



**A study of pilot Project  
On**

**DECENTRALISED TREATMENT & RECYCLING OF DOMESTIC  
WASTEWATER – AN INTEGRATED APPROACH TO WATER  
MANAGEMENT**

**AT**

**SANGAMAM COMMUNITY – A VILLAGE MODEL  
IN OUT-SKIRTS OF**



*Auroville... the city the Earth needs*

**AUROVILLE UNIVERSAL TOWNSHIP  
TAMIL NADU**

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## **1.0 THE CONCEPT OF AUROVILLE**

### **1.1 Background**

The township, founded on 28th February 1968, lies 150 kms south of Chennai in south India. Established on a barren plateau devoid of greenery in 1968, it has now become a green forested area shaded with a wide variety of trees and shrubs, and as such an appropriate place for achieving sustainability and the other goals of Auroville. The township, envisaged for a population of 50,000, aims to provide opportunities for people from all nations and all types of backgrounds to come together to work for the fulfillment of its Charter. Today it has about 1700 residents representing some 35 nations including 350 persons from the adjoining villages. It has also established very cordial relations with the larger population in its vicinity, extending over an area of approx 825 sq. kms. The Auroville Foundation Act, passed by the Indian Parliament in 1988, is one of the key milestones in the development of Auroville. It provides statutory support for preparation of a Master Plan for Auroville to ensure orderly development of the township, which is planned to occupy a circular area of 2000 ha, of which about 850 ha are presently owned by the Auroville Foundation. The Master Plan envisages systematic development of the township to the general exclusion of non-confirmatory developments in the immediate area.

### **1.2 Planning Process**

Auroville, although diverse in terms of the nationalities present and their widely different cultural, economic and social backgrounds, has the common aim of becoming a part of the evolutionary process of humanity, through the universal establishment of higher human values.

### **1.3 Integrated Development**

For Auroville, the ideal of integrated development has to become a reality. This means synthesizing the advantages and merits of urban development, while at the same time taking advantage of the merits of decentralization and rural development. It will require a new approach, able to bridge the rural urban divide and provide equal opportunities for all in their search for a better quality of life.

### **1.4 The Context**

Auroville is located in Tamil Nadu, south India, about 12 kms north of Pondicherry and 150 kms south of Chennai/Madras, adjacent to the Coromandel Coast. Auroville's development has always been, and will always be, closely related to that of the surrounding villages. There are 13 such villages in the immediate vicinity of Auroville, and altogether 126 villages in the wider bio-region of 825 sq.kms. Auroville's immediate influence, in terms of socio-economic development and natural resource management, is expected to extend over this entire region, with its present rural population of around 350,000 people (census 1991), a figure which is expected to increase to 600,000 by 2025.

## **1.5 The People**

Auroville encompasses all aspects of humanity's material development needs, including wasteland regeneration, appropriate technology for sustainable management of natural resources, education, alternative healing practices, collective economic structures, cross-cultural communication and expression, rural development and integral urban planning and management. The people here have regenerated the eroded, barren plateau on which the township is sited, to provide for a better quality of life. Thus Auroville aspires to be The City the Earth Needs, a place to demonstrate and realize for future generations the practical possibility of harmonious and sustainable living, while at the same time coexisting with all the multitudinous forms of plant and animal life.

## **2.0 INTRODUCTION TO THE SANGAMAM PROJECT**

### **2.1 General**

It is situated at about 155 Kms South of Chennai and about 10 Kms North of Pondicherry. The project site is about 3 Kms west of the Sea Coast and 25 m above the Mean Sea Level. Sangamam Project is a housing colony for the workers of Auroville, in the outskirts of Auroville region.

This community being located at the fringe of the City of DAWN – “Auroville” aspires to be a model village, which allows the experimentation, in an integral way, of innovative solutions to the current problems of the villages/housing settlements. This model has a layout that balances open/green spaces with the built environment, and integrates the necessary eco-friendly infrastructure and services. The site is having a gentle sloped ground which allows the surface drainage by gravity. Along one side of the site there is a Canyon which receives all the surface run-off. Along the Canyon several Check dams has been built that helps the run-off water percolate into the ground rather than directly reaching the near by sea. The project aims at experimenting also with different types of cost-effective, energy efficient and eco-friendly housing development.

