Small-Scale Wastewater Treatment Systems and Reuse Studies in Oman

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Types of Wasteswater

- Domestic wastewater (blackwater & Greywater)
- Industrial wastewater
- Oil-production water
- Low quality surface water

Current Practices

- Activated sludge system
- Membrane Bio Reactor (MBR), Sequencing Batch Reactor (SBR)
- Desalination (RO, UF, NF)
- Disposal without treatment or limited treatment

Case Studies: Based on Research Done at SQU

- Greywater Treatment & Reuse
- Polluted surface water treatment in Jabal Akhdar using filtration
- Chicken processing plant wastewater treatment using wetlands
- Fish-processing plant wastewater using aquaponics
- Textile factory effluent treatment

Greywater Projects at SQU

- Assessment of Greywater reuse potential in Oman, started in 2001
- Evaluating Greywater reuse potential for sustainable water resources management in Oman
- Development of low-cost and decentralized greywater treatment systems for proper handling, treatment and reuse in Oman and South Africa

Research Objectives

- Quantification of greywater production
- Characterize greywater quality
- Design simple treatment for Omani conditions
- Assess effects of greywater irrigation
- Recommend guidelines
- Demonstrate greywater reuse systems

Testing Greywater System at Al Hail South Mosque

Preliminary Financial Analysis – 10 year

Description	S1	S2	S3	S4	S5	S6	S7	S8
GW(m3/d)	1.5	1.5	2.5	2.5	6.6	6.6	9.0	9
Capital (RO)	950	950	950	950	4230	4230	4230	4230
Operating (RO)	66	66	109	109	290	290	394	394
Price/m^3 (RO)	0.44	0.66	0.44	0.66	0.44	0.66	0.44	0.66
IRR	17	43	43	108	5	22	14	38
NPV	142	822	802	1936	-1200	1787	377	4460
B/C	**1.1**	**1.7**	**1.55**	**2.3**	**0.8**	**1.3**	**1.0**	**1.6**

Conclusions on Greywater Research

- Greywater appears to be an alternative source of water for selected use in Oman
- Research at SQU helped to evaluate the reuse potential of greywater in Oman
- Development of guidelines is a necessity
- Public awareness is extremely important

Polluted Surface Water Treatment in Jabal Akhdar Using Filtration

- 30 surface water dams
- Waters in the dams are polluted because of eutrophication
- This polluted water has limited use
- Water supply is difficult due to topography
- Water costs more than plain lands
- A private water supply system in existence apart from government supply

