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Application of Logistic Regression Algorithm to the Water Potability System using Thermal Filtration

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***Abstract:* -** Nowadays, the population is growing and our re- quirements are increasing, one of these essential needs which are growing exponentially is freshwater. This kind of water can be utilized for a variety of purposes, including bathing, agriculture, food processing, leisure activities, and as an additional source of electricity. But above all, it is used as clean, potable water for human use. Although it may seem endless, the truth is quite literally the opposite: freshwater makes up a very small portion of the world's total water supply, and as long as humans continue to use it, they will eventually run out of drinkable freshwater. Fortunately, scientists have long anticipated this crisis and have worked to find creative solutions, one of which is desalination, which is the process of taking the largest type of water which is seawater, and turning it into fresh water through a variety of techniques. The researchers want to create a device that uses copper coils to absorb steam from evaporation and assist it in condensing back into water, containers for the salt water, and solenoid valves to aid in the cooling of the copper coil to prevent the coil from overheating, and finally, a mechanism that uses thermal filtration to desalinate seawater. Using a PH sensor to measure the water's acidity, an electrical conductivity to measure its salinity, and turbidity to measure its clarity, the researchers also hope to create an analysis system to verify the potability of the desalinated water. Using the sensor data, they will create a program based on logistic regression to automatically calculate the water's potability. The equipment will distribute the potable desalinated water into storage once its potability has been confirmed.

Keywords: Filter, Thermal Desalination, Logistic Regres- sion, Water Potability.

I. Introduction

For people, water has always been and always will be vital. People have always understood that water is essential to our survival. In addition, people now know that life depends on water and that no living thing, not even plants, animals, or humans can survive on saltwater or seawater. The reason for this is that anything that consumes seawater, including people, animals, and plants, is adversely affected by its salt content and becomes dehydrated as a result. Nowadays, almost all of the freshwater we have comes from precipitation that falls from the sky as rain, mist, or snow. There are several uses for fresh water, such as drinking, rehydrating our bodies with dissolved fluids, and irrigating farms that produce the food that humans and our animals eat. It can also be used to capture and produce energy in the form of hydroelectricity, while seawater can also be used to create hydroelectricity. Though it may appear plentiful, freshwater makes up only 2.5% of the earth's total water content at the moment, with the majority of other types of water being seawater. For this reason, the researchers are working to create a new freshwater supply through desalination, which will aid in addressing the impending issue of water scarcity. Additionally, this study will create a model that makes use of logistic regression, a statistical model with binary dependant variables. The analysis will aid in the study's determination of the water's suitability for drinking.

II. Related Work

According to the research [1], desalination can provide a country with limited water resources while also being able to do it in a sustainable manner. At our current time and the progression of the technology we have made towards desalination, he has brought up the different methods of desalination that are currently the most used and these are the Reverse Osmosis (RO), and the Multistage Flash Desalination (MSF) process. Other more are found but in a much smaller scale and limited scale are the (MED) which is the Multiple Effect Evaporation and the (MVC) or

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the Mechanical Vapor Compression Process. Desalination is also said to impact the environment in less harmful ways than water dams, as water dams result in big problems when used up and down streams.

Historically the first desalination techniques to be introduced for freshwater production are Evaporation and Condensation. The main idea process for this was to

supply seawater with thermal energy (commonly used with waste heat or fuel combustion), producing vapor, and then condensing it, thus separating the water from the salt. Most common desalination technologies use (MED) Multi- Effect Desalination, (MSF) Multistage Flash Desalination, (TVC) Thermal Vapor Compression, and (MD) Membrane Distillation [2].

The growth of our population, as well as the increase of our living standards will inevitably lead to the pursuit of potable water as well as clean energy while also increasing in its demands. Fresh water represents a minuscule portion of the overall world's water potable, and most of this quantity isn't accessible to humanity [3].

Philippines' overall demand for desalination plants or methods is assumed to be low. However, the water supply problems that the country regularly faces during the summer period lead to high water demand, especially for its metropolitan cities. Possible discussion about how to solve water supply shortage leads to desalination. Desalination can also help areas that have insufficient groundwater for their local demands as well when it's having interruptions during events of extreme weather where potable supplies are disrupted, examples of these places being remote islands that litter the Philippines [4].

