ALEXANDRIA'S RAIN COLLECTOR

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Chapter 1 present and justify the problem

Egypt grand challenges

Improvement of water recourses

Introduction:

Water is one of the most prominent blessings given by God on this blue planet. This is because it is the basis of life, and water makes up the largest area of the earth, estimated at 71% of its area, which appears in lakes, seas, oceans, and rivers, and water has many benefits that it provides to nature and the human body.

Hence, we must talk about Egypt's water resources. Egypt is at the top of countries not only in the continent of Africa but also at the world level in terms of concern for water and continuous work on its good management. Therefore, reference must be made to Egypt's water resources, which are divided into traditional water resources available in the waters of the Nile River and limited amounts of rain, torrents and groundwater in Sinai, the northern coasts and the western desert.

As for non-traditional resources, they include recycling water from agriculture, industry and sanitation, besides exploiting the shallow aquifer in the valley and the delta, whose waters come from the infiltration of the Nile water or from canals, drains and agricultural water.

As shown in graph (1) the volumes in brackets are negative values. Source: Compiled and calculated from:

water source	2007/2008	2008/2009	2009/2010	2010/2011	2030	Change (2007-2011) %	Change (2011-2030) %
The Nile River	55.5	55.5	55.5	55.5	57.5	0.00	3.60
Groundwater	6.2	6.2	5.6	6.3	12.9	1.61	104.76
Agricultural water recycling and development of irrigation systems	8	8	5.8	5.8	15.5	(27.50)	167.24
Sewage recycling	1.3	1.3	1.3	1.3	2	0.00	53.85
Rainwater and Torrents	1.3	1.3	1.3	1.3	1.5	0.00	15.38
Seawater desalination	0.06	0.06	0.06	0.06	0.06	0.00	0.00
Total	72.36	72.36	69.56	70.26	89.46	(2.90)	27.33

GRAPH 1

1) The Ministry of Water Resources and Irrigation, toward development strategy and management of water resources in Egypt during the period (2009-2017), august 2009.

2) In accordance with the inventory of greenhouse gasses, which ended in Egypt of its implementation in 1999. which was adopted on the data available for the year 1990-1991.

3) According to the estimates International Database (World Resources Institute Washington). United States, 2006.

4) Estimates of the Central Agency for Public Mobilization and Statistics, 2015.

Causes:

- **Providing clean water for drinking and household uses:**

  Water is an important thing in our life in terms of health, as drinking water is important in maintaining health. If clean water is not available for drinking and household uses, diseases will spread from diarrhea, schistosomiasis, malaria, skin diseases, many infectious and non-communicable diseases, many viruses, and the spread of many diseases.

- **Providing water to increase agricultural lands:**

  Water is important for agriculture. It is used in the cultivation of various agricultural crops, including vegetables and fruits as shown in fig. (2). If water is not available for agriculture, the plants will die, drought will resolve, and thus the population will not meet their food needs, and the situation may worsen and spread famines.

FIGURE 2

- **Providing water to serve the community:**

  This is clear in using water in villages and tourist resorts, and in the construction of parks, public parks and playgrounds such as football and golf fields.

❖ **Sanitation sector problems:**

water scarcity leads people to drink and meet their basic needs of contaminated water as an alternative to freshwater, which causes the spread of water-borne diseases.

❖ **Providing water for various industrial uses:**

Water is important in industry. It is used to manufacture the energy needed for industry. The water of the Nile River is used to generate power from the rush of the Nile waters as shown in fig. (3), by making the water flow quickly from the narrow openings in the Aswan High Dam, and the water rushes to drive the turbines and generate hydroelectric power.

FIGURE 3 ONE OF THE FACTORIES TAKE WATER FROM RIVER NILE TO GENERATE ELECTRICITY

Impacts:

❖ **Poverty and the consequent problems:**

The lack of water leads to drought and desertification, which affects the crops and the health of livestock and poultry negatively, and consequently failing to meet the population's food needs, and their ability to live, work, and education because of their disease, and basic needs are not met. Therefore, areas characterized by water scarcity are witnessing a decline in all areas of life.

❖ **Conflicts:**

PICTURE 4

Conflicts between states may result due to water scarcity and to impose state authority over other countries because of ensuring that this need is provided to their people. There is an example now for the conflicts of water like Israel and Lebanon dispute over the waters of the Hasbani and Wazzani Rivers also Egypt and Ethiopia dispute over the water because Ethiopia wants to build Al-Nahda dam which will decrease the amount of water which comes to Egypt by 25 to 33 billion m cubic and that is a very big amount. As we see in pic. (4) that the area beside Al-Nahda dam is very big and it will affect on the water that reach Egypt very much.

❖ **Biodiversity loss:**

Water scarcity contributes to threatening the lives of living organisms that live in freshwater, because of pollution, increased salinity, drought of floodplains, and desertification.

Arid Areas

Introduction:

one of grand challenges that Egypt face, and we must treat with it is the arid areas. The arid areas are lands that don't have enough water to support the growth of plants. The Desert of Sinai is one of the Egyptian arid lands as it is very dry, having less precipitation than is needed to support most trees or woody plants as shown in fig. (5) an example of the arid areas.

FIGURE 5

Over 96% of Egypt's landmass is desert, from the arid peaks of Sinai (61 thousand km) and the Eastern Desert (22% of Egypt area) to the dunes and slopes of the Western Desert (68% of Egypt area) including the valley in between and as shown in map (6) the desert areas in Egypt. The Western Desert alone covers about two-thirds of Egypt's land area. Indeed, most of Egypt's land areas are arid and they are unexploited. Consequently, this produces a big problem for not benefitting these enormous areas. We must treat these areas and exploit them greatly and achieve the greatest benefit from them in terms of agricultural and mineral wealth.

MAP 6

Causes:

❖ Temperature:

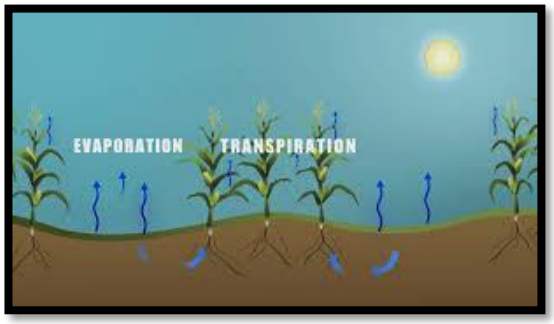


FIGURE 7

The temperature in the desert is very difficult because the temperature there is very high at summer and during the daytime so it effects on both the land and the growing of plants. First the in terms of land, the land receives a big amount of heat from the sun so the water in the soil evaporates very quickly so the land become dry and this process shown in fig. (7). Second in the terms of growing plants, if the land is very dry so we can't grow plants in these areas as it is very hard for plants to grow in this climate because it is not appropriate.

❖ Rainfall:

Deserts are arid ecosystems that receive fewer than 25 centimeters (10 inches) of precipitation a year. Because of:

- Weak weather operations that lead to rainfall and this weakness result in the decrease in the area of vegetation cover in the arid areas.
- Decrease in rainfall in an area affects agricultural production and causes drought and this is what in arid areas because there is a lack in the amount of rainfall water so many plants that require water to grow such as rice and wheat or many other plants cannot grow there. In conclusion, when there is a lack of water in an area, many plants cannot grow there.

❖ **Grazing:**

FIGURE 8

Over grazing happens when plants are exposed to intensive grazing or happens when there are overgrazing of animals and the grazing appears in Egypt as shown in fig. (8). This led to the erosion of the upper layer of soil and this is where the nutrients like [carbon (CO_2), oxygen (O_2), nitrogen (N_2), hydrogen (H), phosphorous (P), potassium (K)] that plants need to grow. When this layer is eroded, the soil condition deteriorates, and this makes the growth of plants in this soil impossible. This will lead to lack of crops and this will cause aridity in the end. So, we see that overgrazing is a major contributor to aridity.

