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Application of Engineering Microorganism for the Effective Treatment of Paint Shop Wastewater

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Abstract

Nowadays, there are increasingly stringent regulations requiring more and more treatment of industrial effluents to generate product water which could be easily reused or disposed of to the environment without any harmful effect. Some pollutants such as high organic, inorganic matter, heavy metals or paint stuffs resist degradation by conventional treatment methods and persist in the environment. In the present article an attempt is made to access the feasibility of recycle/reuse of wastewaters from automobile industry through conventional and advanced treatment process.

The present article describes the use of engineering microorganisms as an alternative method for treatment of such recalcitrant pollutants than conventional microorganism. The Reactor performance was evaluated using parameters like pH, DO and COD at different loading rates. It has shown that though the efficiency of the reactor decreases with the increase in organic load still the effluent parameters are maintained well within the specified limits. It also emphasizes the need for current and future research to focus on developing economically feasible and environmentally sustainable wastewater treatment practices.

Keywords: bioreactor, engineering microorganism, HRT, Paint shop wastewater, reactor performance

I. Introduction

The limited availability of fresh water is a global crisis. Many under developed areas of the world already face a shortage of clean drinking water and irrigation water for food production, while in industrialized nations, such as the India, the quality of available water for public and industrial use will be a larger issue [1].

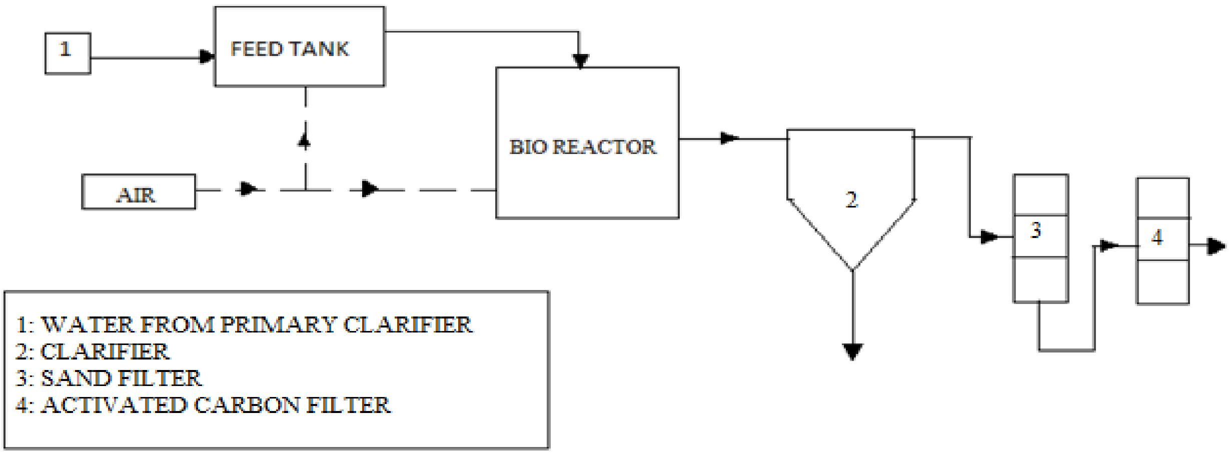
Portions of Africa, India, China, Australia, Europe, Mexico, the Middle East and southwest United States are identified as having a water scarcity, defined as a supply less than 200 m3/person/year. However, in recent times, the need to replenish our water resources has been receiving increasing attention. This has led to the development of strategies to return water to its source in the least toxic form possible, to enable reutilization of water. These strategies and processes may be collectively termed as ‘wastewater treatment’ [2].

Automobile industries produce large quantities of wastewaters, which are characterized by a complex combination of organic, inorganic matter with oil and grease and heavy metals. If partially treated or untreated wastewater is discharged it damages the geo-environment. Sustainable growth in automobile industry warrants water conservation. The effluent recycle/reuse provides a novel opportunity to augment the increasing demand and enhance the idea of closing the water cycle [3].

The presence of paint in the water body increases the Chemical and Biological Oxygen Demand (COD and BOD respectively) [3]. Additionally, effluent containing paint stuffs are found to have a large concentration of suspended solids. These factors upset the ecological balance of the receiving water body. Several heavy metals of paint have been found to be potentially toxic. Thus, the presence of paint stuff is a serious environmental concern [4].