#### **Overall Objectives of the Sangamam Housing Colony**

- To promote a sense of unity and community living, creating an open space for the co-existence and integration of different religions, caste and culture.
- To provide an integrated solution to the material and social needs of the rural population, especially the young, and improve their standard of living.
- To allow for holistic experimentation to find innovative solution to many of the current problems of inadequate housing, water supply, waste management and infrastructure in the community while causing the least impact on environment.
- To provide a planned housing facility to the workers of Auroville and avoid any slum /squatter development.
- To provide an opportunity for living a collective life to the residents of this community.
- To provide a green and eco-friendly community space for happy living with all the basic necessities for residential settlement.
- To be a demonstration centre and creative prototype serving as a replicable example for future projects in the area and in India at Large.

- The aim is to utilize maximum the local available building materials and cost effective building construction technology.

### **Salient Features of the Sangamam Housing Colony Project**

- The neighborhood township Auroville is the main work place for the residents of the Sangamam community.
- The Sangamam Community is also in a growing stage where first phase of the development has already been done.
- The land as well as the constructed building is made available for free of cost to the residents.
- The residents take care of all the management of the community and bear the running expenses for the maintenance of all services.
- The access road to Auroville as well as to Pondicherry is well developed. The internal access road is opened for the developed area.



**TWIN DWELING UNITS**





**ROW DWELING UNITS**



**COMMUNITY HALL**

#### **Potential of Site**

- The site receives an annual average rainfall of 1200mm.
- The type of soil is red soil which has a very good load bearing capacity.
- As the area is blessed with high precipitation, the rain water is harvested to meet the inferior domestic water needed for other than drinking & cooking purposes.
- Solid waste management comprises of making compost with all the organic part of the waste and re-uses it as manure in the kitchen gardens.
- The most of storm water is infiltrated into the soil by constructing percolation wells & check dams.
- The level difference of highest and lowest point on the site is about 4 m. At the lowest level the wastewater treatment unit is placed and at the highest level the overhead water tank is positioned.
- Water for drinking purposes is drawn from a Bore well developed very close to the OHT.
- As the underground water resources is the only source of potable water for the Project site, hence the implementation of rainwater harvesting &

wastewater recycling system at the project site helps in reduction of potable water demand.

**Technical Problem foreseen:**

- Any mismanagement or leakages in the rainwater harvesting system can directly affect the water supply system as the potable water demand may drastically increase.
- The wastewater treatment system is being maintained properly, but in case of any problem raised due to improper operation and maintenance of the system it can lead to over demand of potable/harvested rain water for irrigation purposes.

## **2.2 AMENITIES AND FACILITIES PROVIDED**

### **Physical Infrastructure**

**Overhead Water Tank :** An innovative overhead water tank with 3 chambers has been built to store and supply underground water, recycled wastewater and harvested rainwater.

Potable water is pumped from a bore well existing near by, to the topmost container of capacity 50,000 liters.

Treated wastewater from the wastewater treatment system is being pumped into the middle container of capacity 15,000 liters.

Harvested rainwater from the rooftop surfaces is collected into an over ground open lined pond and pumped into the bottom most container of the tank, capacity 15,000 liters.



**THREE STOREYED OVERHEAD WATER TANK**

**Water Supply :** Houses are connected with three separate pipelines one for the supply of underground water and the rest others for harvested rain water and treated wastewater.

Treated wastewater & Harvested rainwater & from the middle and bottom containers is being used for inferior domestic uses like flushing the toilets, watering the garden etc.

**Collection of rainwater :** Rainwater from the roof surfaces is collected through a separate pipe system and transferred to an over ground lined storage pond. The collected water is being pumped to the bottom most container of the overhead water tank.

In Second phase of development the storm water from unpaved surfaces will be collected into an over ground unlined pond for recharging the ground water & harvesting of fish culture.



**RAINWATER HARVESTING POND**

**Sewage treatment :** The sewage treatment unit consists of anaerobic up flow reactor as a primary treatment and Root Zone Treatment (RTZ) System as secondary treatment system.

A maturation pond is also in place for tertiary treatment. The treated wastewater is finally supplied to the houses for inferior domestic uses like toilet flushing and garden irrigation.



**WASTEWATER TREATMENT UNIT**

**Solid Waste Disposal :** Segregation of biodegradable and inorganic waste at the source i.e. at the point of waste generation is the first important step to achieve efficient Solid Waste Management Program. Three different barrels for Paper, Plastic & Glasses are placed in the community and these barrels are emptied after every week by collector of the Auroville Eco-service to be transferred to a segregation yard from where different recyclable items are sent/sold out of Auroville.



## **2.3 Aims and Objectives of the Study**

- (i) To promote & replicate the concept of Decentralization of the wastewater treatment for a new or any existing township.
- (ii) To encourage the user's participation in treating and handling their waste at the source itself.
- (iii) To design and implement a suitable decentralized domestic wastewater treatment system as a model to be replicated.
- (iv) To study and compare the efficiency of two different secondary treatment systems.
- (v) To develop water resource management scheme to ensure and secure the availability of fresh water so that the water demand of this community is Sustainably met.
- (vi) To try and bring up the recommendations for reuse of Treated Wastewater.
- (vii) To study the practical problem in DTS and reuse/recycle of treated sewage.

