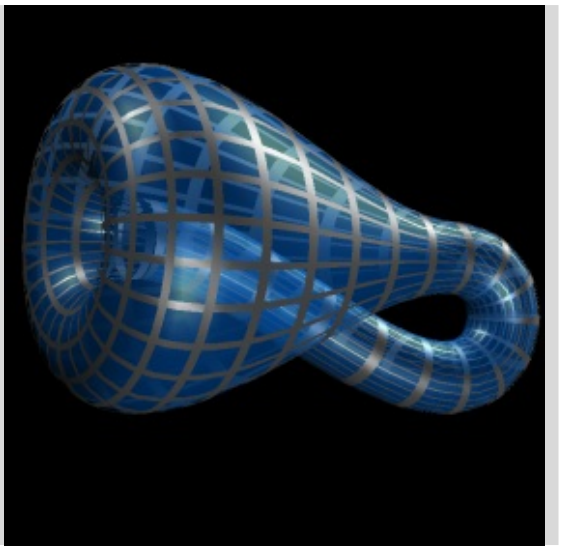

Design of DTS for Laughing Waters Residential colony

Submitted to:

Laughing Waters Owners and Residents Association
Ramagondanahalli

Submitted on:
16th February, 2007

Paradigm Environmental Strategies Pvt. Ltd.,
16/2-13, Pratheeksha, Behind Gym,
Near Vijaya Enclave, Kodichikkanahalli
Bangalore 560076.
Telefax: +91-80-26487904, Email: info@penstrat.com

www.penstrat.com

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Cover page photographs:

1. Mobius strip – is a surface with only one side and only one edge. It has the mathematical property of being non-orientable. It can be embedded in three-dimensional Euclidean space.
2. Klein bottle – is a three-dimensional analog of the Mobius strip. It has only one surface. It is a two-dimensional differentiable manifold which is not orientable. It can exist in four-dimensional Euclidean space only.

Together, the Mobius strip and Klein bottle stand for the Constancy of Change, Unconventional, Continuity and Sustainability. It represents something simple, yet profound -- something anyone could have discussed centuries prior to its discovery, but didn't – ***a Paradigm shift!***

Contents

List of acronyms:

Sl.No.	Acronym	Expansion
1.	ADEPT	Appropriate Decentralized Environment Protection Techniques
2.	BOD	Biological Oxygen Demand
3.	BWSSB	Bangalore Water Supply and Sewerage Board
4.	COD	Chemical Oxygen Demand
5.	DTS	Decentralized wastewater Treatment Systems
6.	FBR	Fluidized Bed Reactor
7.	FFR	Fixed Film Reactor
8.	HRT	Hydraulic Retention Time
9.	KLD	Kilo Litres per Day
10.	LWORA	Laughing Waters Owners & Residents Association
11.	m	Meters
12.	mg/l	Milligram per litre
13.	PGF	Planted Gravel Filter
14.	Q	Discharge Quantity
15.	Sq.m	Square Meters
16.	STP	Sewage Treatment Plant
17.	TDS	Total Dissolved Solids
18.	UASB	Up-flow Anaerobic Sludge Bed Reactor

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1 Introduction

The residents of 214, Laughing Waters Ramagondanahalli, Bangalore 560 066 represented by their Association LWORA, wish to integrate an environmental friendly and low maintenance Waste Water Treatment plant for treating the domestic black and grey water generated within the colony. The treated effluent is proposed to be utilized for secondary use like irrigation of the landscape.

The fundamental criteria for choosing the DTS is that it is an environment friendly and low maintenance waste water treatment option for treating the domestic black and grey water. The system is not dependant on electricity for its treatment and its installation cost is comparable to conventional STP. The treated effluent shall conform to the KPSCB norms and will be utilized for secondary use like toilet flushing and irrigation of the landscape.

2 Background

Laughing Waters (LW) is a residential colony located at Ramagondanahalli, Whitefield on Airport Road. The colony was developed by Prestige Builders in 1994. It consists of 360 households. The developers had provided for four independent sewer network with each connected to a dedicated septic tank and soak pit.

Of late, the residents have experienced overflowing septic tanks and heading up of sewage within the drain. The frequency of cleaning and de-sludging septic tanks has also increased. Besides creating unsanitary conditions near certain sites and ground water contamination, it is also proving to be costly.

LWORA approached M/s. Paradigm Environmental Strategies (P) Ltd., who has expertise in 'Appropriate Decentralized Environmental Protection Techniques (ADEPT)', to provide a viable solution for managing their waste water. LWORA has conducted a preliminary techno-commercial evaluation of DTS and the conventional Sewage treatment plants before finalizing on the same.

