Portfolio

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STEM School for Boys in 6th Oct.

Grade 11. Semester 1

2022-2023

Capstone Group 215

Contents

Introduction

Egypt, like many other countries, faces a variety of issues affecting the economy, environment, and social life, interrupting long-term development. These issues represent an obstacle or a gap between the country's current state and the desired state. Egypt is dealing with several issues that must be addressed collaboratively. The project's goal is to address some of the major issues that Egypt faces daily. These issues are among the eleven challenges that Egypt faces, as illustrated in Fig (1).

Figure 1: Egypt's grand challenges

These challenges have a significant impact on Egypt's economy and strength, so they must be addressed. The project's goal is to overcome some major issues in each of the challenges listed below: Manage and increase sources of clean water, Increase the industrial and agricultural bases of Egypt, Address and reduce pollution fouling on air, water and soil, Work to eradicate public health issues/disease, Improve uses of arid areas.

Chapter 1

Egypt grand challenges

Increase the sources of clean water

Water is one of the most important resources for all living things. Even though water is a renewable resource, scarcity of high-quality water remains a major issue in many parts of the world. We need water for a variety of reasons, including growing food, keeping clean, generating electricity, controlling fires, and, most importantly, staying alive, so, increasing the sources of clean water is one of the most important things we look for. Clean sources of water include freshwater and saltwater, as we can use the salt water after desalination for a variety of things like washing and agriculture, in addition to the freshwater that will be used for drinking. However, there are many problems that can affect water usage, the most serious of which is wasting it, As previously stated, water is the most important thing in our lives and we cannot exist without it; therefore, wasting it will cause many problems in our country, such as in Somalia, where water scarcity is causing an increase in the number of deaths.

Increasing the clean sources of water is the most critical plan for the preservation of water in our country, but the preservation of the existing water sources such as the River Nile is exposed to great dangerous problems which are

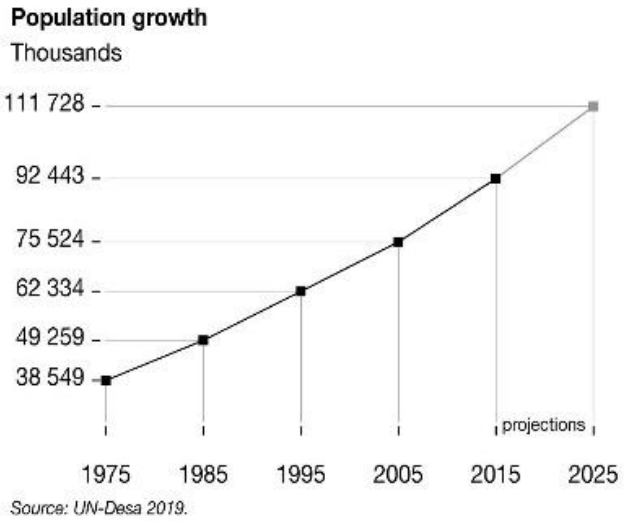
- The pollution that is resulted from the artificial usage of humans needs many ways to treat this sewage wastewater
- The building of the Ethiopian Dam will deprive Egypt’s legal share of water, which is an undesirable outcome given Egypt's already severe water shortages as the main source of water in Egypt is The River Nile which provides it 97% of its sources of water, so, solving the problem of

low sources of clean water will be important to solve many problems we will face.

causes:

Overpopulation:

Egypt's population is growing at an alarming rate, increasing by 41% since the early 1990s. According to government reports, approximately 4,700 newborns are added to the population each week, and future projections indicate that the population will grow from 92 million to 110 million by 2025 according to the growth rate in the last years as shown in graph 1.



Graph (1) Egypt's Population growth

Because of increased water requirements for domestic consumption and increased use of irrigation water to meet higher food demands, Egypt's water supply is under strain, and increasing the number of births with this great rate will cause big danger on our country

Pollution:

The Nile River's pollution has been consistently understated. Because so many people rely on the Nile for drinking, agricultural, and municipal purposes, water quality is critical. The truth is that municipal and industrial waste are polluting the Nile's water, with numerous incidents of wastewater leakage, the dumping of dead animal carcasses, and the release of chemical and hazardous industrial waste into the river and by this pollution that cause a great decrease in usage of water of the river Nile making Egypt one of the most countries that suffer from problems with the water.

Factory pollution is one of the main causes of Nile river pollution. The river Nile was used by factories to dispose of their wastes, and waste heat and other wastes from all factories wastes that contain a percentage of chemicals and other things that cannot be treated affect the Water Validity, leading to an increase in the percentage of infections of dangerous diseases that result in death, and losing the validity of the river Nile's water will pose a major threat to Egypt.

Impacts:

Death rate:

Water scarcity will worsen as a result of pollution, causing a slew of issues. The most concerning is the rising death rate as a result of dangerous diseases such as diarrhoea, amoebiasis, and malaria.

Bad sanitation extends to untreated drinking water; statistics show that approximately 95.5% of the population consumes untreated water. According to the World Health Organization's (WHO) 2008 report unsafe drinking water, inadequate sanitation, insufficient hygiene, and ineffective water resource management account for 5.1% of all deaths and 6.5% of all disabilities in Egypt each year.

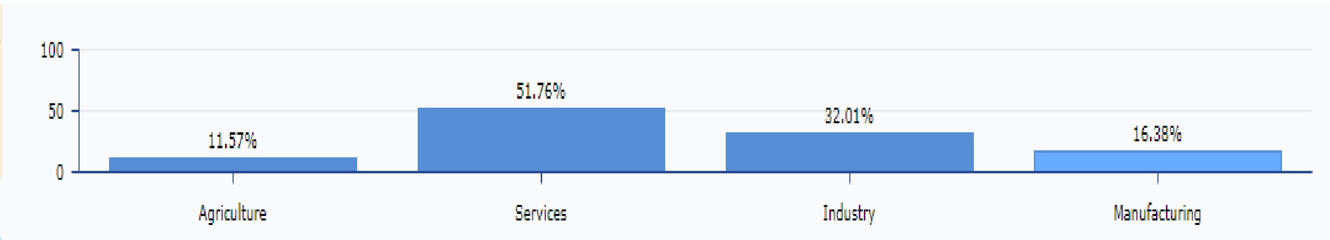
The environment:

When water pollution causes algae to bloom in a lake or marine environment as shown in figure (2), the spread of newly introduced nutrients stimulates the growth of plants and algae, lowering oxygen levels in the water and resulting in the death of fish, which is considered one of the most important meals in human life because it provides protein, an important element in the human body.

Figure 2: Effects of pollution on marine environment

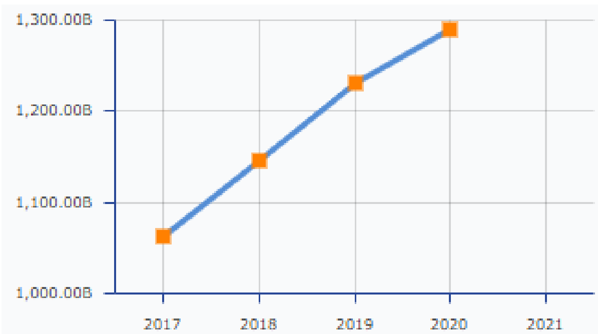
Industrial bases and agricultural bases

The Agricultural base is the part of the economy of a country or region that produces goods in large quantities in factories. The industrial base is building up a country's capacity to process raw materials and manufacture goods for consumption or further production. Although Egypt began industrialization many years ago (the 1920s), it is still far behind other countries that began the process much later than Egypt. According to global EDGE, Egypt's economy relies mainly on agriculture, media, petroleum imports, natural gas, and tourism as shown in Graph (2).



Graph (2) Egypt's economy realizing mainly on agriculture, media, petroleum imports

The gross domestic product (GDP) in Egypt is $1,289,649,795,936 in 2020 as shown in graph (3). As shown in the graph, the percentage of agriculture in the GDP is very low, indicating the problem Egypt is facing.



Graph (3) The gross domestic product (GDP) in Egypt

The growth rate of the GDP is 3.57%. This growth rate is relatively low and there are strategies the country is launching to develop its industrial and agricultural bases as the Egyptian Government's launch of the structural reform program in 2016 focused on raising the productive capacity and competitiveness of the real economy. It had a special focus on industry and agriculture.

The program concentrated on food security-related topics such as the green economy, environmental protection, and water management. The Egyptian government intends to increase its water share through desalination, conserving water consumption by improving irrigation technology, and providing new water sources such as reusing wastewater in agriculture and trying to maximize groundwater use, according to the minister.

Causes

The Agricultural lands:

On one hand, nearly 92.1% of the total number of owners in the Republic own an area of agricultural land, accounting for approximately 47.2% of the total area of agricultural owned, leaving approximately 8% of the total number of owners in the Republic owning the area of agricultural land, accounting for about 52.8% of the total agricultural land owned. On the other hand, encroachment on agricultural land for urban expansion and excavation increased, particularly between 25/1/2011 and 18/3/2014. That’s regarding poor service operations, wasteful irrigation and poor drainage occur to the land.

Inconsistent industrial policies:

A package of industrial policies is expected to include incentives for investors and exporters. However, because they are inconsistent, these policies are ineffective or even have a negative impact on industrial development as the Governments' unrealistic official statements do not indicate the presence of transparency, which discourages foreign direct investment.

