

Van de Graaff Associated with Vacuum Water Treatment for Filtering Water Microorganisms and Impurities

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Abstract— There is no effective way to keep the humanity living on the currently existing water resources. Water pollution had been shown alarming obstacle. So, it is one of the most important grand challenges that is a must to solve. In order to overcome water crisis, it is suggested to use vacuum system. This device is utilized to give healthy water and have no impact on the surroundings. With the modifications that are suggested by this study, the device will be Electrostatic generator (van de Graaff) consolidated with the vacuum chamber to give pure water. In addition to producing some useful waste like fertilizers, that agricultural institutions can benefit from. Besides having the property of being efficient, eco-friendly and cheaper than water filters, it can exploit any polluted water, which mean cleaner environment with drinkable water and elimination of many diseases. Facing challenges that affect the development of the Vacuum system is an important aspect to be studied, so solutions are indicated by study for all the challenges facing them like Van de Graaff constructing, connecting the plates in Van de Graaff, Vacuum chamber evacuation and the real application.

Index Terms— Water pollution, Van de Graaff, Ozone, Vacuum chamber, Humidity, Liquid Nitrogen, Distilled Water

1 INTRODUCTION

Water pollution field is the majority of the current age because of its importance in developing the humanity. There are many projects and filters for water like bio-sand which mainly relies on simple layers of sand and the Reverse Osmosis. There is no effective way to keep the world working with these filters and reduce pollutants in water. The efficiency is an essential component of any plan to get back on the track of balanced growth. So, New projects and filters must be developed to achieve the required efficiency.

Also, Water impurities and pollutants should be taken in mind as they may affect people environmentally and economically. As a result, these new solutions should clean water, eliminate most of the impurities in water and turn them to useful humanity needs. For an example, Sewage water is in lakes, there are a technology that can use this water and turn it into useful water, is probably the most close-to- Nature form of Water.

In order to finding an eco-friendliness filter to decrease water pollution, it suggested to use vacuum system. Vacuum are devices that enable the water to evaporate and transport The water will be transported as a vapor to utilize the pressure of the vacuum chamber and the water container until the water vapor fill the vacuum chamber.

There are many challenges facing vacuum system such as output impurities in water and how to reduce them, electrostatic generator to get the highest performance, suitable substrate to collect almost all the impurities and

producing free oxygen atoms, then water with ozone that produced from the combination of oxygen O₂ with one free oxygen atom was evacuated in the vacuum chamber until it reaches a pressure less than 20 mmHg to enable the water to evaporate and transport the vacuum chamber. The water will be transported as a vapor to utilize the pressure of the vacuum chamber, lastly the liquid nitrogen will be used to condensate the water vapor.

Unlike costly and difficult to be obtained Water filters, this device provides inexpensive clean water source for any person at any time. As a result, from these challenges, this research is proposed to be figured out to help solving them, that's why there can be found new, efficient and clean water sources. Also, it is said to help finding clean environment with healthier people from the technique of wastewater treatment by electrostatic vacuum water treatment projects.

2 RELATED WORKS

Harnessing the impurities of water can provide fertilizers for agricultural lands, once technical and cost obstacles are overcome. [3]. Electrostatic vacuum treatments (E-Vac) can provide an answer to several problems which traditional wastewater treatment face. [14].

Electrostatic generator is used for eliminating most of the impurities by physical electrocoagulation [15]. Free oxygen atoms which convert oxygen to Ozone is found to increase water purity [7].

Ozone gas will prevent water from reacting with carbon dioxide to form carbonic acid [16]. It also helps to elevate the percentage of Oxygen in water. About medical field, the distilled water Access faster to the blood and helps to remove toxins from the cells [6]. Also, doctors recommend distilled water for babies and people with problems in the kidney [5].

For Van de Graaff rollers or electrodes, Teflon and

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aluminum foil are used [15]. Van de Graff will convert the dynamic electricity into static electricity by friction. This static electricity will attract the opposite charge impurities toward it. That will lead to collecting almost all the impurities around the two hollow spheres and leave the water behind with only the small uncharged particles and some types of viruses [1,4].

For Vacuum stage, Water will be evacuated in the pressure less than 20 mmHg then opening the hose that connect the vacuum chamber with water container to enable water to evaporate and transport the vacuum chamber [2]. The water will be transported as a vapor to utilize the pressure of the vacuum chamber and the water container until water vapor fill the vacuum chamber [12]. Then, Water vapor inside the vacuum chamber will be measured using humidity sensor to know the amount of liquid water will be produced. Although non-condensation of water in the vacuum chamber yet because of low pressure. So, liquid nitrogen will be used to condensate water in a few minutes [17].

The Vacuum chamber size, pressure and type of the electrodes in Van de Graaff affect water filtration quality [11]. One of the limiting factors is cost of the Vacuum pump. Pressure is an important limiting factor in the Electrostatic Vacuum generator(E-Vac) [10].

