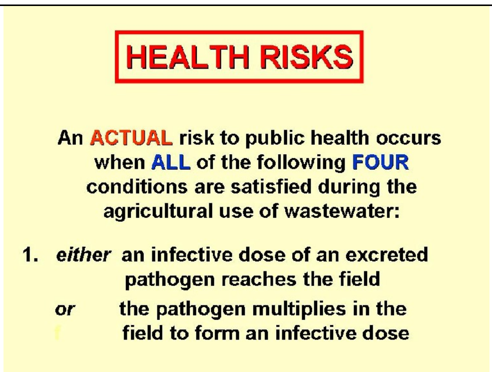
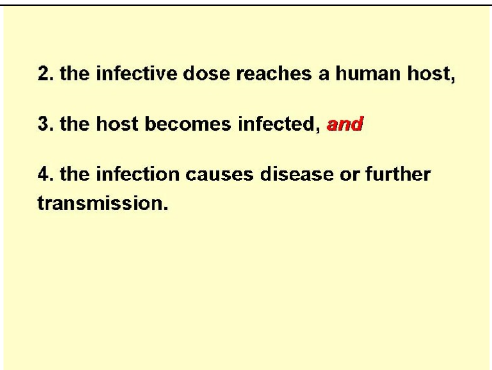
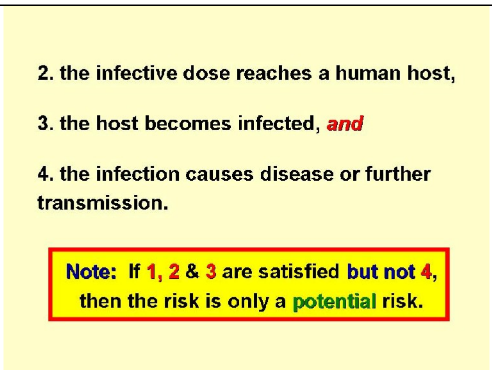
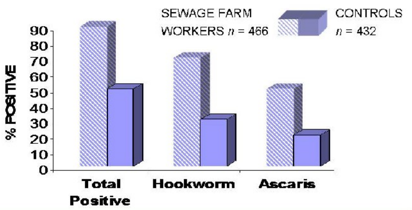
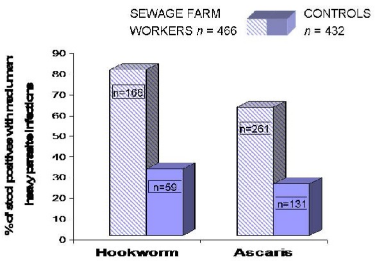
WASTEWATER REUSE 2
Health aspects

1.		In this presentation we're going to look at the health aspects of wastewater use in agriculture, and in particular the …
2.		health risks involved. An **actual** risk to public health occurs when *all four* of the following conditions are met. Firstly, an infective dose of an excreted pathogen reaches the wastewater-irrigated field, *or* the pathogen multiplies in the field to form an infective dose.
3.		Secondly, the infective dose reaches a human host. Thirdly, the host becomes infected; and fourthly the infection causes disease or further transmission.
4.		If the first three conditions are met, *but not the fourth*, the risk is not an actual risk, but only a **potential** one.

5.	The agricultural or aquacultural use of wastewater will only be of **public health *importance*** if it causes an **excess incidence or prevalence of disease, or excess intensity of infection.**	Furthermore, the agricultural use of wastewater is only of public health **importance**, if it causes an *excess incidence* of disease, an *excess prevalence* of disease, or an *excess intensity of infection.*
6.	The agricultural or aquacultural use of wastewater will only be of **public health *importance*** if it causes an **excess incidence or prevalence of disease, or excess intensity of infection.** … and it does if the waste-water is untreated, but **not** if it is treated correctly.  **The epidemiological evidence …**	And it does if the wastewater is untreated, but it doesn't if the wastewater is treated correctly. We know this from the **epidemiological evidence**, which we're now going to examine.
7.	'Sewage farms' in India use raw wastewater for irrigation  **Prevalence of hookworm and *Ascaris* infections in "sewage farm" workers and control group in India**	First of all we're going to look at some evidence from India. The chart shows the prevalence of hookworm infection and *Ascaris* infection in a group of 'sewage farm' workers (and in India sewage farms means irrigation with untreated wastewater), compared with these infections in a control group. You can see that in both cases, and for the total positive, there are clear excess prevalences of infection.
8.	 **Intensity of parasitic infection in sewage farm workers and control group in India**	This chart shows, for the same group of people, the percentages with medium-to-heavy intensities of infection with hookworms and *Ascaris*, and you can see that there are clear excess intensities of infection between the two groups in both cases.

