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Biological Treatment of Edible Oil Refinery Wastewater using Activated Sludge Process and Sequencing Batch Reactors - A Review

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Abstract

This review paper intends to provide an overall vision of ASP and SBR technology as an alternative method for biological treatment of edible oil refinery wastewater. Edible oil refinery effluent is considered the most harmful waste for the environment if discharged untreated. Edible oil effluent is a yellowish liquid that contains high Dissolved Solids, Oil and Grease, high COD and BOD values, low pH, Total Kjeldahl Nitrogen, Ammonia Nitrogen, and Total Phosphorus. The activated sludge process is used to treat waste stream that are high in organic loading and biodegradable compounds. It is most widely used biological process for the treatment of edible oil refinery wastewater. Sequencing batch reactor is a modification of activated sludge process which has been successfully used to treat edible oil refinery wastewater. The same can be successfully treated by sequencing batch reactor process.The advantages of SBR technology are single-tank configuration, easily expandable, flexibility in operation, feasibility of operation at low retention time, control over microbial population and various reactor configuration. Their studies resulted in very high percentage removal of BOD, COD, Total Dissolved Solids and Suspended Solids respectively. The review discusses some of the published works in addition to experiences of the authors.

Keywords: Edible Oil Industry, Activated sludge process (ASP), Sequencing Batch Reactor (SBR), Operational parameters, Effluent treatment

Introduction

India is a leading player in edible oils, being the world’s largest importer (ahead of the EU and China)and the world’s third-largest consumer (after China and The EU).The Indian edible oil industry is composed of some 15,000 oil mills, 600 solvent extraction units, 250 vanaspati units and about 400 refining units.The sources of edible oil manufacture are soyabean, groundnut, rapeseed, sunflower, safflower, cotton seed,coconut, mustard, rice bran, neem, mahuwa etc. The refined edible oil manufacturing units generate solid waste (spent earth) and wastewater. The wastewater come out from oil refinery create serious environmental problem such as great threat to aquatic life due to its high organic content. Hence its treatment is essential prior to its disposal. The choice of effluent treatment method depends on the organic content present in the effluent and its discharge conditions.

In the edible oil industry, wastewaters mainly generated from the degumming, deacidification and deodorization and neutralization steps . In the neutralization step, sodium salts of free fatty acid (soap stocks) are produced whose splitting through the use of H_2SO_4 generates highly acidic and oily wastewaters . Its characteristics depend largely on the type of oil processed and on the process implemented that are high in COD, oil and grease, sulphate and phosphate content, resulting in both high inorganic as well as organic loading of the relevant wastewater treatment works. . (Aslan et al., 2009)

Previously, effluent from the vegetable oil industry used to be discharged directly into soil or groundwater. But, due to the emergence of environmental consciousness, the Pollution Control Boards have become stricter and imposed stringent norms. So studies on treatment of oily wastewaters have gained increasing importance. (Aslan et al., 2009)

Edible oil effluents can be treated either separately or in conjunction by chemical or biological means. The problems with chemical treatment are the increased chemical handling costs and the production of chemical sludge that is difficult to treat and dispose of. Biological treatment methods offer an easy and cost effective alternative to chemical methods in the treatment of edible oil effluent. Biological treatment of edible oil wastewater could be treated by Conventional Activated Sludge Process and Sequencing Batch Reactor. (Bux et al., 2009)

Characteristics of the wastewater generated at an edible oil refinery were given in table 1. (Rajkumar et al ., 2007)

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Effluent Guidelines. (IFC, EHS Guidelines et al., 2007)

Table 2 present effluent guidelines for edible oil sector. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks.

Table 1

Sr. No.	Parameter	Influent
1.	Colour	Yellowish
2.	pH	2.0±0.8
3.	Temperature, ^0C	35±1
4.	Total Dissolved solids, r	4800±2.0
5.	Oil and Grease, mg/l	150±1.0
6.	BOD_5 (20 ^0C) , mg/l	359±11.0
7.	COD, mg/l	7000±8.0
8.	TKN mg/l	6.08±0.5
9.	Phosphate, mg/l	57.4±0.8
10.	Sulphate, mg/l	2.0±0.2

Table 2

Parameter	Guideline Value
pH	6-9
Temperature increase, ^0C	$<3^b$
Total Suspended solids, mg/l	50
Oil and Grease, mg/l	10
BOD_5 (20 ^0C) , mg/l	50
COD, mg/l	250
Total Nitrogen mg/l	10
Total Phosphorus, mg/l	2
Total coliform bacteria, MPN/100ml	400

