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Wastewater for Aquaculture: The Case of Mirzapur, Bangladesh

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Waste Water Treatment for developing country

- Wastewater – concentrations of suspended and dissolved organic and inorganic solids.
- Conventional technologies for wastewater treatment are too costly.
- Do not allow - re-use of valuable energy and nutrients contained in the wastewater.
- In the context of developing world - Think about (a) Pollution Prevention and (b) Re-Use!
- Need to consider - Low cost, solution, Environment free, Eco-friendly, Integrated, Sustainable, Employment generation.

Low cost Wastewater Treatment

- Duckweed-based wastewater treatment systems are inexpensive to install as well as to operate and maintain.

- Nutrients will end up as fish protein (via duckweed feeding) and crop protein (via irrigation).
- Key step in waste recycling, driven by photosynthesis.
- Energy efficient, cost effective and applicable under a wide variety of rural and urban conditions.

Why Duckweed?

Characteristics of duckweed

- Family: *Lemnaceae*
- 4 Genera: *Spirodela, Lemna, Wolffia, Wolffiela*
- Size: < 2mm to 20 mm
- 37 species identified
- World wide distribution
- High growth rate
- High nutrient uptake
- Low fibre, high protein (30-40%)
- Duckweed a crop?

Parameters	Water Hyacinth	Duckweed
Temperature range	> 20 C	5 - 40 C
N-removal (g/M^2.D)	0.25 – 1.3	0.2 – 1.67
P-removal (g/M^2.D)	0.05 – 0.24	0.01 – 0.3
Protein content (% DW)	LOW	25 – 40%
Fibre content	HIGH	LOW
Growth rate	+	++
Harvesting/Handling	DIFFICULT	EASY
Mosquito development	+	-
Acceptability by animals	- ±	+

