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A review on innate green coagulants efficacy in treating industrial effluents

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ABSTRACT

The other side of industrial development is pollution of water bodies across the world making water unfit for any use. This is adding to the crisis of water for consumption and also rendering available water not safe for consumption. Industrial wastewaters are to be treated appropriately within limits before discharge into natural waters. In spite of having stringent regulations several industrial effluents do not meet discharge standards attributed to insufficient treatment processes and use of chemical treatment methods. This paper is an attempt to review treatment of industrial wastewaters using natural coagulants in order to reduce the pollutant concentrations from the industrial wastewaters. A summary of industrial wastewaters treated by specific natural coagulants is also presented. Studies reviewed illustrated positive and good results of pollutant removal. It can be concluded from the review that natural coagulants have potential to treat and reduce pollutant load from various industrial effluents and hence can be successfully utilized.

Key words : *Green coagulants, Wastewaters, Treatment, Pollutant load.*

Introduction

Industrial revolution although have facilitated the nation to advance over the previous two centuries, contamination of water bodies by industrial effluents has become one of the grave issues to be concerned about. Wastewaters from industries contain harmful chemicals, inorganic wastes, heavy metals and even organic sludge, which are discarded into surface water bodies leading to their accumulation (Singh *et al*., 2018). Pollution of water bodies render them unfit for any purpose. Release of higher concentrations of industrial effluents is attributed yet times to the fact of using old or obsolete technologies by industries till date. In general, treatment of industrial effluents is taken up in three stages comprising of primary treatment using mechanical methods, secondary treatment employing biological methods followed by tertiary treatment which includes physical, chemical as well as biological methods (Shah, 2017).

The principal objective of wastewater treatment is to protect environment with regard to public health and socio-economic concerns. Research and development in search of novel techniques for wastewater treatment is constantly at work. One of the treatment methods that has been receiving attention during the recent years is coagulation and flocculation. This process is not only simple but is also effective in removing various pollutants. However, studies on use of chemical coagulants have reported traces of chemicals into treated water and also reaction with other constituents of the wastewater (Turkar *et al*., 2011).

Hence, researchers across the world are inclined towards search for green coagulants having potential to remove pollutants as well as to protect environment. Effectiveness of the coagulation process depends upon type of coagulant, dose of coagulant, pH of the wastewater, turbidity of the wastewater etc. Hence, selection of coagulant is essential and also plays a vital role in efficiency of the treatment. An appropriate coagulant can reduce the biochemical oxygen demand and phosphorus from wastewater without changing the pH of the wastewater to an extent upto 80-90% (Zajda *et al*., 2019). The present review attempts to identify such appropriate coagulants which proved to possess potential for reducing the strength of the wastewater.

Principles of green coagulation

A wide range of green coagulants have been screened and selected for the treatment of wastewaters which include polysaccharides from microorganisms, starches, derivatives of cellulose, galactomannans, chitin, gelatin, alginates and glues. Yet times green coagulants are blended with chemical coagulants where they act as coagulant aids, enhancing the efficiency of the treatment and quality of the treated waters. The principles encompassing treatment by green coagulants are bridging, adsorption and charge neutralization (Amran *et al.,* 2018).

Benefits of green coagulants

Green coagulants are understood to be harmless for humans, being eco-friendly in nature, they are non-toxic,biodegradable and does not leave residues after treatment. Further, sludge generated from green coagulant treatment can be utilized as soil conditioners upon appropriate treatment eliminating the problems associated with disposal of sludge (Ferrari *et al.,* 2016; Wei *et al.,* 2018). Also treated water can be reused for washing vehicles and flushing toilets (Paula *et al.,* 2016). More over green coagulants are economical. Studies by Mohamed *et al.,* 2014 have presented cost effectiveness of green coagulants over chemical coagulants in treating wastewaters from car wash. The reasons for green coagulants to be economical are many among them some are these are locally sources, they are available in large quantities, produce less and biodegradable sludge, can be obtained from rejects like orange and banana peels, rice husk, groundnut shells, plant and agrowastes etc (Gautam *et al*., 2020)

Stronger floc formation through bridging of green coagulants over alum was reported by Vijayaraghavan *et al*., (2011). They also presented that even at high shear levels these linkages were breakage resistant, illustrating the better flocs formed by green coagulants which evidently results in better coagulation and enhanced efficiency.

