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ADVANCED TECHNOLOGIES FOR WASTEWATER TREATMENT BY UV – A REVIEW–

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ABSTRACT

Reclamation and reuse ofwastewater is one of the most effectiveways to alleviatewater resource scarcity.Disinfection plays a key role in reuse of wastewater for eliminatinginfectious diseases.Water disinfection using ultraviolet light is a newer process that currently has a limited use area.

Ultraviolet(UV) disinfection is now widely implemented as a tertiary treatment forwastewater reclamation.

The purpose of this paper is to present the most representative studies on the use of ultraviolet in wastewater treatment.

INTRODUCTION

Reclamation and reuse of wastewater is one of the most effective ways to alleviate water resource scarcity. Disinfection plays a key role in reuse of wastewater for eliminatinginfectious diseases. Hazardous chlorination by-productsrestricted the use of chlorine for the disinfection of water andwastewater [5].Chlorination is the conventional wastewater disinfectionmethod used around the world because chlorine is an effectivedisinfectant against many enteric bacteria, but it has lower efficiency against viruses, bacterial spore-formers, and protozoan cysts [8]. In recent years, the use of chlorination has been decreasing, mainly due to toxic, mutagenic, and/or carcinogenic disinfectionby-products (DBPs) formed in the disinfection process and chlorine residuals [7]. Thus, a number of alternative disinfectants havebeen researched and implemented, such as ozone and ultraviolet (UV) light [2].

Ozonation and UV have lately emerged as a viable alternative byvirtue of their operational costs and accurate maintenance operation.Water disinfection using ultraviolet light is a newer process that currently has a limited use area.

Ultraviolet(UV) disinfection is now widely implemented as a tertiary treatment for wastewater reclamation.Ultraviolet (UV) disinfection is a well established, cost-competitive technology. In the late1800's researchers first discovered the germicidal effects of sunlight, and systems based onfluorescent tube technology have been operating since the 1950's. More recently, UVdisinfection has been attracting a lot of attention due to the discovery of chlorinatedDisinfection Byproducts (DBP), and new measurements confirming the effectiveness of UVto inactivate Cryptosporidium [3].

Ultraviolet (UV) sanitizing units are used in many water purification systems to control bacteria and havecertain applications in animal drinking water systems. UV units can be effective water treatment tools, butit is important to recognize what UV can do, what its limitations are, and what maintenance is required [9].

Certain contaminants in water can reduce the transmission of UV light through the water, whichreduces the UV dose that reaches the bacteria. These UV absorbing contaminants includeturbidity, iron, and humic and fulvic acid, common to surface water supplies. Suspended particlesare a problem because microorganisms buried within particles are shielded from the UV light andpass through the unit unaffected. UV disinfection is most effective for treating high-claritypurified reverse osmosis or distilled water [4].

MATERIAL AND METHOD

Ultraviolet or UV energy is found in the electromagnetic spectrum between visible light and x-rays andcan best be described as invisible radiation. In order to kill microorganisms, the UV rays must actuallystrike the cell. UV energy penetrates the outer cell membrane, passes through the cell body and disruptsits DNA preventing reproduction. UV treatment does not alter water chemically; nothing is being addedexcept energy. The sterilized microorganisms are not removed from the water. UV disinfection does notremove dissolved organics, inorganics or particles in the water. Generally, UV is simple to install and requireslittle supervision, maintenance, or space. Improvedsafety, minimum service time, low operationand maintenance costs, and the absence of achemical smell or taste in finished water areprimary factors for selecting UV technologyrather than traditional disinfection technologies [8].

A special lamp generates the radiation that createsUV light by striking an electric arc throughlow-pressure mercury vapor – fig.1. This lamp emits abroad spectrum of radiation with intense peaksat UV wavelengths of 253.7 nanometers (nm) anda lesser peak at 184.9 nm.

