Application of Soil Bacteria in Waste Water Treatment

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In the Cold Rolling Mill of Tata Steel. various kinds of solid and liquid wastes are generated. The liquid. effluent is treated in a waste water treatment plant producing acceptable discharge quality. In the oily waste treatment section of this plant. a typical problem was faced with the liquor, due to increasing content of iron and sulphate. The aeration tank liquor became black and the evolving H2S from the process was poisoning the surroundings. The normal bacteria culture failed to combat the degenerated situation. This problem was overcome by treatment with soil from the lower ash pond of the steel works along with other reagents. The soil was found to contain thiobacillus ferroxidan, a special bacterium particularly effective in situations with high iron and sulphate. due to its ability to oxidise sulphide to sulphate and ferrous to ferric. This was an innovative eco-friendly approach for solving the atypical problem of deteriorating water quality in the treatment plant nowhere tried out before. to the authors' knowledge.

Kt:y Words

Microbes. Bio-treatment. Bacteria, Aerobic, Anaerobic, BOD. Waste water treatment. Effiuent

Acronyms used:

ACF : Activated Carbon Filter
AO : Absorbed Oxygen
ATL : Aeration Tank Liquor
BOD: Biological Oxygen Demand
CAF : Cavitation Air Floatation
CGL : Continuous Galvanizing Line
COD: Chemical Oxygen Demand
CPCB : Central Pollution Control Board CRM : Cold Rolling Mill
OAP : Oi-Ammonium Phosphate
DO : Dissolved Oxygen .
OOP : De-Oiling Poly-electrolyte
MGF : Multi Grade Filter
MLSS : Mixed Liquor Suspended Solids

PLTCM Pickling Line & Tandem Cold Mill
ppm : Parts per millions.
SPM : $kin Pass Mill
SRB : Sulphur Reducing Bacteria
SVI : Sludge Volume Index
WWTP : Waste Water Treatment Plant

INTRODUCTION

For the major part of the twentieth century. physical science dominated science and engineering. As one marches into the. twenty first century biology emerges as the cynosure in the field of science and among the biological sciences, microbiology has carved a special niche. Both national and international societies are becoming intensely interested in microorganisms and their activities. In nature microbiological mechanisms have been 'responsible for the break-down of biodegradable waste matter' which either inadvertently or by design. finds its way into the aquatic environment. Before explaining the relationships between microbes and waste management one needs to know the nature and classification of these micro organisms.

FUNDAMENTALS OF MICROBES

Classification of microbes

Pollutants are biodegraded' in sewage and wastewater treatment plants, essentially in a chemical transformation process. This process does not require the growth of microbes. However there are no practical non-growth bio-treatment systems.

Microbes are generally classified as either *eukaryotes* or *prokaryotes* on the basis of the complexity of their cellular structure. Eukaryoticmicrobes comprise fungi, including yeast. algae and protozoa while *prokaryotic* microbes include *bacteria* and *cyanobacteria* (formerly called bluegreen algae). Recently it has become evident that a third group of microbes. the *archaebacteria,* exists

The three nutritional items that are quantitatively the most important for microbes are a carbon substrate, an energy source and an electron donor. These, together with the electron acceptor, are governed by the enzymes in the cell. The detailed classification based on nutritional requirements is shown in Table-I.

Table 1 : Classification of microbes

Type	Carbon substrate	Energy source	Electron donor
Heterotrophs	Organic		
Autotrophs	Inorganic		
Phototrophs		Light	
Chemotrophs		Organic/ Inorganic	
Organotrophs			Organic
Lithotrophs			Inorganic

Microorganisms that generate energy by enzyme-mediated electron transport from an electron-donor to an electron-acceptor are said to have a respiratory metabolism. When O2 is used as electron acceptor, the process is called *aerobic respiration.* Micro organisms depending on aerobic respiration are called *obligately aerobic*. whilst micro organisms that generate energy by fermentation and grow and survive without O2 are called *obligately anaerobic*.

