The Hematic Harvest

Group 225

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Introduction

This term, we addressed one of Egypt's pressing environmental problems: slaughterhouse wastewater treatment. Such wastewater is highly problematic due to its high salinity, fats, and organic load, which account for a large percentage of water pollution and present severe threats to public health and the environment. Our main objective was to design a system of water purification that would reduce salinity to below 500 ppm and eliminate a high proportion of organic material and fats as well. Achieving this would make the treated water safer for potential reuse and reduce the environmental pollution caused by such wastage.

In an attempt to tackle this challenge, we investigated several low-cost and sustainable ways of tackling this challenge, including the use of activated carbon, biochar, natural coagulants, and simple filtration systems. We then employed the Engineering Design Process (EDP) to design our research, system design, construction, and testing after selecting the most suitable approach. Every step of the project was documented in our portfolio, such as the materials we used, challenges we faced, and solutions we reached as a team. Our work is one step closer to creating realistic solutions to Egypt's water pollution problem, driven by innovation, teamwork, and a shared vision for a cleaner, greener future.

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Chapter 1

- Egypt Grand Challenges
- Problem to be solved
- Research
- Other Solutions Already Tried

Egypt Grand Challenges

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11 Egypt Grand Challenges

Recycle garbage and waste for Economic and Environmental purposes

Egypt suffers from the problem of the proliferation of garbage because of the succession of several governments, and the absence of the principle of reward these governments, and the absence of the principle of reward experts to make a point of the garbage problem. This garbagecan be turned into a blessing by recycling operations.in the greater Cairo: solid waste management is a huge challenge. This city produces more than 15,000 tons of solid waste everyday which is putting tremendous strain on city’s infrastructure. Only 60 percent of the waste produced in Cairo is collected, of which less than 15 percent is properly recycled or reused. A big portion of the waste is released untreated into canals, rivers or streets and open areas which causes a burden on water, soil and air, as well as having a negative impact on the economy and tourism. The recycling operations are available in many countries, such as China, which is keento import solid wastes such as plastic from Egypt and the other poor countries. For making these operations. The awareness of the citizens is required in order to be the mobilization of garbage. The recycling operations can be in many forms. Such as the distribution of differentcolors for garbage bags to homes for the classification of glass, paper, plastic and metals as shown in figure. The Economic size can be increased from the garbage in Egypt. From the Egyptian Ministry of the Environment Report, issued in 2011, which showed that only resultingfrom the uses of the houses of solid waste volume amounting to an annual 21 million tons, which means that the average daily production of solid waste of 58 thousand tons, in While whatis recycled from the waste does not exceed 20% of them. The report confirms that recycling operations are in accordance with the health and environmental conditions. As for agricultural waste, the report indicates that it is about 52 million tons per year, and that what is recycled which less than 15%. The report states that in the event of recycling 50% of agricultural residues, Egypt will get a set of annual economic returns, including access to energy“biogas" the equivalent of 2.6 million tons of oil, and about 19.8 million tons of manure, and one million tons of fertilizer superphosphate, and about 541 thousand tons of ammonium nitrate fertilizer.

Fig. (1)

Recycling can benefit our community and economically as shown below andenvironmentally as follows. it:

The Economic Benefits

- solve the problem of employment
- save clients tons of money and upgrade electronic services
- extracting valuable materials and increase profitability

- Reduces the amount of waste sent to landfills and incinerators.
- Conserves natural resources such as timber, water, and minerals.
- Prevents pollution by reducing the need to collect new raw materials.
- Saves energy.
- Reduces greenhouse gas emissions that contribute to global climate change

Address and reduce pollution fouling our air,water and soil.

What is pollution: it is the process of making land, water, air or other parts of theenvironment dirty and unsafe or unsuitable to use. In other words, pollution is the addition to the ecosystem of something which has a detrimental effect on it.

The Air pollution

It is the most prominent and dangerous form of pollution.It occurs due to many reasons such as:

1) Excessive burning of fuel is a necessity of our dailylives for cooking, driving and other industrial activities.
2) Releases a huge number of chemical substances which are so dangerous in the air every day.
3) Smoke from chimneys, factories, vehicles or burning ofwood basically occurs due to toxic coal burning. It has many effects like: Release of Sulphur dioxide and hazardous gases into the air causes globalwarming and acid rain, which in turn have increased temperatures, erratic rains and droughtsworldwide.

To reduce air pollution, there must be less amount of fossil fuel burnt, and conserve electricity as it’s often produced by burning fossil fuels.

The water pollution

Most water pollution doesn't begin in the water itself, but around 80 percent of ocean pollution enters our seas from the land, and it causesfrom: Sewage, Nutrients, Chemical waste, radioactive waste, Oil pollution, etc. And it has many of bad effects like the death of aquatic organisms, disruption of food-chains and hurt the human with many diseases like: Hepatitis A, Lead Poisoning and Malaria.

Fig. (2)

To reduce the water pollution, by reducing plastic waste, reduce air pollution which causes acid rains to pollute water reservoirs with heavy metals.

The soil pollution

Soil can be polluted by many reasons such as accidental leaking of harmful chemicals for the soil during transportation, mining activities, using pesticides and fertilizers in agricultural activity and dumping waste illegally, which will damage the soil and maybe leak to the underground water and pollute it and pollution. will be transferred from the underground water into a water reservoir such as oceans or rivers by aquifers resulting in polluting air also by evaporating this polluted water. Soil pollution will lead to degrading the rich of minerals in the soil and reduce food crop production which will lead to many more problems.

To reduce soil pollution, we should have strict laws to prevent dumping waste and recycling it, reduce chemical fertilizer and stop deforestation as the roots of plants can hold the soil together.

Fig. (3)

Fig. (4)

Radioactive pollution

The radioactive pollution is mostly caused by the radiation thatcomes from nuclear plants, uranium mining and nuclear weapons, or other nuclear industries that can have a long-range effect on an environment both locally and hundreds of miles away from the original contamination site.

The Effect: the radioactive has a very strong effect in the environment (the soil, the water and the air) and it has a deadlyeffect in the humans body.it makes the plants poisoned. Makesthe air clean. Make the creature in the water dead.

Fig. (5)

Improve Uses Of Arid Areas

Arid areas cover 47% of earth's land surface. Human impact in arid and semiarid lands has led to soil degradation through Salinization, waterlogging, and wind erosion and has entailed desertification now. Aridity results from the presence of dry, descending air. Therefore, aridity is found mostly in places where anti cyclonic conditions are persistent, as is the case in the regions lying under the anticyclones of the subtropics.