The economic problem:

After researching the economic problem of Egypt, I got two probable explanations. One explanation for Egypt's economic downfall was a failure of leadership. Members of Egypt were forced to rely on a single export due to their reliance on agricultural production at the cost of other industries. As Egypt is building bridges and houses lavishly spending money borrowed from European banks. Another explanation for Egypt's economic problem was environmental. They didn't have the coal resources Britain and Europe had

Impacts

The Impact of Industrialization on Employment:

It is important to evaluate the employment effect of various industries on the economy. This is because Egypt is a country that suffers from a high number of population and hence a high level of unemployment. Thus, the employment impact of the industry is an important angle in any economic research. Because Egypt is a labor-rich but capital-scarce country, the allocative efficiency of resources in manufacturing means that Egypt should focus on labor-intensive activities. Meaning that Egypt should specialize in textiles, wood and furniture, metal products, food processing, and paper, as in all these activities the value of the capital-labor ratio is below the mean value for the total manufacturing activities.

wages and finance:

Wage levels have worsened, compared to cost, ranging between 35-40% in the private sector, and reaching between 92 and 107% in business sector companies, while global levels revolve to enable this industry to compete globally around 6 and 7% of the cost.

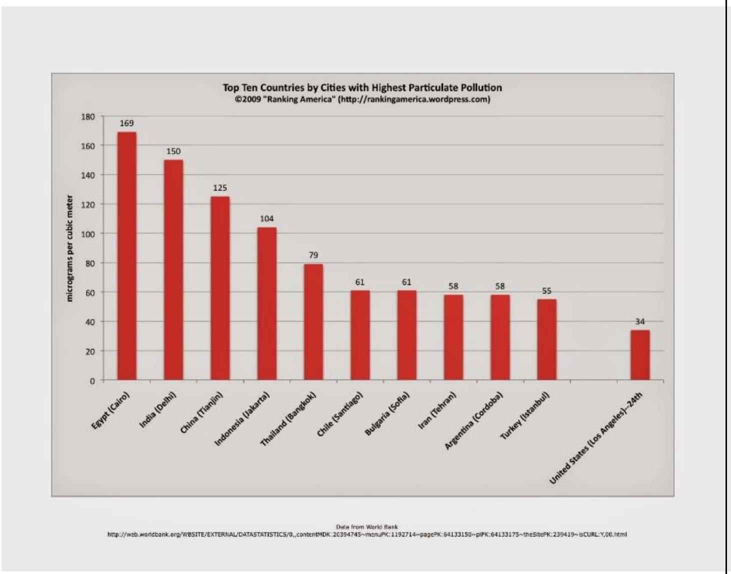
Pollution

Pollution is the reduction in the quality of air, water, or land due to the introduction of harmful materials in the environment. Pollutants can be natural such as volcanic ash. However, in most cases, they are caused by human activity.

Like many other countries, Egypt is suffering from pollution. Egypt mainly suffers from water pollution. According to savethewater.org about 38 million people drink polluted water, they also state that the pollutants that enter the water without being treated are estimated at 4.5 million tons per year shown in figure (3) Water pollution is in Egypt is mainly distributed among three cities. Qalyoubia with 50%, Cairo with 35%, and Giza with 12%. Water pollution in Egypt is mainly caused by wastes dumped by factories in the water and sewage remnants.

Figure (3) water pollution

Egypt also faces Air pollution. According to (eeaa.gov) Vehicles are the main source of air pollution in Egypt. Carbon monoxide and 50% of the materials that pollute the environment are caused by fuel consumption, Shown in graph (4). The number of vehicles is increasing hugely in Egypt in 2005 they had already exceeded 3.5 million. Another reason for air pollution is the burning of solid wastes. A study done by the EEAA in 2001 showed that the burning of solid wastes accounts for 36% of the annual load of pollution.



Graph (4) Pollutions rate of Egypt.

Egypt is directing many efforts towards reducing pollution. There are a lot of projects that were launched such as “The greater Cairo air pollution management and climate change project” which was launched in 2020. 200 million dollars were invested to improve the quality of air in Egypt. Another project that was launched is the (PMEH) Pollution Management and Environmental Health in 2015 both projects were supported by the world bank.

Causes

Harmful human activities

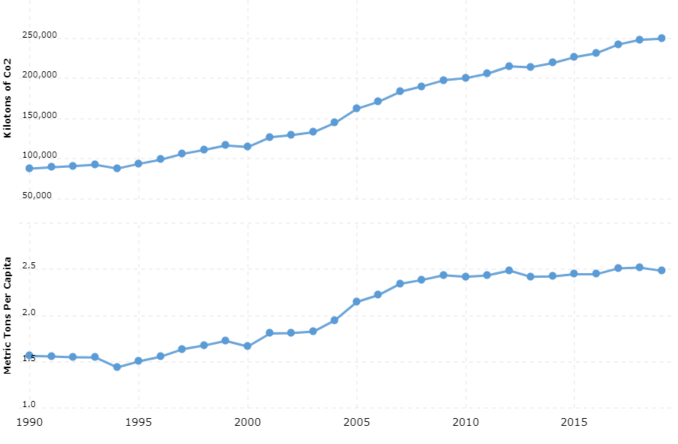
Humans are one of the main reasons for pollution as their activities have a lot of bad effects on the environment. Many factories dump their wastes in the water which causes water pollution. Many people also dump their wastes in the streets which causes land pollution. Farmers who use insecticides to eliminate pests also lead to air and land pollution.

Urban congestion

The increase in people's numbers requires more energy. Which causes an increase in the burning of fossil fuels which leads to air pollution. The increase in people also causes an increase in wastes which causes land and water pollution.

Burning of fossil fuels

Fossil fuels are one of the main sources of energy shown in graph (5). But they are also one of the main sources of pollution as burning them causes the emission of various air pollutants in addition to greenhouse gases.



Graph (5) Increasing of carbon dioxide rate.

Impacts:

Global warming

The burning of fossil fuels leads to the emission of greenhouse gases which leads to global warming. Global warming has a lot of negative effects such as the rising of temperature which affects wildlife it also causes the melting of ice mainly in the two poles which leads to the rise of the sea level.

Bad effect on agriculture

The use of insecticides has harmful effects on agricultural products. Polluted irrigation water can also have bad effects on agricultural products. Pollution leads to acid rains which lead to soil pollution.

Deterioration of public health

The state of public health is badly affected by pollution, Air pollution causes diseases like lung cancer and other respiratory diseases. Drinking polluted water causes poisoning and kidney problems.

Improving the use of the arid area

Land is considered arid when it lacks water to the point of hindering the development of plants and animals. Egypt has 1,000,000km^2 of land, but only 4% of that land is inhabited by its 104-million-person population, as shown in the adjacent figure (4), usually around the Nile's valley and the Delta. This is because 11.3% of Egypt's annual GDP relies on water-intensive agriculture. As Egypt's demand for agricultural areas grows, a way to supply arid areas with agricultural water must be found.

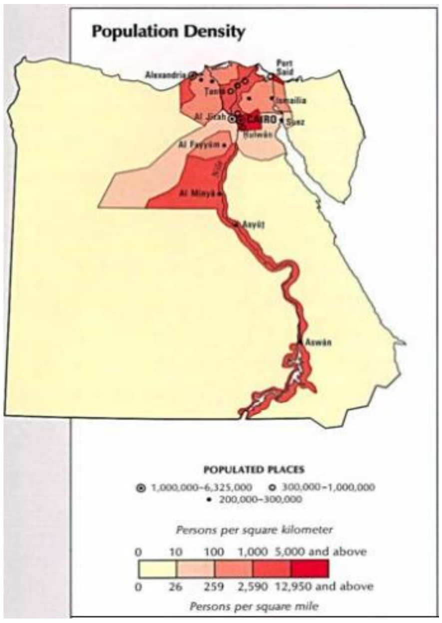


Figure (4) Egypt's Population density

Causes

Water logging and soil salinity:

Increased water wetland and soil salinity caused a rapid deterioration in Egyptian territory because of outdated surface irrigation, the reuse of agricultural drainage water with high salinity, and seawater leaks in coastal areas as a result of poor drainage systems. These all factors that contribute to soil degradation due to improper was water recycling.

Soil fertility depletion and land physical degradation:

Intensive agriculture, increased irrigation water rates, and a lack of fertilizer and nutrients led to significant deterioration in the quality of the land and its production. All this led to clear degradation of the soil structure, especially in some areas of north and northeast Delta.

The absence of public services:

Arid areas lack public services, public goods, and public infrastructure which causes citizens to avoid arid areas in favor of more developed urban areas. One way to attract citizens would be to build cities in arid areas which would be able to provide all these public services and goods, but that is impossible without water for domestic and industrial purposes.

Impacts

Waste of resources:

These arid areas contain a large sum of unexploited natural resources such as oil and natural gases which already make up about 24% of Egypt’s annual GDP. If we don’t start developing these lands, we will never make use of these resource-rich environments.

Internal migration:

People have started migrating from arid and countryside areas to urban areas like Cairo and more fertile agricultural areas near the Nile causing extreme cases of urban congestion in the case of cities and raising the already high unemployment rate of 7.2% in the case of agricultural areas as there is simply not much agricultural land left meaning most migrating farmers won’t find a place to work or land to tend to.

Desertification:

If these arid lands remain uninhabited, they will be subject to even more extreme forms of desertification which will increase the cost of their recovery or make them completely uninhabitable. Wind erosion alone is responsible for 71-100 tons of soil/hectare being claimed by the desert yearly. The following figure () shows the areas most vulnerable to desertification.

Unsustainability:

If these arid areas are not developed and made suitable for agriculture, it will eventually lead to a shortage of agricultural land able to sustain Egypt’s population which grows by 1.9% each year as shown in figure (5).

