Guidelines for the Safe Use of Urine and Faeces in Ecological Sanitation Systems*

Ecological sanitation

Ecological sanitation (ecosan) is aimed at closing the nutrient and water cycles. Nutrients from human excreta should be returned to the soil to fertilize crops. Urine is diverted from faeces in eco-toilets, and reused as fertilizer. Faeces potentially contain pathogenic micro-organisms, and need to be sanitized before use as fertilizer.

Pathogens in excreta

Faeces contain disease-causing organisms called pathogens to a much higher degree than urine. Therefore, it is important to avoid cross-contamination between urine and faeces. Compared to conventional mixed systems, source-separation of faeces and urine in toilets will result in:

- less volume of material requiring sanitization;
- reduced odour and fewer flies;
- lower risk of pathogens leaking from the system; and
- safer handling.

Organisms that can cause disease include viruses, bacteria and parasitic protozoa, as well as hookworms and other parasitic helminths. Some may lead to severe illness or even death. Others may not be the direct cause of any symptoms but could still lead to diarrhoea, malnutrition or increase the risk of other infections for the infected individual.

In some cases the pathogens can survive for long periods outside the human body and in other cases they are readily destroyed. Factors such as heat, pH, moisture, solar radiation/UV-light, nutrient availability and presence of other microorganisms affect survival. To avoid the risk of being exposed to pathogens it is important to reduce contact with the excreta, and to decrease the number of pathogens in the material. Pathogens such as protozoa and viruses will decrease naturally since they are not able to multiply outside the host, but bacteria may continue to multiply under favourable conditions. As there is currently no ideal indicator organism to ensure the quality of the excreta, the guidelines focus on treatment methods where different process parameters can be recorded.

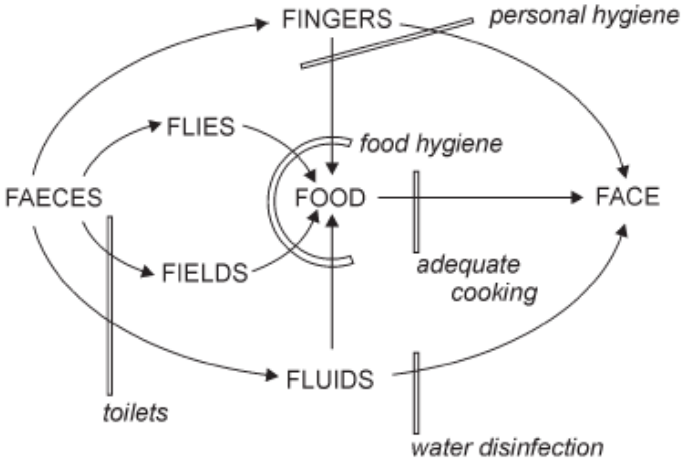

Figure 1: Barriers required to prevent the spread of diseases and pathogens

Primary treatment of faeces

The purpose of primary processing is to reduce the volume and weight of faecal material to facilitate storage, transport and secondary treatment, and to make further handling safer. This process takes place where the faeces are being deposited, either in or under the toilet. Usually the containment period is 6-12 months, depending on the size of the collection chamber. During this phase, pathogen levels will be reduced as a result of storage time, decomposition, dehydration, increased pH, and the presence of other organisms and competition for nutrients.

Storage and Desiccation: Urine is directed away from the faeces to keep the processing chambers dry and the volume small. Ash or lime is added after defecation to lower the moisture content and to raise the pH-level, thus creating unfavourable conditions for pathogens. Cellulose-containing materials like rice husks or sawdust can also be used as a compostable desiccant. Material is usually kept for 6-12 months before secondary treatment. Reaching low moisture levels is highly climate dependent and the material will not always be dry enough for pathogens to be inactivated even if urine is diverted. Faeces are kept separate from both urine and water. By ventilation and the addition of dry material, the pathogen levels will gradually decrease. The use of solar heating can further increase pathogen die-off.

Alkaline treatment: the addition of wood ash or lime will reduce the number of pathogens due to the elevated pH. This treatment also reduces odour and the risk of attracting flies to the toilet.

Secondary treatment of faeces

The purpose of secondary treatment is to make human faeces safe enough to return to the soil. Secondary processing includes high temperature composting, chemical addition of urea and longer storage times. Incineration is used if a completely sterile end product is needed.

Thermal composting: pathogens are destroyed if the compost is kept at an operational level of at least 50°C for 7 days. Addition of bulking material to the faeces is necessary to reach thermophilic temperatures and co-composting with organic household waste is an option. A crucial part of the treatment is the number of turnings needed for all material to be evenly heated and that further maturation of the compost is allowed.