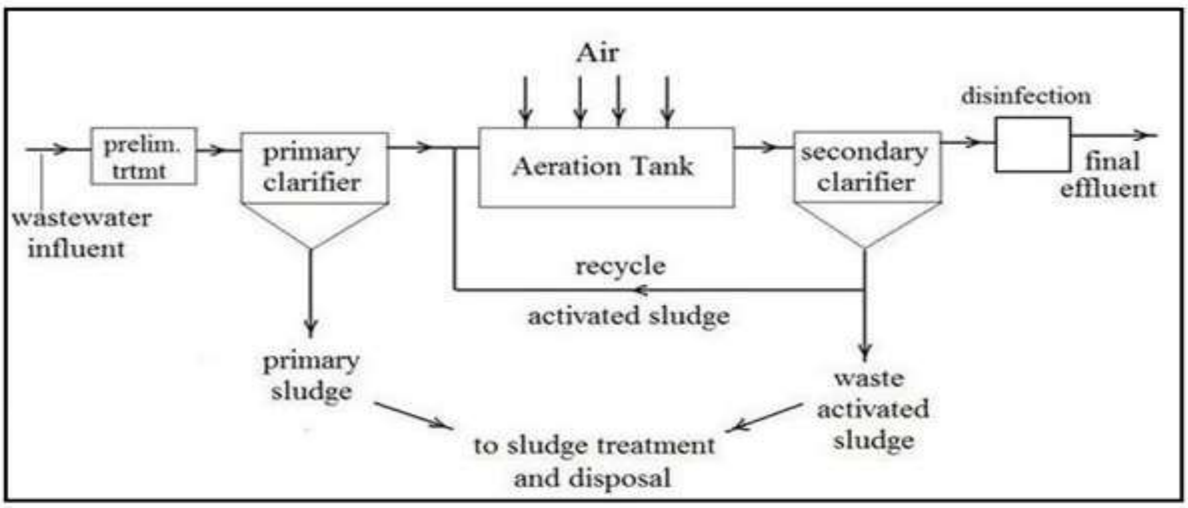
Treatability studies

The cheapest way of discharging of edible oil effluent is to release into the river. But discharge of effluent into water bodies cause water depletion and results in aquatic pollution. Therefore, these problems make it essential to study the effect of different type of treatment on edible oil refinery effluent quality and environment. Based on effluent characteristics a pre-treatment is necessary. Physical pre-treatment of effluent consist of stages such as screening, grit removal and oil and grease trap prior to the secondary treatment in biological treatment system. After the pre-treatment Activated Sludge Process(ASP) and Sequential Batch Reactor (SBR) biological treatment process are more popular among biological treatment. (Mkhize et al .,2000)

Activated Sludge Process

The activated sludge process is used to treat waste stream that are high in organic loading and biodegradable compounds. It is most widely used biological process for the treatment of edible oil refinery wastewater. Historically, activated sludge technology commenced with the investigation of fills and draw reactors. The first activated sludge plant was really a sequencing batch reactor wherein the sewage was introduced batch wise into the reactor for a specified period of time. The contents of the reactor were then aerated for a predetermined period, following which the sludge flocs were allowed to settle and the supernatant liquor was decanted.(Rathod et al.,)

$$\text{Organic material} + O + \text{Nutrients} \xrightarrow{\text{Micro-org.}} CO_2 + H_2O + \text{Energy} + \text{Micro-org.}$$



Activated Sludge Wastewater Treatment Flow Diagram

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In conventional activated sludge process the edible oil refinery effluent treatment plant (ETP) comprises of following units, viz. equalization basin, neutralization unit, clariflocculator, primary clarifier, aeration basin, secondary clarifier, and filter press. The wastewater is first pumped into an equalization basin, where the floating oil is skimmed out. The wastewater is neutralized with addition of lime and is pumped to a clariflocculator where alum is added. The addition of alum results in fast settling of lime sludge, which is drained out and passed through the filter press. The overflow of supernatant from the clariflocculator is supplemented with diammonium phosphate as a nutrient and let into aeration basin for biological treatment. The surface aerators are provided in aeration basins for oxygen transfer and mixing of biomass with wastewater. The overflow from aeration basin passes through a clarifier. The residual colour of the treated effluent is removed by the addition of sodium hypochlorite solution. The settled sludge from secondary clarifier is partly recirculated to aeration basin in order to maintain a proper food/microorganism (F/M) ratio and the excess activated sludge produced in the process is taken to the filter press.(Rajkumar et al ., 2007)

Activated sludge process is potentially viable to treat edible oil refinery wastewater only for removal of COD, BOD, TSS, Fecal Coliform and up gradation of pH and DO recovery and TKN and phosphate upto particular limit. (Sandile P. Mkhijze et al ., 2001).