❖ **The human behavior:**

Wrong and poor irrigation methods affect the soil badly. Also, cutting trees causes many negative results on the soil as the trees help in binding soil particles together. Other unacceptable behavior made by human is the wrong use of the soil and growing the stressful crops for the soil many times in sequence, which causes the weakness of the soil. Last, using traditional ways of irrigation that destroy the soil.

impacts:

❖ **economic:**

Aridity leads to many economic problems such as:

- reduced agriculture and this will reduce the crops that we eat and feed on like rice and wheat and this will affect the nutrition for the human.
- problems in industry because there are a lot of crops that go into industry such as cotton and olives, so generally it will affect the economy.

Also, the land of reduced agriculture affects animals that feed on herbs like cows and goats, which will lead to many economic problems as these animals play a big rule in nutrition and in the environmental system.

❖ **demographic:**

As known, most of the lands of Egypt are desert lands (96%) and very few people in Egypt live in the deserts in tribes like the tribe of (Sons of Ail) in the western desert. So, most of population lives in the valley and delta where is a good water, a good climate to live in, a good soil to grow crops and there are good chances of work. This is a small area (4%) for a big number of populations 98.42 million (by statistics of the year of 2018) as shown in fig (9). So, it causes a lot of problems such as overcrowding, problems in water and lack of recourses.

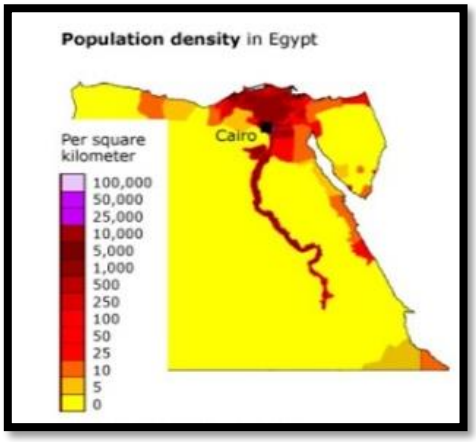


FIGURE 9 THE CONCENTRATION OF POPULATION IN DELTA AND VALLEY

❖ **soil erosion:**

The elimination of vegetation cover and its radical destruction are the most important environmental damage to desertification, as it causes soil erosion. Adding salt to the soil and losing nutrients, making it unsuitable for agriculture, also making it vulnerable to natural disasters such as sandstorms, floods and forest fires.

Urban congestion

Introduction:

FIGURE 10

The urban congestion is the big increase in numbers of citizens compared with the available resources, for example, if a certain area of the earth is inhabited by 100 people, but the amount of water and food there is only enough for 90 people, then this area suffers from urban congestion from the big problems which the urban congestion causes is the traffic congestion and this affects all the people who lives in these cities as shown in fig. (10).

Egypt is the most populous country in the Arab world and the third in the African continent. The biggest example in Egypt is Cairo, as there is great urban congestion. Egypt suffered from urban congestion for a long ago. The population in Egypt is around 105 million persons. The Greater Cairo Metropolitan Area (GCMA), which has more than 19 million inhabitants, is host to one-fifth approximately (18%) of people who live in Egypt. The population of Cairo is expected to further increase to 24 million by 2027. There are a lot of challenges that are facing Egypt at the local level and the global level. At the local level Egypt and the Egyptians suffer from misuse of rainwater because they don't know how to get benefits from rainwater for example in the last days there was a lot of rainwater in Alexandria, there wasn't an advantage to it. At the global level, there are a lot of challenges that will threaten the water level in Egypt. So, we must learn how to conserve every drop of water to benefit from it in areas that suffer from urban congestion.

Causes:

- **The bad distribution of the population in Egypt:**

  The population of Egypt is approximately 105 million, according to the United Nations census data. Egypt suffers from urban congestion and this is because of the bad distribution in Egypt where the population is concentrated in specific areas that do not exceed 8% of the total land area in Egypt such as Cairo. There is approximately one-fifth of Egypt's population are live in Cairo.

❖ **Increased number of births and decrease in the number of deaths:**

FIGURE 11

As a result, to the improvement in the public health and there is an improvement in hospitals people are examined and treated well so they will take the right medicine so their health becomes better so they can live for more years, besides, there are a lot of persons less than 20 years old in Egypt and that is harming the economy in Egypt because they aren't work or they are burden on their parents because they don't earn money and their parents are forced to work more than one job to earn enough money. The fig. (11) shows that there is a great in increase in the number of populations not only in Egypt but also in the world.

❖ **An increase in the number of immigrants to a specific region:**

FIGURE 12

The increase in the number of immigrants lead to an increase in numbers of people in a specific area like Cairo in addition, it will lead to a lack of resources so people in these areas will become hungry and it is possible that they will fight over food. In the last time there is a big increase in the people who migrate as shown in fig. (12).

Impacts:

❖ **Water Scarcity:**

As a result of urban congestion in Egypt is water scarcity. In addition to overuse of water, there is a serious challenge is facing Egypt now. Egypt is threatened by a decrease in the level of the Nile River, and we are depending on the Nile river as the main resource. Egypt's share of the Nile will decrease, and this will lead to a decrease in water availability per capita, and with the increase in population, there will be a big problem.

❖ **Pollution:**

FIGURE 13

One of the most dangerous impact of urban congestion is pollution especially air pollution because it leads to polluting many things, for example, it will lead to acid rain, damage the facades of buildings also it will damage the soil and damage the agriculture, so it can also cause a decrease in crops and an increase in famines. As we see in fig. (13) the people in these areas get rid if their rubbish on the roof of the houses and this make a lot of pollution which cause many diseases.

❖ **public health problems:**

In Egypt there is a large number of people and this population uses the available resources, and these resources are exposed at any time to running out, such as non-renewable energy, and one of these reasons is overpopulation. When there is a large number of people in a certain area, those resources in this region are exposed to the possibility of running out more, and this impedes the process of sustainable development and prevents its good effects, which have a great role in the development of society and making society better.

Pollution

Introduction:

The pollution is one of the most serious problem that faces the world. In Egypt there is a poor air quality, especially in Cairo, Alexandria and other urban areas. The annual cost of the health effect caused by air pollution in greater Cairo is about LE 45-48 billion in 2016. This equals about 1.4% GDP in Egypt.

Egypt receives about 55 billion m cubic of water every year this water is used and reused because it isn't enough for the population and agricultural field. Many Egyptians die every year because of the poor water.

In 2017, the united nations said in one of its reports that 40,000 people in different parts of Egypt die every year because of pollution.

Every day Cairo receives a high dose of pollutants composed of 52 percent carbon oxide (CO), 14 percent Sulphur dioxide (SO2), 21 percent hydrocarbons, 10 percent dust, solid materials, and 2 percent (NO) nitrogen oxides.

Types of pollution:(air and water pollution)

Air pollution

Introduction:

The Air pollution is the mixture of tiny solid particles and gases in the air. There are two types of pollution such as indoor air pollution and outdoor air pollution. Form the examples of air pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2) and sulfur dioxide (SO2).

PICTURE 14 THE BLACK CLOUD ABOVE CAIRO

In Egypt, there too many populations in a small area this means there too many vehicles in these small areas. There are 1.2 million vehicles in Cairo alone most of them are old and spread a lot of harmful gases. Most of the harmful gases caused by fumes coming from these vehicles. There are 1.2 million vehicles in Cairo alone most of them are old and spread a lot of harmful gases. In the last years, these gases formed a large black cloud above Cairo (as shown in the picture 14).

Causes:

- **The factories smoke:**

Cement factories are the major source for the air pollution as it spread. There are some factories don't increase the height of their chimneys to save the money like Helwan factory in (figure 15) this harms the populations a lot as it is a poisonous gas. There are also factories don't use filters because it should be always cleaned to prevent it from being plug so this costs the factories money. So, the harmful gases are emitted from the burning of fossil fuel that happens inside these factories like methane gas (CH4), carbon monoxide (CO) and carbon dioxide gas (CO2). These gases poison the air and harm the human and the environment.