Fig. (6)

"In selected areas of other arid and semi-arid regions in the world clearly show the importance of studying the environmental impact of irrigation practices on water and soil quality. Studies mainly refer to waterlogging and salinization. As regards agrochemicals, fertilizers have been considered through nitrate leaching. The impact of micropollutants such as pesticides and heavy metals on water and soil quality is studied mainly by modeling. Pharmaceutical compounds emerge as pollutants when wastewater is used for irrigation without any previous treatment, situation which is now the object of new studies. There is an obvious need to study in-depth knowledge related to appropriate technologies for the use, treatment, and reuse of wastewater which is a valuable resource in arid and semi-arid regions." (Fernández-Cirelli , 2009)

Regarding agricultural and forestry related issues, the development of standards for exported goods which incorporate the environmental impacts of products would help reduce the market for unsustainably produced commodities. Engagement of the auto-industry which principally imports leather from Latin American arid lands is critical. The use of supply-chain tracking technologies and sustainability mandates can ensure that they are no longer responsible for the clearance of further natural areas.(Alishir Kurban,)

In addition, renewable technology like desert solar-powered water pumps can make desert farming more productive and viable. Urbanization of desert areas for human settlement can also reduce pressure on Nile Valley by spreading population concentration more evenly. Proper utilization of arid land can promote food security, economic progress, and environmental sustainability. Egypt must invest in research, technology, and infrastructure to unlock the potential of its deserts while protecting the environment and preserving resources.

Fig. (7)

Fig. (8)

Manage And Increase The Sources Of Clean Water.

Definition: Water can be considered as the most important natural resource that can be utilized by man to develop his prosperity as well as his essential needs. Water quality management, water pollution control and environmental protection are the main issues to preserve living conditions for the future.

Fig. (9)

Water is a fundamental human need. Each person on Earth requires at least 20 to 50 liters of clean, safe water a day for drinking, cooking, and simply keeping themselves clean.

Why should we increase resources of water?!

- ♣ Every organism on earth needs water to live.
- ♣ It minimizes the effects of drought and water shortages
- ♣ It guards against rising costs and political conflict
- ♣ It makes water available for recreational purposes.
- ♣ It builds safe and beautiful communities.

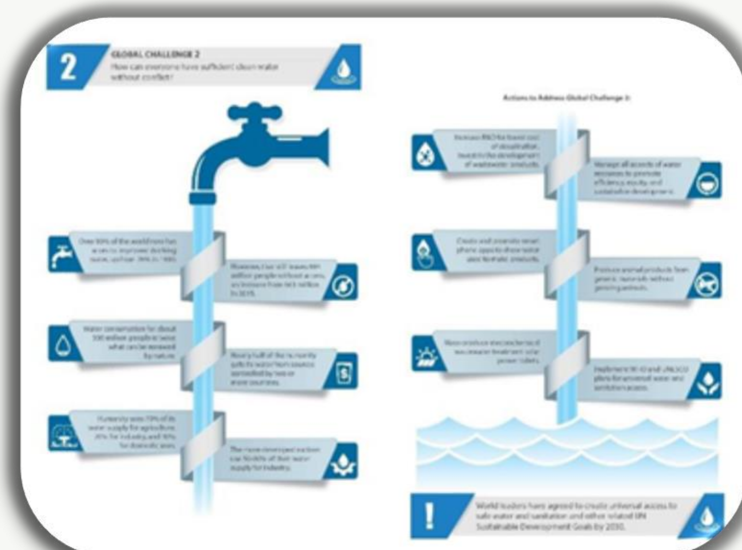

Fig. (10)

Ways to manage water resources:

♣ By increasing supply: Through storage in dams; diverting water from excess areas to scarcity areas through link waterways; artificially recharging ground water; desalinating sea water; towing icebergs from the Antarctic to water scarcity regions; controlling pollution and reclaiming polluted water through recycling; and cloud seeding.

Fig. (11)

♣ By reducing degradation: Devising methods for controlling/reducing evaporation losses in irrigation; using better drainage in irrigated agriculture to reduce soil salinization.

♣ By reducing waste.

♣ Save water at home.

Although Egypt's got a lot of sources of water, there is a big danger of water thirst in the few next years due to the continuous population increasing with the same amount of water. The most important resource of water in Egypt is Nile River.

Some major factors playing havoc with water security in Egypt:

♣ Uneven water distribution.

♣ Misuse of water resources.

♣ Inefficient irrigation techniques.

♣ The rapid population.

♣ More water requirements for domestic consumption.


Fig. (12)

♣ Increased use of irrigation water to meet higher food demands.

Increase The Industrial And Agricultural Base Of Egypt.

Industrial and agricultural base expansion of Egypt is a vital grand challenge that will directly impact the economic growth, employment opportunities, and national sustainability of the country. Egypt's economy has long been dependent on the services and tourism sectors, but industry and agriculture development are at the core of long-term growth and resilience.

Industrial Base Expansion

To enhance the industrial sector, Egypt must invest in vocational training, technology, and infrastructure. Developing local manufacturing capabilities, especially in sectors such as textiles, construction materials, electronics, and renewable energy can reduce import dependence and increase exports. Industrial parks, logistics hubs, and public-private partnerships can attract foreign investment and stimulate innovation. Additionally, the adoption of green and energy-efficient technologies can deliver sustainable growth.

Fig. (13)

Agricultural Base Strengthening

In agriculture, enhancing production through new technologies such as precision farming, greenhouse farming, and the use of treated wastewater can help address food security and create rural employment. Improving irrigation efficiency, soil fertility, and investment in agricultural research will enhance productivity. Moreover, integrating agro-industries with agriculture like food processing can create value-added agricultural output and create new markets.

Fig. (14)

Industry is a gauge of economic progress and industrial sector occupies a high degree of importance in the Egyptian economy where industry plays a major role in providing employment, opportunities and reduce unemployment. The problems of industrial environment include the emission of gasses from plant smokestacks and the dumping of waste liquid factories in waterways, the surplus cost of energy sources Also we have another big challenge that egypt face it ’s “Agriculture” it ’s one of the Egyptian sources of the income.it considers in Egypt is the mainstay of the economic and social stricter. in agriculture farmers engage directly by preparing soil, planting crops, harvesting those crops and preparing them for transportation. Agriculture is facing many problems such as desertification, water and soil pollution, climate, decrease in sea so we must solve this problem to make Egypt more effient.

