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Evaluation the effect of some operational conditions on the drinking water quality in reverse osmosis system

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ABSTRACT

Pulsed electric field disinfection is an effective non-thermal water disinfection technology. Compared to conventional disinfection techniques, PEF inactivation has several advantages including no by-products. In this context, the use of silver ions in conjunction with a reverse osmosis filtration system has been proposed as a safe and cost-effective treatment approach that can be used in a point of use technologies. This system contains two silver meshes as electrodes inside a reverse osmosis membrane with the application of a pulsed electric field on it as a disinfection method, After conducting chemical and physical tests of the water samples before and after the treatment system, it was noticed that most of these characteristics were significantly affected by increasing the number of electrical impulses and the intensity of the applied voltage as a result of the increase in the ionization process of silver in water.

1. Introduction

The most important need of the twenty-first century is access to clean and safe drinking water. About 783 million people in the world do not have access to clean water, and about 2.5 billion do not have access to adequate sanitation [1]. Humans and aquatic organisms suffer from pathogenic contamination of potable water sources. Bacteria that live in the human intestine are known intestinal bacteria. such as E. coli inhabit the intestine and cause diarrhea, hemorrhagic colitis and hemolytic uremic syndrome [2].Table 1.

According to the World Health Organization, inadequate drinking water, sanitation and hygiene is responsible for 84,200 diarrheal deaths annually [3]. As a result, pathogen eradication has become a critical factor in any therapeutic approach.

All the main methods of disinfection using chlorine, ozone and ultraviolet rays UV have been studied, they include: (i) Destruction of the cell wall., (ii) Changes in cell permeability, (iii) Changes in the colloidal composition of the cytoplasm, (iv) inhibition of enzyme activity, and (v) changes in the DNA of the organisms [4]. Although chlorine is widely used, the formation of carcinogenic organochlorine compounds is a major problem in this process [5]. Similarly, an insufficient dose of ozone in water leads to the disinfection of various by-products [6]. The adverse consequences of chemical disinfection methods have led to the development of advanced disinfection process techniques.

Non-thermal disinfection of water using pulsed electric field disinfection is a promising method. When compared to typical disinfection procedures, inactivation has various advantages, among which is the absence of disinfection byproducts. It is gaining traction as a viable alternative to current heat treatment methods, which impair the flavor, quality and nutrition of liquids after they have been processed cited in [7].

The aim of the present work was a study the effect of some operational conditions such as pulsed electrical field with applying low voltage on the physical, and chemical characteristic of drinking water in lab-scale system.

2. Principle of reverse osmosis

Reverse osmosis (RO) is a method that separates and removes dissolved solids, organics, pyrogens, submicron colloidal debris, color, nitrate, and bacteria from water using semipermeable spiral wound membranes. Water enters the minute holes of the semipermeable membrane and is given as filtered water termed permeate

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Table 1
Common characteristics of tap water.

Parameters	Value	Limits
PH	7.74	6.5–8.5
T (°C)	22.5	25
Tub (NTU)	3.04	5
TDS (mg/L)	704	1500
EC (μS/cm)	1081	2000
TH as (caco3) (mg/L)	206.54	500
Cl^- (mg/L)	60.72	350

water. Rejected water consists of impurities in the water that are concentrated in the ejection stream and are flushed down the drain. These membranes are semi-permeable, allowing water molecules to flow through them but rejecting salt ions. Cellulose acetate, polyamides and other polymers are used to make reverse osmosis membranes. The spiral-wound hollow fiber membrane used for processing depends on the composition of the feed water and the operating conditions of the plant. [8,9].

