International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

ZOO WASTEWATER TREATMENT USING MORINGA OLEIFERA: A Review

Sujay S. Rashinkar [1], Sanjana M[2], Drushya PM[3], Karthik Kumar K[4], D. Istalingamurthy[5]

[1-4]*Scholars, Department of Environmental Engineering, JSSSTU-SJCE, Mysuru- 06, Karnataka, India*
[5]*Professor, Department of Environmental Engineering, JSSSTU-SJCE, Mysuru- 06, Karnataka, India*

Abstract - *The application of environmentally friendly wastewater treatment processes is becoming more and more popular because these processes are environmentally friendly and benefit us by reducing cost and have a great biodegradability. In this project work, the wastewater was collected from the lake which is situated within 200m of the zoo premise. Before conducting laboratory-scale methodological studies, analysis of wastewater for probable constituents or parameters was carried out. This document compiles information about the use of OM in modern applications, mainly for wastewater treatment. The obtained result showed high BOD, whereas Nitrate nitrogen, TSS, Turbidity, COD, and pH were acceptable. This project study showed that this treated wastewater can be reused for other purposes after disinfection, which can reduce the cost of using municipal water and help in improving water management inside the zoo premises.*

Key Words: *Moringa oleifera*, Natural Coagulant, Zoo Wastewater, Coagulation, Alum.

1. INTRODUCTION

A zoo is a place where animals stay in captivity and is put on a show for humans to view. The phrase "zoo" is brief for "zoological park". Zoos incorporate wide kinds of animals which can be native to all components of the Earth.

Though humans domesticated animals for lots of years, those collections have no longer resembled cutting-edge zoos. The first zoos had been created as private collections utilizing the wealthy to show their energy. These personal collections had been called menageries. Wall carvings located in Egypt and Mesopotamia are evidence that rulers and aristocrats created menageries as early as 2500 BC. They left data of expeditions to distant places to convey a lower back exceptional animal which includes giraffes, elephants, bears, dolphins, and birds. There is evidence that ancient zoo proprietors employed animal handlers to make certain their animals thrived and reproduced.

From the mid-20th century, the zoos had been finding approaches to help conserve wild animals and their habitats, and the animals in our zoos now fulfill several roles, from schooling to ambassadors for his or her species. Some of the species we keep are extinct inside the wild and could have disappeared absolutely without zoos. The modern-day zoo has changed to reflect this new position and advanced dramatically over the years. It is now a complicated operation, with experts in many special disciplines such as animal husbandry, health, nutrients, behavior, and statistics preserving.

The zoo conservation strategy aims to help conserve the earth's rapidly disappearing wild lifestyles and biodiversity in widespread. Further, these steps helped to create attention amongst people regarding the conservation of nature. Zoological gardens provide a possibility to open up a whole new global of curiosity and interest, and sensitize visitors regarding the value and want for conservation of flora and fauna.

One of the zoo's targets is to encourage zoo site visitor's empathy for wild animals for knowledge and awareness about the need for conservation of herbal sources and production the ecological stability. The goal of the sector zoo conservation method is to help preserve the earth's fast-disappearing wild existence and biodiversity in general. Further, these steps helped to create cognizance among humans concerning the conservation of nature. Zoological gardens offer a possibility to open up an entirely new world of interest and sensitive visitors regarding the price and need for conservation of the natural world.

1.1 Sources of Zoo Wastewater

Hosing down of animal exhibits, exhibit moat filling, toilet flushing, lawn and garden irrigation. Sources are also from cage pools, fountains, cage wash water, waste from zoo hospitals.

1.2 The important constituents of Zoo Wastewater:

Zoo animals pass long time in water, and all are dependent upon supplies of good quality water. The cost of water in the zoo has increased and will continue to increase. The generation of wastewater in the zoo is not continuous i.e., high flow occurs in morning hours because of the cage and other washing activities and decreases inter.

The important constituents of zoo wastewater include:

a) Physical constituents - color, odor, and solids.

b) Chemical constituents - organic matter, inorganic matter (chloride, nitrogen, and Sulphur), and gases (carbon dioxide, hydrogen sulfide, ammonia, and methane).

c) Biological constituents - bacteria, protozoa, and viruses.

