Removal of Toxic Pollutants from Industrial Effluents

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ABSTRACT

Industrial effluents are an integral part of liquid waste generated in the course of several human commercial endeavors. These effluents are made up of several formsof chemical and biological constituents that could be detrimental not only to environment but to biodiversity resources. Therefore Common Effluent Treatment Plants (CETP) has been installed and is in operation at numerous industrial clusters throughout India to deal with industrialeffluents. They serve to reduce effluent treatment cost, provide better collective treatment, and reduce land cost for small-scale and medium scale industrial facilities that cannot afford individual treatment plants. Optimum working conditions for treatment of effluent to be on par with discharge standards is a major mandate for CETP. The general principle is still the same: a stage-by-stage reduction in contaminants of decreasing particle size which includes coagulation, clari-flocculator, aeration and settling of biological sludge in the form ofsuspended solids. The main aim is to achieve a certain degree of effluent quality intended for disposal or reuse option. The quality of the effluent is assessed by the following parameters: - pH, BOD, COD, TDS, SS, and Ammonical-nitrogen.

Keywords: Effluent, coagulation, clari-flocculator, aeration, settling, biological sludge, pH, BOD, COD, TDS, SS, Ammonical-nitrogen.

INTRODUCTION

Industrial effluents are discharges from various industries, and various organic pollutants have been found in different water resources. They belong to various classes such as pesticides, fertilizers, hydrocarbons, phenols, plasticizers, biphenyls, detergents, oils, greases, pharmaceutical discharges, etc. Hence industrial wastewater creates a serious environmental problem. Here this project will propose an effective way to treat industrial effluents. Four common ways to treat wastewater include physical water treatment, biological water treatment, and chemical treatment and sludge treatment. It will overcome the challenges faced by the wastewater.

Objective

1. To improve quality of wastewater
2. Elimination of pollutants, toxicants and many such
3. Preservation of water quality of natural water resources

By the end of this thesis, one can investigate the process of treatment of wastewater in PETL, before releasing it into the ecology.

Plant Details

The concept of Common Effluent Treatment Plant emerged as a necessity Consequent to the industrial development in Patancheru Industrial belt. The various incentives offered by Government of Andhra Pradesh created a hub of activity in this area during 1970-80. Thus, Patancheru is reckoned on the industrial map. The establishment of Chemical, Pharmaceutical industries brought a distinction to this area and have become an address for bulk-drug manufacturers. It is a known fact that with this development, pollution has become an issue.

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Table 1.1 Inlet parameters.

INLET PARAMETRES	UNITS	STANDARD	ACTUAL
pH	-	5.5-9.0	7-8
Total Dissolved Inorganic Solids	mg/L	5000	3000
Chemical Oxygen Demand	mg/L	15000	3500
Ammonical Nitrogen	mg/L	50	35
Oil and Grease	Mg/L	20	10

Plant Operation

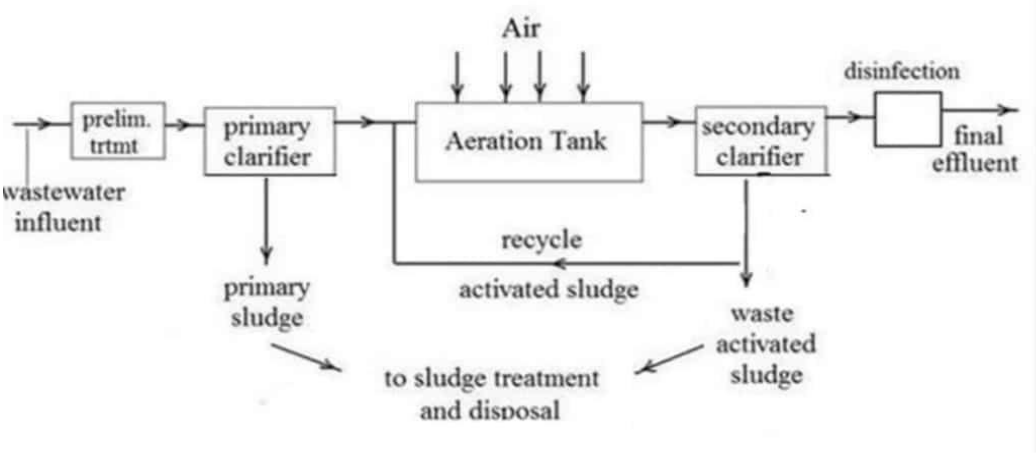
Components of the plant

- Receiving Sump
- Primary Treatment Tanks- Equalization Tanks
- Flash Mixer
- Clari-Flocculator
- Decanter (centrifuge)
- Aeration Tanks
- Secondary Settling Tanks
- Decanter (2)

