Soils ARE dirt

Rebecca Lines-Kelly

Wollongbar Institute of Primary Industries, Industry & Investment NSW, Wollongbar NSW 2477
Email: rebecca.lines-kelly@industry.nsw.gov.au.

Abstract
'Soils ain't dirt' is a common mantra of soil scientists trying to educate people about the importance of soils, but the reality is that soils ARE dirt, for soil fertility depends on the excrement of living things to nourish it. Human excrement is an important component of soil fertility, and we need to overcome our intuitive disgust to find ways to return our excreta to the soil as valuable fertiliser and soil conditioner. There are many innovative techniques available to do this, but soil scientists still have important roles to play because they can educate people about this issue and reduce community fear, participate in excreta nutrition trials, and catalyse governments and institutions to take action.

Key Word
Soil, dirt, human excreta, urine, faeces, nutrients.

Introduction
The word 'soil' comes from the Latin *solium* meaning seat, or *solum*, meaning ground, and the word 'dirt' comes from the Old Norse *drit,* meaning excrement, the material expelled from living bodies, and a known source of contamination and disease. 'Soils ain't dirt' is a common mantra of soil scientists trying to educate people about the importance of soils, but the reality is that soils ARE dirt, for soil fertility depends on the excrement of living things to nourish it. 'Soils ain't dirt' exacerbates a perceptual dichotomy between soils and dirt at a time when we need urgently to reconnect the two.

Excreting urine and faeces (from the Latin *fæx* meaning 'dregs') is an unavoidable human activity, but when we gather in groups, our combined excretions overwhelm the decomposing capacity of soil organisms. Instead of building our soil fertility, our excreta become a source of odour and contamination, and their disposal is a necessity for the health of the community. Common diseases caused by contact with excreta include salmonella, cholera, dysentery and hepatitis (Santamaria & Toranzos 2003). All cultures have evolved sanitation systems to deal with excreta. Chinese records indicate their use as agricultural fertiliser 3000 years ago, particularly once fallow rotations changed to crop-crop rotations. Mixes of excreta and other organic materials such as human hair were used until the introduction of synthetic fertilisers in the 1980s (Shiming 2002). Until the mid-19th century, the contents of English cesspools had a market as agricultural fertiliser, but this market collapsed with the discovery of the fertiliser value of guano, so unwanted excreta literally flowed in streets and into streams. The appalling stench from the Thames River in 1858 was the catalyst for sewering the city and inspiring a revolution in public health (Black & Fawcett 2008b).

Many countries are now in a similar position to 19th century London. Population growth has outstripped infrastructure development; currently 2.6 billion people have no toilets at all and their untreated faeces and urine create huge health hazards for their communities (George 2009). In Western cultures sewerage systems enable us to flush and forget about our excreta, but these water-based systems are becoming unsustainable. Clean water is an increasingly rare resource and sewerage infrastructure is expensive to build and maintain. Disposal of faeces and urine pollutes waterways and represents an enormous loss of organic matter and plant nutrients that should have been returned to the soil. While recovery of dewatered biosolids for land use is becoming increasingly sophisticated, there are still contamination issues dealing with biosolids extracted from sewerage systems that contain both human and industrial waste.

There is growing interest in returning human excreta directly to the soil, an interest driven by water scarcity and stress, degradation of freshwater resources, increasing population, the resource value of excreta and its nutrients, and delivery of the United Nations Millennium Development Goals, particularly environ-mental sustainability and eliminating poverty and hunger (World Health Organisation (WHO) 2006). In 2008 two popular books, 'The big necessity' (George 2009) and 'The last taboo' (Black & Fawcett 2008b) looked at the appalling state of global sanitation and the social and ecological results of our refusal to deal with it.