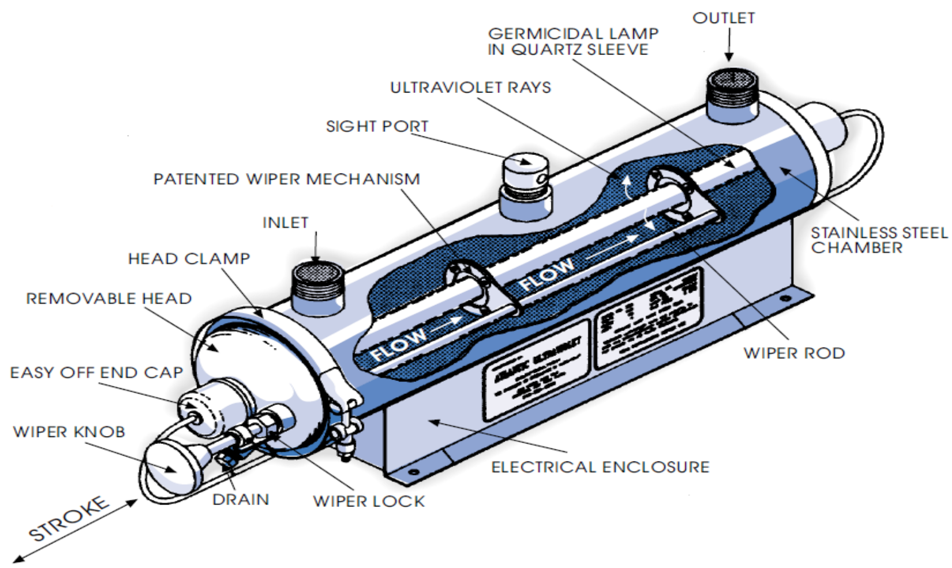


***Figure1* - Schematic of typical UV Reactor [10]**

The optimum wavelenght to effectively inactivate microorganisms is in the range of 250to 270 nm. The intensity of the radiation emitted by the lamp dissipates as the distance from the lamp increases. Low-pressure lamps emit essentially monochromatic light at a wavelenght of 253.7 nm.

Standard lengths of the low-pressure lamps are 0.75 and 1.5 meters with diameters of 1.5-2.0 cm. The ideal lamp wall temperature is between 95 and 122 °F [11].

RESULTSAND DISCUSSIONS

Research over the years have identified ultraviolet (UV) sterilizers as probably the most cost effectiveand efficient alternative technology available to home owners to eliminate a wide range of biological contaminants from their water supply. According to this, numerous studies have been carried out, the most representative of these are presented in this paper.

Adegbola A.A. and Olaoye R.A have investigated the effectiveness ofultraviolet water purification asreplacement of chlorine disinfection indomestic water supply.

Water from an established contaminatedwell in Ogbomoso, Nigeria, were subjected, simultaneously and in parallel, to chlorine dosing and contact withUV light, over a period of seven days without pre-filtration, and additional seven days with pre-filtration.Pre-filtration was accomplished by the use of a calibrated pressure filter.Effluent water samples were taken daily for the two scenarios to the laboratory for physical, chemical and biological analyses.Figure 2 shows the schematic diagram of the photovoltaic system used to power the ultrasound sterilizer.

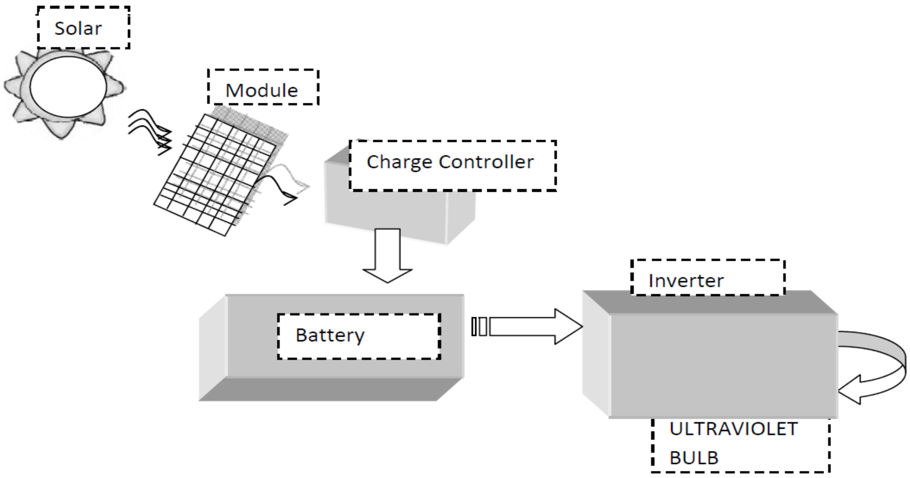


***Figure2*–Schematic Diagram of a Photovoltaic System [2]**

The experimental results showed that the ultraviolet water purification method was more effective only when the raw water pre-filtration process was introduced. In this case, the number of colonies, coliforms and E. coli organisms recorded mean values in seven of 1 and 0. In both cases, it was confirmed that the UV method did not produce bi-products and did not alter the taste, or other water properties, in contradiction with the chlorine disinfection method.

In the experiment, it is noteworthy that certain factors, namely: chemical and biological films that develop on the surface of the UV lamp, color, turbidity and short-circuiting in the water flowing through the UV sterilizer could negatively affect the effectiveness of UV disinfection [2].

In another study, [5],was undertaken to characterize the efficacy of flow-through pulsed UV light for inactivationof Escherichia coli and Bacillus subtilis spores in synthetic (SMWE) and real municipal wastewater effluent(RMWE).

Microbial inactivation experiments were performed on a laboratory scale using the UV pulse system using a SteriPulse®-RS4000 pulsed light sterilization system. The system consisted of a controller, the camera including the lamp and the power supply (figure 3).

