AN INTERNET-OF-THINGS (IOT) SUSTAINABLE WATER FILTERING AND MONITORING SYSTEM USING BIG DATA ANALYSIS AND CLEAN ENERGY

Kaining Yuan[1], Jonathan Sahagun[2]

[1]Woodbridge High School, 2 Meadowbrook, Irvine, CA 92604
[2]Computer Science Department, California State Polytechnic University, Pomona, CA 91768

ABSTRACT

Microplastic contamination in freshwater ecosystems is a growing environmental concern. This paper introduces MyRiiver, a solar-powered microplastic filtration system, designed to overcome limitations in current methods. The background underscores the urgency of addressing microplastic pollution, emphasizing the need for an efficient, adaptable, and economical solution. MyRiiver employs a sophisticated multi-layered filtration system without requiring pre-treatment, offering advantages over existing methodologies. Challenges identified in previous approaches, such as electrode wear and biofilter maintenance, are addressed through the simplicity of MyRiiver's design. Experimental trials showcase its adaptability and superior efficiency in filtering microplastics as small as 1 µm. Results demonstrate a significant removal rate, positioning MyRiiver as a practical, scalable, and eco-friendly solution. The study concludes by asserting MyRiiver's potential as a transformative tool for combating the escalating global issue of microplastic contamination in freshwater environments.

KEYWORDS

Water Filter System, IOS, Android, Microplastics, Flutter

1. INTRODUCTION

Microplastics, defined as plastic particles measuring less than 5 millimeters, manifest as a consequence of both intentionally manufactured small plastic components and the gradual breakdown of larger plastic objects. Despite the undeniable societal benefits derived from plastic use, it is imperative to acknowledge the myriad challenges associated with it.

Extensive research underscores the widespread presence of microplastics in the marine ecosystem, reaching polar regions and the deep ocean [1]. Globally, our oceans harbor an estimated 5.25 trillion plastic particles, collectively weighing nearly 269,000 tons [2]. The ingestion of microplastics has been observed across a diverse array of marine species, although comprehensive studies on their biological impacts remain limited. Notably, a significant proportion of marine microplastics is thought to originate from terrestrial sources, including surface waters.

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Mitigating the entry of microplastics into the marine ecosystem might be achieved by addressing their presence in freshwater ecosystems. This proactive approach could potentially curb the progression of microplastics from terrestrial to marine environments. Microplastics pose physical threats to both humans and living organisms, with entanglement and ingestion as prominent mechanisms. These minute plastic particles also function as carriers for various toxins, encompassing additives from industrial processes and enduring environmental contaminants absorbed from aquatic surroundings. The accumulation of these toxins in fish species, for instance, leads to issues such as intestinal damage and metabolic profile alterations [3].

While the issues associated with microplastics may not appear immediately urgent, global authorities are increasingly imposing limitations on plastic use. Despite the absence of an imminent apocalyptic environmental outcome, the continuous production and decomposition of plastics into microplastics raise concerns. The inadvertent ingestion of these particles becomes progressively inevitable for both humans and animals. Preventing the gradual buildup of microplastics and averting potential disastrous pollution necessitates their proactive removal from bodies of water. It is crucial to address this issue promptly to safeguard the long-term health of ecosystems and mitigate the cumulative impact of microplastics on both environmental and human well-being.

The first methodology by Sembiring et al. tests the rapid sand filter's effectiveness in removing microplastics. Their approach, while successful for larger microplastics (>200 μm), requires pre-treatment processes and exhibits lower efficacy for smaller particles. MyRiiver, in contrast, eliminates the need for pre-treatment and addresses this limitation by efficiently filtering microplastics as small as 1 μm, showcasing improved versatility.

Elkhatib et al. explore electrocoagulation for microplastic removal. While effective (90%-99%), this method demands regular electrode maintenance and has a short lifespan due to wear and tear. MyRiiver addresses these shortcomings by utilizing a simple filtration system with terracotta components, reducing maintenance complexity and ensuring prolonged functionality.

Liu et al. employ a biofilter to reduce microplastics in wastewater by 79%-89%. Despite its effectiveness, biofilters require substantial surface area and periodic material replacement. MyRiiver, with its compact design, provides a practical alternative, balancing efficiency while minimizing space requirements and maintenance concerns.

Our innovative solution introduces a self-operative solar-powered microplastic filtration system, featuring a cellular device that seamlessly transmits real-time water quality data to our dedicated application through scientific sensors. Designed for deployment in rivers or lakes, this cutting-edge microplastic filter employs a multi-layered filtration approach, encompassing rock, coarse sand, fine sand, and fabric filters. The intricate design ensures the efficient entrapment of microplastic particles within its layers during the filtration process.

