Contents lists available at ScienceDirect

Process Safety and Environmental Protection

journal homepage: www.elsevier.com/locate/psep

Review

Photocatalytic treatment technology for palm oil mill effluent (POME) – A review

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ARTICLE INFO

Article history:
Received 29 February 2016
Received in revised form 29 April 2016
Accepted 6 May 2016
Available online 3 June 2016

Keywords:
Photocatalytic degradation
Palm oil mill effluent
Treatment techniques
Photocatalysis
Titanium-dioxide
Reactor configuration

ABSTRACT

This review provides insight into various techniques utilized for the treatments of palm oil mill effluents (POME). Generally, POME treatment is achieved in two ways, these are (1) pre-treatment stages, involving majorly the reduction of oil and grease and suspended matter and (2) an advanced treatment stage, in which wastewater contaminants (e.g. BOD_5, COD) are reduced to standard discharge limits. Different methods utilized in the treatment of POME such as coagulation-flocculation, anaerobic, aerobic and membrane technology are explained fully and recent trends in their advancement and improvement are outlined. Though, various pilot or industrial scale treatment plants have been reported in scientific literature for POME treatments methods such as anaerobic, aerobic and membrane technology, the literature is still scarce for application of photocatalytic degradation technology to POME treatment as the technology is still in development stage and has not been fully utilized on an industrial scale in palm oil mill industries. This is mainly as a result of inadequate investigation involving POME degradation. The review presented here is focused on photocatalytic degradation technology and reflects published outcomes with the aim of offering the technique as an attractive and sustainable process units. Also the potential of the process to replace some of the well-known separation and degradation technologies has been highlighted at advanced treatment stage for POME.

Contents

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http://dx.doi.org/10.1016/j.psep.2016.05.020

1. Introduction

Processing of palm oil fruit (also known *Elaeis guineensis*) for extraction of oil can be achieved by combination of different methods such as pressing, sterilization, digestion, stripping, classification, purification and vacuum drying. Most of these methods require excessive use of water. It has been reported by Chang (2014) that 1.5 m^3 of water is required to process one tonne of fresh fruit bunch (FFB) of palm fruit and 50% of this amount ends up as palm oil mill effluent (POME) which causes a prodigious menace to water environmental system.

Fresh POME is highly viscous liquid, brownish in colour and is discharged at a temperature of 80–90 °C. It is extremely poisonous with very low pH between 3.5 and 4.2, high chemical and biological oxygen demand (COD: 16–100 g/L, BOD_5, 30 °C: 10–44 g/L), high suspended solids (SS: 5–54 g/L), and high salt content. The raw effluent released as pollution by an average-sized palm oil mill that can process 30 tonne/h FFB is equivalent of 300,000 person (Tabassum et al., 2015). It also generates huge amount of greasy effluent with enormously high organic content, particulate air emissions, noise, odour, and smoke. The environmental problems of the palm oil mill industry are generally linked to: (a) Water pollution, as a result of haphazard release of raw or partly treated POME into open waterways; (b) Inadequate provisional storage capacity of solid waste constituents released from boiler and incinerator; solid decanters and sludge separator residue from spent bleaching earth; (c) Wrong land-application procedures for solid and liquid wastes; (d) Air pollution generated from solid fuel reservoirs and furnaces for empty fruit clusters; (e) Stink release from effluent treatment methods that are poorly managed, especially if they are located very close to neighbouring residential areas; and (f) Noise from machines used in the milling processes (Tabassum et al., 2015).

Traditionally palm oil mills are cited very close to rivers or streams to ease access to water for milling operations and for subsequent discharge of effluent into such water bodies. Generally, before the establishment of stringent environmental laws, POME are usually released into rivers and streams untreated. Though, this enhance the growth of microplankton used as food by aquatic organisms such as prawn, fish and crab, excess discharge will remove oxygen from the water bodies and this choke the life of aquatic organisms. Therefore, the influence of citing palm oil mills very close to small water bodies for the purpose of discharging raw POME into them can be devastating to its eco-system and may also be relatively beneficial (Wu et al., 2010).

The smoke and other particulates in the air emissions from palm oil mills is a serious basis of public nuisance if the mills are poorly located close to the inhabitants and the emissions are unabated. Though, noise is usually a much lesser environmental concern, its level should however be kept within acceptable limits at the palm oil mill through perimeter fencing (Tabassum et al., 2015).

Generally, POME is a mixture of wastewaters that are produced and released after process operations of the following units viz.: sterilizer condensate containing 36% of total POME, hydrocyclone wastewater containing 4% of total POME, and clarification wastewater containing 60% of total POME. Other sources of relatively clean wastewater such as boiler blowdown, steam condensates, turbine cooling water, overspills from the vacuum dryers and some surface washings may be included in the collective palm oil mill effluent (POME) being sent to the wastewater treatment plant. The final capacity of the collective POME discharge will largely be dependent on the palm mill operations (Tabassum et al., 2015). Typical physical characteristics of the raw POME are presented in Table 1.

A well-managed palm oil mill with very good operational practice will generate about 2.5 m^3 of POME in every tonne of

Table 1 – Characteristics of POME and its respective standard discharge limits set by Malaysian Department of Environment.

Parameters	Average discharge values	Standard discharge limits
Temperature (°C)	85	–
COD (mg/l)	50,000	100
BOD5 (mg/l)	25,000	50
pH (no unit)	4.7	5.0–9.0
Oil and grease (mg/l)	4000	100
Total solids (mg/l)	40,500	–
Suspended solids (mg/l)	18,000	400
Ammoniacal nitrogen (mg/l)	35	–
Total volatile solids (mg/l)	34,000	–
Total nitrogen (mg/l)	750	150
Phosphorus (mg/l)	180	–
Magnesium (mg/l)	615	–
Boron (mg/l)	7.6	–
Calcium (mg/l)	439	–
Manganese (mg/l)	2.0	10
Zinc (mg/l)	2.3	10
Copper (mg/l)	0.9	10
Iron (mg/l)	46.5	50
Potassium (mg/l)	2270	–
Chromium (mg/l)	10.2	–