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Assessing the feasibility of faecal sludge co-treatment in a sewage treatment plant

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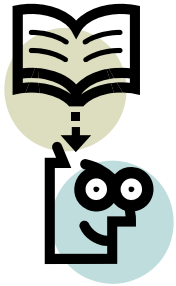
FSM practice

- Proper planning of FSM often lacks;
- FS disposed of mostly untreated and uncontrolled;
- The major challenges on FSM are:
  - Emptying;
  - Transporting;
  - Storage or treatment;
  - Safe disposal or re-use.
- Sometimes discharging of FS in municipal wastewater treatment plant.

Context



- Option of treating or stabilizing FS by discharging it into a sewage treatment plant;
- The characteristics and amount of FS added can affect the performance, operation and maintenance of the sewage treatment;
- For treatment plants of over 100,000 PE the discharge of septic tank sludge may not create adverse problems in the plant.

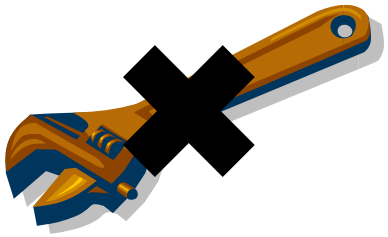
Research questions

- Is it possible to co-treat FS in an activated sludge plant?
- How much FS can be added before deterioration occurs?
- What are the effects on aeration capacity, effluent concentration, settler?

Research objective

- To evaluate and propose key considerations for FS co-treatment with municipal wastewater in an activated sludge wastewater treatment plant.

Methodology



- Mathematical modelling of the effects of discharge of FS under steady state and dynamic conditions;

- Requires fractionation of the organics and nitrogenous compounds in terms of their biodegradability (like with wastewater);

- The biodegradability of FS depends to a large extent on the storage duration in containment .

Faecal sludge “definition”

- Sludge from on-site sanitation systems and unsewered public toilets: “fresh FS”;
- Sludge from septic tanks : “digested FS”

Inventory of literature data on public toilet (fresh) and septic tank (digested) sludge

Parameter	Public Toilet	Septic Tank
Total solids (mg/L)	30,000-52,500	12,000-35,000
TVS (%TS)	65-68%	50-73%
COD (mg/L)	10,000-250,000	3,000-90,000
BOD_5 (mg/L)	7,600	840-30,000
TN (mg N/L)	-	190-1,500
TKN (mg/L)	3,400	1,000
NH_4-N (mg/L)	2,000-5,000	150-1,200
Total P (mg P/L)	450	40-300

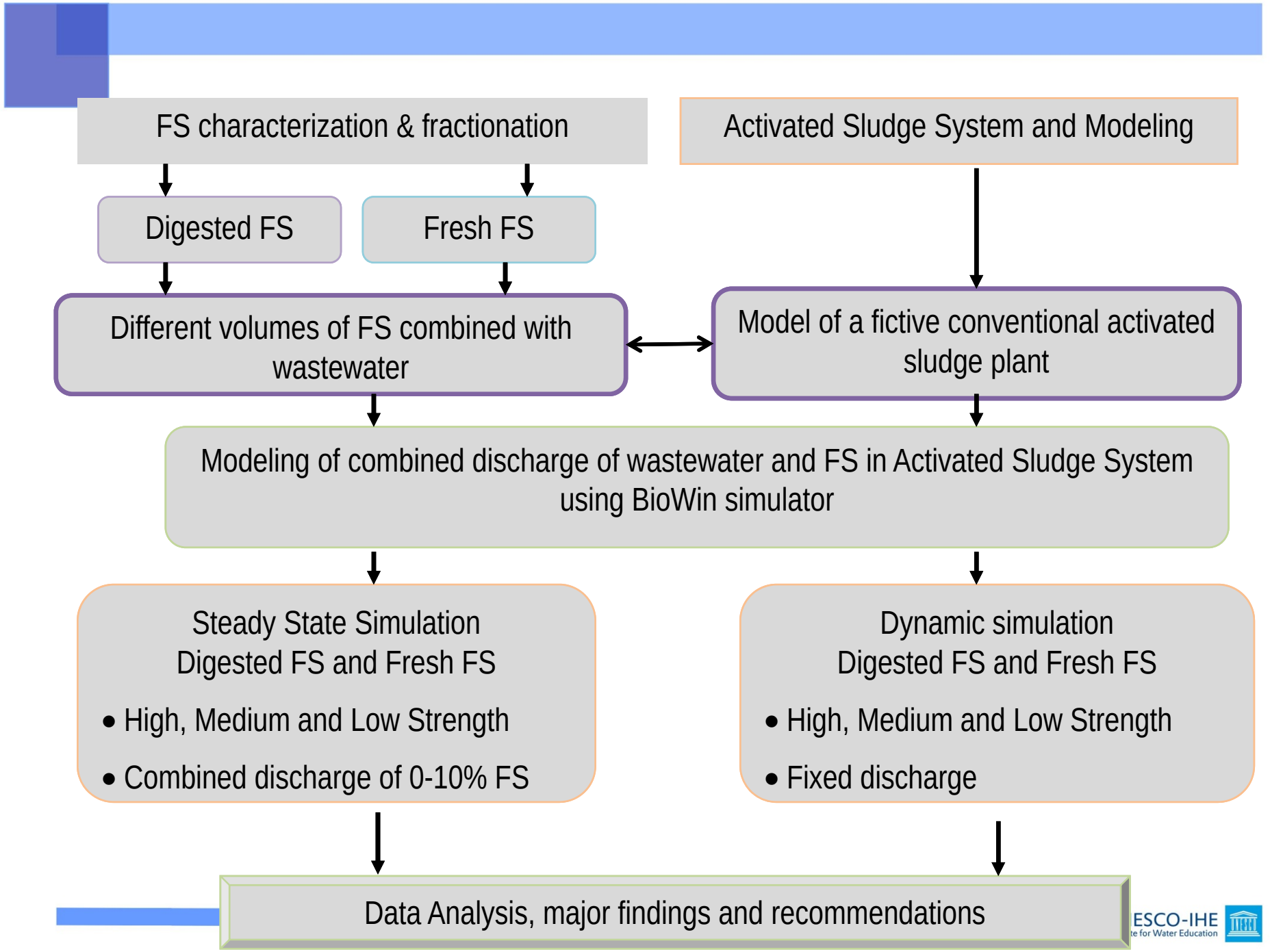
Category	High strength		Medium strength		Low strength	
	Total COD (mg COD/L)	TN (mg N/L)	Total COD (mg COD/L)	TN (mg N/L)	Total COD (mg COD/L)	TN (mg N/L)
Digested faecal sludge	90,000	1,500	45,000	400	3,000	200
Fresh faecal sludge	250,000	5,000	65,000	3,400	10,000	2,000