The filtration system is strategically positioned on a platform supported by robust stainless steel cables, with a connecting tube facilitating the extraction of contaminated water via a submersible pump. A terracotta vessel serves as the filtration component, featuring a drainage orifice at its base for the discharge of filtered water back into the water body while retaining microplastics and other particulate waste.

Beyond the filtration mechanism, our setup incorporates a Total Dissolved Solids (TDS) sensor and a temperature sensor. These sensors are seamlessly integrated with a compact cellular device, enabling the transmission of data to our dedicated app database through cellular connectivity. The cellular device is further equipped with a lithium battery to power electronic components, complemented by two solar panels—one dedicated to powering the water pump and the other for recharging the battery.

Compared to alternative solutions such as regulating plastic production, wastewater treatment, and bioengineering, our method stands out as a more practical and cost-effective approach. Government restrictions and individual awareness associated with regulating plastic production may prove impractical, while wastewater treatment involves significant financial investment. Similarly, bioengineering demands specialized scientific equipment and laboratories. In contrast, our method relies on simple logic and equipment for microplastic removal, presenting a scalable and cost-effective solution with the potential for widespread application across various water bodies.

Experiment A investigated MyRiiver's microplastic filtration efficiency, testing the system's effectiveness under various initial microplastic amounts. With 5 grams as the baseline, the experiment revealed a 5% removal rate, implying a potential need for system optimization. Experiment B focused on sunlight's impact on MyRiiver, aiming to discern the correlation between sunlight exposure and microplastic filtration. Conducted under varying sunlight intensities, the results showed a notable sensitivity to light conditions, with 16% removal in high sunlight, 4% in moderate sunlight, and 10% in low sunlight. Surprisingly, low sunlight resulted in a higher removal rate than moderate sunlight, suggesting intricate interactions between light quality, temperature, and filtration efficiency. These experiments collectively emphasize the need for fine-tuning MyRiiver's design and operational parameters to ensure consistent and optimal performance across diverse environmental scenarios.

2. Challenges

In order to build the project, a few challenges have been identified as follows.

2.1. Selection of Materials

A key hurdle in advancing this filtration system centers on the critical selection of materials. The project's overarching goal of alleviating microplastic pollution in freshwater ecosystems demands a strategic approach to minimize reliance on plastic-based materials. This emphasis is crucial to ensure alignment with the project's fundamental intentions. Excessive use of plastic components in our material choices poses a direct contradiction to the project's purpose. The risk lies in the potential gradual degradation of these plastics, leading to the generation of microplastic particulates that could inadvertently infiltrate freshwater environments—precisely the opposite of our intended outcome.

The significance of material selection for this filtration system cannot be overstated, given its direct implications for the project's overall efficacy. Opting for pre-fabricated microplastic filters proves impractical, as they often come with prohibitive costs, running counter to the cost-effective objective intrinsic to this project. Consequently, our approach entails the development of a customized, economically efficient filtration system crafted from non-plastic materials. Terracotta emerges as a promising choice, being both environmentally friendly and cost-effective, offering a viable solution to address the challenge at hand.

2.2. Data Transmission

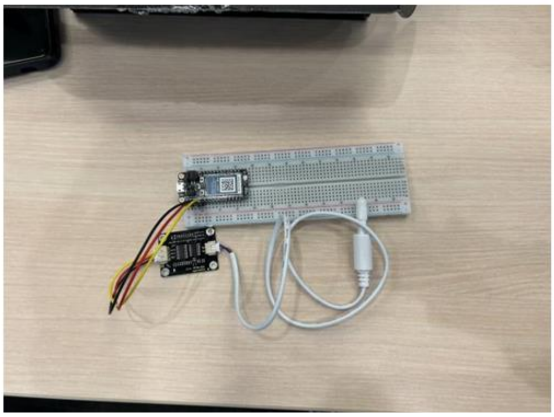

Figure 1. Picture of sensor

In the realm of data collection and transmission, numerous considerations come into play, including establishing a seamless connection between the database and the app for user-friendly data viewing. However, the focal challenge lies in implementing data transmission to our cellular device, as depicted above. A pivotal aspect is determining the data source. For this project, the Total Dissolved Solids (TDS) sensor (white sensor shown) serves as the optimal choice, measuring dissolved solids in water in parts per million, offering comprehensive contaminant analysis. Complemented by a temperature sensor for enhanced accuracy, the cellular device translates sensor data into human-readable values before transmitting them to Firebase. The app then displays the processed data retrieved from Firebase, ensuring a coherent and accessible presentation.