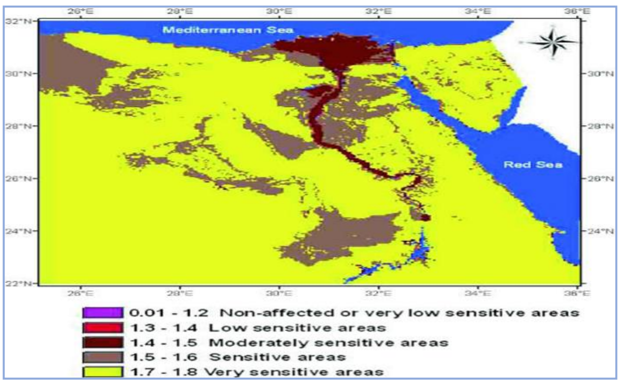


Figure (5) shows the unsustainability in Egypt

Work to eradicate public health issues

Public health is the science of preventing disease, extending life, and promoting health through the organized efforts and informed choices of society, organizations, public and private communities, and individuals, according to the World Health Organization.

Public health studies play an important role in combating the most lethal human killers. Public Health professionals who have completed a Health Studies related course are constantly fighting many diseases like diabetes, cancer, heart disease, and dementia in order to maintain the population's health and well-being, As a result, we are all about to face a slew of public health issues at any given time, as there are numerous factors putting our lives in jeopardy due to the dangerous diseases that may affect us as a result of the activities that we engage in all the time and fail to take preventative measures, so, our government contributed efforts to solve these problems by creating systems like healthcare system and EHIS in Egypt.

The Ministry of Health and Population governs Egypt's healthcare system, which includes the government, public, parastatal, and private sectors. According to reports from 2016, there were 1.5 beds for every 1,000 people. In comparison to the global average of 2.7 beds per 1,000 people, so, need to increase this percentage in our country.

The Egypt Health Issues Survey (EHIS) was funded by the United States agency for international development and was launched as part of the Ministry of Health and Population's commitment to collect data on a number of key health issues in Egypt, particularly the prevalence of hepatitis and hypertension, smoking, and obesity, all of which are major risk factors for no communicable diseases (NCDs) such as diabetes and cardiovascular disease. Egypt has the world's highest rate of hepatitis C infection, and NCDs are among Egypt's leading causes of death.

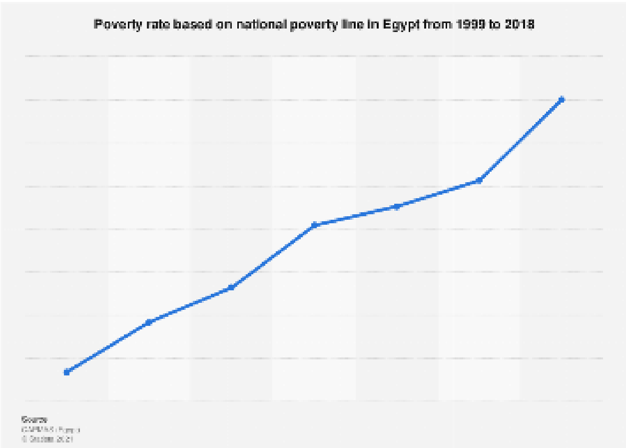
Causes

Poverty:

Poverty is a major cause of illness and a barrier to receiving needed health care. This is a financial relationship: the poor cannot afford to buy the things necessary for good health, such as adequate quantities of quality food and health care. However, the relationship is also related to other poverty-related factors, such as a lack of information on appropriate health-promoting practices or a lack of voice required to make social services work for them, poverty has bad effects on healthcare like:

- Lack of affordable and adequate housing
- Complications are more common among the sick
- Recovery time is longer
- Lack of access to health care insurance

Egypt’s poverty increased from 1988 to 2018 by a high percentage as shown in graph (6), Egypt's poverty rate is forecast to be 27.9 percent in 2022. This was nearly 0.7 percentage points lower than the previous year, but it is still high. Overall, from 2018 to 2019, the poverty rate fell to 29.2 percent in 2019, before rising to around 32 percent in 2020. Since 2020, projected poverty rates have been decreasing. They are expected to fall even more in 2023. The pandemic coronavirus (COVID-19) outbreak contributed to an increase in poverty in 2020.



Graph (6) Increasing the poverty in Egypt

Low-quality education:

low-quality education contributes to a variety of public health problems, as, a person’s attitude toward life is heavily influenced by their level of education, as, Egypt places 32 among all countries in the rate of illiteracy.

This includes either his or her consumption behavior or social behavior.

A lack of education will almost certainly lead to a state in which people do not care about their environmental behavior because they do not understand how their daily actions affect our environmental system. It also contributes to public health issues because uneducated people are more likely to drink and smoke, resulting in negative health consequences.

Unhealthy eating habits:

Another factor that contributes significantly to public health issues is our attitude toward food, as many people consume a lot of fast food and others like poor people eat unhealthy food.

This leads to obesity and may reduce life expectancy because unhealthy food can cause heart attacks, strokes, and other serious health problems. Many people may be unaware of the negative consequences of poor nutrition; these people are at high risk for public health issues, and their children may suffer as well.

Water problems:

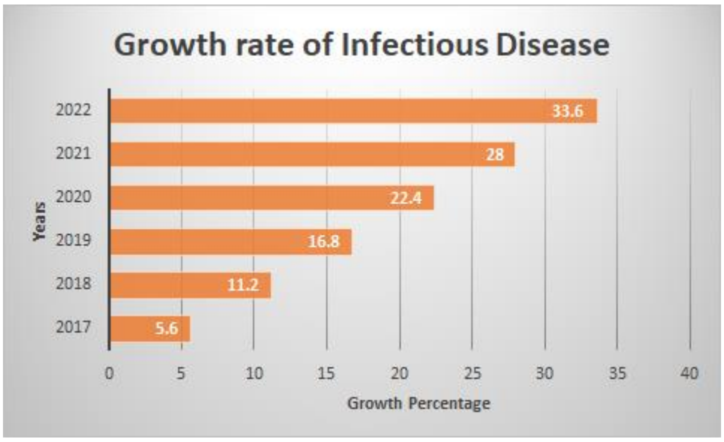
Water is the foundation of life, and life cannot exist without it. It is a source of drinking water for humans and animals, as well as an agricultural source. It is also an important factor for the industry. Thus, our lives on the planet are inextricably linked to water, and Egypt's lifeblood is the Nile. Its revenue is used for domestic purposes, agriculture, and manufacturing, confirming the importance of water in our lives. According to a 1959 agreement, Egypt's share of the Nile is 55.5 billion cubic meters per year.

Water is polluted via Chemical And Industrial Processes causing environmental and health issues and Wastewater Plants. Campaigns have shown that wastewater plants contaminate groundwater in villages and agricultural areas, based on monitoring by the ministries of health, housing, and irrigation. These issues will result in the spread of disease among those who do not have access to safe drinking water.

Impacts:

Non-communicable diseases:

No communicable diseases are those that cannot be transmitted from one person to another such as: autoimmune diseases, heart attacks, and diabetes These diseases are frequently linked to our consumption habits.



Graph (7) shows increasing the growth rate of infectious diseases

Type 2 diabetes, for example, is frequently caused by excessive sugar consumption and a lack of physical activity. These non-communicable diseases affect many people worldwide, causing serious health problems and by time the number of these infections increases as shown in graph (7).

HIV:

HIV is a major global problem that is frequently transmitted through sexual contact, and it is a serious disease that claims the lives of many people. It is especially dangerous in countries where HIV treatment is inadequate. These people typically have very short life expectancies. As a result, HIV can be regarded as a serious public health issue, and it is frequently caused by a lack of education or a refusal to use contraception.

Problem to be solved

Metal Industry wasted water and water scarcity

Egypt has an annual water deficit of nearly seven billion cubic meters, and the country might indeed run out of water by 2025. So, it’s important for us to address water waste and spread awareness about water scarcity. The problem of water scarcity is mainly a result of the country relying heavily on the Nile River as its main source of water. The River Nile is the backbone of Egypt’s industrial and agricultural sectors.

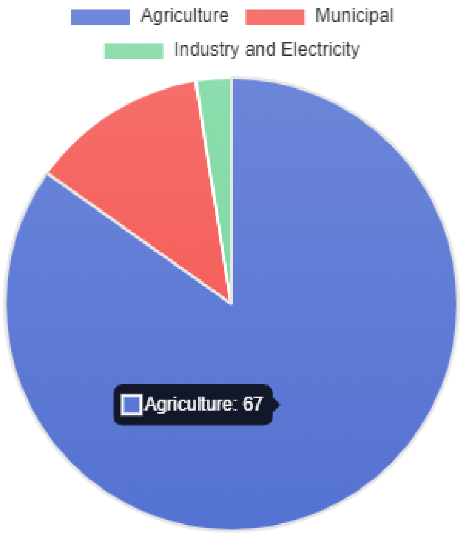


Figure (6) Agriculture

Agriculture is critical to the economy as shown in figure (6), accounting for 14.5% of GDP. In 2016, this amounted to 256.9 billion Egyptian pounds in agricultural income. In addition, the sector employs 29.6% of the working population and accounts for 11% of total exports. Due to water scarcity, the government implemented measures in January 2018 to reduce the cultivation of water-intensive crops such as rice.

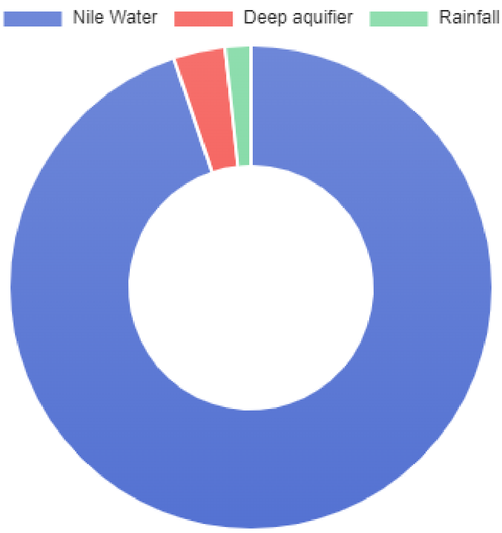


Figure (7) Dependence on the Nile River

Despise the huge dependence on the Nile River as shown in figure (7) it doesn't even cover half of Egypt's 114 billion cubic meters of water demand. 34 billion cubic meters of wastewater is recycled annually to make up the deficit, but 20 billion cubic meters of water demand is still unaccounted for. This demand will only grow with Egypt's population, agriculture, and industry, so the only option is to find a more efficient way to recycle wastewater for domestic and agricultural uses.

