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Smart Aquarium Monitoring and Cultivation System using JarFish IoT 1st Generation

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Abstract: Internet of Things (IoT) is a basic understanding about a device that has the function to enable or disable via internet network. Therefore, IoT systems can include various kinds of devices that people used in daily activities. Devices with IoT inside of it can we find anywhere and become important because in the last 3 decades, internet is the most useful technology development in this era. We develop an IoT devices to facilitate fish farming and rearing activities to help the fish owners. Since they don't have time take care of the aquarium, we assist them with this invention. So, this will help them much more without them losing time on their daily activities. There will be a pH level sensor to know the exact pH inside of the aquarium, Turbidity sensor to understand when to clean the dirty water and fill with the new cleaner water, automatic feeding systems with RTC so it can put out fish food inside of the aquarium with time that user want, and lastly water drain & fill systems so the user didn't have to fill and drain manually. We develop it with ESP32 as the micro-controller and Blynk as the main page. So, the user can monitor and also maintain manually the aquarium, regardless of where they are. With JarFish Monitoring System the aquarium is able to maintain its pH level at 6.2, temperature at 23°C, and turbidity at 1023 mNTU.

Keywords: *IoT, JarFish, Microcontroller, Blynk, RTC*

1. Introduction

Nowadays, people who owns a fish tank or an aquarium are too busy with their daily activities that made them incapable to take care their fishes properly. Sometimes they forgot to feed their fish on time, clean the fish tank frequently, not checking the pH properly, and so on. So the fish tank become dirty and the waste from the fish can accumulate inside the tank, thus, making the water inside of it muddy.

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As a country, Indonesia is well known for its maritime resource and therefore all the uniqueness of said resource appeals to many of the nation's citizens. However, despite this trend, it seems common for the nation to be especially casual when it comes to the cultivation process of their fishes. Although, time is of the essence for most fish owners, it is not permissible for one to simply neglect the wellbeing of their pets because of it. A previous study however has shown that alternative methods are available by leveraging the use of Blynk app, though this also not known by many fish owners. Even though the study primarily focuses on the monitoring of fish development which is useful for improving management [1].

Due to improper management, it might make the fishes suffocated because of the dirty water or even worse, starved to death. Improper maintenance therefore mostly affects the water quality which is a major factor that influence the quality of fishes inside an aquarium. However, the traditional methods of evaluating and maintaining water quality is an expensive venture in terms of time, manpower [2], and money, which is an unappealing downside to many which motivates most of them to ignore the process entirely. To avoid these things from happening, it needs an automatic system so it can get maintain regularly and minimize human error. It has been proven by using an IoT based approach to cultivate fishes would improve the growth and health for aquatic life, an effect which magnifies when applied to maritime industries which are common in Indonesia [3]

Similar projects have been made before [4], however, it only focuses mainly on notifying the user of the conditions within the aquarium. Despite it being useful, the user still must perform most of the cultivating process by themselves. JarFish however, is intended to allow the user the information regarding the condition of the aquarium and the ease of maintaining said aquarium by leveraging the usage of various automated system within JarFish. Another project similar to JarFish also allows the user information access and automatic maintenance system of an aquarium [5], however, it does not grant the user control privileges over the systems working within JarFish. For safety reasons, JarFish always allow the user to maintain the aquarium manually should they choose to. The means to control these various systems can be done by using a companion mobile application that comes with JarFish. This further instigated through a study made by the U.N. [6], that a form of redundancy is required when it comes to water quality monitoring system integrated with basic techniques such as, oxygenation and pumps.

2. Research Methodology

Due to the number of systems and its respective sub-systems involved, careful planning is required to implement the entirety of these system structures to work together simultaneously. The various systems in which this project entails is autonomous in nature and are designed to run independently yet in conjuncture with one another. To be put in perspective, one of the features included, a pH detector, did not simply read the current level of acidity of the water inside the aquarium. Instead, its readings would then be used to activate or deactivate pumps which are connected to either an alkaline or an acidic solution to maintain the aquarium's ideal pH level.