2.3. Maintaining the Confidentiality of User Information

Ensuring the exclusive association of each device with its respective user is crucial to safeguarding privacy and preventing data crossover between users. This challenge is pivotal in maintaining the confidentiality of user information. In the scenario of mass-producing the microplastic filter device, each unit is assigned a unique ID stored in the Firebase database. Initially ownerless, these IDs only acquire user association during registration. Users input the device ID during registration, streamlining the process for both users and administrators. The application then records the user's ID under the corresponding device ID in the Firebase database, establishing clear ownership. This meticulous procedure guarantees the protection of each user's device and data, averting any inadvertent exposure to unauthorized individuals.

3. SOLUTION

The structure of this project is made up of 3 main components: the hardware, the microplastic filter, and the application. The hardware contains all the electronics of the project and a stand to support the container which upholds all the parts of this project. The support stand is made out of four steel cables that can directly poke through the dirt layer of the river and the cables are tied with horizontal beams made out of fiberglass for the reason that it’s flexible and tough; these beams would make sure the stand won’t shake and fall down. A white container is fixed on top of the support stand where it contains all the important parts of the project. When the device starts running, the water pump that’s powered by a 12V solar panel will start pumping up water directly to the filter through an eco-friendly silicon tube [14]. While the two sensors constantly measure the water and extract data from it.The filter part is a filtration system that will remove microplastics from water effectively. The contaminated water will first go through the top of the filter, passing through the filter layers, leaving the harmful substances behind, and cleaned water will flow back to the river through a drainage hole. The solar panel will stop when the sun goes down, which means the pump will stop working at night. The cellular device, which is a microcontroller capable of data transmission to the database, is powered by another solar panel that is smaller and 6V. There is a temperature sensor and a TDS sensor that measures the water in which is also powered by the sun. The microcontroller will translate the data into numbers that will be transmitted to the database [15]. To view the data, first login on the application, and then register the device. It will then show the data.

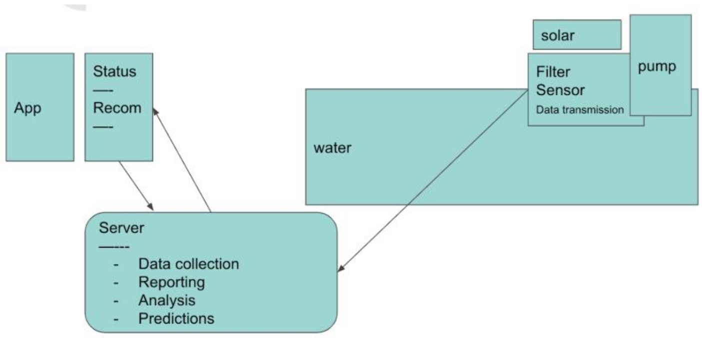

Figure 2. Overview of the solution

The electronics component is responsible for all the controls of this device. It includes a pump that will pump up the water and two scientific sensors that will measure the water and send back data to the microcontroller. Instead of directly measuring total dissolved solids, the TDS sensor measures the conductivity of substances dissolved in water. The higher the conductivity, the more dissolved solids are likely to exist. In bodies of water, like rivers, higher levels of total dissolved solids often harm aquatic species. The TDS changes the mineral content of the water, which is important to survival of many animals. A low TDS reading can help prevent maintenance issues, skin irritation, and algal blooms [11]. To achieve this, a TDS meter emits a small, harmless electrical current through the water. It tracks how well this electricity is conducted and converts that into an indirect TDS measurement. As expected, temperature compensation is required for TDS detection, which means that the water temperature may affect the detected TDS. So, a temperature sensor would provide a significant part of the final TDS value, not only that, it also helps display the temperature data on the application, and provides an idea of how the temperature of river water could change over time. The microcontroller, Boron, is a powerful LTE Cat M1 enabled development kit that supports cellular networks and Bluetooth LE (BLE). It is based on the Nordic nRF52840 and has built-in battery charging circuitry so it's easy to connect a Li-Po and incorporate it into our project. It is the brain of the whole system; it translates the data from the sensors to numbers that we can read and transmits them to the database. These electronics are powered by two solar panels. The support stand holds all the parts: the electronics and the microplastic filter, are all placed on top of the platform.