Role of microbiology in wastewater treatment

Microorganisms playa vital role in processing of

Tata Search, 2005

industrial and domestic waste. With proper analysis and environment control, almost all waste waters can be biologically treated. The role of a biological treatment process is to coagulate and remove the non-settling colloidal solids as well as to stabilize the organic matter.

For industrial waste water, the objective is to remove or reduce the concentration of organic and inorganic compounds. For domestic wastewater, the major objective is to reduce the organic content.

Environmental requirement

The pH of the environment (generally the optimum pH for bacterial growth is 6.5- 7.5) is a key factor in the growth of micro organisms. Most bacteria cannot tolerate pH above 9.5 or below 4.

Microbial growth theory for bio-treatment

The predominant microbes responsible for the oxidation of biodegradable carbonaceous pollutants in biotreaters are chemoheterotrophic bacteria. Such bacteria reproduce by binary fission. When the necessary requirements for bacterial growth are satisfied, the growth rate of a bacterial culture can be expressed as:

$dx/dt = \mu x$ Where,
x = microbial cell mass, t = time,
μ= specific growth rate coefficient

The equation (1) is used for describing binary fission; the rate of increase is proportional to the mass of organisms However, this equation lets the mass increase without limit, which is invalid because no living thing can grow after its their supply of food is exhausted. One could improve understanding of microbial growth by assuming specific growth rate as a function of the concentration of some nutrients e.g. nitrogen, carbon etc [3].

Factors related to operation of a biological reactor

The F /M ratio (or sludge loading) is the ratio of the mass of food (expressed in terms of BOD5*) entering the reactor per day and the sludge mass contained in the reactor[3] and is related to other parameters as shown:

$F/M = Q.\ S_0 / X_t.V$

Where,
F = Mass of food (expressed in tenns of BOD5)
M= Micro organism concentration in the entire sludge
Q= Daily flow
S_0= Substrate concentration i.e. organic loading in reactor
X_t= MLSS in reactor
V= Volume of reactor
["Note: BOD5 means quantity of oxygen consumed after 5 days incubation.]

BRIEF DESCRIPTION OF OILY WASTE SECTION OF WWTP. CRM

Oily wastes from PLTCM roll coo. -:-& CGL#2 SPM are collected in the collec1ion tanks. These are then mixed with deoiling polyelectrolyte (DOP) and alum maintaining a pH of 7.0. The oil is removed as sludge after mixing by cavitation air floatation (CAF). The wastewater is sent for biological treatment in the aeration tank following bio oxidation of biodegradable organic material; it is filtered through multi-grade filler (MGF) and then through activated carbon filter (ACF). After filtration, a part of the filtered water is used as makeup water in industrial cooling water circuit or as gardeningwater. The process layout is shown in Fig.l

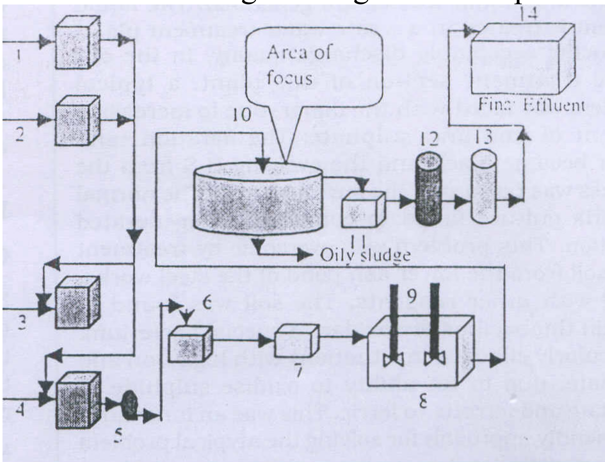

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Fig. 1 : Process layout

Legends of the diagram

1. Oily waste from CGL#2 SPM - Collection tank-l
2. Oily waste from PLTCM - Collection.tank-2
3. Continuous Tank -1
4. Continuous Tank -2
5. Feed Pump
6. CAF- 1
7. CAF- 2
8. Aeration Tank
9. Surface Aerators
10. Clarifier
11. MGF *I* ACF Feed Tank
12. MGF
13. ACF.
14. Final Effluent Tank

The oily sludge formed during the mixing in the CAF unit is filtered through a filter press. Filtrate from the filter press comes back to the aeration tank. The inlet and outlet quality of the effluent is given in Table 2.