Faecal sludge fractionation

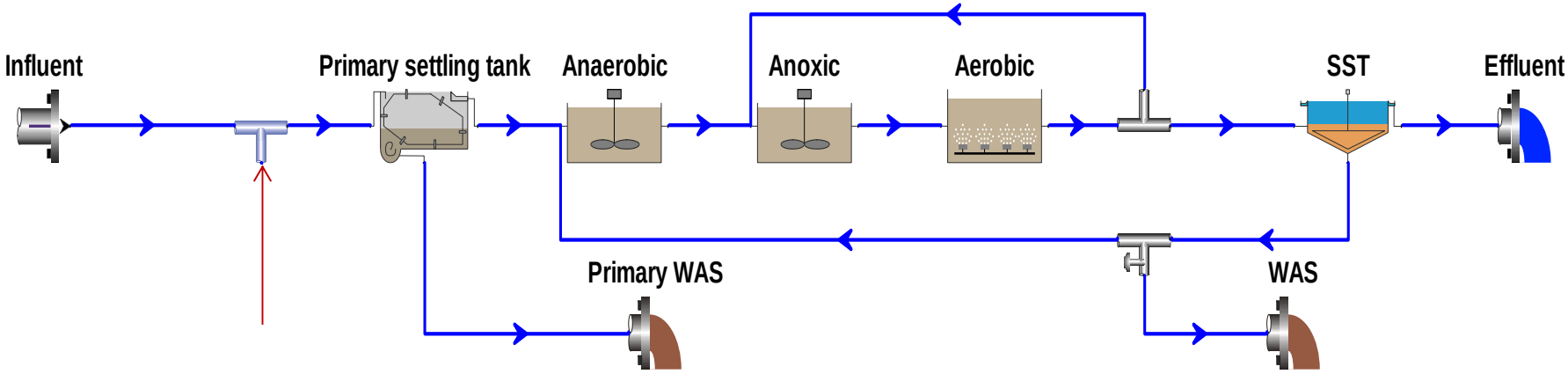
Fraction	COD		N	
	Digested FS	Fresh FS	Digested FS	Fresh FS
Soluble biodegradable /ammonia	0.12	0.15	0.20	0.47
Soluble unbiodegradable	0.09	0.03	0.75	0.52
Particulate biodegradable	0.31	0.69	-	-
Particulate unbiodegradable	0.47	0.13	0.05	0.01

