Entry to Stockholm Junior Water Prize 2024

High Voltage Plasma Water Purifier from E-Waste

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Abstract

The primary goal of this project is to address and mitigate the pervasive issue of water pollution caused by the unregulated discharge of industrial and domestic waste, a challenge predominantly stemming from industrial and domestic sectors. To this end, the project is an innovative prototype that harnesses the power of plasma technology for water purification. This state-of-the-art prototype transforms contaminated water into a plasma stream, effectively eradicating industrial dye, microbiological substances through a dual approach involving ultraviolet radiation and plasma sterilization. This critical phase is facilitated by applying an alternating current (AC) from a DC power source to the water, accomplished through the use of high-voltage & carbon electrodes. The circuit, using readily available and minimal components, to convert low-voltage DC electricity to high-voltage AC electricity and plasma, is a major innovation not previously developed. Solar panels are being used to charge the battery for the DC supply. It not only introduces a new dimension in water purification but also plays a significant role in the environment & reducing costs. Subsequently. A notable feature of this process is its ability to occur without a significant increase in temperature, a phenomenon known as non-thermal plasma. (non-thermal plasma is suitable for industrial purposes only). Furthermore, the device boasts an advanced automatic flow and pressure control system for industrial design enhancing its efficiency and reliability. For usage in remote areas, the design is even simpler. We only need two carbon electrodes along with the circuit. The circuit can create atmospheric pressure plasma. This straightforward method, suitable for individual use, effectively eradicates all microbiological contaminants (*E-coli*, TC, FC), microorganisms, and industrial dye present in the water. Its potential to replace current secondary and tertiary industrial wastewater treatments is promising. This breakthrough represents a significant stride towards sustainable, environmentally-friendly & cost effective water treatment practices, heralding a new era in the fight against water pollution.

Keywords: Plasma generation, non-thermal Plasma, pulsating DC power, Renewable energy, Ozone, cost improvement, E-waste, Eco friendliness.

Contents

Abbreviations

CRT-cathode ray tube
UV-ultra violet
WHO: World Health Organization
SDG: Sustainable development goals
MOSFET: Metal oxide semiconductor field effect transistor
DC: Direct Current
BOD: Biological Oxygen Demand
COD: Chemical oxygen demand

Biography

The author,Zabeer Zarif Akhter, a Class 11 student at St. Joseph Higher Secondary School in Dhaka, Bangladesh, has demonstrated a deep engagement in science and technology following his completion of SSC examination at Bogura Cantonment Public School & College. Currently, he is involved in the Ministry of Information & Communication Technology's Team Bangladesh-NASA GLEE MISSION as an intern. He contributes on electrical and ionic thruster related problems of that satellite project. Zabeer recently secured the top position at the BCSIR Science & Industrial Technology Fair and has been active in debate competitions on platforms like Bangladesh Television and ATN Bangla. Additionally, he is a skilled classical singer. The author has researched in my sectors of electronics like high voltage, ionization, plasma etc. His focus is on solving real-world problems with technology, exemplified by his project addressing water wastage in flushing systems. He is excited to participate in the Bangladesh Stockholm Junior Water Prize to further his contributions to scientific innovation.

Acknowledgement

I would like to acknowledge all who have contributed to the development of this project. Their support has been essential to the project's successful completion. I would like to thank Prof. Dr.Tanvir Ahmed for providing me access to the laboratory at Bangladesh University of Engineering Technology(BUET) , which enabled me to enhance this project. I would also like to extend my gratitude to Prof. Dr.Mohidus Samad Khan from BUET for his mentorship and provision of resources, particularly in conducting dye removing experiment at BEXIMCO industrial park. I also want to thank my school teachers for providing me banners and posters for presentation.. Last but not least, I want to thank my family for supporting me and allowing me transform my room into a mini lab. The accomplishments of the project were greatly influenced by everyone who provided me with feedback and gave support.

1. Introduction

According to unicef over 1.5 million children are at increased risk of waterborne diseases,[1]drowning and malnutrition due to extensive flooding in north-eastern Bangladesh. Globally, 600 million children still lack safely managed drinking water[2].According to WHO Some of the common water-borne diseases that Bangladesh people suffer from are diarrhea, cholera, dysentery, hepatitis, etc. Diarrhea is the most common water-borne disease that is caused by a virus[3].The World Health Organization says that every year more than 3.4 million people die as a result of water related diseases[3.1], making it the leading cause of disease and death around the world. Each year, an estimated 1.7 to 2.2 million persons die from waterborne diseases[4].Most of these deaths are due to diarrheal diseases, and most occur in children and other vulnerable populations. More bluntly put, approximately 300,000 children die every day from diarrhea acquired from unsafe drinking water. The wastewater from chemical industries and households frequently contains harmful substances. These pollutants range from organic compounds to heavy metals, posing significant risks to both the environment and public health. Issues such as bioaccumulation and eutrophication underscore the urgency for effective water treatment solutions. There are some conventional water treatment methods used all over the world. While biologically-based treatments are cost-effective and widely utilized, their efficacy in removing certain pollutants is limited. These methods often involve using microorganisms to degrade organic matter, but they can be slow and less effective against complex chemical contaminants[5]. Physical treatments rely on mechanical separation techniques, such as filtration through activated charcoal or other mediums. These methods are advantageous due to their chemical-free process. However, they often fall short in completely removing more stubborn or molecularly complex pollutants[6]. Chemical treatments, especially oxidation processes using agents like chlorine dioxide or ozone, are effective against a range of organic pollutants. However, the potential formation of harmful by-products is a significant drawback, necessitating careful management and additional treatment steps.[7][8]

