Technological Developments for Lake and River Water Contamination Monitoring Systems Across the Globe

Dinesh M., Prakash S.

Abstract: This paper is an outcome of investigation to understand how the technology has been involved in monitoring the quality of water in realtime situation around the world. From the review of many papers it's evident that water quality monitoring system is very much essentional as the scarcity of potable/good quality water has increased across the world due to various reasons, and its found that new technological methods are used to measure various parameters like Dissolved Oxygen, pH of water, turbidity, temperature etc . Many technologies are used to measure the level of contamination at lakes and other water resources. These technologies are invented in silo for specific measurement. We need an integrated approach to get the measurement of contamination by encompassing in all the angles. With the emergence of technologies like IoT, Cloud, Robotic Process Automation (RPA)., we will be able to develop technology platform that will enable to extrack data which comprehends wide variety of contaminants. This paper specifically focuses on the survey of new emerging technologies that can be integrated for measuring contamination with high precision and accuracy in lakes and rivers.

Keywords—Farming; Remote Sensing; GSM; IoT, RPA, Cloud , Fresh water farming, Acquaculture (key words)

I. INTRODUCTION

One of the biggest challenges which India is staring in the recent times is the scarcity of Quality Potable water for human usage. Its estimated that 70% (World Economic Forum Report) of water available in water bodies are not usable and nearly 40 million Litres (World Economic Forum Report)[19] untreated water enter the water bodies every day. The untreated water from industries, domestic waste water are let in to the water bodies which will lead to major health hazards.

The water pollution can be simply classified into various categories like

Ground Water: Many people live in Rural Areas, and ground water becomes the main source. The use of contaminants like pesticides, fertilizers and from septic unit percolate into aquifer, enabling ground water pollution.

Surface Water: Because of uncontrolled growth in cities, many Industries in the city leave the untreated water directly into the lakes and rivers. The Surface water Pollution problem could also be treated as socio-economic. There should be proper enforcement of laws by the respective town planning authorities as well. **Ocean Water:** The Oceanic pollution basically originates on land. Pollutants and contaminants such as chemicals, effluents from factories, city streams and rivers lead into the sea. Marine debris especially plastics from sewers and drains is also one of the main concerns. Apart from this the oil spill and leaks from travelling ships and tankers do not dissolve in the water. This forms into a thick sludge and polluting the water. **Point Source:** The contamination originating from a source individually can be termed as Point Source pollutant. This includes discharge of wastewater from a manufacturer, effluents discharged from industry without treatment into lakes or rivers etc. The Point source contamination can originate on land but can travel hundreds of miles through rivers and can reach the ocean. **Non-Point Source:** Non-Point source of pollution is derived from many sources which are distributed widely. This is one of the leading sources of pollutant in USA. Its very difficult to control this type of pollutions, as the sources are distributed widely. **Transboundary:** In transboundary pollution the contaminants or pollutants in the water gets spilled from a country to another. One of the best examples could be the Atreyee river is a transboundary river, which is flowing between India and Bangladesh is in the verge of dying because of dumping crematorium waste, release of untreated sewage and sand mining. **Sewage and Wastewater:** The wastewater from household is untreated and left into water bodies. More than 80% of worlds waste water is left into water body without being treated according to UN. **Oil Pollution:** The oil pollution is caused due to spill of oil into marine ecosystem, and because many human activities. Oil spills can be due to crude oil tankers, drilling rigs and wells, and oil spills from refined petroleum products.Also, the dumping of untreated waste into rivers, percolates into ground water there by creating lot of health hazards. The fertilizers used in agricultural sector gradually enter lakes, river water and other inland water bodies, where it gets transformed into Nitrates. The Nitrates are hazardous and impacts the newborn babies with "Blue Baby Syndrome" which starves the baby's body with oxygen. Also, for small children the excess nitrate in water leads to stunted growth in height.

Its estimated that around 4lakh people in India lose their lives per year and around 15lakh Children die, who are under five [18].

At present maintaining and monitoring a good quality of water is a big challenge in both developing and developed countries. Hence need of the hour is the government should come out with a policy to safeguard the inland fresh waters.