2. A Comprehensive study of reuse of treated Zoo wastewater

2.1 Taronga Zoo Wastewater Treatment and Reuse System

Taronga zoo is located in Mosman on the shores of Sydney harbor, on 120 hectares of sloping land. Between 1989 and 1992, Mosman Council's water quality monitoring showed high fecal coliform counts at beaches adjacent to Taronga zoo. Water from the animal cage wash down and all stormwater discharged directly into the harbor causing concerns for public health, beach closures, and complaints from residents. In 1992, Taronga Zoo, in partnership with Clean up Australia, Sydney Water Corporation, and the Department of Health launched a program to clean up the runoff from Taronga zoo.

The wastewater treatment plant recycles first flush stormwater and wastewater from animal cage hoedowns and moats. It treats 100-650 m^3/day with an average flow of 250 m^3/day.

1. Screens and grit chamber-removes solids.
2. Aeration basin reduces nutrients.
3. Clarifier-removes remaining solids.
4. Microfiltration-removes bacteria and viruses.
5. Ultraviolet disinfection- destroys remaining pathogens.

The following benefits have been observed at the zoo by providing a wastewater treatment system.

1. Improved discharge water quality into Sydney.
2. Reduced usage of Sydney's freshwater supply, a saving of $70,000 per year.
3. Demonstration of using recycled water.

Recycled water is distributed around the zoo through a separate reticulation system comprising of 2,500m of PVC pipe. It is used for:

1. Lawn and garden irrigation-automatically controlled popup sprinkler systems that irrigate 10ha of lawn at night.
2. Animal exhibit hose down.
3. Moat filling-moats are barriers between the exhibit and visitors and provide animal drinking water.
4. Toilet and urinal flushing.

2.2 Victoria Zoo Wastewater Treatment and Reuse System

Victoria zoo is one of the oldest zoos in Australia and it is modeled based on the London zoo. This zoo first opened its gate to visitors in the year 1862. Before the introduction of this zoo, the animals were housed at the botanical gardens in Melbourne. The zoo is spread across an area of 55 acres. In recent years the structure and management of the Zoo have been completely transformed with Zoos Victoria now located on 3 sites at Parkville, Worrigee, and Hallsville. The Zoo has been progressively implementing a Long-Range Master Plan as part of a modernization program. At the Parkville site, many animal enclosures have been rebuilt along with enhancements to the landscape and botanical setting.

The water recycling project was implemented to resolve a long-term wastewater discharge problem as well as improve water conservation practices. The Zoo resolved in consultation with the EPA, Melbourne Water, and the City of Melbourne to recycle and reuse stormwater via an on-site water recycling plant. The new plant exemplifies Zoos Victoria's commitment to sustainable practices and the environment.

The whole of the Zoos stormwater drainage system, including animal wash down areas, converges at one point of discharge at the northern end of the site. A diversion weir has been constructed at that point with a baffle that diverts dry weather runoff together with first flush wet weather flows to the water recycling plant. The water is stored in two large underground concrete holding tanks, one 750 KL raw water tank and one 145 KL treated water tank. The harvested water is recycled to class 3A quality by a sophisticated reverse osmosis plant. The recycled water is then reticulated throughout the Zoo for use in ponds, animal hose-down areas, and landscape irrigation as part of a water management program. An interactive "water discovery exhibit" weaves its way throughout the Zoo, culminating in the water recycling plant building at the northern end of the site.

List of the innovative facilities and methods adopted to reduce waste:

1. Rainwater harvesting.
2. Waste to energy plant.
3. Wetland boardwalk.
4. Composting facility.
5. Zero waste to landfill.

Victoria zoo is working towards zero waste to landfill in their three zoos. This is achieved by ensuring the

collection of all recyclable materials. The zookeepers collect over 800 kg of elephant dung per day and recycle it. They even may park benches to recycle plastics from zoo operations. They have opted for "NO STRAWS" in all zoos and eliminated single-use plastics.

Public space recycling

Onsite at Melbourne Zoo they have a three-bin system: waste, green waste recycling, and comingled recycling. Green waste is composted onsite using the in-vessel composter. At Hallsville Sanctuary and Worrigee Open Range Zoo, they currently have a two-bin system: waste and commingled recycling. The aim is to provide the three-bin system across our three zoos: Rubbish, Bottles and Cans, and Compostable Food & Paper.

Composite Organic Waste

At Melbourne Zoo, animal waste is collected and composted together with the visitor and horticulture waste. This material is composted onsite through an in-vessel composter called **Hot Rot**. It's then commercially blended to create Zoo that is suitable for use as soil conditioners and organic fertilizers.

Reusable goods

Many new exhibits are made up of materials that are reclaimed and recycled from previous structures.