## **2.4 Scope of Work**

- Construction of sewage collection and Treatment system.
- Construction of collection system and reservoir for harvesting rainwater.
- Installation of sewage treatment system with the objective to meet the equality of the treated sewage suitable for disposal reuse/recycle of flushing of toilet and irrigation.
- Installation of distribution system for reuse of treated sewage and rainwater
- To evaluate and study the performance of this demonstration project.
- To study the performance of sewage treatment system and reuse/recycle of treated sewage and harvested rainwater and monitoring of parameter pH, COD, BOD, TKN, SS and Fecal Coliforms.
- Preparation of report on the basis of study of this demonstration project.

## **3.0 WASTEWATER TREATMENT SYSTEM**

### **3.1 Description of Wastewater treatment units**

The wastewater treatment system consists of Up-flow Anaerobic Reactor as primary treatment unit. This system was designed & implemented for 300 person equivalent. The cross section of this reactor is trapezoidal section in the bottom and rectangular in the top. The wastewater from final receiving chamber is allowed to enter in this reactor at the bottom through a pipe and water rises up at a very low velocity. The treated waste water is collected through gutter along longitudinal walls and enters the secondary treatment system.

#### ***Primary Treatment Unit***

- Type of Primary treatment: Up flow anaerobic reactor.
- Design capacity: 300 Persons.
- Type of Structure: Reinforced Cement Concrete
- Size of unit: 10m x 3m x 4m
- Design Load Characteristics

- i) Hydraulic load : 1600 lts/m<sup>2</sup>/day
- ii) Organic load: 0.512 Kg/m<sup>2</sup>/day
- **Actual Load Characteristics**
  - i) Hydraulic load: 160 lts/m<sup>2</sup>/day (As per Standards)
  - ii) Hydraulic load: 177 lts/m<sup>2</sup>/day (As per Actual measurement before commissioning of recycling system)
  - iii) Hydraulic load: 81 lts/m<sup>2</sup>/day (As per Actual measurement after commissioning of recycling system)
  - iv) Organic Load (Maximum): 0.037 Kg/m<sup>2</sup>/day (As per Actual measurement before commissioning of recycling system)
  - v) Organic Load (Maximum): 0.011 Kg/m<sup>2</sup>/day (As per Actual measurement after commissioning of recycling system)
- Volume: 114 m<sup>3</sup>
- Cross sectional area: 12m<sup>2</sup>
- Longitudinal Sectional area at the centre: 40m<sup>2</sup>
- Year of commissioning: July 2002

### ***Secondary Treatment Unit***

The wastewater treatment systems consists of Horizontal root zone system as secondary treatment which receives partly treated wastewater from primary treatment unit.

### ***Horizontal Root Zone Treatment Unit***

The secondary treatment units are implemented in Phase level hence the first level is designed for 50 persons. In the root zone treatment, wastewater passes through filter bed by uniform horizontal flow. Root zone treatment are sealed filter beds consisting of sand, gravel and soil system, occasionally with a cohesive element, planted with vegetation which can grow in wetlands. The wastewater passes through the filter bed where biodegradation of the wastewater takes place.

### **Root Zone Treatment system**

- Type of treatment system: Horizontal Root Zone treatment.
- Type of Structure: Reinforced Concrete floor with Brick walls.
- Size of Unit: 10m X 5m X 1.2m
- **Design Load Characteristics**
  - i) Hydraulic load: 160 lts/m<sup>2</sup>/day
  - ii) Organic load: 0.024 Kg/m<sup>2</sup>/day
- **Actual Load Characteristics**
  - i) Hydraulic load: 106 lts /m<sup>2</sup>/day (As per Actual measurement before commissioning of recycling system)
  - ii) Hydraulic load: 49 lts /m<sup>2</sup>/day (As per Actual measurement after commissioning of recycling system)
  - iii) Organic load: 0.0030 kg /m<sup>2</sup>/day (As per Actual measurement before commissioning of recycling system)
  - iv) Organic load: 0.0021 kg /m<sup>2</sup>/day (As per Actual measurement after commissioning of recycling system)
- Type of plant species: Arundo donax**

- Plan area of filter bed: 50m<sup>2</sup>
- Year of commissioning: March 2004

### **Tertiary Treatment Unit**

**Maturation Pond** : In this treatment unit, Maturation pond act as tertiary treatment, effluent from Root zone treatment unit enters in the Maturation pond. The important function of maturation pond is the removal of excreted pathogens to achieve an effluent quality which is suitable for its downstream reuse.

