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DESIGN AND ANALYSIS OF WATER TREATMENT PLANT

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ABSTRACT: Changes in design of water-treatment plants usually result from the desire to improve operating performance, the need to modify treatment processes, the urge to benefit from technical advances, or the efforts to reduce the impact of increasing construction costs. All have had an influence on the water-treatment plants now under operation. The various functions and equipment of the facility including the mixing and settling basins, the second plant expansion, new plant construction, new sludge-removal units, filter media, valves, under drains, the filter design, surface-wash system, and the current plans and investigations underway. The overall design of the wastewater treatment plant consists of 3 stages: i) Primary treatment which consists of screening, grit removal and sedimentation ii) Secondary treatment consists of a bioreactor iii) Tertiary treatment consists of nitrogen removal, adsorption and pH control. For plant design, the following parameters are assumed/experimentally determined for the wastewater. Further, the total flow rate and the concentrations keep varying at different times of the day, as well as are subject to seasonal variations. For example, in morning hours the flow rate and BOD value is high. Similarly, during rainy season solid contents like silt are more due to surface run-off.

I. INTRODUCTION

To provide safe and pure drinking water to environment, people and living organisms. Distribution of Krishna treated water to Hyderabad was proposed on 6th SLSC meeting held on 20-1-2004.To provide additional drinking water to the twin cities from river Krishna with AMRP main canal as source. It has been proposed to take up Krishna Water Supply project in three phases for supplying 270 MGD. To meet the projected demand of HMWS&SB's service area up to horizon year 2021. Drinking water treatment plants are used to remove particles and organisms that lead to diseases and protect the public welfare and supply pure drinking water to the environment, people and living organisms. In addition, they also provide drinking water that is pleasant to the senses : taste, sight and smell and provide safe, reliable drinking water to the communities they serve. Water treatment, as a word originally means the act or process of making water more potable or useful, as by purifying, clarifying, softening it. To provide drinking water to the public is one of the most important tasks of communities and the design of water supply systems has to follow the rules of engineering sciences and also needs technical knowledge and practical experience. Water is treated differently in different communities depending upon the quality of water which enters the plant. For example; ground water requires less treatment than water from lakes, rivers and streams.

1.1 KRISHNA WATER DISTRIBUTION TAILS

Phase-I (2004 - 2006)
STAGE -1 for supplying 45 MGD (Million Gallons Per Day)
STAGE -2 for supplying 45 MGD (Million Gallons Per Day)
Phase –II (2006 -2011) for supplying 90 MGD (Million Gallons Per Day)
Phase –III (2011-2014) for supplying 90 MGD (Million Gallons Per Day)
The current demand for water supply in the city is 460 MGD, but the Water Board is supplying only 340 MGD, a major shortfall, that deprives the surrounding municipal areas, many of which get water once in three days, some only once in seven days. Godavari water will come to the city a few months before the Assembly elections in 2014.
Alwal would be the first GHMC circle to get Godavari water, which would traverse 186 Kms from Yellampally (Karimnagar) barrage. Subsequently, Qutubullapur, Rajendranagar, Kukatpally, Serilingampally, Kapra and Malkajgiri circles and the Secunderabad cantonment would get Godavari water treated at the Ghanpur mega balancing reservoir.

1.2 OBJECTIVES OF THE PROJECT

The main object is the supplying of Krishna treated water to Hyderabad from Kodandapur water treatment plant by the help of mechanically pumping and by gravity.
To drawing raw water from AMRP canal through MS pipe line from the canal intake to the three WTP's (water treatment plant's) (phase-I of stage I & stage-II of 45 MGD+45 MGD and phase –II OF 90 MGD) total 180 mgd of water for Krishna drinking water supply project.
To pump out the clear water after filtration by the pumps from the pump house of Kodandapur to Nasarlapally a distance of 34 km with 157 m through 8 pumps.
The pumping of clear water from pump house at Nasarlapally to Godakondla with a distance of 24 kms and head of 163 m.
To pump the clear water from Godakondla to Gungal with distance of 20 Kms and head of 148 m.
To pump the clear water from the Gungal to Sahebnagar reservoir by gravity.

