Water Quality Sensing With Sensors and Mobile Smart Phone

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Computer Science and Applications

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CERTIFICATE

I hereby certify that the work being presented in the dissertation entitled, **"Water Quality Sensing with Sensors and Mobile Smart Phones"**, in partial fulfillment of the requirements for the award of degree of Master of Technology in **Computer Science and Applications** submitted to the Computer Science and Engineering Department of Thapar University, Patiala, is a authentic record of my own work carried out under the supervision of **Dr. Sharad Saxena** and **Mrs. Sunita Garhwal** and refers other researcher's work which are duly listed in the reference section.

The matter presented in the dissertation has not been submitted for the award of any other degree of this or any other university.

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TABLE OF CONTENTS

Certificate..... i

Acknowledgement..... ii

List of Figures……..... v

List of Tables……..... vi

Chapter I: Introduction……..... 1-16

1.1 Introduction..... 1

1.2 Water Quality Measurement..... 2

1.2.1 Biological Contaminants..... 2

1.2.2 Chemical Contaminants..... 3

1.3 Measurement Techniques..... 7

1.3.1 Chromatography..... 7

1.3.2 Electrode Measurements..... 8

1.3.3 Radiation Measurements..... 8

1.4 Water Quality Sensors..... 9

1.4.1 Smart Phone Sensors..... 9

1.4.2 Software Based Smart Phone Sensors..... 9

1.4.3 Smart Phone Sensor Attachments 10

1.4.4 Wireless Smart Phone Sensors 11

1.5 Sensor Prototyping Platform..... 12

1.5.1 Microcontroller Architecture..... 12

1.5.2 System-On-Chip Computer System…… 13

1.5.3 Wireless Device Communication…… 13

1.5.4 Wireless Networking (Wi-Fi) ……. 14

1.5.5 Bluetooth……. 15

1.7 Dissertation Outline…… 15

1.6 Summary……..... 16

Chapter II: Literature Survey……..... 17-48

2.1 Introduction..... 17

2.2 Literature Survey..... 17
2.3 Summary..... 48

Chapter III: Problem Statement and Objective……..... 49-50
3.1 Problem Statement..... 49
3.2 Objective..... 50

Chapter IV: Simulation and Experimental Setup……..... 51-64
4.1 Introduction……..... 51
4.2 Sewage Treatment Process…..... 51
4.3 Sensor Placement…..... 52
4.4 Sensor Hardware…..... 53
4.5 Phone Application software…… 54
4.6 Measurement Procedure……... 56
4.7 Data Flow……. 57
4.8 Results…….. 58
4.8.1 pH……. 58
4.8.2 Temperature…….. 59
4.8.3 Dissolved Oxygen……. 61
4.8.4 Conductivity…….. 63
4.9 Summary…… 65

Chapter V: Conclusion and Future Scope…….……..... 66
5.1 Conclusion..... 66
5.2 Future Scope..... 66
Paper Communicated……..... 67

References……..... 68

LIST OF FIGURES

FIGURE	DESCRIPTION	PAGE NO
Figure 4.1	Sewage Treatment Plant	52
Figure 4.2	Block Diagram for Data Collection and Communication	53
Figure 4.3	Phone Application Software	55-56
Figure 4.4	Flow Diagram	57
Figure 4.5	Graph for pH	59
Figure 4.6	Graph for Temperature	61
Figure 4.7	Graph for Dissolved Oxygen	62
Figure 4.8	Graph for Conductivity	64

LIST OF TABLES

TABLE	DESCRIPTION	PAGE NO
Table 1	pH classification of water	4
Table 2	Conductivity classification of water	5
Table 3	Effect of temperature on water	5
Table 4	Wireless Devices	14
Table 5	Literature Survey	38
Table 6	Specification of Sony Xperia Z1	55
Table 7	Tabulated Data for pH	58
Table 8	Tabulated Data for Temperature	60
Table 9	Tabulated Data for Dissolved Oxygen	62
Table 10	Tabulated Data for Conductivity	63

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The goal of this thesis is to develop cost-effective sensor technologies that will enable a user with minimal training to make rapid measurements of multiple water quality parameters on-site immediately without water sampling. Such technology would enable water quality measurements significantly faster than traditional methods based on collection of water samples, sample transportation to a laboratory, and subsequent measurement in a controlled setting. In contrast to other stand-alone water quality sensors that already enable immediate measurements on-site, our water quality sensor leverages the abundant processing power, intuitive touch-based interface, connectivity, and general ubiquity of smart phone systems, a novel approach that places priority on cost-effectiveness, portability, and ease of use. In this work, the water source taken for quality measurement relates to the daily use by humans. P Parameters for measurement that form an cumulative measurement of overall water quality include the concentration of inorganic and organic compound, pH, temperature, conductivity, and dissolve oxygen [1]. When these parameters exceed desired limits, the water quality is compromised and there are chances of long and short -term negative effects to human health. Whereas most urban populations in developed countries attain their water from distribution systems that are centrally monitored and regulated, the availability of economical technologies allow persons to make speedy water quality measurement at the sampling point without sampling would benefit the majority of the population residing in developing countries, who use and consume water that is neither monitored nor treated. In addition, the rural population in developed countries (in Canada and US alone, these amounts to approximately 40 million people [2, 3]) generally get water from private wells and could possibly benefit from access to drinking water quality data. In some part of the world population use river and other natural resources of water for their daily needs. The sewage

and effluent generated from the cities and factories can pollute these natural resources. Speedy and on-site water quality measurements are also influential for regular uses such as spa, pool, and maintenance of aquarium. In this thesis multiparameter water quality sensor is used for the online measurement of different water parameter that have achieved portability, cost-effectiveness, and ease of use by integration with mobile smart phone systems. The sensors are capable of quantifying commonly-used water quality parameters including pH, temperature, conductivity and dissolve oxygen. The multiparameter sensor transfer the data to smartphone using different technologies and software's available free of cost in the market. The sensor node that can wirelessly interface to any smart phone. The distinguishing features of this model include high portability (both fit into the palm of a hand), operation without instruction manuals by interaction with a user through a graphical interface, high data mobility by exploiting the internet connectivity of smart phones, and rapid water quality measurements with sensitivity and accuracy comparable to that of commercially-available stand-alone water quality sensors. The model can potentially be used to monitor water quality parameters relevant for water consumption or recreational use.

1.2 WATER QUALITY MEASUREMENT

Generally, water quality is decided by the existence of entities in water that are harmful to human health. In this section, we will discuss water quality in terms of contaminants that are either biological or chemical in nature, and introduce standard methods to quantify the presence of these contaminants.

1.2.1 BIOLOGICAL CONTAMINANTS

Biological contaminants include pathogenic micro-organisms such as bacteria, protozoa, viruses, and algae that can cause illness and death in humans [1]. Biological contamination is often caused by industrial, agricultural, and domestic run-off entering the water supply. This form of contamination is measured based on selected indicator micro-organisms, whose presence is quantified through a multi-stage process that involves water sample collection, incubation, and enumeration. A water sample is incubated in a medium that is selectively nutritious to a particular indicator organism. Over the course of days, single cells multiply into entire colonies, which can then be counted by visual inspection. Based on the number of colonies, it is possible to indirectly figure out the concentration of the indicator

microorganism in water sample. While this method is relatively simple and cost-effective, the incubation period required to grow the sample is on the order of several days. There are currently no viable technologies that can enable rapid, on-site measurement of biological contaminants, although some recent research progress suggests the possibility of direct visualization of individual micro-organisms using automated high-power microscopes and computer algorithms [4,8].

1.2.2 CHEMICAL CONTAMINANTS

Chemical (or inorganic) contaminants can have negative long-term human health effects in addition to adverse effects in industrial and household settings through equipment damage. Chemical contaminants include carcinogens, metals (such as copper, iron, arsenic, and manganese), nitrates (fertilizer by-products), and treatment by-products (such as chloramines)
[1]. Some chemical indicators, such as pH, hardness, dissolve oxygen can also be used as indirect indicators of biological contamination. In contrast to indirect methods for measuring biological contaminants, chemical contaminants can be measured directly due to their homogenous distribution, distinguishable chemical attributes, and well-established measurement physics. There is one more parameter which directly affect the water quality is temperature.

There are some conventional parameters which gives a general idea about the water quality. Those parameters which are measured to get a general image of aquatic environment, including the impact of the local environmental conditions and drainage basin, annual and seasonal variability, and the condition to support aquatic life. Following are the description of some of the most commonly measured conventional parameters.

- **pH**

Measurement of hydrogen ion concentration in water is called pH. It is generally used to show the acid/base condition of water.

Table 1. pH classification for water

Sr. No	pH value	Water condition
1	7	Neutral
2	>7	Alkaline
3	<7	Acidic

Most natural water holds the pH value between 6.0 to 8.5. As pH is calculated as the negative logarithm of the hydrogen ion concentration (i.e., $pH=-\log([H^+])$, one pH unit represents a tenfold difference in hydrogen ion concentration; pH 6 is ten times less acidic than pH 5. Both Chemical and biological process are affected by pH. pH <4.5 and >9.5 are usually harmful to aquatic organisms, and even less intense pH values can affect biological processes and reproduction.

Solubility of organic compounds, salts and metals are affected by pH. In highly acidic condition support to dissolve some minerals and release chemical substance and metals in to water. Chemical form of some components can also be determined by pH , which in turn can affect bioavailability, reactivity and toxicity. For example, most metals are more readily absorbed by living things at low pH because of positively charged ions.

For example, ammonia is a general toxic chemical in water, and takes available in two forms: ammonium ion, NH^+ and the ammonia, NH_3. The relative proportion of the two forms depends on temperature and pH. Ammonia (NH_3) is more toxic to aquatic organisms because it can cross biological membranes such as gills. As temperature or pH rises, the relative proportion of NH_3, and hence the toxicity to aquatic organisms, increases.

The water inputs and chemical characteristics of the surrounding land is reflects by the pH of water bodies. The pH of surplus water from the land, or input of the groundwater to surface water, is afflicted by the soils to which water contacts as it moves through the land of minerals and type of minerals. Draining water from forests and swampland may be have low pH and due to unsteady organic acids contained in the organic element within these ecosystems.

- **CONDUCTIVITY**

Conductivity is the capability of a substance to conduct an electric current. It is the reciprocal of resistance. If the ions concentration in water is higher than the water can conduct more current. Conductivity is depend on the amount of dissolved solids, especially mineral salts in the water, and also depends on the temperature, ion mobility and amount of electrical charge on each ion.

The unit of conductivity is micro siemens per centimetre (µS/cm). Conductivity generally ranges between 10 and 1,000 µS/cm in most lakes or rivers. Following is the classification of water based on the conductivity.

Table 2. Conductivity classification for water

Classification	**Conductivity (**µS/cm)
Freshwater	<600
Moderately saline	600-6000
Saline	>6000

Measurements of conductivity can be used to define a pollution zone, like high volume of untreated effluent discharge or run-off. High levels of conductivity shows water less suitable for irrigation and drinking.

- **TEMPERATURE**

It is one of the most crucial characteristics of an aquatic system. Following are some of main effects of temperature on aquatic system.

Table 3. Effect of Temperature on Water

Sr No	**Parameter**	**Effect**
1.	Dissolve Oxygen Level	Oxygen Level decrease with increase in temperature.
2.	Chemical Process	Chemical reaction increase with increase in temperature.
3.	Biological Process	Affects the metabolism, growth and reproduction of aquatic animals.
4.	Composition of Species in aquatic ecosystem	A limited temperature range is required for the survival for the most of the species.
5	Water stratification and density	Variation in water density and temperature between layers leads to seasonal turnover and stratification

6	Environmental clues for life-history stages	Water temperature changes may act as a signal for fish to spawn or for aquatic insects to emerge.

Sun is the most important source of heat for fresh water, although temperature can also be varied by the temperature of water inputs, exchange of heat with air and heat gained or lost by condensation or evaporation.

Fluctuation in water temperature is changes between day and night (diurnal temperature changes) and over longer time periods (e.g., seasonally). In the spring, snowmelt reduce the temperature of river below ambient temperature.

With the latitude and elevation water temperature varies along the river length. Sometimes a variation in temperature is seen between small sections due to local conditions. For example, a shaded deep pool is cooler than a sunny shallow area. According to the solar radiation penetration level and characteristics of mixing. The surface water temperature usually ranges between 0ºC -30ºC, despite this in hot springs it may exceed 40ºC.

The water temperature can get affected by Human activities also that include the discharge of heated industrial effluents or cooling water, harvesting of forest and agriculture, climate change and urban developments that affecting water temperature can include the discharge of cooling water or heated industrial effluents, agriculture and forest harvesting (due to effects on shading), urban development that changes the path of storm water runoff, climate change and characteristics.

- **Dissolved Oxygen**

The oxygen dissolved in water is called dissolved oxygen (DO). The oxygen get dissolve by diffusion aeration of water and from photosynthesis. The value of dissolve oxygen can vary in seasonal and daily pattern. It decreases with, salinity, higher temperature and elevation. In water at 1 atm pressure maximum solubility of oxygen is seen. Atmosphere and photosynthesis by aquatic plants are the main source of dissolved oxygen. Oxidation and respiration by aquatic animals, microorganisms are main source of the depletion of the dissolved oxygen.

Surface water generally saturated or supersaturated with oxygen due to the sufficient light for photosynthesis. A reduction is seen in the dissolve oxygen during winter season.

For a healthy aquatic ecosystem dissolve oxygen is essential. Dissolve oxygen is required for the aquatic animals to survive. Different species and life stage require different amount of dissolve oxygen.

1.3 MEASUREMENT TECHNIQUES

Chemical contaminants can be measured using a variety of instruments, which we have categorized into those based on chromatography, electrode measurement, or radiation measurement. Instruments that measure chemical contamination in water vary dramatically in terms of cost, accuracy, and portability. Following are different techniques which are used for the measurement of water quality parameter.

1.3.1 CHROMATOGRAPHY

Chromatography instruments (chromatographs) provide the greatest sensitivity and accuracy for quantifying chemical contamination. To measure a chemical species dissolved in water, chromatographs work by separation of ions in a sample and subsequent detection. A separation vessel consisting of a long column is filled with a material known as the stationary phase. The water sample is mixed with another liquid having known concentration of ions and fed through the column. A third liquid known as the effluent is added to the top of the column to wash the sample mixture through the column. The stationary phase is selective and preferentially binds to the ions in the sample solution, separating the ions as they travel down the column at different rates. A detector placed at the bottom of the column detects the arriving ions of the sample. Differences in the arrival time (retention times) of the ions are used in conjunction with a calibration standard to identify the ion concentrations and sample composition. The detector can be a colorimetric sensor, a conductivity sensor, or a mass spectrometer [9]. The ion chromatograph is a very powerful tool and, combined with an auto sampler (a device that enters the sample into the column), a concentrator, and analysis algorithms, can be highly automated and perform rapid measurements. However, due to the complex nature of the system, it is very expensive and requires careful sample preparation and highly trained personnel. The system is also very bulky due to a large array of complimentary components.

