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Bioremediation of Vanki River Water & Industrial Effluents using *Calotropis procera* Latex Exudate and its Comparative Analysis against *Moringa oleifera* Leaves Extract

Riya S. Barot[1], Feny R. Bhagat[2], Reena G. Desai[3]
[1,2,3]*Department of Microbiology, Dolat Usha Institute of Applied Sciences and Dhiru Sarla Institute of Management & Commerce, Valsad, Gujarat, India.*
[1, 2, 3]*Veer Narmad South Gujarat University, Surat, Gujarat, India.*

Abstract:** This study was carried out to check the effectiveness of Calotropis procera latex for bioremediation and to compare its efficacy with Moringa oleifera leaves extract. It was observed that considerable reduction in various physicochemical and bacteriological properties of the samples took place with Calotropis procera latex. After 1 hour of treatment itself, it carried out pH reduction of 11.11%, 30.00% and 12.50%, while Moringa oleifera leaves extract carried out 0.00%, 20.00% and 0.00% reduction and after 24 hours, turbidity was reduced to 90.00%, 61.87% and 65.36% with Calotropis procera latex and 75.00%, 60.43% and 32.03% with Moringa oleifera leaves extract for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent, respectively. Vanki river water showed a reduction in TSS and TDS of 2000 mg/L and 34000 mg/L with Calotropis procera latex and 3000 mg/L and 46000 mg/L, respectively with Moringa oleifera leaves extract. With Calotropis procera latex, the COD and BOD values were 544 mg/L, 608 mg/L and 800 mg/L; and 0.04 mg/L, 0.240 mg/L and 0.012 mg/L for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent, respectively. When treated with Moringa oleifera leaves extract, the COD values reduced to 864 mg/L, 800 mg/L and 896 mg/L and BOD values reduced to 0.004 mg/L, 0.251 mg/L and 0.022 mg/L, respectively. The total coliform count reduced to 130 MPN/100 ml, <1.8 MPN/100 ml and 7.8 MPN/100 ml for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent, respectively after treatment with Calotropis procera latex. Thus, Calotropis procera showed better results in comparison with Moringa oleifera. So, it could be considered as the best alternative to prevent pollution.

Keywords:** Latex, Leaves extract, Calotropis procera, Moringa oleifera, Reduction, Bioremediation.

I. INTRODUCTION

Pollution of water has become a major threat from past few decades due to the surge in various anthropogenic activities and emerging exigencies of population. To cope up with this issue, there has been a realization for the treatment of water bodies and their surrounding territories so as to provide an adequate amount of potable and contaminant free water to the society. Dreadful effects on the ecosystem arises every year due to the release of substantial amount of wastewater by many industrial processes. Also, necessity to treat contaminated water has arisen so as to confront with the prompt requirements. Globally, over 3 billion people are at a risk of disease because the water quality of the rivers, lakes and groundwater is unknown, due to a lack of data. Meanwhile, a fifth of the world's river basins are experiencing dramatic fluctuations in water availability, and 2.3 billion people are living in countries categorized as "water-stressed," including 721 million in areas where the water situation is "critical," according to recent research carried out by the United Nations Environment Programme (UNEP) and partners [10]. UNEP researchers surveyed more than 75,000 bodies of water in 89 countries and found that more than 40 percent were severely polluted. Bioremediation is a technology for removing pollutants from the environment thus restoring the original natural surroundings and preventing further pollution [20]. Bioremediation has been regarded as a sustainable waste treatment natural process for deleterious materials such as water [4] and is also considered as an eco-friendly technology for purification of polluted environment. There has been an elevated demand and recognition for biological treatment of the contaminated water. The use of natural coagulants has been popular since earliest times as they are cost-effective and also have a bright future due to its biodegradability nature [14]. Also, complications such as power failure, manpower, lack of chemicals and other operational systems can be doped out through such usage.

