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The Effect of *Moringa oleifera* as a Primary Treatment in Urban Wastewater in Martínez De La Torre, Veracruz

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ABSTRACT

Wastewater treatment is a priority, as most of this is discharged into rivers, lakes, seas, and soil. Since there is no treatment facility in Martnez de la Torre, Veracruz, these fluids are released straight into the Filobobos River without treatment. Hence, the *Moringa oleifera* seed was evaluated as a primary treatment. In this study using wastewater from a direct discharge, pH, turbidity, total suspended solids, and conductivity were determined as control measures. In the jar test, the treatments were carried out using different amounts of coagulant salts (aluminum and iron sulfate) and moringa powder; starting the agitation at 120 rpm for 5 minutes and immediately it was reduced to 60 rpm in 10 minutes with a rest time of 1 hour. After that, the quality parameters were analyzed. The moringa coagulant achieved an average maximum reduction of 71.84 per cent and 89.36 per cent in turbidity and Total Suspended Solids, respectively, which was higher than the salts used. Furthermore, its application had no effect on pH and conductivity parameters, and the coagulant based on *Moringa oleifera* as a primary treatment agent, since these qualities do not alter and post-treatment is not required, as in the case with salts.

INTRODUCTION

Water is the most significant resource in this study and our daily lives, and its availability is decreasing as a result of physical, chemical, and/or biological contamination, which degrades quality and has an impact on health, social, technical, and economic development.

Currently, research into better processes and the elimination of contaminants that impair water quality is of the utmost importance; one of these processes is the improvement in coagulation, using natural agents which can reduce the process and the cost of operation.

As a result, the need to detoxify effluents is becoming increasingly essential, necessitating the search for innovative solutions based on research into various water treatment methods that enable improved quality and adequate protection of water resources. Table 1 shows typical pollutants in wastewater.

The advantages of using natural methods for the treatment of domestic wastewater are: the implementation of relatively simple technology, low operating and investment costs, low energy consumption, the treatment process can be adapted quickly, achieving a high level of performance after the start of operations, and high nutrient removal (Rozkosný et al. 2014) since they possess a complex chemical structure, which generally consists of various types of polysaccharides and proteins. Some of them have coagulating or flocculating qualities, and in many places, the natives use them scientifically to purify murky water with excellent results (Vásquez 1994). Among the group of known substances that possess these binding properties are some organic compounds of plant origin, which can be obtained from the stem or seeds

Table 1: Contaminants in water.

Class	Examples
Suspended solids	Rubbish, water erosion, powder, and colloids.
Organic matter	Organic chemicals and organic residues like lees or sediment.
Dissolved ionics	Heavy metals, nitrates, carbonates, chlorates.
Microorganisms	Pathogens, viruses, and parasites
Gases	Methane, carbon monoxide, carbon dioxide, and sulfide
Other	Micro plastic, medicines, and colorants

of a huge variety of plants such as beans, corn, *Moringa oleifera*, among others (Norde 2011).

MATERIALS AND METHODS

Twelve urban residual water samplings were made from a direct discharge located in the eastern coordinates: 703 632.2, North: 2 219 480.1 Zone: 14 hemispheres: North; As can be observed in Fig. 1, the discharge of residual water is continuous during February and May, as the dry season in Martnez de la Torre is anticipated during these months. Each sample was tested for pH, conductivity, turbidity, Biochemical Oxygen Demand in Five Days (BOD5), Total Suspended Solids (TSS), Fats and Oils, Fecal and Total Coliforms, Total Nitrogen, and Ammoniacal Nitrogen, following the Techniques outlined in the Standard Methods (APHA-AWWA-WPCF 1998).

Because the residual water in the jar test had sediment particles, the dose of coagulants 300, 600, and 900 mg.L^{-1} in a multiple agitation equipment for 5 min at a revolution of 120 rpm and then 10 min at 60 rpm in the jar test, leaving to stand and settle for one hour to obtain coagulation and a better reading of data. Since documented data such as those of Solís-Silvan et al. (2012) show that chemical coagulants such as iron sulfate and aluminum sulfate have an ideal floc formation range of 6.0-8.0, the pH was used without dampening the water for this operation.

Fig. 1: Wastewater discharge point.

To determine the optimal doses of the coagulation-flocculation process, 3 doses were tested for each coagulant (300, 600, and 900 mg) evaluated in triplicate. In jar testing, tests were conducted on leftover water that had been exposed to the coagulation process. The turbidity removal, measured in NTU, was used to evaluate the results. The results were compared with the different coagulants to determine the most effective one. In addition, parameters such as pH and conductivity were monitored.

