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Biodegradation of Coke Oven Wastewater with Starch as Co Substrate in an UASB Reactor

P. Sivarajan [1], N. Nagarajan [2], N. Ashokkumar [3]
[1]Associate Professor/ Corresponding author, Dept. of Civil Engineering, Annamalai University, Tamilnadu, India
[2] Associate Professor/ Co-author, Dept. of Civil Engineering, Annamalai University, Tamilnadu, India
[3] Associate Professor/ Co- author, Dept. of Civil Engineering, Annamalai University, Tamilnadu, India

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Abstract:
Anaerobic degradation of coke oven wastewater with starch as co substrate was carried out in an UASB reactor seeded with anaerobic sludge of VSS concentration 45000mg/Lobtained from anaerobic digester treating starch effluent of sago industry. The reactor was operated with synthetic starch and coke oven wastewater at various mixing ratio *viz*. 95/5, 90/10, 85/15, 80/20 and 75/25.The COD and phenolics (mixture of phenol and chlorophenols) removal were monitored. Removal efficiency of COD were ranging between 70 to 78% and phenolics removal efficiency ranged among 73.3 to 82%.Maximum of 82% of phenolics and 78% of COD removal efficiency were obtained at a mixing ratio of 85/15.

Keywords*: Anaerobic degradation, UASBR, coke-oven wastewater, Co-substrate*

Introduction:

Consequence of industrial activities have paved the way for synthetic chemicals into the ecosystem. Naturally the fraction of discharge to degradation is always more, which results in accumulation of such substances to the environment. The washing of the ammonia stills, which accumulates from the gas coolers in a coke oven plants yield contaminated effluent. These effluents contain cyanide, ammonia, sulphide and large amount of phenolics (mixture of phenols and chlorophenols) which are very toxic to the ecosystem. Phenolics present in the waste of a coke-oven units is a destructive pollutant, which is lethal to animals, soil microbes and some aquatic species in the low mg L^{-1} range concentrations.

As they are persistent, mutagenic as well as carcinogenic, they cause severe ecological snag and due to their harmfulness their release into the environment is of great concern [**1**] Moreover, phenolics has an impact on human health and it is recommended that human acquaintance should not surpass 20 mg on an average working day. Due to their high solubility in water they can easily penetrate within different aqueous environments and contaminate groundwater [**2**]. Henceforth, it is positioned in the list of priority contaminants by the U.S. Environmental Protection Agency [**3**]. Steam chemical coagulation, sludge concentration, stripping, aeration, settling and sometimes dilution are some of the methods which have been used to decrease unfavourable influence on environmental conditions under nonidentical conditions **[4,5]**. Though, treatment of wastewater containing phenolic compounds is not easy, as the effective removal of each other is resisted by the contaminants. Organic pollutants can be removed in colossal quantities from the wastewater at comparatively low cost by biological treatment and can be carried out both by aerobic and anaerobic conditions **[6]**. Biodegradation of phenolics by aerobic bacteria is hindered **[7]** and anaerobic processes are found to be suitable for proper degradation**[8,9].**

Particularly the UASB reactor with high metabolic activity, good biosolids settling ability, notably characterized by anaerobic granular sludge can be successfully implemented for the treatment of

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high strength coke oven waste water. The present research is aimed to evaluate the degradation of coke oven wastewater with starch as co-substrate at various mixing ratios in an UASB reactor.

MATERIAL AND METHODS

Grab samples of aqueous untreated effluent from a coke oven industry BHEL, Trichy, Tamilnadu, India was collected and tested for its characteristics as per standard method **[10]** The **c**hemicals used were of the highest grade and commonly available. The sludge collected from an anaerobic digester treating starch effluent of sago industry at Rasipuram, Salem, India was used as microbial seed in the UASB reactor. The VSS concentration of the seed used is 45,000 mg/L The inoculum was washed to remove undesired substances before feeding into the UASB reactor.To study the anaerobic treatability of coke oven wastewater a UASB reactor was fabricated and its operational performance was investigated.The process essentially contained a raw feed storage tank, feed pump, acidogenic reactor, methanogenic reactor, and gas measurement assembly. Both the reactors, acidogenic and methanogenic were fabricated with 1:4 volume ratios.

