Aqua-Tech Purifier

STEM OCTOBER 11th DISTRICT

| Abdelrahman Waleed | Anas Ashraf | Moaaz Alaa | Omar Ahmed |

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ABSTRACT

At the current time, Egypt suffers from several different problems called EGYPT Grand Challenges. One of the most important of these problems is the problem of water pollution. So, we were challenged to purify polluted water through three different stages of filtration. The chosen water is the house's sink drain water to make it suitable for a certain application. After research, the most effective solution was chosen, which is purifying the water biologically, chemically, and physically. At the beginning of the water cycle in the filter, there will be a pre-filter to prevent large objects from passing through. The first biological stage will be moringa seeds which will be mixed with the water to reduce the turbidity, the second chemical stage will be activated carbon from coconut shells to decrease the salinity and ph., and the final physical stage will be Electrolysis. The filter was designed to be capable of handling the three stages, along with a complete system to transfer water from one stage to another after being filtered with a specific amount in a certain period of time, using Arduino, water pumps, and hoses. The system will only allows the water to exit if it meets the chosen threshold. Otherwise, it will repeat the cycle of filtration at least 5 times. We were required to balance the levels of three pollutants in the water to bring them back to their natural levels. The pollutant levels in the water were adjusted to become suitable for agriculture after five filtration cycles, and the pH level was balanced from 5 to 7.1, the salinity from 1228 to 250, and the turbidity from 100 to 15 within a period of 50 minutes. **The energy consumed by the prototype =** 144000 **joules .**The prototype achieved TDS of **166** mg/L ± **2** mg/L and has efficiency = **79 %** $\pm$ **0. 64 ,** reduce the turbidity of the wastewater from **100** to **15** with efficiency **85±0.5%,** make the water nutralize and provide the PH from **5** to **7.1.**

INTRODUCTION

Deteriorating economically, environmentally, and socially, Egypt has reached a critical point in solving its grand challenges. Five challenges have concerned Egypt: Recycle garbage and waste for economic and environmental purposes, Addressing and reducing pollution fouling our air, water, and soil, Improve uses of arid areas, Manage and increase the sources of clean water, Increase the industrial and agricultural base of Egypt. All these five challenges are related to this semester's capstone challenge. The capstone challenge in this semester is making a treatment for wastewater in a closed-cycle system by using at least three different stages (physical or chemical, biological…..) and pass through these stages by at least five cycles. The wastewater must be treated from three parameters (salinity, PH, turbidity…) but the main parameter is salinity. Salinity of the wastewater must be at least 1000 ppm, and we must reduce it to a value less than 500 ppm. the population has been growing rapidly, but water sources haven't. The per capita water share has decreased from 4000 cubic meters in the 1800s to less than 1000 cubic meters in 2015, which is less than the water poverty line .so, If the problem is solved: Access to clean water will improve, especially in rural areas. Diseases transmitted by contaminated water will decrease. Agricultural productivity will increase as treated wastewater can be reused for irrigation. However, if the problem is left ignored: Water pollution will increase, contaminating rivers, canals, and groundwater sources. spread of diseases like cholera, typhoid, and diarrhea. Agricultural land may become damaged, especially if polluted water is used for irrigation. There were many attempts to solve this problem. One attempt was at the **New Cairo Wastewater Treatment Plant**. It was Egypt's first public-private partnership, and it aimed to expand the usage of freshwater. This plant uses a pretreatment, mechanical, biological, and physical processes to treat the water. **The decrease of Nile pollution and sustainability is two of the project's** strengths. On the contrary, its construction **required high costs, and it has a low water capacity of only 312 thousand cubic meters every day**. The chosen water is the house sink drain. Moringa seeds, activated carbon and electrolysis were chosen to solve this problem. Moringa seeds have natural coagulation properties and ability to reduce turbidity. Activated carbon, a highly adsorptive material that removes organic compounds, odors, and helps in pH balance. Electrolysis, an efficient chemical method that reduces salinity by breaking down salts in water.