Primary Treatment

Levels of waste water treatment

Due to presence of different types of contaminants and nature of contaminants in effluent -physical, chemical, and biological, the unit operations and processes in waste water treatment can also be categorized as such. There are three broad levels of effluent treatment: primary, secondary, and tertiary. Sometimes preliminary treatment precedes primary treatment.[1]



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Steps of primary treatment:

The steps involved in the primary effluent treatment physical, chemical methods. sedimentation, coagulation, flocculation. Firstly, the waste water from different industry is collected in one tank by testing the parameters like TDS, pH, etc., is called as unloading tank. This is the tank where the waste water from different companies is collected at one place. Then the water is passed to the Equalization storage tanks. In the PETL, Patancheru there are four equalization storage tanks of large capacity in which the waste water is stored.

Equalization storage tank:

Rectangular shaped tanks whose main function is to buffer i.e. to collect the raw incoming effluent that comes at widely fluctuating rates and pass it on to the rest of the effluent treatment plant at a steady flow rate. . The internal blower does not settle the solids while maintaining the suspension level.

Equalization of wastewater is a vital part of treatment process management systems and for the minimization and control of inconsistencies in wastewater. The equalization of contaminants and flow are engineered to deliver a constant rate of flow and contaminants to the treatment process. Larger equalization tanks provide a solution that reduces the impact of batch dumps and unwanted discharges. Aeration Blowers provide energy to maximize the suspension of solids in the wastewater to ensure a homogenized waste stream flows into the treatment system. This equipment has been proven to be more energy-efficient and has lower maintenance than mechanical mixing.

Flash Mixer, Agitators:

A flash mixer is a chamber that contains mechanical stirrers, which is designed to assure fast, thorough, mixing of non-ferric alum with concentration of 80 ppm, for the purpose of creating floc. This takes the charge of the effluent into consideration. After screening out debris and testing the raw water, water treatment really begins at the flash mix chamber. Here, chemicals are added to the water, primarily to aid in coagulation and flocculation. In the flash mixer, the water is agitated violently for a short period of time before being released into the Equalization storage tank and flocculation basin.