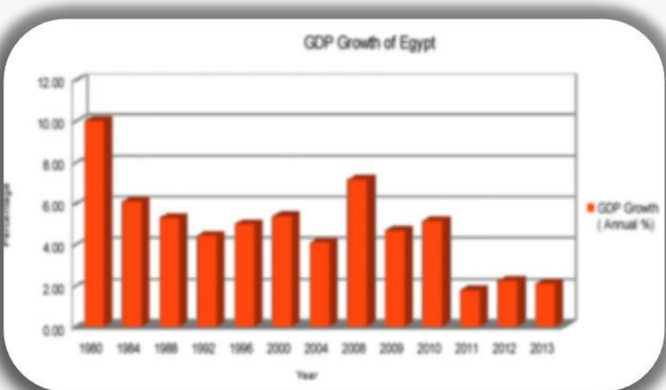

Fig. (15)

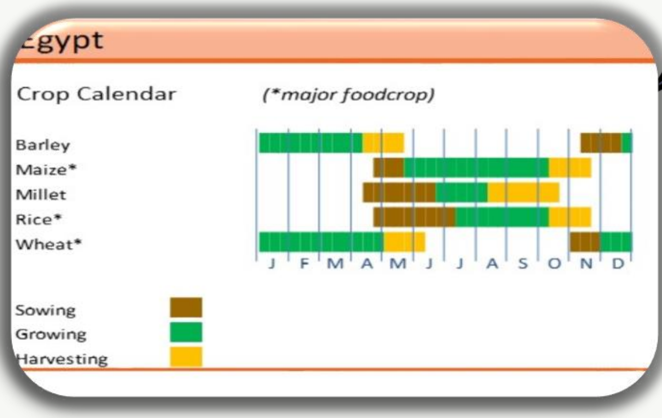

Fig. (16)

In short, by building a strong foundation in industry and agriculture, Egypt can better meet the demands of its growing population, reduce unemployment, and establish a more diversified and independent economy.

Problem

to be solved

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What is the problem that we are addressing ?

Slaughterhouse Wastewater:

Slaughterhouses produce massive volumes of wastewater that are extremely contaminated with organic matter like fats, carbohydrates, proteins, and hydrocarbons. Slaughterhouse wastewater is also regularly contaminated with pathogenic bacteria, viruses, and parasites due to animal processing activities.

If left untreated, slaughterhouse wastewater poses severe health threats to the general public and the environment. It can pollute nearby water sources, undermine soil quality, and pass on hazardous infections to human beings, animals, and livestock. According to the World Health Organization, exposure to untreated animal waste can lead to diseases such as salmonellosis, hepatitis, and other types of gastrointestinal infections (WHO, 2022).

In Egypt, the problem is quite critical due to the presence of many uncontrolled or badly managed slaughterhouses both in and out of the cities. Wastewater typically ends up going directly into canals, farms, or sewer systems without treatment. This pollutes irrigation water, not just undermining the safety and quality of the crops but also introducing pathogens into the food supply chain.

Additionally, the breakdown of organic matter in slaughterhouse waste results in the release of pungent odors and greenhouse gases like methane and ammonia, further contributing to environmental degradation and climate change.

To sum up, Slaughterhouse wastewater is a key public and environmental health problem in Egypt and worldwide. Its complex composition of infectious pathogens and organic pollutants makes it one of the most challenging wastes to treat, and therefore an extremely urgent concern of identifying new, effective, and sustainable wastewater treatments.

Research

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The purpose of research is to inform action. Thus, the study should seek to contextualize its findings within the larger body of research. Research must always be high quality in order to produce knowledge that is applicable outside of the research setting with implications that go beyond the group that has participated in the research.

Furthermore, the results of the study should have implications for policy and project implementation. Gaining experience, knowing more facts, exploring more viewpoints and getting knowledge quickly are the benefits of the research. Therefore, we searched for every topic we will benefit from in our project to determine and understand the Challenge we are facing to solve and then be able to define and making a solution thatcould be affective in the Egyptian society.

Table.(1)

Topic	**Related to**	**Lessons That We Learned**
Egypt Grand Challenges	Related to the problem	We learned about Egypt's critical issues like water scarcity, pollution, and population pressure on water resources.
Water scarcity in Egypt	Related to the problem	Egypt is below the water poverty line; urgent need for sustainable water management.
Slaughterhouse wastewater	Related to the problem	This type of wastewater contains harmful pathogens and chemicals that contaminate water bodies.
Industrial waste discharge	Related to the problem	Unregulated dumping worsens pollution and increases treatment costs.

Public health risks	Related to the problem	Contaminated water leads to diseases such as cholera, hepatitis, and other infections.
Climate change impact	Related to the problem	Reduced rainfall and rising temperatures affect freshwater availability.
Population growth	Related to the problem	Higher population increases water demand and strain on existing purification systems.
Water purification techniques	Related to the solution	We learned about chemical, biological, and physical methods to purify polluted water.
Filtration systems	Related to the solution	Techniques like sand filters, activated carbon, and membrane systems are effective in treating wastewater.
Natural purification	Related to the solution	Constructed wetlands and reed beds use plants to filter wastewater naturally.
Reusing treated water	Related to the solution	Treated wastewater can be reused in irrigation, reducing freshwater consumption.
Recycling and awareness	Related to the solution	Community involvement in recycling and water conservation leads to better water security.

Other Solutions Already Tried

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1) Anaerobic Digestion Systems, India:

Anaerobic digestion systems have been implemented in slaughterhouses across many parts of India, primarily Gujarat and Maharashtra. These systems break down organic matter (e.g., blood, fats, and proteins) in the absence of oxygen to produce biogas that can be used as energy.

Strengths:

I. **Energy Production:** The treatment process converts slaughterhouse waste into biogas (methane), which can be used to generate electricity or heat, waste being converted into an energy resource.

II. **Pathogen Reduction:** The digestion process reduces pathogens considerably, eliminating the risk of disease transmission by untreated wastewater.

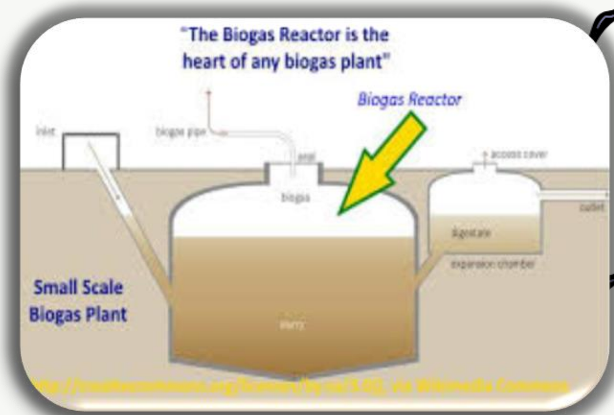


Fig. (17)

Weaknesses:

I. **High Initial Cost and Maintenance:** These systems have high infrastructure costs, and frequent monitoring and maintenance, which can serve as a deterrent for small or unregulated slaughterhouses.

