Surface Water Analyzer & Notifier (SWAN) using Automated Volumetric Analysis and GSM Module

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***Abstract*— This is an undertaking to safeguard surface water bodies from degradation due to pollution discharge from various human institutions. It provides a way to account for the degree of pollution in such water bodies and thereby regulate the aforementioned institutions. We have used existing electronic sensors and actuators to automate the process of volumetric titration. The method involves using valves and timing circuits to find out the amount of time taken for a color change to occur in the sample water. This time is used as a reference to approximate volume of pollution parameter in the sample water. Result was successfully able to automate volumetric titration and measure pH, DO and temperature of the sample water. The values of these parameters are analyzed and a report is generated to be sent to the authorized person's mobile phone. The report is received from the test done on our sample water. This methodology can be used to automate volumetric titration. But the time error in valve control delay leads to a slight error in measure of parameter. Also for titration methods involving many reagents this method will not be suitable as it becomes complex and expensive.**

Keywords—Automated titration, SWAN, surface water, pollution monitoring, quality of water, NGT, CPCB.

I. INTRODUCTION

Water is the most important element for mankind's survival. It is a valuable resource that is being used extensively for industrial and agricultural production. With the development of economy and industry, a whole new range of pollutants are being discharged into the surface water bodies such as rivers and lakes. This is causing an ecological crisis and is deeply affecting the lives of fresh water creatures such as fish, reptiles, migratory birds and plants. Detecting the degree of pollution timely so as to ensure prevention of further deterioration of water quality is important for water conservation and is a necessary condition for rejuvenation of the lake ecosystem. The pollution control board of India (PCB) has defined several water quality parameters to be of a certain level in order to define the surface water body as being pollution free.

In India, 580 people die of water pollution related illness every day. In many developing countries, dirty or contaminated water is being used for drinking without any proper treatment. One of the reasons for this is the lack of awareness amidst public and administrative bodies. The lack of water quality monitoring system which creates serious health issues. Also natural phenomena such as volcanoes, algae tints, rainstorms, and earthquakes affect the quality and ecological status of water. Therefore, water quality monitoring is one of the first steps required in the rational development and management of water resources. Central Water Commission (CWC) monitors water quality, by collecting samples from representative locations within the processing and distribution system. These samples are analyzed at state of the art laboratories. At these laboratories samples from raw water, filter water and treated water are taken for analysis. The estimation of water parameters like turbidity, pH, dissolved oxygen, etc. is done with the help of meters. The main disadvantage of the existing system is that there is no continuous and remote monitoring. Other disadvantages include requirement of human intervention low reliability and the apathetic state of protection of lakes. Due to these disadvantages of the existing system it is required to develop a system that will allow real time and continuous monitoring of water quality. The main aim here is to develop a system for continuous monitoring of water quality using different sensors with low power consumption and low cost. Ph, temperature, dissolved oxygen and phosphorous content are the parameters that we are using for analysis of water quality. SWAN helps to monitor the quality of water with the help of information sensed by the sensors immersed in water, so as to keep the water resource within a standard described for domestic usage and to be able to take necessary actions to restore the health of the degraded water body. Using different sensors, this system can collect various parameters from water, such as pH, temperature, dissolved oxygen and phosphorous content and send SMS to an authorized person automatically when water quality detected does not match the preset standards, so that, necessary actions can be taken.

II. METHODS AND PROCEDURES

The core method we use to find out the value of four pollution parameters can be divided into two parts.

- Sensor based (pH and temperature)-We use inexpensive and readily available sensors in the market to measure these two parameters.
- Automated Volumetric Titration(DO and phosphorus)-We are using solenoid valves, pipes, color sensors and motors to automate the lab process of Volumetric Titration to find out the value of DO and phosphorus content

As the entire system is automated we make use of a GSM module to relay messages between SWAN and the human controller. A coded message sent by him will initiate the process of parameter evaluation and in the end make the SWAN send the status report. Also SWAN itself will alert the human authority automatically when there is imminent danger to the lake.