If the challenges facing the E-Vac could be overcome, then a new efficient and clean water source will be found to help in developing the humanity and getting new and magnificent world [8,9]. Also, our group predicted the efficiency of the project to be 97:99% greater than the other

attempts in the Vacuum treatment field, which mean huge drinkable water production, with having the quality of being clean and green to the environment.

3 METHODOLOGY

3.1. Participants

We are a group of 2 stem students from STEM Egypt High school for boys in the 6th of October city. We are 2 males (100% males), M: 17 years old and we are completely Egyptian Students.

3.2. Research Design

This study is made to investigate the efficiency result from combining vacuum water treatment with electrostatic chargers' generator. Also, the study aims to examine the treated ultrapure water produced from this integrated system.

3.3. Measures

TDS meter is used to test the total dissolved solids (TDS) of the water. Electrical conductivity meter is used to measure the purity of water. To test the water pH, digital pH meter has been used. The time needed to produce a liter of water is measured by using digital timer. Manometer is used to measure the pressure inside the vacuum chamber.

Materials

TABLE 1. SHOWS THE MATERIALS USED IN BUILDING THE PROTOTYPE.

Material	Amount / Size / Description
Van de Graaff generator	1 (positive pole and negative pole)
Glass container	1 (50*30*20 cm)
Water current maker	1 (small fan)
Hose	3
Vacuum pump	1
Stainless steel container	2 (20*20*20 cm)
Tabs	5
Liquid Nitrogen	1 litter
Sea Water	4 litters
Sewage Water	4 litters
Tap Water	4 litters

3.4. Building the Prototype

Step1: constructing Van de Graaff by making 5 holes in the pipe for the wires, the motor, and the nail, then doing two rollers, one made of Teflon placed downward in the motor side, and the other made of aluminum foil, after that fixing the motor and the roller in their places and making sure that they are parallel to each other to enable rubber band to move freely, furthermore, Putting the rubber band in the pipe and stretch it to make sure that they will make enough friction to create static charge, then connecting the two plates together using silicone to make a hollow sphere, in addition to making a hole in the sphere and fixing the pipe in, then attach 2 metal brushes to the rubber band; one of them connected to the hollow sphere & the other

connected to the discharger. This step is said to take about 3 minutes in water treatment.

Step 2: (This step is said to take about 5 minutes in water filtration) Making Vacuum through Fill the metallic container with water. Then, connect it with the hollow stainless steel container by a hose. After that, connect the vacuum pump with the stainless steel container. Finally, Connect the vacuum pump with the electricity (220 volts) (Make sure that the stainless steel container has no holes.)

Step 3: The vacuum chamber is put in metal container filled with liquid nitrogen. the liquid nitrogen will lower the temperature of the vacuum chamber to condensate the water vapor once it present in the chamber which will help to create a continuous cycle by making vacuum in it again.

Step 4: Conduct each component with the other to figure

out the prototype as shown in figure 1.

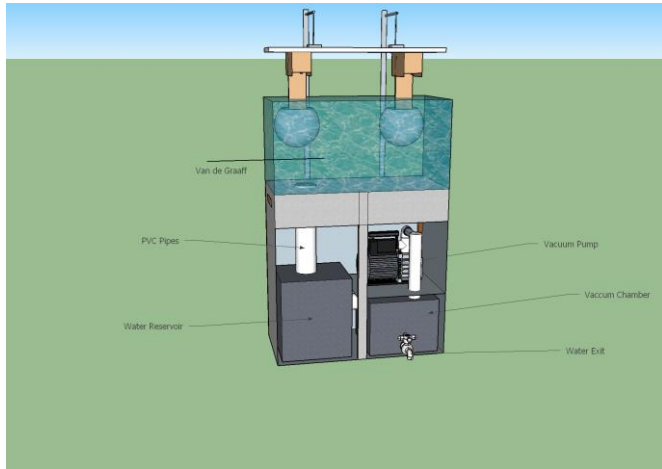


FIGURE 1. SHOWS THE PROTOTYPE MODEL.

Experiment 1:

The purpose from this experiment is to get the electrical conductivity (E.C) of the water samples (seawater / sewage water / tap water) after treating it to know the ability of the device to remove its impurities and compare it to the normal drinkable tap water as shown in table (2).

TABLE 2. SHOWS THE ELECTRICAL CONDUCTIVITY OF DIFFERENT WATER SAMPLES.

Water Sample	E.C Before treatment (Micro Siemen/cm) (Error±5μS)	E.C after treatment (Micro Siemen/cm) (Error±5μS)	Control (Micro Siemen/cm)
Sea Water	120000	9.8	416.4
Sewage Water	1500	12.4	416.4
Tap Water	416.4	4.2	416.4

From these results, it was observed that the device is able to remove almost all the impurities in water from different sources. That lack of impurities causes a drop in electrical conductivity to range of 4-20 micro Siemen/cm which is the typical range for ultrapure water.

