Desalinator slope

Keywords: Thermal Desalination – Heating Coils – Mineralization – Seawater - Agriculture

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Introduction:

Egypt has the goal of achieving sustainable development, where it has all the required natural and artificial resources; however, it faces some major problems that are called “Grand Challenges”. There are about eleven Grand Challenges, where five relevant grand challenges will be discussed only. Those challenges hinder the development of Egypt. They are arid areas, overpopulation, pollution, lack of water resources, and urban congestion. Also, they affect Egypt in many aspects such as the economy, environment, and social aspects. That’s why this project was developed to help Egypt achieve sustainable development, overcoming those challenges.

I. Present and Justify a Problem and Solution Requirements

EGYPT Grand Challenges:

Improve Sources of Clean Water

Human civilizations depend on many factors for survival, where freshwater is one of the most significant. Earth, the blue planet, contains 1.32 x 10^9 km^3 of water, where that percentage is considered 70% of the whole planet. That percentage is divided into 97% of marine, saltwater, and the rest, 3%, is freshwater. Those 3% are not completely reachable, where 90% of it is divided into a frozen part in the north and south poles and another part suspended at a depth of more than 700m under the ground **as shown in figure (1)**.

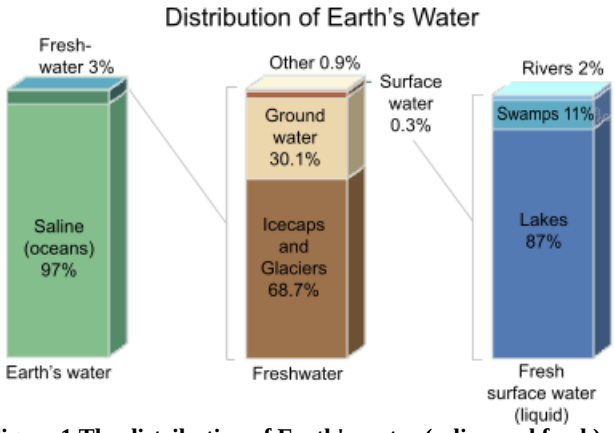

Figure 1 The distribution of Earth's water (saline and fresh)

Freshwater has many uses in domestic, agricultural, and industrial sectors, where the amount of water in each sector differs according to the country. In Egypt, **as shown in figure (2)**, agriculture has the biggest percentage of 77%, followed by industry and domestic use of 3% and 12%

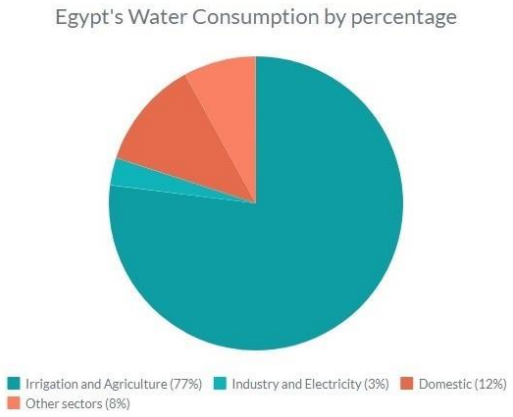

Figure 2 Uses of water in Egypt by percentage

respectively. These different uses of freshwater in different fields in Egypt imply the importance of improving freshwater resources immediately; however, many challenges impede achieving this goal, accompanied by the other circumstances of water resources in Egypt, which will be discussed.

Egypt's water resources are represented in the River Nile, agriculture water use, drainage water use, rain and precipitation, seawater desalination, and groundwater **as shown in figure (3)**. The River Nile supplies Egypt with 55.5 x 10^9 m^3 of water, where it is the main supplier of freshwater resources. Agricultural water reuse, the second main freshwater supplier with 11.1 x 10^9 m^3, is the purified water to be used in agriculture. Groundwater, water buried under the ground very deep, is the third biggest water supply in Egypt with 6.7 x 10^9 m^3. Groundwater in Egypt exists in aquifers in the western desert, Sinai, beneath and west of the delta, and even beneath upper Egypt. Those resources are formed due to the leakage of Nile water into them, which makes them a dependable resource of water. Drainage water, which is the use of excess water from fields and lands for other purposes, is the fourth biggest water resource in Egypt with 1.3 x 10^9 m^3 of water. Finally, rainwater, which is the fifth water resource in Egypt, supplies Egypt with the same amount of drainage water reuse. The north part of Egypt is the place that receives the biggest part of rainwater in Egypt, ranging from 100 mm/year to 250 mm/year, where this water is primarily used in agriculture. Seawater desalination, which is the art of making seawater fresh, is the least abundant source with 1 x 10^8 m^3 of water.

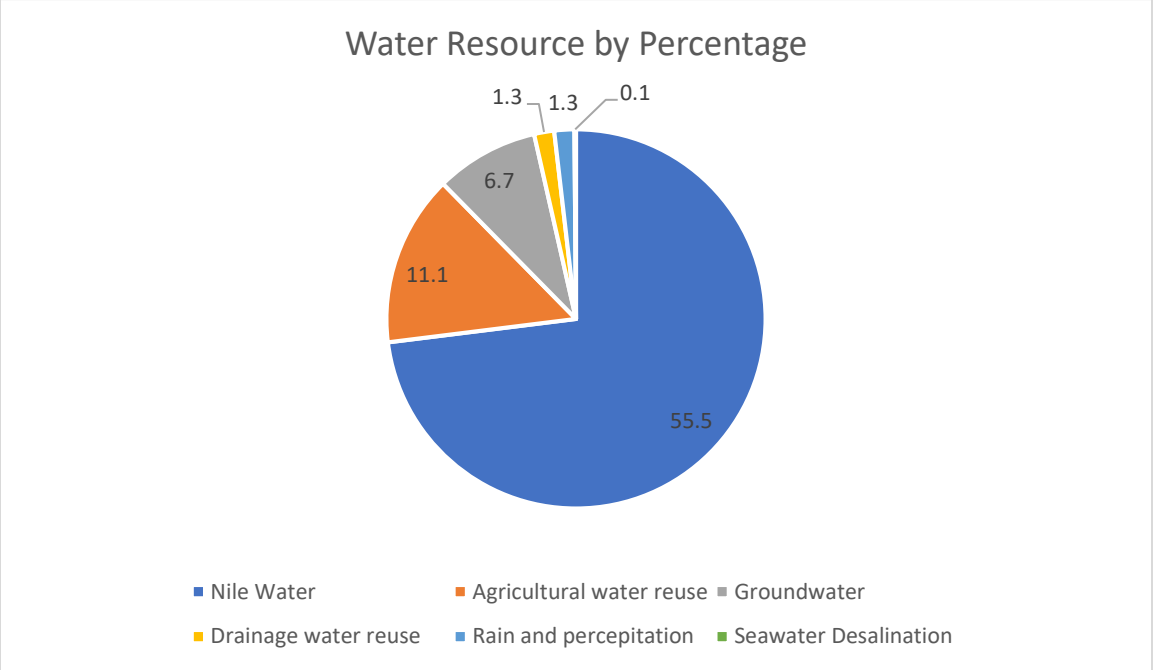

Figure 3 Water resource in Egypt by percentage

Causes:

- **Lack of infrastructure and poor management of services.**

Sometimes the disruption of water supply can be hindered by the local infrastructure. Although great efforts have been made to provide safe water for all the citizens, about 8.4 million Egyptians have a lack of access to improved, safe water in rural areas. Neglecting the remote areas is a direct result of poor management and poor distribution.

- **Overpopulation**

When the problem of population is discussed, it turns out to be a problem of bad distribution of citizens, where Cairo's population density reached 19,376 people per km^2. That extreme density led to consuming large amounts of water while exhausting Egypt's water resources and infrastructure, which in turn, increases the burden on the Egyptian government. **As shown in figure (4)**, the per capita water share changed from about $1000m^3$/year in 1996 to about $700m^3$/year in 2020, which is under the poverty line.

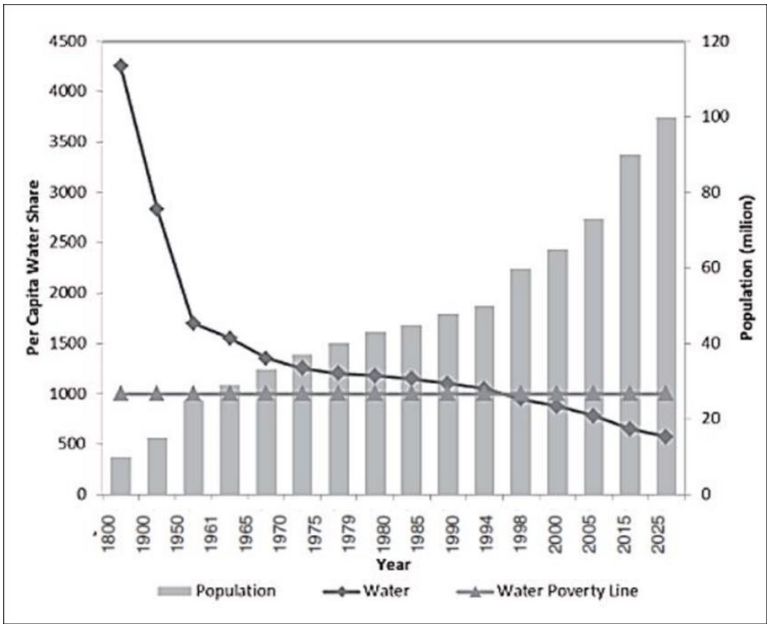

Figure 4 Per capita water share per year from 1800 to 2025

- **Water Pollution**

Pollution has a lot of effects on clean water resources; polluting the available resources will have a lot of negative impacts and will cause a lot of public health. Groundwater, for example, is affected by fertilizers and other harmful substances. As a result, an available resource of water is ruined.