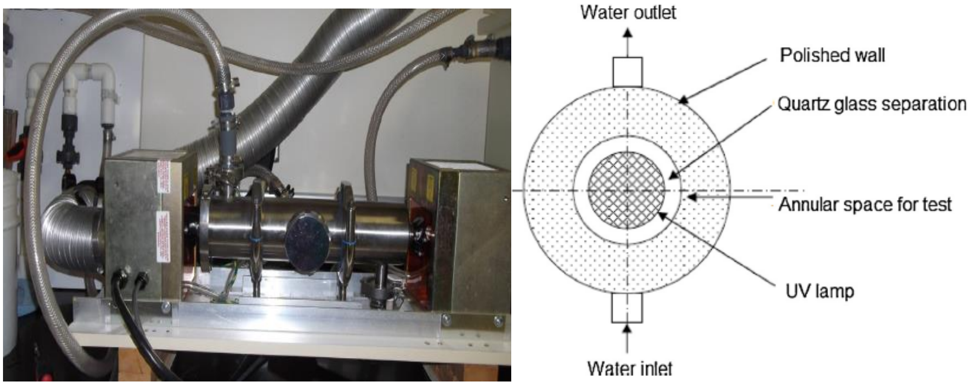


Figure 3 **- Picture and schematic diagram of the flow-through pulsed uv chamber[5]**

The disinfection efficiency was evaluated at various flow rates(2–20 L/min) and number of passes in a flow-through pulsed UVlight chamber using E. coli and B. subtilis spores in SMWE.Usinga single pass, complete inactivation, was observed until 10 L/min flow rate for E. coli and5 L/min flow rate for B. subtilis spores (fig. 4).In this study, the effects of UV disinfection on chemical oxygen demand (COD), total organic carbon (TOC), total solid suspensions (TSS) and
turbidity (figures 5-6) were also analyzed.

According to the graphical representation, the experimental results showed a decrease of the solid suspension content from 25.3 to 7.3% for E. coli inoculum (10 L / min) and 20.3 to 5.2% for B. subtilis (6 L / min) . The reduction in chemical oxygen demand ranged from 32.05 to 9.72% for the initial microbial population of E. coli and from 31.86 to 7.78% for the B. subtilis initial microbial population.

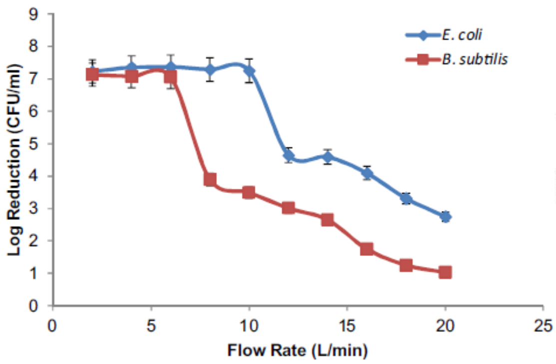


Figure 4 **- Log reduction profiles of E. coli and B. subtilis spores [5]**

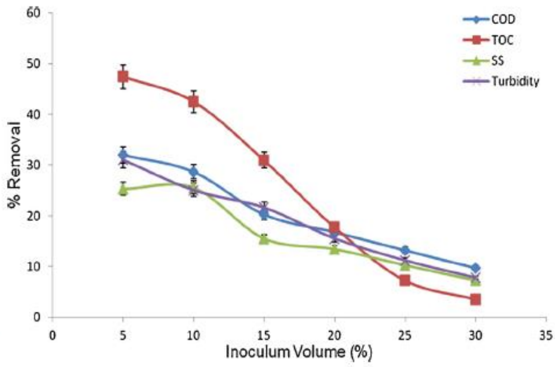


Figure 5 **- Effect of flow-through pulsed UV treatmentfor E. Coli [5]**

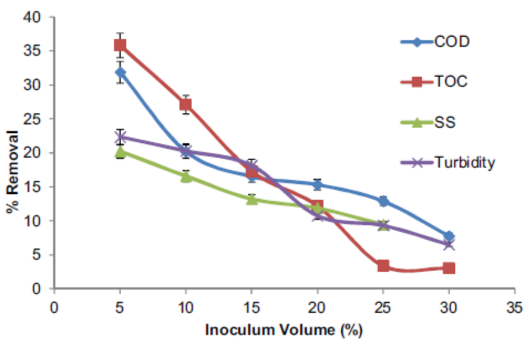


Figure 6 **- Effect of flow-through pulsed UV treatment with 6 L/min flow rate on COD,TOC, SS, and turbidity for B. Subtilis [5]**

Recorded values for total organic carbon also showed a reduction after UV treatment, with a reduction of over 45%, and the degree of elimination of turbidity decreased with the increase in microbial inoculum.The results clearly show the potential of pulsed UV light in the sewage treatment process. In conclusion, UV light has a great potential to disinfect residual water or other liquid waste with added potential in improving quality [5].

