Bacterial Reduction in Wastewater Treatment System

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Introduction

- Humans and the other warm blooded animals have coliforms as intestinal flora.
- These coliforms are excreted and are discharged to be treated by Municipal Sewage Treatment Plants.
- However if the wastewater remains untreated, bacterial pathogens present in the sewage effluent can result in diseases such as diarrhoea, dysentery, typhoid, infected hepatitis etc upon exposure to the contaminated water.
- Indicator organisms to monitor bacteriological quality of water include Escherichia Coli (E.Coli) and Coliforms.

Indian Scenario

- In India cities and towns generate 38000KL waste water daily.
- Sewage treatment facilities are limited in our country and many of the treatment facilities are not functioning properly.
- The organic pollutant (measured as BOD/COD/SS) removal performances of conventional technologies employed in a majority of STPS under GAP/NRAP have been extensively studied and reported.
- But microbial pollutants(measured as MPN of Total and faecal coliforms) removal performances are not getting monitored properly.

Indian Scenario (contd)

- Total urban wastewater generation: 38255mld
- STPs Capacity : 11788 mld
- STPs number wise : 38% ASP, 28% WSP, 20% UASB, 14% others
- STPs capacity wise: 60% ASP, 26% UASB, 6% WSP, 8% others
- CPCB and SPCBs are the regulatory agencies for water quality monitoring

Ministry of Environment & Forest Recommendations

- Ministry of Environment and Forest , Govt of India constituted a committee in 1999 to recommend coliform standards for treated sewage discharged into the rivers and lakes.

Parameter	Not to exceed	Discharge into/on
BOD(mg/l)	30	Water body
BOD(mg/l)	100	Land for irrigation
TSS(mg/l)	50	Water body
TSS(mg/l)	200	Land for irrigation
Faecal Coliform(MPN/100ml)	1000 desirable 10000 max permissible	Water body or for agriculture and aquaculture

Ministry of Urban Development Recommendation

- Ministry of Urban Development and Poverty alleviation constituted in the year 2004 a committee to determine the norms for coliform level in the treated wastewater specific to the stretch of the river Yamuna in Delhi.
- The Committee made the following recommendations which have been mentioned in the adjacent table:-

Parameter	Value	Remarks
Faecal Coliform (MPN/100ml)	500	Desirable
Faecal Coliform (MPN/100ml)	2500	Maximum Permissible
BOD	3 mg/l or less	

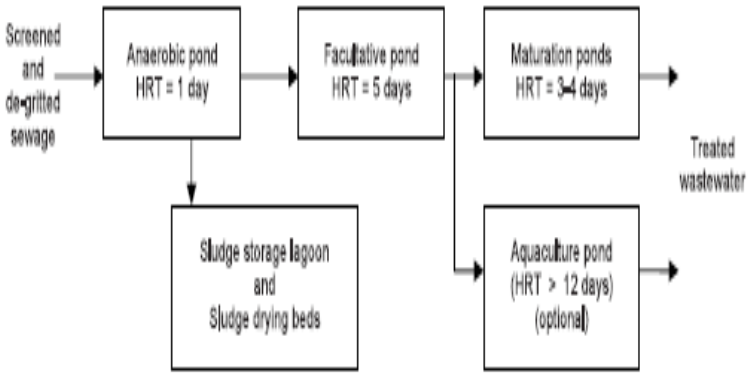
Standard for discharge of treated sewage into the stretch of River Yamuna in Delhi

Parameter	Not to exceed	Remarks
BOD	10 mg/l	Immediate goal
Faecal Coliform	2500 MPN/100ml	See adjacent note

- Note- Tertiary Treatment after conventional treatment processes like ASP or TF is required to achieve the recommended standards for BOD and FC. Tertiary Treatment options include chemicals aided flocculation, sedimentation with or without post granular media filtration and or chlorination.

