SBT TECHNOLOGY OF IIT BOMBAY

Prof H S Shankar
Department of Chemical Engineering
Indian Institute of Technology Bombay
Email: hss@iitb.ac.in

APPLICATIONS OF SBT

- Rain water harvesting
- Drinking water
- Swimming pool

- Sewage treatment
- Industrial wastewater treatment,
- Industrial air purification

- Municipal solid waste Processing
- Commercial production of Soil
- Animal House waste processing
- Hospital waste treatment

Why This Technology

Agriculture

Animal Husbandry

Fisheries

Sewage Treatment

Water Supply& Sanitation

Waste Water Treatment

Rain water Harvesting

Restoration of Rivers and Lakes

Process Chemistry

Respiration

$(CH_2ON_xP_yS_zK_y)_n + nO_2 + nH_2O = nCO_2 + 2nH_2O$ + Mineral (N, P, S, K) + Energy (1)

Photosynthesis

$nCO_2 + 2nH_2O$ + Minerals (N,P, S,K) + Sunlight =
$[CH_2ON_xP_yS_zK_y]_n + nO_2 + nH_2O$ (Photosynthesis) (2)

Nitrogen Fixation

$N_2 + 2H_2O$ + Energy = $NH_3 + O_2$ (in soil) (3)
$N_2 + 2H_2O$ + Light = $NH_3 + O_2$ (in water) (4)

Acidogenesis

$4C_3H_7O_2NS + 8H_20 = 4CH_3COOH + 4CO_2 + 4NH_3 + 4H_2S + 8H^+ + 8e^-$
(5)

Methanogenesis

$8H^+ + 8e^- + 3CH_3COOH + CO_2 = 4CH_4 + 3CO_2 + 2H_2O$ (6)

Adding 5 and 6 give overall biomethanation chemistry

$4C_3H_7O_2NS + 6H_20 = CH_3COOH + 6CO_2 + 4CH_4 + 4NH_3 + 4H_2S$
(7)

Mineral weathering

$CO_2 + H_2O = HCO_3^- + H^+$ (8)
Primary mineral + $CO_2 + H_2O = M^{+n} + n\ HCO_3^-$ + soil/clay/sand (9)

Nitrification

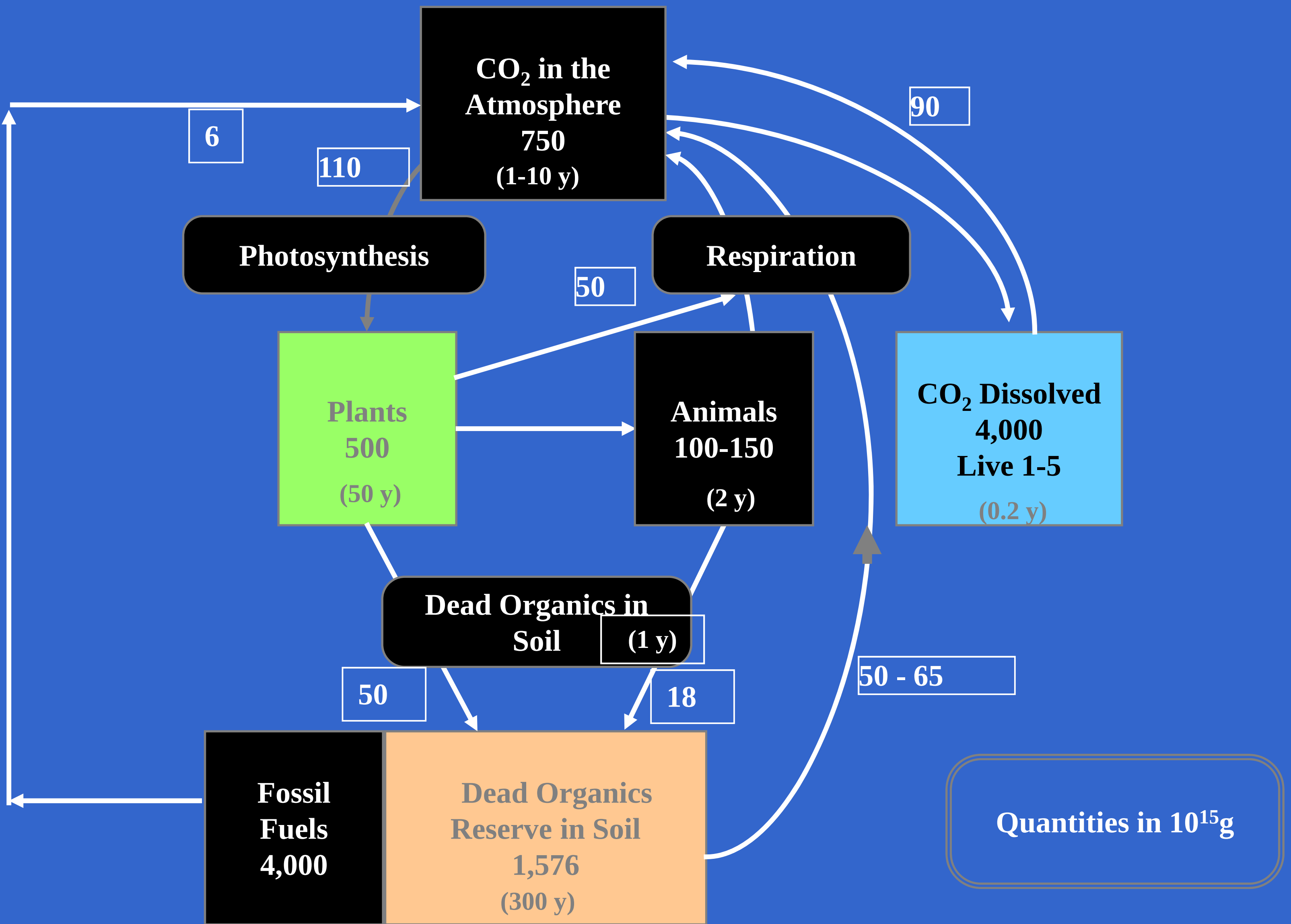
$NH_3 + CO_2 + 1.5O_2$ = Nitrosomonas + $NO_2^- + H_2O + H^+$ (10)
$NO_2^- + CO_2 + 0.5O_2$ = Nitrobacter + NO_3^- (11)

Denitrification

$4NO_3^- + 2H_2O$ + energy = $2N_2 + 5O_2 + 4OH^-$ (12a)
$NO_2^- + NH_4^+ = N_2 + H_2O$ + energy (12b)

A Natural Water body near Mumbai, India

A natural water body near Mumbai, India now converted to marsh land due to nutrient overload



Global Carbon Cycle (Meilli, 1995)

Source: Encyclopedia of Environmental Biology, Vol.1, Academy press, 1995, pp.235-248

Energy Consumption in Different Habitats

1. Water	500 kJ/g live C. yr
✓ 2. Land	3 kJ/g live C. yr

Source: Global Carbon Cycle , Meili, 1995, Encyclopedia of Environmental Biology, Vol.1, Academy press, 1995, pp.235-248

Lessons from Carbon Cycle

Global carbon cycle shows that terrestrial ecosystems reveal high population densities compared to aquatic ecosystems indicating very high oxygen availability in terrestrial ecosystems

Current Technologies for waste treatment engage aquatic ecosystems needing much mechanical energy for oxygen transfer .

Hence the interest in terrestrial engineered ecosystems for waste treatment- a design consistent with carbon cycle

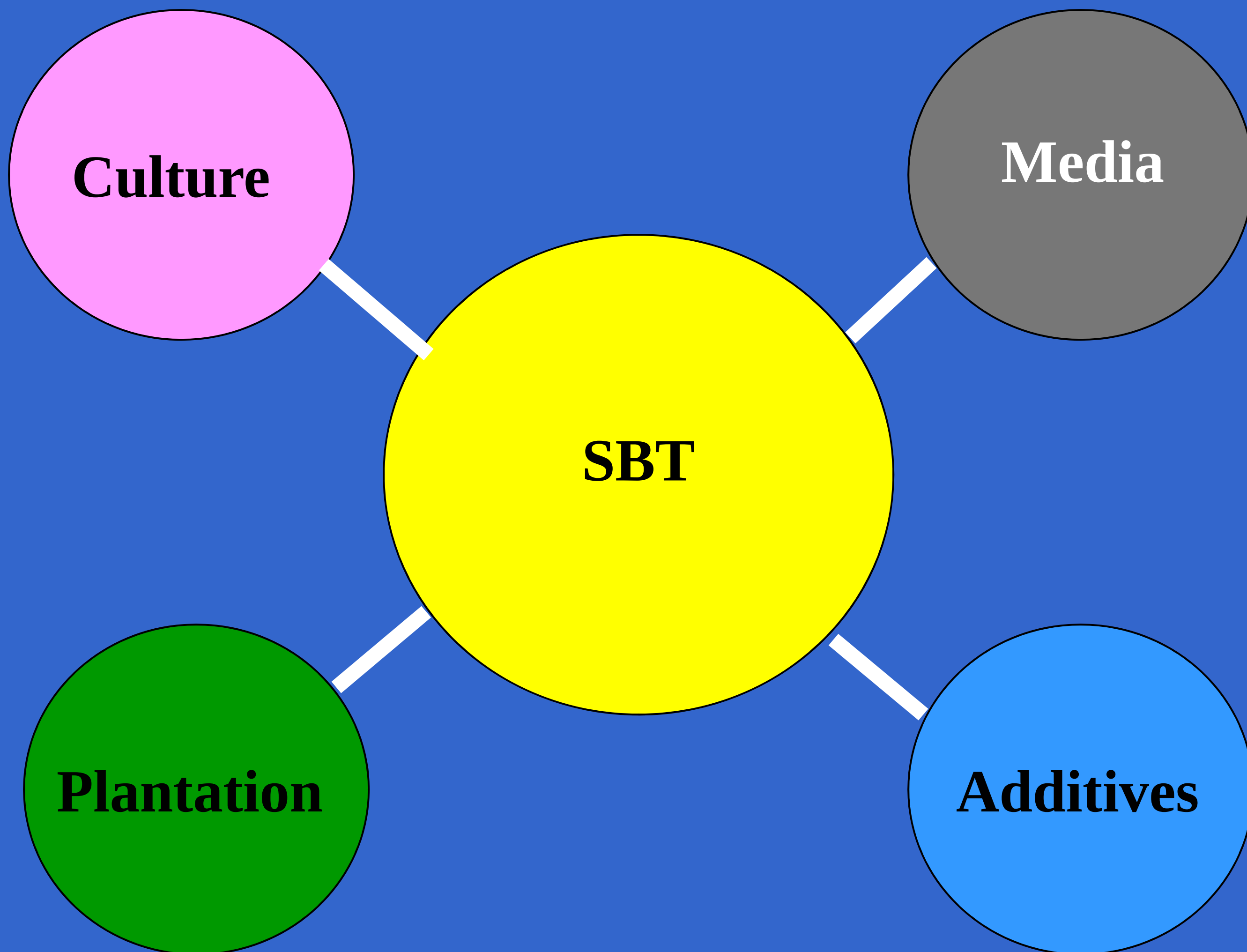
Media and Culture

1. Partially weathered soil-like primary minerals of suitable particle size , composition, liquid hold up, hydraulics

2. Geophagus worm such as Pheretima Elongata and bacterial culture. Appropriate culture for special situations.

3. Selected Green plants particularly with tap root system

Elements of SBT



SBT Media And Culture

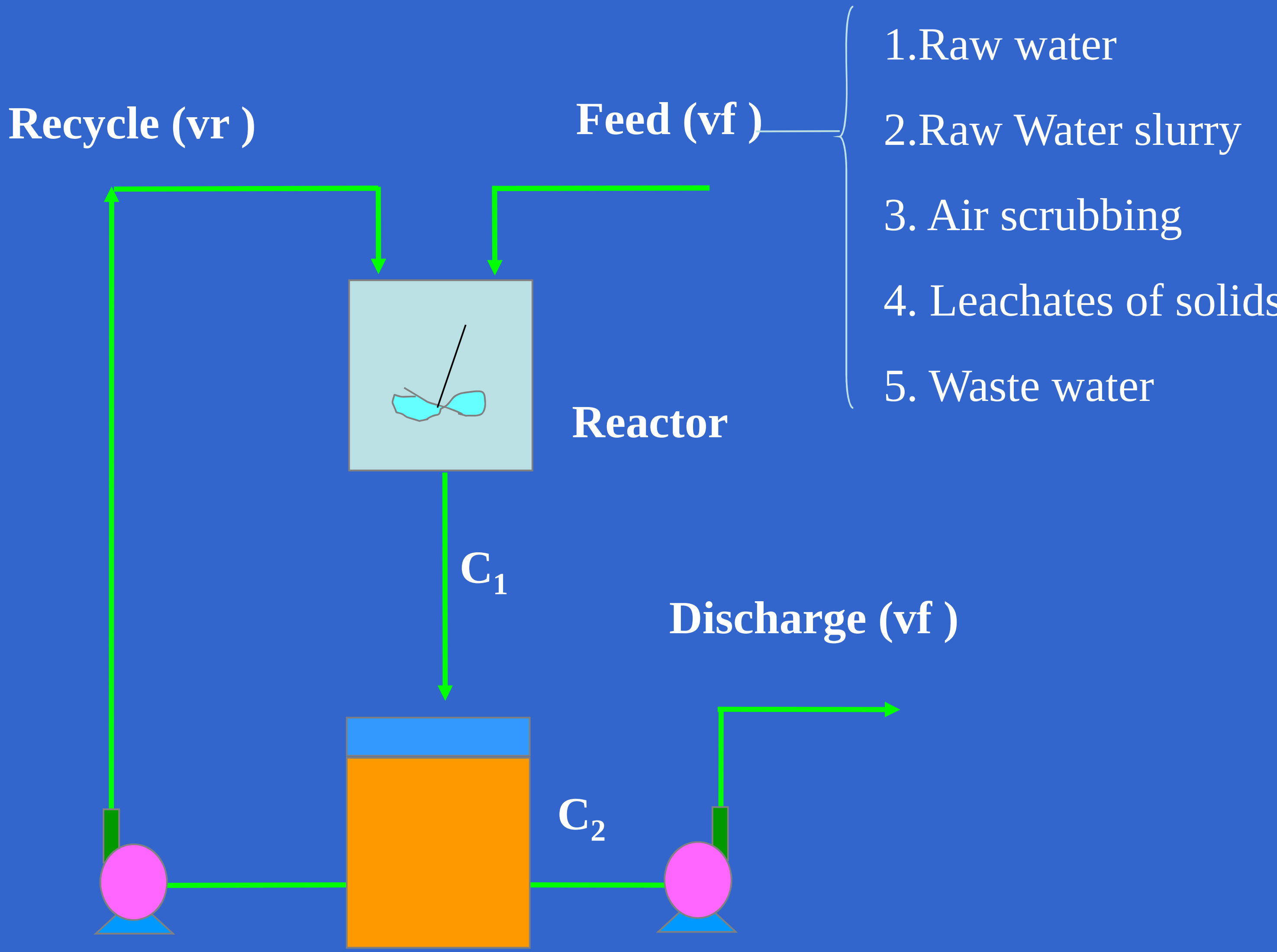
1. Partially weathered soil-like primary minerals of suitable particle size , composition, liquid hold up, hydraulics

2. Geophagus worm such as Pheretima Elongata and bacterial culture. Appropriate culture for special situations.

3. Selected Green plants particularly with tap root system

Source
US Patent: *6890438 B2 (May 2009) Process for treatment of organic wastes*;
US Patent 7604742 (October 2009) Soil Conditioning Products from Organic wastes