Calotropis procera belongs to the family *Apocynaceae* and are excessively available in tropical zones. It is commonly known as Apple of Sodom, Sodom apple, rubber bush, rubber tree [6] and king's crown and its latex have been confirmed as a good clarifying agent. Calotropis roots can be washed, cooked and transformed into a biosorbent for wastewater Cu remediation [9]. *Moringa oleifera*, also commonly known as moringa, drumstick tree, horseradish tree or benzolive tree [16], belongs to the family *Moringaceae* and is a fast-growing, drought-resistant tree, native to the Indian subcontinent [22]. It is cultivated for its leaves and seed pods and is also used for water purification and as a traditional herbal medicine.

The intendment of the current study was to employ convenient environment friendly water treatment processes using natural coagulants such as latex of *Calotropis procera* and leaves extract of *Moringa oleifera* and also to examine the reduction of bacteriological contaminants and turbidity and to have a control on other physiochemical properties. The latex of *Calotropis procera* has a good potential as a clarifying agent in water treatment along with the purpose of reduction of bacteriological contaminants and physiochemical properties in comparison with the leaves extract of *Moringa oleifera*. Although *Moringa oleifera* have been investigated widely over the past years and have been indicated as an effective natural coagulant for water treatment, the use of *Calotropis procera* is a major concern for this study as it has not been studied widely. So, this will serve as an important benefaction for the bioremediation purpose and water treatment can be efficiently done.

II. METHODOLOGY

A. Sample Collection

Fresh river water sample was collected from Vanki river flowing through Abrama in Valsad district, Gujarat and the other two samples of industrial effluent were collected from Textile industry and Paper & Pulp industry located in Vapi, Valsad, Gujarat in labelled and pre-sterilized bottles.

B. Latex and Leaves Collection

The latex of *Calotropis procera* was collected from Tithal road, Valsad, Gujarat from the stem at the petiole region by detaching the leaves [2] in a pre-labelled clean plastic container and used immediately or stored at 4° C [13]. Also, leaves of *Moringa oleifera* from Chhipwad, Valsad, Gujarat were collected and then grinded in an electric mixer to obtain its extract in liquid form and used for further studies.

C. Physico-chemical and Bacteriological Analysis of Untreated Samples

Vanki river water and effluent samples were analyzed within 6 hours of collection, before treatment with the coagulant. Physical tests were carried out to determine physical characteristics such as colour, odour, temperature, pH and turbidity. Various chemical methods were employed to assess the chemical properties such as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS) and Total Suspended Solids (TSS).

1) *Colour and Odour:* Colour and odour of all the untreated samples were determined by using the human sense organs.
2) *Temperature:* Temperature was checked immediately after bringing all the untreated samples to the laboratory by using a thermometer.
3) *pH & Turbidity:* pH of all the untreated samples was determined by using pH strips. Absorbance readings of all the untreated samples was determined at 530 nm by using colorimeter to check the turbidity or the optical density (OD).
4) *Chemical Oxygen Demand (COD):* For detection of Chemical Oxygen Demand, 2.5 ml of each of the sample was taken in three different COD tubes. Addition of glass beads, followed by 1.5 ml of $K_2Cr_2O_7$ and 3.5 ml of H_2SO_4 was done and another tube with 2.5 ml of distilled water and the rest contents same as that of the samples was run as a 'control.' The tubes were kept in COD digester for 2 hours and after that the content was allowed to cool at room temperature. The content was then transferred into four different Erlenmeyer flasks and 2-4 drops of Ferroin indicator was added. The burette was filled with freshly prepared Ferrous ammonium sulphate and titration was performed until the colour changed from blue green to reddish brown [3].