A huge amount of water is wasted out of industrial wastes with the characteristics to be treated. Industrial wastewater is present in places like the 10th of Ramadan city, New Nubaria city, New Borg El Arab city, and Mubarak industrial zone in Quesnna. For example, on the 10th of Ramadan city there an industrial waste (treated and untreated) with a flow rate of about 130,000 m3 / day coming from a heavy industrial zone south of the city, and in New Borg El Arab City presently the Industrial Wastewater produced is 45,000 m3 /d.

Positive consequences.

Adaptation to climate change:

it became clear that developing new efficient and low-cost treatment methods was the best approach to climate change adaptation. water treatment by removing all water pollutants and additives, including metallic ions, non-metallic ions, organic pollutants and compounds, and any residue pollutants. If implemented in real life, It can generate and treat seawater fully through its simple and efficient.

Economic impacts and saving money:

Over 80 percent of Egypt’s water supply goes towards agriculture and irrigation, and as such, water scarcity represents a dire threat to Egyptian farmers. In 2016, agriculture income totaled 256.9 billion Egyptian pounds. Furthermore, the industry employs 29.6% of the labor force and represents 11% of total exports. Due to water scarcity, the government enacted measures to curb the production of water-intensive crops in January 2018. By increasing sources of water. A great improvement in agricultural is expected to occur. The benefits of proper water management are numerous, particularly in locations exposed to water scarcity, and many of them can have a direct positive economic impact on a company's operating accounts. In some businesses, the consumption of network water is the largest expense, just after Human Resources. Allowing the reuse of recovered wastewater reduces network use, saving money and assuring a supply for the industrial production process, making it less vulnerable to potential resource shortages.

Negative consequences.

The danger of climate change:

The effects of climatic change have become more visible: hotter weather, higher sea levels, deadlier storms—reminders of the climate crisis' existential nature. Global temperatures are rising as a result of human activity, and an environmental crisis has emerged with far-reaching consequences in the Middle East and North Africa. Egypt has few internal renewable freshwater resources. Egypt may face a water crisis as the effects of climate change worsen and experience a decrease in water quality due to a decline in water quantity, surpassing absolute water scarcity (> 500 m3 /person/year). Furthermore, future predictions include flooding, soil salinity, and water scarcity.

Economic impacts:

Egypt is currently using more water than its internal renewable resources, mostly freshwater inflows from the Nile. Egypt's water stress is predicted to increase in the future due to rapid population growth, rising temperatures, and increased water usage in Egypt and other Nile basin countries. Growing water scarcity would put severe strains on Egypt's economy and leave the country more exposed to renewed internal strife if not addressed appropriately.

Environmental impacts:

Water shortage and saltwater intrusion, combined with other climate change indicators, threaten to damage Egypt's agricultural productivity, soil quality, and water supplies. Desalination procedures are expensive to construct, and they are complicated further by harmful wastes thrown into the Nile.

<u>Research</u>

Topics related to the problem

Agricultural growth:

Agriculture is a major component of the Egyptian economy, contributing 11.3 percent of the country's gross domestic product. The agricultural sector accounts for 28% of all jobs, and over 55% of employment in Upper Egypt is agriculture related. Not to mention, 76.7% of the country's annual water supply is used in agriculture. This demand for water will only continue to grow with the agricultural sector as it develops to keep up with Egypt's rapid population growth of 2.5%. Since Egypt is already suffering a water deficit according to the minister of irrigation, agricultural drainage water, and industrial wastewater will have to be recycled in order to sustain agricultural growth.

Overpopulation:

According to the minister of irrigation, Egypt relies on the Nile River for 97% of its water resources, but that doesn't even cover half of Egypt's 114 billion cubic meters of water demand. 34 billion cubic meters of wastewater is recycled annually to make up the deficit, but 20 billion cubic meters of water demand is still unaccounted for. Already, 7.3 million people are deprived of access to safe water, among which 5.8 million live in rural areas and 1.5 million in urban areas. 12% of people living in rural areas aren't connected to the water system while, in urban areas, 4% of don't have access to the water system. This problem is expected to grow in severity as Egypt's population continues to increase by 2.5% each year.

Pathogens in the Nile River:

The Nile River has been Egypt's lifeline since the days of the Pharaohs, where it represents 97% of Egypt's total water supply. Despite its importance, 150 million tonnes of industrial waste are dumped into the Nile River each year, according to the Environmental Affairs Agency. Climate change presents another challenge, where rising sea levels are set to push Mediterranean salt water deep into the fertile Nile River delta, potentially shrinking Egypt's already struggling agricultural sector by as much as 47% by 2060 as a result of saltwater intrusion. Already, 7% of all Egyptians suffer from lack of water and the UN predicts that Egypt will suffer from a nationwide water shortage by 2025. Hydrologists agree that a country suffers from water scarcity when a citizen's yearly intake of water goes below 1000 cubic meters. In 2018, Egyptian officials admitted that an individual's share had gone down to 570 cubic meters per year and is expected to reach 500 cubic meters annually in 2025.

Topics related to the solution

New water treatment technology:

Human beings did not have advanced water treatment technology shown in figure (8) a long time ago. They used simple grid interception and natural sedimentation methods for water treatment to reduce disease transmission through water. After years of observation and summarization, they discovered a method of filtering out fine suspended solids with sand, followed by a chemical coagulation pretreatment.

Figure 8: New Water treatment technology

Membrane filtration technology is a new and emerging water treatment technology that is gaining acceptance in the water treatment industry. The low-pressure membrane filtration method is also replacing traditional filtration for surface water treatment, such as distillation, which is one of the physical phases by many ideas like evaporation and condensation that can be used in the treatment of water, this project was used in the of seas and oceans, but we cussed it in our project in the removing of mineral salts in some solutions of industrial wastewater

Thermal hydrolysis Exelis is another new treatment technology that can be productive in less space and requires less wastewater to remain viable, also it produces 130 percent more biogas than the next most productive thermal hydrolysis systems using the same amount of sludge

Metal Industry wastewater:

The iron and steel industry are frequently regarded as one of the primary forces driving a country's economic and technological progress, Water is used in the manufacturing of iron and steel for cooling and by-product separation. During the initial conversion, it becomes contaminated with products such as ammonia and cyanide. Benzene, naphthalene, anthracene, phenols, and cresols are among the waste streams. Water is used as a base lubricant and coolant in the forming of iron and steel into sheets, wire, or rods, as well as hydraulic oils, tallows, and particulate solids. Hydrochloric acid and sulfuric acid are required in the water used in galvanizing steel. Wastewaters contain acidic rinse waters as well as waste acid. Hydraulic oil, also known as soluble oil, pollutes much steel industry wastewater.

There are many steps needed for the treatment of wastewater from steel and iron manufacturing that describes the normal wastewater treatment processes employed for effective treatment of the wastewater of steel plant as shown in figure (9).

Figure 9: shows the processes for the treatment of wastewater

Biological Activated carbon:

Activated carbon, also known as activated charcoal, is a type of carbon that is widely used to filter contaminants from water and air, among other things, through a process called (BAC). The biodegradability of biological activated carbon (BAC) is dependent on the reversibility of adsorption and the biodegradability of the ad's sorbates. The BAC process was designed to take advantage of the synergistic effect of pollutant adsorption on adsorbent and subsequent degradation by microbial activity in the wastewater treatment process. Because of its high surface area and pore size, activated carbon has a significant effect on absorbing organic pollutants in wastewater and a high quillified removal for all the unwanted tastes and odors, and microbial activity has been demonstrated for its biodegradation potential.

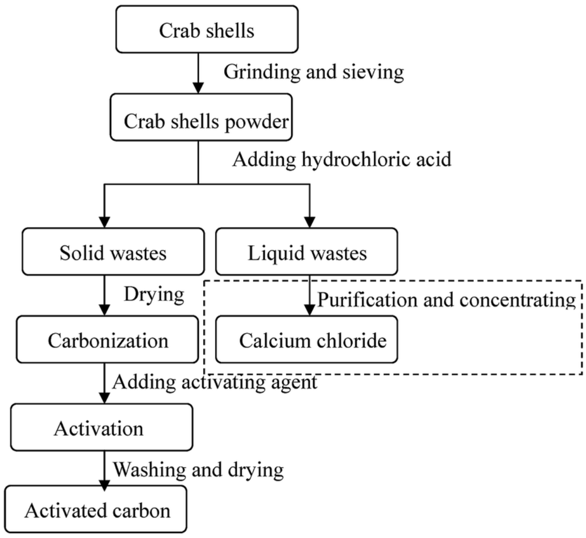


Figure 10: BAC process

Biological activated carbon (O3/BAC) in conjunction with ozonation is regarded as a critical component in the wastewater treatment process generated by domestic and other industrial activity. BAC microbial biofilms can regenerate activated carbon, and it is used in the final process to end the process as shown in figure (10).

Other solutions already tried

New Cairo Wastewater Treatment Plant

The New Cairo Wastewater Treatment Plant is Egypt's first project involving a public-private partnership (PPP) shown in figure (11). The facility was scheduled to be ready for operation by March 2012 after construction started in February 2010. The project's primary goal is to build a wastewater treatment plant that is both affordable and safe for the environment for the city of New Cairo and the surrounding area in order to accommodate current and future population expansion. The facility will initially be able to service more than a million people with a capacity of 250,000m3/day. The final capacity will be 500,000m³/day. The initiative aims to promote PPP as a model for the nation's future water and wastewater projects.

