [12]

## III. SYSTEM HARDWARE ARCHITECTURE

### A. *Turbidity Sensors:*

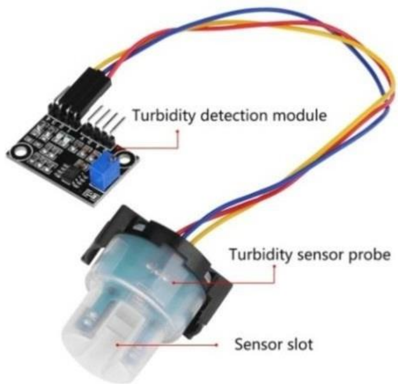


Fig 3: Turbidity Sensor

Turbidity indicates the concentration of suspended and colloidal material in water, and it is measured in nephelometric turbidity units (NTU). Drinking water should have turbidity that is less than 1 NTU. Table1 shows turbidity level in NTU for different water samples. The SEN0189 module is used as a turbidity sensor. The SEN0189 module measures the turbidity (amount of suspended particles) of the water in rivers, lakes, etc.

A turbidity probe is made of the plastic-covered circuit. Inside the housing, it contains a probe circuit that includes a photo emitting diode and phototransistor, which receives the light. It is made waterproof so that the water does not move inside the housing. The amount of light received determines the turbidity of water. As the particles in the water increases, the amount of light transmitted decreases, which helps us to measure the amount of turbidity in water.

The Circuit design inside the turbidity probe is shown in figure 6. As mentioned earlier, it has a Photo transmitter diode and a transistor that acts as a receiver in this circuit. These are the essential component of the turbidity sensor. Figure 6 Circuit Schematic for Turbidity Probe [7]

It operates on a voltage of 5V and an operating current of 40mA. It has the analog output from 0 to 4.5V, with the response time less than 500mS. Also, it has an operating temperature range from 5 to 90 degrees Celsius. The table below shows the safest turbidity level in NTU for different water samples.

Fig.4 shows a graph by DF Robot, showing the relationship between voltage and turbidity for the turbidity sensor. The sensor will give output 4.2 V in pure water (i.e., NTU < 0.5) when the temperature is 10~50$^o$ C. The following equation (1) for converting voltage to turbidity is as below.

$$NTU = -1120.4 (x \quad ^2 + 5742.3(x \quad - 4352.9 \qquad (1)$$

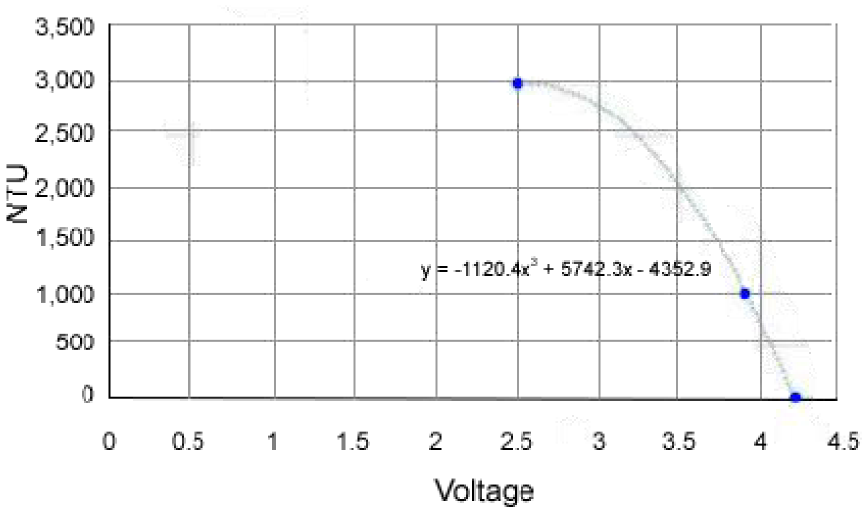


Fig 4: Graph between turbidity & voltage

Moreover, fig 5 gives a relation between voltage vs. temperature at constant NTU value.