#### **Design of Maturation Pond**

Type of Structure: Reinforced Concrete floor with Brick walls

- Size of Unit: 5.75m X 5mX 1m
- Cross sectional area: 5m<sup>2</sup>
- Longitude Sectional area: 5.75m<sup>2</sup>
- Plan area: 28.75 m<sup>2</sup>
- Capacity of unit: 28.75 m<sup>3</sup>
- Hydraulic Retention time: 4.5 days (as per actual daily sewage inflow)
- Year of commissioning: March 2004

#### **Present status of the treatment system:**

- Person Equivalent: 30 Nos
- Average rate of sewage flow = 3m<sup>3</sup> /day

### **3.2 Performance Study**

#### **Frequency & Method of Sampling:**

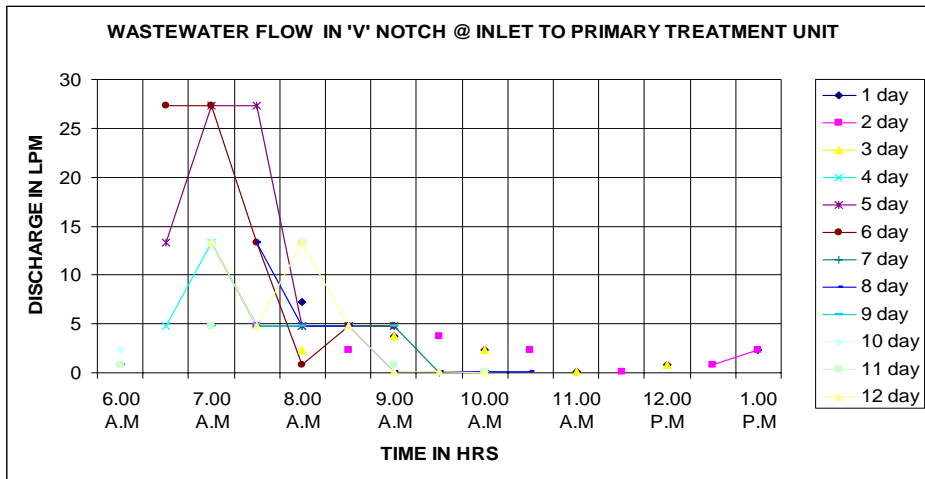
In general the samples for analysis of raw sewage and treated wastewater have been taken every month. Both grab & composite sampling methods were adopted during the period of study & analysis. Also, for several months wastewater samples were collected on weekly basis for analysis by volumetric composite method with respect to the flow.

#### **Tested Parameters**

- pH
- Total Suspended Solids (mg/L)
- Total Kjeldahl Nitrogen (mg/L)
- Chemical Oxygen Demand (mg/L)
- Biochemical Oxygen Demand (mg/L)
- Fecal Coliforms (MPN/100 ml)

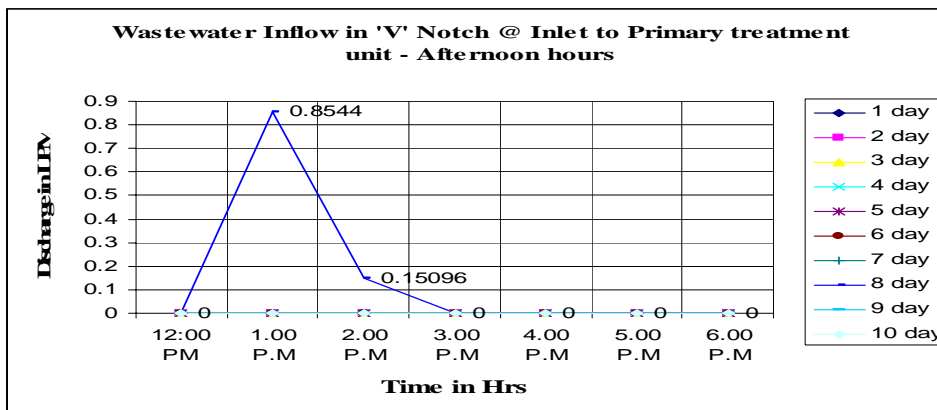
### **3.3 Study of Inflow**

- (i) Measurement of raw sewage flow over “V” notch installed in the final receiving chamber (which is set just before the inlet to the primary treatment system) has been recorded. At the same time, supply & consumption of potable water, treated wastewater and harvested rainwater is also recorded to study the actual water balance.



