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RESEARCH ARTICLE

BIOTREATMENT OF HIGH STRENGTH TOXIC PETROCHEMICAL (i.e. ACRYLONITRILE) WASTE WATER TO REDUCE COD AND CYANIDE

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ABSTRACT

Bio treatment a high strength toxic petrochemical (acrylonitrile) waste water to reduce COD and cyanide. Among the waste water generated in petrochemical industry, the process waste water stream generated during the manufacturing of acrylonitrile are considered to be one of the most toxic as they can take cynides are extremely harmful to lives on earth including human and can cause irreparable damage to environment. Biological degradation of the high strength toxic petrochemical waste water using laboratory scale immobilized cell bio reactor (immobilized cells act as bio catalyst – 4% sodium alginate beads in 0.85% saline, containing 4.6 mg/ L of mixed culture. This was added dropwise to 2.0 M $cacl_2$ solution and each drop hardened in to a bead containing entrapped cells. The beads were allowed hardened further in $cacl_2$ solution at 5 ^{0}c for 24hr. COD reduction was measured for various organic loading.

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INTRODUCTION

Among the wastewater generated in petrochemical industry, the process wastewater streams generated during the manufacture of Acrylonitrile are considered to be one of the most toxic as they contain Cyanides, which as everybody is aware, are extremely harmful to life forms on earth including humans and can cause irreparable damage to our environment. This chemical components need to be controlled under the level for safe disposal. Here some of the waste streams also contain very high amounts of total dissolved solids (TDS) along with high Cyanide content. Acrylonitrile manufactured plant, contains Cyanides, nitrogenous organics (COD about 15,000 mg/L) and Ammonia. Here COD and Cyanides reduction is discussed. Minimum National standard for the discharge of Cyanide is 0.2 mg/L and COD is 250 mg/L

Literature Review

Some of the low volume wastewater containing high level of very toxic components and dissolved solids are generally disposed off by incineration. Several types of incinerators such as Liquid injection, Rotary kiln and Fluidized bed incinerators are capable of treating the toxic petrochemical wastewater. These processes are highly cost intensive because fuel oil or compressed natural gas is used to burn the wastewater. One major disadvantage of these processes is during incineration the extremely toxic pollutants are converted to carbon dioxide and nitrogen. Many chemical or biological methods are used for Cyanide removal from petrochemical wastewater; Biological treatment is the most commonly used technique worldwide and also the most economical for the treatment of both industrial and domestic wastewater.

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Objective of the Study

- Biological degradation of the high strength toxic nitrogenous petrochemical wastewater using laboratory scale fixed film column bioreactors.
- Evaluation of the toxic pollution removal efficiency of the different biomass support material (attachment media), stones (pebbles) and plastic net scrubbers for use in the fixed film bioreactors for wastewater biotreatment.
- Biodegradation of high strength wastewater using laboratory scale Immobilized cells bioreactor (Immobilized cells here act as biocatalyst). Entrapment of petrochemical activated sludge biomass with Sodium Alginate beads was carried out by using 4% Sodium Alginate in 0.85% saline, containing 4.6 mg/L of mixed culture. This was added drop

wise to 2.0 M $CaCl_2$ solution, and each drop hardened in to a bead containing entrapped cells. The beads were allowed hardened further in $CaCl_2$ solution at 5ºC for 24 h.

Description of the Setup

Here, Two laboratory scale growth fixed film bioreactors were used in the present study. To examine and compare the efficiency of the conventional biofilm support medium pebbles (small stones from river bed) and plastic net scrubber for the biotreatment of the high strength petrochemical wastewater. The growth of the actively degrading microorganisms takes place on the surface of the packing (support) material. Aeration was done through diffuser stones, placed at the bottom of the both bioreactors, bellow biomass support material. The aeration was adequate to maintain the dissolved oxygen (DO) level at about 2 mg/L in the bioreactor. Reduction in COD & Cyanide is shown in the results.

Description of the Setup

Bioreactor set up is shown in Fig. 2 with proper air flow rate (0.5 L/min.) the Alginate beads loaded with activated sludge cells (immobilized cell-biocatalyst) could be fluidized and the reactor was operated as a fluidized bed reactor. Reduction in Cyanide and COD is shown in the results.