PICTURE 15 THE SMOKE OF HELWAN FACTORY

- **The cars emissions:**

Cairo was a source of 40% of greenhouse gas (GHG) as it contains a lot of old cars. Some example of these gases are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). These gases cause an increase in the temperature of the earth, and this is known as greenhouse phenomenon. The increase of these gases also is harmful for the human because it causes respiratory system infections, heart diseases and cancer. The following graph in fig. (16) shows the resources of greenhouse gas emissions.

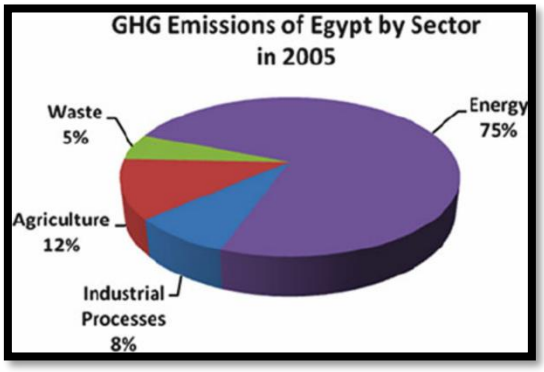
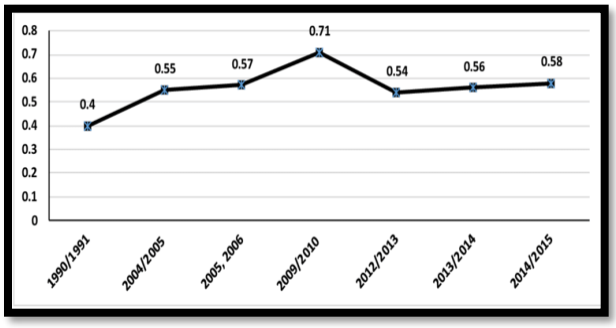


FIGURE 16 THE SOURCE OF GHG

❖ **The natural electric generator:**



GRAPH 17 THE AMOUNT OF INCREASE OF CO_2

The natural electric generators spread a huge amount of carbon dioxide gas every year the (graph 17) shows the amount of carbon dioxide gas from 1990 to 2015. The natural electric generators are divided into two types the nonrenewable resources and renewable resources. The first type is the renewable resources these resources are the cleanest sources of electricity as they don't form from reactions like wind, solar and hydro. The second type is nonrenewable sources of electricity these sources pollute the air as they formed from burning or reactions like in nuclear, coal, oil and gas fuels. In fig. (18) the percentage of electric from renewable and non-renewable source. The following graph shows a prediction for the percentage of each source by the year 2030.

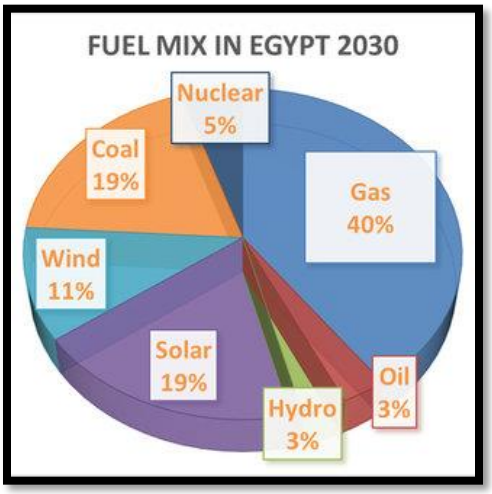


FIGURE 18 THE PERCENTAGE OF ELECTRIC SOURCES IN EGYPT

The impacts:

❖ **The affection of air pollution on public health:**

The short-term effects which is temporary, it includes discomfort like irritation to the nose, throat, eyes, or skin. Air pollution also causes headaches. Bad smells made by factories, garbage or sewer systems all of these are considered as air pollution.

In the long term of air pollution which can last for years; they can lead to person's death. Also, the long term of health effect from air pollution includes heart diseases, lung cancer and respiratory diseases also pollution can cause damage to people's nerves, brain, kidney, liver and other organs. Nearly 42000 deaths in Egypt caused by air pollution. The young children and older adults will be more sensitive to air pollution as their immune system tend to be weaker.

❖ Effect on environment:

Like animal, plant and people, the entire ecosystem can suffer from the air pollution. Air pollution particle eventually falls back to the surface of the earth so it will directly pollute the water and the soil. This can kill crops or reduce yield. It can also kill some trees and other plants. Sulfur dioxide (SO2) and nitrogen oxide (NO) particles in the air can create acidic rains when they mix with water and oxygen in the atmosphere. These air pollutants mostly come from coal fired power plants and motor vehicles. When this acid rain reaches the soil, it changes its composition and when it falls on water area; it decreases the water quality and causes decay to building and monuments. The fig. (19) shows the negative effect of acid rains on plants.

FIGURE 19 THE EFFECT OF ACIDIC RAINS ON PLANTS

❖ Global warming:

It is an environmental phenomenon caused by natural and it refers to rising the air and the ocean temperature around the world. This caused by the increase in the greenhouse gases (GHG) in the atmosphere. The greenhouse gases (GHG) trap heat energy in the earth's atmosphere. Carbon dioxide gas (CO2) is one of the most gas that has a negative effect on the global warming. There other gases emitted from natural and agricultural fields like methane gas (CH4), nitrous oxide (N2O) and fluorinated gases. Fluorinated gases are like chlorofluorocarbon (CFCs) compound. The pic. (20) shows the method of global warming phenomena.

PICTURE 20 GREENHOUSE PHENOMENA

Water pollution

Introduction:

FIGURE 21

Water pollution is a major issue to reserve living conditions for the future. Some researchers say that Egypt may suffer from the scarce of water by the year 2025 because of the high population growth. Water is considered as the most vital natural resource in the environment that is used by humans to develop their essential needs and prosperity.

About 3% of the water resources in Egypt are from rains and non-renewable groundwater. The annual cost of the health effects associated with the polluted drinking water is estimated at LE 26 billion to 56 billion in 2016/2017. the river Nile receives daily pollutants from different sources including pesticides and chemical fertilizer from agricultural activities, industrial water discharge, Domestic wastewater as shown in fig. (21).

Causes:

- **Human activity and Industrial wastewater discharge:**

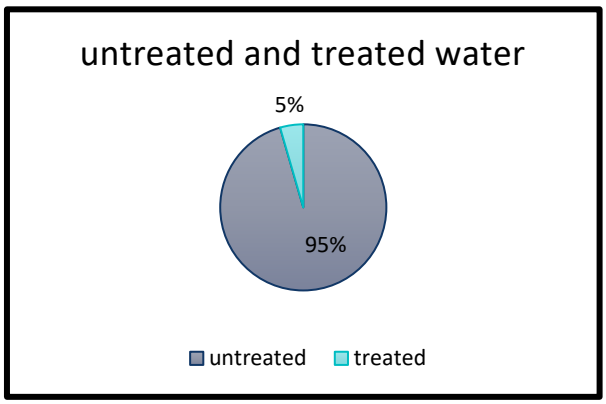
FIGURE 22

Deterioration of Nile water quality because of uncontrolled and increasing agricultural and industrial activities, considered as a big challenge. River Nile is the main industrial and agricultural sector of Egypt. Mainly Egypt's agriculture and industrial sector is based on River Nile, also it is main source of drinking water for citizens in Egypt.

There are about 700 factories are built along the river Nile. As shown in fig. (22) there are many factories get rid of their discharges in the Nile river. industrial wastewater is often containing a lot of poisonous materials and highly toxic, containing heavy metals which cause serious risk not only on human health but also, they affect the animals' health and affect the agricultural production. Fish die in large numbers from poisoning materials which are thrown by factories in seas and rivers because of the high levels of ammonia and lead of these materials. Agricultural production quality and quantity has been affected because of using untreated water for irrigation, especially in the Nile Delta, where the water is highly polluted.