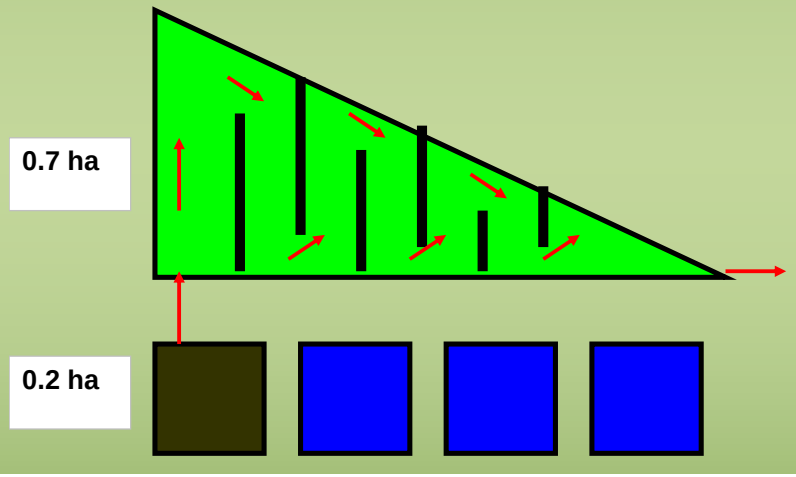
Protein yield of selected crops

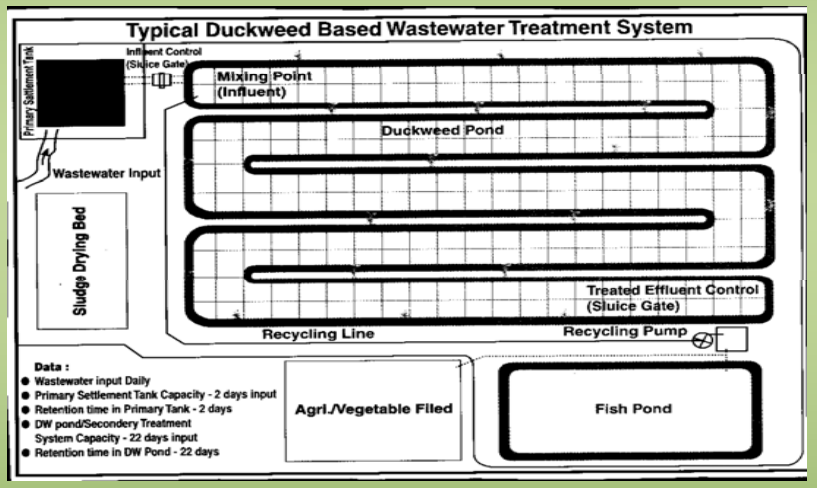
Crop	Production T dm/ha.y	Protein (% dm)	Protein (kg/ha.y)
Duckweed	17.6	37	6510
Soybean	1.59	41.7	660
Cottonseed	0.76	24.9	190
Peanuts	1.6 - 3.1	23.6	380 - 740
Alfalfa	4.4 – 15.7	16-17	690 - 2670

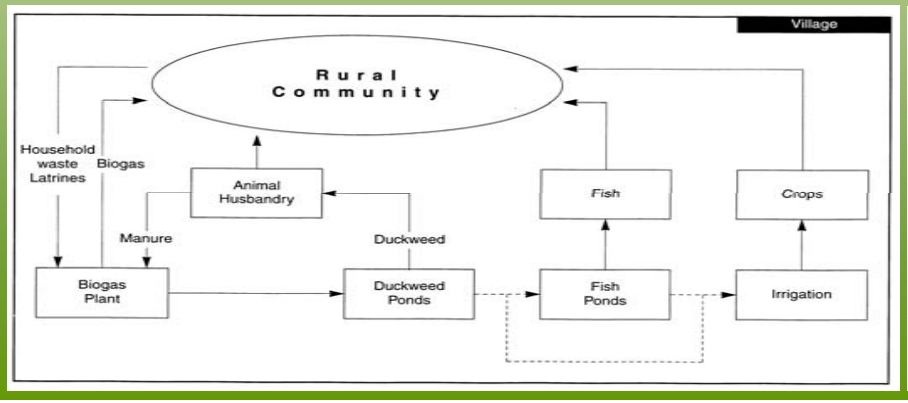
Advantages of duckweed:

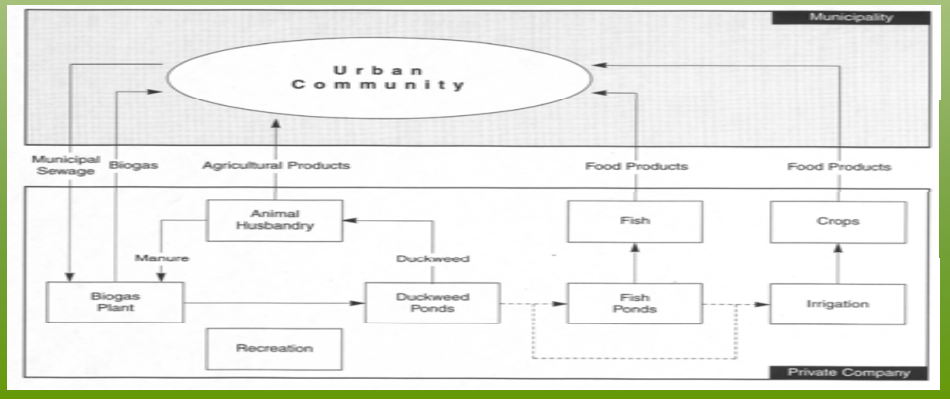
- **Effective nutrient removal/recovery**
- **Production of high quality feed**
- **Low mosquito count**
- **Reduced water losses via evapo(-transpi-)ration**
- **Reduced odour problems (high BOD)**
- **Possible cost recovery via aquaculture or other feed applications**

Duckweed WWT and aquaculture in Bangladesh









A Case study of PRISM Bangladesh

•**PRISM Bangladesh is operating a duckweed based wastewater treatment system in Mirzapur Kumudini Hospital Complex (KHC) since 1990.**

