Three Tier Systems for Residential complex – Success Story

Er. Rajendrakumar V. Saraf

***Chairman Viraj Envirozing India Pvt. Ltd., Pune*. sarafrv@virajenvirozing.com**

Abstract

Residential Complexes are integral part of increasing urbanization to provide houses for growing urban population. Number of tenements in Residential Complex is from less than 10 to more than 500. Amenities available are from minimum essential to many more like club house, swimming pool, Garden etc. Water consumption varies from 135 to 300 LPCD. Water consumption increase with amenities and rise in quality of life. Municipal authorities are finding difficult to supply adequate water to the residential complexes. The problem becomes severe when the complexes are on the outskirt of the town. Ground water cannot suffice the entire water demand. Many societies of Residential complexes have to get water by the tanker. Author has introduced Three Tier System in Water Supply & distribution, to reduce fresh water consumption. Besides direct use of rain water is an additional feature. Fresh water consumption is reduced by 30 to 50%. Dependence on Municipal water supply and tanker is eliminated. Society remains green even in hot summer by using treated sewage for irrigation. The details of the system and findings are given in the Paper.

Introduction

India is witnessing the rapid growth of urbanization due to shift of rural population to the urban area. Urban population was 17% in 1951. It had shot up to 31% by 2011. Demographers predict that by 2025, 42.5 percent of the country's population will be urban dwellers. (1) Residential complexes or townships are coming in around fringe area of municipal town to provide houses for the urban population. Despite the rules and regulation the urban India continues to grow in a haphazard fashion without availability of basic amenities like water supply & sewerage system. Municipal authorities are not in position even to achieve adequacy. At most of the places the total water demand is more than water available in designated water resources for the town. Stress on water supply & distribution system is experienced. Municipal authority is finding difficult to develop the infrastructure & provide vital amenities like potable water supply & sewerage system. At most of the places amount of water available & capacity of Water Treatment Plant is inadequate for urban population in the defined boundaries of the Town. The ever increasing demand of urban area is being fulfilled on the cost of water that goes for Agricultural. This indirectly threatens the food security. Obviously growing urbanization in fringe area will increase the stress on the water resources & supply. Major number of towns of India has not yet provided the sewerage system. The sewage treatment plant is still in consideration. Sewage simply flows through constructed/unconstructed gutter. At many places it overflows on road or get ponded on open land. It is well documented that the root cause of epidemics is most hazardous sewage that contaminate the ground water & surface water. Besides, the discharges of raw sewage making river water unfit to drink even for animals. An ideal situation will be having a master plan for the optimum growth of urbanization based on the resources availability. At present it is not possible to halt the urban growth as India is going through the developing phase.

House dweller of Residential complexes needs water for personal hygiene, cleaning, washing, cooking & gardening. The list is further extended to water require for pet, car & floor wash, gardening, swimming pool etc. Potable quality of water is mainly required for drinking & cooking, however the Municipal Authority supplies potable water for all the activities including toilet flushing. Sewage (Black water) & Sullage (Grey water) are collected separately from the

individual flat however both join together and get collected & transported through the sewerage system. 90% of potable water is converted to the sewage and disposed off into the nullah or sewerage system provided by the Municipal town.

Water Resources and Water Supply

Followings are major sources of water for the residential complex

a. Water supply from Municipal Authority
b. Well water in own premises
c. Surface water (Lake, River etc)
d. Tanker water (Well water or treated water from Municipal Authority)
e. Rain water

Small residential complexes do not have water treatment plant. Water from well or tanker is received in Ground water storage tank (GSR) and then pumped to Overhead Tank (OHT) for further distribution. Large Residential complex has Water Treatment plant. Water source to water distribution is as shown in Figure -1

