Hygiene of greywaters

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Introduction

Grey wastewater usually is formed from washings and from kitchen. If the household do not need to worry about the water availability the daily water consumption for one person can be approximately 100 litres in spite that there would be a dry toilet since water is used for bathing, washing for dishes, cloths, cleaning the house and other purposes. If there is no greywater reuse, the volumes of the used freshwater and the formed greywater are almost the same. Therefore in Finland and many other countries the households without living without connection to centralised wastewater treatment unit must be able to treat also their wastewater also in the case they have a dry toilet. Anyhow if there is a dry toilet the treatment of greywaters should be easier and it should not mean a risk to surface water bodies or to groundwater.

Very often when a dry toilet system is introduced there is a schematic drawing describing a) the toilet with a connection to storage tank of urine and faeces or the common composting tank where both faeces and urine enter and b) washing machines for dishes and laundry and c) a shower and basin for hand washing and d) possible a kitchen sink. Usually these drawings present that the greywaters from washing machines, shower and kitchen sink and hand washing basin are lead via a collection well to a soil treatment filter.

The wastewater from dish machine is usually hot with pH at the level of 10 and also the washing machine for cloths tends to use alkaline detergent with rather hot temperature although the cloth washing is today often done at 40 or 30^{o}C. Temperature above 50-60^{o}C and alkaline pH can efficiently destroy microorganisms (Atlas and Bartha, 1998). Therefore we might suppose that greywaters are microbiologically safe and there is no risk for faecal contamination.

Materials and methods

The hygiene quality of two some untreated greywaters was analysed twice from two different households both living in rural area in North Savo, Finland. The other (Ra) of these families had small children. The number of sampling sites was limited since in the other sites it was not possible to sample the collection well water without contaminating the sample from the walls of the well. The wells sampled for the present work were covered so that it can be assumed that they were not contaminated by any wild animals.

The greywaters were studied in May and August. The May sampling was done after snow had melted but is still can be wet. It is possible that some garden work in had already started in May. The August sampling was taken in the moment that the most summer holidays are already behind but it is still summer so that people spend plenty time outdoors.

The microbiological analyses were done within a few hours after sampling as two parallel analyses. *Escherichia coli* was determined using the spread plate technique in ChromoCult agar (Merck)

(instead of LTTC medium) and incubated at 37°C for 24 h and the colonies were further confirmed by Kovacs indole reagent according to SFS EN ISO 9308-1 (2000). Enterococci were cultured on Slanetz-Bartley agar and incubated at 37 °C for 48 h according to SFS EN-ISO 7899-2, (2000). The spores of sulphite reducing clostridia were determined with sulphite–iron agar after a heat treatment and anaerobic incubation at 37 °C for 48 h by the standard plate count method or membrane filtration method according to the expected numbers of these bacteria determining the volume of sample water needed (SFS-EN 26461-2, 1993). Heterotrophic bacteria were counted on R2A medium (Reasoner and Geldreich, 1985) since it gives a higher number than the standard method (Zacheus, 1998) after 14 days at 20 °C (SFS EN ISO 6222, 1999).

The F-specific coliphages were determined by the ISO method (SFS EN-ISO 10705-2, 2001, SFS EN-ISO 10705-1, 2002) or its modification from a single layer method of Grabow and Coubrough (1986) where it is possible to study a 100 ml sample. The *E. coli* host was ATCC 15597.

The detection limits were either one colony forming bacterium or one plaque forming coliphage particle in 100 ml. If there was a microbial number "zero" (less than the detection limit) in some parallel assays, a value of 0.5 was used for counting geometric mean.

Results and discussion

The microbiological data is presented in Table 1.

Table 1. The numbers of indicator microorganisms and the heterotrophs in 100 ml of collection well of grey wastewaters. The detection limit is 1 CFU or PFU in 100 ml.