MATERIALS

Item	Usage	Amount	Source	Image
Plastic Box	Container of the filters	3	Plastics store	
Moringa seeds	To reduce turbidity	100gm	Herbalist	
Silicon hose	Transfer water between filter phases	4 meters	Electronic store	
Arduino Uno	Embed software with hardware	2	Electronic store	
Gauze	A pre filter	2 rolls	Pharmacy	
Active Carbon & Organza bag	Activated carbon (cocoonut shells) was put in organza bag to neutralize water and reduce organic matters	200 gm 4 bags	Recycled Gift shop	
H-Bridge	Controlling pumps	2	Electronic shop	
Water pump	Pump water to transfer through hoses	4		
Carbonic rods	To be used in Electrolytic cell	2	From old battery	
Bread board& Jumpers& crocodile	Connecting different devices	1 board 15 jump. 2 Croco.	Electronic store	
Dc motors & 3d printed fans	Stirring and mixing water with moringa seeds	2 motors 2 Fans	Electronic store 3d printer	

Table.(1)

METHODS

There are 4 main phases that have been followed to construct the prototype :

The First Phase was the Moringa seeds:

-The **first** step was fixing the gauze on top of the first box to make the pre filter that filters large particles as shown in figure (1)

-The **second** step was grinding Moringa seeds and filter the non-grinded particles with the sieve as shown in figure (2)

-The **third** step was mixing grinded Moringa seeds with water to put it on the wastewater to start filtration as shown in figure (3)

Fig.(1)

Fig.(2)

Fig.(3)

The second main phase was the activated carbon:

-The **first** step was activating the carbon found in coconut shells physically by heating the shells in the muffle furnace at 500 C for 15 min then soaking the resultant powder in ZnCl2 for 12 hours then washing the solution from ZnCl2 by water then heating the resultant in muffle furnace at 350 C in 15 min to form the powder as shown in figures (4)(5)

Fig.(4)

Fig.(5)

-The **second** step was putting the powder in the organza bag then fixing it in the hose as shown in figure (6)

Fig.(6)

The third phase was the electrolytic cell to reduce the salinity by doing a reaction: $(2H_2O \rightarrow 2H_2 + O)$

-The first step was extracting the carbon rods found in old batteries to be used as cathode and anode in the electrolytic cell

-The second step was connecting it with crocodiles to the power supply and fixing it in the box

The fourth phase was the circuit for controlling the system:

- By using Arduino uno and 2 motor drivers to control the activity of the water pumps. As shown in figure (7)

Fig.(7)

TEST PLAN

Testing the prototype should pass **through 3 steps** to get the best readings and highest efficiency:

-The **first** one is testing the salinity parameter and how the prototype will reduce it to meet the design requirements, salinity should be filtered by electrolytic cell, it will be tested by TDS sensor in the beginning of each cycle.

-The **second** on is testing the PH parameter which will be neutralized by the activated carbon, it will be tested by using PH sensor at the beginning of each cycle

-The **third** one is testing turbidity that will be filtered by Moringa seeds, it will be tested using Turbidity sensor

RESULTS

After doing all the methods and the test plan, there were Negative and Positive results:

Negative results:

There were some negative results before achieving the positive results due to mistakes made during the construction of the prototype and test plan:

– A high concentration of Moringa powder was added without doing research on the optimum concentration, leading to the turbidity of water after the first process, **we solved this problem** by searching about the best amount of it and we put a small spoon on half liter of water.

– When the system was turned on for the first time, there was a wrong in a code for Arduino and the water pump push the water to the three stages for one cycle only and didn't complete, **we solved this problem** by correcting the code on the Arduino.

– The activated carbon was put directly in the water, which make the water pump clogged, **we solved this problem** by putting the activated carbon in an organza bag as shown in figure (8) .