One possible solution to this problem is the use of engineering enzymes for effective treatment of wastewater treatment and reuse. According to Aitken (1993) enzymes were first proposed for the treatment of industrial waste in the 1930’s but it wasn’t until recent that enzyme technology received much attention for the improvement in biological remediation for industrial effluents [3]. Engineering microorganisms are proprietary high concentrated enzymes having good production strength. They can work in both aerobic and anaerobic condition but most probably used in aerobic condition.

Fig 1: Process flow diagram



It helps to increase MLSS by 30% than conventional wastewater treatment processes and also alters the rate of reaction and % degradation. The main advantage of the system is it's a close-loop system i.e. the treated water is recycled for the sanitation purpose, gardening or again to the paint shop activities.

I. Materials and methods

Fig 1 shows schematic of process flow diagram. Water from primary clarifier comes to the feed tank (100lit/day) which is provided with the diffuser at the bottom.The wastewater is then fed to the bioreactor having capacity of 500m^3. Air is fed to the tank to prevent the sewage creating odor and allows sufficient O_2 to the micro-organisms present in it. The treated water is then fed to the settler and taken to sludge beds. The overflow from the settler is fed to the filters for removal of fines. The water coming from the filters is used for sanitation and gardening purpose.

II. Procedure

A number of issues were taken into account when siting the pilot system, including: access to electrical and water supplies, structural integrity, spill and leak containment, and access to equipment needed to unload and position the pilot plant.

The bioreactor (500lit) was fed raw wastewater (80lit/day) from the primary clarifier. The seed concentration at the time of start-up was approximately 500 mg/l MLSS. Start-up was quick with almost complete COD removal and 90% nitrification occurring within the first six days.

Experiments were divided into two phases depending upon micro-organisms used.

Phase 1: Conventional treatment

Phase 2: Engineering microorganism in wastewater treatment

In **phase 1** conventional microorganism were added to the bio reactor whereas in **phase 2** engineering enzymes were added. For both the phases change in COD concentration was observed w.r.t hydraulic retention time. The influent COD values were varied within the range of 400 mg/lit to 600 mg/lit and then pH was I the range of 8 to 9. The activated sludge target concentration of 1000-1500 mg/lMLSS was achieve after one month of operation and was maintained +/- 3500 mg/lMLSS throughout normal operation after addition of engineering microbes.

The wastewater characteristics for process given in table 1

Sr. No	Parameter	Process effluent	Units
1	pH	8-9	
2	Total suspended solids	250-300	mg/lit
3	Total dissolved solids	824	mg/lit
4	B.O.D. 3 days at 27 Deg. C	150-200	mg/lit
5	C.O.D	400-600	mg/lit
6	Oil & Grease	10	mg/lit

Limits of treated effluent are given in table 2:

Sr. No	Parameter	Treated effluent	Units

1	pH	7.7-8.47	
2	Total suspended solids	<100	mg/lit
3	Total dissolved solids	<2100	mg/lit
3	B.O.D. 3 days at 27 Deg. C	<100	mg/lit
4	C.O.D	<100	mg/lit
5	Oil & Grease	<10	mg/lit

III. Result and discussions

4.1Design of bio reactor

The influent flow rate maintained for the bioreactor is $100m^3$/day.

Characteristics of wastewater obtained from experimentation work is given as,
bsCOD in influent wastewater = 400mg/lit
Influent nbVSS conc. = $50g/m^3$
The biomass concentration = $2000g/m^3$
Inert inorganics = $10g/m^3$
Consider,
k = cell debris fraction = 0.10
Ks = half velocity constant substrate concentration = $40g/m^3$
$f_d$and k_d = 0.1
Y = 0.3gVSS/gbsCOD
Sludge retention time = 5d
Hydraulic retention time = τ = 5d

Volume of the reactor = $\tau * Q$ (1)

= 5*100 = $500m^3$

4.1.1 The effluent bsCOD concentration

The effluent bsCOD concentration for a bioreactor is only a function of the SRT and kinetic coefficients for growth and decay and is given by,

$$S = \frac{Ks[1+(Kd)SRT]}{SRT(Yk-kd)-1} \quad (2)$$

= $7.06gVSS/m^3$

4.1.2 The total sludge production as kgVSS/d and kgTSS/d

The total sludge production as kgVSS/d is given by,

$$P_{XT,VSS} = X_T(V)/SRT \quad (3)$$

= 200kgVSS/d

The total sludge production as kgTSS/d is given by,

$$P_{X,TSS} = \frac{QY(So-S)}{1+(kd)SRT} + \frac{(fd)(kd)YQ(So-S)SRT}{1+(kd)SRT} + QXo,i + Q(TSSo - VSSo) \quad (4)$$