Impacts:

- **Diseases**

Unsafe water and poor sanitation result in countless deaths. In Egypt, diarrhea is the second leading cause of death among under 5 children. These deaths are directly related to the loss of large quantities of water and electrolytes. Statistics show that 3,500 – 4,000 under-five children die of diarrhea every year.

- **Food shortage and hunger**

Water shortage causes a lot of economic problems. Agriculture is widely affected by the scarcity of water. Shortage of a lot of food supplies will push the country to import food, and therefore make a lot of economic challenges.

- **Loss of biodiversity**

The lack of water resources can lead to the extinction of many species in certain habitats. Improving water resources affects life in all dimensions; it’s a necessity.

Deal with the exponential population growth:

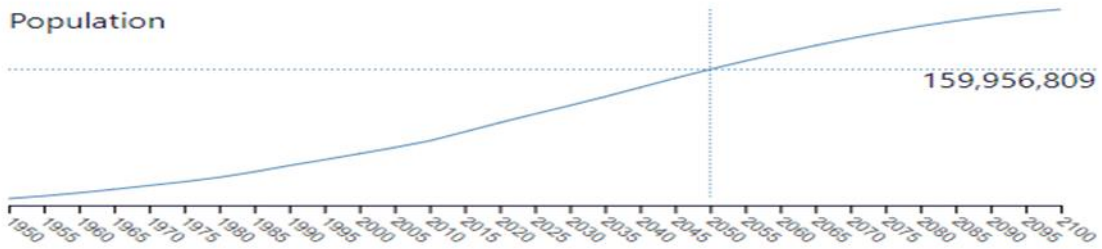

Figure 5, increasing population over time

The rapid increase in population considers as one of the serious problems. All the country's supplies are affected by it. Egypt's population still grows by about 1.5 million people each year, which is an unacceptable rate; By this rate, Egypt will reach a population of 160 million people by 2050 **as shown in figure (5)**, and Providing enough clean water resources, food supplies, and work opportunities will be a big deal. Still, most of the population is nonproductive, where the number of people between 0

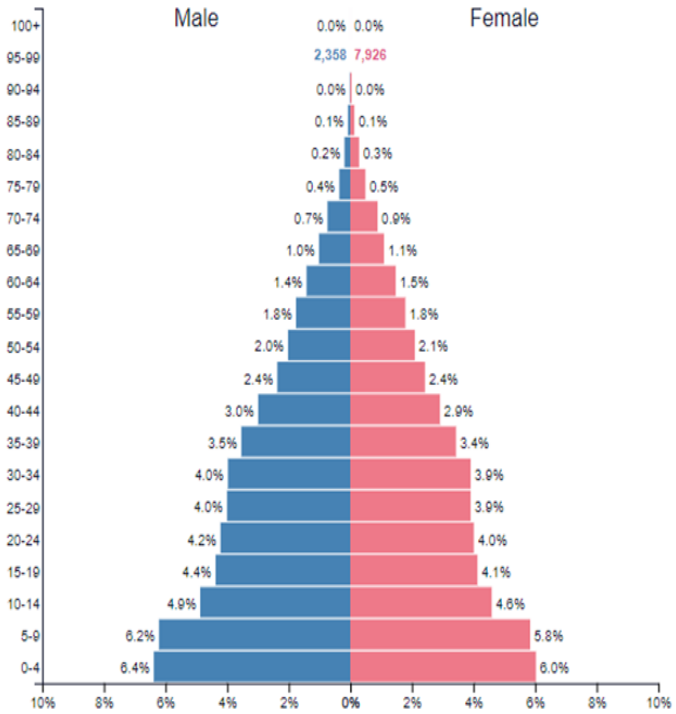

Figure 6, The population pyramid in Egypt.

to 9 years is large **as shown in figure (6)**, and this increases the burden on the government. This causes to consume the country's supplies and as a result, cause a lot of economic problems. Providing clean water resources for those millions of people is not that easy, especially, when mainly depending on the Nile water. So, seeking other water resources is important. One of the solutions that will help in this problem will be educated on this subject. Teaching the people about the impacts of the population will help a lot on this point. The role that the country should play is also another important thing. organizing the country for example is crucial to prevent congestion in the cities. The population in Egypt increases from 102,334,404 to 104,258,327 people from the year 2020 to the year 2021 with about 1.88% increase percentage **as shown in figure (7)**. Such a number is a very large one, which will cause many problems in the coming years.

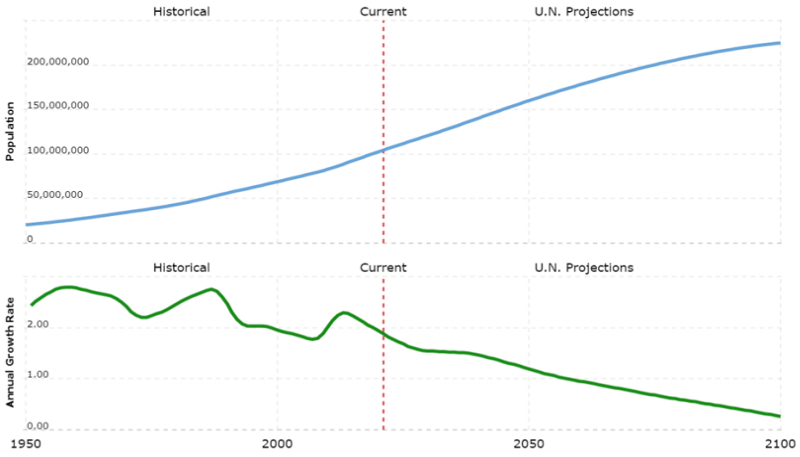

Figure 7, population growth in different years, and the annual growth rate

Causes:

- **Poverty**

Poverty is believed to be the leading cause of overpopulation. The lack of education leads to higher birth rates, which results in impoverished areas. Poverty has a strong correlation with the population as the UN has predicted that the 48 poorest countries in the world are also the biggest contributors to population growth.

- **Reduced Mortality Rates**

Improvement in medical technology has led to lower mortality rates; which is the number of deaths in a particular area; medical care has improved a lot in the last decades. This delay has led to overpopulation.

- **Immigration**

Immigration into countries and areas may lead to overpopulation. A big problem that Egypt faces because of the density of people in the main cities that consumes the services and causes urban congestion. Whereby increasing the density of people, the population number increases.

- **Fertility Treatment**

Though it does not play an important role, compared to the other causes of overpopulation.

Improved fertility treatments lead to an increase in the population. Due to the fact that woman's chances of having babies increase.

- **Lack of family planning**

The lack of education is a very serious problem. A lot of families have little or no knowledge about family planning. As a result, they attain more than the desired children's number, which in turn, increases the rate of population growth.

Impacts:

- **Resource Consumption**

As the population grows, Food, water, and fossil fuels are all being consumed at high rates, which places a lot of demands on producers and the planet itself. Another thing is that the increase in the consumption rate is proportional to the decrease in the planet's resources.

- **Extinction**

The effect of overpopulation on the world's different species is one of the impacts. Due to the destruction of natural habitats, lots of species are affected. The extinction arises due to the unbalance between the number of consumers (such as people) and the number of consumed ones (such as chickens).

- **Global Warming**

As the population grows, the demand for fossil fuels increases. The burned fossil fuels increase and This leads to an increase of the Co2 concentration in the atmosphere, which leads to global warming. Whereby increasing the concentration of Co2, the amount of heat stored in the earth increases.

Reduce Pollution

Pollution is from the grand challenges that face Egypt, there are many types of it for example (water, air, and noise pollution). The available water in Egypt for one person decreases with time because all the wastes (e.g. industrial, domestic, and agricultural wastes) are thrown in the river which is the mean source of water in Egypt. by increasing pollution with time in Egypt, the government began to search

for more water sources rather than the Nile to reduce the risks in the next years, for example,

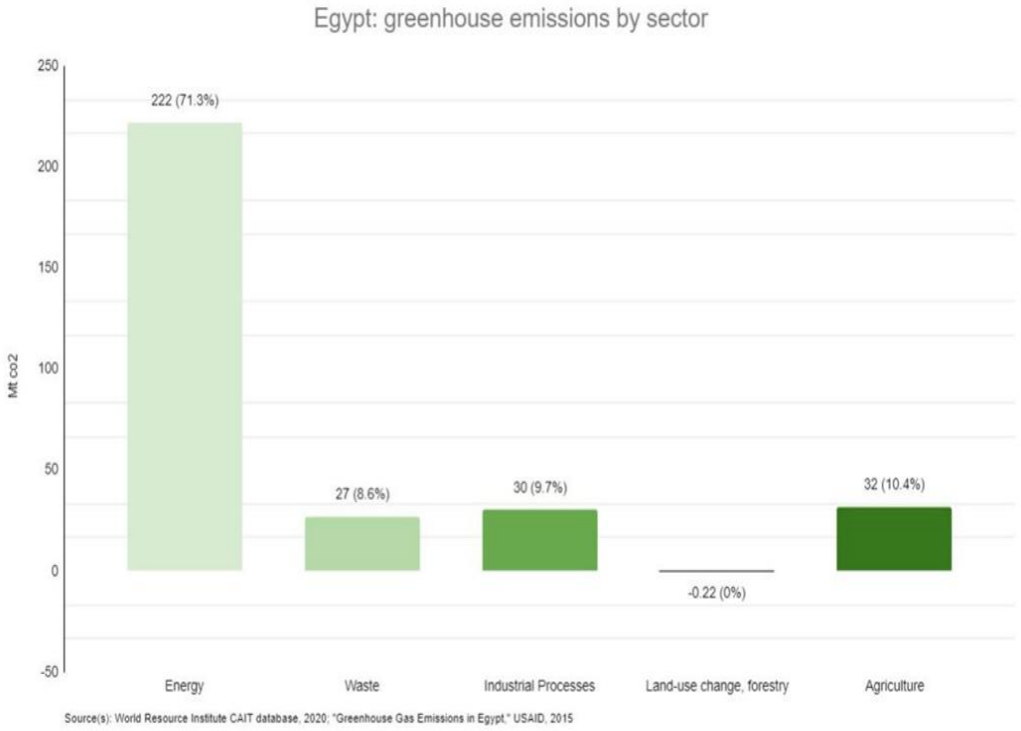

Figure 8, greenhouse emissions from different sectors

groundwater. The government must look for more solutions to stop the pollution like the process of extraction of groundwater from aquifers to increase the average amount of water per one person. The pollutants from different factories (e.g. wood and paper pulp processing, chemical producing, and distillation factories) cause water pollution, which in turn limits the amount of clean water. in addition, about 43 town and 2500 villages with a population quantity of more than 20 million citizens between the Aswan high dam and Cairo along the Nile valley throw their untreated sewage and wastewater in the Nile. **Figure (8)** shows the different sectors causing the greenhouse emissions in Egypt.

