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An analysis of drinking water for arsenic contamination using a color sensor

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Abstract

One type of chemical element that can contaminate surface water and cause a variety of problems for humans is arsenic. Numerous studies are being conducted to identify the cause of waterborne arsenic poisoning and to provide a comprehensive picture of the problem. The majority of research is meant to be employed in lab settings. In addition to creating a technique, this research clarified a basic concept that might be used to quickly determine the arsenic content in water. The approach was developed using a basic colour sensor and a modern arsenic detection kit. To ascertain the percentage of water tainted with arsenic, samples were gathered from multiple sites inside Khulna, Bangladesh. To validate the system, data analysis and recording were employed.

Keywords: arsenic detection kit; color sensors; percentage of arsenic; rural people

Introduction

Most of the time arsenic is found in ground water, especially in some pointed countries including Bangladesh, Argentina, China, Chile, India, Mexico and United States of America. According to World Health Organization (WHO) around 140 million people of almost 50 countries are drinking arsenic contaminated water [1][2]. Now-a-days the rural people of this countries (Especially Bangladesh) are suffering for safe water and also having problem to solve this problem with advance method. Arsenic is mainly found in the ground water in the form of dissolved As2O3. It is highly toxic in inorganic form. People can be exposed to highly toxicity through drinking arsenic contaminated water, using contaminated water in making food, washing dishes, irrigating and watering the food crops and also smoking tobacco [3]. But the main problem is the water which defines no alternative using because water is life and human must drink water for body tissue. By drinking long term arsenic contaminated water one can get not only chronic diseases but also skin cancer and skin lesions [4]. Mainly inorganic arsenic which is found in water is too much harmful for body. Arsenic contaminated water is colorless, odorless and tasteless. That's why people of rural areas found nothing but a simple water for their daily life and at the end of the day poison rises at its best, people get sick and further person die for having skin cancer or other diseases [2][3][5]. The WHO and the United States Environmental

Protection Agency (EPA) both have declared the maximum range of
arsenic contaminated water is 10 parts per billion(ppb), but it varies to 50 parts per billion(ppb) in some countries [6]. Main challenge in this condition is to develop a solution that will detect the arsenic level in the easiest way, the rate of percentage will be able to aware the rural uneducated people and also the cost will be minimum [7]. Now a days the most popular solution is to use the Arsenic Detection Kit. But for the field work it is complex as it contains many chemical reagents and also it depends on the visualization of the user [1][8][9]. That's why it varies from operator to operator [3][10]. For this detection process one must have the knowledge of working with this kit and must do it in laboratory. Without education it is impossible to use this kit [11]. Though the cost is limited and time needed for detection is low, but for rural people it is not the easiest way. Another process is to use the electrochemical arsenic electrode which is complex in implantation and costly [6]. Both of the process is not suitable for our desired output. So that, a system was found that is simple and well enough to detect arsenic in a short time limit. It will aware the rural people whether it is by displaying the percentage of arsenic or by making audio sound that will reflect the observer what is the percentage of arsenic. Is it in safe level or not will be deliverd.

II. METHODS AND MATERIALS

A. Procedure

In most cases, found that the contamination of arsenic in water rises due to geochemical soil leaching (reductive dissolution or desorption) brought about by excessive ground water withdrawal [10]. The arsenic in water is colorless and can not be found without any chemical mechanism. For that reason, researchers have been using different techniques like: Electrochemical electrodes, photo system and different types of chemical reagents. At present different types of spectrophotometry has been used to measure the arsenic, using toluidine blue or safranin O, leuco malachite green, methyle orange etc [8][12]. In china silver salt & arsenic spot methods are primary methods to detect arsenic.
Most challenge now-a-days is the process simplicity of the detection with a compact device that will come in low cost [13]. The research works for detecting arsenic are complex and those are not suitable for the rural area's uneducated people. In this work, an idea has been delivered that can detect arsenic contamination in water easily by using arsenic detection kit and color sensor.