Figure (11) New Cairo Wastewater Treatment Plant

Mechanism

The receiving point, inlet and general bypass chambers, flow metering, coarse and fine solids screening, and grit removal make up the input works and pre-treatment facilities.

In order to move wastewater from the receipt point to the plant, 2,200mm reinforced concrete pipes will be installed. Four 1.5m-wide automated screens will be used to screen coarse and fine solids, respectively.

Figure (12) Circular units

Grit will be removed using four circular units shown in figure (12), each having a capacity of 11,679 m3, and collected using four airlift pumps.

The facility will include four 6-meter-long distributions well outputs, four gravity units, and five horizontal centrifugal pumps for initial treatment. There will be six biological reactors erected, totaling 14,580 m3, with an average solids' retention duration of 5.02 days. There will be six units each of anoxic region and aerobic area, each with a volume of 2,970 m3 and 11,610 m3, respectively.

Fourteen horizontal centrifugal pumps with frequency converters will recirculate the sludge. Seven horizontal centrifugal pumps with frequency converters will pump out extra sludge. Six secondary settling tanks will be used to recover waste sludge and pump it to flotation thickeners shown in diagram (1).

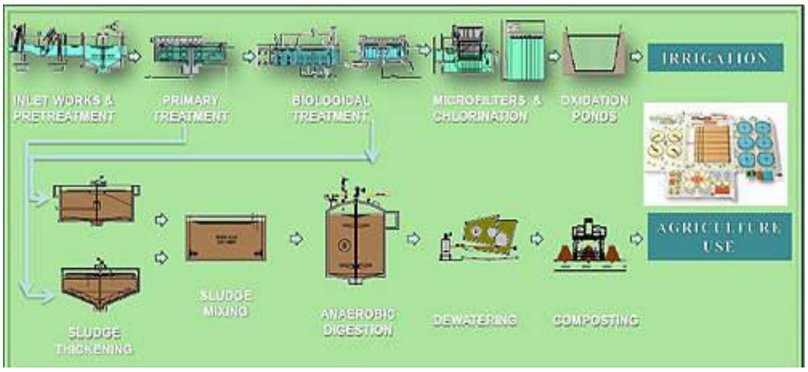


Diagram (1) Treatment process of the plant

11 textile mesh filters, each capable of filtering 1374.37m3/h, will be used for micro-screening. The facility will include three automated chlorination systems in addition to two chlorination chambers for disinfection.

Advantages

- The plant enabled a reduction in the quantity of pollutants (raw sewage) dumped into the river Nile. This improved the river's water quality, which had positive direct effects on ground pollution levels, fisheries, the river ecosystem and on human health.

- Its low cost when compared to treating, processing and consuming "new" water and the process also saves water that might otherwise be lost through runoff or contamination.

Disadvantage

Activated Sludge used in treatment process has some weakness points like:

- Low pathogen removal.
- High CAPEX and OPEX.
- Biogas is explosive; therefore, risky in case of improper operation.
- High maintenance requirements.

Bahr El Baqar Water Treatment Plant

Figure (13) Bahr El Baqar Water Treatment Plant

It is the biggest water treatment shown in figure (13) facility in the world. It is situated in Sinai, 10 km south of the Port Said tunnels. Over roughly 155 acres, the plant is constructed. It is regarded as one of the most significant initiatives to develop the Sinai Peninsula and make the most of its natural riches. By recycling and using wastewater from industry, agriculture, and sewage that is transferred from the western to the eastern bank under the Suez Canal, the initiative will aid in the reclamation of 400,000 acres. All water will be distributed in Sheikh Jaber's Canal after purification. three drains, the greatest of which is Bahr El Baqar Drain 106 km, which empties into Manzala Lake, collect sewage, industrial, and agricultural effluent.

Mechanism of wastewater treatment

Phase 1: Pre-Treatment phase:

Water will flow to the next stage of treatment from the intake building, which is made up of the refineries and intake pumps, where the coarse and fine refineries work to remove all tiny and big planktons.

Phase 2: Water Treatment:

Water is treated for first sedimentation by adding substances that will assist balance pH levels and aid in the development of flocculants and sedimentation in the bottom of sedimentation basins. The process then went into the 11,600 m2 lamella sedimentation tanks, which employ pipes and sedimentation tanks for a more effective process. The project also uses 120 triple disc filters, each of which has a planned capacity of 1,992 cubic meters per hour. To achieve the highest quality and standards of filtered irrigation water, 32,800 square meters of fine polyester membrane with a filter size of 10 microns are used as the filtering surface.

Phase 3: Post-Treatment Phase:

Includes the chlorine or ozone injection method for water sterilization. The created water is then discharged into the Sheikh Jaber Canal.

Advantages

- Residents benefited from the project mainly through increased availability of freshwater. The reduction in pollutants dumped into the river led to improved public health.
- It is less expensive than treating, processing, and drinking "fresh" water.
- The dry sludge with a drying level of 24% is conveyed by belt conveyors to solar drying units, which are distributed and stirred continuously to produce a final product (sludge) with a drying level shown in figure (14) of 75%, which will be used in agricultural applications such as land reclamation or in construction such as cement bricks and backfill materials.

Figure (14) Solar dry sludge

Disadvantage

Continuous Power Supply: The sewage treatment plant's working system needs an infinite supply of power. In its absence, it may cease to function and perhaps create certain issues.

Although sewage treatment plants are supposed to be environmentally benign, some facilities nonetheless leave an environmental impact when water is treated. Because the treated organic waste must go somewhere, and it might occasionally be harmful.

Activated sludge process

The activated sludge process was named after Adern and Lockett, who developed it in England in 1914. It involved the production of an activated mass of microorganisms capable of aerobically stabilizing a waste, and it Is defined as a "suspension" of microorganisms, both alive and dead, in wastewater. Because the microorganisms are activated by an air (oxygen) input, the product is known as activated sludge. Activate-sludge is the sludge that settles in a secondary sedimentation tank after being freely aerated and agitated in an Aeration tank for a period shown in figure (15).

Figure (15) The Activated sludge

Mechanism:

The mechanism of the projects happens consequently step by step as a diagram as shown in diagram (2) including the following steps:

First, Oxidize the organic solids. second, encourage coagulation and flocculation, as well as the conversion of dissolved, colloid, and suspended solids into settle able solids. In an activated sludge process, the following operations are carried out.

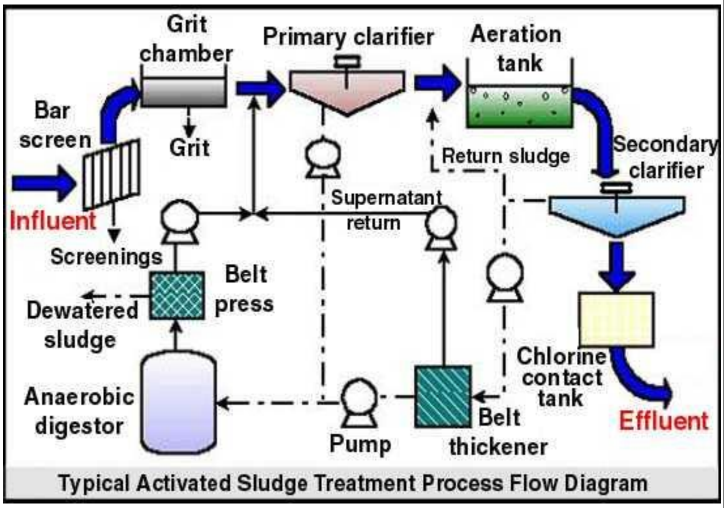


Diagram (2) mechanism of Activated sludge

Then, In the primary sedimentation tank, sewage is treated. The detention period is limited to 1 1/2 hours.

In the aeration tank, settled sewage from the Primary Sedimentation Tank is mixed with the required amount of activated sludge. The aeration tank's mixture of activated sludge and wastewater is known as ‘mixed liquor or mixed liquor suspended solids MLSS or MLVSS mixed liquor volatile suspended solids, According to the degree of purification.

After that, The Mixed Liquor Suspended Solids is aerated in the aeration tank for 6-8 hours, referred to as the hydraulic detention time. Each m3 of wastewater treated produces approximately 8m3 of air. Typically, the volume of sludge returned to the aeration basin is 20 to 30% of the wastewater flow air supply 8-10 m3 of sewage.

The aerated Mixed Liquor Suspended Solids form flock particles ranging in size from 50 to 200pm, which are then removed by gravity settling in the secondary sedimentation tank, leeching a relatively clear liquid as the treated effluent. In most cases, the clarification step can remove more than 99% of the suspended solids.

Finally, the majority of the settled sludge is returned to the aeration tank (and is referred to as return sludge) to maintain the high population of microbes that allows for the rapid breakdown of organic compounds. Because the process produces more activated sludge than is desirable, some of the return sludge is diverted or wasted to the sludge handling system for treatment and disposal.

Advantages:

- The activated sludge treatment process produces high-quality effluent (industrial wastewater that are released into water)
- It guarantees a 99% reduction in particles in the process of treatment of sewage and industrial wastewater
- The activated sludge process can withstand various organic and hydraulic shock loads.

- In comparison to the water stabilization pond, the activated sludge treatment plant requires less land. It also ensures the maximum removal of nutrients such as N2, K, and Ph from organic matter.

Disadvantages:

- The activated sludge process necessitates a significant investment to build big factory for the process as shown in figure (16)
- It also necessitates a continuous power supply and Its operation and maintenance necessitate the use of skilled labor.

Figure (16) Activated sludge big factory

Chapter 2

Solution and Design requirements

Solution requirements

Cost

The amount of money that is needed to buy the materials used in treatment process must be as low as possible, this can be achieved by implementing the most efficient design which saves construction materials.