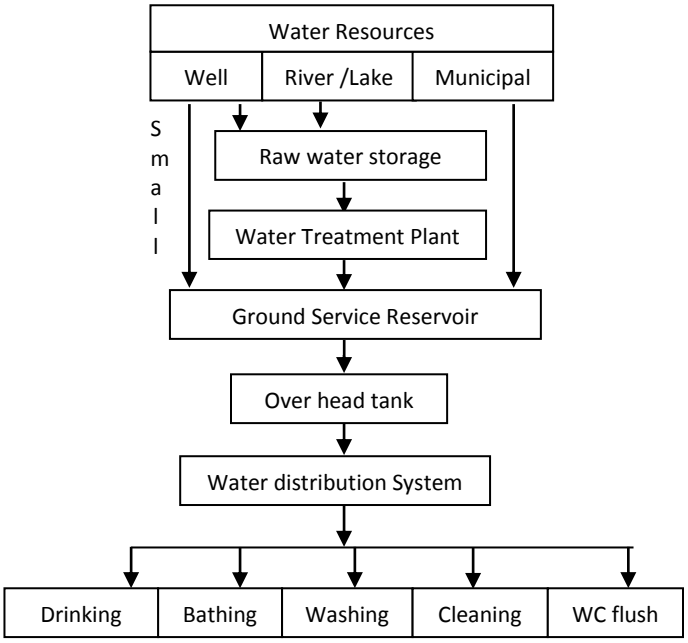

FIGURE -1 - Water source to water distribution in Residential Complex

Rain Water - Roof Top Rain Water Harvesting.

Where ever possible Roof top water can be collected in Raw Water Tank. After the treatment it can be used as Utility water. Use of rain water will increase the Green Water Footprint & reduce the Blue Water Footprint.

Water Quality

Study is carried out to find out the various taps provided in Residential complex, usage and quality of water required. The findings are given in Table -1. It shows that Potable (Drinking), Soft (Utility) & Recycle (WC flush) are three Qualities of water required for the Residential Complex. However Potable water is supplied for all the activities. Potable & utility water will be as per IS 10500 (2) for Drinking Water.

TABLE – 1 – Water Taps in Residential Complex, Usage & Water Quality

Sr. No.	Location of Tap	Activity	Water Quality
1	Kitchen Tap 1	Drinking	Potable Water
2	Kitchen Tap 2	Cooking	Potable water
3	Bathroom (Shower/Mixer unit)	Bathing	Disinfected soft water
4	Wash basin	Washing	Disinfected soft water
5	Toilet WC Flush	WC Flushing	Recycle / Raw water
6	Toilet Health faucet	Anus Cleaning	Disinfected soft water
7	Dry Balcony Tap 1	Utensil Washing	Disinfected soft water
8	Dry Balcony – Tap 2	Washing Machine	Disinfected soft water
9	Swimming pool & fountain	Make up water	Soft water
10	Lawn & plantation	Irrigation	Recycle water
11	Fire fighting tanks	Firefighting	Recycle water
12	Parking	Car washing	Well water / Recycle water
13	Road Side	Road washing	Recycle water

Water consumption for various activities

A survey is carried out for 50 houses to find out water consumption for various activities. The average consumption observed for activities is given under VEIPL in Table 2 along with the values given in literature. It is observed that water consumption depends on the awareness of water conservation, economical status and type of water gadgets used.

TABLE -2 Water Consumption for Various activities

		Water Consumption LPCD			
Sr. No.	Purpose	VEIPL	Ajay Jindal (3)	Neeraj Sharma (4)	Sustainable Building Design (5)
1	Drinking	2.5	3	3	7
2	Cooking	4.5	4		
3	Bathing	23	20	30	20
4	Flushing	35	40	45	40
5	Washing cloths	45	25	30	45
6	Washing utensils	25	20	22	23
7	Gardening	0	23		
8	Total leakages			15	
	Total	135	135	145	135

Waste Water generation

The waste water from residential complexes is categorized as black & grey water. Black water is generated after flushing WC & grey water is generated from all other activities. The black water & grey water are separately collected in vertical lines located on vertical wall. Both the lines join at ground level in inspection chamber. Then it joins the sewerage system laid down in residential complexes. Thus Residential Complex generates Black & Grey Water.

Three Tier Model

A. Salient Features

It is developed by author exclusively for the Residential Complexes at the outskirt of Municipal towns.

This model is implemented at +200 Residential Complexes. It is consist of the followings

