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Performance Evaluation of Sewage Treatment Plant

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Abstract: **-- Current increases in population growth have resulted in an increased quantity of waste generation. These wastes pose a serious threat to public health when they are not readily disposed of. The use of domestic wastewater for irrigation is advantageous for many reasons including water conservation, ease of disposal, nutrient utilization, and avoiding surface water pollution. So, treated domestic wastewater reuse prevents the risk to both public and the environment. An attempt is made to evaluate the performance of sewage treatment plant, Block-C near Gangamma gudi area in Tirumala with capacity of 5 MLD. Considerable reductions in pollutant loads were achieved by using coagulants such as Poly Aluminium Chloride (PAC), Lime and Poly Electrolyte (PE).The optimum dosage was found to be 50 mg/l of PAC, 50 mg/l of Lime and PE of 2 mg/l. COD removal of about 90% and turbidity removal is 100% at optimum dosage of coagulants and the optimum cost for treating 5 MLD wastewater is about 10815Rs/-.**

Keywords**: Wastewater, COD, Turbidity, PAC, PE.**

I. INTRODUCTION

1.1General

Every community produces both liquid and solid wastes and air emissions. The liquid waste, wastewater is essentially the water supply of the community after it has been used in a variety of applications. Wastewater may be defined as a combination of the liquid or water carried wastes removed from residences, institutions, commercial and industrial establishments together with groundwater, surface water and storm water. As population is increasing day by day, the quantity of waste generation also increases. When untreated wastewater accumulates and is allowed to go septic, the decomposition of the organic matter it contains will lead to nuisance conditions including the production of malodorous gases. These waste pose a serious threat to public health when they are not readily disposed of.

1.2 About Tirumala

Tirumala being one of the holiest temples of India, regular flow of pilgrims in and out of the town every day of about 90 lakhs every year. Tirumala Tirupathi Devastanam provide and maintain the housing for these visitors. In addition to this population, there is also a resident

population of about 20,800. As there were no industries present in the town, the effluent is domestic in nature. To keep high standards of hygienic conditions, a well-equipped sewage treatment must be required. A sewage treatment plant should be considered as a social priority. Wastewater collected from different areas must ultimately return to receiving waters or to land or reused. The level of treatment must be achieved in a given application- beyond those prescribed by discharge permits- to ensure protection of public health and the environment depend upon detailed analysis of local conditions and needs , application of scientific knowledge and engineering judgment based on past experience, and consideration of federal, state, and local regulations.

The various unit operations and unit processes used in the Sewage Treatment plant, phase-c in Tirumala are screen and grit chamber, Aeration tank, Secondary clarifier, Stabilization tank, Flash mixer, Reactor clarifier, Pressure sand filtration, Chlorination system, Chlorine contact chamber, De-chlorination system, Sludge pit, Centrifuge, Sludge cake drying shed, Sludge drying beds. All these unit operations and processes are grouped together to perform various levels of treatment known as preliminary, primary, secondary, and tertiary.

Chemicals are added to enhance the removal of suspended solids and organic matter from the wastewater. These chemicals are termed as coagulants and flocculent. Coagulant is the chemical, added to destabilize the colloidal particles in wastewater resulting in floc formation. A flocculent is a chemical, typically organic, added to enhance the flocculation process. Typical coagulants and flocculants include natural and synthetic organic polymers, metal salts such as Alum or Ferric sulphate, and Pre hydrolysed metal

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salts such as Poly Aluminium chloride (PAC), poly Electrolyte and poly Iron chloride (PIC). Jar test is the most widely used experimental method for coagulation-flocculation. A conventional jar test apparatus is used in the experiments to find optimum dosage of coagulants by varying the dosage in mg/L. Optimum dosage is essential because insufficient dosage or overdosing would result in the poor performance in flocculation. Therefore, it was crucial to determine the optimum dosage in order to minimize the dosing cost and obtain the optimum performance in treatment.

1.4 Specific Objective of the present study

The present study aims at the performance evaluation of Sewage treatment Plant, Block-C in Tirumala and suggest combination of coagulants [Among Poly Aluminium Chloride (PAC), Poly Electrolyte (PE), Lime] achieves optimum removal of pollutants and Cost trade-off for the dosage of coagulants by conducting experiments on samples from Sewage Treatment Plant, Block-C in Tirumala.

