Products that can be made from our Pee and Poop

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Our current global resource model is linear in nature; it involves take-use-dispose. This model can lead to wastage and has little emphasis on resource optimisation. With consumption of global resources expected to rise due to increasing population size, new ways of resource optimisation are required to ensure we do not consume beyond what we have. One of the new economic models that has been gaining traction is based on circular economy principles. In this approach, the continual and/or efficient use of resources through reduction, reuse and recycling is promoted. Circular economy models attempt to create a closed-loop system, minimising the use of resources and the creation of wastes.

In sanitation, the current take-use-dispose models are wasteful. We routinely used two modes of sanitation. In urban centres, flush toilets are used. This technology uses 6 to 9 litres of drinkable water – of which there is a limited supply – to move our pee and poo in sewers until it reaches a wastewater facility. Once at a treatment facility, selected constituents in the wastewater are consumed by microorganisms. Eventually, these microorganisms grow to a point where the tanks that hold them need to be emptied. In South Africa, the majority of this "waste" ends up at land disposal sites.

Outside sewered areas, dry sanitation technologies are used. While saving on water, the technologies fill up with human waste becoming a thick sticky paste called faecal sludge. This faecal sludge needs to be emptied and is then transported to a centralised location for disposal, usually a land disposal site. Land disposal sites that can only handle a certain amount of sludge disposal and many can fill quickly if the balance is skewed more towards disposal than degradation. Growing population sizes mean ever-growing sanitation waste volumes to be treated.

With the number of land disposal routes expected to become limited, circular economy principles are being considered as a sustainable option to manage human faecal waste. At the Water Research Commission (WRC), South Africa's premier water knowledge hub based in Pretoria, research is being undertaken to examine if the resources contained in human faecal waste can be repurposed into products of economic value thereby introducing circular economy principles into the management of human faecal wastes.

To understand what products of economic value can be extracted from human faecal waste, one needs to understand what is contained in our pee and poop. Water makes up the largest fraction of both our pee and poop. Pee or urine contains around 90% water Pee also contains essential plant macronutrients (Nitrogen, Phosphorus, and Potassium) that are routinely used in fertilisers. If pee can be separated from poo, there exist an opportunity to harvested and recycled these nutrients. In comparison, around two-thirds of poop is water. The remainder consisting of solid material with organic material represents the highest fraction followed by bacterial biomass, protein or nitrogenous matter, carbohydrate or any other non-nitrogenous undigested plant matter, and undigested lipids. These constituents can be extracted and properties changed through innovative engineering processes to manufacture products of economic value. Below are of some of the innovations tested that have been down to have this capability.

Large volumes of urine can cause eutrophication of water bodies that leads to oxygen depletion and subsequent adverse aquatic life effects. Several pee innovations have been demonstrated in South Africa that seek to repurpose urine. If urine can be separated from human waste streams, there exist an opportunity to repurpose it and prevent downstream

pollution challenges. At the University of KwaZulu-Natal, Professor Ademola Olaniran has shown that it is possible to convert urine through innovative engineering processes into struvite, a phosphate mineral that can used as a fertiliser. Professor Olaniran's research also looked at health and safety implications for reusing urine-derived struvite for horticultural purposes. At the University of Cape Town (UCT), Dr Dyllon Randall has been exploring the production bio-bricks from urine. Dr Randall's research collected urine from men's urinals and feeding this to selected bacteria, a gelling-like substance was produced which binds masonry sand together to form a bio-brick. The research first aimed at illustrating the possibility; new research is aimed at optimising processing of products and developing the business models to scale up the innovations.

Bio-brick formation from urine undergoing stress testing

The capabilities for repurposing poop have also been demonstrated. By turning poop into products of economic value, there is opportunity to generate additional revenue streams from products that would otherwise be disposed of. Worldwide, many wastewater works are converting their plants into resource recovery facilities. The process used involves anaerobic digestion which coverts the fermenting waste into biogas. This biogas can be scrubbed and cleaned as reused for heating or generating electricity. More recent advancements involve producing renewable fuel options for motorised vehicles which can cut diesel usage and

reliance and greenhouse gas emissions. Several car manufacturers have noted the possibility; Toyota has developed a concept car that runs of fuel derived from poop waste. The concept car has hydrogen fuel cells which is fed with fuel derived from poop waste. In South Africa, BMW have been using a similar process at its facility in Bronkhorstspruit to supplement its electricity demand using cow poop and other organic wastes. This indicates that South Africa has capability to undertake such engineering projects and there exists potential to convert our wastewater treatment works into fuel generation centres.

Where there is potential for revenue, businesses will follow. In sub-Saharan Africa, large populations have no access to toilets. New social-driven business models have been sprouted in Kenya and Uganda to provide toilets and collect the human faecal wastes and convert into economic products. In Kenya, a social enterprise called Sanivation provides mobile toilets at households and the waste collected twice a week. This waste is then taken to resource recovery facility where the high temperatures in solar concentrators sterilise the waste which is then processed further turned into charcoal briquettes that are used as fuel for burning. In Uganda, Water for People have been using a similar approach to convert human sanitation waste into charcoal briquettes. As part of the business model, Water for People investigated the quality and market potential of the briquettes produced was compared to market-based fuel product, charcoal, that is used for household heating purposes. The investigations revealed that sanitation-derived briquettes can deliver the same fuel value as charcoal.

Other processes being demonstrated involve conversion of human faecal waste into protein feeds or commercial oils. While several of these concepts have demonstrated in South Africa through WRC research, it has yet to sprout resource recovery business models linked service delivery as happened in Kenya and Uganda. With many of these concepts having shown to be successfully demonstrated, the next stage is how we translate research into practice and develop the appropriate business tools for municipalities to utilise as part of their operations, including conducting user acceptance of alternate fuels, price-competitiveness among market-related products together and reliability of product quantity and quality.

Faecal waste re-purposed into briquettes. Image: Water for People Uganda

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