# 3.2 Environmental transmission of pathogens

Where do the pathogens come from?

How do pathogens in excreta contaminate the environment?

***Learning objective:*** To know and be familiar with environmental transmission routes for pathogens, especially in relation to water and sanitation.

The environment surrounding us is full of bacteria and other microorganisms. However, most of them are not harmful to us. The disease causing organisms are referred to as pathogens. In this module we are dealing with pathogens in different waste fractions and how they can be transmitted in the environment resulting in potential exposure of humans and animals.

Chemicals in excreta and other waste fractions may also constitute a health problem, for example if they end up in our drinking water or on crops that we consume. It is mainly considered an issue for greywater in sanitation systems with diverted flows (see chapter 4). For excreta, chemical aspects are partly covered in module 4.8 (agricultural use). For wastewater, and especially for sludge, there has been an intense debate regarding environmental pollution that however is not within the scope of this training material.

## Origin of pathogens in wastewater
## - contribution from different waste fractions

- Faeces
  - contain the major amount of pathogens, enteric infections
- Urine
  - only a few diseases transmitted through urine
- Greywater
  - e.g. laundry, washing diapers, from food stuffs
- Industry
  - abattoir, food industry (plant pathogens)
- Storm water
  - e.g. surface run-off – animal faeces

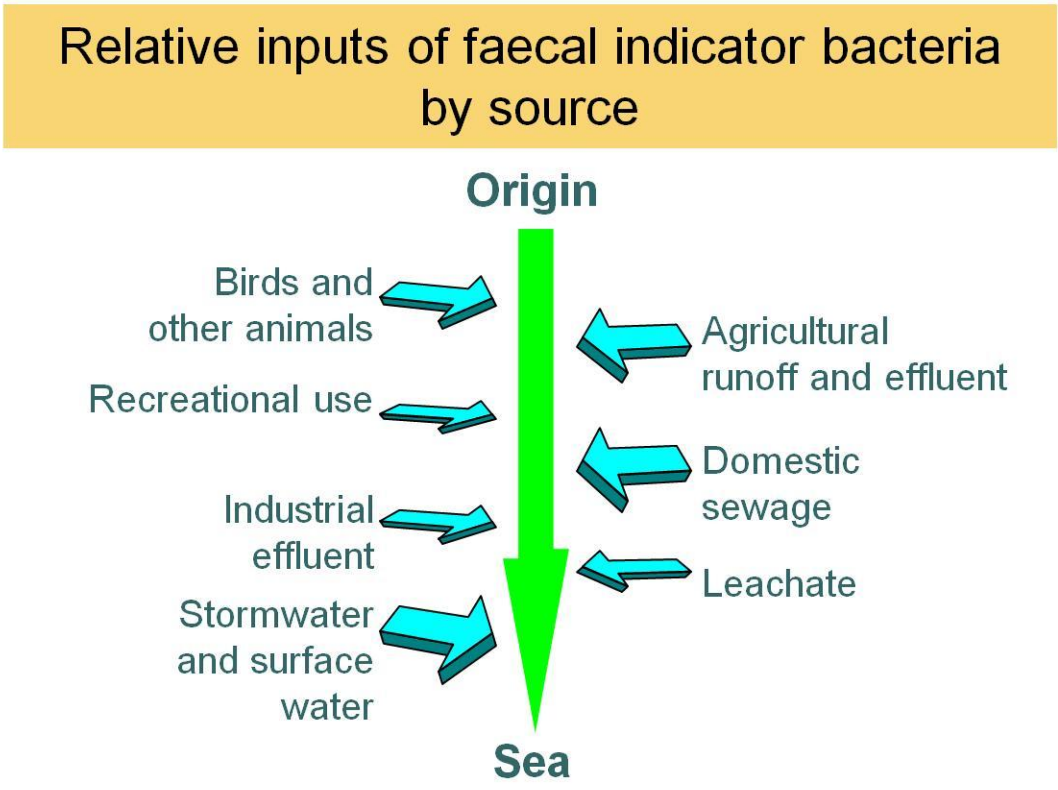
Taking a closer look at wastewater, gives us an idea of the importance of different waste fraction as contributors of pathogens. Pathogens in wastewater have different origin. A healthy individual do not excrete any pathogens in urine or faeces. By an enteric (gastro-intestinal) infection large amounts of pathogens may be excreted in the faeces and end up in the sewage. Only a few diseases are known to be transmitted through urine. Bacteria that cause urinary tract infections are not further transmitted in the environment.

Greywater may also contain enteric pathogens, for example from laundry, showering and food stuffs in the wastewater from the kitchen.

The content of industrial wastewater is dependent on the type of industry. Regarding disease transmission abattoirs and food industries are of concern, and the food industry may also contribute plant pathogens.

Stormwater may contain pathogens from e.g. animal faeces that are transported by surface run-off. More details on what pathogens that can be present in different waste fractions are given both later on in this module and in module 3.1.

Wastewater from hospitals may be of special concern. But symptomless individuals and ill persons being treated in their homes contribute to household (domestic) wastewater or. Hazardous waste and hospital waste is not within the scope of this training manual.




The arrows show the relative contribution of faecal indicator bacteria to wastewater (or sewage), which also indicates the potential contribution of enteric pathogens.

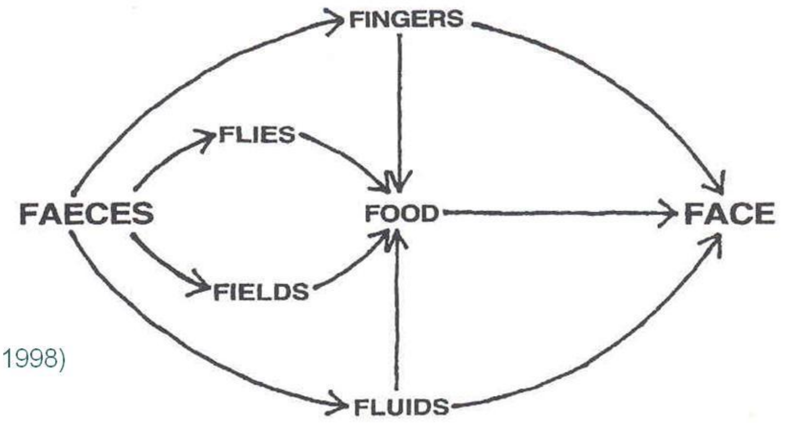
As can be seen domestic (household) sewage is a major source but agricultural and surface runoff are also significant sources. Leachate is contaminated water that is transported from landfills (seepage). This is a general picture, the local variation is large, but it is important to be aware of that pathogens are present in many flows, not only in domestic sewage. However, the training material is focused on waste from humans and households, i.e. excreta and greywater.