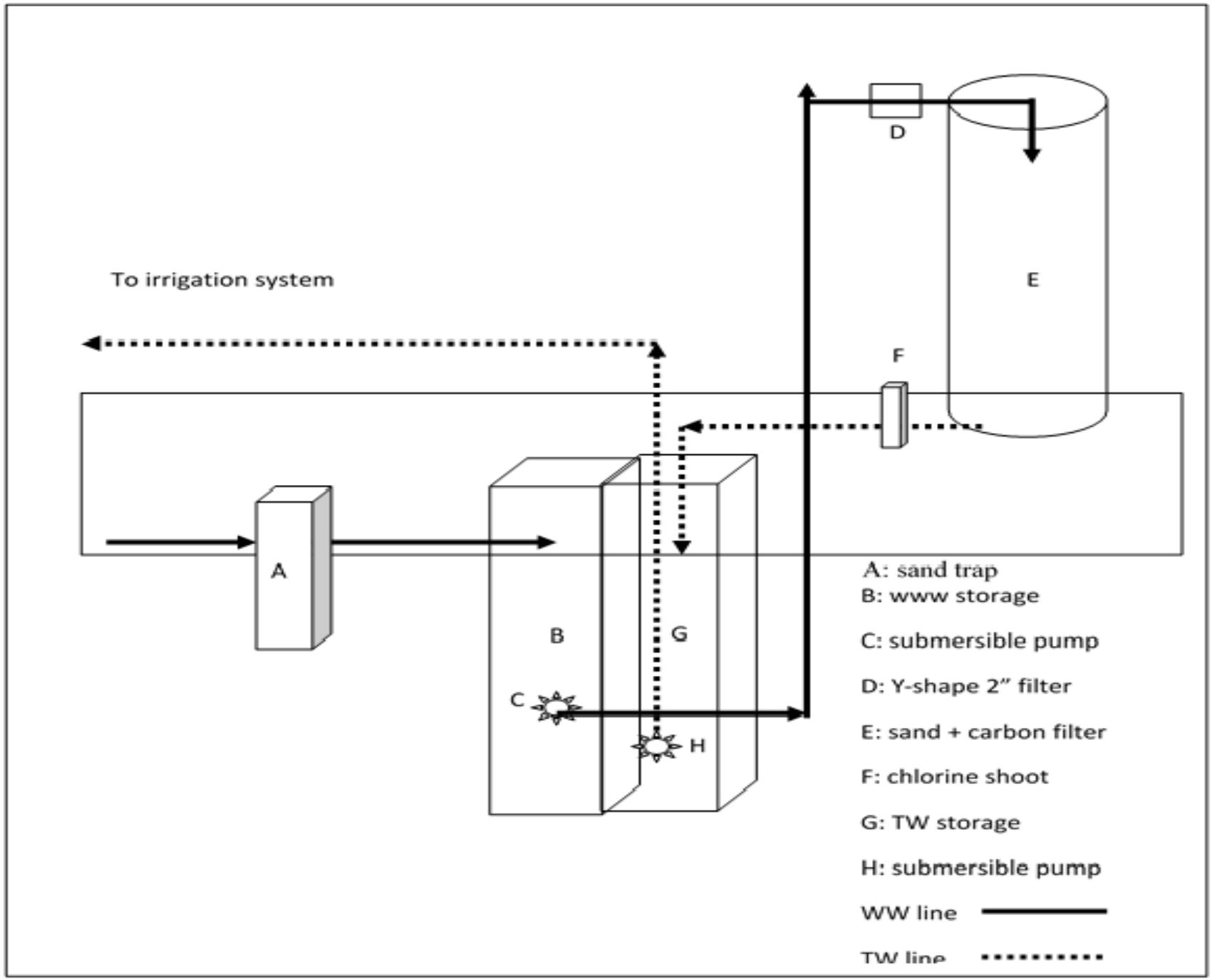
Objectives

- Design & implement a low-maintenance small scale treatment system: settlement pond, waste water tank, multi-layer filter, chlorine chute & treated water tank

- Assess the social acceptability of the treatment system among the villagers

Study Area

- Hajamta reservoir is located in Shanut village in Jabal Akhdar with an altitude of 2300 m
- Reservoir capacity is 5000 m^3
- Height is 7m & constructed in 1994
- Purpose of construction was to supply domestic water


To irrigation system
D
E
F
A
B
G
C
H
A: sand trap
B: www storage
C: submersible pump
D: Y-shape 2" filter
E: sand + carbon filter
F: chlorine shoot
G: TW storage
H: submersible pump
WW line
TW line

Treatment Plant Performance

Based on 7 monitoring data:

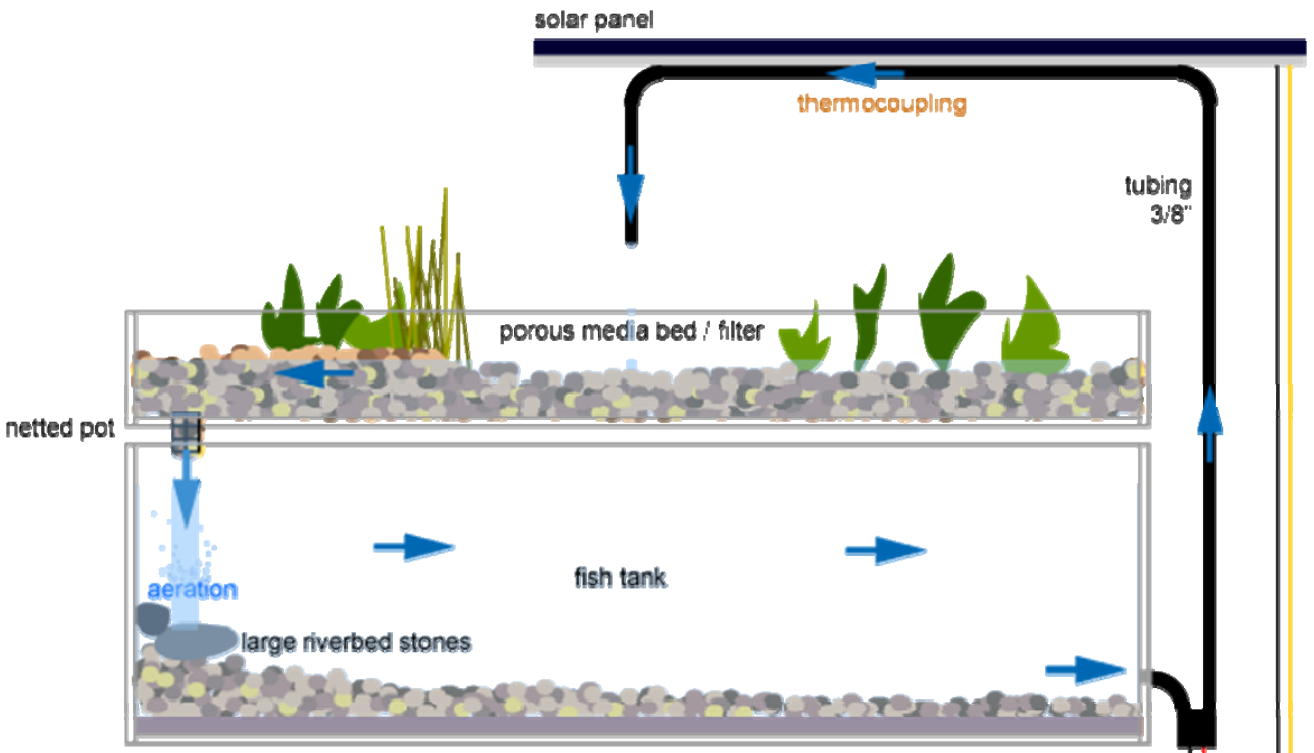
- COD reduction 30%
- BOD^5 vary between 0.1 & 3.6 mg/l.
- BOD^5 was reduced by 31% in average after the treatment
- Turbidity reduction 87%
- TSS reduction 86%
- Coliform and E. Coli not present after chlorination system installation