Schematic of Water Renovation



120 Cu M Plant at M P. Airport, AAI, Udaipur, Rajasthan

Plant

3MLD Sewage purification in Corporation Of Bombay

Some of our plants

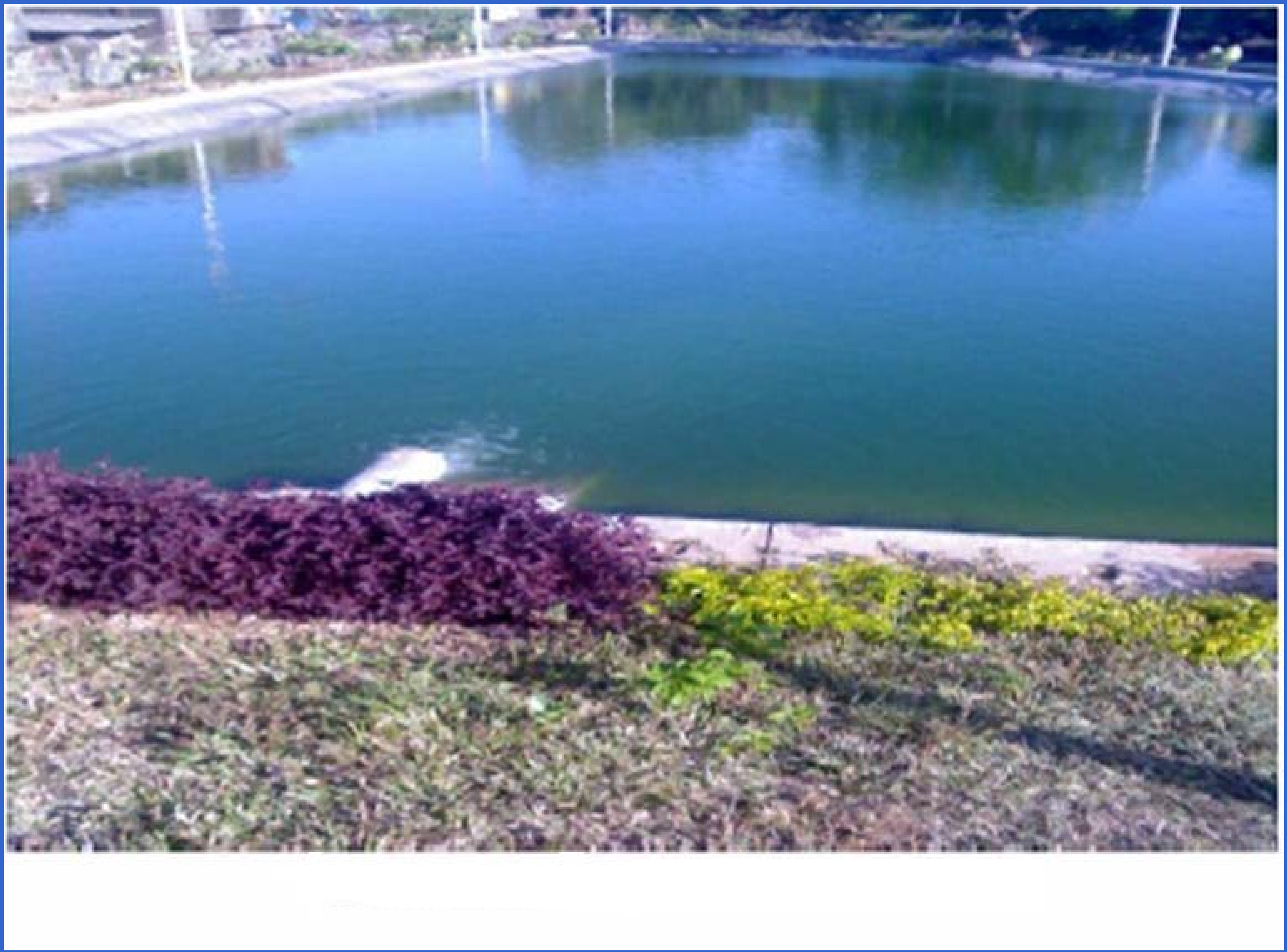
25 KLD plant at Godrej, Pondicherry

75 KLD plant atFRLHT Hospital, Bengaluru

3000 KLD plant at BMC (Worli), Mumbai

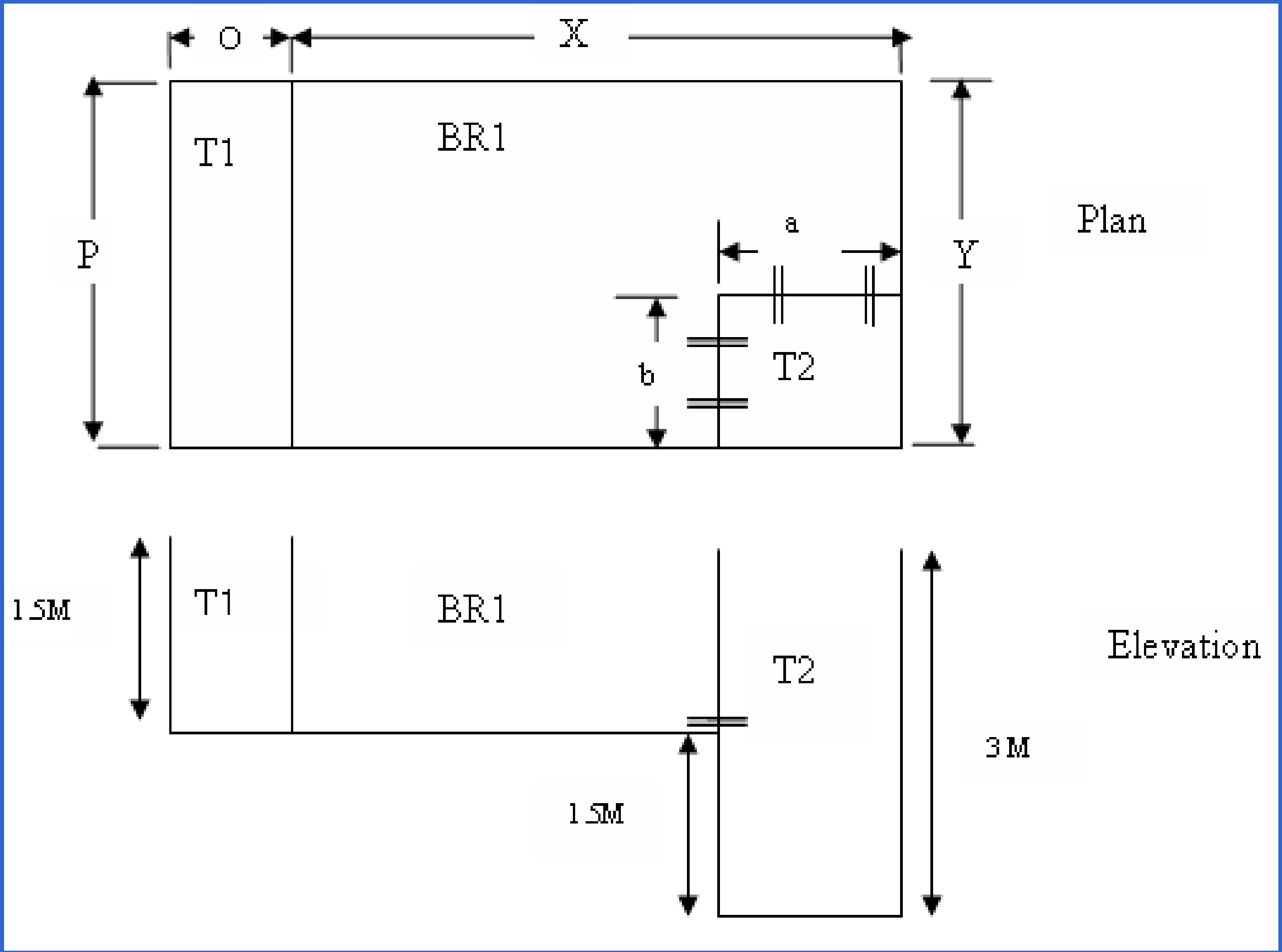
Renovation of wastewater from toilet, bath, wash, kitchen etc. for a handicapped rehabilitation centre

Renovation of septic tank waste water for irrigation in a Research Center

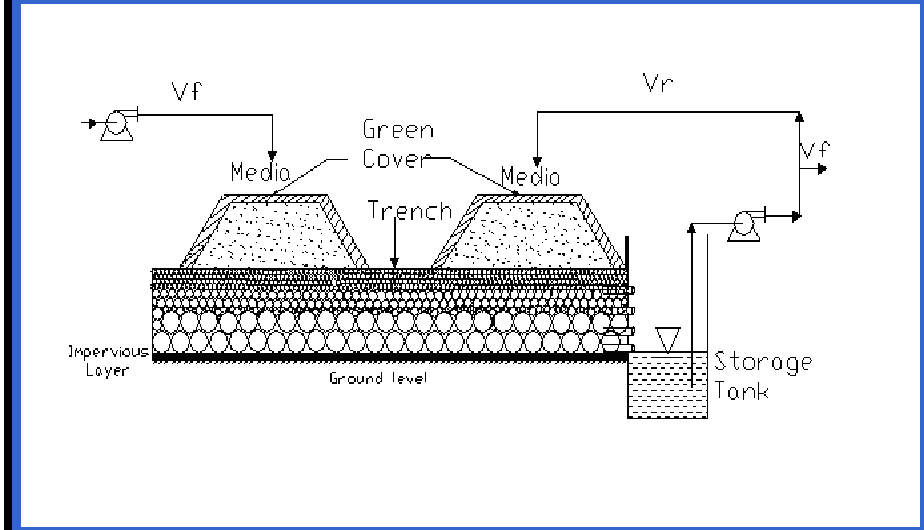


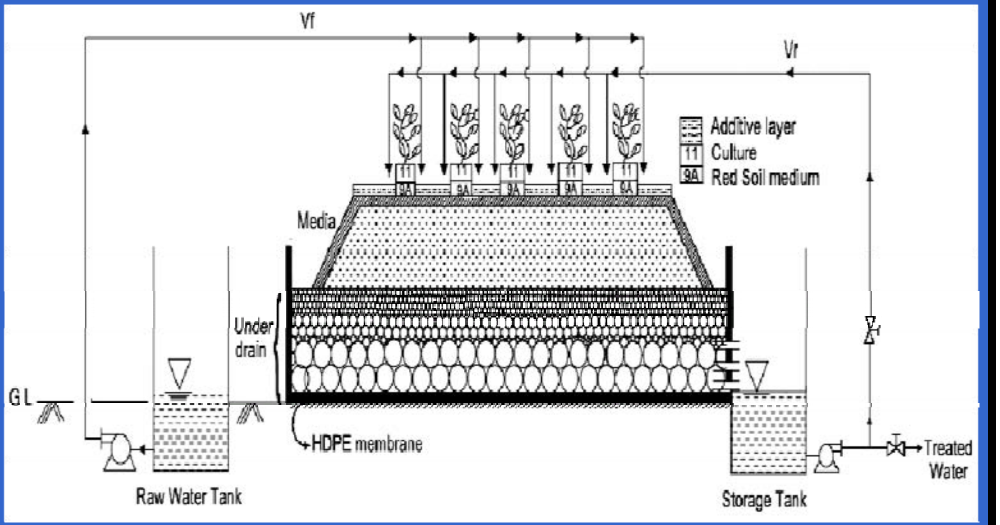
Storage Tank – treated water at BMC being used for race course and marine outfall pump cooling

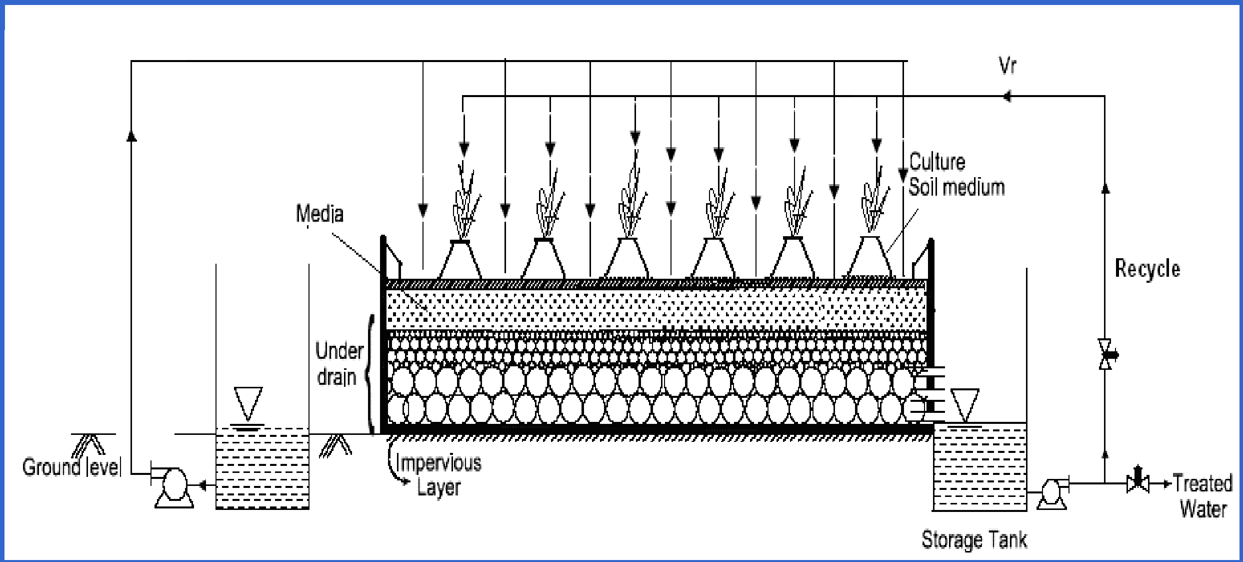
Typical Sketch of Plant



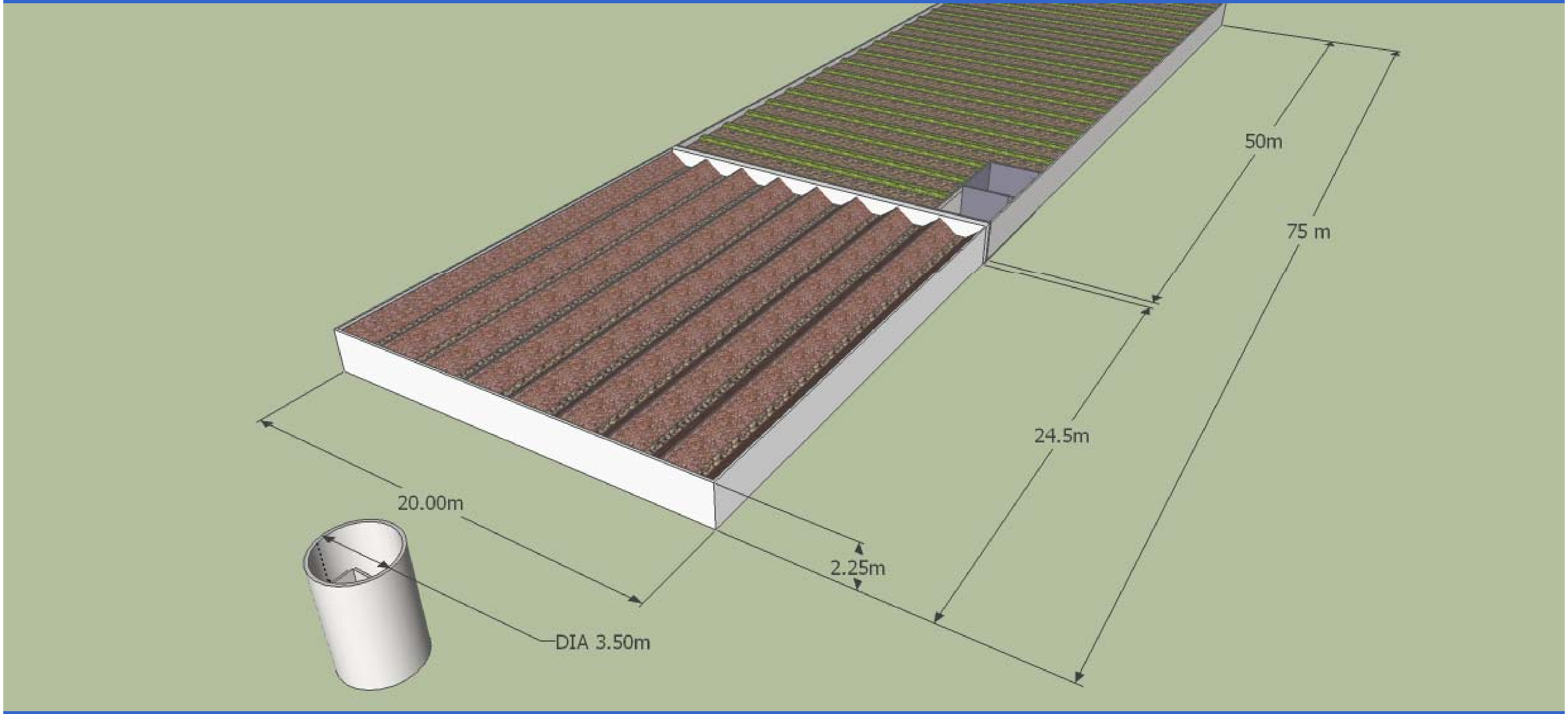
Sectional view of Plants







3D VIEW OF SBT PLANT



MUNICIPAL CORPORATION OF BRIHANMUMBAI
DADAR LABORATORY

Subject: Analytical report of samples collected from soil based technology plant at LGP.

SBT plant at LGP is monitored regularly for assessing its performance in terms Its effluent quality. So 2 nos. of samples were collected from SBT plant at LGP. The raw Sample & the sample after treatment were analyzed for the following parameters.

The results are tabulated as follows.

Date of sampling: 31/08/2007

Sr.No.	PARAMETERS	RAW	FINAL
1	COLOUR	Sewagew	Clear
2	pH	7.1	7.3
3	TSS	N.D.	N.D.
4	D.O.	B.DL.	6.4
5	BOD	75	1.4
6	COD	344	16
7	CHLORIDES	156	114
8	FREE NH_3	10.64	B.D.L.
9	OIL & GREASE	B.D.L.	B.D.L.

All parameters except PH are expressed in mg/L.
B.D.L.- Below detection limit.
N.D.- Not done due to some technical reason.

Submitted for your information please.