Where the largest sector is energy with about 71.3 % of the total greenhouse emissions. And the second largest sector is agriculture with about 10.4% of the total greenhouse emissions.

Causes:

- **Getting rid of industrial wastes in water resources**

Where these wastes contain many pollutants such as mercury, sulfur, arsenic, asbestos, oils, petrochemicals, and cadmium, such materials are separated hardly from water. such industrial processes account for about 9.7% of the total greenhouse emissions in Egypt.

- **The production of weapons and the processing of ore**

Such a thing produces radioactive wastes (e.g. cesium, iodine, uranium, radon, and thorium) which in turn pollute the underground water.

- **Fertilizer runoff**

Where the excess water carrying fertilizers runoff from the lands to the water source (e.g. river, lakes, and streams) which in turn passively impacts the aquatic life and people because of the spreading of toxic algal blooms.

- **Urban congestion**

The density of people in their area increases, by moving from arid areas to areas characterized by their industrial base and the availability of water. and by increasing the number of people the pollution increases in air, and water. On the

other hand, the toxic gases and dust particles from the exhausts of the means of transport and factories cause air pollution and water pollution.

Impacts:

- **Global warming and respiratory system diseases**

The exhausts coming from factories and transport increase the percentage of greenhouse gases which increases global warming, and infect the respiratory system in humans and can cause lung cancer, and causes water pollution.

- **Increasing health problems**

Drinking polluted water cause many problems in the human body especially the digestive system. And eating fish that contains a large percentage of mercury lead to other health problems.

- **The death of marine creatures**

The death of marine creatures is due to the large percentage of toxic materials. Which in turn passively affects the activities of fishermen due to the lack of food.

- **The lack of clean water**

The lack of clean water needed for people in their live activities (e.g. drinking, washing clothes, cooking, and cleaning).

Reduce Urban Congestion

Egypt is facing a large challenge which is Urban congestion (**as shown in figure (9)**), and the government of Egypt is looking for solutions to overcome this grand challenge. Big cities like Cairo are overcrowded, as when the people become blocked in one city to find a job or better education or any reason, problems are being originated. So, people have to pay attention to such a problem to reduce its risks. The Urban congestion varies between different cities, and Cairo counts for the largest population with about one-fifth of Egypt's population which is more than 19 million inhabitants. The density of people in Cairo ranges from 40,000 persons per kilometer squared to about 100,000 persons per kilometer squared in older districts. The

Figure 9, Urban congestion in Egypt

population of Cairo will be doubled after passing 35 years if the rate of population growth in it continued by the amount 2%, however in some parts of it the growth rate is more than 3%.

Causes:

- **The Internal Migration**

Internal Migration is the movement of people in the same country from their regions to new ones and over relatively short distances which don't change the population number in their country but affects the density and the distribution patterns in the same country. Another thing is that marriage is the cause for about 42% of migrating immigrants. In addition, the migration of the wife to her new home causes the number of male immigrants to be less than the number of female ones (59%:19% respectively).

- **Housing**

Most people leave their rental residence into a newly purchased dwelling. The large unused space in the living homes of people or the shortage of their living places make some people prefer to change their residence and move to a new one.

- **Employment**

Where people leave their old residence and change it with a new one to find a better social level or to find a better job.

- **Education**

Several college students have to move to a new city in order to have a better education and university, for example: in Asyut or Suhag some college students go to Giza or Cairo to take part in a better university such as Cairo or Ain-Shams university.

Impacts:

- **Traffic congestion**

In Cairo, traffic congestion impacts the economy because 8 billion dollars is lost every year which represents about 3.6% of Egypt's gross domestic product, and the wasted time which can be put in more productive uses, there are other impacts came from the traffic congestion where the more fuel consumption the less air quality in such areas**. Figure (10)** shows different means of transport that cause traffic congestion, where private cars account for the most use of about 75,3% of the total use. According to these things

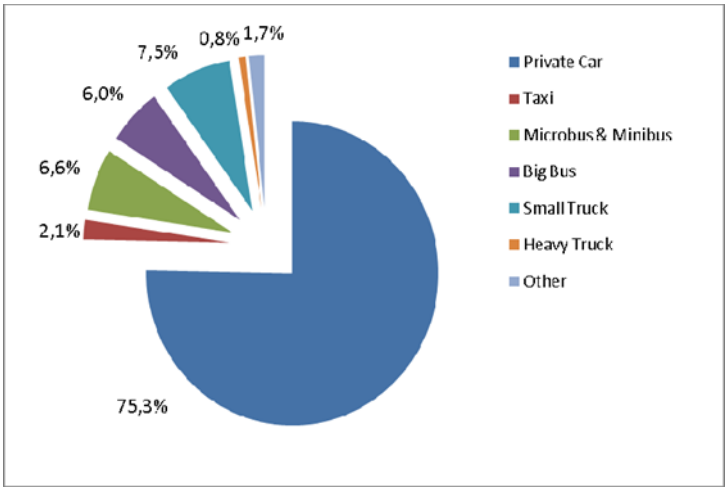

Figure 10, Traffic congestion among different means of transport

solving the problem of traffic congestion of different types of transports especially in Cairo and other big cities is so important for the Egyptian government.

- **Increasing diseases**

The number of diseases is in a state of growing risk as by increasing the density in a given locality it became more difficult to deal will all people, and to deal with pollution in such areas.

Improve Use of Arid Areas

Arid areas are from the grand challenges that face Egypt, where the lack of water resources and the low fertility prevent the development of animal and plant life, Egypt occupies about one million square kilometers; the hyper-arid areas occupy about 86% of Egypt's land, and 14% in the arid climatic conditions **as shown in figure (11)** the Egyptian Western Desert occupy large places of arid areas in addition to the Egyptian Eastern desert. Many problems are originated in arid regions such as Urban congestion is by considering the fact that most of Egypt's area is a desert, people prefer to be near the Nile river which leads to another big problem which is increasing the sources of pollution like noise, air, and water pollution. There are many types of arid areas in Egypt from them: arid areas which receive precipitation less than 10 inches of water every year, and semi-arid areas which receive from 10 to 20 inches of water per year. The Egyptian government and people must solve this challenge as it threatens life.

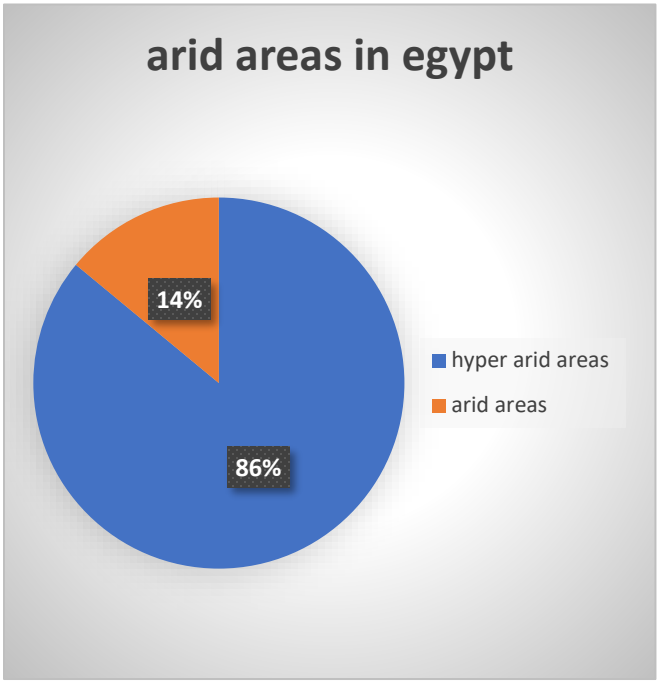

Figure 11, Arid areas in Egypt

Causes:

- **Decrease the fertility of the soil**

Removing fertile soil to build factories, and to manufacture brick, which causes the land to be weak.

- **Depending on the limited water resources**

Where the continues mismanagement of other resources like underground water, rainwater, and the water that can be extracted from the humidity of weather.

- **Overgrazing**

Which is when a farmer farms livestock for a long period of time and after that leaves the land after harvesting and doesn't fertile the land again, which makes the land unready for the coming season. and the movement of air which makes the sand of both the Eastern and the Western desert move with the movement of air and reaches the Nile valley.

