Design and construction of the plasma water activation device

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Abstract
Design and construction of the plasma water activation device have been presented in this article. In this design, one of the electrodes, which is plate ss316, is placed in water. The other electrode which is made from tungsten is placed inside a glass tube and immersed in water. Air is also blown into the water through a constant rate air pump of 5 L/min. To create plasma in water, an AC power supply with voltage and current of 15 kV and 30 mA has been used. The results of analysis of nitrite, nitrate, and pH in three water samples that have been irradiated with plasma for 10, 20, and 30 minutes showed a very significant change compared to the control sample.

Keywords: Plasma activated water, Nitrite, Nitrate, pH

Introduction
Freshwater is a scarce commodity that makes up only 2.5 percent of the earth's total water, and less than one percent of that amount can be readily available as terrestrial and surface water resources. At present, this vital commodity of life has been affected by population growth and overdevelopment, which has also led to the destruction of groundwater resources (1). According to available statistics, up to 10.6 billion cubic meters of surface water in Iran, including saline and brackish water. Also, despite the drought in recent decades, which has brought the country's water resources to a critical level, as well as the high need for water in agriculture and green space, much attention has been paid to the use of lower quality water resources. For example, one of these unconventional sources of water is gray water, which is effluent from household uses other than toilets (2). It is also important to develop new innovative strategies that are more effective and efficient in combating bacterial infections, with increasing concerns about the emergence of antibiotic-resistant bacteria in the health and food industries (3)(4). Using plasma is a very cheap solution to this problem. The use of plasma technology is very effective in eliminating biological contaminants of water (fungi, bacteria, viruses). The method is simple: water is processed with electric plasma before it reaches its target. Plasma activated fluid (PAL), including PAW, is antibacterial against a number of microorganisms.
Previous studies showed that low-temperature plasmas can be used to generate plasma-activated water (PAW) by treating water under specific conditions, which has the capability of bacterial and fungi inactivation on contaminated solid surfaces or liquids (5)(6). Also, PAW can be used as fertilizer because it is a rich source of nitrogen oxide.

Experimental setup
Preparation of the materials
The fundamental method of generation of PAW involves operating a plasma generator inside the water to generate the ions, which lead to reactive species for bacterial inactivation (7).
The major components of the system included a high-voltage power supply, an air pump, and electrodes (Figure 1). The device was specifically designed to activate water by inserting an electrode beneath the water’s surface. The working gas for the plasma was normal air that was pumped by an air pump. Based on the preliminary study, the water volume, voltage, frequency, and airflow rate were set at 100 mL, 15 kV, 50 kHz, 30 mA, and 5 L/min, respectively. Plasma-

activated time was (10, 20, 30 min). After inactivation, the PAW was stored at room temperature.

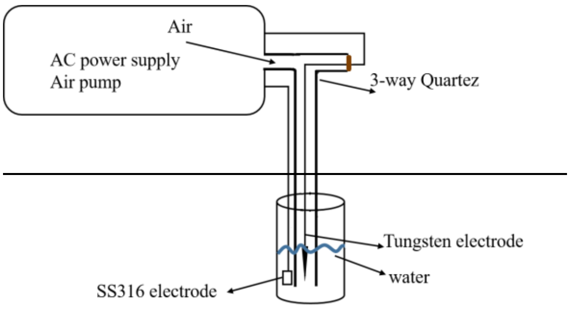

Figure 1. Schematic diagram of PAW device.

Results and discussion

Nitrite, nitrate, and pH levels of plasma-activated water have been measured. The results show that the production of plasma inside water along with aeration could significantly increase nitrite and nitrate and decreases pH as shown in table I. This solution would be a good candidate as fertilizer. Reactions between water gas-phase species and lead to the formation of aqueous species like nitrite, nitrate, and hydrogen peroxide.

Table I: pH, nitrate, and nitrite levels of plasma-activated water

Water sample	pH	Nitrate mg/kg	Nitrite µg/kg
Untreated water	7.58	6.16	10.12
10 min	7.28	25.2	30.56
20 min	3.46	40.6	45.5
30 min	3.16	45.92	52.32

Conclusions

Design and construction of the plasma water activation device have been presented in this article. By creating plasma in water along with aeration, the amount of nitrate and nitrite increases significantly, and also the pH decreases. This solution can be used as fertilizer in agriculture and greenhouses and also as a disinfectant solution that can have many applications in agriculture, medicine, and daily life.

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