2/10/07
Supdt. Chemist(Dadar Lab)

(8)10/7
Ex.Eng.Mech.(S)City-I

कार्य. अभि. यां. (शह.) शहर-1/ 3336 19 OCT 2007

Ch.E.(S.O)
CC to E.E.Mech.(S)City-I
E.E.Mech.(S)City-II
O/C Laboratory

A. E. (LGP) I
A. E. (LGP) II
A. E. (Colaba)
K. E. (LGP)

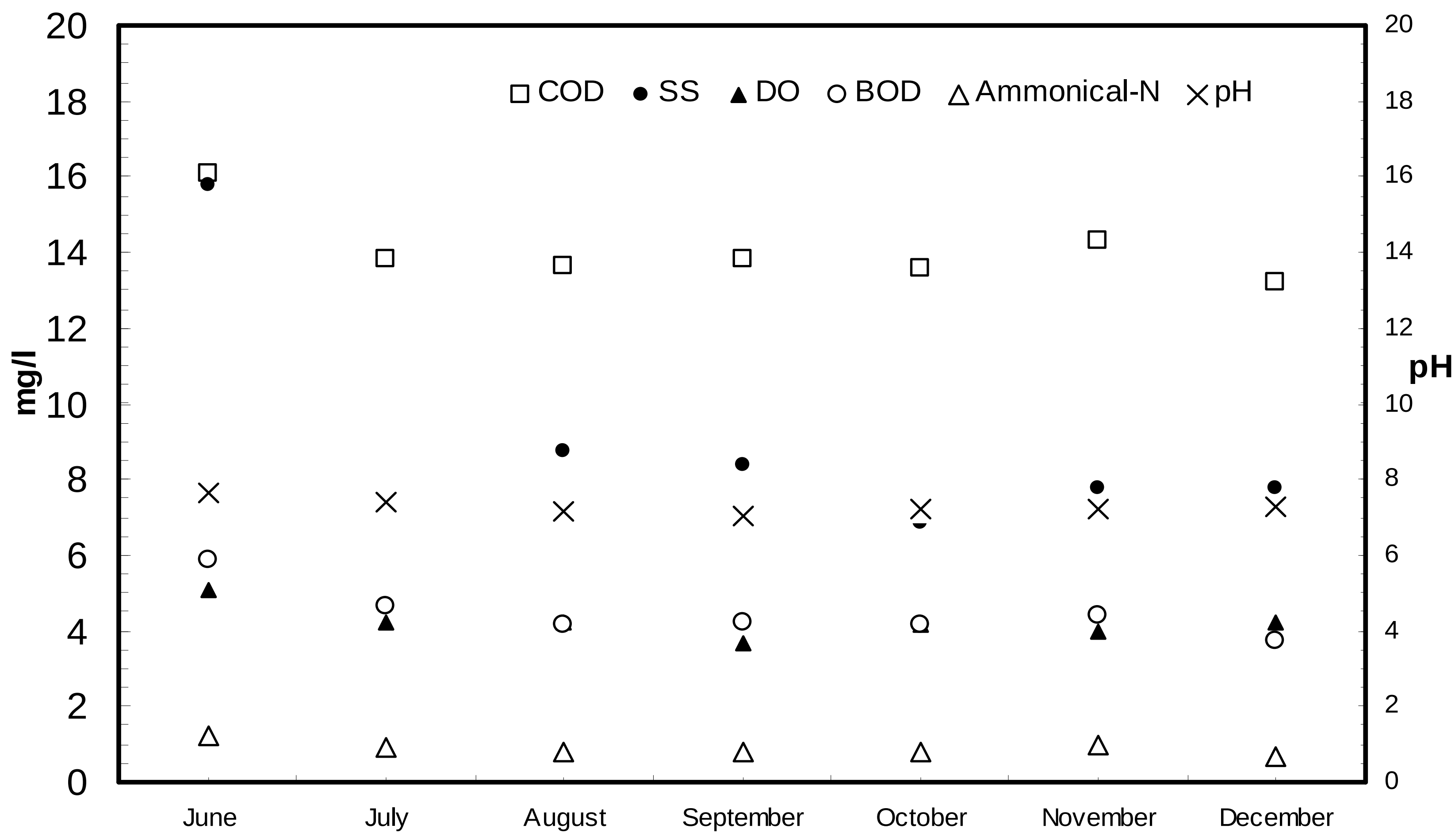
22 OCT 2007

23 OCT 2007
2006

Physicochemical Performance of Plant

Parameters	Influent	Effluent
pH	6.8 - 7.1	7.3
SS (mg/l)	78 - 293	9.0
DO (mg/l)	ND - 2.8	4.2
COD (mg/l)	186 - 360	14.1
BOD (mg/l)	64 - 130	4.4
Turbidity (NTU)	46 - 148	0.4
TDIS (mg/l)	1030 - 1786	644.1
Ammoniacal-N (mg/l)	9.3 - 3.4	0.9
TKN (mg/l)	11.2 - 23.1	1.6
Orthophosphate-P (mg/l)	0.47 - 3.44	0.05

Performance Variation of Plant

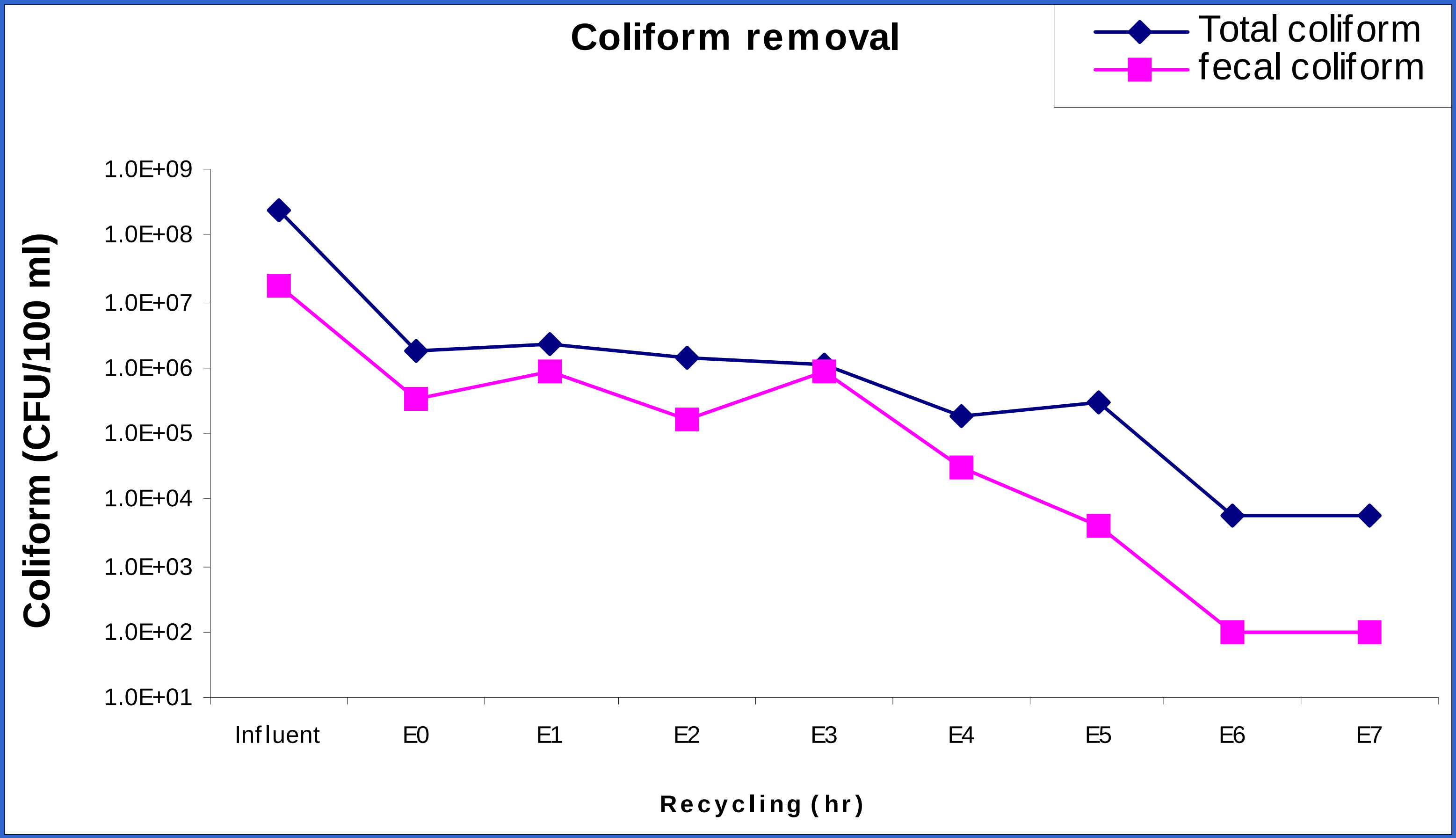


Performance of plant over a period of six months

Microbial Performance of Plant

	Total coliform		Fecal coliform	
Month	Influent CFU/ 100 ml	Effluent CFU/ 100 ml	Influent CFU/ 100 ml	Effluent CFU/ 100 ml
Jun		110		55
July		4.4×10^4		2.5×10^3
Aug		8.2×10^3		3.5×10^3
Sep	3.5×10^8 to 1.5×10^{10}	7.9×10^3	1.7×10^6 to 1.45×10^7	3.3×10^3
Oct		1.7×10^4		1.3×10^3
Nov		1.5×10^4		1.1×10^3
Dec		3.7×10^4		1.9×10^3
Avg		2.6×10^4		1.5×10^3

Coliform Removal



Effect of recycling on micro-organism removal;
E0: Effluent 0 hr, E1: Effluent 1 hr etc Kadam., (2005)

Nitrogen Removal

Process	COD (mg/l)		NH_4-N (mg/l)		NO_2-N (mg/l)		NO_3-N (mg/l)		Total Nitrogen (mg/l)	
	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff
IA	250	80	43	9	0	0.1	0	2	43	11.1
IB	137	9.4	25	2.9	0.1	0.0	2	0.7	27.1	3.6
IIA	250	80	43.5	9	0	0.1	0	3	43.5	12.1
IIB	102	3.5	15	2.2	0.05	0.0	3	0.7	18.0	2.9
IIIA	250	80	43.5	8	0	0.1	0	2	43.5	10.1
IIIB	170	15	33	3.8	0.04	0.0	2	0.5	35.0	4.3

Iron Removal

Initial iron (mg/l)	Residual iron (mg/l)	Total dissolved solids (mg/l)	EC (µS/cm)	pH
5.0	0.128	113	170	7.45
5.0	0.09	111	168	7.36
5.0	0.08	110	163	7.28
5.0	0.07	109	162	7.20
5.0	0.06	109	162	7.12

*Drinking water Standard is 0.3 mg/l

Arsenic Removal

Initial Arsenic (µg/l)	Initial Phosphate (mg/l)	Residual As(V) µg/l	Residual Phosphate mg/l	Arsenic Removal %
300	5	7	0.31	98.3
300	5	6	0.28	98.3
300	5	7	0.30	98.6
300	5	6	0.26	98.3
300	5	7	0.27	98.6
300	5	7	0.26	98.6

*WHO, Drinking water Standard is < 10 µg/l; < 50 µg/l (India)

ABOUT VISION EARTHCARE

A company in SINE

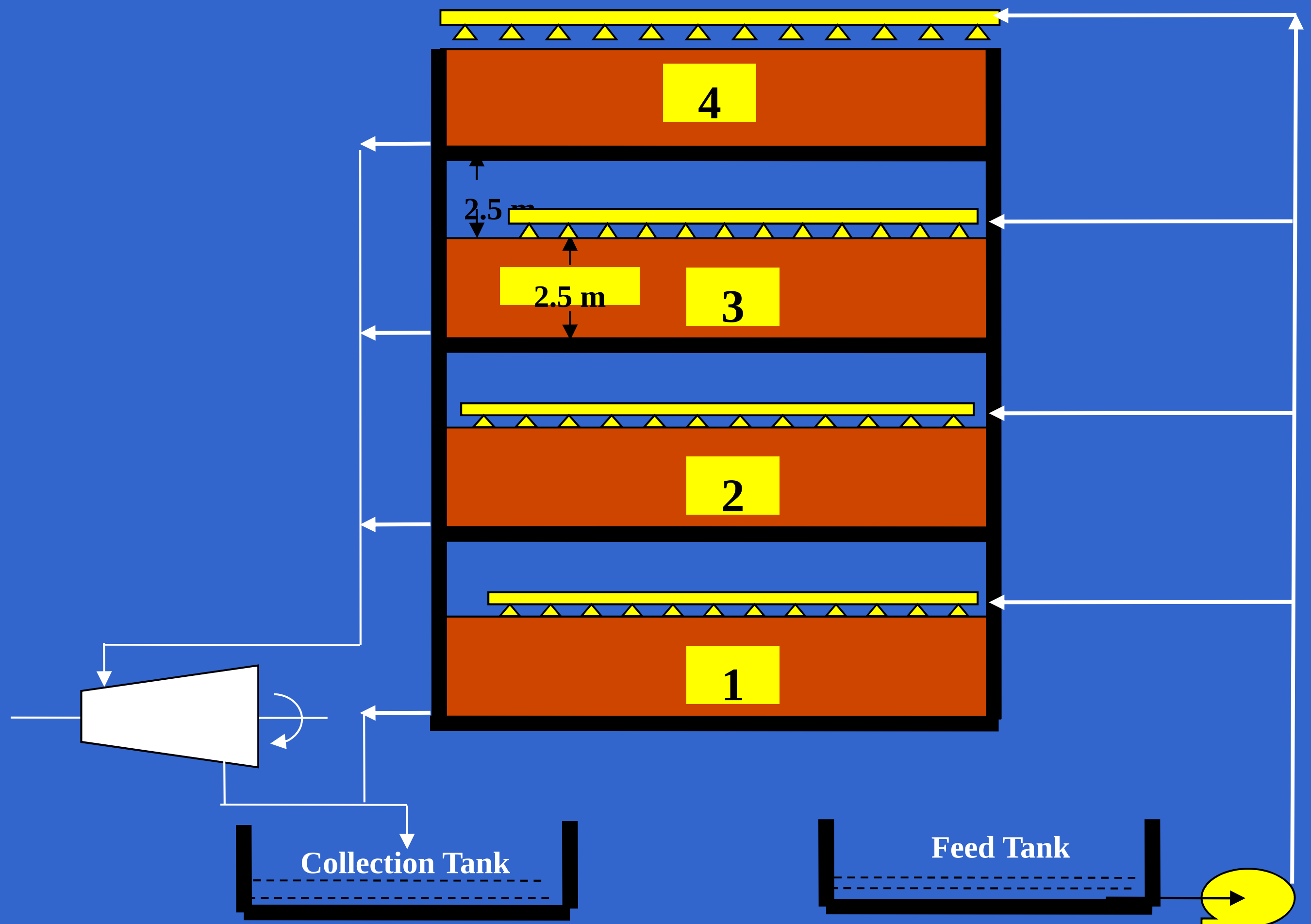
SINE is Innovation Centre of IITB

SINE Was Set Up 2005

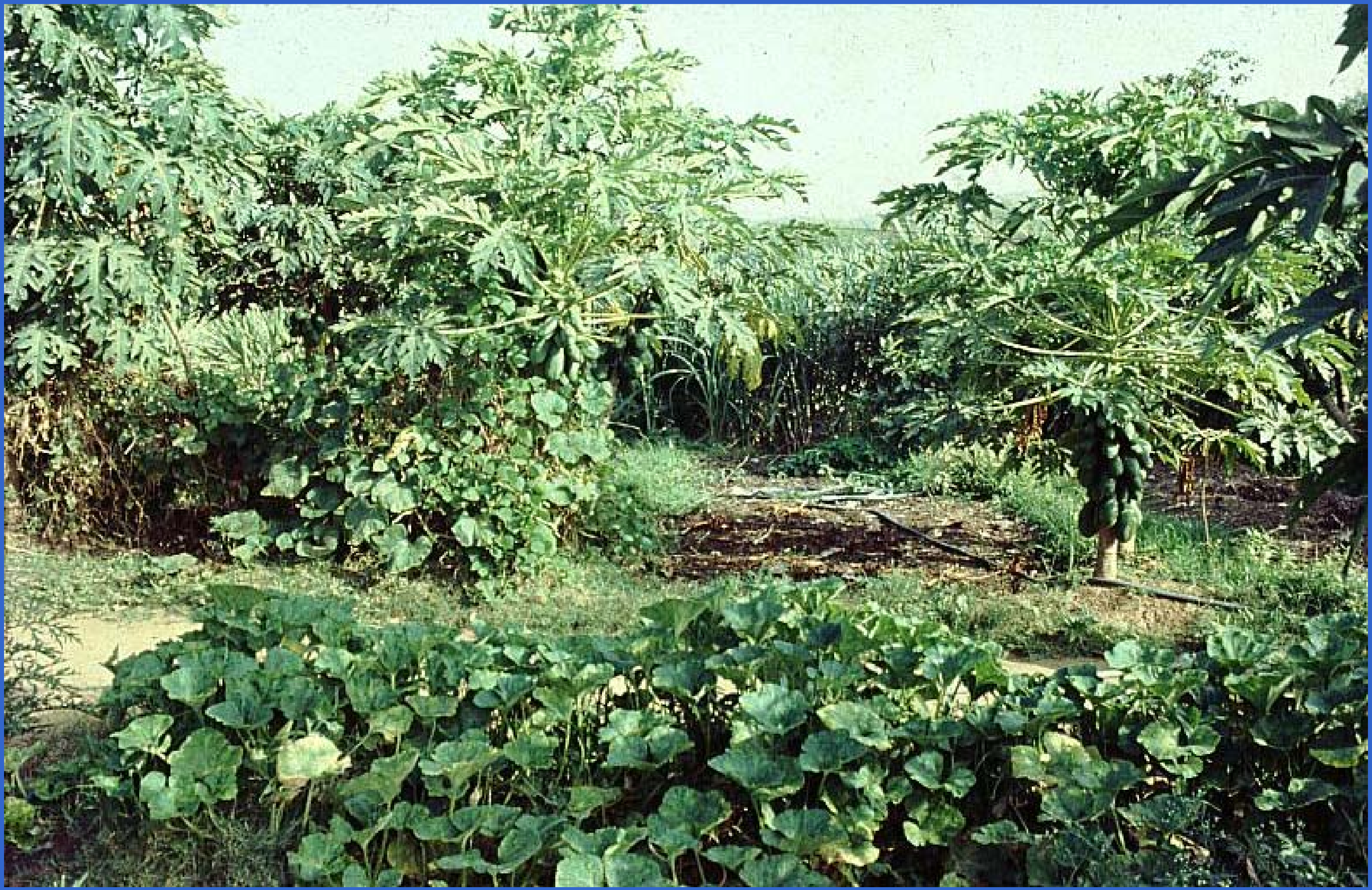
SINE is Supported by GOI

Other Offerings ?