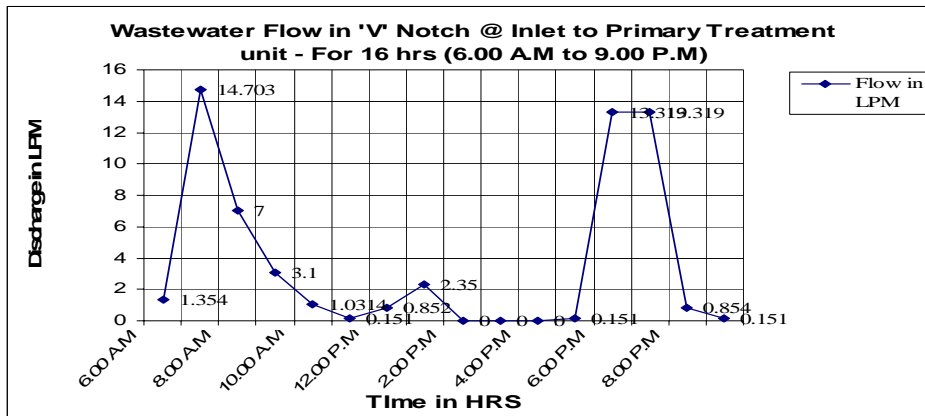
**Graph 1: Graphical representation of the raw sewage inflow to the Primary treatment unit during Morning Hours**

The above graph represents the volume of inflow to the primary treatment unit during the morning & noon hours. It has been observed that 7:00 AM is the peak hour and the corresponding flow is nearly 27 liters per minute.



**Graph 2 :Graphical representation of the raw sewage inflow to the Primary treatment unit during afternoon Hours**

- (ii) The above graph represents the peak flow in the afternoon at 1:00 PM and the corresponding volume of wastewater inflow to the primary treatment unit is about 0.85 liters per minute.



**Graph 3 :Graphical Representation of the raw sewage flow to the Primary treatment unit during Morning to Evening (6.00 A.M to 9.00 P.M)**

- (iii) Flow measurement has been carried out for continuous 16 hrs from 6.00 A.M to 9.00 P.M and the peak hour flow is recorded as 13.3 Liters per minute in the evening hour and 14.7 Liters per Minute in the morning hour respectively.

### 3.4 Results of Analysis

Periodical Analysis of Wastewater Samples (A Report for the period during November 2002 – March 2006)

Characteristics of raw sewage has been analyzed for both morning and afternoon hours and presented in Table 1& 2.

**Table 1 Series of analysis carried out during the morning hours for Raw Sewage**

Date of Sampling	Time	Type of Sample	Test Parameters		
			pH	TSS (mg/l)	BOD (mg/l)
02/11/02	6.00 AM to 1.00 PM	Composite	4.8	78	178
11/11/02	6.00 AM to 1.00 PM	Composite	6.4	96	144
14/11/02	6.00 AM to 1.00 PM	Composite	6.3	114	148
21/11/02	6.00 AM to 1.00 PM	Composite	6.8	164	136
23/01/02	6.00 AM to 1.00 PM	Composite	6.5	128	114

*[Location of Sampling: At the final receiving chamber (Inlet to the Primary unit)]*

**Table 2: Series of analysis carried out during the afternoon hours for Raw sewage**

Date of Sampling	Time	Type of Sample	TEST PARAMETERS		
			pH	TSS (mg/L)	BOD (mg/L)
22/02/03	2.00 P.M to 7.00 P.M	Composite	6.5	168	316
21/04/03	2.00 P.M to 7.00 P.M	Composite	7.1	376	112
31/05/03	2.00 P.M to 7.00 P.M	Composite	6.6	150	72
30/06/03	2.00 P.M to 7.00 P.M	Composite	6.5	398	120

*[Location of Sampling: At the final receiving chamber (Inlet to the Primary unit)]*

**TABLE 3 Characteristics of wastewater after the commissioning of Wastewater Treatment System**

Date	Type of Sample	Test Parameter	Inlet-Primary	Outlet-Primary	Outlet - Secondary
21/06/04	Grab	pH	6.5	6.5	7.9
22/09/04			6.5	6.6	7.2
05/11/04			8.3	8.4	8.4
21/06/04	Grab	TDS (mg/l)	234	186	397
22/09/04			243	156	238
05/11/04			56	16	10
21/06/04	Grab	COD (mg/l)	132	41	34
22/09/04			120	38	32
05/11/04			400	56	48
21/06/04	Grab	BOD (mg/l)	68	23	15
22/09/04			60	18	13
05/11/04			210	20	14
21/06/04	Grab	Fecal Coliform (MPN/100 ml)	$13 \times 10^6$	$57 \times 10^4$	$29 \times 10^3$
22/09/04			$11 \times 10^6$	$46 \times 10^4$	$24 \times 10^3$
05/11/04			$93 \times 10^6$	$460 \times 10^4$	$4.8 \times 10^3$
12/01/05	Grab		7.3	7.5	8.9
07/06/05	Grab		6.5	6.7	6.7
08/07/05	Grab		6.7	7.2	7.4
01/09/05	Composite & Grab Sample		6.8	7	7.4

