

Measurement and Monitoring of Water Quality using Smart Sensing in Home Water Purifier

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Abstract—Contaminated drinking water results in transmission of certain disease such as diarrhea, cholera, dysentery, typhoid, hepatitis A and polio. Around 8,29,000 people will die every year due to these diseases contaminated water. To avoid this, most of the houses are installed with water purifiers. But there is no inbuilt system for water purifiers to show the quality of water after purification. The most distinctly used parameter to estimate the water quality is the Total Dissolved Solids (TDS). The TDS level helps in indicating whether the drinking water is fit for consumption, or requires filtration, or is highly contaminated. Therefore, maintaining the TDS level in water purifiers is an essential requirement for sustaining the safe drinking water. This work aims to develop an inbuilt system for measurement and monitoring the quality of the water. The proposed work prevents the risk of unsafe drinking water by intimating the quality condition of the purifier and displaying the filtration status. So, this proposed work automatically measures, monitors, and displays the input and output TDS along with the filtration status of water purifiers. Nine different filters are tested with the proposed method and the status of purifier along with the water TDS values are correctly displayed in the RO system.

Index Terms— Water Purifier, TDS level maintenance, Quality inspection, RO quality check, filtration Status.

I. INTRODUCTION

It is noted that pollution of water is root causes medium of disease spread which may results in death. It accounted for the deaths of 1.8 million people in 2018. India and China are with high scale of water pollution [9]. In India, an average 580 people die owing to water borne diseases. Over the past few decades, water purification gains its importance across the globe to ensure human health by providing them a good quality of drinking water. Monitoring the quality of water is a challenge task because more chemicals are used in day to day lives. In developing countries, 30% of the productivity is lost due to unhealthy drinking water. In developed countries, proper measures are taken by framing suitable authorized bodies for the sake of ensuring the quality of water. Purification of water involves removing of unwanted biological contaminants, gases, suspended solid and undesirable chemicals and to maintain the TDS to the appropriate level. According to the latest National Sample Survey (NSS) report, over one-fifth of urban households in India use electric water purifier, which includes

Reverse Osmosis (RO) for treating drinking water. Though the water purifiers have been installed everywhere, users could not know whether the filtration process is going well, or whether the users are getting a good quality of drinking water. Since a valuable amount is spent on water purifiers, knowing the quality of water and filtration process in home water purifiers becomes essential. Monitoring of water quality ensure with sound decision on ensuring water quality. It will alert on the issues caused because of the unsafe water for drinking and benefits of using purified water.

Hence, the proposed work focuses on developing an inbuilt system for measuring, monitoring, and displaying both the input and output quality of drinking water along with the quality of the filtration process. The proposed method uses Arduino ATmega and TDS sensors.

This paper is organised into 5 sections including the introduction. Section II discusses the various literatures related to the proposed work development. Proposed methodology is discussed in section III and the results obtained through the proposed works are given in section IV. This article is concluded in section V.

II. LITERATUREREVIEW

Roy R. (2019) has published an article on “An Introduction to Water Quality Analysis”. Water Quality shows the biological, physical, and chemical attributes of water, in respect of its nominated use. This article provides the standards of water quality that can be used to make sure the beneficial use of water for the purpose which was designated [1]. Preeti Gupta et al. (2009) has published an article entitled “The Assessment of Water Quality Parameters of Kerwa Dam for Drinking Suitability”. This paper shows the results of the attempt which was put in place to estimate the quality of water in Dam of Kerwa. The outcomes acquired were compared with two international standards that are WHO and BIS. This report focuses on calculation of all parameters like chloride, total hardness, TDS, chloride, Sulphate, nitrate, alkalinity, fluoride, Calcium, pH, and magnesium and analyzing whether the parameters are within the permissible limits [2].