Multistage Operation

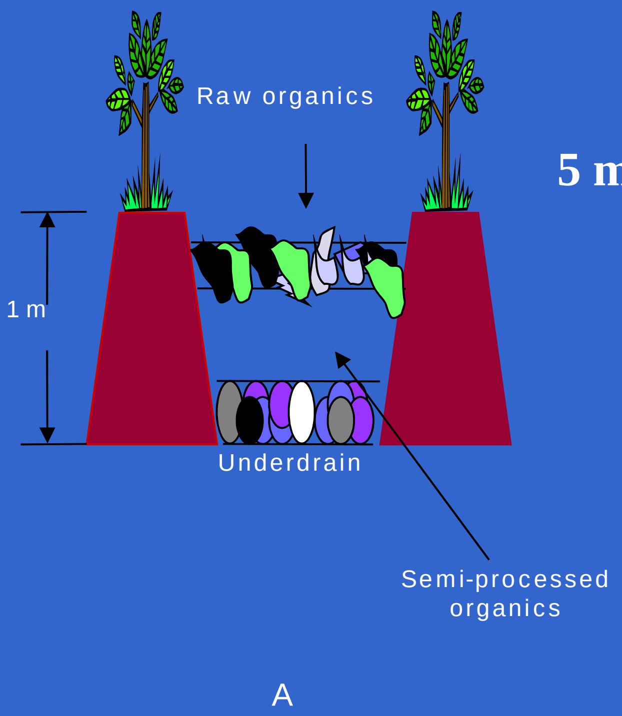


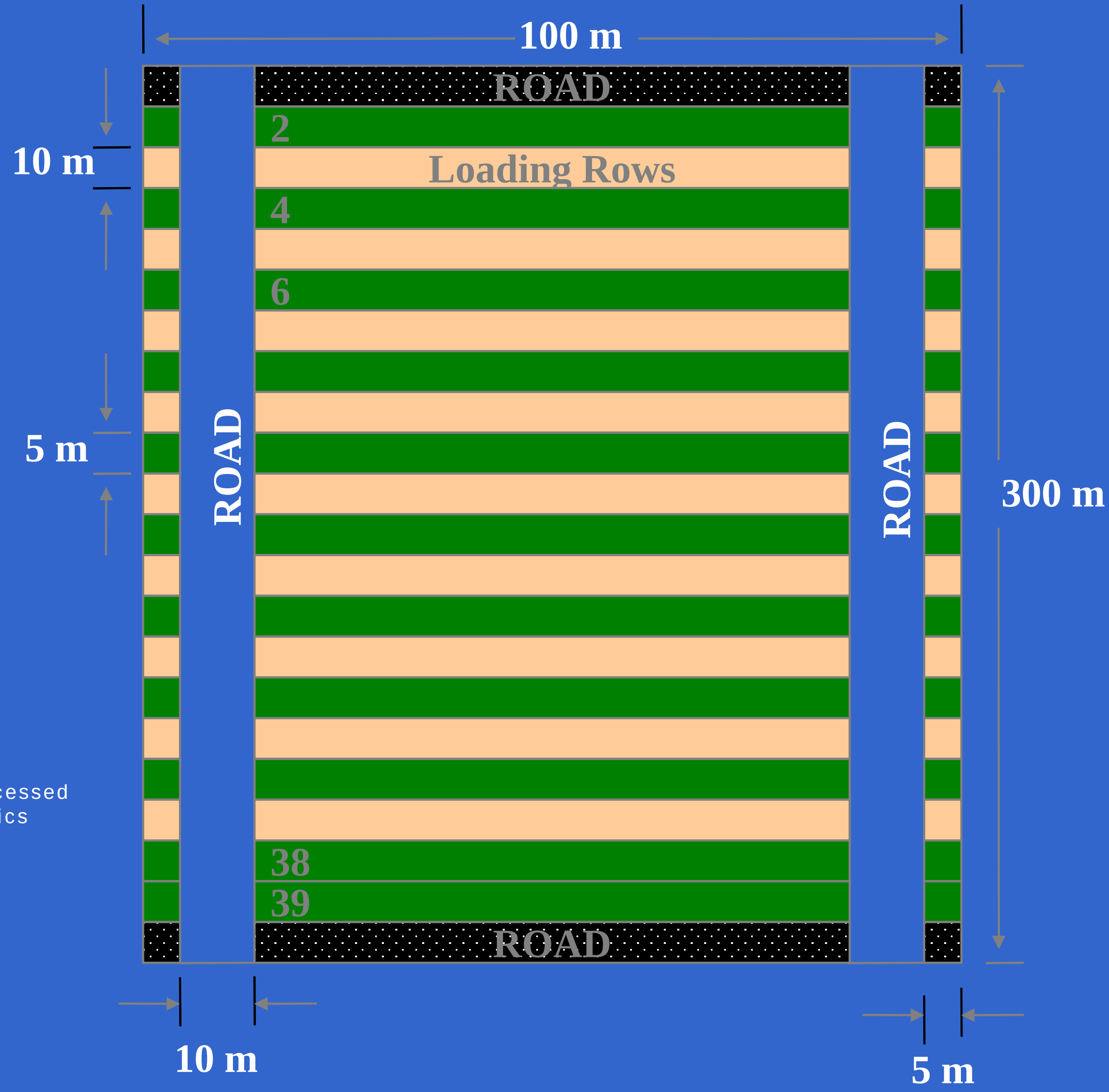
Plant



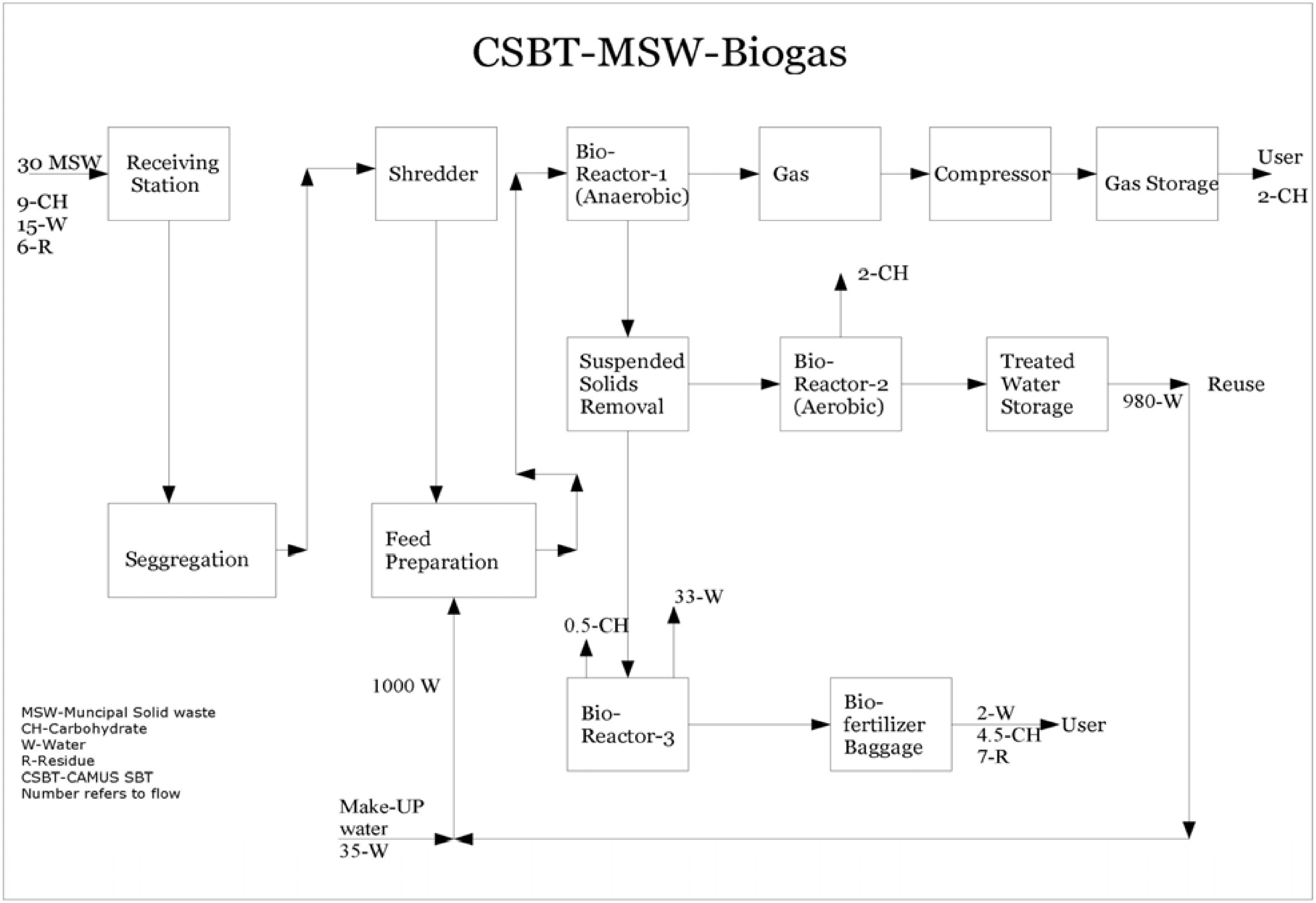
Close up of hospital solid waste processing

ORGANIC RESIDUE PROCESSING

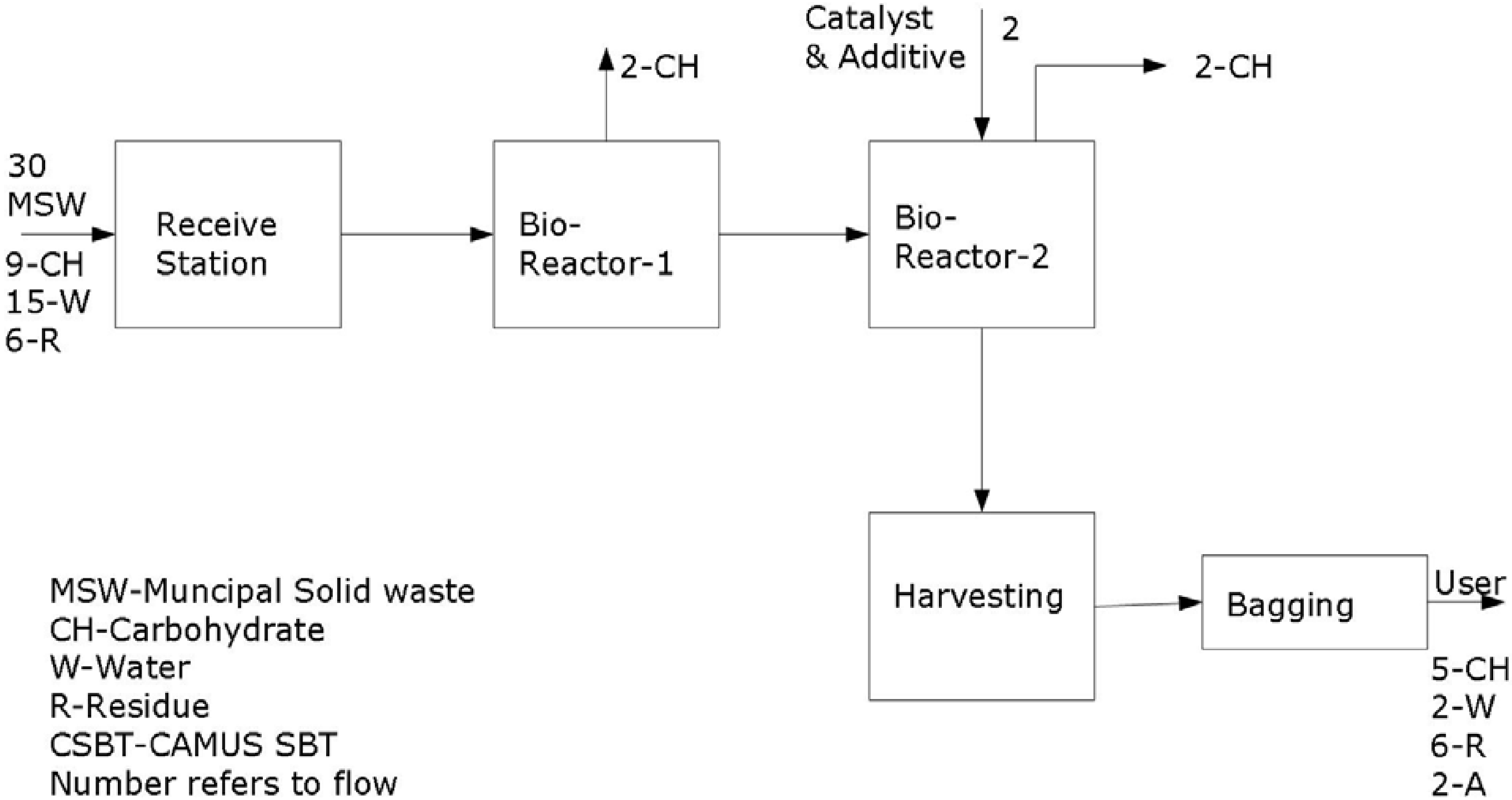




Schematic of organic residue processing.


CSBT-MSW-Biogas
30 MSW
9-CH
15-W
6-R
Receiving Station
Seggregation
Shredder
Feed Preparation
Bio-Reactor-1 (Anaerobic)
Gas
Compressor
Gas Storage
User
2-CH
Suspended Solids Removal
Bio-Reactor-2 (Aerobic)
2-CH
Treated Water Storage
Reuse
980-W
0.5-CH
33-W
Bio-Reactor-3
Bio-fertilizer Baggage
2-W
4.5-CH
7-R
User
1000 W
Make-UP water
35-W
MSW-Muncipal Solid waste
CH-Carbohydrate
W-Water
R-Residue
CSBT-CAMUS SBT
Number refers to flow

CSBT-MSW Processing



MSW-Muncipal Solid waste
CH-Carbohydrate
W-Water
R-Residue
CSBT-CAMUS SBT
Number refers to flow

CSBT-MSW-Biogas Estimate

#	Item	Cost (Rs. Lakhs)
1.	Civil*	
2.	Electro-Mechanical and Technological consultancy	
	Total (1+2)	410
3.	3-Year O&M Cost**	150
4.	Annual revenue from Bio-gas	130

*-Receiving station existing
**-O&M Includes power cost

CSBT-MSW –Manure Estimate

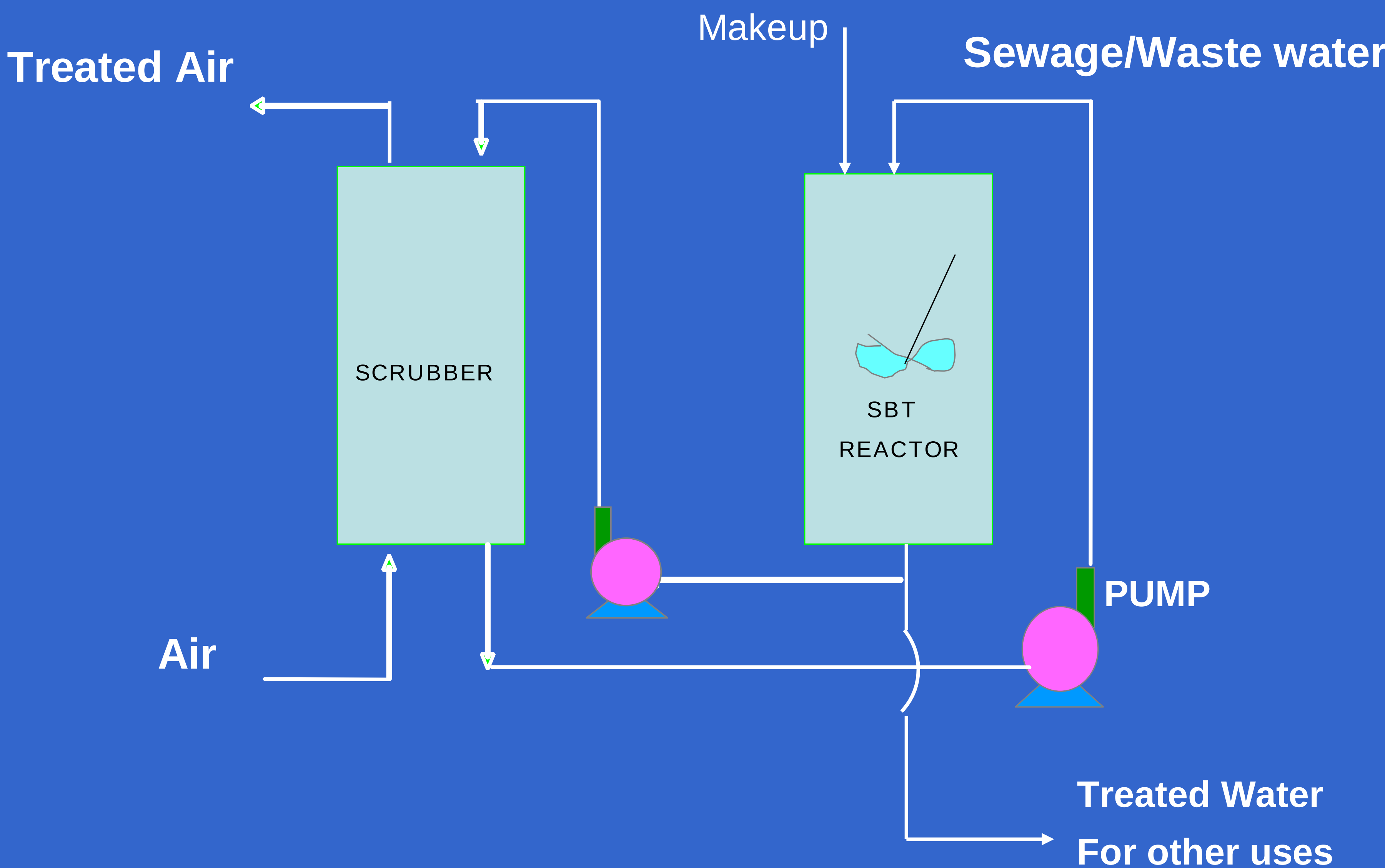
#	Item	Cost (Rs. Lakhs)
1.	Civil*, Mechanical and Electrical, Technological consultancy	225
2.	3-Year O&M Cost**	60

*-Receiving station existing
**-O&M Includes power cost

Contractors

- Ultra Dimensions Pvt. Ltd.
- CH Four, Pune
- Mailhem Engineering Pvt Ltd, Pune
- Vivian Solid Waste Management Pvt. Ltd
- Ramky Enviro Engineering Pvt. Ltd.
- D K Infra Structures.

