WASTE STABILIZATION PONDS 2
Introduction 2

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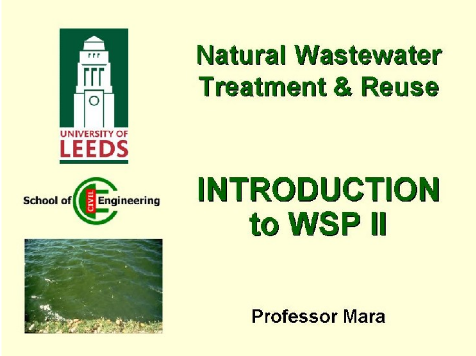
<td>1.</td>
<td>
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<td>This is the second introductory presentation on waste stabilization ponds.</td>
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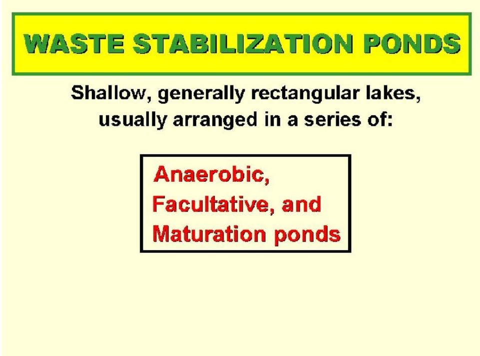
<td>2.</td>
<td>
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<td>Ponds are shallow, generally rectangular, ‘lakes’ arranged in a series of anaerobic, facultative and maturation ponds</td>
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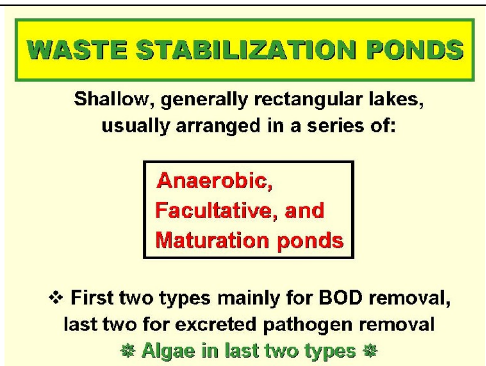
<td>
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<td>Anaerobic and facultative ponds are mainly for BOD removal, and excreted pathogen removal occurs mainly in facultative and maturation ponds, although some BOD removal occurs in maturation ponds and some pathogen removal in anaerobic ponds.
Algae occur in facultative and maturation ponds, but hardly ever in anaerobic ponds.</td>
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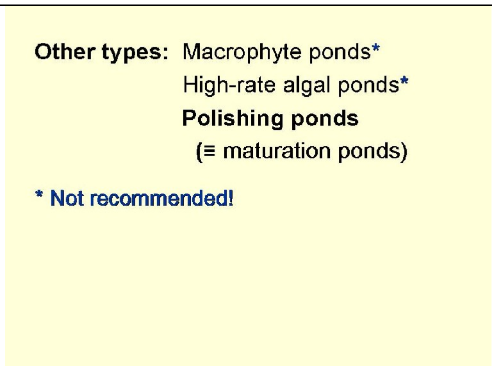
<td>4.</td>
<td>
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<td>There are a few other types of ponds, such as macrophyte ponds and high-rate algal ponds, but these cannot be recommended for general use. There are also ‘polishing’ ponds, and these are essentially maturation ponds used to improve the quality, and commonly the microbiological quality, of the effluent from a conventional, electro-mechanical wastewater treatment plant.</td>
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5.	Other types: Macrophyte ponds* High-rate algal ponds* **Polishing ponds** (≡ maturation ponds) * Not recommended! RETENTION TIME in pond series: depends on climate (temperature), but in general ~5–50 days (in conventional WWTW ≤1 day)	The hydraulic retention time in a pond system is anywhere between, very typically anyway, 5 and 50 days. This is *much* longer than in conventional works where the retention time is generally well under a day.
6.	**Advantages of WSP** **1. Usually the CHEAPEST option** **– both in terms of capital and O&M costs.** **2. VERY HIGH removals of excreted pathogens:** **– up to 6 log_{10} unit reduction of excreted bacteria** **– up to 4 log_{10} unit reduction of excreted viruses** **– 100% removal of helminth eggs & >90% of protozoan cysts**	Ponds have many advantages. They are usually the cheapest, both to construct and to operate and maintain. They can achieve *very* high removals of excreted pathogens. For example, up to a six log_{10} unit reduction of excreted bacteria (that's a removal of 99.9999 percent, with each of these nines being a significant figure); up to a four log unit reduction of excreted viruses; and 100 percent removal of helminth eggs, and generally over 90 percent removal of protozoan cysts and oocysts.
7.	**Advantages of WSP (continued)** **3. VERY simple O&M – only unskilled (but supervised) labour needed.** **4. Good resistance to shock hydraulic & organic loads.** **5. Good resistance to heavy metals.**	Ponds are very simple to operate and maintain, and only unskilled (but supervised) labour is needed for this. Because of their large size they have very good resistance to shock loads, both hydraulic and organic. And they have excellent resistance to heavy metals, up to at least a mixed heavy metal content of 30 mg per litre.
8.	**Comparative Costs** **Arthur (1983) World Bank Technical Paper #7** **Case study: Sana'a, Yemen** **Population: 250,000; flow:120 lcd; BOD: 40 gcd; design temp: 20°C; FC: 2 ×10^7 per 100 ml.** **Effluent:** **≤25 mg/l BOD, ≤10^4 FC per 100 ml** **Opportunity cost of capital (OCC): 12%** ← or 'discount rate' **Land cost: US$ 5 per m²** **Note: OCC & land cost were varied......**	We're now going to look at a case study developed by Jim Arthur for the World Bank in the early 1980s. He compared four different wastewater treatment processes to treat the wastewater from the city of Sana'a in the Yemen Arab Republic. Arthur designed these systems for a population of 250,000, a wastewater flow of 120 litres per person per day and a BOD contribution of 40 grams per person per day. The final effluent was to have no more than 25 mg/l BOD and below 10,000 faecal coliforms per 100 ml. Initially Arthur used a discount rate, or

