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Studies on a Novel treatment Plant for a Paint Industry

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ABSTRACT

Paint industry effluent is a complex mixture of inorganic pigments, organic dyes and solvents. It contains heavy metals like zinc, cadmium, iron, aluminum, lead and chromium. It is having nearly 30- 40% suspended and settleable solids. Hot alkali wash of paint tanks contributes to high pH. In this communication hydrogen peroxide is used to oxidize all heavy metals to their respective oxides. This oxidation method made the treatment economical and more efficient.

Keywords: Treatment Plant, Effluent, Hydrogen Peroxide and COD.

INTRODUCTION

Rapid industrialisation led to geometrical rise in the level of air, water, space, noise and land pollution. One of the major concerns in India is the increasing level of land pollution largely due to the uncontrolled disposal of industrial effluents. Their impacts on the ecological bodies are noticeable. Paint is generally considered as a mixture of pigment, binder, solvent and additives. Paint classification can be made on many different bases; one convenient method is to classify paints based on their primary solvent for waste reduction and disposal. Using this approach, paints can be classified as water based, organic solvent based or powder (dry) and without solvent [1].Water based paints have advantages over some types of organic solvent based coatings because they generally decrease VOC emissions, eliminate organic solvents for thinning and reduce the use of organic solvents during clean-up. The major waste that paint industry must manage is dominantly equipment-cleaning wastes, which makes up 80% of the waste generated in paint manufacture [2]. Biodegradation is a natural process that has been practiced on a broad range of substances. Bacteria and microorganisms decompose almost anything found in nature. This method has the potential for solvents, especially aliphatic, alcohols, esters, but it cannot be applied for all types of solvents generally in mixture form. Besides this, it can result in the generation of solid residuals that would also be classified as hazardous [3]. Distillation is the separation of more volatile materials from less volatile materials by a process of vaporization and condensation. It is capable of recovering volatile species with a little degradation. This means that this method can give chance to recycle or recover materials [4]. Steam stripping, refers to a type of distillation technology that is used to treat wastewater that contain low concentrations of volatile organic compounds [5].It is distinguished in two significant ways from the technology of batch distillation which uses steam to strip volatile compounds.

Carbon adsorption can be used to treat spent solvent wastewater by adsorbing the organic compounds onto specially prepared carbon granules. Activated carbon is derived from virtually any carbonaceous material including wood, coal, coke and petroleum residues [6].The treatment system itself is quite simple, consisting of a packed column in which the wastewater generally enters from the top. Carbon adsorption can also be used for a wide variety of spent solvent wastewater. Besides the treatment alternatives, disposal ways of solvent containing wastewater was searched. Downgrading is the term applied when a contaminated solvent is utilised for another purpose within a plant. Waste exchange is the term used when a used solvent is sold or exchanged for credit or another material in another plant or industry. Both activities involve used solvent, which can be employed in another operation [7]. Chemical oxidation is a very attractive technique for the purification of water contaminated with organic substances, especially those that are highly toxic for biodegradation. “Oxidation by organisms air, ozone, and other oxidizing agents is commonly used for treatment of many substances. In recent years, claims have been made for accelerating biodegradation of organic such as solvents by addition of peroxides, or other oxidizing agents” [8].

MATERIALS AND METHODS

The treatment of paint effluents is divided in to three parts. i.e. primary, secondary and tertiary. Primary treatment consists of dosage of hydrogen peroxide followed by the addition of sodium aluminates. Secondary treatment consists of addition of anionic polyelectrolyte. Tertiary treatment consists of aeration followed by clarification. Hot alkali after washing the paint tanks is collected separately. This used hot alkali is recovered using activated carbon filter and sand bed. This is a major step to reduce cost of treatment process. The used caustic soda can be used in detergent industry.

The solvents used in the process to manufacture different types of paints are -
i) Ethyl ester, ii) Butyl ester, iii) Amyl acetate, iv) Methyl ethyl ketone, v) Cyclohexane, vi) Amyl alcohol vii) Chlorinated hydrocarbons and viii) Petroleum solvents.