AIR PURIFICATION



Selection of Completed Works

MJP (GOM 95 Villages under tender)

GOV GUJARAT(In Progress)

Bangalore Municipal Corporation(In Progress)

Ganga Action Plan Uttarakhand (In Progress)

AAI Lucknow Airport 2012

Mumbai Rail Vikas Nigam 2012

BPGC Ltd Bombay 2012

Air Force Hospital Bangalore 2011

FRLHT Hospital Bangalore 2010

AIDS Rehabitalization Bangalore 2010

Selection of Completed Works

Air Force Hospital Bangalore 2011

FRLHT Hospital Bangalore 2010

AIDS Rehabitalization Bangalore 2010

- Airports Authority of India (AAI) – 2008
- BrihanMumbai Municipal Corporation, 2008, 2007, 2005 (Upgradation,O&M, 3000 cu.m/d plant)
- VazirSultan Tobacco, Hyderabad, 2004
- Delhi Travel Tourism Dev Corporation, 2004
- Bombay Presidency Golf Club, 2002 (500 cu. m/day), 1996
- Naval Housing Colony, Mumbai, 2002

ABOUT VISION EARTHCARE

A company in SINE

SINE is Innovation Centre of IITB

VEC Commenced operation 2006

Based on SBT Technology of IITB

About 30 plants in operation

Revenue 2010 INR 14 million

Order on hand 2011 INR 40 million

CEO is Dr. Chandrashekar (PhD UMICH)

Film : India Innovates

(Min. of Ext. Affairs)

http://www.youtube.com/watch?v=dKWVtZ81mY0

Thank You

120 Cu M Plant at M P. Airport, AAI, Udaipur, Rajasthan

Patents

- US Patent No: 6890438 " Process for treatment of organic wastes" H.S.Shankar, B.R.Patnaik, U.S.Bhawalkar, issued 10 May 2005

- US Patent No 7604742 B2 Soil Conditioning products from organic waste H.S.Shankar, B.R.Patnaik,U.S.Bhawalkar, issued October 2009

- Indian patent no 203425 " Process for Water and waste waterwaste water renovation " , H.S.Shankar,B.R.Patnaik,U.S.Bhawalkar , issued 12 December 2006

- Indian patent no 203744 Process for treating organicsolid wastes, Patnaik, B.R., Bhawalkar, U.S., Shankar, H.S., issued 8 January 2007

SBT Preliminary Financial Highlights

Smaller capacities capex scales capacity **0.5
Smaller capacities Opex scales inversely as capacity ** 0.5
Smaller capacities space scales as capacity **0.5

Capacity (MLD)	1	5
Outlet water quality **(mg/lit)	BOD < 10 COD < 60	BOD < 10 COD < 60
Investment (Rs Cr)	1.4	5.5
O&M (Rs/1000 Litres)	3	2
Area (ha) **	0.15	0.60
Process Power (kWH/1000 Lit)	0.02	0.02

** or as desired per site ; space landscaped green as desired
Earthbundh Civil Structures /equivalent
ha = 10000 sqm ; MLD million Litres per day

Comparison of Power Consumption

Process	kWh/1000 gallons
SBT **	**0.12**
Activated sludge Process*	2.00
Membrane Bioreactor*	5.00
Moving Bed Bioreactor*	2.00
Fluidized Bed Bioreactor*	3.00

- ***Aquatic environment**
- ****terrestrial environment**

OTHER TECHNOLOGIES

Moving Bed Bio Reactor

Sequencing Batch Reactor

Fluidized Aerobic Bioreactor

Membrane Bioreactor

Activated Sludge Process

Oxidation Pond

Upflow Sludge Blanket Bioreactor

Recent Publications

- Kadam,AM,Ojha,Goldie.,Nemade,P.D.,Shankar,H.S(2009).Waste water treatment using laterite based constructed soil filter, Ecological Engineering 35(7) 1051-1061

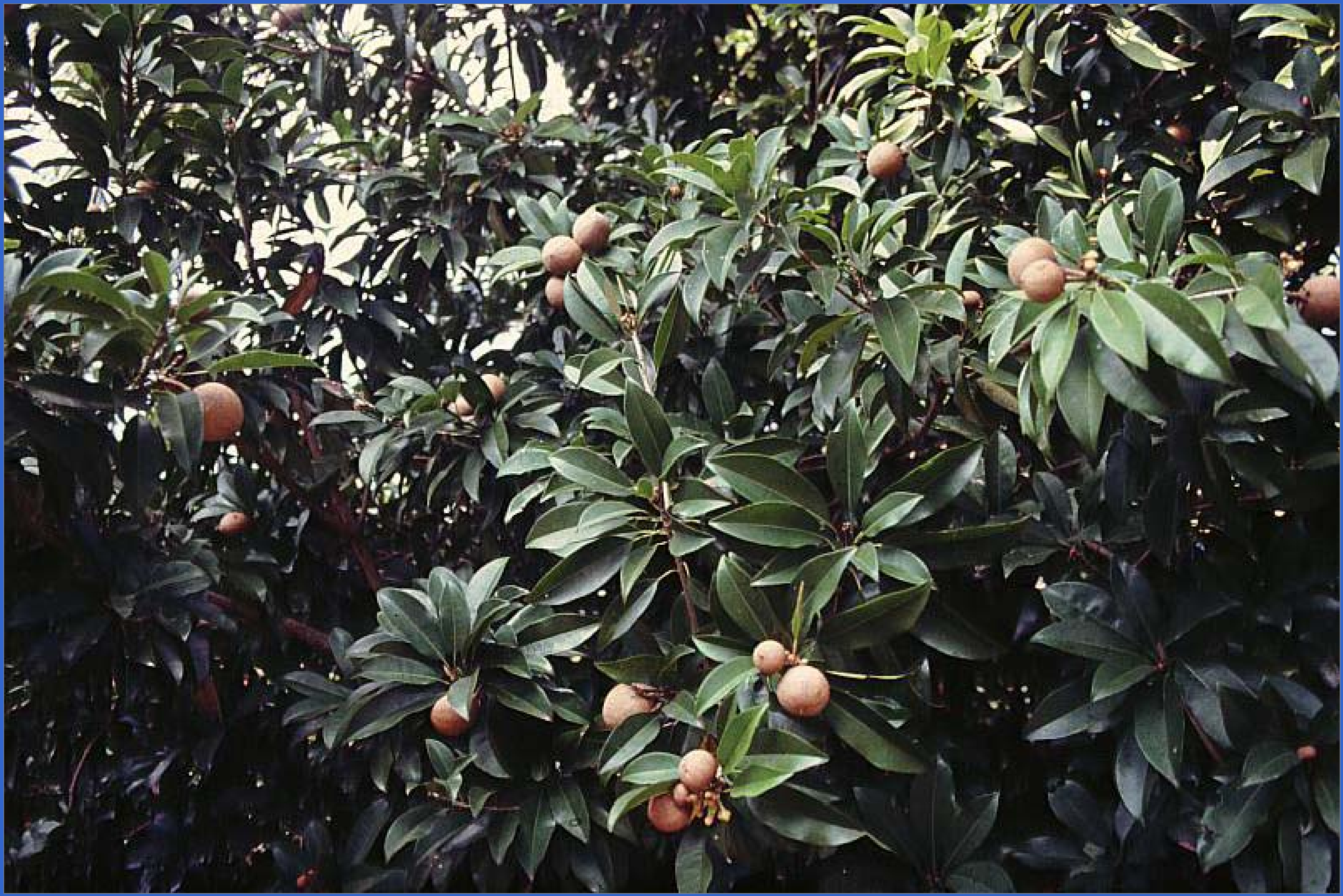
- Nemade,P.D.,Kadam,A.M.,Shankar,H.S.(2009),Remediation of aresenic and iron contaminated ground water using novel constructed soil filter system, Ecological Engineering , 35, 1152-1157

- Kadam,A.M.,Oza,G.H.,Nemade,P.D.,Dutta,S.,Shankar,H.S.,Shankar,H.S .(2008) Municipal waste water treatment using novel constructed soil filter system,Chemosphere,975-981

- Kadam,A.M.,Oza,G.H.,Nemade,P.D.,Shankar,H.S.,Shankar,H.S.(2008) Pathogen removal from municipal waste water treatment using novel constructed soil filter system,Ecological Engineering, 33(1)37-44

Recent Publications

- **Patnaik, B.R., Bhawalkar, U.S., Gupta, A., Shankar, H.S., "*Residence Time Distribution model for Soil Filters, Water Environment Research, 76(2), 168-174,2004*"**
- **Patnaik, B.R., Bhawalkar, U.S., Shankar, H.S., "*Waste Processing in Engineered Ecosystems*", 4th World Congress on Chemical Engineering, 23-27, September 2001, Melbourne, Australia**
- **Patnaik, B.R., Bhawalkar, U.S., Kadam, A, Shankar, H.S., "*Soil Biotechnology for Waste Water Treatment and utilization*", 13th ASPAC 2003, International Water Works Association Conference 13-18, October, 2003, Quezon City, Philippines**



Chickoo plant after SBT restoration of soil

Chickoo plant affected by fungal disease

SBT Features

- Very Low Life Cycle Cost
- Very Long Life
- Very Low Energy Consumption
- Very Low Operating Cost
- All Green Ambience
- Modular & Multi-level and greenhouse Designs
- Water ,waste water, solid waste and air purification
- Reusable Water (Products)
- Green Technology Carbon Credits

PRESENTATION SUMMARY

Lessons from Carbon Cycle

Process chemistry

Media Layout

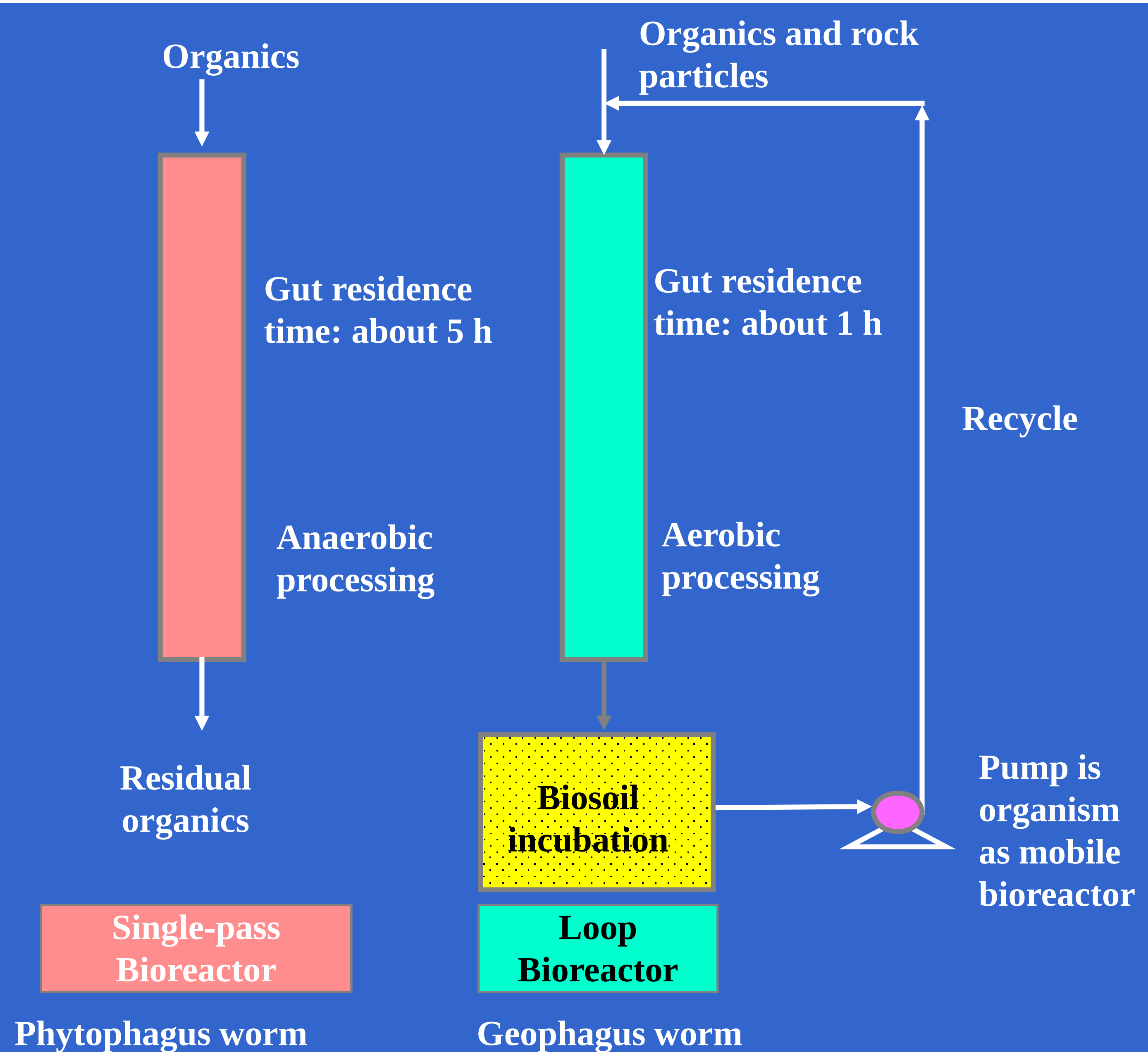
Media design for waste water

SBT Performance in sewage Treatment

Other offerings

Vision Earthcare

SBT Film of GOI



Bioprocessing by the two types of organisms

Source: Bhawalkar (1996)

Media Features

Oxygen Transfer

Residence Time Distribution

Liquid Hold up

Hydraulic Loading

Organic Loading

Nitrogen Fixation

C & N Removal

Efficacy of % media in Bioreactor bed

Experimental Equipment
CSF & CF

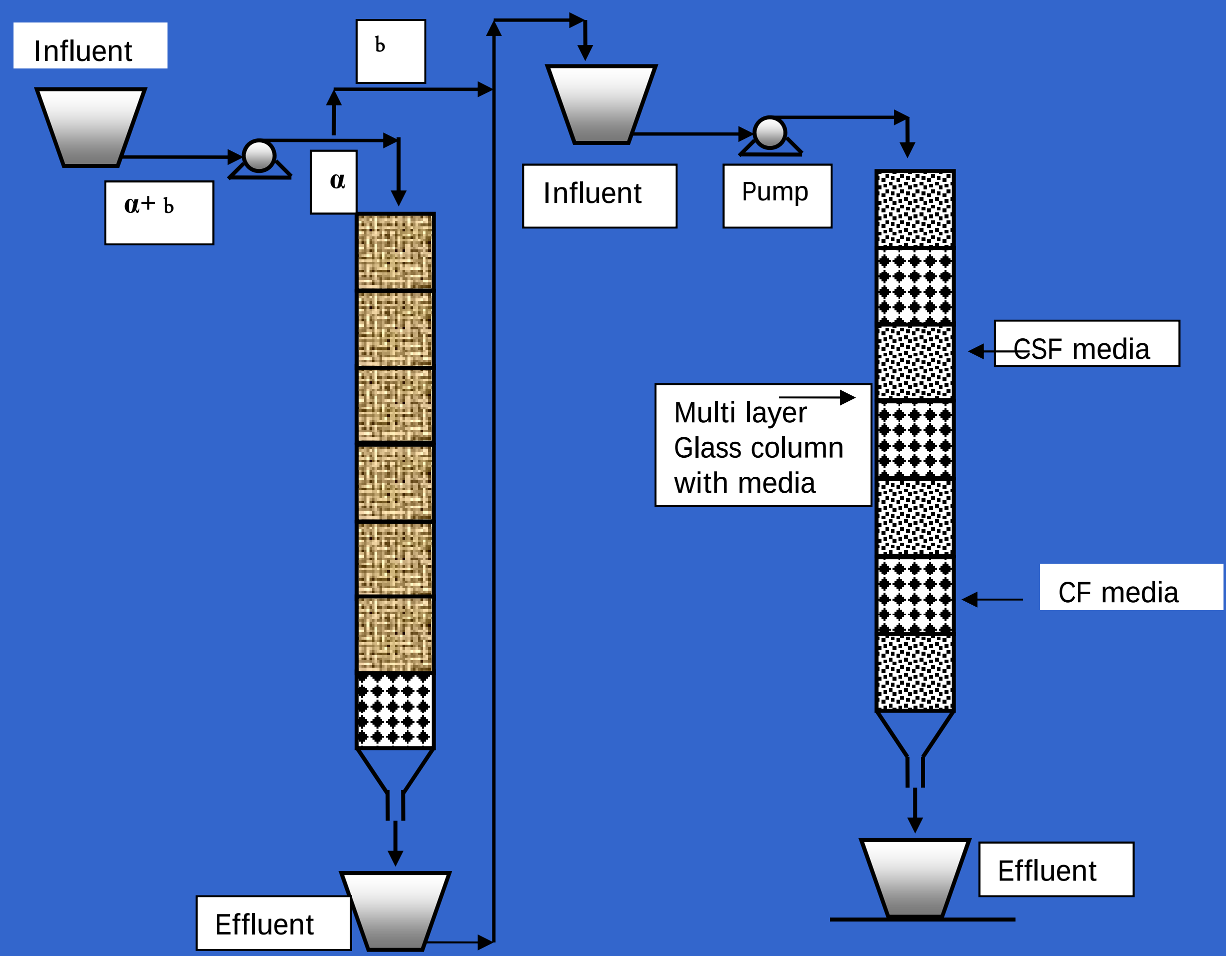
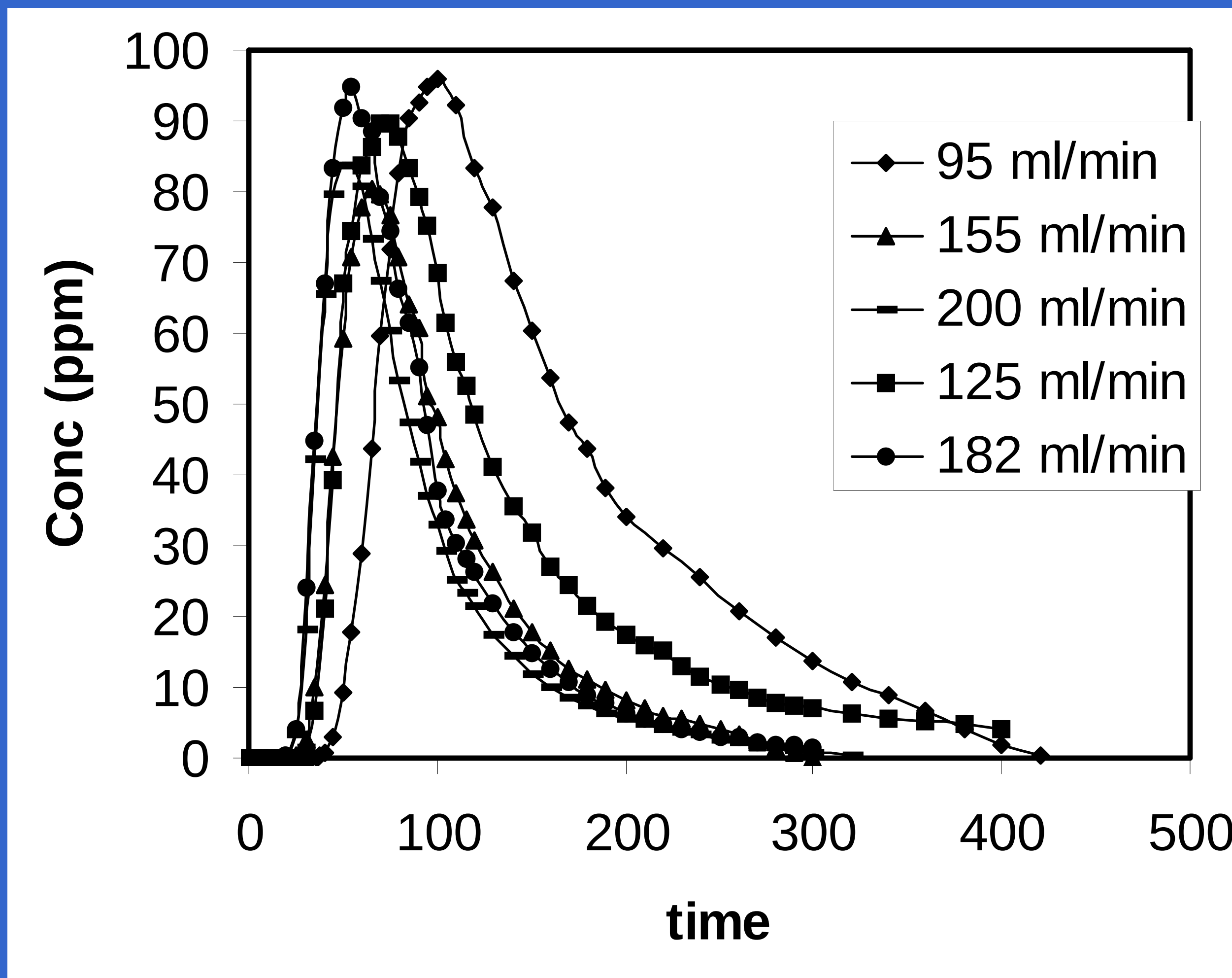