Sequencing Batch Reactor process

Sequential Batch Reactor treatment process are used all over world and have been around since the 1920s. With their growing popularity in Europe and China as well as The United states, they are being used successfully to treat both municipal and industrial wastewater, particularly in areas characterized by low or varying flow patterns. A number of industries, including edible oil refinery, dairy, pulp and paper, tanneries and textile, were used SBRs as practical wastewater treatment alternatives.(Wisaam et al., 2007)

The Sequencing Batch Reactor (SBR) is a mixed-culture, suspended growth activated sludge treatment system. Conventional activated sludge system require separate tanks for the unit processes of biological reaction (aeration of mixed liquor) and solids-liquid separation (clarification) and also require process mixed liquor solids (return activated sludge) to be returned from the final clarification stage to the aeration tanks. In contrast, SBR technology is a method of wastewater treatment in which all phases of the treatment process occur sequentially within the same tank. Hence, the main benefits of SBR system are less civil structure, inter-connecting pipework, process equipment and consequent saving in capital and operating costs. (Slater el at., 2006)

Physical Description of the SBR System

An SBR system may be designed as consisting of a single or multiple reactor tanks operating parallel. Each operating cycle of a SBR reactor comprises five distinctive phase, referred to as: FILL, REACT, SATTLE, DRAW, and IDLE phase. A detailed discussion of each of this phase of the SBR is provided in the following section:(D. Dohare et al., 2014; Mahvi et al., 2007;CPHEEO manual 2012)

Fill

The During the fill phase, the basin receives influent wastewater. The influent brings food to the microbes in the activated sludge, creating an environment for biochemical reactions to take place. Mixing and aeration can be varied during the fill phase to create the following three different scenarios. (Ronald F. Poltak et al., 2005)

Static Fill – Under a static-fill scenario, there is no mixing or aeration while the influent wastewater is entering the tank. Static fill is used during the initial start-up phase of a facility, at plants that do not need to nitrify or denitrify, and during low flow periods to save power. Because the mixers and aerators remain off, this scenario has an energy-savings component.

Mixed Fill – Under a mixed-fill scenario, mechanical mixers are active, but the aerators remain off. The mixing action produces a uniform blend of influent dioxide and water to derive wastewater and biomass. Because there is no aeration, an anoxic condition is present, which promotes denitrification. Anaerobic conditions can also be achieved during the mixed-fill phase. Under anaerobic conditions the biomass undergoes a release of phosphorous. This release is reabsorbed by the biomass once aerobic conditions are reestablished. This phosphorous release will not happen with anoxic conditions.

Aerated Fill – Under an aerated-fill scenario, both the aerators and the mechanical mixing unit are activated. The contents of the basin are aerated to convert the anoxic or anaerobic zone over to an aerobic zone. No adjustments to the aerated-fill cycle are needed to reduce organics and achieve nitrification. However, to achieve denitrification, it is necessary to switch the oxygen off to promote anoxic conditions for denitrification. By switching the oxygen on and off during this phase with the blowers, oxic and anoxic conditions are created, allowing for nitrification and denitrification. Dissolved oxygen (DO) should be monitored during this phase so it does not go over 0.2 mg/L. This ensures that an anoxic condition will occur during the idle phase.

React

This phase allows for further reduction or "polishing" of wastewater parameters. During this

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phase, no wastewater enters the basin and the mechanical mixing and aeration units are on. Because there are no additional volume and organic nitrification occurs by allowing the mixing and aeration to continue—the majority of denitrification takes place in the mixed-fill phase. The phosphorus released during mixed fill, plus some additional phosphorus, is taken up during the react phase. (Ronald F. Poltak et al., 2005)

Settle

During this phase, activated sludge is allowed to settle under quiescent flow enters the basin and no aeration and mixing takes place. The to settle as a flocculent mass, forming a distinctive interface with The sludge mass is called the sludge blanket. This phase is a critical because if the solids do not settle rapidly, some sludge can be drawn subsequent decant phase and thereby degrade effluent quality. (Ronald F. Poltak et al., 2005)