03/10/05	Composite & Grab Sample	pH	6.7	6.7	6.6
03/11/05	Grab		6.5	6.6	6.5
01/12/05	Composite & Grab Sample		6.6	6.9	6.9
19/01/06	Composite & Grab Sample		6.3	6.7	6.7
25/02/06	Composite		6.3	6.7	6.6
12/01/05	Grab	TSS (mg/l)	96	108	62
07/06/05	Grab		87	2	4
08/07/05	Grab		62	4	2
01/09/05	Composite & Grab Sample		97	7	4
03/10/05	Composite & Grab Sample		356	22	26
03/11/05	Grab		116	32	3
01/12/05	Composite & Grab Sample		64	10	3
19/01/06	Composite & Grab Sample		118	22	18
25/02/06	Composite		130	10	16
12/01/05	Grab	TKN (mg/l)	18	36	6.4
07/06/05	Grab		27	3.2	4.6
08/07/05	Grab		42	8	5
01/09/05	Composite & Grab Sample		58	12	7.8
03/10/05	Composite & Grab Sample		29	18	17
03/11/05	Grab		53	14	7
01/12/05	Composite & Grab Sample		33	19	14
19/01/06	Composite & Grab Sample		27	16	12
25/02/06	Composite		49	17	14
12/01/05	Grab	COD (mg/l)	281	85	51
07/06/05	Grab		333	67	50
08/07/05	Grab		141	54	25
01/09/05	Composite & Grab Sample		214	32	12
03/10/05	Composite & Grab Sample		222	57	32
03/11/05	Grab		114	68	37
01/12/05	Composite & Grab Sample		176	66	31
19/01/06	Composite & Grab Sample		112	96	44
25/02/06	Composite		180	54	45
12/12/05	Grab	BOD (mg/l)	119	28	18
07/06/05	Grab		204	19	18
08/07/05	Grab		54	18	10
01/09/05	Composite & Grab Sample		130	15	5
03/10/05	Composite &		53	19	11

	Grab Sample				
03/11/05	Grab		58	29	14
01/12/05	Composite & Grab Sample		84	27	13
19/01/06	Composite & Grab Sample		56	43	13
25/02/06	Composite		94	25	20
12/01/05	Grab	Fecal Coliforms (MPN/100 ml)	0.46x10 <sup>6</sup>	0.24x10 <sup>4</sup>	2.3x10 <sup>2</sup>
07/06/05	Grab		46x10 <sup>6</sup>	11x10 <sup>4</sup>	48x10 <sup>2</sup>
08/07/05	Grab		93x10 <sup>6</sup>	46x10 <sup>4</sup>	28x10 <sup>2</sup>
01/09/05	Composite & Grab Sample		7.5x10 <sup>6</sup>	11x10 <sup>4</sup>	20x10 <sup>2</sup>
03/10/05	Composite & Grab Sample		11x10 <sup>6</sup>	43x10 <sup>4</sup>	7x10 <sup>2</sup>
03/11/05	Grab		2x10 <sup>6</sup>	92x10 <sup>4</sup>	440x10 <sup>2</sup>
01/12/05	Composite & Grab Sample		5x10 <sup>6</sup>	95x10 <sup>4</sup>	600x10 <sup>2</sup>
19/01/06	Composite & Grab Sample		1.9x10 <sup>6</sup>	100x10 <sup>4</sup>	80x10 <sup>2</sup>
25/02/06	Composite		1.5x10 <sup>6</sup>	1200x10 <sup>4</sup>	95x10 <sup>2</sup>

### 3.5 Water Balance Study

The supply of potable water and reuse of treated wastewater & harvested rainwater has been recorded to study the actual water balance.

Scenario 1: Before commissioning of recycling system

Scenario 2: After commissioning of recycling system

#### ***Before commissioning of Recycling System***

As per the actual readings recorded on the Overhead Tank a total consumption of potable water for 30 PE, person equivalent is 6635 lts/day which indicates that the consumption of potable water per person per day is 221lts/day.