1.3.2 ELECTRODE MEASUREMENTS

Ion-selective electrode measurement is another technique to quantify chemical contamination in water. This technique works on the basis of a redox reaction and uses two electrodes. One electrode is immersed in a reference solution with known ion concentration and a second electrode is encased in a selectively permeable housing and immersed in the sample solution. Only the desired ions pass through the housing to the second electrode. Knowing the concentration and standard potential of the reference solution and the measured potential between the two electrodes, one can determine the concentration of the targeted ion species in the sample solution. Depending on the construction of the selective membrane, various ion concentrations can be measured. One variation of this technology is the popular electrode-based pH meter [10]. Ion selective electrode measurements are very accurate, but require frequent calibration, are limited to measurement of a few ionic species, are notoriously fragile, and are costly.

1.3.3 RADIATION MEASUREMENTS

Perhaps the simplest and most widely-used method for measuring chemical contamination is based on radiation or light-based measurement. There are several forms of light-based water quality measurement. The most universal is based on direct observation of a water sample either by eye or by using a color-sensitive image sensor to arrive at a qualitative description of water quality (for example, \the water is murky" or \the water is crystal clear"). Quantitative descriptions of water quality can be obtained through photo-sensitive measurements.

It can be difficult to confidently determine the presence of a particular chemical contaminant in a water sample based solely on direct observation or photo-sensitive measurement of a water sample. To overcome this limitation, indicator solutions can be added to a water sample to produce a characteristic color change due to the presence of a particular chemical species.

The concentration of the targeted species can then be quantified based on the magnitude of color change. Due to the availability of color indicators for a wide range of water quality parameters, light-based measurement is a very powerful and versatile tool for

water quality determination and will be used here to realize an inexpensive, portable, and easy-to-use water quality sensor.

1.4 WATER QUALITY SENSOR

In this work, multiparameter sensors are chosen for measurements as the basis of a portable, cost-effective water quality sensor. Although spectral measurement and analysis of samples in lab provides the most rigorous means to quantify the parameters by devices such as spectrophotometers and spectrometers are expensive, bulky, and generally confined to operation in laboratory settings. Portable sensors on the other hand, can be implemented into highly portable devices consisting of cost-effective measurement system. Currently, there are several commercially available multiparameter sensors are available which are capable of water quality measurements.

1.4.1 SMART PHONE SENSORS

Smart phones are advanced cellular phones that run operating systems capable of high-level computational tasks such as downloading and running mobile application software (apps), internet browsing, and emailing. In late 2012, the number of smart phones in operation worldwide surpassed one billion, and last year alone, another one billion smart phones were sold. Smart phones are broadly classified by their operating system, with the vast majority of smart phones currently using Google's Android operating system (81%), followed by Apple's iOS operating system (13%), and then Microsoft's Windows operating system (4%). Due to the rising popularity of apps and the open accessibility of app development tools, there has been a growing trend in industry and academia towards the development of sensors integrated with smart phones to leverage their portability, connectivity, ease-of-use, and ubiquity [22, 23]. In this section, survey several approaches for developing smart phone sensors, parsing past works into those based on software implementation, physical sensor attachment, and wireless sensor nodes.

1.4.2 SOFTWARE-BASED SMART PHONE SENSORS

One approach to realizing a sensor based on smart phones is to write software applications (apps) that use sensors already integrated onto smart phones to perform measurements. There are a large number of commercially available applications that can be downloaded (through online vendors such as Google Play for Android devices or the App

Store for Apple devices) to transform smart phones into portable sensors. Pelegris et al. created an application that monitors the heart rate of a user by analyzing the color change of a finger placed on the camera [24, 25]. Delaney et al. developed a microfluidic sensor to measure chemiluminescence by using the camera of a smart phone in conjunction with a paper-based chip [26]. For applications in telemedicine, Martinez et al. built an application to capture an image of an assay and to tag it with relevant information. The image can subsequently be sent electronically to health-care professionals for analysis [27]. Lopez-Ruiz et al. designed a portable sensor to detect gaseous oxygen levels based on an illuminated membrane placed over the smart phone camera [28]. A variety of smart-phone-based colorimetric sensors have also been realized for water quality measurement. For validating the effectiveness of water disinfection, Copperwhite et al. developed a UV dosimeter that uses a smart phone to take color images of a colorimetric sensing substrate [29].

Similarly, Shen et al. created a smart-phone-based pH meter by taking color images of pH reagent test strips [30]. A commercially available app by the company LaMotte also operates on the same principle [31]. Recently, Sumriddetchkajorn et al. developed an app that enables measurement of chlorine concentration by imaging a water sample mixed with a colorimetric reagent [32]. Generally, software-based smart phone sensors are easy to implement and have a low cost of distribution. However, they have a couple significant disadvantages. First, the sensing hardware is located inside the smart phone and cannot be accessed or modified. Available literature on the performance specifications of sensors integrated into smart phones is sparse, making it difficult to predict the accuracy and precision of the sensor measurements. Second, this type of sensor suffers from limited environmental control. Measurements are typically performed in open environments and can be detrimentally affected by ambient light, heat, noise, or vibrations.

1.4.3 SMART PHONE SENSOR ATTACHMENTS

An alternative route to realizing smart phone sensors is based on custom hardware attachments physically interfaced to a phone. One common approach is to construct the attachment with all the necessary hardware to perform measurements and then wire the attachment to a smart phone to enable control of the attachment. For example, the company Oscium Analyzers has recently released an oscilloscope, a spectrum and logic analyzer, and a power meter that operate by connection to the serial port of the iPhone or iPad [33]. Other

examples of sensors interfaced with smart phones through the serial port include blood glucose monitors developed by Sanoff [34] and pH meters developed by Sensorex [35]. Moreover, a wide range of smart phone sensor attachments have been designed for connection through the 3.5 mm audio input/output port (which is universal to nearly all mobile devices and has analog input capabilities). This includes credit card readers [36] and oximeters [37, 38].

Smart phone sensor attachments have also been developed to augment the measurement capability of components already integrated onto the smart phone. For example, the camera in most smart phones can be vastly improved by using additional external optical components. Breslauer et al. first demonstrated that a camera phone (a precursor to the smartphone) can be used as a portable microscope by mounting a microscope objective in front of the camera [39]. A research group from UCLA has created a clip-on device containing a lens and illumination optics to realize a high-magnification flouorescence microscope [40] and flow cytometer [41]. Recent work from this group has also demonstrated clip-on devices to enable virus detection [42], blood analysis [43], allergen testing [44], and urine analysis [45]. Lee et al. developed a phone-based DNA detector by attaching a custom-built sample holder, including an excitation light source and emission filter, to the back end of a mobile phone [46]. Sumriddetchkajorn et al. created a colorimetric water quality sensor to quantify chlorine concentration based on holding a smart phone to an aperture in the sensor and capturing images of a water sample mounted against a white background [47]. Several crowd-funding projects have been proposed based on lens attachments to smart phones to enhance imaging capabilities [48{50].

1.4.4 WIRELESS SMART PHONE SENSORS

Smart phone sensors that require a physical attachment are specific to the dimensions and specifications of current smart phone models. Due to the rapid evolution of smart phones, these sensors can quickly become obsolete and out-of-date. One way to overcome this limitation is to develop sensor nodes that wirelessly interface with smart phones through standard wireless protocols (such as WiFi or Bluetooth). There are many benefits of this approach: the sensor is universally compatible with all smart phone systems, sensor operation is more elegant due to the absence of physical connection, and the smart phone can communicate with multiple sensors at once.

There has been tremendous research and development in wireless sensors spanning a wide range of applications. The GoPro series camera and the Nikon DSLR cameras, for example, now have wireless interfaces to enable camera control and data transfer with mobile devices [51, 52]. Nike and Apple have collaborated to create a wireless sensor integrated into Nike running shoes that can be used with Apple mobile devices to monitor exercise [53]. The iGrill wireless thermometer provides meat temperatures readings that are wirelessly sent to a smart phone [54]. A variety of biomedical devices have been demonstrated based on wireless communication with smart phones, including pulse rate monitors [55, 56], electrocardiograms [57{60], stethoscopes [61], and health monitoring stations [62]. Due to the diversity of applications for wireless sensors [63], some have endorsed the idea of creating an open wireless sensor platform to enable developers and designers to rapidly create and prototype new concepts [64]. Indeed, the potential impact of wireless sensors in a diverse range of applications is enormous.

1.5 SENSOR PROTOTYPING PLATFORMS

Smart phone sensors generally require on-board or embedded computation to collect, store, analyze, or transmit sensor data. Depending on the amount of processing required, several prototyping platforms with varying capabilities can be used. In this section, we will discuss prototyping platforms based on simple microcontroller units (MCU) and more powerful system-on-chip (SOC) computer systems.

1.5.1 MICROCONTROLLER ARCHITECTURE

Microcontroller units (MCU) account for the majority of embedded electronic systems and are ideal for applications that require low data rates and simple calculations. They generally consist of a microprocessor capable of simple computational tasks and a number of interfaces, input and output (I/O) pins, displays, and sensors. While MCUs have been in use for several decades, it has only been in the last few years that portable and low cost prototyping platforms have become widely available. One of the most popular is the Arduino prototyping platform [65]. The Arduino hardware consists of a microcontroller with general input and output pins and its software is written in a C-based programming language. A large community of developers have been attracted to the Arduino platform because the hardware and software are both open-source and the development interface is simple and

easy to use. The open-source hardware has spurred the development of a number of add-on boards (shields) that connect to the Arduino and control peripherals such as motors, displays, wireless and wired communication platforms, and input devices. Table 1.1 outlines some of the specification of a typical Arduino micro-controller platform.

1.5.2 SYSTEM-ON-CHIP COMPUTER SYSTEMS

System-on-chip (SOC) systems are suited for applications that require on-board computation to perform more intensive tasks such as signal processing at high data rates, video acquisition, image processing, high bandwidth communication, and user interaction. SOCs are basically entire computer systems on a single chip capable of running an operating system. Compared to the MCU development process, the SOC development process is signiffcantly longer due to increased hardware and software integration and includes time-intensive tasks such as customization of the hardware system components, boot optimization, kernel development, and application development. Recent developments in open-source integrated hardware and software systems have led to the proliferation of single-board computing systems. One of the most popular low-cost SOC options is the BeagleBone prototyping platform. The BeagleBone system includes a central processor with on-board RAM and ethernet, USB, HDMI, and general purpose I/O pins [66]. Add-on hardware allows for the integration of camera systems, wireless connectivity, motor control, touch-screen technology, and external storage. Software development resources are open-source and readily available.

1.5.3 WIRELESS DEVICE COMMUNICATION

Wireless connection protocols and standards have been developed in the last few years for general use in electronic devices.

Table 4. Wireless Devices

Parameters ↓	Arduino 	Beaglebone Black 
Processor	ATmega 328	ARM Cortex - A8
Clock Speed	16 MHz	1 GHz
RAM	2 Kbyte	512 Mbyte
Flash Storage	32 Kbyte	2 GByte
Input/Output	14 GPIO, 6 Analog	69 GPIO
Operating System	--	Linux
USB	--	1
Ethernet	--	10/100
Video	--	Mini-HDMI
Power Consumption	0.15 W	1.5 W
Cost	$30	$45
Size	53 mm x 75 mm	55 mm x 90 mm

The most widely used wireless standards applicable for device communication are revived in this section.

1.5.4 WIRELESS NETWORKING (Wi-Fi)

Wireless LAN (WLAN) is the most widely used wireless connection standard. The WLAN standard is based on the IEEE 802.11 standard, which runs at frequencies of 2.4 GHz and 5 GHz. Hardware that qualifies for certification bears the trademark WiFi [67]. A WiFi connection allows multiple devices to be connected to a wireless access point (hotspot or router). WiFi is most commonly used to connect consumer electronic devices to local networks, which can then access the internet. Due to price reduction of wireless LAN chipsets over the last few years, wireless access is now ubiquitous for a large number of devices. WiFi is very well suited for high data rates and the latest offcial standard supports

speed up to 600 MBits/second. The range of WiFi devices can be up to several hundred meters, with this upper bound set by each country's radiative power restrictions. In order to guarantee secure transmission of data between devices several encryption technologies are available, including the password protected Wireless Equivalent Privacy (WEP) standard and, more recently, the WiFi Protected Access II (WPA2) [67, 68]. Although powerful, the main limitations of WiFi hardware include high power consumption and complex infrastructure requirements.

1.5.5 BLUETOOTH

The Bluetooth wireless communication standard is a short range, point-to-point communication system suited for low data rates that was primarily designed to eliminate the need for short cables. Bluetooth specifications are maintained by the Bluetooth Special Interest Group (Bluetooth SIG). The Bluetooth system transmits data on the unlicensed 2.4 GHz frequency band using a frequency hopping spread spectrum (FHSS) to reduce the effects of interference and fading. A Bluetooth device can be connected to several other devices, but can only communicate with a single device at a time. The range of a Bluetooth radio varies between 1 m to 100 m, depending on the class of the device. The data rate for Bluetooth is limited to 24 Mbits/s [69], much lower than that of WiFi. In order to allow secure communication of devices, two devices must be paired using a passcode before any information can be transmitted. In 2013, the Bluetooth SIG released the Bluetooth Low Energy (BLE) standard to further reduce power consumption [70], which is attractive for mobile devices running on batteries.

1.7 DISSERTATION OUTLINE

The goal of this thesis is to propose a portable, easy-to-use, low-cost water quality sensor model that enables a user to make measurements of multiple water quality parameters immediately at the point of sampling. To achieve this goal, the water quality sensor will leverage the computation power, connectivity, and intuitive display of mobile smart phones. In Chapter 2, related work is discussed. In Chapter 3, problem statement and objective of the thesis is discussed. In chapter 4, the simulation and application setup is discussed along with the results obtained from the experiment. In chapter 5, conclusion and future scope is discussed.

1.6 SUMMARY

In this chapter the discussion about the different water polluting parameter, different conventional parameters which are used to describe the water quality, techniques used for the measurement for these parameters, have been described. Different hardware platform used for the development of these communication devices are also discussed. After that the techniques used for the efficient data collection and transfer has been discussed.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

In the following chapter we have reviewed various research papers that have explored the various studies that have been done to understand the properties of sensors and other hardware used for the measurement of water quality. Meaningful research has been added to the developed study to extend the existing study to a new parameter. In the chapter various research papers have been added by virtue of extracts of all the papers that have been considered for reference.

2.2 LITERATURE SURVEY

Breslauer D. N. *et al.* given a straightforward, practical, and essential strategy for the analysis and screening of hematologic and irresistible maladies utilizing light microscopy. In numerous locales of the world, be that as it may, the obliged hardware is either occupied or deficiently convenient, and administrators may not have satisfactory preparing to make full utilization of the pictures acquired. Illogically, these same areas are regularly very much served by cellular telephone systems, recommending the likelihood of utilizing compact, camera-empowered cell telephones for demonstrative imaging and telemedicine. Toward this end, a cellular telephone mounted light magnifying instrument has been manufactured and exhibited its potential for clinical use by imaging P. falciparum-contaminated and sickle red platelets in splendid field and M. tuberculosis-contaminated sputum tests in fluorescence with LED excitation. In all cases determination surpassed that important to distinguish platelet and microorganism morphology, and with the tuberculosis tests we exploited the digitized pictures to show robotized bacillus tallying through picture examination programming. It is normal that such a telemedicine framework for worldwide social insurance by means of cellular telephone offering economical brilliant field and fluorescence microscopy incorporated with robotized picture examination – to give a vital apparatus to malady analysis

and screening, especially in the creating scene and rustic ranges where research center offices are rare yet cell telephone base is extensive.

