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Development of an Anthocyanin-Based RGB Colorimetric Sensing System for Water Quality Assessment and Heavy Metal Detection

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***Abstract*— Heavy metal contamination in water is a serious issue for both the environment and public health. It has harmful effects on people and ecosystems. Traditional detection methods can be costly, slow, and require complex lab equipment. This project introduces an affordable and user-friendly way to initially screen for heavy metal contamination in water. It uses hibiscus extract as a natural indicator and RGB-based color analysis. Hibiscus extract changes color when it comes into contact with contaminated water samples. A smartphone camera captures these color changes, and RGB (Red, Green, and Blue) values are extracted for analysis. These RGB values are then compared to reference values to identify potential contamination. This method is eco-friendly, easy to use, and suitable for basic water quality monitoring. The results show that RGB analysis can effectively measure visual color changes, providing a practical way to detect heavy metals.**

***Index Terms*—Anthocyanin, Colorimetric sensing, RGB analysis, Water quality, Heavy metal detection.**

I. Introduction

Heavy metal contamination in water is a major environmental and public health concern. Toxic metals like lead, mercury, cadmium, and chromium can enter water sources through industrial waste, agricultural activities, and other human actions. While traditional detection methods are reliable, they tend to be costly and need specialized lab equipment. This project uses RGB color analysis to detect changes in color caused by heavy metals in water. The method offers a simple, low-cost, and environmentally friendly way to monitor preliminary water quality and contamination.

II. Procedure

Water samples were collected from the chosen source and stored in clean containers to prevent contamination.

A hibiscus strip or solution was prepared and added to the water samples. The heavy metal ions reacted with the hibiscus strip or solution and caused a visible color change.

The samples were left to react for a specific time to ensure complete color development.

Images of the reacted samples were taken using a smartphone or camera in consistent lighting to keep color measurements uniform.

The captured images were processed, and RGB (Red, Green, and Blue) color values were extracted from the selected area.

These RGB values were analyzed and compared to those of uncontaminated reference samples.

Differences in RGB intensity helped to identify the presence of heavy metal contamination and assess the extent of color change.

The results were recorded, analyzed, and interpreted to evaluate the effectiveness of RGB color analysis as a preliminary method for detecting heavy metals.

A. Experiment Materials Used

- Hibiscus flower petals
- Water samples
- Distilled water
- Glass or plastic containers
- Smartphone camera

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• RGB color analysis software/application

III. Experimental Principle

The system detects color changes in hibiscus extract when exposed to water samples. RGB image analysis quantifies these changes to indicate possible heavy metal contamination.

A. Natural Indicator-Based Detection

This experiment uses hibiscus extract as a natural indicator for monitoring water quality. The petals contain natural pigments called anthocyanin, which give them their red color. These pigments react to changes in the chemical composition of the water, causing noticeable shifts in color under different conditions.

B. Interaction with Water Samples

When hibiscus extract is added to water samples, the pigments come into contact with the dissolved substances in the water. If heavy metal contaminants are present, the chemical makeup of the extract can change, resulting in a visible shift in color intensity or shade. These changes help indicate possible contamination and are central to the detection process.

C. RGB Color Analysis (Characterization Study)

The color variations from the experiment are photographed with a smartphone camera. The images are then analyzed using RGB (Red, Green, and Blue) color analysis. This method converts the detected colors into numerical values that reflect the intensity of the red, green, and blue components. Any significant changes in these values, when compared to reference samples, suggest differences in water quality.

D. Detection and Interpretation

The RGB values obtained are compared with those of uncontaminated samples. Changes in RGB intensity offer a straightforward way to identify potential heavy metal contamination. This method allows for preliminary screening of water samples without needing costly lab instruments, making it economical and suitable for basic environmental monitoring.

IV. Results and Discussion

The experiment utilizes the color-changing properties of hibiscus extract and RGB image analysis for preliminary heavy metal detection in water samples.

A. Observed Results

The water samples displayed visible color changes after reacting with the hibiscus extract. These changes were recorded and analyzed using RGB color analysis.

B. Discussion

Differences in RGB values were noted between the reference and test samples. The findings suggest that RGB analysis can reliably detect color changes and serve as a simple, low-cost method for initial screening of heavy metal contamination.

TABLE I: RGB Values of Reference and Contaminated Samples

Sample	R	G	B
Reference Sample	147.5	118	90
Contaminated Sample	127	115	89

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Fig. 1. [caption not provided in the source manuscript]

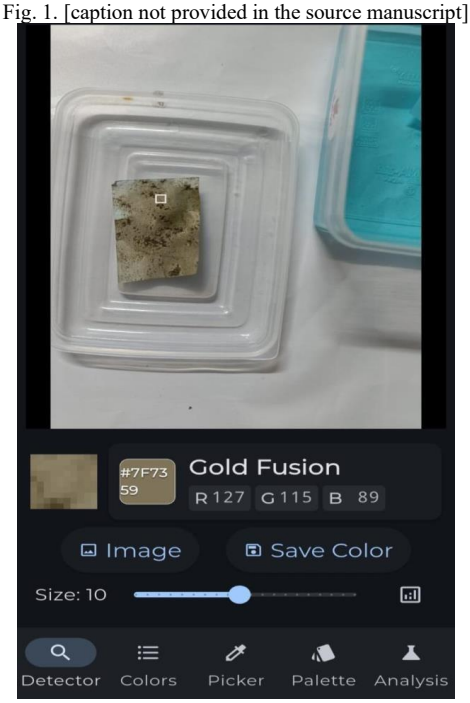

Fig. 2. [caption not provided in the source manuscript]

V. Conclusion

This project showcased a straightforward and affordable way to detect possible heavy metal contamination in water using hibiscus extract and RGB color analysis. The identified color changes were effectively converted into measurable RGB values, allowing for preliminary evaluations of water quality. The method is eco-friendly, easy to implement, and well-suited for basic environmental monitoring.

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