3 Project Design

This proposal involves designing a Decentralised wastewater Treatment System (DTS), which conforms to the ADEPT portfolio. The DTS application is based on the following treatment modules

- Primary treatment
- Secondary anaerobic in fluidized bed / baffled reactors
- Tertiary anaerobic treatment in fixed film reactors

4 Sources of wastewater

Wastewater is generated from cooking, washing of utensils, clothes and floor etc, bathing and toilet flushing. The quantity is assumed to be 100 lpcd and the total quantity of wastewater from 345 households would be 180 KLD.

5 Design characteristics of the Wastewater generated

The characteristics of each wastewater stream are based on the data submitted by LWORA . The quantities indicated are of those at the end of the four existing streams.

The water balance chart is shown in Figure 1.

Table 1 Wastewater stream characteristics

Stream No	Nos. of households	Qty KLD	Peak flow	COD mg/l	BOD mg/l
1.	100 HH	50	5.0	800	400
2.	225 HH	115	11.5	800	400
3.	10 HH	5	0.5	800	400
4.	10 HH	5	0.5	800	400
Total	345 HH	175	17.5	800	400

6 Wastewater Treatment System

The design concept is as per the annexed flowchart (Refer: Wastewater treatment Process Flow chart - Figure 2). Each of the streams is applied with a treatment appropriate to it.

Stream 1

The Stream 1 comprising of domestic wastewater generated from 100 households is conveyed to a Settler-Fluidized Bed Reactor (T1) linked to an Fixed Film Reactor. The total HRT is 69 hours. The treated water is sent into the planted gravel filter (PGF)

The design details of T1 is as given in table below:

Table 2 Design details of T1

Total waste water –50 KL/day	Peak hours – 10
Inlet COD – 800mg/l	Inlet BOD – 400 mg/l
Outlet COD-< 60 mg/l	Outlet BOD – <20 mg/l

Dimensions of the treatment modules are

1. Settler - (4.2m +2.1m) Length x 2.5m Width x 2.0 m Depth
2. Fluidized bed reactor -0.9m Length x 6.2m Width x 1.8m Depth – 6 Nos.
3. Fixed film reactor – 1.5m Length x 6.2m Width x 1.8m Depth – 4 Nos.
4. Planted gravel filter – 10m Length x 16m Width x 0.6m Depth – 1 Nos

Stream 2

The Stream 2 comprising of domestic wastewater generated from 225 households is conveyed to a Settler-Fluidized Bed Reactor (T1) linked to an Fixed Film Reactor. The total HRT is 69 hours. The treated water is sent into the planted gravel filter (PGF)

The design details of T2 is as given in table below:

Table 3 Design details of T2

Total waste water –115 KL/day	**Peak hours – 10**
Inlet COD – 800mg/l	Inlet BOD – 400 mg/l
Outlet COD-< 60 mg/l	Outlet BOD – <20 mg/l

Dimensions of the treatment modules are

1. Settler - (6.45m +3.4m) Length x 3.0m Width x 2.0 m Depth
2. Fluidized bed reactor -0.9m Length x 15m Width x 1.8m Depth – 6 Nos.
3. Fixed film reactor – 1.5m Length x 15m Width x 1.8m Depth – 4 Nos.
4. Planted gravel filter – 10m Length x 40m Width x 0.6m Depth – 1 Nos

Stream 3 and 4

The Stream 3 and 4 comprising of domestic wastewater generated from 10 households each are conveyed to a Settler-Fluidized Bed Reactor (T3) linked to a Fixed Film Reactor. The total HRT is 79 hours. The treated water is sent into the planted gravel filter (PGF)

The design details of T3 is as given in table below:

Table 4 Design details of T3

Total waste water –5 KL/day	**Peak hours – 10**
Inlet COD – 800mg/l	Inlet BOD – 400 mg/l
Outlet COD-< 60 mg/l	Outlet BOD – <20 mg/l

Dimensions of the treatment modules are

1. Settler - (1.2m +0.6m) Length x 1.2m Width x 2.0 m Depth
2. Fluidized bed reactor -0.8m Length x 1.0m Width x 1.8m Depth – 6 Nos.
3. Fixed film reactor – 1.2m Length x 1.0m Width x 1.8m Depth – 4 Nos.
4. Planted gravel filter – 3.2m Length x 1.8m Width x 0.6m Depth – 1 Nos

Reuse of treated water

About 30% of the treated wastewater is lost by evapotranspiration by the plants in the PGF. The outflow from the planted gravel filters is routed to individual underground sumps and pumped for irrigation purposes. Thus a total of 120 KLD would be available for landscaping purposes.

Sludge

The DTS units (T1, T2 and T3) are de-sludged once in 24 months and the sludge disposed off through BWSSB. The characteristics of the sludge will similar to the septic tank sludge. The total volume of sludge generated is estimated at about 30KL per annum.

