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Comparative Study of the Disinfection Effectiveness of Processed *Moringa Oleifera* Seed Extract and Aluminium Sulphate in the Disinfection of Raw and Waste Waters.

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Abstract: *Conventional aluminium sulphate, used for water treatment is expensive, its significant effect on pH of water after treatment as well as its culpability in inducing Alzheimer's disease and strong carcinogenic properties have necessitated this research on a low cost natural coagulant (Moringa oleifera) that is more effective, non-toxic and has no significant effect on pH of water after treatment. Raw and waste waters were collected and triplicate analyses were done. The pH of $Al_2(SO_4)_3$ solution was 3.64 ± 0.02 while that of Moringa oleifera processed powder was 6.81 ± 0.10. Both solutions have solubility of 90 ± 0.00. Total coliform bacteria reduced from (900. 00 ± 0.00 to 550.00 ± 0.00) per 100 mL of water using $Al_2(SO_4)_3$ and (900 , 00 ± 0.00 to 17.00 ± 0.00) per 100 mL of water using MOPP in raw water treatment. Total coliform bacteria reduced from (>1800. 00 ± to 1600.00 ± 0.00 and >1800.00 ± 0.00 to 25.00 ± 0.00) per 100 mL of water in $Al_2(SO_4)_3$ and MOPP respectively waste water treatment. The quality of raw and waste water treated using MOPP was better than that treated with $Al_2(SO_4)_3$. In comparison to know its effectiveness, MOPP is more effective than $Al_2(SO_4)_3$ in the treatment of raw and waste water.*

Keywords: *Moringa oleifera, water treatment, aluminium sulphate, raw water, waste water.*

I. Introduction

A greater percentage of the earth's surface is covered by water, an essential natural liquid resource that supports life and acts as vehicle for biological systems and industrial processes while lack of it leads to morbidity and mortality, especially in local communities and municipalities where chemical pollutants and water borne diseases are prevalent and persistent due to low quality surface waters (Alo *et al.,* 2012). Natural water sources are consequently tainted with both chemical and biological pollutants. Hence, chemical and bacteriological constituents such as water borne pathogens are essential indices of water quality management and can be used as a measure of water quality (Mangale *et al.,* 2012a, 2012b). Conventional technologies may not be appropriate for those communities in terms of economics, availability and operational constraints (Egbuikwem and Sangodoyin, 2013). Appropriate treatment technology can render this poor water source into safe potable water (Arafat and Mohamed, 2013). These technologies are however limited by high costs, maintenance, availability and lack of trained personnel for their usage and maintenance.

Developing countries are facing potable water supply shortages because of inadequate financial resources and deforestation. The cost of water treatment is increasing, and the quality of river water is depreciating due to pollution from sanitary wastes and runoffs during the rainy season (Gidde *et al.,* 2012). Conventionally, urban water treatment utilizes aluminium sulphate that leaves the treated water not wholly safe for human consumption. In the light of the attendant deleterious effects created by use of synthetic coagulants such as aluminium sulphate, which is used worldwide, there is a high demand to find a natural coagulant as an alternative that has good disinfecting properties (Sapong and Richardson, 2010). Consequently, this research was designed to compare the disinfection effectiveness of the extract of *Moringa oleifera* seeds (MOPP) with $Al_2(SO_4)_3$ on raw and waste water samples.

II. Materials And Methods

2.1 Sample Collection

Ripe fruits (pod) of *Moringa oleifera* were harvested from North Bank and Fiidi village of Makurdi metropolis of Benue State in North Central, Nigeria during the rainy season and cracked to obtain the seeds. Raw water samples were collected from River Benue and waste water samples from Wurukum Abattoir of the same town. Commercial aluminium sulphate (alum) was purchased from stall in the area.

2.2 Sample Treatment and Extraction

The seeds were peeled to obtain the nuts and air-dried in the laboratory for 2 weeks and then dried in an oven at 40^{o}C for 1 hour. Thereafter, the dried seeds were ground into powder. Commercial aluminium sulphate was ground to fine mesh (Onyuka *et al.,* 2013).

Moringa oleifera oil was extracted by Soxhlet method using diethylether for 24 hours on an electric heating mantle.