II. STUDY AREA

2.1 Location

The temple town of Tirumala is located on a hill-top at an altitude of 849.0m above MSL in the chittoor District of Andhra Pradesh. Tirupathi is located at the foot-hills of Tirumala. However access to Tirumala is only by ghat road from Tirupathi. Bearings of Tirumala are 13°14´N and 79°23´E.

2.2 Climate

The climate of Tirupathi is generally arid. The maximum and minimum temperatures are in the range of 41°C and 16°C respectively. The total rainfall per year is about 670mm average. Tirumala is generally cooler than Tirupathi, the maximum and minimum temperatures are in the range of 36°C and 9°C.

2.3 Water supply

Tirumala town is provided with treated water through pipes. The average daily consumption is about 4,860 cum/day. The lowest recorded consumption is 3,100 cum/day, whereas the peak demand is up to 6,400 cum/day. The average per capita consumption works out to 120ltr/person/day. Apart from this domestic supply, there is a substantial demand of water for gardening and horticulture.

2.4 Existing Drainage system

The township spreading over an area of 520 hectares, is divided into seven drainage blocks identified as A, B, C, D, E, F, and G. In A, B, C, and D drainage areas establishment of sewage treatment plants takes place. The wastewater from drainage area F is combined with C. In our present study plant-C existing in drainage area C is taken.

Drainage Area-C

This is present towards the south of the temple, laid with underground sewers carrying fouls sewage to the treatment plant passing through Rambageecha, Bus stand, public toilets, Annaprasadham complex, Kalyanakatta, Employees Canteen and shopping complex.

Drainage Area-F

This contains Balaji nagar and is laid with sewers carrying foul sewage to Sewage treatment plant, Block-D which consists only treatment level up to secondary treatment and the treated secondary effluent is diverted to the plant-C for further treatment.

2.5 About Treatment Plant

LOCATION: Gangamma gudi area, Drainage Block- C in Tirumala

CAPACITY: 5 MLD including sewage from plant-D.

PROCESS UNITS

The raw wastewater is treated through following treatment units.

- Screen and grit chamber
- Aeration tank
- Secondary clarifier
- Stabilization tank
- Flash mixer
- Reactor clarifier
- Pressure filtrations
- Chlorine contact tank
- De chlorination tank
- Centrifuge and
- Sludge drying beds

to remove grit, consisting of sand, gravel, cinder or other heavy solid materials that have subsiding velocities or specific gravities substantially greater than those of the organic putrescible solids in wastewater.

Aeration Tank-Aeration tank is a RCC tank of size 48.0m×16.0m×5.50m and left open to atmosphere. Required tank capacity should be determined from the biological process design. Vertical axis surface aerators are used to aerate the wastewater.

Flash Mixer-This is a RCC tank of size 2.0m×2.0m×2.0m. This is provided with an agitator of suitable size and capacity. This is also provided with inlet, outlet and a drain pipe. The sewage is received in this tank where an appropriate quantity coagulant and flocculants i.e., hydrated lime, poly aluminium chloride, polyelectrolyte etc. Solutions are dosed and mixed thoroughly with sewage.

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Fig 1 Treatment units in Sewage Treatment Plant, Block-c, Tirumala

Reactor Clarifier-This is a RCC tank of size 14.0m dia× 4.0m. This is provided with central
Flocculation zone and peripheral clarifier zone. It is provided with clariflocculator mechanisms. The sewage dosed and mixed with coagulant and flocculants is received in the central flocculation zone where slowly rotating blades of flocculator help suspended solid come together and form bigger particles which settle down easily. The settle sludge is pushed to the central bottom outlet by slowly rotating scrappers of the mechanisms. The clear supernatant water overflows out into clarified sump and the sludge flows by gravity to sludge sump through valve provided with.

Chemically Treated water sump-This is a RCC tank of size 10.0m×7.0m×3.0m. The clear supernatant water is received in this and is pumped to pressure sand filter (4 Nos.) by PSF feed pumps.

Pressure Sand Filters-Pressure sand filters in MS construction with plate thickness of 9.00m, each of diameter 3.0m and total height of support 3.5m, epoxy painted with three coats and complete with all accessories and required items pipes, valves etc. complete. The media consists of granular silica sand of depth 1.2m and effective size of the silica sand is 2.5mm with a uniformity coefficient of < 1.5mm. The chemically treated water from the tank is fed into the pressure sand filter, 4 no's of filter feed pumps having capacity 70 cum/hour at 25 m head are provided for feeding water in PSF. The function of PSF is to remove fine particles and turbidity from the water.