❖ Agricultural Wastewater and Domestic Sewage Pollution:

Along the Nile valley between the Aswan High Dam and Cairo, there are 43 towns and approximately 2,500 villages, with a high population \exceeding 20 million; all of them get rid of their waste water and untreated sewage into the Nile. As an indication of the level of infrastructure still deteriorated across Egypt, according to the statistics of CAPMAS 2010/11, only 24.7% of the rural population was linked to a sewage system, as opposed to 88% of urban areas' populations. Those "linked" to a sewage tank will empty this tank into the Nile or near freshwater sources, or onto ground where the water source will pollute through the soil.



STATISTICS 23

In turn, the bad sanitation extends to drinking water, making it untreated, statistics (23) show that about 95% of the Egyptian population drink untreated water. The World Health Organization (WHO) report in 2008 saying: "Safer Water, Better Health" shows that 5.1% of all deaths and 6.5% of all disabilities (disease and injury) in a year in Egypt are because of unsafe drinking water, unsuitable sanitation capacity, insufficient hygiene and a wrong management of water resources.

❖ Waste water pollution in the Nile Delta

Human wastewater is largely causing a lot of pathogens, nutrients, oxygen demanding compounds and suspended solids. Diseases and parasites are spread commonly in wastewater. So, treating wastewater is a big challenge. While social programs are being set up in many regions along the Nile to increase their capacity for water treatment, the population in the area continues in growing even these facilities can't meet the demand of population. The rural areas contain about half of the Egyptian population (45 million), 75% of this people have no access to sewerage systems or wastewater treatment facilities. Septic tanks are the common disposal facility where a limited amount of water can be collected for biological digestion.

Impacts:

❖ Water-based diseases:

Water-based diseases come from hosts that either live or spend part of their life cycle in water. These diseases are passed to humans when they are ingested or contacted our skin. The most famous example in this category is bilharzia disease and this disease is shown in fig. (24), which happens due to contact with snails which serve as hosts for this disease. The disease continues to spread where irrigation projects produce habitat that the host snails like to live in. Major outbreaks of bilharzia disease often follow the construction of large dams.

FIGURE 24

There are many governorates of Egypt depend on Nile water as the primary source of drinking water, so determining of the prevalence of water-borne protozoa in water sources is important.

In Egypt, sewage is usually treated primarily and discharged into seas, rivers, lakes, and canals. Therefore, the population will be infected by Cryptosporidium, Giardia and other protozoa with significant chances. Only few sporadic studies have been done on different water sources, and different governorates seem to have the same problem. Sewerage water in the middle districts of the Nile Delta is far from being drinkable and ideal. Biological agents, especially the neglected protozoal infections such as giardiasis and cryptosporidiosis, set up a real risk factor for the population.

❖ water quantity and availability:

Pollution and poor water quality impact the quantity and availability of water in several ways. Polluted water which can't be used for drinking, bathing, industrial purposes, and agriculture effectively reduces the amount of water in the region, directly affecting water quantity and availability. The more polluted water is, the more difficult it is to treat it to useable standards, and high costs of treatment are customary. Generally, treatment processes for polluted water remove pollutions through formation of a waste sludge.

The poorer water quality of the source of water, the greater level of treatment that will be needed to bring it to a practical standard, and less clean water will result from treatment. Also, high level of water pollution requires a high amount of energy to treat; energy use has effects for water use and availability. There are also a great number of characteristics of the built environment that affect water quantity and water quality. For example, impermeable surfaces reduce the quantity of water that infiltrates to groundwater, affect the base flow of streams, and also increase the volume of water that runs off the land surface, also creating more erratic stream flows and conveying greater amounts of pollutants. Both reduce the quality of water. At the same time, actions that improve water quality can also increase the quantity of water that watersheds produce. Forested areas help to filter water and to improve water quality prior to runoff entering streams.

- **Chemicals in drinking water:**

Chemicals in water can affect the human health effects. The chemicals that pollute drinking water may come from:

Fluoride: Fluoride in the water is very important for protecting the teeth from dental caries and prevent weakness of the bones, but higher levels of fluoride can effect the human health badly.

Arsenic: Arsenic can be occurred naturally or can be occurred by phosphorus from fertilizers. High concentrations of arsenic in water can have an adverse effect on health.

Recreational use of water: Untreated sewage, industrial effluents, and agricultural waste are often discharged into the water sources like lakes, coastal areas and rivers endangering their use for recreational purposes like swimming and canoeing.

Petrochemicals: Petrochemicals pollute the groundwater from underground petroleum tanks.

Other heavy metals: These pollutants come from mining waste and tailings, landfills, or hazardous waste dumps.

Chlorinated solvents: Metal and plastic effluents, fabric cleaning, electronic and aircraft industry are often discharged in the ground or in water sources so it pollutes groundwater.

The problem to be solved

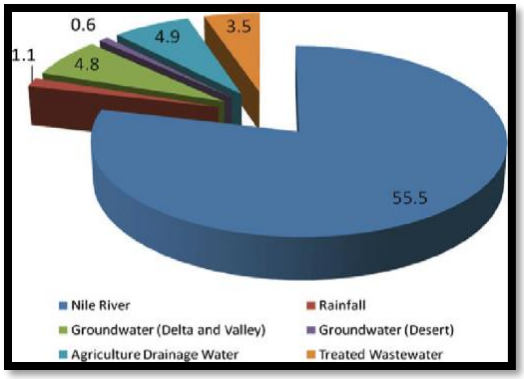


FIGURE 25

Egypt has many waters resources; the major source of water is the River Nile that provides about 80% of all water availabilities water in the country and the fig. (25) shows the share of water from the available sources in Egypt. Egypt also has groundwater as major a source in some areas like deserts and oasis. There is another Water resource in Egypt which is rainfall water. Egypt has a big problem with water, which is the wasted rainfall water that falls on Egypt by an extensive amount every year. The pic. (26) shows a beautiful view for the River Nile in Egypt while the rain is falling.

PICTURE 26

Egypt suffers from weakness in water sources by an amount of 30 billion cubic meters. Egypt annually needs at least 110 billion cubic meters of water to cover its needs. However, it currently has only 80 billion cubic meters, of which 55.5 billion cubic meters come from the Nile. The Egyptian population in Egypt increase every year and the amount of water decreases every year, so the amount of water per patio decreases every year until it reached to 534 cubic meter per patio. Rain fall water is a major source of water in Egypt and One of big problems that Egypt face is wasted rainfall water. There is a lack of use of rainwater in Egypt because of the lack of water collection projects in Egypt, such as tanks that are on the roofs and lacks for collecting water. Rainwater, if properly used, it could be one of the most important sources of Egypt's water. Egypt has an amount of rainfall water of 1.8 billion cubic meters, and this is a big amount of water that if used it will solve many of the water problems and this is according to the reports of the UN's food and agriculture (FAO) Although Egypt has an extensive amount of rain water, Egypt has failed to take benefits from this water. Water experts agree that by maximizing rainfall storage projects, Egypt could generate an amount of water that is about 1.8-billion-meter square annually, if only the governor of Egypt built rainwater collecting projects.

Causes:

Egypt belongs to an arid and semi-arid climate region and about 960 000 km2 or 96% of the Egyptian area is covered by desert (the Sinai Peninsula, the Eastern Desert and the Western desert) these areas have an acute shortage of rain water To combat this problem, water harvesting techniques have generally been used to get water. In reality: Egypt doesn't have many projects. Or devices are designed to collect rainwater into lakes or a tank and because of the dam that Ethiopia built nowadays on the Blue Nile, which provides Sudan and Egypt with water. As a result, experts expect that Egypt will suffer a lot from the lack of water. Thus, we should make a good use of rain water in order to use water in drinking and in agriculture to Compensates the lack of water of the Nile. for example, Alexandria in the last years has a lot of rainfall water. If Egypt collected water that fell on Alex in the last two weeks, it could have been able to get benefits from this water in different fields in life, such as drinking or in industry.