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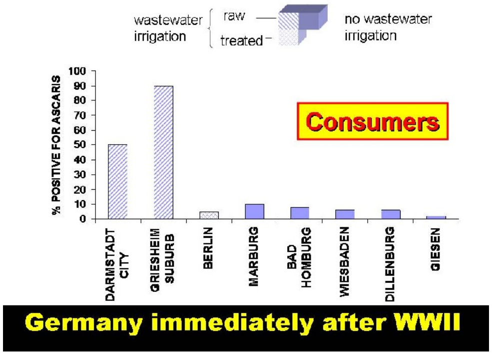

</td>
<td>Now we’re looking at Ascaris prevalences in several German cities immediately after World War II. In fact we’re looking at Ascaris prevalences in the general populations who ate irrigated salad crops. In Darmstadt, where untreated wastewater was used for crop irrigation, the prevalence was around 50%, and in one suburb, Greisheim, it was about 90%. But in Berlin, where treated wastewater was used for irrigation, the prevalence of Ascaris was much lower − under 5% and about the same as in cities which didn’t use wastewater for irrigation.
In Berlin the treatment used was conventional treatment − primary sedim-entation, tricking filters and secondary sedimentation − and the two periods of sedimentation effectively removed most, if not all, of the Ascaris eggs.</td>
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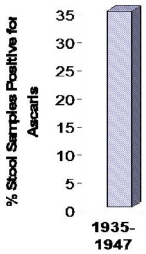

Relationship between Ascaris-positive stool samples in the population of western Jerusalem and the availability of vegetables and salad crops irrigated with raw wastewater in Jerusalem, 1935-1982.
</td>
<td>Now we’re going the examine the situation in Jerusalem over the period from 1935 to 1982. In fact we’re looking at the prevalence of Ascaris infection in the population of <u>Western</u> Jerusalem. Up to 1947 these people bought and ate salad crops irrigated with untreated wastewater just outside <u>Eastern</u> Jerusalem, and their Ascaris prevalence was about 36%.</td>
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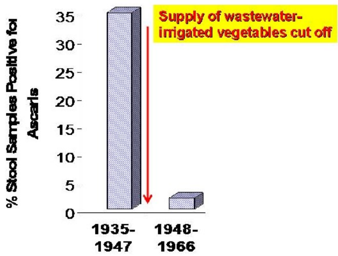

Relationship between Ascaris-positive stool samples in the population of western Jerusalem and the availability of vegetables and salad crops irrigated with raw wastewater in Jerusalem, 1935-1982.
</td>
<td>1948 saw the creation of the State of Israel and the first Arab-Israeli war, one outcome of which was that Jerusalem was partitioned, and this meant that the raw-wastewater-irrigated salad crops from Eastern Jerusalem could not be sold to the residents of Western Jerusalem, and this had the effect that their prevalence of Ascaris fell to around 2% over the next 18 years.</td>
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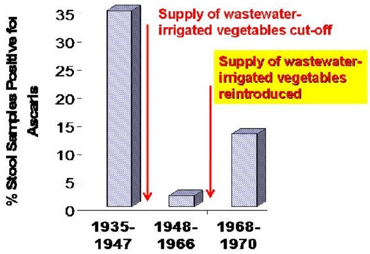
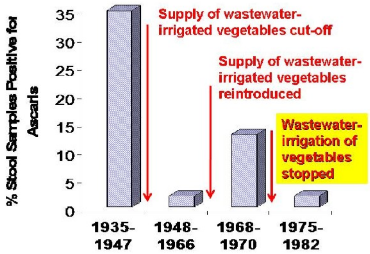
12.



Relationship between Ascaris-positive stool samples in the population of western Jerusalem and the availability of vegetables and salad crops irrigated with raw wastewater in Jerusalem, 1935-1982.

In 1966 there was another war and the outcome of this one was that the city of Jerusalem was reunited, so once again the raw-wastewater-irrigated salad crops from Eastern Jerusalem were on sale in Western Jerusalem; and over the next five years *Ascaris* prevalence in Western Jerusalem increased to around 13%.