1.3 HYDERABAD METROPOLITAN AREA

Hyderabad metropolitan area includes urban and extends to semi urban and panchayat limits by about 1905.04 SqKm. With twin cities of Hyderabad and Secunderabad located in the core portion. HUDA covers the following areas:

METROPOLITAN AREAS:

SL.NO	Name of area	Area in SqKm
1.	Municipal Corporation of Hyderabad(MCH)	172.60
2.	Ten (10) municipalities, Kukatpally, Alwal, Kapra, Malkajgiri, L.B Nagar, Qutubullapur, Serilingampally, Uppal and Rajendra Nagar and Gaddi Annaram.	418.56
3.	Urban Panchayat Area	94.58
4.	Semi Urban Panchayat Area	15.78
5.	Rural Panchayat Area	1162.62
6.	Osmania University and Secunderabad Cantonment.	43.02
	Total	1970.16

Table: 1 Metropolitan areas

1.4 THE POPULATION OF HYDERABAD AND WATER DEMAND

The population of future water demand of the city including surrounding Municipalities for different horizon years is below.

Year	Projected population(in millions)	Water demand (in MGD)
2004	6.804	245
2006	7.193	290
2011	8.166	320
2016	9.083(estimated)	360
2021	10.018(estimated)	400
2031	11.810(estimated)	500

Table: 2 Population of Hyderabad and water demand

1.5 LOCATION OF WATER TREATMENT PLANT

The Kodandapur treatment plant was located at village called Kodandapur is at 29 Km from Nagarjunasagar. 116 Km from Hyderabad. The total area of plant is 331 acres. The total length of the pipeline pumping and gravity is 114 Kms. Enroute Reservoirs were constructed at Nasarlapally, Godakondla, Gungal and at Sahebnagar to join the city at IS Sadan.

1.6 SOURCE OF WATER

The raw water tapping is through an independent control cum regulating sluice from AMRP Main canal (SLBC). The raw water is being drawn from A.Madhava Reddy project Main Canal at Ch.26.328 Kms.

In view of meeting the future demand criteria for the city, Hyderabad Metropolitan Water Supply and Sewerage board (HMWS&SB) has selected Krishna River as source. The phase-I and phase-II of Krishna Drinking Water Supply Project is commissioned for a drawal of 180 MGD (90 MGD+90MGD) sourced from Nagarjuna sagar reservoir.

Krishna Drinking Water Supply Project envisages for tapping 16.5 TMC of raw water from Krishna i.e 270MGD in three phases. Each phase consists of 5.5 TMC raw water drawls for adding 90 MGD of treated water to the water supply system of Hyderabad City.

The implementation programme of the three phases is as below.

S.No	Phase & Stage /year	Raw water tapping per annum	Quantity of additional treated water to be added(in mgd) per day
1.	Phase-I		
	a)Stage-I(2002 -2004)	2.75TMC	45MGD
	b)Stage –II(2004-2005)	2.75TMC	45MGD
2.	Phase-II(2005-2006)	5.5TMC	90MGD
3.	Phase-III	5.5TMC	90MGD
	Total:	16.5TMC	270MGD

Table: 3 Source of water

Physical	
Temperature	10^oC to 15.6^oC
Odour	0 to $4P_o$ value
Colour	10 to 20(platinum cobalt scale)
Turbidity	5 to 10 ppm(silica scale)
Taste	No objectionable taste
Chemical	
Total solids	Upto 500ppm
Hardness	75ppm to 115 ppm
Chlorides	Upto 250 ppm
Iron and manganese	Upto 0.3 ppm
Ph	6.5 -8
Lead	0.1 ppm
Arsenic	0.05 ppm
Sulphate	Upto 250 ppm w
Carbon alkalinity	Upto 120 ppm
Dissolved oxygen	5 to 6 ppm
B.O.D	Nil

Table: 4 Standards of drinking water

II. TEST RESULTS

SAMPLE	TEMPERATURE	TURBIDITY
Distilled water	27	0 NTU
Krishna river water	27	8 NTU
Drinking water(Hasthinapuram)	27	0.1 NTU
Drinking water(secunderabad)	27	0.2 NTU

Table: 5 Turbidity values

Jar	Dosage of coagulant	Remarks
1	5mg	Poor
2	10mg	Average
3	15mg	Excellent
4	20mg	Excellent
5	25mg	Excellent
6	30mg	Excellent

Table: 6 Jar test values

S.NO	Volume of sample	Burette reading		Volume of run down
		initial	Final	
1.	Blank	0	3	3(P)
2.	River water	3	7	4(Q)
3.	Blank	0	3	3(P')
4.	Drinking water(secunderabad)	3	5. 7	2.7(Q')

Table 7: Values of COD

Sample 1: River water
COD in mg/lit = (P-Q)xNx8x1000/ml of sample taken
= (4-3)x0.1x8x1000/5
=160mg/lit.
Sample 2: Drinking water
COD in mg/lit = (P-Q)xNx8x1000/ml of sample taken
= (3-2.7)x0.1x8x1000/5
= 48mg/lit.