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* Correspondence Author

Dinesh M., Research Scholar, Department of Computer Science & Engineering, VTU RRC, Bangalore, City, India.
E-mail: dinesh.svdm@gmail.com

Dr. Prakash S., Department of Computer Science & Engineering, East Point College of Engineering, Bangalore, India.
E-mail: prakash.hospet@gmail.com

Also, we need to conserve the water bodies by educating and bringing in the awareness among public, upgrade and increase research in water quality monitoring systems.

Traditionally the people used to take sample of water to their lab and test the samples. But this is a time-consuming process, at present there are lots of improvement in technology. The enormous growth of mobile technology satellite communication, Remote Sensing, Geographic Information Systems, Wireless Sensor Networks (WSN) is used in water quality monitoring. All these technologies are in silo, till date there is no integrated approach towards the convergence of all these technologies for better outcome.

Hence this paper aims at identifying the existing technological implementation, in and across the world. Analyze the challenges in implementing the same in India. How, various technological work is done in the areas of IoT, Cloud, GPRS, GIS, Remote Sensing and AI for measuring the Realtime data of water contaminants that can be implemented towards Indian Geographical conditions. Also, the review aims how an integrated approach could be more effective for water quality monitoring systems for lakes in India.

II. WATER RESOURCES AVAILABLE IN INDIA

The total land area of India is 32,87,509 sq. km, in this the coastal line is about 7500 km [19] India mainly depends on its south west monsoon rains. Since India is not too far away from equator, in south it exhibits tropical monsoon and in north it has temperate climate.

The monsoon contributes to high level of precipitation during June to October and contributes to 75% of rain fall in the country.

Major rivers flowing across India are Ganga, Indus, Krishna, Godavari, Mahanadi, Sabarmati, Cauvery, Narmada, Brahmini, Tapi, Mahi and Pennar. Analysis, Comparative Investigation, Investigation'.

The classification of river basins based on the catchment area is as shown in the table.

Table1. River Basin Classification in India[11]

River Basin	Catchment Area in Sq-Km (%)	No. of Basin
Major	More than 20,000 (82.4%)	13
Medium	Between 2000-20,000 (8%)	48
Minor	Less than 2000 (9.6)	52

The rivers in the North India are perennial and have water through out the year. But in the south, the rivers are rain fed, basically depends on monsoon rains.

Also, in the southern state of Kerala, the land width is hardly 100km (land between sea and mountain), hence the river flow length also is 100 km. Sometimes the river is approximately 10-40 km in length as the land width in the west coast is less.[11]

In India the quality of water is being monitored by a separate entity known as Central Pollution Control Board (CPCB). The CPCB has formed a network monitoring stations in various rivers and inland waters systems.

Presently they have around 870 water quality monitoring stations in 26 state and 5 union territories. It covers 189 rivers, 53 lakes, 4 tanks, 2 Ponds, 3 Creeks, 3 Canals, 9 Drains, and 218 Wells [11]. Besides this Bio monitoring is also done at specific places.

The reports of Water Quality Statistics are presented annually in the India year books[18].

Since 1978, the Central Pollution Control Board started monitoring the quality of water under the Global Environment Monitoring System (GEMS) Programme. In parallel one more program started in 1984 called as MINARS (Monitoring of Indian National Aquatic Resources). The Table 2 shows the monitoring stations established on various water bodies

Nearly Twenty Eight parameters of bacterial and chemical are analyzed apart from observations in the field. Also Nine(9) different trace of metals were also monitored. The various metals under the screening are Arsenic (As) , Mercury (Hg), Chromium (Cr),Cadmium (Cd),Copper (Cu), Nickle (Ni), Iron (Fe) and Zinc(Zn). Also, Pesticides like Alpha/Beta/Gama BHC, Alpha Endosulphan etc. are monitored.

Along with this few organic pollutants are also monitored monthly, quarterly accordingly.