Decant

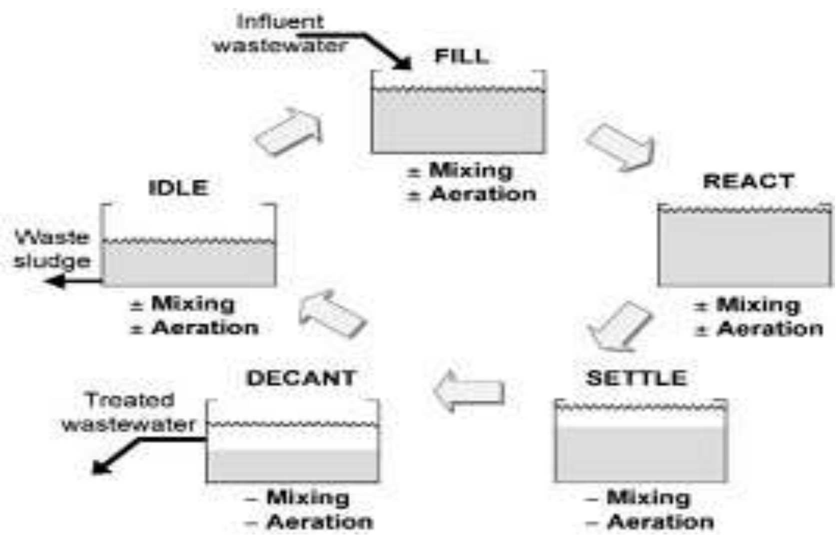
During this phase, a decanter is used to remove the clear supernatant effluent. Once the settle phase is complete, a signal is sent to the decanter to initiate the opening of an effluent-discharge valve. There are floating and fixed-arm decanters. Floating decanters maintain the inlet orifice slightly below the water surface to minimize the removal of solids in the effluent removed during the decant phase. Floating decanters offer the operator flexibility to vary fill and draw volumes. Fixed-arm decanters are less expensive and can be designed to allow the operator to lower or raise the level of the decanter. It is optimal that the decanted volume is the same as the volume that enters the basin during the fill phase. It is also important that no surface foam or scum is decanted. The vertical distance from the loadings, the rate of organic removal increases dramatically. Most of the carbonaceous BOD removal occurs in the react phase. Further decanter to the bottom of the tank should be maximized to avoid disturbing the settled biomass. (Ronald F. Poltak et al., 2005)

Idle

This step occurs between decant and fill phases. The time varies, based on the influent flow rate and the operating strategy. During this phase, a small amount of activated sludge at the bottom of the SBR basin is pumped out a process called wasting. (Ronald F. Poltak et al., 2005)

Continuous-Flow Systems

SBR facilities commonly consist of two or more basins that operate in parallel but single basin configurations under continuous-flow conditions. In this modified version of the SBR, flow enters each basin on a continuous basis. The influent flows into the influent chamber, which has inlets to the react basin at the bottom of the tank to control the entrance speed so as not to agitate the settled solids. Continuous-flow systems are not true batch reactions because influent is constantly entering the basin. The design configurations of SBR and continuous-flow systems are otherwise very similar. Plants operating under continuous flow should operate this way as a standard mode of operation. Ideally, a true batch-reaction SBR should operate under continuous flow only under emergency situations. Plants that have been designed as continuous-inflow systems have been shown to have poor operational conditions during peak flows. Some of the major problems of continuous-inflow systems have been overflows, washouts, poor effluent, and permit violations. (Ronald F. Poltak et al., 2005)



Typical cycles in SBR process. (Ronald F. Poltak et al., 2005)

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Common modifications in SBR

SBRs can be modified to provide secondary, advanced secondary treatment, nitrification, denitrification & biological nutrient removal. In SBR biological phosphorus removal can be achieved by incorporating an anaerobic phase within the process cycle, usually at the beginning during filling.. SBRs were originally configured in pairs so that one reactor was filling during half of each cycle (while the waste water in the other reactor was reacting, settling& being decanted).The modified configurations available include 1 SBR with an influent holding tank; a three SBR system in which the fill time is one third of the total cycle time;& a continuous inflow SBR.(Metcalf and Eddy & CPHEEO manual 2012)

In recent years, some modifications of SBR has been used by researchers, such as continuous flow SBR (Mahvi et al.,2004), Sequencing Batch Biofilm Reactor(SBBR), anaerobic Sequencing Batch Reactor (ASBR) & anaerobic aerobic Sequencing Batch Reactor.

