

A Study of Health, Safety and Environment Management System in Chemical Industry

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ABSTRACT: The present study paper has covered the wastewater treatment, solid and liquid waste incineration plant, Air and Noise pollution monitoring in the chemical industry. To understand various environmental problems associated with the chemical industry wastewater treatment plant and the environmental protection measures taken up by the company.

KEYWORDS: Waste water treatment, Effluent, BOD, COD, Physical and Chemical Parameters,

I. INTRODUCTION

Environment means surrounding in which any organization or living system operates. It includes natural physical entities like air, water, land and its resources, man, flora fauna and their interrelationship. Our environment consists of four systems Atmosphere, Hydrosphere, Lithosphere and Biosphere. The biosphere is an open system where individual living thing takes materials required by them from the support system. Lithosphere, atmosphere and hydrosphere extract energy for life functioning and discharge waste products.

Pollution: the word pollution is derived from a Latin word, "pollutus", which means to make dirty, to pollute. The problem of environmental pollution; which initially started with the advent of men on earth, grew extremely acute in the developed as well as developing country.

Water Pollution: water is the basic ingredient in the entire life cycle. Water used for various activities is then disposed off into natural water bodies. These water bodies are getting polluted due to present of various undesirable substances, which lead to harmful effects on man and the environment. The two major causes of water pollution are Discharge of all city waste and Discharge of industrial effluents into the river/other bodies of water/open land.

Air Pollution: It may broadly be defined as the presence of one or more contaminants like dust, smoke, mist, odor in the atmosphere which are injurious to human beings, plants and animals or which unreasonably obstruct the comfortable enjoyment of life and property.

Solid Waste: Solid waste is the term now used internationally to describe the non-liquid waste material arising from domestic, trade, commercial, industrial, agriculture and mining activities and from the public service, solid waste comprises different materials such as dust, food waste, packing in the form of paper, metals, plastic and furnishing waste and hazardous and radioactive waste.

II. RELATED WORK

Water is the basic ingredient in the entire life cycle. Water used for various activities is then disposed off into natural water bodies. These water bodies are getting polluted due to present of various undesirable substances, which lead to harmful effects on man and his environment. The two major causes of water pollution are

- a) Discharge of all city waste
- b) Discharge of industrial effluents into the river/other bodies of water/open land.

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The present Waste water study is related to Chemical Industry and the waste is treated activated sludge process (Aerobic Technique) developed by company. The waste water is given primary treatment (chemical and physical) in each plant to recover and recycle products, reduce bacterial toxicity and bring the quality to acceptable limit for further treatments at waste water treatment plant.

III. OBJECTIVES OF THE STUDY

- To understand various environmental problems associated with the chemical industry.
- To study the working of the wastewater treatment (Tower biology), plant of the industry.
- To study the environmental protection measures taken up by the company.

IV. ENVIRONMENTAL POLLUTION CONTROL

The present study paper has covered the wastewater treatment, solid and liquid waste incineration plant, Air and Noise pollution monitoring in the chemical industry.

1. Wastewater Treatment

The industry has set up the treatment of wastewater with, the Activated Sludge Process, to reduce COD, BOD levels much below the statutory limit. The wastewater is given primary treatment (chemical and physical) in each plant to recover and recycle products, reduce bacterial toxicity and bring the quality to acceptable limit for further treatments at wastewater treatment plant. The wastewater contains traces of complex organic molecules of amines, phenols, thiophosphoric esters and tarry compounds and solvents. The Treatment plant is designed to treat 2200m³/ day, with an average COD and BOD of about 1700 mg/l and 450 mg/l respectively. The operational procedure is divided into three steps and Tertiary Treatment as follows.