Table 2: Inlet waste and treated water quality

Parameter	Inlet Design		Actual	Treated water	
	PLTCM	CGU2 SIM	Mixed	Limit	Actual
pH	6to8	9 to 10	6-9	6.9	6.5-85
Oil Free	-	1(,00	<500	Nil	Nil
ppmEmulsion	8000	25000	500.2000	5	<5
TSS (ppm)	2000	200	900. (000	50	<35
BOD 5 (ppm)	600	600	350 - 600	20	<20
COD (ppm)	600	600	5000-17000	150	< 150

Organic waste after pretreatment is introduced into the aeration tank where an aerobic bacterial culture is maintained in suspension. Organic mater is brought into intimate contact with the sludge from the secondary clarifier in the aeration tank. The concentration of micro organism in the sludge is very high and is in active state of growth. Air is introduced into the tank either in the form of bubbles through nozzles or by surface aerators. Micro organisms utilize the O_2 of the air and convert the organic matter according to the following equations [3].

Organic matter → (Bacteria)

$$COHNS + O_2 + \text{nutrients} \xrightarrow{\text{Bacteria}} CO_2 + NH_3 + C_5H_7NO_2 - \text{other end product} \quad ...(3)$$

↓ new cell

Endogenous Respiration

$$C_5H_7NO_2 + 5O_2 \xrightarrow{\text{Bacteria}} 5CO_2 + 2H_2O + NH_3 + \text{Energy} \quad ...(4)$$

PROBLEMS FACED AND THE ROOT CAUSE ANALYSIS

The problems faced during operation in the oily waste section of CRM waste water system were as follows :

- ★ The colour of the ATL started changing to black from normal brown, which is the natural colour of ATL.
- ★ Intense smell of rotten egg (i.e. H_2S) was polluting the surrounding area.
- ★ Sludge bulking (huge sludge formation) was found in secondary clarifier, which led to high turbidity of the final effluent. The clarifier effluent was blackish. Both these were unacceptable environ-mental conditions.
- ★ Sludge Volume Index (SVI), which is an indication of the settling characteristic of the sludge of secondary clarifier was calculated to be 90.5 i.e. high normal (normal range is 40 to 100).
- ★ O_2 uptake test (Fig. 2) showed a flat response, signifying that the bacteria were no longer active.

Root cause analysis

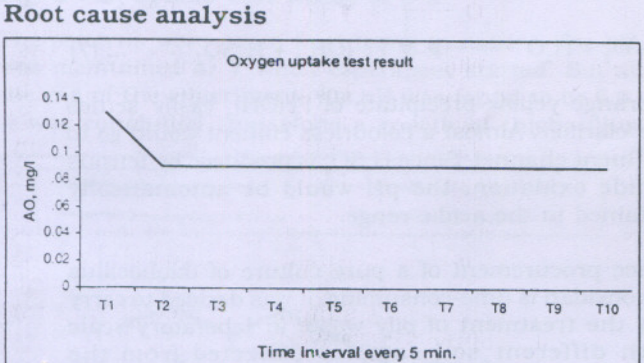


Fig. 2 : Absorbed O_2 result after blackening of ATL

If SO_4^{2-} radical is present in waste water, it is biologically reduced under anaerobic condition to sulfide, which in turn combines with hydrogen to form H_2S.