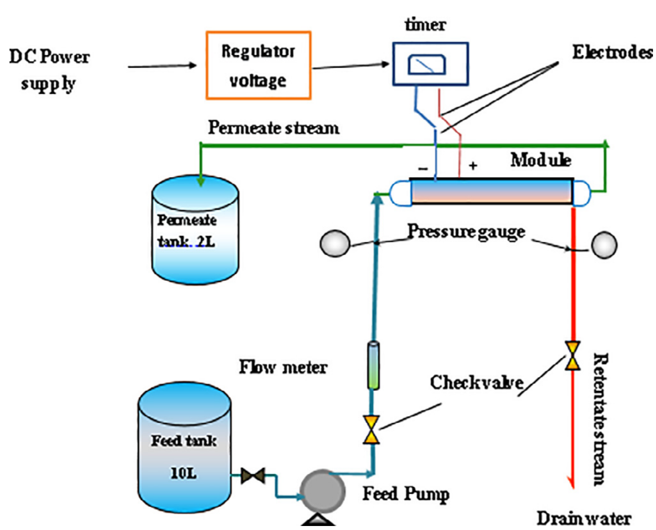


Fig. 1. Schematic diagram of RO experimental system.

3. Experiment setup

In the current study silver ions with pulsed electric field were used for water purification, the reverse osmosis system was designed for experimental work, as shown in Fig. 1.

- **Feed tank:** Used to store drinking water from the distribution network with volume capacity (10*L*).
- **Feed pump:** With max pressure (10 bar) to regulate the flow in the system, and supplies water with certain properties to the module.
- **The module:** Consists of modified Reverse Osmosis filter, which works to get rid of bacteria, especially E. coli bacteria and other impurities entering the cell.
- **Fixed power supply and Regulated Voltage (12–24 V):** To discount the current fluctuations of power supply.
- **Permeate tank**: After the water purified in the module, it goes to the permeate tank with capacity (2L), and the concentrated water is rejected to drain. Both permeate tank and feed tank should be protected from dust and microbiological contamination.
- **Flow meter, check valves, Pressure gauges** for monitoring the work and control flow.
- **Silver ionizing unit**

This unit consists of two meshes, made of a set of fine silver wires of a purity of 99% (that is 99% silver, and most probably copper trace amounts) and a diameter of 0.70 mm. that work as a pair of electrodes or cells with (mean effective size = 2 cm) inside a reverse osmosis membrane and application of a pulsed electric field on it as a disinfection method as shown in Fig. 2.

4. Results and discussion

All the experiments were conducted at room temperature, and the data obtained confirms the effectiveness of the treatment system for improving on general water quality parameters. Below table shows the common characteristic of tap water.

A number of experiments have been conducted to examine the effect of applied voltage and electrical pulse on the treatment efficiency of the modified RO system.

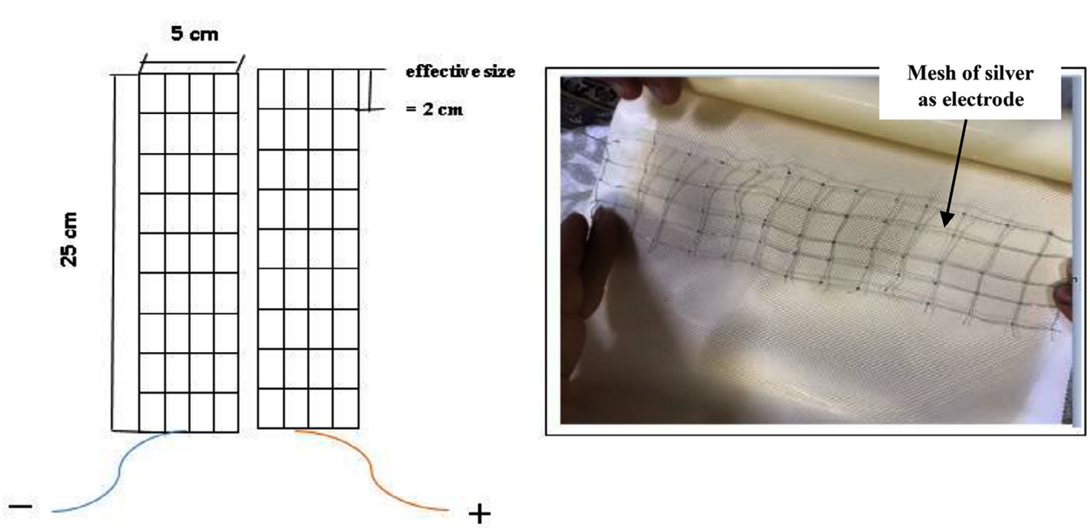


Fig. 2. silver mesh: (a) dimensions, (b) photo illustrate the mesh as electrode in RO module.