II. **Partial Treatment:** Anaerobic systems may not be able to remove all chemical pollutants or odor-causing substances entirely, so additional treatment stages may still be required.

Fig. (18)

2) Constructed Wetlands, South Africa:

South Africa has utilized constructed wetlands near certain meat processing facilities to treat slaughterhouse effluent naturally. The constructed wetlands mimic the natural process of marsh filtration using plants, soil, and microbial activity to break down pollutants.

Strengths:

- ✓ **Low Cost Operation:** These systems are not overly expensive to sustain — when they are operational, which makes them perfect for rural or poor areas.
- ✓ **Environmentally Friendly:** Constructed wetlands provide habitats for wildlife and purify the surrounding environment as they passively treat wastewater.

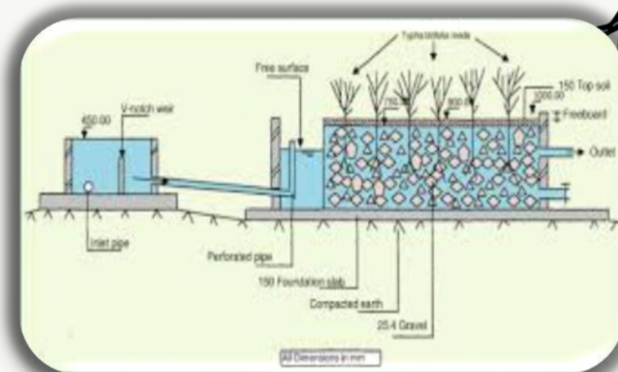


Fig. (19)

Weaknesses:

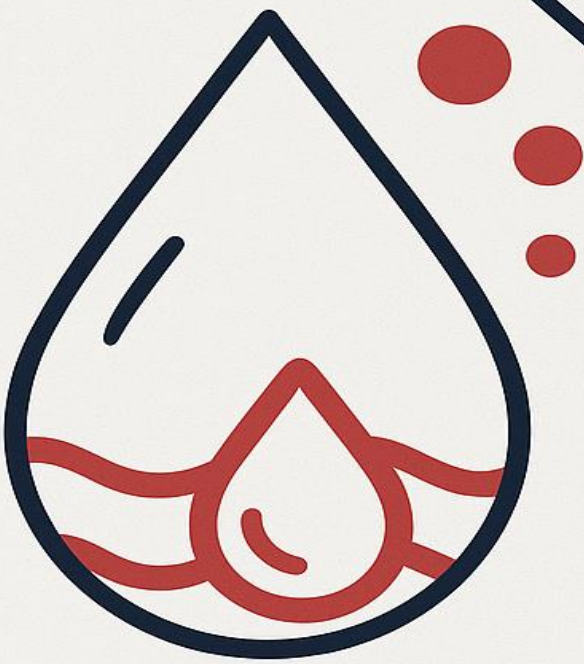
- ✓ **Space Needs:** They require large surfaces of land to effectively function, which is challenging in city or crowded areas.
- ✓ **Slower Processing Time:** These systems will process waste more slowly than mechanical or chemical treatment processes, limiting their uses in high-volume operations.

Fig. (20)

Chapter 2

- Design Requirements
- Solution Requirements
- Selection Of Solution
- Selection Of Prototype

Design Requirements



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Design requirements state the important characteristics that our design must meet in order to be successful. The design requirements for our project will differ fromthose of anyone else, because ours will apply to our specific problem statement and the product, system, or experience that we are designing. Our requirements will bemore specific and directly related to meeting the needs of our project's users. In our project, we should consider some design requirements to guarantee the success of the project, and here are some of design requirements that we are focusing on:

1. **Sufficient Sample Volume**
   - ✓ Ensure **enough wastewater** is collected for recycling and data collection.
2. **Water Quality Parameters**
   - ✓ Input wastewater must have **salinity > 1000 ppm**.
   - ✓ Treat **at least 3 parameters** (salinity + 2 others selected by the team).
   - ✓ Base threshold values on **scientific references** and **local application** needs.
3. **Treatment Methods**
   - ✓ Use **3 distinct techniques** from different categories (physical, chemical, biological).
4. **Closed-Cycle Circulation**
   - ✓ Include a **suitable pump** for continuous water flow within a **closed-loop system**.
5. **Smart Flow Control**
   - ✓ Integrate an **automatic two-way gate.**
   - ✓ Redirect untreated water for reprocessing.
   - ✓ Release treated water based on quality readings.
6. **Efficiency Monitoring**
   - ✓ Track treatment effectiveness for **5 cycles** of the same sample.
   - ✓ Use **graphical fitting** to predict **system lifespan**.
7. **System Capacity & Performance**
   - ✓ Record **clean water** every **10 minutes for 1 hour**.
   - ✓ Identify an additional **measurable performance factor**.

Solution Requirements

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The Applicability

As we make a solution from an idea, it is hard because that not all ofyour thinking can be applied in our life, we come over of this problem as we chose a solution to solve a problem that we found in our society, so our solution and our prototype is applicable to solve this problem.

Fig. (21)

The Efficiency

Project Efficiency is a ratio to determine the relation between the outputs from a processagainst the resources invested into performance of this project. Project Efficiency can bemeasured by the volume of output obtained per input utilized.

Fig. (22)

In other words, if the outputs are adequate to inputs, then project efficiency is equal to 100%, so in other words the project implementation has been accomplished within the planned constraints (which were identified on the project planning stage, in terms of workforce, cost, time andobjectives) and with the planned outcomes.

The Safety

As we make any design to be a real solution, we should consider safety as the first and most important point that our design requires. Without safety there is no project to build to solve any problem, we should choose a safe way to go on, in order not to cause other problemsthat can't be solved without safety.

Fig. (23)

The Availability

Fig. (24)

The materials of the solution must be available in Egypt, we have to use local materials which are obtainable in Egypt to make use of our national resources and reduce the load on Egypt that we spend too much of our GDP in importing materials, so we are able to find the needed materials in the Egyptian trusted shops such as electronics

The Accuracy

Fig. (25)

The accuracy in results depends on the efficiency of the project. Accuracy is similar to the percentage of solving the problem, we tried to raise it till we reach 100% or the nearest value for.

Constraints:-

Construction Restrictions:

- No manufactured materials are allowed in the stages of your prototype.
- Using old water filters or any of their components is strictly forbidden.

Design & Testing Conditions:

- Your prototype must be fully testable anytime, anywhere.

Safety Compliance:

- Strict adherence to all school safety protocols is mandatory.