Chan C. C. *et al.* proposed a vitality productive model for analytic evaluation portable ECG observing. The model is produced with business discrete segments to demo a patient driven restorative environment. The model uses a cell telephone as an entryway to transmit the deliberate ECG information back to the therapeutic cloud: Bluetooth for ECG sensor to the cellular telephone, while 3G/Wi-Fi for the cell telephone to the medicinal cloud. Accordingly, the patients are not attached to the doctor's facility or home, and can go outside for basic life. The model can ascertain on the cellular telephone the RR interims. More precise RR, QRS interim can be gotten from server. The stage can likewise investigate the non-direct examination of heart rate variability in patients with congestive heart disappointment taking into account multi-scale entropy. The span of the created ECG sensor hub is 75mm x35mm x 20mm which is littler than a charge card in zone. The commotion thickness of the speaker is 22nV/√ Hz, and the aggregate force of the sensor frontend is beneath 100uA. For remote transmission, the Bluetooth module with a smaller scale controller devours current under 110mA. The model can screen ECG constantly for more than 24 hours or with 3 weeks remain by time.

Che U. K. *et al.* recommended a scaled down compact heart rate locator framework that is actualized by cutting edge equipment ICs and basic sensor circuit with programming executable on Android stage. The bio sign is initially separated by means of photograph plethy smography (PPG) standard into electric sign. At that point a chip is utilized to undercover bio signal from simple to computerized arrangement, suitably for encouraging into a RF module (nRF24L01 for RF transmission). On the beneficiary end, the PC and/or advanced mobile phone can dissect the information and showcase the heart rate status for social insurance observing. The lodging for compact gadgets and PCB is customized made by utilizing the new 3-D printer with ergonomic outline. Introductory model size is 40 x 30 x 20 mm and could be littler in later form. Some application programming running on Window application and Android telephone have been created to show result for clients. Later on, unadulterated Bluetooth innovation will be utilized for remote individual correspondences rather than RF modules. In the meantime, the information can be sent to PC support utilizing existing accessible systems (3G, 4G, WiFi, and so forth.) for wellbeing database logging reason.

Copperwhite R. *et al.* gave a report on the improvement of a novel camera telephone based UV-dosimeter for observing the sunlight based disinfection(SODIS) of water. The dosimeter comprises of an UV pointer, methylene blue, scattered in an ethyl cellulose-based polymer lattice. To give quantitative estimation of UV measurements, it was shown that the utilization of a camera telephone to investigate dosimeter shading change because of UV presentation. The dosimeter reaction displays magnificent concurrence with a polynomial model over the UV introduction extent tried. A striking point of preference of the dosimeter portrayed here is that it can be stored on a mixed bag of substrates with the possibility to be joined into water compartments. It is conceived that utilization of such a dosimeter in conjunction with cell telephone innovation will improve the utilization of SODIS in this way affecting altogether on the test of giving clean savoring water creating locales of the world.

Coskun A. F. *et al.* shown a customized nourishment allergen testing stage, termed iTube, running on a mobile phone that pictures and naturally examinations colorimetric measures performed in test tubes toward touchy and particular identification of allergens in sustenance tests. This financially savvy and smaller iTube connection, measuring pretty nearly 40 grams, is mechanically introduced on the current camera unit of a PDA where the test and control tubes are embedded from the side and are vertically enlightened by two different light-discharging diodes. The enlightenment light is consumed by the allergen test that is enacted inside of the tubes, bringing about a power change in the procured pictures by the mobile phone camera. These transmission pictures of the example and control tubes are digitally handled inside of 1 sec utilizing a shrewd application running on the same phone for recognition and evaluation of allergen pollution in sustenance items. It is assessed that the execution of this phone based iTube stage utilizing distinctive sorts of financially accessible treats, where the presence of peanuts was precisely measured after a sample preparation and brooding time of ~20 min per test. This mechanized and expense effective personalized sustenance allergen testing device running on cell phones can likewise allow transferring of test results to secure servers to make individual and/or open spatio-transient allergen maps, which can be helpful for general wellbeing in different settings.

Coskun A. F. *et al.* exhibited an advanced detecting stage, termed Albumin Tester, running on a PDA tha timages and naturally investigations fluorescent examines bound to expendable test tubes for sensitive and particular recognition of egg whites in pee. This light-

weight and smaller Albumin Tester connection, measuring roughly 148 grams, is mechanically introduced on the current camera unit of an advanced cell, where test and control tubes are embedded from the side and are energized by a battery controlled laser diode. This excitation shaft, subsequent to examining the example of interest situated inside of the test tube, interfaces with the control tube, and the subsequent fluorescent discharge is collected opposite to the course of the excitation, where the PDA camera catches the pictures of the fluorescent tubes through the utilization of an outer plastic lens that is embedded between the test and the camera lens. The obtained fluorescent pictures of the example and control tubesare digitally handled inside of one second through an Android application running on the same phone for evaluation of egg whites focus in pee example of hobby. Utilizing a simple sample planning methodology which takes ~ 5 minutes for each test (counting the brooding time), tentatively affirmed the discovery furthest reaches of our detecting stage as 5–10 μg/mL (which is more than 3 times lower than clinically acknowledged typical extent) in cushion and additionally pee samples. This computerized egg whites testing device running on an advanced mobile phone could be valuable for right on time determination of kidney illness or for observing of incessant patients, particularly those agony from diabetes, hypertension, and/or cardiovascular diseases.

Daponte P. *et al.* delivered and talked about that the cutting edge cell phones contain distinctive sensor advances, so they can be utilized as stand-alone estimation instruments on an extensive variety of utilization areas. A study of estimation applications in view of cell phones is given. In the first part, the advancement of cellular telephone innovations, including the sensors and versatile networksdevelopments, is exhibited. At that point, to highlight the sensors and the correspondence capacities, the building outline of the equipment and programming advances, which are accessible on most recent arrangement of cell phones, is accounted for and talked about. A survey of estimations applications utilizing the shrewd sensors and the correspondence interfaces availableon cell phones, it is additionally introduced. A grouping of cell phone applications,which looks the cell phone as a handheld estimation instrument, is displayed. Inthe last part, the reconciliation of enlarged reality to the estimation applications andnew sort of estimation frameworks, having a cell phone as handling backing, is introduced.

Deeb S. S. demonstrated a typical variety in both ordinary and inadequate shading vision and defined for recombination and quality change between the compared, very

homologous OPN1MW, an OPN1LW qualities underlie this variety. The capacity to characterize the cone mosaic in the living retina using versatile optics gives the open door later on to correspond visual execution with the proportion of the three classes of cone and their spatial dissemination in the retina. Case in point, does fluctuation in the L:M proportion have an effect on visual execution or do post-receptoral procedures conform for this variety. The irregular dispersion of cones in the focal human retina suggests cell movement amid advancement. This is additionally proposed by the perception of arbitrary distribution of cone sorts in a female heterozygous for protan shading vision; fixing would be normal as an after effect of Xchromosome inactivation. The changing of expression from L to M and visa versa amid cell division may also contribute to the dedication to separation to L or Mcones. The improvement of retinal cones is coordinated by a number of translation components that impact articulation of the three photograph shades.

Delaney J. L. *et al.* depicted the first approach at consolidating paper micro fluidics with electro chemiluminescent (ECL) identification. Inkjet printing is utilized to deliver paper microfluidic substrates which are consolidated with screen-printed electrodes (SPEs) to make basic, modest, expendable sensors which can be read without a customary photograph indicator. The detecting mechanisms in light of the orange radiance because of the ECL response of tris(2,20-bipyridyl)ruthenium(II) (Ru(bpy)32þ) with certain analytes. Utilizing a customary photograph finder, 2-(dibutylamino)- ethanol (DBAE) and nicotinamide adenine dinucleotide (NADH) could be distinguished to levels of 0.9 μM and 72 μM, respectively. Significantly, a portable camera telephone can likewise be utilized to recognize the radiance from the sensors. By dissecting the red pixel power in advanced pictures of the ECL discharge, an alignment bend was developed showing that DBAE could be distinguished to levels of 250 μM utilizing the telephone.

Drey L. L. *et al.* displayed an exceptionally straightforward strategy yielding high-differentiation pictures of follower, blended cells, for example, human neuro blastoma (SH-EP) cells by standard brilliant field microscopy. Cells are enlightened through a shading channel and a pinhole gap set between the condenser and the cell culture surface. Refraction by every cell body creates a sharp, splendid spot when the picture is defocused. The method permits vigorous, programmed cell checking from a solitary brilliant field picture in an extensive variety of central positions; it does this through free, promptly accessible picture investigation devices. Differentiation may be upgraded by swelling cell bodies by short

brooding in PBS. The methodology was benchmarked against manual numbering and computerized checking of fluorescently marked cell cores.. Checks from day-old and naturally seeded plates were thought about in a scope of densities, from meager to thickly congested. By and large brilliant field pictures delivered the same considers fluorescent pictures, with under 5% slip. This technique will permit routine cell checking utilizing a plain splendid field magnifying lens, missing cell-line alteration or cell re-colouring.

Fairchild M.D. has considered the problems with real life for finding solutions by understanding various appearance models of colour. The digital cameras automatically removes the exposure by compensating proper shifting illuminance but these will not get adjusted in the visuality of human. It is possible for constructing DIP algorithms that will analyze image appearances automatically by applying local correction.

Harp D. L. has surveyed various methods that are in existence for chlorine quantification and thus came to conclusion that there is lack in methods of analyses for chlorine display that would be free from interferences completely. A random rating method for chlorine analyses was conducted. The sliding scale is used for ratings denoting 10 for quality and 1 for not appropriate quality for the analyses conducted. Many would consider this as the "ideal" system for routine chlorine measurements.

Healey J. *et al.* had presented a prototyped model of wellness monitoring which has the properties of recording, transmitting and analyzing ECG or accelerometric data. This model provides application for recording events or activities related to medical sciences. The hardware part allows transmitting recorded data wirelessly to mobile phones. The researchers conducted experiments using the system for activity monitoring, exercise monitoring and medical screening tests and present preliminary data and results.

Hudson J. *et al.* proposed to expand the utilization of heartbeat oximetry by gain by the wide accessibility of cell telephones, in this manner have composed, created and assessed a model heartbeat oximeter interfaced to a cellular telephone. Convenience of this Phone Oximeter was tried as a feature of a fast prototyping procedure. Stage 1 of the study (20 subjects) was performed in Canada. Clients performed 23 undertakings, while verbally processing. Time for fulfillment of undertakings and investigation of client reaction to a cell telephone convenience poll were utilized to assess ease of use. Five interface enhancements

were made to the model beforeevaluation in Phase 2 (15 subjects) in Uganda. The absence of past heartbeat oximetry experience and cellular telephone utilization expanded middle (IQR [range]) time taken to perform errands from 219 (160–247 [118–274]) in Phase 1 to 228 (151–501[111–2661]) in Phase 2. Client input was sure and general ease of use high (Phase 1 – 82%, Phase 2 – 78%).

Chase R. W. G. recommended that the propagation of pictorial shading in the twenty-first century is including numerous new and intriguing innovations. Specifically, the expanding utilization of advanced signs for transmitting data is having repercussions in TV, as well as in photography and printing. In any case, the huge number of bits needed in pictures exhibits an extreme test; the way that this test has been met by cunning administrations of information pressure is a most captivating story. With bit rates at reasonable levels, electronic cameras giving satisfactory determination are practicable, and, when joined with the more current printing systems, for example, electro photography and ink plane, shading pictures of high caliber can be made on very cheap gear, bringing about the accomplishment of desktop distributed. The object of the book is to depict the key standards of shading reproduction, whether by photography, TV, printing, or electronic imaging, so that those drew in producing, offering, purchasing, enhancing, or simply utilizing shading pictures will have the capacity to understand the nature of the phenomena that they experience.

Kerry S. J. *et al.* portrayed a standard to characterize one medium access control (MAC) and a few physical layer (PHY) particulars for remote network for settled, versatile, and moving stations (STAs) inside of a neighbourhood. The reason for this standard is to give remote integration to programmed hardware, gear, or STAs that oblige fast organization, which may be compact or hand-held, or which may be mounted on moving vehicles inside of a neighbourhood. This standard likewise offers administrative bodies a method for standardizing access to one or more recurrence groups with the end goal of neighbourhood. In particular, this standard:

- Describes the capacities and administrations needed by an IEEE 802.11-consistent gadget to work inside of specially appointed and framework arranges and the parts of STA versatility (move) inside of those systems.
- Defines the MAC methodology to bolster the offbeat MAC administration information unit (MSDU) delivery services.

- Defines a few PHY flagging strategies and interface works that are controlled by theIEEE 802.11 MAC.
- Permits the operation of an IEEE 802.11-conformant gadget inside of a remote neighbourhood) that may coincide with numerous covering IEEE 802.11 WLANs.
- Describes the prerequisites and methodology to give information classifiedness of client data being transferred over the remote medium (WM) and validation of IEEE 802.11-conformant gadgets.
- Defines systems for element recurrence determination (DFS) and transmit force control (TPC) that may be utilized to fulfil administrative prerequisites for operation in the 5 GHz band. The regulations and conformance tests are recorded.
- Defines the MAC methodology to bolster neighbourhood (LAN) applications with nature of administration (QoS) necessities, including the vehicle of voice, sound, and video.

Khan W. Z. *et al.* reviewed that cell telephone detecting is a developing region of enthusiasm for analysts as PDAs are turning into the center communication device in individuals' ordinary lives. Sensor empowered cell telephones or PDAs are floating to be at the focal point of a next unrest in interpersonal organizations, green applications, worldwide ecological checking, individual and group human services, sensor augmented gaming, virtual reality and keen transportation systems. More associations and individuals are finding how cellular telephones can be utilized for social effect, including how to use versatile innovation for ecological security, detecting, and to influence in the nick of time data to make our developments and activities all the more naturally agreeable. The specialists have portrayed completely each one of those frameworks which are utilizing advanced cells and cellular telephone sensors for people great will and better human telephone collaboration.

Kozlovszky M. *et al.* added to an android based portable information obtaining (DAQ) arrangement, which gathers customized wellbeing data of the end-client, store break down and imagine it on the shrewd gadget and alternatively sends it towards to the server farm for further preparing. The smart mobile gadget is proficient to gather data from a largeset of different remote (Bluetooth, and Wi-Fi) and wired (USB) sensors. Installed sensors of the cell phone give extra helpful status data, (for example, user location, attractive or commotion level, speeding up, temperature and so on.). The client interface of proposed programming arrangement is suitable for diverse gifted clients, exceedingly configurable and gives journal usefulness to store data (about rest issues, can go about as an eating routine log,

or even can be utilized as a torment journal). The product empowers connection investigation between the different sensor information sets. The created framework is tried effectively inside of our Living Lab office. Sensor information securing on the individual cell phone empowers both end clients and parental figures to give better and more compelling wellbeing observing and encourage counteractive action. The outcomes depict the inside structural planning of the product arrangement and its fundamental functionalities.