EXPERIMENTAL METHODS FOR UASB REACTOR

The reactor was fed with synthetic starch water with OLR of 2.2 kg COD/m^{3}d at 24 h HRT, pH of 7.2, nutrients at the ratio of 100:5:1. and operated with an up-flow velocity of 0.08 m/h throughout the start-up period. After stabilization, the reactor was operated with synthetic starch and coke oven wastewater at various mixing ratio *viz*. 95/5, 90/10, 85/15, 80/20 and 75/25.

The COD and phenolics (mixture of phenol and chlorophenols) removal were monitoredby spectrophotometric method and reported.

RESULTS AND DISCUSSION

The effluents were analysed for various physio-chemical parameters as per Standard methods **[10]** Table 1 presents the result of the analysis of coke oven industry effluent parameter. It is found that the coke oven effluent is coloured,alkaline, has low BOD:COD ratio and phenolics. The parameters such as pH, Total Suspended Solids (TSS), TDS, COD, BOD, phenolics and chlorides in the effluents from coke oven industries are exceeding the tolerance limits prescribed by the Statutory Authorities, Government of India.

S.No.	Parameters*	Coke oveneffluent
1	pH	8±1
2	Total suspended solids	400±25
3	Total dissolved solids	3420±450
4	COD	1900±200
5	BOD	170±25
6	Chlorides	2000±150
7	Sulphates	240±20
8	Phenols	1500±100
9	2-Chlorophenol	300±20
10	2,4-dichlorophenol	150±10

Based on the results it is summarized that colour causes aesthetic problems, excess suspended solids present in the effluent will cause deposition of solids in inert stretches of a stream and will damage the aquatic life, substances like phenolics are resistant to biodegradation and this may be undesirable for certain water quality requirements, effluents provide obnoxious odours which in turn have a high irritation on the surrounding area and presence of excess sulphates will inhibit the biological process to large extent.

REMOVAL OF COD

Starch was mixed with the coke oven wastewater collected from M/s Bharath Heavy Electrical Limited, Trichy at the mixing ratios of 95/5, 90/10, 85/15, 80/20 and 75/25. Figure 1 shows the COD at different mixing ratios throughout the process. The inlet and outlet COD at the mixing ratios of 95/5, 90/10, 85/15, 80/20 and 75/25 was ranging from 2120-520, 2040-480, 2000-440, 1960-480 and 1880-560 mg/L, respectively. Due to the dilution effect of wastewater, the COD of the feed decreases as the coke oven effluent ratio increases. The removal percentage of COD at various mixing ratios was shown in the figure 2. It is clear that the COD removal increases as the mixing ratio of the coke oven industry wastewater increases *viz.* 75.5, 76.5, 78, 75.1 % for 95/5, 90/10, 85/15, 80/20 and further increase in the coke oven industry wastewater leads to decrease in the COD removal efficiency. This may be due to the inhibitory effect of the coke oven industry wastewater. Maximum COD removal of 92% was obtained in treating simulated coke oven wastewater in a sequential batch reactor was reported by Papadimitriou **[11]**.