a. Water Source is well water as Municipal water is either inadequate or not available
b. Raw water is collected in Raw Water Storage Tank
c. Following are three qualities of Water supply as per the quality of water required for the activities
    1. Drinking Water
    2. Utility Water
    3. Recycle Water
d. Municipal Water is received in the Drinking water tank & excess goes to Utility Water Tank
e. Process to make utility water is as below
    Raw Water -> Pump -> Pressure Sand Filter -> Activated Carbon Filter -> Softener -> Blending -> Softened water storage Tank -> Pump -> On line Chlorination -> Overhead Tank -> Distribution
    Hardness of water is adjusted between 40 to 50 mg/l as $CaCO_3$ by the blending unit
f. Process to make Drinking water is as below
    Softened water storage Tank -> Pump -> RO Plant -> RO Water Storage Tank -> Pump -> Overhead Tank -> Distribution system
g. Roof Top Rain Water is collected in Raw water Storage Tank and is treated further in Water Treatment Plant.
h. One Tap is provided for Drinking water in the Kitchen.
i. Utility water is supplied through taps in kitchen, bathroom wash basin & dry balcony.
j. Black & Grey water are collected separately and transported to Sewage Treatment plant through sewerage system for further treatment.
k. Treatment for Grey water is as below
    Grey water -> Screen Chamber -> Aeration Zone of Deep tank Aeration System (DTAS) -> Biological Treated Sullage tank -> Pump -> DTAS on line Flocculator -> Pressure Sand Filter -> Activated Carbon Filter -> Cascade Aerator -> Chlorination -> Recycle Water Storage Tank -> Pump -> Overhead Tank -> Distribution
l. Recycle water is supplied through taps for WC Flush, Irrigation and Car Wash
m. Treatment of Black Water is as below
    Black Water -> Anaerobic Bioreactor -> Anaerobic Fixed Media Up flow Bioreactor -> Deep Tank Aeration System -> Chlorination -> Treated Black water Storage Tank -> Irrigation, Excess for Disposal
n. Thus there are Three (Drinking Utility & Recycle) Water Distribution system and Two (Grey & Black Water) Sewerage system.
o. The model is as shown in Figure-2.