opportunity cost of capital, of 12 percent and a land price of 5 US dollars per m^2.

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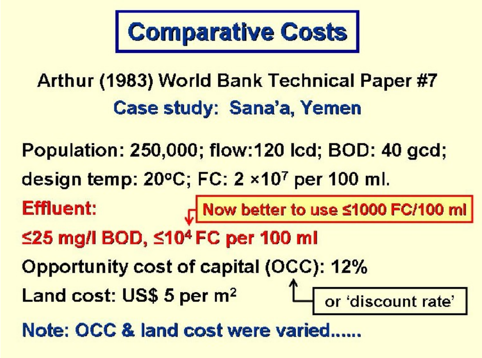
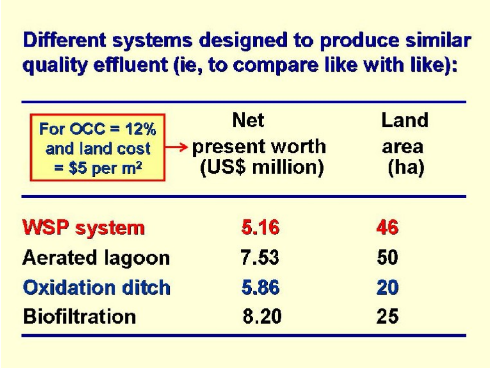


[Actually, if we were doing these calculations now, rather than, as Arthur did, in the 1980s, we'd most likely use a final faecal coliform count of 1000 per 100 ml, and not 10,000 per 100 ml.]

10.