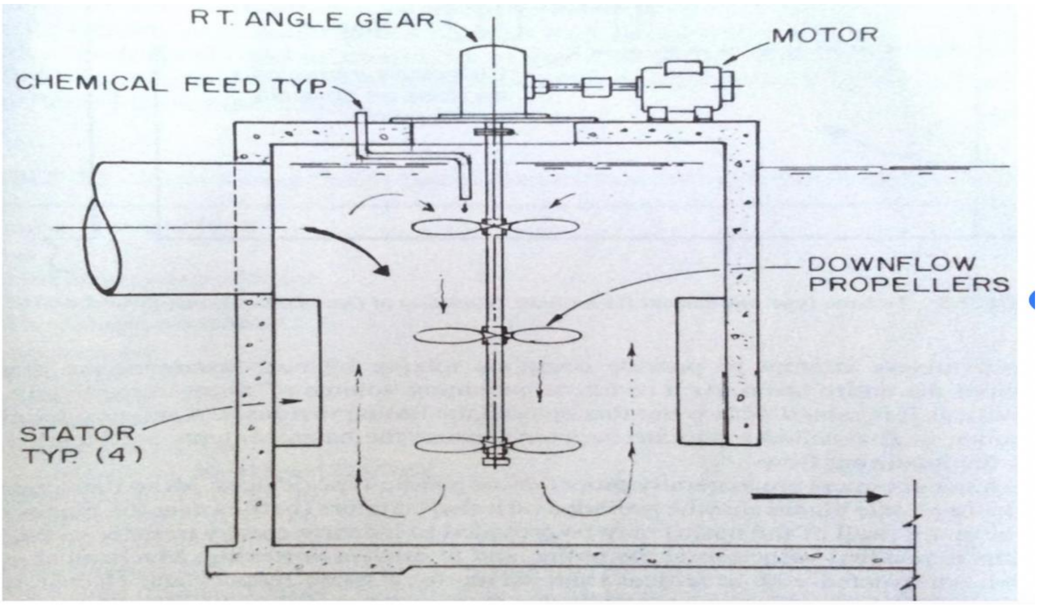

Fig 2.2 Schematic diagram of Flash mixer

Clari-flocculator

In common waste water treatment plants, the flocculator and the clarifier are combined together to achieve economy in construction. The combined unit of flocculator and clarifier is known as clari-flocculator in waste water treatment process. Clari-flocculator shall have two concentric tanks with inner tank serving as flocculation basin and outer tank serving as clarifier. The treatment chemcial like non-ferric alum is used for coagulating the S.S and the solids are separated. The S.S removed is collected in the sludge storage tank. The sludge separated is sent to decanter -1 for further separation of liquid and solids in the form of cake .

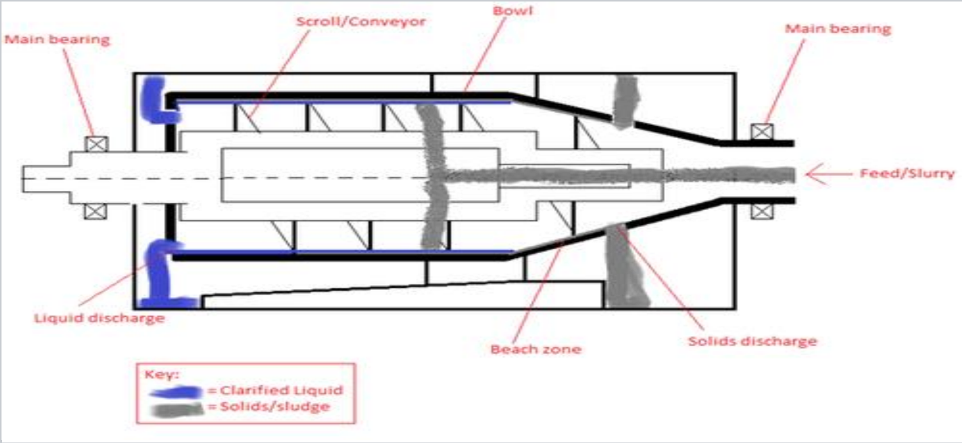

Fig 2.3 A schematic diagram of a Horizontal Decanter Centrifuge

Decanter (centrifuge)

The feed product is pumped into the decanter centrifuge through the inlet. Feed goes into a horizontal bowl, which rotates. The separation takes place in the cylindrical part of the bowl. The fast rotation generates centrifugal forces up to 4000 x g. Under these forces, the solid particles with higher density are collected and compacted on the wall of the bowl. A scroll (also screw or screw conveyor) rotates inside the bowl at a slightly different speed. This speed difference is called the differential speed. This way the scroll is transporting the settled particles along the cylindrical part of the bowl and up to the end conical part of the bowl. At the smallest end of the conical part of the bowl, the dehydrated solids leave the bowl via discharge opening. The clarified liquid leaves through a paring disc (internal centripetal pump). The chemical added to separate the solid particles from the water is poly-electrolyte or polymer solution. This solution helps to separate the oil and grease and other organic contaminants very fast in short period of time.

Sludge Treatment Process

Sewage sludge is a byproduct of treated wastewater. It is composed of both organic and inorganic materials, a large concentration of plant nutrients, organic chemicals, as well as pathogens. Therefore, it is extremely important to properly treat such sludge in order to minimize its environmental repercussions. Here is a brief overview of the sludge treatment process to help you gain a better understanding of the treatment techniques and process requirements:

Step 1 Sludge Thickening

The first step in the sewage sludge treatment plan is called thickening. In this step, the sewage sludge is thickened in a gravity thickener to reduce its overall volume, thus enabling the easy handling of the sludge. Dissolved air flotation is another alternative that can be used to effectively to thicken the sludge by using air bubbles to allow the solid mass to float to the top.

Step 2 Sludge Digestion

After amassing all the solids from the sewage sludge begins the sludge digestion process. This is a biological process in which the organic solids present in the sludge are decomposed into stable substances. While destroying any present pathogens to enable easy dewatering. The sludge digestion process is a two-phase process. These bacteria hydrolyze the large molecules of proteins and lipids present in the sludge and break them down into smaller water-soluble molecules, which they then ferment into various fatty acids and methane, after

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which the methane is collected and reused to power the digestion tank and generate power (depending on the quantity retrieved) .