a) Pre-Biological Treatment

- Metallic Grids** Incoming wastewater and domestic wastewater first pass through the metal grids, provided on the lines for removal of floating materials.
- Neutralizer** In neutralizer p^H is controlled between 5 to 9 by the addition of HCl or caustic soda lye.
- Clarifier** Clarification is a sedimentation process used to remove small quantities of fine solids to produce a clear liquid effluent. Domestic and Industrial wastewater is collected in the tank and the suspended solids are allowed to settle down due to gravity for the period is about 5 hours. A slope is provided at the bottom of the clarifier to collect the sludge in the sump. A wooden dredger collecting the sludge in the sump. The settled solids are removed to sludge drying beds. The liquid effluent percolates through the sludge bed to sump and then pumped into neutralizer. Solids sludge beds, sun dried & manually-removed in drums and after packing, transferred to an incinerator plant for burning. The lighter floating liquid is removed at the other end of the clarifier through oil separator.
- Buffer Tank and Equalizer:** The Clarifier wastewater overflows into the buffer tank through metallic grid the p^H is continuously monitored and then it is pumped into equalizer. In equalizer wastewater is homogenized by passing compressed air through perforated ring pipe fitted at the bottom, normally 100m³/hr air is passed. The wastewater stays for the period 36 hours. Equalizer COD is maintained below 1600mg/l whenever it crosses the limits and depending upon the process capacity, fresh water or process water is added for dilution, p^H value of equalizer is maintained between 7 & 10. If the p^H of equalizer fall below 7, caustic soda lye is added. If p^H is about to fall nearly 10, the neutralizer p^H is maintained around 7 till necessary control is achieved. The wastewater in equalizer is analyzed for its Nitrogen content, chlorides, reducible substance, BOD, phosphorous (total & inorganic) phenols active ingredients and amines.

b) Biological Treatment

The Aerobic Treatment is carried out in towers, having a capacity of 2,200m³. Compressed air 3 kg/cm² pressure is passed in these towers through injectors fitted at the bottom of these towers, along with reticulated water and feed water. Air rate depends upon DO in tower 1 to 12 ppm for better results. The feed is at a constant rate of about 30-40 m³/hr. The stay period is about 60-80 hours. Injectors are led to feed, plus recycled water at a rate of about 120 m³/hr. If inlet rate drops below 90 m³/hr, injectors are back flushed. The overflow from towers occurs at 15m of height. A NaOH/antifoam reagent line is provided at the top, a foam detector and spare port holes are also provided at 15.5 m of the towers. There are four openings given in order to replace the exhaust gases in the ambient air. This is carried out by

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keeping the tower height near 15 m and keeping the exhaust fan on. The ambient air enters the towers through the openings tangential to the tower water surface this, giving a cooling effect. The towers temperature is maintained below 39°C for better efficiency of the bio-degradation reaction. The tower P^H is generally maintained between 7 & 8 by adding caustic soda lye through the pump.

Wastewater contains dissolved organic material, this mixture promotes the growth of bacterial culture, which after acclimatization uses the organic matter for food and the oxygen supplied from the air for respiration some other chemicals like Ammonium Molybdate, Boric acid, Ferric chloride, Manganous sulphide, zinc sulphate and urea are also added for the proper growth of bacteria.

c) Post Biological Treatment (Cyclone Conical Separator)

The treated wastewater overflows from the towers and enters in the cyclones fitted in conical settler which are 11m in height and 10m in diameter and having capacity 325m³ some part of treated waste water coming from the tower to settler is recalculation. In a cyclone, air is expelled out & the bacterial mass settles down and is recycled back into towers by pump. Generally the tower sludge recycling rate is kept 1:1 with respect to feed towers. This ratio may change according to requirement. It consists of a cyclone at its center and has a conical bottom. The overflow from the tower enters in the cyclone from the top tangentially and spirals down to the apex of the conical section, it then moves upwards through four tangential openings given at the bottom of the cyclone. The bacterial masses move radically to the walls and as they are heavier, they settle down in the conical bottom of the settler.