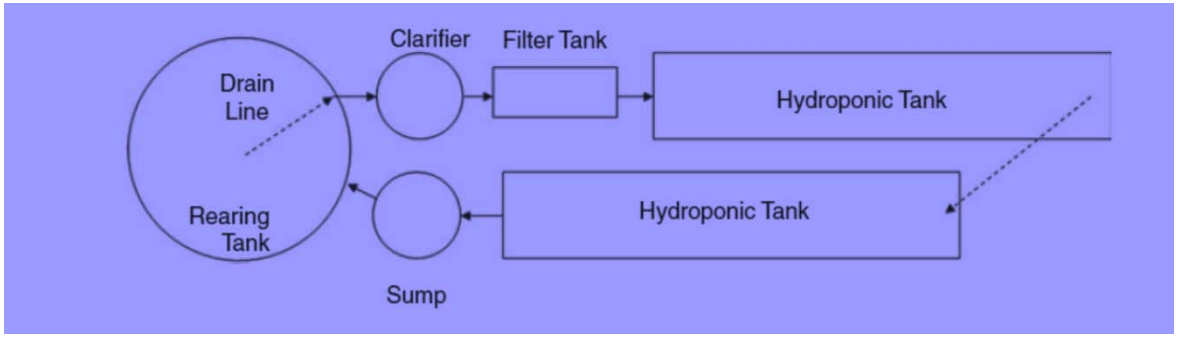
Survey Results

- 100% agreed that reservoir water has algae and also smelly
- 30% used reservoir water for washing clothes
- 25% use for cleaning kitchen and home
- 95% agreed that treated water appeared algae free and no smell was detected
- 100% agreed that treated water could be stored in closed tank
- 100% agreed that treated water could be used for washing clothes, cleaning homes
- 85% agreed that the system was easy to operate
- 95% would like to have the system in this home

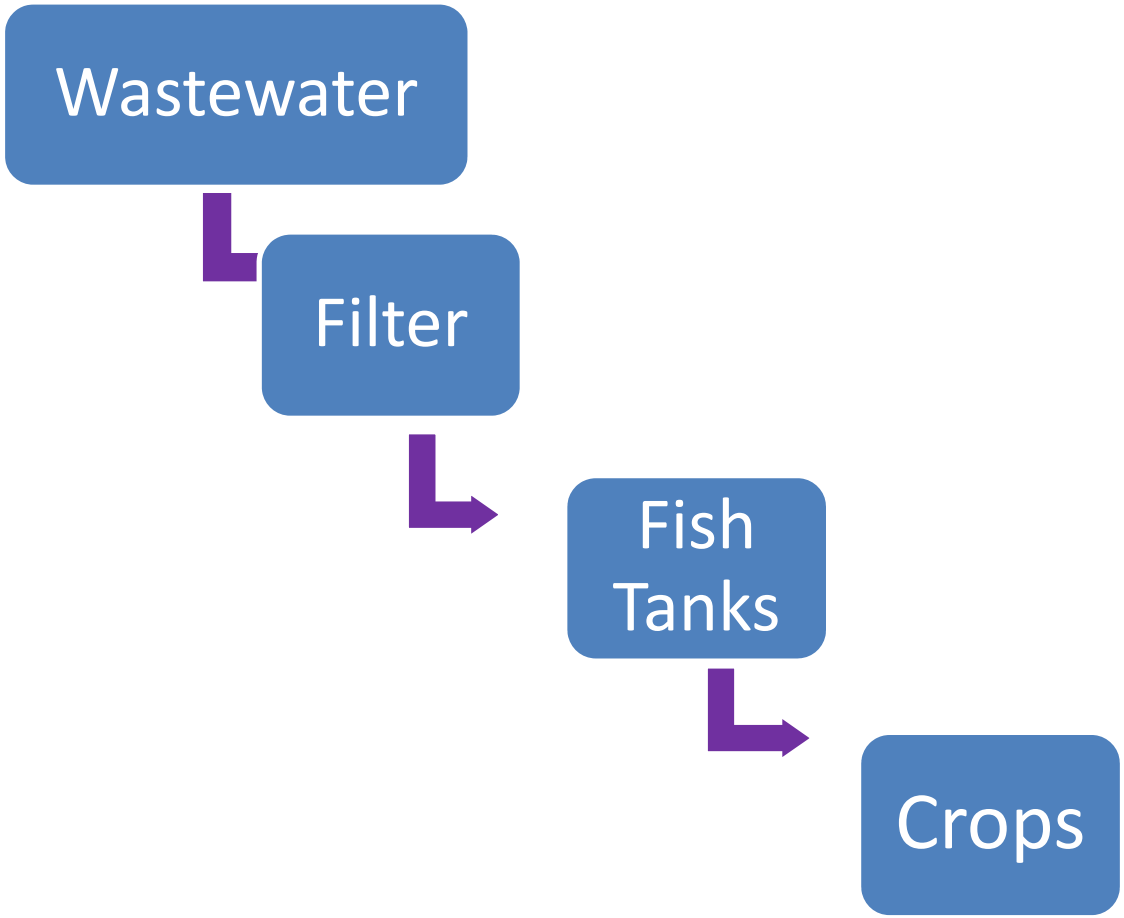
Reuse of Treated Wastewater for Aquaculture