The research on Salinity Detection in Households Using Raspberry Pi 3b+ focuses on a household water storage measurement device that includes a pH sensor and a turbidity sensor. A water reservoir's pH level should be between 6.5 and 8.0. The pH data is kept track of, and if the pH falls outside of the acceptable range, the water is tested again. A turbidity sensor is used to measure density, and the two values are compared. If the pH and turbidity levels detected are within the scope of the said acceptable range, the system will display the output as potable water [5].

III. METHODOLOGY

The researchers present the structure of the methodology that has been used in the study. This study contains methodol- ogy, algorithm, system design, stages or phases under system design or paradigm, and statistical tools that analyze the collected data.

3.1 System Design

Fig. 1 shows the Agile Development Method Life Cycle used by the researchers. During the planning stage, the researchers plan out the project. This involves addressing the resources needed for development, setting expectations, and gathering thoughts about various methods the researchers can finish the project. Designing stage, the researcher designs a system based on the information gathered and the resources and materials needed. The researcher will assign tasks that were planned in the project's planning stage during the

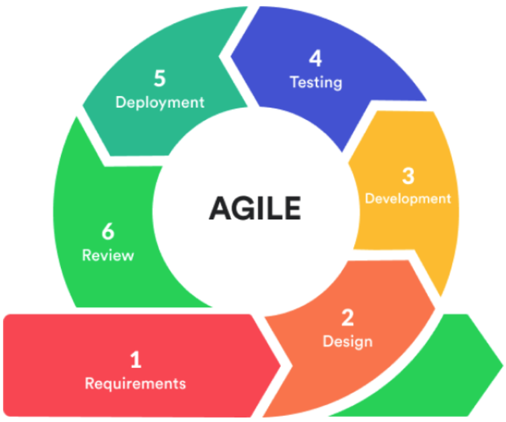

Fig. 1. Agile Development

Development stage. These tasks will include developing the system, documenting the project, and focusing on the physical aspects of the product, such as hardware and device assembly, to make sure it fulfills the researcher's intended prerequisite purpose. This is also the stage where iterations and improvements are made. During the Testing phase, the researchers will test the product using its intended features and search for flaws or any remaining issues that need to be fixed for quality assurance. The researcher will gather input regarding the product throughout the feedback phase and use it as a guide when returning to the development phase until the product meets customer needs. The product will be implemented during the deployment phase.

a) Requirements: The data, concepts, illustrations, and pre-existing designs of the researcher, various sources of information, and potential problems with relation to their decision. Additionally, the researcher performed several interviews with the experts in the sector to determine whether it is feasible and beneficial to the consumers. Additionally, with the aid of relevant studies, the researcher can start and complete the development process.

b) Design: Fig. 2 shows the conceptual framework for the water potability system. The input will be the Saltwater that will be desalinated, as well as the sensor data needed by the analysis system. The process will be the actual desalination of the seawater and the analysis done by the system. The output of the process will be water that has passed desalination and subsequently the analysis and will be deemed potable or fit for human consumption. The design of the project started with the choice of desalination; the team decided on Thermal Desalination with post-filtration filters to accommodate seawater. For the desalination system numerous parts such as aforementioned filters, manual pump for water distributions, copper coils for desalinated water passage, and multiple water storage for post-filtered water and clean water. As for the development of the analysis system, the team used a microcontroller and multiple sensors like the PH sensor, Turbidity sensor, and Electrical Conductivity sensors. The input of these sensors will serve as the data needed by the program inside the microcontroller to analyze if the desalinated water is potable or not. The LED lights will give a signal if the analyzed water is deemed potable or not according to the analysis executed by the system. The green LED will light up if the result of the analysis is potable, otherwise, the red LED will light up for non-potable.