Alkaline treatment: the addition of urea, ash or lime to the faeces will help eliminate the pathogens by elevating both the pH and the level of ammonia. A pH of over 9 for at least 6 months will kill most pathogenic organisms. At a higher pH, shorter time periods could be recommended.

* Based on Schönning, C. and Stenström, T.A. 2004. Guidelines for the Safe Use of Urine and Faeces in Ecological Sanitation Systems. EcoSanRes Publication Series. Report 2004-1. SEI; Stockholm, Sweden. Available from www.ecosanres.org

Addition of chemicals is mainly an option in large-scale systems involving trained personnel.

Storage: in areas where ambient temperatures reach up to 20°C, a total storage time of 1.5 to 2 years will eliminate most bacterial pathogens and will substantially reduce viruses and parasites. At higher ambient temperatures, storage times could be shortened to around 1 year.

Incineration: this can be an option as it will ensure that all pathogens and parasites are destroyed, but some nutrients will be lost during the incineration.

Composting systems

Human faeces, or faeces plus urine, are deposited in a chamber along with organic household and garden waste, and bulking agents such as straw, wood shavings or twigs. A variety of organisms break down the solids into humus. Temperature, airflow, moisture, carbon materials and other factors are controlled to varying degrees to promote optimal conditions for decomposition. After about 6-8 months (Winblad and Simpson-Hebert, 2004), the material is usually moved to a site for high-temperature composting as secondary treatment.

In a soil-based composting system, faeces, or faeces plus urine, are deposited in a chamber together with a liberal amount of ordinary soil and sometimes wood ash as well. Most pathogenic bacteria are destroyed within 3-4 months (Winblad and Simpson-Hebert, 2004) as a result of competition with soil-based organisms and unfavourable environmental conditions. Secondary treatment is as above, or as further composting storage in shallow pits for an additional 12 months. Due to UV-radiation, dryness and competition with other soil organisms, the amount of pathogens is decreased.

Treatment of urine prior to use as fertilizer

Contamination of urine with faeces considerably increases the need for urine sanitization. The recommended treatment of urine for large-scale systems is storage. Storing at ambient temperature significantly decreases the number of pathogens in the urine. Recommended storage time at 4-20°C is between one and six months, depending on the type of crop to be fertilized. For urine that is significantly contaminated a longer storage time and/or a higher temperature is recommended. The urine should preferably be stored undiluted to provide a harsh environment for pathogens, and in a sealed container to prevent loss of nitrogen.

When single households use urine as a fertilizer, there is no need for storage prior to application. The only guidelines given are that the crop is intended for the household's own consumption, and that the last application is made at least one month prior to harvesting. The risk of transmission of disease via urine-fertilized crops is generally lower than between family members.

Practical recommendations on reuse

Urine should be applied close to the ground to avoid aerosol formation. The urine should thereafter be incorporated into the soil, either mechanically or by subsequent addition of water. Separate equipment should be used for the transportation of unsanitized faeces and for the treated product.

Treated faeces should be worked well into the soil, and not left on the surface. Treated faeces should not be used for vegetables, fruit or root crops that will be consumed raw. Precautions such as wearing gloves and thorough hand wash-ing should be followed by the person handling the excreta.

A period of at least one month between application and harvest is recommended both for urine and for treated faeces. This will further reduce the risk of pathogens due to microbial activity in the soil, UV-radiation from the sun, and desiccation. This one month period also is needed for the crops to utilise the nutrients.

Local adaptations

Both physical conditions, e.g. climate and topography, and cultural aspects need to be considered when setting up an ecosan project. Different cultural and religious beliefs may influence the whole system, including the attitudes towards the use of excreta products. To achieve a well-functioning system, it is necessary that the users accept the procedures.

General hygiene aspects of eco-sanitation

- Urine diversion is always recommended. This reduces the amount of faecal material to be sanitized and lowers the risk for disease transmission. This also reduces odours and flies.
- Faecal collection should occur above ground in closed compartments that will not leak into the groundwater or the surrounding environment.
- Handling and transport systems should involve minimal contact with the faeces.
- Toilet paper and material such as tampons and sanitary pads/napkins should only be put into the toilet if they are bio-degradable. Otherwise, they should be treated as solid waste.
- Anal cleansing water should not be mixed with urine, but infiltrated into soil or added to the greywater and subsequently treated.
- Contents of potties and diapers/nappies and should be put into the faecal compartment.
- Further addition of absorbent material, such as ash or lime, or a bulking agent, such as sawdust, may be needed when diarrhoea is prevalent.

References

WHO. 1989. Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture. World Health Organization, Geneva, Switzerland.

Winblad, U. and Simpson-Hébert, M. (eds) 2004. Ecological Sanitation. Stockholm Environment Institute: Stockholm, Sweden.

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