Chemical Oxygen Demand (COD) (mg/L) was calculated as follows:

$$\text{COD} = \frac{(\text{A}-\text{B})\times\text{Normality of Ferrous Ammonium Sulphate}(0.1\text{ N})\times 8\times 1000}{\text{Volume of sample used (ml)}}$$

Here, A = Volume of Ferrous Ammonium Sulphate of blank (ml)
B = Volume of Ferrous Ammonium Sulphate of test (ml)

5) *Biological Oxygen Demand (BOD):* For the detection of Biological Oxygen Demand (BOD), 10 ml of each of the untreated samples were taken in different BOD bottles and to it 290 ml of dilution water was added. BOD bottle filled with 300 ml of dilution bottle was labelled as 'control.' These BOD bottles containing different samples and a 'control' were used for the determination of '0' day reading for Dissolved Oxygen (DO). Test for Dissolved Oxygen was carried out by adding 2 ml of Manganese sulphate (36.4 %) and 2 ml of Alkali-Iodide azide solution to the content present in each of the BOD bottles. The content was mixed by inverting the bottles several times and the brown precipitates obtained were allowed to settle down. 2 ml of concentrated H_2SO_4 was allowed and was mixed well to dissolve the precipates.2 ml of starch indicator was added to 203 ml of sample and titration was done with 0.025 N of Sodium thiosulphate ($Na_2S_2O_3$) until the blue colour disappeared. The same procedure was performed after keeping the BOD bottles for 5 days in a BOD incubator and the readings were noted down and BOD of the samples was calculated [3].

Biological Oxygen Demand (BOD) (mg/L) was calculated as follows:

$$\text{BOD} = \frac{(\text{S0}-\text{S5})-(\text{B0}-\text{B5})\times\text{Volume of dilution taken from BOD bottle(ml)}}{\text{Volume of sample taken from BOD bottle(ml)}}$$

Here, S0 = Dissolved Oxygen of '0' day test

S5 = Dissolved Oxygen of '5' day test

B0 = Dissolved Oxygen of '0' day blank

B5 = Dissolved Oxygen of '5' day blank

6) *Total Dissolved Solids (TDS):* The initial dry weight of the crucible was noted and 5 ml of the water sample was filtered through Whatmann filter paper in the crucible. The crucible was then placed inside the hot air oven (103°C) for 1-2 hours and the sample was allowed to dry. After drying, the crucible was cooled to room temperature and the final dry weight of it was noted down and calculation of the total dissolved solids present in different samples was done [3].
7) *Total Suspended Solids (TSS):* The pre-weight of the Whatmann filter paper was noted down and it was then placed in the funnel. The water sample (10 ml) was filtered through it and then the filter paper was placed in a petri plate to allow it to dry in the hot air oven for 1-2 hours. After drying, the filter paper was allowed to cool and its weight was measured in a weigh balance and noted down. Calculation of total suspended solids present in different samples was done [3]. Bacteriological properties for the untreated water and effluent samples were analyzed for the determination of microbial load by Pour plate method or the Total viable count method and the Most Probable Number (MPN) technique was used for the verification of the presence of coliforms.
8) *Total Viable Count (TVC) method:* For detection of Total Viable Count of the untreated samples, dilution of each of the sample was prepared in the order of 10^{-1}, 10^{-2}…,10^{-6}. 0.1 ml from each of the dilution was transferred into sterile melted and cooled Nutrient agar tube and was mixed well and poured immediately in labelled, sterile petri plates. The plates were incubated at 37°C in the incubator for 24 hours. Total number of colonies on each of the plate was counted and the final number of organisms present in the sample was calculated [8].
9) *Most Probable Number (MPN) method:* Water sample was shaken vigorously before use so as to ensure uniform distribution of organisms. Inoculation of water sample was done in the following manner with the aid of sterile pipettes: 5 tubes of 10 ml double strength (2x) MLBB medium inoculated with 10 ml of sample, 5 tubes of 5 ml single strength (x) MLBB medium inoculated with 1 ml of sample, 5 tubes of 5 ml single strength (x) MLBB medium inoculated with 0.1 ml of sample and one tube of 5 ml single strength (x) MLBB medium was left uninoculated to act as a 'control.' All the tubes were incubated for 24-72 hours at 37°C. Tubes were examined after 24 hours for acid and gas production and if not found the tubes were reincubated. After examination of each 3 sets, the presence of acid and gas was recorded and the number of tubes showing acid and gas production were counted. Calculation of the most probable number/100 ml of the water sample was calculated by comparing with mcCrady table [8].