Sample Collection: Local paint industry provided samples to conduct the study. They have 10 different tanks to manufacture different colors of paints of their choice. All tank washings except caustic soda, samples were taken in equal proportion and made composite. These composite samples are then treated.

Description of samples

Table.1

S.No	Description
1.	5-in-1 colour
2.	Gloss colour
3.	Solvent borne cement primer.
4.	Grey
5.	Gloss
6.	Brilliant white.
7.	Sat Black.

Table-2. Analysis of Samples

S.No	Parameter	Sample No 1	Sample No. 2
1.	pH	11.74	5.10
2.	Total Dissolved Solids	740 mg L^{-1}	1160 mg L^{-1}
3.	Total Suspended Solids	260 mg L^{-1}	590 mg L^{-1}
4.	Chlorides as Cl	271 mg L^{-1}	306 mg L^{-1}
5.	Sulphates as SO_4	64 mg L^{-1}	119 mg L^{-1}
6.	Chemical Oxygen Demand	599 mg L^{-1}	650 mg L^{-1}
7.	Biochemical Oxygen Demand	172 mg L^{-1}	195 mg L^{-1}
8	Oil & Grease	3.0 mg L^{-1}	2.0 mg L^{-1}

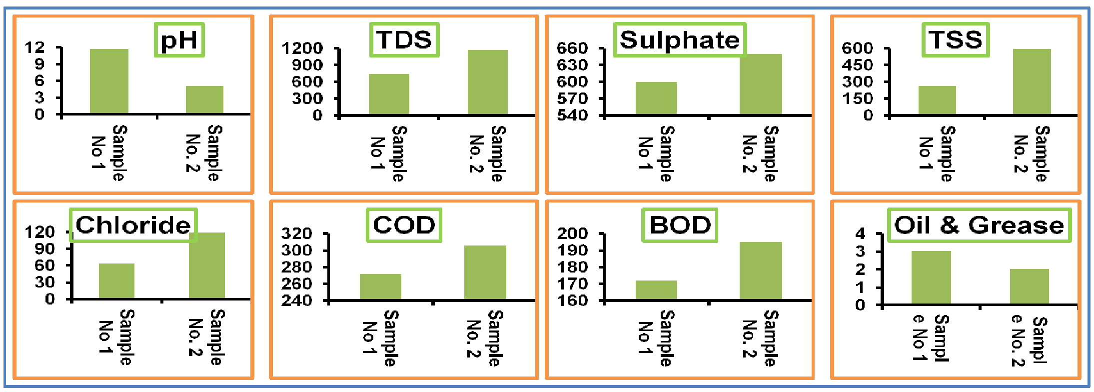

Fig 1. Various parameter of samples collected from paint industry

Table - 3. Composite Sample Analysis

S.No	Parameter	Units	S.No:3	S.No:4	S.No: 5	S.No: 6	S.No:7
1.	pH	---	12.16	10.14	10.8	5.26	10.5
2.	TDS	mg L^{-1}	1990	1366	989	262	709
3.	TSS	mg L^{-1}	1647	1090	462	156	685
4.	Chlorides	mg L^{-1}	128	426	408	98	186
5.	Sulphates	mg L^{-1}	20	102	86	72	128
6.	C.O.D	mg L^{-1}	592	686	540	380	476