Kumar P. S. *et al.* proposed remote patient observing frameworks fit for gathering basic patient information, for example, circulatory strain readings, Electrocardiograph (ECG) waveforms, and heart rate can hinder the requirement for rehashed visits to the doctor's facility. Besides, such frameworks that constantly screen the human physiology can give significant information to visualize the onset of discriminating wellbeing issues. The way to such remote wellbeing diagnostics is the outline of negligibly meddlesome, minimal effort sensors that don't hinder an understanding's quotidian life yet in the meantime gather solid commotion free information. To this end, a Bluetooth-based remote sensor framework with a dispensable sensor component is planned and actualized and a reusable remote segment that can be worn as a "band-help". The sensor is a piezoelectric polymer film put on the wrist in vicinity to the spiral supply route. The band-help estimated sensor permits non-meddlesome observing of the pulsatile stream of blood in the course. The sensor, utilizing the Bluetooth module, can speak with any Bluetooth empowered PC, cellular telephone, or PDA. The information gathered from the patient can be remotely seen and broke down by a doctor.

Lamprecht M. R. *et al.* proposed an overview that watchful visual examination of organic examples is effective, yet numerous visual analysis tasks done in the research center are dull, dreary, and subjective. Here analysts portrayed the utilization of the open-source programming, CellProfile that consequently recognize and measure a mixture of organic questions in pictures. The applications showed here incorporate yeast state tallying and grouping, cell microarray annotation, yeast patch examines, mouse tumour evaluation, wound recuperating tests, and tissue topology estimation. The product consequently recognizes protests in computerized pictures, checks them, and records a full range of estimations for every article, including area inside of the picture, size, shape, and shading force, level of relationship between hues, surface (smoothness), and number of neighbours. Little quantities of pictures can be prepared naturally on a PC; andhundreds of thousands can be broke down utilizing a processing group. This free, simple to-usesoftware empowers researcher to

thoroughly and quantitatively address numerous questionsthat beforehand would have obliged custom programming, consequently encouraging revelation in a mixed bag of organic fields of study.

Lao C. K. *et al.* represented a small scale versatile heart rate identifier framework that is actualized by cutting edge equipment ICs and basic sensor circuit with programming executable on both PC and Android stage. The bio sign is initially removed by means of photograph plethysmo graphy(PPG) standard into electric sign. At that point a microprocessor is utilized to secret bio signal from simple to digital format, suitably for encouraging into a RF module (nRF24L01 for RF transmission). On the collector end, the PC and/or advanced cell can examine the information utilizing a powerful calculation that can recognize tops of the PPG waveform, subsequently to calculate the heart rate. Some application programming running on Windows and Android telephone have been created to show heart rate information and time area waveform to clients for wellbeing care monitoring. Later on, immaculate Bluetooth innovation will be used for remote individual correspondences rather than RF modules. In the meantime, the information can be sent to PC console using existing accessible systems (3G, 4G, Wi-Fi, and so on.) for health database logging reason.

Lee D. *et al.* researched the practicality of utilizing cell telephones cameras for DNA location. DNA intensification utilizes the convective polymerase chain response (cPCR) system because of its basic instrument, which requires no warm cycling control. Fluorescence increase investigation and data entropy analysis are utilized independently to figure out if the test examples contain target DNA (Positive) or not (Negative). The fluorescence increase technique utilizes the splendor of the caught pictures before and after DNA intensification to ascertain values over an edge level demonstrate that the test specimen is sure. The data entropy technique characterizes the likelihood, P(C/X), which demonstrates whether the fluorescence picture tends towards a particular shape. In the event that a DNA format is effectively enhanced, the caught fluorescence picture ought to be a flawless circle. P(C/X) gives a limit of 0.5 to recognize a circle and values over 0.5 demonstrate the test specimen is sure. Exploratory results demonstrate that P(C/X) is more successful for deciding DNA location results. The data entropy examination technique is connected to ten cellular telephones of three unique brands furnished with camera sensors, which have pixel numbers running from 120 M to 800 M. The clinical assessment study (n = 60) for screening hepatitis

B infection (HBV) plasmid tests demonstrates that the precision rate of all models of cellular telephones ranges from 85% to 100%. This showed that fruitful DNA location can be accomplished utilizing the most widely deployed electronic gadget.

Letterman R.D. recommended that wellbeing and stylish parts of water quality are the main thrust behind water quality regulations and water treatment hone. As a result of the many-sided quality of the studies the per user is asked to survey the referred to writing, wellbeing advisories and criteria reports from USEPA, and the Toxicologic Profile arrangement from the Agency for Toxic Substances and Disease Registry for more points of interest on any contaminant specifically noteworthy. Besides, in light of the fact that new data on waterborne malady bringing about life forms and concoction contaminants is being found, audit of writing subsequent to the distribution of this overview is prescribed preceding utilizing the data in this as the premise for choice making.

Martinez A. W. *et al.* depicted a model framework for evaluating bioassays and for trading the consequences of the examines digitally with doctors situated off-site. The framework uses paper-based micro fluidic gadgets for running multiple assays at the same time, camera telephones or convenient scanners for digitizing the power of shading connected with each colourimetric measure, and set up correspondences foundation for exchanging the advanced data from the test site to an off-site research facility for investigation via a trained restorative expert; the analysis then can be returned specifically to the medicinal services supplier in the field. The small scale fluidic gadgets were created in paper utilizing photolithography and were functionalized with reagents for colourimetric examines. The consequences of the tests were evaluated by looking at the intensities of the shading grew in every test with those of adjustment bends. A case of this framework evaluated clinically important a massings of glucose and protein in counterfeit urine. The blend of designed paper, a compact method for acquiring advanced pictures, and a technique for exchanging results of the measures with off-site diagnosticians offers new open doors for cheap observing of wellbeing, especially in circumstances that oblige doctors to travel to patients (e.g., in the creating scene, in emergency management, and amid field operations by the military) to get analytic data that may be gotten all the more adequately by less profitable work force.

Munawar A. *et al.* proposed an Open Sensor Platform, in view of Open System Architecture outline, for the coordination of cell telephone (MP) and sensors. This stage uses business off-the-rack (COTS) accessible equipment and programming devices, along these lines dispensing with the requirement for hand crafted sensor's reconciliation sheets. The configuration includes Data Acquisition (DAQ) gadget, connected with Host PC, giving an interface to correspond with sensors. Sensors information is read from DAQ by means of Host PC application and on request remotely sent to MP. Cell telephone is utilized as information recovery specialists, so as to recover the sensory data and ahead sending the data to end client via Cellular or Web administrations. This mix dispenses with the requirement for devoted hardware in sensors, permits the expansion of several sorts of sensors and executes various wireless protocols (BT or Wi-Fi), keeping in view the necessity of reach and information rate. Sensors history information is kept up on Host PC, where nitty gritty investigation may be performed. Mobile phone applications are created utilizing Native language, while Host PC applications are produced in Graphical dialect, which comes about into full included, proficient and user friendly applications improvement. The practicality of our solution is bolstered by the contextual investigation under taken, where we validated our outline with the assistance of model open sensor platform. Its numerous applications incorporate; observing the test chamber's inward conditions, bringing environmental parameters, research facility experimentations and so on. This work effectively accomplishes the joining of sensors and mobile phone in a promising manner.

Ozcan A. examined a percentage of the rising applications and the future open doors and difficulties made by the utilization of cell telephones and their inserted parts for the advancement of next-era imaging, detecting, diagnostics and estimation apparatuses. The huge volume of cell telephone clients, which has now come to ~7 billion, drives the fast changes of the equipment, software and top of the line imaging and detecting advances implanted in our telephones, changing the mobile phone into a savvy but then to a great degree capable stage to run, e.g., biomedical tests, and perform logical estimations that would typically require propelled research centre instruments. This quickly developing and proceeding with pattern will help us change how solution, designing and sciences are practiced and taught all around.

Renzetti S. *et al.* had demonstrated a report to highlight the expenses forced on water supply organizations and the more extensive group by water misfortunes. Stopping these

breaks – while immoderate and drawn out – gives advantages financially, earth and socially. In light of the administrative environment in which Canadian water organizations work, some of these advantages particularly those outer to the office or those that may accumulate to the office in future time periods-may not be completely tallied when offices apportion their constrained spending plans amongst spill discovery endeavours and the numerous other contending needs confronting them. The concerns raised here point to potential territories for future examination furthermore solid changes to advance expanded endeavours for hole recognition. These incorporate the accompanying:

• Adoption of a far reaching objective of widespread water metering
• Development of formats to bolster full-cost bookkeeping and, evaluating for water supplies
• Co-operation amongst the areas to declare regulations that set principles for break discovery endeavours and give motivating forces to advance enhanced productivity and discerning venture choice.

Ruiz N. L. *et al.* displayed a compact instrument outlined and described for the determination of vaporous oxygen. It is in light of extinguishing the glow power of the platinum octaethyl porphyrin complex when it is energized, utilizing a light-emanating diode (LED) with an outflow top at 380 nm. The glow discharged by the platinum complex is recognized by bringing a picture with a shading CCD small scale camera integrated in the model which makes it conceivable to do a two-dimensional examination of the iridescence. This picture is prepared by a microcontroller to get the red shading segment of the RGB shading space, accordingly tossing any superfluous shading data. The handling is completed for the pixels more than an extensive territory of the detecting layer, which takes into consideration a factual treatment of the got data. The measured R-esteem for the film, can be specifically identified with the centralization of the encompassing oxygen. The subsequent instrument has been completely described and adjusted, including floats because of temperature and time. Also, an application for Android camera gadgets, for example, cell phones was produced keeping in mind the end goal to utilize them as locators and picture processors to give a forecast of the vaporous oxygen fixation.

Schaefer S. *et al.* recommended that Optical microscopy is a straightforward, yet vital, imaging innovation and Conventional research facility grade optical magnifying lens are massive and excessive, keeping their utilization to lab settings and confining their openness in locales of constrained assets. With the point of conquering these confinements, analysts

understood a convenient, minimal effort, and exceedingly computerized optical magnifying instrument that incorporates mass-produced parts, including light-discharging diodes, a web camera, optical circle drives, and a microcontroller. Their execution is equipped for brilliant field and fluorescence imaging with micrometer-scale determination and controlled mechanical activation of both the lens and test. They interfaced the lighting, picture catch, and mechanical actuators of the magnifying instrument into a solitary programming environment, empowering robotization of basic magnifying instrument operations, for example, picture centring and extensive range test perception. Blend of mechanical incitation and programming mechanization into a conservative, minimal effort magnifying lens framework is an essential beginning stride toward the objective of making optical microscopy all around available, compact, and simple to utilize.

Selinummi J. *et al.* built up a mechanized picture examination programming, CellC, and accepted for evaluation of bacterial cells from computerized magnifying lens pictures. CellC empowers mechanized identification of bacterial cells, correlation of aggregate number and particular tally pictures and gives quantitative evaluations of cell morphology. The product incorporated an instinctive graphical client interface that empowers simple utilization and in addition consecutive investigation of numerous pictures without client mediation. The acceptance of list uncovers connection is to be superior to 0.98 when complete bacterial numbers by CellC when contrasted and manual identification, with all validated picture sorting.

Shamir L. *et al.* portrayed the fundamental ideas, wording and programming tools for PR-based imaging examines for biology. The data gave is directed towards the seat researcher searching for an alternative to conventional picture processing approaches. Albeit the vast majority of the current applications of PR are utilized for dissecting extensive picture datasets (e.g. PSLID, CellProfiler-Classifier), these strategies can be connected simply to more conventional imaging tests performed in non-pro research facilities. The foremost point of interest of the methodology was its potential for handling an expansive mixed bag of image types without obliging modified software or parameter tuning for every imaging trial. The capacity to contrast pictures with one another paying little heed to picture sort can lead to the revelation of new information from existing information. General succession correlation calculations, for example, BLAST have changed the chronicling and recovery of grouping information out in the open archives, for example, GenBank into a field (genomics) where

new learning is routinely integrated from existing arrangement accumulations. By similarity, the joining of summed up picture examination calculations with vast, various, and very much expounded open picture vaults is a fundamental stride toward more finish information extraction from natural pictures. For instance, metadata fields used to clarify pictures either manually or by utilizing particular calculation sweep serve as the premise for characterizing instructional courses for PR calculations. The subsequent classifiers can then expound pictures where these fields haven't been characterized. While this procedure can be completely mechanized, the instruments produced for this methodology can likewise be utilized intuitively to offer conversation starters about potential new connections inside of these picture accumulations. Despite the fact that the procedures sketched out in this audit can prompt general picture examination calculations, picture information represents a few difficulties that are just now starting to be tended to: quantitative picture correlations inside of various settings, relevant ranking calculations, and coordinated image repositories.

Shen L. *et al.* proposed and studied that resistant tests are turning out to be capable and minimal effort symptomatic devices, particularly inresource-restricted settings. Reasonable techniques for evaluating these tests have been indicated utilizing desktop scanners, which need convey ability, and cameras, which experience the ill effects of the regularly changing encompassing light conditions. In this work, a novel methodology of evaluating shades of colorimetric indicative examines with a cell phone that permits high exactness estimations in an extensive variety of encompassing conditions is presented, making it a really compact framework. Rather than straightforwardly utilizing the red, green, and blue (RGB) intensities of the shading pictures taken by a cell phone camera, chromaticity qualities to develop adjustment bends of break down fixations are utilized. It is exhibited the high exactness of this methodology in pH estimations with direct reaction scopes of 1–12. These outcomes are practically identical to those reported utilizing a desktop scanner or silicon photograph identifiers. To make the methodology embrace a bleunder diverse lighting conditions, an alignment system to remunerate for measurement lapses because of variability in surrounding light is produced. This procedure is pertinent to a number of common light sources, for example, daylight, glaring light, or cell phone LED light. At last, the whole approach can be coordinated in an ""application"" to empower a single tick perusing, making our cell phone based methodology operable with no expert preparing or complex instrumentation.

Skoog D. A. *et al.* presented a book titled "Logical Chemistry – An Introduction", which incorporates basics of sampling and insights, established methods of gravimetry and titration (acid–base, redox, complexometric), nuclear and molecular spectroscopy, detachments (GC, HPLC, narrow electrophoresis),and electrochemistry. Each is all around created, with plenty of numerical illustrations and end-of-section issues. The mass spectrometry is incorporated in the chromatography material as opposed to showing up as a stand-alone section. A few subtle elements of redox titrations are omitted, as are some particular cases of spectroscopy strategies, (for example, Scatchard plots and the technique for constant variety). Another sample of exclusion is the F-test in the measurements segment. In any case, what really matters is that the discarded themes aren't missed, and the staying material has a lot of profundity throughout.