Overview of Wastewater Treatment Processes

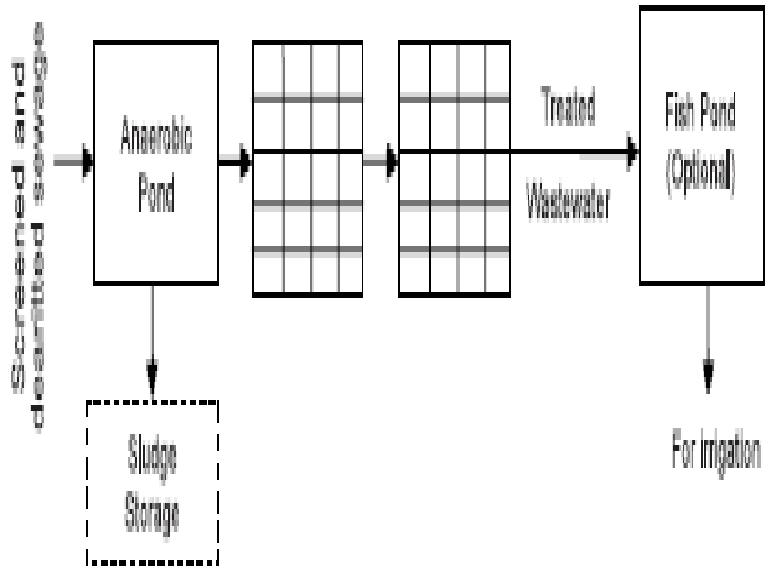
Waste Stabilization Pond Systems



Performance of the Unit

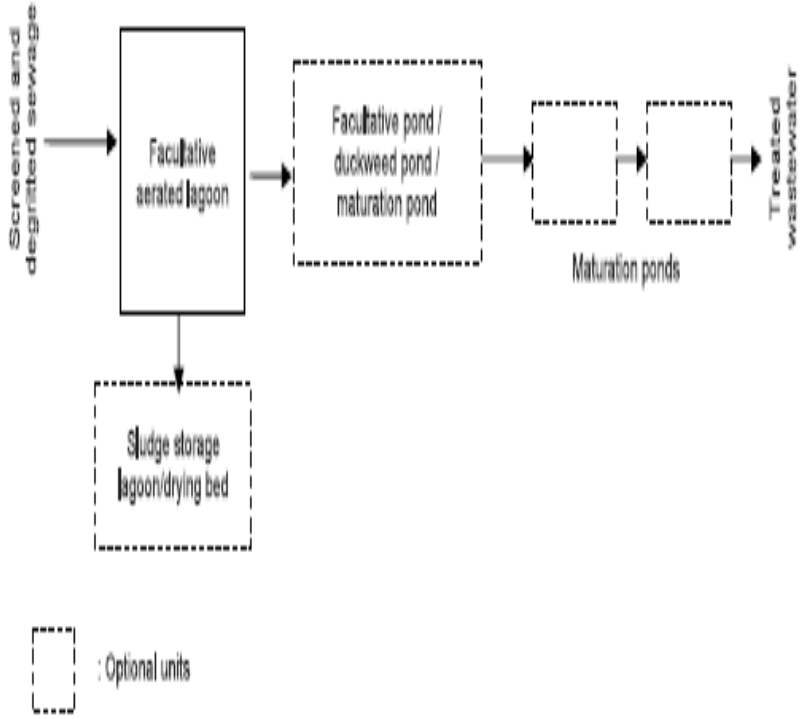
- Can reliably produce high quality effluent with low BOD,SS,Faecal coliform and high D.O.levels.
- BOD reduction of the order of 90% or so.
- Suspended solids reduction is somewhat low due to possible overflow of algae.
- Coliform reduction can be up to 6 units.
- Total Nitrogen removal between 70-90%.
- Total Phosphorus removal between 30-45%.
- Detention time: 6 to 8 days