Chlorination system -Vacuum feed type tonner mounted chlorination of capacity 0-2.5Kg/hour complete with all accessories. Chloride solution booster pumps, horizontal centrifugal type each of capacity 5 cum/hour at 12 m head and required items like pipes, valves etc, complete.

Chlorine contact chamber-This is a RCC tank of size 6.0m×6.0m×3.0m with baffle arrangement. The optimum quantity of chlorine gas is dosed in this tank by means of chlorination system.

De Chlorination system-This is a RCC tank of size 1.5m×1.5m×2.0m with mixing mechanism similar to flash mixer and feed solution tanks. This system is online in between chlorine contact chamber and treated water reservoir. Sodium Meta bisulphate is used for Dechlorination purpose.2 no's dosing pumps are provided for SMBS dosing.

Chemical sludge pit-This is a RCC tank dimensions 4.0m×2.0m×2.5m + 0.5m free board. This tank is equipped with 2 no's of agitators for mixing purpose. The chemical sludge from the bottom of clariflocculator is collected in this tank. The sludge is pumped to centrifuge by sludge pumps (2 no's).

Centrifuge-Solid bowl type centrifuge of capacity 5 cum/hour with input solid concentration of 1.0%.The chemical sludge from sludge pit is fed into the centrifuge with the help of 2 no's screw pumps of capacity 4.5 cum/hr at 20m head. The decantation of sludge is takes place in the centrifuge and the sludge comes out from the centrifuge in the form of cake. The leachate coming out from the centrifuge is collected back in collection tank. The sludge generated is further disposed of in the area designated by Pollution Control Board or can be used for land filling purpose in the TTD premises.

III. PERFORMANCE EVALUATION

The methodology developed to study the performance of the Sewage Treatment Plant involves identification and characterization of flow associated with the operation of Sewage Treatment Plant. The parameters analysed for performance evaluation are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total suspended Solids (TSS), Oil & Grease, Chlorides, Sulphates, Nitrates, Nitrites and Phosphorus. Performance of various unit operations/ processes of Sewage Treatment Plant was studied, Grab sampling method is adapted for the collection of samples both from inlet and outlet of individual units. The trend in removal of the pollutants are represented graphically (shown in figure 2 and 3). (BOD), Chemical Oxygen Demand (COD), Total suspended Solids (TSS), Oil & Grease, Chlorides, Sulphates, Nitrates, Nitrites and Phosphorus. Performance of various unit operations/ processes of Sewage Treatment Plant was studied, Grab sampling method is adapted for the collection of samples both from inlet and outlet of individual units. The trend in removal of the pollutants are represented graphically (shown in figure 2 and 3).