#### ***After commissioning of Recycling System***

Water has been supplied in two different combinations;

1. Potable water and treated wastewater
  - Potable water supply – 3017 lts/day
  - Treated wastewater supply – 2304 lts/day

Total volume supplied = 5321 lts/day for 30 PE
2. Potable water, harvested rain water and treated wastewater
  - Potable water supply – 2836 lts/day
  - Treated wastewater supply – 1170 lts/day
  - Harvested rain water supply – 680 lts/day

Total volume supplied = 4686 lts/day for 30 PE

#### ***Result – Water Balance Study***

- Potable water consumption before commissioning of recycling system is about 221 LPCD



- Potable water consumption after commissioning of recycling system is about 101 LPCD
- Ultimate saving in potable water uses 120 LPCD

### 3.6 Cost of Construction of the Wastewater Treatment system

SI No	Description	Total Cost	For Person Equivalent	Cost/ Person
1.	Primary treatment unit (Upflow Anaerobic Reactor)	Rs.2,75,000.00	300	916.00
2.	Secondary treatment unit (Root Zone Treatment)	Rs.1,00,000.00	50	2000.00
3.	Tertiary treatment unit (Maturation Pond)	Rs. 25,000.00	50	500.00
	<b>TOTAL COST</b>	<b>Rs 4,00,000.00</b>		<b>3416.00</b>

Hence total cost required for the construction of wastewater treatment system is Rs 4000.00 per person.

### 3.7 Cost of Operation and Maintenance

SI No	Description of work	Amount (Rs)
1	<b>MONITORING</b> Wastewater Analysis cost (Oct 2002 to March 2006)	26,500.00
2.	<b>MAINTENANCE</b> <b>Operation and maintenance</b> (Since commissioning till date)	30,000.00
3.	<b>ONSITE LABORATORY</b> Cost of Equipment and chemicals	12,000.00

### 3.8 Land Requirement

SI No	Description	Total Area (m <sup>2</sup> )	Person Equivalent	Area / Person (m <sup>2</sup> )
1.	Primary treatment unit (Up-flow Anaerobic Reactor)	34	300	0.11
2.	Secondary treatment unit (Root Zone treatment)	62	50	1.24
3.	Tertiary treatment unit (Maturation Pond)	33	50	0.7
	<b>TOTAL</b>	<b>129</b>	<b>—</b>	<b>2.4</b>

*Area requirement per person for the treatment of wastewater is nearly 2.4m<sup>2</sup>/person*

### 3.9 Problems Encountered

- **Acceptance for reuse of treated wastewater:** In the beginning, there have been some reluctance for reuse of treated wastewater for flushing the

toilets due to a new approach for the users but after a little while they became used to it.

### 3.10 Quality of Treated wastewater for Recycling

The study revealed that the quality of treated waste water from Root Zone treatment system is good enough to directly pump in the Overhead Tank for supply to be reused. Also, if the treated waste water from secondary is allowed to pass into the maturation pond and left for few days before being pumped into the OHT, the color of treated water changes to green due to algal growth. In this study project, the treated wastewater from secondary treatment unit (Root Zone system) has been directly pumped into OHT for recycling. The average tested quality of treated wastewater from the maturation pond is for pH 7.4, TSS 72 mg/l, TKN 12 mg/l, COD 37 mg/l, BOD 13 mg/l and Fecal Coliform is  $1.58 \times 10^4$  MPN.

By recycling of treated wastewater & harvested rainwater consumption of fresh water has been reduced from 221 lpcd to 101 lpcd thus reducing the consumption of fresh water by 45.7%.

The cost of monitoring, operation & maintenance of the treatment system has been about Rs. 20,000/- per annum which is quite reasonable.

## 4.0 CALCULATIONS FOR HYDRAULIC AND ORGANIC LOAD IN PRIMARY AND SECONDARY TREATMENT UNIT

### Primary Treatment Unit – Up-flow Anaerobic Reactor

#### Design Criteria:

- Person Equivalent: 300
- Water consumption: 200 lts /person/day
- Wastewater generation: 80%of water consumption
- Plan area of the treatment unit: 30m<sup>2</sup>
- BOD<sub>5</sub> in the raw sewage = 320 mg/L

#### Calculations as per Design Criteria:

1. Hydraulic load =  $\frac{PE \times \text{Wastewater generation}}{\text{Surface area of Primary unit}}$

$$= \frac{300 \times 200 \times 0.8}{30}$$
$$= 1600 \text{ lts/m}^2/\text{day}$$

2. Organic Load =  $\frac{PE \times \text{BOD value} \times \text{Qty of Inflow}}{\text{Surface area of primary unit}}$

$$= \frac{300 \times 320 \times 200 \times 0.8}{30 \times 10^6}$$
$$= 0.512 \text{ kg/m}^2/\text{day}$$

**Calculations as per Actual Load for Two different scenarios as listed below:**

1. Actual Hydraulic load and Organic load before commissioning of wastewater recycling process
2. Actual Hydraulic load and Organic load after commissioning of wastewater recycling process.