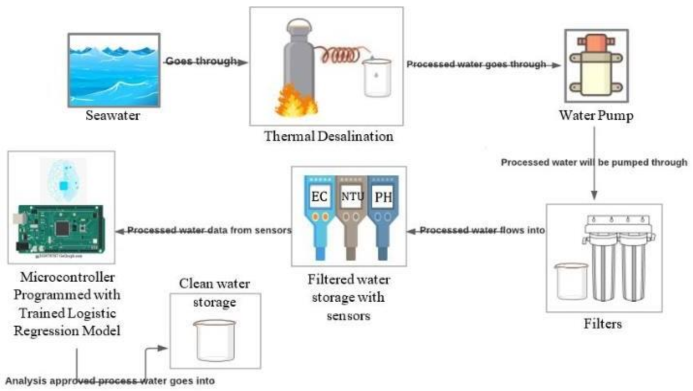

Fig. 2. Conceptual Framework for Water Potability System

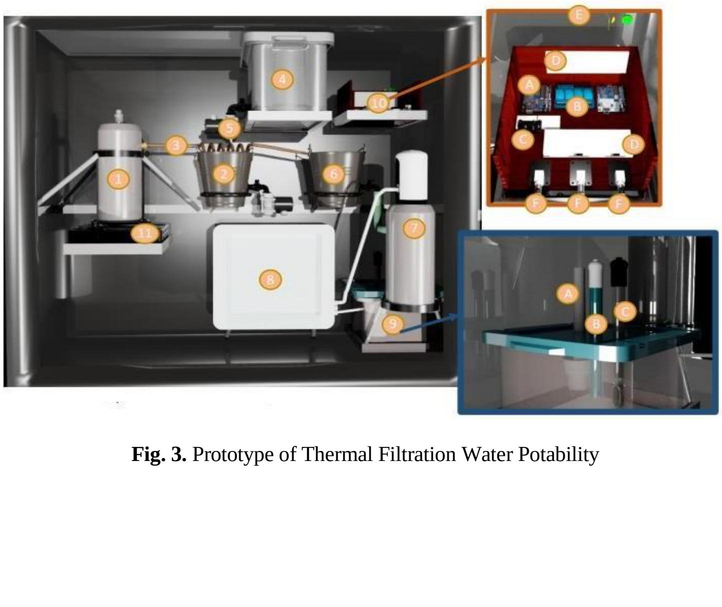

Fig. 3. Prototype of Thermal Filtration Water Potability

Fig. 3 shows the Prototype of the Thermal Filtration Water Potability System, the components are as follows:

1. Saltwater Chamber – Storage for saltwater
2. Cooling Reservoir – Used to store water from the cooling mechanism reservoir to cool the copper coils.
3. Copper coil – where the steam from the saltwater chamber passes through.
4. Cooling Mechanism water reservoir – water storage that is used to allow water to flow to the copper coils and to the cooling reservoir.
5. Solenoid Valve – control units which, when electrically energized or de-energized, either shut off or allow fluid flow.
6. Desalinated Water Reservoir – desalinated water storage
7. Water Pump - used to increase the pressure of water to move it from the desalinated water reservoir to the ultrafiltration filters
8. Ultrafiltration Filters - remove particulates and solids on a microscopic level, this ensures that the desalinated water will be safe to drink.
9. Final Reservoir – Clean water storage

a. Turbidity Sensor - detects water quality by measuring the levels of turbidity.

b. PH Sensor - to measure the amount of alkalinity and acidity in water and other solutions.

c. Electric Conductivity Sensor - to monitor the number of salts or impurities in the water.

10. Arduino and other equipment

a. Arduino Uno – Microcontroller board where codes are stored to control the device.

b. 4 Channel 5V Relay Module – Used to control the solenoid valves.

c. 5v power supply module – To supply another energy source to the Arduino.

d. Breadboards – Used to build the circuits.

e. Led lights (Red, Yellow, and Green) – Used to determine filtered water potability.

f. Sensor Connectors – Translates sensor reading into numerical data.

11. Heat Source – Used to boil the saltwater

c) *Development*: In the development phase, the researchers used a microcontroller attached to sensors to detect the PH, turbidity, and salinity of the water. The researchers used Python programming and a microcontroller to develop a logistic regression model that would verify if the system was potable or not. As for the user, the researchers included LED lights with designated functions for the user to identify the water's potability. In the development of the desalination system, the researchers used a water pump to enable water to flow through the filters. These are used for post-treatment filtration of the processed water that has gone through the desalination system and a metal container to facilitate the water during the thermal filtration process, a metal coil to accommodate the vapor, and also help condense it back to the water.

