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Developing Cost Effective Treatment of Drinking Water for Use in Rural Areas

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Abstract
Use of ultraviolet radiation for purification of drinking water is a known method since many years. This technology is very convenient and effective, as it doesn't alter the taste of water neither requires the need of adding chemicals into the water. Ultraviolet wavelength ranges from 250-260nm.The optimum microbial killing efficiency (germicidal effect) of UV radiation is seen at 254 nm wave lengths, hence selection of appropriate UV wavelength is very important. The main aim of the study was to develop a cost effective technology for the treatment of drinking water suitable for rural population.
In this study, an UV water treatment unit was developed to treat the drinking water to kill all the micro-organisms present in it, thus making the water sample free from disease causing pathogenic organisms. This ultraviolet chamber consisted of ultraviolet light, water storage tank and tap. The main advantage of this UV treatment unit is its low cost and easy handling.
The batch experiments were carried out for water sample of 5litres, 10 litres 15 litres and 20 litres. The destruction time of these were 660, 780, 1020 and 1200 seconds respectively. The dosage of ultraviolet radiation required to kill all the pathogenic bacteria in the water sample was calculated as 0.3432, 0.4056, 0.5304, 0.624 W/cm^{2}respectively. From this study, it was concluded that fabricated UV treatment chamber is economical and affordable for use by the rural population.
Keywords: *Ultravioletradiation, UV germicidal effect, Drinking water treatment.*

Introduction

70 % of Indian population live in rural areas with 29% of them below poverty line. Due to which the concept of safe drinking water assumes greater significance in countries like India where people lack the availability of even the bare minimum infrastructure. These rural people face difficulty in availability of pure drinking water in day to day life. Safe drinking water remains inaccessible to about 1100 million people in the world (Gadgil 1998). Accessibility to safe drinking water is thereby required to reduce the burden of waterborne diseases. Safe drinking water supply was included in the ten targets, i.e., the Millennium Development Goals (MDGs) to halve, by 2015, the proportion of people without

sustainable access to safe drinking water.[1] Drinking water is directly related to the health and quality of life for the rural residential. In rural areas they use direct bore wells or well water or lakes or pond as source for drinking without purifying due to the high cost of purifying equipment's. Many of them are not even aware of consequences of drinking unpurified water which can lead to dreadful diseases like cholera.[2,3]

Most common cause for water contamination poor sanitation facilities in rural areas. Water contamination is mainly due contaminants of industries/ sewage/human waste/animal waste/ slaughter wastes being let into them.

Presently there are numerous available methods to make water portable, like use of chlorine, chloramines and ozone or chlorine dioxide. But all of these methods alter the taste, odour and physical appearance of water, thus making it difficult for consumption. UV radiation for disinfection is of growing interest in the water industry. Use of UV radiation for water treatment has the advantage of not requiring addition of any chemicals, and also it doesn't cause any change in taste or odour of the water. UV devices are the most effective when the water has already been partially treated for sediments and organic chemicals. Therefore UV disinfection devices are often combined with other water treatment devices like sediment filters and carbon filters.[4]

Though the germicidal properties of UV light were discovered in 1887, its use for treatment of drinking water was tried first in 1910 at Marselles, France. Till 2006 there was just a single commercial water purification device utilizing UV light for disinfection. As of now, a few states have created controls that enable frameworks to disinfect their drinking water supplies with UV light. UV research proceeds for raising more devices incorporating UV innovation for its proposed germicidal impact.[5]

UV disinfection is rapid and destroys the microorganisms by damaging their DNA, thus making them incapable of reproducing and infecting. UV light has proved efficiency against pathogenic organisms, including those responsible for cholera, polio, typhoid, hepatitis and many other bacteria.[6]

Water borne diseases are very commonly seen in Indian rural due to the lack of water treatment facilities. Due to high cost and maintenance of purification equipment's, normal people cannot afford them at home. The aim of this project was to develop a cost effective water treatment system which will help the rural and economical backward population.

Materials and Methods

Analysis Materials: The chemical used were Mac Conkeymedia (Hi Media).

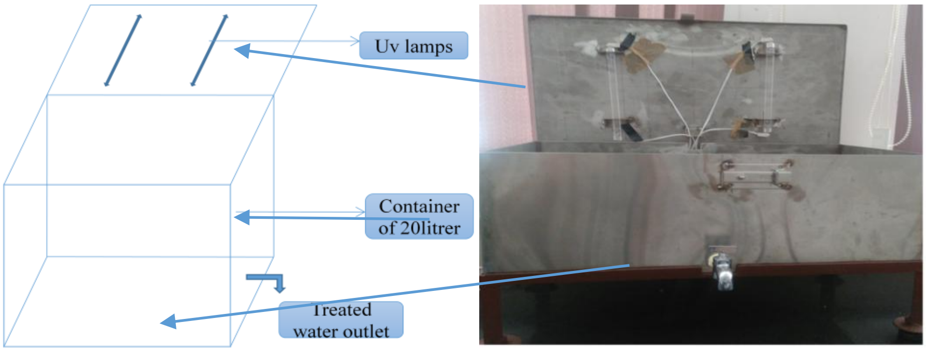
Treatment Materials: Fabricated stainless steel chamber fitted with ultraviolet bubs (Philips Company) of 11W capacity, 254 nm and 8 inch length was used.