Step 3 Dewatering

After retrieving useful gases and other byproducts, the remaining sludge is then dewatered before final disposal. In most cases, dewatered sludge usually contains a significant amount of water, as much as 70 percent, in spite of its solidified state. Therefore, it is important to dry and dewater the sludge beforehand by the help of mobile decanters. By passing the sludge through a centrifuge, it becomes easier to retrieve all the water and enable easier handling of the solid waste in shorter duration at reduced costs. Other alternatives include the rotary drum vacuum filter and the belt filter press.

Step 4 Disposal

Once the sludge has been effectively dewatered, it can be buried underground in a sanitary landfill or can be used as a fertilizer, depending on its chemical composition. In cases where the sludge is too toxic to be reused or buried, you can simply incinerate the sludge and convert it into ash.

Secondary Treatment

Aeration tank:

The biological treatment of the wastewater takes place in the aeration tank. This contains countless microorganisms, such as bacteria, that are able to break down the colloidal, organic contaminants dissolved in the wastewater. The bacterial present in the aeration tank has a life time of 45-60 days during which they multiply and prolong their survival as a group by feeding on the organic matter in the effluent various parameters like COD, BOD, TDS, Ammonical nitrogen etc. It should be found out before sending the effluent into aeration tank. The aeration tank present at PETL is of (55 x 22.5 x 3.5)m^3 which can hold a volume of 4770 m^3. Extended aeration system is used in PETL which incorporates surface aeration technology. Keeping in mind the costs of running the diffusers alone, the diffusion technique is cost effective compared to surface diffusion. But the cost of the equipment governing diffusion is very high compared to surface aeration equipment.

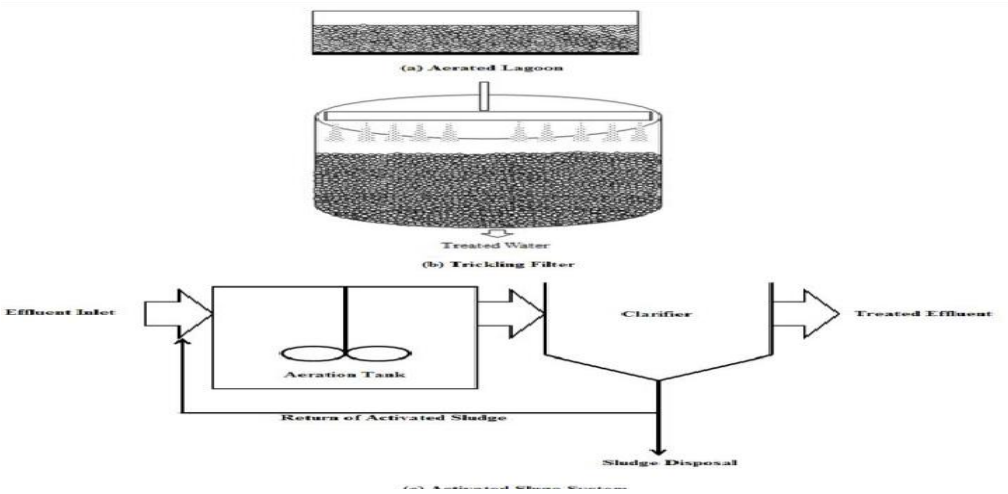

Fig 3.1 Aeration tank

Microbial Needs

Microorganisms that are natural to the industrial effluent environment play a vital role in the treatment process. The mixture of microorganisms that come in contact with and digest biodegradable matter from the effluent is called as Activated sludge. Beneficial bacteria, protozoa, metazoa, algae, and fungi feed on organic material in wastewater, breaking it down. Bacteria clump together, or floc, forming masses that settle and separate from wastewater liquids. This settled mass is called sludge.

Bacteria account for 95% of the microorganisms in wastewater. They are single-celled microorganisms that are classified based on their response to oxygen. A theoretical requirement of 3500-4000 ppm of bacteria is required to achieve required outlet parameters but practically a dose of 6000-8000 ppm of bacteria is used in order to achieve the required outlet parameters since in order to consume 100 BOD there is a requirement of 5 Nitrogen and 1 Phosphorus molecules respectively.

