Brilliant Green Dye Removal and Reduction in Turbidity of Lake Water using Moringa Oleifera Seed Powder and Disinfection of Lake Water with US/UVC

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ABSTRACT

This study explores the application of Moringa Oleifera (MO) seed in water and wastewater treatment and dye removal. We have collected lake water and exposed it with different dosing of MO and found that 500 ppm dosing with original, Low pH of 3 and high pH of 11 of lake water sample show turbidity removal from 65 NTU to low as 2 NTU. MO found to be suitable for the dye removal, 15 ppm dye concentration of Brilliant green dye was removed with 15 minutes of stirring with 500 ppm dosing of MO. We noticed that MO treatment of lake water at natural pH increases the bacterial population of lake water in manifolds when it kept for overnight. For disinfection of lake water, we use US and UVC, combination of US and UVC provides complete disinfection within 20 minutes.

Keywords: Moringa Oleifera, Lake water, Turbidity, Disinfection and UVC

1 Introduction

Moringa is well known for its use in various fields such as health benefits, water treatment. It has benefits of being rich in Vitamins and minerals with anti-inflammatory, anti-oxidant properties. Moringa seeds are very effectively used for the purification of water, coagulation, and flocculation characteristics of moringa seeds provides its application in turbidity removal [1]– [3]. Low cost of moringa and various application of Moringa make it more versatile to use in water treatment, several studied have been published regarding use of moringa as medicinal plant and water treatment. [4]– [6]. Moringa is also widely used in study for dye removal [7]– [10]. Most of the study used activated seeds of MO, and studied on synthetic water, here we tried to explore MO seeds impact without any activation or modification. We used MO seeds in its natural forms, just removed hard cover of seeds manually and dried in sunlight for 8 hours and then grinded in household mixer grinder. This MO powder was used during all experiments, we prepared fresh seed powder frequently to avoid aging effect on it. We used seeds powder directly for dye removal without any activating techniques found to be efficient also in dye removal. We have noticed that using directly grinded powder of MO seeds for turbidity removal reduces the turbidity but also increases the bacterial count whenever left for the overnight. After several repetitive experiments we observed same trends with slight difference in bacterial colony. Further we decided to treat it with chemical free method using US and UVC combination. UVC and US have high disinfection potential and these methods doesn't utilize any chemical so reduces the risk of disinfection by-products which are carcinogenic in nature.

2 Materials and Methods

2.1 Moringa oleifera

Moringa Oleifera (MO) was obtained from the local market in the form of seeds, seeds were dried and stored at room temperature in gas tight container to avoid moisture contact. Hard cover of seeds was manually peeled and dried in direct sunlight for 8 hours then directly grinded in powder form using

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household grinder. 250, 500 and 1000 ppm concentration of MO was prepared for the study of its effects on Lake water. We have prepared fresh MO solutions for everyday experimentations to avoid ageing effects. Moringa have several nutritional, health, culinary and environmental uses with benefits. Almost every part of MO is used in various applications makes it very useful.

2.2 Lake Water

Lake was obtained from the Ramgarh lake, this lake has historical and ecological significance in the Gorakhpur area. Perennial Lake Ramgarh Taal is 6th biggest lake of India situated in Gorakhpur degrading day by day due to discharge of pollutants in form of sewage, solid waste, constructional activities. Ramgarh lake is used for recreational purposes, fishing, agricultural irrigation, sewage discharge (treated and untreated both way) and it has potential impact on ecology. Shrinking area of lake due to constructional activities causing and water degradation of water quality day by day causing dangerous threat to the lake and its ecological system. Satellite view of Ramgarh lake is given in Figure 5 [11] Typical physiochemical quality of Ramgarh lake water given in Table 5

Figure 5: *Ramgarh Lake*

Table 5: *Ramgarh Lake water*

Parameter	**Unit**	**Value**
Total coliform	CFU/mL	1450±100
Enterobacter	CFU/mL	750±50
Other Coliform	CFU/mL	570±50
Escherichia coli	CFU/mL	55±10
pH	--	7.1±1.0
Conductivity	µS	590±50
TDS	ppt	300±25
Salinity	ppt	0.26±0.02
Resistance	Ω (Ohms)	1.69±0.15
Temp.	ºC	23.4±1.8

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DO	mg/L	8±1.5
COD	mg/L	100±30
Turbidity	NTU	65±5

2.3 Chemicals

Brilliant green dye was used to study the effect of MO on dye removal was procured from local supplier, chemical for COD and DO analysis were Silver sulfate, sulphuric acid, potassium dichromate, mercury sulfate, alkali-iodide-azide etc were used of AR grade. For microbial analysis Nutrient agar and Chromogenic agar (Himedia HiCrome™ Chromatic Coliform Agar (CCA M1991I)) used to measure bacterial colony. CCA identify Coliform bacteria such as Enterobacter, E. coli, Salmonella on color basis, Red to brown color colony shows the colony of Enterobacter, E. coli were grown in blue color.