Plasma technology offers a new and innovative approach to water treatment. It works by creating plasma within the water itself, triggering beneficial physical and chemical reactions for purification. Physically, strong electric fields, UV radiation, and shockwaves break down pollutants. Chemically, reactive molecules like radicals and ions break down both organic and inorganic contaminants. A key advantage of plasma treatment is its ability to handle a wide variety of pollutants without additional chemicals, making it ideal for complex industrial wastewater. The plasma generator circuit have made from e-waste materials and the high voltage have created from batteries (DC) so for recharge purpose solar panels are used here. Plasma treatment is versatile, capable of addressing pollutants typically found in industrial effluents and municipal sewage. This includes not only organic compounds, dye but also inorganic substances, which are often challenging to remove through conventional methods. Plasma technology proves effective in sterilizing water, destroying microorganisms through mechanisms like UV radiation and oxidative stress, making it suitable for applications in healthcare and public sanitation. Surface Treatment: Apart from water purification, plasma technology can be used for surface treatments, such as in managing hospital waste, further underscoring its multifaceted utility. In plasma physics, high voltage generates plasma through electrical breakdown, a phenomenon where a gas becomes ionized and conducts electricity when exposed to a strong electric field. Plasma, often called the fourth state of matter, consists of charged particles (ions and electrons).When high voltage is applied to a gas, it creates an electric field. If this field strength exceeds the breakdown voltage, gas molecules in the field's region become ionized. Ionization can occur through processes like electron impact ionization, where high-energy electrons collide with gas molecules, knocking off electrons and creating more charged particles. Once ionization begins, the newly created ions and free electrons accelerate in the electric field, causing further ionization through collisions with other gas molecules. This chain reaction rapidly increases the number of charged particles, forming plasma. The properties of the generated plasma depend on factors such as gas composition, pressure, and the characteristics of the applied electric field. High-voltage plasma sources are used in various applications, including materials treatment in plasma processing, plasma thrusters for spacecraft, and plasma displays in electronics. In summary, generating plasma by high voltage involves creating conditions where the electric field is strong enough to ionize the gas and initiate plasma formation Sustainability and Eco-friendliness. Now a days e-waste is a big problem & it has multidimensional negative impact on environment shown in figure 2.2.An intriguing aspect of plasma-based water treatment technology is its integration with sustainability principles. The high-voltage circuitry required for generating plasma can be constructed using electronic waste components, such as parts from three wheeler motor drivers, damaged CRT TVs, and used laptop batteries shown in figure 1. This approach not only provides an effective water treatment solution but also contributes to e-waste reduction, addressing two environmental issues simultaneously. For power supply we can easily use solar panels because I am using DC current for input. This process has also a great impact to reduce carbon footprint and encourage people to use renewable energy sources .In conclusion, while traditional water treatment methods – biological, physical, and chemical – have their merits and limitations, the advent of plasma-based technology offers a groundbreaking approach. Its ability to efficiently treat a wide range of pollutants, coupled with its eco-friendly and sustainable design, positions it as a pivotal solution in our ongoing battle against water pollution. As we continue to advance in technology and environmental awareness, embracing such innovative methods will be key in safeguarding our water resources for future generations.

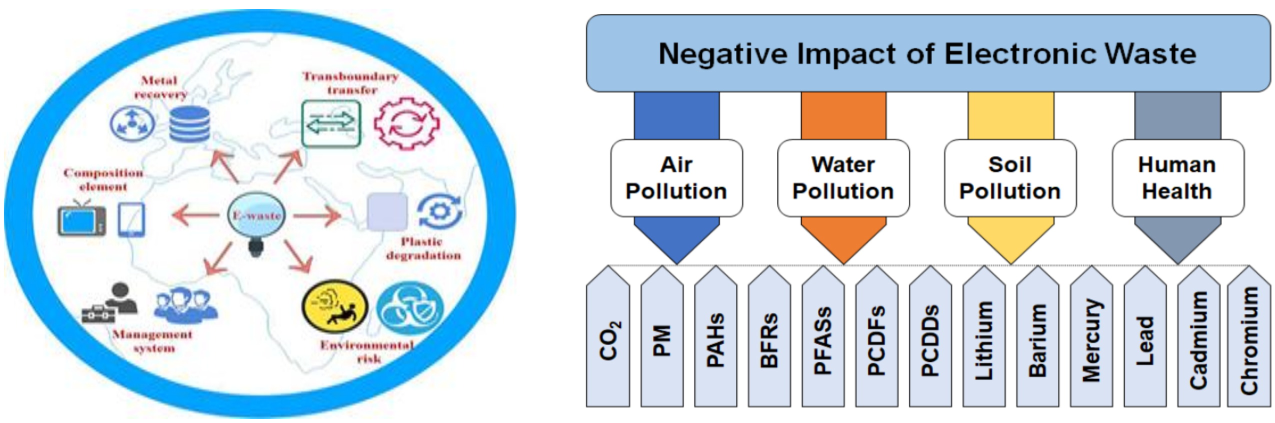

Figure 2.2: Multidimensional E-waste problem

2. Materials and Methods

2.1 System description

By repurposing N-channel MOSFETs sourced from auto rickshaw abandoned motor driver circuits, along with resistors, diodes, zener diodes, inductors, and flyback transformers salvaged from old CRT TVs, and utilizing cells extracted from discarded laptop & phone batteries, this project aim to construct a circuit capable of generating voltages ranging from 10,000 to 12,000 volts. The accompanying circuit diagram is provided in Figure 3. The components used to build this device were all sourced from electronic waste shown in figure2. In our country and around the world, many devices are discarded as inoperative due to minor issues, leading to significant environmental impact[14]. Often, due to inexperienced technicians, many daily-use home appliances that could be repaired are simply thrown away, contributing to electronic waste[26]. However, many of these devices contain reusable parts that can be recycled. In this project, the components used were all reusable parts from various devices or home appliances. By utilizing electronic waste, this project not only showcases an innovative approach to resource management but also highlights the importance of recycling and reusing materials to reduce environmental pollution. This method not only provides a cost-effective solution but also promotes sustainability by reducing the need for new raw materials. Additionally, the device is powered using DC sources or batteries, which were collected from old laptops and mobile phones. The ability to generate such high voltage from DC batteries makes this circuit quite innovative. Since the battery is a DC source, solar panels are used for charging, making it easily usable in areas without electricity.

2.2 Materials

- 470 ohm ,10K ohm resistors
- Fast recovery diodes
- 12V Zener diodes
- 100 uH inductors
- MKP Capacitor -1uF
- Heat sink
- Old TV flyback
- 12-18 volt li-ion/polymer battery
- Solar panel (2 inch*3 inch) 15-20W
- 2 electrodes (carbon rod from dead dry cell)

