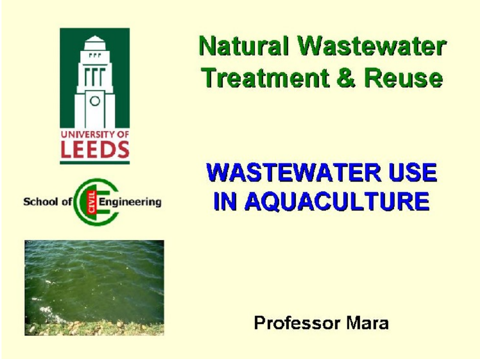
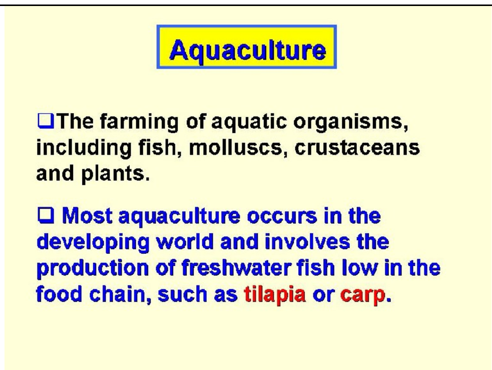
Aquacultural Use of Wastewater

1.		This presentation is on wastewater use in aquaculture, specifically growing fish in wastewater-fed fishponds.
2.		Aquaculture means ‘water farming’, just as agriculture means ‘field farming’, and so we’re talking about the farming of aquatic organisms such as fish, but also molluscs, crustaceans and plants. However, in developing countries, especially those in Asia, aquaculture is most commonly the production of freshwater fish that are quite low in the food chain – for example, tilapia and carp.
3.		Aquaculture occurs in all parts of the world, and this slide shows salmon farming in cages in a seawater loch on the west coast of Scotland.
4.		But it’s wastewater-fed fish culture in developing countries that we’re going to consider in this presentation.