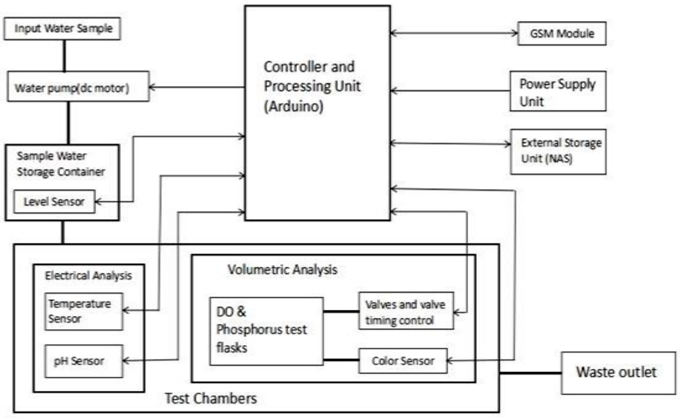

Fig. 1. Block diagram of methodology used in SWAN

The SWAN has the following functional units:

A. Sampling Unit

The water from freshwater bodies such as lakes is taken as input sample water. This is being drawn into the sample storage container via a dc motor. Three different samples corresponding to three different depth levels of the lake are taken and stored separately. This is achieved via a system of pipes with valves which are installed into the lake. The valves open and close corresponding to commands from the microcontroller. The Sample Storage Container (SSC) is kept at constant air pressure. After a certain level (predetermined) of depth is filled in the Sample storage container the dc motor is turned off. A level sensor is used to detect this change. Now the water from the SSC is directed into the testing unit via opening of valves in the pipe system.

B. Testing Unit

The testing unit contains two different chambers. The Volumetric Analysis Chamber (VAC) which uses the method of automated volumetric analysis technique to detect DO and phosphorus content and the Electrical Analysis Chamber (EAC) which uses commercially viable and cheap sensors to detect pH and temperature. A little quantity of water is led into the EAC as it contains probes that are to be immersed in the sample water.

The EAC consists of a main flask, indicator containers and titrant containers. In the VAC we use valves with timing control to allow only 100mL of sample water to be taken in two times. This is done using the following principle. Under constant pressure and a fixed orifice whose area of cross section is known we can calculate the volume per second of liquid being flown out of the orifice. Knowing this value we can find out the time period for which the valve needs to be open to allow only 100 mL of water into the flasks in the EAC. A drop of indicator solution is added into the flask. Now the titrant container valves are opened and a timer is started simultaneously. When there is a color change in the main flask because of addition of titrant the timer is stopped and the valve is closed. This color change is detected by a color sesnor. The time noted is used to calculate the volume of titrant required to cause a color change. All these data are stored in the microcontroller.

C. Control and Processing Unit

The microcontroller acts as both a controller and processor. All data input from sensors and from the EAC is stored and processed here. The timely opening and closing of valves and the control of all actuators is done here. The volume data sent by the EAC is used to calculate the DO and phosphorus content of the sample water. Now all parameter values are stored onto the external memory unit (NAS). Also the data is sent to the communication unit.

D. Communication Unit

This consists of the GSM900a module. All data sent by the microcontroller are input into a predetermined text message and sent to the concerned authority whose mobile numbers are coded in the GSM. The data sent can be protected using digital encryption and certification techniques. This ensures that the data recorded and sent is authentic. The encryption can also be used to identify the individual SWAN unit from where the message was sent.

E. Color Detector Design

In order to detect end point in volumetric analysis indicators are used that change color at the end point. To automate this process we have used IR sensor which notes the initial analog reading of the solution in the beaker and detects the instant of change in this reading when the color of the solution changes. Fi g 2. shows Color detector for detection of color change at end point

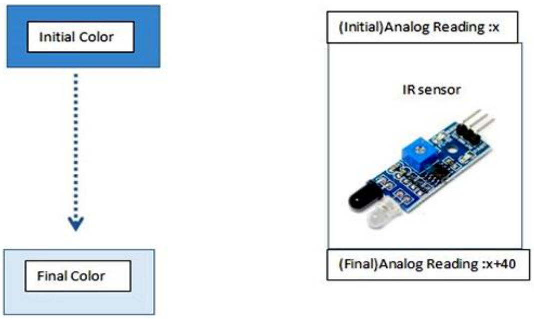

Fig. 2. Color detector for detection of color change at end point

III. PERFORMANCE EVALUATION & RESULTS

The prototype was tested with different inputs and it was tweaked to work in conditions prevalent in the Mysuru region.