The chart below referring to Figure 2, explains the overview architecture of the JarFish Monitoring System. The system itself runs on Blynk cloud platform, enabling it to be controlled via an application or a website using an internet connection. The system also consists of a microcontroller which process information obtained from several sensors and running several functions attached to it. These processes consist of:

- pH sensor (PH-4502C)
- Temperature sensor (DS18b20)
- Turbidity sensor
- Feeder System with RTC
- Control systems

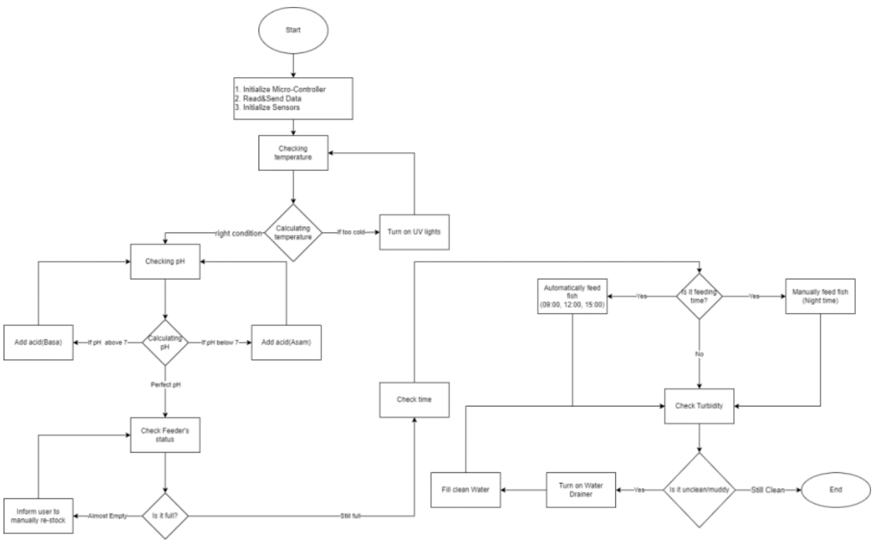

Fig 1 Flowchart JarFish

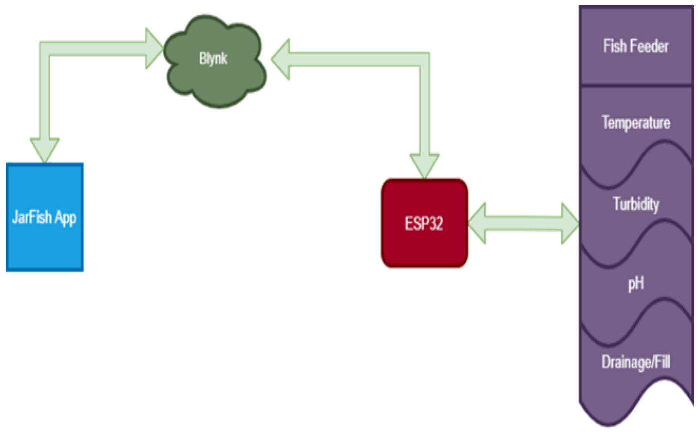

Fig 2 JarFish System Architecture

2.1. pH Sensor

The proposed plan would require the sensor to be submerged within the aquarium and implanted on the side of the aquarium as to maximize the available room for the fishes inside. Inside the thin glass bulb at the end of the sensor bulb are located two electrodes that measure voltage. One electrode is contained by a liquid with fixed acidity and the other electrode would then be the one to respond to the acidity of the water. Which then the probe would measure the difference between the voltages of the two electrodes. This difference would be then translated by the microcontroller connected to the sensor probe into pH readings [7]. When used, the readings from pH sensor would then be sent back into the microcontroller to then run its respective functions which involves increasing or decreasing the pH value, when necessary, based on the reading received from the sensor.

2.2. Temperature Sensor

The proposed plan would require the sensor to be submerged within the aquarium and implemented on one of the side walls of the aquarium, preferably around the area where temperature readings may not be disturbed by surrounding activities, such as, a water circulation system. The function of the temperature sensor would be used to obtain temperature readings from the aquarium. Temperature readings are valuable information which can be used to allow users to adjust the conditions surrounding the aquarium to accommodate the temperature change or to prepare them for unavoidable situations, such as, weather and climate change.

2.3. Turbidity Sensor

The proposed plan would require the sensor to be submerged just at the water surface level to obtain the readings regarding the condition of the water inside the aquarium. As noted in a previous study, if the water was too dirty or fully turbid, it will reduce the amount of light passing through the water and therefore may leads to the fishes within to go blind, which sends the fish into a state of panic and potentially harmed itself [8]. Turbidity sensor readings output are turbid values. Which determines how turbid or clean the water condition inside the aquarium. Should the water be too dirty, the user can then use this information as a mean to clean their aquarium.

