WATER PURIFICATION USING HIGH VOLTAGE PLASMA

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Abstract - *Water treatment is a crucial step in providing secure and hygienic water supplies for a range of uses, including drinking water, business operations, and waste water management. Traditional water treatment techniques have trouble in adequately removing microbes, new contaminants, and persistent pollutants. As a result, there is an increasing need for creative and environmentally friendly methods to enhance the filtration of water. The prototype's goal is to eradicate the leakage of untreated industrial waste, which are primarily produced by the industrial and residential sectors. In this project, a plasma-based water filtration prototype has been developed to treat the water.*

Key Words: **Plasma generation, non-thermal Plasma, waste water management, plasma-based water filtration.**

1. INTRODUCTION

Only 2.5% of the water on Earth is fresh water, and only a small portion of this is easily measurable which is available as ground as well as surface water sources. Fresh water is therefore a limited resource. (Fig. 1)[1]. Today there is a much greater need for better environmental circumstances. Water is thoroughly examinedand a crucial topic because it is thought to be safe for humans and the rest of nature. Hazardous chemicals are typically present in wastewater from houses and the chemical industry. These compounds have the potential to be dangerous or even detrimental to both the human species and the planet's ecology. Therefore, it's imperative to just keep an eye on these substances in water and remove them from that environment. The greatest method to prevent water pollution is to inform individuals of the risks associated with utilizing hazardous items in their homes and places of employment. Understanding how to treat water to make it harmless is essential because this is not at all achievable [2].

Currently, population increase and excessive development are putting stress on this resource that sustains life and have also caused aquifer depletion [3- 5]. Humans and industrial and agricultural water needs compete in numerous ways. Indeed, agriculture accounts for around 70% of global freshwater draws [6-7].

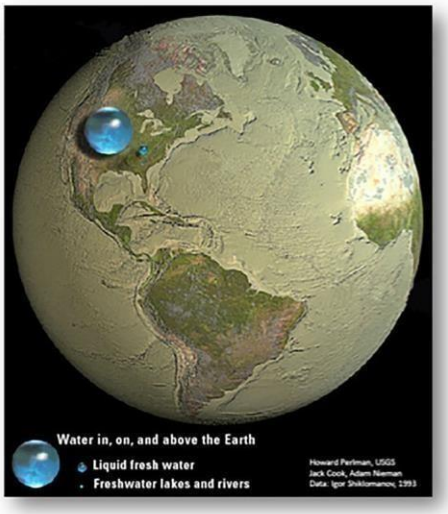

Fig -1: Pictorial representation of freshwater availability[1].

Pollution lowers water quality, which has the consequence of lowering the amount of water that is available for use in agricultural or drinkable purposes [8]. Many various techniques for treating water have been tried and developed over the years. Physical, chemical, and biological treatmentprocedures comprise the four categories.

The range of techniques for treating water is the greatest with biological technologies. The biggest benefit is the low operating cost, which is why municipalities and industries utilize it most frequently. The biggest drawback is that thetechnique for removing dangerous pollutants is not very effective. Additionally, the biological breakdown of contaminants occurs much more slowly than other processes [9]. Physical methods use a supporting system, such as filter paper and charcoal, to separate waste materials from water in a pure mechanical manner. The absence of chemicals in thismethod is a benefit. On the other hand, most harmful substances cannot be removed by physical means, especially when it comes to organic basic compounds. Chemical oxidation procedures are more frequently utilized to treat water that has been contaminated by organic chemicals, in contrast to the physical method. Chlorine, chlorine dioxide, ozone, and potassium permanganate are the most prevalent oxidants.

However, this reagent produces the dangerous by-products [10]. The ozonization procedure, which is effective but more expensive in comparison, is used to alleviate this problem.

With the application of the A/C voltage for the discharge ignition to occur, different electrode configurations in the coaxial reactor design can produce plasma in the liquid. This discharge into the liquid will start a variety of chemical and physical processes that are utilized to purify water. The electric discharge will begin a number of physical processes, such as the creation of a strong electric field, UV radiation, and shockwaves. The best chemical reaction, however, makes use of ions, radicals, and molecules with a high oxidation potential. [2]. Based on the previous procedure without using any additional chemicals, this may be used to treat the factory's wastewater. This procedure allows for thetreatment of both organic and inorganicpollutants. Plasma can also be used to sterilize and disinfect the surface of hospital waste.