Duckweed Pond System



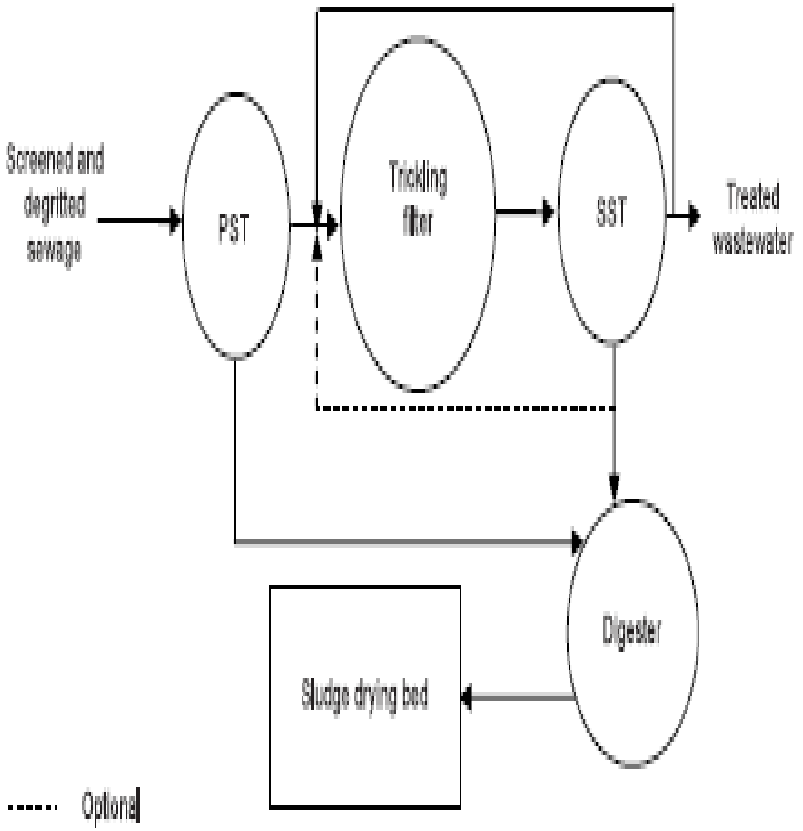
- Retention period 7-21 days
- Shallow depth of water from 1.25-2.0 mts.
- For settled wastewaters BOD and SS removal upto 30 mg/l is achievable
- High mineral and nutrient removal rate due to uptake of duckweeds.
- Capital cost of the same order of WSP with additional cost of floating cell material.

Facultative Aerated LAGOON (FAL)



- No primary or secondary settling required with no sludge recirculation.
- Anaerobic bottom layer and aerobic top layer.
- Simultaneous degradation of sludge in the bottom layer and organics in the top layer.
- BOD removal 70-90%
- Suspended solids removal 70-80%
- Coliform removal 60-99%

Trickling filter



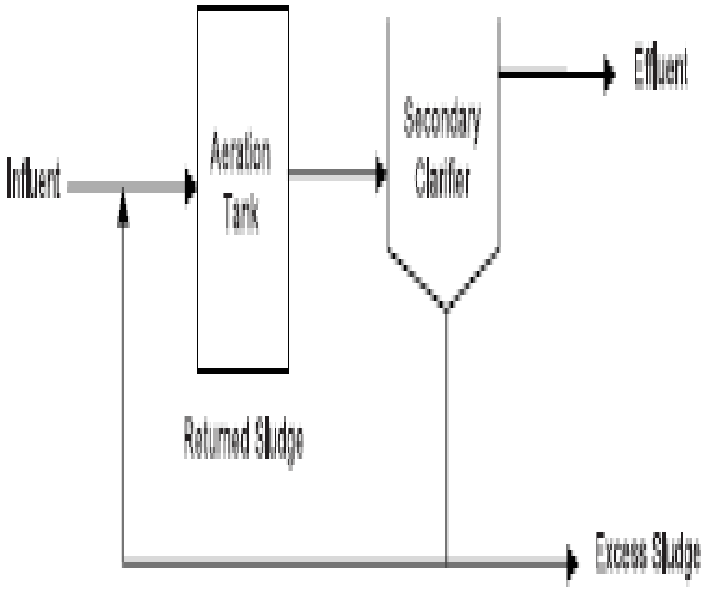
- Proven 100 year old technology
- Less monitoring required than ASP
- Rugged system with simple and silent operation.
- Consistent effluent quality
- Stand alone treatment process for sewage if operated at low rates.
- To be used in combination with ASP for efficient peformance.
- Low pathogen removal