D. Physico-chemical and Bacteriological Analysis of Samples After Treatment with Calotropis procera Latex & Moringa oleifera Leaves Extract

A 2% concentration of latex of *Calotropis procera* and the leaves extract of *Moringa oleifera* was prepared and mixed well to dissolve the active components and allowed for 5 minutes. The samples were treated with the latex and leaves extract and the effect after treatment was studied as before for its physicochemical and bacteriological quality. A comparison was made to observe the effectiveness among the two. The reading for pH and turbidity was taken at 1 hour and 24 hours' interval after the treatment of the samples.

III. RESULTS AND DISCUSSION

A. Collection of Samples

River water was collected from Vanki river, Valsad, Gujarat. Effluent samples of Textile industry and Paper & Pulp Industry were collected from Vapi, Valsad, Gujarat as shown in Fig. 1.

Fig. 1: Samples from Vanki river, Textile Industry and Paper & Pulp Industry

B. Latex and Leaves Collection

Latex and leaves of *Calotropis procera* collected from Tithal road, Valsad, Gujarat is as shown in Fig. 2. Leaves collected from *Moringa oleifera* from Chhipwad, Valsad, Gujarat and its extract form is as shown in the Fig. 3.

Fig. 2: *Calotropis procera* and its latex

Fig. 3: *Moringa oleifera* and its leaves extract

C. The Effect of Calotropis procera Latex and Moringa oleifera Leaves Extract on Colour and Odour of the Samples

The raw, untreated sample of Vanki river had fishy smell with greenish colour, Textile effluent was odourless with indigo colour and Paper & Pulp industrial effluent had creamish colour with a woody smell. A significant reduction in odour and a varying difference in the colour of the samples took place with the latex of *Calotropis procera* in comparison with the leaves extract of *Moringa oleifera.*

D. The Effect of Calotropis procera Latex and Moringa oleifera Leaves Extract on Temperature of the Samples

A constant temperature of 23°C, 22°C and 23°C was found for Vanki river water, Textile effluent and Paper & Pulp industrial effluent, respectively both for untreated and treated samples.

E. The Effect of Calotropis procera Latex and Moringa oleifera Leaves Extract on pH and Turbidity of the Samples

A reduction in pH and turbidity was obtained well with the latex of *Calotropis procera* in comparison with the leaves extract of *Moringa oleifera* as indicated in TABLE I & TABLE II. The degree of pH reduction/ increment and degree of clarification increased with respect to the increase in time interval after the treatment of the samples. The increase in clarification degree was until the time when there was no further decrease in turbity of the samples and in this case, it was 24 hours (TABLE II).

TABLE I

Effect of *Calotropis procera* latex and *Moringa oleifera* leaves extract on pH of Vanki river water and effluent samples

pH reading									
Samples	**Before treatment**	**After treatment with *Calotropis procera* latex**				**After treatment with *Moringa oleifera* leaves extract**			
	Initial reading	**Final- 1 hr**	**% Reduction/ Increment**	**Final- 24 hrs**	**% Reduction/ Increment**	**Final- 1 hr**	**% Reduction/ Increment**	**Final- 24 hrs**	**% Reduction/ Increment**
Vanki river water	9	8	11.11%	7	22.22%	9	0.00%	7	22.22%
Textile effluent	10	7	30.00%	7	30.00%	8	20.00%	7	30.00%
Paper & Pulp Industrial effluent	8	7	12.50%	7	12.50%	8	0.00%	8	0.00%

The results obtained in the TABLE I indicates that the initial pH reading of 9, 10 and 8 for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent had shown good reduction with the latex of *Calotropis procera* after 1 hour of treatment itself by carrying out reduction in pH of 8 (11.11%), 7 (30.00%) and 7 (12.50%), respectively and after 24 hours of treatment, it carried out reduction in pH of 7 (22.22%), 7 (30.00%) and 7 (12.50%), respectively. While, the samples treated with *Moringa oleifera* leaves extract carried out reduction in pH of 9 (0.00%), 8 (20.00%) and 8 (0.00%) after 1 hour and 7 (22.22%), 7 (30.00%) and 8 (0.00%) after 24 hours for Vanki river water, Textile efflent and Paper & Pulp Industrial effluent, repectively.