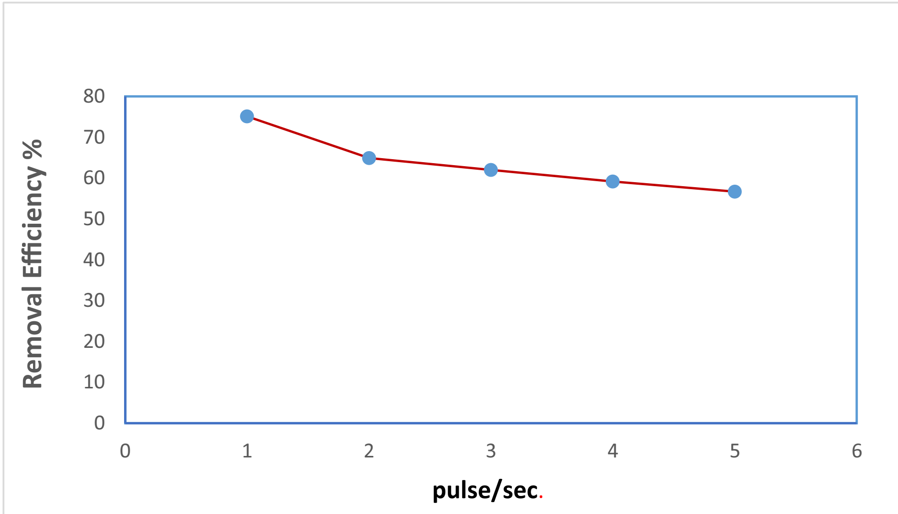


Fig. 3. a) Effect of number of electrical pulse on removal efficiency of turbidity at 12 V, 1 L/min, and 10 bar pressure. b) Effect of number of electrical pulse on removal efficiency of total dissolved solid (TDS) at 12 V, 1 L/min, and 10 bar pressure. c) Effect of number of electrical pulse on removal efficiency of Total Hardness (TH) at 12 V, 1 L/min, and 10 bar pressure. d) Effect of number of electrical pulse on removal efficiency of Chloride CL^{-} at 12 V, 1 L/min, and 10 bar press.