Fig. 4. Prototype of Thermal Filtration Water Potability System

Fig. 4 shows the developed Water Potability System using Thermal Filtration and it is ready for series testing and evaluation.

d) Testing: For the logistic regression analysis device testing, the researchers conducted trials of testing that will compare the proposed data detected by the sensors to the actual water level. The researchers tested the analysis multiple times to ensure that it was accurate, usable, and reliable. These trials of testing also served as the database that was used as the reference to train the logistic regression model. On occasions that the analysis fails to interpret the data accurately, the researchers will clean the sensors and rerun the system to see where the error was. For the desalination system testing, the researchers ran the device multiple times to ensure the filters were working and reliable. The researchers used a familiar set of LED light colors (red and green) to ensure that the user will understand if the filtered water is drinkable or not. They also submitted a desalinated water sample to a government-accredited water testing facility to give extra assurance that the filtered water is potable. With the help of a confusion matrix, experimental testing was also employed to test the accuracy, precision, and recall of the system.

Table I: Confusion Matrix for Water Potability System Using Thermal Filtration

TP	FN	TN	FP	Accuracy	Precision	Recall
52	4	56	8	95%	94%	97%

*TP = True Positive, FN = False Negative, TN = True Negative, FP = False Positive

Table 1 represents the confusion matrix and the results for Thermal Filtration Water Potability Analysis, it indicates that the true positive and true negative have 52 and 56 respectively. false positive and false negative have 8 and 4 respectively. Therefore, the accuracy, precision, and recall have 95%, 94%, and 97% respectively, it confirms that the performance of the system is very good in water potability analysis.

e) Evaluating: The researchers gathered a survey that helped the researchers evaluate the system, so the system and the device improved and satisfied the needs of each respondent.

Table II: Respondents Who Will Evaluate the System.

Respondents	Quantity	Percentage
Male	10	38.46%
Female	10	38.46%
IT Professionals	3	11.53%
Water Sanitation Expert	3	11.53%
Total	26	100%

Table 2 shows the different respondents that the project will need. With the use of evaluation forms, the researchers will commence multiple trials to ensure the desalination system's usability and the accuracy of the analysis system that comes with it. The main respondents will be (10) Male and (10) Female. Certain criteria must be met to be qualified to be included in the evaluation and these are (1) Age must be (18- 50) years old, [2] Willing with full consent, (3) Filipino, (4) The respondent must be literate, (5) Physically and mentally healthy. Exclusion from participating in the evaluation is (1) Being below 18 or over 50 years old, (2) Is not Filipino,

(3) Illiteracy, (4) Having a Mental or Physical disability, (3) Does not consent to the evaluation. This is to ensure that the information relayed by the researchers about the projects; device operation, maintenance, testing, and evaluation will not be hindered by any physical or mental difficulty and will be made with the full consent and willingness of the participants. The researchers also consulted (3) IT professionals, and (3) professionals on water sanitation expert and had them assess the desalination system as well as the desalinated water output that the system made, running several tests to see if the desalination system is working properly as well as the analysis system if the output it is providing is satisfactory. The combined feedback and evaluation of the respondents and the professionals will be taken for any future iterations and improvements of the project. The IT Professional must have a bachelor's degree in information technology and/or Computer Science, or a National Certificate in Programming

from TESDA. Qualifications for the Water Sanitation expert include a degree in Public Health and currently specializing in water sanitation or the professional could be part of the Philippine government sector that specializes in water sani- tation/potability like the Department of Water, Department of Water Resources, Local Water Utilities Administration. This is to ensure that the professional respondents' expertise is in line with the project needed assessment. The researchers inquired on social media and announced their intentions to gather data and feedback about the proposed project. They also gave a brief overview of what the project was about.

f) Implementation and Deployment: In the deployment of the system, the user was tutored on the functionalities of the system as well as the manual on how to operate it both in the manual part as well as the systems function and how to ascertain if the analysis part was complete and if the operation was a success or a failure. The desalination system will produce the desalinated water and the sensors (PH, turbidity, and electrical conductivity) will send the data gathered by the sensors about the water to the microcontroller. The logistic regression analysis model in the microcontroller will then verify if the water is potable or not. The user will turn on the analysis by pressing a button that will trigger the sensors to read the water's parameter level. The users will be able to have the drinkable water after the system verifies that it is potable.