  Bacteria, 20-90%

  Viruses 50-90%

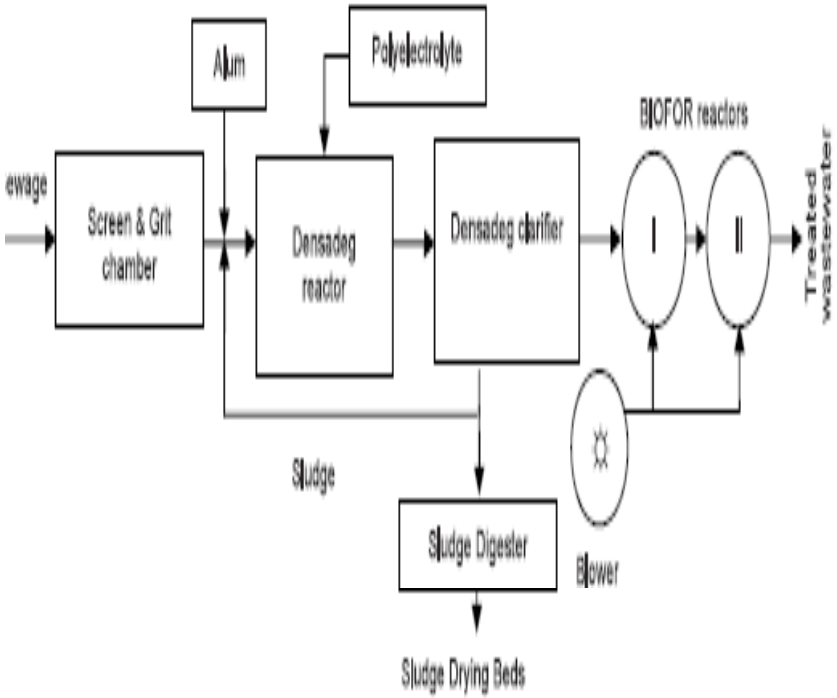
  Giardia cysts 70-90%

Activated Sludge Process (ASP)



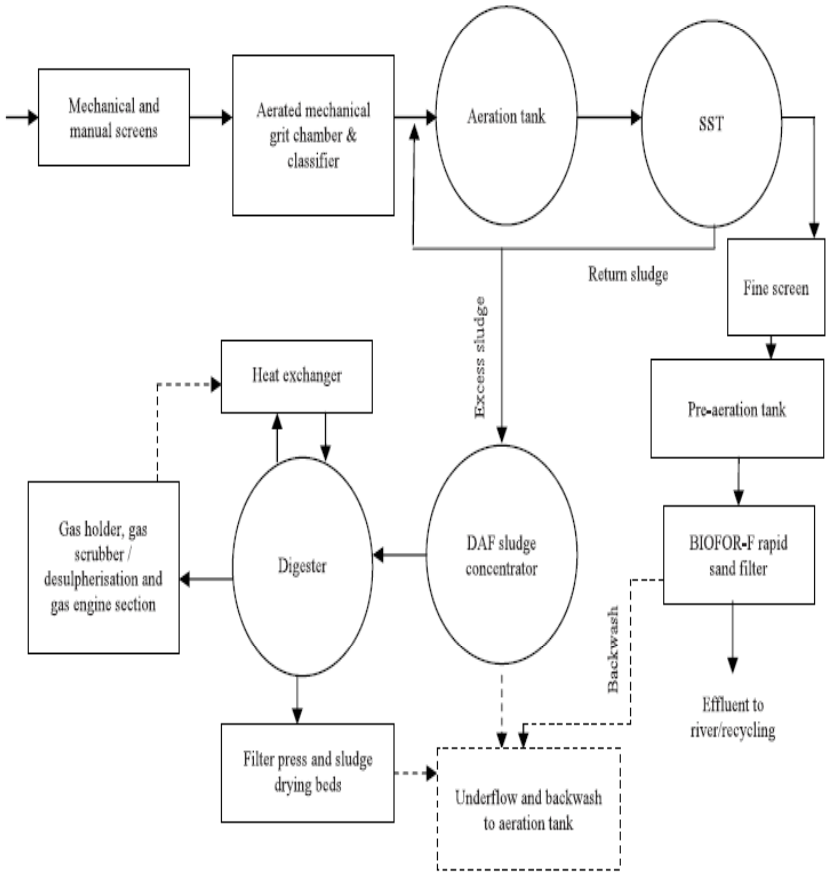
- Proven and tested methodology all over the world for the last 7-8 decades.
- Several modifications available for specific requirements.
- Uninterrupted power supply required for aeration and sludge recirculation.
- Reactor sludge levels to be carefully monitored and sludge is to be withdrawn from the system.
- 80-90% removal of bacteria.
- 90-99% removal of viruses.

BIOFOR Technology (Biological Filtration and Oxygenated Reactor)



- Enhanced primary treatment with addition of chemicals and coagulants.
- High rate primary tube settlers and integrated thickening offering space economy.
- Suspended solids and BOD removal of the order of 90% and 70% respectively in the primary clarifier.
- Low turbidity with suspended solids under 15 mg/l and total system efficiency of 98%.
- Pathogen removal of 2 on the log scale.