2.4. Feeder System with RTC

The proposed plan would require a fish food container to be placed on top of the aquarium to provide easy access for the fish food to simply be poured instantly into the aquarium. The plan is based on existing project [9] within the same field which also utilizes the RTC with the automatic feeder mechanism. Within the feeder, is located a servo motor, which are used to move the lid covering the container to allow fish foods to pour into the aquarium and to stop them from doing so. This feeder system can be operated automatically or manually. When it runs automatically, the feeder would done its job by referring to the time obtained by the RTC which, through the program written within of the microcontroller it attached to, would only allow the feeder to remain active at a specific time.

2.5. Control Systems

Also included in the system are control systems. These are various functions of JarFish Monitoring System that can operate without the need of sensor readings. These functions are previously maintained using a relay. Although small, the relay is used to determine whether the devices connected to it should be powered or not. Its functions are properly implemented before use through the microcontroller. This component is operated with the similar function as used in another project [10]. The functions mentioned above consist of:

- **UV Light**

The UV Light is connected to a microcontroller which are controllable wirelessly via an application.

- **Water Drainage System**

Attached to the aquarium, are two pumps responsible to allow user to either drain water from the aquarium or refill water into the aquarium. These pumps are attached to a microcontroller and controllable wirelessly via an application.

- **Water Filtration and Circulation System**

Also included, a water filter which are always on and used to maintain the clean condition of the water inside the aquarium. The water circulation system however can also be used to distribute acidic/alkaline solution into the water evenly.

3. System Development

The JarFish system is developed using various technologies. One of the main components are microcontrollers and its corresponding sensors. The system is developed to run automatically and relies primarily on its sensors input. However, the system also developed in such a way that it allows user to also have a bit of control as well.

3.1. Planning Phase

We started the planning with a discussion and exchanging ideas based on topics and the project we will work on it. We decided we want to develop a smart aquarium with sensors and regulator so it can get easily controlled. The sensors are:

- **Temperature Sensor**

To detect the temperature. If the temperatures are too cold, fish's metabolism will slow down, which leads them to become sluggish or sleepy [11]. We use Temperature Sensor DS18B20. This sensor plays an important role in terms of aquarium monitoring because temperature affects biological and chemical procedures which in turn would affect the fishes inside the aquarium [12]. Therefore, when the temperature is too low, the user can attempt to increase the temperature by turning on the UV light attached to the aquarium. This method of temperature control is devised based on previously existing project [13].

- **pH sensor**

To detect the pH in the water is it too high or too low. Too low of pH on fish tank can reduces fish ability to swim, eat, reproduce, or grow and too high of pH can denaturing fish's cellular membranes. The normal pH is 7. Most common causes to changes in pH levels are caused by dissolved carbon dioxide that creates carbonic acid which acidifies the water would lower the pH levels of the water. Various other factors that affected the change in pH levels includes but not limited to are water hardness, fish and plant waste, topping off the water and water evaporation [14]. The process began by the pH Sensor acquiring the current pH value of water inside the aquarium. The reading would then be sent to the microcontroller to be evaluated. The evaluation of the readings is separated into the three categories:

- High Acidity

In this case, a pump connected to an acidic solution would pump said solution into the water. By making use of the water filtration and circulation system, the solution is expected to be thoroughly mixed without the need of manual mixing. The acidic solution, due to its low pH value is also expected to decrease the acidity levels of the water inside the aquarium to its desired ideal levels. To achieve this, the pump is controlled to only remain active until the ideal acidity levels are reached.

- Ideal Acidity

In this case, no pumps needed to be activated because the acidity level inside the aquarium is/or already at its ideal level.

- Low Acidity

In this case, a pump connected to an alkaline solution would pump said solution into the water. By making use of the water filtration and circulation system, the solution is expected to be thoroughly mixed without the need of manual mixing. Due to its high pH value, the alkaline solution is expected to increase the acidity levels inside the aquarium to its desired ideal levels. To achieve this, the pump is controlled to only remain active until the ideal acidity levels are reached.

After the process ended, a possible new pH reading would be sent to the user.