•**Wastewater generated by the hospital, residential girls school and staff quarters are collected and being treated through the duckweed based treatment system.**







DW protein = 6000 kg/ha.y
Soy bean protein = 600 kg/ha.y

At a glance of the project

DESCRIPTION	VOLUME/QUANTITY/UNITS
General Information	
System capacity	14 million liters.
User group	3,000 persons.
Land used	2.4 hectares.
Primary Treatment	
System capacity	750,000 liters.
Land used	0.25 hectare
Retention time	24 hours
Dimensions	L-45m, W-45m,D-2.5m
Secondary Treatment	
System capacity	12 million liters
Land used	0.89 hectare
Retention time	20-24 days
Dimensions	L-575m, W-9m,D-2m, (water depth-0.5-1.5m)
Duckweed plug flow	
DW species grown	Spirodella,Lemna minor,Wollfia
DW standing crop density	650 gm/meter^2
Methods of harvesting	Manual with net/ring harvesters
Estimated DW crop harvest	500 kg/day
Frequency of DW crop harvest	Daily
Annual DW production	180,000 kg
Use of DW harvested	Fish feed
Perimeter crops	Banana, vegetables, etc.

Tertiary Treatment	
Dimension	L-30m, W-10,D-2m
Treated effluent outputs	300,000 liters/day
Treated quality	
Ammonia (NH_3)	1.22 mg/l
Nitrates (NO_3)	0.8 mg/l
Phosphates	0.09 mg/l
TSS	7.8 mg/l
BOD	8.2 mg/l
Total coliform count	<100/100ml
Fish pond	
Land for fish pond	1 hectare
Fish pond water area	0.6 hectare
Type of fish culture	6 carps polyculture
Fingerling stocking rates	10,500 no.
Mix of fish	
Rohu	15%
Catla	15%
Mrigal	20%
Grass carp	20%
Silver carp	20%
Mirror carp	10%
Estimated fish production	7,000 kg/year
Frequency of fish harvest	Weekly

Water Quality Performance

Parameter Monitoring

Location	BOD_5 (mg/l)	NH_3 (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)	K (mg/l)	P (mg/l)	TDS (mg/l)
Concrete house	319.95	33.37	1.4	10.50	149.30	2.23	470.19
Suction point	236.11	27.22	1.4	7.00	200.25	3.29	402.44
Mixing point	125.12	19.91	0.7	0.50	91.71	1.57	318.20
First bend	89.21	11.41	1.0	0.30	104.32	0.99	294.81
Third bend	30.44	2.38	1.2	0.20	102.74	0.53	243.15
Fifth bend	16.16	1.39	1.2	0.00	73.73	0.60	220.93
Last bend	9.8	1.22	1.2	0.00	96.32	0.26	202.15

Heavy Metal Monitoring in ppm

Metals	Sediment (Sludge)	Border (Sludge)	Desludging (Sludge)	Polishing (Sludge)	Start (DW)	Swiss Sewage sludge (stnds. 1)	Swiss compost (stnds.1)
Pb (Lead)	22-25	24-26	46-50	4-6	0-3	500	120
Cd (Cadmium)	2.5-5	2-2.5	2.5-4	0-1	0-2	5	1
Cr (Chromium)	70-90	84-109	88-93	47-59	20-24	500	100
Co (Cobalt)	14	14-15	14	4	4-6	60	--
Cu (Copper)	44-48	50-55	118-121	30-39	169-249	600	100
Ni (Nickel)	45-46	46-48	50-51	21-26	12-14	80	30
Hg (Mercury)	0-0.6	0-0.8	0-1.25	0	0	5	1
Zn (Zinc)	176-189	148-169	350-368	5-7	28-43	2000	400
As (Arsenic)	3.3-3.9	4.3-5.0	15.0-15.3	4.2-4.8	21.9-4.3	--	--