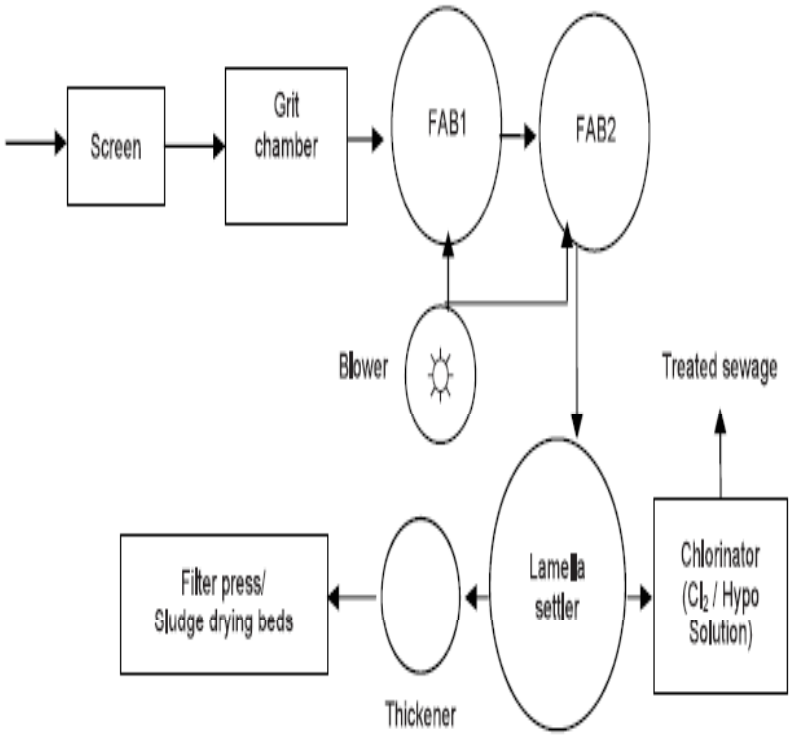
High Rate Activated Sludge BIOFOR-F Technology



- Compact layout as a result of high rate processes.
- Higher aeration efficiency through diffused and tapered aeration system.
- Space saving as primary sedimentation is dispensed.
- Compliance with strict discharge standards.
- Absence of aerosol and odor nuisance in the working area.
- Self-sufficient in energy requirement due to gas engine based cogeneration sysytem.

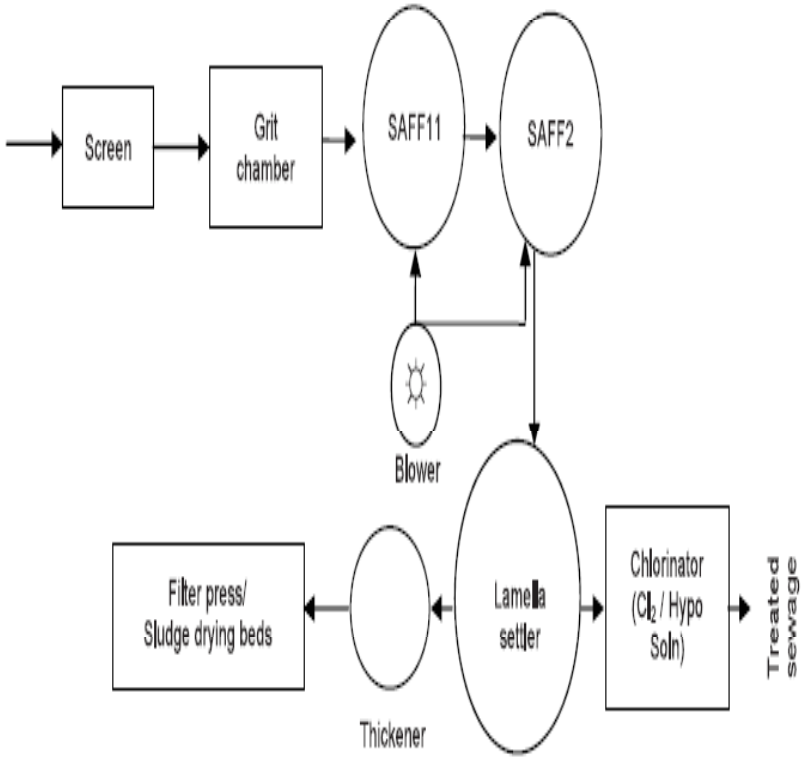
Notes :

Fluidized Aerated Bed (FAB)



