



# Wastewater treatment using *Moringa oleifera* Lam seeds: A review

Déborah L. Villaseñor-Basulto<sup>a</sup>, Pablo D. Astudillo-Sánchez<sup>a</sup>, Jorge del Real-Olvera<sup>b</sup>,  
Erick R. Bandala<sup>c,\*</sup>

<sup>a</sup> Department of Basic and Applied Science and Engineering, Centro Universitario de Tonalá, Universidad de Guadalajara, Av. Nuevo Periférico 555, Jalisco, Mexico

<sup>b</sup> Environmental Technology Unit, Center of Research and Assistance in Technology and Design of the State of Jalisco, Av. Normalistas 800, Guadalajara, Jalisco, Mexico

<sup>c</sup> Division of Hydrologic Sciences, Desert Research Institute, 755 E. Flamingo Road, 89119-7363 Las Vegas, NV, United States

## ARTICLE INFO

### Keywords:

*Moringa oleifera*  
Greener wastewater processes  
MO applications  
Field trends

## ABSTRACT

Using “greener” processes to treat wastewater has become increasingly popular because these processes are environmentally friendly and offer a wide variety of other benefits, such as reducing costs, reducing the generation of by-products, and providing greater biodegradability. In particular, *Moringa oleifera* (MO) has historically been used as a natural coagulant to treat contaminated effluents and it continues to be used today. This paper is a collection of information related with using MO in contemporary applications, mainly wastewater treatment. It reviews the main active components involved in the processes, the most significant mechanisms identified, seed processing techniques and some practical applications, and the main trends in the field, as well as provides comments and recommendations for further developments and identifies knowledge gaps and future research directions.

## 1. Introduction

Water is a key factor for economic development worldwide because it is widely used in different productive sectors—such as industry, livestock and agricultural production, and urban supply— which has led to water overuse. According to UNESCO, reduced water quality contributes to water scarcity. Factors such as rapid urbanization, increased farming activities, pesticide use, land degradation, high population density, and unsuitable waste disposal are affecting the quality of available fresh water sources [1]. One of the main challenges of this century will be achieving water recycling processes to ensure worldwide water supply. Effective water resource management and contamination control are required to fulfill this water challenge. To accomplish these requirements, investment in a sustainable sanitation system is needed that includes technical, economic, social, and ecological approaches [2].

Wastewater treatment is a key process in sanitation systems. One of the major challenges that water treatment processes face is the removal of hydrophobic colloids because this particulate matter, which is mainly organic in nature, is usually present at high concentrations and sizes compared with other pollutants [3]. In wastewater treatment processes, one of the primary processes is coagulation followed by flocculation. Coagulation and flocculation are physicochemical processes that are frequently used at the beginning or end of wastewater treatment processes. In conventional treatment processes, many

different types of coagulants are commonly used depending on the chemical features of the contaminants present in the water. In general, coagulants are classified as inorganic, as well as synthetic organic, or natural organic polymers [4]. A new trend in wastewater treatment is currently being developed that uses more environmentally friendly materials, such as natural organic polymers, which have a variety of benefits, including reducing costs, preventing variations in the pH of the treated water, reducing the production of sludge, and providing greater biodegradability [5]. Although it seems like a recent idea, it is worth mentioning the existence of Sanskrit manuscripts that describe using substances from plant sources to treat domestic wastewater [6]. Although different natural coagulants have been studied for wastewater treatment in recent years [5,7–9], there is a significant lack of systematic information on the main advantages and disadvantages, challenges, and perspectives for using such natural materials for wastewater treatment.

The goals of this work are to undertake an in-depth review of state-of-the-art uses of *Moringa oleifera* (MO) seeds and their related products to treat wastewater, identify current knowledge gaps, and determine future research directions.

## 2. 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

\* Corresponding author.

E-mail address: [erick.bandala@dri.edu](mailto:erick.bandala@dri.edu) (E.R. Bandala).

**Nomenclature****Acronyms**

|        |                                              |
|--------|----------------------------------------------|
| AB-FFS | Anionic Blue-FFS dye                         |
| AMR    | Pathogen antibiotic multiresistance          |
| AR     | Pathogen antibiotic resistance               |
| BOD    | Biochemical oxygen demand                    |
| BR5    | Black reagent 5 dye                          |
| C-F    | Coagulation-flocculation                     |
| C12:0  | Lauric acid                                  |
| C14:0  | Myristic acid                                |
| C16:0  | Palmitic acid                                |
| C16:1  | Palmitoleic acid                             |
| C18:0  | Stearic acid                                 |
| C18:1  | Oleic acid                                   |
| C18:2  | Linoleic acid                                |
| C18:3  | Linolenic acid                               |
| C20:0  | Arachidic acid                               |
| C20:1  | Eicosenoic acid                              |
| C22:0  | Behenic acid                                 |
| C24:0  | Lignoceric acid                              |
| cMoL   | <i>Moringa oleifera</i> lectin               |
| COD    | Chemical oxygen demand                       |
| EC     | Electrical conductivity                      |
| EMB    | Encapsulated <i>Moringa oleifera</i> beads   |
| EXAFS  | X-ray absorption fine structure spectroscopy |
| FC     | Thermotolerant coliforms                     |
| FQs    | Fluoroquinolones                             |
| FTIR   | Fourier-transform infrared spectrometry      |
| GMG    | Glucomoringin                                |
| IDPs   | Intrinsically disordered proteins            |