Nutrient value of human excreta

The nutrient content of excreta is substantial. One estimate is that on average each person excretes 500kg urine and 50kg faeces (10kg dry matter) a year, with a nutrient content of 5.7kg nitrogen, 0.6kg phosphorus and 1.2kg of potassium. Most of the nutrients are in the urine which contains 90% of the nitrogen, 50-65% of the phosphorus and 50-80% of the potassium. These figures vary from person to person according to bodyweight, climate, water intake, and diet characteristics, especially protein content. Urine has much higher fertiliser value than faeces, which are more useful as organic matter for soil organisms to break down and improve the condition of the soil (Heinonen-Tanski and van Wifk-Sijbesma 2005).

The phosphorus value of human excreta is of particular importance given the dwindling resources of non-renewable rock phosphate currently used to produce agriculture fertiliser. Currently 148 million tonnes of rock phosphate are mined each year for fertiliser, and at this rate the supply will be exhausted within 100 years, sooner if demand for food production increases as populations increase (Cordell *et al*. 2009). Globally, humans consume around 3 million tonnes of phosphorus each year and excrete almost all of this in urine and faeces, but only around 10% of this valuable resource is recirculated back to agricultural soils and aquaculture ponds. Most of the phosphorus excreted by urban humans ends up in waterways where it is a pollutant, or in sewage sludge buried in landfills.

Cultural responses to management of human excreta

We face a dilemma with our excreta. It is a valuable resource, but also a potential source of illness, disease and untimely death, if not handled correctly, and human cultures reflect this dilemma. Some are faecophobic, with strong taboos against handling and talking about human faeces; while faecophilic cultures have no taboos, and are happy to use faeces and urine to build the fertility of their soils. These attitudes are largely determined by existing tradition and religious beliefs or practices (Avvannavar and Mani 2008).

Faecophobic cultures are disgusted by faeces. The emotion of disgust is universally recognised around the world, and is thought to be an evolutionary mechanism to defend the body from pathogens and parasites (Curtis and Biran 2001). It is reinforced by child rearing practices and by some religions which mandate strict hygiene practices. Levels of disgust vary. Decomposed faeces such as those in septic tanks evoke less disgust than fresh faeces; faeces of babies and family members are more acceptable than those of strangers (Curtis and Biran 2001). People used to defecating in the open find the idea of indoor toilets disgusting, while people with indoor toilets find outdoor defecating disgusting. Nomad cultures are faecophobic because they have no need of latrines or agricultural fertiliser. These differences indicate that while disgust is a universal primal emotion, it is context-dependent, according to culture, tradition and familiarity (Avvennavar & Mani 2008).

Faecophilic cultures tend to be agricultural, where there is a strong understanding of soil fertility and the need for nutrients. Human excreta are regarded as part of the natural cycle, and burial in soil proved to be a safe method of decomposition. Originally people would have defecated in fields away from their homes to return excreta to the soil, and this habit became tradition. Faecophilic cultures are not common, but include China and Vietnam where there is a long history of excreta use as fertiliser (Winblad and Simpson-Hebert 2004). Interestingly, all cultures are more relaxed about urine than about faeces; urine has many uses, including therapeutic drink, antiseptic, insecticide, and production of gunpowder, detergent, dye and fertiliser (Drangert 2004). In some areas of Sweden urine is collected from residential areas and used on agricultural land for its fertiliser value (Johansson *et al*. 2009).

The range of cultural attitudes and practices to management of human excreta means that any attempts to introduce new sanitation practices are fraught with difficulty. The literature is littered with examples of failed projects where innovative installations were ignored or shunned because the designers did not take into account people's attitudes and beliefs concerning sanitation (Avvannavar and Mani 2008).

Innovative sanitation

Given the current issues we face in managing our excreta, including disease, water scarcity, dwindling phosphorus, and increased demand for food production, the ideal sanitation system is waterless, odourless, and returns our nutrient-rich excreta to the soil with minimum danger to us. These are among the goals of the ecological sanitation movement (http://www.ecosan.org/) which has worked with communities around the world for the past decade to develop sanitation systems that safely return excreta to the soil (Schonning and Stenstrom 2004). Design options include arborloos where trees are planted in filled pits, dry toilets where excreta are collected and composted elsewhere, urine diversion toilets which enable separate collection, waterless urinals, double alternating composting pits, composting toilets, constructed wetlands, and windrow composting. There are many informative, well illustrated publications that detail construction methods, and benefits and costs, of the different systems, including *Ecological sanitation* (Winblad and Simpson-Hebert 2004), *Smart sanitation solutions* (Netherlands Water Partnership 2006), *Toilets that make compost* (Morgan 2007) *Compendium of sanitation systems and technologies* (Tilley *et al*. 2008), all available on the web.