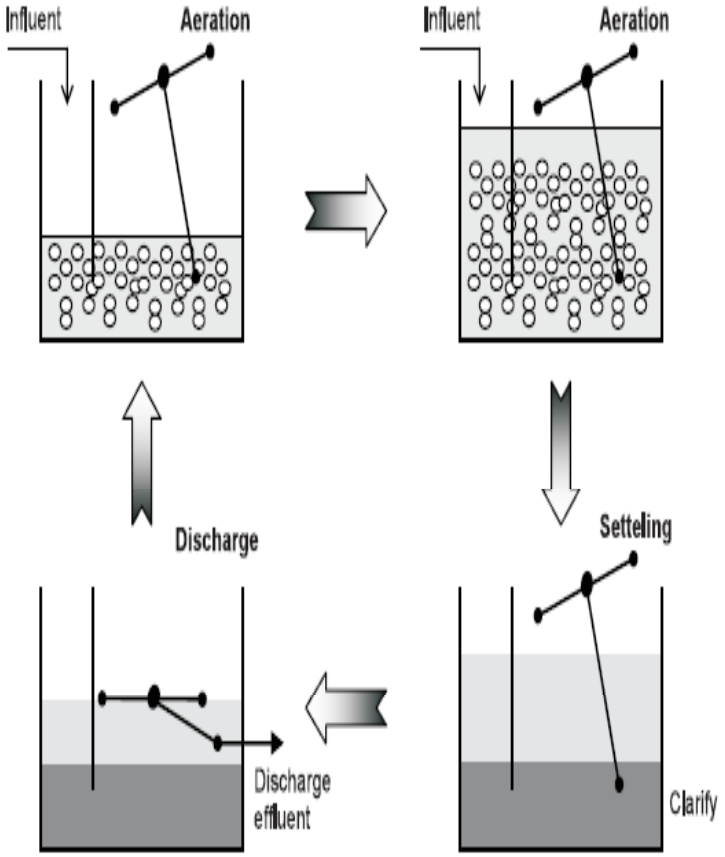
- Two stage biological oxidation.
- Treatment scheme without primary sedimentation and sludge digestion.
- Reactors upto depth 5m ensures low land requirement.
- High BOD removal with effluent concentration less than 10 mg/l
- High Suspended solids removal with effluent concentration less than 20 mg/l
- Faecal coliforms removal of the order of 2-3 on log scale.

Submerged Aeration Fixed Film Technology (SAFF Technology)



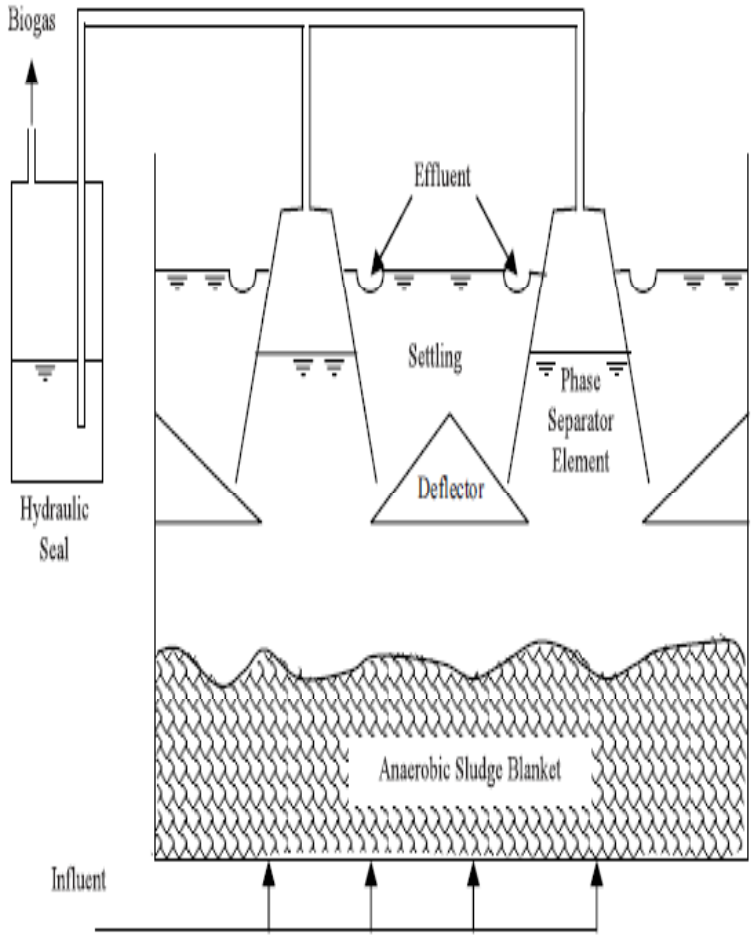
- Essentially a trickling filter with enhanced oxygen supply through submerged aeration.
- Unconventional plastic media with high void ratio and specific surface area.
- High BOD removal with 98% efficiency with effluent BOD concentration less than 10 mg/l.
- High Suspended solids removal with effluent concentration of 20 mg/l.
- Faecal coliforms removal of the order of 2-3 on log scale at SAFF 2 Stage.