2.3 Salt Extraction of Bio-Active Constituents

Extraction of protein bio-active constituents by sodium chloride (NaCl) was done by adding 10 $cm^3$of 1 M of NaCl. 5 g of the *Moringa oleifera* cake (residue stock after oil extraction) was added to 1 litre of 1 M NaCl and mixed for 30 minutes using a magnetic stirrer. The mixture was filtered on Whatman number 1 filter paper, and the clear filtrate applied to microfiltration cartridge (Suhartini *et al.*, 2013).

The bio-active constituent (*Moringa oleifera* processed powder, MOPP) was dried at 50^oC–55^oC in an oven and yielded a white powder which was soluble in water (Shanchez –Martin *et al.,* 2012).

2.7 Jar Test of Alum and *Moringa oleifera* Seed Processed Powder

Jar test protocol was observed to stimulate coagulation–flocculation, settling and quantitation of water treatment chemicals.

Stock solutions were prepared by dissolving 2 g each of processed *Moringa oleifera* seed powder and aluminium sulphate in 100 mL solution with distilled water. Raw and waste water samples were measured into 500 mL beakers labeled 1–5 with dosage of alum and processed *moringa* powder using a calibrated pipette, each stock solution dosage of alum and *moringa* solution was added into the raw water and waste water samples in the beakers as rapidly as possible. 1.0 mL stock solution contains 0.02 g solute or 20 mg. The sequence of addition was *moringa* solution followed by alum solution, with stirring paddles lowered into the beakers and the jar tests mixer turned on. The beakers indicated different floc sizes. Larger flocs showed higher settling rate with concomitant tolerable pH, lowest turbidity, suspended solids, colour and bacteria load, and was considered as optimum dosage.

2.8 Variation of dose

The varying quantity (mL) of 2 % of *moringa* processed powder and aluminium sulphate were dosed into five beakers containing 500 mL of the test water samples and flocculated with the settling time of 30 minutes.

2.9 Variation of contact time

The optimum dose obtained was varied for raw and waste water at different contact times (second) and settling time of 30 minutes to obtain the optimum contact time.

2.10Variation of flocculating speed

The optimum contact time obtained was varied for raw and waste water at different speed in revolution per minute (rpm) at a settling time of 30 minutes to obtain the optimum flocculating speed.

2.11Variation of pH

The optimum flocculating speed obtained was used to vary the pH of raw and waste water to acidic, neutral, and alkaline to obtain the optimum pH at a settling time of 30 minutes (Vikashni *et al.,* 2012).

2.12Determination of total coliform bacteria

10 mL of MaCconkey broth was filled in 15 bottles using sterile syringe. The inverted Durham tubes were inserted in each of the bottles and then autoclaved for 15 minutes at 121^oC. The bottles were then removed. 10 mL of the water sample was inoculated in the first five bottles. 1 mL of water sample was inoculated in the second five bottles, while 0.1 mL of water was inoculated into the last five bottles. The bottles were put in an incubator and observed at the end of 24 and 48 hours presumptive and confirmatory test respectively. The number of positive bottles indicated by colour change and gas formation in each of the rolls were recorded and compared with the bacteria load in the Most Probable Number (MPN) table. This procedure was repeated for all the water samples (Egbuikwem and Sangodoyin, 2013).

III. Results And Discussion

3.1 Results

Intrinsic physico-chemical properties of the water treatment agents are presented in TABLE 1, and results of disinfection effectiveness of the treated water samples are given in TABLES 2 to 5. TABLE 6 reflects the overall water quality after treatment. Weight of cake obtained after Soxhlet extraction of 177.2 g of *Moringa oleifera* seeds was 124 g, representing 69.98 % yield.

Amount of bioactive substance produced when 5 g of Moringa oleifera cake was centrifuged for 30 min at 4000 rpm, and then filtered and dried was 0.80 g, representing 16.00 %.

