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A Review on Wastewater Treatment for Petroleum Industries and Refineries

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ABSTRACT

The industrial wastewater treatment is gaining more and more importance with the rapidly increasing need for expansion of existing plants and erection of new plants to cater the needs of chemical, pharmaceutical and petrochemical products and intermediates. The treatment of the wastewater is key to the sustainable and acceptable industrial growth. Petroleum industries and refineries are important from economic growth point of view. The wastewater from these industries mainly contains oil, organic matter and other compounds. The treatment of this wastewater can be carried out by physical, biological and chemical treatment methods. The current review summarizes studies and investigations carried out for the treatment of petroleum industries and refineries.

Keywords: Effluent, oxygen demand, organic matter, aerobic, chemical treatment.

I. INTRODUCTION

Industrial wastewater treatment is important study area in environmental engineering. Industrial sectors like paint, pigment, sugar, distilleries, pharmaceutical, leather, fine chemicals, additives, textile, oil, wood, plastic etc. face the problem of efficient and low cost treatment methods. Various biological methods are found useful in treating organic matter [1, 2, 3]. Also membrane separation was used successfully by various investigators [4, 5].Though these techniques are familiar continuous research is still going on in order to make the treatment more economical and acceptable. Adsorption has many advantages over other methods like cost, simplicity and adaptability [6,7,8,9]. Low cost adsorbents are being tried for adsorption of pollutants from wastewater [10,11,12]. Petroleum industries and refineries govern the financial growth of the countries. In India there are many public sector and private firms in this sector. The treatment of petroleum and petrochemical wastewater is widely studies area of research. The current review focuses on reviewing the investigation and studies on wastewater treatment for petroleum industries and refineries.

II. STUDIES AND RESEARCH ON PETROLEUM INDUSTRY AND REFINERY WASTEWATER

Rasheed and. Muthukumar discussed the petroleum industry wastewater by using sequencing batch reactor [13]. They first pre-treated wastewater with sonication for 30 min and then subjected to biological treatment. They operated the SBR in fill, aerobic, anoxic, and anaerobic modes. They were able to remove around 57 percent COD by sonication. For their research they obtained Petroleum refining wastewater from the central effluent treatment plant facility available at industrial estate, Chennai, India. The samples were kept under deep freeze until used for investigation. Initial COD of the effluent was 40000 mg/l and pH was 5.4. Field frequency of 30 KHz was use for sonication. According to them, the dissolved compounds of the solution diffuse through the micro bubbles and the bubbles expand in size until they reach a critical size and quick re-condensation or collapse of bubbles occurs. Formation and collapsing of cavitation bubbles thus makes the compounds to undergo pyrolytic fragmentation. In these investigations, mode 1 was of 25 h, which consists of fill (1h), aerobic reaction (8 h), anoxic (8 h) and anaerobic (8 h). Mode 2 was done with operating time of 21 h

consisting of fill (1 h), aerobic reaction (10 h), anoxic (6 h) anaerobic (4 h). They observed that % COD remaining decreased with an increase in time. Also they found that the increase in aeration react period increased the reduction of COD. They concluded that hat the COD reduction was higher for Mode 2 which has higher aerobic period than mode 1. Also the time for biodegradation decreased because of sonication. Seif from Egypt carried out physical treatment of petrochemical wastewater[14]. He carried out statistical study on the results of sample analysis of about two years from different sources in the petrochemical company. According to him, discharging industrial wastewater into Nile or Nile branches and canals has been causing health troubles, especially on drinking water. He carried out investigation in order evaluate the state of the discharge wastewater and finds the way to decrease its effect on the surface water bodies. In sewer the maximum COD was around 1400 to 1500 mg/l and maximum BOD was 25 to 30 mg/l. He concluded that separation and individual treatment for each source was a good alternative against treatment full quantity after mixing of different sources. Parilti carried out investigation on treatment of a petrochemical industry wastewater by a solar oxidation process using the box-wilson experimental design method [15]. He used an advanced oxidation treatment.The Fe(III)/ H2O2/Solar-UV process was applied to a petrochemical refinery wastewater in Izmir, Turkey by him. He pre-treated the wastewater for the oil & grease by the lamella separator before the biological treatment. He also obtained the composition of the wastewater before treatment. Initial COD of the water was 1200 mg/L to 2800 mg/L and BOD was 800 mg/L and 1400 mg/L. The reactor system consisted of the system consists of sun light collectors, water preparation tank, circulation pump and a control panel. He found that the correlation coefficient (R2) between the observed and predicted value was 0.9622 for TOC removal. BOD to COD ratio obtained was 0.5 by them. About 49 percent degradation of the petrochemical industry wastewater was possible. Jafarzadeh et.al. carried out investigation on electro coagulation method for treatment of petrochemical effluent[16]. According to them, electro coagulation has some advantages for polluted water treatment compared to traditional chemical coagulation. They obtained the phenol removal efficiency of 51% was obtained at 75 min operating time. They conducted the batch electro coagulation experiments for 15-75 min for different current densities. They obtained maximum phenol removal efficiency of 65, 64, 60, 57, 50 and 42%, after 75 min for current densities of 54, 46, 34, 28, 22 and 17 mAcm−2, respectively. Chavan and Mukherji investigated effect of N:P ratio on treatment of hydrocarbon-rich wastewater using oil degrading bacteria and phototrophic microorganisms in rotating biological contactors[17]. In their study they developed a consortium of phototrophic microorganisms and a bacterium on the discs of a rotating biological contactor (RBC) for treatment of wastewater containing diesel oil. Burkholderia cepacia and oil tolerant phototrophic microorganisms were fed to the reactor. According to them, advantages of this system include good total petroleum hydro-carbon (TPH) removal, no soluble carbon source requirement and good settle ability of biosolids. They observed that the N:P ratios 28.5:1 and 38:1, both yielded high and almost comparable TPH and COD removal efficiencies. The N:P ratio was found to be critical factor in the process. Cavalcanti et.al. reviewed investigations on adsorption by organoclay for removal of effluent from petrochemical wastewater[18]. They observed that organophilic clays were effective as adsorbents for the removal of organic substances with high toxicity, such as phenols and BTEX compounds. According to their discussion, the mechanisms that control these interactions depend on the type of cation that forms. Increase in temperature does not favour the adsorption. Macarie et.al. carried out anaerobic treatment of a petrochemical wastewater from a terephthalic acid plant[19]. They used two UASB reactors and a downflow tubular fixed film reactor. An overall reduction of 84% in COD and 80% in TSS for a hydraulic retention time of 3.4 days was possible by using a lab scale arrangement consisting of a static primary sedimentation of raw wastewater, followed by an anaerobic treatment of the settled wastewater with a downflow fixed film reactor. UASB reactor as biological step was not successful. They concluded that proposed arrangement was a good alternative to the conventional aerobic process used to treat PTA effluent. Also they pointed out that it was necessary to solve the problems related to disposal of primary settled solids and reduction in chemical consumption for effluent neutralization. El-Ashtoukhy investigated the treatment of petrochemical wastewater containing phenolic compounds by electro coagulation using a fixed bed electrochemical reactor[20]. They used an electrochemical reactor with a fixed bed anode made of