III. PURIFICATION METHODS

i. SCREENING

Screening is the first unit operation used at wastewater treatment plants (WWTPs). Screening removes objects such as rags, paper, plastics, and metals to prevent damage and clogging of downstream equipment, piping, and appurtenances. Some modern wastewater treatment plants use both coarse screens and fine screens.

- Coarse screens
- Fine screens
- Comminutors and grinders

ii. AERATION

Water aeration is the process of increasing the oxygen saturation of the water. This also helps to produce active sludge which can be used as fertilizers.

- Water quality.
- Aeration methods.
- Natural aeration.

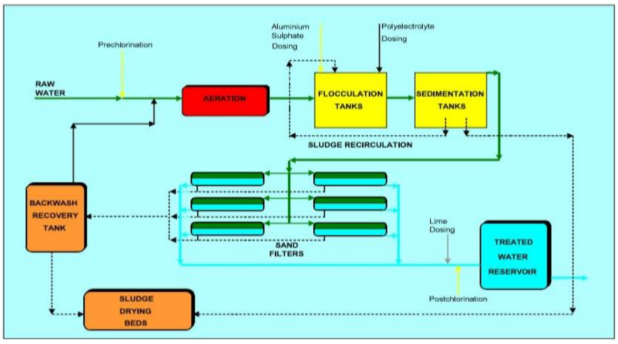

Fig 1 Flow diagram of water treatment plant

IV. DESIGN OF WATER TREATMENT PLANT DATA

Total population = 530000
Maximum turbidity in water in monsoon = 1500PPM
Raw water has hardness of 100mg/lit as $caco_3$
Softening plant works for 2 shifts of 8 hours per day
Per capita demand = 135 litres Average quantity of water required
$= 5.3 \times 10^5 \times 135$
$= 76.85 \times 10^6$ lit/day
$= 76.85 \times 10^3$ cu.m/day
$= \frac{76.85 \times 10^3}{24 \times 60 \times 60} = 0.89$cu.m/sec
Maximum demand of the city
$= 1.5 \times 76.85 \times 10^3$ cu.m/day
= 1.33 cu.m/day

5.1 DESIGN FOR SCREENS

Provide 2mm dia holes on 8mm thick sheet

5.2 COAGULATION

Alum required for chemical feeding
Let the optimum dose be 5 to 8 mg/lit (determined by jar test)
The average quantity of alum required
$= \frac{76.85 \times 10^6 \times 5}{10^6}$ to $\frac{76.85 \times 10^6 \times 8}{10^6}$
= 385 to 615 kg/day
The maximum requirement in summer will be 1.5 times more
$= 385 \times 1.5$ to 615×1.5
= 577 kg/day to 923 kg/day
The quantity of alum shall be first mixed with the water to form a solution of 5% strength
Maximum capacity of the solution feed device $= 923 \times 20$ lit/day
$= \frac{923 \times 20}{60 \times 24}$
= 12.82 lit/min
Min dose which will be feeded during average demand
$= \frac{12.82}{1.5}$ lit/min
= 8.5 lit/min
Quantity of solution to be feeded in one shift of 8 hours
$= 12.82 \times 60 \times 8$ lit
= 6153.6 lit
Providing two solution tank
The capacity of the tank $= \frac{6153.6}{2}$ = 3077 liters = 3.077 cu.m
Keeping depth of the tank of solution (assume)
m and 15 cm as free board
The side of the square tank $= \sqrt{3.077} = 1.75$ m
Size of the each tank solution
$= 1.8 \times 1.8 \times 1.15$ m

5.3 DESIGN OF APPROACH CHANNEL

The flow of raw water will be divided into two channels
Maximum flow in each channel
$= \frac{1.333}{2}$ cu.m/sec
= 0.667 cu.m/sec
Providing a velocity of 60 cm/sec
The cross sectional area of the above channel $= \frac{0.667}{0.6}$ sq.m

= 1.11 sq.m

Provide 1.2 × 1.0 m channel with 92.5 cm water depth, having free board of 7.5 cm at the maximum flow.

5.4 DESIGN OF MIXING TANKS

Mechanical flash mixtures will be used for mixing the coagulant solution with the water.