The clear biological treated effluent overflows from the settlers into 'v' notch through fitted in settlers and through the troughs, it falls down in outlet pipeline. The stay period in the settler is six hours. The treated effluent is analyzed for COD, BOD, P^H , Suspended particles, Phenolic compounds, amines and active ingredients.

d) Tertiary Treatment Plant-(Sand Filters)

The sand Filter is 10 m³ capacity and 1.5 m of height is filled with sand. Overflow from settlers enters in static mixer where alum dosing solution of 10% and polymer dosing solution of 0.1% dosing is carried out for coagulation of suspended solids which do not settle in clarifier or which take more time for settling. In static mixer coagulants (alum & polymer) get mixed with treated water from settlers. Then this mixed water enters into sand filters into bed through the inlet pipe and the distributors. The water rises through the downwardly moving sand bed and the filtered water is discharged from the filter via an overflow at the top of the filter unit. Another overflow is provided for recirculation of treated water into the towers. Compresses air and process water line are provided from top to filter for brushing of the sand bed and washing of the sand bed.

In sand filter coagulated suspended particles get suspended troubled sand is lifted by an air lift pump which is at the bottom of filter to the collection vessel in the upper part of the filter. The sand then falls down into the sand washer where it is rinsed in counter current flow with a small amount of filtrate & process water. The clear water from sand filters ultimately sends to the creek. Thus, by the above determined procedure the COD of treated water is maintained up to 250 mg/l and BOD is maintained up to 40-50 mg/l.

2. Incinerator

The incinerator is basically a heat recovery and waste disposal plant. The company has set up the Rotary Kiln Incinerator, having capacity 203 Mio. K Cal/ hour (2000 T/year) which can handle solid and liquid/slurry wastelike Rubber, Agrochemical, and Healthcare, etc. The incineration plant is equipped with a Drum Burning Chamber for decontamination of metallic waste. The complete destruction of all organic waste and the waste heat is recovered in a membrane type water tube boiler to generate steam. The off-gases are scrubbed and continuously monitored for CO, NO_x and SO₂.

3. Noise Pollution Monitoring

The noise monitoring, sampling was carried at various dept. and locations such as Boilers, Tank area, Generators, Compressors, Mills, Mixers etc.

V. MATERIAL AND METHODS

1. Wastewater

The wastewater sample of production plants (Health Care, Agro Chemical, Rubber Chemical) and before and after treatment of wastewater treatment plant Tower and Settler outlet are analyzed for physico-chemical parameters.

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a) **Physical Parameter**

- i) **Colour** of the waste water is directly seen externally and note down the colour of the sample will visual observation.
- ii) **Temperature** measurement deeping the thermometer for about one minute in the sample bottle on the site itself.
- iii) **p^H** meter is calibrated for 7 and 9.2 p^H buffer solution and dip the electrode of p^H meter in a sample for p^H measurement.
- iv) **Total Suspended Solids (TSS)** sample has mixed thoroughly in a beaker allowed it to stand for one hour and filtered through pre-weighed G-3 sintered glass crucible by the water ejection system. The water was removed completely from crucible by filtration. The crucible transferred in oven at 103-104°C and dry; allowed to cool outside and then transferred in desiccators. The crucible was weighed. The TSS was calculated by using a standard formula.

b) **Chemical Parameters**

- i) **Dissolved Oxygen (DO) By (Winkler's Iodometric)** 2 ml of manganous sulphate and 2 ml of alkali-iodide solution were added to the collected sample in 250 ml reagent bottle. The bottle stoppered tightly and mix thoroughly by inserting the bottle inverting several times. Allow the precipitate to settle and add to it 2 ml of concentrated sulphuric acid mix thoroughly till precipitate dissolves.

200 of above solution was titrating against 0.025N sodium thiosulphate solution till pale yellow colour was obtained. Add 1ml of 2% starch solution. Titrate again till faint blue colour disappears. The DO was calculated by using a standard formula.