Arthur designed his four systems to produce effluents which were closely similar. So the aerated lagoon system was designed with maturation ponds, and the oxidation ditch and biofilters were followed by effluent chlorination, in order to get the FC count the same as that produced by ponds; that is, to below 10,000 per 100 ml.

What Arthur did next was to compare the costs of the four systems, in net present value (or net present worth) terms. Ponds were the cheapest at an NPV of just over 5 million US dollars; the next cheapest was the oxidation ditch at just under 6 million dollars; and the other two were more expensive. The figures in the table are for a discount rate of 12 percent and a land price of 5 dollars per m^2.

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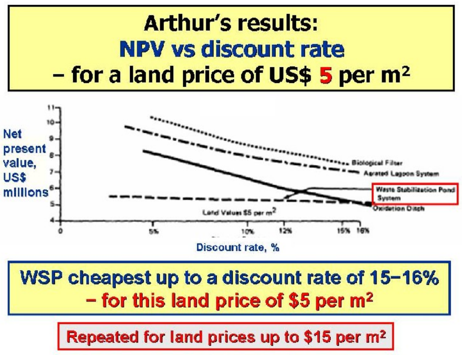
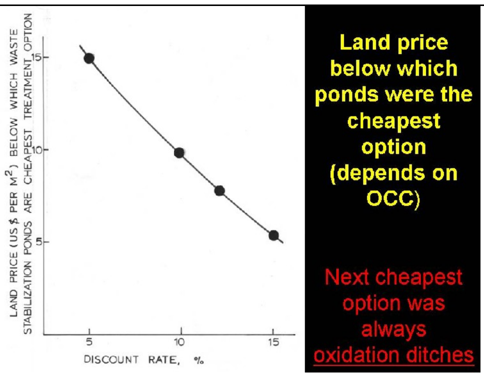


He then allowed the discount rate to vary while keeping the land price constant at 5 dollars per m^2. His figure, reproduced in this slide, shows that ponds were cheapest up to a discount rate of somewhere between 15 and 16 percent; for higher rates, the oxidation ditch was cheapest.

He then repeated this for land prices up to 15 dollars per m^2,

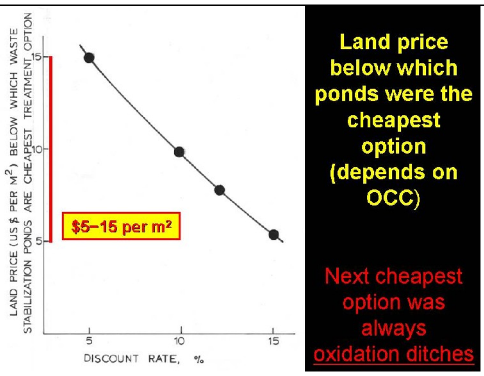
12.



and his results are plotted in this figure. The *y* axis is the land price below which ponds were the cheapest option, and the *x* axis is the discount rate.

You can see that there's an almost linear relationship between these two parameters.

13.

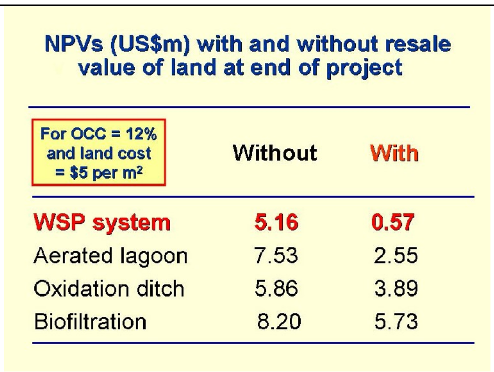


This shows the range of land prices, between 5 and 15 dollars per m^2, below which (depending on the discount rate) ponds were the cheapest option. The next cheapest option was always oxidation ditches.

14.

