International Journal of Petroleum and Petrochemical Engineering (IJPPE)
Volume 2, Issue 2, 2016, PP 17-21
ISSN 2454-7980 (Online)
DOI: http://dx.doi.org/10.20431/2454-7980.0202004
www.arcjournals.org

Biological Treatment of Petroleum Wastewater: A Review on Research and Studies

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Abstract: *The wastewater from petroleum industries contains high organic matter content, oil and grease, dissolved solids and turbidity. The petroleum wastewater normally treated in a plant comprising of primary, secondary and tertiary treatments. The high organic loading needs to be treated in biological treatment step. Biological treatment can be suspended growth or attached growth type. Activated sludge process is one of the major treatment methods used. The anaerobic treatments have advantages such as reduction in sludge content, reduction in diffuser and aeration cost and generation of gas with high hydrocarbon. Many investigators have investigated biological treatments for treatment of petroleum refinery wastewater. Current review summarizes research and studies on biological treatment of petroleum wastewater.*

Keywords: *activated sludge, chemical oxygen demand, aerobic treatment, anaerobic treatment.*

1. INTRODUCTION

The effluent treatment for industrial wastewater can be carried out by physical, chemical and biological treatment methods [1-9]. Adsorption is one of the major physico-chemical treatment methods used in wastewater treatment [10-13]. Biological treatment facilities mainly contain activated sludge process, trickling filters and anaerobic reactors [14-16]. Biological treatment of effluent can be carried out by aerobic and anaerobic treatment methods. Aerobic treatments use oxygen for stabilization of organic matter. This method has high pumping cost. Most of the effluent treatment facilities employ activated sludge for the secondary biological treatments. In anaerobic treatment, the waste material is broken down into simpler and simpler compounds. Hydrolysis, acidogenesis, acetogenesis and methanogenesis are important steps in anaerobic treatments. The waste gases contain high methane concentration and can be utilized as fuel. The petroleum waste water contains high COD and BOD. Biological treatment suits these wastewaters. Various investigators have carried out investigations on biological treatment of petroleum wastewater. Current review summarizes research and studies on petroleum wastewater treatment by biological methods.

2. BIOLOGICAL TREATMENT OF PETROLEUM WASTEWATER: SUMMARY ON RESEARCH AND STUDIES

Fabio et.al. carried out investigation on membrane bioreactor for petrochemical wastewater treatment [17]. They carried out optimization studies of these bioreactors. They studied the appropriateness of membrane bioreactor (MBR) technology in treating petrochemical wastewater under the variable conditions. They carried out studies in five experimental stages. In the first stage, they examined the operating conditions of the full scale MBR. In the next stage, they introduced the addition of more external carbon source, then they decreased the anoxic compartment volume. Then they changed the configuration with an increase of the influent load. They then assessed the impact of spent caustic soda on nitrification with laboratory experiments. In the last stage, they studied the impact of fouling and clogging layers on the removal of trace metals/metalloids. They observed that the composition of wastewater affected the effectivity of treatment. They found that ammonification was not effective in the pre-denitrification configuration. According to their work, the MBR was able to cope with the variable petrochemical effluents. The addition of acetic acid improved denitrification rate.

Moving bed biofilm reactor was used by Mahmoudkhani et.al. for treatment of contaminated waters with petroleum[18]. They treated water around Tehran Refinery. This water was contaminated with petroleum compounds. They observed that denitrification process in the preceding the aerobic MBBR, filtration and activated carbon had occurred. They were able to remove formaldehyde, phenol and

total petroleum hydrocarbon (TPH) up to 96, 79 and 94%, respectively. According to their suggestion, the moving bed biofilm process coupled with filtration could be used as an ideal and efficient option for the total nutrient removal.Badrul reviewed characterization, treatment and disposal of petroleum sludge[19]. The petroleum wastewater contains waste oil, waste water, sand, and mineral matter. The sludge generated can accumulate in crude oil tanks, refinery products tanks, desalters, and elsewhere during oil production and processing. The oil contain of refinery sludge is around 40 percent. Treatment and disposal of slop oil can be carried out by various methods such thermal, mechanical, biological, and chemical. Mulligani and Gibbs described various innovative biological treatment processes for wastewater in Canada[20]. Methods such as biofilters and membrane bioreactors have potential to combat the treatment problem of large amounts of sludge. Expanded granular sludge blanket (EGSB) reactors, according to them are better alternative to UASB reactors. Methods involving processes such as biosorption and biosurfactants combined with ultrafiltration membranes can be used for metal removal. According to Benyahiaet.al., treatment of refinery wastewater is a true technological challenge[21].The characteristics of refinery wastewater are governed by type of crude oil, composition of condensate. They traced specific sources of wastewater pollutants. They developed a biomass extraction method for harvesting Pseudomonas P. and Baccili S. cells from a commercial biological product.