- ii) **Biological Oxygen Demand (BOD)** a desired volume of distilled water was kept for aeration (air tubing with diffused stone) in a clean bucket for saturation with dissolved oxygen. 1ml per liter was added each of phosphate buffer, magnesium sulphate calcium chloride and ferric chloride, prepared as per APHA, if the sample for estimation of BOD was raw effluent, 1ml/l of tower outlet was added as bacterial seed to the diluted water. If the sample for estimation of the BOD was a tower outlet or domestic water does not seed the diluent water. p^H of the sample was adjusted between 7 and 8. The required amount of sample was taken in a clean 1000 ml measuring cylinder dilute with diluent water, prepared as per 600 ml (for 6 ml of sample diluted 600 ml is 1% sample). The sample was mixed thoroughly after addition of diluent water. The sample was transferred in 2 numbers of clean, dried 250 ml reagent bottles up to the mouth and without leaving the air bubbles, stopper the bottles.

Similarly, 250 ml reagent bottles were filled with only diluent water. (With or without seed, as the case may be) as per above. Bottles are labeled, preferably with alphabetical order as A1, A2, A3..... Bottles with odd numbers are used for final dissolved oxygen of the same series. Incubate the bottles with even numbers at 20 °C in BOD incubator. Make entry of sample details, monitoring alphabet letter against the sample. Initial dissolved oxygen (IDO) is estimated of odd numbered bottles. The incubated bottles are removed after five days, bring them up to room temperature and estimated dissolved oxygen (FDO). The BOD was calculated by using a standard formula.

- iii) **Chemical Oxygen Demand (COD)** 20 ml of well mixed sample diluted to 20 ml was taken with distilled water in 250 ml capacity conical flask.

1. Add one small spatula full of mercury sulphate (approx. 200 mg)
2. 10 ml of 0.25 N potassium dichromate solutions.
3. 25 ml of concentrated sulphuric acid (LR grade) by measuring cylinder.

The mixture was heated on a reflux condenser for 15 min and the flask was cooled, the condenser was washed with distilled water. Then flask was removed from enamel tray, containing water and it was cooled to room temperature. Titrate the reflux mixture with 0.1 N ferrous ammonium sulphate using ferroine indicator. The colour change was from bluish green to reddish brown. One blank was run, using 20 ml distilled water. The COD was calculated by using a standard formula.

- iv) **Phenolics (Chloroform extraction method)**(APHA 1992)500 ml distillate or a suitable portion containing not more than 50 µg phenol, diluted to 500 ml, in a 1 liter beaker. A 500 ml of distilled water blank and a series of 500 ml phenol standards containing 5, 10, 20, 30, 40 and 50 µg phenol was prepared.

The treat sample, blank and standards were as follows. The 12 ml 0.5 N NaOH added immediately and the p^H was adjusted to 7.9 ± 0.1 with phosphate buffer. Under some circumstances a higher p^H may be required. A 10 ml phosphate buffer is required and transferred to a one liter separately funneled and 3.0 ml aminoantipyrine, 3 ml K₃Fe(CN)₆ solution were added and mixed well and let coloured developed for 15 min. the solution should be clear and light yellow.

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The CHCl_3 was extracted immediately using 25 ml of 1 to 5 cm cells and 50 ml for 10 cm cell and shaken separator funnel at least 10 times, let CHCl_3 settle again shaken 10 times and let CHCl_3 settle again. The CHCl_3 extract was filtered through filter paper or filtered glass funnel containing a 5 g layer of anhydrous Na_2SO_4 . The dried extract was collected in clean cells for absorbance measurements; do not add more CHCl_3 .

The absorbance of sample and standards was read against the blank 460 nm. The absorbance of the sample was plotted against micrograms phenol concentration. The phenol value was calculated.

