Technology Options: Session 4 : Reuse

Module 5: Session 4

Experience of farmers in fish culture

Farmers have learned by experience how to grow fish in wastewater-fed ponds :

- wastewater is a fertilizer providing nutrients but the addition of too much wastewater will use up all the dissolved oxygen and kill the fish
- thus there is a need to balance wastewater input to simultaneously produce feed for the fish and maintain adequate dissolved oxygen

Farmers use indicators to assess water quality

- a medium green colour of the water from not too dense a growth of phytoplankton which allows light to penetrate to between 10-20 cm into the water column
- minimal surfacing of the fish in the pond at dawn to gulp air which indicates sufficient dissolved oxygen

Experience of farmers in fish culture (continued)

Farmers use various strategies to fertilize fish ponds

- relatively high strength faecal sludge or concentrated wastewater is added to the pond at intervals of a few days
- less concentrated wastewater or polluted surface waters are allowed to flow, or are pumped into fish ponds. Wastewater may be added continuously or for only a few hours each day depending on:
  - need i.e., how much phytoplankton is in the water
  - the relative size or volume of the pond and the wastewater flow rate
  - dilution due to heavy rain such as in the rainy season
  - season with respect to lower winter temperature in temperate climates

Primary and secondary fertilization

In some areas there is only anaerobic wastewater and no supply of clean oxygenated water. Under such circumstances the farmers :

- fill up the pond with black wastewater and leave it for 2-3 weeks for natural purification to improve the water quality before fish are stocked – primary fertilization
- wastewater is subsequently added according to need to maintain nutrient levels – secondary fertilization

Research into wastewater-fed fish culture

Research has subsequently provided a scientific basis for the key parameters in wastewater-fed fish culture:

- herbivorous and omnivorous fish such as carps and tilapias
- natural food chain organisms such as phytoplankton, zooplankton and benthic organisms
- organic loading rate of 10-30 kg BOD_5/ha/day
- nutrient loading rate of 4 kg of nitrogen and 1 kg of phosphorus per ha per day
- minimal night time dissolved oxygen of 1-3 mg/l
- maximum permissible concentration of un-ionised ammonia of 0.5 mg/l

Differing approaches of sanitary engineers and aquaculturists to wastewater-fed pond design

	Sanitary Engineer	Aquaculturist
Aim	Maximum sewage treatment	Maximum fish production
BOD loading rate (kg/ha/d)	200-300	10-20
Relative area	Low	High

Fish population management

Stocking strategy

- farmers usually stock about 3-5 fingerlings/m^2 of pond surface area of a polyculture of carps (Indian major carps and Chinese carps) and tilapia

Harvesting strategy

- farmers usually harvest fish at frequent intervals of 0.5-3 months, followed by restocking, to maximize production
- frequent stocking and harvesting increases fish yield but reduces the size of the harvested fish. However, large harvests of relatively small fish are mainly purchased by poor consumers in India and Vietnam

Yields

- yields in well managed ponds are about 5-7 tonnes/ha/year

Fish culture in conventional stabilization ponds

- Fish culture associated with conventional wastewater stabilization ponds is rare but designs recommend complete treatment of the effluent before it is used in a fish pond
- Thus there is a series of anaerobic, facultative and maturation ponds before the effluent is used in the fish pond
- The treated effluent would meet the current WHO tentative guidelines of 10^3 faecal coliforms/100 ml but such a high degree of treatment before the effluent enters the fish ponds would minimize use of nutrients