Average Annual Income and Expenditure

Description	Year 1 (Taka)	Year 2 (Taka)	Year 3 (Taka)	Year 4 (Taka)	Year 5 (Taka)	Year 6 (Taka)	Year 7 (Taka)	Year 8 (Taka)	8 years Average
1. Recurring operational Cost									
Land rental (2 ha)	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
Staff salary and wages	85,600	92,020	98,922	106,341	114,317	122,891	129,036	136,480	110,701
Field supplies (duckweed)	10,000	12,000	13,500	14,300	15,200	15,960	15,678	16,512	14,144
Field supplies for Agri & Fish	28,000	29,000	30,000	31,000	33,000	32,300	34,000	33,600	31,363
Energy/fuel cost (pump)	43,500	45,500	47,900	50,430	55,720	58,500	62,400	63,100	53,381
Maintenance	13,700	14,000	14,500	15,200	16,720	17,556	18,375	18,500	16,069
Miscellaneous	6,285	6,580	7,000	7,350	7,700	7,900	7,500	7,720	7,254
2. Total Annual Operation Cost	213,516	225,100	237,822	250,621	268,657	281,107	292,989	301,912	258,966
Depreciation (10 years)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Management Overhead (7.5%)	15,981	16,833	17,837	18,797	20,149	21,083	21,974	22,643	19,412
Financial costs (9.5% on WC)	10,450	10,925	11,590	12,350	13,300	13,352	13,916	14,340	12,528
Subtotal Admin&Finance costs	51,431	52,808	54,427	56,147	58,449	59,435	60,890	61,943	56,941
Total Annual Recurring costs	264,516	277,908	292,249	306,768	327,106	340,542	353,879	363,855	315,853
Income from Farm Revenue:									
Sale proceed from DW fed Fish	128,778	253,800	316,509	402,231	404,982	445,702	419,440	413,354	348,100
Sale proceed from Agri. /fruit	25,000	30,000	34,000	44,000	65,000	58,250	56,667	60,223	46,643
Miscellaneous sales	3,600	4,400	4,600	5,200	5,400	5,200	5,100	5,600	4,888
Total Income from sales	157,378	288,200	355,109	451,431	475,382	509,152	481,207	479,177	399,630
3. Operational Profit	-55,707	63,100	117,287	200,810	206,725	228,045	188,218	177,265	140,718
4. Net profit before taxes	-107,138	10,292	62,860	144,663	148,276	168,610	127,328	115,322	83,777

1 US Dollar = 80 Bangladeshi Taka

Low cost resource recovery and sustainability

- High quality duckweed crop for feed application in fish/animal supplement - livestock.
- Treated effluent for safe irrigation and reuse of water.
- Composted sludge can be used as agriculture fertilizer when not toxic.
- Biogas generated for energy.
- Productive utilization of fallow land and wastewater; and
- Duckweed wastewater treatment systems by turning wastewater into valuable duckweed meal, return a net profit against capital and recurrent cost.
- Because of this effective resource recovery, the duckweed treatment system seems economically more sustainable.

Aquaculture and sanitation

- Flexible and can be set up both as small scale decentralized systems, as well as large-scale systems.
- Direct economical benefits from fish sales and integrated aquaculture (poultry feed) and other by-products (periphery crops ie; vegetables, fruits);
- Urgently needed high quality animal feed;
- The system provides incentives to install and optimally use sanitary latrines;
- Contribute to an improved sanitation and health condition due to reduction of indiscriminate discharge of pathogens and contaminants into the environment;
- Reduce possible bad odors, usually are produced from wastewater;
- Reduction of mosquito breeding sites,
- Substantially improve employment situation of the local population in the immediate surrounding;
- Considering these positive effects, it is clear that duckweed holds great potential in wastewater and sanitation projects if combined with duckweed feed applications in aquaculture for developing world.

- **Recommendation:** it is recommended that Government can consider the option of duckweed based wastewater treatment in new projects, or possibly also in ongoing projects, in the field of wastewater treatment and sanitation in the developing countries.


Thank You!