Activated Sludge Process:

Design parameters for activated sludge system for wastewater were given in table 3. **(CPHEEO manual 2012)**

Table 3 Design Parameters for activated sludge systems for sewage (CPHEEO manual 2012)

S.no	Parameters	Units	Conventional	Complete mix	Extended aeration
1	Flow Regime		Plug Flow	Complete mix	Complete mix
2	F/M ratio	d-1	0.3 – 0.4	0.3 – 0.5	0.1 – 0.18
3	Θc	D	5 – 8	5 – 8	10 – 25
4	KgO_2/kg BOD removed	Ratio	0.8 – 1.0	0.8 – 1.0	1.0 – 1.2
5	MLSS	mg/l	1500 – 3000	3000 - 4000	3000 – 5000
6	MLVSS/MLSS	Ratio	0.8	0.8	0.6
7	HRT	Hrs	4 – 6	4 – 5	12 – 24
8	Q_R/Q	Ratio	0.25 – 0.5	0.25 – 0.8	0.5 – 1.0
9	BOD Removal	%	85 – 92	85 – 92	95 – 98

Literature review on operational parameter of ASP

Optimal aeration of a conventional activated sludge process depends on the manipulation of the three basic design parameters, which are: organic loading rate (BX) or the sludge age (RS); maintaining the correct mixed liquor suspended solids value (MLVSS) and dissolved oxygen (DO) concentration in the mixed liquor.(Surujlal et al ., 2004)

Activated sludge process is efficient to remove colour and COD from real textile wastewater. Moreover, hydraulic retention time (HRT) and mixed liquor volatile suspended solids (MLVSS) affect the performance of the activated sludge process.(Kapil Kumar et al ., 2014)

The removal efficiency of BOD was found to be 94.56% and that of TSS was 93.72%. BOD and TSS removal efficiencies of the activated sludge plant(Aeration tank + Secondary clarifier) are 91.27% and 86.76% respectively.(K. Sundara kumar., 2010)

Design parameters of Sequencing Batch Reactor (SBR) were given in table 4.

Table 4 Design Parameters for SBR systems for wastewater (CPHEEO manual 2012)

S.no	Parameters	Units	Continuous Flow & Intermittent Decant	Intermittent Flow & Intermittent Decant
1	F/M ratio	d-1	0.05-0.08	0.05-0.3
2	Sludge age	D	15-20	4-20
3	Sludge yield	Kg dry solids/kg BOD	0.75-0.85	0.75-1
4	MLSS	mg/l	3000-4000	3500-5000
5	Cycle Time	H	4-8	2.5-6
6	Settling Time	H	>0.5	>0.5
7	Decant Depth	M	1.5	2.5
8	Fill volume Base	-	Peak flow	Peak flow
9	Process oxygen			
	- BOD	Kg O_2/kg BOD	1.1	1.1
	- TKN	Kg O_2/kg TN	4.6	4.6

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Literature review on operational parameter of SBR

The major factors affecting SBR performance include organic loading rate, HRT, SRT, dissolved oxygen, and influent characteristics such as COD, solids content, C/N ratio. Depending controlling of these parameters, the SBR can be designed to have function such as carbon oxidation, nitrification and denitrification, and phosphorus removal. (Mahvi et al., 2008)

Biological treatment technology offers an efficient and cost-effective means for treating edible oil industrial wastewater. Biological treatment of edible oil effluent may be carried out either aerobically, anaerobically or using the combination of both (Mahvi et al., 2008).

SBR is well suited to tannery wastewater for effective COD and N removal. It lowers soluble COD to a level essentially consisting of initial soluble inert COD and additional residual COD generated as metabolic products. It offers the flexibility of adjusting the degree of N removal by appropriate manipulation of the operating parameters. Compared to continuous-flow activated sludge, the V_O/V_F ratio is the essential additional parameter for this purpose.(S. Murat et al ., 2002)

The application of butanol (electron donor) for the biological treatment of effluent containing high sulfate concentrations significantly reduced the sulfate concentration. The anaerobic sequential batch reactor filled with mineral coal achieved high sulfate reduction efficiencies (99%) in a short period of operation at different initial sulfate concentrations (0.25-3.0 g SO_4^{2-} L^{-1}). (Arnaldo Sarti et al ., 2011)

Mixing supplied by mechanical impeller resulted in better organic matter efficiency and operating stability. The ASBR using mechanical mixing attained mean efficiency removal values of 60% (COD Total) and 78% (COD Filtered), as well as mean efficiency of suspended solid removal of 79%. These results can be directly connected to the maintenance of granular biomass integrity.(Arnaldo Sarti et al ., 2007)