Assume the detention period of 1 minute

Capacity of each flash mixture = 0.667 × 60 cu.m

= 40.02 cu.m

Provide depth of 3.0 m

$= \sqrt{\frac{40.02}{3}}$ m = 3.65 m

Provide size = 3.70 × 3.70 × 3.70 m

5.5 DESIGN OF FLOCCULATING TANKS

Assume flocculating time of 30 minutes

The capacity of each flocculating tank = 0.667 × 60 × 30 cu.m

Provide 4 channels = $\frac{1200.6}{4}$

= 300.15 cu.m

Provide 3.0 m depth of water, 30m length of the channel

Width = $\frac{300.15}{3\times30}$ = 3.335m

Provide size of flocculating tank = 30m × 3.335m × 3.0m

5.6 DESIGN OF SETTLING TANK

Surface loading = 2000 lit /hr/m^2 of plan area

Surface area of each tank = $\frac{0.667\times60\times60\times10^3}{2000}$

= 1200.6sq.m

Diameter of tank = $\sqrt{\frac{1200..6}{\pi/4}}$

= 39.1 m

The weir loading in the settling tank at average flow

$\frac{Q}{\pi d} = \frac{76.85\times10^3}{\pi\times39\times2}$

= 313.61cum /day

Providing a detention period of 2.5 hours

$= \frac{1.33}{2} \times 60 \times 2.5$ cum

= 100.05 cum

$= \frac{100.05\times10^3}{4\times39^2} = 5.02 \cong 5$m

Pipe dia = 39m,

5.3 depth with

30 cm free board

5.7 DESIGN OF RAPID GRAVITY FILTERS

Quantity of water to be treated

= 1.5× 76.85×10^6 lit/day

=115.2×1010^6 lit/day

Assume rate of filtration 4500 lit/m^2/hour, 30 mnutes for washing

Total filter area = $\frac{115.275\times10^6}{23.5\times5\times4500}$ = 1090sq.m

Providing 16 units of rapid gravity filter with 2 numbers of as stand by

Surface area each unit = $\frac{1090}{14}$ = 77.862 sq.m

Provide each unit of each size = 10 × 8m

5.8 WASH WATER TANK

Over head tank 20m above the bottom of the strainer

Quantity of wash water = 2.5% of total water

= 2.5% × 10 × 8 × 4500 × 23.5

= 2.1 × 10^5 lit/unit

= 211.5 cum/unit

Capacity of wash water tank = 423 cum

Assume depth 3.0 m

Dia of the tank = $\sqrt{\frac{423}{3\times\pi/4}}$ 13.5 m

Depth = 3.3 m

Free board = 30cm

One shift of 8hrs

14 rapid gravity filters = $\frac{211.5\times14}{8}$ = 370.12 cum/hr

Provide 4 units each 125 cum/hr

Pumping sets = dia 30 cm

The velocity of flow = $\frac{125\times3}{\frac{\pi}{4}\times0.3^2\times60\times60}$ = 1.47 m/sec

Friction loss of 25m

The water hp of the pump= $\frac{WQH}{75}$

$= \frac{1000\times370.12\times25}{75}$

= 34.27HP

Efficiency = 90% & 70%

$= \frac{34.27}{0.9\times0.7}$

= 54.39 = 55HP

5.9 WASH WATER SUPPLY MAIN

Filter for back washing = 30 cm in dia

Velocity in pipe = $\frac{211.5}{30\times\frac{\pi}{4}\times0.3^2\times60}$

= 1.663 m/sec < 3 m/sec

The loss of head due to friction

$= \frac{4flv^2}{2gd}$

Friction f = 0.001,

Length of the pipe = 21 m,

Velocity v = 1.663 m/sec,

Gravity g = 0.981

Diameter d = 0.3

$= \frac{4\times0.001\times21\times1.663^2}{2\times0.981\times0.30} = \frac{0.0399}{0.5866}$ m/run

$= \frac{1}{14.75}$ m/run

1 meter head loss in every 14.75 m length of the pipe

Total head loss 20 m

$= \frac{20}{14.75}$ = 1.356m

Size of filters = 10 × 8 m

Side small trough at about 1.80 c/c

Surface area = 4 × 1.8 = 7.2 sq.m

Rate of wash water = $\frac{211.5}{30\times10\times8}$

= 0.0881 cum/m^2/min

Water collected by each side trough

= 0.881 × 7.2

= 0.634 cum/min

Side trough size 25 cm× 20 cm
Carrying capacity Q = 327.5× by^3
$= 327.5 \times 0.25 \times 0.20^3$
$= 0.655$ cum/min > 0.634 cum/min
Provide 25cm × 25cm trough with 20 cm water depth
The capacity of the main trough = $\frac{211.5}{30}$
= 7.05 cum/min
Provide 35cm × 45cm main trough with 40 cm water depth
Carrying capacity Q = $327.5 \times 35 \times 40^2$
= 7.336 cum/min
> 7.05 Cum/min
Section adopted is safe.
Rate of wash water = $\frac{211.5}{30}$ = 0.1175 cum/sec