Cyclic Activated Sludge Process (CASP)



- Essentially activated sludge process operated in batches through auto-control.
- Aeration and settling in one tank leading to lower plant foot print.
- Uninterrupted power supply is a must as the whole process is auto controlled.
- High BOD removal with effluent concentration less than 10 mg/l
- High Suspended solids removal with effluent concentration less than 20 mg/l
- Faecal coliforms removal of the order of 2-3 on log scale.

Upflow Anaerobic Sludge Blanket Process (UASB)



- Process not vulnerable to power cuts.
- Recovery of gas with high calorific value.
- Low sludge production.
- No primary treatment, suspended solids in the waste water acts as carrier material for microbial attachment.
- Recovery of gas with high calorific value.
- Low sludge production.
- Post treatment of UASB is invariably required.

East Kolkata Wetland; Use of Wastewater in Pisciculture

Location	TC (MPN/100 ml)	FC (MPN/100 ml)
Inlet to pond	220000	90000
Outlet to pond	900	300
Inlet to pond	1100000	90000
Outlet to pond	2200	1100

- Raw wastewater of Kolkata city is used for pisciculture in 3900 hectares (364 fisheries).
- Fish production 5-7 metric tonnes per hectare/year
- Pond outlet water is used in the agriculture.
- Retention time in pond 12-14 days.

F.C. Removal in STPs

- **1. UASB followed by Oxidation Pond.**
- **Influent FC : 1x 10^8**
- **Effluent FC : 1x 10^5**
- **FC Removal : 99.9%**

- 2. Stabilization Pond System (AP+ FP)
- Influent FC : 2.1x10^7
- Effluent FC : 4.6x10^3
- FC Removal: 99.98%

FC Removal in STPs (Contd)

- 3. Activated Sludge Process
- Influent FC: 5.7x10^7
- Effluent FC: 1.3x10^5
- FC Removal: 99.7%

- 4. ASP (Allahabad) : Treated Wastewater FC Count : 10^6 to 10^7
- 5. ASP (Varanasi) : Treated Wastewater FC Count : 10^5 to 10^7
- 6. WSP (Vrindavan) : Treated wastewater FC Count : 10^6
- 7. WSP (Karnal) : Treated Wastewater FC: 10^5

FC Removal in STP (Contd)

- 8. Duckweed Pond System (Bhubaneshwar) : FC Count in Treated Waste Water : 2 to 8x10^3
- 9. UASB (Panipat) : FC Count in Treated Waste Water: 10^6 to 10^7
- 10. BIOFOR (SNH Nalla, Delhi): FC Count in Treated WW: 1x10^6
- 11. FAB (Molarband): FC in Treated WW: 1x10^5
- 12 SAFF (Holambi): FC in Treated WW: 750

FC Removal in STPs (Contd)

- 13. ASP, Bhatpara :
  Influent FC: 7x10^7
  Effluent FC: 9x10^4
- 14. ASP, Bangur :
  Influent FC: 1.8x10^6
  Effluent FC: 1.7x10^4
- 15. TF, Kalyani :
  Influent FC: 1.1x10^6
  Effluent FC: 1.1x10^4
- 16. TF, Srirampore:
  Influent FC:2.8x10^6
  Effluent FC: 1.3x10^4
- 17. WSP, Konnagar :
  Influent FC: 1.1x10^6
  Effluent FC: 3.3x10^3
- 18. WSP, Jagaddal:
  Influent FC: 1.8x10^6
- Effluent FC: 1.0x10^4

Occupational Health of Sewage Farm Workers

- In Varanasi during GAP pre-project sewage farm workers using untreated sewage (F.C. 10^7 to 10^9/100ml) for agriculture showed high prevalence of diarrheal disease, helminthic infection and skin disease.
- Microbial examination of stool revealed high presence of Hookworm (41.7%), moderate presence of Roundworm(29.2%), Trichuris trichura(16.7%) and Giardia lamblia(33.3%).
- Post project study revealed that after installation of STP (F.C. 10^6/100ml) the prevalence of diarrheal disease markedly reduced from 55.3% to 30.5% (six months prevalence).
- Similarly prevalence of skin diseases were reduced from 42.5% to 6.2% during post-project period.
- But microbial examination of stool of sewage farm workers did not show any marked reduction in Hookworm, Roundworm, Trichuris trichura and Giardia lamblia.