Table 1: Intrinsic physico-chemical properties of 2 % MOPP and 2 % alum $Al_2(SO_4)$ solution

Parameter	$Al_2(SO4)_3$	MOPP
pH	3.64± 0.02	6.81± 0.10
% Solubility in water	90±0.00	90±0.00

Values are mean ± Standard Deviation (SD)

Table 2: Disinfection effectiveness of raw and waste waters treated with varying dose of 2 % aluminium sulphate, $Al_2(SO_4)_3.4H_2O$ and MOPP

Dose (mL)		Total coliform	bacteria per 100 mL water	
	Raw water		Waste water	
	$Al_2(SO4)_3$	MOPP	$Al_2(SO4)_3$	MOPP
0.2	900.00±0.00	80.00±0.00	16.00±0.00	80.00±0.00
0.3	900.00±0.00	40.00±0.00	16.00±0.00	35.00±0.00
0.4	550.00±0.00	40.00±0.00	16.00±0.00	35.00±0.00
0.5	550.00±0.00	40.00±0.00	16.00±0.00	35.00±0.00
0.6	550.00±0.00	40.00±0.00	16.00±0.00	35.00±0.00

Table 3: Disinfection effectiveness of raw and waste waters treated with a constant dose of 0.4 mL $Al_2 (SO4)_3$ and MOPP at varying contact times.

	Total coliform	bacteria per	100 mL	
	Raw water		Waste water	$Al_2(SO_4)_3$
Contact time (min)	$Al_2(SO_4)_3$	MOPP	$Al_2(SO_4)_3$	MOPP
10	550.00±0.00	17.00±0.00	16.00±0.00	35.00±0.00
30	550.00±0.00	10.00±0.00	16.00±0.00	30.00±0.00
60	550.00±0.00	10.00±0.00	16.00±0.00	25.00±0.00
90	550.00±0.00	10.00±0.00	16.00±0.00	25.00±0.00
120	550.00±0.00	10.00±0.00	16.00±0.00	25.00±0.00

Table 4: Disinfection effectiveness of raw and waste waters treated with a constant dose of 0.4 mL and optimum contact time of 10 mins for $(Al_2SO4)_3$ and 30 mins for MOPP at varying speeds of flocculation.

	Total coliform	Bacteria	per 100 mL water	
	Raw water		Waste water	
Speed (rpm)	$Al_2(SO_4)_3$	MOPP	$Al_2(SO_4)_3$	MOPP
50	550.00±0.00	7.00±0.00	1600±0.00	30.00±0.00
100	550.00±0.00	7.00±0.00	1600±0.00	25.00±0.00
150	550.00±0.00	7.00±0.00	1600±0.00	25.00±0.00
200	550.00±0.00	7.00±0.00	1600±0.00	25.00±0.00
250	550.00±0.00	7.00±0.00	1600±0.00	25.00±0.00

Table 5: Disinfection effectiveness of raw and waste waters treated with constant dose of 0.4 mL, 10 mins contact time and speed of 200 rpm for $Al_2(SO_4)_3$ and constant dose of 0.4 mL, 30 mins contact time and speed of 100 rpm for MOPP at varying pH.

		Total coliform	bacteria per 100 mL water	
pH	Raw water		Waste water	
	$Al_2(SO_4)_3$	MOPP	$Al_2(SO_4)_3$	MOPP
6.00	425.00±0.00	6.00±0.00	900.00±0.00	25.00±0.00
6.50	550.00±0.00	7.00±0.00	900.00±0.00	25.00±0.00
7.00	550.00±0.00	7.00±0.00	900.00±0.00	25.00±0.00
7.50	425.00±0.00	9.00±0.00	900.00±0.00	25.00±0.00
8.00	425.00±0.00	6.00±0.00	900.00±0.00	25.00±0.00

Table 6: Quality of raw and waste waters after treatment with $Al_2(SO_4)_3$ and MOPP

			Raw water		Waste	water		
	Parameter	**Before treatment**	**After treatment with $Al_2(SO4)_3$**	**After treatment with MOPP**	**Before treatment**	**After treatment with $Al_2(SO4)_3$**	**After treatment with MOPP**	**WHO's standard**
	Physical							
1	Temperature (°C)	30.50±0.00	30.00±0.00	29.50±0.00	31.50±0.00	31.00±0.00	30.50±0.00	
2	Turbidity (NTU)	38.20±0.01	6.90±0.01	1.90±0.01	233.60±0.02	42.00±0.00	19.20±0.10	5 maximum
3	Colour (Pt Co Colour)	72.00±0.00	12.00±0.00	5.00±0.00	480.00±0.00	69.00±0.00	38.00±0.00	5 maximum
4	Suspended solids (mg/L)	26.00±0.00	3.00±0.00	2.00±0.00	218.00±0.00	24.00±0.00	15.00±0.00	
	Chemical							
5	pH	7.20±0.01	6.57±0.00	7.00±0.00	6.56±0.02	6.21±0.00	6.56±0.01	6.80 – 8.40
6	Iron (mg/L)	0.47±0.00	0.34±0.00	0.12±0.01	1.84±0.00	0.38±0.00	0.22±0.00	0.05 – 0.3
7	Aluminium (mg/L)	0.54±0.00	0.40±0.00	0.00±0.00	0.62±0.02	0.47±0.00	0.00±0.00	0.5
8	Sulphate (mg/L)	28.00±0.00	18.00±0.00	2.00±0.00	45.00±0.00	22.00±0.00	4.00±1.00	200
9	Hardness (mg/L)	100.00±0.00	100.00±0.00	80.00±0.00	280.00±0.00	140.00±0.00	100.00±0.00	100