3 Experimental setup and procedure

3.1 Experimental setup

For turbidity measurement Digital Nephelometer (ELICO CL 52 D) was used, magnetic stirrer with temperature control for stirring the samples, Labman Multiparameter used to measure physio chemical parameters such as Temperature, conductivity, resistivity, pH and salinity. Ultrasonic bath of 2litre capacity with 100-watt ultrasonic power and 100-watt heating power working at 40kHz was used as source of ultrasonic power. Lake water was poured in ultrasonic bath and exposed with array of UVC LEDs UVC irradiation was produced using light-emitting diodes (LEDs) of 275 nm wavelength (5 V and 100 mA). Seven LEDs (procured from M/s Chip Indus Private Ltd, Hyderabad, India) were fixed to a black cardboard sheet connected in parallel and placed above the ultrasonic bath (Figure 6).

Figure 6 contains details expression of complete experimental set up for water disinfection of lake water.

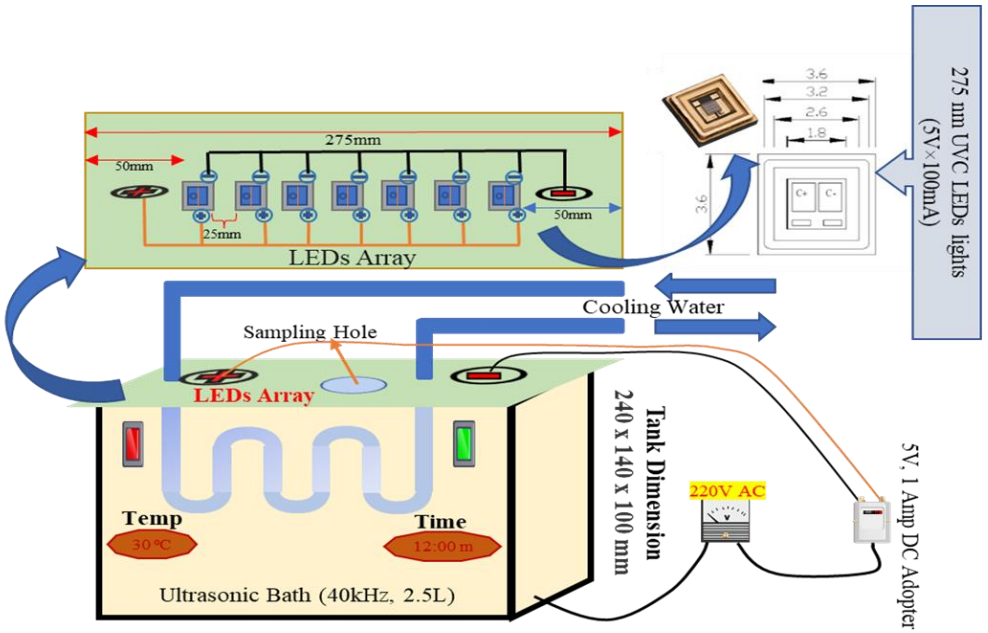

Figure 6: *Experimental setup*

3.2 Microbial Analysis

Microbial analysis was important part of this study, CCA petri dishes was prepared by pouring the CCA in sterilized petri dishes and used for the microbial measurement. 1ml of sample poured and spread on surface

of CCA petri dish, dishes were incubated by putting inverted in incubator at 37 ^{0}C for 24 hours[12], [13]. Triplicated of each sample were put in incubator and average of colony were reported as colony for respective bacteria. All small glassware and utensils were cleaned and autoclaved properly to avoid any external contamination. Instructions for microbial analysis and other measurement such as DO, COD was taken from book standard method for water and wastewater examination [14].

4 Results and Discussion

4.1 Effect of pH on Turbidity removal

Analysis for turbidity removal from MO dosing of 150 mg/L, 500 mg/L and 1000 mg/L was performed at standard, acidic and basic pH. Original lake water was treated with respective concentration of MO, results of its effect on physiochemical parameters given in Table 6. It was observed that dosing of MO doesn't affect much TDS, Conductivity, Resistivity and salinity and pH of lake water. Turbidity of lake water reduced to 5 NTU for dosing of 500 ppm and 6.4 NTU for 1000 ppm dosing. COD was observed to increase with increase in dosing of MO. Moringa treatment of lake water increases the bacterial population in many fold, we have observed that initial bacterial population which was around 1500 CFU/ml of Total coliform, increases to 650000 CFU/ml. we have investigated this several times and observed that original lake water treated with MO increases the Bacterial colony when left for overnight.