Faecal indicators are further presented in module 3.4.

The pathogens found in domestic sewage reflect the health situation in the community. The presence of pathogens is dependent on what type of infections people have, and how common these are, i.e. the prevalence of an infectious disease in the population (see module 3.1).

## The "F-diagram" - main routes to spread diarrhoea

The main ways diarrhoea is spread – by faecal pathogens contaminating fingers, flies, fields, food and fluids and then eventually swallowed



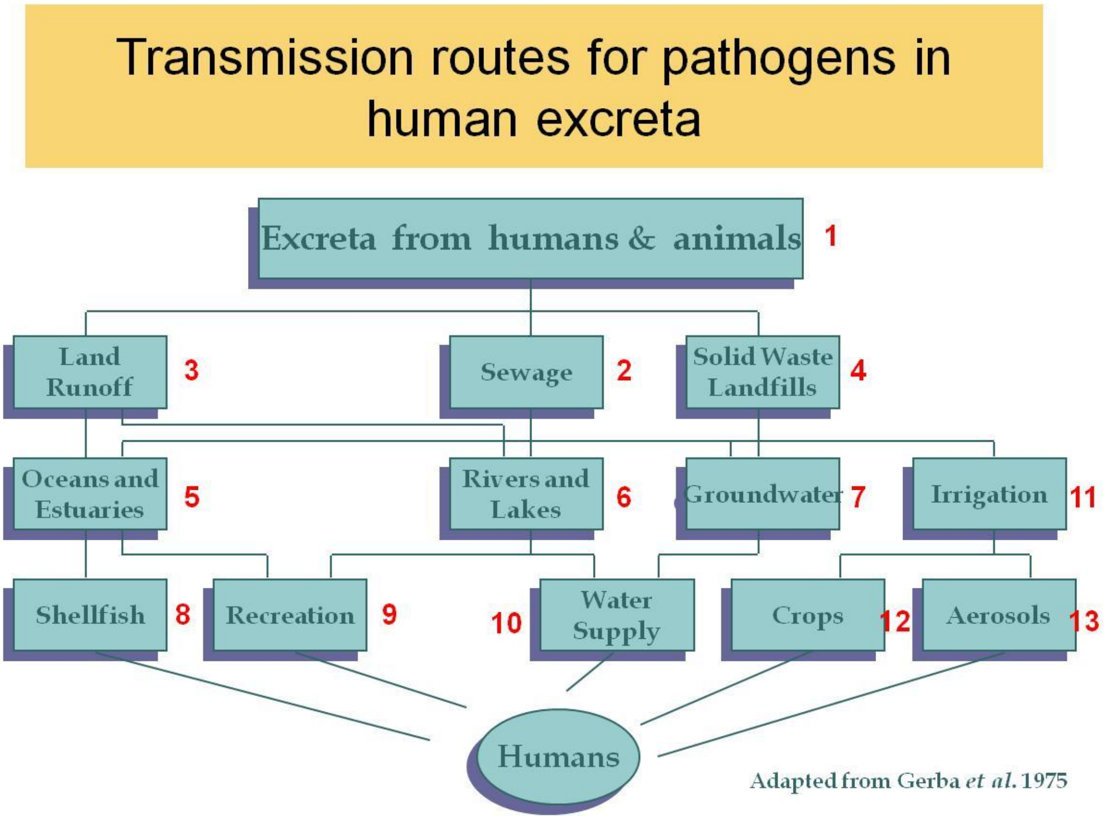

(Esrey et al. 1998)

The faecal-oral transmission route is the main route when it comes to sanitation. The main route of transmission we are dealing with when it comes to sanitation is the faecal-oral transmission route. That is, pathogens are excreted in faeces and eventually they reach our mouth and are ingested. Urine may also contain pathogens, but to a much lesser extent than faeces. The faecal material can either be a potential contaminant in the surrounding environment as it is, e.g. if open defecation is practiced, or as a (small) part of wastewater. As stated, the prevalence of infections that result in excretion of pathogens varies between communities. In some societies child faeces is considered non-harmful, but many infections (like rotavirus) are more common among children so it is important to see everybody´s faeces as potentially harmful.

Disease and various symptoms are dealt with in module 3.1, but the main focus/concern is diarrhoeal disease caused by gastrointestinal (enteric) infections. To describe the spread of diarrhoea in society this F-diagram is often used. It describes how pathogens from faeces reach the face (mouth) by fluids such as water, by food or by fingers. The diagram is simple and may most easily be attributable to technically less developed areas of the world, but the same principle is valid for all sanitation systems – the faecal material is just present in different forms.

Flies can mechanically transport microorganisms from faeces to food. The arrow from fields → food illustrate the risk for transmission if faeces from humans (or animals) is used as a fertilizer without proper treatment before use, or if open defecation is practiced.