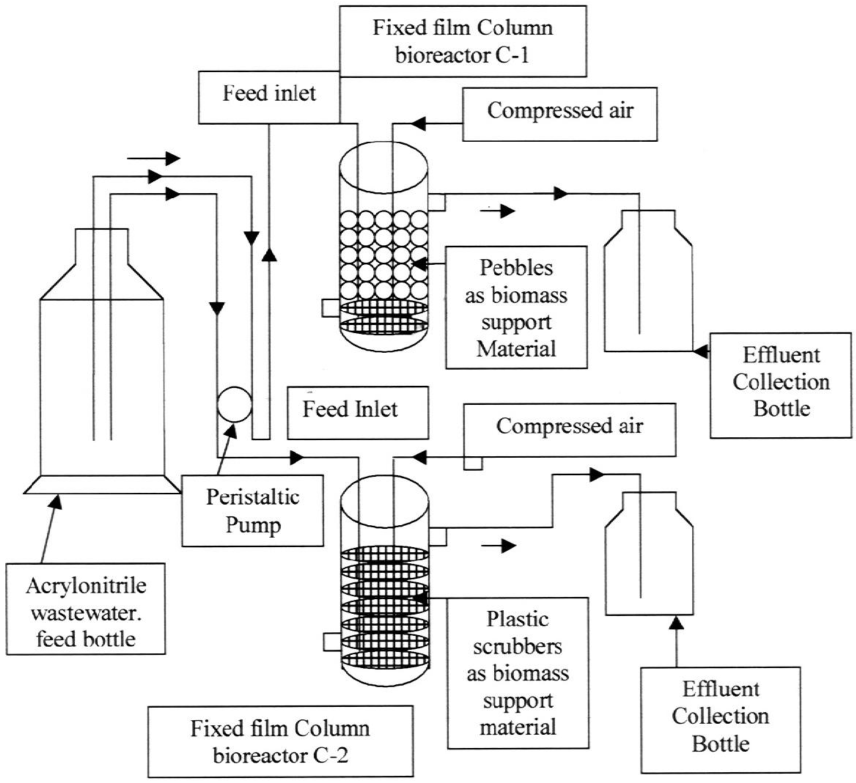

Fig. 1. Experimental setup of the fixed film reactor used for study

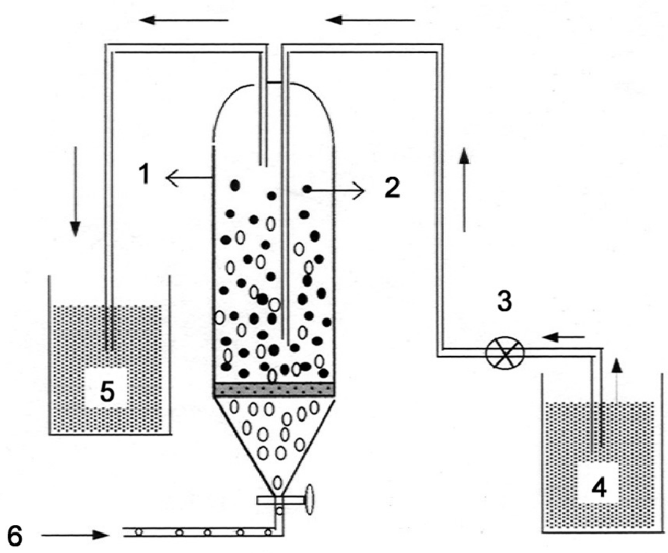

Fig. 2. Experimental Set up for Immobilized Cell Bioreactor

1. Fuidized Bed Bioreactor 2. Immobilizezd Cell Biocatalyst 3. Control Valve for Incoming Wastewater 4. Tank for Incoming Wastewater 5. Collection Tank for treated Wastewater.

RESULTS AND DISCUSSION

Effect of Hydraulic Residence Time (HRT) decides the residence time of the wastewater in the bioreactor for an economically viable treatment process.

The HRT should be as low as possible, so that a maximum volume of wastewater was treated in a short period. However, the HRT should also be such that the microorganisms get adequate / optimum contact time with the effluent for a maximum COD reduction.