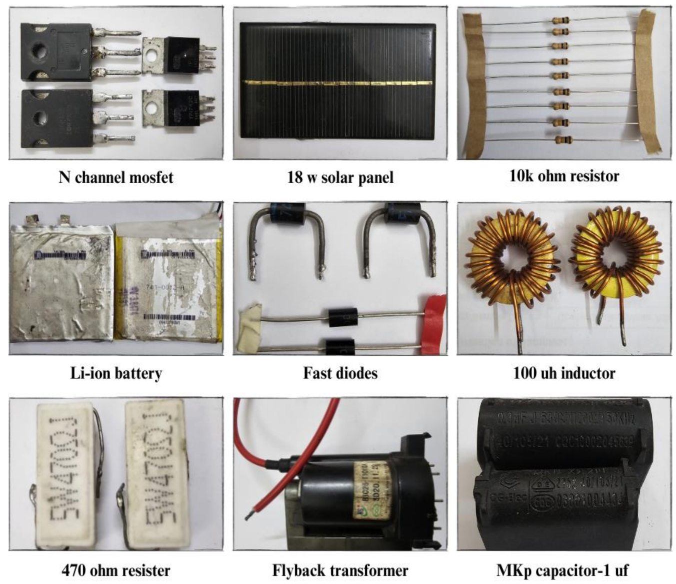

Figure 1: List of equipment used in the project

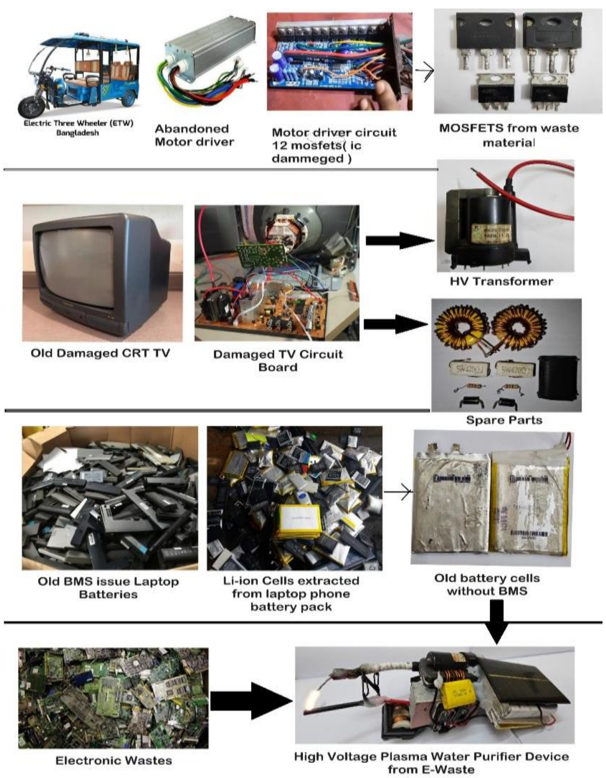

Figure 2: Equipment collection from E-waste

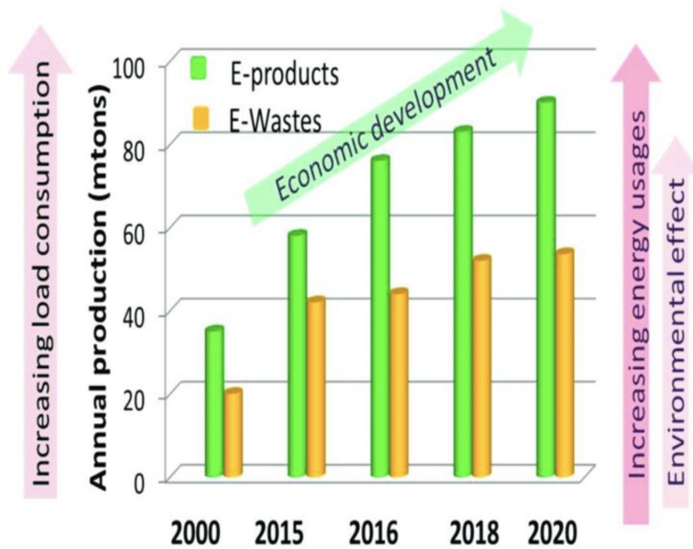

Figure 2.1: Growth of e-waste [25]