Table 6: *Treatment at original pH of Lake water*

		After 2-hour Treatment		
	Before Treatment	250ppm	500ppm	1000ppm
pH	7.048	7.04	7.037	7.04
TDS (ppm)	274	297	309	310
Conductivity (µS)	548	591	619	629
Resistivity (k Ω)	1.8	1.7	1.6	1.59
Turbidity (NTU)	64.9	3.5	5	6.4
Sal (psu)	0.27	0.22	0.3	0.31
COD (mg/L)	149	200	179	251

4.1.1 Acidic pH

To understand the effect of pH on treatment process we have added HCl in lake water up to desirable result, low pH has not significant impact on Turbidity removal compared to original pH of lake water, but low pH significantly removes bacterial population. pH 3 removes almost all coliform bacteria from the lake water. 500 ppm concentration of MO at 3 pH reduced the original Turbidity 64.9 NTU to 2.4 NTU. Increase in COD was observed with increase in MO dosing. Increase in conductivity and decrease in resistivity was observed due to ions added in the form of acid. We have measured pH after 2-hour treatment and found that pH of MO and Lake water back to normalized pH around 7.0. after repetitive experiments we have noted same. Various observed data is given in Table 7.

Table 7: *Effect of acidic pH*

		After Treatment 2 hour					
	Before Treatment	**250ppm**		**500ppm**		**1000ppm**	
		pH-3	**pH-5**	**pH-3**	**pH-5**	**pH-3**	**pH-5**
pH	3/5	7.021	7.037	7.024	7.04	7.021	7.04
TDS (ppm)	274	467	342	506	341	505	347

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Conductivity (µS)	548	944	676	1029	680	1022	708
Resistivity (k Ω)	1.8	1.08	1.48	0.99	1.45	1	1.42
Turbidity (NTU)	64.9	5	7.6	2.4	8.9	8.6	13.7
Sal (psu)	0.27	0.46	0.33	0.5	0.34	0.49	0.34
COD (mg/L)	149	147	91	324	102	459	252
Total Coli.	1450	0	1040	0	630	0	870

4.1.2 Basic pH

Basic pH gives almost similar trends as acidic pH, increase in disinfected almost all bacteria at high pH 11, increase in conductivity and reduction in resistivity observed as expected. Coliform bacteria found to be zero at all dosing of MO at pH 11. Physiochemical parameters before and after treatment of Lake water after 2-hour treatment at high pH of 9 and 11 given in Table 8

Table 8: *Effect of high pH*

		After Treatment 2 hour					
	Before Treatment	**250ppm**		**500ppm**		**1000ppm**	
		pH-9	**pH-11**	**pH-9**	**pH-11**	**pH-9**	**pH-11**
pH	9/11	7.021	7.013	7.018	7.013	7.018	7.0101
TDS (ppm)	274	288	1030	305	771	336	663
Conductivity (µS)	548	574	2080	606	1508	680	1320
Resistivity (k Ω)	1.8	1.72	0.48	1.62	0.66	1.56	0.75
Turbidity (NTU)	64.9	5.9	18.6	9.7	19.4	10.6	19.7
Sal (psu)	0.27	0.28	1.06	0.3	0.76	0.32	0.67
COD (mg/L)	149	81	90	168	180	315	350
Total Coli.	1450	370	0	650	0	1020	0

4.2 Dye Removal

We performed MO on Brilliant green dye (BGD) to enumerate dye removal capacity of moringa. 500 ppm only concentration of MO was selected for dye removal study, 5 ppm, 10 ppm and 15 ppm initial concentration of BGD was put under 500 ppm MO. MO shows excellent behaviour for dye removal 5 ppm dye was removed only in first 5 minutes. 15 ppm initial concentration of dye takes almost 15 minutes to degrade. 15 minutes treatment found to be enough for removing up to 15 ppm dye concentration. Table 9

Table 9: *Dye removal with MO (500ppm)*

	MO/500ppm		
time	BGD/15ppm	BGD/10ppm	BGD/5ppm
5	8.00	4.00	0.30
10	2.00	0.10	0
15	0.50	0.00	0.00
20	0.00	0.00	0.00

4.3 Microbial Disinfection

After observing that high increase in microbial colony after MO treatment of original Lake water, we decided to treat this high bacterial and low turbid water using US sonication and combination of US and UVC[15], [16], both are well proven method for microbial deactivation without using any chemical [17] – [21]. *Figure 7* shows nature of colony and effect of US and UVC on bacterial colony, blue color colony represent E. coli (EC), pink to red colony indicating Enterobacter (EE) bacteria. Except EE and EC other colonies present in petri dish counted as Other coliforms (OT) and Total colonies present in petri dish counted as Total Coliforms (TC). We can easily understand the effect of US removes almost ~99% bacteria after 60 minutes of treatment. But due to high disinfection capacity of UVC high population bacteria removes in just 20 minutes.