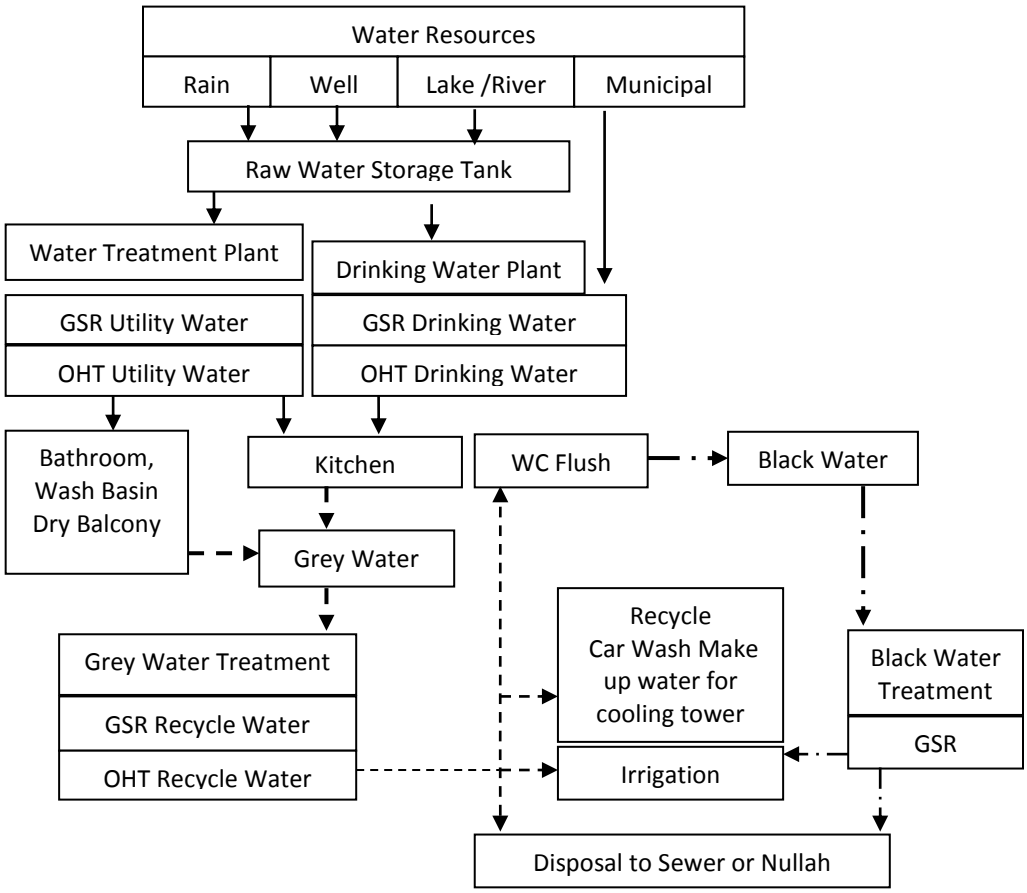

FIGURE – 2 Three Tier Model for Water Quality management in residential Complex

B. Deep Tank Aeration System (DTAS)

B.1. Process

DTAS is patented process for Biological Treatment of waste water. Black water or sewage flows by gravity to Anaerobic Bioreactor followed by Up-flow Anaerobic Fixed media Bioreactor. Partially treated black water / Sewage enter the screen chamber. Screened waste water joins circular Aeration zone of DTAS. DTAS has Aeration zone fused with Settling Zone. Fixed Aerator of High Oxygen Transfer efficiency is mounted on the top of Aeration zone for aeration and supply oxygen for aerobic treatment. Sewage with Mixed Liquor Suspended Solids will enter in the settling zone. Settling Zone is rectangular on one side of circle. MLSS will enter through the outlet pipes provided on the wall. Suspended solids will settled down and clear treated sewage will overflow on weir of settling zone & get collected in the launder. The settled MLSS from the settling zone will be drawn by the specially designed draft tube provided with Energy efficient Aerator. The treated sewage then gets collected in the Biologically Treated Sewage Storage Tank. Biologically Treated Sewage will be then pumped to Tertiary Treatment Plant. Tertiary Treatment Plant is consists of DTAS online Flocculator, Alum Dozer, Pressure Sand Filter & Activated Carbon Filter. Fully treated Sewage will be aerated in Cascade Aerator. The aerated treated sewage will be chlorinated with the help of Chlorine Dozer. The chlorinated sewage will get collected in the treated water storage tank.

B.2. Salient Features

It is compact Sewage treatment Plant requires minimum area. It operates in extended aeration zone. Therefore waste sludge generation is least. Excess organic biomass in form of sludge is drained out to septic tank once in week. Therefore additional treatment for sludge is not required. Flow is by gravity so pumping of raw sewage is totally eliminated. Tertiary treatment includes

online Flocculation, Sand Filtration, Activated Carbon Filtration, and Aeration & Chlorination. It gives Fully Treated water without off smell & turbidity. Turbidity, COD & BOD are respectively less than 5 NTU, 50 mg/l & 5 mg/l. Area foot print is smaller than the Conventional Process. It requires 30 % less energy as compared to conventional process. It treats flow from 15 to 300 m^3/ day. Treated Sewage can be used for Flushing of WC, Car washing, Road washing & Irrigation

Case Studies

A. Details

RC1, RC2, RC3 are three Residential complexes on the outskirt of Pune. The respective number of flats is 416, 652 & 478. The design population @ 5 persons per flat is respectively 2080, 3260 & 2390. Occupants of RC1, RC2 & RC3 respectively belong to Middle income group, Upper Middle income group and Upper income group.

The findings regarding population in these Residential Complexes are as below

a. Occupancy was not 100% for first two years
b. Minimum & maximum population is respectively 2 & 7. Average population is 3 persons per flat. Total population is lesser than designed population.

B. Water Consumption

The references for deriving water consumption are National Building Code (6) & the experience with similar project. Water Consumption for various activities is based on Table -2 and is given in Table - 3

TABLE – 3 - Water Consumption

	RC 1		RC 2		RC 3	
Details	LPCD	Total, l/d	LPCD	Total, l/d	LPCD	Total, l/d
Drinking	10	20800	10	32600	10	23900
Utility	80	166400	80	260800	105	250950
Flushing & other	45	93600	45	146700	45	107550
Total Water Demand	135	280800	135	440100	160	382400

Waste Water Generation

Grey water is generated during backwash, rinse & regeneration of Filters & softeners. Rejects from RO plant joins the Grey water stream. Drinking water used for drinking and cooking does not generate any waste water. Utility water after its usages in wash basins, bathrooms and Dry balcony get converted to the Grey water. Recycle water used in WC flushing generates the Black water. Recycle water used for Car wash and irrigation does not generate any waste. Grey & black water are separately collected and transported through sewer line to the site of Waste Water Treatment Plant.

Black water generated from RC1 RC2 & RC3 is respectively 84240, 133030, 90820 l/day. Grey water quantity is respectively 156000, 254030 & 270542 l/day. Waste water treatment plants are designed for full capacity. The characteristics of fully treated Grey water for RC1, RC2 & RC3 are given in Table – 3

Fully treated waste water is used for WC flush and irrigation on Landscape area.