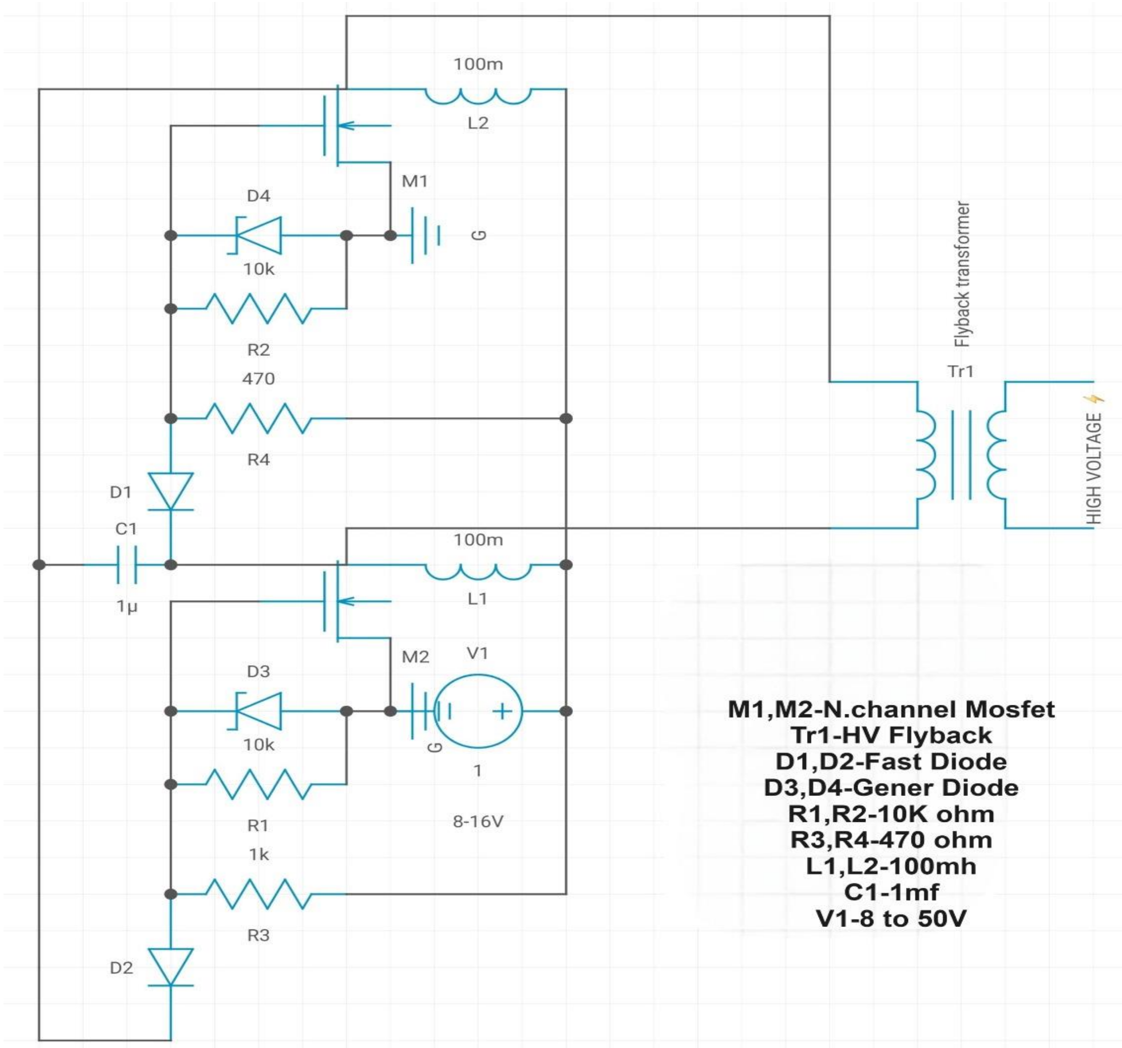

Figure 3: Circuit Diagram

This circuit works to create high voltage by efficiently driving a transformer with minimal switching losses. Here's a short description of how it operates. Oscillation Generation: The circuit uses a feedback mechanism to create a self-oscillating circuit. It typically consists of two MOSFETs or transistors, a transformer, and a resonant tank circuit composed of an inductor and a capacitor. Zero Voltage Switching: The driver ensures that the MOSFETs switch on and off at the moment when the voltage across them is zero. This minimizes switching losses and heat generation, making the circuit more efficient. Resonance and Induction. The oscillating circuit induces a high-frequency alternating current in the primary winding of the transformer. The resonant frequency is determined by the inductor and capacitor values in the tank circuit. Voltage Step-Up: The transformer steps up the voltage from the primary winding to the secondary winding, producing a high voltage output. The high frequency allows for a more compact transformer design. By operating at zero voltage switching points and utilizing resonance, this circuit efficiently generates high voltage suitable for applications like plasma generation.

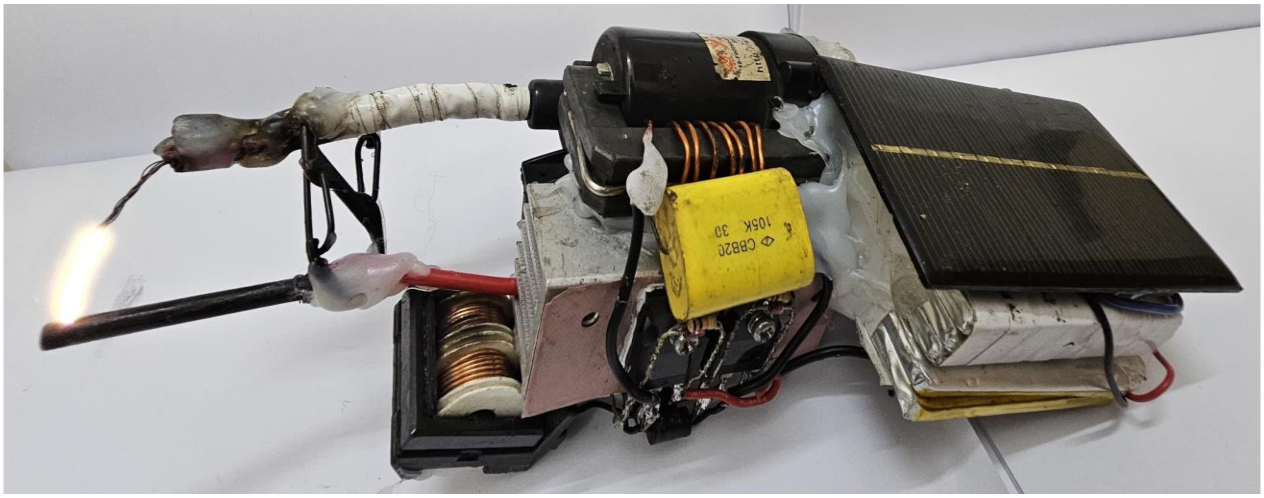

Figure 4: Portable Plasma water purifier device for individual level

2.3 System work process

2.3.1 Process of reducing BOD, COD

High voltage plasma reduces Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) from water through several mechanisms involving the generation of reactive species,[8]physical disruptions, and oxidation processes. Here's how it works;

Generation of Reactive Species: High voltage plasma creates reactive oxygen species (ROS) such as hydroxyl radicals (•OH), hydrogen peroxide (H_2O_2), ozone (O_3), and superoxide anions (O_2•−).These ROS are highly reactive and can oxidize organic contaminants present in the water, breaking them down into simpler, less harmful compounds. The ROS generated by plasma can react with complex organic molecules, breaking them down into smaller, more biodegradable compounds or completely mineralizing them into carbon dioxide (CO_2) and water (H_2O). This reduction in complex organic molecules leads to a decrease in both BOD and COD since these parameters measure the amount of oxygen required to biologically and chemically oxidize organic matter in the water.

Plasma can kill microorganisms, including bacteria, algae, and viruses, that contribute to BOD by consuming oxygen during their metabolic processes. By reducing the microbial load, the plasma treatment lowers the biological demand for oxygen.

High voltage plasma can induce coagulation and flocculation, where fine particles and organic molecules aggregate into larger clusters.

These clusters can then be more easily removed by filtration or sedimentation, further reducing BOD and COD levels.
The strong electric field and localized heating effects from the plasma can physically disrupt the structure of organic molecules, making them more susceptible to oxidation and degradation.
Overall, high voltage plasma treatment effectively reduces BOD and COD in water by breaking down organic pollutants, killing microorganisms, and enhancing the removal of contaminants through oxidation and physical processes.

2.3.2 Process of removing Biological contaminants

Applying high voltage plasma kills microbiological substances in water through several mechanisms, including the generation of reactive species, physical disruption of cell membranes, UV radiation, and thermal effects. Here's a detailed explanation of these processes:
High voltage plasma produces reactive oxygen species such as hydroxyl radicals (•OH), hydrogen peroxide (H_2O_2), ozone (O_3), and superoxide anions (O_2•−).These ROS are highly reactive and can damage microbial cell membranes, proteins, lipids, and DNA, leading to cell dysfunction and death. For example, hydroxyl radicals can initiate lipid peroxidation, disrupting cell membranes and causing cell lysis.[12]
The strong electric fields generated by high voltage plasma can cause electroporation, where pores form in the microbial cell membranes. These pores disrupt the membrane's integrity, leading to leakage of cellular contents and ultimately causing cell death.
Plasma can emit UV radiation, which can damage the DNA and RNA of microorganisms. UV radiation induces the formation of thymine dimers and other DNA lesions, preventing replication and transcription, leading to cell death.
The energy from the high voltage plasma can generate localized heating, which can denature proteins and other critical biomolecules within the microorganisms.
Heat can cause coagulation of cytoplasmic contents, leading to loss of cellular function and death.
The strong electric fields and shock waves generated by high voltage plasma can physically disrupt the structure of microorganisms. This mechanical stress can damage cell walls and membranes, leading to cell rupture and death, shown in figure 5.
High voltage plasma can produce various reactive nitrogen species (RNS) in addition to ROS. These include nitric oxide (NO) and nitrogen dioxide (NO_2).Both ROS and RNS can interact with and oxidize cellular components, enhancing the antimicrobial effects. By combining these effects, high voltage plasma effectively kills a wide range of microorganisms in water, including bacteria,

viruses, fungi, and protozoa. This makes plasma treatment a powerful method for water disinfection and sterilization.