Table2. Distribution of Monitoring Station, Water body wise

Sl No	River (main stream), Tributaries and Sub-Tributaries, Lake, Ponds, Tanks, Canals, Creeks and Groundwater Stations	Total
1	Baitarni (5)	5
2	Brahmani (11) Tributaries-Karo (1), Koel (2), Sankh (2)	16
3	Brahmaputra (6) Tributaries-Burhidihing (1), Dhansiri (6), Disang (1), Jhanji (1),Subansiri (1), Bhogdoi (1),Bharalu (1),Borak (1),Deepar Bill (1), Digboi (1),Mora Bharali(1),Teesta (4),Dickhu(1), Maney(2),Ranchu(2)	31
4	Cauvery (20) Tributaries-Arkavati (1), Amravati (1), Bhawani (5), Kabini (4), Laxmantirtha (1), Shimsa (2), Hemavati (1),Yagichi(1)	36
5	Ganga (39) Tributaries-Barakar (1),, Betwa (3), Chambal (7), Damodar (5), Gandak (1), Saryu-Ghaghra (3), Gomti (5), Hindon (3), Kali (West) (2), Kali Nadi (2), Khan (1), Kshipra (2), Mandakini (Madhya Pradesh) (1) , Parvati (3), Ramganga (1), Rapti (1), Rihand (2), Rupanarayan (1), Sai (1), Sone (5), Tons (Madhya Pradesh) (2), Yamuna (23),Sind (1), Johila (1),Sankh(1), Gohad (1), Kolar (1), Sai(1), Churni (1), Tons (Himachal Pradesh) (1),Sikrana (1),Daha (1), Sirsa (1), Dhous (1), Farmer (1)	127
6	Godavari (11) Tributaries- Manjira (2), Maner (2), Nira (I),), Wainganga (4), Wardha (1),Kolar (1), Kanhan(1), Purna(1),Karanja (1), Indravati (2), Shankhani (1)	28
7	Indus Tributaries-Beas (18), Chenab (1), Jhelum (3), Larji (1), Parvati (1), Ravi (3), Sutlej (21), Tawi (1), Gawkadal (1), Chuntkol (1), Sirsa (3), Swan (1)	55
8	Krishna (19) Tributaries- Bhadra (3), Bhima (10), (Ghataprabha (2), Malprabha (3), Muneru (1), Musi (2), Nira (1), Paleru (1), Tunga (1), Tungabhadra (6), Panchganga (3), Chandrabhaga (2)	54
9	Mahi (9) (2G, 7) Tributaries-Anas (1), Panam (1)	11
10	Mahanadi (18) Tributaries-Ib (4), Hasdeo (2), Kathajodi (1), Kharoon (4), Kuakhai (2), Sheonath (3), Birupa (1),Arpa (1), Kelo (2)	38
11	Narmada (14) (3G,11) Tributaries-Chhota Tawa (1)	15
12	Pennar (1G, 4)	5
13	Sabarmati (2G, 4) Tributaries-Shedhi (1), Khari (1)	8
14	Subarnerekha (4G,2)	6
15	Tapi (11) (3G, 8) Tributaries-Girna (2M), Rangavali (1)	14
16	Medium & Minor Rivers Ambika (1), Ulhas(2),Ulhas-Bhatsa (1)Ulhas-Kalu(1), Imphal (4), Mandovi (2), Palar (1), Pamba (3), Pariyar (3), Rushiku-lya (2), Tambiraparani (7), Achankoil (2), Chalakudy (1), Damanganga (6), Ghaggar (21), Kallada (1) , Kali-Karnataka (1), Manimala (2), Mindhola (1), Nagavalli (3), Amlakhadi (1), Chaliyar (2), Iril (2), Kharkhala (1), Karmana (1),Kolak(2),Kundalika(1),Meenachil(1),Muvattupuza(1),Patalganga(2),Umtrew(1),Vamanpuram(1),Zuari(2),Gumti(2),Kalna(1),Valvant(1),Madai(1),Khandepar(	117
17	Lakes (55) Hussaingar(1), Saroornagar(1), Himayatsagar(1), Pulicate(1) ,Salaulim(1), Kankoria(1), Ajwah(1), Sursagar(1), Braham-sarovar(1), Govindsgar(1), Pongdam(1), Renuka(1), Wuller(1), Dal(1), Ulsoor(1), HebbalaValley(1),. Oruvathikotta(1), Sasthamcotta(1), Ashthamudi(1), Paravur(1), Vembanad(1) ,Periyar(1), Kodumgallor(1), Kayamkula(1), Punnamada-kayal(1), Pookotekayal(1), UpperLake(1), LowerLake(1), MultaiLake(1), Loktak(4), Umiam(1), Ward(1), Thadlaskena(1), Osteri(1), Bahour(1), Harike(2), Pichola(1), Udaisgar(1), RamgarhJaipur(1), Pushkar(1), Fatehsagar(1), Kalyana(1), Nakki(1), Udhagamadalam(1), Kodaikanal(1), Yercaud(1) ,Lakshminarayan Baridigh(1), Rudrasagar(1), Ramgarh-UttarPradesh (1), Naini(1), Rabindrasarovar (1) Tanks (4) Dharamsagar(1),Bibinagar(1),Kistrapetrareddy(1),,Goysagar(1), Ponds (2) Elangabeel System(1), Lakshadweep(1),	61
18	Creeks, Canals, Tanks, Ponds, Drains Creeks (3M), Agra Canal (1M), Gurgaon Canal (1M), Western Yamuna Canal (9M), Agartala Canal (1),Drains (10M)	25
19	Groundwater	218
	Total	870