Fig. Plot of concentration of tracer versus time of 2m CSF column of 0.285m diameter , 100 L bed volume, d_n = 9mm



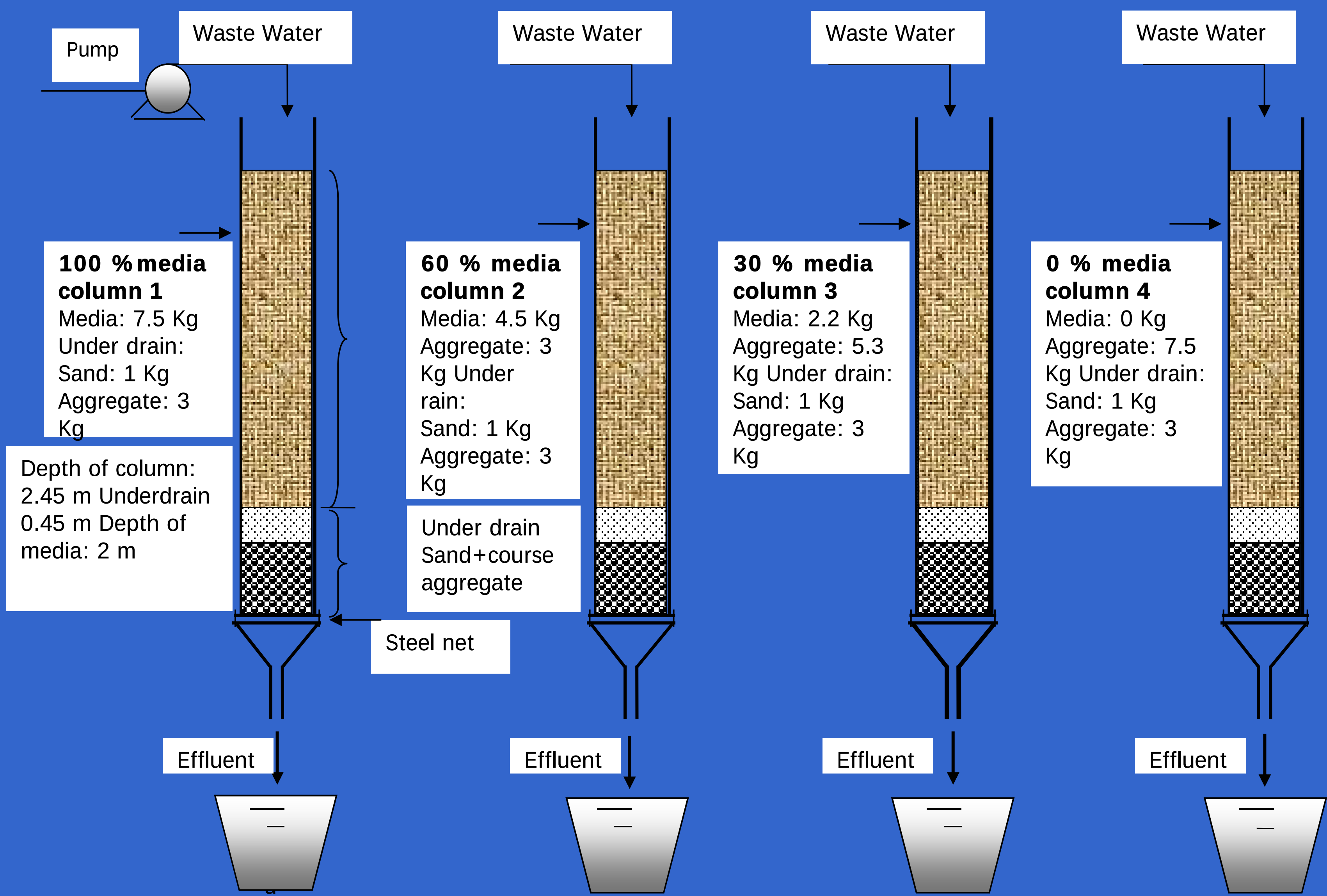
Media Features

To understand features Experiments are performed in 4 CSF reactors each of volume 9L (2 m length and 0.00762m diameter)

Column	% of media
1	100
2	60
3	30
4	0

This study is helpful in the selection of proper media required for the treatment.

Experimental Equipment

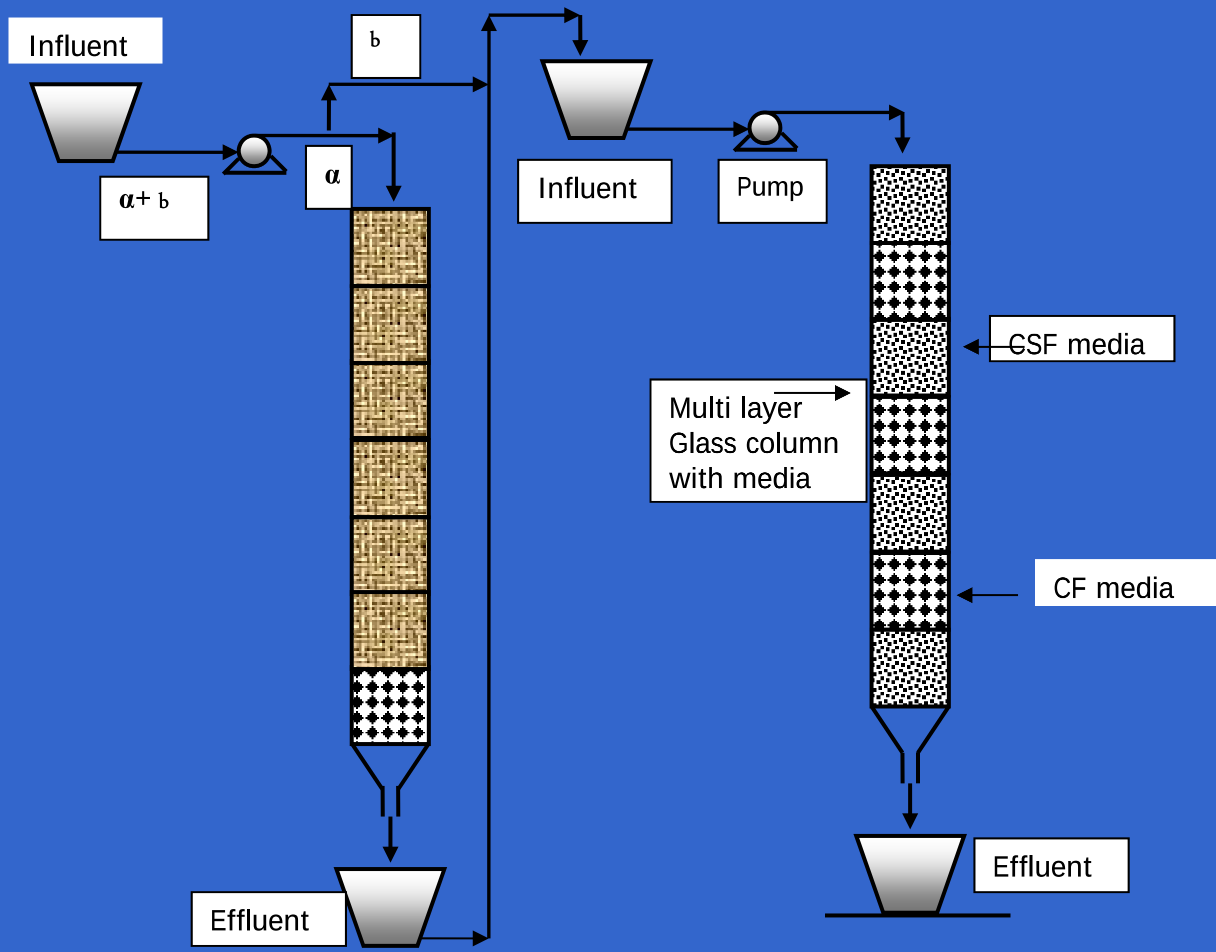


N Fixation

Carbon removal in 9L vessel with 100 % media zero N in feed Showing nitrate production so the considerable ammonia production so considerable oxygen supply at the 4 hr residence time and 0.06 m/hr superficial velocity

Flow rate	60 mL/min		30 mL/min		4 mL/min	
Parameter	Inf	Eff	Inf	Eff	Inf	Eff
$NH\text{-}_4^+$-N (mg/L)	0	1.5	0	0.21	0	2.6
NO_3^--N (mg/L)	0	2.4	0	3	0	9.5
NO_2^--N (mg/L)	0	0.07	0	0.36	0	0.3
COD (mg/L)	250	177.4	250	145.1	250	5

Experimental Equipment
CSF & CF



Carbon and Nitrogen removal in 9L CSF

with varying media

Column	Flow rate (ml/min)	COD (mg/L)		NH_4^+-N (mg/L)		NO_2^--N (mg/L)		NO_3^--N (mg/L)	
		`Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff
1 (100%)	**50**	**250**	**44**	**21.3**	**2.4**	**22.5**	**0.3**	**0**	**11**
2 (60 %)	50	250	176	21.3	3.5	22.5	0.49	0	10.5
3 (30 %)	50	250	198	21.3	4.1	22.5	0.56	0	10.8
4 (0 %)	50	250	237	21.3	7.8	22.5	1.06	0	11.6
1 (100%)	**5**	**250**	**1.5**	**21.3**	**1.1**	**22.5**	**0.1**	**0**	**41**
2 (60 %)	5	250	32	21.3	1.5	22.5	0.15	0	19.5
3 (30 %)	5	250	52	21.3	1.9	22.5	0.72	0	38.5
4 (0 %)	5	250	201	21.3	7.0	22.5	0.87	0	16

Result of oxygen transfer experiment by sodium sulfite oxidation experimental of 2m CSF column, 0.285m diameter, 100 L bed, d_p = 9mm

Run	Q (ml min^{-1})	Hydraulic Loading (cm h^{-1})	Run Time (min)	Initial conc of sodium sulfite (mol L^{-1})	Final conc of sodium sulfite (mol L^{-1})	Oxygen Transfer Rate (g L^{-1} s)	Rate constant (s^{-1})
RS1	80	7.5	80	0.72	0.28	4×10^{-4}	2.16×10^{-5}
RS2	125	11.8	80	0.69	0.29	3.2×10^{-4}	2.67×10^{-5}
RS3	180	16.9	70	0.55	0.29	2.9×10^{-4}	2.16×10^{-5}
RS4	220	20.7	70	0.46	0.26	1.6×10^{-4}	2.24×10^{-5}

Result of physical oxygen transfer experiment by DO experimental of 2m CSF column, 0.285m diameter , 100 l bed, dp = 9mm

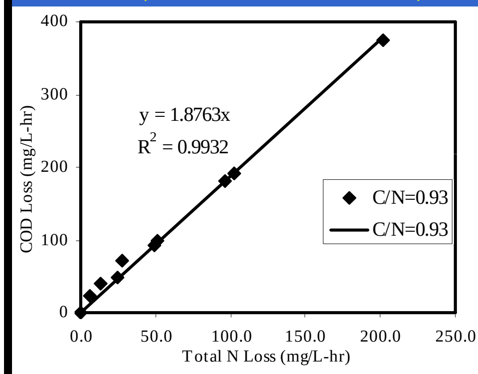
Run	Q ($mL\ min^{-1}$)	Hydrau. Loading ($cm\ h^{-1}$)	Run Time (min)	Inlet DO (mgL^{-1})	Outlet DO (mgL^{-1})	Oxygen Transfer Rate ($g\ L^{-1}\ s$)	Rate constant (s^{-1})
RP1	80	7.5	90	0.55	5.85	7.1×10^{-8}	1.69×10^{-5}
RP2	105	9.9	90	1.04	5.33	7.5×10^{-8}	1.70×10^{-5}
RP3	140	13.2	90	1.13	5.62	1.1×10^{-7}	2.63×10^{-5}
RP4	185	17.4	90	0.22	5.82	1.7×10^{-7}	3.91×10^{-5}

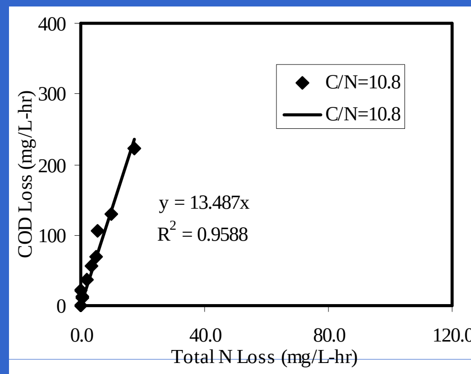
Experimental results and model parameters for RTD studies of 2m CSF column with 0.285m diameter, 100 L bed, dp = 9mm

Run No	Bed (L)	Q (mL min^{-1})	Hydrau. Load (cm h^{-1})	τ (min)	Tracer Recovery %	Hold up (L)	Total Hold up $H=Q\tau$ (L)	α	Pe
R1	**100**	**95**	**8.93**	**155**	**94.3**	**4.4**	**14.72**	**0.7**	**12.1**
R2	**100**	**125**	**11.76**	**133**	**96.6**	**5**	**16.62**	**0.6**	**9.7**
R3	**100**	**155**	**14.58**	**102**	**94.1**	**5.3**	**15.81**	**0.7**	**10.1**
R4	**100**	**182**	**17.12**	**91**	**90.2**	**5.5**	**16.56**	**0.6**	**12.3**
R5	**100**	**200**	**18.81**	**90**	**93.0**	**5.7**	**18**	**0.6**	**11.5**

Relationship between Total N loss to COD Loss.