$$\text{Organic matter} + SO_4 \xrightarrow{\text{bacteria}} S^{-2} + H_2O + CO_2 \quad ...(5)$$

$$S^{-2} + 2H^+ \xrightarrow{\text{SRB}} H_2S \quad ...(6)$$

If waste water contains iron (Fe), H_2S combines with the same to form FeS that in turn might cause black colour of the ATL. Though an aeration tank is an aerobic reactor, the type of surface aerator provided is perhaps unable to maintain the required dissolved oxygen (DO) level up to a certain depth of the aeration tank. Consequently, anaerobic condition exists at and near the bottom of the tank. Thus, the smell of H_2S emanating from the aeration tank confirmed the presence of SO_4^{2-} radical, while black colour of ATL confirmed the presence of iron in sufficient quantity. The FeS that had formed not only blackened the ATL but increased the F/M ratio as well. As a result, aerobic bio-degradation reduced drastically.

The above conclusion was made on the following assumptions :

- ★ Iron was present in sufficient quantity to have blocked the normal metabolism of aerobic micro organism.
- ★ The rate of biochemical reaction at the tank bottom in anaerobic condition was faster than that of aerobic reaction at the tank surface.
- ★ Sulphur reducing bacteria prefer SO_4^{2-} radical of organics present in waste water more than obligately aerobic bacteria.

It was subsequently established that CGL#2 waste from SPM contained a large quantity of surfactant. The source of surfactant was the wet temper fluid Nova Proof 8400 supplied by M/s Henkel used to clean the galvanized sheet. The particular formulation not only contains alkaline sulfonate, it also contains an appreciable amount of non-biodegradable constituents, as evident from COD/BOD ratio (=8), which is not suitable for aeration tank (<5).

In view of the problem faced in aeration tank, M/s Henkel subsequently proposed to substitute Nova Proof 8400 by Grolub 983. Although this product contains biodegradable constituents in greater amounts, it also contains alkyl naphthalene sulfonate. Consequently, SO_4^{2-} radical in aeration tank continued to exist (Table-3).

It was further confirmed that PLTCM had generated oily waste containing high iron for a week (Table 3). The aeration tank contents thus became black due to the formation of ferrous sulfide.

Table 3 : Iron content of oily waste and ingredients of temper fluid used in CGL#2 SPM

Sl. No.	Date in year 2003	Iron as Fe in ppm in oily waste	Details of ingredients present in the temper fluid used in CGL#2 SPM		
			Sl.No.	Ingredient	Percentage
1	28-Nov	717	1	Water	65-70%
2	29-Nov	477	2	Triellylene amine	12%
3	1-Dec	611	3	Ethylene glycol	4.50%
4	2-Dec	426	4	Triethyleamine oxalate	1%
5	3-Dec	371	5	SO_4 base dispersent	12%
6	4-Dec	265			
7	5-Dec	339			
8	8-Dec	20			
9	9-Dec	28			

In the light of the above, the problems faced can be summarized as :

*Blackening of ATL emitting obnoxious smell of H2S.

*Sludge bulking of secondary clarifier, resulting in carry-over of blackish water with high turbidity in the final effluent.

***CORRECTIVE AND-PREVENTIVE ACTIONS TAKEN**

After analysing the root cause, the following actions were taken to arrive at a fruitful solution.

Accessibility to aeration tank top by working personnel was provided because aeration tank needs close observation all the time. Moreover, nutrients e.g. DAP, urea etc. are dosed from the top of the aeration tank. Exposure to H_2S for long time causes dizziness and vomiting. Sometimes it may lead to death. Two extra circular air spurger were provided to get rid of H_2S smell. With this action, H2S nuisance was reduced to great extent.

- To increase the aerobic biochemical reaction rate, extra carbon and nutrient in the form of molasses, straw and DAP were added. No favourable result was however obtained. Iron load reduced to normal. It was concluded that no new generation of FeS was taking place. It was planned to drain out aeration tank liquor enriched with FeS to normalize the aeration process. The effort failed probably because of stoppage of aerobic biochemical reaction; this was caused by a high death rate of the aerobic microorganism due to high iron content present in the aeration tank.