Importance

- Use of eco-friendly Moringa Oleifera as a natural coagulant for the process of coagulation to treat wastewater.
- They are respectful of the environment since they are composed of natural and sustainable compounds throughout their life cycle.
- The cost of natural coagulants will be less compared to chemical coagulants.
- The natural coagulant prevents the wear of the establishment and the machinery, achieving lower maintenance costs.
- Moringa oleifera is a non-hazardous (low concentrated) stifling plant whose seeds contain an edible oil and water-soluble substance so that it won't leave a residue that is harmful to the environment.

2.3 Importance of treating and reusing wastewater

Importance of reusing water-The global crisis of water consumption is one of the serious issues that is faced by the human race. Many parts of the world are depleted with the privilege of supply of pure water; main reasons include excessive wastage, leakage, and contamination, letting of rainwater as a run-off, etc. Hence, it is our responsibility to work in the path of reducing water consumption by following various methods such as rainwater harvesting, recycling, and reusing wastewater. In many cases reusing wastewater without prior treatment may be harmful due to its varied characteristics in such situations the wastewater has to undergo treatments (physical, chemical, biological) to be reused.

The main objective of this study is to use Moringa Oleifera seeds as a natural coagulant as it has sufficient removal capability for the main pollutants such as pH, Turbidity, Nitrates, Sulphates, TDS, TSS, BOD and COD in the Zoo wastewater.

3. PROPERTIES OF MORINGA OLEIFERA

Moringa oleifera has been frequently reported for its wide use as a vegetable, functional food, and medicinal plant with a rich nutritional composition and diverse pharmacological activities. In some reports analyzing Egyptian MO seeds, a large amount of fatty acids-particularly omega 9 (76%) and saturated fatty acids (e.g., palmitic, stearic, and arachidic acid) (12%)-were found and the oil obtained from the seeds showed nontoxic effects. The MO seed lipid content has been suggested to be related to harvesting practices or regional conditions leading to variations in the range of 30% to 42%. It has been reported that the presence of fatty acids does not significantly affect MO seed coagulation activity, and therefore oil extraction is not needed to use MO seeds as a coagulant in coagulation-flocculation (C-F) processes. However, it has also been reported that keeping the MO seed oils could have additional benefits because the presence of some fatty acids (e.g., palmitoleic, oleic, linoleic, linolenic, cis-11-eicosenoic, and cis-11,14-eicosadienoic acid) in the range of 0.01% w/v significantly prevent the formation of S. aureus biofilm.

Crude extracts from different tissues of MO have been analyzed that show antibacterial activity against both gram-negative and gram-positive bacteria. Among them, extracts from leaves, bark, roots, flowers, fruit, and seeds have been reported.

3.1 Scope

The use of Bio-coagulants in Zoo wastewater treatment has the following benefits:

- Reduced expenditure on the processing of costly chemicals.
- The process is very economical for developing countries.
- Use of Moringa Oleifera seed as a natural coagulant because they are locally available, eco-friendly, does

not affect human and environment.
- The process being biological does not generate any non-treatable waste.
- Natural coagulants do not increase the acidity of wastewater.

3.2 Research Gap

- Natural coagulants are not being used on large scale they are only being restricted to a lab study.
- If used in more quantity it increases the organic load in water which again has to be treated.
- Since these natural coagulants contain organic matter, they require proper storage, and the storage requirements are not been identified properly.
- And some plants are only locally available so, proper storage is a must otherwise the efficiency of the coagulant decreases over the period.

4. RESULTS AND DISCUSSIONS

Water is been vastly used for animals, gardens, commercial establishments, and sanitation facilities inside zoo premises. The wastewater generated for these purposes has been analyzed for the following parameters. To decide the type of treatment that can be implemented to reuse the wastewater.

Table 4.1 Initial Wastewater Characteristics

Parameters	Results
pH	7.85
Turbidity	170 NTU
TSS	246mg/L
TDS	250mg/L
BOD	720mg/L
COD	650mg/L

Table 4.2 Comparison between MO seeds and Alum [14]

Parameters	By Using MOSP as Coagulant				By Using Alum as Coagulant			
		After Treatment				After Treatment		
	Before Treatment	500mg	200mg	50mg	Before Treatment	500mg	200mg	50mg
pH	7.05	7	7	7.05	7.05	2.4	2.8	3.1
TSS	633	196.23	213	222	633	208.9	229.9	238.5
TDS	800	256	256	289	800	280	304	315
COD	7500	2850	3015	3156	7500	3075	3267	3316
BOD	2130	1043	1103	1213	2130	1044	1258	1364.9
TURBIDITY	265	108.65	121.2	129.5	265	113.95	136.1	149.2