2. PROPOSED SYSTEM

Several components have been used in this project of which High Voltage Generator is the important component where it can produce high voltage electrical supply. The plasma production device and other parts of the purification procedure can be powered by a lithium-ion battery. Conductive materials called electrodes are employed to aid in plasma discharge and interaction with water. Water is supplied or circulated across the plasma-water contact zone using a water pump. It guarantees a steady flow of water, enabling the plasma to be purified by coming into touch with freshly formed water.

The combination of these components enables the plasma water purification process, where the plasma generated by the high voltage system interacts with water, causing chemical and biological reactions that lead to the degradation and removal of contaminants present in the water.

Table -1: Components with specifications

COMPONENTS	SPECIFICATIONS
High Voltage GeneratorBoost Inverter	DC 3.7V-7.4V to 1000KV
18650 Li-ion Rechargeable Battery	1200mAh
Micro Submersible MiniWater Pump	DC 3-6V
Electrodes	-

2.1 High Voltage Generator

High voltage generators are essential for plasma generation. They produce a high voltage electrical supply that is applied to the electrodes or plasma source. The gas is ionized by the high voltage, generating the plasma required for water filtration. For a variety of uses, it can create a wide range of high voltages. According to the voltage range given, the generator can produce voltages ranging from 3.7V to 1000kV (or 1,000,000 volts). In research and development labs, high voltage generators are frequently used for experiments, testing, and studies involving high voltage phenomena. They can be applied to physics, materials science, and electrical engineering, among other disciplines. High voltage generators are used to simulate high voltage conditions for testing and calibrating power system equipment, such as transformers, circuit breakers, and insulators.

2.2 Lithium-Ion Battery

Lithium-ion batteries ensure the system can operate even in areas without a stable power supply. Lithium-ion batteries are rechargeable energy storage devices that utilize lithium ions moving between positive and negative electrodes to generate electrical power. They are utilized in many different applications and have gained a lot of popularity because of their high energy density, lengthy cycle life, and light weight. Portable electronic devices including smart phones, tablets, laptops, digital cameras, and wearable technology frequently use lithium-ion batteries. These devices can run for long periods of time without needing to be frequently recharged thanks to their high energy density. They serve as the main form of energy storage in electric cars. In comparison to other battery technologies, they offer a greater driving range while providing the necessary power to run the car. Large lithium-ion battery packs are used by EV manufacturers to store energy for propulsion.

2.3 Electrodes

Electrodes are conductive materials that serve as the interface between an electrical circuit and a non-metallic medium, facilitating the transfer of electrical current. They are connected to the high voltage generator and are responsible for initiating and sustaining the plasma required for the purification process. Batteries' essential parts are their electrodes. Electrodes are made of materials that can conduct reversible electrochemical reactions in rechargeable batteries like lithium- ion batteries. Electrons can move between the positive (cathode) and negative (anode) electrodes during charging and discharging, storing and releasing electrical energy. A non-spontaneous chemical reaction is fueled by an electric current through a process called electrolysis.

2.4 Water Pump

The plasma-water interaction zone is supplied with water using water pumps. They make sure that water is flowing continuously so that the plasma can be purified by coming into contact with new water. . The pump keeps the water flowing at the necessary rate for effective treatment. A mechanical tool called a water pump is used to transport water from one place to another. It provides the necessary force to push or pull water through pipes, hoses, or other conduits. They ensure a consistent flow of water for domestic use, such as drinking, bathing, cleaning, andirrigation.