Analytical tools: Autoclave (New bio science co) is used to sterilise the glass bottles used for water sample collection both before and after UV treatment.

Study samples were collected from wells, in and around the KLE Dr. MSSCET college campus.

Water samples were tested by Multiple Tube Broth dilution method and MPN (Most probable number) value was calculated for each sample both before and after UV radiation treatment. Those samples showing change in color/ gas production/turbidity were inoculated on MacConkey agar plate followed by incubation at 37^0c for 18 hrs. After overnight incubation micro-organisms were identified by their characteristic growth biochemical reactions by standard microbiological procedures.

UV chamber was made up of stainless steel of thickness 3 mm and argon welding was used in the preparation of the chamber. Two Ultraviolet bulbs of 11W capacity, 254 nm and 8 inch length were then fitted on the top side of the chamber. Water sample was collected through the tap fitted at the bottom of UV chamber after the treatment as shown in figure 1.



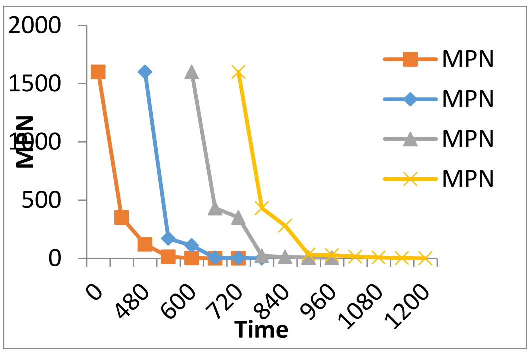
The sample above said procedure was repeated in batches to study the effect of ultraviolet radiation on micro-organisms using different parameters like UV radiation exposure time and different volumes of water subjected or treatment. 5litres, 10 litres, 15litres and 20litres were the volume of water analyzed for effectiveness of UV treatment.[1]

Results and Discussion

Table 1 shows the MPN values after treating with ultraviolet light with variation of time. Fig.3.1 shows the plot of MPN values at different time.

Table 3.1 showing the MPN valuesin relation with duration of UV treatment.

Time in seconds	5lt MPN	10lt MPN	15lt MPN	20lt MPN
0	1600			
420	350			
480	120	1600		
540	12	170		
600	2	110	1600	
660	0	4	430	
720		0	350	1600
780			21	430
840			11	280
900			6.8	33
960			4	27
1020			0	14
1080				6.8
1140				2
1200				0



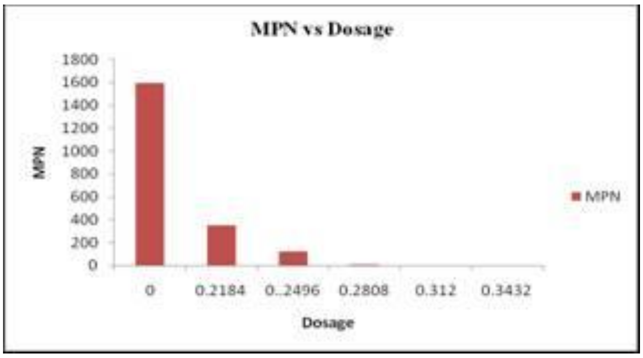
Graph-1 shows the MPN value with time

UV radiation dose is defined as the measurement of the energy per unit area that falls upon a surface. UV dose is the product of UV intensity (I) and exposure time (t). Intensity is usually expressed in W/cm^2 and exposure time in seconds (s).

$$Dose = Intensity \times Time$$

Table No.2 shows the MPN value against the dosage of UV radiation used for treatment of 5 litres of water

Dosage (W/cm²)	MPN Value
0	1600
0.2184	350
0..2496	120
0.2808	12
0.312	2
0.3432	0

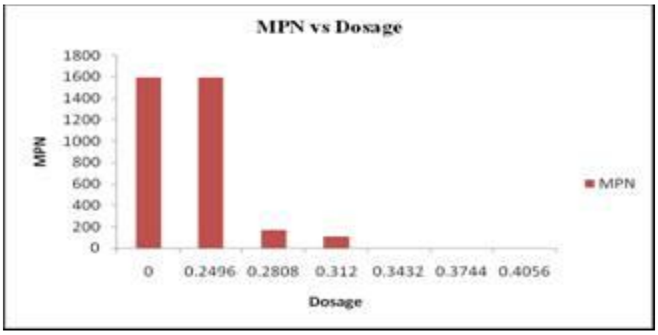


Graph 2 Dosage of UV radiation required for treatment of 5litres of water sample.