Biodegradable COD fraction Digested FS:
0.12+0.31 = 0.43

Biodegradable COD fraction Fresh FS:
0.15+0.69 = 0.84

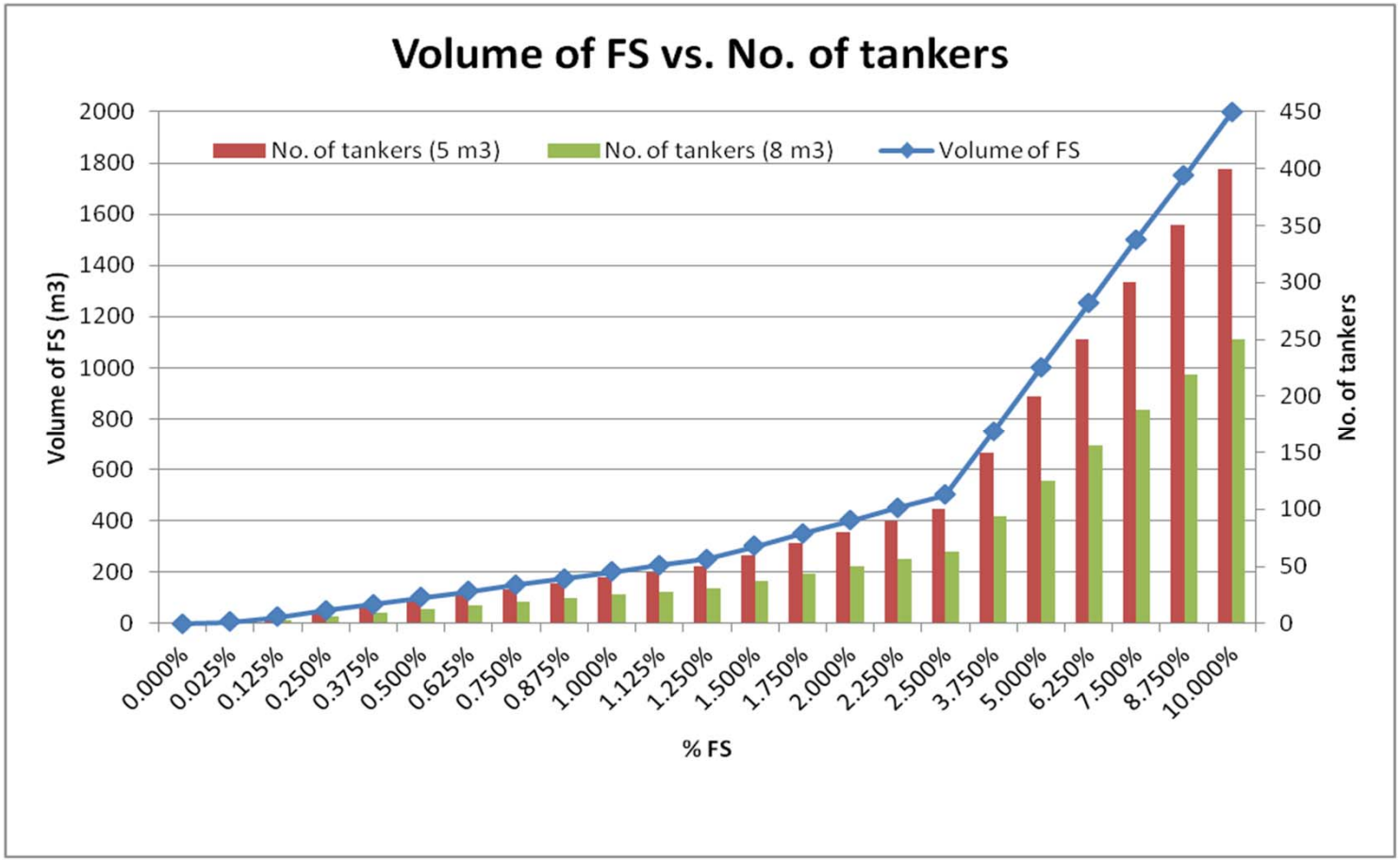

FS characterization & fractionation
Activated Sludge System and Modeling
Digested FS
Fresh FS
Different volumes of FS combined with wastewater
Model of a fictive conventional activated sludge plant
Modeling of combined discharge of wastewater and FS in Activated Sludge System using BioWin simulator
Steady State Simulation
Digested FS and Fresh FS
• High, Medium and Low Strength
• Combined discharge of 0-10% FS
Dynamic simulation
Digested FS and Fresh FS
• High, Medium and Low Strength
• Fixed discharge
Data Analysis, major findings and recommendations
ESCO-IHE

Design and operational conditions of the activated sludge plant



Parameters	Value	Influent (mg/l)	Value
Flowrate (m^3/d)	20,000	Total COD	750
Temp.	20 ◦C	TN	60
SRT (days)	10	TP	15
Reactor TSS (mg TSS/L)	4500	TSS	400

Amount of faecal sludge added to the plant



Assessment criteria
(Key Performance Indicators)

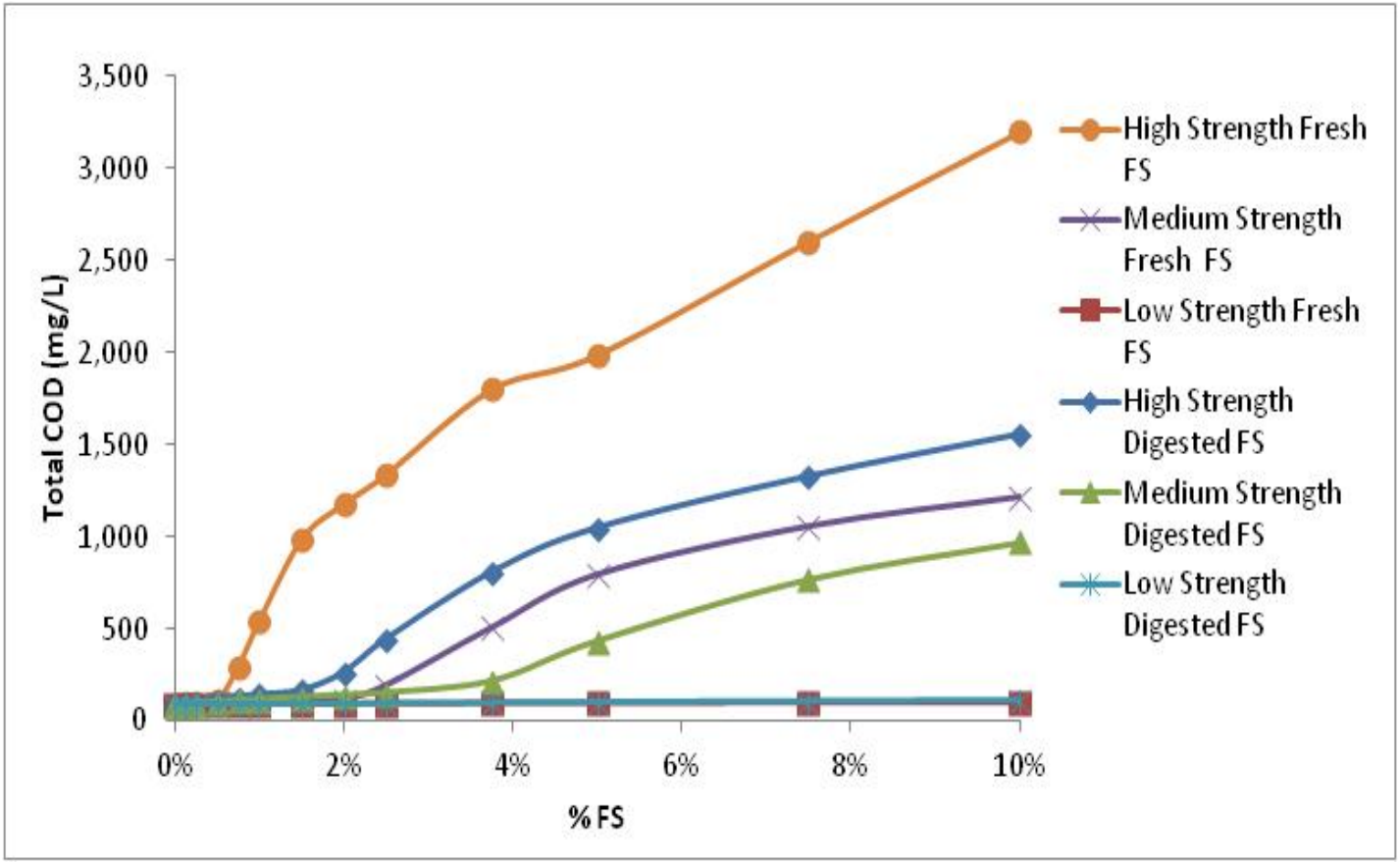
- Effluent Standards (*Urban Waste-Water Treatment Directive (91/271/EEC)*):
  - TCOD = 125 mg/L
  - TN = 15 mg/L
  - TSS = 35 mg/L
- Reactor TSS concentration ≤ 6,000 mg/L;
- Aeration capacity and costs.