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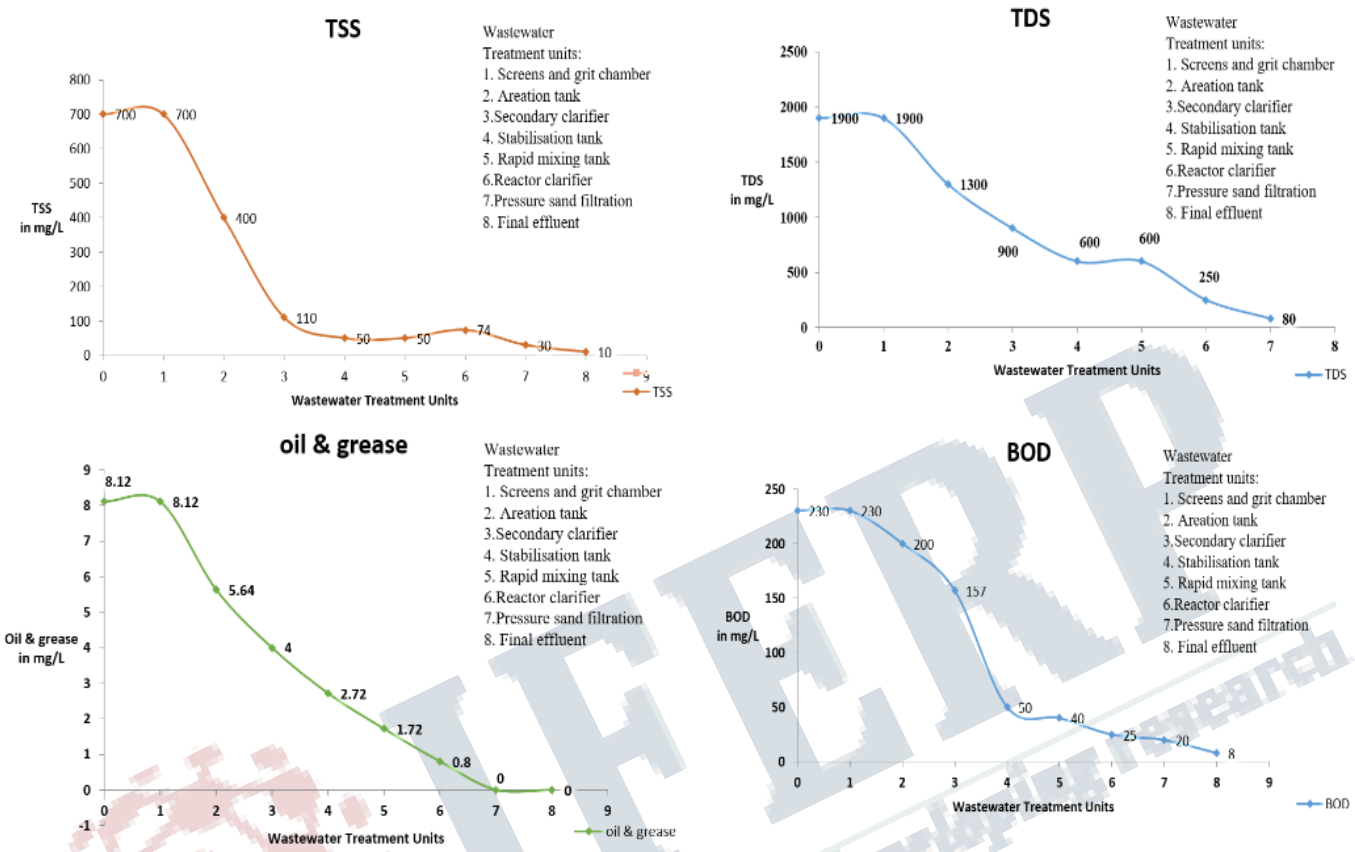

Fig 3.2 Unit wise removal of TSS, TDS, Oil & Grease, BOD

Table 1 Inlet, Outlet and Removal Efficiencies of the Parameters

Sl no	Parameter	Inlet concentration (mg/l)	Outlet concentration (mg/l)	Standard concentration	Removal Efficiency (%)
1	**pH**	6.38	7.00	6.5-7	-
2	TSS	700.00	10	<10mg/L	98.6
3	TDS	1900.00	25	-	98.7
4	Oil & Grease	8.12	0.0	Not detectable	100.00
5	BOD5@20^{0}C	230	08	< 10mg/L	96.50
6	COD	528	48	< 50mg/L	90.90
7	Chlorides	99.99	37	< 0.05mg/L	63.00

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8	Phosphorous	20.4	0.75	-	96.30
9	Sulfates	80.00	1.35	-	98.30
10	Nitrites	5.12	0.25	-	95.11
11	Nitrates	1.35	0.00	-	100

Observations from the Graphs and the Table

• pH of inlet and outlet are 6.38 and 7.10 respectively.