From the above graph it is evident that highest reduction of MPN value was at 0.2496 W/cm^2. And optimum dosage of UV radiation required for the treatment of 5 liters of water sample is 0.3432 W/cm^2.

Table No 3 shows the MPN value against the dosage of UV radiation used for treatment of 10 litres of water sample.

Dosage (W/cm²)	MPN Value
0	1600
0.2496	1600
0.2808	170
0.312	110
0.3432	4
0.3744	2
0.4056	0

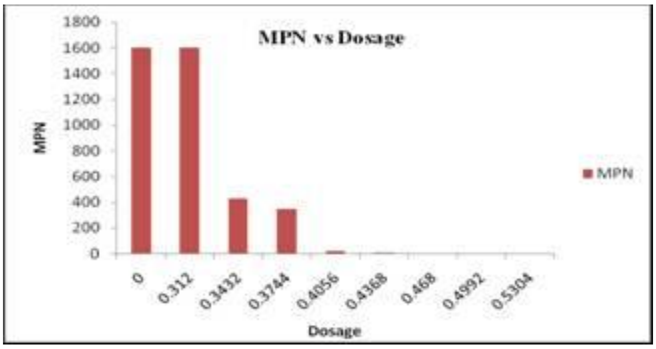


Graph-3 Dosage of UV radiation required for treatment of 10 litres of water sample

From the above graph it is evident that the optimum dosage of UV radiation required for the treatment of 10 liters of water sample is 0.4056 W/cm^2.

Table No. 4 shows the MPN value against the dosage of UV radiation used for treatment of 15 litres of water sample.

Dosage (W/cm²)	MPN Value
0	1600
0.312	1600
0.3432	430
0.3744	350
0.4056	21
0.4368	11
0.468	6.8
0.4992	4
0.5304	0

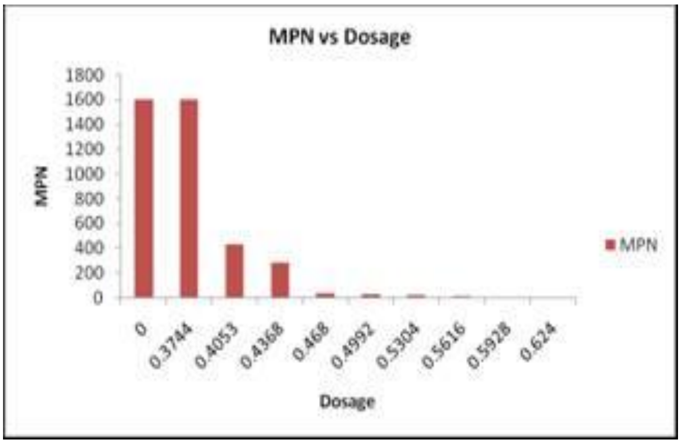


Graph 4 Dosage of UV radiation required for treatment of 15 litres of water sample

From the above graph it is evident that the optimum dosage of UV radiation required for the treatment of 15 liters of water sample is 0.5304W/cm^2.

Table No.5 shows the MPN value against the dosage of UV radiation used for treatment of 20 litres of water sample.

Dosage (W/cm²)	MPN Value
0	1600
0.3744	1600
0.4053	430
0.4368	280
0.468	33
0.4992	27
0.5304	14
0.5616	6.8
0.5928	2
0.624	0



Graph 5 Dosage of UV radiation required for treatment of 20 litres of water sample

From the above graph it is evident that the optimum dosage of UV radiation required for the treatment of 20 liters of water sample is 0.624W/cm^2.

Conclusions

Ultraviolet disinfection is a very effective method for disinfecting drinking water. UV chamber is cost effective as well as easy to operate with no change in colour/ odour/ taste. UV is effective not only against wide range of disease causing bacteria, but also against parasites like *Cryptosporidium* and *giardia* and viruses.

Overall effectiveness of UV radiation depends upon the preliminary treatment of water. Time required for UV radiation to kill the in 5 litres of water was found to be 600 seconds. Similarly 720 sec, 960 sec and 1140 seconds were required to treat 10, 15 and 20 litres of water respectively.

The strength of UV radiation required to disinfect 5l litres of water was 0.3432W/cm^2. Similarly for 10, 15 and 20 litres were found to be 0.4056, 0.5304 and 0.624 W/cm^2 respectively.

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