* It was decided to load aeration tank with a wide range of microorganisms present in cow dung and sludge of the BOD plant in JUSCO. It was assumed that some species of bacteria might survive and grow in spite of onslaught of iron. But there was no result.

* The simpler solution was to drain out the ATL and to develop new bacteria culture of aerobic nature, as per the usual practice. But draining out 400 m^3 black liquor was a hazardous job and it could have an appreciable adverse impact on the environment. Draining through either the effluent channel or the surface drain would not only be an aesthetic inhibition but would create a great risk of H_2S poisoning in the surrounding area.

* It was decided to convert FeS to some other form of iron compound, free of sulphide radical and also to change into an aesthetically accepted colour. Once that could be achieved, aeration tank could be drained through effluent channel with enhanced dilution. But it was observed in the laboratory that with hypochloride (NaOCl) addition, colour immediately reverted to original brown. But the following difficulties were likely to be faced in actual operation.

Sludge would accumulate in the aeration tank bottom, which would block the clarifier.

Residual CI_2 may result in CI_2 hazard in the surrounding area of aeration tank and in the effluent channel path.

Sludge from the aeration tank has to be manually cleaned and separately disposed.

- Aeration tank has to be made absolutely free of Cl_2, otherwise no new bacteria could be cultured.

* The only way left was to biochemically convert FeS to some less harmful iron compound. Since at the time of happening, CGL#2 SPM was under shut-down, there was a shortage of organic loading. A search for bacteria was launched which would meet the following specifications:

It should be autotroph i.e. it would derive carbon from atmospheric CO_2,.
It must be obligately aerobic.
It should derive energy by oxidation of sulphide to sulfate and ferrous to ferric.

A bacterium known as thiobacillus ferrooxidans (Table-4) was found to meet the above requirements.

Table 4 : Characteristics of Thiobacillus Ferroxidan

Condition	**Characteristic**
Optimum growth pH	1.3 - 4.5
Temp range	10-37°C
Motility	0 to several polar or flagella
Shape	Rod. 0.5 - 1 micrometer
Trophy	Obligately aerobic and chemo litho autotroph
Energy path way	Oxidation of Fe^{-2} and reduced sulphur
Gram staining	Gram negative
Nitrogen source	Ammonium salts etc

The advantage of this bacterium is that it can be isolated by pure culture. Another welcome feature is that it is widely distributed in soil, coal mine drainage water and marine environments.

The biochemical reaction that takes place with thiobacillus ferroxidan is as follows

$$FeS + O_2 + H_2O \rightarrow \downarrow \quad Fe(OH)_3 + H2SO_4$$

The orange yellow precipitate of Fe $(OH)_3$ easily settles in the clarifier. Almost a colourless effluent would go to the effluent channel. Since H_2SO_4 is produced by ferrous sulphide oxidation, the pH would be automatically maintained in the acidic range.

* Since procurement *of* a pure culture of thiobacillus ferroxidan is time-consuming, it was decided to carry out the treatment of oily waste in laboratory scale with different soil samples collected from the premises of the TISCO Works.

* Before taking up the laboratory scale experiment, a test-tube experiment with different soil samples was conducted, five cc aeration tank slurry, a few drops of soil water and a few particles of DAP and urea were mixed in the test tube and the test tube was put under airing. Surprisingly one of the soil samples collected from lower ash pond near the Works general office showed a colour change from black to brown after 2 hours of airing. No other soil sample showed such a change. A laboratory scale study therefore was made with a solution of the soil sample, collected from the lower ash pond. 500ml of aeration tank slurry collected from the discharge drain line of secondary clarifier was added with 3 cc of soil water; a few

Particles of DAP and urea were added and then airing was started. The slurry was selected from the specific line, as microorganisms exist here in the most active state. The pH was all along maintained at around 7.