Aquaponics

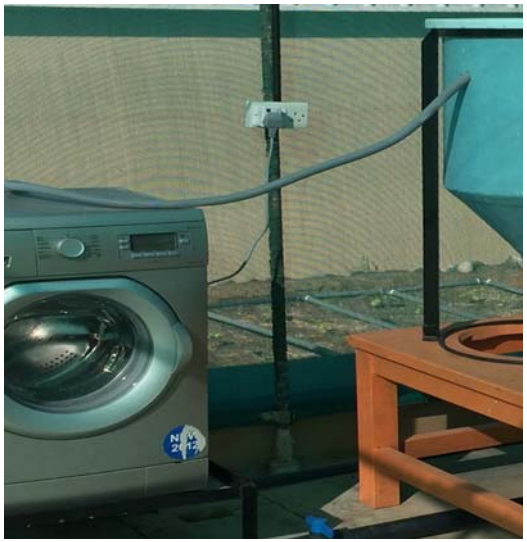

solar panel
thermocoupling
tubing
3/8"
porous media bed / filter
netted pot
aeration
fish tank
large riverbed stones
pump
fuses
battery
12 VDC
charge controller


Clarifier
Filter Tank
Drain
Line
Hydroponic Tank
Rearing
Tank
Hydroponic Tank
Sump

Integrated Aquaculture Using Wastewater



Experiment at SQU

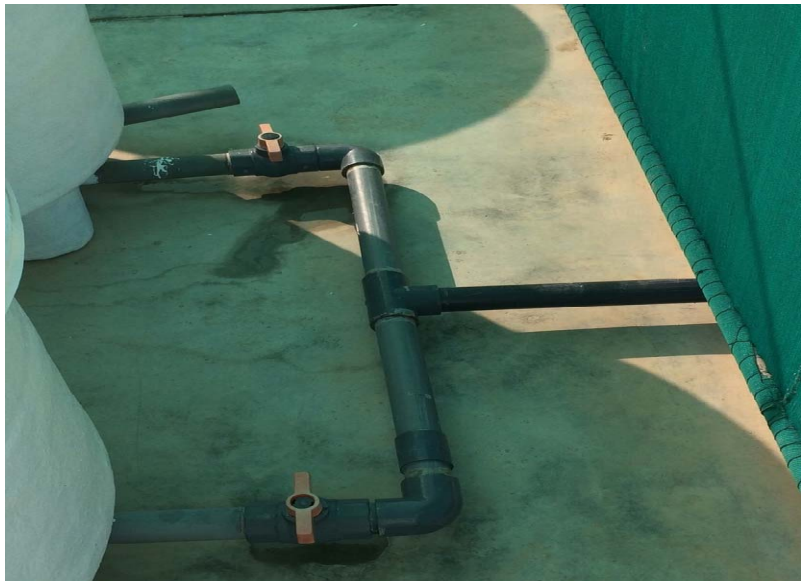


Fish wastewater

3 steps filtering

Then

Water goes to fish tanks



Fish tanks are connecting to field for crop

Irrigate to crops tanks are connecting to field for crop

Benefits of Using Wastewater for Integrated Aquaculture

- This system consumes as little as 1% of the water consumed by conventional fish pond systems
- Nitrogenous fish waste is used for plant growth
- Dual-cropping
- No wastewater is released into the environment
- Hydroponic plants grow faster than those raised by conventional methods