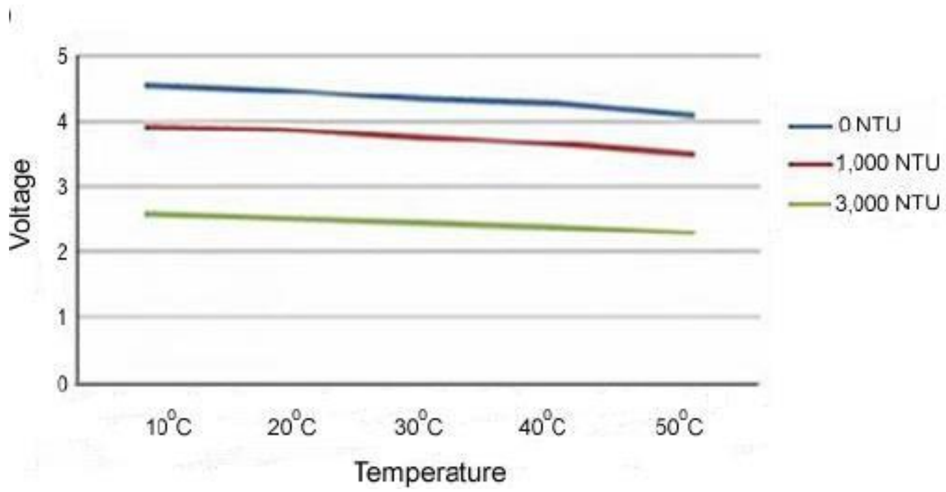


Fig 5: Graph between voltage and temperature

TABLE 1. TURBIDITY LEVEL IN NTU FOR DIFFERENT WATER SAMPLES

| **Turbidity Level (NTU)** | **Water Quality Index** |
|---|---|
| 0.1 | Safe and Pure Water For Drinking |
| 0.2 to 1.0 | Drinkable Water |
| 1.1 to 1500 | Impure and Non-Drinkable Water |

*B. Turbidity signal Conditioning Circuit:-*

Turbidity Circuit is the crucial circuit which is connected to the turbidity sensor probe to measure the turbidity of the water. It provides two output modes analog and digital signal. The circuit has a facility of threshold adjustment for digital mode. A user can choose any mode according to the microcontroller. Analog Mode is selected to acquire the analog signal, and the digital mode is chosen for the digital signal.

Figure 6 shows the turbidity circuit, all input pins of connector P2 connected to the voltage follower circuit having the gain 1. Meanwhile, the Arduino microcontroller data pins require 20 mA current to work, the required current amplified by using ten times larger input resistor than the output resistor.

Aout is the analog output pin used to get the analog signal. It is also possible to change analog mode and digital mode by using the SW1 switch.

LMV358 is an op-amp used in the turbidity circuit due to its characteristic of low voltage. Since turbidity measured data transfer with low voltage. Its operating voltage range is between 5 V to 30 V & the temperature range is between $40^0$ to $125^0$ C. It does not have crossover distortion. Its low supply current is 210 uA. It has a rail to rail output swing. The performance of this amplifier ranges from 2.7 V to 5 V.