5.10 STRAINER DESIGN
Minimum openings in strainers should be 1/3%
Strainer openings =$\frac{10\times8}{3\times100}$ =0.267sq.m
Assuming the strainer opening 2.5mm
Number of openings in the strainer = $\frac{0.26\times1000\times100}{2.5\times2.5}$ = 4272 nos
Spacing of strainers both ways = $\sqrt{\frac{9.8\times7.8\times1000}{4272}}$ =13.37 cm

Provide 13c c/c both ways strainer openings

5.11 DESIGN OF WATER SOFTENING PLANT
Quantity of maximum soft water required 8 hours shift = $\frac{14.5\times76.85\times10^3}{3}$

= 38425cu.m
Water softening plant remove 100% hardness of water
For 2 shifts, = $\frac{38425}{2}$
= 19212.5 cu.m
Hardness removed = 19212.5 × 100%
= 19212.5 cu.m
Provide 30 beds of 2.2m× 2.2m ×1.45m depth
Quantity of salt required = 50kg/cu.m of resin
Quantity of required solution for shift = 40 × 25 × 2.2 × 2.2 × 1.45 = 7018 kg/shift
5% brine solution in water softening
Quality of brine solution = $\frac{7018\times100}{5}$ = 140.36 cu.m
For brine tank size = 4.5 × 4.5 × 1.5m
Average flow rate over resin beds = $\frac{19212.5}{7}$
= 2744.62 cu.m/hour
Average velocity of flow through each unit = $\frac{2744.62}{25\times60\times2.2\times2.2}$
= 0.378 m/min

The time taken to pass through resin bed = $\frac{1.45}{0.378}$ = 3.84min

5.12 DESIGN OF CHLORINATION PLANT
Disinfection of water will be done by post chlorination method
Dose of chlorine to be added will vary from 0.5 to 1.0 in ppm
Quantity of chlorine required = 6.4kg/hr
Liquid chlorinator having capacity of feeding chlorine rate of 6.40 to 10.0 kg/hr

5.13 DESIGN OF CLEAR WATER RESERVOIR
Underground clear water reservoir having capacity of about 8 hrs will be added
Quantity of water to be stored = $\frac{76.85\times10^3}{3}$
= 25617 cu.m
Depth provided 5.0m, free board 50 cm
Reservoir plan area = $\frac{25617}{5}$ = 5124.5sq.m

V. CONCLUSION

- The construction vision is not only limited to beauty of the residential/industrial plans but is also environmental friendly.
- Waste water treatment is an important initiative which has to be taken more seriously for the betterment of the society and our future.
- Wastewater treatment is the process, wherein the contaminants are removed from the wastewater as well as the household sewage, to produce waste stream or solid waste suitable for discharge or reuse.
- Wastewater treatment method is categorised to three sub divisions, physical, chemical, biological. The construction site consists of Effluent treatment plant (ETP), whereas there is also for provision of sewage treatment plant.

REFERENCES

[1] omelia, c (1998). "Coagulation and sedimentation in lakes, reservoirs and water treatment plants". Water science and technology. 37 (2): 129.
[2] Bhole a.g., bogawat n.g. (1978) significance of sludge re circulation in the process of flocaulation, jour. Indian wat. Wks. Asscn., x, 1, jan/march, 119-125.
[3] Chaudhuri m., engelbrecht r.s. (1970) removal of viruses from water by chemical coagulation and floaoulation,3our.aww'a, sept., 563-566.
[4] Manwaring j.f., chaudhuri m. , engelbrecht r.s., (1971) removal of viruses by coagulation and floaoulation, jour.awwa, march, 298-300.
[5] Shelton s.p., drewry w.a. (1973) tests of coagulants for the reduction of viruses, turbidity and chemical oxygen demand, jour.awwa, oct., 627-635.
[6] Qasemy, nawid. "rapid sand filtration". Authorstream.com. Nawid11. Retrieved 27 january 2015.
[7] http://outsidethesink.rtu.lv/documents/principles%20of%20water%20treatment.pdf
[8] http://www.lenntech.com/history-water-treatment.htm
[9] www.epa.gov/safewater
[10] https://en.wikipedia.org/wiki/water_treatment

[11] http://ec.europa.eu/environment/water/water-drink/index_en.html
[12] http://ec.europa.eu/encironment/water/water_drink/legislation_en.html