Table 1. Influence of Organic Loading Rate (OLR) on the Performance of the Fixed Film Bioreactors

HRT (d)	Organic Loading Rate (kg. COD/m^3/d)	Cyanide loading rate (g/m^3/d)	Fixed Film Reactor	COD Reduction (%)	Cyanide Reduction (%)
1.3	8.64	2.17	Stone media	46	10
			Plastic media	55	19
	11.3	3.10	Stone media	37	32
			Plastic media	47	32
	16.0	5.95	Stone media	33	24
			Plastic media	42	26
2.7	i.94	1.22	Stone media	52	29
			Plastic media	60	38
	3.10	1.37	Stone media	40	30
			Plastic media	66	45
	4.76	1.65	Stone media	56	27
			Plastic media	65	43
	6.3	1.84	Stone media	61	37
			Plastic media	65	56
4.5	1.77	0.82	Stone media	75	58
			Plastic media	78	63
	2.75	0.95	Stone media	78	52
			Plastic media	83	55
	3.65	1.10	Stone media	79	55
			Plastic media	86	67
	4.60	1.82	Stone media	78	76
			Plastic media	86	82

Information given in the Table-1 is shown graphically by Fig. 3, 4, 5 and 6.

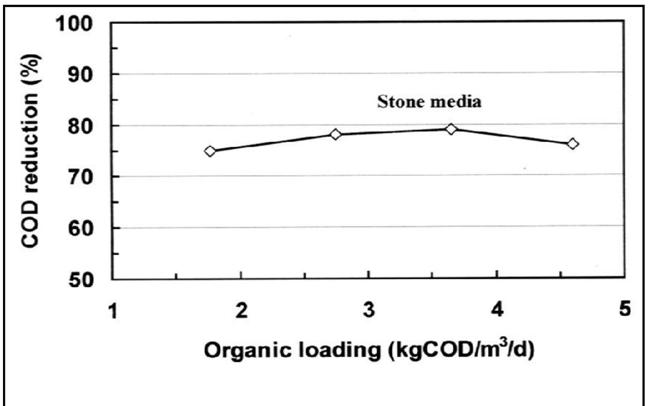

Fig. 3 : Effect of organic loading rate on the COD reduction by fixed film reactor with stone media

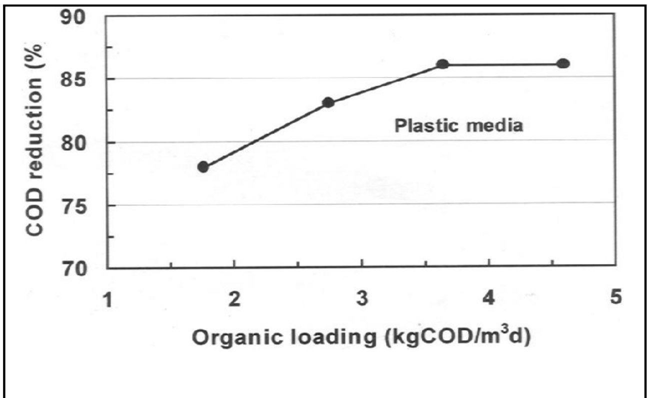

Fig.4 : Effect of organic loading rate on the COD reduction by fixed film reactor

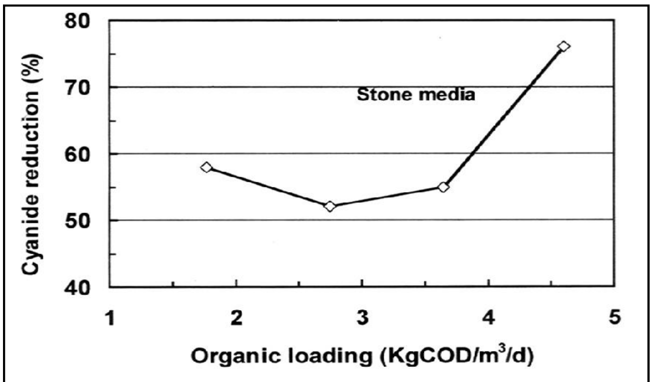

Fig. 5 : Effect of organic loading rate on the Cyanide removal by fixed film with stone media