The classification of water resources is done based on the usage. The central pollution board has classified the water resources as shown in the table.

Table 3. Classification of Water Based on Usage

Designated best use	Class	Criteria
Drinking water source without conventional treatment but after disinfections	A	Total coliform organisms MPN/100mL shall be 50 or less. pH between 6.5 and 8.5 Dissolved oxygen 6 mg/l or more Biochemical oxygen demand 2 mg/l or Less
Outdoor bathing (organised)	B	Total coliform organisms MPN/100ml shall be 500 or less pH between 6.5 and 8.5 *Dissolved oxygen 5 mg/l or more Biochemical oxygen demand 3 mg/l or Less
Drinking water source with con-ventional treatment followed by disinfection	C	Total coliform organisms MPN/ 100ml shall be 5000 or less pH between 6 and 9 Dissolved oxygen 4 mg/l or more Biochemical oxygen demand 3 mg/l or Less
Propagation of wild life, fisheries	D	pH between 6.5 and 8.5 Dissolved oxygen 4 mg/l or more Free ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, con-trolled waste disposal	E	pH between 6.0 and 8.5 Electrical conductivity less than 2250 micro mhos/cm Sodium absorption ratio less than 26 Boron less than 2mg/l

III. SURFACE WATER QUALITY MONITORING PARAMETERS

The results obtained from various water monitoring bodies predominantly shows the organic pollution. The Biochemical Oxygen Demand (BOD) and Coliform count shows the gravity of degradation of water.

Coliform Trend

The trends of coliform which was measured and distributed from year 1995-2011 are as shown below data from [19]

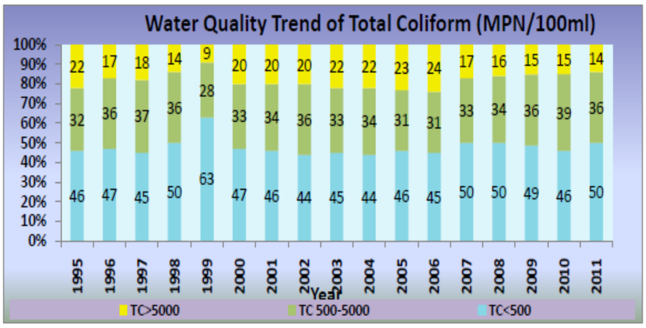

Fig1. Total Coliform Data Trends MPN/100ml[18]

Total Coliform (TC) values < 500 MPN/100 ml -between 44-63% - Year 1995-2011. There was a high percentage of as observation as 63% in year 1999 but decreased to 50% during 2011 [11]

In year 2011, there was a trend of decreasing in TC values to around 14%, which is good.

Biochemical Oxygen Demand (BOD) Trend

The total number of observed BOD values were below 3mg/l were around 57-69 % in between years 1995-2011.