Results of the faecal sludge modelling

- Steady state simulations;
- Dynamic simulations.

Steady state simulations results
Effluent TCOD

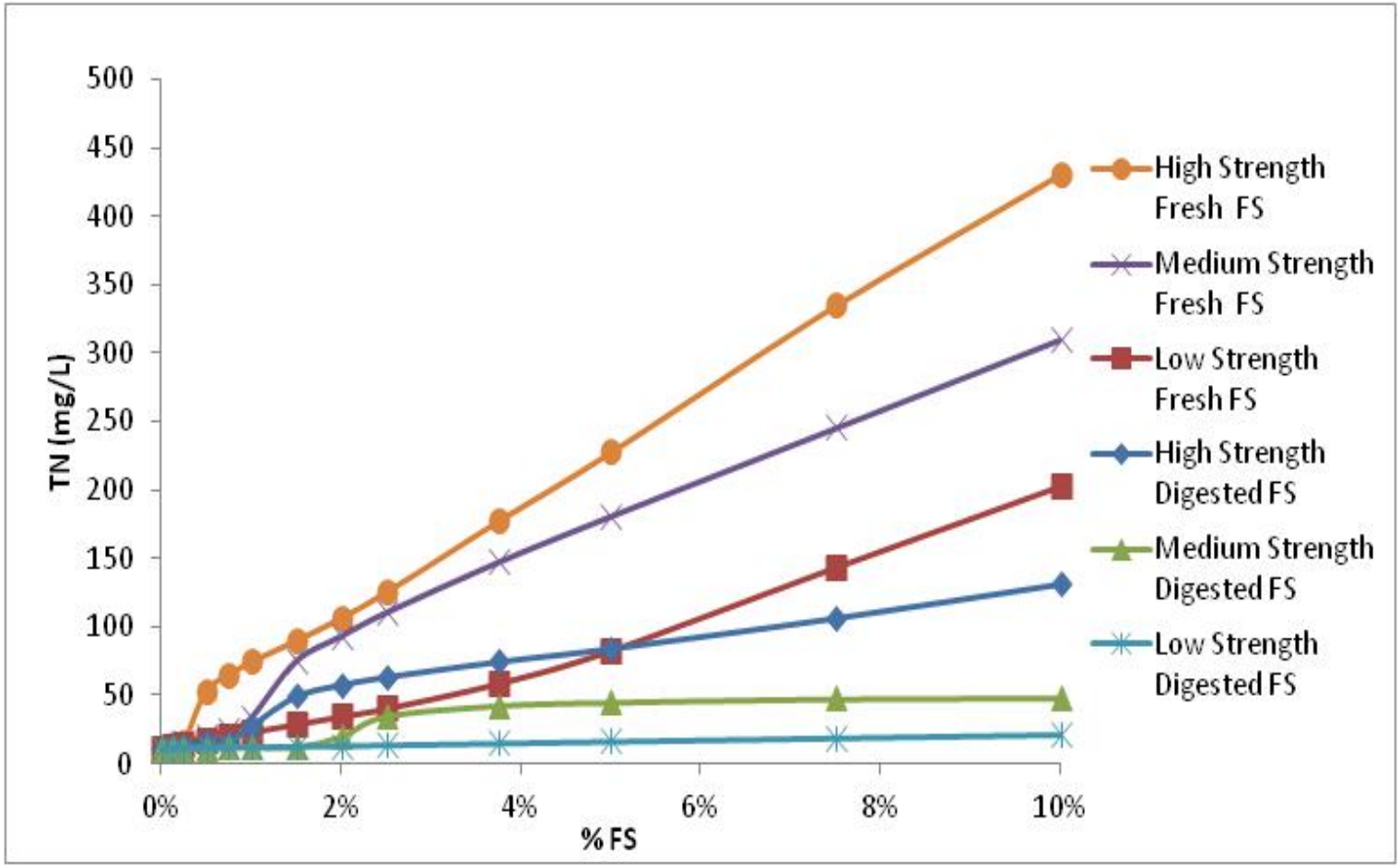
limit =125 mg/l



Steady state simulation results