Wastewater Treatment & Reuse at A'Saffa Poultry Farm at Thamrait

Current Treatment System at A Saffa Poultry Farm

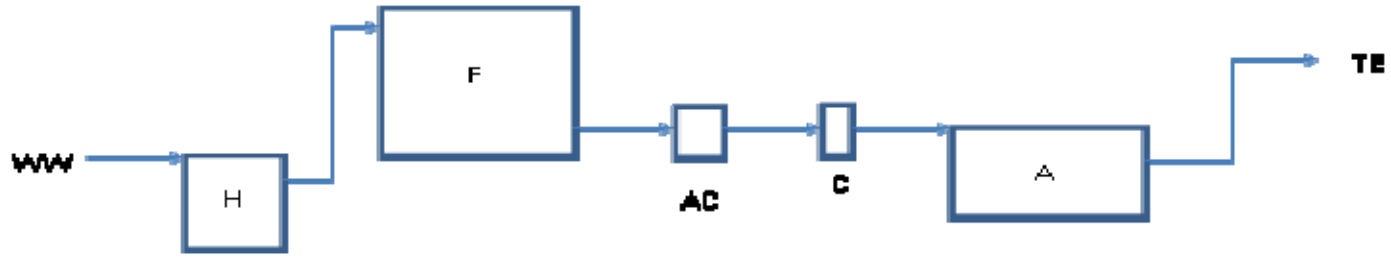
- The current produced wastewater is 1200 m^3/day and expected to reach 1500 m^3/day due to future expansion
- The current preliminary treatment (simple aeration tank) showed biochemical oxygen demand (BOD) of 200 mg/L, chemical oxygen demand (COD) of 613 mg/L, Nitrates of 7.5 mg/L and Fecal Coliform bacteria of 158 x 10^6/100 mL.

Objectives

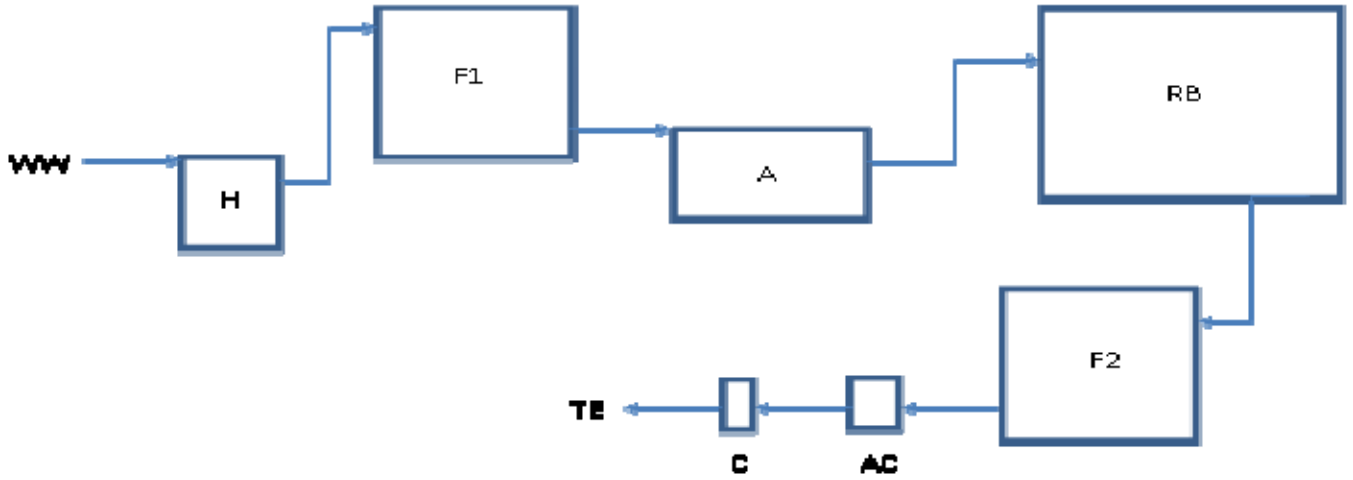
- To treat the poultry wastewater of Earlier A'Saffa Poultry Farm to produce effluent which satisfies existing Omani government regulations for wastewater reuse for irrigation purposes.