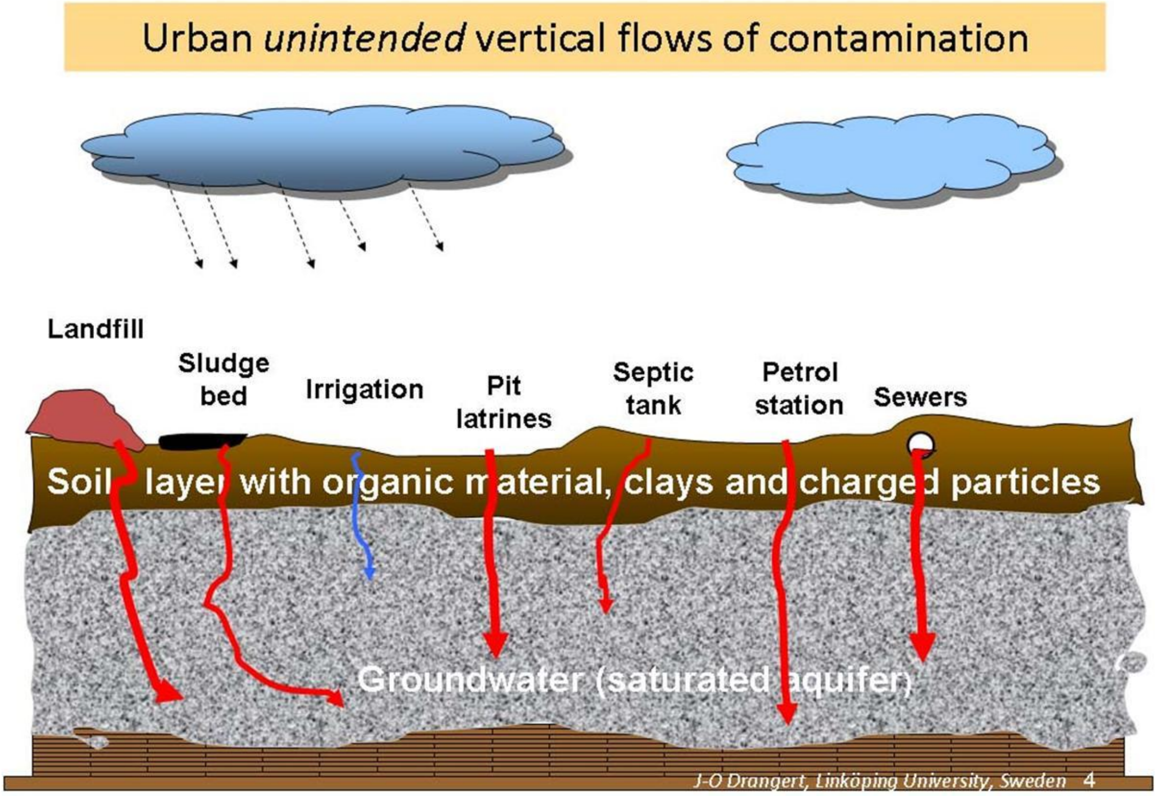
Fingers may carry pathogens if faecal material in some way have been touched, e.g. when maintaining a toilet, changing a diaper or touching a contaminated surface. It can also be possible for an infected person to contaminate food that is then served to other persons, if hands are not properly washed after defecation.




Another systematic way of describing the transmission routes for pathogens in water and sanitation systems are by schedules/pictures such as this one.

The enteric (meaning from the intestine) pathogens are excreted in human or animal faeces (1). The faeces either end up in sewage (wastewater) (2), on land (3) or in solid waste landfills (4). From all these sources pathogens can be transported to oceans and estuaries (5), rivers and lakes (6) or to groundwater (7). This water may then be used for growing of shellfish (8), for recreation (swimming etc.) (9), as water supply (for drinking water) (10) or for irrigation of crops (11, 12). By consumption of crops, shellfish and drinking water it is then possible for humans to ingest the pathogens, i.e. be exposed. When swimming or performing other water-related activities water may accidentally be swallowed. Sewage/wastewater may directly, or after some treatment, be used for irrigation of crops and apart from contaminating crops, pathogens may also be ingested by exposure to aerosols formed when irrigating the crops (13).

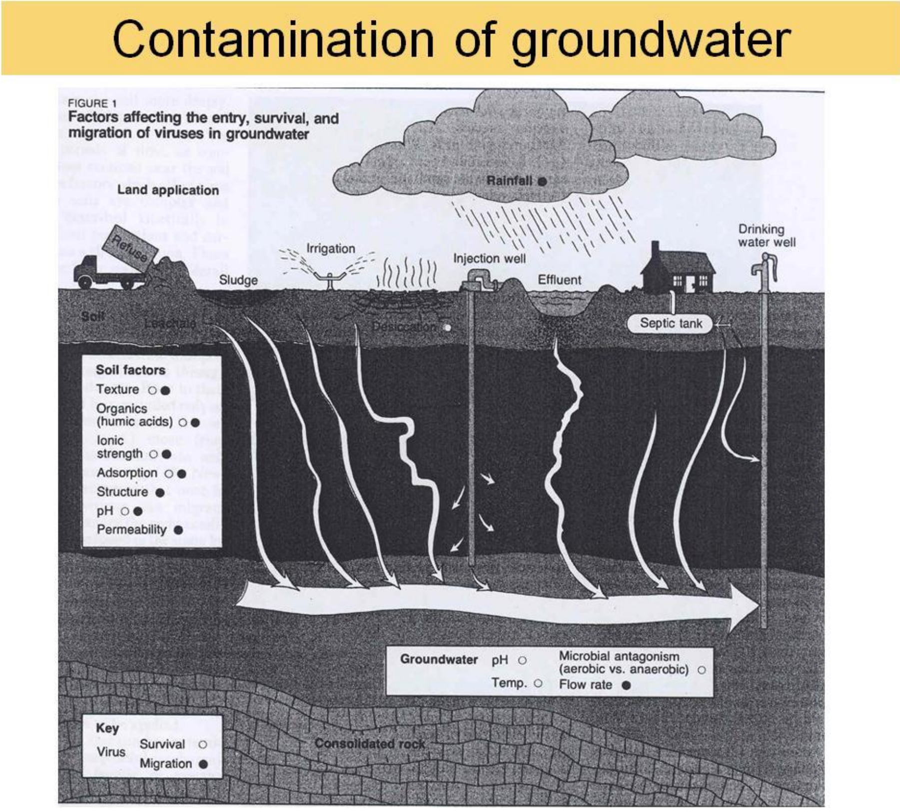
How exposure and risks can be managed is further described in module 3.3 and 3.4.




Drinking water is of special concern since it is a necessity for life. Still, it is estimated that 1 billion people do not have access to adequate drinking water sources. Prevention of contamination of drinking water is of outermost concern. Drinking water quality is dependent on several aspects of which content of pathogenic microorganisms is one. Other aspects include chemical compounds such as nitrate and metals and substances causing problems with smell or colour.

Drinking water may be produced from surface water or groundwater. Contamination of these sources may occur through run-off from latrines or land and from outlets of wastewater, both untreated and treated. Treatment of surface water is necessary to produce a drinking water of acceptable quality.