IV. Result And Discussion

This chapter presents the data gathered from the Users, IT Professionals, and Water Sanitation Experts who served as the respondents of this Research. It also provides the analysis and interpretation of data that has been organized according to the research questions. rated the desalination system as highly acceptable with a weighted mean of 3.63.

Table III: Result of IT Professional Evaluation

Criteria	Mean	Interpretation
Functionality	3.63	Highly Acceptable
Reliability	3.83	Highly Acceptable
Maintainability	3.67	Highly Acceptable
Usability	3.67	Highly Acceptable
Total Mean	3.70	Highly Acceptable

Table 3 shows the Summary of the Evaluation done by the IT Professionals. The system's functional suitability was rated with 3.63 which is interpreted as highly acceptable. In addition, the usability of the system is also interpreted as highly acceptable as it was rated with an overall mean of 3.67. Moreover, the system's reliability is rated with a mean of 3.83, and the maintainability with 3.67, which both interpretations are highly acceptable. To conclude, the professionals rated the system as highly acceptable with an overall average of 3.70.

Table IV: Result of Water Sanitation Experts

Criteria	Mean	Interpretation
Functionality	3.67	Highly Acceptable
Reliability	3.50	Highly Acceptable
Maintainability	3.56	Highly Acceptable
Usability	3.78	Highly Acceptable
Total	3.63	Highly Acceptable

Table 4 shows the result of the evaluation done by Water Sanitation Experts. The system's functional suitability was rated with 3.67, which is interpreted as highly acceptable. Additionally, the usability of the system is also interpreted as highly acceptable as it was rated with an overall mean of

3.78. Furthermore, the desalination system garnered a mean of 3.5 for reliability and 3.56 for maintainability, which both verbally translated to highly acceptable. All in all, the water sanitation experts rated the desalination system as highly acceptable with a weighted mean of 3.63. Table 3 shows the Summary of the Evaluation done by Water Sanitation Experts. The system's functional suitability was rated with 3.67, which is interpreted as highly acceptable. Additionally, the usability of the system is also interpreted as highly acceptable as it was rated with an overall mean of 3.78. Furthermore, the desalination system garnered a mean of 3.5 for reliability and 3.56 for maintainability, which both verbally translated to highly acceptable. All in all, the water sanitation experts

Table V: Survey result for Users

Criteria	Mean	Interpretation
Functionality	3.90	Highly Acceptable
Usability	3.78	Highly Acceptable
Total	3.84	Highly Acceptable

Table 5 shows the Summary of the Evaluation done by the end-users. The system's functionality was rated with 3.9 which is interpreted as highly acceptable. Moreover, the usability of the system is also interpreted as highly acceptable as it was rated with an overall mean of 3.78. To conclude, the experts rated the system as highly acceptable with an overall mean of 3.84.

V. Conclusion

The developed system garnered an average of 3.73 for the criteria of functional suitability from the Water Sanitation Expert, IT Professional, and Users. On the other hand, the device accumulated an average of 3.74 for the criteria of usability. Moreover, the garnered mean for the reliability criteria from both the IT professionals and water sanitation experts is 3.7, followed by maintainability with an average of

3.61. All of these values fall in the interpretation of highly acceptable. In terms of accuracy, precision, and recall the system shows very promising results, with this the concluded that the system will be a great help in water filtration and can be improved a lot in the future. The research objective was to develop a device that will convert saltwater using thermal desalination and other filters into potable water and develop an analysis system using a logistic regression algorithm to verify the water's potability. The result from the survey that was conducted has proven that the system was able to desalinate saltwater and verify its potability using the water potability analysis. In conclusion, the objectives of the research "Thermal Filtration Water Potability Analysis Via Logistic Regression Algorithm" were met. This endeavor of finding another source of drinkable water was deemed a success.

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