2. Stack Monitoring (Air Pollution)

The air samples were collected from the incinerator plant Emergency stack and final incineration stack for SO_2 , NO_x parameter analysis.

a) **Sulphur dioxide (SO_2) (Hydrogen Peroxide Method)** A measured volume of air is drawn through a dilute solution of hydrogen peroxide at about pH 5. The sulphur dioxide in the air is absorbed and oxidized to sulphuric acid. The resultant increase in acidity of the solution is determined by a simple titration using an indicator.

In two gas bottle 3% H_2O_2 was filled (35 ml in each) the bottles were joined in series with one end connected to stack and the other end connected to measure suction. A 200 liter was sucked at the rate of 50 l/hr. The content of the two gas bottle was mixed and titrate 0.1 N NaOH using a mixed indicator and SO_2 was calculated

b) **Nitrogen oxide (NO_x)** Nitrogen oxides as nitrogen dioxide are collected by bubbling air through a sodium hydroxide solution to form a stable solution of sodium nitrate. The nitrate ion produced during sampling is determined calorimetrically by reacting the exposed absorbing reagent with phosphoric acid sulphanilamide and N (1-Napthyl) ethylenediaminedihydro chloride (NEDA)

10 ml of the collected absorbent was taken in a test tube and 1 ml H_2O_2 , 10 ml of sulphanilamide solution and 1.4 ml of NEDA solution were added with thorough mixing, after the addition of reagent a blank is prepared same manner using 10 ml absorbing reagent. After a 10 minute colour development interval absorbance measured at 540 nm against the blank. $\mu\text{g of NO}_x / \text{ml}$ solution was read from the calibration curve.

3. Noise Pollution Monitoring

The noise monitoring, sampling was carried at various dept. and locations such as Boilers, Tank area, Generators, Compressors, Mills, Mixers etc.

The Noise measurement meter (dB meter) was calibrated before use; hold the meter pointing the sensor towards the unit, where the noise level was to be measured in the working area. The switch was rotated, till the pointer remains on a scale between 1 and 10 numbers. The number on which the pointer rests is noted (It flickers on the scale) this count was added to the windows on the scale.

VI. RESULTS AND DISCUSSION

1. Wastewater

In the present study the physical and chemical characteristic of the untreated and treated wastewater from the wastewater treatment plant, and manufacturing units were studied and discussed. The aim of the study is to know the level of water pollution and efficiency of the control measures taken up by the industries.

a) Physical Parameter

i) **Colour** of the effluent before treatment was yellow in colour due to acids, phenols, amines, alkali was used in the manufacturing process in Agro and Rubber chemical unit. Canteen waste water colour was pale green. The aerobic treatment was carried out and the colour of the effluent after treatment is pale yellow.

ii) **Temperature** during the winter season is ambient, i.e. 36°C , when the ambient temperature was between 25°C and 30°C and during the summer season, the ambient temperature was about 30°C and 35°C . Which is below the Pollution Control Board limit 40°C .

iii) **pH** of the wastewater before treatment ranged between 8 to 10 and after treatment ranged between 7 to 8 which is within the Pollution Control Board prescribed limit 5.5 to 9.0

iv) **Total Suspended Solids (TSS)** the average value after treatment was 50 mg/l which is within the Pollution Control Board prescribed limit 100 mg/l

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b) Chemical Parameters

- i) **Dissolved Oxygen (DO)** is not present in the wastewater (before treatment) due to washing of inorganic reluctant such as hydrogen sulphide, amines, phenols, nitrites, ferrous ions and other oxidizable substances in Agro and Rubber Chemical plant. But the after treatment the average value was 3.0 mg/l
- ii) **Biochemical Oxygen Demand (BOD)** the average value before treatment was 510 mg/l and that of the after treatment was 34 mg/l the obtained results for BOD is too low compare with the Pollution Control Board prescribed limit 100 mg/l
- iii) **Chemical Oxygen Demands (COD)** the average value of the wastewater before treatment were 1420 mg/l and that, of the after treatment 239 mg/l which is within the Pollution Control Board prescribed limit 250 mg/l
- iv) **Phenolics** the average value of the Phenolics in the wastewater before treatment was 1.62 mg/l and after treatment was 0.01 mg/l which is well below stipulated Pollution Control Board limit is 1 mg/l.