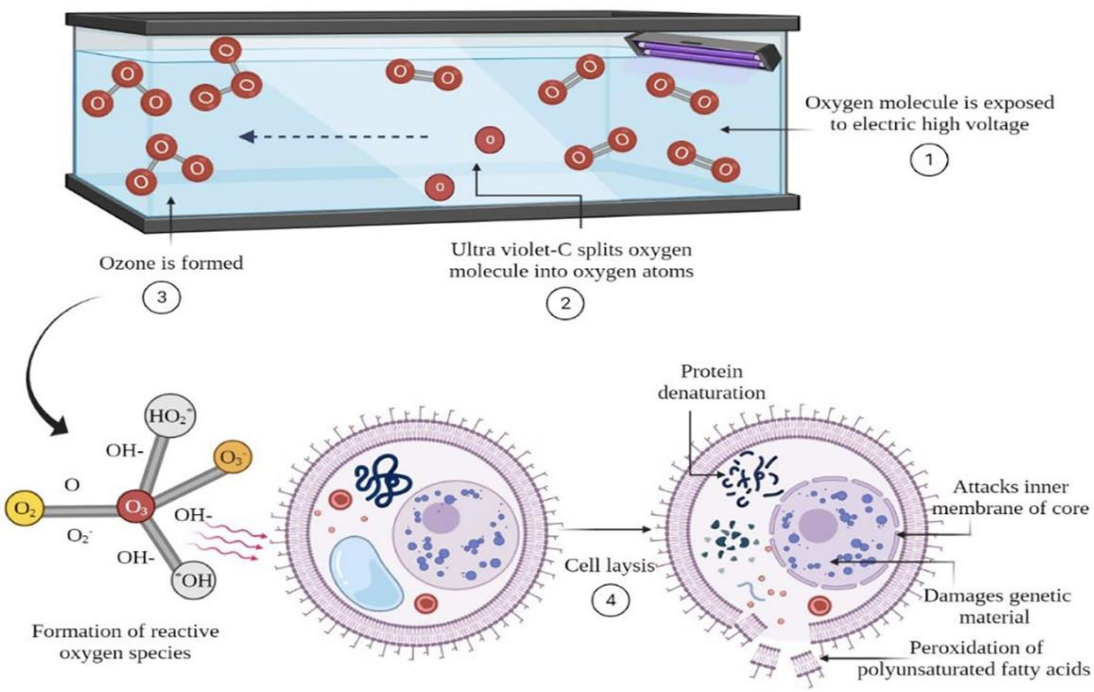

Figure 5: Action mechanism of plasma treatment in water imparting antimicrobial activity.

2.3.3 Process of removing industrial dye

High voltage plasma can effectively remove industrial dyes from water, including dyes measured by the Platinum-Cobalt (Pt-Co) scale, through a combination of advanced oxidation processes, physical disruptions, and enhanced coagulation[9]. Here's a detailed explanation of the mechanisms involved:

High voltage plasma generates reactive oxygen species such as hydroxyl radicals (•OH), ozone (O_3), hydrogen peroxide (H_2O_2), and superoxide anions (O_2•−).These ROS are highly reactive and can oxidize dye molecules, breaking them down into smaller, less harmful compounds or completely mineralizing them into carbon dioxide (CO_2) and water (H_2O).

The ROS attack the dye molecules, breaking chemical bonds and leading to decolonization (loss of color) and degradation into simpler organic or inorganic molecules. This oxidative degradation process effectively reduces the concentration of the dye, making the water less toxic and more environmentally friendly.

High voltage plasma emits ultraviolet (UV) radiation,[10] which can directly break down dye molecules through photolysis. UV radiation can also enhance the generation of ROS in the water, further improving the oxidative breakdown of the dyes.

The energy from the high voltage plasma can create localized heating, enhancing the reaction rates of oxidative processes and leading to more efficient dye degradation.[10]

Strong electric fields and shock waves generated by high voltage plasma can physically disrupt dye molecules, aiding in their breakdown. This mechanical stress destabilizes the dye structure, making it more susceptible to oxidative attack. Plasma treatment can induce coagulation and flocculation, causing fine dye particles and degraded fragments to aggregate into larger clusters. These clusters can then be more easily removed from the water by filtration or sedimentation.

In addition to ROS, plasma can produce reactive nitrogen species (RNS) such as nitric oxide (NO) and nitrogen dioxide (NO_2). RNS can also participate in the degradation of dye molecules, adding another layer of chemical reactions that contribute to dye removal. By combining these mechanisms, high voltage plasma treatment effectively breaks down and removes industrial dyes, including those measured by the Pt-Co scale, from water. This results in cleaner effluent that meets environmental standards for discharge or further treatment.[11]