7.	B.O.D	mg L^{-1}	165	212	150.	136	142
8.	Oil & Grease	mg L^{-1}	50	3.0	2.0	2.0	3.5

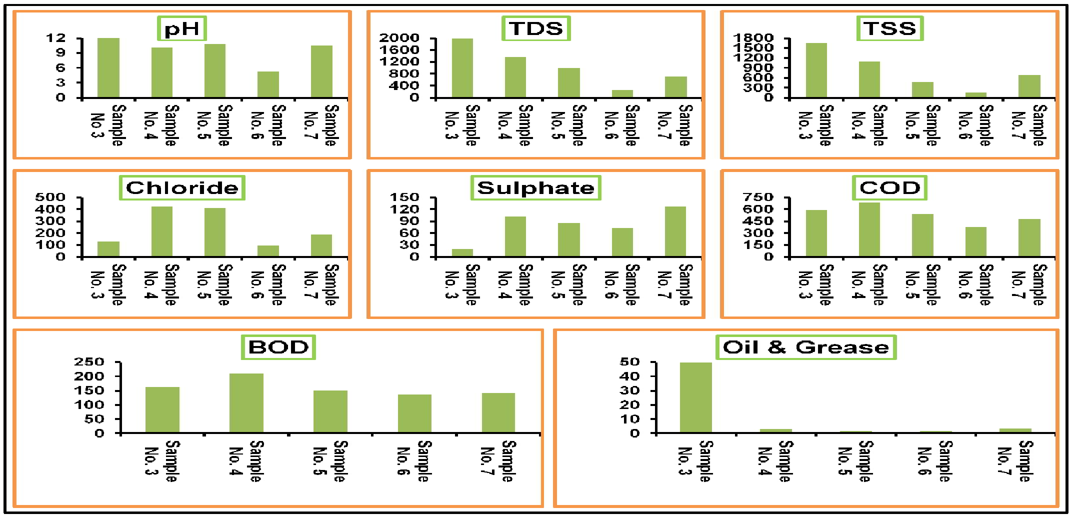

Fig 2 showing various parameter of composite sample analysis

RESULTS AND DISCUSSION

Samples Analysis: It was observed that most of the samples pH is more than 10 excepting Satin Black and Gloss. pH varied between 5.10 to 12.16. Total Suspended Solids (TSS) was more prominent in all samples. TSS varied between 260 mg $L^{-1}$to 1647 mg L^{-1}. Total Suspended Solids contributes to high COD and BOD content in the effluent samples. Chloride varied between 98 mg $L^{-1}$to 426 mg L^{-1}. Sulfate values varied between 20 mg $L^{-1}$to 128 mg L^{-1}.COD values varied from 380 mg $L^{-1}$to 686 mg L^{-1}. BOD values varied from 136 mg $L^{-1}$to 212 mg L^{-1}.Oil and Grease in all samples is below the specified standard, except in sample gloss color. For treatment purpose all the samples were made composite in equal proportions.

Response of Washings to Primary Secondary and Tertiary Treatment

Sample No:1 5-in-1 color was exposed to primary, secondary and tertiary treatment at fixed pH and COD rate of removal observed. Before treatment the COD is 599 mg L^{-1}. The results are tabulated in table.4

Table - 4

pH (Fixed)	8.5	7.5	6.5
COD (After Primary Treatment)	490 mg L^{-1}	350 mg L^{-1}	320 mg L^{-1}
COD (Secondary Treatment)	280 mg L^{-1}	160 mg L^{-1}	130 mg L^{-1}
COD (Tertiary Treatment)	110 mg L^{-1}	90 mg L^{-1}	70 mg L^{-1}

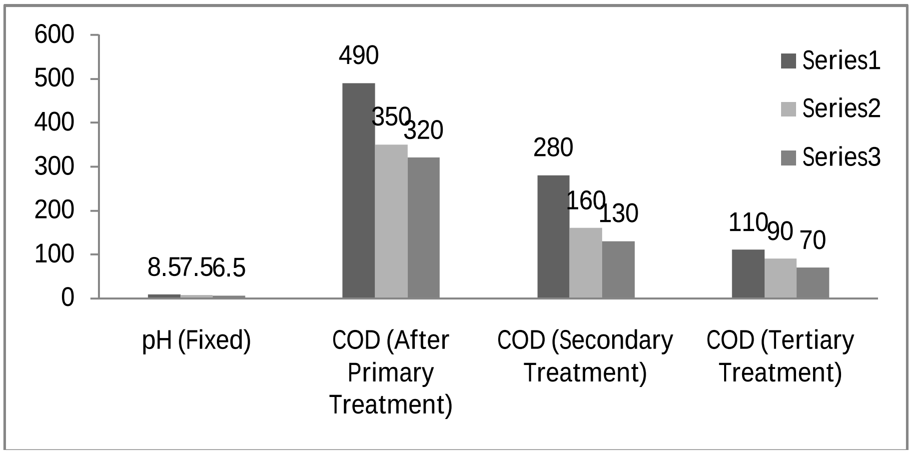

Fig 3 Showing the variation of COD with pH after Primary, Secondary and Tertiary Treatment.