If solved:

First from the Environmental sector rainwater runoff is a known source of groundwater pollution. Contaminants like used oil, industrial waste, chemicals, and bacteria are washed directly into lakes, rivers and other water supplies. So, if we collected this amount of water the ground pollution will decrease, and the amount of water on the sink will decrease so the excess water will take its way in the sink. Also, the runoff rainwater may cause damages for building so, by collecting the water, the buildings will be protected from falling or eroded.

Second from the Economic sector using rainwater harvesting for jobs like Irrigate crops and human daily activity. So, by irrigating the crops the agricultural sector will thrive, then we can develop our industry so we don't have to import industrial products. For the excess of these resources like industrial products and agricultural products we could export it and then our Egyptian pound value will increase and this will lead to develop the economic. To conclude "if we used all the available resources in Egypt with the right way, we will be a great economic country and we could compete America and China in economic growth".

Third from Social sector by using collected water, you can decrease your water usage and replace it with a completely free resource which can help you save your money and reducing demand on the municipal water supply. If we collected the rain water, the amount of water on the sink will decrease so the excess water will take its way in the sink smoothly so, there will be no traffic jam because of the rain that filled the street. Also, this will save the souls of citizens as when the water level is too high it may cause an electric field around the electric source like the streetlights and electric cabins which will cause the death of the people who walk in this field by wrong. Collecting rainwater reduces the amount of runoff that makes its way into our water supplies by rerouting it into the rainwater tanks. This in turn decreases the amount of these untreated pollutants and reduces groundwater contamination.

If not solved:

From the Environmental sector, rainwater runoff is a known source of groundwater pollution. Contaminants like used oil, industrial waste, chemicals, and bacteria are washed directly into lakes, rivers and other water supplies. So, if we didn't collect this amount of water the ground pollution will still exist, and the sink couldn't absorb this huge amount of water so the water will make floods in the roads. One other thing is the runoff rainwater, it may cause damaging and eroding for building and houses.

Second from the Economic sector, the water floods will make a lot of problems like the erosion of the building and the government will spend a lot of money to rebuild or repair this erosion. Also, the rain floods damage the crops and erode the soil so the governorate will spend a lot of money increase the soil production again.

Third from Social sector, if we didn't collect the rain water, the floods will increase and the sinks won't absorb this amount of water so, the traffic jam will increase because of the rain that filled the street. Also, many people die every year because the water level is too high, so the water makes an electric field around the electric source like the streetlights and electric cabins. Also, collecting rainwater will increase the amount of runoff that makes its way into our water supplies by rerouting it into the rainwater tanks. This increases the amount of these untreated pollutants and increases groundwater contamination.

The research

Topics related to the problem

FIGURE 1

❖ Floods and torrents:

One of the problems resulting from heavy rains is floods and torrents, especially those that happen suddenly and this happens always in Egypt and fig. (27) shows one of these floods.

The heavy flow of rain that reaches the level of torrents may lead to the destruction of many villages, the disappearance of some of them, the death and home Lessing of many people, and the destruction of roads.

Perhaps the history of Egypt is full of such accidents that amount to 120 accidents that caused the home Lessing and killing of many people and the destruction of roads and buildings, such as the Taba torrent in 1987, which led to the destruction of the Taba road, and then came the stronger torrent from it in 1990 that led to the destruction of a mining center in Marsa Alam. As for the killing and home Lessing of many people in the village of Dornka in Assiut, where 1500 people were dying, came in less than 15 minutes, which happened in 1994.

❖ Dredging and soil erosion:

Soil is the surface layer of the earth's crust, which consists of rocky sediments that have been subjected to fragmentation processes resulting from various erosion processes, such as water and air erosion. It acts as a threat to human food security because it destroys the important soil layers for agriculture.

Soil dredging occurs for several reasons, which are:

Water erosion: occurs because of heavy rains or severe floods and torrential torrents, as the runoff of that water resulting from them, whether in small rivers or canyons, which leads to massive erosion of the soil and the destruction of plants.

Aerobic erosion: resulting from wind or hurricanes on places with loose, light soils such as sandy soils in the desert.

❖ **Acidic rain:**

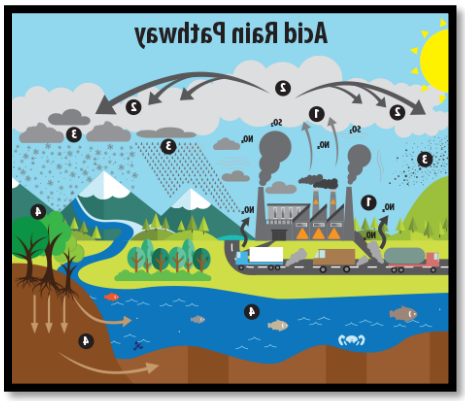


FIGURE 28

Acidic rains formed from all pollutants in the air and fig. (28) shows how the acidic rain are formed. Acid rain affects humans and the environment, and from an environmental point of view, we find that it affects fish and amphibians such as frogs. The high percentage of acidity in the water bodies in which these organisms live lead to deformation or death of embryos. Also, the high percentage of acidity in the rains affects the number of snails that birds feed on and provides them with the necessary calcium to maintain the cohesion of eggs and thus deformation of eggs. Likewise, the indirect effect on human health comes, as humans suffer from many diseases such as Alzheimer's, kidney disease, and brain damage. As for the ancient monuments, they did not escape the effects of acid rain, especially since many of them are made of marble and limestone, which costs the state a lot of money to save and fix it.

Topics related to the solution:

❖ **The rain water gardens:**

A rain water garden is a shallow depression in a yard, planted with many groups of deep-rooted native flowers and its mechanism is show in fig. (29). Also, the shrubs and grasses that don't be harmed when the water touches its roots for long time. These gardens are designed to collect the rainwater from downspouts, driveway and sidewalks. After collecting this water, it goes to garden and the plants take its need from water, then the rest goes under the ground as shown in the fig. Then through pipes to be used in another thing. The rain gardens not only water the plants and vegetation but it also filters out 90% of the chemicals that found in runoff water like pollutants, fertilizers, harmful chemical compounds. Also, this type is useful to prevent floods.

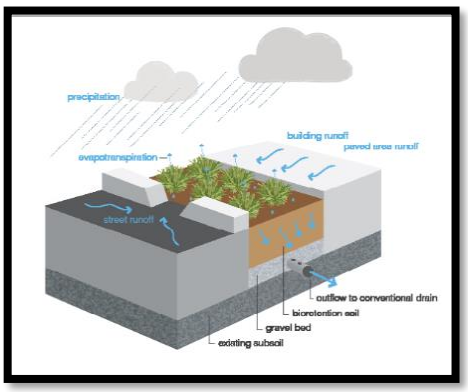


FIGURE 2

❖ The green Roof:

FIGURE 30

The green roof as shown in fig. (30) is a method of collecting the water rain like rain water gardens but it's paced on the top of a building but it's most useful than rain water grounds as it purifies the air, reduces the ambient temperature, regulates the indoor temperature and increase the solar panels efficiency. It Purifies the air as the plants in green roof filter the air from harmful gases and take carbon dioxide gas (CO2) from air from the air and changes it to oxygen gas (O2). the green roof reduces the ambient temperature as the plants absorbs 50% of sunlight and reflects 30% of it so it helps in creating cooler and pleasant climate. It increases the solar panels efficiency as it reduces the temperature on the roof and this cool increases the solar panels efficiency.