The 69% value was found in 2007 and gradually it got reduced in the coming years.[11]

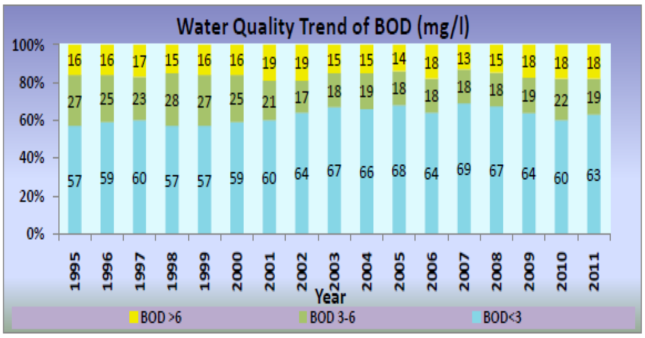

Fig2. Water Quality Trend (BOD, mg/l)

In [5], a biological approach along with chemical towards the analysis of quality of water was studied and they have listed various methods of evolution and its benefits. The various biological methods are

1.Saprobic Approach 2. Saprobic Index 3.Diversity Approach

4.Biotic Approach 5.Biotic Score 6. Biological Monitoring Working Party 7. Average Score Per Taxa 8.Two Way Indicator Species Analysis 9.River Invertebrate Predication and Classification System 10.Water Framework Directives

[5] gives few good methods for assessment of water quality prior to computer system analysis. It describes various methods to evaluate water quality by biological and chemical methods, and it emphasizes that due to lack of knowledge in utilizing the information it could not be applied appropriately. Also, this paper clearly says the need of Artificial Intelligence based system for Biological Data in assessment process.

IV. ADVANCED TECHNOLOGICAL DEVLOPMENT IN WATER QUALITY MONITORING

Remote Sensing & Quality Monitoring

In the visible part of Electro Magnetic Region (EMR), water has very low spectral reflectance. Also, there are few more substances which exhibits high spectral reflectance in near Infrared or visible range of EMR.

Since water absorbs all the incident energy in both Middle Infrared (MIR) and Near Infrared (NIR) wavelength ranges. The most important character of water is that, because of its low reflectance in NIR and visible band, Remote sensing become easy to identify from the other landmarks like vegetation or soil cover in the reflective portion of infrared portion of earth.

The Total Radiance (R) of Remote Sensing System for a given water body is a function of electromagnetic energy and is given by [18]

$R_t = R_p + R_s + R_v + R_b$ where,

R_p = Atmospheric Path Radiance

R_s = Free-surface Layer Reflectance

R_v = Subsurface Volumetric Reflectance

R_b = Bottom Reflectance

Ideally when a clear water is measured with various levels of muddy and silty soil suspended, the spectroradiometer measurement shows that reflectance, peak is drawn towards the longer wavelengths. This trend continues as more suspended sediments are added to water.

Its observed that in the wavelengths range from 400-500 nm, there is a strong chlorophyll absorption of Blue light and in the range of 675 nm there is a strong chlorophyll absorption of red light.

For an accurate and better monitoring of water quality at a resource through Remote Sensing, the relationship between water quality parameters and spectral reflectance need to be identified before proceeding.

As the water quality parameters changes the reflectance also changes, in these scenarios an empirical formula can be used. The formula may not hold good in multi temporal domain, since the type and number of constituents in water shall be in different ranges. Also, the elevation of sun angle and atmospheric composition with time shall affect the calculations between spectral reflectance and water quality parameter.

A brief summary of water quality parameters and the type of Remote Sensing technique useful for water quality monitoring has been listed in the below table.