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<tr><td>5.</td><td>
</td><td>And this is very important as most people in southeast Asia, the most densely populated part of the developing world, get most of their animal protein from fish grown in wastewater- or excreta-fertilized fishponds, so in terms of global food production this process is hugely important.</td></tr>
<tr><td>6.</td><td>
</td><td>We're going to look at the design of a wastewater-fed fishpond system, and our design aim is the minimal treatment of the wastewater with maximal production of microbiologically safe fish.</td></tr>
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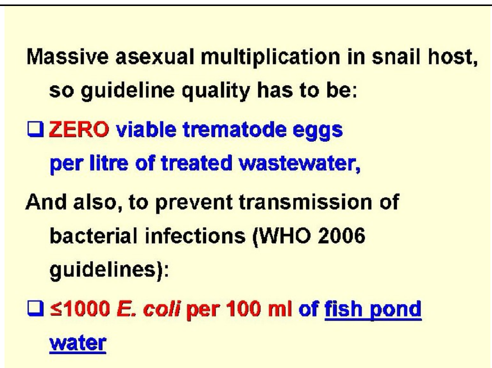
</td><td>The 2006 WHO guidelines for wastewater use in aquaculture are concerned with the eggs of trematode worms, in particular schistosome eggs and those of Clonorchis sinensis, the Oriental liver fluke, and Fasciolopsis buski, the giant intestinal fluke; and also with faecal bacteria.</td></tr>
<tr><td>8.</td><td>
</td><td>Now there's massive asexual multiplication of the trematodes in their first (or only) aquatic host which is a freshwater snail; so the guideline quality has to be zero viable eggs per litre of treated wastewater. And to prevent the transmission of bacterial infections, there should be no more than 1000 E. coli per 100 ml of the water in the fishpond.</td></tr>
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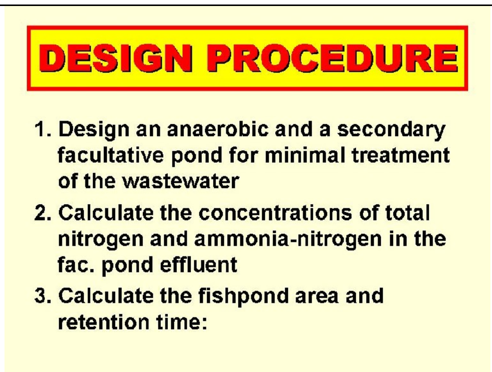
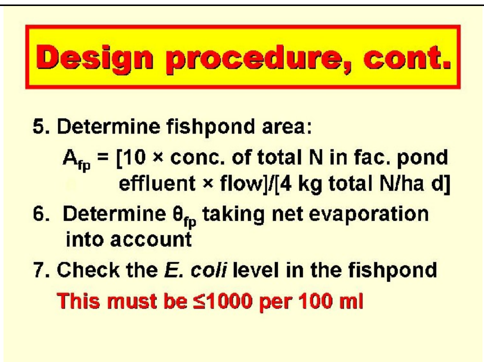
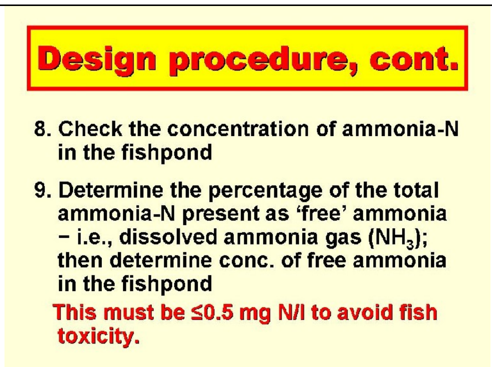
9.		The design procedure we use is as follows. First, we design an anaerobic pond and a secondary facultative pond in the normal way, and we then calculate the concentrations of total nitrogen and ammonia nitrogen in the facultative pond effluent. For these calculations we use Reed's equation and the Pano & Middlebrooks equation, and details of these (and all the other equations) are given in the Design Summary document for this presentation.
10.		Next, we design the fishpond, which receives all the fac. pond effluent; and the design criterion we use is a total nitrogen loading of 4 kg per ha per day. If there's too much nitrogen, then there's a correspondingly high concentration of algal biomass and therefore risks of deoxygenation at night and thus fish kills. And if there's too little nitrogen, then we get low fish yields.
11.		So the fishpond area in m^2 is given by 10 × the concentration of total N in the fac. pond effluent, which is the fishpond influent, in mg/l × the flow in m^3/day, divided by 4, the total N loading in kg/ha day. We then calculate the retention time in the fishpond, taking net evaporation into account; and then we determine the *E. coli* count in the fishpond, and this must be no more than 1000 per 100 ml.
12.		Next we calculate the concentration of ammonia-N in the fishpond, using the Pano & Middlebrooks equation; and then finally we determine the percentage of this that is 'free' ammonia, i.e. dissolved NH_3 gas, so that we can then calculate the concentration of free ammonia in the fishpond, and this has to be no more than 0.5 mg N/l in order to avoid any toxicity to the fish.

Note: Design details (including all required equations) are given in *The Design of Wastewater-fed Fishponds: A Summary*, which is available in 'Supporting material'.

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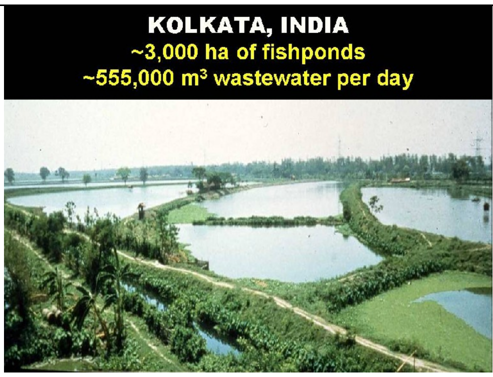
<td>
</td>
<td>This slide shows some of the wastewater-fed fishponds in Kolkata in India. All of the city’s wastewater, some 550,000 m^3/day, is used to feed around 3000 ha of fishponds, and these produce just under 20% of the fish consumed in the city.</td>
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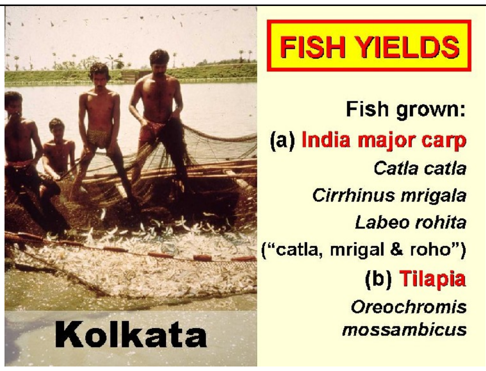
<td>
</td>
<td>The fish they grow are mainly three species of Indian major carp, with some tilapia as well.