Stockman A. *et al.* delivered a transient chromatic adjustment that is rolled out by a sudden improvement of foundation shading allows a less demanding and closer approach to cone segregation than does relentless state adjustment. Utilizing this system, centre wave sensitive(M-) cone phantom sensitivities in 11 normals and 2 protanopes and long-wavelength-touchy (L-) cone ghastly sensitivities in 12 normals and 4 deuteranopes were measured. Albeit there is incredible individual variety in the adjusting force needed for powerful separation, there is little variety fit as a fiddle of the M-and L-cone spectral-affectability works crosswise over subjects. At center and long wavelengths, our mean ghastly sensitivities concur greatly well with dichromatic phantom sensitivities. Utilizing our unearthly affectability information, tritanopic colour-coordinating information, and Stiles' 13, we infer new arrangements of cone essentials. The consistency of the proposed essentials in view of either the Stiles-Burch 20 CMF's or the CIE 100 expansive field CMF's with one another, with protanopic and deuteranopic unearthly sensitivities, with tritanopic colour-coordinating information, and with short-wavelength-delicate (S-) cone otherworldly affectability information recommends that they are to be favoured over basics in light of the CIE 20 CMF's.

Sumriddetchkajorn S. *et al.* understood that a broadly utilized and savvy strategy in deciding the measure of chlorine in water is colourimetry, subsequently proposing and tentatively shows how a cell phone inserted with an advanced camera can be utilized to capacity as a colourimeter for the examination of chlorine fixation. The key thought is to organize both the reference material and the little straightforward jug such that they both fit

in the field of perspective of the camera. Thusly, one shading picture naturally contains two picture locales, one from the reference material and another from the little straightforward container, prompting a self-referencing design. Therefore, a particular shading proportion from these two picture areas is utilized for particularly changing over the water shading inside the little straightforward container into its comparing chlorine focus. By utilizing a substance response between potassium–starch arrangement and chlorine broke down in water, trial exhibition demonstrates an extremely encouraging result in deciding 0.3–1.0 ppm chlorine concentration with <7% estimation mistakes. Other key components incorporate ease, convenience, simplicity of usage, and perhaps substantial dissemination by means of use mark.

Sumriddetchkajorn S. *et al.* recommended for financially savvy checking centralization of deposit chlorine in water can be basically refined by means of colorimetry where the chose demonstrating compound material responds with the chlorine in water to change its shading. To stifle lapses from perusing the shading level by exposed eyes and from change of ecological enlightenment, this paper proposes a portable stage based colourimeter installed with a self-referencing investigation for changing over the shading level of water to its relating chlorine focus. The key thought depends on a two-dimensional (2D) shading examination in a versatile shut chamber. In particular, our 2D shading investigation with self referencing is performed through the game plan of both the reference material and the glass bottle in a manner that they both fit in the field of perspective of the cell phone's camera. Along these lines, one shading picture intrinsically contains two picture areas, one from the reference material and another from the glass bottle. Therefore, a particular shading proportion from these two picture locales is utilized for particularly changing over the water shading inside the glass bottle into its relating chlorine focus. By utilizing a compound response between o-drudging arrangement and chlorine broke down in water and a shrewd cell telephone, the exhibit demonstrates an exceptionally encouraging result in deciding 0.06–2.0 ppm chlorine focus in water. Other key elements incorporate expense adequacy, conservativeness, compactness, and simplicity of usage.

U.S. Registration Bureau displayed information on condo; single-family homes; produced/trailers; empty lodging units; age, sex, and race of householders; wage; lodging and neighborhood quality; lodging expenses; hardware and powers; and size of the lodging units. They likewise display information on home loans, rent control, rent appropriations, past unit

of late movers, and explanations behind moving. The report created shows information from the American Housing Survey, which was supported by the U.S. Branch of Housing and Urban Development and led by the U.S. Enumeration Bureau. The U.S. Enumeration Bureau leads the American Housing Survey (AHS) to acquire forward lodging insights for the U.S. Branch of Housing and Urban Development (HUD). Notwithstanding the information demonstrated in this report, clients may get to an abundance of data taking into account the American Housing Survey (AHS) by method for the Internet. Through the AHS Web webpage, information outlines are accessible for clients to see the outcomes from the 1993 - 2007. The AHS Web webpage likewise offers clients the chance to download National small scale information for the years 1997, 1999, 2001, and 2003 by utilizing Ferrett.

Wei Q. *et al.* proposed optical imaging of nano scale objects, whether it is in light of dispersing or fluorescence, is a testing assignment because of diminished recognition sign to commotion proportion and differentiation at sub wavelength measurements. The report demonstrates a field of convenient fluorescence microscopy stage introduced on a PDA for imaging of individual nano particles and in addition infections utilizing a lightweight and reduced pick mechanical connection to the current camera module of the wireless. This hand-held fluorescent imaging gadget uses (i) a smaller 450 nm laser diode that makes sideways excitation on the specimen plane with a rate edge of∼75, (ii) a long-pass flimsy film impedance channel to dismiss the scattered excitation light, (iii) an outside lens making 2 optical amplification, and (iv) a translation stage for center modification. We tried the imaging execution of this advanced cell empowered microscopy stage by distinguishing disconnected 100 nm fluorescent particles and in addition singular human cytomegalo viruses that are fluorescently named. The extent of each identified nano-question on the cell phone platform was accepted utilizing filtering electron microscopy pictures of the same specimens. This field-versatile fluorescence microscopy connection to the cell phone, measuring just ∼186 g, could be utilized for particular and delicate imaging of sub wavelength items including different microorganisms and infections and, along these lines, could give a profitable stage to the act of nanotechnology in field settings and for directing viral burden estimations and other biomedical tests even in remote and asset constrained situations.

Wright W. D. depicted a trichromatic colorimeter that has been exceptionally outlined with a specific end goal to make an exact re-determination of the locus of the ghostly hues in the shading triangle for whatever number spectators as would be prudent. A spectrometer

framework is utilized as a part of which two spectra are shaped from the same source. From one of these, three bits to go about as primaries are reflected back through a lower piece of the scattering framework, so that the blending of the three radiations is effected by killing the kaleidoscopic scattering by which the hues were initially isolated. From the other range the test shading and a desaturating shading are chosen and blended in a comparable way, and the composite beams are then brought into the two parts of a basic bipartite field. During the time spent being blended with alternate hues, each ghostly shading is sifted by its arrival section through the scattering framework and the instrument in this way turns out to be extremely successful in evacuating stray light. The intensities are controlled with photometer wedges.

Wright W. D. proposed another trichromatic colourimeter a progression of shading matches through the range has been made by ten spectators. The outcomes have been found the middle value of and a mean arrangement of trichromatic coefficients for the otherworldly hues inferred. These outcomes are contrasted and past determinations made by Konig and Abney. The varieties in the coefficients that have been discovered amongst the ten onlookers must, as a consequence of another technique for basing the trichromatic units, be ascribed to varieties during the time spent gathering, however their greatness gives off an impression of being of a little request. Then again, there are huge contrasts in the measure of the macular shade in diverse eyes and most likely some variety in its prevailing tone. These varieties have been examined by matches on standard white, results for 36 eyewitnesses being given in the paper and a mean worth decided, this quality, joined with the mean ghastly coefficients, has been used to register a normal locus for the otherworldly hues in the shading triangle, with white at the inside. Different focuses talked about in the paper incorporate the system of shading coordinating, the range of power over which matches stayed substantial, and varieties of radiance.

Wu Y. Y. C. *et al.* talked about that the patient-driven medicinal environment is an essential pattern as of late. The earth can spare time and cash for patients to go to doctor's facility, enhance patients' life, and diminish the misuse cost for medicinal treatment. In this paper, a medicinal services framework taking into account cellular telephone for patient-driven medical environment is proposed. The framework gives the remote observing and crisis caution for both patients and doctors. Also, the developed versatility of framework permits patients to engage some open air exercises. Framework configuration, circuit plan, Wi-Fi area calculation advancement, investigation, framework confirmation and prototype

improvement are given. The framework exchanges by Bluetooth to the cell telephone the recorded ECG and EEG signals from the patients sensors. The cellular telephone then by 3G/GPRS/Wi-Fi administrations exchanges the recorded data along with area data (by GPS or Wi-Fi area) back to the medicinal cloud. The specialists recovered the patient's human services data and show on their tablets or cell telephones. At the point when the deadly conditions happen, the cellular telephone can send a SMS specifically to specialists versatile to alert the specialists. The analysts embraced business discrete parts to fabricate the demo prototype, and the last model gives the entire capacities said to 5-hour proceeding with operation and Wi-Fi area right rate of 76%.

Yu B. *et al.* added to a remote electrocardiogram (ECG) checking framework is produced which coordinates Bluetooth Low Energy(BLE) innovation. This BLE-based framework is included a solitary chip ECG signal procurement module, a Bluetooth module and a PDA. Apple's iPhone 4S is chosen as the cell phone stage, which inserted with Bluetooth v4.0, Wi-Fi and iOS. The observing framework has the capacity procure ECG motions through 2-lead electrocardiogram (ECG) sensor, transmit the ECG information by means of the Bluetooth remote connection, process and displaythe ECG waveform in an advanced mobile phone. The outcomes show that implementation of Bluetooth Low Energy (BLE) innovation in the current ECG checking framework not just disposes of the physical limitations forced by hard-wired connection additionally highly reduces the force utilization of the long haul observing framework.

Zhu H. *et al.* exhibited wide-field fluorescent and dim field imaging on a PDA with minimal, light-weight and practical optical segments that are mechanically connected to the current camera unit of the mobile phone. For this reason, battery fueled light-radiating diodes (LEDs) to pump the example of enthusiasm from the side utilizing butt-coupling is utilized, where the pump light was guided inside of the specimen cuvette to consistently energize the example. The fluorescent emanation from the example was then imaged utilizing an extra lens that was situated directly before the current lens of the mobile phone camera. Since the excitation happens through guided waves that engender opposite to discovery way, a reasonable plastic shading channel was adequate to make the dull field foundation needed for fluorescent imaging, without the requirement for a slight film obstruction channel. The outcomes are accepted through execution of this stage by imaging different fluorescent smaller scale questions in 2 hues (i.e., red and green) more than a substantial field-of-

perspective (FOV) of ~81 mm2 with a crude spatial determination of ~20 μm. With extra advanced handling of the caught wireless pictures, through the utilization of compressive examining hypothesis, we exhibit ~2 fold change in our determining force, accomplishing ~10 μm determination without an exchange off in our FOV. Further, it is additionally shows dull field imaging of non-fluorescent example utilizing the same interface, where this time the scattered light from the items is distinguished without the utilization of any channels. The ability of imaging a wide FOV would be exceedingly imperative to test vast specimen volumes (e.g., >0.1 mL) of e.g., blood, pee, sputum or water, and for this end it is exhibited fluorescent imaging of named white-platelets from entire blood tests, and also water-borne pathogenic protozoan parasites, for example, Giardia Lamblia blisters. Measuring just ~28 g (~1 ounce), this minimized and practical fluorescent imaging stage joined to a wireless could be truly helpful particularly for asset restricted settings, and may give an essential device to wide-handle imaging and evaluation of different lab-on-a-chip tests created for worldwide wellbeing applications, for example, observing of HIV+ patients for CD4 checks or viral burden estimation.

Zhu H. *et al.* stream cytometer and fluorescent microscopy are the for the most part utilized device as a part of the biomedical science are examined in this theme. In the telemedicine application new open doors are made because of the financially savvy interpretation of these innovations to asset constrained environment and remote. With the practical, lightweight and smaller optical fluidic connection here toward this course, here we show the joining of imaging cytometer and fluorescent microscopy on a mobile phone utilizing a minimized, lightweight, and financially savvy pick fluidic connection. In this wireless based pick fluidic imaging cytometer stage, fluorescently named particles or cells of hobby are ceaselessly conveyed to our imaging volume through an expendable micro fluidic channel that is situated over the current camera unit of the phone. The same micro fluidic gadget additionally goes about as a multi-layered select fluidic wave aide and effectively controls our excitation light, which is butt-coupled from the side aspects of our micro fluidic channel utilizing reasonable light-radiating diodes. Since the excitation of the example volume happens through guided waves that engender opposite to the location way, our phone camera can record fluorescent films of the examples as they are coursing through the smaller scale channel. The advanced casings of these fluorescent motion pictures are then quickly handled to evaluate the check and the thickness of the marked particles/cells inside of the objective arrangement of hobby. The outcomes are tried and the execution of our PDA based

imaging cytometer by measuring the thickness of white platelets in human blood tests is checked, which gave a good match to a financially accessible hematology analyzer. We further described the imaging nature of the same stage to exhibit a spatial determination of ~2µm. This mobile phone empowered select fluidic imaging stream cytometer could particularly be valuable for quick and delicate imaging of natural liquids for leading different cell checks (e.g., toward observing of HIV+ patients) or uncommon cell examination and for screening of water quality in remote and asset poor settings.

Zhu H. *et al.* a financially savvy and reduced imaging cytometer stage introduced on advanced cell is shown which is equipped for estimation in human blood tests. Utilizing optical connection to advanced mobile phone a brilliant field and fluorescent pictures of blood tests are caught and handled through PDA application for deciding hemoglobin focus and checking of red/white platelets. It is watched the outcomes acquired from this advanced mobile phone based blood investigation stage is practically identical to the outcome accomplished from a seat top haematology analyser. The outcomes got can be exchanged to focal server or can be put away on the telephone memory.

The summarized literature survey is shown in following Table 1.

Table 5. Literature Survey

Year	Author	Work Done
2014	Sumriddetchkajorn S. *et al.*[32]	The analysts have recommended for financially savvy observing amassing of build up chlorine in water can be basically expert by means of colorimetry where they chose showing substance material responds with the chlorine in water to change its shading giving key elements that incorporates cost adequacy, minimization, compactness, and simplicity of execution.
2014	Wei Q. *et al.*[42]	The rising applications and the future open doors and difficulties made by the utilization of cellular telephones and their installed segments for the advancement of cutting edge imaging, detecting, diagnostics and estimation instruments are talked about.