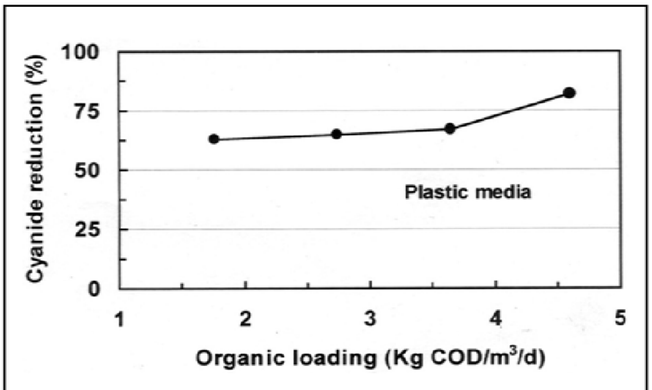

Fig. 6 : Effect of Organic loading rate on the Cyanide reduction by fixed film reactor with plastic media

Results collected from experiments in Immobilized activated sludge cells are shown in Table-2.

Table 2. Summary of Data Collected from Immobilized Cell Bioreactor Experiments

Phase No.	Average Feed Parameters		Average Effluent Parameters		% COD Removal	% Cyanide Removal
	COD mg/L	Cyanide mg/L	COD mg/L	Cyanide mg/L		
1	4460	3.0	1580	1.2	60	35
2*	10350	4.2	4050	2.0	63	52
3*	14800	4.1	5340	2.7	65	60

The immobilized cell reactor was run for about 10 d at each phase of feeding at a HRT-2d and the average values are given in the above table.
* At higher feed COD levels, the Algenate beads were observed to disintegrate by 8-10 d inspite of adding $CaCl_2$ (100 mg/L) in the wastewater.

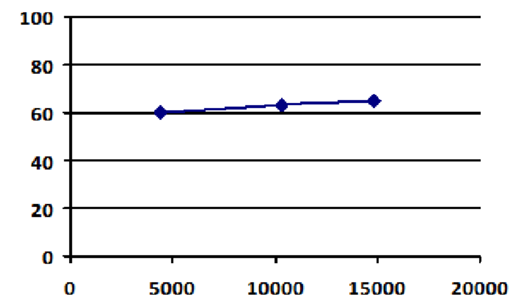

Fig. 7 : COD mg/L Vs %COD Removal for Immobilized Activated Sludge Cell Reactor

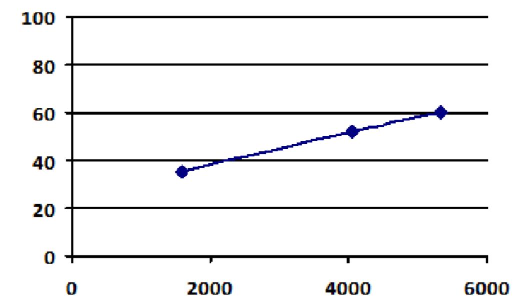

Fig. 8 : Cyanide mg/L Vs %Cyanide Removal for Immobilized Activated Sludge Cell Reactor

Conclusion

- The data collated during the present study indicated a general trend that the percentage COD and Cyanide degradation increased with increased HRT.
- Among different HRTs studied, a HRT of 4.5 day was found be optimum for realized COD and Cyanide reduction as high as 75-86%.
- At the optimum HRT of 4.5 day with the stone media, the highest COD reduction was 75-86% and for plastic net scrubber it was found 78-86% Cyanide reduction was found 58-76% and 63-82% respectively for same HRT. So, plastic net scrubber was more effective obviously due to more surface for attachment and aeration.
- An alternative method of Biotreatment using the activated sludge immobilized cells. Experiments showed that the activated sludge cell returned about 70-75% activity after immobilization. Using the immobilized activated sludge cell reactor showed 60-65% COD reduction and 35-60% Cyanide reduction was observed with greater than 4d HRT. The stability of the Alginate beads became a problem when concentrated feed was used beads, disintegrated. Other more stable materials should be used for formation of beads so that we can get more reduction in COD and Cyanide.
- So, here for present study plastic net scrubber gives the best results among all we tried.
- These types of packing materials can be tried for tertiary treatment wastewater for any kind of material for desired level of purification

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