❖ Smart sinks:

The smart sinks as shown in fig. (31) are an important method to filter and recycling the rain the wasted water. The smart sinks are highly effective method of removing the particles and sediment from wasted water and this reduces the environmental negative impacts. The water that filtered from this smart sink is clean and clear. These smart sinks are easily to be used and designed to suit different types of work environments and it can be used in different fields like dental shops, art studios and building sites. Sediments and particles are collected from wash up water via 3 disposable bags and it is used in eliminating drainage system blockage. Smart Sinks are approved as a pre-treatment filtration system like (Qld) Urban Utilities, Sydney Water, (SA) Water, and (WA) Water Corporation.

FIGURE 31

The prior solutions

Roof catchment system

Introduction:

Collecting rain water to use it is a critical thing because there is much wasted rainwater. In the last few days about 2 million-meter cubic of rain water falls on Alexandria. Harvesting rainwater means direct collection for rainwater for either human or agricultural. The roof catchment system is from the easiest way to collect rainwater and can be equipped in many houses and instructions. Also, it is an inexpensive type of water harvesting.

Mechanism:

There are 3 fundamental elements for rainwater harvesting first the collection area. Second, the transmission system. Third storage facilities. And fig. (32) shows the mechanism of the roof water catchment surface.

In the most buildings the collection areas always are the roofs of these instructions. The materials and the area of this roof affect the quality and the amount of water.

The transmission system usually consists of pipes that deliver the water which falls on the rooftop towards the storage vessel. Both rooftop surfaces and the pipes should build of chemically inert materials like aluminum, wood, plastic or fiber glasses to prevent adverse effects from happening.

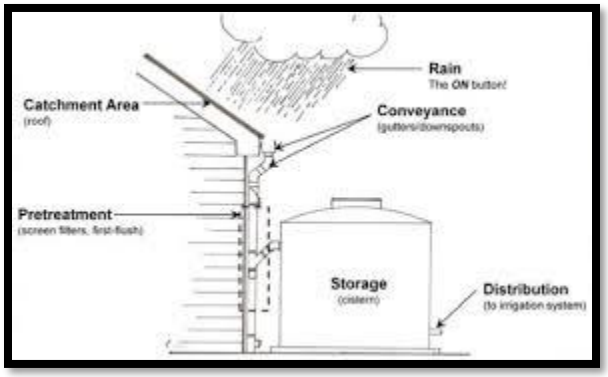


FIGURE 32 THE MECHANISM OF ROOF CATCHMENT SYSTEM

The water tanks should construct with an inert material like stainless steel or fiber glasses. The storage should construct as a part of the building or may be built as a unit separated from the building and in some distance away from it. So, when the rainwater falls on the inclined surface, it goes into the pipes and the pipes move it into the storage. The following graph shows the mechanism of roof catchment system. This solution was done by Brazil and Maldives.

Advantages:

- the quality of the rain water is high.
- the system is independent; this means that it is suitable for separated settlements.
- the available materials and the crafts of men can help in rainwater system construction.
- no costs of energy will be needed to run this system.
- this system is simple to be maintained by the owner.
- can be constructed on any building.

Disadvantages:

- the high in the first capital cost may prevent some families from buying it.
- The water availability may be limited and may not suffices so supplementary water resource may be needed and for long dry season the storage volume should be too high.
- Free water that collected from rainwater harvesting has flat test while some people prefer to taste the mineral rich water.
- The water which is low in minerals may cause some deficiency for people who suffer from low lack of nutrition.

Underground tanks:

Introduction:

the problem of water is an old problem and there are lots of solutions that try to collect the rain water to solve the problem of water in the past and now.one of these solutions is that the solution of (underground tanks) and we will show how it works and what is the advantages and disadvantages of this prior solution. Underground tanks collect water to make ecological and economic sense. It is a suitable solution which can collect a big amount of water and it is used in many areas. An underground storage tank (UST) system is a tank (or a combination of tanks) and connected underground piping having at least 10 percent of their combined volume underground. The tank system includes the tank, underground connected piping, underground ancillary equipment, a motor that pushes water up into pipes and any containment system. this solution has been applied in idea to collect water and storage it in underground water tanks.it has been applied in Egypt in big companies of water to storage water. It has been also applied in united states to collect rainfall water from the surfaces of houses and storage it into tanks.

Mechanism:

FIGURE 33

Underground water tanks work with the system of pump and pipe to transport water to the tank and transport it to the application areas. The tank is installed into a depth to shield it from freezing in areas that have cold weather as shown in fig. (33). And we can say that Mechanism Water stored within the wet season may be used in the dry season and lifted from the tank with a rope pump or with a deep well pump which can elevate water up to 30 m. These tanks can be constructed of concrete blocks or with other materials. The tanks are partly (1.5 built below the soil surface. The water falls on the roof of and the roof is shaped to collect water into pipes that go to the under-water tanks. We can use the water from this tank by using a motor to raise the water up into pipes so people can use it in drinking and house using.

Advantages:

- These tanks are out of the sunshine effect that makes the water warm and can help some microbes to grow such as Algae.
- Saving space as their tanks are underground so the area will be used for multiplied purpose and this point is very important in areas where space is small or limited.
- The cleanness of water: these tanks are very safe because they can't be stricken by the weather changes like strong winds or extreme heat.
- We can use water in the rainwater harvesting system in several non-drinking functions and it leads to reduce the bill.

Disadvantages:

- **costly:**

  it costs more money because you have to dig a pit and extra plumbing which might increase the value of water also, you may need a pump to push the water quickly because water cannot move from right down to up depend on gravity and it may cost plenty of cash because its requirement cost Materials to build It and also the cost of pipes that are used.

- **Regular Maintenance:**

  Rainwater harvesting systems require regular maintenance as they may get at risk of rodents, mosquitoes, algae growth, insects and lizards. They will become breeding grounds for several animals if they are not properly maintained.

- **Storage Limits:**

  The collection and storage facilities may additionally impose some quite restrictions on what quantity of rainwater you'll be able to use. During the heavy downpour, the collection systems may not be able to hold all rainwater, which ends in going to drains and rivers.

Chapter 2 generating and defending a solution

solution requirements:

- **durability:**

To work well, the materials must be strong material, and not materials that can be damaged easily. We must provide a safe solution and build the collector components from strong materials because it will be very dangerous if the solution can be broken easily, for example, if we collect a big amount of water and have a big tank or a lot of tanks. Also, the water in these tanks is used by many people in the area where is the tank. If the tank destroyed or anything happened and damaged the tank, then it will be a big problem because water is wasted and people will have a big problem as they depend on this water in drinking. So, it is important to take care about durability.

- **Cost:**

We must collect water in a way that doesn't cost a lot of money. The collector's components must be marked from inexpensive materials. we mustn't used to bring materials that are very expensive or rare require high energy to make it work. We must collect it in a low cost. The project must be available and low-cost because many products in some countries have failed because they were not available in some countries or difficult to find in some other countries and had a high price.

- **eco-friendly:**

The collector components must be made from materials that don't pollute water. For example, if the tank was built from a material that pollute water then it will affect the agriculture because this water will be used in irrigation crops, so the crops might be toxic or harmful to us as we eat these crops. But if the tank is built from substance that doesn't pollute water, then the plants will be healthy. The water must be clean and pure so, that we can use it in our homes or drinking it.

- **location:**

The location will help collecting water the collector must be in an area that have a lot of water, not in an area that have little water. For example, the solution mustn't be put in the desert or in dry places where there is rare rain. The solution must be put in the coastal areas like Alexandria in Egypt where there is a lot of rainfall water and this water isn't collected or used. Another example, we can put our solution at the top of mountains where there is a rainfall water.

Design requirement

The design requirement of our prototype is to collect to the largest amount of rainwater in the shortest time. So, we searched a lot to find the specification of the catchment area, shape and the accurate slope to prevent water to splash out of the collector and fill these levels: 200ml, 400ml, 600ml, 800ml, and 1000ml as fast as possible. Also, we made a tank of 1 liter to take this amount.

Selection of solution

Any rain water collector is built from three fundamental components which are the collection area, the storage and conveyance system.