The goal of water treatment, usually from surface sources such as lakes, reservoirs, or rivers, is to remove contaminants and organisms through a combination of biological, chemical, and physical processes to make it safe for drinking. Some of these occur in the natural environment, whereas others occur in engineered and constructed water treatment plants. The engineered processes usually mimic or build on natural processes. Groundwater, on the other hand, is generally of better quality and is often used without treatment, e.g. from wells. This makes groundwater sources vulnerable to contamination.




This picture represents a rural or peri-urban situation without piped water, with possible contamination from similar sources as in slide 6. The use of a septic tank, resulting in infiltration of wastewater can contribute pathogens to groundwater. The risk for exposure to pathogens (and risk for infection) from drinking water (the well) will be dependent on the quantity of pathogens that reach the groundwater and the bore hole or dug well. This will be dependent on type of organism and soil factors such as pH, structure, ionic strength, texture etc. Part of the organisms will be adsorbed to soil particles and part will reach the groundwater. One part of the organisms may also be inactivated (die) during the time it takes for transportation through the soil and further in the groundwater. The survival in groundwater will also be dependent on the conditions such as pH and temperature of the water.

One example of transport of microorganisms from latrines to groundwater wells is from Eldoret in Kenya. The wells were situated up to 40 m from the latrines and were considered safe. Possible contamination was however tested by adding bacteriophages to the latrines. Bacteriophages are viruses that infect bacteria, and in this case a type of phage that infects Salmonella and do not exist naturally in the environment was used. Samples were collected from the wells and after a few days phages could be detected. This illustrates that pathogens, especially viruses, can be transported long distances in soil and that not only the distance but also flow direction and topography need to be considered when choosing a place for wells (and latrines) (Drangert et al., 1996).

## Contamination of drinking water

- Drinking water quality
  - Heterotrophic bacteria, *E. coli*, metals, nitrate (other aspects smell, colour)
- Contaminated surface- or groundwater
  - Wastewater outlet, latrines, run-off
- Contamination during distribution
  - Growth in pipes, intrusion of wastewater
- Contamination of finished water
  - During storage and handling, e.g. reservoirs, vendors

Microbiological quality is often determined by analysing for so called indicator bacteria which include coliforms and E. coli. The general content of bacteria, represented by e.g. heterotrophic bacteria is also a quality measure for which guideline or regulatory values exist. (Indicator bacteria and guidelines are further described in module 3.4). Details on how to purify water is however not included in the training material. The main message is that a sanitation system that is likely NOT to deteriorate the quality of drinking water sources should be chosen (as discussed in chapter 2). To protect groundwater the depth and placement of latrines (pits) and infiltration units are crucial. Collection of faeces above ground is preferred. Surface water used for drinking water production or recreation need to be protected from wastewater discharge (outlet) and run-off from land where both human and animal faeces can contribute pathogens. To avoid so called down-stream pollution where waste and wastewater deteriorates the water (e.g. a river) that is used further down is necessary.

Contamination may occur both from transport of pathogens through the soil and from the stand pipe, e.g. due to untight lids.

Contamination may further occur during distribution of the drinking water in pipes. One important aspect is to keep pipes as whole as possible and under pressure so that wastewater does not intrude. Growth on inner surfaces of pipes is inevitable, but should be controlled ideally by distributing a water low in organic substances and with a proper content of disinfecting chemicals.

Even if a safe water is delivered to the household, contamination may occur during storage and handling, e.g. if the storage container is not clean at start, if un-clean hands touch the water or if insects, birds or their droppings enter the container (e.g. if a proper lid is not attached). For drinking water (as well as for food) it is important that the whole chain from production to consumption is kept clean and safe.

## Waterborne diseases and sanitation

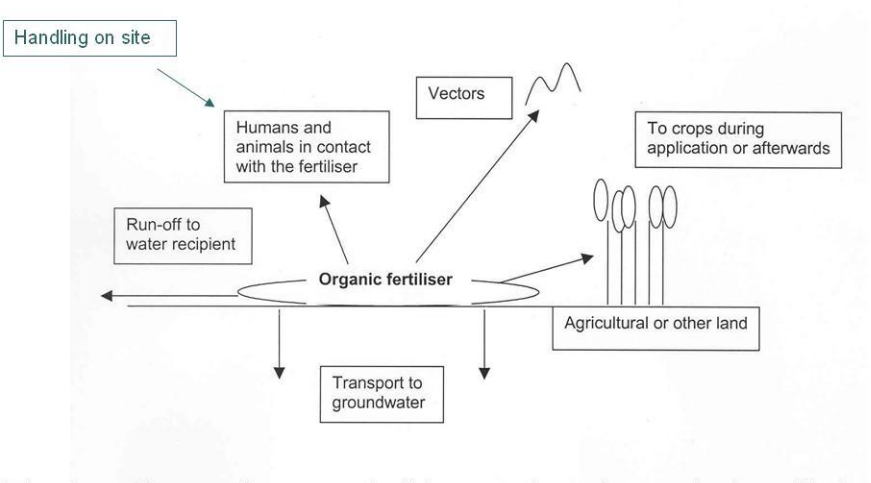
Waterborne diseases: caused by the ingestion of water contaminated by human or animal faeces or urine containing pathogenic bacteria or viruses; include cholera, typhoid, amoebic and bacillary dysentery and other diarrhoeal diseases.

A sanitation system including reuse need to avoid disease transmission mainly by :

- protecting ground- and surface water
- safe handling and use of the waste products in agriculture

As described in module 3.1 water-related diseases can be divided into categories.  As stated, we are mainly dealing with the first group – the waterborne diseases in this training material. The origin of the pathogens causing the diseases is as stated human or animal faeces or urine, but the risk in a sanitation system is related also to other waste fractions. Since the training material aims at covering reuse of various waste fractions in agriculture, the potential exposure to pathogens occur not only by ingestion of water, but also by ingestion of crops that in turn has been in contact with contaminated water or waste products. Other groups of water-related diseases may also be of concern when it comes to sanitation systems and a few like the urinary transmitted schistosomiasis are mentioned. The waterborne diseases are of concern in relation to sanitation in all settings, whereas many of the other water-related diseases mainly are related to tropical areas around the world.