For biogas production, ASBR system was satisfactorily successful for palm oil wastewater (COD inf 53,867-79,600 mg/L). COD removal of this system was 93%. Biogas was produced in the range of 9,906-13,978 m3/d. While, the highest biogas production rate for this ASBR system reported 0.5 m^3/kg COD. (Tungporn Promtong et al .,)

An optimal operation strategy that minimizes the total aeration demand along the SBR process can be easily programmed (switching times) in accordance to particle swarm optimization (PSO) results.(A. Ferrari et al., 2010)

Performance of ASP and SBR

The performance of STP's typically comparable with each other but depends on system design & site specific criteria. The avg. performance data values reported in CPHEEO manual 2012 is given in Table 5.

Table 5

Parameters	% removal efficiency	
	Sequential Batch Reactor	Activated Sludge Process
BOD	89-98%	85-95%
TSS	85-97%	85-90%
Total Nitrogen Removal	>75%	No treatment
Biological Phosphorus removal	57-69%	No treatment
Total Coliforms	99%	90-96%

Review of ASP on nutrient removal efficiency

Approximately 80% of COD content can be removed in five days. So, it is concluded that a reaction period of five days is enough to obtain satisfying removal efficiency for the edible oil wastewaters with similar characteristics.(S. Aslan et al ., 2009)

Vegetable oil effluents can be successfully treated, in terms of COD removal, using activated sludge as a form of on-site pre-treatment process. The effluent, however, requires some manipulation to attain an optimum TKN/COD ratio of 0.05–0.1. (Sandile P. Mkhijze et al ., 2001)

The Bacillus cereus 103PB produced the highest activity in reducing TSS, Oil and Grease, so it might be applicable to a edible oil wastewater treatment system for the removal of TSS and Oil and Grease.(Jeremiah David Bala et al ., 2014)

Physicochemical treatment process significantly influenced the relative biodegradability of organic matter in edible oil wastewater.(K. B. Chipasa et al ., 2001)

Experiments were performed in laboratory scale activated sludge process (ASP) unit under steady state condition, varying mixed liquor volatile suspended solids (MLVSS) (2500, 3500 and 5000 mg/l) and hydraulic retention time (HRT) (18, 24 and 36 h). The results showed that decolourization and chemical oxygen demand (COD) removal increased with increase in MLVSS and HRT. At 18 h HRT, decolourization was found to be 46, 54 and 67%, which increased to 67, 75 and 90% (36 h HRT) at 2500, 3500 and 5000 mg/l MLVSS, respectively. COD removal was found to be 62, 73 and 77% (at 18 h HRT) which increased to 77, 85 and 91% (36 h HRT) at 2000, 3500 and 5000 mg/l MLVSS, respectively.(Kapil Kumar et al ., 2014)

Review of SBR nutrient removal efficiency

Vegetable oil effluents can be successfully treated, in terms of COD removal, using activated sludge as a form of on-site pre-treatment process. The effluent, however, requires some manipulation to attain an optimum TKN/COD ratio of 0.05–0.1. (Sandile P. Mkhize et al., 2001)

Regardless of addition of acetate, the SBR system has achieved removal of total solids (TS), total volatile solids (TVS), total suspended solids (TSS), and total volatile suspended solids (TVSS) in the treated liquid by at least 77.5%, 95.6%, 99.3%, and 98.4%, respectively, which indicated that adding an external carbon source to the SBR appeared to had little impact on slurry solids removal. (J. Zhu et al ., 2006)

The edible oil effluent was amenable to biological activated sludge treatment in terms of COD reduction at high organic loading rates. At this stage the main parameter of concern was the COD. The mixed liquor COD was determined to cater for dilution effects during the fill-and-draw operation. The results showed an average COD reduction of 75%.(Sandile P. Mkhize et al ., 2001)

Addition of an external carbon source to the SBR system appears to help improve the removal of dissolved phosphorus (DP) because the treatment scheme with acetate had achieved a reduction of DP by 87%, while the other only 68%.(J. Zhu et al ., 2006)

Overall review of edible oil wastewater biological treatment by ASP and SBR

ASP

The study showed that aerobic activated treatment can reduce the soluble COD component of edible oil effluent while largely being incapable of efficient fat oil and grease (FOG) removal. High effluent TSS was, however, a persistent problem due to lack of filamentous growth and subsequent poor floc formation, subject to shearing. Protozoa also demonstrated fluctuations during biological treatment of edible oil effluent with uncontrolled preflocculation responsible for elevated effluent TSS. (K Reddy ., 2002)