The reduction of Turbidity was determined by the HACH 2100AN team performing 27 tests: 9 using *Moringa oleifera* powder in the coagulation process, 9 using industrial grade aluminum sulfate, and 9 with reactive grade iron sulfate heptahydrate; with doses of 300, 600, and 900 mg.L^{-1} of each coagulant.

The results of the optimal dose were subjected to an analysis of a statistical mean test with a confidence level of 95%, and the same statistical method was performed for the conductivity and hydrogen potential parameters.

RESULTS AND DISCUSSION

Results

Table 2 shows the findings of the residual water characterization, and Table 4 lists the treatments that were performed to find the best coagulant doses. The clearance efficiencies

Table 2: Characterization of the wastewater generated in Martínez de la Torre, Veracruz.

Parameter	Unit	Average	Minimum	Maximum
pH	pH Units	7.77	7.65	7.9
Conductivity	mS.cm^{-1}	638.67	636.00	642.00
Turbidity	NTU	25.00	36.70	16.90
BOD_5	mg.L^{-1}	56.60	54.50	58.00
TSS	mg.L^{-1}	49.70	20.00	112.00
Fats and oils	mg.L^{-1}	13.31	13.10	13.45
Nitrogen Total	mg.L^{-1}	10.89	10.72	11.00
Ammoniacal Nitrogen	mg.L^{-1}	9.76	9.67	9.85
Fecal Coliforms	NMP.100mL^{-1}	4 600.00	4 600.00	4600.00
Total Coliforms	NMP.100mL^{-1}	24 000.00	24 000	24 000.00

Source: Author

of turbidity and TSS obtained to estimate the appropriate coagulant dose are shown in Table 5.

DISCUSSION

As can be seen from the characteristics of the wastewater obtained and compared to Metcalf and Eddy, Inc. (1998) classification, wastewater is classified as gross domestic water of weak concentration; however, as shown in Table 3, wastewater has three parameters that override national and international Mexican standards.

According to the findings, the United States Environmental Protection Agency (1998) recommends that the turbidity of residual water at the exit of the clarification processes (coagulation-flocculation) be less than 1 NTU because filtration processes can cause pressure elevation and inadequate treatment; and the American Water Works Association (2001) recommends 1 NTU as the average value and 5 NTU as the maximum allowable value for clarified water. On the other hand, the European Union (1998) established 2 and 1 NTU, respectively, and the World Health Organization (WHO) suggests that the median turbidity of treated water is ideally less than 0.1 UNT for effective disinfection, although the WHO does not determine an admissible value of turbidity based on health criteria (WHO 2006, Montoya et al. 2011).

However, water turbidity can be considered as a parameter both in supply sources and in distribution processes and systems (Burlingame et al. 1998, Lusardi & Consonery 1999, Letterman & Viswanathan 2004), since it is a fast and inexpensive interpretation to interpret water quality (Burlingame et al. 1998).

Furthermore, turbidity is associated with the potential microbiological risk in water for human consumption.

In the case of coliforms, the microorganisms that make up this group, Escherichia, Enterobacter, Klebsiella, Serratia, Edwarsiella, and Citrobacter, live as independent saprophytes or as intestinal bacteria; fecal coliforms (Escherichia) are of intestinal origin (Canosa 1995), and their presence in water indicates recent bacterial contamination and is an indicator of water body degradation and it was recommended by the United States Environmental Protection Agency (1998) and is based on studies that showed that they have a direct relationship with diseases associated with swimming in marine and freshwater environments (Arcos-Pulido et al. 2005).

The reduction of TTS and turbidity have a close relationship, as seen in Fig. 2. In Fig. 3 you can see that the TSS is present homogeneously in the samples. TSS is responsible for the gray color of domestic water, and when these waters are treated, the solids agglomerate and degrade because of gravity.

Similarly, Henckens et al. (2002) found that turbidity is a metric that is affected by a variety of factors, the most important of which are the properties of the suspended particles in the water, such as form, color, size, and organic and inorganic matter ratio (BOD/COD).

Studies such as those by Tomanovic & Maksimovic (1996) and Henckes et al. (2002), show that there is a good correlation between TSS and turbidity in water bodies, while Bertrand-Krajewski (2004) discovered a linear relationship

Table 3: National and international maximum allowable limits.