Fig.(8)

Positive results:

After solving the issues that were producing the negative results, positive results were achieved.

- For the first design requirement, water quality, the moringa seeds able to reduce the turbidity of the water, the activated carbon able to make the water neutralize, electrolysis able to reduce TDS. the results after 50 minutes are as shown in table (2)

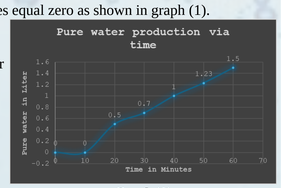
Water parameter	Inlet	Outlet	Removal Efficiency
TDS	**1228**	**250**	**79 % ± 0.64**%
Turbidity	**100**	**15**	***85±0.5%***
PH	**5**	**7.1**	-

Table.(2)

– The amount of pure water produced after 10 minutes equal zero as shown in graph (1). But, after 50 minutes the three stages (moringa seeds , activated carbon , electrolysis) of the filter were able to produce **1.5** liter of pure water to use it in the agriculture and irragation.

– Our project can be used for a long time because it is easy to refix it and change the filters inside it.

- The removal efficiency was calculated using the formula: efficiency = 1 - $(\frac{outlet}{inlet})$ $*$ 100

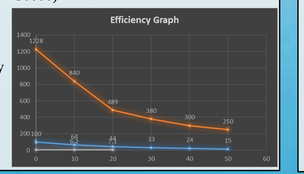


Graph.(1)

- **The energy consumed by the prototype =** Potential * Current * Time = (12 * 2 * 30000) + (12 * 2 * 30000) = 144000 **joules** .

Comparing to the design requirements:

The prototype achieved TDS of **166** mg/L ± **2** mg/L and has efficiency = **79 %** $\pm$ **0. 64 ,** reduce the turbidity of the wastewater from **100** to **15** with efficiency **85±0.5%,,** make the water nutralize and provide the PH from **5** to **7.1** as shown in grarh (2)



Graph.(2)

ANALYSIS

Laws and Theories

The laws that were used during building and testing the prototype:

- Calculation of the energy consumed:

1-Power = electric potential *electric current

$\sum$ Watt =$\sum$ volt * $\sum$ ampere. (As mentioned in fig.9)

- Calculation of the efficiency:

2-Efficiency = (1- $(\frac{filter_{out}}{filter_{in}})$)*100

- Calculation of the flow rate:

3-Flow rate= $\frac{Volume\ of\ water}{time}$

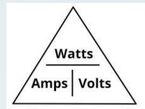


Fig.(9)

Trial.1 (Failed)

- The first trial for the prototype didn't come with positive results:

The power supply which was only 9v wasn't sufficient to power the 4 pumps and the other circuit's components.

- This problem was solved by using a DC Adaptor that supplies 12v and 2A to be able to power the whole system.

Trial.2 (Partially failed)

- The problem of the power supply was solved but:

The pumps couldn't afford to pump the water after adding the sensors on the same power supply. As the power supply had a huge load on it.

- This problem was solved by using a separate power supply for the **(electrolysis stage and the sensors)** .

Trial.3 (Succeeded)

- This trial came up with promising results:

Stage one: The moringa seeds to reduce the turbidity

This graph shows the output data of the turbidity sensor:

It shows the turbidity's concentration via time

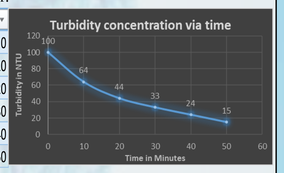
The efficiency = 85±0.5%

Fig.(10)

Fig.(11)

Turbidity	Time
100	0
64	10
44	20
33	30
24	40
15	50

Table.(3)



Graph.(3)

Stage two: The Activated Carbon and the reduction of the salinity (TDS)

This graph shows the output data of the TDS sensor:

It shows the Salinity's concentration via time

The efficiency = 79 ±0. 64%

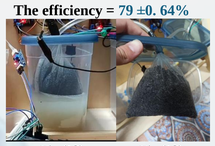
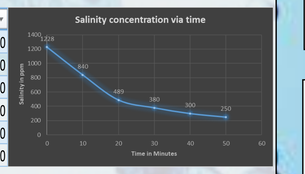


Fig.(12)

Fig.(13)

TDS (Salin	Time
1228	0
840	10
489	20
380	30
300	40
250	50

Table.(4)



Graph.(4)

Stage three : The electrolysis and the Ph.