TABLE II
Effect of *Calotropis procera* latex and *Moringa oleifera* leaves extract on turbidity of Vanki river water and effluent samples

Turbidity (Absorbance Reading at 530 nm)									
Samples	**Before treatment**	**After treatment with *Calotropis procera* latex**				**After treatment with *Moringa oleifera* leaves extract**			
	Initial reading	**Final- 1 hr**	**% Reduction/ Increment**	**Final- 24 hrs**	**% Reduction/ Increment**	**Final- 1 hr**	**% Reduction / Increment**	**Final- 24 hrs**	**% Reduction/ Increment**
Vanki river water	0.2	0.08	60.00%	0.02	90.00%	0.14	30.00%	0.05	75.00%
Textile effluent	1.39	0.59	57.55%	0.53	61.87%	1.03	25.90%	0.55	60.43%
Paper & Pulp Industrial effluent	1.53	0.76	50.33%	0.53	65.36%	1.42	7.19%	1.04	32.03%

In the case of turbidity, *Calotropis procera* latex had shown significant effect as shown in the TABLE II. Initial turbidity of the samples was 0.2, 1.39 and 1.53 and it carried out reduction in tubidity of 0.08 (60.00%), 0.59 (57.55%) and 0.76 (50.33%) after 1 hour of treatment and 0.02 (90.00%), 0.53 (61.87%) and 0.53 (65.36%) after 24 hours of treatment for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent, respectively was obtained after treatment of samples with latex of *Calotropis procera*. Leaves extract of *Moringa oleifera* had shown reduction in turbidity of 0.14 (30.00%), 1.03 (25.90%) and 1.42 (7.19%) after 1 hour of treatment and 0.05 (75.00%), 0.55 (60.43%) and 1.04 (32.03%) after 24 hours of treatment for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent, respectively.

F. The Effect of Calotropis procera Latex and Moringa oleifera Leaves Extract on Different Chemical Properties of the Samples

Different chemical properties such as Total suspended solids (TSS), Total dissolved solids (TDS), Biological oxygen demand (BOD) and Chemical oxygen demand (COD) was observed after treatment of the samples. It was determined that the latex of *Calotropis procera* had a good effect on these properties in comparison with the leaves extract of *Moringa oleifera* (TABLE III, TABLE IV & TABLE V).

TABLE III
Effect of *Calotropis procera* Latex and *Moringa oleifera* Leaves Extract on Different Chemical Parameters of Vanki River Water

Sample	Vanki river water		
Values/ Parameters	Initial	After treating with *Calotropis procera* latex	After treating with *Moringa oleifera* leaves extract
TSS	6000 mg/L	2000 mg/L	3000 mg/L
TDS	118000 mg/L	34000 mg/L	46000 mg/L
COD	928 mg/L	544 mg/L	864 mg/L
BOD	0.005 mg/L	0.004 mg/L	0.004 mg/L

The results listed in TABLE III depicts that untreated Vanki river water showed a reduction in TSS value from 6000 mg/L to 2000 mg/L after treatment with *Calotropis procera* latex and in the case of *Moringa oleifera* leaves extract, the value obtained was 3000 mg/L. The initial TDS values obtained for untreated Vanki river water was 118000 mg/L and it was reduced to 34000 mg/L after treatment with *Calotropis procera* latex and after treatment with *Moringa oleifera* leaves extract, the TDS reading was reduced to 46000 mg/L.
COD of untreated Vanki river water reduced from 928 mg/mL to 544 mg/L and 864 mg/L after treatment with *Calotropis procera* latex and *Moringa oleifera* leaves extract, respectively. While BOD value changed from 0.05 mg/L to 0.04 mg/L for both of the treatments.