## Possible transmission routes for pathogens from organic fertilisers (e.g. faeces)




- The handling and reuse of all types of waste products with human or animal origin involve hygienic risks

Reuse of ”waste products” containing plant nutrients is encouraged as described in chapter 1. The fertilizer product may be wastewater, sewage sludge, animal manure, human urine and treated faeces or organic household waste (food waste) and is organic as in comparison to chemical fertilizers.

The use of organic waste fertilizers will always involve some risk of humans and animals being exposed to pathogens in the material. Exposure occurs during handling of the material, since there is risk for accidental ingestion for a person coming in direct contact with it. Direct contact is also possible after application. Further spread of pathogens to the surrounding environment and waters and to crops may result in exposure by ingestion, e.g. when drinking the water, during swimming or when consuming food crops.

## Contamination of food

- Contaminated seeds, uptake of pathogens?
- Organic fertilisers – human excreta, wastewater, animal manure
- Irrigation – wastewater, contaminated surface water
- Handling and storage
- Cooking
- Storing of cooked food, growth of pathogens

As drinking water, food may be a potential source of pathogens resulting in foodborne transmission of disease. Pathogens may be present from the beginning and in the crop if seeds are contaminated, but this risk is considered quite low. The fertilizer products from human (and animal) waste could as stated contribute pathogens to the crop, as could wastewater or contaminated surface water that is used for irrigation. Later in the food chain it is possible that food is contaminated by improper handling and storage, for example if the hand hygiene is insufficient or if animals or insects come in contact with it.

It is also common that raw food is contaminated due to other reasons, e.g. that meat or eggs are contaminated from the production process. Some bacteria can grow on food, thus resulting in high numbers and potential infection by consumption. Others produce toxins that are not removed by normal cooking procedures. Gastrointestinal disease caused by infection or a toxic reaction after food consumption is generally referred to as food poisoning. In general, pathogen risks are however possible to manage, as described in subsequent modules, whereas chemicals cannot be removed from food or water as easily (in analogy with the example of bacterial toxin).

When discussing reuse of waste products as fertilizers we are dealing with cereal, vegetable and fruit crops that are fertilized. Animal products like fish and meat may also contain pathogens that infect humans by consumption. Appropriate handling and proper cooking is essential to minimize these risks.

Health aspects related to aquaculture is not specifically included in the training material but further information on guidelines for irrigation and fertilization of crops is given in module 3.4.

## Pathogens in faeces

- May contain bacteria, viruses, parasitic protozoa and helminths that cause infections
- Diarrhoeal disease of main concern
- Faeces should be considered a health hazard
- Need to be treated before use as a fertiliser
- Easier to handle and treat if diverted from other waste fractions

As described in module 3.1 infectious disease can be caused by bacteria, viruses, parasitic protozoa and helminthes and the main risk in relation to sanitation systems is exposure to the pathogens causing diarrhoeal disease. It may seem quite obvious that the majority of these pathogens are excreted in faeces and if a person is infected large numbers of pathogenic organisms is present in the faeces. As also stated (in module 3.1) the prevalence of various infectious diseases varies tremendously between societies and populations. However, despite these variations, faeces should always be considered as a material that is hazardous to health. Faeces should be handled with care and need to be treated before it is used as a fertilizer. Treatment of faeces is further discussed in modules 3.3, 3.4 and chapter 4. Exceptions where treatment is not necessary can be found e.g. for growing of trees in shallow pits (like the Arbor Loo, see chapter 5).

If faeces is separated from other waste fractions such as is done in urine diverting toilets (including separate greywater collection), the other fractions can be used as fertilizers with adapted treatment, and the treatment and handling of the faecal fraction can be conducted in a safer and more optimized way, compared to a mixed waste. This is generally true both in high-tech systems and low-tech systems, and can be proven/considered sustainable both when economical resources for sanitation are scarce and plentiful. A basic problem in waterborne sewage systems is the production of large volumes of contaminated wastewater that need to be treated, which for various reasons is not feasible at all places around the world (see chapters 1 and 2).

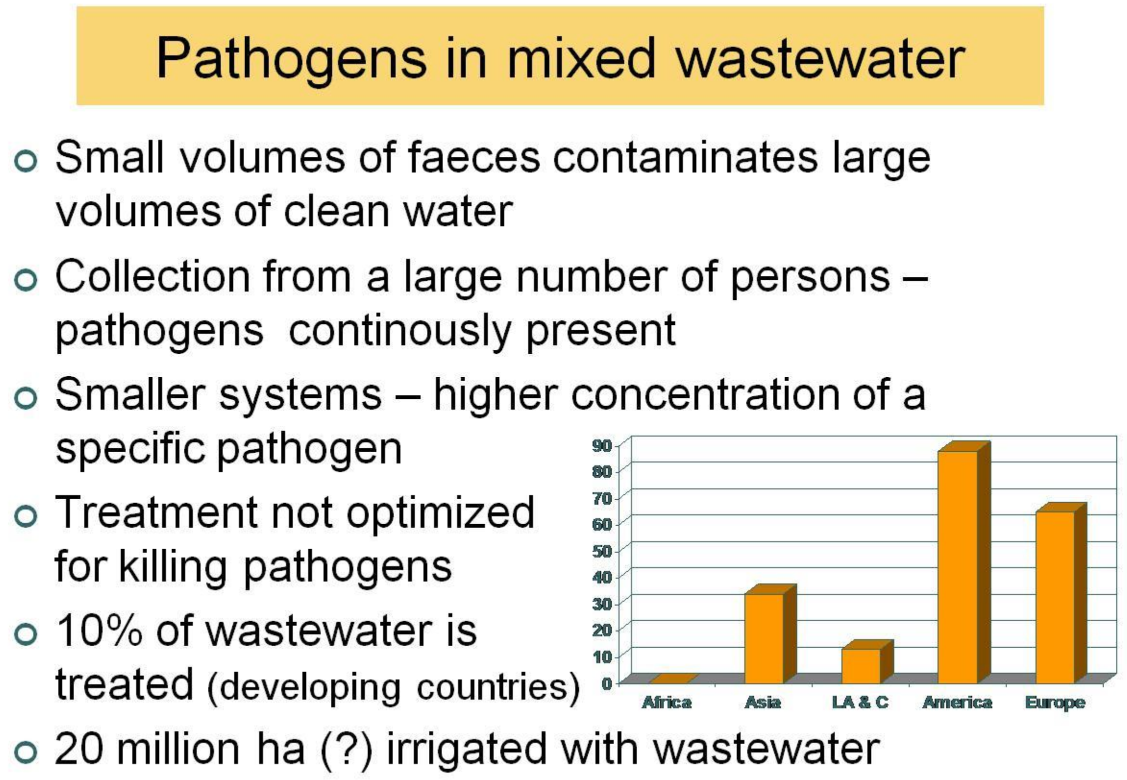
Examples of the most important waterborne pathogens possibly constituting a risk in sanitation systems are given in module 3.1.