Foods-to-Microorganism Ratio

If the F/M ratio is too low, nutrient deficiencies can occur. An environment deficient of phosphorus, nitrogen, and/or sulfur interrupts the development of the cell wall, creating water resistance, which results in floc dispersion, sludge bulking, and foaming. It becomes difficult for nutrients to penetrate the cell wall. Slime bulking may occur in environments deficient in phosphorus or nitrogen or high in organic acids.

Retention Time

The time spent by the effluent in the aeration tank right from input to output is called retention time.

The retention time for a batch of effluent is 36-48 hours whereas the retention time for sewage is about 24 hours. During this retention time microorganisms have a chance of breaking down organic matter present in the effluent which results in enhancing the parameters such as COD, BOD, and TDS etc. towards required ranges.

Secondary Settling Tanks

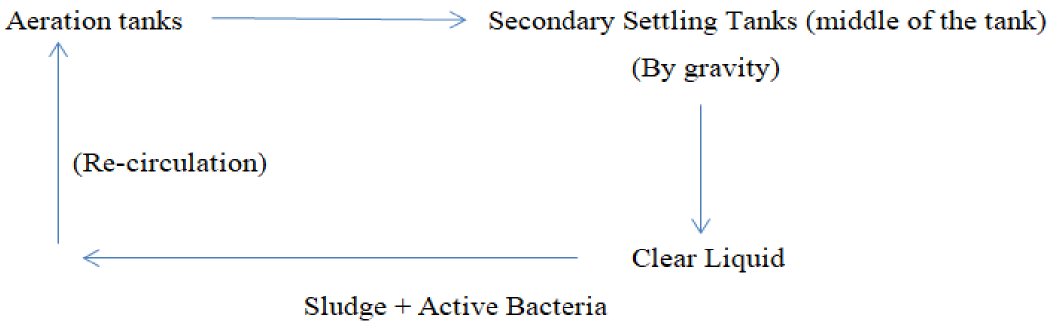

Fig 3.2 Process Flow chart

Secondary Settling Tank

Clarifier is a component of modern system of water supply or waste water treatment.

It allows suspended particles to settle out of water or wastewater as it flows slowly through the tank, thereby providing some degree of purification. They are also used in activated sludge systems for separating treated water from biomass, settling sludge and sufficiently thickening it so that when the sludge is returned to the tank inlet, the concentration levels can be maintained.

Table 3.1 Outlet Parameters

OUTLET PARAMETERS	UNITS	STANDARD	ACTUAL
pH		5.5-9.0	7-8
Total Dissolved Inorganic Solids	mg/L	2100	1700
Total Suspended Solids	mg/L	100	50
Chemical Oxygen Demand	mg/L	250	200

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Biochemical Oxygen Demand	mg/L	30	16
Ammonical Nitrogen	mg/L	50	1-5
Oil and Grease	mg/L	10	10

Effluent Analysis

Fig 4.1 & 4.2 COD Digestion Apparatus

Procedure for chemical oxygen demand:

1. Take 20 ml of sample or diluted sample
2. Add 0.4 g of $HgSO_4$
3. Add 10 ml of $K_2Cr_2O_7$ solution
4. Again add 30 ml of H2SO_4 reagent

NOTE: (add 10 gm. of $AgSO_4$ to 1 liter of H2SO_4)

Keep the sample in COD digester reactor at 150 ^{0}C for one and half hours to two hours.

5. Add 20 ml of distilled water to condenser remove that sample from COD reactor and cool it for 15 min.
6. Titrate with ferrous ammonium sulphate (FAS) using indicator (ferroin indicator) until the colour changes to brick red

Calculation

COD (mg/l) =[((A-B) * FAS Normality * 8 * 1000)/ taken volume of sample] * dilution factor

Where,

A = blank

B = taken sample or diluted sample

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over

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a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water.

BOD reduction is used as a gauge of the effectiveness of wastewater treatment plants. BOD of wastewater effluents is used to indicate the short-term impact on the oxygen levels of the receiving water.

Procedure to determine the BOD of water:

1. Take four 300 ml BOD bottles and add 10 ml of samples to 2 bottles and fill the remaining volume with dilution water
2. Fill remaining 2 BOD bottles only with dilution water for blank.
3. Immediately close the bottles when filled and there should not be any air bubble in the bottle.
4. Mark the bottles as blank and sample.
5. Incubate one sample and one blank bottle at 20 degree Celsius for 3 days
6. Analyze immediately remaining 1 blank and 1 sample bottle of Dissolved oxygen (DO).
7. Analyze incubated bottles for DO after 3 days.