Table 4. Water quality Parameters and the type of Remote Sensing technique Used[18]

Sl. No.	Water Quality/Water Pollution Parameter	Remote Sensing Technique Employed	Remarks
1.	Total Suspended Solids (TSS)	Visible spectral region of EMR	Reflectance increases with the increase in sediment concentration, empirical relationships could be established for TSS estimation.
2.	Temperature	Thermal Infrared and Passive Microwave regions of the EMR	Infrared radiometers (in 8-14 µm region) based on Aircraft/Satellite can be used to estimate temperature of water body; the characteristics of temperature change depends upon nature of pollutants and effluents.
3.	Agricultural Runoff	B&W and Colour Infrared (CIR) photography	Change in vegetation can be identified and monitored through CIR; B&W IR imagery can also be used to identify the source of agricultural pollution.
4.	Eutrophication of Lakes	Colour Infrared (CIR) photography	Monitoring of floating algae identification and delineation of potential areas of algal blooms are possible with CIR image. Water transparency, colour, chlorophyll, algal blooms and aquatic vegetation of lake eutrophication can be monitored.
5.	Oil Pollution	Ultraviolet (UV) photography Thermal Infrared (TIR) Scanners Passive Microwave Sensors	Good weather condition and low altitude aerial survey is required to monitor oil pollution, limited to day time monitoring. All weather, day and night capability. All weather, day and night capability.
6.	Water Depth	Blue/Green portion of visible spectrum Aerial photogrammetric methods LASER Profile technique (LIDAR)	In clear water, blue light penetrates up to 15-20 m and green light penetrates up to 1-2 m Measures of parallax in stereopair photographs with at least three reference targets LIDAR systems can be used to measure accurate profile of water depths.
7.	Municipal and Industrial Discharge (Effluents)	Satellite/Airborne TIR imagery	Temperature difference between the effluents and the water (in which the effluent is discharged) can be identified and monitored as dispersal pattern of Effluent Plumes.
8.	Colour/Material Insolation	LASER Spectrometers	May not be possible to detect through satellite imagery; ground based LASER Spectrometers can be used for identification of chemical composition of the solution/water.

One of the techniques in Remote Sensing Network is to prepare a Distribution mapping of water resources and create a study model of the same. This will give an insight how the land mass or greener environment metamorphosized over a period.

The Remote sensing methods help us understanding the long-term usage of land and the contaminations because of the usage of the land. This will help the government or analysts to identify the future problems, accordingly the government agencies to mitigate the issue and take appropriate measures. The Remote sensing techniques and GIS help in creating spatial distribution and mapping of contaminants across the area. Also, it gives images of mapping of present and earlier years. This helps in comparing the spatial distribution of contaminants and its maps, which helps us to study the patterns of land usage and changes in the environment by the human activity.

The Remote sensing technologies have gradually over period helped to identifying a special tool for analyzing geostatisticaldata and extrapolate the spatial upgradations in an environment.

The Indian Space Remote Sensing Programme, has evolved National Natural Resource Management System (NNRMS) for establishing the necessary ground based data reception processing and disseminating the systems at National Remote Sensing Agency (NRSA), Space Application Centre (SAC) etc.

The following table depicts the Remote Sensing Techniques that can be adapted in Water Quality Monitoring

Table 5. Remote Sensing Spectral Region

S. No.	Water Pollution/ Quality parameter	Spectral Region	Remarks
1	Total suspended solids (TSS)	Visible spectral region of EMR	Reflectance increases with the increase in sediment concentration. Empirical relationships could be developed for TSS estimation
2	Temperature	Thermal infrared and passive microwave	Infrared radiometers (8-14 µm region) based on Aircraft/satellite can be used to estimate the temperature. The temperature variation is function of nature of pollutants and effluents
3	Agriculture runoff	B&W and colour infrared photography	Change in vegetation can be identified & monitored through colour infrared. B & W IR image also can be used to identify the sources of agriculture pollution
4	Eutrophication	Colour Infrared (CIR)	Monitoring of floating algae can be done with CIR data Identification & defining of potential areas of algal blooms Water transparency, colour, chlorophyll, algal blooms, aquatic vegetation of eutrophication can be monitored
4	Oil Pollution	Ultraviolet Thermal infrared / Passive microwave	Good weather and low level flying is required to monitor oil pollution. Limited to day time monitoring Day/night capability
5	Water depth	Blue/green regions of visible spectrum Aerial /Laser profile	In clear water blue light penetrates upto 15 to 20 meters, & Green light penetrates upto 5 - 7 meters. Lidar systems can be used to be measure accurate profiling of water depths
6	Municipal & Industrial discharge	Satellite/ airborne thermal infrared	Temperature difference between the effluents and the receiving waters can be identified and monitored
7	Colour/ material insolation	Laser spectrometers	May not be possible to detect through satellite techniques. However ground based laser spectrometers are used for identification of chemical composition

The Remote Sensing Images also helps in monitoring the inventory of glaciers, Glacial Mass balance and Glacial retreat in Himalayas regions, also the impact of climate changes.