# Excretion of pathogens in faeces

| | Incidence (per 100.000) | | Excretion (per g wet weight) | | Duration (days) | |
|---|---|---|---|---|---|---|
| | Typically | Variation | Typically | Variation | Typically | Variation |
| **Bacteria** | | | | | | |
| *Salmonella* | 500 | 300-700 | $10^{6,0}$ | $10^4 - 10^8$ | 37 | 25 - 55 |
| EHEC | 30 | 20-40 | $10^{2,5}$ | $10^{1,5} - 10^{3,5}$ | 8 | 5 - 13 |
| **Viruses** | | | | | | |
| Rotavirus | 1200 | 800-1600 | $10^{9,0}$ | $10^7 - 10^{11}$ | 5 | 0,5 - 60 |
| Hepatitis A | 6 | (4-8) | $10^{5,0}$ | $10^4 - 10^6$ | 20 | 12 - 33 |
| **Parasites** | | | | | | |
| *Giardia* | 1100 | 900-1300 | $10^{6,5}$ | $10^5 - 10^8$ | 90 | 22 - 365 |
| *Cryptosporidium* | 200 | 150-250 | $10^{7,5}$ | $10^7 - 10^8$ | 7 | 1 - 40 |
| *Ascaris* | 20 | 14-26 | $10^{4,0}$ | $10^{3,5} - 10^{4,5}$ | 245 | 90 - 665 |

Depending on the infection, various amounts of pathogens are excreted in the faeces as the examples listed in the table shows. The duration of excretion, i.e. how many days, also varies tremendously. Some infections may even be chronic with constant excretion. And in many locations with bad sanitary conditions it is not uncommon that most people are infected with one or more gastrointestinal infections.

This table should be seen as an example that illustrates the variation between different pathogens, but also between infected individuals, e.g. that excretion numbers can vary over a 1000-fold. Excretion numbers can also vary during the course of infection with higher numbers in the first (acute) phase of the illness.




When water-flush toilets are used, small amounts of faeces will contaminate large volumes of more or less clean water. In large sanitation systems (many people connected to the same system) a large variety of pathogens will be continuously present since it is likely that someone connected to the system will have the infection in question. In smaller systems it is less likely to find a specific pathogen at any time but during events of infection or during outbreak situations, the concentration of a pathogen may instead be higher, resulting in a significant risk if people are exposed to the wastewater or sludge.

Where wastewater treatment plants are in place, the sewage/wastewater will be treated in various processes that are categorized either as mechanical, biological or physical treatment.

However, the treatment plants are not optimized for reducing (killing) pathogens. The concentration of pathogens in outgoing wastewater varies a lot and is dependent on type of pathogen and type of treatment process(es). It is only a final disinfection step that effectively can remove pathogens by killing them. It is therefore very important that the outlets from treatment plants are placed so that the harm to recipients and exposure to humans are minimized.

Treatment and barriers to hinder disease transmission is further discussed in module 3.3. For details regarding treatment of mixed wastewater further reading of specialized text books is recommended (examples given at the end of chapter 3).

It is also important to remember that even if a sanitation system (or only a toilet) producing a wastewater is in place, only a small fraction is estimated to be collected and treated in functional wastewater treatment plants. It is difficult to obtain reliable figures on the percentage of wastewater that is being treated in the world. In many developing countries, the bulk of domestic and industrial wastewater is discharged without treatment or after primary treatment only and it is estimated that only 10% is treated effectively.  The graph shows estimates for the % of wastewater that is treated in various parts of the world.

According to the International Water Management Institute (IWMI) and the International Development Research Centre (IDRC) untreated wastewater is increasingly being used for irrigation in urban and peri-urban agriculture, and even in distant rural areas downstream of the very large cities, as a result of both increased amounts of wastewater and of water scarcity. The current knowledge on the magnitude of wastewater used in various countries are presented in the book (Wastewater use in irrigated agricultural) by IWMI and IDRC, and whether the previous estimate of 20 million ha being irrigated with wastewater is an over estimation or not is debated.

# Health risks related to untreated wastewater

- Local environmental pollution
  - Accidental exposure
- High risk of down-stream pollution
  - Exposure from e.g. swimming and intended household use
- Pollution of drinking water sources
  - Surface run-off and ground water infiltration
- Contamination of irrigated crops
  - Exposure from consumption and during irrigation

The lack of proper wastewater management (on top of the lack of sanitation *per se*) results in health risks due to exposure to untreated or insufficiently treated wastewater. In poor peri-urban areas the local environmental pollution with wastewater flowing on the ground or in so called wastewater ditches is often the most obvious sanitation problem. Direct contact with this water, especially for children, pose a significant risk for infections by (unintentional) ingestion. Intended use of this water, or of streams polluted with such water, is often necessary and implies health risks through direct contact when for example washing clothes, cleaning or preparing food. In such areas the drinking water sources is often unprotected, e.g. a shallow dug well is used, and it is easily polluted by surface run-off or infiltration of wastewater.

The risk for contamination of crops is high, and constitutes a health risk especially if the crops that are grown are to be consumed raw. Risks from use of insufficiently treated faeces, and of other waste fractions, result in similar risks. As described in slide 5, there is also a risk for ingestion of pathogens during irrigation (fertilization) of the crops.

