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A Comprehensive techno-economic study of effluent treatment plant of yarn manufacturing industry to meet the zero liquid discharge standards

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ABSTRACT

The yarn manufacture industry, which we are working of zero liquid discharge, is mainly a chemical Industry effluent treatment plant discharging around 10,000m^3/day. So achieving zero liquid discharge, this huge discharge can be eliminated and daily water consumption of industry can be reduced. The effluent coming to effluent treatment plant is having some significant effluent characteristics like mostly varying PH, high BOD, high, COD, heavy metal. Basic study of current effluent plant including load, parameters of effluent & treatment. Identify the gap between present ETP at yarn manufacture industry and zero liquid discharge ETP. ZLD process also makes effective use of wastewater treatment, recycling and reuse. We use primary data collection method and collect the parameter of effluent and treated effluent as well as load calculations for better design.

Keyword: *Wastewater, Heavy Metal, ZLD.*

1. INTRODUCTION

Water as we all know is important for life cannot be wasted. If water is used in an industrial plant there should be some methods to recycle it. Effluent treatment plant is types of waste water treatment method which is mainly designed to purify industrial waste for its reuse and recycle. The purpose of effluent treatment plant is to meet the standards for emission or discharge of environment pollutants from various Industries set by the Government and avoid hefty penalties, safeguard environment against pollution and contribute in sustainable development, clean industry effluent and recycle it for further use, reduce the usage of fresh/potable water in Industries.

Industrial effluents contain various materials, depending on industry. For example effluent contains oils and greases. Some heavy metals and some contain toxic materials. Since industrial waste water contains a range of impurities and therefore specific treatment technology called effluent treatment plant is required. The effluent treatment plant is work at various levels and involves various physical, chemical and biological treatment processes to treat waste water from different industry department like chemical, textile, power plant, etc.

Effluent treatment plant is a process design for treating the industrial waste water for its reuse and recycle and safe removal to the environment.
Influent: untreated industrial waste water
Effluent: treated industrial water
Sludge: solid part separated from waste water by ETP.

2. PRESENT EFFLUENT TREATMENT PLANT

Indian rayon is one of the largest producers of viscose rayon filament yarn in India. The production of yarn is a very complex operation & includes a process be relevant to their respective department.

Some type of the pollutants is present on the industry, in the effluent coming out of the different process.

Table1. Known significant water pollutant from some industries

Categories of sources	Known significant pollutant
Textile mils	BOD,COD, dissolved solids, suspended solids, oil & grease, color , heavy metals (Zn)
Inorganic chemical manufacturing	BOD, COD, dissolved solids, PH, heat
Power plant	BOD.COD. suspended solids. Dissolved solids, oil & greases , turbidity, heavy metals, nitrogen, phenols

The effluent treatment plant of Indian Rayon is total discharge 10.000m^3/day. Total department of industry influent send to ETP. Total number of drain is 5. Quality of effluent carried by this drain is around 3000 m^3/day. The department contributing effluent to this drain is viscose, chemical department, power plant and boiler house. This drain carries around 4500 m^3/day of effluent. This stream is basically acidic and carries effluent from a spinning department, after treatment department, spin bath department. This drain carries around 2500 m^3/day of effluent. This stream is basically textile department, administration building, and new spinning department and continuous spinning department.
This drain carries the rejected water to the reverse osmosis plant. This is directly feed to the discharge pipe.
Chemical required for ETP- water, Lime, Sulphuric acid (H_2SO_4)

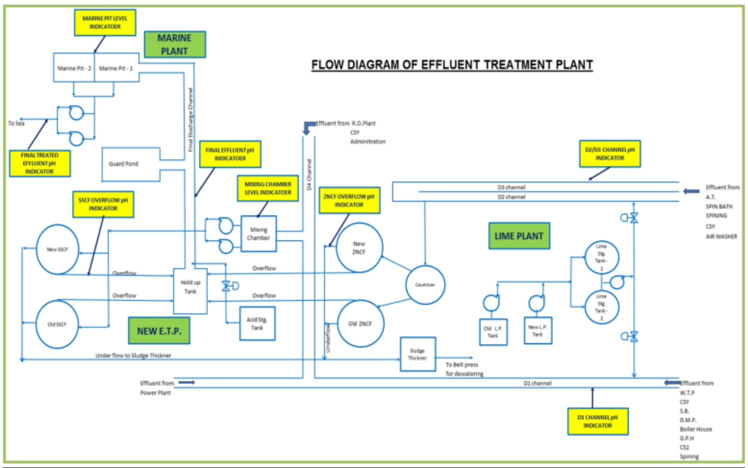

Figure-1 present effluent treatment plant

The acidic stream

This stream contains sulphuric acid and zinc sulphat. The stream are connected and pumped into the overhead in which lime solution is continuously fed for neutralization. Lime dosing is under auto control for maintaining an alkaline PH. The zinc sulfate content is precipitated as zinc hydroxide due to reaction with lime. The liquid passed through the caustic cussing tank for proper mixing and then two zinc clarifiers where the lime sludge containing zinc hydroxide in solid from settle down. The bottom sludge is sometimes pumped into the sludge thickener. The clean overflow from clarifiers is sent in to hold up tank.