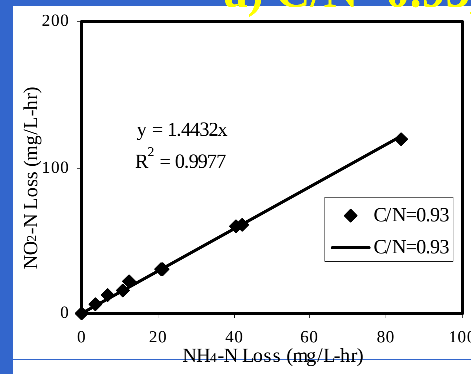
a) C/N=0.93, b) C/N=10.8

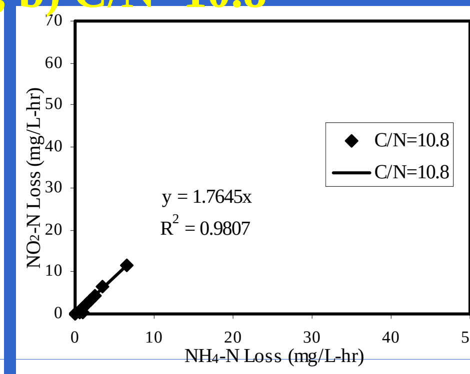




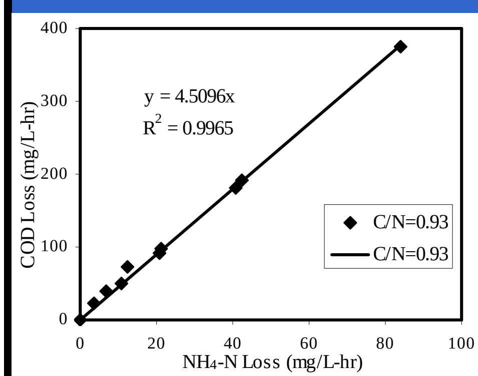
Relationship between NH_4-N loss to NO_2-N loss

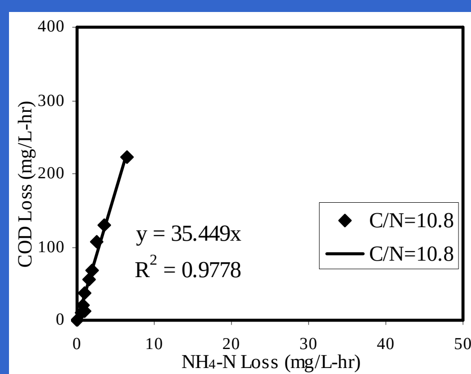
a) C/N=0.93, b) C/N=10.8



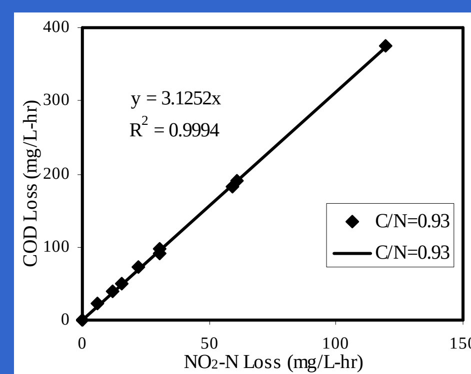


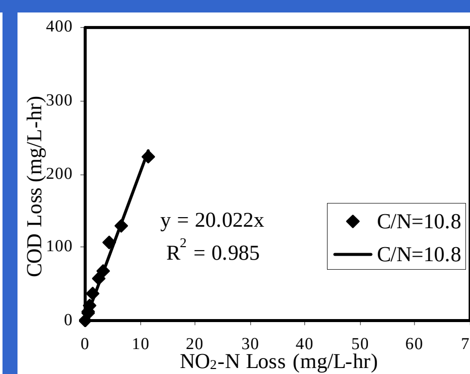
Relationship between NH_4-N Loss to COD Loss
a) C/N=0.93, b) C/N=10.8



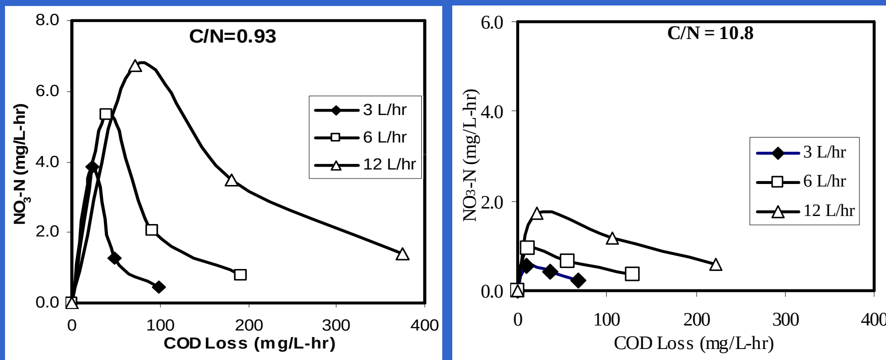


Relationship between NO_2-N Loss to COD Loss
a) C/N=0.93, b) C/N=10.8

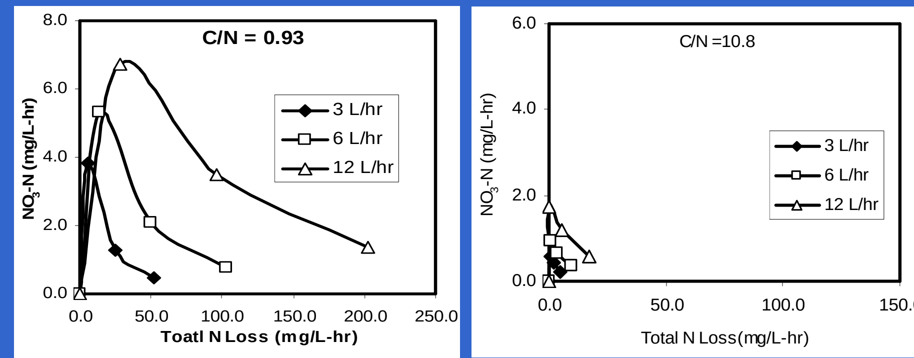




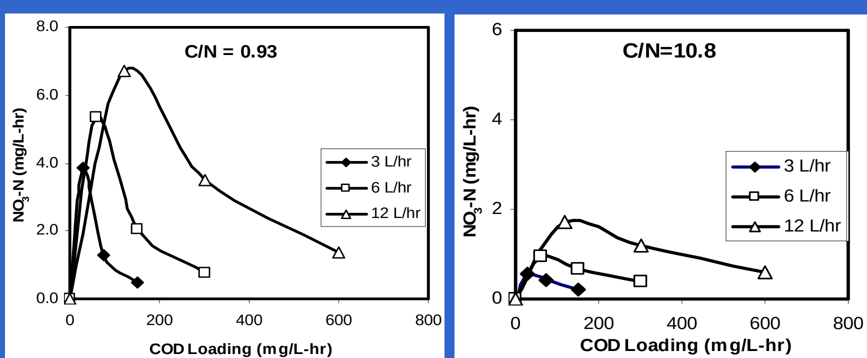
Relationship between COD Loss and NO_3 Production a) C/N=0.93, b) C/N=10.8



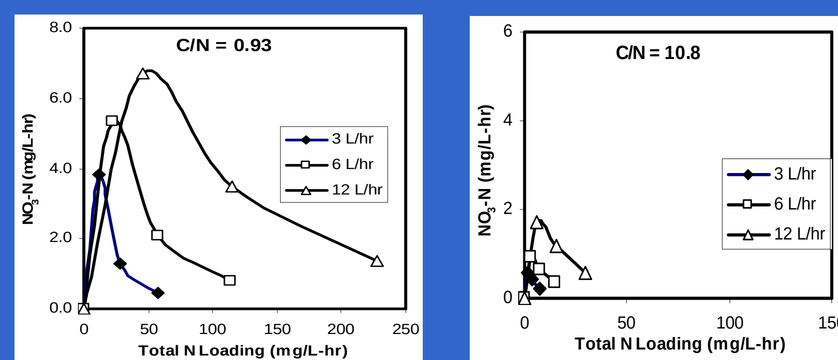
Relationship between Total N Loss and NO_3 Production a) C/N=0.93, b) C/N=10.8



Relationship between COD loading and NO_3 Production a) C/N=0.93, b) C/N= 10.8



Relationship between Total N Loading and NO_3 Production a) C/N=0.93, b) C/N=10.8



Model

The likely reactions are as follows;

1) NO_2^- (A) $\Longleftrightarrow$ NH_4^+ (B) (X1)

2) NO_2^- (A) $\Longrightarrow$ NO_3^- (C) (X2)

3) NH_4^+ (A) + NO_2^- (B) $\Longrightarrow$ N_2 + $2H_2O$ (X3)

- 4) Cell Synthesis (X4)

5) Carbon catabolism (X5)

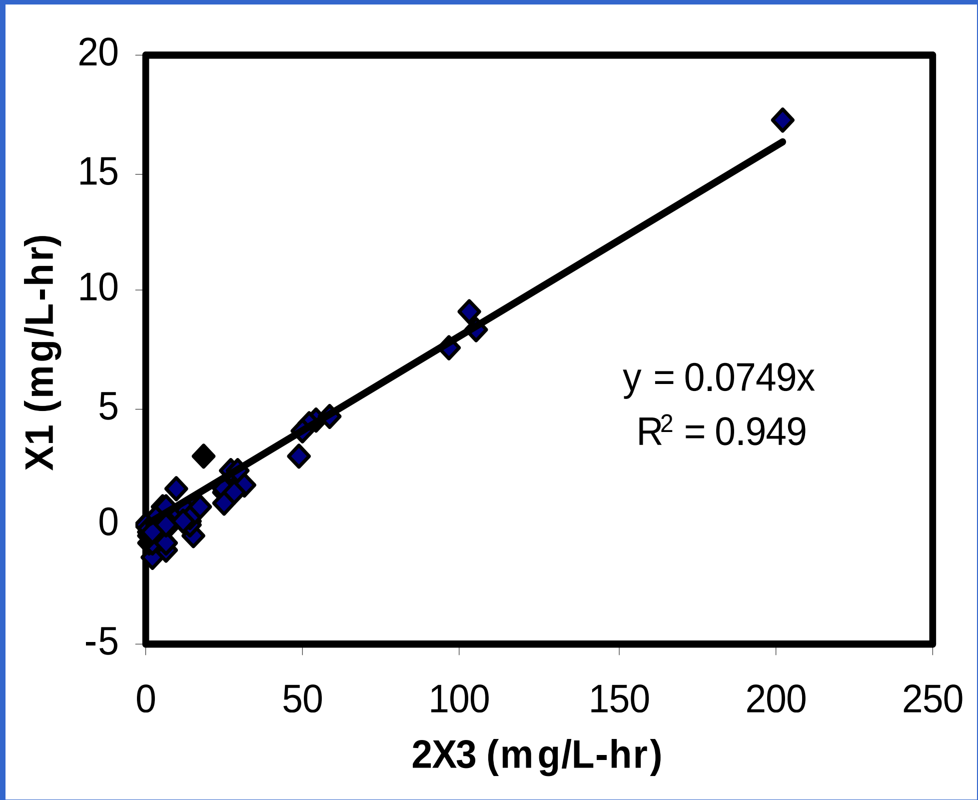
For the above reactions, we get from stoichiometry

X1 = 0.5* F* [(Ao-A) - (Bo - B) +(Co-C)] / Vr,

X2 = F*(C - Co) / Vr ;

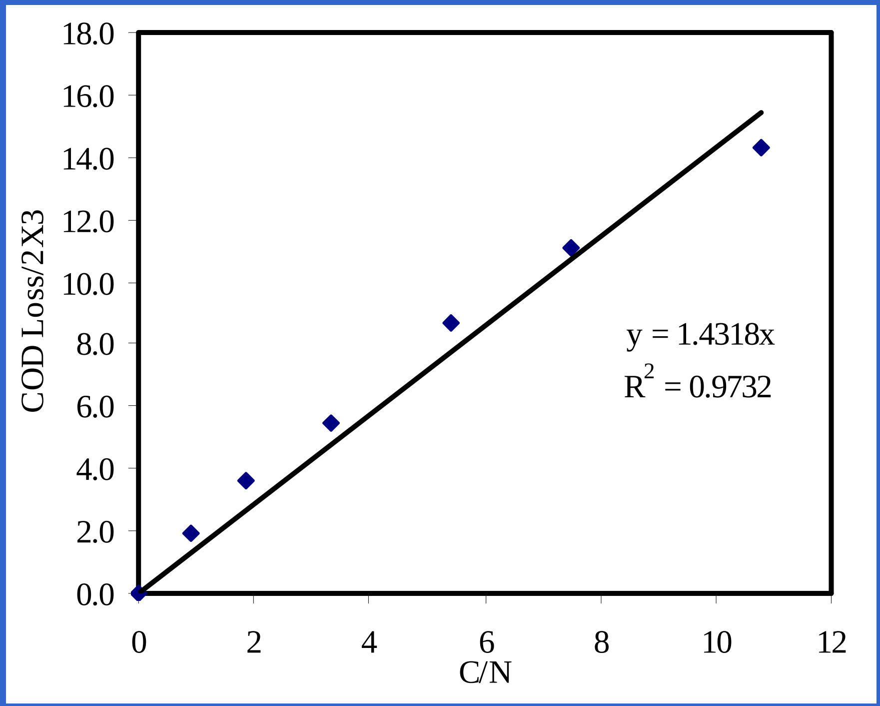
X3 = 0.5* F* [(Ao-A) + (Bo-B) + (Co-C)]/ Vr

where, Ao (Nitrite), Bo (Ammonium), Co (Nitrate) are feed concentrations and A, B, C outlet concentrations, F feed flow, Vr reactor volume, α is (g. COD / g. N content of cells)



Relationship between anammox nitrogen loss (2X3) and predicted ammonia production (X1)

X3 / X1 = 6.67 (= λ)



$$\frac{CODLoss}{2X3} = 1.43\, C/N$$

It is well known that ammonium-N (X1) of nitrite reduction leads to cell synthesis; accordingly we can write cell mass X4 as

X4= α X1

where α of cell is g.COD / g N .

$$\frac{CODLoss}{X4} = \frac{2.86\lambda C/N}{\alpha}$$

UNDERSTANDING YIELDS IN AGRICULTURE

i) COD Loss/X4 = 2.86 (C/N) λ / α (From Model)

ii) Solar Input = 320 GJ/ha.yr = 20 ton/ha.yr

iii) Corn USA with α = 74, C/N =18 , λ = 7 gives
X4 = 4.1 ton/ha.yr ; observed X4 = 4 ton/ha.yr

iv) 200 kg/ha.yr urea-N Corn USA with α = 74,
C/N = 9 , λ = 7 gives X4 = 8.2 ton/ha.yr;
observed X4 = 8 ton/ha.yr

v) Wheat India with α = 60 , C/N = 60 , λ = 7
gives X4 = 1 ton/ha.yr; observed
X4 = 0.82 ton/ha.yr

Thermodynamics

- Assuming exergonic reactions supply energy for endergonic reactions

$$\boldsymbol{\Sigma\ Xi\ \Delta Gi = 0}$$

Simplifying

$\Delta G4 = -\ [\ X2\ \Delta G2\ +\ X3\ \Delta G3 + X5\ \Delta G5] / \alpha X1 - \Delta G1 / \alpha$

- $X3\ (\lambda *\ \Delta G1 + \Delta G3 + \boldsymbol{\alpha} * \Delta G4 / \lambda) =\ - X5 * \Delta G5$

ΔG1- Free Energy change of Nitrite reduction
ΔG2- Free Energy change of Nitrite oxidation
ΔG3- Free Energy change of Anammox reaction
ΔG4- Energy required for cell synthesis
ΔG5 – Energy of Carbohydrate oxidation oxidation
$X4 = \alpha\ X1$
$X5$ = COD Loss

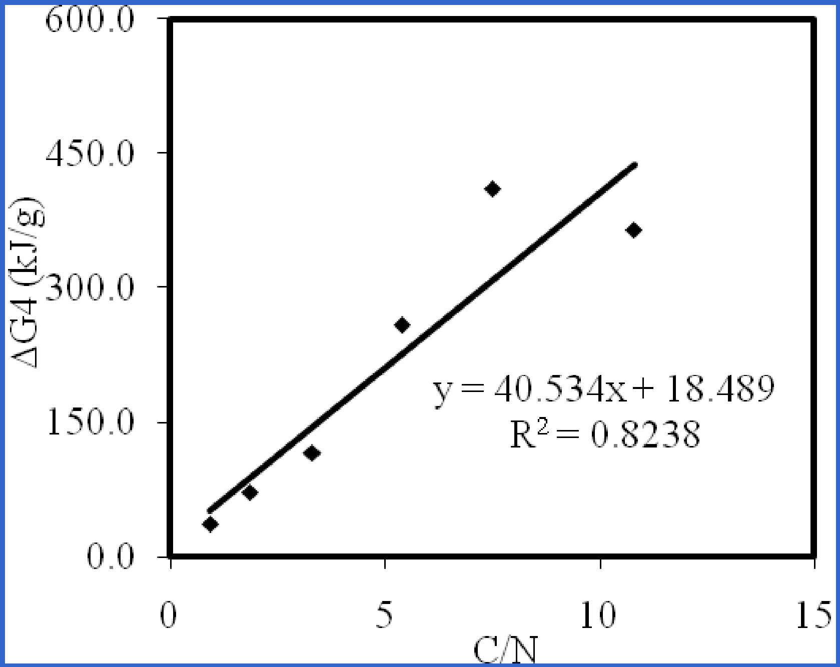


Fig. Relationship of C/N to ΔG4 (kJ/g) with α = 10

Shows a way of understanding energy needs of productions from soils

ENERGY CONSUMPTION IN AGRICULTURE

i) COD Loss/X4 = 2.86 (C/N) λ / α (From Model)

ii) Solar Input = 320 GJ/ha.yr = 20 ton/ha.yr

iii) Corn USA with α = 74, C/N =18 , λ = 7 gives
X4 = 4.1 ton/ha.yr ; observed X4 = 4 ton/ha.yr
energy consumption 98MJ/kg

iv) 200 kg/ha.yr urea-N Corn USA with α = 74,
C/N = 9 , λ = 7 gives X4 = 8.2 ton/ha.yr;
observed X4 = 8 ton/ha.yr; energy
consumption 49MJ/kg

v) Wheat India with α = 60 , C/N = 60 , λ = 7
gives X4 = 1 ton/ha.yr; observed
X4 = 0.82 ton/ha.yr

Hydrogen production 160 MJ/kg;
Ammonia production 32 MJ/kg
American Soil C/N 3.5 to 35

