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Review

Oil and grease removal from wastewaters: Sorption treatment as an alternative to state-of-the-art technologies. A critical review

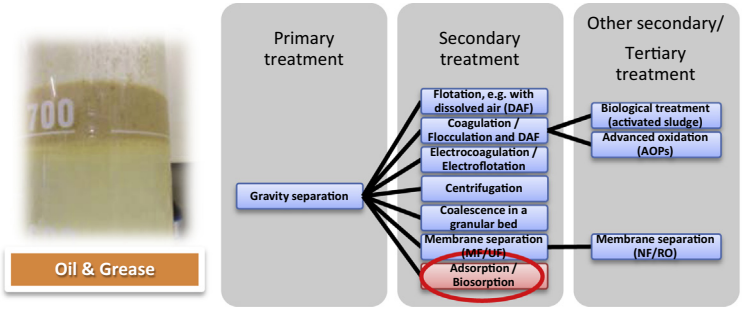
Ariana M.A. Pintor *, Vítor J.P. Vilar, Cidália M.S. Botelho, Rui A.R. Boaventura *

LSRE-Laboratory of Separation and Reaction Engineering – Associate Laboratory LSRE/LCM, Departamento de Engenharia Química, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

HIGHLIGHTS

- Oil and grease is a widespread pollutant of several types and sources.
- Review of state-of-the-art technologies for oil and grease removal.
- Sorption is an emerging technology with high efficiency and low cost.
- Review of natural and synthetic sorbents for oil and grease removal.
- Comparison of advantages and disadvantages of oil and grease removal technologies.

GRAPHICAL ABSTRACT



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ABSTRACT

Oil and grease (O&G) is a class of pollutants with very low affinity to water. Their removal from wastewaters is often challenging and involves the combination of different treatment technologies, according to the specifications for the treated water and the O&G substances involved. O&G can be classified according to its type and source and this influences the choice of the treatment process.

This paper presents a review of the state-of-the-art technology on O&G removal. Treatment usually involves several steps, including primary, secondary and tertiary treatment. Gravity separators accomplish removal of free oil as a primary treatment. Secondary treatments include chemical, electrical and physical methods which target emulsified oil, such as, coagulation/flocculation, dissolved air flotation, electro-coagulation/flotation, and membrane separation. Tighter membranes and advanced oxidation processes can refine treatment in a tertiary step.

Many of these treatments present, however, disadvantages such as production of hazardous sludge or high energy requirements. In this context, sorption as a secondary treatment is gaining focus in the literature, especially using natural organic sorbents. These present the advantages of lower cost and biodegradability, and may enable the recovery or recycling of sorbed O&G. Additionally, some of them may be reused up to a limited number of working cycles. Several kinds of sorbents and mechanisms for oil sorption and recovery are reviewed in this article.

Contents

* Corresponding authors. Tel.: +351 225081669; fax: +351 225081674.
E-mail addresses: ampintor@fe.up.pt (A.M.A. Pintor), bventura@fe.up.pt (R.A.R. Boaventura).

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Nomenclature

List of acronyms

AOP	advanced oxidation process
API	American Petroleum Institute
BOD_5	biochemical oxygen demand (5 days)
COD	chemical oxygen demand
CPC	cetylpyridinium chloride
CPI	corrugated-plate interceptor
CTAB	cetyltrimethylammonium bromide
DAF	dissolved air flotation
GAC	granular activated carbon
GP	granular palm shell
IAF	induced air flotation
MF	microfiltration
MFC	mechanically agitated flotation cell
NF	nanofiltration
O&G	oil and grease
PAC	polyaluminium chloride
PEG	polyethylene glycol
PES	polyethersulfone
PET	poly(ethylene terephthalate)
POME	palm oil mill effluent
POSS	polyhedral oligomeric silsesquioxane
PPI	parallel-plate interceptor
PVDF	polyvinylidene fluoride
PVP	polyvinylpyrrolidone
TDI	toluene diisocyanate
TMp	trimethyloylpropane
TSS	total suspended solids
UF	ultrafiltration
UV	ultraviolet
VORW	vegetable oil refinery wastewater
WWTP	wastewater treatment plant
x-PEGDA	cross-linked poly(ethylene glycol) diacrylate

1. Introduction

Growth in industrial production and urbanisation, which had its onset in the 18th century with the Industrial Revolution and increased considerably in the last decades, brought about great improvements in manufacturing processes and in the living conditions of populations. However, as a result of overexploitation and inadequate waste management, it has also led to the emergence of many environmental impacts. Among these, contamination of water resources has been one of the most afflicting.

Among the many classes of pollutants, one regularly found in waters and wastewaters is "Oil and Grease" (O&G). O&G is a group of organic substances whose defining characteristic consists in a very low affinity to water. Allocation of contaminants to the O&G category is usually determined by the method of chemical analysis, in particular the solvent used for extraction from the aqueous phase. Substances typically classified as O&G include hydrocarbons, fatty acids, soaps, lipids and waxes [1]. Such a wide range of compounds constitutes a class of complex nature; therefore, it is not surprising that Rhee et al. [2] consider O&G "one of the most complicated pollutants to remove" in oil processing wastewaters.

Since most substances in this class have very low biodegradability, their release to the environment via wastewaters may impact the biosphere [3]. Even the thinnest layer of oil will affect aquatic life by decreasing both the penetration of light and the oxygen transfer between air and water [4]. For this reason, discharge limits for oil and grease are imposed by environmental law in most countries.

In addition to its ecological impact, O&G affects the operation of traditional wastewater treatment plants, inhibiting biological activity in activated sludge reactors and causing clogging and fouling of pumps and piping [2]. Furthermore, the presence of oily matter in wastewaters is often indicative of the occurrence of toxic micro pollutants, especially those which are hydrophobic in nature. High concentrations of benzene, toluene and xylene have been associated with discharges of petroleum refinery wastewaters in the municipal system [2], and mono- and polyaromatics have been detected alongside other long-chain hydrocarbons in stormwater runoff [5]. To protect the normal functioning of sewage treatment plants, emissions of oil and grease to the local wastewater drainage system are also subject to regulation.

For the aforementioned reasons, wastewaters heavily loaded with oil and grease can neither be directly discharged onto the