Kulkarni and Goswami, in their review discussed various methods used for petroleum wastewater treatment [22]. According to them, it can be treated effectively by various physical, chemical and biological treatment processes. According to their studies, combination of fixed film and activated sludge processes provided advantages of both the methods. They concluded that combination of suitable treatment methods with optimization of affecting parameters can provide economical and effective solution for the wastewater treatment in petroleum industries and industries. Kenari et.al. carried out in depth investigation on the nitrogen content of a petroleum refinery wastewater[23]. They also studied biological treatment of this wastewater for nitrogen removal. They performed nitrification and denitrification process. By using aeration treatment, they observed that the nitrogen removal during conventional activated sludge process was not efficient. Their laboratory studies indicated that a simultaneous nitrification and denitrification (SND) process could easily be realized in the same activated sludge plant. They also observed that the higher MLSS value (10.0 g/L) and mixing rate (300 rpm) is effective in improving total nitrogen removal. Mota et.al.carried out a review on advanced oxidation processes (AOP) for petroleum wastewater treatment [24].The AOP is characterized by the generation of hydroxyl radicals, which are highly reactive and non-selective substances. These substances are used to degrade toxic organic compounds present in a medium. AOP can be carried out with various techniques such as H_2O_2/UV, Fenton and photo-Fenton, Ozone (O_3), heterogeneous photo catalysis, electrochemical oxidation, wet air oxidation and supercritical water oxidation. According to this review, many investigations have indicated that AOP was highly efficient method. In some cases it reduced the organic pollutant concentration to almost zero level. An investigation on anaerobic treatment for petrochemical wastewater was carried out by Gasim et.al.[25]. In their investigation, they operated up-flow anaerobic sludge blanket (UASB) reactor. They used water displacement method for collection of biogas. In their experiments they obtained maximum COD removal of 83%. Even at influent concentration of about 7000 mg COD/L, they obtained excellent results. They also observed that even when the load increased two times, the performance remained intact.

A complete1y mixed, high-rate, activated sludge process was used for treatment of petroleum wastewater by Agathos [26]. They investigated design and operational aspects of a model bio-treatment facility. This was used as a secondary treatment step in the detoxification process after a pretreatment. They obtained more that 70 percent COD removal in an acc1imated sludge treatment. They also carried out analyses for COD, MLSS, phenol, and biomass characteristics. Brito investigated the diversity and abundance of ammonia oxidizing bacteria (AOB) and Archaea (AOA)[27]. They carried out studies over five oil refinery wastewater treatment plants in the UK. For these studies they used culture-independent molecular techniques. They found that only three refineries wastewater treatment plants were nitrifying. They observed that high amount of AOA may play an important role in nitrification in the reactors. The modified Ludzack-Ettinger pre-denitrification process was used by Adabi et.al. for petroleum wastewater treatment[28]. In their investigation, they used an anoxic tank coupled to anoxic MBR operated at SRT and HRT of 60 days and 24hr. They obtained COD and phenol removal efficiencies higher than 90% and 99%

respectively. Also almost 100% removal of cyanide and ammonia was obtained by them. Oubrayme et.al.carried out an investigation on wastewater treatment in petrochemical refinery plant SAMIR[29]. They carried out the diagnostic evaluation of the SAMIR wastewater treatment plant. In their work, they also suggested steps to improve performance with respects to the elimination of pollution. They observed that 92% and 96% removal of turbidity and 92% and 95% removal of was obtained during treatment. The COD removal varied between 50% and 94% and the BOD removal varied 60 and 92%. Change in raw water quality can be the reason for the variation. The removal of hydrocarbons justified optimization of coagulation-flocculation and biological aeration basins. Amin et.al.co-treated petroleum refinery wastewater with municipal wastewater in continuous flow bench scale reactors[30]. They treated municipal wastewater and a mixture of municipal and refinery wastewater separately in two separate reactors. They increased organic load of effluent from 20% to 40%, 60%, 80% and 100%. They concluded that there was minimal impact on effluent COD while still meeting the standard effluent discharge limits. Gasim et.al. used UASB reactors for petroleum wastewater treatment[31]. They operated two UASB reactors in parallel to evaluate the treatment efficiency of petroleum refinery wastewater. They obtained COD removal of 77-83% in their investigation.

3. CONCLUSION

Various investigators have carried out investigations on biological treatment of petroleum wastewater. Current review summarizes research and studies on petroleum wastewater treatment by biological methods. The composition of wastewater affected the effectivity of treatment. Investigations also indicated that the MBR was able to cope with the variable petrochemical effluents. Many investigations have indicated that AOP was highly efficient method. Alsostudies revealed that the nitrogen removal during conventional activated sludge process was not efficient. Expanded Granular Sludge Blanket (EGSB) Reactors, according to investigators is better alternative to UASB reactors.COD and phenol removal efficiencies higher than 90% and 99% were obtained by using MBRs.

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