= 215kg/d

The biomass fraction is given by,

$$X = [Y(So-S)SRT]/[1+(kd)SRT](\tau) \quad (5)$$

$= 70.58/\tau$

= $14.116gVSS/m^3$

4.1.3 Food to Microorganism (F/M) ratio

$$\frac{F}{M} = \frac{total\ applied\ substrate\ rate}{total\ microbial\ biomass} \quad (6)$$

$= \frac{QSo}{VX}$

=0.861kg/kgd

4.2 Kinetics of bioreactor

4.2.1 Rate of utilization of soluble substrates and rate of biomass growth with soluble substrates

The substrate utilization rate in biological systems can be modeled with the following expression for soluble substrate. Because the mass of substrate is decreasing with time due to substrate utilization and is used in substrate mass balances, a negative value is shown.

$$r_{su} = -\frac{kXS}{Ks+S} \quad (7)$$

$$r_{su} = -\frac{5*2000*60}{40+60}$$

= -6000 $gbsCOD/m^3d$

The biomass growth rate is proportional to the substrate utilization rate by the synthetic yield coefficient and biomass decay is proportional to the biomass present.

The biomass growth rate is given by,

$$r_g = -Yr_{su} - kdX \quad (8)$$

= [(-0.4)*(-6000)]-[0.1*2000]
= $2200gVSS/m^3d$

So from rate of utilization of soluble substrates and rate of biomass growth with soluble substrates the net biomass yield is given as,

$$Y_{bio} = -\frac{r_g}{r_{su}} \quad (9)$$

= 0.367gVSS/gbsCOD

4.2.2 Total volatile suspended solids and active biomass

The VSS production rate in the aeration tank can be defined as the sum of the biomass production ,the nbVSS production and the nbVSS in the influent.

Total VSS production rate is given by,

$$r_{XT,VSS} = -Yr_{su} - k_dX + f_d k_d X + QXo,i/V \quad (10)$$

$r_{XT,VSS}$ = $2532.5gVSS/m^3d$

The observed solid yield accounts for the actual solids production that would be measured for the system and is given by,

$$Y_{obs} = -\frac{r_{XT,VSS}}{r_{su}} \quad (11)$$

= 0.42 gVSS/gbsCOD

The fraction of active biomass in the mixed liquor VSS is given by,

$$F_{X,act} = (-Yr_{su} - kdX)/r_{XT,VSS} \quad (12)$$

= 0.87

Thus, accounting for the nbVSS in the wastewater influent and cell debris produced, the MLVSS contains 87% active biomass.

4.1.3 Results
The COD values of treated effluent at different operating days of **phase** 1are given in the table 3:

Day	Influent COD	1	2	3	4	5
COD(mg/lit) of bio reactor	600	680	535	430	397	302
Day	Influent COD	1	2	3	4	5
COD(mg/lit) of bio reactor	625	502	570	374	430	300
Day	Influent COD	1	2	3	4	5
COD(mg/lit) of bio reactor	570	489	413	390	320	305

The COD values of treated effluent at different operating days of **phase 2** are given in the table 4:

Day	**Rector COD**	**1**	**2**	**3**	**4**	**5**
COD(mg/lit) of bioreactor	300	260	175	95	65	30

Hydraulic retention time is an important parameter in the application of wastewater treatment for any reactor.The monitoring was carried out on each day. Fig2&3 shows the effect of hydraulic retention time on the percentage reduction of CODand C/Co. From Fig 2 it was observed that the degradation efficiency increases with increase in HRT. The maximum removal of 52% occurs on 5thday of **phase 1** and a reduction of 90% was observed on 5th day of **phase**
2 after that there was no significant reduction in COD values. Hence the optimum value was found to be
The influence of HRT on % reduction of **phase 1** and **phase 2** is plotted in fig 2**:**

52% of phase 1 and 90% of phase 2 which occurs at a HRT of 5th day shown in series1 & series 4 of fig 2 respectively. Series 2 of Fig 2 shows shock loads depending upon increase or decrease in alkalinity of wastewater but series 4 showing continuous degradation of COD at any value of alkalinity of wastewater, means no shock loads were observed in **phase 2**. Fig 3 showing continuous decreases in C/Co with HRT for phase 1&2.