The alkaline stream

This stream receives some acidic effluent also suitably neutralized with lime slurry as per requirement is led to mixing chamber. The mixed effluent from drain 1&4 is also mixed with polyelectrolyte solution which then sent to the suspended solid clarifiers is also periodically pumped into the sludge thickener. The clear overflow from the clarifiers is discharged to the holdup tank. The final discharge from the holdup tank under goes a PH of 6.5-8.3 constantly and its final discharged by leading into the sea.
At this point only the effluent from RO plant is also discharged. The PH is maintained through addition of sulphuric acid. The thickened sludge from the thickener is pumped to the centrifuge to separate water from the sludge. The semi-solid coming from the centrifuge is continuously discharged and used for land and water from centrifuge is sent back to the drain no.

3. LITERATURE SURVEY

s.salvador [(1)], they performed an experimental work on pilot scale for removal of presence of silica stable 98% recovery in nanofiltration and reverse osmosis, were carried out under different condition. The silica scaling can be a limiting factor for membrane treatment at very high recoveries. In this work pilot plant consisting of cation exchanger pretreatment, nanofiltration and reverse osmosis with pretreated ground water as feed water. The experimental observations indicate total recovery (NF+RO) of 98% and 99% and with the addition of two different antiscalants at 99 %.

S.G.J.Heijmana,[(6)] they performed an experimental work on membrane filtration in the Netherlands is severely hindered by the concentrate problem. Two approaches are viable for solving or reducing the concentrate problem (1) low recovery NF/RO without anti-scalant dosing (2) zero liquid discharge. The choice between sludge softening and pellet softening depends on the necessity to remove silica from the feed water. These preliminary results indicate that the use of a weak acid ion exchange resin can be beneficial for the removal of carry-over.

Nasiman Sapari[12] they performed experiments work on Total removal of heavy metal from mixed plating rinse wastewater, were carried out by A mixed plating rinse wastewater containing zinc, hexavalent chromium, trivalent chromium, and cyanide with total dissolved solids of 424 mg/l was treated by a model consisting of a sand filter and ion exchange columns. A strongly acidic cation resin in hydrogen form and a strongly basic anion resin in hydroxide form were used in the columns as cationic and anionic exchangers. The cationic and anionic exchangers were regenerated by using 2% H2SO4 and 5% NaOH, respectively. A 100% removal of zinc, total chromium, hexavalent chromium and trivalent chromium was achieved in the studies.

4. PROPOSED WORK

Zinc removal process

Ion-exchange processes have been widely used to remove heavy metals from wastewater due to their many advantages, such as high treatment capacity, high removal efficiency.
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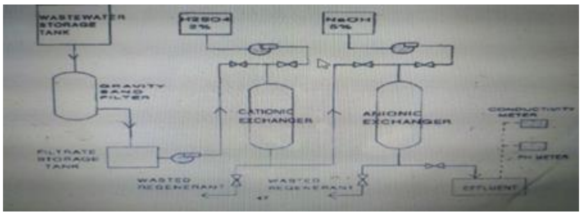


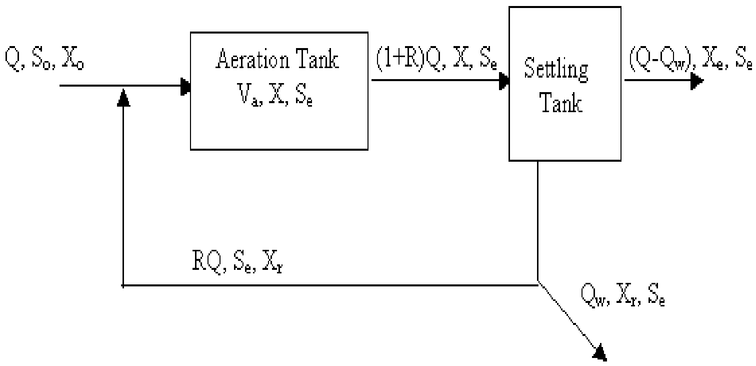
Figure-2 Ion exchanger experimental set-up

Cationic ion ex-changer to remove positive ions, it was passed through a anionic ion exchanger to adsorb the negative ions. Amberlite IR- 120 and Dowex 2-X4 were used as the cation and anion exchanger, respectively. The regenerate chemicals used for the study were 2% H_2SO_4 and 5% NaOH for the cationic and anionic exchanger.