Values are mean ± Standard Deviation (SD)

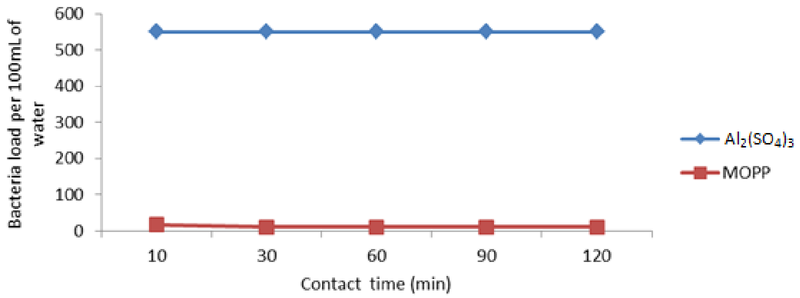

Fig 1: Variation of total coliform bacteria with dose

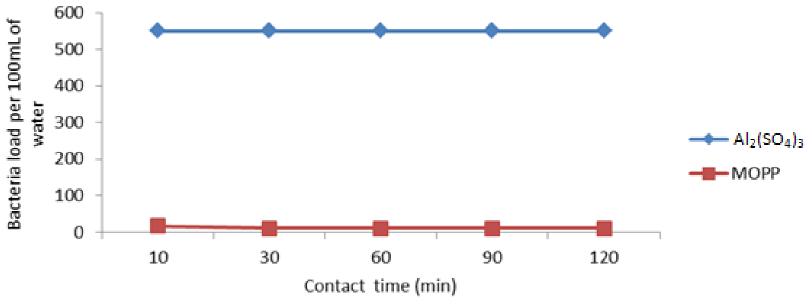

Fig 2: Variation of total coliform bacteria with contact time

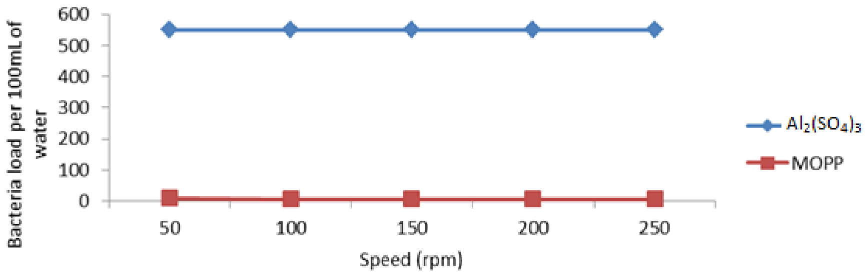

Fig 3: Variation of total coliform bacteria with speed

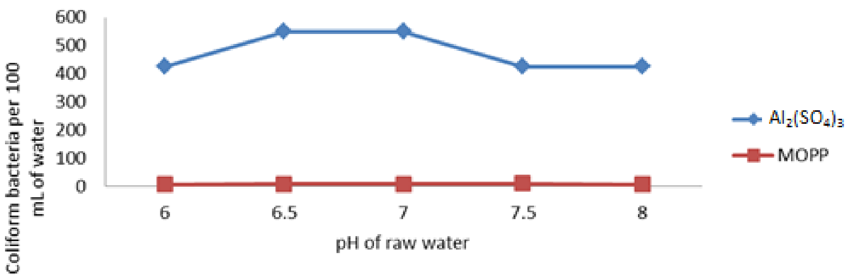

Fig 4: Variation of total coliform bacteria with pH of raw water

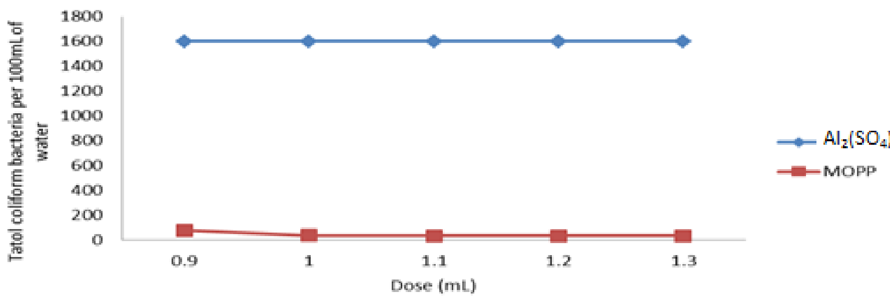

Fig 5: Variation of total coliform dose for waste water treatment

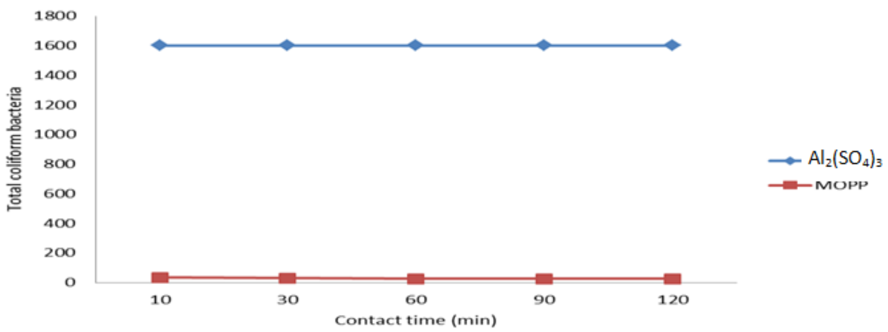

Fig 6: Variation of total coliform bacteria with contact time for waste water after treatement

