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Real Time Heavy Metal Detection Using An IOT Device

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Abstract : Heavy metal pollution in water is a big problem for the environment that affects cities all over the world. Industrial waste, untreated sewage, and chemical runoff all add heavy metals like copper, iron, lead, and mercury to water sources. A global water quality study shows that industrial runoff can cause up to 70% of the heavy metal pollution in cities. Water pollution levels in cities like Mumbai often go above safe levels for the environment, which puts public health and aquatic ecosystems at great risk. Monitoring heavy metal contamination in real time remains difficult due to a lack of low-cost, scalable technologies. The device was made to find heavy metals in water bodies in real time. It is a low-cost and new option for environmental groups and policymakers who work on water quality management. The fact that it can quickly look at and respond to problems with contaminated water makes efforts to lower the risks to public health and the environment from heavy metal contamination even better.

***IndexTerms* - Water Pollution, Heavy metals, Mumbai, IoT device.**

1. INTRODUCTION

Heavy metals in water have become a major environmental issue that affects cities all over the world. Water bodies that have toxic metals like copper, iron, lead, and mercury in them are very bad for people's health, the environment, and the economy. Industrial waste, untreated sewage, mining, and agricultural runoff are the main things that cause this pollution. In cities, where the population is very high, the effects of this kind of pollution are worse because there are more factories and not enough places to deal with trash. Heavy metals in water bodies are a unique environmental problem because they stay in the environment for a long time, are toxic, and tend to build up in living things. Heavy metals are permanent in the environment and recycle through ecosystems, building up in biological populations. Organic toxins, on the other hand, break down over time. All of these things hurt the environment and have long-term health effects, like brain damage, organ damage, slower growth in children, and even cancer.

Urban water bodies are especially at risk because they get a lot of industrial and household waste dumped into them. The situation gets worse when wastewater treatment plants don't work properly, which raises the levels of pollution in rivers, lakes, and reservoirs. Monitoring and managing heavy metal pollution requires accurate detection and detailed mapping of contaminated areas, which is still a big problem. Even though environmental monitoring technologies are getting better, most of the time, heavy metal detection methods are still based on lab analysis. These take a lot of time and money, and they aren't practical for large-scale environmental monitoring. So, there is a huge need for low-cost, real-time detection systems that can directly measure water quality on-site (Abrajano et al., 2024). This problem needs new technologies that are accurate, easy to move, and able to grow.

It is a big step in the right direction to make a portable handheld device that can find and measure heavy metals in water samples. The device can do real-time, on-field analysis and make detailed pollution heatmaps by combining advanced sensor technologies with data mapping capabilities (Pujar et al., 2019). The answer is to make and use a portable device that can detect heavy metals outside of a lab. The device uses advanced sensors to find out how much toxic metal is in water samples, giving both qualitative and quantitative data.

By using a geographic information system (GIS), it is possible to map contamination levels in real time, which helps with environmental monitoring and making decisions.

2. RESEARCH METHODOLOGY

2.1 Prototyping the device

The gadget makes use of test strips and a colour sensor. The presence or lack of particular heavy metals causes the test strips to change colour when submerged in the water sample. An algorithm compares the colour of the strips, as determined by the colour sensor, to the corresponding concentration of the metals. The data is then shown on the LED screen, giving users instantaneous and straightforward results. The method's high accuracy and speedy results make it ideal for testing water quality (Gumpu et al., 2015).

Fig 1: Image of the Prototype

2.2 Working principle of the Device

The gadget makes use of test strips and a colour sensor. When the test strips are immersed in the water sample, the presence or absence of specific heavy metals causes them to change colour. After the colour sensor reads the colour of the strips, an algorithm compares it to the metals' corresponding concentration (Steccanella et al., 2021). After that, the data is displayed on the LED screen, providing users with quick and simple outcomes. The technique works well for testing the quality of water because it is highly accurate and produces results quickly.

2.3 Testing the Device

We took two samples of water: one from a pond close to our school and one from the Arabian Sea. The amount of iron, copper, lead, and mercury in each of them was then measured using the sensor. We then sent the same samples to Mumbai's NABL-certified labs so they could obtain their test results as well. The primary goal was to assess our sensor's performance. We contrasted the data from the laboratory tests for both water sources with the data from our sensor. This made it easier for us to verify that the device was producing results that were accurate.

3. RESULTS AND DISCUSSION

The TCS34725 Color Sensor is a small module that helps measure colors by giving values for red, green, blue (RGB), and brightness. It has something called an IR blocking filter, which helps block out some infrared light (Moparthi et al., 2018). This is good because IR light can mess with how we see color, so blocking it makes the readings more accurate. The sensor is very sensitive and can work properly in lots of different lighting. It still works even if the light is dim or if the object is behind something dark like tinted glass. One of the reasons for this is the sensor's huge dynamic range, it's 3,800,000 to 1, which means it can handle both very bright and very dark situations. Also, you can change some settings like how long it looks at the color and how much it amplifies the signal, which helps it stay consistent in different lights.

The sensor tries to measure color in a way that is close to how our eyes see it, because of the IR filter. After we took readings using this sensor on two water samples, we compared them to lab test results. The results matched closely, which showed that the sensor was actually accurate even when used in a test involving heavy metal content in water.

Table 1. Comparative analysis of heavy metals in water samples collected from Arabian Sea and Local Pond

Sample Source	Heavy Metals	Device Result (mg/L)	Lab Result (mg/L)	Observation
Arabian Sea	Lead	Not detected	Not detected	Consistent with lab results
	Mercury	Not detected	Not detected	Consistent with lab results
	Copper	0.035	0.04	Minor variation, within acceptable range
	Iron	0.17	0.16	Minor variation, within acceptable range
Local Pond	Lead	Not detected	Not detected	Consistent with lab results
	Mercury	Not detected	Not detected	Consistent with lab results
	Copper	0.02	0.03	Minor variation, within acceptable range
	Iron	0.18	0.19	Minor variation, within acceptable range

The device's results were very close to the lab values, especially for copper and iron. There wasn't a big difference for lead and mercury either, which made the results more reliable. This proved that the device can really check water on the spot and doesn't cost too much. You can still do a lot more with it. We could make the sensor better at finding very small amounts of metals, especially lead and mercury, which are harder to find, by making some changes and maybe working on the software a little more. With more changes, it might even be able to be used in more kinds of water, like rivers, wells, or even sewage. One idea for the future is to add more things to the device that it can test for, such as cadmium or arsenic. It would also be helpful if it could send its results directly to phones or the cloud over Bluetooth or Wi-Fi. That would make it easier to use in places where quick reporting is important.

It could be made in larger quantities for use in factories, water treatment plants, or by groups working to protect the environment. People who just want to check if their drinking water is safe might even use it at home if it were made easier to use and understand. This type of sensor could also be very helpful in places where labs can't test water. It could help a lot with stopping water pollution problems in many parts of the world if it works well and keeps getting better.

4. CONCLUSION

Overall, the device that is made is a very good way to keep an eye on water quality in real time that is also cheap. One sign that it is valid is that it can accurately measure heavy metals like iron and copper and agree with lab results. The device is useful for many things, from testing the environment to making sure your home's water is safe, because it is easy to use and carry around. In the future, it could work better and do more if it had more sensitivity, better algorithms, and better connectivity (Huang et al., 2024). As this product gets better, it could help fight global water pollution problems and make safer water resources available to people all over the world.

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