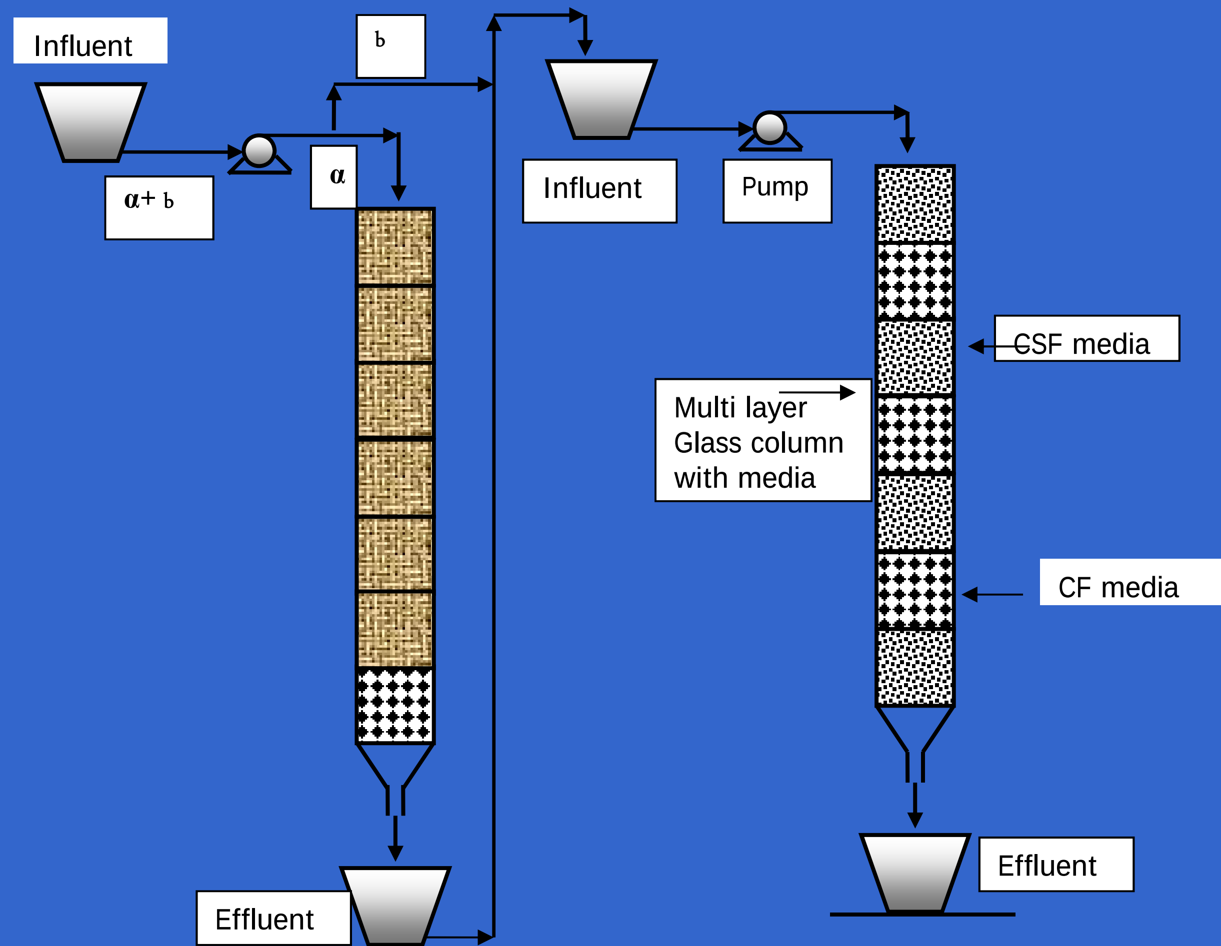
Film : India Innovates

(Min. of Ext. Affairs)

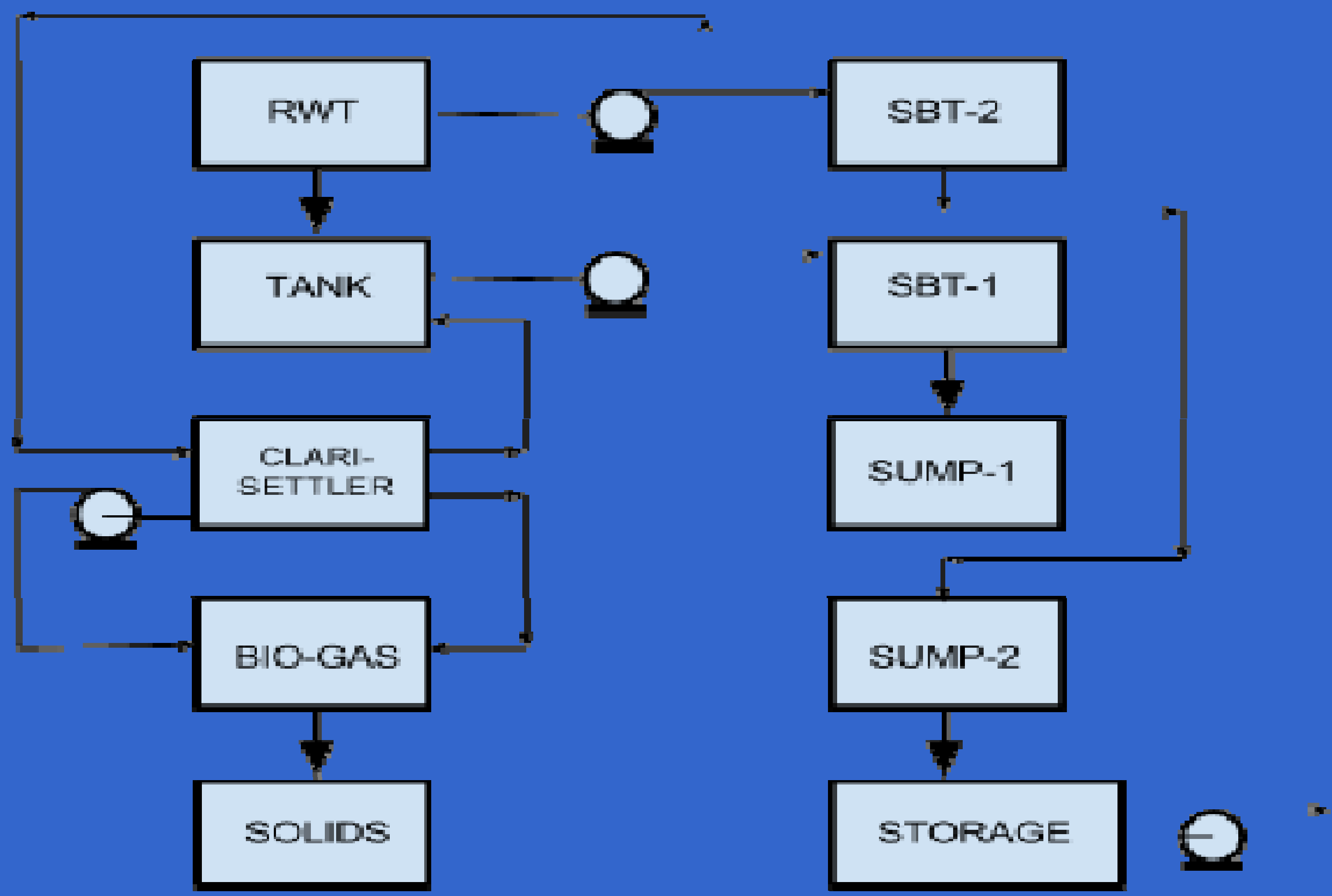
http://www.youtube.com/watch?v=dKWVtZ81mY0

http://www.che.iitb.ac.in/faculty/hss/hss-web.html.

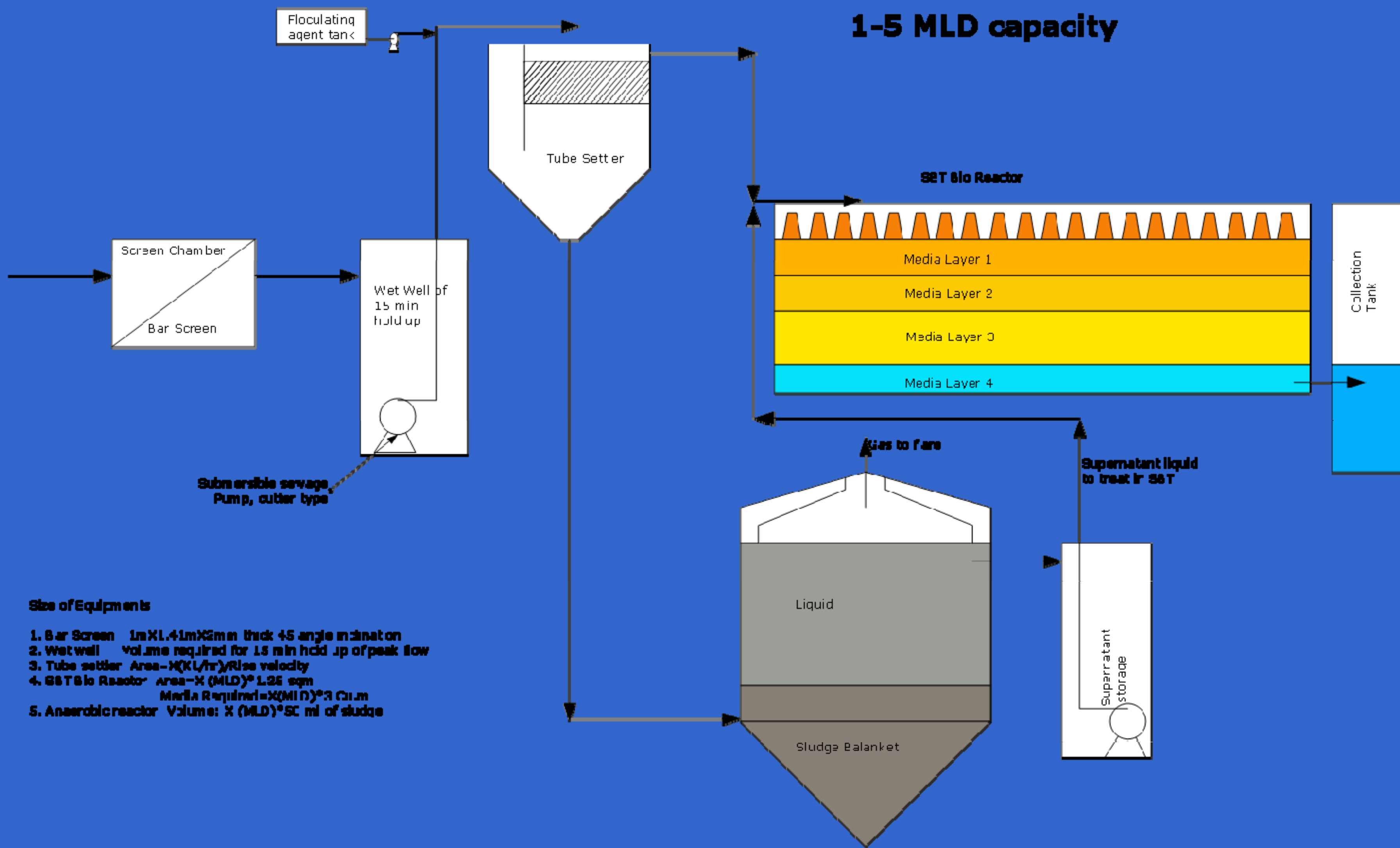
Experimental Equipment
CSF & CF



Typical Process Flow



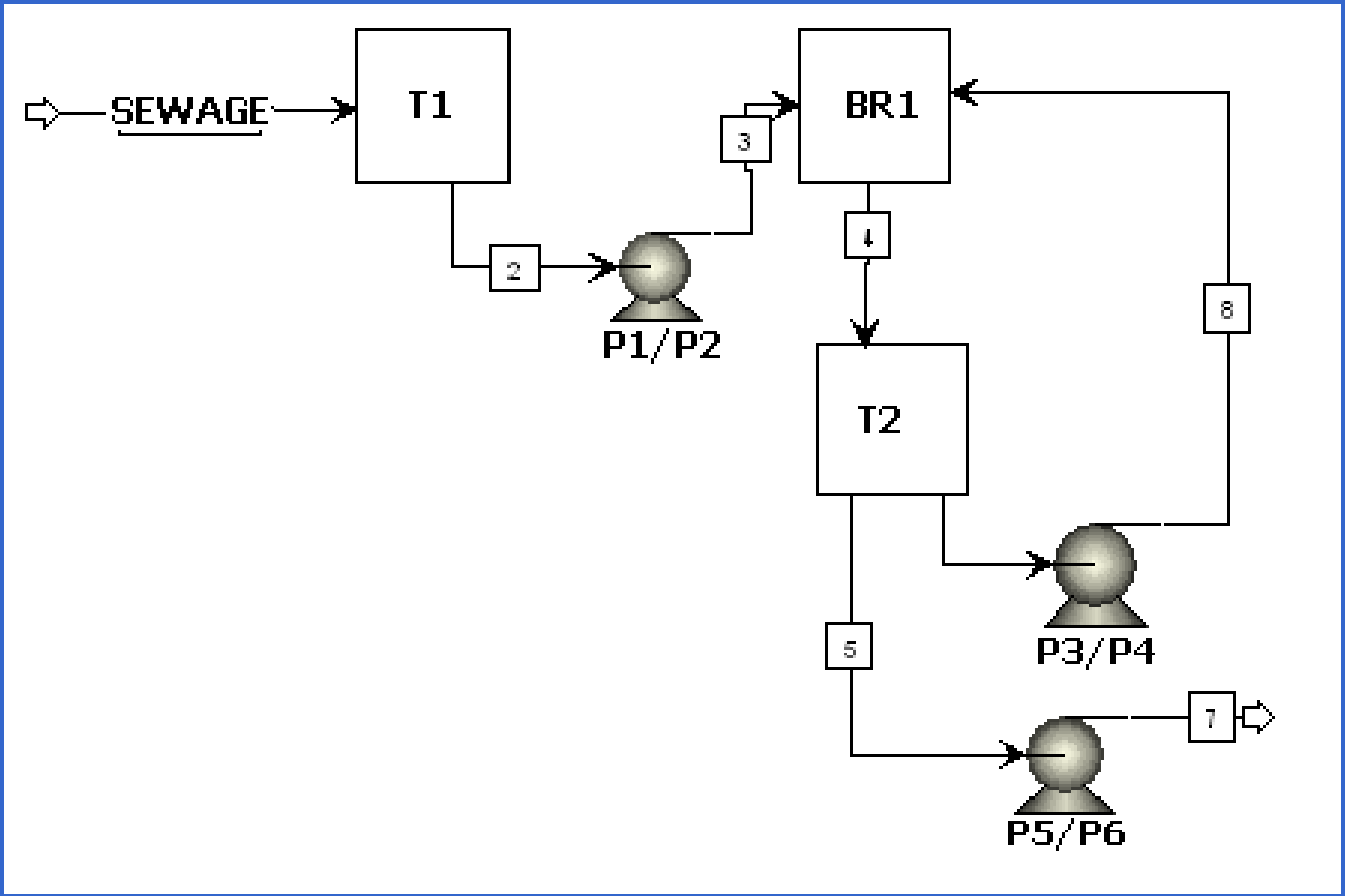
1-5 MLD capacity



Size of Equipments

1. Bar Screen 1mX1.41mX2mm thick 45 angle inclination
2. Wet well Volume required for 15 min hold up of peak flow
3. Tube settler Area=X(KL/hr)/Rise velocity
4. SST Bio Reactor Area=X (MLD)*1.25 sqm
   Media Required=X(MLD)*3 Cu.m
5. Anaerobic reactor Volume: X (MLD)*50 ml of sludge

Schematic Layout
Generally just one feed pump is adequate



PRESENTATION SUMMARY

Lessons from Carbon Cycle

Process chemistry

Media Layout

Media design for waste water

SBT Performance in sewage Treatment

Other offerings

Vision Earthcare

SBT Film of GOI

CSBT-MSW Biogas

SN	Description	Qty
I	CIVIL (MSW PROCESSING)	
1.1	Receiving Station	2000 sqm
1.2	Foundations for equipments	30 nos
1.3	Feed Preparation Tank (brickwork)	100 kL
1.4	Bioreactor Tank 1(brickwork)	1000 kL
1.5	Bioreactor tank 2 (Brick work)	10000 kL
1.6	Collection tanks(brick work)	100 kL
1.7	Storage Tank (brick work)	1000 kL
1.8	Roads and culverts	1000 sqm
1.9	Excavation and redistribution	50000 cum
1.10A	Bioreactor media and culture	10000 cum
1.11	Store shed	1000 sqm
1.12	CSBT landscape development and water distribution	5000 sqm
1.13	Drainage channels	1000 M
1.14	Office and Administration	200 sqm
	sub total of item I	

II	ELECTRO MECHANICAL	
2.1	Hopper	2 nos
2.2	Belt Conveyer	2 nos
2.3	Shredder	2 nos
2.4	Screw conveyors	4 nos
2.4	Gas holder	2 nos
2.5	Compressor	2nos
2.6	Filter press	2 nos
2.7	Pumps	15 nos
2.8	Pipes & piping	2000M
2.9	Exhaust ducting & Fans	4 sets
2.10	Mini Tractor	1 nos
2.11	Mini Dumper	1 nos
2.12	Mini JCB	1 nos
2.13	AC ,Furniture fixtures	1 set
2.14	Site Lighting & cabling	LS
2.15	Control Panel	1 set
III	TECHNOLOGICAL CONSULTANCY	LumpSum

IV	3 YEARS ANNUAL OPERATION AND MAINTENANCE(MSW processing)	
4.1	Operators	10 nos
4.2	Supervisors(3 + 1 manager)	4 nos
4.3	Power @ 10 kWH/ton	600 MWH
4.4	Consumables, catalyst and culture	LS
4.5	Spares & Repair	LS
4.6	Contract services JCB, Tractor, dumper	

CSBT-MSW -Manure

I	CIVIL (Dumping ground development as CSBT herbal garden)	
1.1	Excavation ,segregation & redistribution	60000 cum
1.2	CSBT Bioreactor media and culture	3000 cum
1.3	Water Distribution Piping	20000 M
1.4	Plantation	50000 nos
1.5	MunicipaL Water storage Tanks	500 kL
1.6	Drainage Channels	5000M
1.7	Pumps & panel	2 nos
II	Technological Consultancy	Lumpsum

III	3 Yr O&M Dumping Ground Herbal Garden	
3.1	Gardeners	5
3.2	Supervisors	1
3.3	Power	300 MWH
3.4	Consumables	LS
3.5	Spares and repair	LS
3.6	Contract services	LS

PLASTIC WASTE PROCESSING

SEGREGATION AS PER CODE

PROCESSING RECYCLEBALES BY EXTRUSION AND GRANULATION

PROCESSING NON RECYCLEBALES BY PLASMA PYROLYSIS