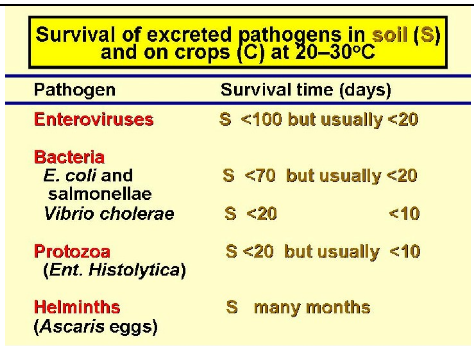
13.



Relationship between Ascaris-positive stool samples in the population of western Jerusalem and the availability of vegetables and salad crops irrigated with raw wastewater in Jerusalem, 1935-1982.

In 1970 the irrigation of salad crops with untreated wastewater was stopped by the city health authority as it was shown that the epidemic of cholera which occurred in the city that year was due to the consumption of salad crops irrigated with raw wastewater containing *Vibrio cholerae*, the bacterium that causes cholera. So, then during the period 1975−1982, *Ascaris* prevalence in the population of Western Jerusalem fell again to the low level of 2−3%.

14.



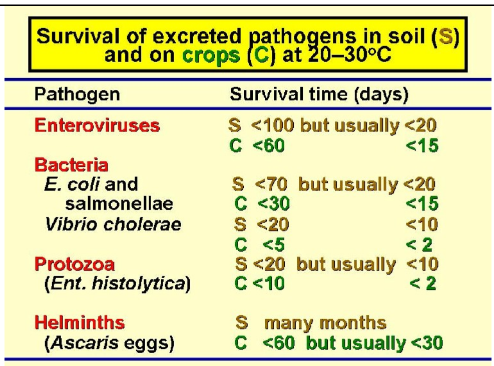
Survival of excreted pathogens in soil (S) and on crops (C) at 20–30°C

Pathogen	Survival time (days)
Enteroviruses	S <100 but usually <20
Bacteria	
E. coli and salmonellae	S <70 but usually <20
Vibrio cholerae	S <20 <10
Protozoa (*Ent. Histolytica*)	S <20 but usually <10
Helminths (*Ascaris* eggs)	S many months

Now some information on how long excreted pathogens survive in soil and on crop surfaces. First how long they survive in the soil, and these figures are for warm climates with temperatures in the range 20-30°C.

- Enteroviruses can survive for up to about 100 days, but usually only for 20 days at most.
- Bacteria such as *E. coli* and salmonellae for up to 70 days, but usually only for 20 days. *Vibrio cholerae*, on the other hand, survives for up to 20 days but usually less than 10 days.
- Protozoan cysts and oocysts are roughly the same as *V. cholerae*, and
- Helminths eggs, *Ascaris* eggs in fact, can survive for many months, even years.

15.



Survival of excreted pathogens in soil (S) and on crops (C) at 20–30°C

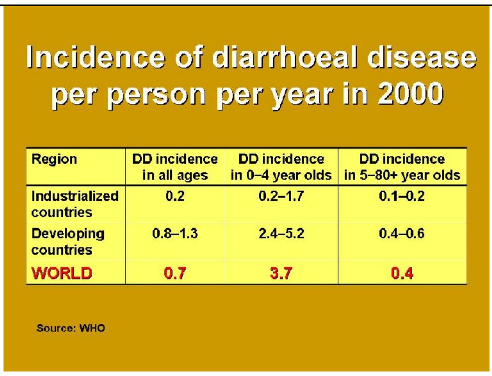
Pathogen	Survival time (days)
Enteroviruses	S <100 but usually <20 C <60 <15
Bacteria	
E. coli and salmonellae	S <70 but usually <20 C <30 <15
Vibrio cholerae	S <20 <10 C <5 < 2
Protozoa (*Ent. histolytica*)	S <20 but usually <10 C <10 < 2
Helminths (*Ascaris* eggs)	S many months C <60 but usually <30

Their survival on crop surfaces is much less as they are exposed to direct sunlight and they desiccate as well. The green figures on the chart tell us that enteroviruses usually survive for less than 15 days; bacteria such as *E. coli* and salmonellae for less than 20 days, but *Vibrio cholerae* and protozoan cysts and oocysts for generally no more than 2 days; and *Ascaris* eggs generally for only up to a month.

16.

Now a word about diarrhoea, and there's a lot of it about.

17.