- **The dry climate in Egypt**

Which affects the amount of rainfall water, which makes the people depend on the Nile river, which in turn affects the available amount of water for each person.

- **Desertification**

Where the land becomes desert as a result of inappropriate agriculture, deforestation, and drought.

Impacts:

Urban congestion

The huge amount of arid lands in Egypt makes people live on Nile valley rather than desert which covers most of Egypt's land, so according to this the density of people increases which lead to Urban congestion, and in turn pollution increases and diseases spread more rapidly.

Decrease in national income

When overgrazing (**shown in figure (12)**) happens to the land, the livestock will not be ready for the next season and this will affect the Egyptian budget which will need too much money and high technology to be reclaimed.

Figure 12, Overgrazing

Problem to be Solved

"Lack of Water Sources in Agriculture"

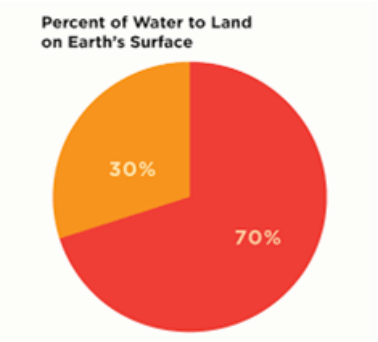

Figure 13, water percentage on Earth's surface to land

Water is life, where it has many uses like agriculture, industry, drinking, and other domestic uses. Although 70% percent of the earth's surface is covered by water (**as shown in figure (13)**), making up 326 million cubic miles of water, 97% of them is found in the oceans, which can't be used for drinking and other uses such as agriculture. From the other 3% of freshwater, only 0.5% is usable as the other part is locked into glaciers and other icy structures. All of that makes usable water resources rare and valuable. This makes each country forced to provide its citizens with the largest possible amount of fresh, usable water supply.

Freshwater resources are declining in the world from an average of 12,065m3 per capita in 1967 to an average of 5,732m3 per capita in 2017, where Egypt has an extreme water crisis as it has an average of 10m3 per capita. Agriculture needs about 87% of freshwater resources, which implies that the decrease in freshwater sources causes an extreme danger as the need for agriculture increases in proportion to the increase in the population count. That population increase appears extensively in Egypt as the population percentage increased by 41% since the 1990s.

Although agriculture is hard and expensive to manage and maintain through all of those difficulties, countries work on preserving agriculture due to its benefits. These benefits include getting rid of urban congestion by attracting them to live around agricultural areas, the increase in the national income caused by agricultural products, and others.

Many factors are affecting the availability of water resources in Egypt, where pollution is the most significant challenge that opposes most of the world's nations, especially in the developing, poor, and arid countries, where Egypt would not be an exception. Pollution has artificial and natural causes. The natural causes arise from the leaching of water, so water reaches natural pollutants. Another natural cause is the geological weathering in the nearby watersheds. Domestic, industrial, and other types of wastewater may reach the water. Also, bacteria from livestock and human wastes may pollute water. Finally, air pollution turns rain into its acidic form, damaging plants and crops and causing extreme health problems to people.

Positive Consequences:

- ### Getting rid of Urban Congestion

Some industrial cities in Egypt like Cairo, which have many services and jobs, have a great concentration of citizens. As an example, Egypt's Greater Cairo Metropolitan Region (GCMR) is ranked the tenth largest mega city in the world. That is primarily due to the great number of services, jobs, and chances in the GCMR and other cities in comparison to other agricultural cities. The lack of water

resources causes the damage and destruction of the agricultural areas, which limits the chances, services, and jobs there. That encourages the citizens of those cities to go to other industrial cities to find jobs.

- **Increasing the national income and decreasing debts to other countries.**

Agricultural activities produce crops, where those crops have a lot of financial benefits. Those crops are sold to other countries, increasing the national income by being sold to other countries. Moreover, those crops are used in different industries, which increases the national income the same way as the crops. Since providing better water resources leads to increasing the crops, national income will increase.

Negative Consequences:

- **Decreasing the variety of crops**

a lot of crops need a significant amount of water per year. Rice, for example, is one of the, most water-consuming crops. With this shortage of clean water resources, such crops will be difficult to be produced at the current rate.

- **Decreasing the quality of soil**

Good Soil has a lot of characteristics. Water is essential to maintain the water's quality. The lack of water will make the soil drier. This will affect all the crops and ad a result causes hunger and starvation.

Research

Topics related to the problem:

Groundwater salinity:

Salinization (**as shown in figure (14)**) is a major environmental problem, which creates disturbances in the natural ecosystem. The high concentration elements like sodium, boron, fluoride, arsenic, sulfate, and high radioactivity increase the salinity of the groundwater. Salinity is the mean source of water in the arid and semi-arid areas located in Egypt. There are three types of groundwater salinity which are: 1- natural/primary salinity, 2-

Figure 14, Ground water salinity

secondary/dry land, and 3- irrigated salinity. The natural salinity is caused by the accumulation of salts from the rainwater by passing time or the dissolution of minerals like (anhydrite, halite, fluoride-salts, sulfate-salts, carbonates, gypsum) from bedrocks, and its ranging time is from thousands to millions of years. dry land/secondary salinity caused as a result of vegetation cleaning which accumulates salts in the groundwater or water levels' rising which cause salt to be on the surface. Egypt's arid and semi-arid regions salt remain on the surface. tertiary/irrigated salinity caused due to the repeated multiple irrigations of water where after evaporation salts remain and accumulate by passing time. Groundwater occupies from Egypt's land about 4.80 km cubed/ year.

The use of flood irrigation:

Flood (surface/furrow) irrigation (**as shown in figure (15)**) is from the ancient's methods used to irrigate crops, where water is delivered by farmers through pipes to their crops. This method causes the water to be unequally distributed through the crops due to the fact that they cannot control the amount of distributed water due to the lack of mechanized spray irrigation systems, and the lost water by evaporation. furrow irrigation is

Figure 15, Flood irrigation

a cheap way that requires low technology and this method is still used up to day. The amount of water lost by evaporation in surface irrigation is less than that of spray irrigation, but the water lost at the edges of the fields during runoff is much large. In the less developed areas, flood irrigation is used as a result of the unavailability of mechanical techniques.

Water logging:

Water logging (**as shown in figure (16)**) is what happens when the soil's pores are wet with water, where the amount of oxygen needed for the roots of the plant to perform the process of respiration. Oxygen gas's solubility in water is about 264 uM at 25 degrees Celsius so it is considered to be relatively insoluble in water, and this explains why water logging reduces the amount of oxygen in the soil pores. The scarcity of oxygen in root the zones' root of plants causes the decomposition of their root tissues usually from the tips. As a result, roots appear to be pruned. The lack of oxygen also affects the plant's development and growth, and if this will continue it will lead to the plant's

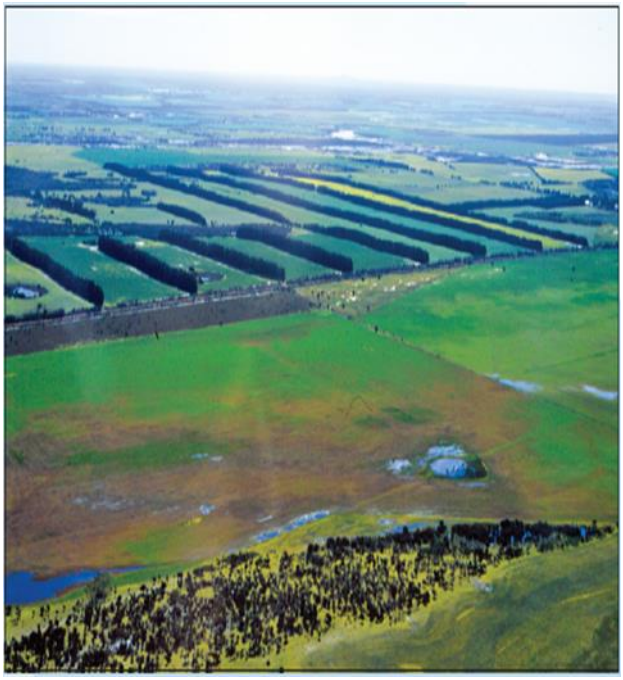

Figure 16, Water logging

death. Another thing that causes waterlogging is the heavy rainfalls where soil can't absorb all the falling water. nitrogen gas which is an important gas for plants to make proteins is lost from waterlogged soils by degassing, where degassing impacts the loss of the green gas nitrous oxide into the atmosphere, such loses, and the less ability of plants to take nutrients from the waterlogged soil leads to the yellowing of the old leaves. Water logging lacks water because of the replacement of air from the waterlogged soil into the atmosphere by more water.

Topics related to the solution

- **Reverse osmosis:**

Reverse osmosis **(as shown in figure (17)**) is the leading technology of the water treatment problem. Over the past 40 years, this technology shares about 44% of desalting production capacity and 80% of the total number of desalination plants installed worldwide.