Sampling household	**Date**	***Escherichia coli***	**Entero-cocci**	**Clostridia**	**F-specific coliphages**	**Heterotrophs**
Ra	May 6th	3 200 000	2 300	50	25	100 000 000
Ra	August 19th	400 000 000	36 000	<1	<1	250 000 000
Ku	May 6th	95 000	11 000	50	25	25 000 000
Ku	August 19th	2 000 000	5 500	<1	<1	430 000 000
Geometric mean		**4 000 000**	**8400**	**5**	**4**	**130 000 000**

The results indicate a clear faecal contamination of both greywaters in both sampling times. Usually the relatively high number of *E. coli* could indicate a fresh faecal contamination. The frequent detection of enterococci confirms the faecal contamination. The number of sulphite reducing clostridia is usually lesser than the numbers of non-sporing *E. coli* and enterococci. The number of coliphages can be low since all people do not emit them. There are so few results that it is not possible to say if the difference between greywaters would be statistical significant according to the families. It seems that the numbers of *E. coli* were higher in August than in May

The numbers of clostridia and F-specific coliphages were higher in May than in August but all these results are rather low. The heterotrophic bacteria can not be held as faecal indicator and they can originate from many sources.

Our results are quite similar as those published by Ottoson and Stenström (2003) who detected that a greywater of 212 inhabitants living in Vibyås (Sweden) contained 10^4 – 10^7 *E. coli* / 100 ml and 10^3 - 10^5 enterococci/100 ml corresponding to $4 \cdot 10^6$ or $8.4 \cdot 10^3$ for *E. coli* and enterococci, respectively, in this work.

The hygienic quality of greywater can be decreased if there is faecal contamination in spite of the fact that toilet wastewaters (black wastewaters) are not lead to these wastewater. It is easy to think that greywater could be faecally contaminated if the anal skin area of babies and small children will be washed after defecation which every mother or father may have done. Also the anal skin area of old people or temporally of all people during diarrhoea can be faecally contaminated so that also these washing wastewater can contain faecal microorganisms. In addition the washing of dirty napkins or other faecally contaminated cloths is a clear reason for faecal contamination of wastewater.

The tested households situate in rural area where many families get a part of their food by fishing and possible by hunting birds and by cultivating some vegetables or by picking berries and mushrooms which forces the people to walk in forests. Fishing is possible in all seasons but those other activities mentioned are possible in August but not in May. Therefore if the cleaning of hunted birds or fishes would be done in kitchen there could have been some residues of intestinal channel of the treated animals leading to faecal contamination of greywater.

There can be also other contamination sources of faecal contamination such as washing of boots or other footwear soiled or cloths used when working with animals since these parcels mainly used in rural areas can sometimes be very dirty and also evidently contaminated by faeces. In some households there can be pet animals such as cats whose faeces might be led to greywaters.

We have also found on our own research work that in some cases the leaching wastewater of a dry toilet (which should not at all be formed, since there should be enough absorption matter to allow composting) or urine from a separating toilet were led partly or totally to greywater. The different leaching wastewater of dry toilets in our own unpublished work contained 2600 – 7 000 000 *E. coli* / 100 ml.

The results of this work suggest that it would be necessary to evaluate if there should be guidelines for the hygiene quality of greywater. Anyhow, there should be a better supervision and guidance for the soil filters or other soil treatment units so that these units will not be overloaded and the treated wastewater will not contaminate the soil or well water in the home plot of the owner and the neighbours. The better treatment system would allow the treatment system to operate a longer period without need to open due to clogging or to replace the entire filter to a new site which would be the most expensive operation during the life cycle of the treatment system. Thus the good maintenance could increase the life cycle of the treatment system can thus save money.

Conclusions

There should be more studies about the quality of greywaters and the variation of their quality in different seasons, areas and households so that the nutrient and microorganism load could better be evaluated and thus the guidelines could be set.

Because many different indicator microbial groups with relatively high numbers were found, there is a need for a good treatment of greywater in order to reduce the numbers of microbial indicators and the possible true pathogens in these wastewaters.

Literature

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