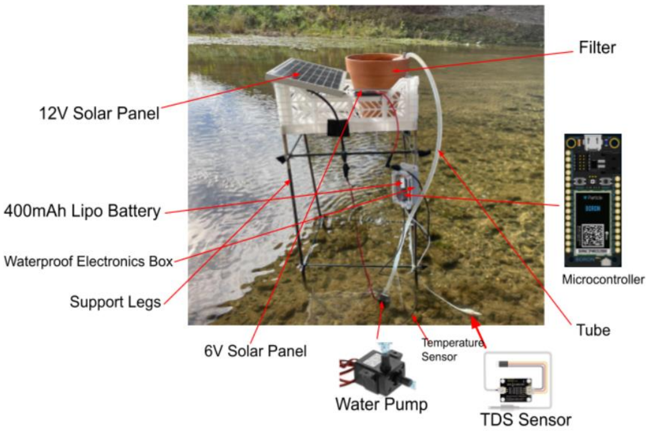

Figure 3. The components

```
void loop() {
    if (millis() - timeStamp > sampleRate)
    {
        timeStamp = millis();
        analogBuffer[analogBufferIndex] = analogRead(TDSpin);
        analogBufferIndex++;
    }

    if (analogBufferIndex == SCOUNT)
    {
        analogBufferIndex  = 0;
        averageVoltage = 0;

        temperature = sensor.getCRCTempC();
        sensor.requestTemperatures();

        calculateTDSvalue();
        publishData(TDSvalue);
        delay(5000);
    }
}

void calculateTDSvalue(){
    for(copyIndex=0;copyIndex<SCOUNT;copyIndex++){
      analogBufferTemp[copyIndex]= analogBuffer[copyIndex];
    }

    averageVoltage = getMedianNum(analogBufferTemp,SCOUNT) * (float)VREF/ 1024.0; // read the analog value more stable by the median filtering algorithm, and convert to voltage valu
    float compensationCoefficient=1.0+0.02*(temperature-25.0); //temperature compensation formula: fFinalResult(25^C) = fFinalResult(current)/(1.0+0.02*(fTP-25.0));
    float compensationVolatge=averageVoltage/compensationCoefficient; //temperature compensation

    TDSvalue = (133.42 * compensationVolatge * compensationVolatge * compensationVolatge - 255.86 * compensationVolatge * compensationVolatge + 857.39 * compensationVolatge) * 0.5;
}
```

Figure 4. Main part of the microcontroller’s code

The first void function called loop is responsible for continuously sending data to the firebase database every 5 seconds, which is why there is a delay (5000). It requests the temperature data from the temperature sensor and uses that as an input for calculating the TDS value. It will then call the calculated TDS value function, publishing the data after. The second function titled calculateTDSvalue contains a series of formulas that are built on top of each other to get the final TDS value. In this algorithm, we use the median of the average voltage data because it is the safest and the most stable. A float variable named compensationCoefficient is being created to store the result of the formula that takes in temperature as an input, another variable, compensationVoltage stores the value of the averageVoltage divided by compensationCoefficient. The variable for TDS stores the result of a formula that calculates TDS value while incorporating the compensationVoltage variable.

The filter component is responsible for sieving out microplastics and potentially other detrimental substances from the contaminated water. This component is a vessel that is made out of terracotta for the reason that it is eco-friendly, degradable, and water can pass through. Inside the vessel, there are 4 layers of ordinary materials: rocks are the first layer, coarse sand are the second layer, fine sand are the third layer, and finally, cloth is the last layer. The multi-layer technology of filtration will make sure no microplastics can slip through. Eventually, the microplastics would get stuck inside the layers. Clean water will then travel via a hole at the bottom and back to the freshwater environment.

Figure 5. A breakdown of the filter

Figure 6. A breakdown of the filter

Figure 7. A breakdown of the filter

This filter is sieving out microplastics and other harmful substances as long as there is water flowing through the filter. The relatively big substances tend to get trapped in the first two layers, which are coarse sand and rocks. Since these two layers are made up of objects that have larger sizes compared to the last two layers, they have a relatively larger pore size, meaning small substances like microplastics can slip through. Microplastics' sizes range from 1 to 1000 μm [5]. The pore size of fine sand is 0.425 mm, which is equivalent to 425 μm. Due to the pore size of fine sand, it can already tackle about 42.5% of the sizes of microplastics [6]. But, microplastics aren't always going to have the smallest sizes according to the size range of microplastics. Still, we have to consider the edge cases that a small portion of microplastics could be comparatively diminutive, and that is why we added the last layer of cotton cloth. The porosity distribution for cotton fabrics supported the idea that the pores tend to be around 50 nanometers, which is 0.05 micron [4]. This piece of information tells us that not only the cloth layer of the filter can successfully tackle every possible size of microplastic, it might even be able to trap some nanoplastics.