Challenges

- To build a wetland without any exposed water which might create esthetical problems
- To avoid attract any birds which may bring disease to the million chicken that live there
- Use as much materials available on site

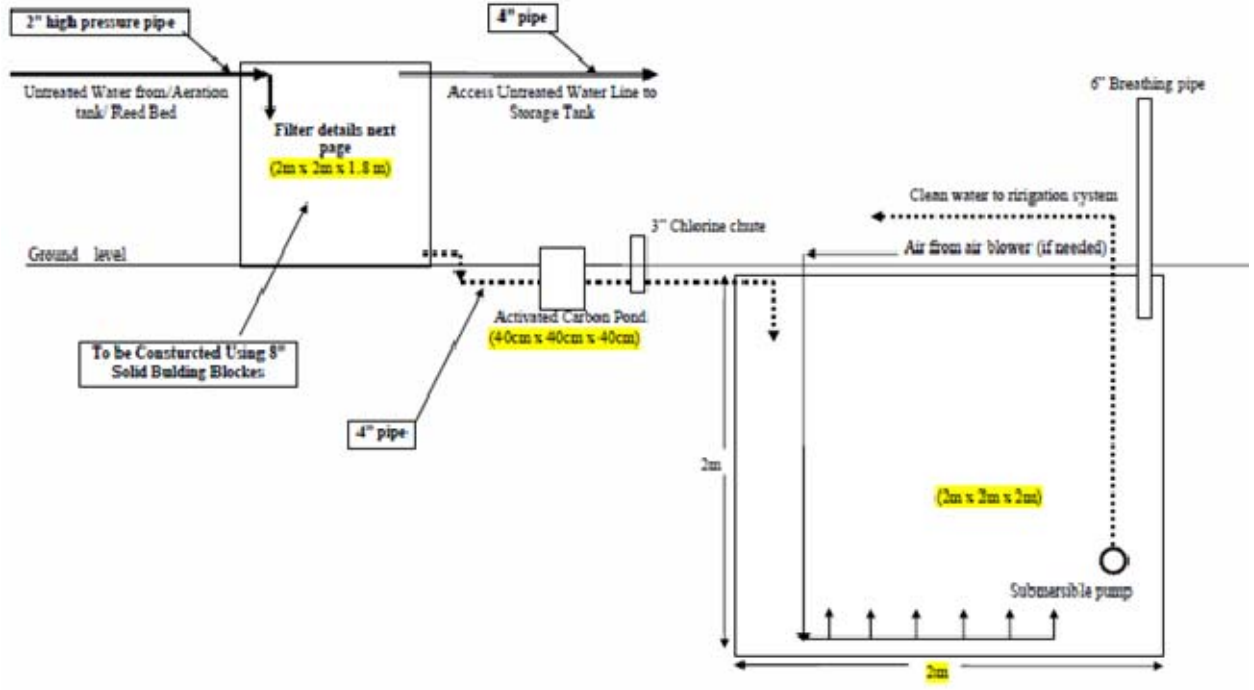


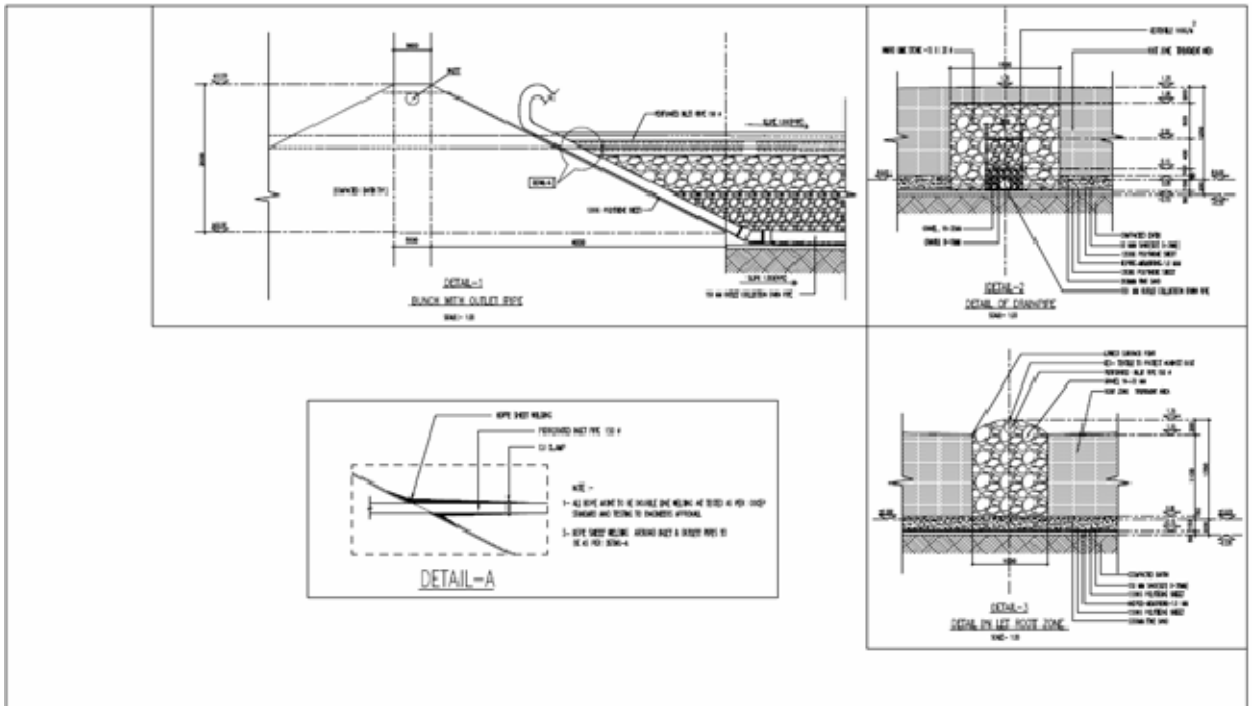
System A: WW = Raw wastewater; H = Holding tank; F = Sand Filter; AC = Activated carbon pond; C = Chlorination chute