Biological phosphorus removal is a well-documented phenomenon that is used to reduce phosphorus in wastewater. Soluble ortho-phosphate in wastewater is converted into stored phosphorus (trapped) in the biological sludge mass of the activated sludge system. The stored phosphorus is then removed from the system with the sludge that is wasted daily (Metcalf and Eddy ., 2003)

The exposure of the activated sludge to the alternating conditions, stresses the poly-P organisms such that their release and uptake of phosphorus is above the normal levels required for metabolism. The phosphorus present in wastewater is not only used for cell maintenance, synthesis, and energy transport, but is also stored for subsequent use by the poly-P organisms (Metcalf and Eddy ., 2003).

SBR

High removal percentage of COD and Oil & Grease can be obtained when a high aeration rate is applied in the treatment process. Aerobic treatment is efficient and feasible in oily wastewater treatment but not suitable for accumulation of Polyhydroxybutyrate (PHB). (Budhi Primasari et al .,2011)

A 28L laboratory scale Modified Ludzack – Ettinger (MLE) activated sludge process was used to treat refinery effluent from the industry. Pre-flocculation of the effluent was necessary to remove most of the fats, oils and greases (FOG), where after being fed to the laboratory scale MLE unit. Routine analyses of COD, total nitrogen, total phosphorus, total suspended solids (TSS), dilute sludge volume index and FOG were conducted in conjunction with microscopic analysis of floc structure, filamentous bacteria and protozoa. An average COD removal of 81% was obtained, for the flocculated effluent, at a sludge age of 15 days and a hydraulic retention time of 24 hours.(K Reddy ., 2002)

The class alpha-*Proteobacteria* could play a primary role in the biological degradation of vegetable oil effluents (VOE). This research would therefore aid in process design and retrofitting of biological processes treating VOE. (F. Bux et al., 2011)

Very high percentage of removal of biochemical oxygen demand, chemical oxygen demand, total kjeldahl nitrogen, total nitrogen, total phosphorus and total suspended solids is possible. (Mahvi et al., 2008)

With digested piggery wastewater, nitrogen and phosphorus removal yields were around 100% and 98%, respectively. Complete denitrification was obtained when the C/N ratio was equal to or higher than 1.7. The feasibility of using non-digested pig manure as an easily biodegradable carbon source for denitrification and dephosphatation studied. (D. Obaja et al , 2004)

An SBR operated with anaerobic and aerobic cycle stages could be considered a suitable technology for organic load removal from wool dyeing effluents. Soluble COD and BOD_5 degradation efficiencies of 85 ± 6% and 95 ± 4%,

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respectively, alongwith colour removal were achieved. (Isolina Cabral Goncalves et al ., 2005)

Biological phosphorus and nitrogen removal could be achieved in SBBR, which consists of PUF media and suspended biomass and the results were comparable with SBR containing only suspended biomass. (B. Manoj Kumar 2003)

Effluent BOD was within standard limits of discharging in the creek. The overall BOD removal efficiency was 96 %. Total suspended solids removal efficiency of 92.74% of which about 18.67 % of suspended solids were removed in degritor (primary treatment) itself. The removal efficiencies of total nitrogen and phosphates were 75.67 % and 71.79 % respectively. (Prachi N. Wakode et al., 2014)

A SBR technology is applicable for edible oil refinery wastewater, where conventional or extended aeration activated sludge treatment is appropriate. This technology is applicable for BOD & TSS removal, nitrification, de nitrification & biological phosphorus removal. SBR technology extremely flexible to adapt to regulatory changes for effluent parameters such as nutrients removal. The technology finds its applicability for industrial pretreatment of smaller flow as well as where the waste is generated for less than 12 hours per day. (Metcalf and Eddy ., 2003)

Advantages of ASP and SBR

ASP

Conventional ASP is applicable for biological treatment of edible oil wastewater treatment. Industrial wastewater is treated with the help of activated sludge process but used only for removal of COD, BOD, TSS, Fecal coliforms and upgradation of pH and DO recovery and TKN and phosphate upto some extent by using some tertiary treatment additionally.(Anne-Emmanuelle Stricker et al., 2006)

Intermittently Decanted Extended Aeration (IDEA) treatment system showed that the operational costs can be minimized by 3%, by decreasing the number of operating cycles. For the conventional activated sludge wastewater treatment system, by utilizing a smaller capacity air blower, a saving of 12% could be made in the operational costs. (Fu E. Tang., 2011)