Lab Equipment Policy:

- Do not remove any tools or materials from the labs.
- All lab-required tests must be conducted inside the lab.

Selection Of Solution

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From the beginning of our capstone project, we focused on one critical question:

"How can we treat slaughterhouse wastewater in an effective and sustainable manner?"

Following a strict process of brainstorming, scientific study review, and practical requirement assessment, we chose an option to combine physical, chemical, and biological filtration techniques into a closed-loop treatment system. This system was selected due to its ability to handle the complex nature of slaughterhouse waste e.g., high salinity content, COD, offensive odors, and pathogens.

How the System Works:

Our system processes the wastewater in several cycles repeating the cycle five times, a process that brings the water to a state of purification that is safe enough for reuse irrigating trees that are not edible but can still utilize the residual organic matter.

Treatment is undertaken in these primary steps:

Physical Coagulation: The wastewater undergoes the first step in a chamber where the fats and organic particles start sticking together and settling.

Mesh Filtration Screen: Next, a composite mesh made up of organza, gauze, and treated coconut shells filters out fine suspended solids and organic residues.

Resin-Based Salinity Filter: Then, water flows through a natural resin bed that tends to absorb salt and neutralize chemical impurities.

Chlorine Disinfection: Lastly, controlled chlorination destroys harmful pathogenic micro-organisms, bacteria, and viruses.

This is repeated over and over in a closed-loop system, recycling the partially treated water until it has an acceptable level of purity. The final product water, obtained after five cycles of treatment, is clean enough for agricultural reuse, supporting environmental sustainability and reducing water loss.

This solution not only addresses the health and environmental hazards of untreated slaughterhouse wastewater but is also a low-cost, natural, and scalable solution acceptable in nations like Egypt that do not have wastewater treatment facilities.

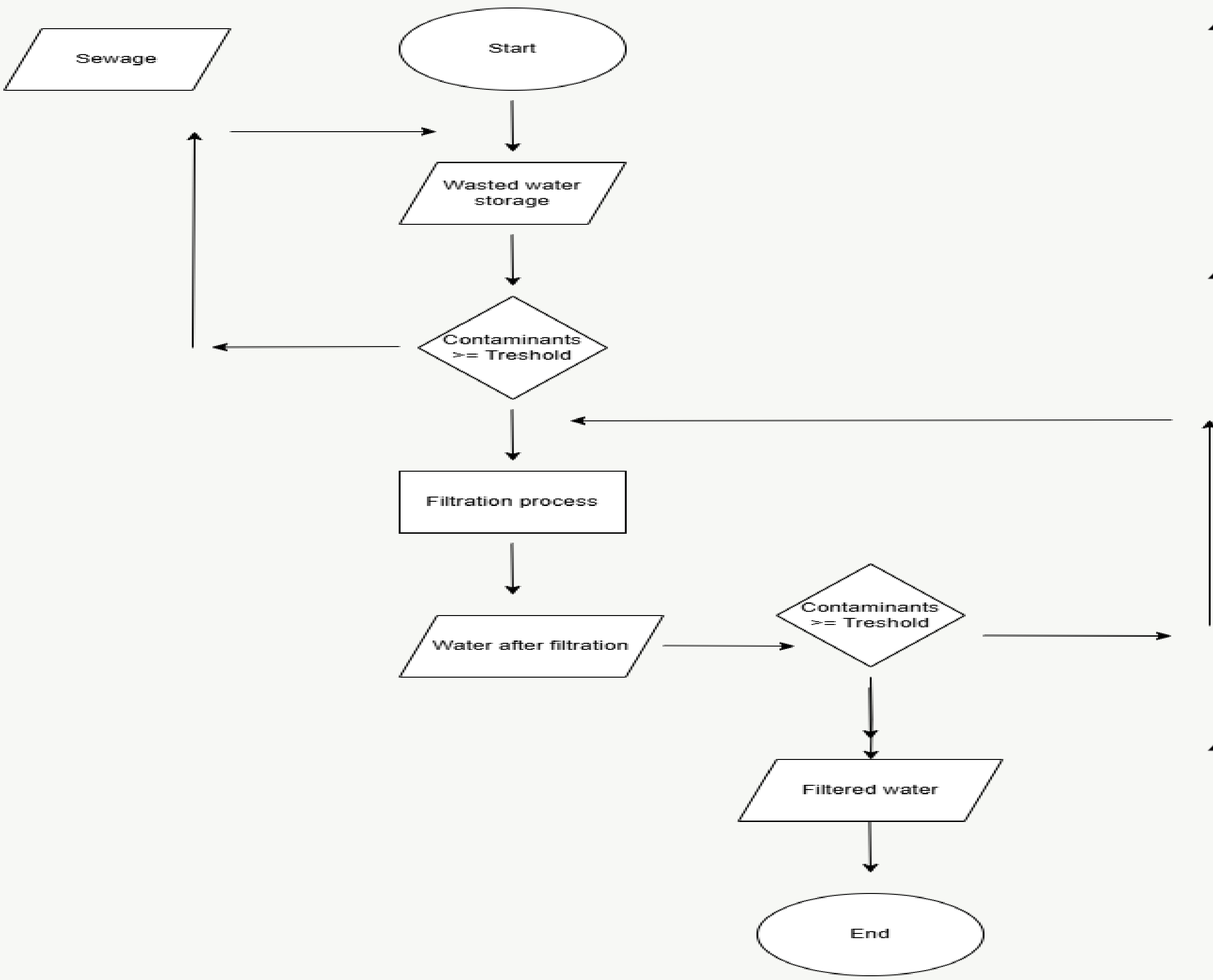

Fig. (26)

Selection

Of Prototype

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After finalizing our solution through research and scientific validation, we moved on to the prototype development phase. Our goal was to build a small-scale but functional model that simulates the wastewater treatment process in a closed-loop system using physical and chemical filtration.

Design Overview:

Our prototype is designed to mimic the sequential stages of slaughterhouse wastewater treatment. It consists of four plastic containers mounted on a custom two-level wooden frame, with two boxes per level. Each container represents a different filtration stage, and the system recirculates water through them in an anti-clockwise direction, starting from the bottom-left container.

Containers:

- ✓ The first container initiates coagulation, breaking down and clumping suspended particles.
- ✓ The second container uses a composite mesh screen (made from gauze, treated coconut shell material, and organza) to filter out solid residues.
- ✓ The third container contains natural resin, which helps in salinity reduction and chemical absorption.
- ✓ The fourth container performs chlorine disinfection, targeting pathogens and odor-causing microbes.