System B: WW = Raw wastewater; H = Holding tank; F1 = 1st Sand Filter; A = aeration tank; RB = Reed bed; F2 = 2nd Sand Filter

Sketch of Water Treatment Unit for A'Saafa Ploutry Farm – Thumrait (drawing not to scale)




DETAIL-1
BUNCH WITH OUTLET PIPE
DETAIL-2
DETAIL OF DRAINPIPE
DETAIL-A
DETAIL-3
DETAIL IN LIFT POST ZONE

Wastewater sample	Before treatment sampling 21/12/13	After treatment sampling 21/12/13	After treatment sampling 29/12/13
Parameter			
pH	7.09	7.19	7.37
Electrical Conductivity – $mScm^{-1}$	4.45	9.43	7.94
Turbidity (NTU)	335	72	47
Ammonical Nitrogen as NH_3-N mg/l	194.6	344.2	209.7
Total Suspended Solids-mgl	345	23	17
Volatile Suspended Solids-mg/l	325	21	11
% Volatile Suspended Solids	94.2	91.3	64.7
Chemical Oxygen Demand mg O_2/l	1336	328	180
BOD-5 (mg O_2/l)	472	72	48
Dissolved Organic Carbon- mg/l	227	112	187
ANIONS- (ppm)			
Fluoride	4.56	4.72	4.97
Chloride	634	1703	1503
Nitrate	9.27	76.57	87.47
Phosphate	10.57	20.84	11.78
Sulphate	3.09	245.7	1744.8

Qualitative Risk Assessment of Using Treated Wastewater for Date Palms at A'Saffa Poultry Farm

- Treated effluent does not meet all the numerical standards set by the Oman Govt.
- Protecting public health Vs. agricultural consideration
- Irrigation with little human contact, growing fruit trees possible
- Minimum risk both to human health and the environment.
- An automated drip irrigation system with very little human contact
- Desert, fenced around and adult male population
- The water is suitable for date palms, excess BOD and Nitrogen will only benefit
- The irrigation water will have no impact on groundwater
- GW is not directly used for drinking, little chance of human health impacts
- Water will be stored in covered containers, will not attract any birds
- There is little chance of this water entering directly in the food chain
- Dates grown will not carry any excess heavy metalsfrom wastewater
- We also expect that the effluent quality will improve further in future

Conclusions from Wetland Experiment

Based on our finding we can make the following conclusions

- Natural filtration and reedbed systems can greatly improve the quality of effluent from a chicken processing farm
- It is likely that use of chicken manure as the base material for the reedbed has contributed some pollutants to the effluent (especially in terms of Biological Oxygen Demand, Nitrate, EC)
- Based on a risk assessment, we conclude that the effluent from the reedbed can be used for growing date palms

Treatment of Textile Plant Wastewater

- Textiles effluent typically contains any combination of dyes, adhesives or other chemicals that require significant treatment before being disposed as wastewater.
- Undertake research on design and development of novel technology for the treatment and re-use of textile effluent water.
- A treatment plant to handle 500 m^3/day of OTM wastewater was designed based on the research work.