- **Turbidity Sensor**

To detect the turbid in the water. If it's too dirty, fishes can be suffocated and die due to their gills possibly obstructed by clay particles present in the water. However, if the water is too clear, it indicates low biological production, which could mean that the fish within won't developed well [12].

The regulators are:

- **Automatic Fish Feeder**

The mechanism to feed Golden Fish would be active regularly in the morning at 9:00 AM, in the afternoon at 12:00 PM, and in the evening at 3:00 PM. Around these times, people usually work or have activities from the morning. Therefore, some help from an automated system may be necessary. But the user still needs to occasionally re-stock the feeder if the food stock runs out.

- **UV Light**

Heating water since UV lights have a warm temperature and also give good color to the fish tank or aquarium

- **Water Pump**

To drain/fill water. If the water is too turbid, the water pump will drain the water from the fish tank and fill the new clean water.

3.2. Designing Phase

The first design is too bland since we don't have enough understanding about fish tank. The features on JarFish, it would be like in the image below minus the fan. Because our project is for indoor environment. The initial design…….

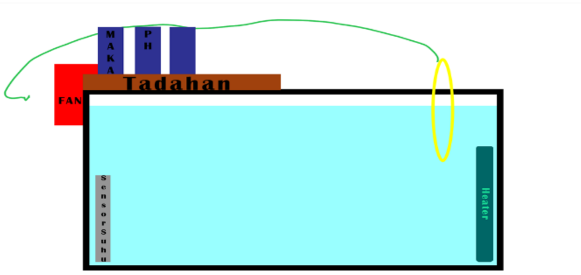

Fig 3 Aquarium Design

3.3. Assembling Phase

In Figure 4, it shows the several angles of the JarFish Monitoring System. The first image from the left shows the front side of the device, the middle of the image shows the various inner workings of the device, and the rightmost image shows mostly the backside of the device, which primarily display the micropumps and the acid/alkaline solution containers.

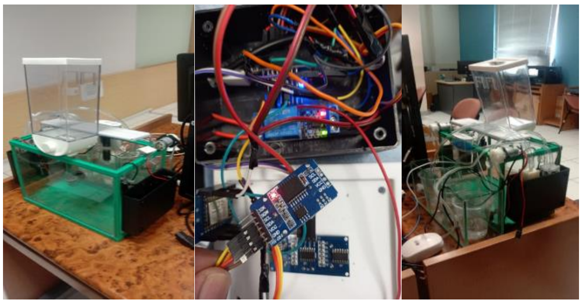

Fig 4 JarFish IoT Hardware

3.4. Application

The application (Figure 5) was designed and produced using tool known as the MIT App Inventor. A simple tool used to build application with easy-to-access interface and back-end programming. The tool has been proven to be functional enough for user to makes use of [15]. This application utilizes several Blynk's API commands given the fact that JarFish is connected to the Blynk services. Some API command simply call information from JarFish, such as temperature and turbidity information. Meanwhile, other API command would either enable or disable certain functions within JarFish such as the UV lights and the various micropumps attached. The application itself is also lightweight enough that it would run on various current Android versions without much of a hassle.

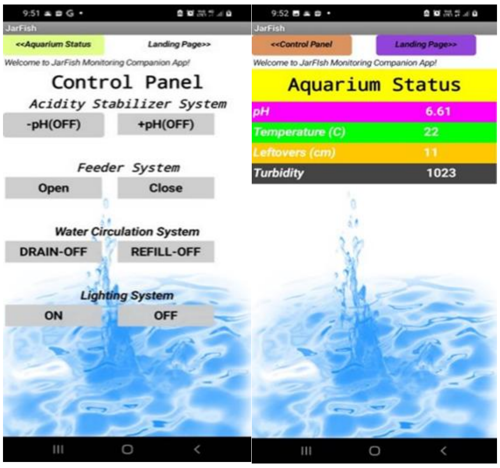

Fig 5 Application Display

4. Results

After conducting a week worth of testing and observation this is what we came up. We observe every 3 hours in a day (09:00 AM, 12:00 PM, 15:00 PM) since it's also the time of the automatic feeder is scheduled to put out food. The fish food that inside the aquarium and dissolve with water, can cause an increase in pH, temperature, and turbidity [16]. To find the average data of the aquarium which consists of pH, temperature, and turbidity data is using the formula:

$$\bar{x} = \frac{\sum f(x)}{n}$$

4.1. Temperature

It shows below (Table 1) that most of the time the temperature is still normal between 27°C -30°C. it only stay on 23°C on 5th of December 2022 because the rain that kept pouring and made the temp become much more colder than usual. After that, the temperature stayed at the state that Koi can live in.