Treatment Methodology: All the collected samples were made composite in equal proportions and treated with different methods by varying chemicals and their concentration and dosage. The effluent contains large quantities of suspended solids and high pH. Hydrochloric acid or sulfuric acid was not used for its neutralization to prevent the increase of the pollution load further. Used dilute caustic soda was not allowed to mix with the tank washings. When it is mixed with the washings the neutralization cost will increase and so also treatment cost .A separate flow diagram was incorporated for its treatment and reuse.
The authors have developed an innovative method to neutralize the effluent. Hydrogen peroxide, which has high oxidation properties, is used to neutralize the pH. The main problem with Hydrogen peroxide is its volatile nature particularly during summer. The 30% hydrogen peroxide dissociation rate is higher and also while handling a lot of safety precautions has to be taken. The 10-15% hydrogen peroxide is safe. Moreover at lower concentrations (10%) the evaporation losses are minimum.

Segregation of Facilities: The following stages of treatment will facilitate for easy and convenient operation of the effluent treatment plant. In every stage pollution load will decrease considerably. Physical impurities like suspended solids and other colored paint material will be removed at screens. Satiable solids will settle down at the sedimentation tank which is represented in Figure 2.

1. Screens: Physical impurities like floating material are removed at screens.
2. Sedimentation Tank: Satiable solids or heavier particles settle down at the sedimentation tank.
3. Primary Treatment Tank: Its main function is to reduce pH simultaneously along with the coagulation.
4. Secondary Treatment Tank. In this tank aeration followed by coagulation will reduce BOD and COD levels.
5. Tertiary Treatment Tank: In this tank also aeration and a polyelectrolyte coagulant is added to reduce further COD and BOD levels.
6. Clarifier: In this unit clear water comes out.
7. Sand Bed: It reduces the turbidity of the effluent, if any.

Treatability Study of Composite Samples

Table 5. Analysis of composite sample

.No	Parameter	Result Units
1.	pH	10.15
2.	Total Dissolved Solids (TDS)	596 mg L^{-1}
3	Total Suspended Solids(TSS)	6020 mg L^{-1}
4	Chlorides	410 mg L^{-1}
5.	Sulfates	72 mg L^{-1}
6.	Chemical Oxygen Demand (COD)	1855 mg L^{-1}
7.	Biochemical Oxygen Demand (BOD)	534 mg L^{-1}
8.	Oil &Grease.	15 mg L^{-1}

It was observed that any caustic soda sample contamination or mixing will increase COD levels substantially. The concentration of above parameters may vary with as per inlet samples.
Treatment study was divided in to two units.
Unit-I operation is treatment of effluent.
Unit-II operation is treatment of caustic soda.

Unit-I

Sedimentation Tank: A known quantity of effluent is being pumped into this tank from effluent storage tank. The effluent will remain undisturbed for 3 hours. The entire settleable solids settles down .The supernatant liquid is drained into primary treatment tank.

Primary Treatment: The primary treatment tank capacity is 10 KL. It is provided with an agitator with motor and reduction gearbox. Hydrogen peroxide and liquid alum are added in this tank. Since the treatment is batch wise, the dosing chemicals are added at a time and agitated for 45 minutes. Approximate dosage of hydrogen peroxide is 1 liter per 1 cubic meter of effluent. Liquid alum dosage is approximately 50 ppm as $Al_2(SO_4)_3$. The optimum pH should be between 9 to 9.5.