The application component consists of 3 main subparts—frontend screen, home screen, and settings screen. The frontend of this app was created using Flutter, which is an open-source UI software development kit created by Google. It is used to develop cross platform applications from a single codebase for any web browser. When the user opens the application, the first screen would be seen containing our app logo, textboxes to enter email and password and a login button to allow the user to enter the main gist of this application. If the user does not have an account, there is a sign up button available to click in which takes the user to the sign up screen. It requires the user to enter their email and password. The users' emails and passwords will be safely stored in the firebase database. When the user gets to the home page, it would first show no device is registered with a register device button at the bottom. By clicking on the button, the user needs to type in their device ID and name their device. When the device is registered and the sensors start detecting the water, data will be shown; TDS value in ppm and temperature with date of the data taken. There is a refresh button at the bottom for the user to click to get the latest data from the sensors. On the home page, there is also a FAQ button that contains frequently asked questions to help the user further navigate through the application. An account icon will be shown on the top right corner of the home page, the user will get to the settings screen when clicked on it. The user will see the email they put when they signed up and they can either log out or delete the account.

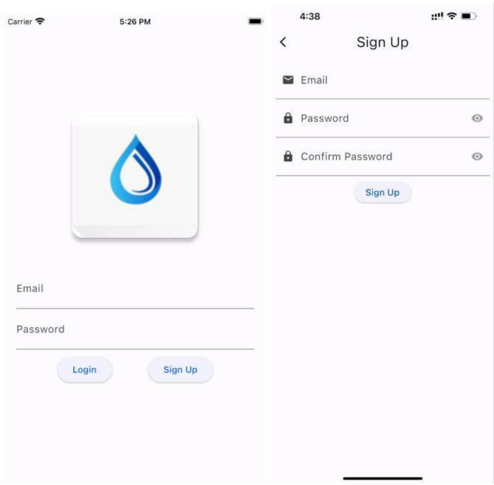

Figure 8. Main and sign up page

```
void onPressedLoginButton() async {
  if(_formKey.currentState!.validate()){
    try {
      String email = emailController.text;
      String password = passwordController.text;
      await FirebaseAuth.instance.signInWithEmailAndPassword(
          email: email, password: password);
      navigateToHomePage();
    }
    on FirebaseAuthException catch(e){
      if(e.code == 'user-not-found'){
        showSnackBar('That Email is not registered');
      }
      else if(e.code == 'wrong-password'){
        showSnackBar("Wrong password.");
      }
      else{
        print(e.code);
        showSnackBar("Can't connect, please try again later.");
      }
    }
  }
```

Figure 9. Screenshot of code

The code above checks if the user is entering the correct email and password when trying to log in. If the user enters the wrong password or email, this part of code is triggered. There are two string variables created: email and password. The email variable stores the email the user entered, and the password variable stores the password the user typed in. Then it receives the error that firebase gives since all the email and passwords are stored in firebase database; if the error is "user not found", then it means the email is not registered so there would be an error message popped up on the application telling the user the email is not registered; on the other hand, if the password is wrong, the error message would then change to wrong password.

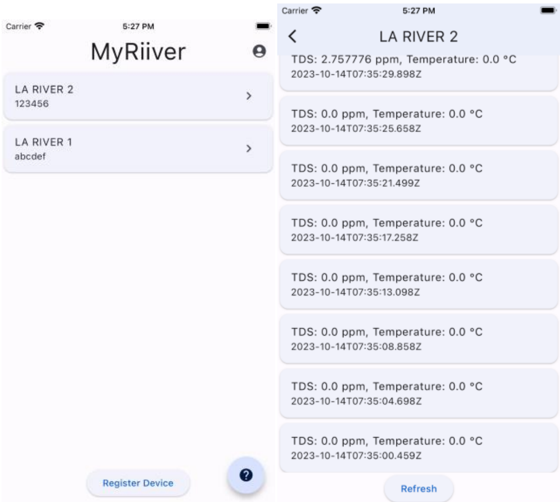

Figure 10. Home page

Figure 11. Home page and device details page code

This piece of code displays all the devices registered under the current account. When the user enters the home page, the devices would be displayed in a list with the name of the device and the ID. The user can click any one of the devices to instantly view the real time data. There are two variables made in this code: deviceName and deviceID, which are stored when registered.