The removal efficiency of BOD was found to be 94.56% and that of TSS was 93.72%. BOD and TSS removal efficiencies of the activated sludge plant(Aeration tank + Secondary clarifier) are 91.27% and 86.76% respectively.(K. Sundara kumar., 2010)

SBR

A significant advantages of the SBR process is process control and flexibility. Because the “react” time is not flow dependent, it can adjusted to meet process objectives. By manipulating oxygen supply and mixing regima, alternative aerobic and anoxic reactor environments can be created for nitrogen and phosphorus removal.(Mahvi et al., 2008)

Second significant advantage of SBR process is small space requirements, equalization, primary clarification, biological treatment, and secondary clarification could be achieved in single reactor vessel. (Mahvi et al., 2008)

The main advantage of using an internal carbon source was the saving in chemicals. This had a very positive effect on the plant’s operating costs. (D. Obaja et al., 2004)

Aerobic activated sludge process could reduce the soluble COD component of edible oil wastewater, while largely being incapable of efficient FOG removal.(K Reddy et al ., 2003**)**

Operational troubles in ASP

The most common problems in the operation of an activated sludge process are bulking sludge, rising sludge and nocardia foam. (CPHEEO manual 2012 & Metcalf and Eddy ., 2003).

1. **Bulking sludge**

Two principle types of sludge bulking problems have been identified.

- Caused by the growth of filamentous organisms.
- Caused by bound water.

The causes of sludge bulking are related to

1. WW characteristics that can affect sludge bulking include luctuations in flow & strength, pH, temperature, nutrient content
2. Design limitations include air supply capacity, clarifier design, return sludge pumping capacity, short circuiting or poor mixing.
3. Operational causes of filamentous bulking include
   - Low dissolved oxygen in the aeration tank
   - Insufficient nutrients: Especially quantity of nitrogen and phosphorus important, also absence of trace element cause bulking.
   - widely varying organic waste loading
   - Low F/M ratio: The F/M ratio should be check to make it is within normal range.
   - Low F/M ratio encourage the growth of filamentous organisms
   - High F/M may result in the presence of small disperse flocs.
   - Insufficient soluble BOD_5 gradient:

2. **Rising Sludge**

Rising sludge may due to denitrification in the settling tank releasing nitrogen bubble which buoys up the sludge. This problem associated with:

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- High sludge age and long retention time in the clarifier.
- As nitrogen gas is formed in the sludge layer, much of it is trapped in the sludge mass & sludge rises or floats.
- Rising sludge can be differentiated from bulking sludge by noting the presence of small gas bubbles attached to the floating solids.

3. Nocardia Foam

A viscous brown foam that covers the aeration basins & secondary clarifiers has produced many problems, including safety hazards, odors and changes in effluent quality. The foam is associated with a slow growing filamentous organism usually Nocardia genus.

This problem associated with:

- Low F/M in the aeration tank
- High MLSS due to insufficient sludge wasting
- Sludge reaeration.

Operational trouble in SBR

(Ronald F. Poltak et al .,2005) The most common problems in the operation of SBR are:

1. **Loss of solids from reactor due to a high sludge blanket. This problem associated with:**
   - Poor sludge settling velocity and compaction.
   - Glutting (old sludge).
   - Classic bulking (young sludge).
   - Filamentous bulking.
   - Foam trapping.
2. **High- effluent TSS. This problem associated with:**
   - Individual particle washout.
   - Individual bacteria cells in effluent.
   - Low F/M ratio.
3. **Foam. This problem associated with:**
   - Excessive foam or scum on the surface.
   - Excessive filaments bacteria.
   - Nutrient deficiency.
   - Over aeration.

Conclusion

Edible oil refinery wastewater treatment has been a challenge throughout the years because of influent chemical and physical characteristics and stringent effluent regulation.Effluent characteristics are strongly dependent on the quality of refinery influent and refining method employed for the particular oil type.Edible oil refinery wastewater can be successfully treated using biological methods as an in-house pretreatment process. ASP and SBR is well suited to edible oil refinery wastewater for effective organic matter and nutrient removal. Additional phosphate removal may be required using chemical addition to prevent shock loading of the receiving wastewater treatment works .Current review findings conclusively showed that in order for edible oil effluent to be successfully treated biological, by pretreatment is essential. SBR process requires optimization to enhance biological remediation of edible oil refinery wastewater.

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