|            |                                                                  |
|------------|------------------------------------------------------------------|
| IT         | Ion trap mass spectrometry                                       |
| L3s        | Infective stage larvae                                           |
| LC/MS      | Liquid chromatography/mass spectrometry                          |
| LIT        | Linear ion trap quadrupole mass spectrometry                     |
| MO         | <i>Moringa oleifera</i>                                          |
| Mo-CBP3-1  | Isoform 1 of the chitin binding protein                          |
| Mo-CBP3-2  | Isoform 2 of the chitin binding protein                          |
| Mo-CBP3-3  | Isoform 3 of the chitin binding protein                          |
| Mo-CBP3-4  | Isoform 4 of the chitin binding protein                          |
| MOC-DW     | MO seed extract with distilled water                             |
| MOC-DW-PC  | MOC-DW extract with delipidated MO seeds                         |
| MOCF (Flo) | MO cationic protein or flocculating cationic polypeptide         |
| MOC-SC     | MO salt solution extraction                                      |
| MOC-SC-PC  | MOC-SC extract with delipidated MO seeds                         |
| MS         | Advanced mass spectrometry                                       |
| NALCO 7751 | Liquid dispersion flocculant                                     |
| NOM        | Natural organic matter                                           |
| NPs        | Nanoparticles                                                    |
| QqLIT      | Quadrupole-linear ion trap mass spectrometry                     |
| QqQ        | Triple quadrupole mass spectrometry                              |
| QqTOF      | Quadrupole time-of-flight mass spectrometry                      |
| RR231      | Red reagent 231 dye                                              |
| RSM        | Response surface methodology                                     |
| SHW        | Sunflower head waste                                             |
| TC         | Total coliforms                                                  |
| TSS        | Total suspended solids                                           |
| UNESCO     | United Nations Educational, Scientific and Cultural Organization |
| WSMoL      | Water-soluble MO lectin                                          |
| WSP        | Whole seed powder                                                |
| WWTP       | Wastewater treatment plant                                       |

composition and diverse pharmacological activities [10]. The typical lipid content (fatty acids and triglycerides) of MO seeds is shown in Table 1. 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 [11] and the oil obtained from the seeds showed nontoxic effects [12]. Additionally, the presence of saponins, flavonoids, steroids, terpenoids, phenols, and triterpenoids was confirmed in the plant material [13]. The MO seed lipid content has been suggested to be related with harvesting practices or regional conditions leading to variations in the range of 30% to 42% [14]. It has been reported that the presence of fatty acids does not significantly affect MO seed coagulation activity [15], and therefore oil extraction is not needed to use MO seeds as a coagulant in coagulation-flocculation (C-F) processes [16]. 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 [17].

*Moringa oleifera* has also been found to have interesting biological activity. For example, ovicidal and larvicidal activity against *Haemonchus contortus* has been reported for low molecular weight (< 12 kDa) MO fractions [18] and saponins and tannins from young MO pods, respectively [19,20]. These compounds have been reported to destabilize cell membrane and cuticle collagen in the parasite but their activity is significantly dependent on the dose and exposure time [21]. Tannins from MO seeds have been found to reduce the motility of the infective stage larvae (L3s) in *Haemonchus contortus* eggs by generating paralysis and interfering in the neuromuscular coordination of the larvae [20,22,23].

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 [10]. Nevertheless, relatively few reports related with the biological activity of distilled water or saline solution extracts of MO seeds are available. In a report from 2012, Segupta et al. [24] showed that MO seed extract reduced the number of helminth eggs in irrigation water. However, these results are linked to the capability of the MO seed extract to reduce the number of helminth eggs based on its coagulation capability and not its biological activity. Other nonaqueous MO seed extracts have shown antibacterial and antifungal activity, but only a few studies reported biological activity in aqueous extracts. For example, water-soluble MO seed lectin was reported to be significantly effective against *Aedes aegypti* larvae [25] and have antibacterial activity [26,27]. The flocculating cationic polypeptide (MOCF) isolated from MO seeds showed antibacterial activity by

**Table 1**  
Lipid content in MO seed (adapted from [126]).

| Fatty Acids              | Values (%) |
|--------------------------|------------|
| Lauric acid (C12:0)      | 0.1        |
| Myristic acid (C14:0)    | 0.1        |
| Palmitic acid (C16:0)    | 7.8        |
| Palmitoleic acid (C16:1) | 2.2        |
| Stearic acid (C18:0)     | 7.6        |
| Oleic acid (C18:1)       | 67.9       |
| Linoleic acid (C18:2)    | 1.1        |
| Linolenic acid (C18:3)   | 0.2        |
| Arachidic acid (C20:0)   | 4.0        |
| Eicosenoic acid (C20:1)  | 1.5        |
| Behenic acid (C22:0)     | 6.2        |
| Lignoceric acid (C24:0)  | 1.3        |

Download English Version:

<https://daneshyari.com/en/article/6671898>

Download Persian Version:

<https://daneshyari.com/article/6671898>

[Daneshyari.com](https://daneshyari.com)