To circulate water across these stages, we used four individual water pumps, each controlled electronically. The entire process runs automatically through a microcontroller-based circuit, which manages timing and flow rates.

Construction Details:

- ✓ The wooden frame was custom-built to securely hold all containers in a stacked layout, ensuring gravity-assist between floors where possible.
- ✓ Transparent plastic boxes were selected for visibility during testing and monitoring.
- ✓ Tubing connects each box in series, and power/control wiring is neatly arranged on a back panel above the setup.
- ✓ The structure is designed to be modular, allowing future improvements or scaling up of individual stages.

This prototype helps us test and demonstrate the core functionality of our wastewater treatment solution, evaluate the effectiveness of each stage, and simulate repeated treatment cycles. After five full loops, the water reaches a quality suitable for irrigating non-edible trees, completing a sustainable reuse loop.

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Chapter 3

- Materials and Methods
- Test Plan
- Data Collection

Materials

And Methods

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The Materials

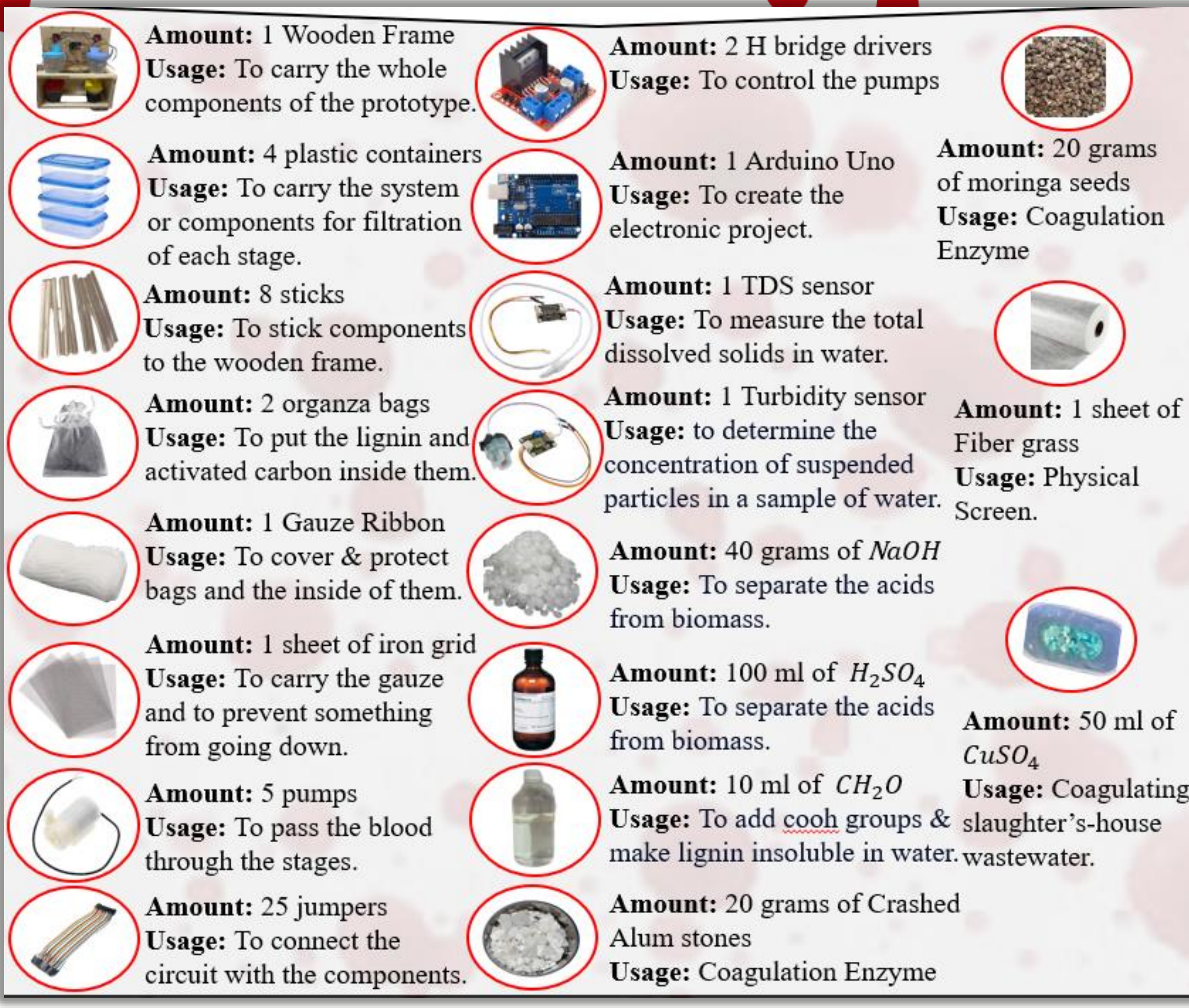

Fig. (27)

The Methods

Stage 1:

Filter Construction Substage 1: Coagulation and Initial Treatment Dissolved 50 g of copper sulphate in 1000 mL of water to make a 0.2 solution. Added 25 g of alum sulphate for coagulation. Added a small amount of moringa seed solution (Figure 28).

Fig. (28)

Physical Filtration Substage 2: Used a mesh made from organza fibers, coconut husks, activated carbon, and recycled fiberglass. Materials sewn into organza sheets (Figure29).

Fig. (29)

Chemical Filtration Substage 3: Used Lignin (Resin) Extracted lignin from 100 g of dried coconut husks in 250 mL of 0.1 M NaOH, heated at 60°C for 2 hours. Added 10 mL of 10% diluted H_2SO_4, stirred, settled, filtered, and washed lignin. Converted lignin into resin: Dried, dissolved in 100 mL water, heated at 60°C for 3 hours. Mixed with 10 mL formaldehyde to introduce carboxyl groups (COOH). Added 10 mL concentrated H_2SO_4 to introduce sulphate groups (SO_4^{2-}).Dried modified lignin(Figures 30 & 31).

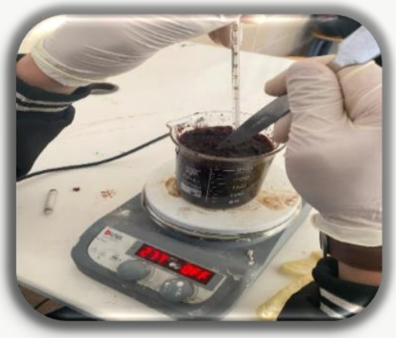

Fig. (30)

Fig. (31)

Disinfection Substage 4: Used sodium hypochlorite (NaClO) as disinfectant

Stage 2:

Prototype Construction: Built a wooden frame with two vertical levels (each: 40 cm x 20 cm x 20 cm).Placed four 1.2 L plastic boxes (two per floor).Installed filters in boxes (bottom left to top left, counterclockwise).Water pumped in a loop through the system. Fifth pump was installed in top left box to release filtered water after 5 cycles.