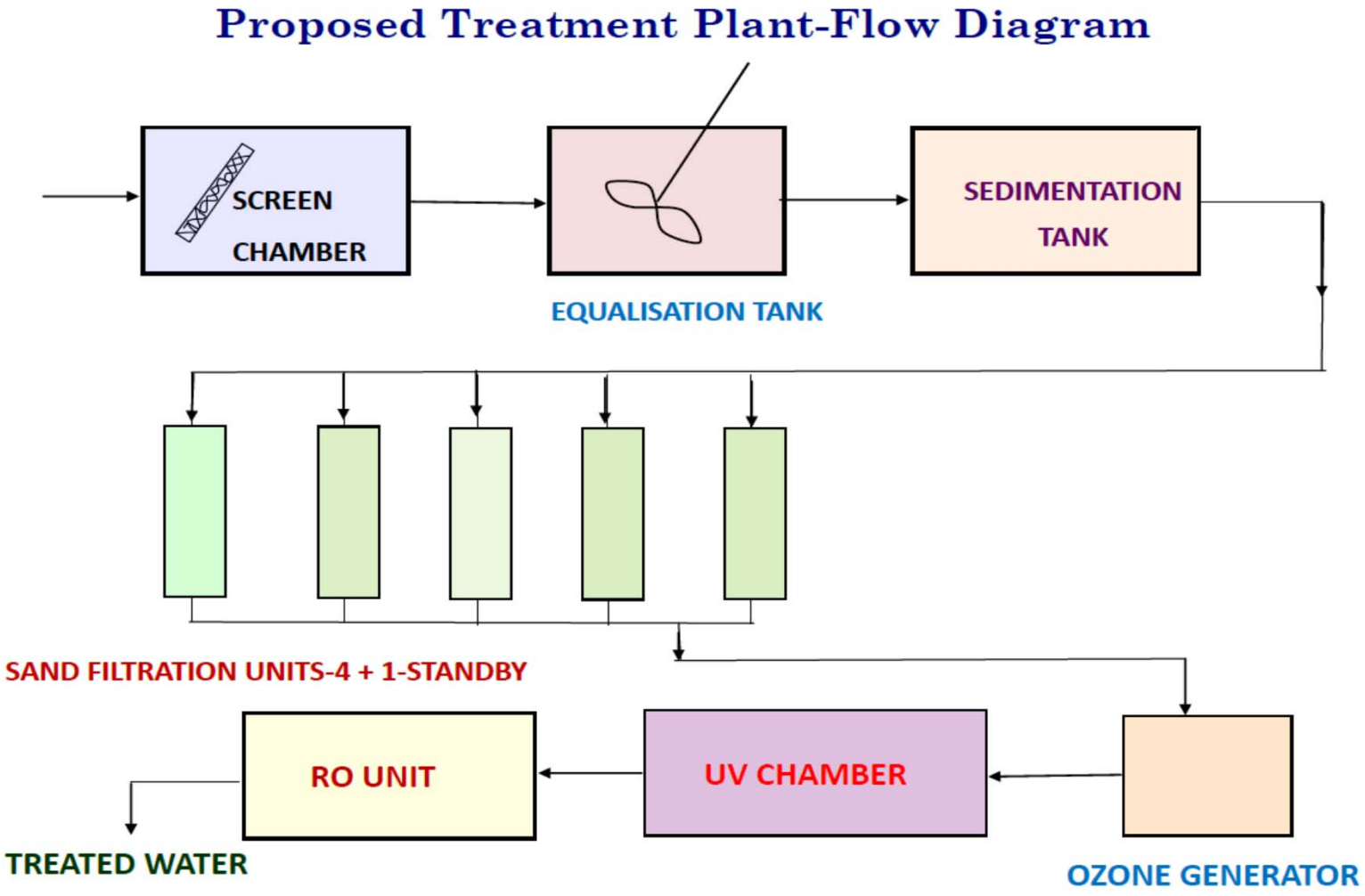
Treatment: Sand Filtration+Ozonised Solution+UV

Parameter	Raw Water	After Filtration	(490+10) ml	(470+30) ml	(450+50) ml	(400+100) ml
pH	9.52	7.70	8.28	8.27	8.26	8.28
COD, mg O_2/L	737	278	Low	Low	Low	Low
BOD, mg O_2/L	ND	ND	ND	ND	ND	ND
TSS, mg/L	128	32	Low	Low	Low	Low
Oil and Grease	ND	ND	ND	ND	ND	ND
TDS, ppm	1620	710	363	257	243	219
Color	Light Blue	Pale Yellow	Colorless	Colorless	Colorless	Colorless
Turbidity (NTU)	23.4	26.0	0.80	0.65	0.59	0.47
Total Hardness, mg/L	167	79	38	27	26	23
Total Organic Carbon, mg/L	199.9	119.4	33.90	33.09	31.70	28.55

Treatment: Sand Filtration+UV

Parameter	Before Treatment	After Treatment	OTM Desired Specifications
pH	7.70	8.28	6.5-8
COD, mg O_2/L	278	Low	Less than 4
BOD, mg O_2/L	D	ND	Less than 3
TSS, mg/L	32	Low	NIL
Oil and Grease	ND	ND	NIL
TDS, ppm	710	219	50-200
Color	Pale Yellow	Color Less	Less than 15
Turbidity (NTU)	26.0	0.47	Less than 5
Total Hardness, mg/L	37	23	Less than 100
Total Organic Carbon, mg/L	119.4	28.55	-

Treating Textile Plant Wastewater



Take Home Message

- Different treatment processes were investigated for small-scale wastewater treatment
- Most of them were successful at lab scale and limited field trials
- New processes should be tested for field trials
- Academic research needs to be translated into reality through various mechanisms