- **Collection area (catchment area):**

Any water collector should contain an area which will collect the water. The collection area is an important thing, as you can't collect the water without it. This area should be built with materials that don't react with water to prevent the water from being polluted. Also, this area should be inclined to force the water to the direction you want to move it. The collection should be built with high-quality materials that don't react with water. The collection area could be an area on a roof like in the figure.

- **Conveyance system (the pipes):**

Pipes are an important thing to collect the water as it delivers the water which falls on the roof it towards the tanks or the storage. Also, the pipes should be constructed with inert materials that don't react with water like fiber glass or aluminum to avoid adverse effects on water. The pipes shouldn't be placed in very lower place than the tank, or you may use an electric motor to pump the water towards the tank.

❖ **The storage:**

A place to collect the water or a storage unit should be constructed. This will take the water from the pipes to collect it. It also should be constructed with inert materials. The storage could be built as part of a construction building or it might be built as a separated unit located in some distance away from the building.

Selection of prototype

The prototype consisted of four faces, each shaped like a trapezoid. The single face has a height of 25 cm, a small base is 10 cm long, and a large base is 53.3 cm long. The slope of each face is equal to 30 degrees to obtain the largest possible area and give the water a suitable speed while collecting water in the tank in the least possible time, as the goal of the prototype is to reach the maximum rate of rain collection. The tank will be placed at the bottom of the prototype to make the force of gravity accelerate the water at a rate of 9.81 meters per second so that the water flows through the hose connected to the tank and the prototype to drain the collected water to the tank as quickly as possible.

The prototype will be tested at a test station in our school, and this station contains a shower to be like the rain with radius of 10 cm, and put on a height of 2 meters. We will calculate the water rate three times to calculate the rate of the water precisely and try to decrease the measurement error.

Chapter 3 constructing and testing the prototype

Materials and methods

Name of the material	Craft sticks	kemaboxy	Plastic bottle (tank)	Epoxy A B	Yellow glue (penta)	Funnel
Picture						
Descript-ion	Wooden sticks that their measure is mm 150 * 18 * 1.6	The coating material	It is a bottle made of plastic	A substance that binds things together strongly and quickly	Binding material	It is a funnel made of plastic
Amount	We used 9 packets of sticks each one contains 100 stick (900 sticks)	A package contains one kilo gram	A bottle its capacity 1.5 liter	100 grams of epoxy	Two buckets each one contains one kilo gram	One funnel
Price	25 L.E. each packet * 9 packets = 175 L.E.	180 L.E.	----------	20 L.E. * 3 packets = 60 L.E.	30 L.E. * 2 buckets = 60 L.E.	5 L.E.
Total Price	480 L.E.					

Methods

We can divide the methods into three stages:

Pre-construction

First, we had a discussion to select the shape of the prototype and how we can build it. The shape we selected was 4 trapezoids with an area of $791.25cm^2$ for each trapezoid and these four trapezoids are connected from the bottom to form a square that square will lead to the tank which Is a bottle with a capacity of 1.5 liters.

The construction

- First, cut off the edges of the craft stick to form a rectangle shape from every stick and arrange them like offset pattern (fig.34)

FIGURE 34 SHOWS THE OFFSET PATTERN ARRANGEMENT IN THE PROTOTYPE

- second, binds these units together with Penta to form 4 big sides with a length of 25 cm and width of 60 cm like in (fig.35)

FIGURE 35 SHOWS HOW WE BIND THE MATERIALS TOGETHER

- Third, wait 24 hours under pressure until it dry.

- Fourth, cut these 4 sides to make a trapezoid with dimensions 53.3 cm $base_1$, 10 cm $base_2$ and 25 cm height from each side like in (fig.36)

FIGURE 36 SHOWS THE SHAPE OF THE FACE AFTER CUTTING

- Fifth, bind these 4 trapezoids together with epoxy like in (fig.37).

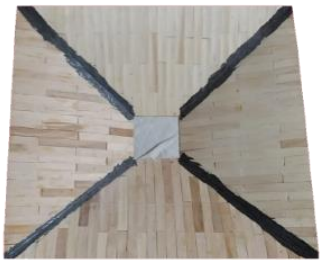


FIGURE 37 SHOWS HOW WE BIND THE FACES TOGETHER

- Sixth, paint the prototype with kemaboxy as a coating material.
- Seventh, wait 24 hours until it dried and paint it again 3 times.
- eighth, bind the funnel to the end of the four trapezoids with epoxy.
- Ninth, make simple cuboid like in the previous steps.
- Tenth put the first part on this cuboid and now finish (fig.38).

FIGURE 38 SHOWS THE FINAL PROTOTYPE

The safety precautions

The safety precaution we followed while building our prototype is wearing gloves to prevent any of our team from being injured. Also, we made rules for using the cutter like if someone is using the cutter, he shouldn't kid with anyone with the cutter. Furthermore, we used the goggles to prevent any one eyes from being injured by the wooden sticks, scissors or the cutter. We also wear our white coat to protect our clothes from being cut or falling a permanent spot on them.

Test plan

After the prototype has been built, it has been tested in the following conditions:

- first, the prototype was on the ground and a water tap that has a diameter of 10 cm was above it.
- Second, a 1.5-liter bottle has been marked every 200 ml till it reached 1 liter, then the marked bottle has been put as a tank in the cuboid under the prototype.
- Third, the prototype has been put under the water tape of height of 1.5 meters.
- Forth, the tap of water was opened with a water pressure of 129 milliliters/second.

Data collection

results

After finishing the prototype, the test plane was done three attempts and we recorded the results in every attempt. After that, we took the average to reach the highest accuracy. The results as shown in figure (x) collected water at a high rate and achieved more than expected as in graph (40).

amount of water	attempt 1	attempt 2	attempt 3	avarage
200 ml	1.74 s	2.20 s	2.24 s	2.06 s
400ml	3.5 s	3.81 s	3.86 s	3.72 s
600ml	4.84 s	4.96 s	4.83 s	4.88 s
800ml	6.34 s	6.21 s	6.03 s	6.19 s
1000ml	7.9 s	7.58 s	7.73 s	7.74 s

Graph 40

negative results:

At first, we used wrong binding materials so after testing we saw that our prototype has been damaged and we have to rebuild it with another binding material. After searching and asking our teachers we knew the best material to bind the prototype is Penta glue as it isn't affected by the water and its stronger than the previous material.

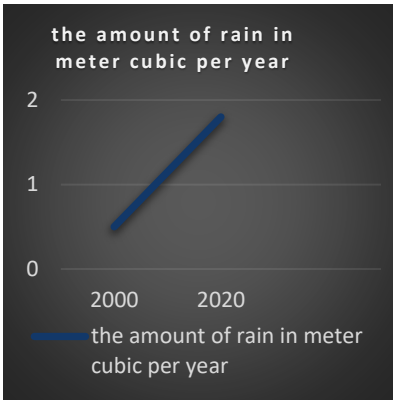
FIGURE 39 SHOWS THE PROTOTYPE TESTING

Positive results:

Our prototype was tested under a water tap that fills the liter in (6.7 ± 0.1) seconds like in figure (39) and our prototype collected the liter of water in (7.74 ± 0.1) seconds. This means that our prototype achieved the requirement as it collected the liter of water in only about one second difference. The rate of collecting water is (166 ± 37) ml/s. Also, we measured the water loss rate which equals 22 ml/L. after testing the prototype we saw that it achieved most of the design requirements and we will discuss in the analysis the scientific base of our prototype.

Chapter 4 Evaluation, Reflection, Recommendations Analysis and discussion

Egypt will face a big problem in the future, which is the poverty of water. However, there is an enormous amount of water that falls on Egypt every year. We see from graph (41) that the amount of rain increases from year 2000 with an amount of 0.5 million m^3 to the year 2020 with amount of 1.8 million m^3. This happened because every year the humidity increases because of rising temperature, which resulted from global warming phenomenon. So, our grand challenge is to collect the wasted rain fall water. So, a simple prototype project is made to solve this problem. It matched the design requirements as it collected a big amount of water in small time.