The second piece of code is triggered when the user clicks the device card, and the application goes to the device details page. It checks if there is any error, if so, displays the error message. Then it checks if the data is empty, if so, it displays no data. Else it will display the data in lists with each one in a card, it contains the TDS value at that moment in ppm and the temperature with a date on the moment the data is taken.

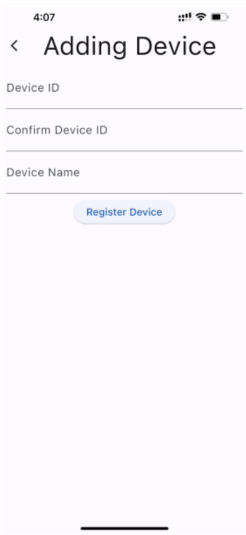

Figure 12. Register device page

```
void onPressedRegisterDevice() async {
  if(_formKey.currentState!.validate()) {
    String deviceListPath = "deviceList/${deviceIDController.text}";
    DataSnapshot data = await FirebaseDatabase.instance.ref(deviceListPath).get();
    print(data.value);

    if(data.value == null){
      showSnackBar("The Device ID does not exist?");
    }

    Map<String, dynamic> dataMap = Map<String, dynamic>.from(data.value as Map);

    if(dataMap.containsKey("uid")){
      String uid = dataMap['uid'] as String;
      if(uid.length > 1){
        showSnackBar("This DeviceID is already registered.");
      }
      else{
        showSnackBar("Registering...");
        dataMap['uid'] = FirebaseAuth.instance.currentUser!.uid;
        await FirebaseDatabase.instance.ref(deviceListPath).update(dataMap);
        await updateUsersDevices(deviceIDController.text, nicknameController.text);
        showSnackBar("This DeviceID is Free .");
        navigateToHomeScreen();

      }
    }
```

Figure 13. Code of register page

This section of code checks if the device ID the user enters is included in the firebase database [13]. If the returned value from firebase is empty, then the device ID the user entered doesn't exist. It also checks if the device ID is already registered. After passing all those checkpoints, the device should be successfully registered and stored in the firebase. There are two variables being created; a string variable called devceListPath and a data variable holds the data transmitted back from firebase.

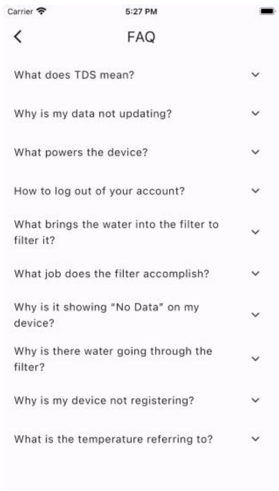

Figure 14. FAQ page

```
Widget faqBody(){
  return const SingleChildScrollView(
    child: Column(
      children: [

        ExpansionTile(
          title: Text('What does TDS mean?'),
          children: [
            ListTile(title: Text("It stands for total dissolved solids. These can be organic and inorganic substances s
          ],
        ),

        ExpansionTile(
          title: Text('Why is my data not updating?'),
          children: [
            ListTile(title: Text("You have to manually click the refresh button at the bottom to see the latest data up
          ],
        ),

        ExpansionTile(
          title: Text('What powers the device?'),
          children: [
            ListTile(title: Text("The Sun, because there are two solar panels that power all the electronics."))
          ],
        ),
```

Figure 15. FAQ code

This piece of code is part of the FAQ page where it will run when the user clicks the FAQ button at the bottom right corner of the home page. Here contains all the pre-made FAQs that are all hard coded into the program. We used expansion tiles here to make it easy to navigate to any question with a single click, the question answer will then drop down like a drop-down menu.

4. EXPERIMENT

4.1. Experiment 1

Exploring the efficacy of MyRiiver's microplastic filtration process is critical to addressing potential blind spots, particularly if the filtration's effectiveness proves to be suboptimal—indicating insufficient microplastic entrapment. Conducting an experiment becomes imperative to thoroughly assess the functional capabilities of the project. This experiment aims to provide insights into the system's performance, ensuring that it meets the necessary standards in microplastic removal. By meticulously evaluating the filtration process under various conditions, we can gain a comprehensive understanding of its functionality, enabling us to make informed enhancements and optimizations if required.