• TSS in the inlet is 700 mg/L, there is no removal in screens and grit chamber

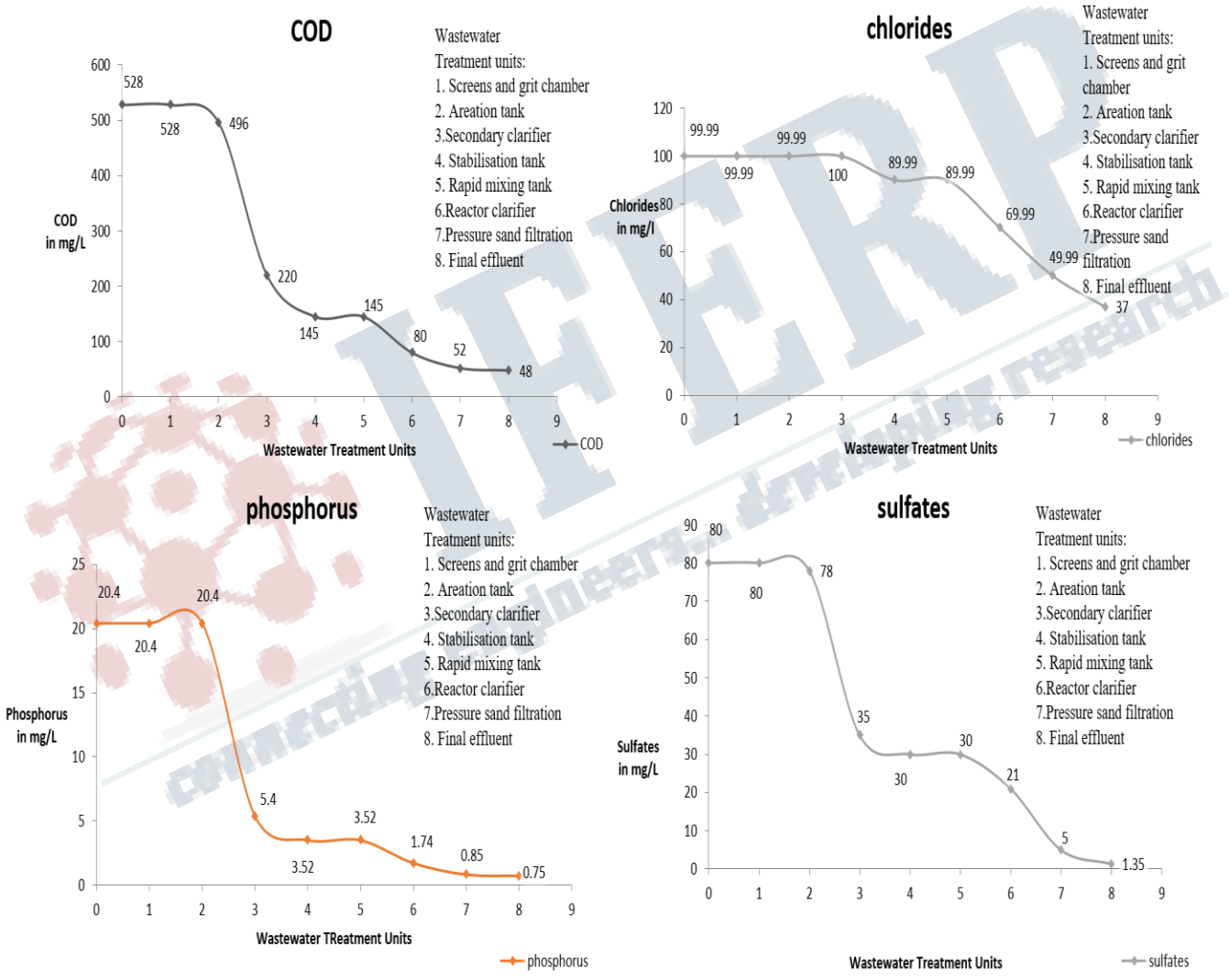

Fig 3 Unit wise removal of COD, Chlorides, Phosphorus, Sulfat

followed by Aeration and Secondary clarifier wher

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84.2% removal takes place. Later followed by Stabilization tank, Rapid mixing, Pressure sand filtration. TSS in the effluent is 10 mg/L.

- Maximum removal of TDS takes place in Aeration tank and Reactor clarifier.
- As there is no Skimming tank in the STP, Oil and grease removal takes place in the existing units.
- BOD graph follows decreasing trend from 230 mg/L to 8 mg/L, the final effluent is in limits (<50 mg/L as per APPCB standards)
- COD removal takes place in Aeration tank and effluent satisfies APPCB standards (50 mg/L).
- Chlorides removal does not satisfy the APPCB standards (0.05 mg/L), so additional treatment is required.
- Phosphorus & Sulphates in final effluent is 0.75 mg/L and 1.35 mg/L respectively, satisfies the limits.
- There is no presence of Nitrates in the final effluent concluding existing treatment is sufficient for Nitrates removal.

IV. COAGULANTS COMBINATION

In this study, three coagulants were used namely
Lime
Poly Aluminium Chloride &
Poly Electrolyte
Three combinations of experiments were carried out

- Lime (Lime only)
- Lime + PAC
- Lime + PAC+PE

The experimental part is discussed in detail.