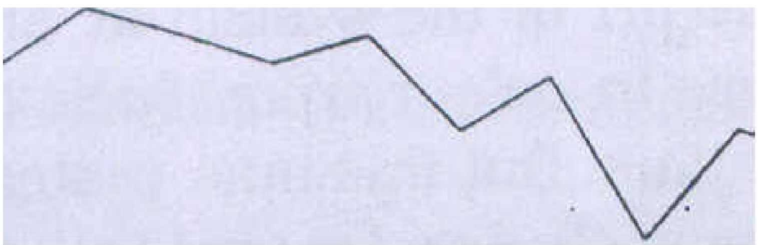
* Next day (D-2*) the first oxygen uptake test was done. The trend of AO variation with time at every five minutes shows a zigzag pattern (Fig.3). The experiment started with a AO content of 0.22 ppm, with highest AO at 0.31 ppm at the 5th minute and the lowest AO at 45th minute corresponded to a value of 0.14 ppm.

[Note: . D-2* means second day.]

The intermittent enhancement of AO was taken as a positive indication of growth of the microorganism. The dip in AO may be interpreted as consumption of O_2 not only for biochemical reaction but also for some other consumption by other interfering radicals i.e. chemical oxidation. However no tangible colour change was observed at the time of performing O_2 uptake test. The experiment could not be continued beyond 0-2 due to stoppage of airing on 0-2 night for some unavoidable reasons.

*The experiment was re-started on the following day (D-3). A colour change (slightly grayish) was noticed on D-6 morning. The oxygen uptake test was conducted. Fig. 4.

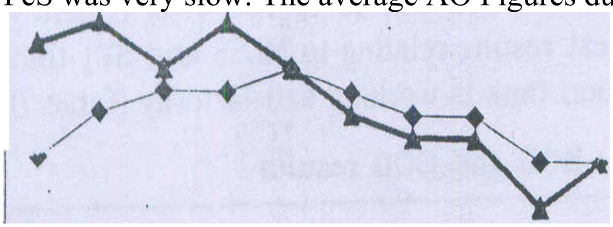
AO test result of 0-2



Time Interval every 5 min.

Fig. 3 : 0, uptake test result of *D-2*

The patterns were again fluctuating in nature. The pH was maintained at 7 when experiment started. But at the end of the experiment. the pH was found to be 6.5. It was concluded that since a growth of thiobacillus ferrooxidan requires an acidic environment at pH=7, the rate of biochemical oxidation of FeS was very slow. The average AO Figures during the period of O_2 uptake test are given in Table 5



Time Interval every 5 min.

Fig. 4 : 0, uptake test results

.Table 5 : Average AO on various days

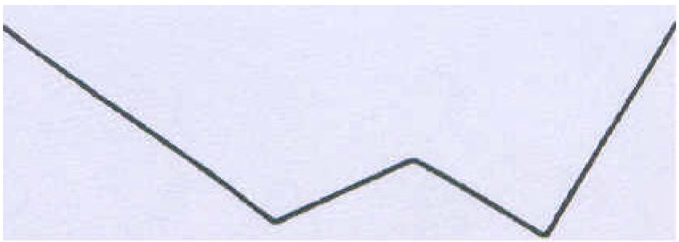
Day	**AO. (ppm)**
D-3	0.19
D-4	0.12
D-5	0.31
D-6	0.10

The increase in AO from 0.19 ppm on D-3 to 0.31 ppm on D-5 clearly indicates that biochemical oxidation of ferrous sulphide had picked up, But 0.10 ppm AO on D-6 indicates the stoppage of micro organism growth, probably due to a high pH (=7) as the particular micro organism grows in acidic medium.

*A new experiment was started on D-8. The ingredients were as follows:

ATL	=	600ml
Mud water	=	100ml
Molasses	=	50ml
Urea &. DAP	=	1 tsp
pH (by adding HC!)	=	6.0

After airing for 71 hours. O_2 uptake test was performed. Fig. 5.
Following characteristics were revealed from the O_2 uptake test curve.
AO test result of D-2



Time interval every 5 min.
Fig. 5 : O2 uptake test results of D-II
Average AO of the system = 0.487 ppm
Min AO at 25th minute (T-5)= 0.28 ppm
Max AO at 35th minute (T-6) = 0.60 ppm
- The curve becomes flat from 45th minute onwards at
  a AO = 0.53 ppm.