Effluent TN

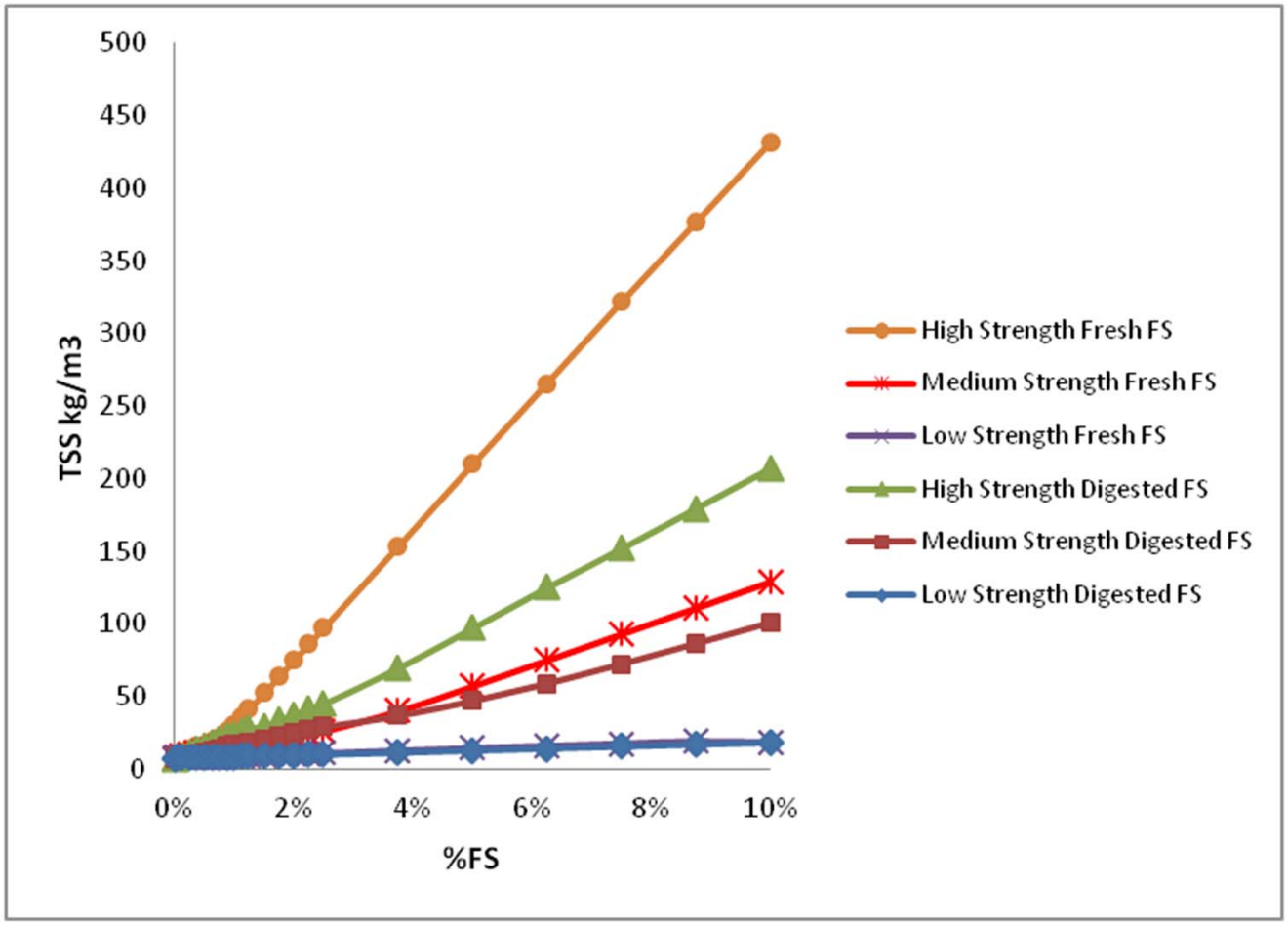
limit = 15 mg/L



Steady state simulation results:

Effluent TSS

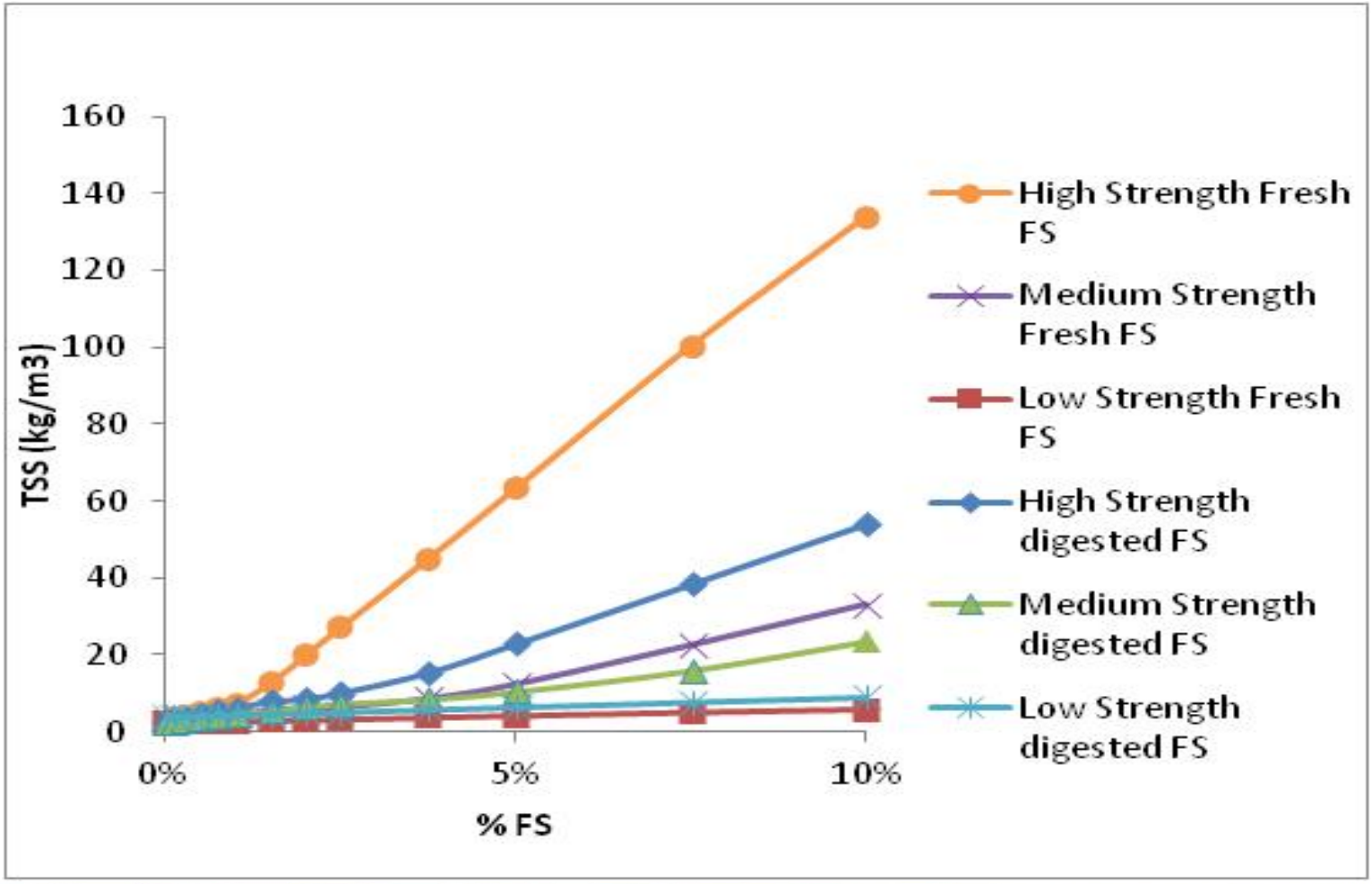
limit = 35 mg /L



Steady state simulation results:

TSS in aeration tank

limit ≤ 6 kg TSS/m^3



Maximum volume of FS that can be discharged

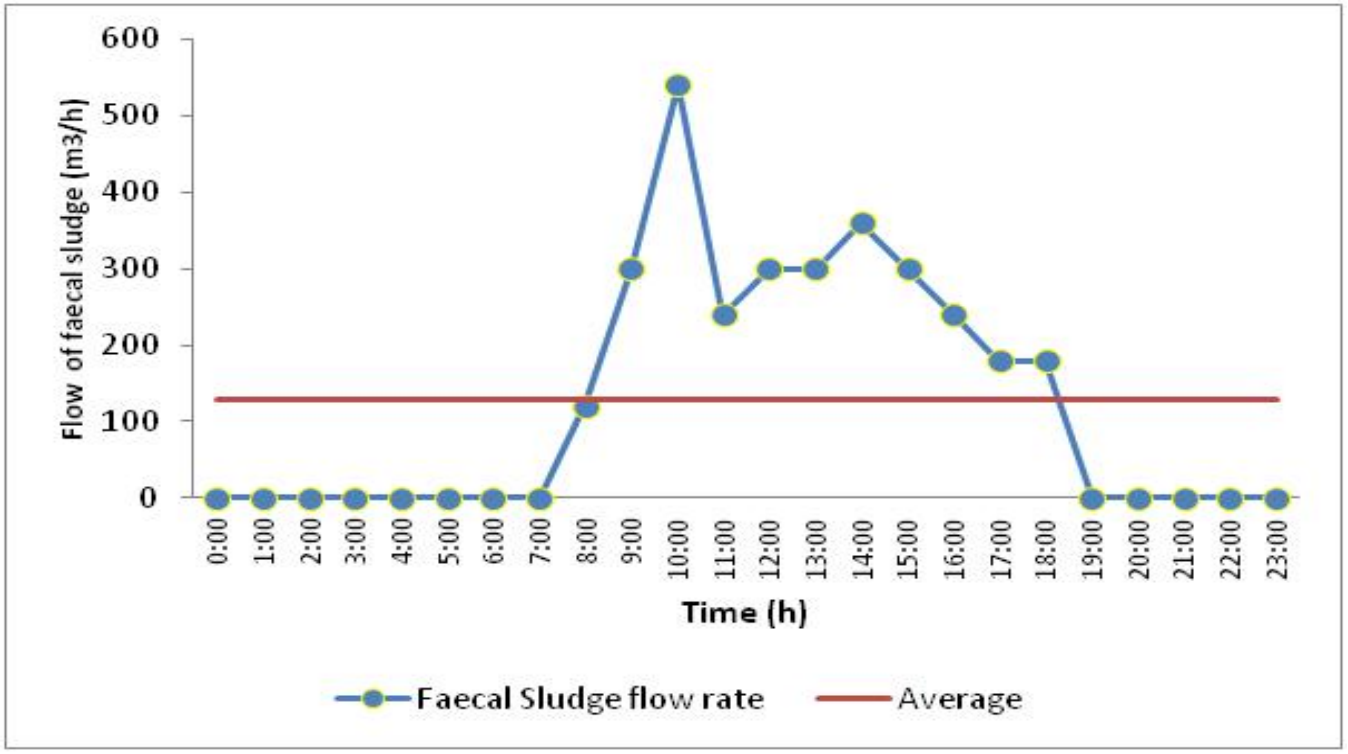
Scenarios	% FS for effluent standard is met		% FS selected	% FS when TSS in aerobic tank is < 6kg TSS/L	Volume of sludge (m^3)	# Tanker loads/d	
	Total COD	Total N				5 m^3	8 m^3
Digested Sludge							
Low Strength	10%	3.75%	3.75%	3.75%	750	**150**	**94**
Medium Strength	1%	1.5%	1%	0.375%	75	**15**	**9**
High Strength	0.5%	0.625%	0.5%	0.25%	50	**10**	**6**
Fresh Sludge							
Low Strength	10%	0.375%	0.375%	0.375%	75	**15**	**9**
Medium Strength	1.5%	0.25%	0.25%	0.25%	50	**10**	**6**
High Strength	0.375%	0.125%	0.125%	0.125%	25	**5**	**3**

Increase in aeration cost

Scenarios	FS (%)	Total aeration cost (€/year) @ € 0.10/kWH		Additional aeration cost (€/year)	
		High Aer. Efficiency (2.3)	Low Aer. Efficiency (0.6)	High Aer. Efficiency	Low Aer. Efficiency
Without FS	0%	118,968	456,046	-	-
Digested Sludge					
Low Strength	3.75%	123,721	474,266	4,753 (4%)	18,220 (4%)
Medium Strength	0.375%	130,094	498,697	11,126 (9.5%)	42,651 (9.5%)
High Strength	0.25%	134,550	515,812	15,591 (13%)	59,766 (13%)
Fresh Sludge					
Low Strength	0.375%	126,062	483,237	7,093 (6%)	27,192 (6%)
Medium Strength	0.25%	137,332	526,440	18,364 (15.5%)	70,394 (15.5%)
High Strength	0.125%	149,178	571,852	30,210 (25.5%)	115,806 (25.5%)

Dynamic simulation results

- Average discharge of faecal sludge = 127.5 m^3/d (0.68%)