4.1 Lime

Lime is alkaline in nature, as dosage of lime is increases, the values of pH also increases. The optimum dosage of lime is determined by varying different dosages of lime in the range of 0.5, 1, 1.5, 2, 2.5,3, 3.5, 4, 4.5……up to100 mg/L and observing pH values by using pH meter. A scatter graph is drawn between dosage and pH, optimum dosage is determined from the graph (Figure 4). pH of raw wastewater is 6.72.

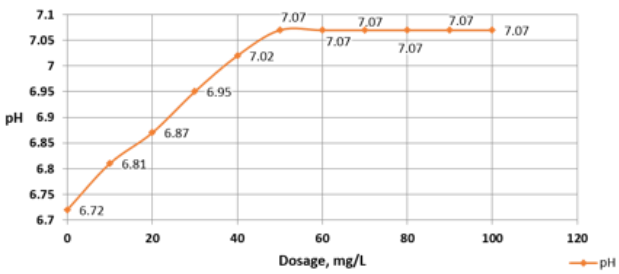

Fig 4 Dosage vs. pH

Observation from the Lime experiment

- From the graph, pH values increases with increasing dosage and then remains constant at the dosage of 50mg/L.
- Hence it is concluded that the optimum dosage of lime is 50mg/L.
- Only lime is not sufficient for the effective treatment, so a combination of lime and PAC are tested for effective removal.

4.2 Combination of Lime and PAC

The optimum dosage of lime is of 50mg/L, hence constant dosage of 50mg/l is maintained in all beakers during jar test and PAC dosage is varied starting from 0, 10, 20, 30, 40---------90mg/L and jar test is conducted to find out the optimum dosage of PAC with combination of Lime from the graphs drawn (Figure 5). Parameters of raw sewage are
pH = 7.04
Turbidity = 200 NTU
COD = 750mg/L

Observation from experiment of combination of PAC & Lime

- From dosage vs. turbidity graph, turbidity values are recorded zero at 40mg/L to 80mg/L dosage of PAC with 50mg/L of lime.
- From dosage Vs. COD graph, least COD values are obtained at 40mg/L, 50mg/L and 80mg/L dosage of PAC with 50mg/L of lime.
- The removal percentages of COD at 40mg/L, 50mg/L and 80mg/L are 62.2%,79% and 68.5% respectively (The minimum remaining COD is 100mg/L)

The required effluent quality must contain COD <50mg/L as per APPCB Standards. So, PAC and lime combination is not sufficient. So, to improve the performance, polyelectrolyte is added along with PAC and lime.

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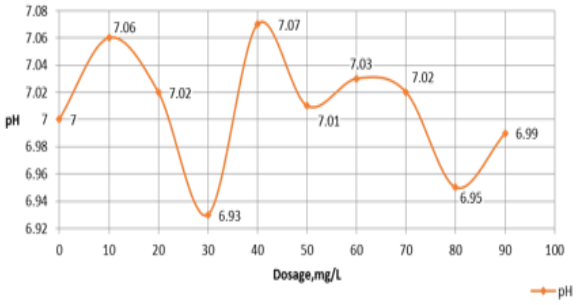