This graph shows the output data of the Ph. sensor:

It shows the Ph. via time

Fig.(14)

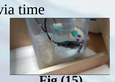


Fig.(15)

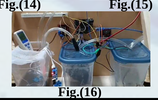
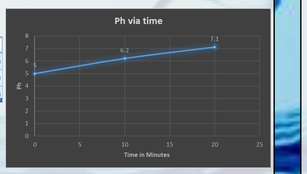


Fig.(16)

Ph	Time
5	0
6.2	10
7.1	20

Table.(5)



Graph.(5)

Learning Transfer

Subject	Connection
Chemistry Lo.8	It helped us in making the electrolysis stage
Mechanics Lo.5	It helped us in calculating the power used by the system
Computer Science Lo.5	Developing a mobile application to display the output data of the sensors
Biology Lo.9	The hormones feedback system is familiar to the sensor feedback system
Physics Lo.9	Studying the back E.M.F of the water pump motor

Table.(6)

CONCLUSION

(Things that start well ends well)

The project was concluded in the following points:

Many obstacles have been faced by Egypt on its way to becoming a developed country. Egypt's grand challenges, one of which is water pollution, are commonly referred to as the problems faced by the country. An attempt to solve this problem was made through a project in which recycling the water using three stages of purification, which are the moringa seeds, activated carbon, and electrolysis.

After finishing the project, we have done several tests and we ended up with the following results:

The water was purified through three different stages of filtration (chemically, physically, and biologically) using Moringa seeds, activated carbon, and ionization.

The levels of the three pollutants in the water were reduced, reaching the following rates: pH (from 5 to 7.1) Salinity (from 1228 to 250) Turbidity (from 100 to 15).This was achieved after five purification cycles within a period of (50 min).

With that, the design requirements have been fulfilled from all aspects, contributing to solving the problem of water pollution, after comparing our results with the prior solutions that we searched about, we found that our project is so close to what we have searched about and what we have taken as a role model. Also, in the prior solution we found that most of them pollute the environment, so we used recycled materials in order not to pollute the environment.

RECOMMENDATIONS

- Using the water after treatment in agriculture of non-food crops **(chosen application)**
- Increasing the voltage in the electrolysis stage will increase its efficiency
- Changing the activated carbon particles periodically after the end of the 5th cycle as it will be polluted
- Passing the water into a filter paper before entering the purification system to remove large pollutant
- Periodically cleaning and changing the tubes of the system after it is polluted
- Cleaning the air pumps from the large particles that clogs the pump.
- Using esp8266 rather than the Arduino uno for higher efficiency and respond
- **Scale-Up for Real-World Application**
  It is recommended to design larger-scale prototypes to evaluate the filter's effectiveness in real-world conditions, such as in households or rural areas lacking access to clean water.

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Mr/ Mostafa Ahmed (Cap teacher at STEM OCT 11th district school)

Mrs/ Zeinb Nassar (Chemistry teacher at STEM OCT 11th district school)

Mr/ Ahmed Sorror (Chemistry teacher at STEM OCT 11th district school)

FOR FURTHER INFORMATION

Abdelrahman.2923002@stemoctober2.moe.edu.eg

Anas.2923018@stemoctober2.moe.edu.eg

Moaaz.2923040@stemoctober2.moe.edu.eg

Omar.2923051@stemoctober2.moe.edu.eg