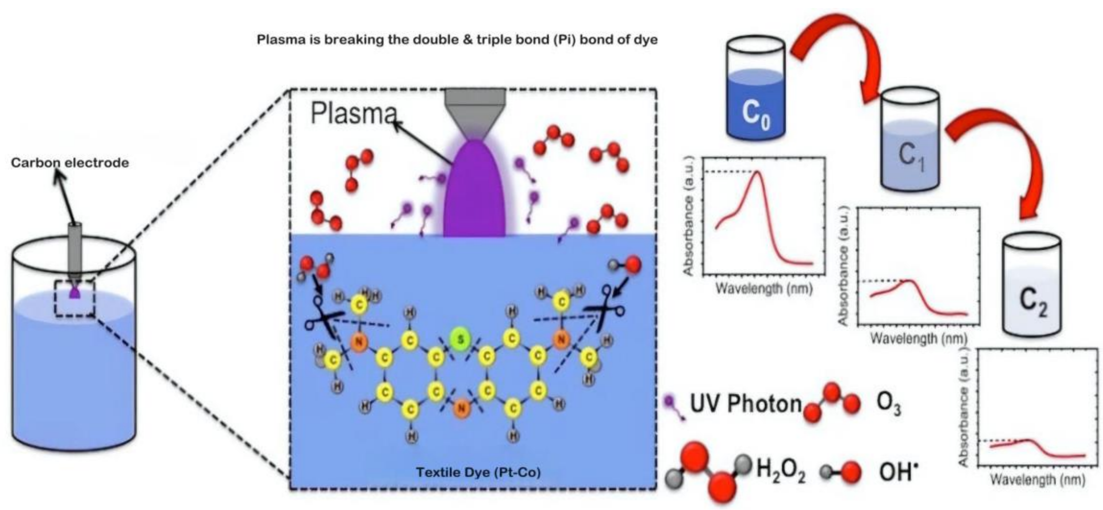

Figure 6: Breakdown process of organic compounds and dye

2.4 Sample collection

Samples of contaminated water were collected from a local lake where domestic waste is regularly dumped. After collection, the samples were stored at 3°C and subjected to initial testing within an hour to ensure their integrity. The dye removal test required a different set of samples, which were collected from the BEXIMCO Industrial Park. These samples predominantly contained textile industrial dyes. The experiment was conducted at the BEXIMCO Effluent Treatment Plant (ETP).

All procedures for sample collection and handling were meticulously followed, adhering to established protocols to prevent contamination and ensure accurate results. This included using sterilized containers, maintaining samples at low temperatures to inhibit microbial activity, and transporting them promptly to the laboratory. Each step was carefully documented to maintain a clear chain of custody, ensuring the reliability and reproducibility of the findings. The strict adherence to these rules underscores the commitment to achieving precise and valid results in water quality testing.

2.5 System implementation

First, connect the circuit to the battery, then attach a high-voltage transformer to the circuit. Secondly, take a sample of contaminated water using a beaker conductive metal container is preferable for more efficiency Connect two electrodes to the beaker through clips in such a way that the negative electrode is immersed in the water, and the positive electrode is positioned 2 centimeters above the water surface. Steel container can also be used as an electrode (cathode). Although water doesn’t conduct electricity, if a high voltage is applied, it acts as a conductor, creating a powerful electric arc or plasma in the distance between the positive electrode and the water shown in figure 7.As a result, all harmful biological substances like microorganism, pharmaceuticals, etc., in the water are destroyed, and many ion compounds mixed in the water undergo transformation, leading to purification.

Figure 7: High Voltage Plasma process and working method & Plasma generator circuit

The dye removal test was conducted at BEXIMCO Industrial Park under the supervision of experienced professionals and with adequate facilities. Primarily, a UV spectrophotometer was employed to quantify the dye concentration. The BOD, COD, and microbiological tests were performed at the Bangladesh University of Engineering Technology's water quality testing laboratory. The pH and TDS were repeatedly measured using a pH and TDS meter.

The following process can be seen in the plasma in water:

1. Plasma Streamers
2. UV Radiation
3. Ozone Disinfection
4. Plasma Sterilization

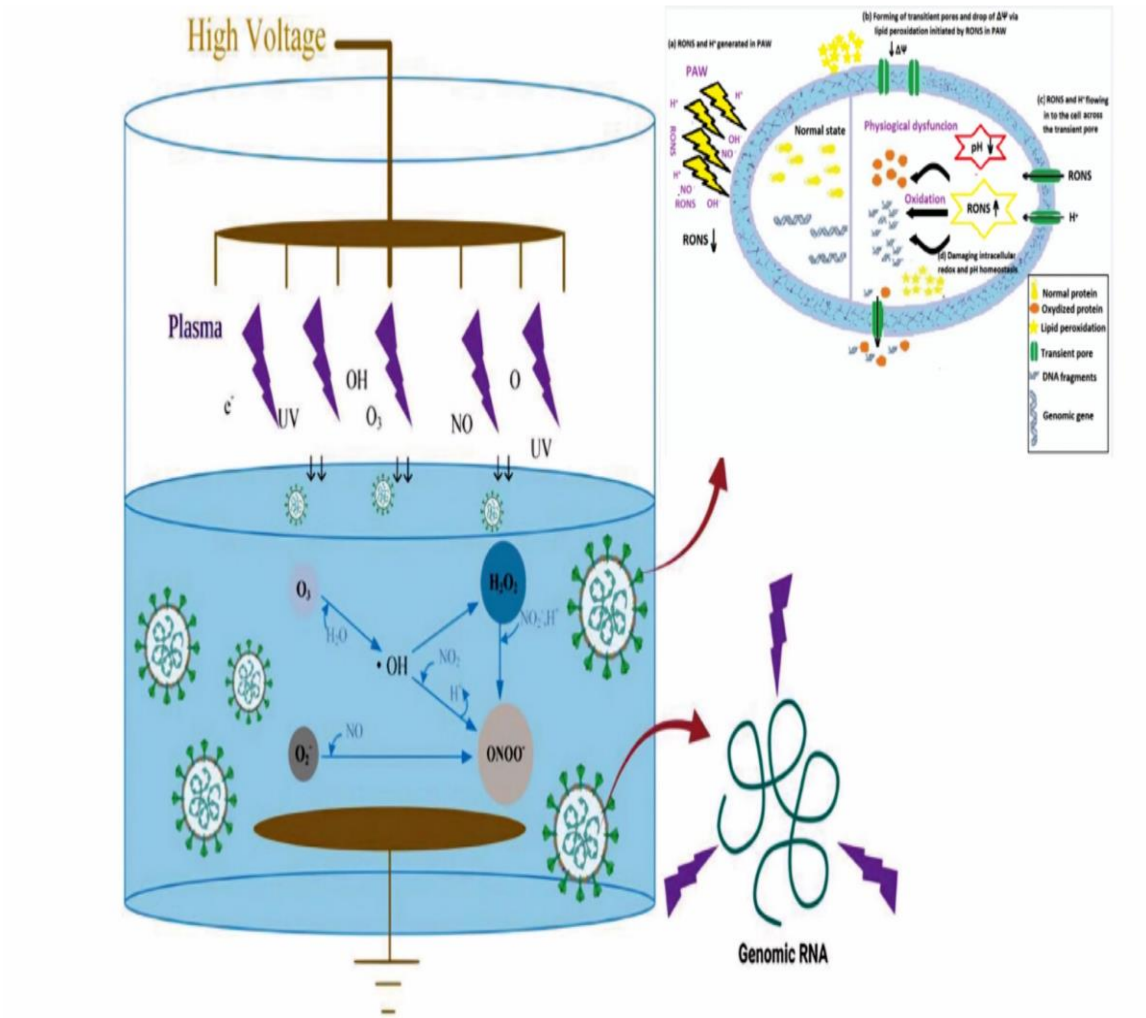

Figure 8: System work process microscopic level

3. Results

There are many tests that have been conducted several times to ensure the quality of water. The main focus is the industrial dye removal test using a UV spectrophotometer. Mainly, it was measured by (Pt-Co) units. Applying three seconds of high voltage can easily kill all microbiological substances like *E-coli*, TC, FC at a time. The BOD (five-day) and COD tests have been conducted, and the results shown below. Almost all the parameters tested were under the acceptable limit (ECR 2023-Bangladesh) Water quality standard.