Enhancement in the average value of AO (= 0.487ppm) from 0.10 ppm (in an earlier experiment) clearly indicated a favourable growth rate of the bacteria present in the soil water at acidic pH of 6. Moreover, a pronounced colour change from black to brown confirmed the presence of thiobacillus ferroxidation in the particular mud water.

* On D-17, 100 kg lower ash pond soil was brought from site; 2 m^3 solution was prepared. The pH adjusted to 5 and the entire volume was charged to the aeration

tank. No appreciable enhancement in AO and colour could be noticed till D-22. O_2 uptake test was conducted on D-20 (Fig. 6). The curve did not show any initiation of oxidation of FeS. Some interfering chemical may be responsible for the zigzag nature of the curve to consumption of O_2 or it may be the chemical oxidation of FeS at a very slow rate. Interestingly, on D-24 morning, the colour of the ATL changed from black to grayish. Finally on D-25 the colour of entire ATL changed to shining orange-yellow.

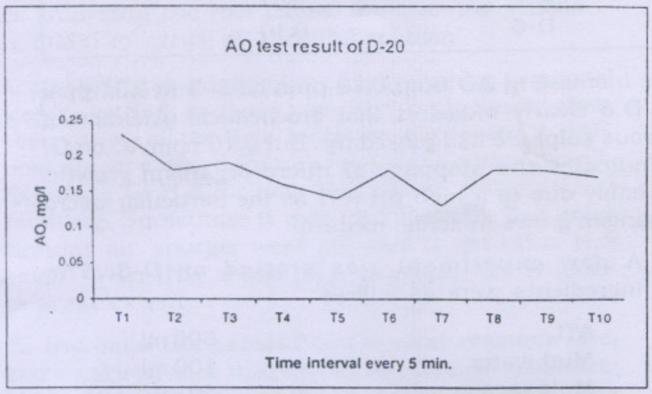


Fig. 6 : AO test result

The O_2 uptake test conducted on D-24 and D-25 showed an appreciable hike in AO level; the maximum AO level reached on D-24 was 4.9 ppm and that on D-25 was 5.6 ppm (Fig. 7).

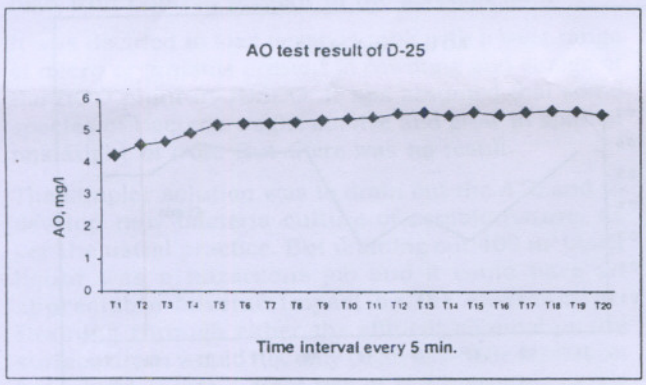


Fig. 7 : O_2 uptake test result of D-25

* Now draining the ATL with such a huge amount of Fe^{+3} contamination was a problem. Issues involved were as follows:
  - During draining, huge dilution had to be done to keep the iron in the final effluent within limit (norms 3 ppm as per CPCB).
  - During draining, a pH of the ATL had to be maintained around 3, otherwise iron would deposit on the entire effluent channel to the river outfall. For this, a huge quantity of HCl is required to maintain pH=3 which was not allowed as per CPCB norms.

It was therefore decided to dispose aeration tank slurry containing mainly Fe^{+3} ions through acid/alkali waste treatment section, which is capable of treating acidic waste, laden with iron.

RESULTS AND DISCUSSION

The ultimate achievement of soil bacteria is that it permanently solved the problem of the iron contaminated oily waste of CRM WWTP plant.