Improved design

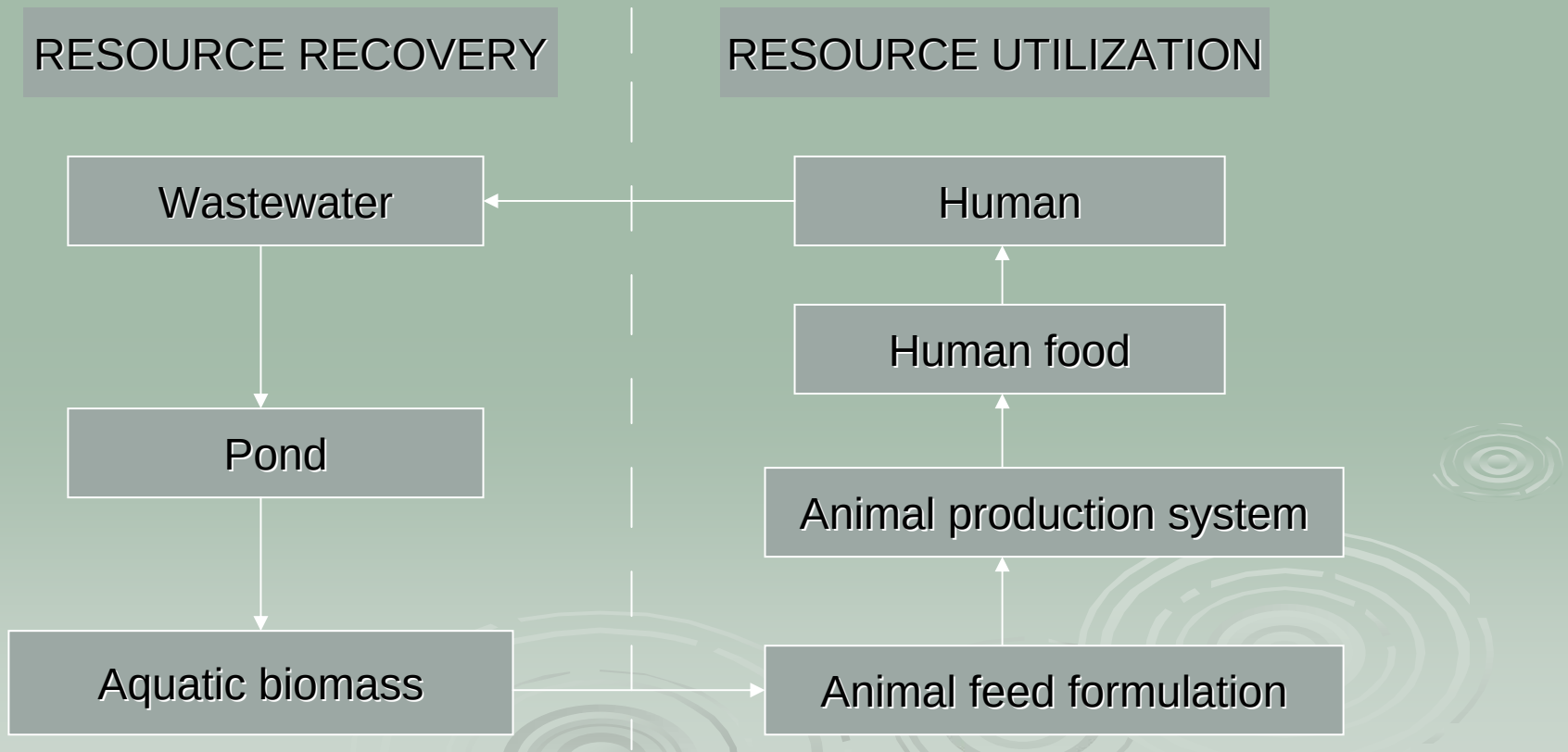
- An improved design has been proposed which provides minimal (but adequate) treatment of wastewater and maximal production of microbiologically safe fish

- The design takes into consideration the extremely rapid die-off of faecal bacteria and viruses in “green water” fish ponds, with the allowed number of faecal coliforms in the pond water 10^3 faecal coliforms/100 ml rather than the wastewater effluent

- Less than 10% of the total pond area would be used for pretreatment of the wastewater before it enters the fish pond, with a much greater production of fish from the wastewater

Production of high-protein animal feed

Most use of wastewater is to produce fish or aquatic vegetables directly but it may be more appropriate to produce aquatic biomass for animal feed with separation of resource recovery and resource utilization:



Relevance of indirect use

Indirect use has benefits because of the “lengthening of the food chain” :

- it may allow wastewater use to be socially acceptable in those societies in which direct use to produce human food is socially unacceptable
- the extra step in the food chain also reduces the risk to public health

The farming of high-value carnivorous fish and shrimp depends on fish meal as a component of their pelleted feed. As marine capture fisheries, the main source of fish meal are fully exploited, fish cultured in wastewater may provide an alternative high-protein source for diets

Tilapia as high-protein animal feed

Research has demonstrated the feasibility of production and use of tilapia raised on faecal sludge as a high-protein carnivorous fish feed :

- yields of almost 7 tonnes/ha/year were produced by seining ponds stocked with a freely breeding population of tilapia
- Trials in which the septage-fed tilapia were fed to carnivorous walking catfish indicated that they were as effective as marine trash fish fed directly, and as fish meal in a formulated fish diet

Duckweed as high protein animal feed

Cultivation of duckweed is traditional Chinese practice to produce green fodder for grass carp fingerlings. There has been much research over the last three decades on duckweed in relation to wastewater

Advantages of duckweed :

- high growth rate producing 10-40 tonnes dry matter/ha/year on nutrient-rich wastewater
- high crude protein content of 25-45% on a dry matter basis although less true protein
- effective in wastewater treatment through shading the water column and taking up nutrients
- harvested easily by net and pole
- readily consumed by fish and poultry

Duckweed as high protein animal feed (continued)

However there are disadvantages with duckweed :

- its growth is adversely affected by low temperature high temperature and high light intensity although the latter two can be partially overcome by shading
- occasional infestation with insects
- difficult to dry so needs to be fed to animals fresh
- decomposes rapidly

Case studies :

- Mirzapur, Bangladesh
- Khulna, Bangladesh – See Research Case study Reports
- West Bank, Jordon Valley