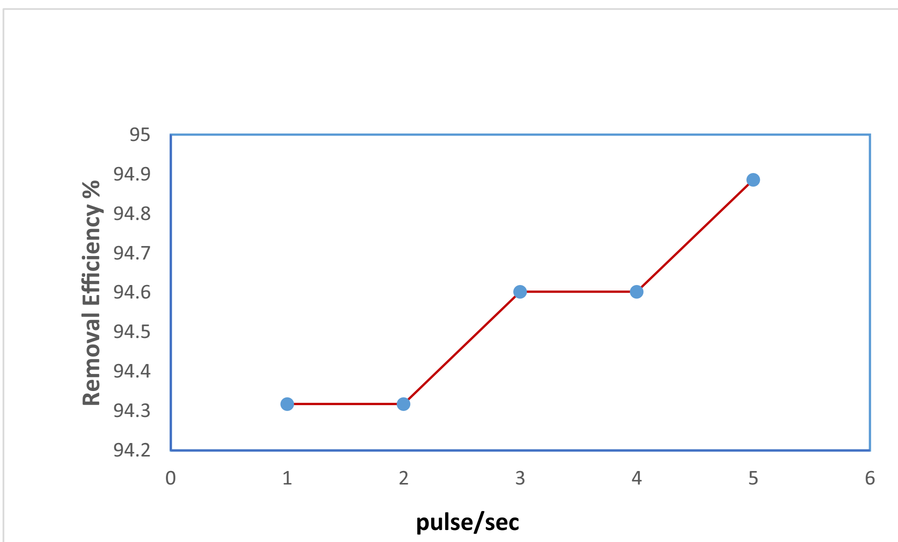
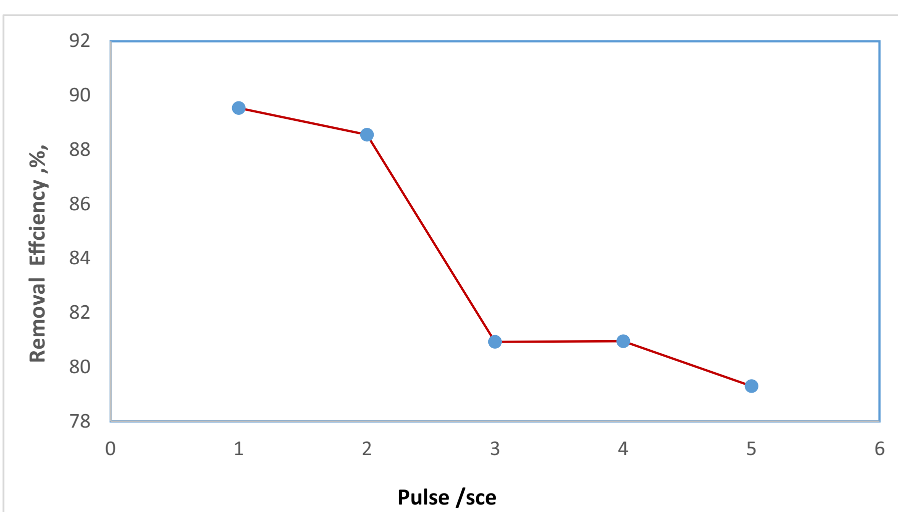


Fig. 3 (*continued*)



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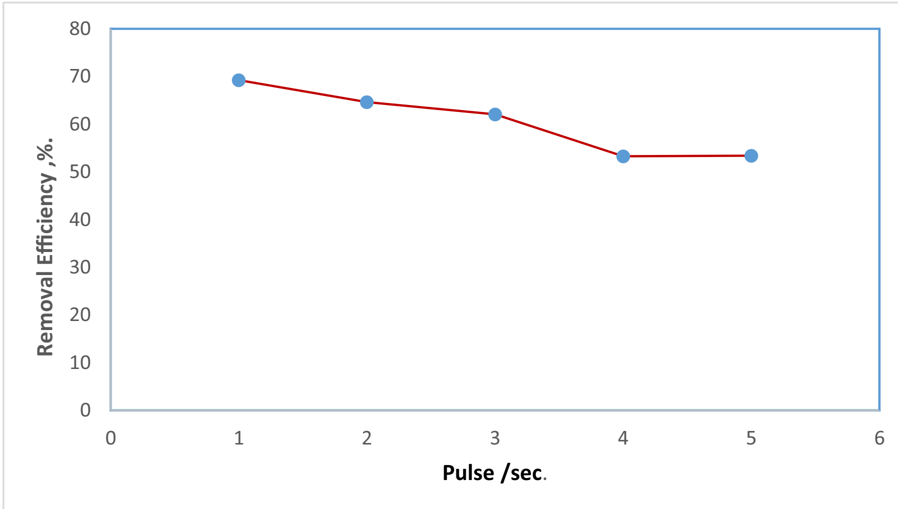