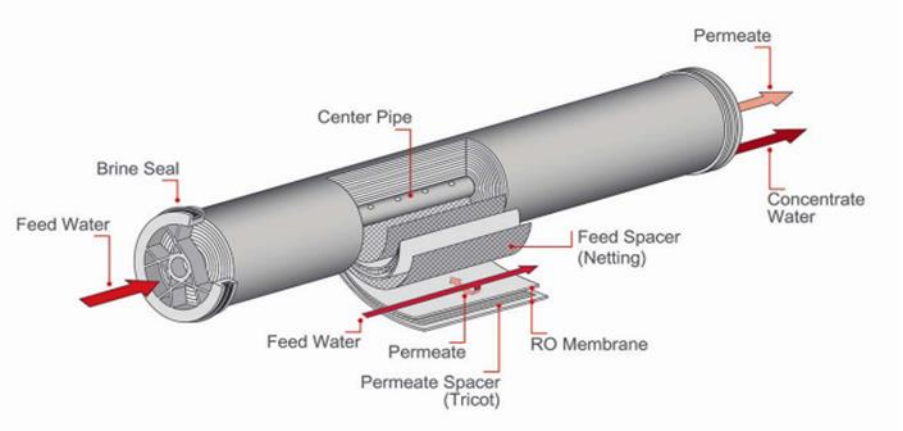

Figure 17, Reverse osmosis

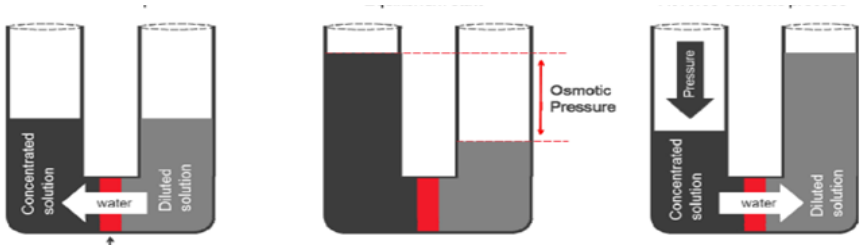

Figure 18, the difference between Osmosis and Reverse osmosis. (a) the behavior of osmosis process (left), (b) the Osmotic pressure(middle), (c) Reverse osmosis (right).

Osmosis is a natural phenomenon, which is defined as the movement of water through a semi-permeable membrane from a low concentration to a high concentration. Such a phenomenon **is shown in figure (18, a)**.

The membrane is permeable to let water, ions, and mineral, but rejects almost all ions and dissolved solids.

The osmosis process will stop when the height of the solution causes the osmotic pressure crucial to stop such a process. This **is shown in figure (18, b).**

Reverse osmosis **as shown in figure (18, c)** on the other hand, is a process that occurs when pressure, greater than the osmotic pressure, is applied to the solution. As a result, Water is forced to flow from the concentrated side.

The flux of the water can be calculated as:

$$Jv = \frac{QP}{S}$$

Where: JV, permeate flux, S, area of the membrane, Qp, permeate flow rate

So, it is compulsory to adjust the surface area to be decreased, this will lead to the most efficient treated water.

In the reverse osmosis plants, the saltwater is pumped into filters, going through a lot of Ro membranes, designed with special materials, to filter

the water from TDS (total dissolved solids) and impurities.

- **Electrodialysis:**

Electrodialysis (**as shown in figure (19)**) is an electrochemical process that is used in water desalination and treatment, too. It is used to remove the dissolved salts and solids by an electric current.

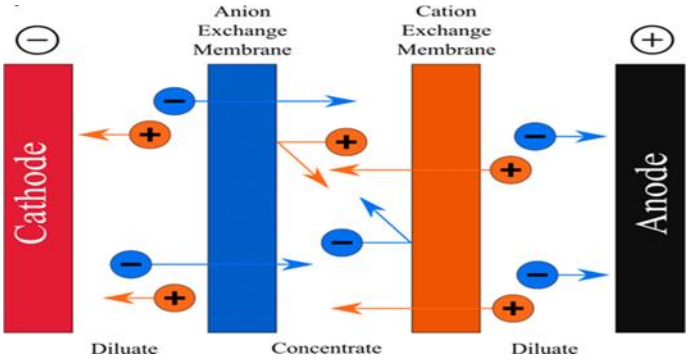

Figure 19, Electrodialysis

The Electrodialysis ion transfer separates salt from water. It is used for substances that can be ionized such as salt (NaCl) separates, in solution, into a mixture of Na^+ and Cl^- ions.

Some substances like silica, for example, do not ionize and hence are not removed by electrodialysis.

The positive ions go towards the cathode, and the negative ions go towards the anode, leaving the pure water in the middle. With no consumption of chemicals, this gives an important advantage to this method of treatment, as it will be safe to use the product water in agriculture and domestic uses.

No chemicals are required in this process of desalination, which makes it a good choice due to its safety. Also, the cost is relatively low compared to other methods such as reverse osmosis. This method does not require a complex pumps system or a lot of special membranes.

- **disinfection of water:**

Dams, streams, and rainwater tanks are examples of how we collect and obtain water. All of these are vulnerable to contain microorganisms such as bacteria and viruses (a bacterium cell **is shown in figure (20)**).

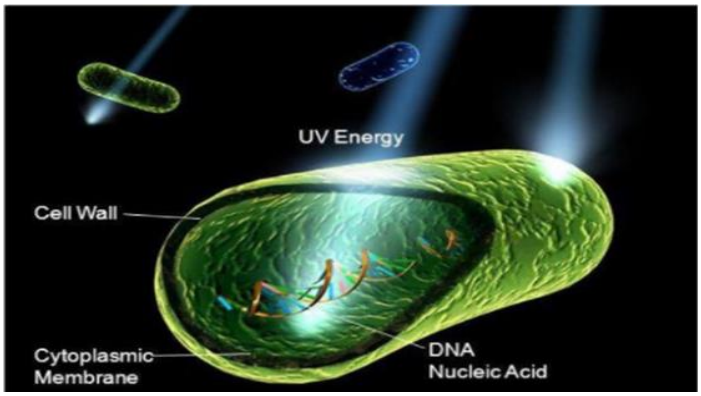

Figure 20, Effect of UV light on bacterial cells (physical disinfection*)*

As a result, water must be cleaned and treated to avoid health problems. Disinfection can be physical or chemical.

Chemical disinfection (**as shown in figure (21)**) is implemented by adding chemical substances such as chlorine, chlorine dioxide, and ozone to kill the microorganisms.

Physical disinfection includes the use of ultraviolet light, heat, and electron radiation. As the waves enter the microorganism and damage its cellular function. As a result, the microorganism will not be able to grow and divide anymore.

As shown in the figure, the UV enters the cell, targeting the DNA to completely eliminate the microorganism present in water.

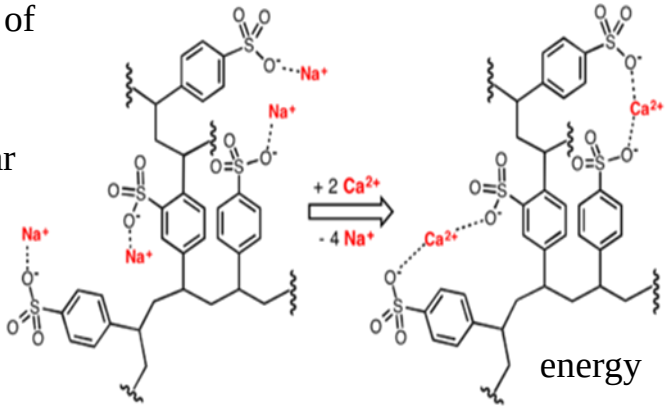

Figure 21, Chemical disinfection

energy

- **Water Softeners:**

The quality of water depends on a lot of aspects. One of them is water softening.

The water softener device is widely used in such a problem. As it reduces the hardness of the water by using sodium or potassium ions to replace calcium and magnesium ions, the ions that make water “hard”

Another method is the use of resins. Reins replaces the hard ions with softer ones. This is called the ion exchange process. As shown in the figure an exchange between Ca (hard ion) and Na (innocuous ion).

Other solutions already tried:

Tampa Bay Seawater Desalination in Florida:

The Tampa Bay Seawater Desalination (**shown in figure (22)**) is an extremely important supply of water in this region. A total of 90 million gallons of drinking water per day. This planet provides up to 10% of the region’s needs. By using one of the most important methods of desalinating and treating water: reverse osmosis. The water, which is produced, has proved to have a high quality. So, the water can be used for domestic uses and all the life fields.

Mechanism:

The treatment of water in the Tampa Bay Seawater plant is divided into three stages:

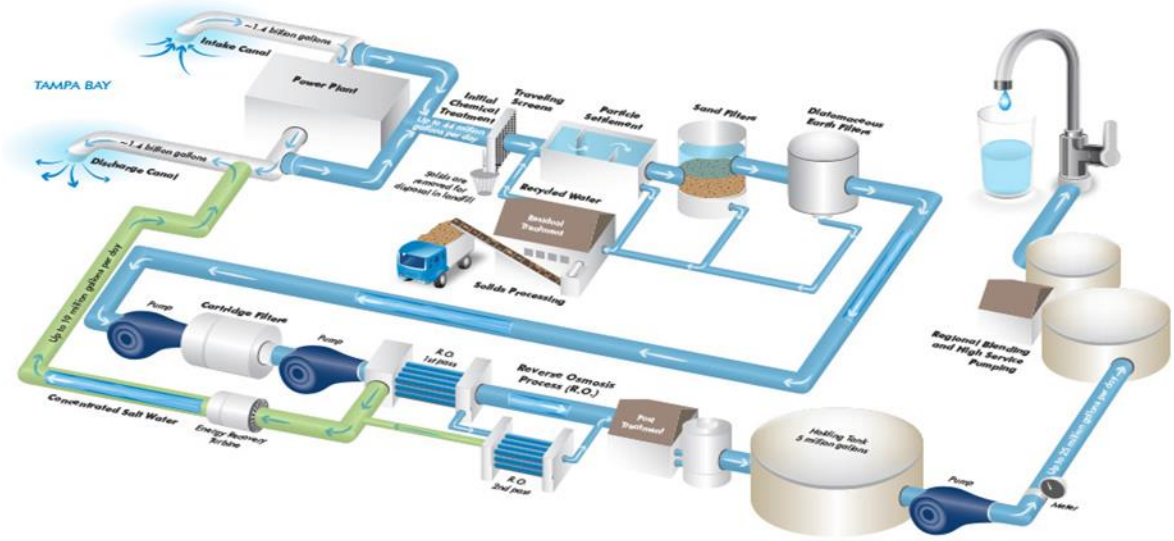

Figure 22, Tampa Bay Seawater Plant

1. Pretreatment
2. Reverse Osmosis
3. Post-treatment, Blending, and Delivery

Pretreatment:

Before getting through the main process “Reverse osmosis”, seawater entering the plant flows through “screens” that remove all of the debris present in the water.