The following observations were made when testing the prototype:

- The solenoid valve control lead to a time delay of 1 second
- The water flowing through the pipe could be reduced to a trickle using smaller diameter pipes.
- The 1 second delay would mean the volume of water flowing through the pipe in that second is unaccounted for , leading to a time error and thereby pollution parameter calculation error in the second decimal point place.
- The color sensing action using IR had different offsets for different colored indicators. Depending on the difference in range of the initial and final colors in the color spectrum the efficiency of the sensor varied.
- The temperature and pH probes were calibrated before use and had minimal errors.
- The volumetric method would need a high number of valves if used to automate different titration procedures wherein number of intermediate titrating was high.

The lakes in the temperate climate as in the Mysuru Region need to have the pollution parameters in a range prescribed by the Central Pollution Control Board (CPCB) and the Karnataka Pollution Control Board (KPCB). These values are tabulated below.

TABLE I. PRESCRIBED RANGE OF PARAMETERS

Parameter	Value	Effect on Lake
Temperature	18°-31° C	Studies have shown a direct relationship between metabolic rates and water temperature. For most fish, a 10°C increase in water temperature will approximately double the rate of physiological function. It also indicates geothermal activity
pH	7.5-8.5	The acidity or basicity of water will directly impact all life in the lake.
Phospohorus	10-40 microgram per litre	This directly influences the algae growth in the lake.
Dissolved Oxygen	4-14 ppm	The DO is an essential compnonent that is necessary for aquatic life to sustain itself. Different species of fish,plant and insects require different DO levels.

The results obtained by our prototype have been compared with those obtained using manual volumetric analysis in a standard lab. We have used standard equipment that was obtained from environmental department of SJCE.

The results obtained have been tabulated below.

TABLE II. SAMPLE 1-POND WATER

Parameter	Desired Value	Value obtained in Lab	Value obtained in SWAN
Temperature	18-31 degree C	23.1 degree C	23.3 degree C
pH	7.5-8.5	8.2	8.25
Phospohorus	10-40 microgram per litre	39.24 microgram per litre	38.12 microgram per litre
DO	4-14 ppm	8.18 ppm	8.76 ppm

We can infer from the above table that SWAN produces values of the sensor based parameters (temperature & pH) in minute errors. But the automated volumetric titration using valves produces a small error that is slightly different than the expected value. To compensate for this we need to take measures to mitigate the time error in valve control. Use of better technology may be one of the ways to do this. But after testing with different samples we have found that our prototype works fairly well and it is in accordance as a proof of concept (Automating volumetric titration)

IV. APPLICATIONS

It contributes to community, well-being and learning.

A. Community

The cleanliness of the lakes, rivers and other water bodies are of utmost importance to humans. SWAN helps maintain clean lakes and rivers and thereby providing an oxygen rich and biodiverse recreational space for humans. It provides regulation on industries and prevents them from dumping wastes indiscriminately. It also gives data on geothermal activity and acts as an Early Warning System.

B. Well Being

Stagnant water with pollutants becomes a breeding ground for mosquitoes, flies and other disease carriers. So SWAN plays a major role in preventing this from happening. Each water body has a very unique biodiverse system that is interdependent. This ecological balance must be undisturbed by preventing pollution. Fish, migratory birds, underwater plants, flora on the banks are all preserved and prevented from dying. For human wellbeing the prevention of foaming and flooding is possible.

C. Research

SWAN provides research data for environmentalists and bio diversity scientists to study and understand the impact of human intervention on the existing lake ecological systems. It helps in collecting data to study on variations in lake chemical components over seasons and over different time periods. It helps in case studies so that further methods of treatment of surface water can be researched.

V. CONCLUSION

In order to mitigate the high cost of existing sensors, the methodology of automating volumetric titration was successfully used to determine the pollution parameters values. SWAN successfully tested and analyzed the surface water quality and sent a report to the relevant authority. It also provided added features such as remote monitoring and authenticated control, thereby providing accountability in the preservation of lakes. This can be deployed to different surface water environments after thorough testing and calibration of all equipment. The main concerns are the errors in value obtained due to time delay. This can be overcome using advances in technology. The work is a proof of concept that volumetric titration can indeed be automated using electronic sensors and circuitry.

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