Amberlite IR- 120 resins Properties **Dowex 2 X4**

Physical form	Amber spherical beads	Physical form	Amber spherical beds
Matrix	Styrene divinybenzene copolymer	Function group	Sulfonic acid
Function group	Sulfonate	Ionic form as a shipped	Cl^-
Ionic form as a shipped	Na+	Effective working range	0-14
Total exchange capacity	>2.00 eq/L (Na+ form)	Thermal stability	OH- From max 60 c Cl^- from max 100 c
Moisture holding capacity	45 to 50 % (Na+ form)		
Shipping weight	840 g/l		

Design of aeration tank



Design Step

1) Selection of q_c, t, MLSS concentration
adopt q_c = 5d. as there is no special fear of toxic inflow, the HRT, t may be kept between 3-4 h, and MLSS= 2000 mg/l

2) Effluent BOD_5

Substrate concentration s = 1/(1/ $q_{c,+ Kd}$)/ QY = 1/ (1/5 + 0.07) /0.038 *0.6
S= 12 mg/l
Assume suspended solids in effluent = 20 mg/l and VSS/SS = 0.8
If degradable fraction of volatile suspended solids (VSS) = 0.7, (BOD of VSS in effluent= 0.7 (0.8*20)) = 11 mg/l

Thus, total effluent BOD_5 = 12+ 11 = 23 mg/l

3) Aeration Tank Volume:

$VX=YQq_c(s_0-s)/ 1+ k_dq_c$

X= 1600 mg/l q_c = 5 day s_0 = 150 mg/l s =20 mg/l	Kd = 0.07 X= 0.8 * MLSS = 0.8 * 2000 = 1600 mg/l Y = 0.6

Q = 6000 m^3/day
V = 0.6 * 6000* 5 * (150-20)/ (1+(0.07*5))
= 866.67
V = 870 m^3
Required volume = 1040 m^3
Detention time t = 870 * 24/6000
= 4 h
F/M = (150-20) (6000)/(1600*870)
= 0.44 kg BOD_5 per kg MLSS per day
Let the aeration tank be in the form of

4) Retune sludge pumping

If suspended solids concentration of retune flow is 1% = 10,000 mg/l
R= MLSS/(10000)-MLSS
= 1600/(10000)-1600
= 0.2
Qr = 0.2*6000 = 1200 m^3 /day

5) Oxygen requirement

1. for carbonaceous demand,
Oxygen required = (BOD_U removed)- (BOD_U removed of solids leaving)
= 1.47 (2160 kg/d) – (960 kg/l)
= 72.5 kg/l

6) Power requirement

Power required = 136/0.7*2 = 97 KW (130 hp)

5. FILTER DESIGN

Rapid Sand Filter Design
Inputs

A flow of between 4-21 m/h can be expected from a rapid sand filter. Area of filter = 10 000 x 1.02/ 23.5 * 10 = 43.3 m^2 Each bed area 43.4/2 = 21.7 m^2	Assume length of the filter L/B = 1.3 So L= 5.31 m B= 4.08 m

Under drainage system:

Total area of holes = 0.2 to 0.5% of bed area. 0.35% (0.2-0.5 % of bed area
Assume 0.3% of bed area = 0.3 * 21.7/100 = 0.065 m^2
Area of lateral = 2 (Area of holes of lateral)
Area of manifold = 2 (Area of laterals)
So, Area of manifold = 4* area of the hole
= 4*0.06
= 0.26 m^2
Diameter of manifold = $(4 \times 0.52 /pi)^{1/2}$
= 57.55 cm
Assume c/c (center to center) of lateral = 30 cm

Holes

Take dia of holes = 13 mm
Number of holes: = n pi $(1.3)^2$ / 4
= 860 cm^2

n = 4 x Total Hole Area /3.14(Hole Diam) ^{2}
= 648 app.650
Number of holes per lateral
= No of holes/number of laterals
= 13
Area of perforations per lateral= 13 x p $(1.3)^2$ /4 = 17.24 cm^2
Spacing of holes = L_lateral/no of holes per lateral = 13.4 cm
Area of lateral = 2 x area of perforations per lateral = 2 x 17.24 = 34.5 cm^2
Diameter of lateral = $(4 \times 34.5/p)^{1/2}$
= 6.63 cm
Check :(Length of lateral < 60* Diam of Lateral)
=60 x 6.63
= 3.98 m.
(l = 2.545 m)
Rising wash water velocity in bed = 50 cm/min
Size of bed = 5.31 * 4.08 =21. 66
Wash water discharge per bed = [0.0083*5.31*4.08]
= 0.18 m^3/s
Velocity of flow through lateral = $\frac{0.18*10,000}{0.345*50}$ = 1.0466 m/s
Manifold velocity = $\frac{0.18}{0.345}$ = 0.52 m/s < 2.25 m/s (ok)
Clear water reservoir for backwashing
For 4 h filter capacity,
Capacity of tank = 4 x 5000 x 7.5 x 5.75 x 2 /1000 = 866.7 m^3
Assume depth d= 5 m
Surface area = 866.59 / 5
= 173.32 m^2
L/B=2 therefore
L= 18.61 m
B= 9.3 m
Diameter of inlet pipe coming from two filter = 50 cm

Velocity in filter effluent pipe during filtration= 0.59 m/s

Air BW

Air Velocity 1000 l of air/ min/ m2 bed area
Air required During BW = 1000 x 5 x 5.31x 4.08x 2
= 2.16 m^3 of air

6. CONCULSION

Water conservation is the key driver of ZLD specially completely depended on RO company but for raw water contain high TDS.so instead of using bore-well water for RO, treated water is beneficial, and also zinc recovery are use in yarn manufacturing process. 70% water is reuse in other application.

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