This process is implemented by three of the traditional processes of water treatment:

1. coagulation
2. flocculation
3. sand filtration

in these processes, chemical substances are added to the water to make microorganisms, algae, and organic materials clump together, so they can be removed easily in the sand filtration process.

Reverse Osmosis

In the main process, which is reverse osmosis, high-pressure forces are applied to the

pretreated water. This causes the water to move through special, semi-permeable membranes to separate the fresh water from salty seawater and the TDS “total dissolved solids”.

Post-treatment, Blending, and Delivery

After the reverse osmosis process, some chemicals are added to the water to make it stable and ensure high-quality water. The water is then delivered to Tampa Bay Water's regional facilities site to be stored.

Advantages:

Safety and health

Because of the many stages of treatment and desalination, the quality of water is extremely good. This affects public health positively. This water is used in everything in life, so It should be clean and safe.

Production rate

The production of treated water is high in comparison with other plants like cater water plants. A total of 90 million gallons of drinking water is produced per day. This covers a wide sector of the needed water in the region.

Strengthening economy

The Tampa Bay Seawater Desalination plant helped the region to do a lot of human activities, including fields like agriculture, industry, and even tourism.

Disadvantages:

Cost:

The cost of the plant is relatively high. The initial project budget was 110 million dollars, but the cost rose to 158 million dollars due to the additional work and the unexpected problems.

Maintenance:

The plant requires frequent maintenance to the complex pumps system and the membranes need to be replaced every six months. This disadvantage is present in all desalination plants that depend on the reverse osmosis process.

Fog water in Egypt:

Egypt has an extreme lack of water resources in all fields, especially agriculture. That's why research on fog water was started. A pilot fog collector was installed at Delta Barrage, an Egyptian city. Research on water quantity, quality, and availability for irrigation was made from

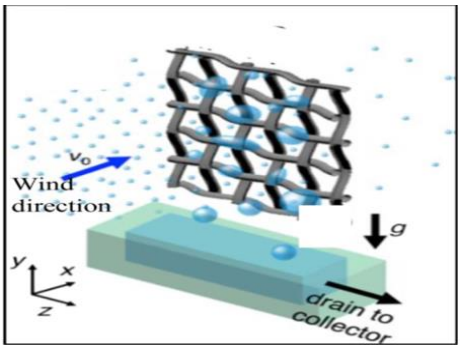

Figure 23, The mechanism of a fog collector

November 2015 to February 2016 by analyzing 10 water samples, where the results showed the consistency of the collected water with the guidelines and national standards. Moreover, there was a slight increase in the nitrate concentration. That increase made the water extremely ideal for agriculture.

Mechanism:

Fog water collectors are made by putting a mesh in the direction of wind-carrying fog, where that mesh makes fog become collected, accumulated, and fall down by the effect of gravity to the rainwater collector (**as shown in figure (23)**). Fog collectors are classified into Standard Fog Collectors, used for experiments or areas with a poorer fog supply as they have a small area, specifically a square meter, and Large Fog Collectors, used for larger installations in areas of a great fog supply. The mesh is usually made from stainless steel.

Advantages:

- **The low cost.**

The cost of fog collectors is really low, whereas a Large Fog Collector costs 400$ and produces 150-750 L, according to the site. The area of a Large Fog Collector is 48m2. If the area was small or the source of fog was minimal or the budget is smaller, it may be convenient to use the Standard Fog Collector of a unit meter square area.

- **The extreme purity.**

The concentrations of heavy metals such as lead, aluminum, zinc, and even manganese were within the national standards. In addition to heavy metals, water quality variables such as pH, Dissolved Oxygen, and turbidity met the national standards. This means that fog collected water is clear, where the increase in the nitrate measurements specifies the use of water in irrigation, solving the agriculture problem.

Disadvantages:

- **Limited use.**

Fog collectors cannot be used in most areas, where fog is may be rare in many places. Moreover, the number of fog events every year is limited, determining strict borders for the use of fog water.

- **Need for more knowledge.**

Although the fog water collector is easy to install and operate, citizens need more, if compared with hand-dug wells, instructions for using it. It is recommended to have and distribute guides for normal citizens to help them identify the basic components and instructions.

Wave-powered desalination plant in the garden island.

A new technology that can produce water by using wave energy, reducing the consumption of expensive energy. Australia has started to take action with this new technology. On the garden island, in western Australia, this project has started to produce clean and inexpensive water.

Mechanism:

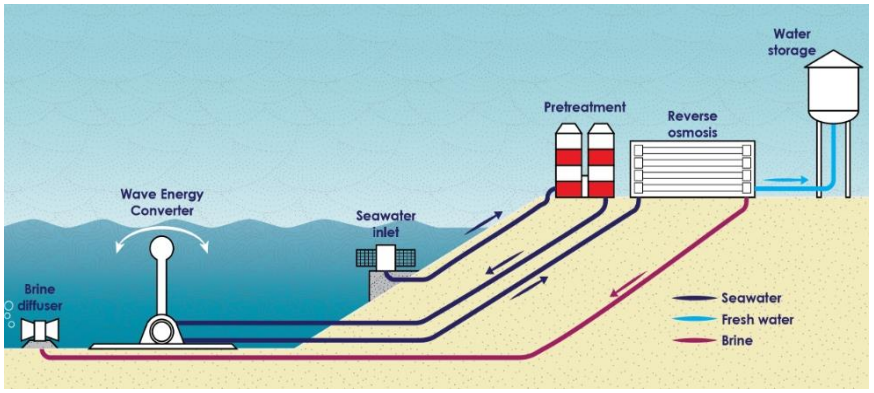

Figure 24, The mechanisms of The Wave Powered desalination plant

The mechanism depends on how to take advantage of a new, clean, and cheap source of energy to power the desalination plant. It consists of a metal flap that oscillates with the movement of the waves. This flap converts the energy into pressurized and stressed seawater, which is directed to the shore for filtration via reverse osmosis. Reverse osmosis is the second step to purify the water from unwanted molecules, ions, impurities, and large particles by passing

through a permeable membrane. Once the water had been treated, the impurities are sent to the brine diffuser which distributes it over a large area to prevent any harm to the marine life. **This is shown in figure (24)**.

Advantages:

- **Clean source of energy:**

As the plant depends on a new technology powered by the wave movement. It does not produce greenhouse gas emissions, which harm the environment and affect the climate.

- **Habitat protection:**

As the plant uses seawater, the desalinated water meets the water quality standards. So, this means reducing the stress on freshwater sources, which are about to be totally consumed.

- **Providing water for agriculture:**

The water produced is safe for the use of irrigation of plants and also the required water for livestock. This helped to improve the agricultural industry there.

Disadvantages:

- **The wave height needed to generate the energy:**

Such a project will not be available in all the seas or oceans. As there is a required amount of power to start the process, which is 10 kilowatts of wave energy per linear meter. Such a rate will not be available in all the places around the world.

- **High-cost materials**

The materials used in the wave-powered desalination are relatively expensive. A lot of turbines and waterproof materials are used in the construction of these energy planets. All of these materials add to the total cost of the project.

II. Generating and Defending a Solution

Solution Requirements

Availability:

The solution and its materials should be applicable in order not to cost too much to apply. Moreover, the low cost will make it a feasible solution that will lead to the utilization of the water sources in Egypt.

Cost:

The solution should have a low cost, where the low cost will make the solution applicable in a bigger number of cities. The cost should be reasonable relative to its output and the commercial value of the crop depends on it.

Environmentally-friendly:

The solution must be friendly to the environment it is built-in. A solution is considered environmentally friendly if it does not harm the environment it is built-in- water in it and the different organisms living in it.

Effectiveness:

The solution must be effective, which means that it gives the biggest possible amount of water suitable for the crop depending on it. Moreover, the solution must effectively contribute to solving the proposed problem.

Design Requirements

Water Quality Parameters:

Water has many parameters that could be tested to ensure the work of the prototype, where those parameters depend on the use of water. The common crops in Egypt are characterized by a wide pH range from 6.5 to 8.4, and they are characterized by a TDS measure less than 500mg/liter, specifically from 200mg/liter to 500mg/liter. The pH can be measured using a litmus paper from the chemistry laboratory, while the TDS could be measured using a TDS water quality instrumentation, bought online.

Efficiency:

The efficiency of the prototype could be measured by comparing the outputs of our project to the outputs of another project. The comparison is based upon the ratio and measures of the resultants when processing 100ml of input water. This comparison ensures the quality of the prototype and how unique and efficient it is. The design requirement for the prototype is to have an efficiency of 80%.

Selection of solution

Due to the scarcity of water resources in Egypt, it is obligatory to search for water resources, and it was hard to make use of utilized water resources such as the River Nile because they are extremely exhausted. That's why the solution was directed to optimizing alternative water resources, instead. Seawater was chosen due to its abundance and great availability in Egypt.

Those water resources should have been utilized to a certain use to define certain quality parameters and efficiency to try to achieve. Agriculture was chosen because it needs 80% of the total freshwater use which makes it necessary to optimize a water source for agriculture specifically.