2013	Coskun A. F.[44]	It is exhibited that a customized nourishment allergen testing stage, termed iTube, running on a mobile phone that pictures and consequently examinations colorimetric measures performed in test tubes toward touchy and particular location of allergens in sustenance tests can be helpful for general wellbeing in different settings.
2013	Coskun A. F.[45]	The creators has exhibited an advanced detecting stage, termed Albumin Tester, running on a PDA that pictures and consequently investigations fluorescent examines bound to expendable test tubes for delicate and particular location of egg whites in pee. This robotized egg whites testing instrument running on an advanced mobile phone could be helpful for right on time conclusion of kidney illness or for observing of incessant patients, particularly those agony from diabetes, hypertension, and/or cardiovascular infections.
2013	Fairchild M.D.[16]	The creators have considered the 'genuine living' issues, which will discover arrangements in a more full comprehension of Color Appearance Models that will help to take care of reasonable issues that might be fathomed as advancement is shown up model.
2013	Daponte P. *et al.*[22]	The scientists have created and talked about that the cutting edge cell phones contain diverse sensor innovations, so they can be utilized as stand-alone estimation instruments on an extensive variety of use areas. A study of estimation applications in light of cell phones is given and new sort of estimation frameworks, having a cell phone as handling backing, is exhibited.
2013	Khan W. Z. *et al.*[63]	The cellular telephone detecting are turning into the center specialized gadget in individuals' ordinary lives. Sensor empowered cell telephones or advanced mobile phones are drifting to be at the focal point of a next upset in interpersonal organizations, green applications, worldwide natural checking, individual and group social insurance,

		sensor enlarged gaming, virtual reality and brilliant transportation frameworks. The analysts have depicted exhaustively every one of those frameworks which are utilizing advanced cells and cellular telephone sensors for people cooperative attitude and better human telephone collaboration.
2013	Kozlovszky M. *et al.*[62]	The specialists have built up an android based versatile information procurement (DAQ) arrangement, which gathers customized wellbeing data of the end-client, store examine and picture it on the shrewd gadget and alternatively sends it towards to the server farm for further preparing. The client interface of proposed programming arrangement is suitable for distinctive gifted clients, very configurable and gives journal usefulness to store data (about rest issues, can go about as an eating regimen log, or even can be utilized as an agony journal). The outcomes portray the inner structural planning of the product arrangement and its fundamental functionalities.
2013	Wei Q. [42]	The proposition of optical imaging of nano scale articles are portrayed, in light of dispersing or fluorescence that is a testing errand because of diminished recognition sign to clamor proportion and difference at sub wavelength measurements. The report demonstrates a field of versatile fluorescence microscopy stage introduced on an advanced cell for imaging of individual nano particles and also infections utilizing a lightweight and minimal select mechanical connection to the current camera module of the PDA.
2013	Zhu H.[40]	A minimized and practical imaging cytometry stage is suggested that is introduced on a mobile phone for the estimation of the thickness of red and white platelets and hemoglobin fixation in human blood tests. It is assessed that the execution of this PDA based blood examination stage

		utilizing mysterious human blood tests and accomplished similar results to a standard seat top hematology analyser.
2013	Sumriddetchkajorn S. *et al.*[47]	It is understood that a generally utilized and practical technique in deciding the measure of chlorine in water is colourimetry, in this way proposing and tentatively exhibits how a cell phone inserted with a computerized camera can be utilized to capacity as a colourimeter for the investigation of chlorine focus.
2012	Chan C.-C. *et al.*[58]	The specialist has proposed a vitality proficient model for demonstrative evaluation versatile ECG checking. The model is produced with business discrete parts to demo a patient driven medicinal environment.
2012	Che U. *et al.*[55]	It is proposed that a smaller than normal convenient heart rate identifier framework that is actualized by cutting edge equipment ICs and straightforward sensor circuit with programming executable on Android stage. The bio sign is initially extricated by means of photograph plethy smography (PPG) standard into electric sign. At that point a chip is utilized to incognito bio signal from simple to advanced arrangement, suitably for sustaining into a RF module and the information can be sent to PC support utilizing existing accessible systems (3G, 4G, WiFi, and so on.) for wellbeing database logging reason.
2012	Copperwhite R. *et al.*[29]	The specialists gave provide details regarding the improvement of a novel camera telephone based UV-dosimeter for observing the sunlight based sanitization (SODIS) of water. The dosimeter comprises of an UV pointer, methylene blue, scattered in an ethyl cellulose-based polymer lattice. It was shown that the utilization of a camera telephone to investigate dosimeter shading changes because of UV presentation. It is conceived that utilization of such a dosimeter in conjunction with cellular telephone innovation will improve the utilization of SODIS along these lines

		affecting essentially on the test of giving clean savoring water creating districts of the world.
2012	Hudson J. *et al.*[37]	It is recommended to expand the utilization of heartbeat oximetry by gain by the wide accessibility of cellular telephones, in this way have planned, created and assessed a model heartbeat oximeter interfaced to a cell telephone. Ease of use of this Phone Oximeter was tried as a feature of a fast prototyping procedure.
2012	Lopez-Ruiz N. *et al.*[28]	Exhibited a compact instrument planned and portrayed for the determination of vaporous oxygen that is in view of extinguishing the glow force of the platinum octaethyl porphyrin complex when it is energized, and utilizing a light-radiating diode (LED) with an emanation crest at 380 nm. What's more, an application was created with a specific end goal to utilize them as locators and picture processors to give a forecast of the vaporous oxygen fixation.
2012	Schaefer S. *et al.*[4]	The scientists have understood a compact, minimal effort, and profoundly computerized optical magnifying lens that coordinates mass-fabricated parts, including light-radiating diodes, a web camera, optical plate drives, and a microcontroller. Their execution is equipped for brilliant field and fluorescence imaging with micrometer-scale determination and controlled mechanical incitation of both the lens and test.
2012	Wu Y. Y. C.[59]	A human services framework in light of cellular telephone for patient-driven medicinal environment is proposed which gives the remote observing and crisis caution for both patients and specialists. Additionally, the augmented versatility of framework permits patients to connect with some open air exercises. The framework exchanges by Bluetooth to the cellular telephone the recorded ECG and EEG signals from the patients sensors. The cellular telephone then by 3G/GPRS/Wi-Fi administrations exchanges the

		recorded information alongside area data (by GPS or Wi-Fi area) back to the restorative cloud. The specialists recovered the patients medicinal services data and show on their tablets or cell telephones. At the point when the deadly conditions happen, the cell telephone can send a SMS specifically to specialists portable to alert the specialists. The specialists received business discrete parts to construct the demo prototype,and the last model gives the entire capacities specified to 5-hour proceeding with operation and Wi-Fi area right rate of 76%.
2012	Yu B. *et al.*[60]	The scientists have built up a remote electrocardiogram (ECG) checking framework which incorporates Bluetooth Low Energy(BLE) innovation. This BLE-based framework is embodied a solitary chip ECG signal procurement module, a Bluetooth module and an advanced mobile phone. The checking framework has the capacity obtain ECG motions through 2-lead electrocardiogram (ECG) sensor, transmit the ECG information by means of the Bluetooth remote connection, process and display the ECG waveform in an advanced mobile phone.
2012	Shen L. *et al.*[30]	The creators have proposed a novel methodology of evaluating shades of colorimetric symptomatic examines with a cell phone that permits high precision estimations in an extensive variety of surrounding conditions, making it a really compact framework. This system is appropriate to various basic light sources, for example, daylight, glaring light, or cell phone LED light. Eventually, the whole approach can be incorporated in an ""application"" to empower a single tick perusing, making our cell phone based methodology operable with no expert preparing or complex instrumentation.

2012	Munawar A. *et al.*[64]	An Open Sensor Platform is proposed which is taking into account Open System Architecture plan, for the mix of cell telephone and sensors. This stage uses business off-the-rack accessible equipment and programming devices, along the1se lines disposing of the requirement for specially crafted sensor's joining sheets. The possibility of the arrangement is upheld by the contextual analysis under taken, where outline is approved with the assistance of model open sensor stage. Its various applications incorporate; observing the test chamber's inside conditions, bringing ecological parameters, research facility experimentations and so forth. This work effectively accomplishes the reconciliation of sensors and cellular telephone in a promising manner.
2011	Zhu H.[41]	It is shown that wide-field fluorescent and dim field imaging on a mobile phone with conservative, light-weight and savvy optical segments that are mechanically connected to the current camera unit of the PDA. For this reason, battery fueled light-radiating diodes (LEDs) to pump the example of enthusiasm from the side utilizing butt-coupling is utilized, where the pump light was guided inside of the specimen cuvette to consistently energize the example. It is likewise shown that dim field imaging of non-fluorescent example utilizing the same interface, where this time the scattered light from the items is distinguished without the utilization of any channels.
2011	Zhu H.[43]	The creator has shows the mix of imaging cytometry and fluorescent microscopy on a wireless utilizing a reduced, lightweight, and financially savvy pick fluidic connection. In this mobile phone based pick fluidic imaging cytometry stage, fluorescently named particles or cells of hobby are constantly conveyed to our imaging volume through an expendable microfluidic channel that is situated over the current camera unit of the wireless.

2011	Kumar P. S. *et al.*[56]	The analysts proposed remote patient checking frameworks equipped for gathering crucial patient information, for example, circulatory strain readings, Electrocardiograph (ECG) waveforms, and heart rate can hinder the requirement for rehashed visits to the doctor's facility. The information gathered from the patient can be remotely seen and investigated by a doctor.
2011	Delaney J. L. *et al.*[26]	The creator portrayed the sensors taking into account the orange glow in which an alignment bend was developed showing that DBAE could be distinguished to levels of 250 μM utilizing the telephone.
2011	Lee D.[46]	The creator researched the attainability of utilizing cellular telephones cameras for DNA identification. The outline of this fruitful DNA discovery can be accomplished utilizing the most broadly conveyed electronic gadget.
2010	Shamir L. *et al.*[7]	The creators portrayed the essential ideas, wording and programming devices for PR-based imaging measures for science. The data gave is coordinated towards the seat researcher searching for a distinct option for customary picture handling methodologies.
2009	Breslauer D. N. *et al.*[39]	The creators have given a straightforward, financially savvy, and basic technique for the conclusion and screening of hematologic and irresistible sicknesses utilizing light microscopy. It is normal that such a telemedicine framework for worldwide social insurance by means of cell telephone give a critical device to infection analysis and screening, especially in the creating scene and provincial ranges where research center offices are rare yet cellular telephone foundation is broad.

2008	Martinez A. W. *et al.*[27]	The creators portrayed a model framework for measuring bioassays and for trading the consequences of the examines digitally with doctors situated off-site. The framework uses paper-based microfluidic gadgets for running various examines at the same time, camera telephones or compact scanners for digitizing the force of shading connected with each colourimetric measure, and set up interchanges base for exchanging the advanced data.
2008	U.S. Census Bureau [2]	U.S. Evaluation Bureau displayed information on condo; single-family homes; made/trailers; empty lodging units; age, sex, and race of householders; pay; lodging and neighborhood quality; lodging expenses; gear and powers; and size of the lodging units.
2007	Lamprecht M. R. *et al.*[6]	The analysts depicted the utilization of the open-source programming, CellProfile that naturally distinguish and measure an assortment of organic questions in pictures. The applications exhibited here incorporate yeast province numbering and grouping, cell microarray annotation, yeast patch tests, mouse tumor evaluation, wound mending examines, and tissue topology estimation.
2006	Deeb S. S.[20]	The scientist demonstrated a typical variety in both ordinary and inadequate shading vision and detailed for recombination and quality change between the compared, profoundly homologous OPN1MW, an OPN1LW qualities underlie this variety.
2005	Selinummi J. *et al.*[5]	The creator added to a mechanized picture examination programming, CellC, and approved for measurement of bacterial cells from computerized magnifying lens pictures. The product incorporated an instinctive graphical client interface that empowers simple use and also successive examination of numerous pictures without client mediation.

2005	Healey J. and Logan B. [57]	Introduced a model wearable wellbeing observing framework equipped for recording, transmitting and investigating nonstop ECG and accelerometer information. The framework likewise gives an application to recording exercises, occasions and possibly vital medicinal manifestations.
2004	Hunt R. W. G.[11]	The creator portrayed the crucial standards of shading proliferation, whether by photography, TV, printing, or electronic imaging, so that those drew in inproducing, offering, purchasing, enhancing, or simply utilizing shading pictures will have the capacity to comprehend the way of the phenomena that they experience.
2002	Harp D. L.[71]	In light of study existing strategies for measuring chlorine and chloramines in water, the creator arrived at conclusion that every single normal technique for chlorine examinations show some absence of specificity and are not sufficiently particular to be totally free of obstructions. Considering the relative precariousness of chlorine and chloramines in watery arrangements, Hach Company's variants of the DPD science, one can be guaranteed of the most dependable, exact and exact information accessible with on location testing utilizing convenient instrumentation. Numerous would consider this as the "perfect" framework for routine chlorine estimations.
1999	Letterman R.D. [1]	The creator proposed that wellbeing and stylish parts of water quality are the main thrust behind water quality regulations and water treatment rehearse and is subsequently asked to survey the referred to writing, wellbeing advisories and criteria archives from USEPA, and the Toxicologic Profile arrangement from the Agency for Toxic Substances and Disease Registry for more points of interest on any contaminant exceptionally compelling.
1993	Stockman A. [12]	The creator delivered a transient chromatic adjustment that is rolled out by a sudden improvement of foundation shading allows a simpler and closer way to deal with cone separation

		than does unfaltering state adjustment.

2.3 SUMMARY

Water quality measurement is very vast subject and has many fields of researches. Here in the chapter, various researches have analyzed as how the different techniques are used for the water quality measurement.

CHAPTER 3

PROBLEM STATEMENT & OBJECTIVE

3.1 PROBLEM STATEMENT

Every living thing on earth needs water to survive. Human bodies are made up of more than 60 percent water. Clean water is used to drink, grow crops for food, operate factories, and for swimming, surfing, fishing and sailing. Water is vitally important to every aspect of lives. Monitoring the quality of surface water will help protect waterways from pollution.

Water quality can be difficult to measure. Water is a vast network of branching rivers, springs, creeks, swamps, estuaries, wetlands, lakes, bays, etc. Each water body can contain dramatically different levels of pollution. Water quality issues influence human and environmental health, so the more monitoring of water the better will be able to recognize and prevent contamination problems.

The traditional method of water quality measurement includes the water sampling. The water sampling process includes the collection of water samples, transportation to a laboratory, and subsequent measurement in a controlled setting.

The first problem arise is in collection of water samples and preservation which is time consuming and involvement of human interference Water samples are collected under a wide range of conditions and the work can be dangerous. Proper precautions are required to insure safety while collecting water samples. Water is a carrier for many disease-producing organisms. Water-born hazards may come from material dissolved in the water, suspended in the water, or in sediment of the stream bottom. Infections or disease can enter the body through accidental ingestion by mouth or through skin broken by injury or another infection.

Second problem transportation of water samples without affecting the water quality parameter. It again a time consuming process. Collected samples should preserve under a specific range of temperature wile transporting. During transportation the samples parameter may be changed due to temperature and other biological process takes place in the water due to pollutants.

Above process are time consuming and high cost is required. The amount related is the salary of the persons involved in sampling and transportation cost.

3.2 OBJECTIVE

Different tools are available which are used to measure water quality parameters. The main objective are:

- To proposed a cost-effective sensor technologies that will enable a user with minimal training to make rapid measurements of multiple water quality parameters without water sampling.
- To reduce the human interference in the water sampling and measurement.
- To reduce the manpower and costly chemicals/instruments requirement in water quality measurement.
- To reduce the runtime cost of the water sampling.

CHAPTER 4

SIMULATION AND EXPERIMENTAL SET UP

4.1 INTRODUCTION

In this Chapter, a model is proposed of a water quality sensor that operates in conjunction with a smart phone through Bluetooth and custom-written application software are discussed. The sensor has been operate with the Sony Xperia Z1. The sensor performs measurements of water samples. Water quality parameters that are measured include pH, Temperature, Dissolve oxygen and conductivity.