A basic chemical reaction was used for this work. Color intensity of different percentage of contamination that was seen using traditional arsenic detection kit was captured by RGB color sensor and stored in microcontroller. These data were used as ideal value for the measurement. After that, some sample of water from different region of Khulna division, Bangladesh, were collected and tested using arsenic detection kit. Each sample of water describes different color intensity of the given strips. Color intensity again was captured using same RGB color sensor and then intensity was compared between the ideal value. Microcontoller automatically matched the color intensity of arsenic contamination of sample water with the ideal value and reflected the percentage of arsenic contamination of that specific sample water. 4 sample of water were used to verify this system.

B. Color Sensors

In this present world there are different color sensing system because of upgradation of modern science. For example: We can use our cell phone cameras to detect the colors of the object or we

can develop a color sensor or can use the upgraded color sensors [6][8][14]. One of the most popular systems among them is the RGB Color sensor. It is the color representation in 3-dimension space. Here 3 axis represents three colors Red, Green, Blue [8].
One can measure the intensity of the object [14]. The color sensors illuminate a sample using in-built red, green, blue color LEDs to create a light that will hit the surface of the measured object and the light will be reflected by the object [15][16]. The light reflected by the object is proportional to the voltage and this is used to determine the different contents of Red, Green and Blue [12][14]. We can find different contents of Red, Green, Blue for different other colors like: Orange, Purple etc. By combining these 3 contents of Red, Green and Blue we can distinguish between different colors [8]. Different colors of different percentage contamination of arsenic in water were measured [6]. It was easy to distinguish that colors of different percentages and will be able to give the different contents of Red, Green and Blue. For this research a simple color sensor model is SEN-00139(Fig 2) was used. A hand made cover was used to find the data accurate. The inside of the box was full black so that the proper RGB values can be found.

C. Arsenic Detection Kit

Arsenic detection kit mainly contains number of chemical reagents [11] and testing pads that help to define the color of arsenic contamination percentages (Fig 2). Basic principle of this arsenic kit is by using zinc and hydrochloric acid we can form arsenic oxide (As2O3) to inorganic arsenic gas [11]. The produced arsenic gas (AsH3) will react with the test paper containing mercuric bromide to form the mixed arsenic/mercury halogenides [6][11]. This will produce colors of different intensities and different percentages of arsenic contamination. This test kit may differ by names of different
companies. But the working principle is same and it is proven that the accuracy of this test kit is good enough [2]. Arsenic detection kit contains complexity, hazards and difficulties using hydrochloric acid [6][11].

D. Block Diagram

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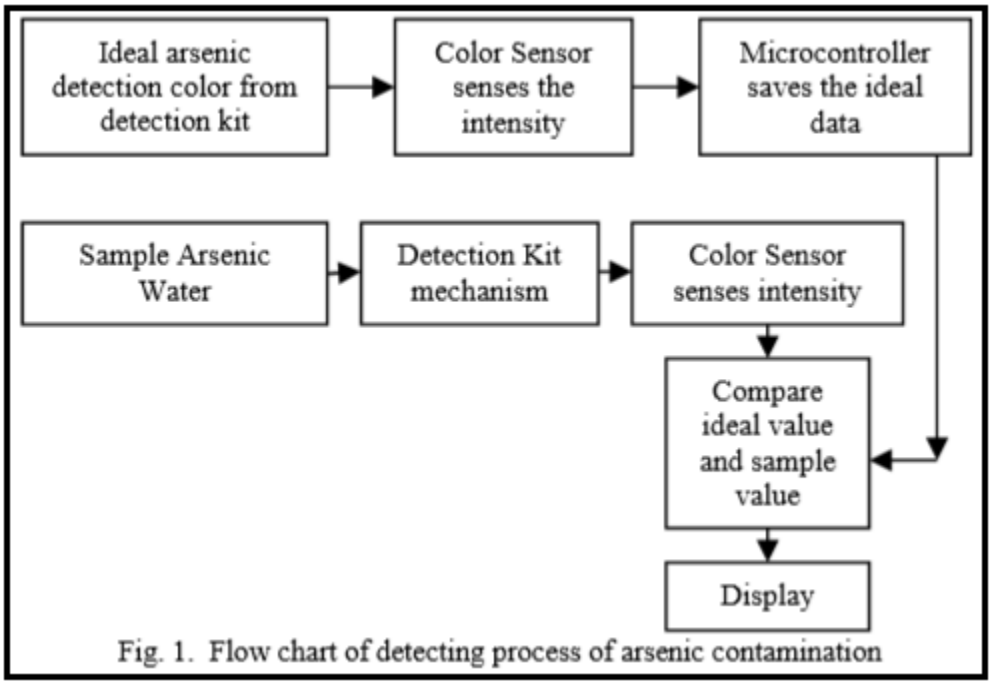