Materials

Materials that will be used in treatment process must be chosen carefully. In other words, it must have been tested against heavy pressure and hard Dissolved solids. Also, it should have been tried before in other process and proved its effectiveness.

Eco-friendly

means "environmentally friendly" or "not detrimental to the environment." This word most frequently refers to green living items or activities that help preserve resources such as water and electricity. Preventing product contributions to plants death or soil pollution is also important. Making that product considers both environmental and human safety. At the very least, the product or output is non-toxic.

Performance and Water quality

How efficiently the solution works. Proved that water quality can affect positively on the environment. Processing good water quality is essential to human health, the environment, agricultural industries and the recreational value of waterways, wetlands and coastal waters.

Usability

A measure of how well a specific user in a specific context can use a product to achieve a defined goal effectively, efficiently and satisfactorily. Designers usually measure a design's usability throughout the development process from wireframes to the final deliverable to ensure maximum usability.

Reliability

Described as the likelihood that a good, system, or service will run without issue in a particular environment or execute its intended purpose satisfactorily for a given amount of time.

Design requirements

- Total dissolved solids (TDS) must be minimized. The design criteria for our project is to reduce the TDS of the treated water; this will be appropriate for our goal of using the treated water in the articulating of rice.

- saving water for irrigation by treating wasted water to water that matches the quality standards of rice agriculture, as treatment of the water that is used in the steel industry and the factories got rid of it. The amount of water produced per unit of time must be measured.

- reduction of Total suspended solids amount (TSS), TSS must be minimized as possible to ensure not harming the soil or the plants with suspended metals

Selection of Solution

Our solution for wasted industrial water and rice agricultural scarcity is an industrial water treatment plant that aims to provide the healthiest water source for rice agriculture. The water treatment system treats mainly steel and heavy metals industrial wastewater. After a sample of the wastewater was taken directly from the steel factory, it was analyzed carefully to determine what pollutants should be treated. The processes are chosen to treat TDS which is the total dissolved solids in water, TSS which is total suspended solids, and any heavy metals or bacteria that can harm the crops.

First process: Coagulation is a crucial first stage of our water filtration. Colloidal Particles (1 nm > > 1µm) are treated with coagulation because it is expensive to remove small particles using only mechanical water treatment like filtration. In steel industrial wastewater, there will be some solids and inorganic materials in the water that must be removed. To remove these particles, ferric chloride will be used as a coagulant to make the harmful particles congeal because the coagulants have the opposite charges of the suspended particles, resulting in their neutralization and allow them to stick together. After coagulation ("Charge Neutralization"), a subsequent procedure known as flocculation is required. The flocculation process is the increase of the size of the particles from micro-floc to large, visible suspended particles called pin-flocs. Additional collisions between pin-flocs cause them to produce even larger, 'macro-flocs'. The whole process is shown in figure (17) Then the flocs can be precipitated in the bottom of the container. Powdered

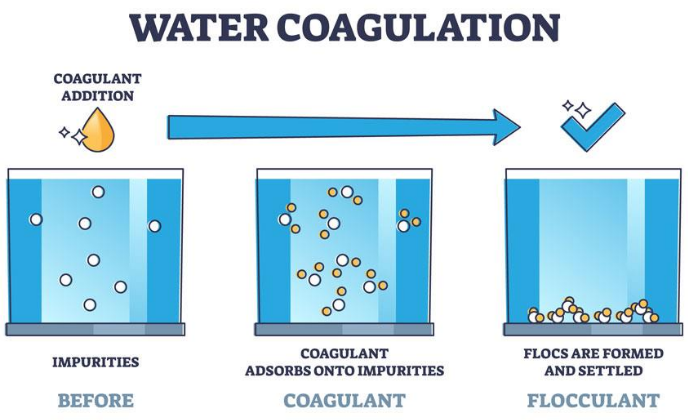


Figure (17) the whole process of Coagulation and flocculation activated carbon will be used beside the ferric chloride in the process duo to its ability to enhance the floc size, growth rate, breakage factor, and fractal dimension.

Second process: bacteria can affect the water quality for irrigation significantly, to remove toxins from water zeolite will be added to water in this stage. Research showed also that the water hardness of steel wastewater can be high so, calcium hydroxide will be added in this process to soften water and remove silica, iron and many other heavy metals ions.

Advantages of the water treatment plant processes

- **Effectiveness:** The technique can be used to remove a variety of components. Numerous elements in the wastewater have a significant impact on efficacy. Effective elimination of SM (80-95%) is generally anticipated. The application determines how much COD, P, and metals are reduced. A yield of >60% can be realized for these applications if this approach is chosen.

- **Fast reaction treatment**: The main consideration behind the use of chemical coagulation is that it speeds up the time it would take for the solids to settle on their own. Therefore, decreasing the overall detention time of the wastewater treatment process.

Disadvantages of the water treatment plant processes

- **Wasted Sludge:** The addition of chemicals also causes a significant amount of sludge to be produced, which must then be processed and disposed of. Because of the added elements' nature, this sludge is also dangerous. The cost of disposal may increase due to the amount the sludge and the difficulty of dewatering it.
- **Coagulants are impermanent:** Coagulation requires coagulants to run the process, Unfortunately, the process of coagulation is an intensive one. This means a short life span for the electrodes, which need to be replaced often.

Selection of prototype

Materials:

This project's prototype is a miniature industrial water treatment plant. The structural materials are relatively simple, consisting of two wooden boards, two plastic pipes with a valve, and two plastic bowls, one for each stage of treatment. The required chemicals are ferric chloride (FeCl3), calcium oxide (CaO3), zeolite, an activated carbon filter.

Prototype Design:

The two wood boards act as structural housing for the prototype as most of the other materials are suspended inside them. Two of the three plastic bowls are attached by their sides to the inner part of the wood boards, where one of them is on top of the other as you can see in (Fig.18)

Figure (18) showing the Prototype design

The first bowl has a plastic pipe attached to its side with a valve to control the flow of water. This represents the physical treatment stage, where after the ferric chloride and activated carbon are added to the first bowl to get rid of organic compounds without disturbing the coagulated sludge precipitate at the bottom of the bowl.

The treated water will then flow into the second plastic bowl through the plastic bulbs. This represents the chemical treatment stage, where after adding zeolite to the second bowl, the fully treated water is allowed to flow into the third and final bowl. In the third bowl.

Chapter 3

Materials and Methods

Materials

Name	Description	Quantity	Cost	Source of purchase	Figures
Ferric chloride ($FeCl_3$)	The inorganic compound is used to remove impurities in water and is used for wastewater treatment.	**0.7** grams for each liter.	Free	El-Dokki National Research Center	
Calcium hydroxide (CaO)	A chemical compound used as a coagulant aid and to maintain pH level.	**0.5** grams for each liter.	Free	El-Dokki National Research Center	
Filter papers	A low, semi-permeable paper barrier placed perpendicular to a liquid or air is used to separate	**2** papers	10 L. E	El-Dokki National Research Center	

	fine solid particles from liquids.				
Zeolite – sodium aluminum silicate ($Na_2Al_2Si_2O_8 . xH_2O$.)	A good medium for filtering toxic substances in the water and removing the solids and organic substances in the water.	**1** gram for each liter.	Free	El-Dokki National Research Center	
Activated carbon–charcoal (C)	form of carbon commonly used to filter contaminants from water	**1.25** grams for each liter.	Free	El-Dokki National Research Center	
Wood structure	To make two stands as a building to hold the containers.	**3** pieces	120 L.E	From wood shop	
Plastic containers	Each container represents a treatment process.	**3** containers	60 L.E	From plastic shop	
Valve	To pass the water from the first treatment to the second treatment.	**1** valve	50 L.E	From plumber shop	

Methods

1. First, the prototype was built using a sketch to create an imaginary representation of the prototype to avoid any possible mistakes.

2. Second, pieces of wood were constructed together in a U shape as shown in the Figure. A horizontal piece of wood joins the two vertical pieces to make them more stable.

3. Two plastic containers were put beneath each other in a wooden shape the distance between them is 15 centimeters. Each container represents a treatment stage and there is a valve in the first container to control the water between the two stages as shown in Figure (19).

Figure (19), represents the prototype

4. There is one centimeter left under the valve to allow the impurities to precipitate during the first stage.

Design requirements

Our first and second requirements are to lower the TDS and TSS amounts as much as possible while maintaining a PH suitable for agriculture. The third design requirement is to maximize the amount of water produced per unit of time.

Test plan

In an attempt to achieve the points of design requirement we have followed these steps:

- After constructing the prototype, we used 2 liters of steel industrial wastewater in the first container which is the first physical stage. We added 1.2 grams of ferric chloride to the water then we used a magnetic stirrer to allow coagulation and precipitation of any impurities in the water. This process was used to lower the amount TSS. during coagulation, we added 1 gram of calcium oxide to maintain the level of the PH in the water.
- More clear water will then flow through the valve to the second container. It was passed through filter paper before the second chemical stage.
- Then during the second stage we added 1.25 grams of activated carbon with 1 gram of zeolite to remove the toxins, heavy metals and TDS with higher efficiency.
- The previous stage removes the odor and color from water. Then the water passes through the final filter paper to the final baker.

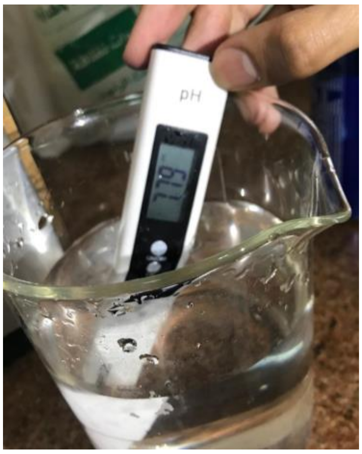


Figure (20), shows the pH meter

- TDS meter and PH meter were used after each treatment stage to ensure the progress. As shown in Figure (20).