Figure 1 Water Balance Chart for LWORA

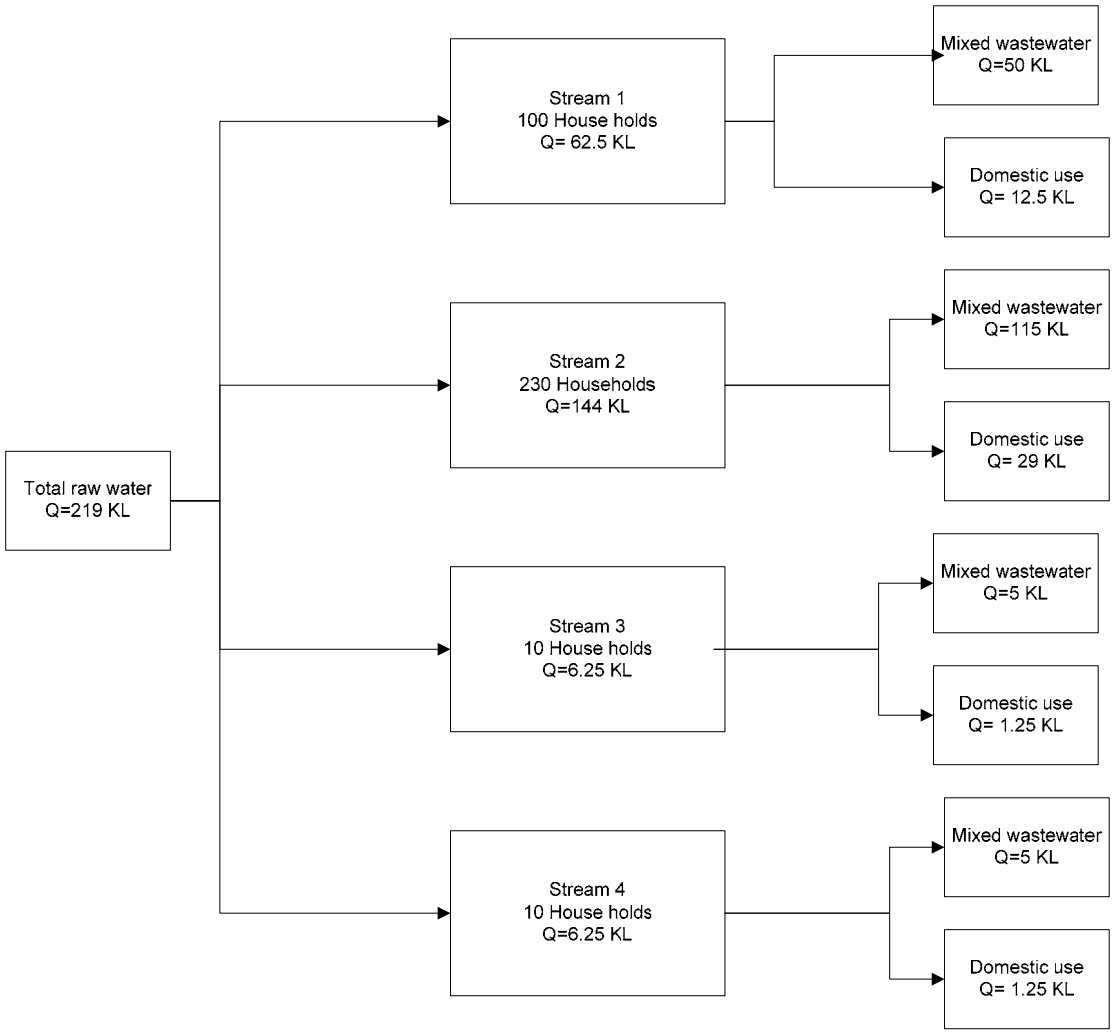
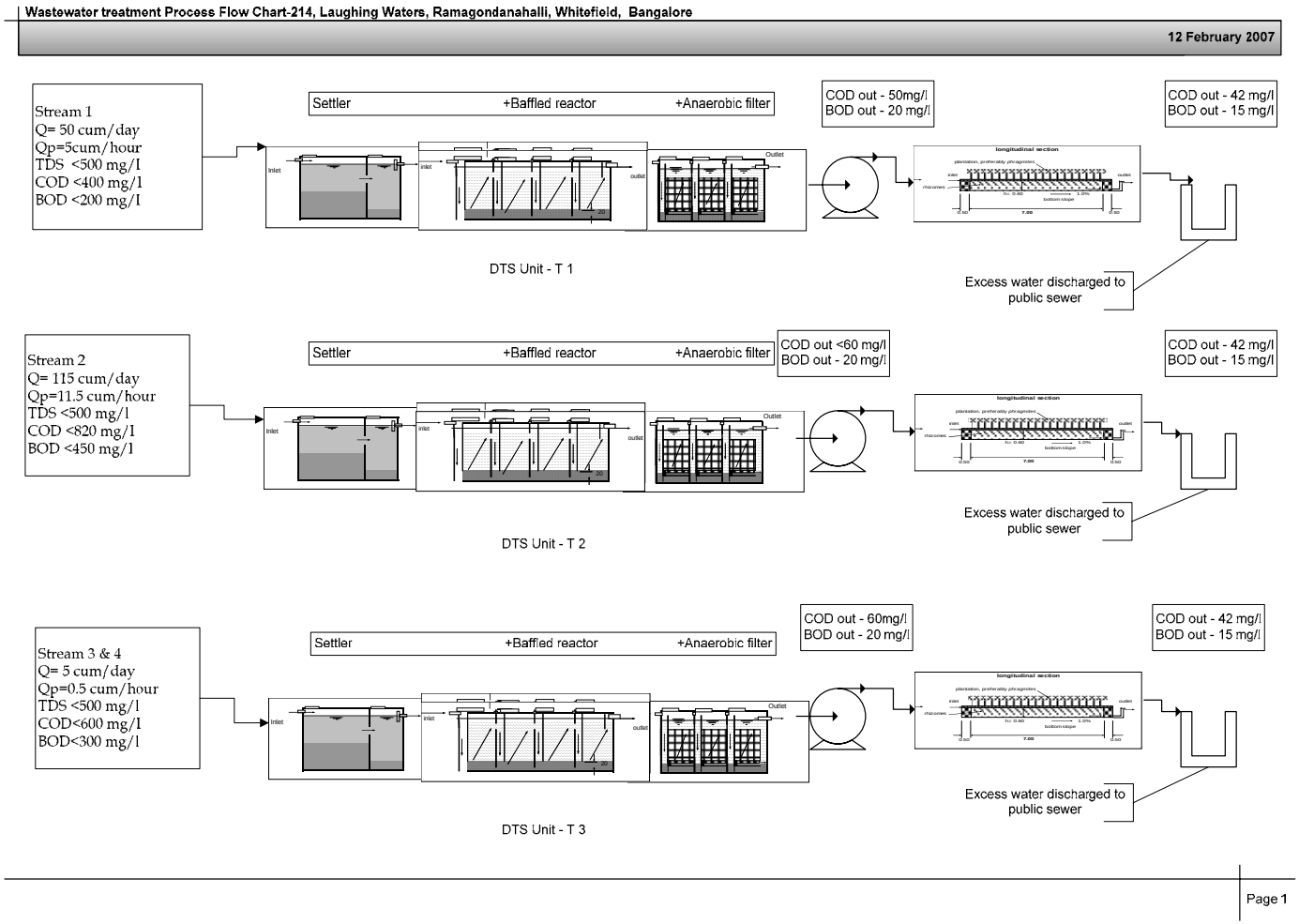