## Typical concentrations of microorganisms in sludge (EC, 2001)

| | | [per g wet weight] |
|---|---|---|
| **Bacteria** | *E. coli* | $10^6$ |
| | *Salmonella* | $10^2$-$10^3$ |
| **Virus** | Enterovirus | $10^2$-$10^4$ |
| **Protozoa** | *Giardia* | $10^2$-$10^3$ |
| **Helminths** | *Ascaris* | $10^2$-$10^3$ |
| | *Toxocara* | 10-$10^2$ |
| | *Taenia* | 5 |

- In wastewater treatment pathogens are concentrated in the sludge

In wastewater treatment sludge is produced. Since the pathogens are attached to particles, a concentration of pathogens will occur. The table shows typical concentrations of the indicator E. coli and some pathogens of importance for human and animal health. Sludge also contains nutrients and is used as a fertilizer in agriculture. In many countries treatment of the sludge (hygienisation) before use is practiced in order to decrease the risk for disease transmission, but regulations vary and other barriers to decrease exposure may also be implemented (see section 3.3).

Sludge will be formed also in single-household systems (septic tanks). A concentration of pathogens occurs, and the material can in some respects related to risks be compared to faeces. The chemical pollution is however of greater concern regarding both wastewater and sludge.

## Microorganisms in urine

- Urine is sterile in the bladder
- Freshly excreted urine contains <10 000 bacteria/ml
- Urinary tract infections - not transmitted through the environment
- *Leptospira interrogans* - low prevalence
- *Salmonella typhi*, *Salmonella paratyphi* - developing countries, faecal-oral transmission more common
- *Schistosoma haematobium* - fresh water snail needed for development

→ low risk for transmission of infectious diseases through urine

Then, does urine contain pathogens that could cause problems in relation to sanitation systems? Urine is a sterile liquid in the urine bladder but when excreted it contains about 10 000 bacteria per ml or less. By urinary tract infections the concentration of bacteria may be much higher, but these are not known to be transmitted through the environment. There are a few other pathogenic bacteria and viruses that have been isolated from urine but the pathogens traditionally known to be excreted in urine *are Leptospira interrogans*, *Salmonella typhi*, *Salmonella paratyphi* and *Schistosoma haematobium*. *Leptospira* is however rather uncommon and the *Salmonellas* are only excreted in urine during the phase of typhiod and paratyphoid fever, which is a rare condition in developed countries. In developing countries the infection is endemic but faecal-oral transmission is still the most common route of transmission (see module 3.1). *Schistosoma* is a parasite, which requires an aquatic snail living in fresh water for one of its developmental stages, and it is not infectious when excreted. It can thus be concluded that the risk for transmission of infectious diseases through urine is low.

# Pathogens in urine and importance of urine as a transmission route

| Pathogen | Urine as a transmission route | Importance |
|---|---|---|
| *Leptospira interrogans* | Usually through animal urine | ? |
| *Salmonella typhi* and *Salmonella paratyphi* | Probably unusual, excreted in urine if systemic infection. | Low compared to other transmission routes |
| *Schistosoma haematobium* (eggs excreted) | Not directly but indirectly, larvae infect humans in fresh water | Need to be considered in endemic areas where freshwater is available |
| *Mycobacteria* | Unusual, usually airborne | Low |
| Viruses: CMV, JCV, BKV, adeno, hepatitis | Not recognised other than single cases of hepatitis A and suggested for hepatitis B | Low |
| *Microsporidia* | Suggested, but not recognised | Low |
| Venereal disease causing | No, do not survive outside the body | - |
| Urinary tract infecting | No, no environmental transmission | - |

A summary of pathogens possibly transmitted in urine and the importance of urine as a transmission route is presented in this table. As stated in the previous slide *Leptospira interrogans* is known to be excreted in urine. There are, to the authors´ knowledge, no reports of this disease through human urine. It is more common to refer to it as a potential risk from animal urine (e.g. from rats). Typhiod fever is a large problem in developing regions and the bacteria can be excreted in urine, but we consider the importance of it as a transmission route as low. Mycobacteria can be found in urine but the infection is usually airborne. The parasitic protozoa *Microsporidia* has been suggested to be transmitted via urine but it is (so far) not a recognized route. Veneral diseases may be thought of as a concern related to sanitation, but the organisms causing such diseases are not relevant since they are not adapted to environmental conditions outside the body and their transmissin occurs person to person when in ”exchanging” bodily fluids. Urinary tract infections (UTIs or urethritis) are common but are not caused by environmental transmission. Urethritis occurs when bacteria, usually from your rectum, travel into your urethra and grow there. Bladder infection, or cystitis, occurs when bacteria travel up past the urethra and lodge in the bladder. Bladder infections are the most common form of UTI, and can often occur at the same time as urethritis. *E. coli* is the most common cause of urinary tract infections.

## Health risks related to urine diversion

**Risk of disease transmission through urine**

The main risks of disease transmission from handling and using human urine are related to faecal cross-contamination of urine and not from the urine itself.

EcoSanRes (2004)

The risk of disease transmission from urine is therefore dependent on the possible faecal cross-contamination, that is, if faeces are misplaced in the diverting toilet. Quantification of this faecal contamination is further discussed in module 3.5.

## Microorganisms in excreta

- Urine
  - Sterile in body
  - Naturally containing some bacteria after excretion
  - Few diseases transmitted through urine
  - Low risk to handle

- Faeces
  - Naturally containing high amounts of bacteria
  - Many diseases transmitted through faeces (faecal-oral)
  - May contain pathogenic bacteria, viruses, protozoa or helminths
  - Significant risk to handle

To summarize the health aspects related to excreta, urine and faeces can be compared and it can be concluded that urine involves low risks compared to faeces. It is sterile in the body if a person is healthy. Only a few diseases are transmitted through urine and therefore risks are low. Faeces also contain large amounts of naturally occurring, non-harmful bacteria. But many diseases are transmitted via the faecal-oral route and it is not unusual that faeces contain pathogens, and they should therefore be handled with caution. This is an important message since urine contains the majority of plant nutrients and, in most cases, therefore is the most valuable fraction (see chapter 4 about agricultural use).