Parameter	Unit	Average amount	MAL 1	MAL 2
Turbidity	NTU	25.00	-	2
Fecal Coliforms	NMP.100mL^{-1}	4 600.00	1 000	1 000
Total Coliforms	NMP.100mL^{-1}	24 000.00	-	1 000

*MAL: Maximum Allowable Limit; **MAL 1: Maximum Allowable Limit NOM-001-SEMARNAT-1996; ***MAL 2: Maximum Allowable Limit Environmental Protection Agency 1998

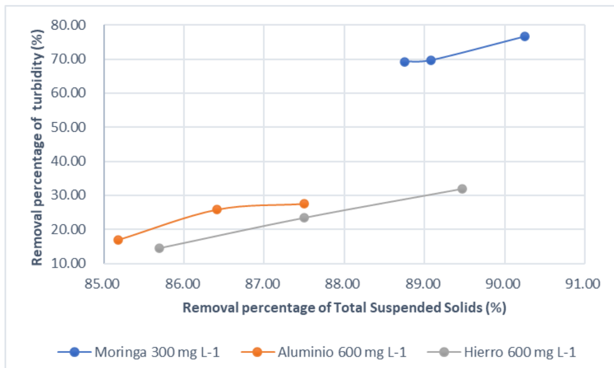

Fig. 2: Optimal per centages of pollutant removal.

Fig. 3: Homogenization of domestic wastewater from Martínez de la Torre, Veracruz.

between these parameters by analyzing unit networks in dry weather conditions and concluded that turbidity is a good indicator of TSS in wastewater, which we can confirm in Fig. 2 because increasing the percentage of turbidity removal is directly proportional to the reduction of TTS.

A 95 per cent mean analysis test was used to determine the significant differences (Fig. 4). It can be seen that the chemical coagulants (Industrial Aluminum Sulfate and Iron Sulfate Heptahydrate reactive grade) both had the same percentage of turbidity removal statistically at a concentration of 600 $mg.L^{-1}$, whereas the use of *Moringa oleifera* at a concentration of 300 $mg.L^{-1}$ has a different statistical percentage than this, being this the concentration used.

Subsequently, the removal percentage of TTS was observed by the same statistical method at 95% as shown in Fig. 5. The concentrations of chemical coagulants at 600 $mg.L^{-1}$ and *Moringa oleifera* at 300 $mg.L^{-1}$ show statistically the same efficiencies, in addition to being the most efficient with removal averages of 86.36%, 87.55%, and 89.36% respectively.

The effects of the coagulants were analyzed using surface tests to see how they affected the pH and conductivity of the samples before and after the coagulation-flocculation treatments proposed by chemical salts and *Moringa oleifera* powder. Fig. 6 shows that the turbidity removal and TSS percentages corresponding to *Moringa oleifera* powder show positive pH differences, whereas the results of the coagula-

Table 4: Treatments to determine the optimal concentration values per coagulant.

Treatment	pH	Coagulant [mg]			Sample [1000 mL]
Moringa oleifera	7.0	300	600	900	1 000
Aluminum sulfate	7.0	300	600	900	1 000
Iron sulfate	7.0	300	600	900	1 000

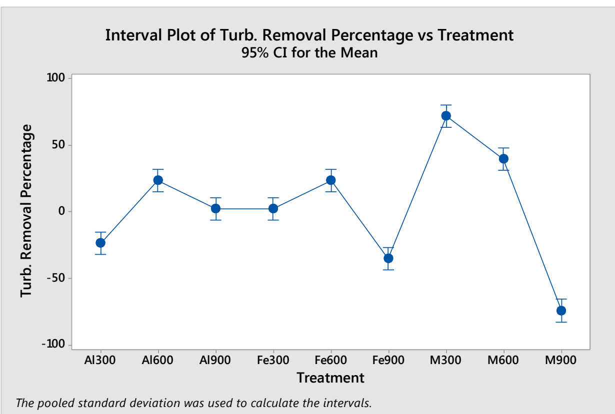

Fig. 4: Mean test with a 95% confidence level for the determination of the optimal dose vs. turbidity.

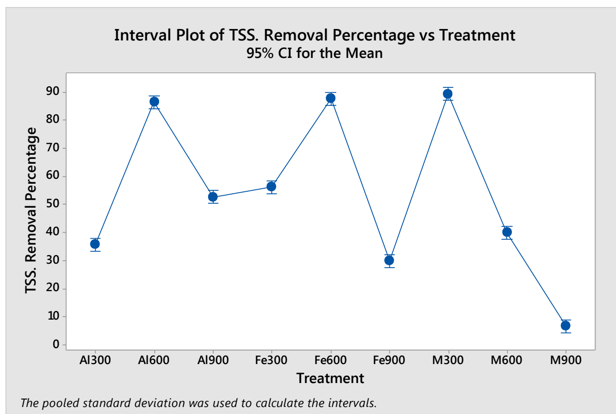

Fig. 5: Mean test with a 95% confidence level for the determination of the optimal dose vs TSS.