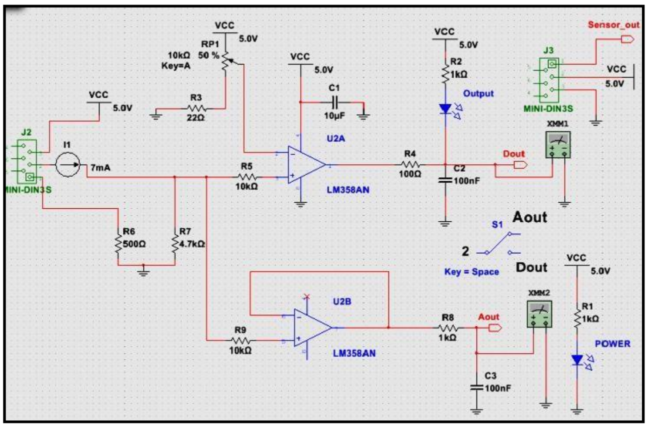


Fig 6: Signal Conditioning Circuit In Multisim

## IV. PROPOSED METHODOLOGY AND SOFTWARE

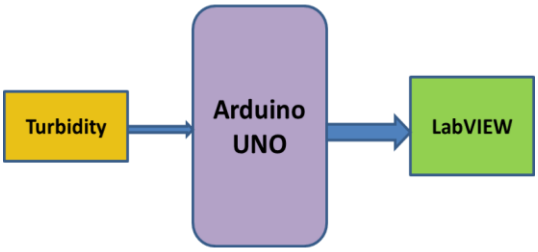


Fig 7: Block Diagram

Figure 4 is shown the layout of the water test diagram with a sensor.

The system built using the Atmega328 based Arduino UNO board as the central controlling unit. The turbidity sensor is used to measure to check suspended solids of the water & send data to the Arduino Uno controller.

The controller of Arduino UNO is to accept analog values from the turbidity sensor and send data to LabVIEW. In this paper, Arduino UNO interface with LabVIEW. LabVIEW is used for calibration of turbidity & as a Display unit in the system. Fig. 8 shows the flow of the program in LabVIEW for turbidity monitoring in the water quality system.

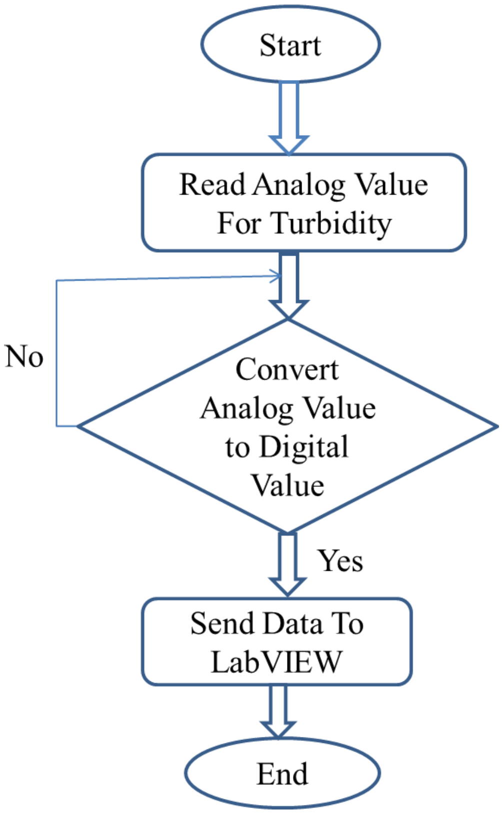


Fig 8: Flow of Program in LabVIEW

*A. Arduino:-*

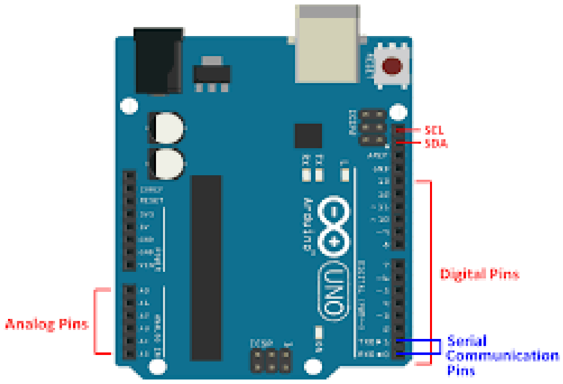


Fig 9: Arduino Board

Arduino Uno is a popularly used microcontroller board that has an 8-bit ATmega328P microcontroller. It also has other components such as crystal oscillator, serial communication, and voltage regulator, to support the microcontroller. Arduino Uno has 14 digital input/output pins, six analog input pins, a USB connection, A Power barrel jack, an ICSP header, and a reset button. Fig 9 shows the Arduino board.