Stool Examination Report
Sewage Farm Workers (n : 47):Varanasi

Species	Pre-project (%)	Post Project(%)
Hookworm	41.7	63.04
Roundworm	29.2	30.43
Trichuris Trichura	16.7	17.39
Enterobias vermicularis	8.3	2.17
E.coli	Nil	Nil
Giardia Lamblia	33.3	26.90
E.nana	Nil	Nil
H.nana	8.3	Nil
Mucous	50.0	41.30
Starch	8.3	32.61
Vegetable cells	29.2	26.09
Pus Cells	Nil	Nil

Health of Sewage farm workers in Titagarh, West Bengal

- Sewage farm workers used primary treated sewage (F.C.10^6 to 10^8) in agriculture.
- Study on disease prevalence (6 months) among sewage farm workers showed high prevalence of diarrhoea (61.2%) and parasitic infection (17.74%)
- The stool examination report(n=62) indicated high presence of Roundworm (75.8%), Hookworm(39.4%) but less prevalence of Trichuris Trichuria (9.1%)

Tertiary treatment

- Tertiary treatment involves a series of additional steps to further reduce organics, turbidity, N, P, metals and pathogens.
- Physicochemical process
  - Coagulation
  - Filtration
  - Activated carbon adsorption of organics
  - Disinfection

Coagulation /Flocculation/ Sedimentation

- Suspended solids removal by Sedimentation
- Synthetic organic polymers
- Alum (aluminum sulfate)
- Iron salts (ferric sulfate, ferric chloride)
- Rapid and Slow mixing
- Reduces microorganisms (transfer to sludge)
  - Bacteria 90 %
  - Virus 60 %
  - Protozoa 90 %

Filtration

- Organic matter removal
- Microorganisms separation
- Mineral colloids removal
- Rapid Sand Filtration
- Dual Media Filtration
- Pressure Filtration

Disinfection

- Most common is halogen: chlorine, chloramine, chlorine dioxide, bromine, or iodine.
- Ozone is more expensive but does not leave toxic residuals
- Metals: copper and silver have been used for disinfection of swimming pool and hot tub water.
- Ultraviolet is also more expensive and does not leave toxic residuals.

Faecal Coliform Removal in WSP

- FC removal in ponds can be modeled by first order kinetics in a completely mixed reactor.
- The resulting equation for a single pond is thus:

$$N_e = N_i / (1 + K_T \theta)$$

where N_e= Number of FC per 100ml effluent

N_i= Number of FC per 100ml influent.

K_T= First Order rate constant for FC removal/day

θ=Retention time in days

- For a series of Anaerobic, Facultative and Maturation Ponds (WSP) the above equation becomes:

$$N_e = N_i / [(1+K_t\theta_a)(1+K_t\theta_f)(1+K_t\theta_m)^n]$$

$$K_T = 2.6(1.19)^{(T-20)}$$

WSP Example

Anaerobic Pond

- Detention time=1 day, w/w temp=20 degrees C

Facultative Pond

- Detention time=3 days, w/w temp=20 degrees C

Maturation Pond

- Detention time=3 days, w/w temp=20 degrees C
- F.C. in raw sewage=10^8/100ml
- F.C. in treated sewage=3.6x10^5/100ml

- Now, instead of one maturation pond if four maturation ponds in series are constructed then FC in treated sewage =527/100ml (<1000/100ml)
- Hence maturation ponds working as Plug Flow Reactor can bring down F.C. count in treated sewage to desirable limit.

CONCLUSION

- Water reclamation should be the ultimate goal
- Non-potable uses
- Treated waste water quality should be fit to qualify for targeted water use
- Minimum or no health risk must be ensured
- Recycling / reuse may minimize fresh water use
- Cautious use of chemical disinfectants to safeguard public health and environment
- Thrust should be on selection of appropriate technology for wastewater treatment
- To ensure better O&M of STPs
- Commercial approach in waste water treatment
- Microbiological quality of treated wastewater (standard) should be framed according to targeted use safeguarding public health.

Thank You