Data collection

Negative result:

The treatment system failed to achieve design requirements as the TDS was increased from 1631 to 2002 ppm, and the produced water was not clear from color and odor as seen in Figure (21). This was due to some problems in the test plan. As we used the wrong amounts of substances and didn't have the right amount of time for the filtering.

Figure (21), the negative result

Positive results:

The industrial wastewater after 2 processes which are coagulation, powder zeolite, and powder activated carbon (PAC). Using the ratio of 0.6 grams of ($FeCl_3$), 0.5 grams of (CaO), 1 gram of zeolite, and 1.25 grams of powder-activated carbon all of them per liter. We Achieved the design requirement by producing treated water with properties of

pH = 7.7 ± 0.2 TDS = 1,640 ppm $\pm$ 0.061

Amount of water produced per unit time = 1.1 L/hour

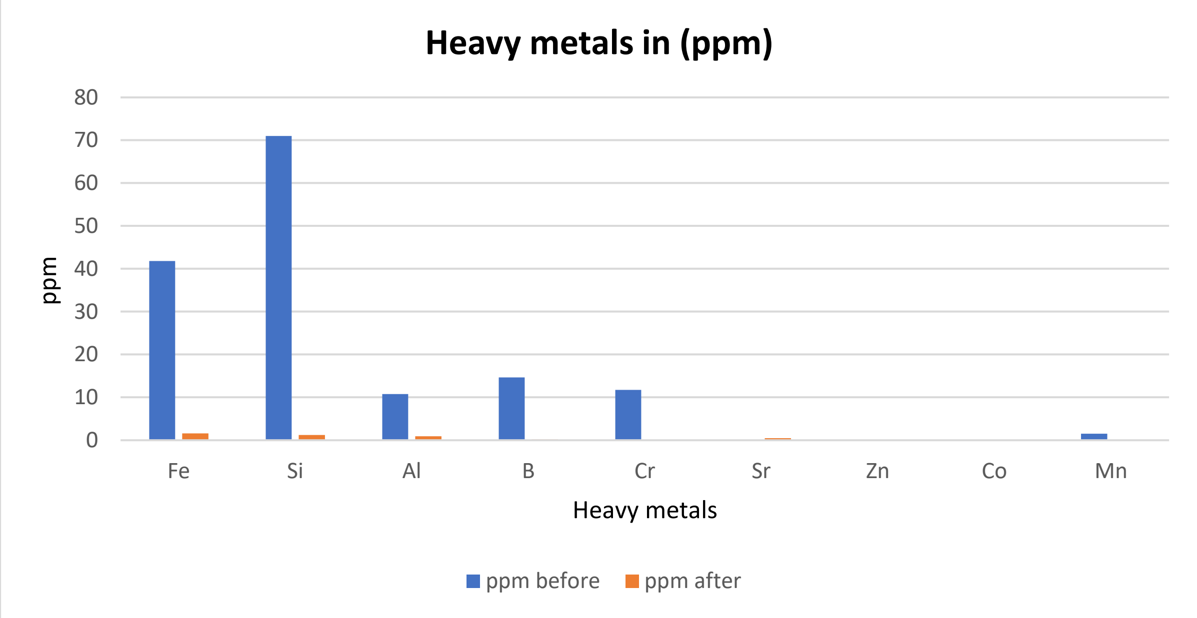
Total suspended solids (TSS)

The amount of total suspended solids before the treatment processes which is the sum of ppm of heavy metals in wastewater such as Fe, Al, Si and B = 140.1256 ppm

The amount of total suspended solids after the treatment processes = 4.491 ppm

So, the treatment processes were able to remove about 135.635 ppm of total suspended solids per liter shown in graph (8), which is the difference between heavy metals amount in ppm.

Heavy metals	Fe	Si	Al	B	Cr	Sr	Zn	Co	Mn
ppm before	41.79	70.99	10.81	14.69	11.71	0.0372	0.1179	0.1395	1.551
ppm after	1.6	1.2	0.92	0.19	0.001	0.44	0.05	0.01	0.03



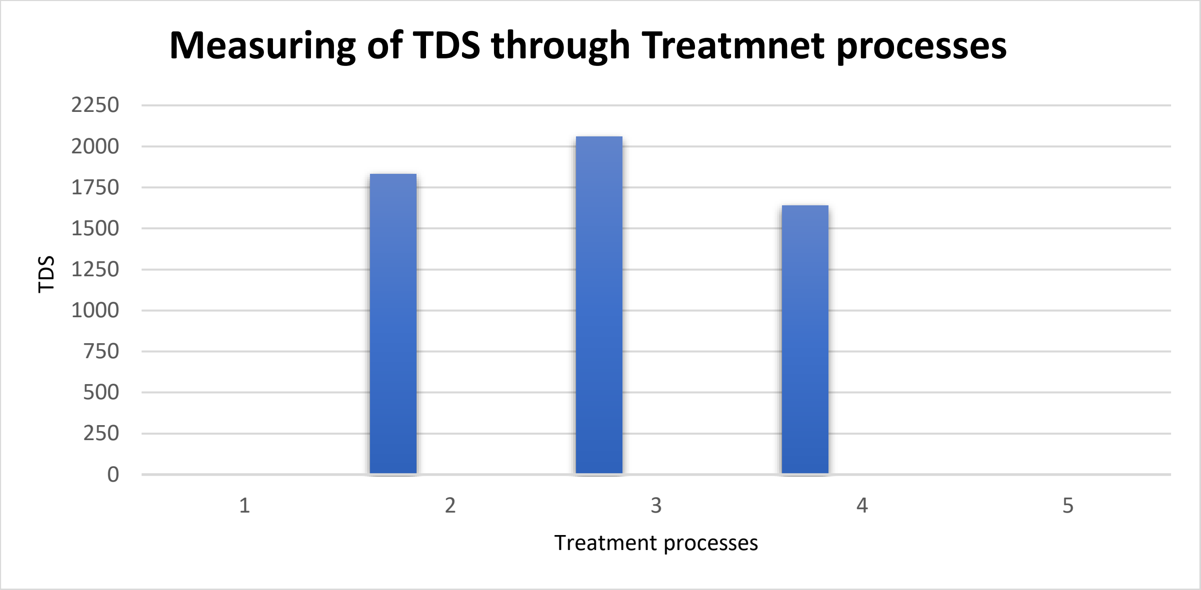
Graph (8) shows the difference in the amounts of heavy metals

<u>Total dissolved solids (TDS)</u>

Frist treatment process which was coagulation had increased total dissolved solids by 200 ppm in water. As coagulant has more ions and dissolved in water during coagulation.

Second treatment process which was powder zeolite had decreased this amount by about 400 ppm that shown in graph (9).

TDS	Treatment processes
1831 ± 0.061	Before treatment processes
2058.7 ± 0.061	After 1st treatment
1640 ± 0.061	After 2nd treatment



Graph (9) shows the calculation of TDS through treatment processes

Amount of water produced per unit time

Calculating the sum of time of all processes which was 50 minutes to produce about 826 mL treated water from 1 Liter wastewater. the vertical design used to increase the rate of processes as fast as possible which was about 1.1 Liter per hour.

Chapter 4

Analysis and discussion

Steel Industry wastewater:

Steel production is split into five parts: a coal washery, a coke oven, a blast furnace, a steel melting shop, and the rolling mills with each stage producing unique wastewater. The coal washery generates wastewater that is rich in coal fines and clay as shown in (Fig. 22) and is often treated in a settling tank (clarifier) with the use of coagulants. The coke oven produces large amounts of wastewater in the volatile gas cooling stages, resulting in tar condensate and highly toxic ammonia liquor rich in chlorides and cyanide as you can see in (Fig.23).

Parameter	Value
Total Solids	1000 - 25000 mg/l
Suspended Solids	800 - 24700 mg/l
Dissolved Solids	200 - 300 mg/l
Hardness	230 mg/l as CaCo3
Alkalinity	86 mg/l as Ca Co3
pH	7.4 - 7.8

Figure (22), coal washery wastewater quality

Parameter	Value
pH	7.5-8.0
Total free ammonia	300-350mg/l
Total phenol	900-1000mg/l
Cyanides	10-50mg/l
Thio-cynates as CNS	50-100mg/l
Thio-sulphates	110-220mg/l
Sulphides	10-20mg/l
Chlorides	4000-4200mg/l

Figure (23), pollutants in coke oven wastewater

Phenol is often extracted from his high toxic wastewater using sophisticated liquid extraction methods. Much like the last stage, wastewater in the blast furnace process comes from cooling down and capturing toxic flu gas through wet scrubbing, forming wastewater rich in iron dioxide and silica. It can be easily treated in a setting tank. Steel melting produces no wastewater. The rolling mills represent the final stage and they produce wastewater rich in iron, as the water is used in cooling down the scale pits.

Coagulation as a treatment method:

Colloidal Particles (1 nm > > 1μm) are almost always treated with coagulation because it is expensive to remove small particles using only mechanical water treatment like filtration. To remove these particles, ferric chloride will be added to the water to make the harmful particles congeal because the coagulants have the opposite charges of the suspended particles, resulting in their neutralization and allowing them to stick together as shown in figure (24).