Secondary Treatment: The effluent from primary treatment tank outlet flow into secondary treatment tank by gravity. Here liquid alum is added up to 200 ppm followed by continuous aeration. Air is supplied to this tank through a blower. The optimum pH should be between 7.0 to 7.5. Aeration should be continued for nearly 2 hours. This liquid flows into the tertiary treatment tank.

Tertiary Treatment: In this tank anionic polyelectrolyte is dosed followed by aeration. Polyelectrolyte (10%) solution 4-5 ppm dosage is sufficient to get clear effluent at the outlet.

Clarifier or Plate Settlers : Here one uses either clarifier or plate settlers to get clear water at the outlet. In case of clarifier the water will flow in clarifier by gravity. In case of plate settler the water will flow underflow. Since it is a batch wise system, clarifier is preferred.

Sand Bed: The clarifier outlet water is discharged into a sand bed. This sand bed reduces the turbidity, if any, in the effluent. It was found unnecessary to add liquid chlorine into the final effluent.

UNIT-II

Operation: Used caustic soda contains mostly organic matter. This organic matter can be removed in two stages. In the first stage the caustic soda is pumped into a sand bed. In the second stage in the sand bed outlet caustic soda is pumped into the granular Activated Carbon Filter (ACF) bed. In this operation all the organic matter is removed. The clear caustic soda can be reused with suitable make up with strong alkali. Otherwise the diluted caustic soda can be sold in the market. There is an urgent need for soap and detergent industry to purchase the clear caustic soda.

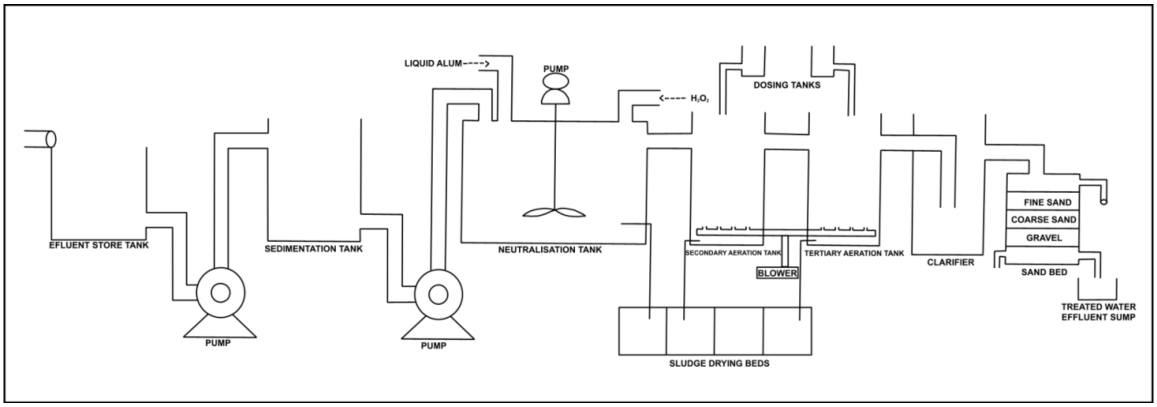

Fig 4: Proposed Treatment Plant

The average analysis of treated effluents from unit I operation is given in table 6.

Table . 6

S.No	Parameter	Result Units
1.	pH	7.4
2.	Total Dissolved Solids (TDS)	796 mg L^{-1}
3	Total Suspended Solids(TSS)	06 mg L^{-1}
4	Chlorides	218 mg L^{-1}
5.	Sulfates	80 mg L^{-1}
6.	Chemical Oxygen Demand(COD)	86 mg L^{-1}
7.	Biochemical Oxygen Demand(BOD)	24 mg L^{-1}
8.	Oil &Grease.	0.17 mg L^{-1}

APPLICATIONS

The authors have developed an innovative method to neutralize the effluent from Paint Industry. Hydrogen peroxide, is used to neutralize the pH. This method is cost effective and also a simplified process.

CONCLUSIONS

In this process of treatment, 88% of COD was removed. Moreover it was cost effective and also a simplified process. The sludge settling time was also less. However the sludge should be separated immediately .When it is kept overnight, the sludge is disturbed due to free hydrogen peroxide.

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