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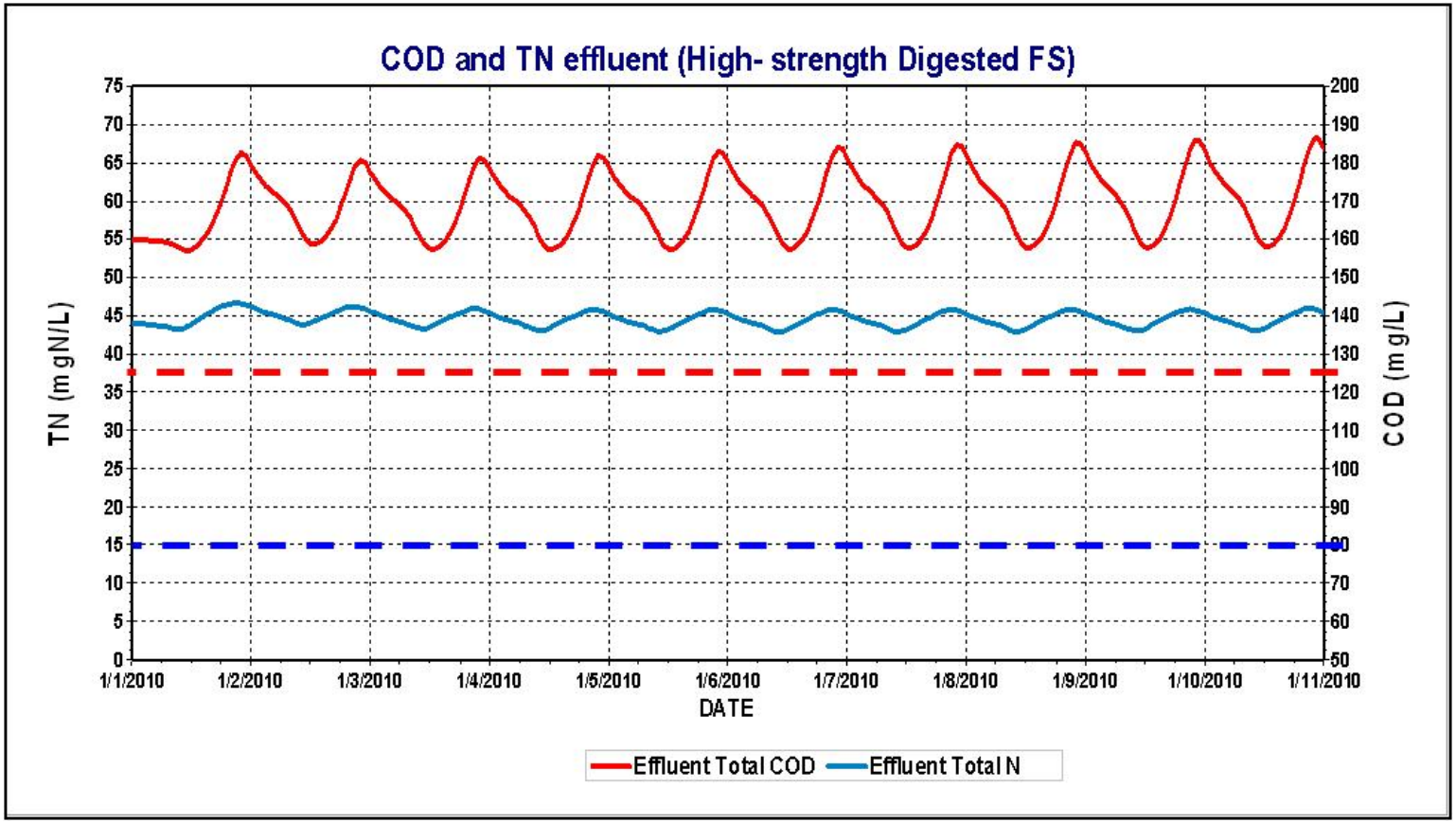
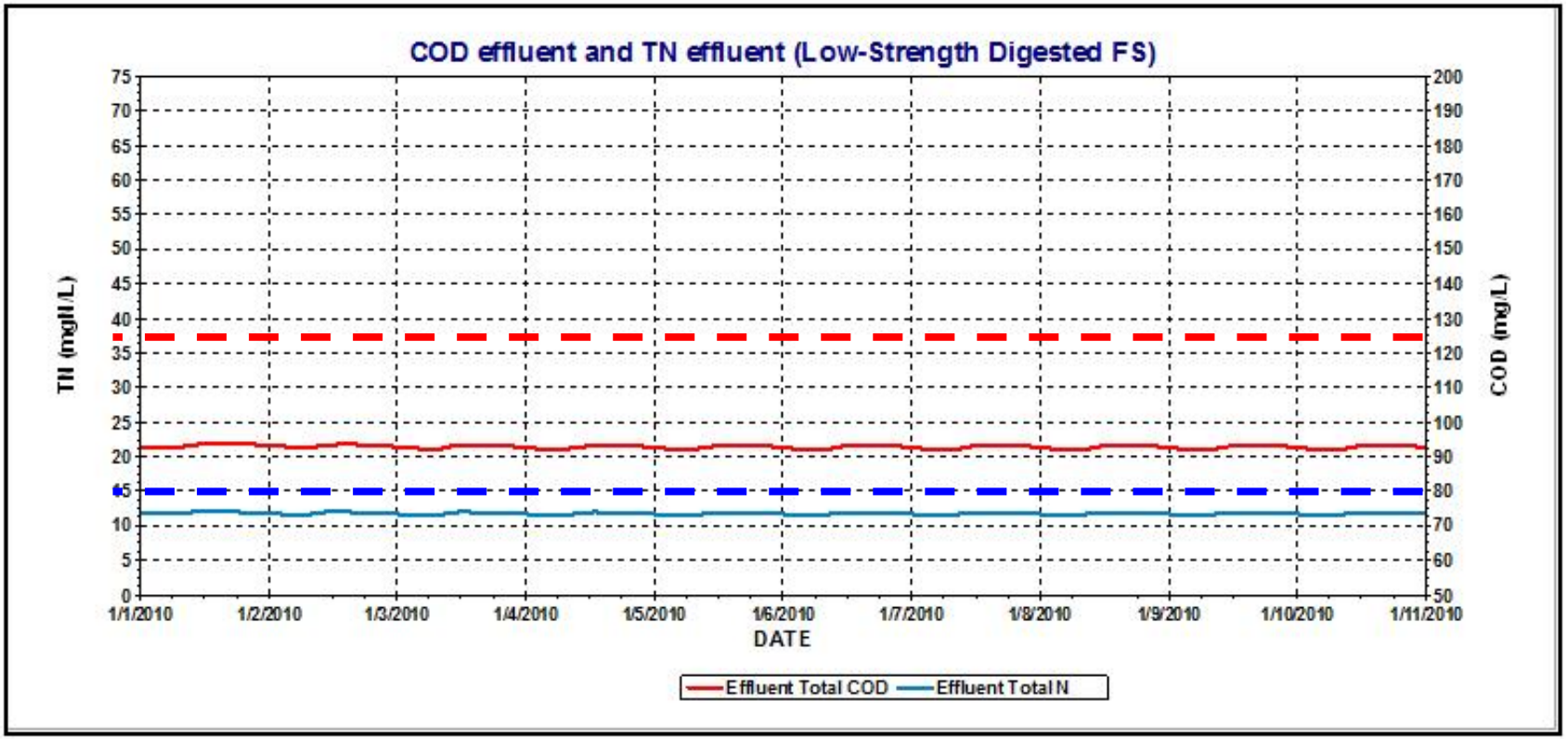
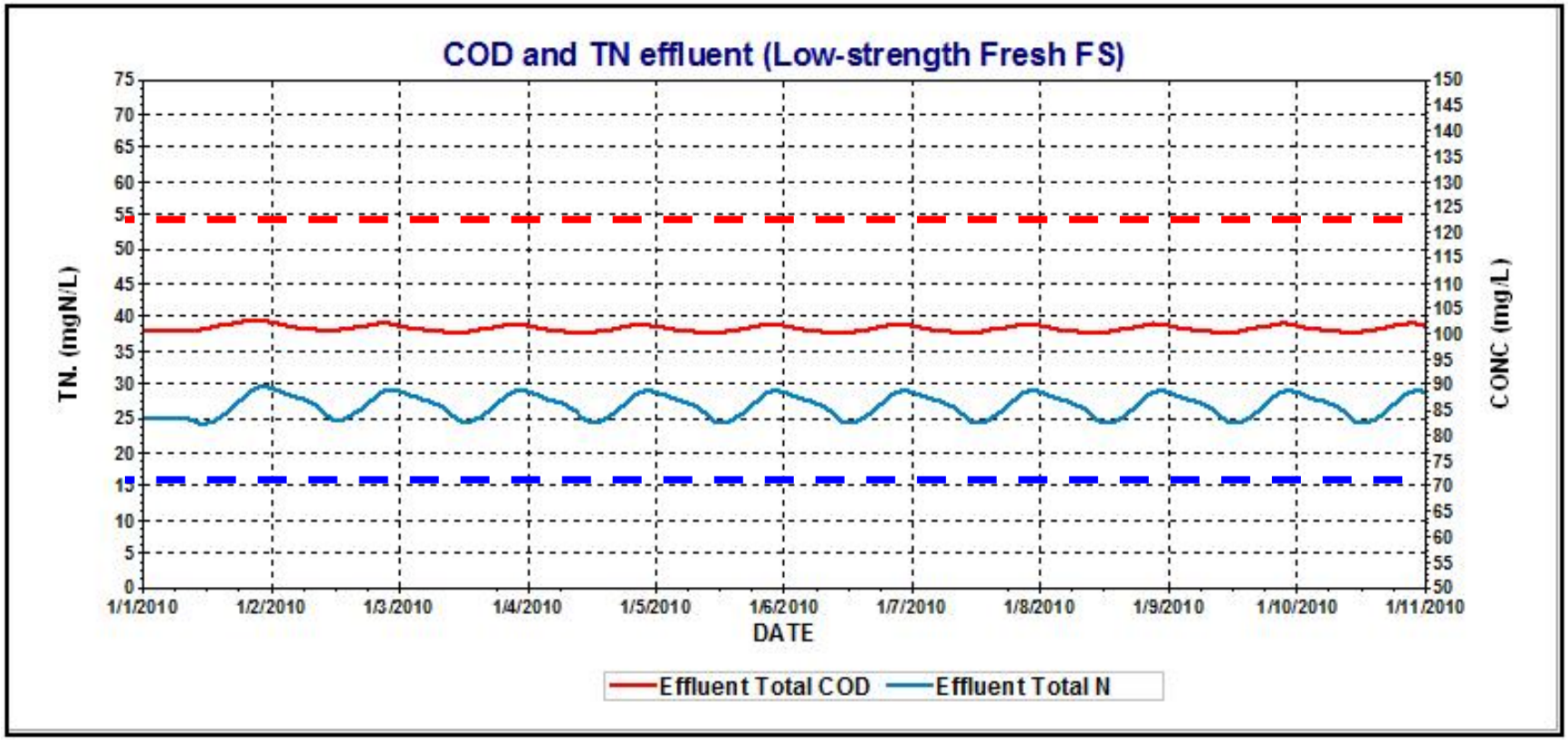
Effluent COD and N high-strength digested FS



Effluent COD and N low-strength digested FS



Effluent COD and N low-strength fresh FS



Attempts to improve effluent quality

- Discharge of FS during the night;
- Combined discharge of FS and influent wastewater in flow equalization tank;
- Discharge of even lower volumes of FS in the plant.

Conclusion:
max. volume of FS that can be discharged

Type of faecal sludge	Max. volume		No. of tanker loads per day	
	%	m^3/d	5 m^3	8 m^3
Digested faecal sludge				
Low-strength	0.638	128	26	16
Medium-strength	0.500	100	20	13
High-strength	0.250	51	10	6
Fresh faecal sludge				
Low-strength	0.125	25	5	3
Medium-strength	0.025	5	1	1
High-strength	0.025	5	1	1

General conclusion

- High increase in effluent COD, N and TSS conc. (low-strength FS has lower impacts);
- Increase in aeration requirement;
- Increase in TSS in aeration tank;
- No significant improvement in effluent quality when discharged FS during the night and by adding flow-equalization tank;
- No feasible approach.

Considerations

- Pathogens removal;
- Resource recovery;
- Energy consumption.

Thanks for your attention!