Fig. 1. Flow chart of detecting process of arsenic contamination

As described before, color sensor will detect the color intensity and will compare the values with the stored ideal values. After comparing, it will produce the percentage into the display.

III. RESULTS AND DISCUSSIONS

Different gray levels were obtained from different arsenic percentage colorimetric analysis. From the starting we calibrated the sensor and fixed the gray level for black and white color. Measuring the fixed color for the different percentages were obtained from the kit box and then we stored the data. We recorded the each and every percentage's gray level content that are given on below table. We recorded one data in the interval of 20 seconds for 5 minutes. We obtain the maximum and minimum of each color component (Red, Green, Blue). After that, calculated the mean value of the gray level for each color component.

We found each and every percentage of arsenic contamination contains different color components. Which reflects, we can easily differentiate the percentages of arsenic. Calibrated color component was for white red 221, green 221, blue 221 and for black red 29, green 29, blue 31. Table II shows that if arsenic is beyond 0.5 mg/L the red component becomes 122-124, green component becomes 110-109, blue component becomes 188.

TABLE I. CALIBRATED COLOR COMPONENT

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SL. No	Color	Red Component	Green Component	Blue Component
1.	White	221	221	221
2.	Black	29	29	31

For 0.1 mg/L of arsenic contamination the red component becomes 178-177, green component becomes 156-155, blue component becomes 85-88. For 0.05 mg/L of arsenic contamination the red component becomes 198, green component becomes 179-180, blue component becomes 99.

TABLE II. COLOR COMPONENTS OF ARSENIC PERCENTAGES

SL. No	% [mg/L]	Color	Red	Green	Blue
1.	0.5		Max= 124 Min= 122 Mean= 123	Max= 110 Min= 109 Mean=109.5	Max= 188 Min= 188 Mean=188
2.	0.1		Max= 178 Min= 177 Mean=177.5	Max= 156 Min= 154 Mean= 153	Max= 85 Min= 88 Mean=86.5
3.	0.05		Max= 198 Min= 198 Mean= 198	Max= 180 Min= 179 Mean= 179.5	Max= 99 Min= 99 Mean= 99
4.	0.025		Max= 168 Min= 168 Mean= 168	Max= 183 Min= 183 Mean= 183	Max= 132 Min= 132 Mean= 132
5.	0.01		Max= 172 Min= 172 Mean= 172	Max= 184 Min= 183 Mean= 183.5	Max= 152 Min= 151 Mean=151. 5