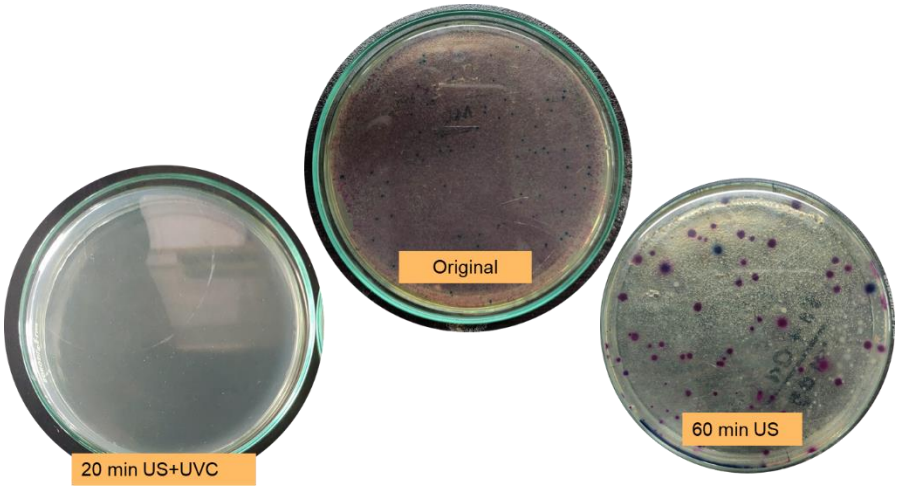

Figure 7: *Colony of Bacteria of original lake water and treated with US and US+UVC*

4.3.1 US only

Ultrasonic bath with 40 kHz frequency with 100-watt ultrasonic power with cooling coil to maintain the temperature to avoid effect of temperature on microbes set up as shown in *Figure 6* was used for microbial disinfection. Figure 8 shows the disinfection rate of EE, EC, OT and TC, Complete disinfection was not even obtained 1 hour of US treatment but able to remove ~99% bacteria. Effect of US is significant effect on microbial activity but its high energy consuming and time taking [22]– [24].

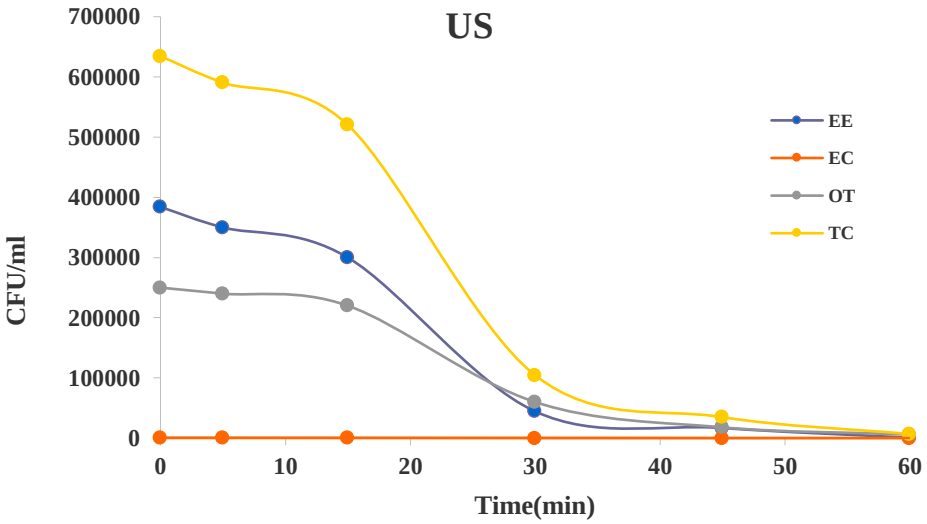

Figure 8: *Effect of US on Enterobacter (EE), E.coli. (EC), Other coliform (OT) and Total Coliform (TC)*

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4.3.2 US/UVC combination

US and UVC combination improve the disinfection rate, while using UVC alone able to completely remove bacterial population in 30 minutes. Combination of UVC with US improve disinfection and complete removal of bacteria was just obtained in 20 minutes *Figure 9* and *Figure 10*. Low turbidity will impact positively on disinfection while treating with UVC, high turbidity doesn't allow easily pass the UVC light from sample, but low turbid sample will easily allow UVC which increases the disinfection rate[25]– [27].