The board operates on 5 volts, and It has 40 mA current on its I/O pins. The board contains 32KB flash memory, 2 KB SRAM & 1KB EEPROM.

To power this board, the USB connection shall be used. To program the board, the Arduino IDE is used, which is written in Java. However, C language can be used for communication with the Arduino board, making it easy to use for any application.

*B. LabVIEW:-*

LabVIEW stands for Laboratory Virtual Instrument Engineering Workbench, which is a high-level graphical programming workbench, which uses a graphical programming language for system design and development of environments. It is developed by National Instruments (NI). Different industries for a variety of systems use LabVIEW for data acquisition, instrumentation control, and automation. It can be used in Microsoft Windows, Unix, Linux, and Mac OSx. LabVIEW can interface with various devices, instruments, cameras, and many other applications. It is possible to make the user interface for the hardware in PC and control using LabVIEW.

It is a virtual instrument due to its appearance and operation.

VISA tools are used for interfacing between the software and the hardware system. The Virtual Instrument Software Architecture (VISA) is required by LabVIEW to communicate with the controller over the serial port (RS-232). VISA resource name is used as a control to mention the port used for communication. The data received from the microcontroller is indicated. Indicators are used to indicate the test conditions.

To create a front panel of user interface sets of tools and objects are required in LabVIEW.

The code can be inserted using a graphical representation of function to control the front panel object. Block diagram resemble flow chart in specific ways. The fig.10 shows the front panel of the LabVIEW. Moreover, fig. 11 shows the necessary LabVIEW G-code for GUI. LabVIEW having a Web publishing toolbar used to access data in any Remote location. This data can show the Front Panel of the System. This toolbar generated URL, by using URL we can access data.

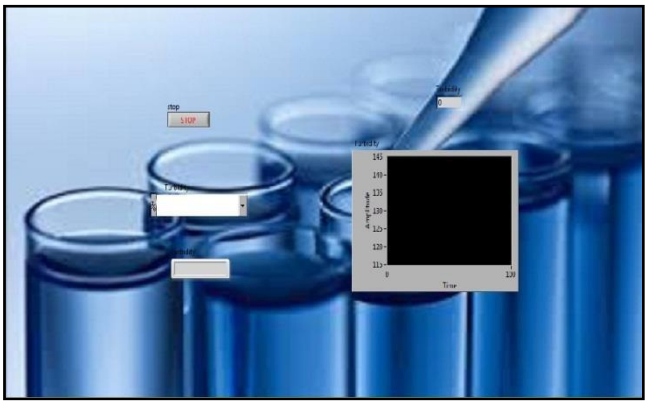

Fig 10: LabVIEW GUI

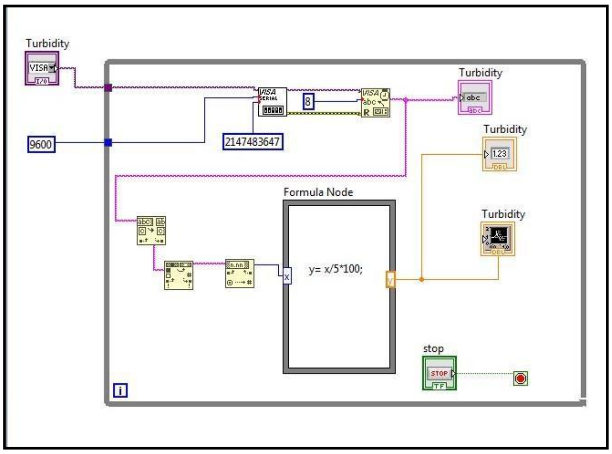


Fig 11: LabVIEW G - Code

The remote control panel manager shows how many clients are connected to the server and also able to disconnect specific clients with the help of the touch button. The use of the remote panel tool is effortless and powerful security because there is three option Allow Viewing and controlling, allow Viewing, Deny access.