GRAPH 41

- We chose the slope of our prototype to be 30^0 because when it's 30^0 it will have a big opened surface, although the water will move into the funnel with its high speed.

- We made the height of the trapezoid to be 25 cm, and the small square had a side length of 10 cm as shown in figure (42), from here we used our math learning outcome about trigonometry (MA 1.01) then we calculated the length of the big base. First, we got $(\cos 30) = \frac{\sqrt{3}}{2}$ then we found the length of the side included between 90^0 of angle 30^0 and we donated it by (X), then we made cross multiplication ($\frac{\sqrt{3}}{2} = \frac{25}{x}$) then make it like equation ($\sqrt{3} \times 25 = 2x$) and after solving this equation the result equals 21.65 cm approximately, since we have the middle side equals 10 cm, therefore the length of one side would equal $21.65 \times 2 + 10 = 53.3$ cm approximately.

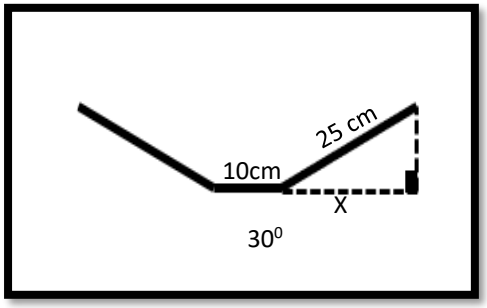


FIGURE 42 SHOWS THE STEPS OF CALCULATION OF DIMENSIONS OF THE PROTOTYPE

- Another thing we put the tank under the prototype, we made that to force the water to move with high speed without losing its force while going up to a high tank, while going up the water loses its motion energy as it would be opposite to the gravity and this is which we have studied in physics learning outcome which talk about forces (PH 1.02). Also, to match the requirement of collecting the greatest amount of water in short time.

- We made the dimensions of our prototype to be like square if we look to it vertically like we learned in math learning outcome which was about cross section (MA 1.03). We made this to collect the biggest amount of water from all directions.

- While we are constructing the prototype, we build a wooden cuboid like a tower to support and stand the prototype on upside state like in figure (43), also, to be like a room for the tank under the prototype. We put it in the middle at a distance of 26.65 cm from each side. This distance is made according to scientific base which the center of mass. So, we calculate the center of mass of the prototype as the following: we have the mass of a side equals 300g and the distance 26.65 which:

FIGURE 43 SHOWS THE FINAL PROTOTYPE

$$= \frac{x1m1+x2m2+x3m3+x4m4}{m1+m2+m3+m4} =$$

$$\frac{300\times26.65+300\times26.65+300\times26.65+300\times26.65}{300+300+300+300} = 26.65cm$$

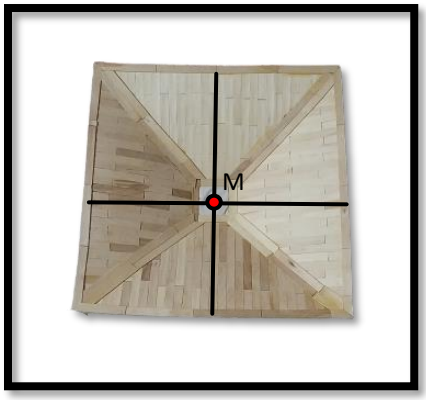


FIGURE 44 SHOW THE CENTER OF MASS OF

so we conclude that the center of mass and the middle of the prototype are the same point so by studying the center of mass in physics (PH 1.05) we knew that the center of mass of our prototype will be in the point (m) like in figure (44) and this means that the mass of our prototype is considerate in its middle, then the water will be collected in its middle.

- Also, we have chosen the materials according to many researches and by using our geology learning outcome (GEO 1.03) which is about building materials, so, we searched about the building materials and found the suitable binding material for our prototype also we found the suitable coating material. the suitable coating material is Kemaboxy as this material is from modern building material and used now in building, but it is useful for us because it increases the hardness of the prototype and works as a water insulator.

- We arranged the sticks of our prototype like offset pattern because after researching we knew that it used for building walls of buildings, also, it gives the wall strength and it is easy to be arranged.

- To conclude, first we choose the dimensions to collect the largest amount of water, we choose the binding materials as it isn't affected by water and the coating material as it is water insulator and will prevent the water from entering between the sticks.

Recommendations

To improve the efficiency of our project and to achieve better results, we have some recommendations to be done on prototype and the real project:

First the recommendations on the prototype:

- First thing is using gorilla glue instead of Penta it because it is a strong and suitable adhesive with a high adhesive ability of 100% of all materials and water-resistant composition.
- Second thing is using wood parts or plastic parts instead of sticks as the sticks aren't compacted together strongly but if we take a wooden part it will be strong.

Second the recommendations on the real project:

- First, attach a filtering system to the funnel to pure rainwater from micro-bacteria and dust.
- Second, using a rain detector to detect when it's raining to open the tanks to prevent the dust and microbes from entering the tanks.
- Third, making the tank of fiberglass material with a polyester gel-layer coating, which is a soft material that copes with different humidity and temperatures.
- Fourth, putting the rainwater collector in rainy coastal areas in Egypt such as Alexandria and Sharm el sheik.
- Fifth, making the surface area from Standing Seam Metal, A high quality enameled roofing material that is easy to clean beside that standing seam metal offers the highest collection efficiency available.
- Sixth, if we want to make it with low cost, we may use rocks like granite as it is high durable and have no porosity. Also, we may use sulphate-resisting cement it doesn't react with acidic rain.

Learning outcomes

Subjects	Learning outcome	Description of the learning outcome	How it was useful in our capstone
English	EN.1.01	This learning outcome is talking about what makes STEM graduation is different, what the 21st century skills are and the grand challenges of Egypt	This learning outcome helped us in identifying Egypt grand challenges and having more information about them
English	EN.1.31	This learning outcome is talking about how to improve your writing skills without being confused and without confusing the reader	This learning outcome helped us in improving our writing in portfolio and poster and improve our writing to be more academic
Computer science	CS.1.01	This learning outcome is talking about how to create 3D design with sketch up	This learning outcome helped us in making a simple design for our prototype in sketch up to check our dimensions
Math	MA.1.01	This learning outcome is talking about trigonometry especially trigonometric function, cosine law and sine law	This learning outcome helped us in choosing the dimensions of our prototype as the height of each trapezoid and the height of the prototype from the ground

Math	MA.1.02	This learning outcome is talking about statistics specially the correlation and regression, also it talks about histogram and drawing statistical table	This learning outcome helped us in expecting the results of the testing of our prototype and doing in statistical operations while writing portfolio or testing the prototype
Math	MA.1.03	This learning outcome is talking about cross section, 3D objects and 2D objects	This learning outcome helped us in imagining the shape prototype, trying to find the best design by imagining and accurately choosing its dimensions
Physics	PH.1.02	This learning outcome is talking about forces, static equilibrium and free body diagram	This learning outcome helped us in knowing the forces which will act on the prototype and this helped us to know how we will build the tank of water and choosing the best place for it also learning the free body diagram helped us while we are trying to make our prototype design

Physics	PH.1.05	This learning outcome is talking about the center of mass	This learning outcome helped us in calculating the center of mass of our prototype to know where we will put the tower or the column that will lift the prototype above the tank
Social studies	SS.1.04	This learning outcome is talking about the water sources in Egypt	This learning outcome helped us in knowing the sources of water in Egypt and knowing the rainy places which contain the most of the rainwater and this helped us in recommending the places for building our rainwater collector
Geology	ES.1.03	This learning outcome is taking about building materials	This learning outcome helped us to know the best binding and coating materials to build our prototype also it helped us in recommending the best materials to build our project in real life

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