These parameters have been selected due to their widespread use and availability of sensors. The sensor takes the measurement and send it to the application software for storage. Application software performs the measurement through control of the smart phone attached sensor, data acquisition and interpretation and storage. The software has been designed to be easy to use and visually pleasing.

4.2 SEWAGE TREATMENT PROCESS

Raw sewage is collected under gravity into the raw sewage sump after allowing it to pass through a bar screen. The bar screen through removing coarse solids from the sewage. The pumped raw sewage is passed through a distribution box and loaded as four equal streams into the first stage of two stage Baffled Anaerobic Reactor. Treated effluent coming out from the 2-stage baffled anaerobic reactor will be allowed to flow into the augmented facultative pond for further treatment. Treated effluent out from the augmented facultative pond will be passed through the multistage roughing filter. Effluent from the filtered effluent sump will be allowed to overflow the sump and flow under gravity through a circular drain into the duck/fish pond.

In the sewage treatment plant raw sewage is coming in and treated sewage is out. For measurement two sensors are place. Sensor one is place at inlet and sensor two at outlet for measurement of raw sewage and treated sewage respectively. Now the measurement is carried out through multiparameter sensors. The multiparameter sensor takes the measurement and send it to the android based application software via Bluetooth. Here the data is saved on the memory card in the form of comma separated value file (csv). From here the file can be transferred to cloud.

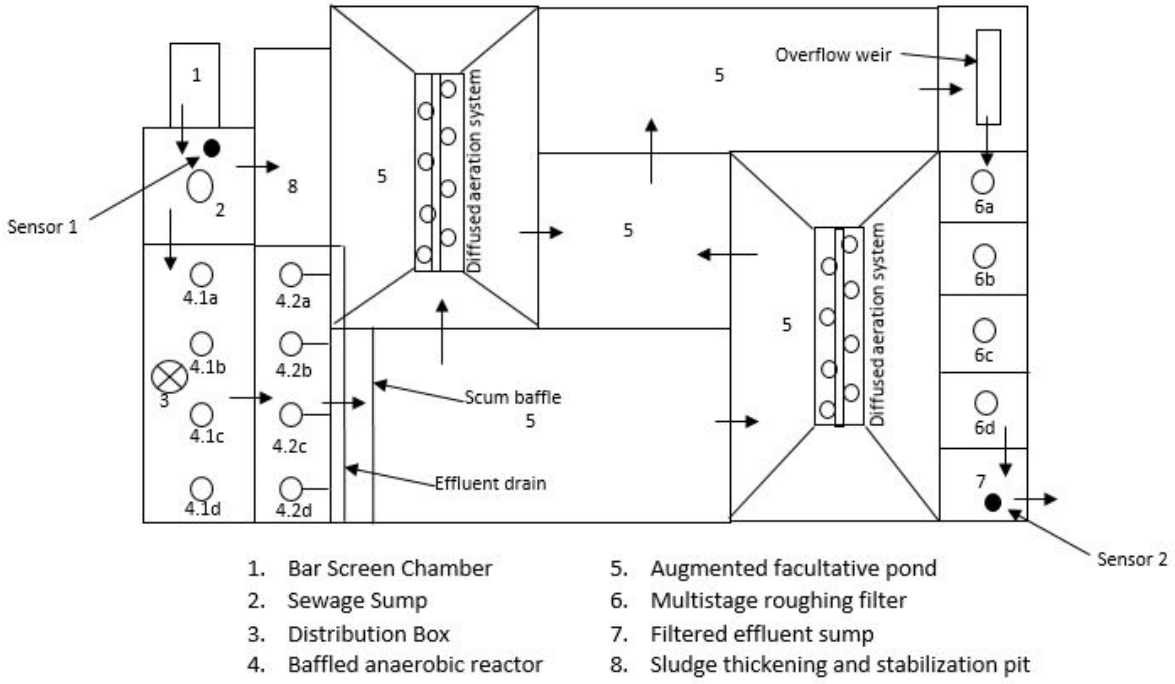


Figure 4.1. Sewage Treatment Plant

4.3 SENSOR PLACEMENT

There are two sensors are placed in the sewerage plant. One is placed at the inlet and second is placed at the outlet. The inlet sensor is used for measurement of parameters for the raw sewerage and the outlet sensor used for the measurement of the treated water parameter. The results are shown in the table as well as graph.

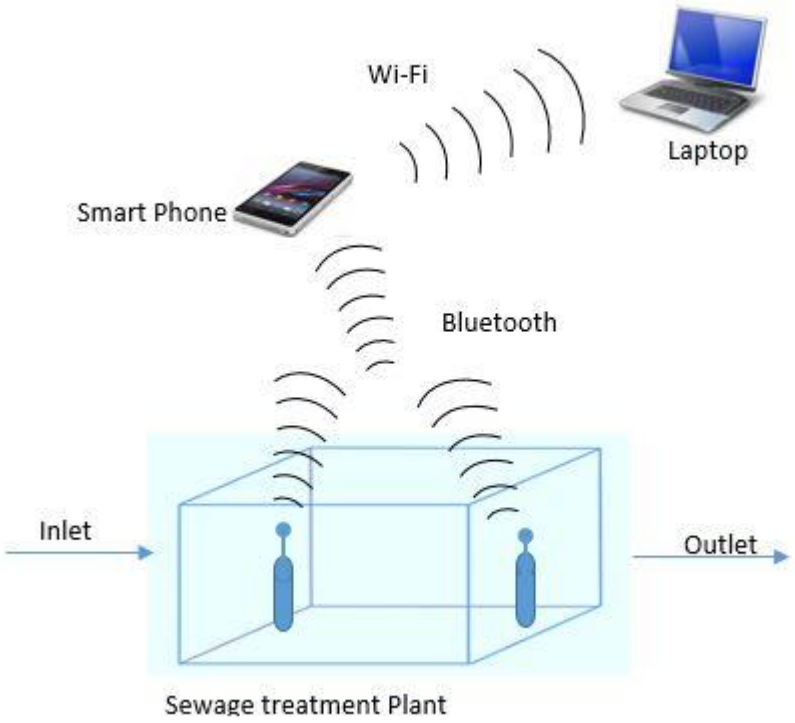


Figure 4.2 Block Diagram for Data Collection and Communication

4.4 SENSOR HARDWARE

The basic hardware components of the multiparameter sensor include four different sensors which are used for the measurement of the different parameters. Here four types of sensors are used.

- pH sensor :The pH electrode uses a specially formulated, pH sensitive glass in contact with the solution, which develops a potential (voltage) proportional to the pH of the solution.

- Temperature: Thermistors are most commonly used for temperature measurement. Thermistors are temperature sensitive semiconductors that exhibit a large change in resistance over a relatively small range of temperature. There are two main types of thermistors, positive temperature coefficient (PTC) and negative temperature coefficient (NTC). NTC thermistors exhibit the characteristic of resistance falling with increasing temperature.

- Dissolve Oxygen: Membrane-type dissolved oxygen electrodes using a galvanic cell. The membrane-type dissolved oxygen electrodes using a galvanic cell are configured as illustrated below. The working electrode uses a noble metal (Ag), and the opposite electrode uses a base metal (Pb). For the electrolyte, an alkaline solution is used. For the membrane, a highly oxygen-permeable Teflon membrane is used. Oxygen which has passed through the membrane is reduced with the working electrode. A reduction current in proportion to the concentration of the dissolved oxygen is generated, and then the dissolved oxygen is measured.

- Conductivity: The probe used to measure conductivity was originally an amperometric system which had two electrodes spaced one centimetre apart from each other.The amperometric method applies a known potential to a pair of electrodes and measures the current. According to Ohm's law:

$$I = \frac{V}{R} \tag{1}$$

Where R is the resistance,
V is the voltage,
I is current.

The higher the current so obtained, the greater the conductivity.

4.5 PHONE APPLICATION SOFTWARE

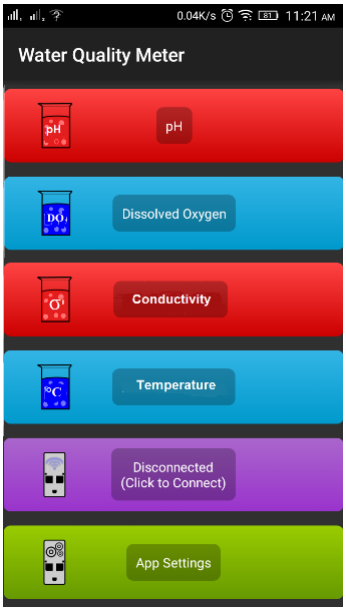
In this topic discuss the application software to enable operation of the sensor. All software applications developed are android based and freely available on Google play store. For this sensor, the software provides a platform for user interaction, allowing the user to control the sensor, obtain measurements, and view results. In the background, the software analyzes and converts the data obtained into a measurement of species concentration.

The software app for the sensor has been designed to provide an intuitive, easy-to-use interface on the Sony Xperia Z1 touch-based screen. When the app has been initiated, it will prompt the user with a list of water quality parameters which can be selected by touching its labelled button. After selection of a particular parameter, the app then guides the user through

the measurement process in two user-initiated steps: a first step to ensure that the sensor is attached to the phone if it is not attached then asked for the pairing of the sensor via Bluetooth. The screenshots corresponding to these steps are shown in Figures 4.2. Then user will select the parameter to analyse and compute measurement of the desired parameter is displays the result numerically and the data is logged. At any point during the measurement procedure, the user can press the home button on the smartphone to exit the app completely. All measurements made while the app is running are logged, and can optionally be exported as a csv file before the app is closed, the file is deleted when the app is closed, so the file must be sure to save.

Table 6: Specification of Sony Xperia Z1

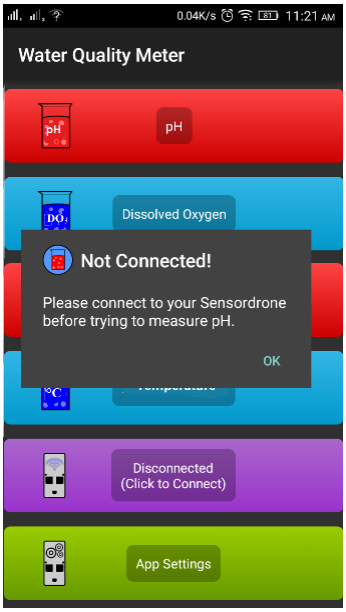
Operating System	Android OS, v4.2 (Jelly Bean)
Display	TFT capacitive touchscreen, 16M colors
Resolution	1080 x 1920 pixels
CPU	Quad-core 2.2 GHz Krait 400
Memory	16 GB, 2 GB RAM
Camera	20.7 MP, 5248 x 3936 pixels
WLAN	Yes
Bluetooth	Yes
GPS	Yes
Messaging	Yes
Battery	Li-Ion 3000 mAh battery
Dimension	144 x 74 x 8.5 mm (5.67 x 2.91 x 0.33 in)
Weight	170 g (6.00 oz)


0.04K/s 11:21 AM
Water Quality Meter
pH
Dissolved Oxygen
Conductivity
Temperature
Disconnected
(Click to Connect)
App Settings

(a)


0.26K/s 11:25 AM
Water Quality Meter
pH
Dissolved Oxygen
Bluetooth is Off
Please enable Bluetooth before proceeding
OK
Disconnected
(Click to Connect)
App Settings

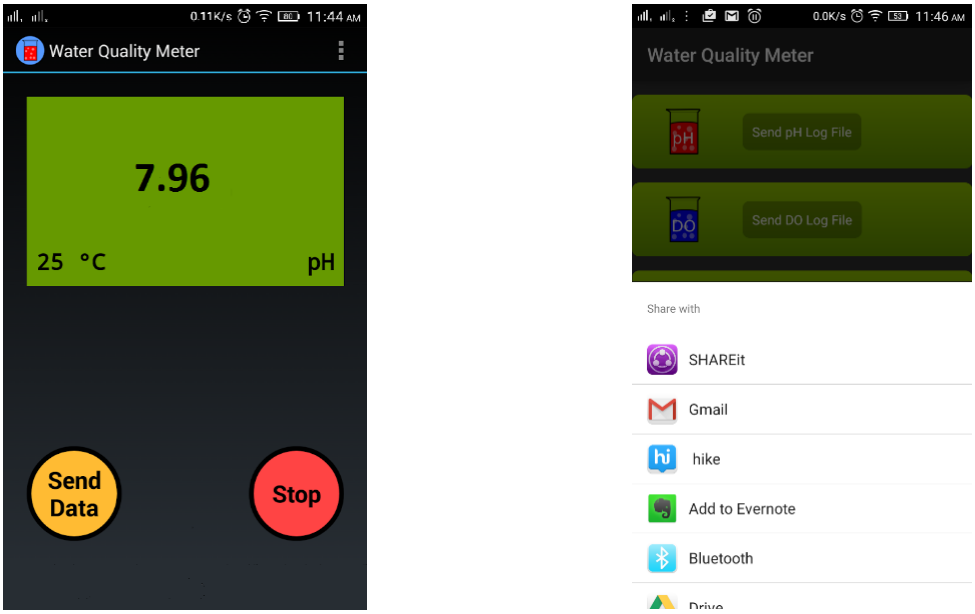
(b)


0.04K/s 11:21 AM
Water Quality Meter
pH
Dissolved Oxygen
Not Connected!
Please connect to your Sensordrone before trying to measure pH.
OK
Disconnected
(Click to Connect)
App Settings

(c)


0.04K/s 11:21 AM
Water Quality Meter
Measure pH
pH Probe Information
Calibrate at pH 4
Calibrate at pH 7
Calibrate at pH 10

(d)



(e) (f)

Figure 4.3. Phone Application Software

4.6 MEASUREMENT PROCEDURE

We will now discuss the entire measurement procedure using the water quality sensor in this Chapter. The measurement procedure consists of 5 steps:

1. The sensor is paired with the smartphone application for the first time measurement otherwise just select the sensor from the pairing list.
2. A parameter is selected for measurement from the app title screen after ensuring that the Bluetooth is on and sensor is attached.
3. Measure is selected to perform the measurement.
4. The water sample is measured and displayed on screen.
5. The measured data is logged and will be saved.

4.7 DATA FLOW

After connecting the multiparameter sensors to smartphone via Bluetooth. The multiparameter sensor starts the measurement and acquiring data. The data retrieval and storage is done by the application installed on the smartphone. The data collected by the application software is logged and stored in the form of CSV file. The data can be transferred to the computer through mail, social network media, or by mirroring the smart phone.

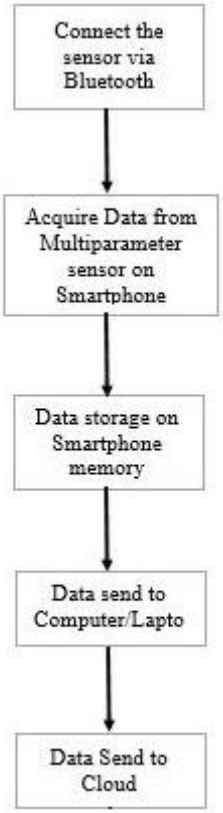


Figure 4.4. Flow Diagram

4.8 RESULTS

The following results are obtained for the parameters chosen for water quality measurement.