## IV. RESULTS & DISCUSSION :-

Table 2 shows turbidity parameter readings of water samples by standard turbidity meter & turbidity measurement by a LabVIEW based system. That shows the output values of the two systems are near matches. The output of the turbidity value shows errors in the final reading.

Fig.12 shows the graph of Voltage vs. Turbidity measured by our LabVIEW based system. It means the output voltage decreases when the turbidity values are increases. According to the result, our system shows accuracy when compared with a standard turbidity meter.

TABLE. 2. TURBIDITY OF DIFFERENT WATER SAMPLES

| **Water Sample Name** | **Turbidity Measured By Standard Turbidity Meter (NTU)** | **Turbidity Measured By our LabVIEW Based System (NTU)** | **O/P Voltage (V)** |
|---|---|---|---|
| RO Water | 0 | 0 | 4. 201 |
| Tap Water | 0 | 0 | 4.201 |
| Hipparga Pond | 0.1 | 0.904 | 4.20 |
| Ujani Dam | 0.1 | 0.904 | 4.2 |
| Bhima River | 0.1 | 0.904 | 4.2 |
| Bore Water | 0.1 | 0.904 | 4.2 |
| Clay Mixture Sample 1 | 340 | 356.606 | 4.1 |
| Clay Mixture Sample 2 | 2000 | 2020.25 | 3.5 |
| Clay Mixture Sample 3 | 2950 | 3000.35 | 2.5 |

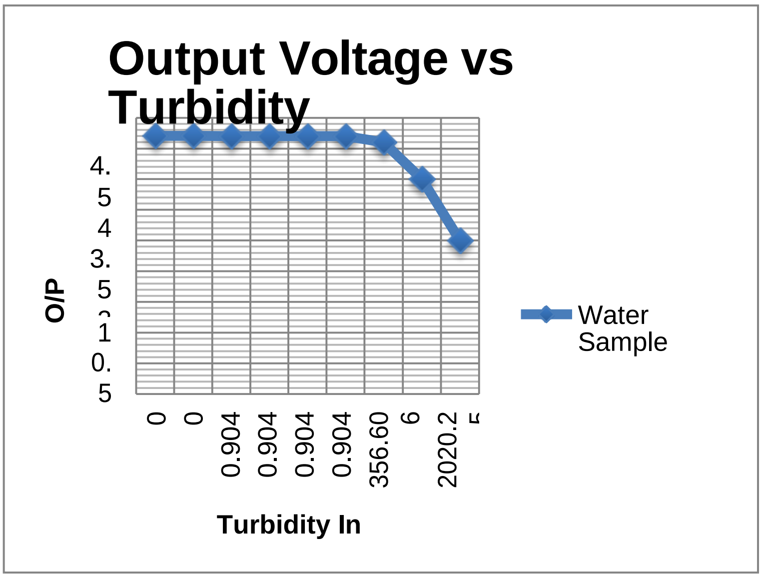

Fig 12: Graph Turbidity vs. Time

The system is used to monitoring the turbidity level of water with the interfacing of LabVIEW. The use of the system is more economical and reliable for water monitoring. Moreover, the system is flexible, easy to operate and install. The system has excellent flexibility.

This paper presents a wireless system for water quality monitoring. In this system, the integration of sensors, transmitters, receivers, Arduino microcontrollers, and IEEE 802.11 Wi-Fi technology. In order to ensure high accuracy, we use industry-standard sensors to measure water quality—moreover, calibration of both the sensors and the system to ensure high reliability. A LabVIEW program has been developed for front panel display and interfacing with the sensors.

## V. CONCLUSION:-

Our LabVIEW based system supports Continous real-time water quality monitoring. Moreover, it also supports data management, analysis, and statistics. The system also generates reports. The result shows that our system can monitor water quality with accuracy.

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