Scott Whittier et al. (1992) has published a patent entitled “The High Flow Rate Reverse Osmosis Water Filtration System for Home Use”. Reverse osmosis (RO) filters for domestic usage in houses placed on wall or nearby sink in the kitchen. This invention is achieved by a planned mixer of rinse and water supply along with attachment for water release, which has been employed for attaching the apparatus to the sink tap then rate of producing an extremely filtered for drinking is attained with help of a filter which has a dual wrapped layer formation, rolled in RO filter fabrication [3]. Low-cost measurement for Electrical Conductivity (EC) provides a method for measuring and monitoring TDS[4].

Aravinda S. Rao et al. (2013) has published a paper on “Design of Low-cost Autonomous Water Quality Monitoring System”. Continuous quality of observing the water has been necessary device for water shed administration control, to provide present information for preservation of the habitat and to origins of contamination; but the above process remains prohibitively expensive [5]. Examination of water standard is one of the major processes, especially for drinking water. Important parameters are pH, TDS, Temperature, color, odor, and turbidity in water quality analysis. TDS is the high priority used parameter to estimate drinking water quality [6].

Khalil et al. (2009) has published an article which gives an up-to-date review of statistical approaches utilized for assessment and redesign of surface water quality monitoring. Knowledge on designing of water quality monitoring systems [7]. The increased use and continuing advancements of real-time remote monitoring (RTRM) and sensing technologies will become a progressively more important tool for evaluating water quality [10]. Prashant Kamidi et al. (2019) has published an article on, “IoT Based Smart Water Quality Monitoring and Prediction System”. The aim of this paper is to build a system for monitoring water quality based on sensors. Arduino Mega 2560 used as a base station and getting data from sensor hubs and sending to it [11].

Niel Andre Cloete et al. (2016) has published a paper entitled “Design of Smart Sensors for Real-Time Water Quality Monitoring”. This Provides some knowledge on smart sensors application for monitoring the quality of water [12]. C.G. Leggett et al. (2000) has published an article entitled “Effects of Water Quality on Residential Land Prices”. This shows how the poor water quality has its impact on people who are consuming it in the residential areas. The necessity for monitoring of water quality is ensured [13].

A. Problem Definition

Though the water purifiers are being installed everywhere, users lack in understanding the quality in filtration process unless the measurement of the outlet water with TDS is done or the proper working of the

filtration process is verified manually. Henceforth it becomes mandate for the users to know about the water quality and the filtration efficiency.

III. PROPOSED METHODOLOGY

The proposed methodology of the system helps to measure, monitor, and display the TDS water quality parameter in both the input and output line of the water purifier along with the filtration status. The proposed method focuses on measurement and monitoring of water quality using smart sensing in-home water purifier which consists of RO filter, TDS sensor, TDS module, Arduino ATmega2560 and LCD. As shown in fig. 1, when water enters the input line, the TDS is measured by the sensor fixed at the input line and after filtration, the TDS of water is measured by the TDS sensor fixed at the output line. Both the measured input and output TDS values are converted into a suitable signal form for further processing, which is then amplified and given to the Arduino ATmega controller. The microcontroller which has been coded gives the input and output TDS values along with the filtration status through LCD.