Contamination Detection by WSN Methods

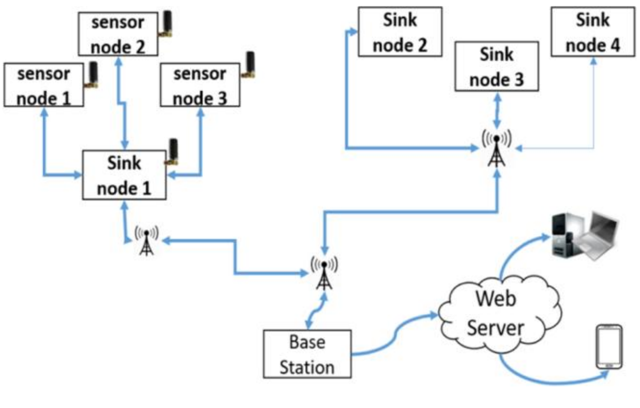

Fig 3. WSN Network Model

The WSN method provides an easy and economic approach towards the water quality monitoring. Few features of the WSN are it has very less energy requirement, optimal cost utilizing as the electronic parts are quite cheap, and no human intervention is required for longer duration. The electronic devices acquire the data and transmit the same without much loss to storage or cloud system. This is quick and less chances of data corruption as not much people are involved as intermediary.

Also, the advantage of WSN is that it can be implemented in the remote area as well without human labor intervention and obviously reduce the cost of implementation.

There are many sensors like DO, Turbidity, TC77 Temperature Sensors, ion selective Sensors (ISE) etc. which are less expensive. The solar powered batteries/technologies can be used in order to reduce the power problem.

The WSN is very good and helpful and the purpose is mainly for data collection from an inaccessible environment, i.e. there are few remote areas where human beings cannot stay for longer duration or where we cannot enter may be inside the water or inside a forest area.

Since most of sensors are powered, the battery power is very important aspect. One of the methods we can implement is the usage of Renewable Energy (RE) i.e. usage of solar panels is encouraged and can stored into battery. Usage of solar charged batteries at each node shall render relaying the data to the server located at base stations. But here the bottleneck is to identify the sustainable battery for longer duration (can be for 6months to one year.)

Most important factors to be considered while implementing the WSN based project is the resource constraints. It can be limited memory inside the system for data logging, non-function requirements like environment conditions, animal hijacking the embedded system, water flooding, extreme climatic conditions, unreliable wireless communication systems, collecting the right and authentic data (Redundancy of Data), Node failures and non-accessibility of data etc.

V. INTEGRATED TECHNOLOGIES USED IN DIFFERENT COUNTRIES ACROSS THE GLOBE

The European Union has come out with integrated approach to monitor the water quality in reservoirs and aqueducts.

Few of the new water quality monitoring technologies employed are Robotics and advanced Sensors with probes.

Due to vast development in semiconductors and nano technologies lot of sophisticated sensors have evolved. Apart from these many numerical simulation models are also have been developed.

The simulation models help in predicting the chemical and biological transformations of various pollutants and its impact on water quality.

Even though the numerical simulation models seems to be effective, but due to lack of practical ground level field data specifically during short duration of time, is not available. This makes this exercise more of theoretical rather than practical implementation [22].

The hydrodynamic model helps in identifying the mass of the conservation flow of water, Equations of salinity, the temperature. All the identified data are tabulated on to a cartesian graph.

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The adaptive grid gives the flexibility in changing the time near the boundaries of reservoir. The water quality module helps to reveal different compounds and various parameters like nutrients, presence of heavy metals, suspended sediments and also the disease causing germs in the water.