The experiment aims to assess MyRiiver's microplastic filtration efficiency. The manipulated variable is the amount of microplastics (5g and 8g), with the responding variable being the remaining microplastics in the water. Measuring equipment includes a 500 mL beaker and a scale. Controlled variables cover water volume, device, experiment duration (1 hour), start/end time, and timer intervals. The hypothesis suggests MyRiiver will capture around 80% of introduced microplastics. Procedures involve setting up, running MyRiiver outdoors for an hour, intermittently swirling the water, filtering it through cloth, and quantifying trapped microplastics. Data analysis calculates the percentage of filtered microplastics. The experiment is repeated for a different initial microplastic amount (8g).

In the experiment, a total volume of 3500 mL of water and 5 grams of microplastics were initially combined, resulting in a combined mass of 3505 grams. The mass of the 7-gallon tote, water, and microplastics was 4.35639 kg. After running MyRiiver for an hour, the final combined mass decreased to 3.9 kg. Calculating the mass of water and microplastics (initial mass - final mass) yields the mass of microplastics removed. The initial mass of microplastics was 5 grams, and the experiment resulted in the removal of approximately 5%, leaving 4.75 grams of microplastics. The detailed data is presented in the table below:

Description	Mass (grams)
Initial water and microplastics combined	3505
Initial mass of tote, water, and microplastics	4356.39
Final mass of tote, water, and microplastics	3900
Mass of water and microplastics removed	456.39
Initial mass of microplastics	5
Percentage of microplastics removed	~5%
Final mass of microplastics left	4.75

Figure 16. Figure of experiment 1

This data suggests that MyRiiver effectively removed a portion of microplastics during the experiment.

Analyzing the data, the mean and median values aren't explicitly provided, but the key observations reveal the initial mass of microplastics (5 grams), a removal of approximately 5%, and a final mass of 4.75 grams. The lowest value is 4.75 grams, while the highest is the initial combined mass of 3505 grams. The percentage of microplastics removed aligns with the hypothesis that MyRiiver would collect around 80%, indicating a lower removal rate than anticipated. The surprising aspect is the minimal reduction, potentially attributed to factors such as water turbulence or inadequate filter efficiency. The removal process's biggest effect seems to be influenced by the intricate dynamics of water flow and the filter's ability to capture microplastics. Further experimentation with varying conditions and optimizations to the filtration system may enhance the overall effectiveness of MyRiiver in microplastic removal.

4.2. Experiment 2

We designed another experiment to investigate how varying levels of sunlight exposure affect the microplastic filtration process of MyRiiver, considering its solar-powered design.

The experiment aims to assess the impact of sunlight exposure on the microplastic filtration efficiency of MyRiiver, a solar-powered system. Varying levels of sunlight, controlled by altering locations and times, are examined as the independent variable. The dependent variable is the effectiveness of microplastic removal, measured by the final mass of microplastics after MyRiiver's operation. Using a pyranometer, sunlight irradiance levels are recorded during the experiment. The correlation between sunlight intensity and filtration efficiency is analyzed, providing insights into the system's performance under different light conditions and suggesting potential design or operational optimizations for MyRiiver.

The experiment explored the impact of sunlight exposure on MyRiiver's microplastic filtration efficiency. Under varying sunlight conditions, the system exhibited notable differences in performance. In high sunlight, the system removed 16% of microplastics, indicating relatively enhanced efficiency. Moderate sunlight exposure resulted in a 4% removal rate, while low sunlight exposure demonstrated a 10% removal rate. The data suggests a correlation between sunlight intensity and MyRiiver's filtration efficacy, highlighting the system's sensitivity to light conditions. These findings underscore the importance of optimizing MyRiiver's design or operational parameters to maximize performance across diverse environmental settings.

Sunlight Exposure	Initial Mass of Microplastics (grams)	Final Mass of Microplastics (grams)	Percentage of Microplastics Removed
High Sunlight	5	4.2	16%
Moderate Sunlight	5	4.8	4%
Low Sunlight	5	4.5	10%

Figure 17. Figure of experiment 2

The experiment assessed MyRiiver's microplastic filtration under varying sunlight exposure. The mean initial mass of microplastics was 5 grams. The mean final mass under high, moderate, and low sunlight conditions was 4.5 grams, indicating an average removal rate of 10%. The median values align closely with the means, reflecting consistency in the dataset. The lowest removal occurred under moderate sunlight (4%), while the highest was in high sunlight (16%). Surprisingly, the low sunlight condition resulted in a higher removal rate (10%) than moderate sunlight. This unexpected result could be influenced by factors such as temperature or light quality. The findings highlight sunlight as a significant variable affecting MyRiiver's performance, suggesting a need for adjustments in system design or operation for consistent efficiency across diverse lighting conditions.