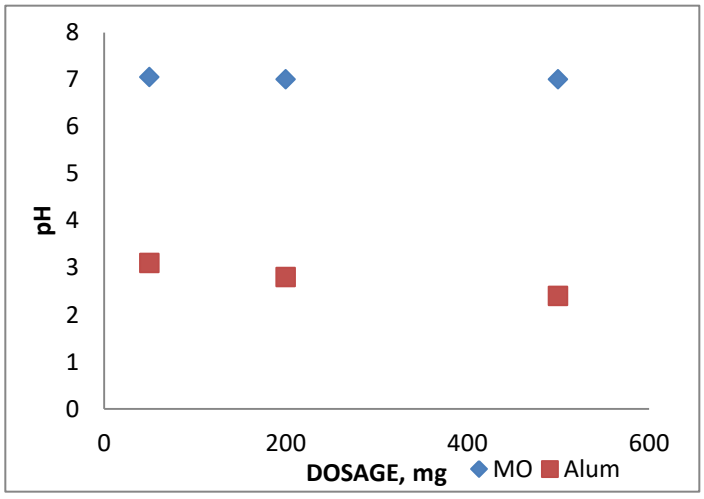
The handling and treatment of wastewater is a very major concern as the urban population increases day by day and the sources of pure water are used to contaminate by the direct pouring of untreated water. So, treatment of water is very necessary before mixing any wastewater (Municipal, dairy, industrial, etc.) moved to the reasonable water resources.

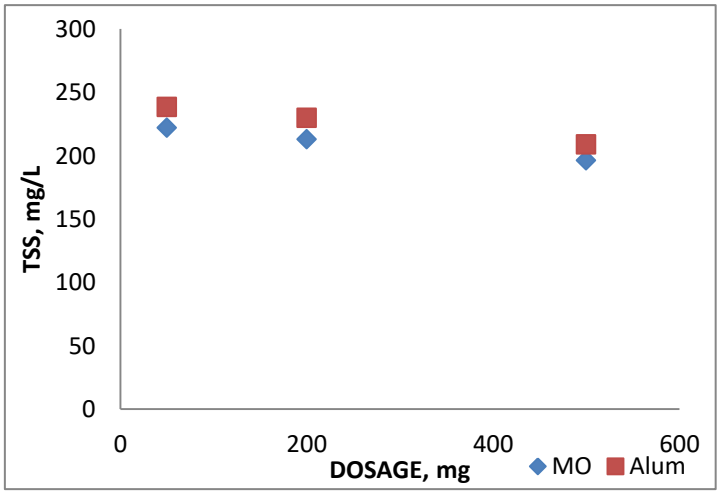
In the study, different quantities of coagulants doses (50 mg, 200 mg, and 500 mg) were used but it is found that increasing the amount of coagulant increases the removal but it is not proportional and significant concerning the quantity of coagulant added.

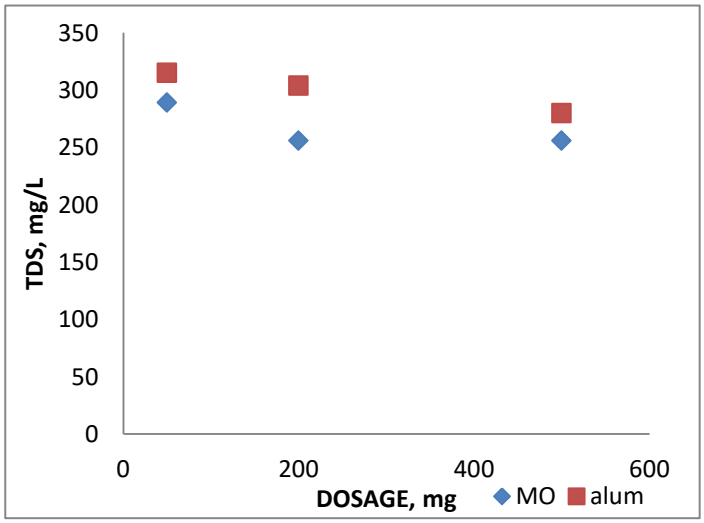
- Parameters like pH, Turbidity, TSS, TDS, COD & BOD of Zoo wastewater has been analyzed as per the standard method
- By referring ("International Conference on "Recent Advances in Interdisciplinary Trends in Engineering & Applications", Treatment of Wastewater Using Natural Coagulants) MO dosage to treat ZOO WW is calculated.