Experiment 2:

The purpose from this experiment is to know the pH of water after treatment as shown in table (3) to determine the quality of water and compare it with WHO (World Health Organization) recommendations to ensure that there are not any health concerns. The ability of the filter to balance the acidity of waters tested to ensure that with difference resources of water it will give the needed range.

TABLE 3. SHOWS THE INPUT AND OUTPUT PH OF WATER SAMPLES.

Water sample	pH Before Treatment (Error±0.1)	pH after Treatment (Error±0.1)	Control pH
Sea water	8.1	7	7.2
Sewage Water	7.8	7	7.2
Tap Water	7.2	7	7.2

These results are concluded that the filter is able to balance the acidity of water in the range recommend from the WHO. This also means that it is safe to drink without any health concerns. It also proved that the problem of the past distilled water filtering has been solved and the water don't form any kind of acids or react with any chemical compound.

Experiment 3:

The purpose of this experiment is to determine the time needed to produce one liter of water.

Notice that the source of the water is the same but it has been tested in different time with under the same conditions with cooling using liquid nitrogen system. The data was collected as shown in table (4):

TABLE 4. SHOWS THE TIME NEEDED FOR PRODUCING ONE LITER OF WATER.

Trials	Time needed to produce one liter in minutes (Error ± 0.1 liter in a minute)
Trial "1"	5.3
Trial "2"	4.9
Trial "3"	5.1

It was observed that the filter need about 5 minutes to produce one liter. In the experiment "8" liters of water are treated together in approximately 40 minutes so after dividing it on 8 (the number of liters), the result was 5 minutes. The results can be predicted by the ideal gas law: $PV = nRT$ where:

P is the pressure of the gas, V is the volume of the gas, n is the number of moles, R is the universal gas constant, T is the temperature in Calvin.

Experiment 4:

The purpose of this experiment is to determine the total dissolved solids in water after the filtration. The water samples for this experiment were taken from different sources. They are sea water, sewage water and tap water. This will give us a clear conclusion about filter ability to remove different kinds of contaminants as shown in table (5).

TABLE 5. SHOWS THE INPUT AND OUTPUT TDS OF WATER BEFORE AND AFTER TREATMENT.

Sample	TDS before treatment (ppm) Error ± 10 ppm)	TDS after treatment (ppm) Error ± 10 ppm)	TDS difference (ppm) Error ± 10 ppm)
Sea Water	10000	8	9998
Sewage Water	5000	6	4994
Tap Water	420	2	418

It was observed that the filter is able to block almost all kinds of water impurities leaving only pure water with small concentration of ozone gas. The results were significantly near. This can tell us that the filter is not affected by the source of input water and will give a

number in range of 1 to 10 ppm. The impurities left from water can be found on the spheres of the van de Graaff and on the sides of the water reservoir.

Experiment 5:

This experiment was done to measure how efficient is the prototype. It was completed by testing the clean water of the prototype many times and testing an ordinary distillation at the same time and measure how the efficiency increased. As shown in table 6, the prototype has a high efficiency. There were some negative results like water must be transported in PVC pipes (Polyvinyl chloride pipes) because water will react with it after time because it is pure, but the other tests had positive values. We calculated the efficiency of our project and we found that the average equals 98%.

	Normal distillation	E-Vac (Electrostatic Vacuum treatment)
Cost per litter	10 cents	2.5 cents
Energy needed per litter	1 kilowatt	0.25 kilowatt
Time to produce litter	30 minutes	4 minutes
Remineralization filter	Needs a zeolite or any other type of remineralization	-
Water pH	6.8	7
Unblocked impurities	- Viruses - Acids - Dissolved gases	-

TABLE 6. SHOWS THE COMPARISON BETWEEN NORMAL DISTILLATION AND E-VAC.

4 DISCUSSION

As the mentioned before, the design of the real project is a huge limiting factor facing the development of the Vacuum treatment. But the mind said "No" and it was decided that there will be a magnificent design for the real application of the E-Vacs.