## Pathogens in greywater

- Lower concentrations of pathogens than in faeces
- Faecal origin of pathogens (bathroom and laundry)
  - Shower and bath, Washing clothes, washing diapers
- Pathogens from food stuffs (kitchen sink)
  - Faceally contaminated vegetables (e.g. from irrigation with wastewater or animal manure), soil
  - Contaminated meat (e.g. chicken)
- Health risk from disposal or reuse
  - Contamination of nearby surroundings
  - Contamination of drinking and recreational water
  - Irrigation of crops

Apart from urine and faeces, greywater is produced within a household. Greywater systems, from collection to treatment and possible reuse may vary a lot in construction and management. The area is widely covered in chapter 4. The constitution of greywater depends on what flows that are collected in the household and what products (chemicals etc.) that are used. Pathogens are generally present in greywater, but in much lower concentrations than in faeces, and thus, lower than in mixed wastewater. Greywater may however be high in nutrients that bacteria can thrive on, resulting in possible growth of bacteria as has been recognized for indicator bacteria (see module 3.3). The origin of pathogens is in part faecal, and can result in contributions from dirty laundry (underwear), washing of diapers or showering/bathing. Different food stuffs can also contain pathogens, either due to that they are faecally contaminated (e.g. from wastewater irrigation or animal manure) or due to ”internal” contamination during production, as for example Campylobacter that is present in 30% of chicken retail products in the Netherlands (http://rivm.openrepository.com/rivm/bitstream/10029/8818/1/250911005.pdf chicken).

Health risks from greywater occur in analogy with mixed wastewater, that is potential pollution of nearby surroundings, pollution of recreational waters and drinking water sources. Greywater is used for irrigation of crops mainly as a water source. Health risks have been recognized and is further described in module 3.4 and in chapter 4.

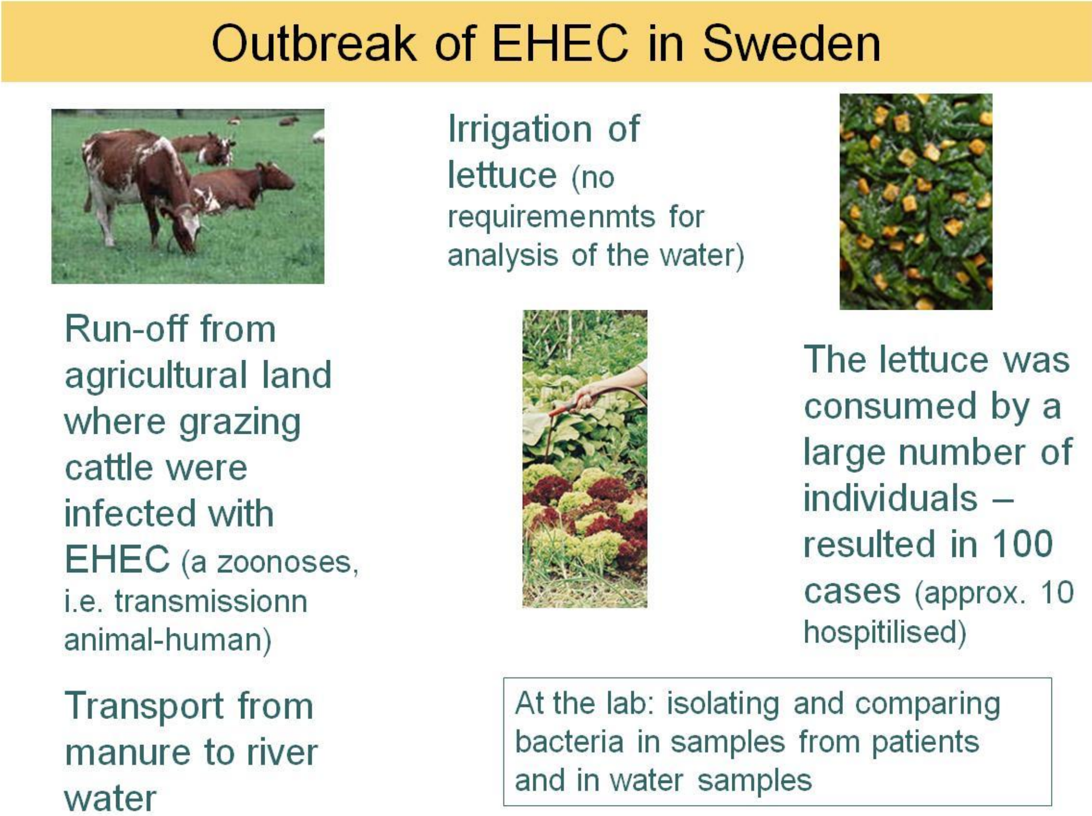
## Transmission by animals

- Zoonoses
  - Transmission humans ⟷ animals
  - May cause symptoms or not in animal
- Vectors
  - Insects, rodents, birds – mechanical transport
  - Birds, wild and domestic animals infected without symptoms
- Intermediate host
  - Animal necessary for lifecycle of pathogen, e.g. malaria, schistosomiasis

Infectious diseases that can be transmitted between humans and animals are called zoonoses. This possibility makes the environmental transmission routes more complex. The infections may cause symptoms or not in the animal.

Different types of animals can also be referred to as vectors, usually animals such as insects, rodents and birds are then considered. The vector-borne transmission may occur by mechanical transport of pathogens by the animals, or the animal is infected and thereby moving the pathogens to another location exposing humans (or other animals).

Some infections also require an animal host for further transmission. This is the case for schistosomiasis where eggs is excreted in urine or faeces and a specific freshwater snail is infected by the larvae after hatching (one of the life stages of the parasite), and the aquatic larvae that then is excreted in the water by the snail have the possibility to infect new human hosts.




An example of a foodborne outbreak caused by surface water contamination illustrates several of the sanitation and health issues covered in this module.

A larger number of EHEC infections than ususal was reported to the surveillance system. The health authorities realised that an outbreak was ongoing. Large efforts were made to find the source, at the most 60 people were involved in the investigation. Lettuce was found to be a risk factor in the epidemiological assessment, and finally one producer was identified. It was noted that the producer irrigated the fields with river water. Water samples were collected and EHEC was found in (isolated from) the water. Bacteria isolated from stool (faecal) samples from patients were compared to the water samples and it could be concluded that it was the same strain of the bacteria. Eventually run-off from upstream agricultural land could be defined as the cause of the outbreak. Here the cattle were infected with EHEC and the bacteria were transported from the cow faeces by surface run-off to the river water that was used for irrigation.

# Further reading:

For more information on drinking water quality guidelines we refer to WHO (www.who.org) and the new edition of the guidelines can be found at.

http://www.who.int/water_sanitation_health/dwq/GDW7rev1and2.pdf