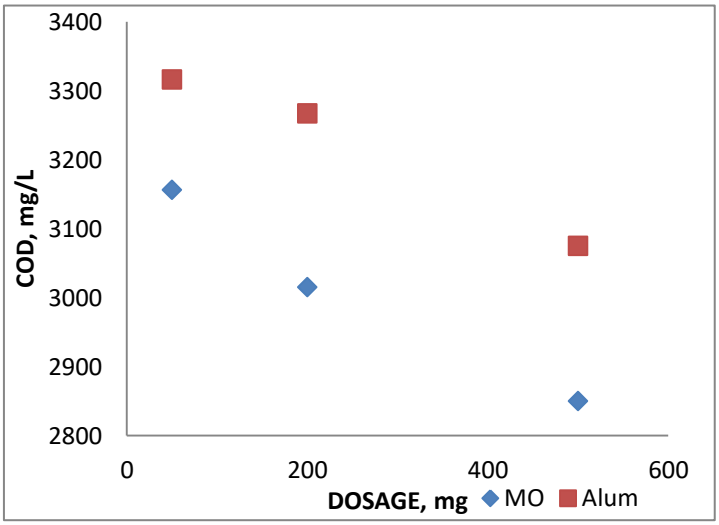
The advantages of coagulation are as follows:

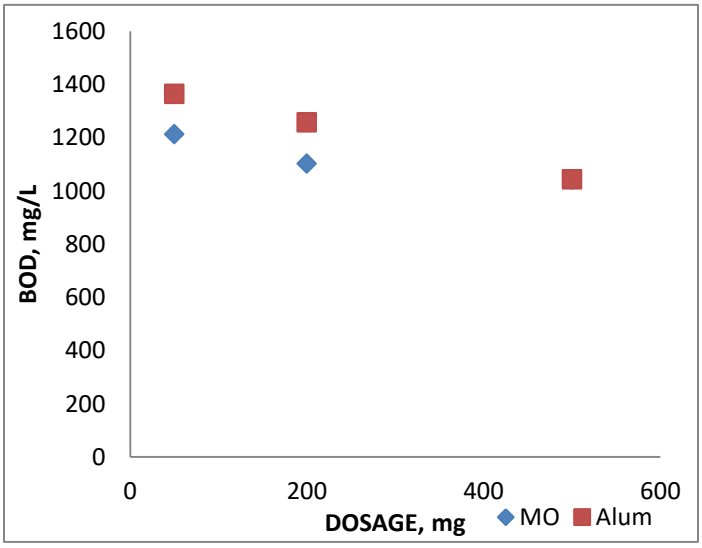
- It reduces the time required to settle out suspended solids and is very effective in removing fine particles that are otherwise very difficult to remove.
- Coagulation can also be effective in removing many protozoa, bacteria, and viruses.

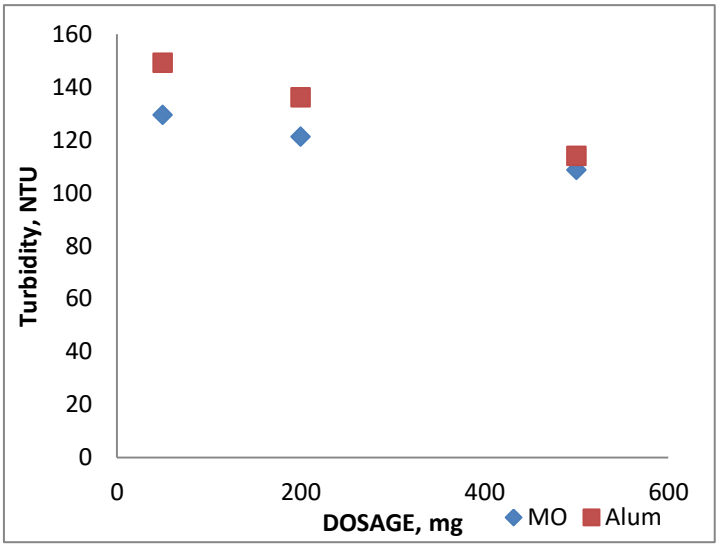












Sl No.	Parameter	Initial Value	50 mg	200 mg	500 mg
1	TSS	246 mg/L	86.29	82.78	76.26
	% removed		64.92%	66.35%	69%
2	TDS	250 mg/L	90.35	80	80
	% removed		63.87%	68%	68%
3	COD	650 mg/L	273.52	261.3	247
	% removed		57.92%	59.8%	62%
4	BOD	720 mg/L	410.04	372.88	352.58
	% removed		43.05%	48.21%	51.03%
5	Turbidity	170 NTU	83.07	77.75	69.7
	% removed		51.13%	54.26%	59%