Table 1 Aquarium Temperature

Date	Time Automatically Feed	Temperature(°C)
05/12/2022	09:00 AM	23
	12:00 PM	23
	15:00 PM	23
06/12/2022	09:00 AM	30
	12:00 PM	30
	15:00 PM	30
07/12/2022	09:00 AM	30
	12:00 PM	30
	15:00 PM	30
08/12/2022	09:00 AM	29
	12:00 PM	28

	15:00 PM	30
09/12/2022	09:00 AM	28
	12:00 PM	27
	15:00 PM	27
10/12/2022	09:00 AM	27
	12:00 PM	28
	15:00 PM	29
11/12/2022	09:00 AM	28
	12:00 PM	29
	15:00 PM	29
12/12/2022	09:00 AM	29
	12:00 PM	30
	15:00 PM	29

Below (Figure 6) is the chart based on the table above. It is found that during the course of maintaining the aquarium using the JarFish Monitoring System the average temperature achieved is 23°C.

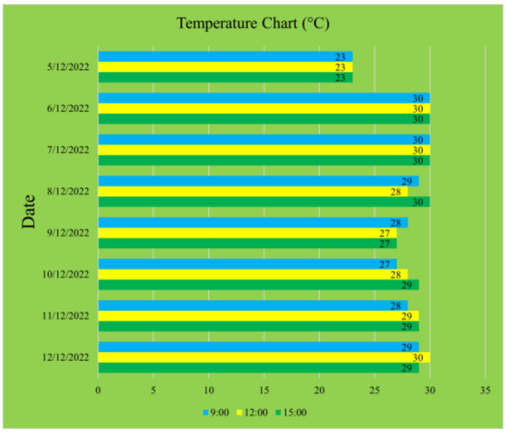

Fig 6 Temperature Chart

4.2. pH level

After we observe it from close (Table 2), the pH level not always consistent because of many factors such as rainwater, depletion of carbon dioxide (CO2), fish foods and fish waste. Since our observation is December, which is a rainy season, it change some quite of time. The exception came on the last day of observation. It change quite drastically because one of the cable that inside of pH sensors got loose even though we manage to put it back where it belong, it doesn't showed up on the Blynk but it showed up on the serial monitor that we use to code. Despite this, the relative average of the pH levels is quite stable and did not fluctuate in the extremes which are consistent with previous studies similar to the project [17].

Table 2 pH Level Table

Date	Time Automatically Feed	pH Level
05/12/2022	09:00 AM	6.54
	12:00 PM	6.54
	15:00 PM	1.84
06/12/2022	09:00 AM	6.32
	12:00 PM	6.35
	15:00 PM	6.37
07/12/2022	09:00 AM	6.21
	12:00 PM	6.20
	15:00 PM	6.21
08/12/2022	09:00 AM	6.25
	12:00 PM	6.47
	15:00 PM	6.48
09/12/2022	09:00 AM	7.26
	12:00 PM	7.26
	15:00 PM	7.26
10/12/2022	09:00 AM	7.26
	12:00 PM	7.26
	15:00 PM	7.26
11/12/2022	09:00 AM	7.26
	12:00 PM	7.26
	15:00 PM	7.26
12/12/2022	09:00 AM	3.91
	12:00 PM	3.66
	15:00 PM	4.22

Below (Figure 7) is the chart of pH level based on the table above (Table 2). It shows that the pH level inside the aquarium remained consistent most of the time. The fluctuations are caused by the koi fish biological activities and part of the JarFish Monitoring System function that maintains the pH level of the aquarium itself.