Figure 2 Wastewater treatment process flow chart – LWORA



7 What is DTS?

DTS stands for Decentralized wastewater Treatment Systems. It qualifies as an "Appropriate Decentralized Environmental Protection Technique" (ADEPT). All ADEPT applications are based on the principle of low-maintenance since most of the important parts of the system work with zero or minimal external energy input. ADEPT application provides state of the art technology at affordable prices because materials/inputs used for construction are locally available.

- DTS is suitable for wastewater for both, domestic and industrial sources
- DTS can cater to wastewater flows of 1-1000 KLD
- DTS are reliable, long lasting and resistant to shock loads
- DTS do not warrant skilled maintenance.

All ADEPT design enables maximum reuse of the treatment products. ADEPT applications are designed to meet requirements stipulated in environmental laws and regulations

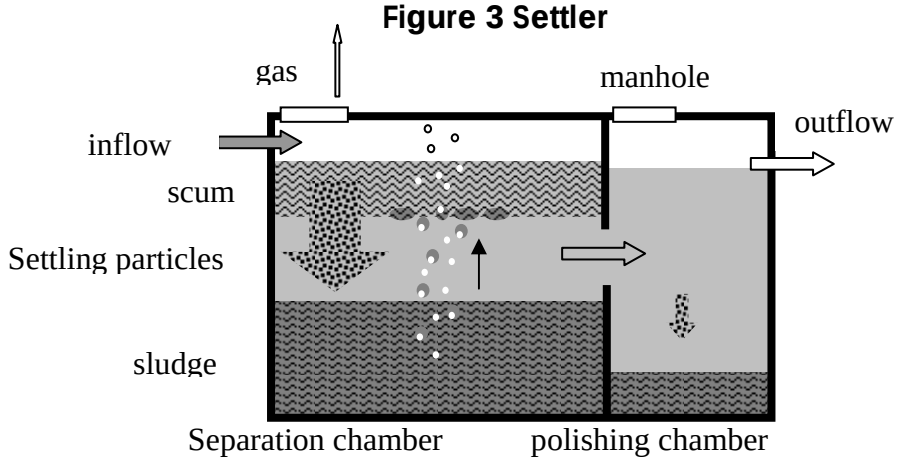
7.1 Description of Treatment Modules

Settler:

The Settler is similar to a septic tank but with low hydraulic retention times. The key processes are physical treatment which retains contaminants by sedimentation/flotation and biological treatment whereby the remaining organic pollutants in the clarified wastewater are partly decomposed by microorganisms. The digestion process ensures that the accumulated sludge is reduced and stabilised. Storage volume for sludge is provided for 18 to 24 months, defining the desludging period.

Average reduction of BOD is between 20 and 40%. The Settler is resistant to shock load and variable inflow.

Figure 3 Settler

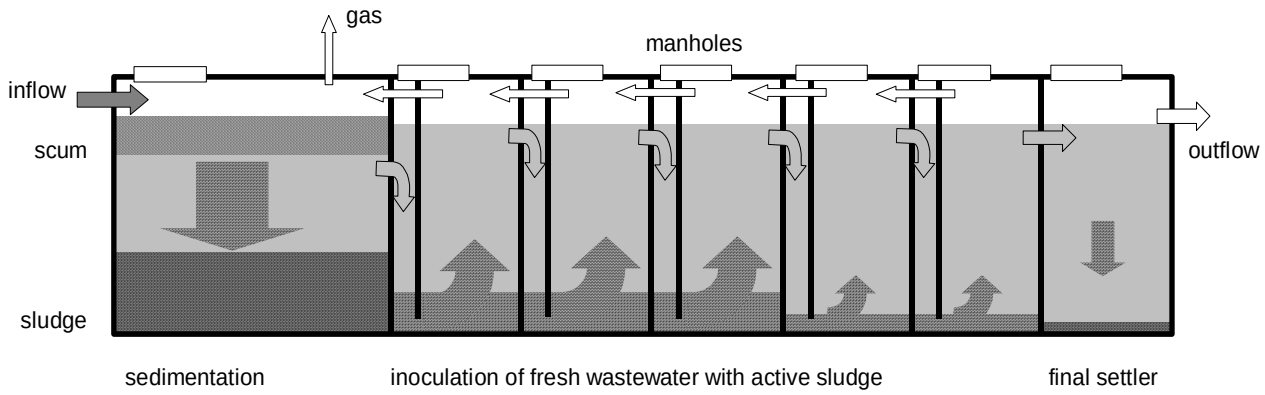


Fluidized Bed Reactor

The Fluidized Bed Reactor consists of a series of chambers, in which the wastewater flows up-stream. Activated sludge is located at the bottom of each chamber. The inflowing effluent is intensively mixed up with the sludge, wherein it is inoculated with bacterial mass which decompose the contained pollutants. In the first chambers the easily degradable substances are broken down. In the following chambers, decomposition of less decomposable substances takes place.

The BOD reduction rate of the Fluidized Bed Reactor is 90 %. The pathogens reduction is in the range between 40 – 75 %. The Fluidized Bed Reactor is resistant to shock load and variable inflow, the operation and maintenance is simple and virtually no space is required since it is an underground construction.

Figure 4 Fluidized Bed Reactor



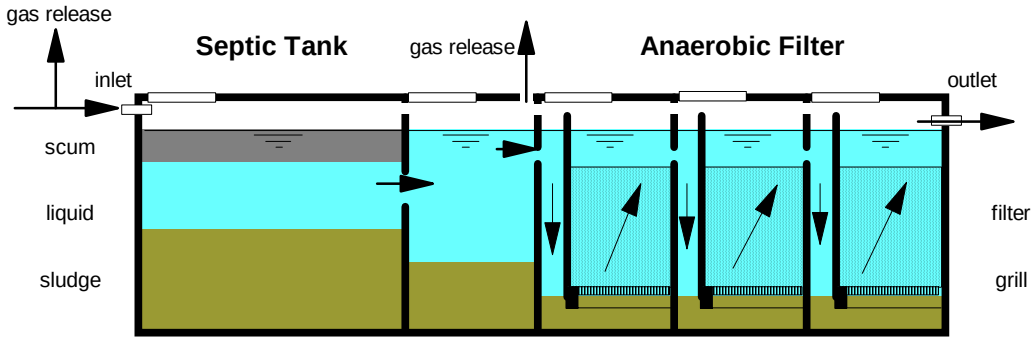
Fixed Film Reactor

The Fixed Film Reactor (FFR), also known as fixed bed or Anaerobic Filter Reactor is very similar to the Fluidized Bed Reactor (FBR). The bacterial mass is lodged on filter materials such as gravel, rocks, cinder or specially formed plastic pieces which provides additional surface area for bacteria to settle. Non-settleable and dissolved solids are treated by bringing them in close contact with a surplus of active bacterial mass fixed on filter material.