Table 1: The results of the contaminated & plasma treated water

Parameters	Contaminated water	Plasma treated water	Acceptable limits
Color Industrial dye	Reddish, brownish(dye) **468 Pt-Co**	Almost colorless **115 Pt-Co** Exposure time; 25 minutes	**≤150 Pt-Co**
pH	7.2	6.4 Exposure time;3 minutes	6.5 to 8.5
TDS	640 mg/L	275 mg/L Exposure time;3 minutes	300 mg/L
TC	226 CFU/100ml	0 Exposure time;2 Seconds	0
FC	162 CFU/100ml	0	0
E-coli	93 CFU/100mL	0	0
BOD	68 mg/L	7 mg/L Exposure time;15 minutes	≤5 mg/L
COD	86 mg/L	22mg/L Exposure time;15 minutes	≤25 mg/L

In this table, the industrial wastewater dye concentration was 468 Pt-Co. After 25 minutes of plasma treatment, it became 115 Pt-Co shown in figure 5 with time consumption, which is below the acceptable limit. According to the table, the process is also effective in rearranging the pH and TDS. The most significant productivity of this process is shown to remove microbiological contaminants. In the table, the total coliform and fecal coliform levels were very high, (TC-226 CF UFC-162 CFU, *E-coli*-93CFU) but after 3 seconds of plasma treatment, it effectively eliminated all those bacteria. The E. coli removal is also remarkable, from 93 CFU to 0. Last but not least, BOD and COD, two of the most important factors, have significantly dropped. The BOD level was 41 mg/L; after treatment, it was just 13 mg/L. The COD level was 86 mg/L after plasma treatment, and it was 22 mg/L. It is noteworthy that water was collected from different sources for various tests, and although the power dispersion was the same in all cases, there were differences in the duration.

By applying an electrical current, ions, highly-reactive short-lived radicals and short-wave radiation are generated in the plasma from the ambient air and atmospheric oxygen, and break down the wastewater constituents [22].

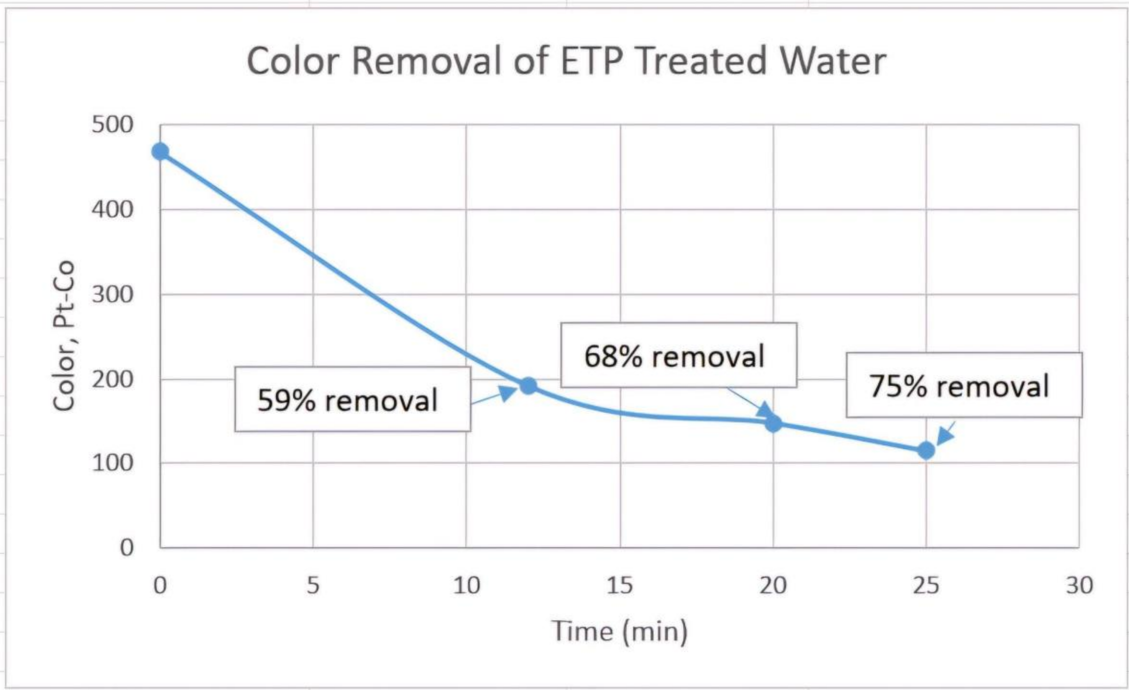

Figure 9: Dye removal over time with power consumption (55W)

As observed in Figure 5, the industrial wastewater treatment process effectively removes dye over time. Figure 6 provides visual representations of this process. The initial dye concentration in the wastewater sample was 468 Pt-Co. After 12 minutes, it significantly decreased to 192 Pt-Co, indicating a substantial 59% removal of dye. Subsequently, at the 20-minute mark, the concentration further reduced to 148 Pt-Co, achieving a commendable 68% dye removal. Finally, after 25 minutes, the dye concentration reached 115 Pt-Co, resulting in an impressive 75% removal. Notably, the power consumption remained remarkably low throughout the process, with a mere 55 watts over 25 minutes, totaling a minimal 0.02 kWh. High watt is expected to reduce the exposure time.