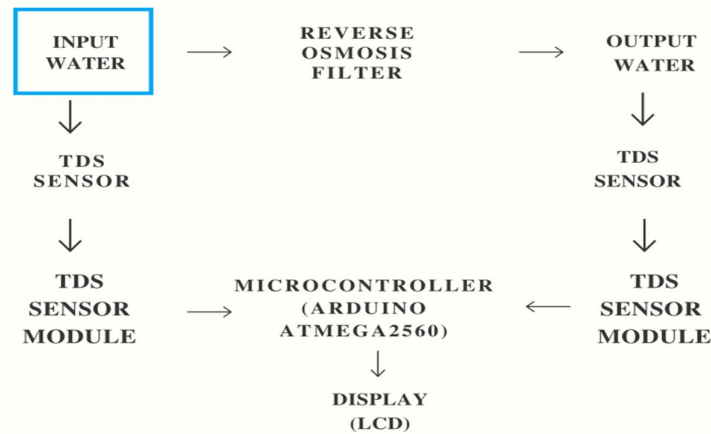


Figure 1. Block diagram of the proposed system

In the input and output line probes of the TDS sensors has been immersed. It has two electrodes (equally spaced) which are inserted into the water to measure conductivity. If the water contains no soluble materials and pure, the conductivity will be zero and therefore, the water will have a 0 ppm. In case, if the water contains dissolved materials, conductivity takes place, the resulting ppm will be proportional to the dissolved solids. All dissolved solids hold an electrical charge, which allows the conduction of charge movement between the electrodes. The result will be shown by the TDS meter (Sensor module) and converted into ppm. The TDS meter used is the gravity TDS meter V1.0. This is an Arduino supported TDS Meter Kit to measure the TDS and to project the cleanliness of water. It is applied to household water, hydroponic and other fields of water quality testing. From the TDS meter, the signal is interpreted by the microcontroller. The microcontroller used is the Arduino ATmega 2560. It can interact with the external world and has been utilized in a broad range of digital maker projects, requires more I/O lines, more memory, and more RAM. The Arduino Mega has been an inclusion to the Arduino class. The size of the board stands out to be bigger than every other board in the class and provides most importantly additional analog pins along with digital pins. The same board makes use of a distinct processor which contributes for a bigger size of program. The Arduino Mega works in the same way, the Arduino Uno does but, the difference is that it uses an ATmega2560 microcontroller and has a greater number of digital pins and analog pins. The microcontroller is coded in "C" for getting the input and output TDS values along with the filtration status.

The measuring and monitoring of the quality of water in both the input and output of the home water purifiers adds to the advantage of knowing the status or the quality of the filtration process. This filtration status display will alert the user about the quality of filtration inside the purifier which is in respect to the condition of the filter in the purifiers. Hence along with the water quality monitoring, filtration status monitoring, and knowing the condition of the filter inside the purifiers are also achieved through the proposed system. The filtration status is estimated using the following steps:

1. If the output TDS value is greater than 50% of the input TDS value, the filtration status will be displayed as 'Bad Filtration'.

2. If the output TDS value is less than or equal to 50% of the input TDS value, the Filtration status will be displayed as, 'Good Filtration'.

Finally, all this estimated input, output TDS parameters along with the filtration status are to be displayed in the LCD. For building real-life and real-world electronics-based projects, it needs a device to display the obtained values and to send messages. The LCD used is the 16×2 LCD Module which displays, 32 ASCII characters in 2 lines. Thus, the proposed methodology measures, monitors and displays the input, output quality in the water purifiers along with the filtration status.

IV. RESULTS AND DISCUSSION

The automatic measuring and monitoring of the input and output water quality had experimented successfully with domestic RO water purifiers. The TDS quality parameter of water is detected by the TDS sensor and the signal goes to the microcontroller and gives us the input and output TDS values along with the filtration status which is displayed using the LCD display.

The Table. I show the results of the proposed system. Both the input and output TDS values are commonly monitored measured and displayed in the home water purifiers irrespective of the condition of the filter. But the Filtration status differs concerning the condition of the filter and filtration process that happens inside the purifiers. The confusion matrix is shown in Table. II. The fig. 2 shows the LCD output for the bad filtration process. Fig. 3 shows the image of a bad filter. The fig. 4 shows the LCD output for the good filtration process. Fig. 5 shows the image of a good filter. Fig. 6 and fig. 7 gives the graphical representation of the input and output TDS values in Parts Per Million (PPM) with respect to time, respectively. The graph has been obtained with the help of the Canva Pro online tool. By fixing the system to existing purifiers of different conditions, the readings were taken, tabulated, and the graph has been plotted.