Stage 3:

Circuit Design Simulated: circuit in Tinker cad or validation. Installed Arduino board; connected VCC and GND lines. Connected two motor drivers to Arduino ,attached to frame. Linked four pumps to motor drivers for operation control. Final prototype included frame, filters, and circuit (Figure 32).

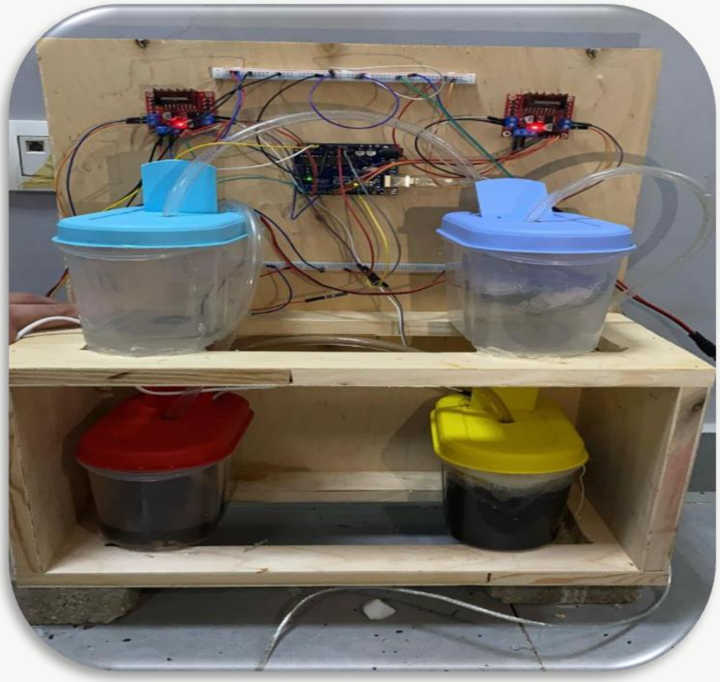

Fig. (32)

Test Plan

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Our test plan divides into many parts and each part should achieve the design requirements that filtrate water in specific time, so we predict some results for each test. So, Our steps that we followed to test the prototype:

1. Verify that the wooden frame (40 cm length, 20 cm width, 20 cm height) is stable, and all parts are securely assembled.

2. Ensure the four filters are placed in the correct order inside the plastic boxes, with proper alignment for water flow.

3. Run water through the prototype and confirm that it flows in the counter-clockwise direction, passing through each Filter stage.

4. Test the mesh screen (organza, coconut husks, activated carbon, fiberglass) to ensure it filters particles effectively without leaks.

5. Check the modified lignin resin in the prototype for its ability to remove Na+, Mg+2, and Ca+2 ions from the water.

6. Verify that sodium hypochlorite (NaClO) is added correctly to the system and visually confirm the water's appearance after disinfection (clearer water, no visible contaminants).

7. Test each water pump to ensure they are working as expected, including the additional pump for water exit after the fifth cycle.

8. Confirm the Arduino and motor drivers correctly control the pumps by testing the circuit setup and connections.

9. Power on the system and monitor to ensure all components (frame, filters, pumps, circuit) work together to filter and circulate water.

10. Run the system continuously for several hours and check the water quality before and after filtration to ensure the system maintains performance.

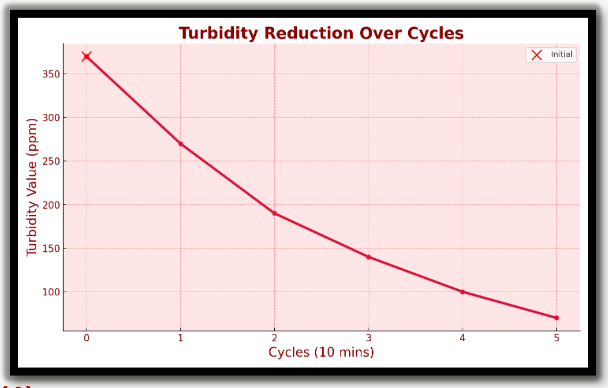
Data Collection

After a long time of research and theoretical work, it was the time for applying the test plan practically:

- **THE TOTAL ENERGY CONSUMPTION :**

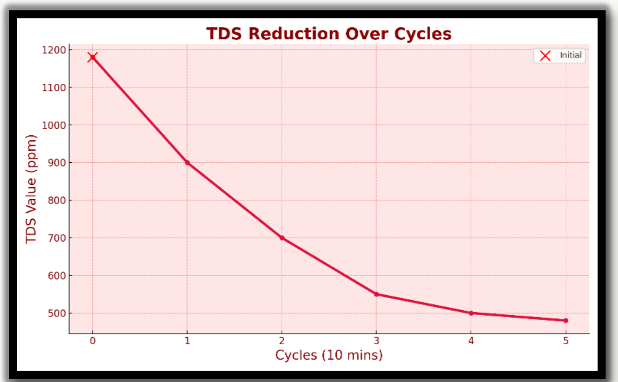
System consumed about **79,200 joules** , or **22wh** per the **5 cycles** of purification.

- **Reading of the Turbidity parameter per each cycle was shown in Graph.(1):**



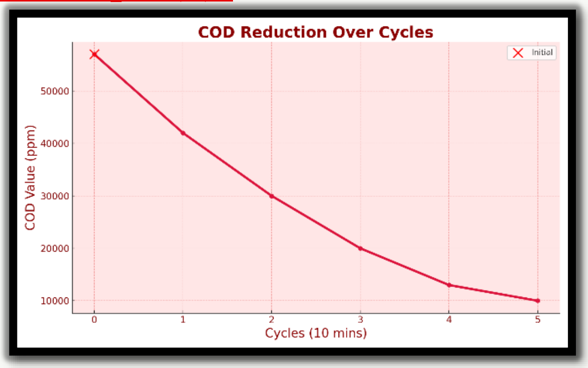
Graph. (1)

- **Reading of the Salinity (TDS) parameter per each cycle was shown in Graph.(2):**



Graph. (2)

- **Reading of the COD (Chemical Oxygen Demand) parameter per each cycle was shown in Graph.(3):**



Graph. (3)

The Readings of each cycle for each parameter as shown in Table.(2):

Table. (2)

_To Sum up, We noticed some points that contains positive and negative results:

1- Turbidity: decreased from **370 ppm** (Cycle 1) to **70 ppm** (Cycle 5).