Table 4.3 various dosages of MO seed used to treat Zoo wastewater (By referring the table 4.2)

1. Effect on pH

- From Table 4.3 it is found that the treatment of wastewater with Moringa Oleifera does not affect the pH of the solution.
- By Reviewing the papers, we found that MO is more advantageous compared to that of alum as it does not increase the acidity of wastewater after treatment.

2. Effect on TSS

- From Table 4.3 it is found that Moringa Oleifera coagulant in wastewater removes 64.2%, 66.35%,69%

of TSS at the doses 50mg, 200mg, and 500mg respectively.

- According to CPCB, the effluent discharge standard forTSS is 200 mg/L. The results obtained show that the TSS is reduced within the standards at the dosage of 50mg.

3. Effect on TDS

- From Table 4.3 it is found that Moringa Oleifera coagulant in wastewater removes 63.87%, 68%, 68% of TDS at the doses 50mg, 200mg, and 500mg respectively.
- According to CPCB, the effluent discharge standard for TDS is 100 mg/L. The results obtained show that the TDS is reduced within the standards at the dosage of 50mg.
- And we can also observe that as the dosage increases there are no further decreases in the TDS concentration.

4. Effect on COD

- From Table 4.3 it is found that Moringa Oleifera coagulant in wastewater removes 57.92%, 59.8%, 62% of COD at the doses 50mg,200mg, and 500mg respectively.
- According to CPCB, the effluent discharge standard for COD is 250 mg/L. The results obtained show that the COD is reduced within the standards at the dosage of 500mg.

5. Effect on BOD

- From Table 4.3 it is found that Moringa Oleifera coagulant in wastewater removes 43.05%, 48.21%, 51.03% of COD at the doses 50mg,200mg, and 500mg respectively.
- According to CPCB, the effluent discharge standard for BOD is 100mg/L. The results obtained show that the BOD is not reduced within the standards. Hence it may require further investigation to reduce the BOD concentration within the standards.

6. Effect on Turbidity

- From Table 4.3 it is found that Moringa Oleifera coagulant in wastewater removes 51.13%, 54.26%, 59% at the doses 50mg,200mg, and 500mg respectively.
- According to CPCB, the effluent discharge standards for Turbidity is within 100 NTU. The results obtained show that the Turbidity is reduced within the standards at the dosage of 50mg.
- Moringa Oleifera seeds contain positively charged proteins called the Moringa Oleifera Cationic Protein (MOCP). So, this protein in the seeds has a positive charge which attracts negatively charged dirt particles leading to coagulation.

5. CONCLUSION

The promotion and development of M. oleifera as a natural coagulant offers many diverse advantages to many countries of the developing world. It could be viewed as a sustainable, appropriate, effective, and robust water treatment means. The effective enhancement of particular wastewater treatment processes can decrease reliance on the importation and distribution of treatment chemicals, creating a new cash crop for farmers and employment opportunities for the rural dwellers in particular. MO seed oil was extracted using ethanol.

Moringa Oleifera seeds are an environmentally affable natural coagulant suitable for the treatment of wastewater containing undesirable parameters like BOD, COD, EC, Total Nitrogen, etc. Founded on the experimental test results; the following conclusion can be drawn.

- By reviewing the papers, we observed that by increasing the MO dosage maximum removal efficiency can be achieved.
- But to treat zoo wastewater more than 500mg of MO is required to completely bring all the parameters within the standard.
- The MO seeds contain significant quantities of a series of low molecular weight, water-soluble proteins which in solution, carry an overall positive charge.
- The proteins are considered to act similarly to synthetic, positively charged polymer coagulants. When added to raw water that proteins bind to the predominantly negatively charged particles that make the water turbid. Under proper agitation, these bound particles then grow in size to form the Flocs, which may be left to settle by gravity or removed by filtration.
- Also, the sludge generated by using MO seed as a coagulant is not toxic and has a substantially smaller volume than the sludge produced when chemical coagulants are used. Sludge produced can be used as a soil improver and its disposal is environmentally sound.

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