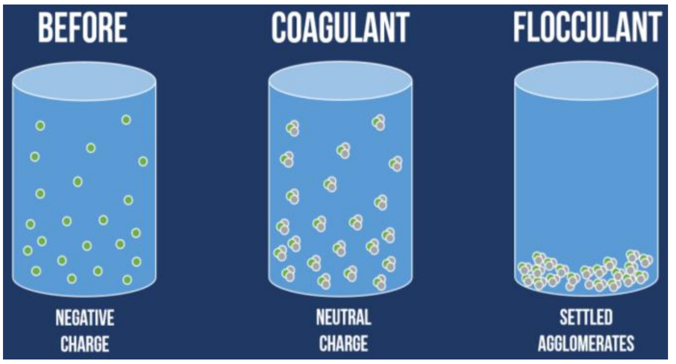


Figure (24), shows coagulation stages

Like repels like and opposites attract, Because of the chemistry of water, most particles are negatively charged. The strength of an electrostatic charge is referred to as "Zeta potential." The strength of a charge is critical in wastewater treatment because stronger charges create a more stable particle suspension in water. The zeta potential is measured on a scale of -61 +61, with higher values indicating a stronger negative or positive charge and a more stable suspension in water. Particles will easily fall out of suspension near 0, but anything above 10 will necessitate coagulation. Coagulation causes destabilized particles to collide and form small masses known as "pin flocs" or "micro flocs" because they are barely visible to the naked eye at around 50 m in size. The process of clumping particles together to form larger agglomerates is known as flocculation. A large molecule with electrostatically charged binding sites is introduced in this process to attract oppositely charged particles or micro flocs. The flocculation reaction is visible because the resulting "flocs" readily separate from the water.

Ferric chloride:

Ferric chloride is an industrial primary coagulant with the chemical formula ($FeCl_3$). It works by breaking down into positive (Fe^{+3}) ions and negative ($3Cl^-$) ions. The positive iron ions (Fe^{+3}) bind to the negative suspended colloids, neutralizing the zeta force, and allowing them to bind together into a micro-floc as demonstrated in figure (25).

$$\underset{\text{Alum}}{Al_2(SO_4)_3} + \underset{\text{Lime}}{3Ca(OH)_2} \rightarrow \underset{\text{Floc}}{2Al(OH)_3} + 3CaSO_4$$

$$\underset{\text{Ferric sulfate}}{Fe_2(SO_4)_3)} + 3Ca(OH)_2 \rightarrow \underset{\text{Floc}}{2Fe(OH)_3} + 3CaSO_4$$

Figure (25), chemical reaction between ferric sulphate and lime

On the other hand, the negative chlorine ions ($3Cl^-$) react with the water, forming an acid that lowers the PH as you can see in (Fig.26).

$$FeCl_3 + 3HCO_3^- \leftrightarrows Fe(OH)_3 + 3CO_2 + 3Cl^-$$

And without alkalinity

$$FeCl_3 + 3H_2O \leftrightarrows Fe(OH)_3 + 3\ HCl$$

Figure (26): chemical reaction between ferric chloride and water

Ferric chloride has the advantage of working over most of the PH range unlike the more commonly used alum ($Al_2(SO_4)_5.14(H_2O)$), which requires high alkalinity to function as shown in (Fig.27). However, it has the disadvantage of disturbing the PH and causing rust due to its high acidity, though that is counteracted by our use of Calcium oxide.

Chemical	Formula	Remarks
Aluminum sulfate	$Al_2(SO_4)_3 \cdot 14(H_2O)$	Most common – often used with cationic polymer
Aluminum chlorohydrate	$Al_2Cl(OH)_5$	Produces less sludge and corrosivity
Ferric chloride	$FeCl_3$	Effective over wider pH range than alum
Ferric sulfate	$Fe_2(SO_4)_3$	Often used with lime softening
Ferrous sulfate	$Fe_2(SO_4)_3 \cdot 7(H_2O)$	Less pH dependent than alum
Aluminum polymers	—	Polyaluminum chloride (PAC) – Polyaluminum sulfate
Cationic polymers	—	Large molecule, synthetic polyelectrolytes
Sodium aluminate	$Na_2Al_2O_4$	Improves alum coagulation

Figure (27), remarks of coagulants

CH.2.03: The effect of structure on the acid-base properties of calcium oxide:

Calcium oxide (CaO) is a coagulant aid that adds density to slow-settling flocs and adds toughness to the flocs so that they will not break up during the mixing and settling processes. It is a metal oxide, meaning it forms a basic solution of calcium hydroxide (Ca (OH)2) when reacting with water as shown in Figure (28). This reaction is highly exothermic, increasing the temperature of the water, which increases the effectiveness of our primary coagulant, ferric chloride (FeCl3), as its efficiency scales with temperature. In addition, its strong basic properties counteract the strong acidic properties of ferric chloride (FeCl3). This is because, as we learned in L.O3 and L.O7 in chemistry, calcium hydroxide (Ca(OH)2) is a diprotic base, meaning it completely dissociates into ions due to its high dissociative constant (Kb) of 3.74X10^-3, which can be calculated with the formula in Figure(29).

$$\underset{\text{(Quick lime)}}{\underset{\text{Calcium oxide}}{CaO_{(s)}}} + \underset{\text{Water}}{H_2O_{(l)}} \longrightarrow \underset{\text{(Slaked lime)}}{\underset{\text{Calcium hydroxide}}{Ca(OH)_{2(aq)}}}$$

Figure (28), reaction between calcium oxide and water

$$\text{Weak Acids: } HA\ (aq) + H_2O\ (l) \rightleftharpoons A^-\ (aq) + H_3O^+\ (aq) \quad K_a = \frac{\text{Products}}{\text{Reactants}} = \frac{[A^-][H_3O^+]}{[HA]}$$

$$\text{Weak Bases: } A^-\ (aq) + H_2O\ (l) \rightleftharpoons HA\ (aq) + OH^-\ (aq) \quad K_b = \frac{\text{Products}}{\text{Reactants}} = \frac{[HA][OH^-]}{[A^-]}$$

Figure (29) the formula of (Ca (OH)2)

Activated carbon:

Activated carbon is purified powdered charcoal. It must have a large volume of microspores in an adequate distribution, allowing for the adsorption of different-sized molecules. The effectiveness of activated carbon for the removal of organic compounds from fluids by adsorption is enhanced by its large surface area, a critical factor in the adsorption process. The surface area of activated carbon typically can range (from 450 to 1,800 m /g), with some carbons observed to have a surface area of up to 2,500 m /g. Powdered activated carbon (PAC) is used primarily to decolorize industrial wastewater or remove off-odors and reduces the load of organic micropollutants entering the aquatic environment. PAC is commonly used for industrial wastewater purification due to its adsorptive qualities with PAC at a dose of 1.25 g L^{-1} and found the removal efficiency to be >94% for all compounds after 5 min of contact time

Zeolite:

Sodium aluminum silicate ($Na_2Al_2Si_2O_8$) is used for water filtration because it is a good medium. It is an effective and dependable filtration medium for readily screening out pollutants. When held in hard water, the sodium in the zeolite in its pores can easily trap the magnesium and calcium salts in the water. The porous texture also causes magnesium and calcium ions to be extracted from the water as it removes both permanent and transient hardness from it. It is caused by the precipitation of calcium and magnesium ions in water. Zeolite facilitates the interchange of Ca^{2+} and Mg^{2+} ions, so it will be a useful use of zeolite to get rid of the magnesium in our water. The capability for solid particle removal is up to 45 percent, as zeolite is recognized as a heavy metal adsorbent because it possesses heavy metal adsorption through cation exchange. When examining water pollutant treatment alternatives in industrial installations, cation exchange media typically prove to be the most advantageous approach. Because these magnetic adsorbents have a high capacity for heavy metals and metallic ions contaminants in water, they will reduce the number of metals in our water and can be used across a wide pH range. These adsorption properties of zeolites can be combined in a composite to produce magnetic adsorbents, resulting in a simple preparation that does not require any special chemicals or procedures.

Recommendation

Water pumps: While relying on gravity to move the water works fine for our small-scale prototype, a full-sized factory would need water pumps to move water horizontally from one facility to another, and to move the wastewater from its source over to the treatment plant.

Arduino: We did not need to implement this recommendation as our PH didn't need adjustment, but that is likely to change in a full-sized treatment plant that receives wastewater from a multitude of diverse sources.
Having human engineers check the PH and adjust it accordingly every time would be both inefficient and needlessly dangerous. We recommend the use of a PH sensor and an Arduino board as shown in Figure (30) to automatically check the PH and adjust it using pumps connected to tanks containing both acids and bases.

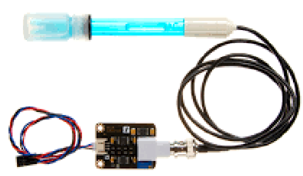


Figure (30), pH sensor Arduino

Adding nutrients: We recommend the addition of nutrients beneficial to rice. Sixteen nutrients are considered important for rice, where N, P, and K are the primary macronutrients; Mg, Ca, and S are secondary macronutrients; and Zn, Fe, Mn, Cu, B, Mo, and Cl are micronutrients. Nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) are the most important nutrients for plants. We didn't add these nutrients to our prototype because they exceeded our chemical budget.

Learning transfers

ES.2.01	This learning outcome helped us in knowing more about the water treatment processes, especially chemical coagulation and flocculation, and how to use them in water treatment.
CH.2.01	This learning outcome helped us know more about the rule of activated carbon in removing odors and unwanted tastes
CH.2.02	This learning outcome helped us in identifying the dissolved and suspended materials in the water
CH.2.03	This learning outcome helped us in the PH scale (H^+) and (OH^-) in the water to know if the symbol of water is acid or base
CH.2.07	This learning outcome helped us in counteract the acidic effect of ferric chloride with calcium oxide.
PH.2.01	This learning outcome aided us in designing a vertical design that used gravity to precipitate the solids beneath the container.
MA.2.01	This learning outcome helped us to knowing about the types of functions (linear – quadratic – exponential) to get the relationship between the quality of water before and after treatment
MA.2.02	This learning outcome helped us in using the rational function to know the relationship between the number of treatment substances and the remaining toxic materials

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