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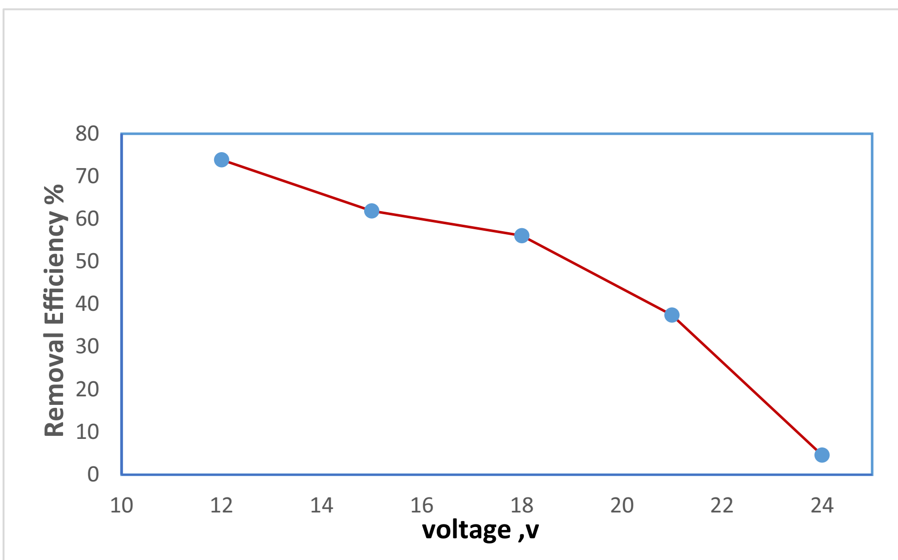


Fig. 4. a) Effect of applied voltage on removal efficiency of turbidity at pulse 2/sec., 1 L/min, and 10 bar pressure. b) Effect of applied voltage on removal efficiency of TDS at pulse 2/sec., 1 L/min, and 10 bar pressure. c) Effect of applied voltage on removal efficiency of TH at pulse 2/sec., 1 L/min, and 10 bar pressure. d) Effect of applied voltage on removal efficiency of CL^- at pulse 2/sec., 1 L/min, and 10 bar pressure.

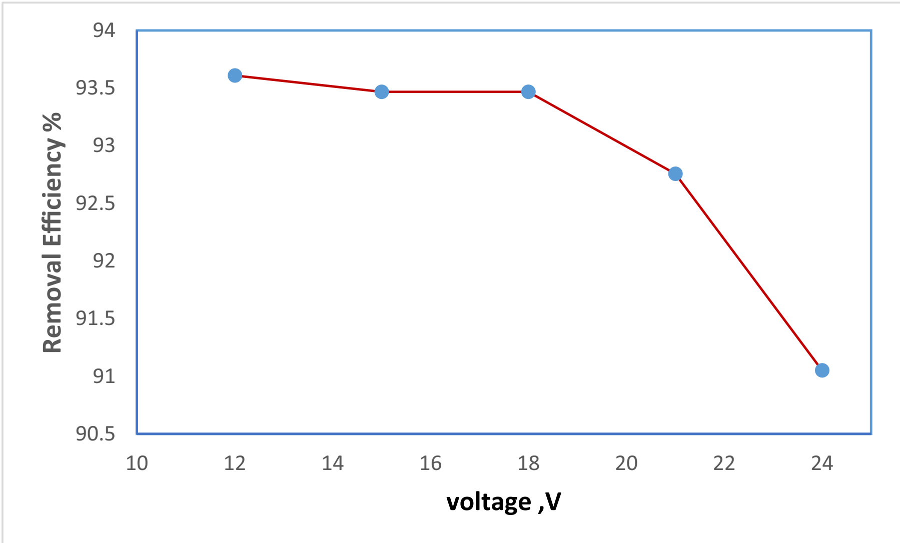
4.1. Effect of electrical pulse on treatment efficiency

The basic principle in the pulse electric field technology is the use of short pulses in low-electric fields of micro to millisecond duration and allows operation at low or moderate temperatures, and thus represents a promising technology. Non-heating preservation [10].