4.8.1 pH

Measurement of hydrogen ion concentration in water is called pH. It is generally used to show the acid/base condition of water. The pH value of 7.0 shows the neutral condition of water, value greater than 7.0 shows the Alkaline and pH less than 7.0 shows the acidic condition. Most natural water holds the pH value between 6.0 to 8.5. As pH is calculated as the negative logarithm of the hydrogen ion concentration.

$$pH = -\log[H^+] \quad (2)$$

Table 7. Tabulated Data for pH

Sr. No.	Inlet Sensor	Outlet Sensor	Sr. No.	Inlet Sensor	Outlet Sensor
1	7.12	7.65	**21**	7.89	7.63
2	7.23	7.61	**22**	7.82	7.82
3	7.44	7.55	**23**	7.53	7.73
4	7.67	7.43	**24**	7.12	7.41
5	7.72	7.48	**25**	7.34	7.39
6	7.73	7.34	**26**	7.64	7.89
7	7.19	7.7	**27**	7.32	7.56
8	7.27	7.35	**28**	7.45	7.52
9	7.54	7.49	**29**	7.33	7.35
10	7.96	7.36	**30**	6.75	7.47
11	7.69	7.41	**31**	7.69	7.88
12	6.53	7.43	**32**	7.06	7.38
13	6.69	7.45	**33**	7.24	7.66
14	6.94	7.58	**34**	7.32	7.32
15	7.52	7.56	**35**	7.34	7.98
16	7.64	7.54	**36**	7.38	7.92
17	7.45	7.75	**37**	7.19	7.25
18	7.49	7.89	**38**	7.23	7.43
19	7.58	7.95	**39**	7.65	7.28
20	7.84	7.31	**40**	7.29	7.23

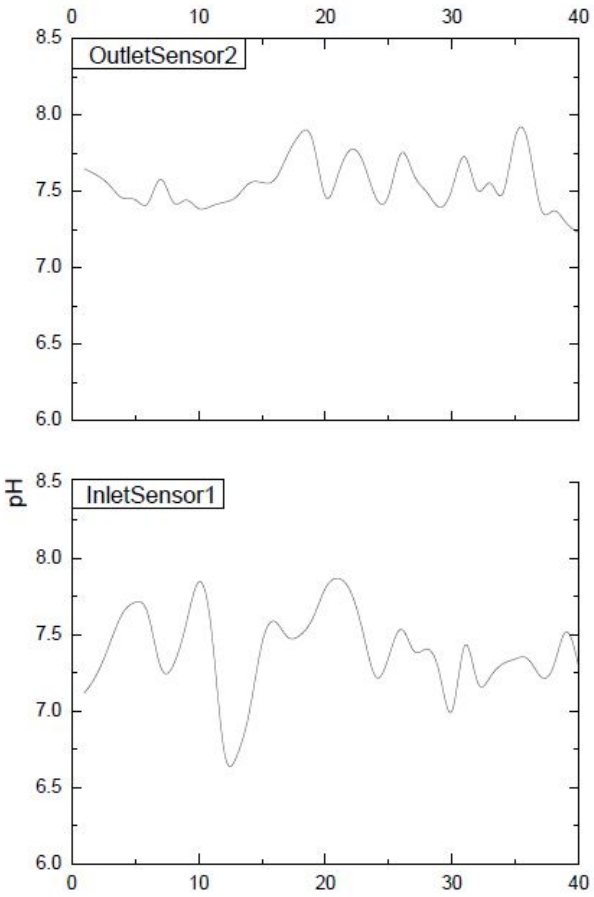


Figure 4.5. Graph for pH

4.8.2 TEMPERATURE

The coldness or hotness of a body is defined as Temperature. The unit of the temperature is kelvin or degree of kelvin Celsius and Fahrenheit scales. The temperature change depends on the amount of heat absorbed or released. The Formula of Temperature is given by

$$\Delta T = \frac{Q}{mc} \tag{3}$$

Where ΔT is the temperature difference,

Q is the amount of heat absorbed or released,

M is the mass,

C is the specific heat

Table 8. Tabulated Data for Temperature

Sr. No.	Inlet Sensor	Outlet Sensor	Sr. No.	Inlet Sensor	Outlet Sensor
1	29	29	**21**	28	29
2	30	29	**22**	29	30
3	31	29	**23**	29	28
4	33	29	**24**	29	29
5	30	29	**25**	29	29
6	30	29	**26**	28	29
7	30	30	**27**	30	31
8	30	30	**28**	33	31
9	30	30	**29**	33	28
10	30	29	**30**	32	28
11	29	29	**31**	31	29
12	28	30	**32**	29	29
13	28	30	**33**	28	28
14	28	30	**34**	29	28
15	28	30	**35**	28	29
16	30	30	**36**	28	29
17	28	28	**37**	29	29
18	28	27	**38**	28	29
19	29	27	**39**	28	29
20	30	29	**40**	28	29

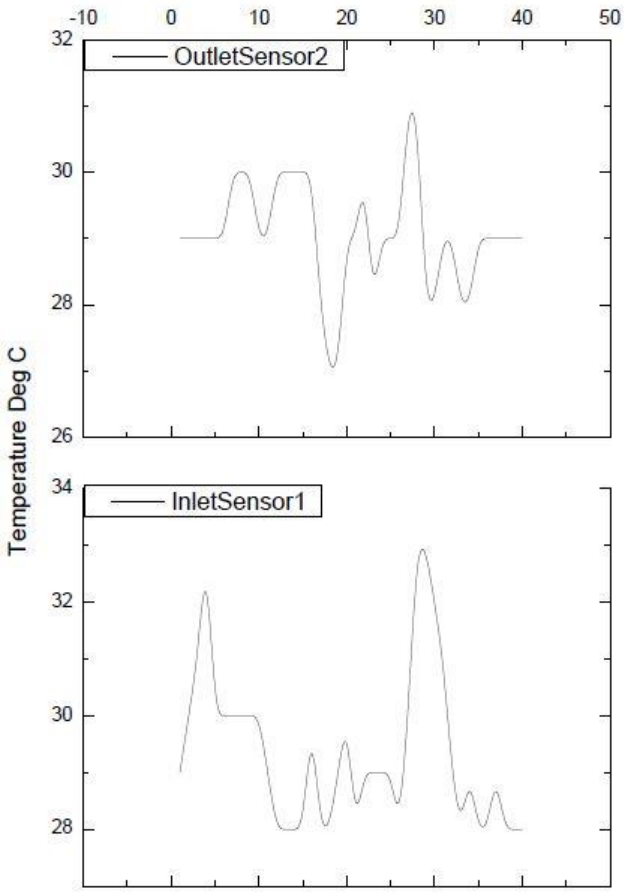


Figure 4.6. Graph for Temperature

4.8.3 DISSOLVE OXYGEN

The oxygen dissolved in water is called dissolved oxygen (DO). The oxygen get dissolve by diffusion aeration of water and from photosynthesis. The value of dissolve oxygen can vary in seasonal and daily pattern. It decreases with, salinity, higher temperature and elevation. A simplified formula is given below:

Photosynthesis (in the presence of light and chlorophyll):

Carbon dioxide + Water ----------> Oxygen + Carbon-rich foods
CO_2 H_2O O_2 $C_6H_{12}O_6$

Table 9. Tabulated Data for Dissolved Oxygen

Sr. No.	Inlet Sensor	Outlet Sensor	Sr. No.	Inlet Sensor	Outlet Sensor
1	7.62	7.60	**21**	7.82	7.64
2	7.54	7.65	**22**	7.84	7.52
3	7.44	7.68	**23**	7.89	7.85
4	7.13	7.63	**24**	7.84	7.64
5	7.58	7.69	**25**	7.80	7.68
6	7.20	7.61	**26**	7.83	7.63
7	6.80	7.54	**27**	7.58	7.42
8	6.40	7.52	**28**	7.13	7.41
9	6.70	7.59	**29**	7.16	7.90
10	7.40	7.60	**30**	7.28	7.92
11	7.65	7.64	**31**	7.41	7.65
12	7.53	7.63	**32**	7.67	7.63
13	7.70	7.58	**33**	7.81	7.88
14	7.40	7.59	**34**	7.69	7.87
15	7.80	7.52	**35**	7.78	7.64
16	7.10	7.57	**36**	7.83	7.68
17	7.68	7.81	**37**	7.69	7.63
18	7.90	7.94	**38**	7.82	7.64
19	7.30	7.97	**39**	7.84	7.65
20	7.40	7.64	**40**	7.88	7.69

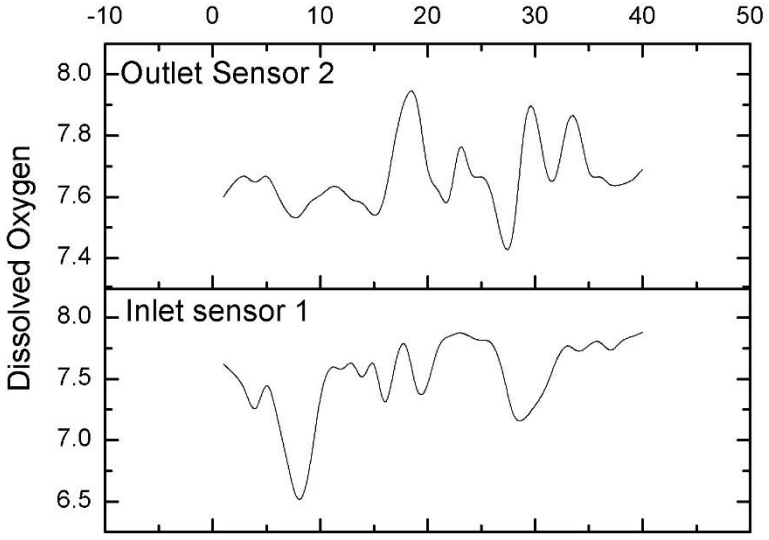


Figure 4.7. Graph for Dissolved Oxygen

4.8.4 CONDUCTIVITY

Conductivity is the capability of a substance to conduct an electric current. It is the reciprocal of resistance. If the ions concentration in water is higher than the water can conduct more current. The total amount of dissolved solid in water helps to estimates the electrical conductivity of water. The unit of electrical conductivity is μS/cm (microSiemens/cm)

EC can be converted to TDS using the following calculation:

$$TDS(ppm) = 0.64 * EC\ (\mu S/cm) = 640 * EC\ (dS/m) \quad (4)$$

Table 10. Tabulated Data for Electrical Conductivity

Sr. No.	Inlet Sensor	Outlet Sensor	Sr. No.	Inlet Sensor	Outlet Sensor
1	233	331	**21**	361	343
2	219	340	**22**	260	334
3	299	320	**23**	321	312
4	236	321	**24**	410	345
5	233	373	**25**	354	325
6	188	345	**26**	336	397
7	198	380	**27**	394	380
8	176	310	**28**	217	345
9	177	375	**29**	233	383
10	196	343	**30**	254	301
11	232	391	**31**	240	327
12	155	341	**32**	220	349
13	383	342	**33**	185	363
14	376	350	**34**	169	380
15	351	363	**35**	179	358
16	385	342	**36**	219	369
17	349	333	**37**	266	348
18	305	343	**38**	269	334
19	339	394	**39**	247	346
20	342	381	**40**	310	344

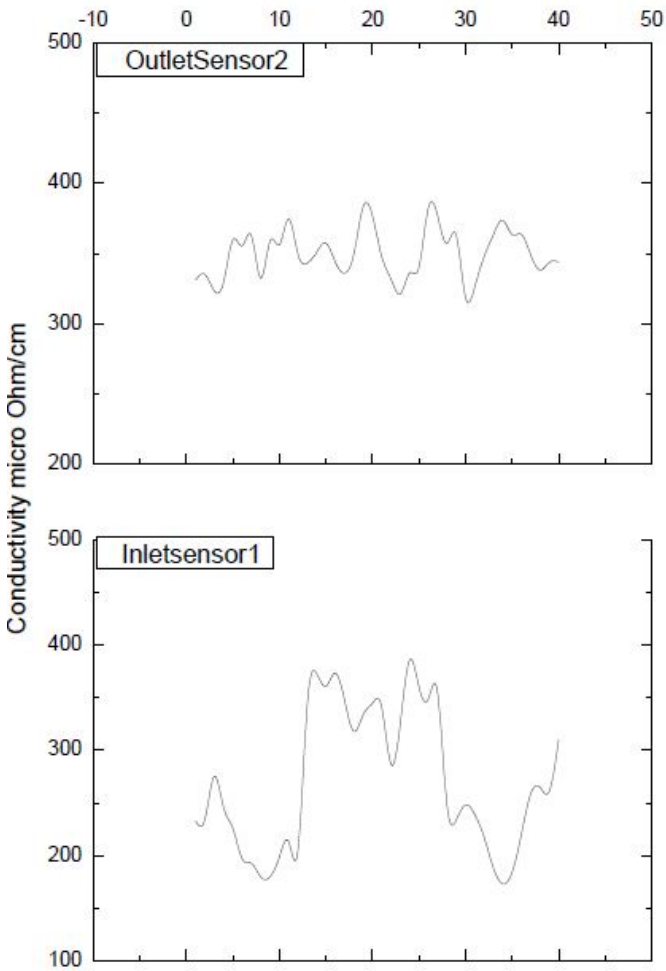


Figure 4.8. Graph for Electrical Conductivity

4.9 SUMMARY

In this chapter a sensor model is developed that operates in conjunction with a Sony Xperia Z1 smartphone to perform water quality measurements. Measurements are performed by exploiting the sensors. The wireless sensor provides several benefits over other standalone measurement tools. First, the measurement process is quick and intuitive. The total measurement procedure for one parameter takes less than thirty seconds and requires no precise measuring of chemicals. The instructions are given to the user on-screen, which largely eliminates the need for a physical user manual. The attachment is completely passive light-weight, and portable. The manufacturing costs are low and the performance of the device is robust. We anticipate that this sensor could be used to determine water quality for recreational uses such as swimming pools, ponds, River *etc*.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

The goal of this work is to develop a model for water quality sensors that would enable a user with minimal training to make immediate measurements of water quality without sampling. To achieve water quality sensor that is highly portable, cost-effective, and easy to use, a strategy is explored in which the sensors leverage the compactness, computing power, and intuitive touch-based displays of smart phones. A model has been developed based on wireless sensor node that communicates to any smart phone through a Bluetooth interface. The results have been shown in graphs and tables indicating the inlet and outlet parameters like pH, Temperature, Conductivity, Dissolved Oxygen in water. It is envisaged from the results that water is treated and purified for further usage.

5.2 FUTURE SCOPE

There are still several areas that require future investigation. As discussed, the performance of the wireless sensor can be easily improved by incorporating diffusing elements into the path, which would reduce the sensitivity of the measurement. The power consumption of the wireless sensor can also be improved by using a more energy efficient Bluetooth implementation (such as the new Bluetooth Low Energy Standard) and by optimizing the circuit with custom-built electronics. Future work should also extend the number of measurable parameters and include those parameters that are relevant for water contamination by industrial and agricultural processes such as turbidity, nitrates, and metals and using Wi-Fi for data communications.

PAPER COMMUNICATED

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