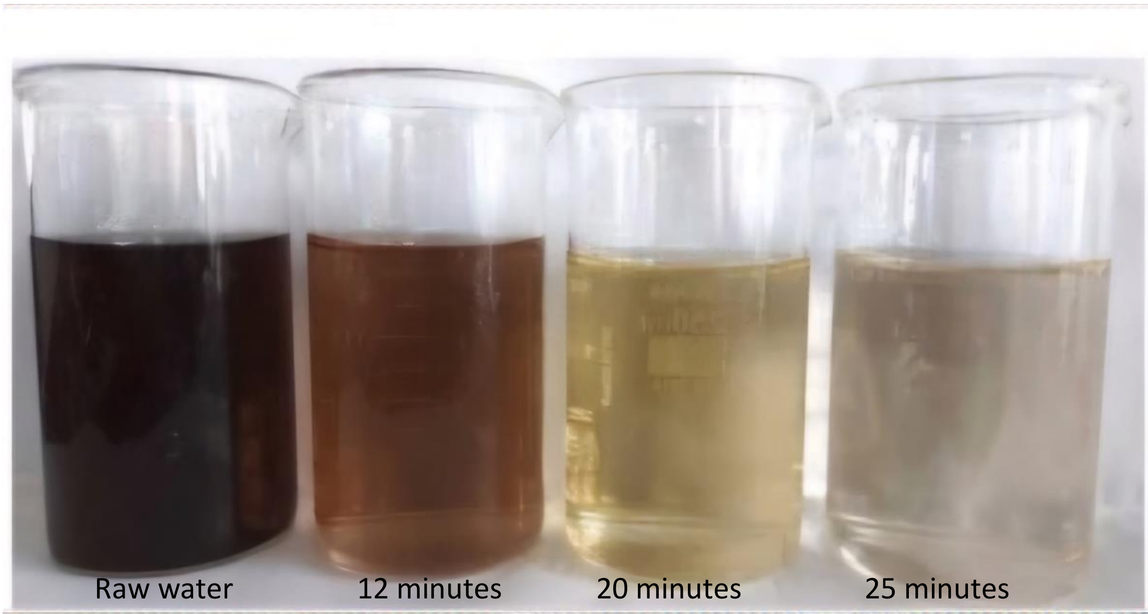

Figure 10: Dye removing stage over exposure time of applying plasma

4. Discussion

Plasma processes offer an environmentally friendly and cost-effective alternative for wastewater treatment. Through the application of electrical current, plasma generates ions, highly-reactive radicals, and short-wave radiation from ambient air and atmospheric oxygen[22]. This dynamic process efficiently breaks down wastewater constituents, contributing to a sustainable and effective treatment solution. The system is an innovative high-voltage plasma generator circuit utilizing recycled electrical waste. Traditionally, the plasma process for water purification is prohibitively expensive and complex, limiting its widespread adoption. However, this circuit, constructed from repurposed materials, presents a cost-effective and eco-friendly alternative.

The primary objective is to eliminate industrial dye, harmful biological substances, such as E-coli, Shigella, and bacillus, TC & FC from water. In our country, the predominant water disinfection method is boiling; however, numerous bacteria can withstand temperatures exceeding 100 degrees Celsius like *E-coli*[23]. The method effectively eradicates various biological contaminants, making it a versatile solution for water purification. Moreover, the circuit demonstrates efficacy in removing industrial dyes(fig-6) and ions, rendering it applicable from individual use to large-scale water treatment plants. The incorporation of solar panels for charging not only enhances sustainability but also holds the potential to significantly improve water purification in flood prone areas of Bangladesh & world, reducing the incidence of water-borne diseases. Beyond its role in water purification, this method contributes to environmental sustainability by repurposing electrical waste and protecting the delicate ecological balance. Scaling up the circuit's implementation, supported by government and private sponsorship, could pave the way for enhanced water treatment plants on a larger scale. The prevalent issue of waterborne diseases in Bangladesh, primarily stemming from bacteria in water sources, necessitates innovative solutions. While home filters effectively tackle heavy metals and arsenic, bacterial removal remains a challenge. Though reverse osmosis filters offer a robust purification method, their high cost and water wastage through by-products pose drawbacks[13].Historically, the concept of plasma-based water purification was hindered by cost and environmental concerns. However, this project's method successfully addresses these challenges, emerging as a timely and impactful solution for water purification in Bangladesh and beyond, offering a promising avenue for sustainable global water management & treatment.

5. Conclusion

As emphasized, it is imperative for humans to treat wastewater to safeguard the environment. The challenge often lies in the substantial costs and maintenance associated with traditional treatment plants, making it difficult for individuals to effectively address contaminated water. While the conclusive data will only emerge once the device is constructed and tested, the proposed solution aims to significantly reduce costs, maintenance requirements, and space utilization.

The envisaged outcome is a paradigm shift, particularly for industries in developing countries, prompting a reevaluation of the practice of discharging untreated sewage. The ultimate goal is to introduce a groundbreaking, cost-effective, and innovative wastewater treatment concept. For instance, the incorporation of plasma technology holds promise as it has the potential to segregate and retain specific organic and inorganic components from the water. Subsequently, the proposed system aims to eliminate biodegradable organic matter such as microorganisms, bacteria, and viruses, thereby presenting a comprehensive and efficient solution to wastewater treatment. This project offers a groundbreaking solution for achieving multiple UN Sustainable Development Goals (SDGs). It tackles clean water scarcity through a sustainable and eco-friendly approach. Clean Water for All (SDG 6):[15]This low-cost, highly effective device eliminates microorganisms, organic pollutant, industrial dye [21] from contaminated water sources using readily available batteries and solar power. This makes it perfect for remote areas or those facing flood-related contamination or drought. Affordable and Clean Energy (SDG 7):[16]The system's ability to convert low-voltage DC to high-voltage AC eliminates bulky transformers, making it highly portable. Its low power consumption allows for seamless integration with solar panels, creating a truly off-grid, energy-saving solution, promotes renewable energy & save fossil fuels.[20]Sustainable Cities and Communities (SDG 11)**:[17]**The project tackles e-waste by repurposing discarded electronics like old TVs, phone batteries, and even parts from electric vehicles. This diverts tons of toxic materials from landfills, preventing harmful substances from contaminating soil and water. It promotes a circular economy by transforming waste into essential tools for water purification. Life on Land (SDG 15):[18]By using e-waste, the project prevents toxic substances from leaching into the environment, safeguarding ecosystems and biodiversity[19].Repurposing lithium batteries, a potential pollutant, further reduces environmental risks. Addressing multiple challenges: This innovative approach not only provides clean water but also fosters a more sustainable future by reducing reliance on virgin materials and fossil fuels. It tackles water scarcity and e-waste simultaneously, promoting public health and environmental protection. This project effectively contributes to achieving SDGs 6, 7, 11 and 15, highlighting its potential to create a significant positive impact.

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