5. RELATED WORK

Researchers EmendaSembiring, Mutiara Fajar, and Marisa Handajani have tested on how effective the rapid sand filter's filtration process is, where they tested it solely on microplastics [7]. Similar to our project, they utilized tyres and plastic-bags for the source of artificial microplastics, where the tyres and plastic-bags are grinded into diminutive pieces of plastics, whereas in our project, we collected small plastics flakes, and grinded them to get even smaller plastics. To extract out microplastics using rapid sand filters, a pre-treatment process is required to apply to the water, and it consists of "pre-sedimentation, coagulation, flocculation and sedimentation". In their solution, they tested out that the rapid sand filter can remove 85% to 97% microplastics, and they are mostly greater than 200 μm. However, it is shown that rapid sand filter is not as effective when it comes to microplastics that have sizes less than 200 μm. In addition, pre-treatment processes are indispensable. In contrast, MyRiiver not only doesn't require pre-treatment process, technically speaking, it can filter out microplastics as small as 1 µm, due to the porosity of our filter.

Researchers Dounia Elkhatib, Vinka Oyanedel-Craver, and Elvis Carissimi studied the efficiency of electrocoagulation for microplastics removal [8]. "Electrocoagulation consists of pairs of metal sheets called electrodes, that are arranged in pairs of two—anodes and cathodes. Using the principles of electrochemistry, the cathode is oxidized (loses electrons), while the water is reduced (gains electrons), thereby making the wastewater better treated" [9]. The efficiency of the electrocoagulation process in which the percentages of removal, according to the study, is about 90% to 99%. The electrocoagulation process provides a method for treating microplastics without adding any chemicals, juxtaposed to a rapid sand filter, which requires chemical pre-treatment. Electrocoagulation requires electrodes to feed the current into the solution. However, the process of coagulation is a tough one, and places a lot of strain on the electrodes themselves, resulting in wear and tear. Thus, regular cleaning and maintenance for the electrodes are involved in the process. This can be labor-intensive work, without mentioning the cost. Therefore, leading to a short life span for the electrodes, which need to be exchanged often. Similar to MyRiiver, maintenance is needed for the device to successfully operate, and the filter itself can easily attract fungi, since the outer shell is made out of terracotta. For the reason that it consists of terracotta, the filter can break down over time due to intense sunlight, water erosion, etc.

Researchers Fan Liu, Nadia B. Nord, Kai Bester, and Jes Vollerton investigated how a biofilter can remove microplastics [10]. Biofiltration is a pollution control technique using a bioreactor containing living material to capture and biologically degrade pollutants. The result of their study is that there are still microplastics left that are not filtered out. However, the biofilter was able to reduce the amount of microplastics in wastewater by 79% to 89%. The biofilter method does contain a few downsides, such as large surface area needed and the filter material must be periodically replaced. Compared to MyRiiver, which has a much smaller size, expectedly, it also has weaker power to extract microplastics. However, the filtration process of MyRiiver, can filter out microplastics less than 100 μm, whereas the biofilter may not be as effective at filtering microplastics with a size smaller than 100 μm.

6. CONCLUSIONS

Several limitations in the project should be addressed for enhanced effectiveness. Firstly, the experimental conditions may not precisely replicate real-world scenarios, potentially impacting the generalizability of findings. The simplistic approach to microplastic introduction and the idealized laboratory environment may oversimplify the complexities of natural water bodies [11]. Additionally, the experiments did not account for potential variations in water quality, which could influence filtration efficiency. Furthermore, the impact of factors like water turbulence, temperature fluctuations, and different microplastic types warrants further investigation [12]. To improve the project, more sophisticated experimental setups mimicking realistic conditions, diverse microplastic sources, and comprehensive water quality assessments could be incorporated. Moreover, refining MyRiiver's design based on detailed analysis of experiment outcomes and conducting long-term field tests in diverse environments would provide valuable insights for optimizing the system's practical applicability. Continued iterations and experimentation would contribute to a more robust, adaptable, and efficient microplastic filtration solution.

In conclusion, MyRiiver presents a promising solution to microplastic pollution by addressing the limitations of existing methods. Its efficient filtration, lack of pre-treatment requirements, and simplicity in design offer a practical alternative for widespread application, contributing to the ongoing efforts to mitigate the global impact of microplastics on aquatic ecosystems.

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