There were many seawater desalination techniques to follow, where thermal desalination was chosen due to its high efficiency since it has a low water loss and has a high output-to-input ratio. Finally, thermal desalination would give pure water; however, agriculture needs some minerals, so some minerals are added to the pure water.

Selection of Prototype

Our Prototype consists of a seawater container. A specific amount of aluminum sulfate is added to the container to make salt precipitates. The treated water is then transported to the heating container. This container is heated by an electric heater coil immersed in water, which evaporates water. There is a roof above the container to condense the vapor and collect water at a pure state. Finally, minerals are added to the pure water to be better for agriculture.

The prototype will meet the first design requirement after purification and mineral addition, where the quality parameters using a pH scale and a TDS scale. Moreover, the second design requirement will be tested by measuring the input seawater and its output, then taking the ratio between them (efficiency).

III. Constructing and Testing a Prototype

Materials: The used materials are shown in table (1):

Material	Description	Image	Quantity	Cost	Usage
Standard Glass	6mm glass.		8 faces	420 Egyptian pounds.	used to contain the water through boiling
Simple immersion coil heater (1.5KW)	A copper coil heater.		1	60 Egyptian pounds.	It is the main heat source
Plastic Press Tap	A plastic tap to transport water out of the container.		1	10 Egyptian pounds.	Makes the water flow out of the prototype
Silicone Sealant	The main binding and waterproof material		1	25 Egyptian pounds.	It is used for joining the glass faces of the prototype and filling the holes in the prototype.
Aluminum sulfate $Al_2(SO_4)_3$	A chemical compound that causes salt precipitates.		250 grams	10 Egyptian pounds.	Pretreatment step for lowering the boiling point by getting rid of the dissolved solids and salts
Himalayan (Pink) Salt	A salt that contains a variety of minerals		400 grams	30 Egyptian pounds.	This type of salt is used for mineralizing the distilled water to be valid for agriculture.

Table (1): shows the used materials in the prototype.

Methods:

1-A simple 3d design was created on sketch up to help in the imagination of the prototype.

2-The dimensions of the glass container and the required angle were calculated to fit the design requirements, and the shapes have been determined:

-Two trapezoid faces with dimensions 0.62 m, 0.64 m, 0.17 m, and 0.45 m and an area of 0.17775 m^2.

-Two rectangular faces with dimensions 0.17 m and 0.2 m and an area of 0.034 m^2.

-One rectangular face with 0.62 m and 0.2 m and an area of 0.124 m^2.

-Two rectangular faces with 0.08 m and 0.43 m and an area of 0.0344 m^2.

Figure 25, the faces of the prototype were sealed together.

3-The faces have been sealed together **as shown in figure (25)** to maintain coherence, and the holes have been filled with silicon to prevent any water from leaking.

4-Two holes were made on the trapezoid sides to lower the temperature inside the container. This helps to maintain the used material from expansion.

5-Two external glass pieces were sealed opposite to the holes at a 45-degree angle to decrease the loss rate and condense this output vapor.

6-The heater was isolated by silicon to isolate the electricity from the used water and then put in the bottom of the container to evaporate water.

7-The roof of the prototype has been prepared to condense the water and direct it into the collecting part of the prototype **as shown in figure (26)**

8-The Plastic Press Tap has been sealed in the prototype to transport the distilled water into the mineralization container.

Figure 26, the roof was prepared to collect water into the container.

Safety precautions:

there are many things that need to be considered while performing and operating the prototype. Some examples are wearing gloves, wearing glasses, and wearing a white coat. Wearing gloves is so important because it prevents the hand from getting cut, burned, or even prevents it from becoming dirty. If the gloves are not worn, then the hand may be cut while using scissors, or a knife. The hand may get burned while touching the prototype during the distillation process, and it may become dirty by touching any surface or wall. Wearing the glasses is one of the most

important things that must be taken into consideration, as it prevents the eyes from getting hurt during carrying out the distillation. If this is not the case, then the eye will be exposed to many dangerous things. For example, if the prototype explodes or breaks, the eyes may get hurt. Wearing a white coat is also important, where it prevents wastes from touching your clothes, it keeps your clothes clean during any process.

Test plan:

Design requirements:

The quality parameters of water are very essential. The TDS and the pH must be considered while conducting the test plan. The prototype was chosen to satisfy the quality parameters of agriculture with a pH range between 6.5 to 7.5, and a TDS ranges between 500 to 700 mg/liter.

Efficiency was another important requirement. It is the ratio between the output and the input. The design requirement of the prototype is designed to be above 80%

Test plan steps:

Phase one: pretreatment:

- The seawater was put in the pretreatment container **as shown in figure (27)**, and (20-30mg/L)

Figure 27, the pretreatment container of aluminum sulphate

of aluminum sulfate ($Al_2(SO_4)_3$) was added to the container in order to precipitate the dissolved solids, lowering the boiling point.

- The container was left for 45 min until precipitates appeared.

Phase two: distillation:

- The pretreated water was moved to the heating container, where an initial volume of 5.6liters of water was added to the coil in order not to harm the coil as the coil must be covered with water.
- One liter, which is the required quantity for the test plan, has been added.
- The heater was turned on to start heating, and the prototype was covered by its roof.

Phase three: mineralization:

- Adding pink salt to the distilled water increases the total dissolved solids (TDS) to be suitable for agriculture with useful minerals and achieve the design requirements.

Data Collection:

Using instruments to measure the quality parameters was essential. A TDS sensor and a pH sensor were used to measure the precise value of the parameters. Three trials have been performed to achieve the best results and avoid any calculations error. Make sure that the prototype has a low loss rate and a good pH and TDS.

After finishing the test plan, this is the data that has been collected **(shown in table (2))**, and the results satisfy the solution requirements.

Quality parameter	pH	TDS	Loss rate
Trail 1	6.94	579	12%
Trail 2	7.1	602	14%
Trail 3	6.88	561	11%
Average	6.97	581	12%

Table (2): The results collected through the three trials of the test plan.

IV. Evaluation, Reflection, Recommendations

Analysis and discussion:

Analysis:

The heater:

Heater coils, which are used in the vaporization step, work through a process is known as resistive or joule heating. as mentioned in the third learning outcome in physics, when an electric current flows into a material that has some resistance, it creates heat. As electrons pass through the conductor, they are scattered and, in the process, lose energy to the surroundings. This energy is given off as heat. This amount of dissipated heat can be calculated in terms of power. Power is defined as energy per time. So, this means that the amount of heat is the rate of energy converted to heat in the used conductor. This means is the rate of transmission of heat in the water.

Power = I × V

This formula means that a current of one ampere through the conductor across a voltage drop of one-volt results in one watt of heat. Another formula can be derived from this equation in terms of ohm's law by substituting the V by R×I, which means power =I^2× R.

The heating element in the coils must have some special characteristics. The best material is nichrome. Nichrome consists of 80% nickel and 20% chromium. It has a relatively high resistance, which increases the temperature as much as possible.

Another feature of this material is the layer of chromium oxide. This layer prevents the coil from breaking or burning out. The heating coil can also be made from copper. It has a high heat conductivity.

Aluminum sulfate and the boiling point depression:

Figure 28, the Precipitated salt due to Alum reaction

During the process of water filtration, large particles, suspended in water, settle out of the solution quickly; however, the smaller particles – small and medium-sized – take a long time to settle out and, sometimes, do not settle out completely. That's why, aluminum sulfate (Al2(SO4)3) is used to react with the smaller particles, primarily bicarbonates (formed from the reaction of carbon dioxide with pure water), and form precipitates that sink, reaching the bottom of the container (**figure (25)**). In addition to making filtration easier, aluminum sulfate is beneficial regarding the act of maintaining the boiling point from elevation.

$$\Delta T_b = K_b .m_{\text{solutions}}$$

According to the equation of boiling point elevation, studied in the second learning outcome of chemistry, the boiling point of a non-volatile solution increases in proportion to the molality of the solute and is a constant relative to each solvent. By getting more solutes out of the solution, the boiling point approaches the

normal value. That enables the solution to boil faster, saving energy and making our prototype faster and more efficient.

Heat Energy:

Heat energy is the energy required to cause an increase in the temperature of an object, where the amount of heat energy is calculated by the following equation:

$H=msd\theta$. H is the required heat energy, m is the mass of the object, s is the specific heat of the object, and $d\theta$ is the needed change in temperature. Water has a specific heat of $1Cg^{-1}\ ^{\circ}C^{-1}$ and the test plan requires the boiling of 6.6 liters of water (equal to 6600g), where the room temperature during the test plan was 20℃ and the boiling point of water is 100℃, so the needed heat energy, as mentioned in the fourth learning outcome in mechanics, is equal to:

$6600\times1\times80=528000C$ =2209152J, and since power = energy per time, where the power of our coil heater is 1.5KW. Therefore, time = energy divided by the power = 1473 seconds = 24.5minutes. This is the required time to make the water heat by the electric coil heater, which is approximately the same as the testes time.

Thermal Expansion:

The overall thermal expansion of a certain material is a direct result of the change in the average separation between its smallest building units, atoms, or molecules, where the expansion is equal to:

$\Delta A= \gamma A_0\ \Delta T$

, where ΔA is the change in the area (expansion), γ is the coefficient of the area expansion, A_0 is the initial length of a glass surface, and ΔT is the change in the temperature of the glass. For illustration, at the boiling point of water (100℃) at an initial temperature of 20℃, $\gamma\Delta T=18 \times 10^{-6} \times 80=1.44\times 10^{-3}$. That's why each of the glass faces would have a new area equal to 1.44×10^{-3} ×initial area. For example, the face of length 0.2m, width 0.17m, and area 3.4×10^{-2} m^2 will have a new area of $1.44 \times 10^{-3} \times 3.4\times 10^{-2} =4.76\times 10^{-5}$ m^2, applying this to all the other faces. This expansion can be decreased by lowering the temperature difference. This will help in maintaining the materials and avoid any destruction of the used glass.