Many ecological sanitation systems separate urine and faeces, because mixing the two creates odours and disease problems that we associate with excreta (Winblad and Simpson-Hebert 2004). Separating the two means the urine can be used as a fertiliser relatively safely, as it is by and large sterile and contains the NPK needed for plant growth in soil (von Munch and Winker 2009). Without the urine, faeces dry more quickly, which reduces their pathogen load, and makes them compost more easily into a valuable soil conditioner. Both EcoSanRes (Jonsson *et al.* 2004) and the WHO (2006) have published guidelines for the safe use of human excreta in food production.

Composting toilets that do combine urine and faeces are being installed in many buildings around the world, including Australia (Davison and Walker 2003). US practitioner Joseph Jenkins describes them as 'humanure' systems that require both faeces and urine to ensure there is enough moisture and nitrogen required for thermophilic composting. They also require substantial amounts of primary carbon cover material such as sawdust, peat moss, rice hulls, grain chaff or paper products for the toilet, and secondary cover materials for the pile such as woodchips. The high dependency on carbon sources means it is not an option in areas where there is little spare organic matter available (Jenkins 2009).

Another option gaining in popularity is biogas where human excreta are fermented anaerobically to produce gas that can be used for cooking, lighting, and heating. The solid effluent can be safely used on soils. Household biogas systems using animal and human excreta are an important part of China's sustainable energy program (Chen *et al.* 2010); in India, the humanitarian organisation Sulabh has built 200 plants fuelled by excreta from public toilets (Patak 2009).

Roles for soil science

According to Esrey (2002) it is not a question of whether ecological sanitation will be adopted; but when, if resources are to be managed for a sustainable future. If this is the case, what roles can soil scientists play in assisting with this process? Soil scientists are already important players in recycling human excreta through their expertise in agricultural use of sewage effluent and biosolids, and septic tank management. As depletion of our resources makes re-use of human excreta a nutritional imperative, we need to be able to talk about our faeces and urine without embarrassment. Soil scientists can desensitise the topic by helping people understand the nutrient value of our faeces and urine, the importance of organic matter for soil fertility and structure, the sanitising role of compost, and the many structures and designs available to help people 'close the nutrient loop' and build our soil fertility. Such conversations will overcome what Black & Fawcett (2008a) described as 'the unwillingness in societies everywhere to talk about excreta disposal and behave as if it was a matter of public importance instead of private embarrassment and shame'.

Research is still needed into the use of faeces and urine applied to agricultural soils. Several speakers at the 3rd International Dry Toilet Conference held in Finland in August 2009 (http://www.drytoilet.org/dt2009/), indicated that work is needed to better manage pathogen loads, transport urine easily, and reduce pharmaceutical residues. Soil scientists also have a key role in optimising excreta's crop fertiliser value, as it is likely that nutrient supplements will be needed (Mnkeni and Austin 2009).

Soil science organisations can also help overcome institutional 'urine blindness' by promoting the importance of nutrient recycling in principle. According to Cordell *et al.* (2009), urine recycling to recover phosphorus is hampered by the lack of an institutional or organisational home in Australia because our flush and forget systems make recycling a peripheral concern to policymakers. Esrey (2002) says the future of ecological sanitation requires 'dialogues with other sectors and professionals, such as those involved in agriculture, planning and architecture' to ensure that ecological sanitation is perceived as an important part of sustainable development, not just as an alternative toilet design.