3. WORKING

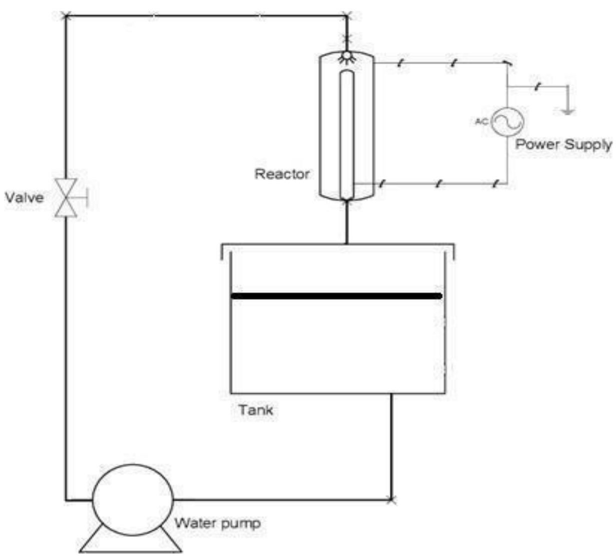

Fig-2: Block Diagram of the proposed system

Water will be drawn from the water tank, sent to the valve for water control, and then sent to the reactor chamber to create plasma. The reactor where the reactor model was created will purify the water. The block diagram up top shows how a water purifier functions by creating plasma. The prototype's main advantage is that it doesn't need any cooling systems because it generates non- thermal plasma, which keeps the water from getting hotter. The device had a pump and a nozzle that accelerated the contaminated water quickly to produce a liquid-gas mixture that could subsequently be transformed into plasma. The electrical discharge is applied to the water using two extremely sharp copper electrodes and is driven by a pulsed DC power supply. For the purpose of producing pure water without rising the temperature, the combination is afterwards slowed down and returned to a liquid state.

4. EXPERIMENTAL SETUP OF PLASMA BASED WATER PURIFIER

Several studies have been conducted to evaluate the effectiveness of plasma water purification. Overall, the results have shown promising outcomes in terms of contaminant removal. Plasma treatment has demonstrated high efficiency in eliminating a wide range of organic compounds, including pesticides, pharmaceuticals, and endocrine-disrupting chemicals. It has also been effective in inactivating bacteria, viruses, and other microorganisms, making the water safe for consumption.

After treating the water with Plasma, conducted two tests to test the micro-organisms content and one test on to check ion concentration

Test on micro-organisms content are-

- Streak plate Method
- Pour plate Method

i. Streak Plate Method-

In this procedure, an agar plate is covered with a loop of culture to evenly disperse the individual cells. The streaking approach gradually dilutes the inoculums such that colony forming units (CFUs) of bacteria can be measured.

No. of organisms= No. of colonies × Dilution factor

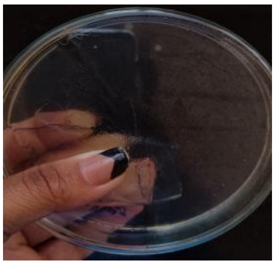

Fig-3: Before treatment **Fig-4:** After treatment

Before: No. Of Organisms = 14 x 10^-4 CfuAfter: No. Of Organisms = 2 x 10^-4 Cfu.

ii. Pour Plate Method-

The colonies develop using this technique both inside and outside the agar media, providing a useful method for counting the number of living cells in a sample.

Fig-5: Before treatment **Fig-6:** After treatment

Before: Too much to be counted

After: No. of microorganisms = 64 x 10-4 cfu/ml

iii. Detection of Ion-Concentration by TDS meter-

TDS meters operate based on the principle of electrical conductivity. Dissolved solids in water, such as salts, minerals, metals, and other organic and inorganic compounds, contribute to the electrical conductivity of the water. The higher the concentration of dissolved solids, the higher the conductivity of the water. The TDS meter typically displays the TDS value in parts per million (ppm) or milligrams per litre (mg/L).The water taken has to undergoes the purification process of plasma generation. After the purification process, can measure the electrical conductivity of the water again using the TDS meter. By comparing the pre-purification and post-purification TDS readings, the post-purification TDS reading is significantly lower than the pre-purification reading, thus indicating that the purification process has successfully removed dissolved solids from the water.

By conducting this experiment increase in the ions quantity in the water can be seen. The below figure shows the TDS measurement before and after the plasma treatment.

Fig-7: Before treatment **Fig-8**: After treatment

5. CONCLUSION

From the work carried out the conclusion is arrived as, plasma water purification offers several advantages over traditional water treatment methods. It can efficiently remove a wide range of contaminants, including organic compounds, heavy metals, and pathogens. The reactive species generated during plasma treatment can break down complex organic molecules into simpler, less harmful compounds. The high temperatures and UV radiation associated with plasma can destroy bacteria, viruses, and other microorganisms, ensuring microbiological safety. This energy consumption may be a limiting factor for large-scale applications. Additionally, the design and optimization of plasma reactors, electrode materials, and operating conditions require further research to improve efficiency and reduce costs.

A developing technology with great potential for numerous applications in the field of water treatment and purification is plasma-based water treatment. Plasma-based water treatment offers a number of promising future developments. To further improve the effectiveness of pollutant removal, future research and development efforts can concentrate on optimizing plasma characteristics, reactor designs, and electrode materials. Future developments may involve the creation of more energy-efficient plasma sources, like atmospheric-pressure plasma jets, which still effectively treat water while using less energy.

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