TABLE I. RESULTS OF THE PROPOSED SYSTEM

Input Tds Value	Output Tds Value	Predicted Filtration Status	Actual Filtration Status
216 PPM	4 PPM	GOOD	GOOD
251 PPM	168 PPM	BAD	BAD
441 PPM	45 PPM	GOOD	GOOD
357 PPM	196 PPM	BAD	BAD
472 PPM	89 PPM	GOOD	GOOD
386 PPM	72 PPM	GOOD	GOOD
354 PPM	350 PPM	BAD	BAD
230 PPM	87 PPM	GOOD	GOOD
532 PPM	160 PPM	GOOD	GOOD

TABLE II. CONFUSION MATRIX

ACTUAL VALUES →	GOOD (1)	BAD (0)
PREDICTED VALUES ↓		
GOOD (1)	6	0
BAD (0)	0	3



Figure 2. Output display for bad Filtration



Figure 3. Bad filter



Figure 4. Output display for good filtration



Figure 5. Good filter

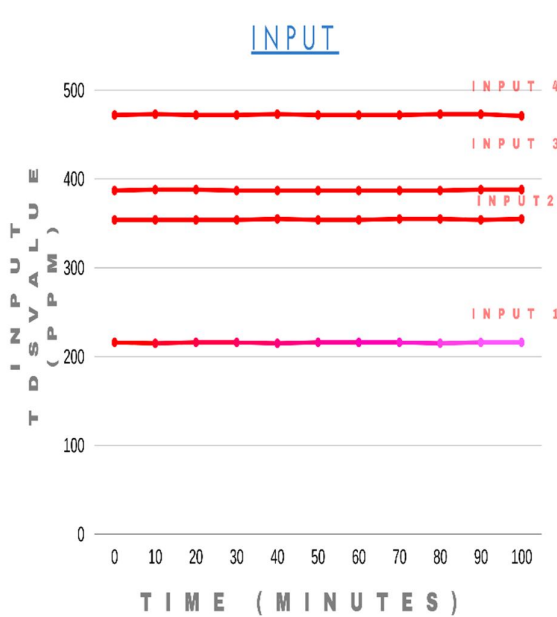


Figure 6. Input Water Quality (TDS)

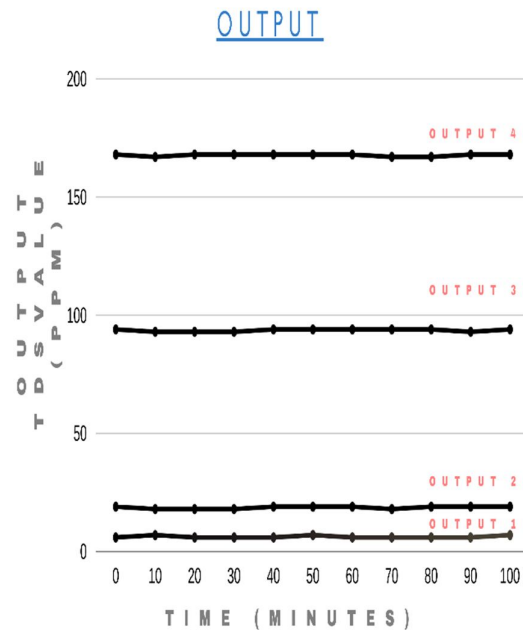


Figure 7. Output Water Quality (TDS)

V. CONCLUSION

Poor water quality has only negative impacts and must be treated quickly within certain limits. The present framework incorporates the utilization of manual recognition by individuals who are happy to donate to the development of the quality of water and ensuring safe human health. The model incorporates Arduino, which has an ease and high similarity with different interfaces, 2D vision-based methodology makes the system progressively moderate [8]. The framework recognizes the quality of water and filtration in time and classifies the filtration process as either good or bad and alerts user by displaying the filtration status along with the input and output TDS value through the LCD. Therefore, making the proposed prototype increasingly possible and beneficial. The system guarantees the reduction of health defects due to poor water quality or poor filtration of home water purifiers in the greater ratio by continuously intimating the input and output quality along with the filtration status. The future scope of the proposed system is to adapt the controller for water purification.

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