TABLE IV
Effect of *Calotropis procera* Latex and *Moringa oleifera* Leaves Extract on Different Chemical Parameters of Textile Effluent

Sample	Textile effluent		
Values/ Parameters	Initial	After treating with *Calotropis procera* latex	After treating with *Moringa oleifera* leaves extract
TSS	5000 mg/L	1000 mg/L	3000 mg/L
TDS	6000 mg/L	2000 mg/L	2000 mg/L
COD	992 mg/L	608 mg/L	800 mg/L
BOD	0.297 mg/L	0.240 mg/L	0.251 mg/L

As indicated in Table IV, the initial TSS and TDS readings of untreated Textile effluent were 5000 mg/L and 6000 mg/L, respectively and it was reduced to 1000 mg/L and 2000 mg/L, respectively after treating with *Calotropis procera* latex. While *Moringa oleifera* leaves extract carried out reduction in TSS and TDS of 3000 mg/L and 2000 mg/L, respectively after treatment.
COD and BOD of untreated Textile effluent was 992 mg/L and 0.297 mg/L., respectively. COD value was reduced to 608 mg/L and 800 mg/L while BOD values changed to 0.240 mg/L and 0.251 mg/L after treatment with *Calotropis procera* latex and *Moringa oleifera* leaves extract, respectively.

TABLE V
Effect of *Calotropis procera* Latex and *Moringa oleifera* Leaves Extract on Different Chemical Parameters of Paper & Pulp Industrial Effluent

Sample	Paper & Pulp Industrial effluent		
Values/ Parameters	Initial	After treating with *Calotropis procera* latex	After treating with *Moringa oleifera* leaves extract
TSS	13000 mg/L	1000 mg/L	2000 mg/L
TDS	70000 mg/L	38000 mg/L	44000 mg/L
COD	1056 mg/L	800 mg/L	896 mg/L
BOD	0.041 mg/L	0.012 mg/L	0.022 mg/L

The above TABLE V shows that in the case of Paper & Pulp Industrial effluent, the initial TSS value reduced from 13000 mg/L to 1000 mg/L and 2000 mg/L after treatment with *Calotropis procera* latex and *Moringa oleifera* leaves extract, respectively. The initial TDS value of 70000 mg/L reduced to 38000 mg/L after treatment with *Calotropis procera* latex and after treatment with *Moringa oleifera* leaves extract, the TDS reading obtained was 44000 mg/L.
Untreated Paper & Pulp Industrial effluent showed COD and BOD values of 1056 mg/L and 0.041 mg/L, respectively. After treatment of the sample with *Calotropis procera* latex, COD value was reduced to 800 mg/L and with *Moringa oleifera* leaves extract, it was reduced to 896 mg/L. BOD values changed to 0.012 mg/L and 0.022 mg/L after treatment with *Calotropis procera* latex and *Moringa oleifera* leaves extract, respectively.
Thus, the results shown in TABLE III, TABLE IV & TABLE V, clearly depicts that in comparison with the leaves extract of *Moringa oleifera*, the latex of *Calotropis procera* gave better results not only for TDS and TSS reduction, but also for BOD and COD tests.

G. The effect of Calotropis procera latex and Moringa oleifera leaves extract on microbial load and total coliform count of the samples

The results indicated in TABLE VI shows that the microbial load and the coliform count obtained before treatment of the samples has been reduced by both the latex of *Calotropis procera* as well as the leaves extract of *Moringa oleifera*.

TABLE VI
Effect of *Calotropis procera* latex and *Moringa oleifera* leaves extract on the microbial load and coliform count of Vanki river water and effluent samples

Samples	Before treatment		After treatment with *Calotropis procera* latex		After treatment with *Moringa oleifera* leaves extract	
	Total Viable Count (cfu/ml) (24 hrs)	MPN/100 ml (72 hrs)	Total Viable Count (cfu/ml) (24 hrs)	MPN/100 ml (72 hrs)	Total Viable Count (cfu/ml) (24 hrs)	MPN/100 ml (72 hrs)
Vanki river water	186.5×10^2 cfu/ml	>1600	-	130	-	240
Textile effluent	295×10^3 cfu/ml	1600	-	<1.8	-	7.8
Paper & Pulp Industrial effluent	92 cfu/ml	>1600	-	7.8	-	7.8

The results in TABLE VI signifies that a reduction in microbial load of the samples has been obtained well by performing Total Viable Count (TVC) method. Total Viable Count of the untreated samples after 24 hours of incubation period were obtained as follows- 186.5×10^2 cfu/ml for Vanki river water, 295×10^3 cfu/ml for Textile effluent and 92 cfu/ml for Paper & Pulp Industrial effluent.