The slide shows the fish being harvested. This is normally done at around 5 o’clock in the morning, to get the fish to the markets early in the day.</td>
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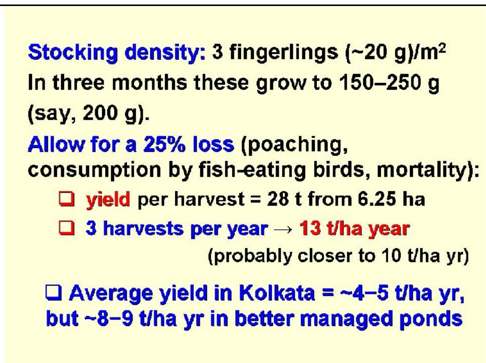
<td>15.</td>
<td>
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<td>The ponds are stocked with fingerlings, which weigh around 20 g, at a density of ~3 per m^2, and in three months these grow to 150−250 g − not a large size, but they are sold at a price the poor can afford.
Allowing for a 25% loss, due to poaching, death and consumption by fish-eating birds, the yield per harvest is just over 4 tonnes per hectare. With three harvests per year, the yield is ~13 t/ha per year, although it’ll usually be closer to 10 t/ha year. The actual average yield in the Kolkata ponds is 4−5 t/ha year overall, but the better managed fishponds produce 8−9 t/ha year.</td>
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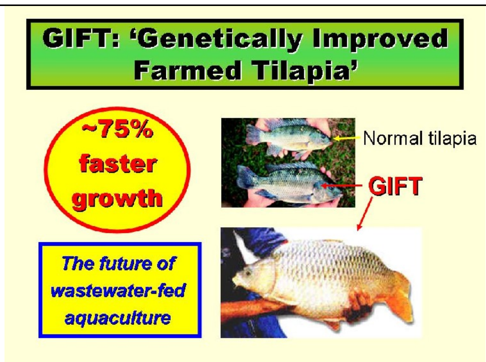
<td>
</td>
<td>GIFT stands for ‘genetically improved farmed tilapia’, and the GIFT strain of tilapia, which was developed by very careful selective breeding of wild and farmed strains, grows ~75% faster than non-GIFT strains, so really it has to be the future of wastewater-fed aquaculture, although (somewhat curiously) very little work has yet been done on growing the GIFT strain in wastewater-fed fishponds.</td>
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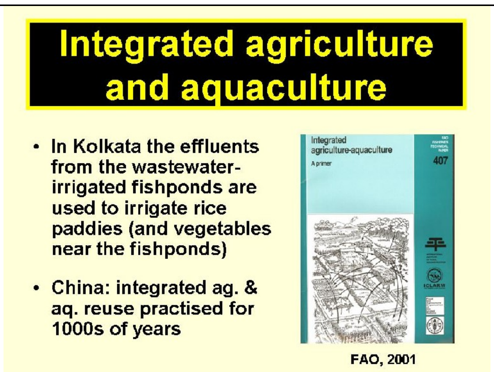
<td>17.</td>
<td>
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<td>Integrated agriculture and aquaculture is also clearly important as the wastewater is used twice: first in aquaculture, and then secondly using the fishpond effluent for crop irrigation. In Kolkata, for example, the fishpond effluents are used to irrigate rice paddies; and in China the integration of aquaculture and agriculture has been practised for around 4000 years.</td>
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