randomly oriented Al raschig rings packed in a perforated plastic basket located above the horizontal cathode. They studied effect of parameters such as pH, operating time, current density, initial phenol concentration, and addition of NaCl, temperature and the effect of phenol structure (effect of functional groups). They obtained 100 percent removal of phenol in two hours for 3 mg/l real refinery waste.Altaher et.al. used coagulation for pre-treatment of petroleum/ petrochemical industries wastewater[21].Their results indicated that that ferric chloride had superior efficiency compared with other coagulants with efficient dose of 800 mg/l. They observed that Alum was having comparable removal efficiency to FeCl3. The disadvantage of alum was its hazardous nature. Also it was observed that increase in pH form acidic range to alkaline range promotes turbidity removal. Mueller et.al. discussed Integrated Fixed-Film/ Activated Sludge Process(IFAS) for refinery and petrochemical wastewater treatment plant upgrades[22]. According to them process flexibility and high degree of treatment are main advantages of activated sludge process. Also the Fixed film processes are inherently stable and resistant to organic and hydraulic shock loadings. These two processes were combined to give cumulative effect of these advantages in the treatment. They found that IFAS was superior to the conventional modes of these two technologies.

Farajnezhad and Gharbani used poly aluminium chloride and ferric chloride for coagulation treatment of wastewater in petroleum industry[23]. They observed that poly aluminium chloride was more effective. They also observed that variation in of pH has no significant effect on color removal of petroleum wastewater. Uddeen et.al. reviewed treatment technologies for petroleum refinery effluents[24]. Their review provided a brief account of different technologies used for the treatment of petroleum refinery effluents(PRE). According to the review, the PRE treatment consists of two main steps, one is pre-treatment and other, advanced treatment. Biodegradation, Photo catalytic degradation, adsorption etc. have been investigated with promising results. The important parameters in these treatment techniques were chemical oxygen demand (COD), biological oxygen demand (BOD), total petroleum hydrocarbon (TPH), oil and grease (O&G), sulphate and phenols. According to Benyahia treatment of refinery wastewater was 'A true Technological Challenge'[25]. The composition of effluent in these industries depends on the crude quality. It varies with the operating conditions. In their investigation they traced the sources of wastewater pollutants specific sources and operations, and identified suitable treatment technologies. They utilized modern powerful tools such image analysis to characterize oil droplet sizes in oily wastewater. Oliver carried out studies treatment of petrochemical wastewaters [26]. He discussed various aspects removal of various contaminants from the wastewater. He also discussed various biological chemical and physical treatment methods for petrochemical wastewater. Gasim et.al carried out optimization of anaerobic treatment of petroleum refinery wastewater using artificial neural networks[27]. They used raw data from wastewater treatment successfully for modeling at different shock loads. The highest COD removal of 82 percent was observed in experiments and it matched with the best suited model data. Awaleh and Soubaneh discussed the various industrial wastewater treatment technologies currently available including physico-chemical and biological processes as well as conventional or advanced oxidation processes[28]. According to them the activated carbons can be used for the removal of metals, chloride, fluoride and COD from industrial effluents. Also according to them a combination using an anaerobic process followed by an aerobic treatment system is a better option.

III. CONCLUSION

Petroleum and petrochemical wastewater can be treated effectively by various physical, chemical and biological treatment processes. The use of sonication removes more than 50 percent of COD. The use of electrochemical method was also successful. Various biological methods, both aerobic and anaerobic were also tested with encouraging results. Combination of fixed film and activated sludge processes provided advantages of both the methods. 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.

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