The results have given us a clear idea about the purity of water, time needed to filter it and the efficiency of the filter itself. The TDS of water was in a range of 1-10 ppm/litter which we could see from table above. To reach that range, the water had to pass through the two stages of the filter which are "Electrostatic water treatment" and "Vacuum water treatment ". In the electrostatic stage, water exposed to electrostatic charge created by the Van de Graaff generator. The positive pole of the Van de Graaff will create positive charges which will collect the negative charges impurities placed in water by attraction and the opposite occurs on the negative pole. This process will leave only small uncharged particles and some kinds of microorganisms which will be moved to the second stage water reservoir. Also Ozone gas will be result of this process which will be used later. In the vacuum stage, the pressure in the vacuum chamber will be lowered to 20 mmHg or lower by using vacuum pump. After lowering the pressure, we open the tab between vacuum chamber

and the water reservoir to leave them interact as a closed system after closing the tab between the vacuum chamber and vacuum pump. The water will move as a water vapor to vacuum chamber to equal the pressure between the two sides. When the water evaporates, it leaves all unwanted impurities moving only pure water to the next stage. Ozone gas will move also to the second stage as it will evolve while evaporating because it is a dissolved gas. When water vapor reaches the vacuum chamber it will condensate because of the low temperature of the chamber. Liquid nitrogen is used to cool down the chamber to lower than 0 Celsius. That will make a vacuum and the cycle will continue until all the water will be in form of ice mixed with ozone gas. As a final step it will be left to cool down to form pure water with ozone gas dissolved in it.

Filter design is different from other methods of filtering because many reasons they are:

1- It only relay on physical processes not chemical ones with will provide longer life span because there is no decay in any parts of filter while filtering. This also guarantee more safety and purity.

2- It has its own "distilled water treatment" with is the ozone gas. Distilled water is known for its unique ability to react with the surrounding. It reacts with carbon dioxide from the air to create carbonic acid. This was a big problem in other water distillers. To avoid this problem, the first

stage, create small amount of ozone gas which is a proved method by WHO. Ozone starts to hold the water particles together and work as a puffer limiting the water activity.

3- Lower in cost because its only inputs are water and electricity not like other methods that uses heat. Also it has a longer life span which will lower the repair cost which lower the total cost.

4- The produced water has many positive impacts on human health. The water has the ability to enter the blood stream faster and reach cells faster. It also helps to leach out toxins from the calls and balance the pH of the blood. It has the ability to fight kidney stones and improve the urinary system. Ozone also helps to improve the immune system and repair white blood cells.

5- The system is able to purify all types of water without the need to add any other stages. This will provide more drinkable water and reduce the wastes.

5 CONCLUSION

With these modifications, our project will be a magnificent project for real application and ultrapure water.

E-vac is considered one of the best projects that helps in filtering water because the pH of the water was 7 which is not acidic or basic and useful in utilizing the pH of the human blood. Also, the TDS was from 0:10 ppm which tell us that the water is clear from any impurities and will reach the body cells faster. About the prototype, the Van De Graaff gave the propriety amount of static electricity to electro flocculate the water in stage 1. And the flow of the water vapor was fast that it filled the vacuum container in just 1 minute. We found that the re-mineralize step will not be needed as the first stage (Van De Graaff) will make Ozone gas that will prevent the water from reacting with carbon dioxide to form carbonic acid. It also helps to elevate the percentage of Oxygen in water. About medical field, we have found that the distilled water access faster to the blood and helps to remove toxins from the cells. Also, doctors recommend distilled water for babies and people with problems in the kidney. Also, the project has the ability to remove viruses, strong acids, and even radioactive elements. As shown in Figure 2.

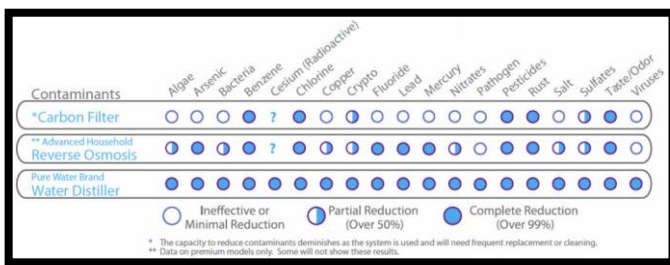


FIGURE 2. SHOWS THE GOALS OF THE PROJECT.

There are many challenges that face our project. Liquid nitrogen cooling system is one of the most difficult challenges facing E-vac project because of its high cost as they may affect the whole project and impede its

development. So, it is recommended to use alternative ways to be used as cooling system for water vapor to provide the project and make it more applicable in the real life. There was a suggested system and other systems as shown in table 7.

TABLE 7. SHOWS DIFFERENT COOLING SYSTEMS AND THEIR PERFORMANCE.

	Ability for water condensation (liters / hour)
Self-filling Water Bottle	0.5
Inspiration system	3.125
NJORD system	0.65
Stunning Water Towers	3.943

That is why, we recommended using stunning Water Towers as water condenser because of its low cost although there still be a problem which is long time to construct it. If this project could be applied in the real life with these features, it is expected to help in producing clean water with lower cost as shown in table 8.

TABLE 8. SHOWS A COMPARISON BETWEEN THE COST OF THE LIQUID NITROGEN COOLING SYSTEM AND STUNNING WATER TOWERS SYSTEM.

	Price (USD)
Liquid Nitrogen cooling system	\$ 1100
Stunning Water Towers system	\$ 550

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