Fig 5 Dosage vs. Ph

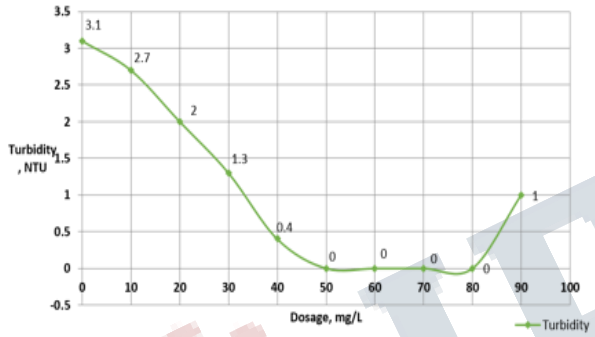

Fig 6 Dosage vs. Turbidity

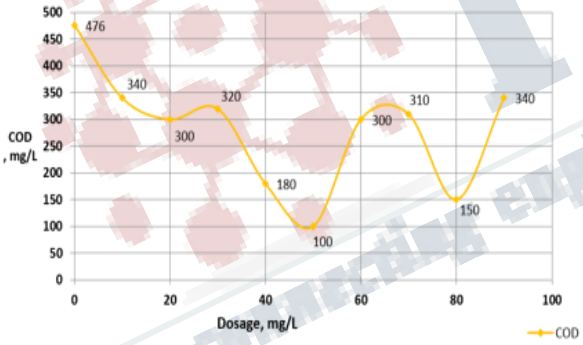

Fig 7 Dosage vs. COD

4.3 Combination of Lime, PAC & PE

To incorporate the results obtained by PAC and lime jar test is to be conducted twice. For the first jar test PAC and lime are used and in second jar test PAC, lime and PE are used. Experiment is conducted at PAC dosages of 40mg/L, 50mg/L and 80mg/L and lime of 50mg/L at varying dosages of PE.

Parameters of wastewater
pH = 7.04
Turbidity = 235 NTU
COD = 1000mg/

Table 2 Observations of PAC of 40mg/l, Lime of 50mg/l and PE of varying dosages

Dosage of PE in mg/L	pH	Turbidity in NTU	COD in mg/L	% removal of COD
0.0	6.96	32	476	0.0
1.0	7.01	-	120	74.8
2.0	7.02	-	86	82.0
3.0	7.01	-	150	68.5

Table 3 Observations of PAC of 50mg/L, Lime of 50mg/L and PE of varying dosage

Dosage of PE in mg/L	pH	Turbidity in NTU	COD in mg/L	% removal of COD
0.0	7.01	32	476	0
1.0	7.03	-	78	83.6
2.0	7.01	-	45	90.5
3..0	7.02	2.7	110	76.8

Table 4 Observations of PAC of 80mg/L, Lime 50mg/L and varying dosage of PE

Dosage of PE in mg/L	pH	Turbidity in NTU	COD in mg/L	% removal of COD
0.0	7.01	32.0	476	0.0
1.0	7.20	3.0	60	87.4
2.0	7.14	4.5	24	95.0
3.0	7.25	5.4	72	84.8

Observations of PAC of 40mg/l, Lime of 50mg/l and PE of varying dosages

- The maximum turbidity removal is 100% at 2mg/L of PE, 40mg/L of PAC and 50mg/l of lime dosage.
- The maximum COD removal is 82% and remaining COD of effluent is 86mg/L at 2mg/L of PE.

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Observations of PAC of 50mg/L, Lime of 50mg/L and PE of varying dosage

- The maximum turbidity removal is 100% at 2mg/L of PE.
- The maximum COD removal is 90.5% and remaining COD of effluent is 45mg/L at 2mg/L of PE.

Observations of PAC of 80mg/L, Lime 50mg/L and varying dosage of PE

- The maximum turbidity removal is 86% at 2mg/L of PE.
- The maximum COD removal is 95% and remaining COD of effluent is 24mg/L at 2mg/L of PE.

The required quality of effluent must contain COD <50mg/L as per APPCB Standards. So, PAC, lime and PE combination gives good results in effective removal of turbidity and COD at 50mg/L and 80mg/L of PAC, 50mg/L of lime and 2mg/L of PE. Out of these two combinations the optimum combination is selected based on cost trade-off.

IV. CONCLUSION

The present study deals with the performance evaluation of Sewage treatment plant, Block-C, in Tirumala. The treatment unit has full-fledged treatment comprising of physical, chemical and biological unit operations/process. The treated effluent is reused for gardening. From the overall study, the following conclusions were made

- Removal efficiency of COD, BOD, total suspended and dissolved solids was found to be 91%, 96.5%, 98.6% and 98.7% respectively.
- The current results suggest that the treated effluent is complying with the standard values and can be used for gardening.
- From experiments on chemical coagulants, the combination of 50mg/L of PAC, 50mg/L of lime and 2mg/L of PE is good and suitable one.
- The required quality of effluent should contain COD <50mg/L as per APPCB Standards. For coagulant combination of 50mg/L of PAC, 50mg/L of lime and 2mg/L of PE, COD was found to be 45mg/L.
- From experiments on coagulants combinations of 50mg/L of PAC, 50mg/L of lime and 2mg/L of PE is suitable for effective removal and removal efficiencies of COD, Turbidity were found to be 90.5% and 79% respectively.

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