The placement of the Distributed Network Monitoring system of sensors in water depends on topography of the land and water area, availability of potential contaminants in the vicinity of the network, spatial and temporal contaminants in a defined area etc.

Many sensors have come up to measure and monitor different parameters of water quality like physio-chemical characteristics of water, presence of heavy metals, organically polluting contaminants and presence of bacteria.

Apart from this, the UN also has come out with an action of Integrated Water Resource Management(IWRM)[1]. The Fig 4. depicts the process by which the water management is being handled.

UN has taken initiative to not only conserve water in various regions of the world but also has actions based on the reports of the water quality at different places in the world.

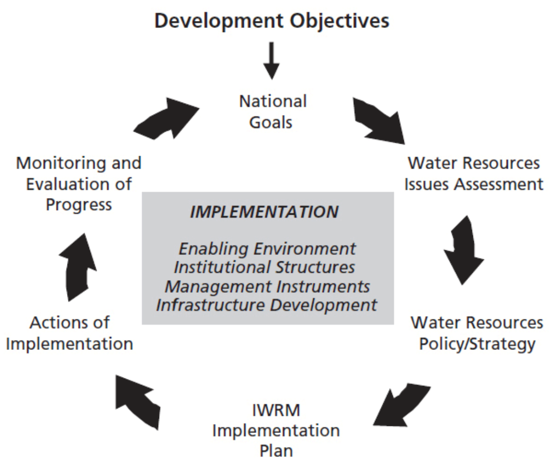

Fig 4. UN, Integrated Water Resource Management (IWRM)[20]

VI. CONCLUSION

This paper has reviewed different technologies used for measurement of contamination of water in lakes across globe. This paper has also explored many integrated approaches using current technologies at different countries.

After the review of many technological publications it's found that there are many wireless sensor technologies used to monitor the quality of water continuously in a real time environment. In most of the cases the observed important parameters are pH, Dissolved Oxygen, Turbidity, amount of Phosphate content in water, temperature and conductivity of water.

The collected data is displayed in visual format for easy interpretation and given to government agency. Still there is scope and long way to go further with better and effective solutions.

Most of the papers discuss about wireless sensor networks and no paper speaks about the vicinity or boundary limitation of the sensors measuring the above said parameters, as its one of the most important parameters. Since the lakes and rivers are having huge area with just few sensors we cannot sample and arrive at a decision for the whole area of the river.

These are some of the points could be addressed in the future research.

The following table give the result of our inferences of usage of various technologies.

Table 6. Result and inference of Sensors and Technology used

Sl No	Sensors and technology	Application and usage
1	pH Sensors alone	Used as instrumental devices
2	Dissolved Oxygen	Used in Many projects
3	Turbidity and Dissolved Oxygen Sensor	Used in Many Projects
4	How many sensors should be placed in the lake/ pond	This is not found in many in any of the papers. As few lakes are up to 150-200 acres, at the same time ponds are of few square meters. This quantity should be identified and shall give effective usage of the Sensors, and increase more research in Sensor Technology.
5	Integration of many sensors like DO, pH, Turbidity	Its found that only two or three different types of sensors they have used. This gives very good data in Realtime.
6	Sensors and Wireless Technology	Most of the projects use this across the world, also few use it through GUI's

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AUTHORS PROFILE

Dinesh M, B.E, M.E (Computer Science & Engineering) Worked Extensively in Embedded systems and Engineering, Product Design, Semiconductors and Silicon Validations. Worked With Many R&D's like Intel, Sony, Siemens, Samsung, Wipro Product Engineering Group

Dr. Prakash Sheelvanthmath, M.Tech, Phd (Computer Science & Engineering) Currently working as Principal of East Point College of Engineering, Bangalore Being HOD of ISE department, transformed the ISE department as the BEST department of the college with good academic results. Department topped the academic results and placement tally consistently for three years under my leadership. Member of Karnataka Federation Chamber of Commerce EMC Corporation recently awarded me for my consistent five years of service in evangelizing third platform technologies to academia.

Recently elected as Vice-chairman & Chairman(elect) CSI (Computer Society of India)-Bangalore Chapter words.