The total coliform count obtained by Most Probable Number (MPN) method was >1600 MPN/100 ml in case of both- untreated Vanki river water and Paper & Pulp Industrial effluent, and 1600 MPN/100 ml in case of untreated Textile effluent sample after 72 hours of incubation period. The count reduced to 130 MPN/100 ml, <1.8 MPN/100 ml and 7.8 MPN/100 ml for Vanki river water, Textile effluent and Paper & Pulp Industrial effluent, respectively after treatment with *Calotropis procera* latex. While in case of treatment with *Moringa oleifera* leaves extract, it reduced to 240 MPN/100 ml for Vanki river water and 7.8 MPN/100 ml for Textile effluent and Paper & Pulp Industrial effluent.

Thus, *Calotropis procera* latex had shown better results in comparison with *Moringa oleifera* leaves extract for total coliform count reduction and overally in case of textile effluent, a significant reduction was obtained compared to the other two samples.

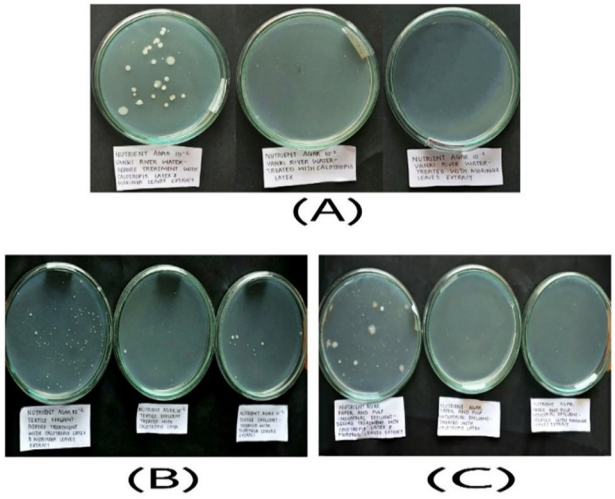

Fig. 4: Reduction in the microbial load of the sample- (A) Vanki river water (B) Textile effluent and (C) Paper & Pulp Industrial effluent

Fig. 4 shows that the untreated samples of Vanki river water, Textile effluent and Paper & Pulp Industrial effluent showed the presence of microbial load on Nutrient agar medium. Reduction in microbial load was obtained after treatment of the samples with *Calotropis procera* latex and *Moringa oleifera* leaves extract as observed in the second and third plates of Nutrient agar medium.

IV. CONCLUSIONS

Pollution rate has been elevated all over the globe, so there seems a huge demand for its control to avoid any harsh effects on the ecosystem. The main agenda implemented in this study was to treat the polluted waterbodies in a way which becomes feasible in terms of cost as well as the method employed. Bioremediation is effective in this case as it requires less manpower, cheaper techniques, is economically beneficial and a better alternative to other conventional methods.

The present investigation has been conducted for the bioremediation purpose of river water and industrial effluents using cost effective natural plant sources. *Calotropis procera* latex as well as *Moringa oleifera* leaves extract was used as an alternative to traditional chemical and physical methods. The study depicts that *Calotropis procera* latex has shown promising results in the reduction of colour, odour, pH, turbidity, TDS, TSS, BOD, COD, microbial load and total coliform counts of the water and effluent samples.

From the overall study, it can be concluded that *Calotropis procera* gave better results compared with *Moringa oleifera* and can be recommended as a preferable bioremediation method to handle the future related problems. Comparatively, *Calotropis procera* has good clarifying and coagulatory properties and can be important economically and socially. Also, this study could be way more beneficial in making further improvements and employing it as a cheap natural bioremediation source.