Naddeo V. et colab., in study [6] have investigated thewastewater advanced treatment by simultaneous combination of UV and US in terms of bacteria inactivation (Total coliform and Escherichia coli) at pilot-scale.

The pilot plant was composed of two reactors: US–UV reactor and UV reactor – fig. 7.

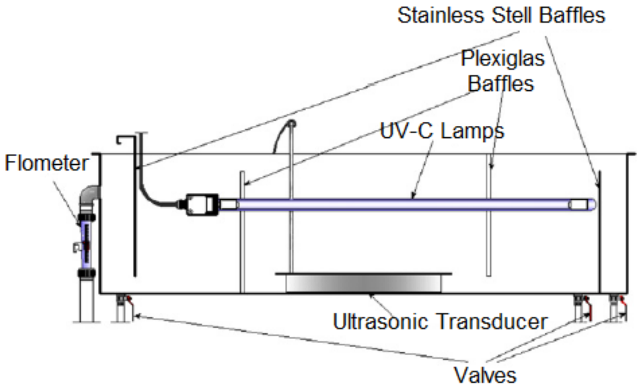
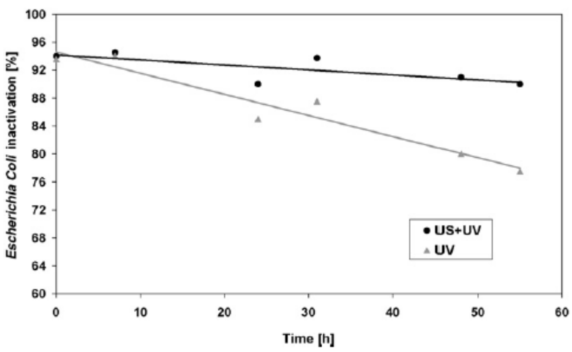


Figure 7 **- Schematic longitudinal section of the US–UV reactor [6]**

The influence of different reaction times, respective US and UV dose and synergistic effect was tested and discussed for two different kinds of municipal wastewater.

The tests were carried out at two wastewater streams having different characteristics; one of these with a very high pathogen concentration (Type-B), both with a very low transmittance.The tests with a Type-A influent, carried out in reactor 1, are performed at 2, 5, 10, 15 and 30 min of retention times with both disinfection technologies turned on.The tests with a Type-B influent, carried out in both reactors, were performed at around 30 min of retention times in both UV and US–UV disinfection, guaranteeing a constant flow by the employment of valves and flowmeters.



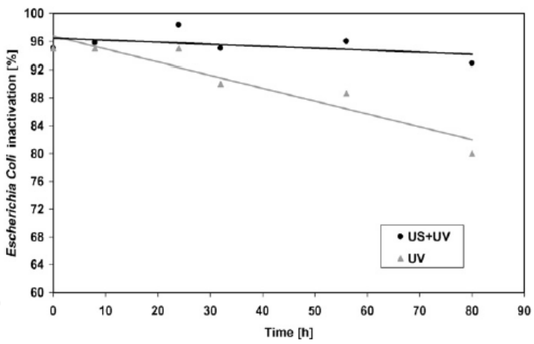


Figure 8**- Escherichia coli inactivation versus length of the test in "sun" condition[6]**

Figure 9 **- Escherichia coli inactivation versus length of the test in "dark" condition [6]**

The results obtained with Type-A influent show that the disinfection efficiency by UV increased from 30% to 98% as retention time increased from 2 to

15 min respectively.The tests with a Type-B influent were carried out for consecutive three days with a retention time of 30min.

In these tests the E. coli inactivation, after some hours of treatment, was about 94% in both reactors. On the third day, after about 55 h of continuous treatment, while in the UV reactor the inactivation went down until 77%, in the US–UV reactor the disinfectant power was still up 90% (fig. 8). In the 'dark' tests the initial inactivation was about 97% in both reactors. At the fourth day, after about 80 h of continuous treatment, the E. coli inactivation decreased to 80% in UV reactor, while in US–UV reactor the inactivation was still higher than 92% (fig. 9).

This innovative combined treatment is able to guarantee high performance of the wastewater treatment process with low transmittance.

An important increase in UV disinfection capacity was observed in the presence of ultrasounds [6].

CONCLUSION

Ultraviolet (UV) disinfection is a well established, cost-competitive technology.

The purpose of this paper is to present the most representative studies on the use of ultraviolet in wastewater treatment. It is noteworthy that certain factors, could negatively affect the effectiveness of UV disinfection.

UV light has a great potential to disinfect residual water or other liquid waste with added potential in improving quality.

The innovative combined treatment is able to guarantee high performance of the wastewater treatment process with low transmittance.

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