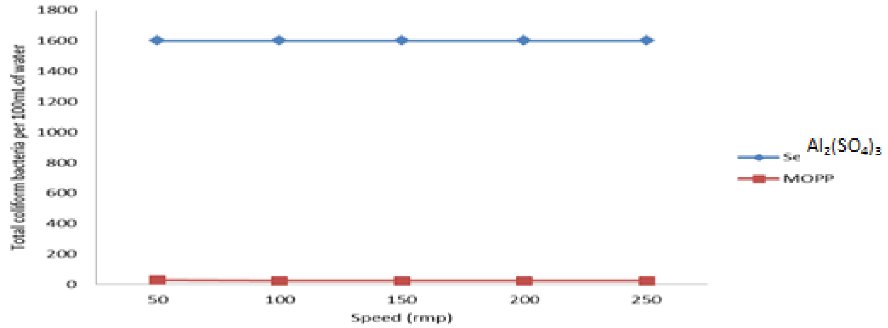

Fig 7: Variation of total coliform bacteria with speed for waste water after treatment

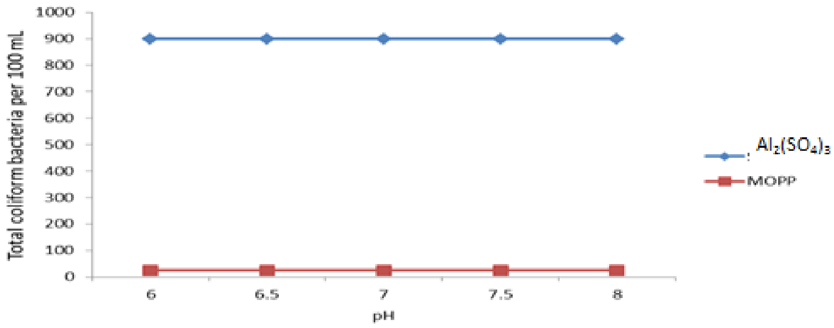

Fig 8: Variation of pH with total coliform bacteria for waste water after treatment

IV. Discussion

Intrinsic properties indicate that both $Al_2(SO_4)_3$ and MOPP have appreciable solubility of 90 % in water; $Al_2(SO_4)_3$ is reasonably more acidic (pH = 3.64 ± 0.02) than MOPP (pH = 6.81), TABLE 1. Results of the disinfection effectiveness of raw and waste water samples treated with alum and MOPP are presented in TABLES 2-5 and graphically in Figs. 1-7, while TABLE 6 summarizes the quality of water samples after treatment.