Soil as a rule is colonised by innumerable micro organism. The discussion here will be limited only to bacteria.

The commonly known bacteria that are likely to be found in soil are autotrophs, heterotrophs, aerobes, anaerobes, cellulose digesters, sulphur oxidizers, protein digester, etc. There are other species of bacteria as well which are yet to be fully characterised.

A large number of acitonomycetes (e.g. millions per gm) are also present in soil. The most predominant groups are nocordia, steptomyces, micromonospora. These organisms are responsible for degrading complex organic substances.

* Further in-depth study of the nature and activities of Thiobacillus ferrooxidan reveals that this particular bacterium with a host of other microbes can be used to treat acidic oily waste.

Nocordia, micromonospora, etc. are normally responsible for carbonaceous BOD removal. On the other hand, thiobacillus ferrooxidan survives in the presence of iron and maintains an aerobic condition. When the ATL in oily waste section once again turned black, it was decided to charge lower ash-pond mud into the aeration tank and maintain the pH of the system at around 5-6. As before, the change in colour from black to brown took place in a week's time. But this time, instead of diverting the orange yellow sludge to acid/alkali treatment section, the aeration tank was kept running with normal waste from the PLTCM & CGL#2-SPM sections.The section since then has been running normally with designed effluent quality from oily waste section. The analytical parameters (Table 6) show the following features:

* Excellent BOD removal in the aeration tank, indicating presence and appreciable growth rate of carbonaceous BOD removal bacteria e.g. Nocordia, Micromonospora species.
* Maintenance of orange yellow colour; this is an indication of the presence and growth of thiobacillus ferrooxidan.
* It was established for an efficient operation of a biological treatment process, SVI should be maintained between 40 to 100. It is evident from the test results relating to MLSS and SVI that the aeration tank is working satisfactorily (Table 7).

Table 6 : BOD and COD results

Date in year 2004	Sample	BOD (ppm)	COD (ppm)
2-Mar	2nd CAF	147	3016
3-Mar	Oily waste	205	7367
19-Mar	Final outlet	19	126
20-Apr	Oily waste	395	9082
20-Apr	Final outlet	19	146
13-May	Oily waste	375	17406
13-May	2nd CAF	156	2226
25-May	Final outlet	18	78
31-May	Final outlet	19	148
4-Jun	Oily waste	210	6796
4-Jun	2nd CAF	190	3883

Table 7: **SVI and MLSS results**

Date in year 2004	SVI	MLSS (ppm)
2-Apr	55.57	5038
6-Apr	54.59	5201
13-Apr	63.92	5788
19-Apr	50.14	4398
20-Apr	50.09	4450
21-Apr	41.48	4467
30-Apr	52.58	3613
8-May	37.01	4224
14-May	37.46	4805
22-May	59.51	5001
29-May	60.45	5541
4-Jun	71.41	5671

The most important conclusion of the work was that soil, which is the natural habitat for a wide range of microorganism, can directly be applied in the treatment process; this is a deviation from the common practice. It reveals that

* Thiobacillus can survive an iron load of 60 ppm from PLTCM. .
* The carbonaceous BOD-removing bacteria function efficiently in an acidic medium contrary to the belief that such bacteria survive only at a pH of 7.
* Onslaught *of* high iron load could easily be detected by a change in the intensity of the shining orange yellow colour of the ATL. The immediate corrective action would be to increase the sludge-wasting rate and the decrease the pH of the ATL to further acidic range around 4.

CONCLUSION

To the authors' knowledge, for the first time soil has been used directly in running any biological treatment process, creating a medium required for micro organism growth. Normally in activated sludge process, bacteria culture is made by addition of cow dung or sludge, brought from other BOD removal plant. However it has been established in this study that soil microorganisms could have a vital role in biological treatment process, because they serve as biochemical agents for the conversion of complex organic compounds into simple inorganic compounds or into their constituent elements. Consequently, one could use this material as an inexpensive source of desirable microorganism for biological treatment processes.

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