**Scenario 1:** Calculation before commissioning of wastewater recycling system

- Person Equivalent: 30
- Water consumption: 221 lts /person/day
- Wastewater generation: 80% of water consumption
- Maximum BOD<sub>5</sub> Value 210 mg/L

1. Hydraulic Load =  $\frac{\text{PE X Wastewater generation}}{\text{Surface area of Primary unit}}$

$$= \frac{30 \times 221 \times 0.8}{30}$$
$$= 177 \text{ lts /m}^2\text{/day}$$

2. Organic Load =  $\frac{\text{PE X BOD Value X Qty of Inflow}}{30 \times 10^6}$

$$= \frac{30 \times 210 \times 0.8 \times 221}{30 \times 10^6}$$
$$= 0.037 \text{ kg/m}^2\text{/day}$$

**Scenario 2:** Calculation after commissioning of wastewater recycling system

- Person Equivalent: 30
- Water consumption: 101 lts /person/day
- Wastewater generation: 80% of water consumption
- Maximum BOD<sub>5</sub> Value 130 mg/L

1. Hydraulic Load =  $\frac{\text{PE X Wastewater generation}}{\text{Surface area of Primary unit}}$

$$= \frac{30 \times 101 \times 0.8}{30}$$
$$= 81 \text{ lts /m}^2\text{/day}$$

2. Organic Load =  $\frac{\text{PE X BOD Value X Qty of Inflow}}{30 \times 10^6}$

$$= \frac{30 \times 130 \times 101 \times 0.8}{30 \times 10^6}$$
$$= 0.011 \text{ kg/m}^2\text{/day}$$

## SECONDARY TREATMENT UNIT – ROOT ZONE TREATMENT UNIT

### Design Criteria:

- Person Equivalent: 50
- Assume BOD<sub>5</sub>: 40 mg /person/day
- Surface area of the Root zone bed: 50 m<sup>2</sup>

### Calculations as per Design Criteria:

$$\begin{aligned} 1. \quad \text{Hydraulic Load} &= \frac{\text{PE X Qty of Inflow}}{\text{Surface area of the treatment unit}} \\ &= \frac{50 \times 200 \times 0.8}{50} \\ &= 160 \text{ lts/ m}^2/\text{day} \end{aligned}$$

$$\begin{aligned} 2. \quad \text{Organic Load - Assuming 40\% removal in the Primary treatment unit} \\ &= \frac{40 \times 50 - 0.4 (40 \times 50)}{10 \times 5} \\ &= 0.024 \text{ kg/m}^2/\text{day} \end{aligned}$$

### Scenario 1: Calculation before commissioning of wastewater recycling system

- Person Equivalent: 30
- Water consumption: 221 lts /person/day
- Wastewater generation: 80% of water consumption
- Maximum BOD<sub>5</sub> Value 28 mg/L

$$\begin{aligned} 1. \text{ Hydraulic Load} &= \frac{\text{PE X Wastewater generation}}{\text{Surface area of Primary unit}} \\ &= \frac{30 \times 221 \times 0.8}{50} \\ &= 106 \text{ lts /m}^2/\text{day} \end{aligned}$$

$$\begin{aligned} 2. \text{ Organic Load} &= \frac{\text{PE X BOD Value X Qty of Inflow}}{50 \times 10^6} \\ &= \frac{30 \times 28 \times 0.08 \times 221}{50 \times 10^6} \\ &= 0.00297 \text{ kg m}^2/\text{day} \end{aligned}$$

### Scenario 2: Calculation after commissioning of wastewater recycling system

- Person Equivalent: 30
- Water consumption: 101 lts /person/day
- Wastewater generation: 80% of water consumption
- Maximum BOD<sub>5</sub> Value 43 mg/L

1. Hydraulic Load =  $\frac{\text{PE X Wastewater generation}}{\text{Surface area of Primary unit}}$   
=  $\frac{30 \times 101 \times 0.8}{50}$   
= 49 lts /m<sup>2</sup>/day
  
2. Organic Load =  $\frac{\text{PE X BOD Value X Qty of Inflow}}{50 \times 10^6}$   
=  $\frac{30 \times 43 \times 101 \times 0.8}{50 \times 10^6}$   
= 0.00208 kg/m<sup>2</sup>/day