Fig. 3. shows the effect of electrical pulse on some parameters removal efficiency of tap water in RO system:

4.2. Effect of applied voltage on treatment efficiency

Voltage is the difference in electrical charge between two points in a circuit, stated in volts, or the rate at which energy is extracted from a source that produces a flow of electricity in a circuit, expressed in volts [11]. The applied voltage has a direct proportional with the strength of electrical field (Ohm's law). Fig. 4. shows the effect of applied voltage on some parameters removal efficiency of tap water in RO system:



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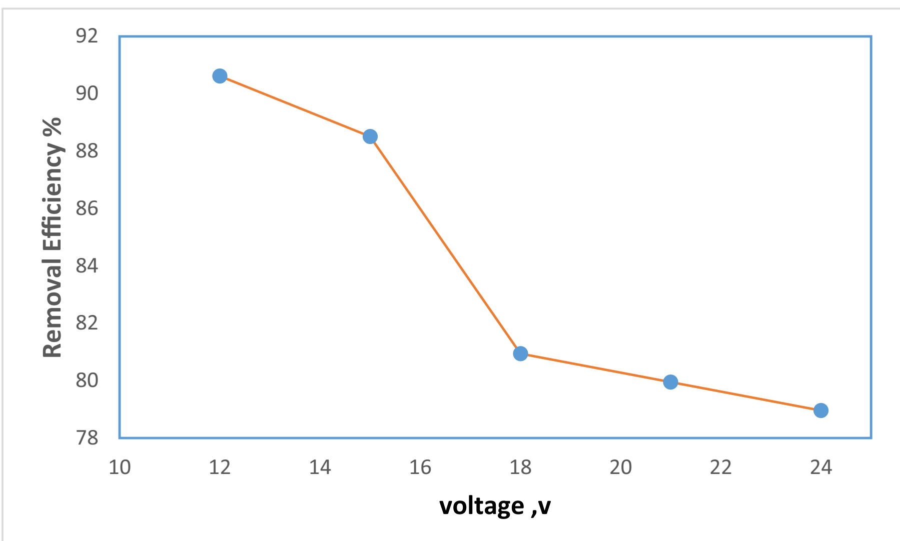

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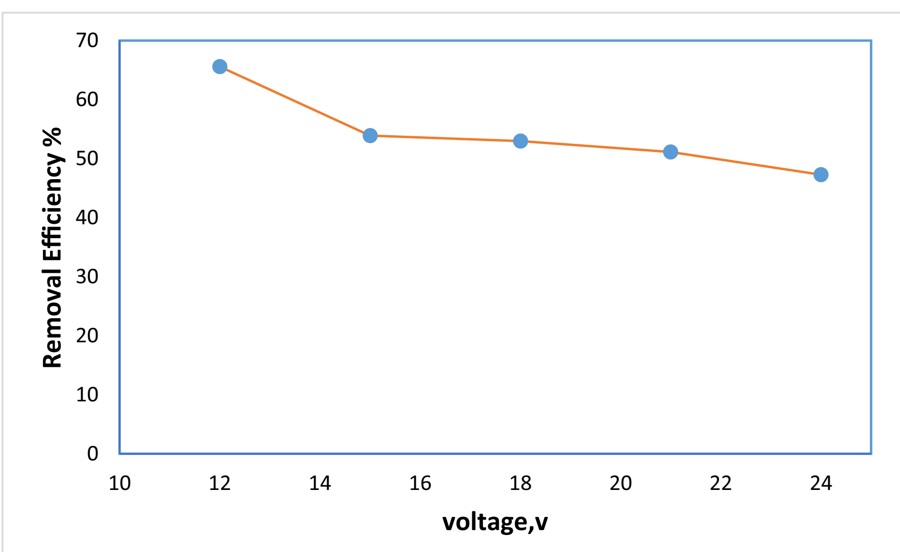

Fig. 4 (*continued*)

5. Conclusion

Pilot scale which utilized in this paper consisted of two pair of silver electrode mesh with electrical pulse and low voltage (12–24) V as a disinfection method, and through examining the physical and chemical characteristics of the drinking water after and before the disinfection process, results show that the increase in pulse frequency and applied voltage, leading to a greater release of silver ions in water, therefore the characteristics were clearly changed, but they were still within the Iraqi standard limits of drinking water.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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