Impending prospects and commercialization of green coagulants

Owing to the potential of green coagulants, it might not be impossible to commercialize them as it can boost the social factor of the local communities which rely on economy from agriculture, also commercialization of green coagulants might come as a solution towards pollution from agrowastes and wastewater. Further, these being renewable constant supply is a possibility which will reduce their cost and can positively substitute the application and hazards from using inorganic metal salts. Nevertheless, the green coagulants also come with a few concerns towards their commercialization which include a larger gap between research and development and actual adoption of these technologies, financial sources for mass production and particularly market awareness, owing to doubts from investors'end.

More precise investigations and studies on applicability of these coagulants has to be taken up in order to fill in the gaps, address optimal working conditions,develop and certify factors like strengths and weakness appropriately. Another problem that hinders the commercialization of green coagulants is the organic content in the treated water. Some studies have fruitfully addressed this concern through use of blended coagulants. The blend of coagulants is applied either in terms of coagulant aids or in terms of composite coagulants (Mohd-Salleh *et al.,* 2019).

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Table 1. Excerpts of studies on wastewater treatment using green coagulants

S.No	Coagulant Used	Industrial Effluent	Country	Efficiency	Reference
1.	Tamarind Seed Powder	Detergent industry waste water	Nigeria	Turbidity and COD removal of 97.72% and 39.55%.	Ronke *et al.*, 2016
2.	Chick pea seed	Slaughterhouse wastewater	India	Reduction percentages of turbidity, TDS, BOD and COD were 68.3%, 82.2%, 83.3% and 84.2%.	Mohammed *et al.*, 2016.
3.	*Cassia fistula* seed	fish processing wastewater	Vietnam	Remove 70.54 - 80.50% of COD, 68.34 - 70.12% of SS and 35.94 - 37.01% color.	Ngan *et al.*, 2017.
4.	*Moringa oleifera, Dolichos lablab* and *Cicer arietinum*	Automobile Service Station Waste Water	India	Cicer arietinum was found most effective. 90% of clear water after treatment and can be effectively reuse.	Jisha *et al.*, 2017.
5.	Chitin/Chitosan	Paper making Industry	China	Chitosan lowered the chemical oxygen demand (COD) by over 80% and turbidity by more than 85%.	Song *et al.*, 2018.
6.	Chickpea (*Cicer arietinum*)	palm oil mill effluent	Malaysia	The removal percentages of turbidity, COD and TSS were determined to be 86%, 56% & 87%.	Lek *et al.*, 2018.
7.	*Moringa oleifera*	Pharmaceutical Waste Water	India	Removed around 80.0% to 99.5% turbidity and color. 90 % to 99.99% bacterial load reduction.	Parmar *et al.*, 2018-19
8.	*Hibiscus sabdariffa*	Dye in Wastewater	Malaysia	96.67% of dye removal.	Hoong *et al.*, 2018.
9.	*Sesamum indicum*	Aquaculture Wastewater	Nigeria	Removal of 82 % was obtained for solids/ particles removal.	Igwegbe *et al.*, 2019.
10.	Orange peel powder, Banana peel powder	Tannery waste water	India	Orange peel powder turbidity was removed to about 72.25%. Banana peel powder turbidity was removed to about 68.11%.	Ayyappan *et al.*, 2019
11.	Fe (III) and Purple Okra (*Abelmoschus esculentus*)	Textile Wastewater	Brazil	Removed 98.2%, 93.8%, 79.2%, and 83.2% of turbidity, color, COD, and ABS254nm.	Freitas *et al.*, 2020.
12.	De-oiled coconut cake	Gelatin based pharmaceutical effluent.	India	COD – 97%, BOD – 94%, Turbidity – 92%, TDS – 70% reduction.	Masali *et al.*, 2020.
13.	*Moringa oleifera* seeds	Wastewater from coffee industry	Indonesia	Reduce TSS to 99.63 ± 0.10%, COD to 98.06 ± 0.04% and BOD to 97.67 ± 0.24%.	Rahmadyanti *et al.*, 2020

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