The fate in the subsurface of contaminants associated with on-site sanitation: A review

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Abstract

One of the possible solution-to the problem of providing all Smith Africans with access to adequate sanitation within the constraints of limited resources is the use of on-site sanitation. However, concerns exist that widespread use of these systems will *cause* subsurface migration of contaminants, ultimately resulting in disease transmition and environmental degradation. Although some work on the potential pollution from on site sanitation was carried out in the early 1980s, there has been a need top update this work in view of its importance in the current debate.

This paper reviews the subsurface movement of contaminants associated with on-sitc sanitation, with a view to establishing a clear definition of the pollution risk associated with the systems. Although the literature was found to be highly fragmented, it was possible to establish certain principles that are consistent with published results.

The risk- associated with initiation of phosphates, helminths and protozoa appear minimal, with phosphate-, undergoing significant adsorption, particularly by clayey soils, and physical filtration restricting movement of helminths and protozoa to very small distances. Although bacteria, and more particularly viruses, are much more. mobile, this has been found to be a problem only when either the water table or a horizon of fractured or karst bedrock occurs at shallow depths. Mobility of viruses and bacteria does not appear to be problematic when the latrine is underlain by a layer of unsaturated oil.

The topic of greatest uncertainty was the pollution risk posed by elevated nitrate levels. Nitrates are not adsorbed, or physically retarded in any way by soil, and may therefore travel large distances in soils with high hydraulic conductivities. Questions remain as to the effectiveness of denitrification process, particularly whether or not they occur to a significant degree, in the unsaturated zone.

Introduction

Objective of the paper

With the need to address the requirement of providing access to adequate sanitation facilities for the approximately 21m. South Africans (DWAF, 1994) who are currently without such facilities, it is clearly going to be necessary to minimise the cost of these systems whilst ensuring that certain standards of quality are met. It is likely that on-site sanitation will be used to a significant degree in meeting these requirements. However, a problem that is often raised in relation to the use of on-site sanitation is the perceived pollution of groundwater that is associated with these systems (The term "pollution" or "pollutant" is used where the concentrations exceed acceptable levels. Otherwise the term "contamination" or "contaminant" is used). A newspaper article, repotting on a judgment of the Pretoria Supreme Court which dismissed an application by two residents' associations to have the Transvaal Provincial Administration (TPA) interdicted from settling the Zevenfontein community at Diepsloot north-west of Johannesburg, carried the following extract *(Saturday Star,* 1993):

> "...The residents' associations had said that the settlement process would unlawfully interfere with their rights, causing, among other things, increased air and water pollution, and an increase in crime...."

It needs to be pointed out that all types of sanitation (both on-site and off-site systems) pose a pollution threat. A key difference between the two is that any pollution from on-site sanitation will be diffuse whereas pollution from water-borne sanitation will be a point source. Experience within Umgeni Water's catchments with regards to water-borne sanitation has indicated that it can cause far worse environmental pollution problems than even basic unimproved pit latrines (Terry et al., 1993). Similar conclusions may be drawn from results presented by Hoffman (1994), who recorded very high levels of both phosphates and *E. coli* in the Kaalspruit immediately downstream of Tembisa (up to 23 *mg/l* as P, and 900 000 counts/100 ml respectively). This was attributed to blockages and overflows emanating from the Tembisa sewage reticulation system, resulting in river pollution close to Tembisa. Further downstream, where the catchment of the Kaalspruit included the informal settlement of Ivory Park, these values were much lower (up to 8 mg/l as P and 350 000 counts/100 *ml* respectively). Natural processes of purification that occurred in the river resulted in a drop in the level of these contaminants between Tembisa and Ivory Park. Of importance is the observation that Ivory Park did not cause a further rise in the levels of these contaminants. Nevertheless pollution from on-site sanitation remains a concern.

When considering pollution from on-site sanitation, one needs to define the problem clearly. There are a number of different aspects to what is a complex problem:

- Human excreta contain a number of different contaminants
- Our concern is for two different potentially harmful effects, each with different responses to the contaminants, namely that in sufficiently high "doses", these contaminants are potentially hazardous to:
  - human health and/or
  - the natural environment
- In order for a "contaminant dose" to be "administered" (i.e. to infect a host, be the host a person or the environment), these

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