Glass:

Glass is mainly composed of organic materials like silica (SiO_2) and soda (Na_2O). Glass is the best choice for health. It is an inert substance that does not react with water or any other substance under ordinary conditions. So, it is the best choice for water containers. Although it has a low coefficient of expansion (9×10^{-6}), it can be used to boil and evaporate water under certain circumstances and specific adjustments that decrease the pressure inside the container.

Cohesion and adhesion:

The reason behind our condensation ideas is cohesion and adhesion forces. Cohesion and adhesion forces are very important properties of water. As mentioned in the first learning outcome in geology, Cohesion is the attraction of a water molecule to another water molecule. Adhesion is the attraction between

water molecules and other substances. These forces drive the movement of the water droplets on the condensation roof. As the water droplets accumulate together and attract each other by cohesion, and they are also attracted to the glass by the adhesion force without falling down again into the container. This causes the droplets to start sliding until it reaches the collecting container.

TDS and pH measures:

There are a lot of aspects that determine the quality of water. The TDS and the pH are the most important in our project. The TDS is the measure of the total dissolved metals in the water. It is measured by the TDS sensor, which measures electrical conductivity. By measuring the electrical conductivity, it is easy to determine the percentage of the TDS. The other quality aspect is pH. PH scale is a scale that differentiates between acids and bases by considering the difference in the concentration of the H+ ions in the solution. A solution with a pH of 7.0 is neutral (neither basic nor acidic), where acidic solutions have a pH lower than 7.0 and basic ones have a pH higher than 7.0. The pH is measured using a device called a pH meter that is an electronic device with a solution of a known pH and a probe. The known-pH solution is in a special glass membrane that permits the passage of H+, and the probe could be inserted to a solution of unknown pH and the difference in the pH scale causes an electric potential to occur which is registered on the meter.

Conclusion

To sum up, the problem of the lack of water resources in agriculture could be solved through the desalination of seawater, utilizing seas as water resources. A prototype that desalinates water through heating, where the coils are heated, due to the flowing of current through it which convert the electric energy to heat one. Such heat makes water boils, condenses, and is finally converted to pure water. The prototype proved its effectiveness by achieving the design requirements of water quality (pH of 6.94 and a TDS of 579mg/L) and efficiency (88% output-to-input ratio), implying the ability of the prototype to be made at a large scale and solve the problem of seawater in Egypt.

Recommendations

Our prototype collects and purifies water at a rate of 880 mL every 30 minutes. As an assumption, if 100 square meters of oranges – one of Egypt's most consumed crops – were planted. They are needed to be covered by an average of 1.5 inches of water. That means that our area will need 4000 liters of water per week, giving us a total of 63 liters per hour. That means if the real-life app needs to increase the production significantly. By calculations, increasing the production rate of the prototype 35.8 times would be enough. As the prototype produces 1.76 liters per hour. A crop like oranges will require an average of 63 liters/ hours in a given area of 100 m^2. So, an increase will make the large-scale project very appropriate.

- **The material recommendation.**

The (borosilicate) will be a good recommendation. As it has a lower expansion coefficient of 3.3×10^{-6} which is lower than the glass used in our prototype. If the substance has a lower coefficient of expansion, it implies that it is the ability to expand decreases. this will make the project more durable, as it can tolerate more heat, which is one of the solution requirements.

- **The use of trace minerals drops.**

The distilled water, which is pure, must be mineralized to be valid for agricultural use. That implies the necessity of adding minerals to it, whereas in the prototype, the use of Himalayan or pink salt is necessary. We recommend the usage of trace mineral drops to make the pure water better for agricultural use and health. The trace minerals drop have higher minerals' concentration with less sodium chloride concentration.

- **Use of waves as a source of electricity**

$P = \frac{\rho g^2}{64\pi} H^2_{m0} T_e$

P = wave energy flux per unit of wave-crest length.

H_{m0}= the significant wave height.

T_e= the wave energy period.

ρ = water density.

g= the acceleration by gravity.

Figure 29, Wave power plant

The output energy gained from the wave-powered desalination is mainly affected by two factors, which are the wave height and the wave energy period. The average wave height in the Mediterranean Sea is 0.75 m. which is a sufficient height to generate 0.806058 KW in a wave period of 3 seconds. This means the production of 23214.24 KW per day supposing that the wave rate would be constant. Such a production will be sufficient for any desalination planet without a significant cost.

- **The location**

Since the solution involves the desalination of the salt seawater to produce water available for agricultural use, it was necessary to recommend a place with an adequate saltwater supply. Egypt has the access to two coastlines which are the Mediterranean Sea and the Red Sea. The Mediterranean Sea was chosen as the Red Sea is one of the saltiest seas in the world with 41 parts of salt per thousand parts of water, where less salt means less used desalination energy and an increase in the project's efficiency. The chosen place was Alexandria due to many reasons. The first one is access to the Mediterranean Sea. The second is the availability of the required material of the solution around the place to avoid the cost of transportation.

- **The project as a reference.**

The prior solutions are so important in the research stage. As we started our work on the idea by searching a lot of solutions, I recommend any team to start searching about our projects and the other projects. Starting from the point we stopped will be very beneficial. This will help the team learn a lot from our mistakes and try to avoid them in many ways. For example, using the recommended materials will be very essential, the recommended extra steps in the project, and the recommended source of energy. This will be a great step to a better solution in all aspects. Increasing the efficiency by making adjustments to the design to decrease the loss rate.

- **The project's benefits.**

Working on such a project influenced us in all ways. Working on the engineering design process helped us gain a way of thinking. Following such steps helped us to be far more efficient. The research conducted made us better researchers. Besides, increasing the writing skills and the way of presenting the concept in a far better way. The imagination of the ideas helped us a lot in increasing our problem solving and how to make the design very efficient. The construction of our prototype increased our experience with certain materials used in everyday life. All these things increased our experiences and made us better STEM students, who think about how to turn science into applications.

Learning Outcomes

Subject	Content	LO	relation
Chemistry	Studying the TDS, molarity, molality, and solutions.	2.01	the term TDS has been used to describe the total dissolved salts in water. The amount of TDS in water is measured using the term ppm, which is called “part per million” and equals mg/l. In addition, knowing the techniques of distillation help in constructing the prototype. Another thing that has been learned from the LO is aluminum sulfate, and its ability to attract fine particles. Such a property has been used in building the prototype as well.
Chemistry	Describing the acidity of solutions, the basicity of solutions, and the rate of dissociation	2.03	calculating the value of PH was learned. Where PH=-log[H^+] is the law used to calculate the value of PH of water before the water was purified and after purification to ensure the value of the effectiveness of such a device. And to know if the value matches with drinkable water, agriculture water or not.
Computer science	Illustrating how to use SQL to make tables to organize the given data.	2.02	The database is used in organizing the data in tables to represent the data and collect it easily. Using SQL helps a lot in such a concept.

Chemistry	Studying the boiling point and what affects it.	2.02	The boiling point of water varies by adding solutes. And according to this, the boiling point is calculated through the law $\Delta T_b = \mathrm{K}_b * m$ for a nonelectrolyte solute and $\Delta T_b \times m \times i$ for an electrolyte solute. So, decreasing the percentage of solutes will make a significance in the boiling water.
Biology	Studying GMOs, the advantages, and the disadvantages.	2.01	Biology is talking about GMOs which is an abbreviation for the word "genetically modified organisms". such a concept can be used to make modified plants, which use less water. Or to modify bacteria to get rid of TDS or impurities in water, which can be used as post-treatment.
Math	Describing relations by polynomial functions to be able to predict on the large scale.	2.01	The skills and the ways used to model real-world situations are used to model the prototype with functions that describe the behavior of different phenomena. The prototype is modeled with an equation that relates the time required to finish the distillation process to the amount of water needed to be purified. The time needed to finish the distillation process in the prototype is inversely proportional to its efficiency, and hence, by increasing the prototype efficiency, the time is reduced.
Geology	Studying the porosity and the permeability, which determines the quality of reservoirs	2.01	the term porosity is used to determine the percentage of pore spaces in different materials. In addition to this, the term permeability is also used to account for measuring the ability of water (how fast) they can flow through such a porous material. And according to that, permeable materials like sand and gravel can be used to make pretreatment for water using filtration before going through distillation.

Geology	Illustrating the techniques of increasing the sources of utilized water.	2.02	, the ways used to increase the supply of water to different communities have been learned. And from these ways is to convert salt water to a fresh one. Another thing in LO that helped in constructing the prototype is the term aqueduct, where they are a system of pipes used to transfer water from place to place. Such an idea can be used to transport water from different places by using pipes. The way used to remove salts from water and make it drinkable or suitable for agriculture is distillation. And according to such a fact, its techniques have been used to build up the prototype.
Geology	The ways to decrease the amount of water used and conserve it as much as possible	2.03	talking about xeriscaping, which is a commercial planned in order to reduce the amount of used water. from the types of xeriscaping is drip irrigation, where water oozes out from a small holed pipe and is supplied to the soil slowly. This helps to conserve water as much as possible
Physics	Learning about ohm's law, electric current, and voltage.	2.03	The concept of power is used, which is the amount of work per unit time can be calculated by using many formulas. The SI unit of power is joules per second or referred to as watts. According to that, the power can be calculated from the relation P=I*V where I is the intensity of the current and V is the voltage. such a formula is used in the prototype to calculate the amount of heat coming out from the coils.

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