Table 5: Per centage of removal of turbidity and total suspended solids.

Treatment	Concentration	Turbidity removal per centage			TSS removal rate		
Moringa oleifera	300	69.23	69.60	76.68	88.75	89.08	90.25
	600	28.79	31.43	58.70	38.75	40.14	41.11
	900	-74.79	-73.85	-73.3	6.54	6.66	6.80
Aluminum sulfate	300	-25.75	-24.74	-20.54	33.93	36.36	36.93
	600	17.03	25.82	27.52	85.18	86.41	87.50
	900	2.02	2.50	2.56	50.00	50.72	57.25
Iron sulphate	300	1.87	1.89	3.79	54.27	56.25	57.89
	600	14.53	23.44	31.90	85.69	87.50	89.47
	900	-38.18	-36.75	-29.88	28.15	30,71	30,89

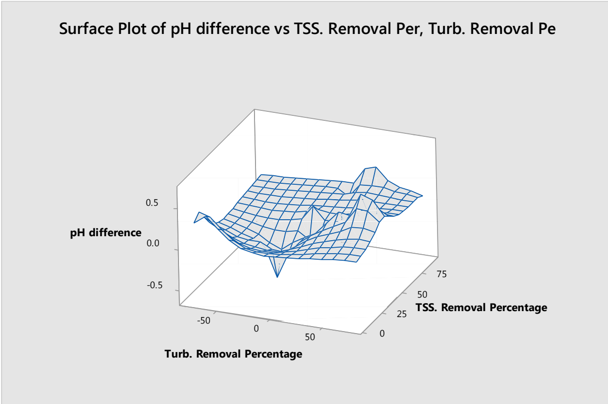

Fig. 6: Test of surfaces applied at pH and removal of contaminants after treatment.

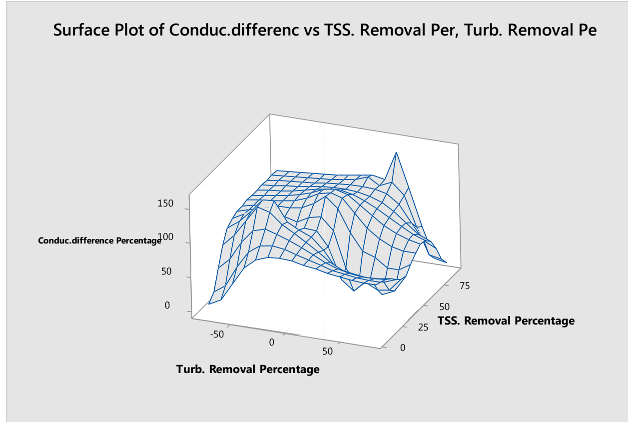

Fig. 7: Surface test applied to the percentage of difference in conductivity and removal of contaminants after treatment.

tion tests with aluminum and iron show negative peaks, due to the pretreatment with aluminum.

Fig. 7 shows that chemical salts tend to increase the conductivity of treated wastewater due to the presence of metal ions. Sandoval & Laines (2013) compared the coagulation efficiency of three types of solutions obtained from *Moringa oleifera* seeds and aluminum sulphate, finding that moringa treatments did not change the chemical properties of the treated water, which is confirmed in said work, since the said solute did not change the properties of conductivity and pH during experimentation, whereas aluminum sulphate, as a chemical salt with metal ions, tends to acidify the water.

CONCLUSION

For the treatment of wastewater from the sewage system in Martnez de la Torre, Veracruz, moringa seed powder is effective as a flocculant and natural coagulant. The appropriate dose of moringa powder for urban wastewater from Martínez de la Torre, Veracruz is 300 $mg.L^{-1}$. Because it did not present free sulfate ions in the medium after the decantation period, the optimal dose of *Moringa oleifera* obtained the maximum percentage of turbidity degradation (71.84 per cent) in 15 minutes of stirring and 1 hour of rest. The decrease in Total Suspended Solids from the moringa coagulant was statistically similar to that obtained by aluminum and iron salts.

Moringa oleifera seed powder does not produce changes in control parameters such as pH and conductivity, whereas aluminum and ferric salts in this experiment reported 42% and 56% due to the presence of metal ions in the wastewater.

The use of *Moringa oleifera* powder is a natural, efficient, and easy to use as an alternative. This type of unconventional treatment will be able to recover the water used within the metropolitan area of Martínez de la Torre and improve the quality of the water of the Filobobos river, in addition, to contributing to the reduction of sludge.

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