The BOD removal rate is in the range of 70-90%. The surplus of activated sludge produced has to be removed in intervals of 1 to 3 years.

The picture shows the combination of an FFR with a settler. The FFR could also be combined with a Fluidized Bed Reactor by incorporating the FFR as the last chamber.

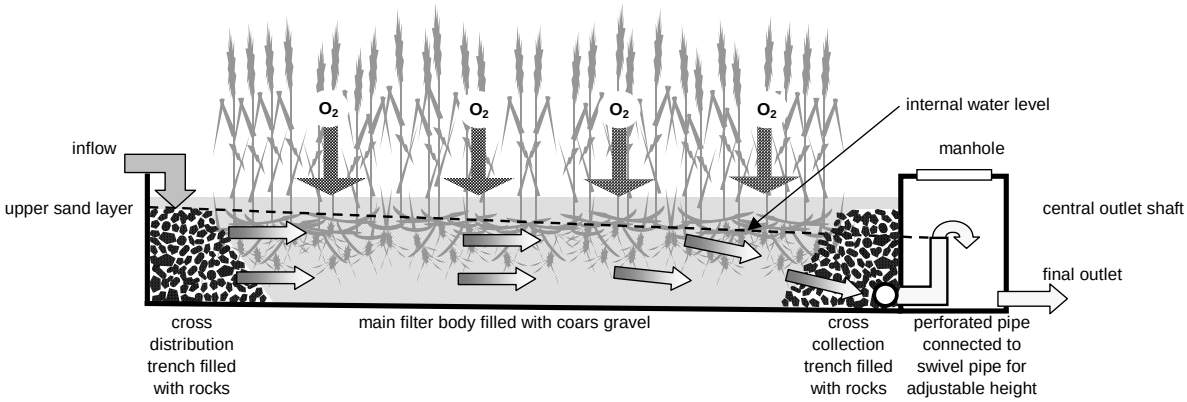
Figure 5 Fixed Film Reactor



Planted Gravel Filter

The Planted Gravel Filter (PGF) also known as Root Zone treatment system is made of reed planted filter bodies consisting of fine gravel. Bottom slope is 1 %. The flow direction is mainly horizontal. The filter is planted with helophytes. The main removal mechanisms are biological conversion, physical filtration and chemical adsorption. Mechanisms of BOD removal are mainly aerobic and anoxic .The function of the PGF is mainly post treatment. Reduction rate of BOD is between 75 - 90 %. Reduction of infective organisms is over 95 %. Operation and maintenance of the system is simple. The spatial requirements are compensated by integrating it with the landscapes.

Figure 6 Planted Gravel Filter



7.2 Sludge generation and disposal

Sludge will be produced in the settler and the Fluidized Bed Reactor. The design provides integrated storage volume for a period of 18 to 24 month.

Disposal: Regular disposal through BWSSB every 18 to 24 months. An onsite processing through the installation of drying beds attached to the DTS could be an alternative option due to the fact that the sludge produced will be harmless and rich in plant nutrients.

8 Design computations of Treatment Modules

The characteristics of each wastewater stream are based on the data submitted by LWORA.

Stream No	Qty KL/day	Peak flow	pH	TSS mg/l	TDS mg/l	COD mg/l	BOD mg/l
1.	50	5	7- 7.5	<350	<500	<800	<400
2.	115	11.5	7- 7.5	<350	<500	<800	<400
3.	5	0.5	7- 7.5	<350	<500	<800	<400
4.	5	0.5	7- 7.5	<350	<500	<800	<400

T1- Decentralized Treatment System for Stream 1

Treatment scheme:
The stream 1 is conveyed to a DTS unit (T1) comprising a settler integrated with an anaerobic upflow fluidized bed reactor and a fixed film reactor with combined hydraulic retention time (HRT) of 53 hours

The design parameters assumed are

Total waste water – 50 KLD
Peak hours – 10
Inlet COD – 800mg/l
Inlet BOD – 400 mg/l
Outlet COD <60 mgl
Outlet BOD <20mgl

Settler:
Desludging intervals = 24 months
Sludge production rate = 0.0033 l/g BOD
Hydraulic retention time = 1.5 hours
Corresponding COD removal rate= 26%
BOD removal rate = 27.6%
Outlet COD = (1-0.26) x 800 = 592 mg/l
Outlet BOD = (1-0.276) x 400 = 290 mg/l