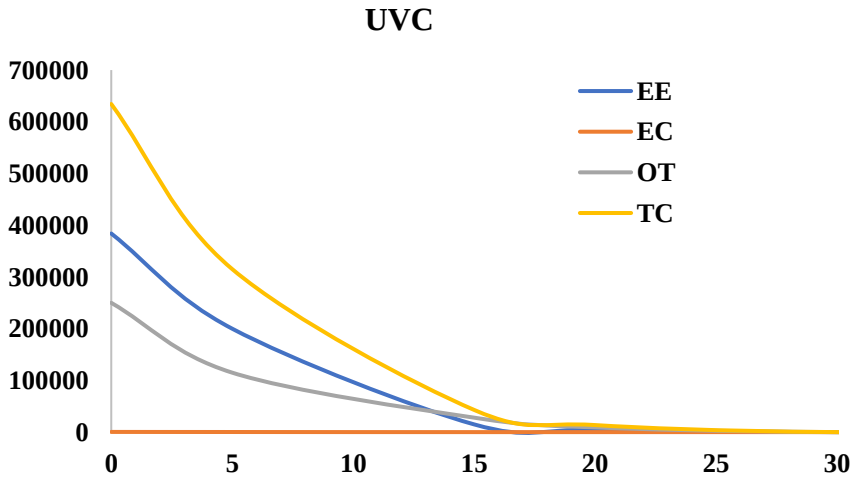

Figure 9: *Effect of UVC on Enterobacter (EE), E.coli. (EC), Other coliform (OT) and Total Coliform (TC)*

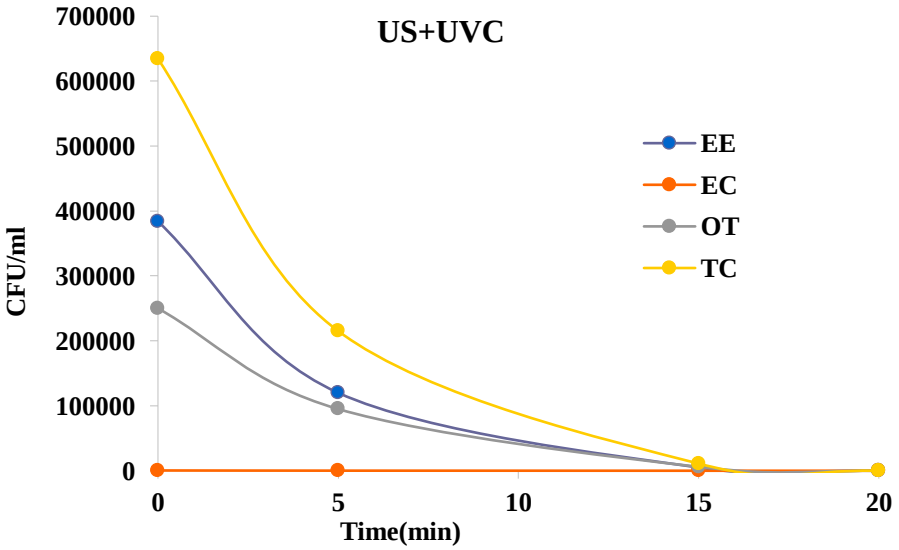

Figure 10: *Effect of US+UVC on Enterobacter (EE), E.coli. (EC), Other coliform (OT) and Total Coliform (TC)*

5 Conclusions

Moringa is conventionally used as medicinal plant and widely available in India, here we have explored application of MO in water treatment and dye removal with study of Disinfection with US and UVC. First, we have investigated the impact of MO powder on Natural Lake water, found that it reduces the Turbidity and makes water clean in appearance. Increasing and decreasing pH of Lake water doesn't impact very

much turbidity removal but kills bacteria at very low pH of 3 and high pH of 11. We also investigated impact of MO on dye, found that 500 ppm of MO is optimum concentration for removal of up to 15 ppm BGD within 20 minutes.

We observed that natural lake water have high number of bacterial population after MO treatment, for disinfection of this bacterial contaminated water we have chosen chemical free method such as US and UVC. Bacterial population of 650000 CFU/ml were completely removed by using US and UVC within 20 minutes.

6 Publisher's Note

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