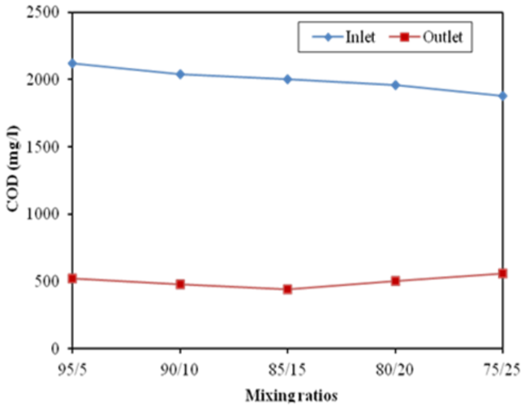

Figure 1 COD in the reactor treating coke oven wastewater

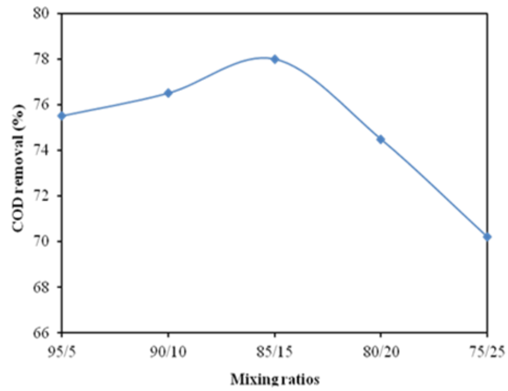

Figure 2 COD removal (%) on treating coke oven wastewater

REMOVAL OF PHENOLICS

The phenolics concentration (O.D.) at 500 nm for different mixing ratios are shown in figure 3. The phenolic concentration at different mixing ratios of starch and coke oven industry wastewater *viz.* 95:5, 90:10, 85:15, 80:20, 75:25, are 0.94, 1.04, 1.22, 1.46, 1.65 at inlet and at outlet of the reactor it was 0.18, 0.19, 0.22, 0.24, 0.44, respectively. Figure 4 displays the percentage removal of phenolics at various mixing proportions. The percentage removal of phenolics increased for mixing ratios of 95:5, 90:10 and 85:15 and further increase in concentration of coke oven effluent lead to decrease in percentage removal of phenolics. The decrease in removal percentage may be due to inhibition effect of coke oven wastewater. Moreover the coke oven effluent contains cyanide which might have inhibited the biological process. Maximum phenolics removal efficiency of 82% was attained at mixing proportion of 85:15and at other mixing ratios *viz.* 95:5, 90:10, 80:20 and 75:25 are 80.9, 81.7, 77.0 and 73.3% respectively. **[11]** obtained a maximum phenolics removal of 90% in a sequential batch reactor and 80% in CSTR treating simulated coke oven wastewater.

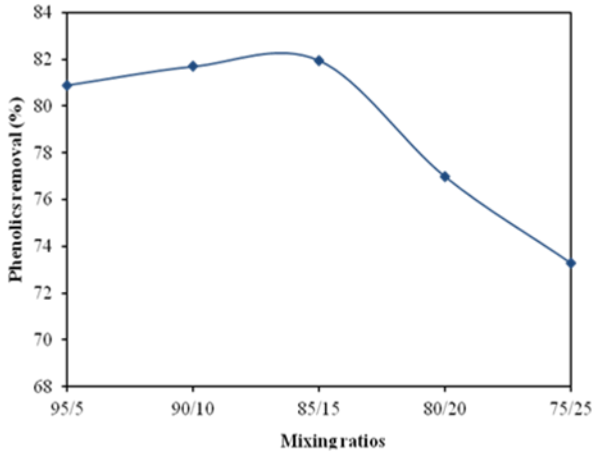

Figure 3 Phenolics in the reactor treating coke oven wastewater

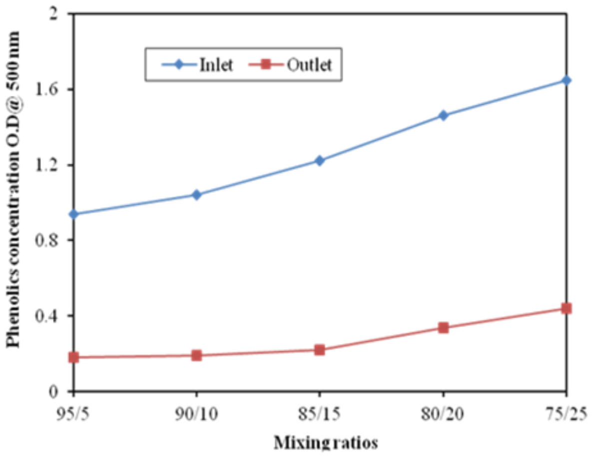

Figure 4 Phenolics removal (%) on treating coke oven wastewater

CONCLUSION

The coke oven effluent is coloured, alkaline, has low BOD:COD ratio and phenolics. The excess suspended solids present in the effluent will cause deposition of solids in inert stretches of a stream and will damage the aquatic life, the presence of excess sulphates will inhibit the biological process to large extent. The degradation of coke oven wastewater with starch as co substrate at various mixing ratio *viz*. 95/5, 90/10, 85/15, 80/20 and 75/25 revealed that the reactor was able to treat coke oven wastewater. The results indicated that a maximum of 82% of phenolics and 78% of COD removal efficiency were obtained at a mixing ratio of 85/15. The study revealed that UASB reactor could be a viable, sustainable and eco-friendly treatment system for treating coke oven waste water with starch water as co-substrate.

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