Volume of integrated settler required is the maximum of the following
- (50/10x1.5+(0.0033x(400-290) x50x30X24/1000))=19.5 KL and
- (2x 50/10x1.5) = 15 KL

Hence provide a settler of dimensions: 6.3 L x2.5 W x 2 D; actual volume provided is 31.5 KL

Fluidized bed reactor (FBR):

Hydraulic retention time= 28 hours

Corresponding COD removal rate= 80%
BOD removal rate = 83%
Outlet COD = (1-0.80) x 592 = 119 mg/l
Outlet BOD = (1-0.83) x 290=49 mg/l

Volume of FBR required =50 /24 x 28= 58.3 KL

Provide a FBR of dimensions: 0.9 L x 6.2 W x 1.8 D – 6 Nos; actual volume provided is 60 KL.

Fixed film reactor (FFR):

Hydraulic retention time= 24 hours

Corresponding COD removal rate= 59%
BOD removal rate = 64%
Outlet COD = (1-0.59) x 119 = 49 mg/l <60 mg/l
Outlet BOD =(1-0.64) x 49 = 18 mg/l <20 mg/l

Volume of FFR required = 50/24 x 24= 50KL

Provide an FFR of dimensions: 1.5 L x 6.2 W x 1.8 D – 4 Nos with filter of porosity 35% and depth 0.75m with effective volume 50 KL. The waste water treatment process flow chart is given in figure 2.

Planted Gravel Filter

The anaerobically treated wastewater is routed to a planted gravel filter planted with selected species- Canas Indica, Colacasia, Papyrus, Reed

Hydraulic conductivity of filter material=500m/day
Hydraulic gradient =1.1%
Max. BOD load on cross section =150g/Sqm
Max. surface BOD load=10g/sqm
Hydraulic retention time= 27.6 hours

Corresponding COD removal rate= 8%
BOD removal rate = 9%
Outlet COD = (1-0.08) x 49 = 45 mg/l
Outlet BOD =(1-0.09) x 18 = 17 mg/l

Cross sectional area is maximum of
50x18/150= 6 Sqm, and
50/500/.11% =9.1 Sqm

Adopt depth 0.6m, Width required 16m

Surface area required is the maximum of
50x(18-16)/10= 10 sqm, and
50x27.6/24/0.6= 96 Sqm

Provide a Planted Gravel Filter of dimensions – 10 L x 16 W x 0.6 D – 1Nos with filter of porosity 35%.

About 30% of the treated wastewater is lost by evapotranspiration by the plants in the PGF. The effective outflow of 35 KL from the planted gravel filter is collected in a collection tank for irrigation purposes.

T2- Decentralized Treatment System for Stream 2

Treatment scheme:
The stream 2 is conveyed to a DTS unit (T2) comprising a settler integrated with an anaerobic upflow fluidized bed reactor and a fixed film reactor with combined hydraulic retention time (HRT) of 54 hours

The design parameters assumed are

Total waste water – 120 KLD	Peak hours – 10
Inlet COD – 800mg/l	Inlet BOD – 400 mg/l
Outlet COD <60 mgl	Outlet BOD <20mgl

Settler:
Desludging intervals = 24 months
Sludge production rate = 0.0033 l/g BOD
Hydraulic retention time = 1.7 hours

Corresponding COD removal rate= 27%
BOD removal rate = 28.6%
Outlet COD = (1-0.27) x 800 = 584 mg/l
Outlet BOD = (1-0.286) x 400 = 286 mg/l

Volume of integrated settler required is the maximum of the following

- (120/10x1.7+(0.0033x(400-286) x120x30X24/1000))=53 KL and
- (2x 120/10x1.7) = 41 KL

Hence provide a settler of dimensions: 9.85 L x 3 W x 2 D; actual volume provided is 59 KL

Fluidized bed reactor (FBR):
Hydraulic retention time= 28 hours

Corresponding COD removal rate= 80%
BOD removal rate = 83%
Outlet COD = (1-0.80) x 584 = 117 mg/l
Outlet BOD = (1-0.83) x 286=47 mg/l

Volume of FBR required =120 /24 x 28= 140 KL
Provide a FBR of dimensions: 0.9 L x 15 W x 1.8 D – 6 Nos; actual volume provided is 145 KL.

Fixed film reactor (FFR):

Hydraulic retention time= 24.3 hours

Corresponding COD removal rate= 59%
BOD removal rate = 64%
Outlet COD = (1-0.59) x 117 = 48 mg/l <60 mg/l
Outlet BOD =(1-0.64) x 47 = 17 mg/l <20 mg/l

Volume of FFR required : = 120/24 x 24= 120KL

Provide an FFR of dimensions: 1.5 L x 15 W x 1.8 D – 4 Nos with filter of porosity 35% and depth 0.75m with effective volume 120 KL. The waste water treatment process flow chart is given in figure 2.