Findings & Observations

Promoter & Developer accepted the model as it reduces the dependence on fresh water, eliminates the disposal of raw sewage & ensures greenery round the year. However engineering & Sales Department raised the following objection.

a. It requires three GSR, three OHT, triple pumping & piping for water distribution system and double lines for sewage collection.
b. The extra civil & piping work will double the cost and take the longer time.
c. The buyer will be reluctant to accept use of treated sewage for WC flushing and irrigation of landscape area.
d. The Cost of RO Water, Treated Water and Recycle water will be more than water supplied by Municipal Authority
e. The Tenements will be reluctant to accept the operation & maintenance cost of water & sewage treatment plant
f. The trained manpower will not be available to operate & maintain the plant.

The objections are ruled out with the following explanations:

a. The total capacity of GSR & OHT remains same. Only two partitions are to be added to make 3 tanks.
b. The recycled water tank is clubbed with the fire fighting tank that reduces the cost.
c. The drinking water line is provided in kitchen & recycled water in toilet. Utility water to bathrooms, kitchen, wash basin & dry balcony.
d. Total water supply is divided into 3 parts therefore pipeline diameter of distribution lines is smaller than single pipe line for single water supply.
e. Three Pumps for Drinking, Utility and Recycle water will be smaller than the pump required for single water supply.
f. Black & grey water are separately collected in vertical lines. There will be one additional horizontal line for grey water & other will be used for Black water.
g. Since flow of black & grey water is separate, diameter of two separate sewer line will be smaller than single sewer line for combined waste. Both line are laid down side by side therefore there will be no additional cost required for excavation.
h. The additional cost of two water line and one sewer line will be marginal (15 to 20%)
i. The treated grey water will be odorless & can remain in W/C flush tank for long period without generation of off smell.
j. The treatment technology used is DTAS that reduces civil & mechanical cost.
k. The cost benefit analysis makes the model more attractive & ensures the sustainable water supply to residential complex.

Findings during & after implementation of Three Tier Model

1. Since sustainable water supply is assured the Buyer purchased flat without any hesitation.
2. The scheme was completed in an anticipated time & no delay was occurred due to implementation of model.
3. The cost of the Flat was comparable with others. The additional cost of Three Tier Model is accepted by the Buyer.
4. The residence found initial problems with 3 type of water supply. After the presentation of the working of three tier model in the meeting of tenements they got tuned up immediately. They were happy to note that drinking water is not wasted for W/C flushing.
5. Three Tier Model is working at RC1; RC2 & RC3 respectively for 6, 10 & 5 years.

6. It has reduced the dependence of fresh water supplied from bore well & tankers. Tanker supply was totally eliminated. Saving of fresh water for RC1, RC2 & RC3 is respectively 39, 41 & 49 %. The higher value is due to usage of recycle water for irrigation.
7. Resident never experience scarcity of water even in hot summer & during water supply cut by Municipal Corporation.
8. The recycle water is keeping the complex Green even in hot summer.
9. Treatment plants are maintained by the agency having the trained manpower. The Water quality is regularly monitored to know the performance efficiency of the Plant.
10. Residents accepted the operation and maintenance cost of water & sewage treatment plant.
11. Because of DTAS used for the biological treatment, the energy cost is very low.
12. Tenements do not have any problem of odor, noise from sewage treatment plant located in their complex.
13. Cascade Aerator provided in the sewage treatment plant developed the confidence in the quality of recycle water.
14. The cost of investment is returned within 3 year due to saving of cost of water to be procured by tanker.
15. The Developer & Promoter RC2 is planning to go for quaternary treatment of recycle water to use it in washing machine
16. This model is the best option to ensure the sustainable water supply.

Conclusion

Municipal Authority is finding difficult to supply water to all. Residential complexes on the outskirt of the town have to depend on limited underground water, tanker water & unpredictable Municipal water supply. The cost of water supplied by tanker becomes unaffordable. Three Tier Models for residential complex saves fresh water & ensures sustainable water supply. It eliminates the use of drinking water for flushing the toilets and irrigation. Direct use of Rain water increases Green Water Foot Print. Reduction in fresh water consumption reduces Blue Water Foot Print and Sewage treatment & recycling drastically makes the Grey Water Foot Print smaller.

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