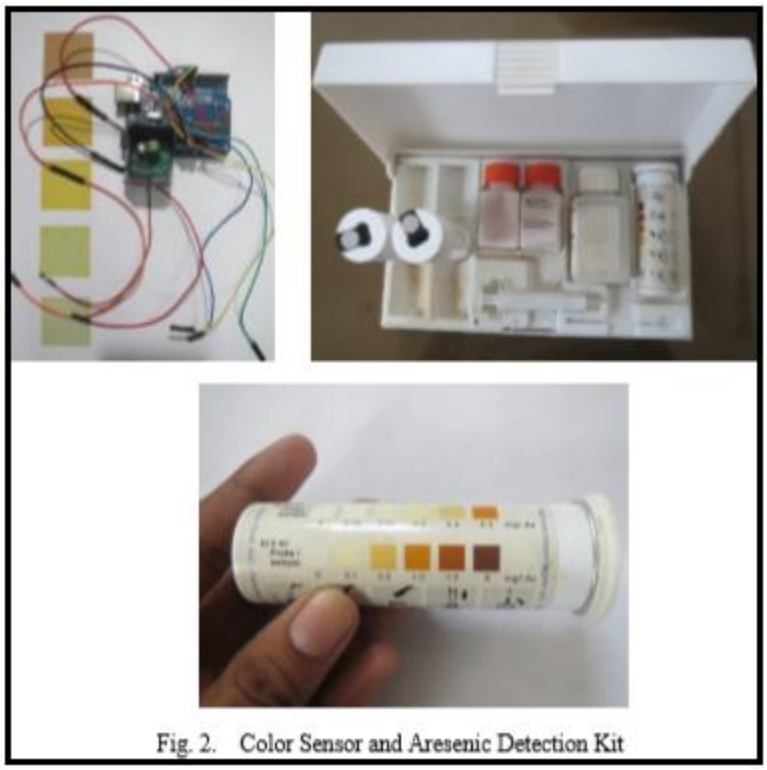

Fig. 2. Color Sensor and Aresenic Detection Kit

For 0.025 mg/L of arsenic containation the red component becomes 168, green component becomes 183, blue component becomes 132. For 0.01 mg/L of arsenic contamination the red component becomes 172, green component becomes 184-183, blue component becomes 151-152.

These data were recorded to microcontroller and by matching with the input components, we found the percentages of arsenic easily from any sample of water. Different types of color sensors can be used to determine the color components and different calibrated results can be used. At the end we collected some sample water from different regions of khulna, Bangladesh and tested with arsenic kit and found that the results from the recorded data were almost similar to the sample tested water's arsenic percentage (Fig 3).

TABLE III. ARSENIC DETECTION FROM SAMPLE WATER

SL. No	Red	Green	Blue	Comment % [mg/L]
1.	120	111	190	0.5% of arsenic. Very Dangerous
2.	166	188	129	0.025% of arsenic. Safe
3.	170	182	134	0.025% of arsenic. Safe
4.	176	188	159	0.01% of arsenic. Safe

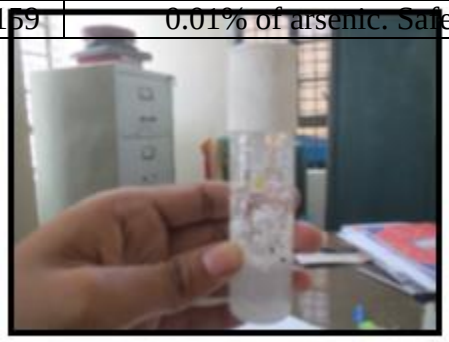

Fig. 3. Sample Water Testing

It has been defined that arsenic detection is an important process which has to be specific. Because of chemical complexity and operator's visual assumptional dependency, the process is becoming tough for the rural people as well as normal people. But the problem has to be stopped. We found that color sensor can be used to develop a system that can easily be used to find arsenic percentage. This research was developed to find a technique that can solve both the chemical complexity and assumptional dependency.

IV. CONCLUSION

Arsenic detection kit can easily measure the percentage of arsenic. But chemical complexity is problematic. Another problem, this process fully depends on the observer's vision. So, we have been developed and found a solution that might not contain any observer visual dependency and complexity of chemicals. Mostly, it is safe and hazard free. We can use a color sensor to find out the color components and it will match the input components with the recorded version. It will match the input and will find the real percentage without no complexity. Result reflects that different arsenic contamination produces different intensities of color. So, it is very easy to distinguish between different percentage with this system. It can be used to design a arsenic detection machine and may help to find the percentage with little or no complexity. Most importantly rural people can use it easily.

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