Planted Gravel Filter

The anaerobically treated wastewater is routed to a planted gravel filter planted with selected species- Canas Indica, Colacasia, Papyrus, Reed

Hydraulic conductivity of filter material=500m/day
Hydraulic gradient =1%
Max. BOD load on cross section =150g/Sqm
Max. surface BOD load=10g/sqm
Hydraulic retention time= 44.4 hours
Corresponding COD removal rate= 13%
BOD removal rate = 14%
Outlet COD = (1-0.13) x 48 = 42 mg/l
Outlet BOD =(1-0.14) x 17 = 15 mg/l

Cross sectional area is the maximum of
120x17/150= 14 Sqm, and
120/500/1% =24 Sqm
Adopt depth 0.6m, Width required 40m
Surface area required is the maximum of
120x(17-15)/10= 24 sqm, and
120x44.4/24/0.6= 370 Sqm

Provide a Planted Gravel Filter of dimensions – 10 L x 40 W x 0.6 D – 1Nos with filter of porosity 35%.

About 30% of the treated wastewater is lost by evapotranspiration by the plants in the PGF. The effective outflow of 84 KL from the planted gravel filter is collected in a collection tank for irrigation purposes.

T3- Decentralized Treatment System for Stream 3 and 4

Treatment scheme:
The stream 3 and 4 are individually conveyed separately to DTS unit (T3) comprising a settler integrated with an anaerobic upflow fluidized bed reactor and a fixed film reactor with combined hydraulic retention time (HRT) of 74 hours

The design parameters assumed are

Total waste water – 5 KLD	Peak hours – 10
Inlet COD – 800mg/l	Inlet BOD – 400 mg/l
Outlet COD <60 mgl	Outlet BOD <20mgl

Settler:
Desludging intervals = 24 months
Sludge production rate = 0.0033 l/g BOD
Hydraulic retention time = 4 hours

Corresponding COD removal rate= 32%
BOD removal rate = 34%
Outlet COD = (1-0.32) x 800 = 544 mg/l
Outlet BOD = (1-0.34) x 400 = 264 mg/l

Volume of integrated settler required is the maximum of the following

- (5/10x4+(0.0033x(400-264) x5x30X24/1000))=3.6 KL and
- (2x 5/10x4) = 4 KL

Hence provide a settler of dimensions: 1.8 L x 1.2 W x 2 D; actual volume provided is 4.3 KL

Fluidized bed reactor (FBR):
Hydraulic retention time= 39 hours

Corresponding COD removal rate= 78%
BOD removal rate = 82%
Outlet COD = (1-0.78) x 544 = 120 mg/l
Outlet BOD = (1-0.82) x 264=48 mg/l

Volume of FBR required =5 /24 x 39= 8.2 KL
Provide a FBR of dimensions: 0.8 L x 1 W x 1.8 D – 6 Nos; actual volume provided is 8.64KL.

Fixed film reactor (FFR):
Hydraulic retention time= 31 hours

Corresponding COD removal rate= 61%
BOD removal rate = 66%
Outlet COD = (1-0.61) x 120 = 47 mg/l <60 mg/l
Outlet BOD =(1-0.66) x 48 = 17 mg/l <20 mg/l

Volume of FFR required = 5/24 x 31= 6.5KL

Provide an FFR of dimensions: 0.8 L x 1 W x 1.8 D – 4 Nos with filter of porosity 35% and depth 0.75m with effective volume 6.5 KL. The waste water treatment process flow chart is given in figure 2.

Planted Gravel Filter

The anaerobically treated wastewater is routed to a planted gravel filter planted with selected species- Canas Indica, Colacasia, Papyrus, Reed

Hydraulic conductivity of filter material=500m/day
Hydraulic gradient =1%
Max. BOD load on cross section =150g/Sqm
Max. surface BOD load=10g/sqm
Hydraulic retention time= 16.5 hours
Corresponding COD removal rate= 5%
BOD removal rate = 5%
Outlet COD = (1-0.05) x 47 = 45 mg/l
Outlet BOD =(1-0.05) x 17 = 16 mg/l

Cross sectional area is the maximum of
5x17/150= 0.6 Sqm, and
5/500/1% =1 Sqm
Adopt depth 0.6m, Width required 1.8m
Surface area required is the maximum of
5x(17-16)/10= 0.5 sqm, and
5x16.5/24/0.6= 2 Sqm

Provide a Planted Gravel Filter of dimensions – 3.2 L x 1.8 W x 0.6 D – 1Nos with filter of porosity 35%.

About 30% of the treated wastewater is lost by evapotranspiration by the plants in the PGF. The effective outflow of 3.5 KL from the planted gravel filter is collected in a collection tank for irrigation purposes.

9 Project Implementation Chart