2- Salinity: dropped from **1180 ppm** to **480 ppm**.

3- Chemical Oxygen Demand (COD): At the first cycle the COD percentage didn't reach the desired value, it reached only 20,000. We fixed that by adding more coagulants reduced significantly from **57,000 ppm** to **10,000 ppm**. The system consumed approximately **79,200 joules** per 5 cycles. Results demonstrate progressive improvement in water quality across all measured parameters over the **five 10-minute** treatment cycles. So, The prototype achieves the design requirements by these results.

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Chapter 4

- Discussion
- Recommendations
- Learning Outcomes
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Discussion

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The filtration prototype was assessed through multiple treatment cycles to evaluate its effectiveness in mitigating environmental and public health risks associated with slaughterhouse wastewater. The wastewater initially exhibited high concentrations of critical pollutants including total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP), turbidity, and salinity. These levels greatly exceeded permissible thresholds for safe discharge or agricultural reuse.

Baseline Contaminant Levels:

- **COD:** 50,000 – 60,000 ppm
- **Salinity:** > 1000 ppm
- **Turbidity:** > 300 ppm

These values were cross-referenced against standard discharge regulations:

- **Safe COD limit: < 10,000 ppm**
- **Salinity for irrigation: < 500 ppm**
- **Turbidity: < 100 ppm**

Performance Metrics After 5 Treatment Cycles:

The treatment sequence (physical, chemical, biological, and polishing) showed cumulative improvements in water quality over five sequential 10-minute cycles:

1. Organic Matter Removal (COD):

- COD reduced from **50,000** ppm to **10,000** ppm (80%)
- Coagulation via moringa protein.

2. Salinity Reduction:

- **Initial:** 1180 ppm
- **Final:** 480 ppm
- Compliant with FAO standards for irrigation.

3. Turbidity Control:

- **Initial:** 370 ppm
- **Final:** 70 ppm
- Lignin and alum stone contributed to colloidal regulation and particle agglomeration.

4. Energy Efficiency:

- The 5 cycles consumed **79,200** joules

Overall Interpretation:

The data validates the prototype's strong capacity to significantly lower pollutant concentrations using an eco-friendly, natural-materials-based approach. The modular system architecture and availability of input materials (coconut shells, moringa seeds, alum) ensure reproducibility and scalability, particularly in Egypt's rural and underserved regions.

The results demonstrate that:

- Water quality improved progressively over time and treatment cycles.
- Removal efficiencies for all major contaminants exceed 70%, reaching >90% in some cases.
- Treated water met reuse criteria for non-potable applications such as irrigation.

We used the following laws in constructing and testing:

- First law: $$P = I \times V$$

(P) which is power in watts = **(I)** which is the Current intensity in amperes × **(V)** which is the electromotive force in Volts , We used it to calculate the power of the system to enter the wastewater, so the total power equals **12 watts** per **5 cycles** of the purification.

- Second law: $$E = P \times t$$

(E) Which is energy consumption in joules = **(P)** which is the power that is calculated from the previous law in watts× **(t)** which is time in seconds , We used it to calculate the energy consumed in the system which equals **79,200 joules** which is also equals **22 wh** per the **5 cycles** of purification**.**

- Third law: $$\text{Efficiency} = \frac{Out - In}{Out} \times 100$$

The **(In)** which is the initial of the second cycle which means the first cycle but the **(Out)** which is the final of the first cycle which means the second cycle so , We used this law to calculate the efficiency between every two cycles.

Recommendations

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Finally, after the prototype had been tested and validated with successful outcomes, we concluded the project with promising results. However, due to time constraints, resource limitations, and the scale of the prototype, certain enhancements could not be implemented. Therefore, we suggest the following recommendations for future development and improvement of the system:

1. Integrating motors for stirring within the filtration containers would significantly increase the rate of chemical and physical reactions, which will lead to faster treatment cycles and improved filtration efficiency.

2. Utilizing Pseudomonas aeruginosa bacteria in the treatment process could enhance the breakdown of excess organic matter. However, this method requires strict safety protocols and disinfection measures, as the bacteria can be toxic and pose serious health risks.

3. As a safer alternative, compost-based biofiltration can be used to naturally degrade organic waste. Composting involves using decomposed organic materials rich in microbes to neutralize organic pollutants, offering a safer, eco-friendly filtration method.

4. 3D Designing the filters to be replaceable will support long-term sustainability of the system and maintain consistent filtration performance. Replacing filters regularly will also prevent clogging and ensure hygiene.

5. Integrating a COD (Chemical Oxygen Demand) sensor that provides real-time, chemical-free readings of water quality would improve monitoring accuracy. This is a more reliable method than using indirect estimations from TDS (Total Dissolved Solids) and turbidity sensors.

6. Automating the chlorine disinfection process with a precise dosing mechanism, such as a dripping stepper motor, can ensure accurate chlorine levels. This will improve the quality and safety of the treated water without the risk of over- or under-dosing.

7. Using high-power water pumps is essential for drawing viscous wastewater, especially since the water contains dense substances such as fats, oils, and blood residues.

8. Adding a physical pre-filtration step before water enters the system is highly recommended. This would prevent blockages caused by coarse debris like bone fragments, hair, or blood clots, thereby protecting the pumps and extending the lifespan of the entire system.

Learning Outcomes

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L.O.	Usage

PH. 2.11: 12V adapters are used to convert the current from AC to DC. Also, step- up converter is used to raise the voltage of an adapter from 5V to 12V.

ME. 2.05: Power and Energy Transfer: develop an understanding of how energy transfers from one set of particles to another in a mechanical system using a formula (P= W/t).

CS. 2.04: A mobile app could be developed that connects to the system (via Wi-Fi, Bluetooth or internet) and monitors or controls the whole water treatment process remotely.

ES. 2.11: To understand the difference between the earth's materials and choose the best materials to use.

MA. 2.06: To understand the limits concept and to know the difference between its graphs and to know which one to use and we learned about continuity which helped controlling the system when it approaches its capacity limit.

CH. 2.09: Redox reactions are about transferring the electrons. This concept aids teams in doing coagulation process with utilizing Aluminum Sulfate.

BI. 2.08: The similarity between the menstrual cycle every 28 days for women and our water filter every 10 minutes.

CS. 2.05: The principles and steps of mobile application development and layers arrangement helped in inspiring us and built a suitable mindset for the project's details and difficulties.

BI. 2.09: Analyze how human activity has affected the dynamic equilibrium of ecosystems and explore the capacity of multiple solutions.

MA. 2.09: The integration concept inspired our ideas to get the final design of the prototype.

List Of Sources

In APA Format

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