Conclusion

Declining phosphorus supplies and freshwater resources are rapidly raising the value of human excreta as important soil fertiliser that provides nutrients, improves soil structure, holds soil moisture and produces more food. But our intuitive disgust in handling our excreta due to its contaminant potential means that closing the 'nutrient loop' requires conversation, education, changes in cultural attitudes, technological innovation and still more conversation. Soil scientists have a role in all of these areas, starting with conversation today on why soils ARE dirt.

References

Avvannavar SM, Mani M (2008) A conceptual model of people's approach to sanitation. *Science of the Total Environment* **390**, 1-12.

Black M, Fawcett B (2008a) A new revolution for urban sanitation. http://www.irc.nl/page/44894

Black, M. Fawcett, B (2008b) The last taboo. (Earthscan and UNICEF, London).

Chen Y, Yang G, Sweeney S, Feng Y (2010) Household biogas use in rural China. *Renewable and Sustainable Energy Reviews* **14**, 545-549.

Cordell D, Drangert JO, White S (2009) The story of phosphorus. *Global Environmental Change* **19**, 292-305.

Curtis V, Biran A (2001) Dirt, disgust and disease. *Perspectives in Biology and Medicine* **44**, 17-31.

Davison L, Walker S (2003) A study of owner-built composting toilets in Lismore NSW. http://www.clearwater.asn.au/resources/519_1.341_TD_DavisonCompostingToiletsStudy.doc

Drangert JO (2004) Norms and attitudes to ecosan and other sanitation systems. (Stockholm Environment Institute). http://www.ecosanres.org/.

Esrey S (2002) Philosophical, ecological and technical challenges for expanding ecological sanitation into urban areas. *Water Science and Technology* **45**, 225–228.

George R (2009) The big necessity: Adventures in the world of human waste. (Portobello Books, London).

Heinonen-Tanski H, van Wifk-Sijbesma C (2005) Human excreta for plant production. *Bioresource Technology* **9,** 403-411.

Jenkins J (2009) Humanure sanitation. Proceedings Dry Toilet 2009, Finland. http://www.drytoilet.org/dt2009/full.html

Johansson M, Kvarnström E, Stintzing A (2009) Going to scale with urine diversion in Sweden. Proceedings Dry Toilet 2009 Finland. http://www.drytoilet.org/dt2009/full.html

Jonsson H, Stintzing A, Vineras B, Salomon E (2004) Guidelines on the use of urine and faeces in crop production. (Stockholm Environment Institute). http://www.ecosanres.org/.

Mnkeni P, Austin LM (2009) Fertiliser value of human manure from pilot urine-diversion toilets. *Water SA* **35**, 133-138.

Morgan P (2007) Toilets that make compost. (Stockholm Environment Institute). http://www.ecosanres.org

Netherlands Water Partnership (2006) Smart sanitation solutions. http://www.irc.nl/page/28448

Patak B (2009) Technologies for human dignity. *Innovations* **4**, 43-57. http://www.mitpressjournals.org/

Santamaria J, Toranzos GA (2003) Enteric pathogens and soil. *International Microbiology* **6**, 5-9.

Schonning C, Stenstrom T (2004) Guidelines for the safe use of urine and faeces in ecological sanitation systems. Stockholm Environment Institute. http://www.ecosanres.org/.

Shiming L (2002) The utilisation of human excreta in Chinese agriculture and the challenge faced. http://www.ecosanres.org/

Tilley E, Lüthi C, Morel A, Zurbrügg C, Schertenleib R (2008) Compendium of sanitation systems and technologies. Eawag. Dübendorf, Switzerland. http://www.eawag.ch.

Von Munch E, Winker I (2009) Urine diversion components. (GTZ Eschborn, Germany). http://www.gtz.de/en/dokumente/gtz2009-en-technology-review-urine-diversion.pdf

Winblad U, Simpson-Hébert M (2004) Ecological sanitation. Stockholm Environment Institute. http://www.ecosanres.org.

World Health Organisation (2006) Guidelines for the safe use of wastewater, excreta and greywater. http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html