Waste water parameters before and after treatment and pollution control standards.

Parameter	Effluent Before Treatment	Effluent After Treatment	Change %	Pollution Control Board Standard
Colour	Yellow	Pale Yellow	--	--
Temperature	Ambient	Ambient	--	5.5 – 9.0
p ^H	8 – 10	7 – 8	--	--
Total Suspended solids	---	50	--	No Limit
Dissolved Oxygen	Nil	3.4	--	--
Biological Oxygen Demand	510	34	-93.33	100
Chemical Oxygen Demand	1420	239	-83.16	250
Phenolics	1.62	0.01	-99.38	1

All parameters in mg/l, except Colour, Temperature and P^H

6.2 Stack Monitoring

Sulphur dioxide (SO₂), Nitrogen oxide (NO_x) and Carbon Monoxide (CO) in the present study investigated sulphur was present in the form of sulphur dioxide produced in rotary kiln and it was ensure to scrub in SO₂ scrubber. The average value of SO₂ was 10.68 mg/Nm³ which is well below stipulated Pollution Control Board limit 300 mg/Nm³.

The value of NO_x was 11 mg/Nm³ which is also well below stipulated Pollution Control Board limit 50 mg/Nm³.

The CO was produced in rotary kiln; it was insured to complete burn in Post Combustion Chamber. The average value of CO is 53 ppm and which is within the Pollution Control Board prescribed limit 100 ppm.

Air monitoring parameters and pollution control standards.

Parameter	Unit	Average Value	Pollution Control Board Standard
SO ₂	Mg / Nm ³	10.68	300
NO _x	Mg / Nm ³	11	50
CO	ppm	53	100

VII. NOISE POLLUTION MONITORING

The noise pollution in Boiler house the average value of noise was 77 dB and near tank area 80 dB. In energy house the average value of noise near generator was 80 dB and near compressor was 84 dB. In Chemical Plant near the mill house was 69 dB and mixer was 79 dB. All these values below the prescribed Pollution Control Board limit is 90 dB.

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VIII. SUMMARY AND CONCLUSION

The present Study of Health, Safety and Environment Management System in Chemical Industry can be sources of pollution in different forms, namely water pollution as a major form and other i.e. air and noise can be less major forms. In industry the untreated and treated effluent were analyzed for physiochemical properties like, pH, TSS, DO, BOD, COD and Phenolics. The untreated effluent was highly alkaline in nature with an ambient temperature i.e. 35 °C. The BOD, COD and Phenolics are as follows 510 mg/l, 1420 mg/l and 1.62 mg/l. whereas the treated effluent was 40 mg/l, 239 mg/l and 0.01 mg/l. TSS and DO was 50 mg/l, 3.0 mg/l respectively. These values are below the limits prescribed by Pollution Control Board.

The BOD reduction was about 93.33%, COD reduction 83.60% and phenolics reduction 99.38%. This clearly indicates that the wastewater treatment plant is working efficiently and this water could be used for gardening and any other purpose.

The stack monitoring study, the analysis data of stack pollution of gaseous emission from incinerator plant. The gas given out was SO₂, NO_x and CO and Average values were 10.68 mg/Nm³, 11 mg/Nm³ and 63ppm. Which are below the limits prescribed by Pollution Control Board.

The noise pollution in Boiler house the average value of noise was 77 dB and near tank area 80 dB. In energy house the average value of noise near generator was 80 dB and near compressor was 84 dB. In Chemical Plant near the mill house was 69 dB and mixer was 79 dB. All these values below the prescribed Pollution Control Board limit is 90 dB.

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