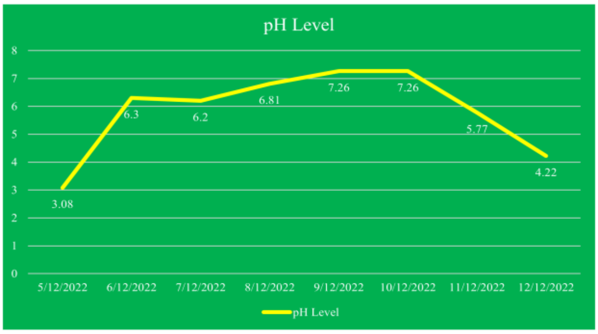

Fig 7 pH Level Chart

4.3. Turbidity

Since the aquarium always maintained clean, the turbidity also remained constant most of the time at 1023. On the first day (05/12/2022) it shows at 12 pm and 15 pm it become much turbid. It happened because we were testing it outside the aquarium for a while to make sure the turbidity sensors working as it should be. We dip the sensor inside of a basket full with muddy water. After that it stay the same at 1023-1025. On the last day of the observation, it really become so low. It happen because the wire from the turbidity sensor was broken and then we fix it at 4 pm and it show 1023 at the time.

Table 3 Turbidity Data Table

Date	Time Automatically Feed	Turbidity
05/12/2022	09:00 AM	1023
	12:00 PM	508
	15:00 PM	450
06/12/2022	09:00 AM	1025
	12:00 PM	1023
	15:00 PM	1023
07/12/2022	09:00 AM	1023
	12:00 PM	1023
	15:00 PM	1023
08/12/2022	09:00 AM	1023
	12:00 PM	1023
	15:00 PM	1023
09/12/2022	09:00 AM	987
	12:00 PM	1023
	15:00 PM	1018
10/12/2022	09:00 AM	1023
	12:00 PM	1023
	15:00 PM	1023
11/12/2022	09:00 AM	1023
	12:00 PM	1023
	15:00 PM	1023
12/12/2022	09:00 AM	13
	12:00 PM	12
	15:00 PM	6

Below (Figure 8) is the chart for the turbidity level achieved during the observation based on the table above (Table 3). The average turbidity achieved during the time it was used with the JarFish Monitoring System is 1023 mNTU.

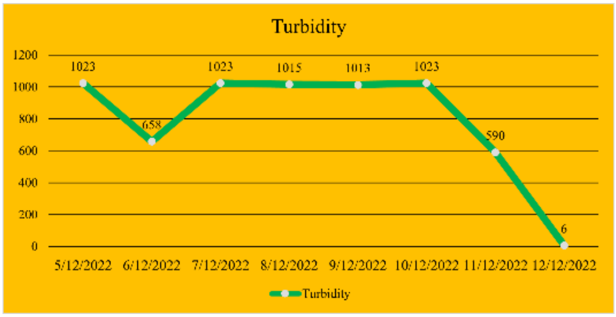

Fig 8 Aquarium Turbidity Chart

4.4. Power Monitoring

The lower table (Table 4) shows how the electricity used for 24 hours and we observe it for about 20-25 days with everything inside of the aquarium is turned on. The experiment is modeled after an earlier project [18].

Table 4 Electricity Usage

Electricity Usage				
Average Power Usage/Day (kWh)	Total Uptime	Average Cost/day	Cost/Week	Cost/Month
0.063 kWh	24 hours	Rp 85.2	Rp 596.2	Rp 2,395

As we see from the table of the Electricity Usage, JarFish is considered as a low power usage because it only consumes about 0.063 kWh even though there are a lot of things inside of it. Which consists of various electronic components; most notable ones are the microcontrollers and micropumps. The measurement is done using a device shown in Figure 9.

Fig 9 Power Monitoring Device

5. Conclusion

In this project, we made a system to monitor an aquarium with IoT (Internet of Things) by using sensors, NodeMCU as the micro-controller board, and controller by Blynk cloud. As its today, monitoring an aquarium still manually. With IoT, it can monitor all of these at ease with just an app without the need to physically check the aquarium periodically when it is not possible to do so. When the water inside the aquarium too dirty, user can easily drain the dirty water and fill the new clean water. When the temperature way too cold, it can easily turn the UV lights on and then switch it off when the temp already normal. When the pH way too high or too low, it can just push the button inside the app and turn on. If it's too high user can turn on the Acid pump. Meanwhile, when it's too low they can turn on the Alkali pump/valve.

Based on the week long experiment, it is found that the JarFish Monitoring System managed to successfully maintains the ideal average of pH at 6.2, temperature at 23°C, and turbidity at 1023 mNTU.

This project could be very efficient to people that own fish but don't have much time to take care properly since they have many activities thorough the day. The project can also undergo further improvement by making use of computer vision to allow for better monitoring process. Computer Vision should allow the user to receive data constantly in real-time without input delays.

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