Test for dissolved oxygen:

1. Add 2 ml of 36.4% of Manganous sulphate ($MnSO_4$, H_2O) solution inserting the tip of pipette tip into the sample because the drops of solution can allow inserting the oxygen into the solution.
2. Add 2 ml of the alkali-iodide-azide reagent by above method.
3. Allow reacting the solution with the oxygen present in the sample.
4. When precipitates are settled down at the bottom add 2 ml of concentrated sulphuric acid by placing the pipette tip very near to sample surface.
5. Mix well to dissolve the precipitates.
6. Take 203 ml of sample from BOD bottle in to a conical flask.
7. Titrate immediately with 0.025 N sodium thiosulphate solution using starch indicator until blue colour disappears and note down the burette reading.
8. Determine the burette reading for blank in the same manner.

Calculations

Blank correction = B.R for blank at D_0 – B.R for blank at D_3

BOD mg/l = [(B.R for sample at $D_0 – D_3$) – blank correction] * dilution factor

Dilution factor = bottle volume (300 ml)/sample volume

Where,

B.R =Burette reading

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D_0 = initial

D_3 = day 3 after incubation

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) are a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. TDS concentrations are often reported in parts per million (ppm). Water TDS concentrations can be determined using a digital meter.

Total dissolved solids are often caused by the following:

- Industrial sewage and waste
- Plankton
- Silt
- Urban runoff
- Road salts during winter
- Pesticides and fertilizers

Total dissolved solids are measured as parts per million (ppm), and standard drinking water recommends a limit of 500ppm. The lower the TDS, the better the water quality. For drinking water and fountain beverages, a TDS of up to 500 is acceptable, but for boiler-based steam ovens, TDS should be kept very low—less than 100 ppm.

Fig 4.3 & 4.4 Muffle Furnace, Hot Air Oven

Procedure for Total dissolved Solids:

1. Total Dissolved Solids is calculated through Gravimetric analysis.
2. Sample is treated for every 4 hours (before treatment & after treatment).
3. Take 10ml/20ml/50ml of sample, filtrate the sample using filter paper.
4. Add the filtered sample into a ceramic crucible.
5. Place the crucible on a heat plate at a temperature of 100-120 ^{0}C (to remove water content).
6. Now place crucible in hot air oven at 180 ^{0}C to obtain TDS.

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7. Adjust the temperature to 500 ^{0}C in digital muffle furnace to obtain inorganic TDS value.

8. Cool the crucible using desiccator.

Calculations

TDS = [(A-B) * 1000]/ml of sample

Where,

A= initial crucible reading

B= final crucible reading

Ammonical nitrogen:

Amonical nitrogen (NH_4-N) is a measure for the amount of ammonia, a toxic pollutant often found in landfill leachate and in waste products, such as sewage, liquid manure and other liquid organic waste products.

Formula: NH4-N

Molecular weight: 32.062 g/mol

Boiling point: -195.8 Celsius

Melting point: -209.86 Celsius

Density: 1.2506 g/l

1) Reflux 5 minutes add collect 100ml sample boric acid flask by continuous flow of water discharge (100ml-150ml)

2) Titrate against 0.02N sulfuric acid

Calculation

= Titrated value * value (factor)/ sample taken (100ml/50ml/20ml)

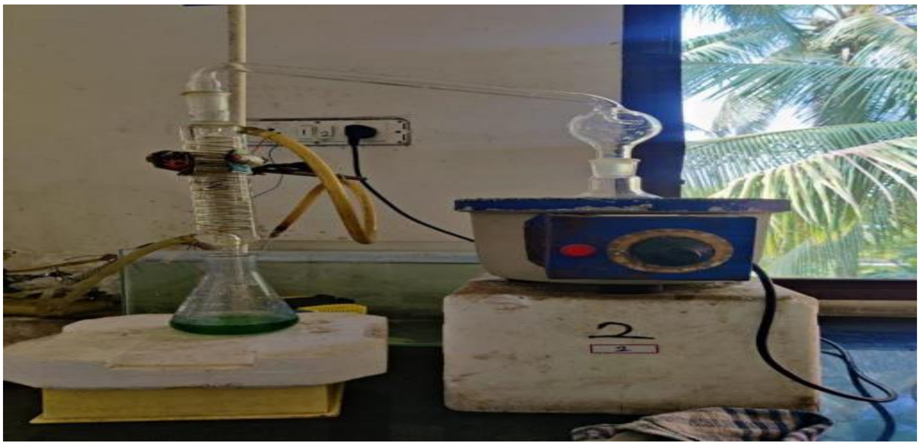

Fig 4.5 Simple Distillation Apparatus

Procedure for NH_4-N:

- Take 100ml of sample in vile, add 10ml of borate buffer 6N ,NaOH , adjust pH 12.5 to 9 by adding solution of 3-5 drops and take 20ml or 25ml of boric acid in conical flask.

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RESULTS AND DISCUSSION

Table 5.1 Results of M/s Patancheru Envirotech Ltd., from January 2009 to Oct 2010

MONTH	TSS in mg/l		TDIS in mg/l		COD in mg/l		Ammonical Nitrogen in mg/l	
	IN LET	OUT LET	IN LET	OUT LET	IN LET	OUT LET	IN LET	OUT LET
STANDARD	--	100	5000	2100	15000	500	50	50
JAN, 2009	708	351	4214	2800	6277	1901	321	212
FEB ,2009	407	212	3001	2692	5021	1142	150	193
MAR ,2009	308	74	3406	2205	5858	538	113	99
APR, 2009	286	122	2325	1430	3883	371	70	68
MAY, 2009	224	69	1975	1338	3739	230	40	51
JUNE,2009	309	62	2388	1642	2699	199	41	32
JULY,2009	198	28	1879	1525	2140	199	28	17
AUG,2009	257	30	1932	1616	2233	185	32	15
SEP,2009	696	33	2005	1200	2242	144	30	8
OCT,2009	656	36.28	1969.36	1388	2403	171.44	31.22	6.98
NOV,2009	830.33	34.86	2026	1731	2260	159	33	8
DEC, 2009	699	32.9	1818	1463	2103	146	36	8
JAN, 2010	557.9	35.43	2411	1599	2962	278	33.86	9.04
FEB, 2010	571	38	2598	1769	3620	232	37	8
MAR, 2010	413.5	32	2207	1852.5	3257	279.7	35.5	3.9
APRIL,2010	488.9	50.4	2034.4	1552.9	3084	245.3	38.8	9.6
MAY, 2010	509	50	2293	1994	3133	254	39	7.1
JUNE,2010	535	78	2073	1856	2901	264	35	6
JULY,2010	519	73	2368	1846	3261	250	38	3.2
AUG,2010	514	52	2350	1837	3245	215	56	4.3
SEP,2010	503	49	2334	1856	3272	213	48	4.1
OCT,2010	485	47	2319	1847	3269	215	51	3.2

Table 5.2 Results of STP at Amberpet

MONTH	TSS in mg/l		TDIS in mg/l		COD in mg/l		Ammonical Nitrogen in mg/l	
	IN LET	OUT LET	IN LET	OUT LET	IN LET	OUT LET	IN LET	OUT LET
STANDARD	--	100	---	2100	---	250	---	50
JULY ' 09	212	11.8	495	610	320	45	31.7	23.8
AUG' 09	195	17	641	617	202	51	28	24
SEP' 09	131	12	565	546	136	31	25	12
OCT' 09	190	12	429	557	288	30	27	13
NOV, 09	265	12	416	619	348	47	28	22
DEC, 09	202	12	431	628	323	32	28	31
JAN, 2010	238	12	414	594	461	46	32	34
FEB, 2010	198	8	422	566	360	49	34	37
MAR, 2010	199	8	440	575	273	51	40	35
APR, 2010	188	12	556	558	277	36	35	28
JUNE,2010	264	20	666	664	408	66	38	20
JULY,2010	320	10	760	708	480	62	30	18
AUG,2010	129	4	725	708	389	63	22	12
SEP,2010	140	9	740	651	278	67	34	10
OCT,2010	150	8	870	832	363	61	37	12

CONCLUSION

The study reveals that there is an efficient reduction in parameter from treatment units of CETP. Maximum % COD reduction is obtained at biological treatment. TSS, Ammonical nitrogen, TDIS, pH variations are there in outlet.

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