As less research has been conducted on the bioremediation potential of *Calotropis procera* in comparison with *Moringa oleifera*, this study could be beneficial in making further improvements and employing it as a cheap natural bioremediation source.

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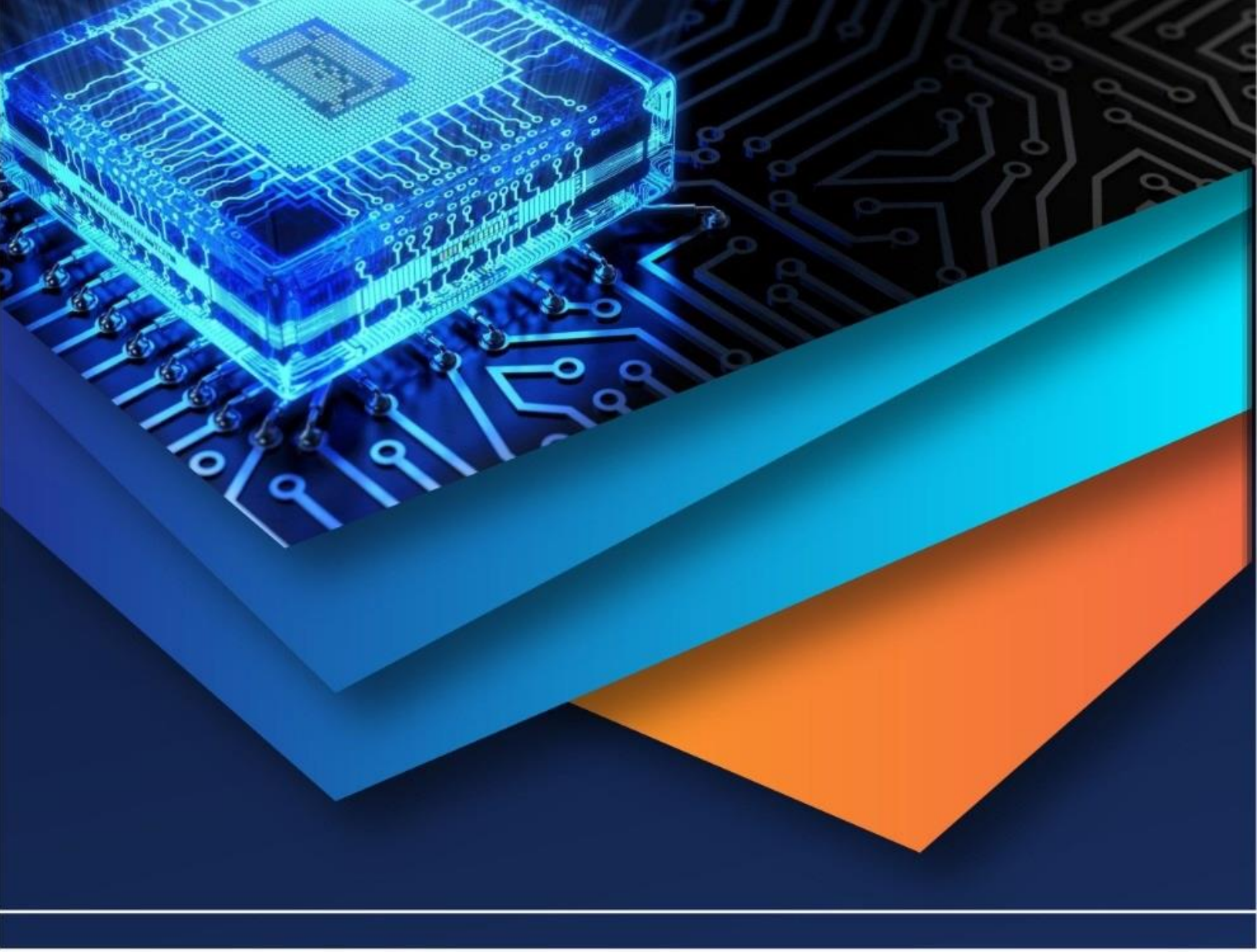

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