Region	DD incidence in all ages	DD incidence in 0–4 year olds	DD incidence in 5–80+ year olds
Industrialized countries	0.2	0.2–1.7	0.1–0.2
Developing countries	0.8–1.3	2.4–5.2	0.4–0.6
WORLD	0.7	3.7	0.4

This table gives the incidence of diarrhoeal disease in the industrialized and developing countries, and in the world as a whole, in the year 2000. Most diarrhoeal disease occurs in the under-fives in both industrialized and developing countries, although the incidence is much higher in developing countries. In the world as a whole the incidence of diarrhoeal disease was 0.4 per person per year in the over-fives, a little higher in developing countries and a little lower in industrialized countries.

It's important to know the order-of-magnitude of these incidences of diarrhoeal disease in the world when we come, in fact in the last of these four presentations, to decide what is the tolerable level of the risk of disease from using treated wastewater for crop irrigation, and so determine the degree to which the wastewater should be treated.

18.

Now a word on microbiological requirements for foods. This is important because we, as engineers, are taught that drinking water shouldn't contain any coliform bacteria per 100 ml, so we tend to think that any coliform at all is really bad. But food microbiologists take a somewhat different view.

<table>
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<td>19.</td>
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<td>This slide shows the maximum number of total coliforms permitted in some dairy products in the European Union: butter, 1000 per 100 g; milk, 100 per 100 ml; and ice cream, 10,000 per 100 g; …</td>
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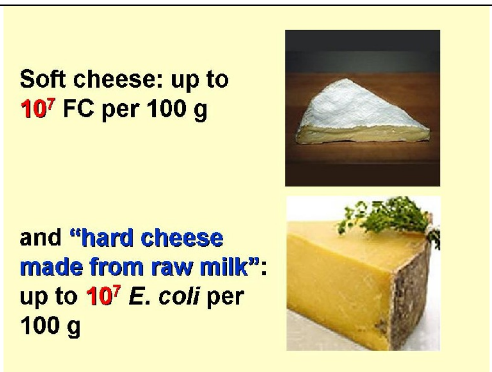
<td>
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<td>and soft cheeses, typical French cheeses such as brie or camembert, the maximum number of faecal coliforms is 10^7 per 100 g; and for 'hard cheese made from raw milk', so typical English cheeses such as cheddar, it's up to 10^7 *E. coli* per 100 g.</td>
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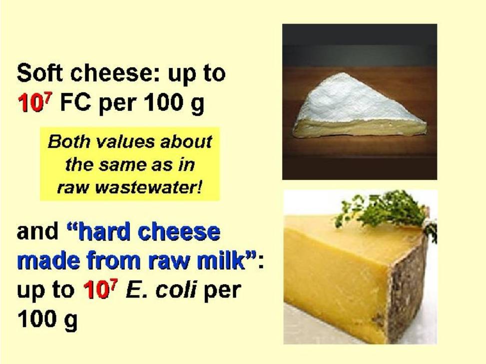
<td>
</td>
<td>Both these values are about the same as in raw wastewater!</td>
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<tr>
<td>22.</td>
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<td>And for shellfish eaten raw, such as oysters, up to 300 faecal coliforms per 100 g is OK.</td>
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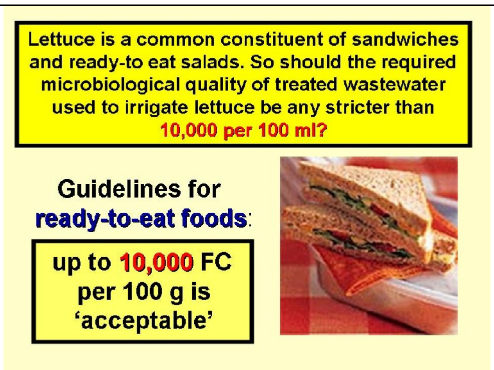
</table>

23.		But, perhaps even more extraordinary for an engineer, in England the Public Health Laboratory Service, now part of the Health Protection Agency, published in 1999 guidelines for the microbiological quality of ready-to-eat foods − any food you buy which is meant to be eaten without being cooked: sandwiches, for example. For these to be of 'acceptable' quality their faecal coliform count has to be below 10,000 per 100 g!
24.		Now lettuce is a common constituent of sandwiches, so this raises the interesting question: *Should the required microbiological quality of treated wastewater used to irrigate lettuce be any stricter than 10,000 per 100 ml?* We will attempt to answer this question in the next two presentations.

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