GROUNDWATER AND SANITATION; NUTRIENT RECYCLING AND WATERBORNE DISEASE CYCLES

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Abstract

Freshwater is a fundamental requirement for human life. Many urban or urbanising areas are reliant upon groundwater for drinking water supply. The provision of sanitation is a key requirement for the improvement of human health, particularly in the urban environment. The removal of human excreta from the urban environment may directly improve human health, but traditional forms of disposal (flush and discharge; drop and store) represent a waste of nutrient resources. It is recognised that urine particularly contains nutrients that are of potential use in agriculture. Ecological alternatives in sanitation seek to simultaneously remove human waste from the environment whilst reusing the useful constituents through the principal of *sanitise and reuse*, thus closing the nutrient cycle.

However, there is another cycle to consider; the waterborne disease cycle. Groundwater is recharged at, or close to, the land surface, and as such is vulnerable to contaminant sources at or near the land surface. Human (and to a lesser extent animal) faeces may contain pathogenic microorganisms. Where faecal matter is allowed to contact groundwater, microbiological contamination of the water results. Groundwater is often consumed without treatment, and consumption of groundwater that contains pathogens may result in further disease outbreaks and the presence of pathogens in the victim's faeces. Improper disposal of these faeces may result in further groundwater contamination, allowing the continuation of the waterborne disease cycle. When considering sanitation options, the aim should be to close the nutrient cycle, but to break the waterborne disease cycle, i.e. to recycle the nutrients without recycling the pathogens.

To protect groundwater from contamination by human excreta we need to understand how the two may come into contact. On-site sanitation (drop and store) provides the most obvious pathway. These systems effectively concentrate and store large volumes of faecal material in one place, often in an unlined storage chamber, providing a potential point source of contamination. Where hydraulic loading is sufficient (i.e. where urine, wash water or rain water is mixed with the solid waste), pathogens may potentially move down to the water table. This is particularly likely where the depth to groundwater is shallow, and is inevitable if the base of the storage chamber intersects the water table. This latter scenario may occur where the pit is constructed in the dry season, and the water table rises during the wet season.

Figure 1 presents data from a sewage contaminated aquifer in Kampala, Uganda, obtained by monitoring protected springs. In the studied areas, sanitation coverage is poor,

and the protection around the springs is often in a poor state of repair (eroded retaining walls, blocked or absent drainage ditches). This results in 'peaks' of microbiological contamination during the wet seasons as excreta discarded on the land surface is washed directly into the springs. However, a base level of contamination remains even during the dry season, particularly in higher-density population areas. This contamination results from direct leakage from pit-latrines to the water table.

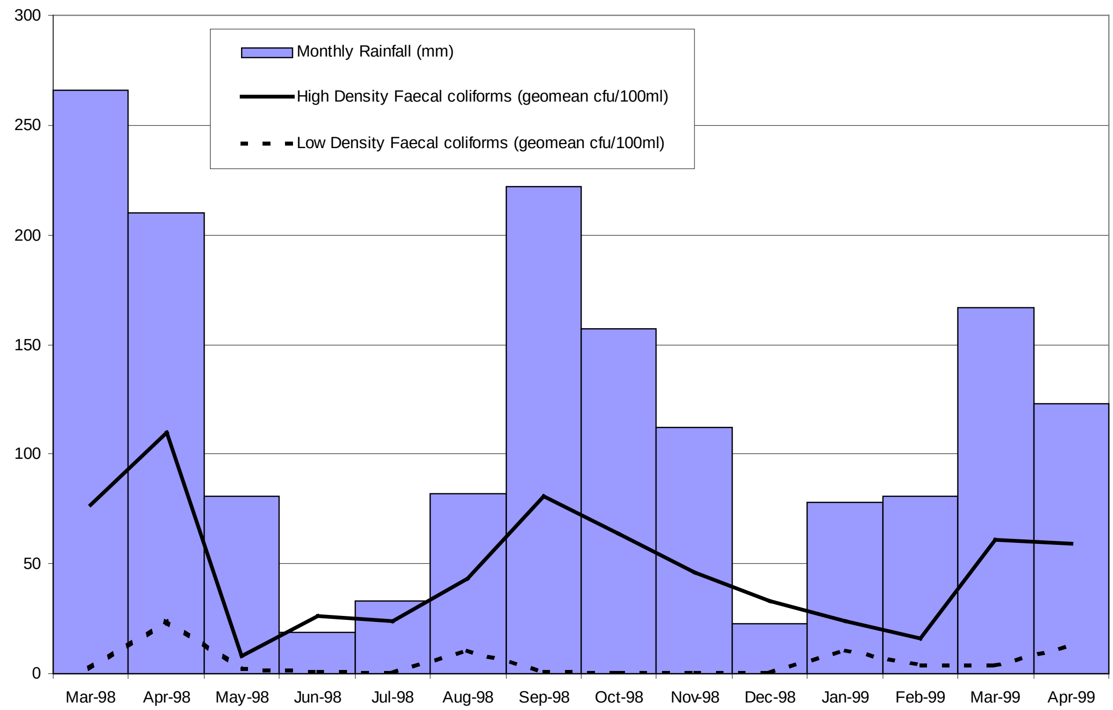

Figure 1. Sewage derived microbiological contamination of the Kampala aquifer (from Barrett and Howard, 2001)

However, off-site sanitation (flush and discharge) also poses a hazard. Waterborne sewerage systems are known to leak, and the mixture of urine, faeces (and often other domestic and industrial wastes) may reach the water table. Table 1 Presents data from water table piezometers in Nottingham, UK. Of 11 piezometers installed and monitored, all showed contamination by sewage. Of even greater concern is more recent evidence (Powell *et al*., in prep) that sewage derived bacteria and viruses are penetrating to significant depths within the aquifer (>50m). Clearly traditional water borne sewerage systems are also failing to adequately protect the underlying groundwater. The fact that sewage disposal may contaminate underlying groundwater clearly demonstrates the need for an integrated approach to groundwater and sanitation management.

Table 1. Microbiological quality of the Nottingham Aquifer, UK. (after Barrett et al., 1999)

Site	$\delta^{15}N$ ($^{0}/_{00}$)*	*E. coli* (mpn/100ml)	Faecal streptococci (mpn/100ml)	Coliphage (pfu/ml)
A	7.92	13	9	0
B	14.4	20	33	1
C	13.4	5	2	1
D	24.3	22	9	1
E	13.9	1	180	0
F	11.6	2	160	1
G	11.6	75	160	0
H	9.97	160	160	0
I	9.32	1	2	0
J	9.28	13	3	1
K	11.1	9	160	0

The option of ecological alternatives in sanitation should therefore be attractive to those responsible for groundwater resource management as they represent a potential means of disposing of human excreta without resulting in contamination. However, to further promote the use of such alternatives, evidence of their beneficial impact on groundwater resources relative to traditional solutions is needed. The call for research often frustrates those who prefer to see action in the field. However, these two activities are not mutually exclusive. Such research need not be technically complex or expensive and can be tailored to local needs. For example, simple monitoring of groundwater quality, using selected indicator parameters such as faecal coliforms, before, during and after the construction of sanitary installations would be of great benefit to those involved in groundwater and sanitation management. Likewise, comparative surveys of groundwater quality in areas where different technical solutions have been applied would be of use. Of course, such monitoring needs careful thought and planning and is only useful if subsequent data interpretation is carried out. A critical aspect of any such monitoring would be the archiving and dissemination of results.

References

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