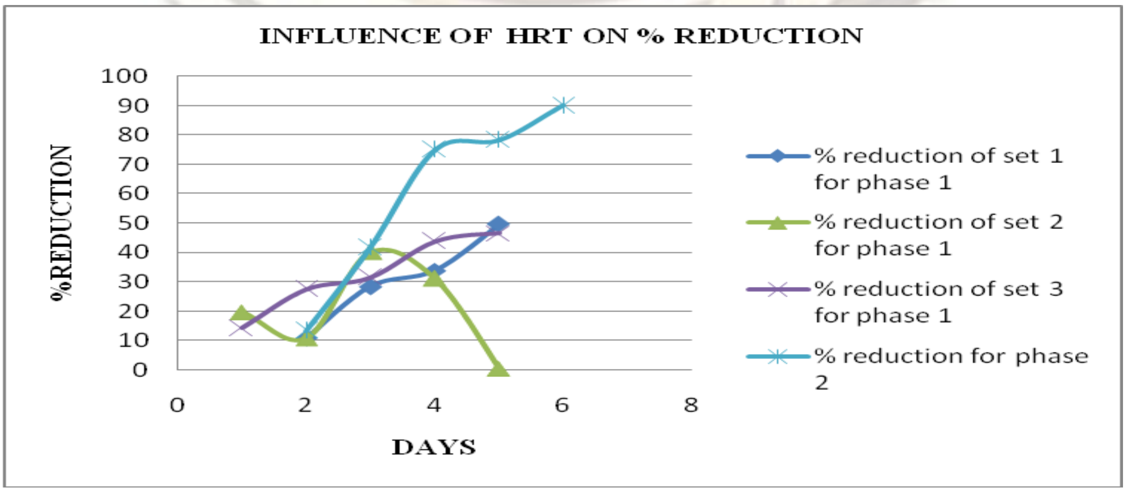


Fig 2

The influence of HRT on C/Co of **phase 1** and **phase 2** is plotted in fig 3:

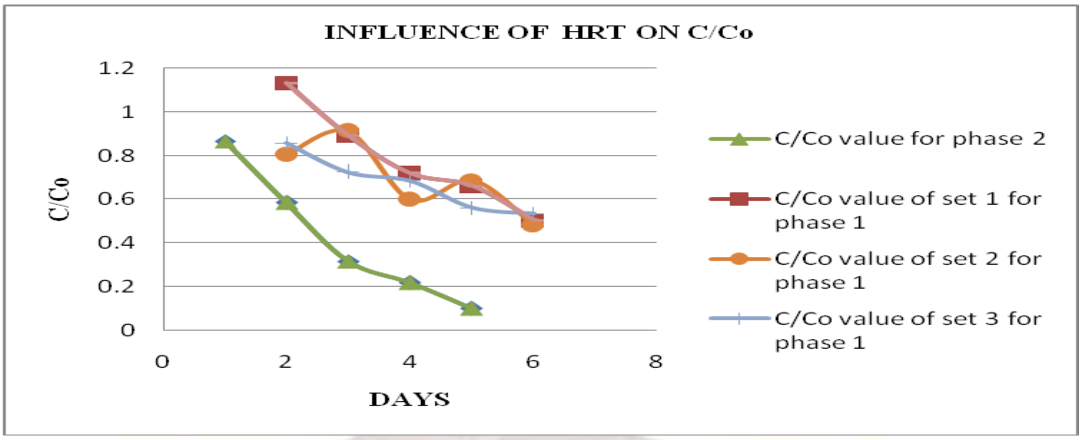


Fig 3

IV. Conclusions

The experiments were conducted in a bio reactor for two different types of microbes used that are conventional microbes and engineering microbes at various HRT. From this work the following conclusions were drawn:

- Use of engineering microorganism shows 30 % increase in MLSS than conventional microorganism.
- Reduction of COD was seen more by using engineering microorganism than conventional microorganisms.
- The percentage reduction of COD increaseswith increase in HRT. Anoptimum COD removal of 90 % occurs on 5day HRT of **phase 2**.
- Use of engineering microorganism decreases possibilities of shock loads due to increase or decrease in alkalinity.

From the present study, it is found that the application of engineering microorganism is effective for the treatment of paint shop wastewater.

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