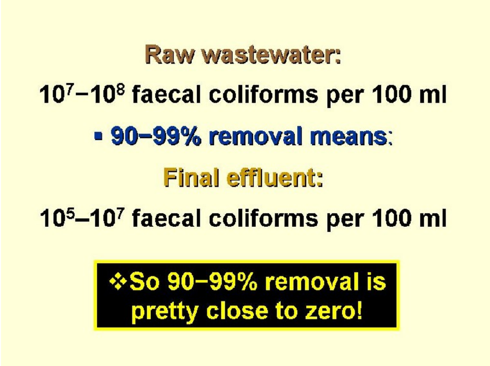
Now 5 to 15 dollars per m^2 is 50,000 to 150,000 dollars per ha, which are very high land prices – much higher than the best quality agricultural land in England, for example. So land costs are unlikely to militate against ponds – provided, of course, that we honestly compare the costs of different treatment systems, as Arthur did.

15.



This slide shows Arthur's results as before, but with one very important difference: in the column on the right we have included the resale (or 'salvage') value of the land at the end of the project life. And this is really where ponds score highly: their NPV is now *very* much less than those of the other three systems.

16.	**Land for WSP is an investment** Concord, CA 1955: $50,000 per ha 1975: $370,00 per ha	So land bought for ponds is an investment, and a really good example of this has been reported for the city of Concord in California. The city bought land for ponds in 1955 for 50,000 dollars per ha, and by 1975, twenty years later, it was worth 370,000 dollars per ha.
17.	**Land for WSP is an investment** Concord, CA 1955: $50,000 per ha 1975: $370,00 per ha Inflation in USA during 1955–75 was ~100%, so: $50k in '55 = $100k in '75. ∴ 'real' profit was $270k per ha ➢Easy to convert the land to other uses	Inflation in the US during this period was more or less exactly 100 percent, so 50,000 dollars in 1955 was equal to 100,000 dollars in 1975; and thus the profit in real terms was 370,000 dollars minus 100,000 dollars, or 270,000 dollars per ha. And, of course, it's very easy to convert the land from ponds to some other use – an industrial estate, for example.
18.	**Disadvantages of conventional wastewater treatment processes in developing countries** • COST – *very* high, both capital and O&M – high foreign exchange requirement (including for spare parts) • SKILLED LABOUR required for good O&M • Very POOR removal of excreted pathogens – only 90–99 percent — *only* 90–99% ??	In developing countries conventional wastewater treatment processes, such as activated sludge, have several major disadvantages. The first is cost, and we can say that their costs are always very high, with a high requirement for foreign exchange. Secondly, to operate and maintain them properly requires skilled labour – labour that would be better employed in local manufacturing industries, for example. And thirdly, they only achieve a 90–99 percent removal of excreted pathogens.
19.	Raw wastewater: 10^7–10^8 faecal coliforms per 100 ml ▪ 90–99% removal means: Final effluent: 10^5–10^7 faecal coliforms per 100 ml	A 90–99 percent removal of BOD would be excellent, but for faecal coliforms, for example, it's actually rather poor. Why? Because raw wastewater contains between 10^7 and 10^8 FC per 100 ml, so a removal of 90–99 percent means that the final effluent would contain somewhere between 10^5 and 10^7 FC per 100 ml.

20.		So, really, a 90–99 percent removal of excreted bacteria is pretty close to zero.
21.		This slide shows an oxidation ditch serving a small town near Hanoi in Vietnam. The oxygen required for BOD removal is supplied by four rotors,
22.		but the installed power was only 2 kW, and, to make matters worse, the power is not normally switched on (this is actually quite common as the local authority can't afford to pay the electricity bill).
23.		So we have to ask the question: Was an oxidation ditch the best choice in this case?

24.		And the answer is a resounding No.
25.		When we are comparing natural wastewater treatment, in ponds for example, with conventional electro-mechanical treatment such as activated sludge, the choice really boils down to a choice between land and electricity. And we have to remember that money spent on land is an investment, but the money you spend on electricity is money gone forever – you just don't see it again!