Dose variation of the treatment agents indicate that the optimum value of $Al_2(SO_4)_3$ is 0.4 mL and 0.3 mL for MOPP for raw water. MOPP has its optimum value at 0.3 mL with waste water. With $Al_2(SO_4)_3$, dose variation has no noticeable effect on waste water, TABLE 2.

The optimum contact time for 2 % $Al_2(SO_4)_3$ using raw water was 10 minutes while that of MOPP was 30 minutes, which showed that $Al_2(SO_4)_3$ has shorter contact time due to its charge attraction, while MOPP takes longer time for the destabilization of water colloids. For waste water, $Al_2(SO_4)_3$ has optimum contact time of 10 minutes, while it took MOPP 60 minutes to attain optimum value. Varying contact time has no effect on bacteria reduction with $Al_2(SO_4)_3$ treated water, while MOPP has significant reduction on bacteria load. This result is in agreement with the report of Meneghel *et al.* (2013).

The optimum contact time for $Al_2(SO_4)_3$ was 200 revolution per minute (rpm) while that of MOPP was 100 rpm which implies that, MOPP is effective at lower speed and needs less energy of flocculation as compared to $Al_2(SO_4)_3$. The value for $Al_2(SO_4)_3$ treated water was constant at 550.00 ± 0.00 per 100 mL of water, while that of MOPP treated water was constant at 7.00 ± 0.00 per 100 mL of water, but far lower in value as compared to $Al_2(SO_4)_3$.

$Al_2(SO_4)_3$ was more effective at pH of 6.50 because it is an acidic substance, while MOPP was optimum at pH of 7.00, because the substance pH is very close to neutral Total coliform bacteria for $Al_2(SO_4)_3$ and MOPP at pH of 6.0 and 8.0 was reduce but it was due to unfavorable pH at 6.0 that was too acidic and 8.0 that was basic (Mustapha, 2013). The quality of water treated with MOPP has a very significant reduction in Total coliform bacteria from 900 to 7 per 100mL of water while that of $Al_2(SO_4)_3$ treated water has no significant effect and increases the chance of having Alzheimer's infection (Onyuka *et al*., 2013).

The optimum dose for $Al_2(SO_4)_3$ in the treatment of waste water was 1.0 mL while that of MOPP was also 1.0 mL. There was no significant reduction in total coliform bacteria for $Al_2(SO_4)_3$ treated water while, the total coliform bacteria reduced from 1800.00 ± 0.00 to 35.00 ± 0.00 per 100mL of waste water .

The best contact time for $Al_2(SO_4)_3$ treated water was 10 min while that of MOPP was 60 min. There was no significant change in total coliform bacteria using $Al_2(SO_4)_3$ while there was a significant reduction of total coliform bacteria from 35.00 ± 0.00 to 25.00± 0.00

The optimum speed in $Al_2(SO_4)_3$ treated water was 200 rpm while that of MOPP was 100 rpm, indicating that $Al_2(SO_4)_3$ is an artificial inorganic coagulant that works more effective at high speed while MOPP is natural organic bioactive coagulant that coagulates faster at low speed, 25.00 ± 0.00 per 100 mL of water. There was no noticeable change in Total coliform bacteria using $Al_2(SO_4)_3$ coagulant while there was a very significant reduction of total coliform bacteria to 25.00 ± 0.00 per 100 mL of water (Ndibewu *et a*l., 2011).

The optimum pH medium for $Al_2(SO_4)_3$ is 6.50 while that of MOPP was 7.00 in waste water treatment. There was no significant effect on total coliform bacteria using $Al_2(SO_4)_3$ while the total coliform bacteria reduce significantly to 25.00 ± 0.00 per 100 mL of water using MOPP treated water which clearly showed that MOPP is a preferable disinfectant for waste water treatment.

The total coliform bacteria did not significantly reduce in $Al_2(SO_4)_3$ treated water but significantly reduced in MOPP treated water.

V. Conclusion

From the study, it could be inferred that MOPP is more effective in the disinfection of raw and waste water as compared to the conventional aluminum sulphate.

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