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TESI DI LAUREA

Solid-liquid separation on concentrated blackwater with respect to P-recovery

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Abstract

Nowadays our society looks with interest to sustainability in all its forms. One of the most important ways of sustainability is to reuse what we produce and in particular human residues. The main elements we can find in the organic matter composition of all organisms are carbon, hydrogen, oxygen, nitrogen and phosphorus. Water and minerals like calcium, sulfur and others are even essential. 20 % of the world's population does not have access to safe drinking water and 50 % to safe or sufficient sanitation (WHO/UNICEF, 2000). To improve this situation we should start considering the most common actions we do daily.

Conventional sanitation concepts based on flush toilets, sewer and central WWTP, are wasteful of water and are not an ecological solutions for both industrialized and developing countries. Alternative wastewater systems, thought on source control, are called NASS, novel approach to sanitation or ecosan. One of the main advantages of NASS is its contribution to the sustainable ecosystems concept by applying recovery and reuse potential for the nutrients in urine and faeces. Ecosan projects are based on the separate collection and treatment of different wastewater flows, black and grey water, to minimize the water consumption and exploit the potential for nutrient recovery and reuse (Esrey et al., 1998; Wilderer, 2001; GTZ, 2003). Ecosan systems therefore greatly help in saving limited resources.

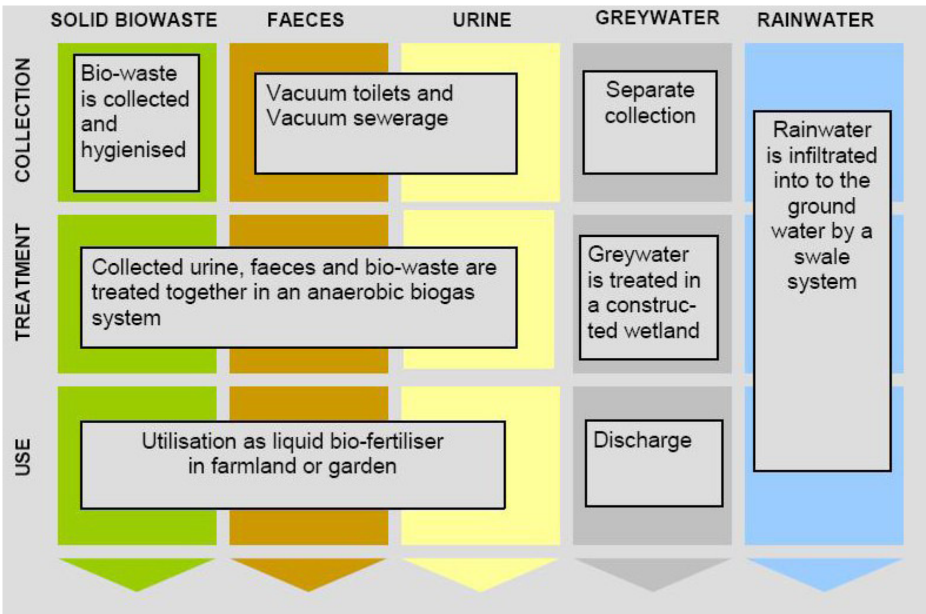

Figure 1: Ecosan System in Flintenbreite, Lübeck (Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH)

This is particularly urgent with regard to fresh water and mineral resources. For example, current estimates for phosphorus state that economically extractable reserves will be exhausted within the next 100 years (Steen, 1998).

Waste from toilets known as blackwater (BW), contains high concentrations of the valuable nutrients. It is constituted of only 1-2 volume % of the total domestic wastewater stream, but it contains up to 95% of the total nitrogen and 90% of the total phosphorus (Kujawa-Roeleveld and Zeeman, 2006).

Black water is composed by urine, faeces and toilet paper. Phosphorus recovery from wastewater in the long run even seems to be a necessity as the available phosphorus resources become increasingly scarce (Driver et al., 1999). Chemical precipitation involves the addition of chemicals to alter the physical state of dissolved and suspended solids and facilitate their removal by sedimentation (Metcalf and eddy, 2003).

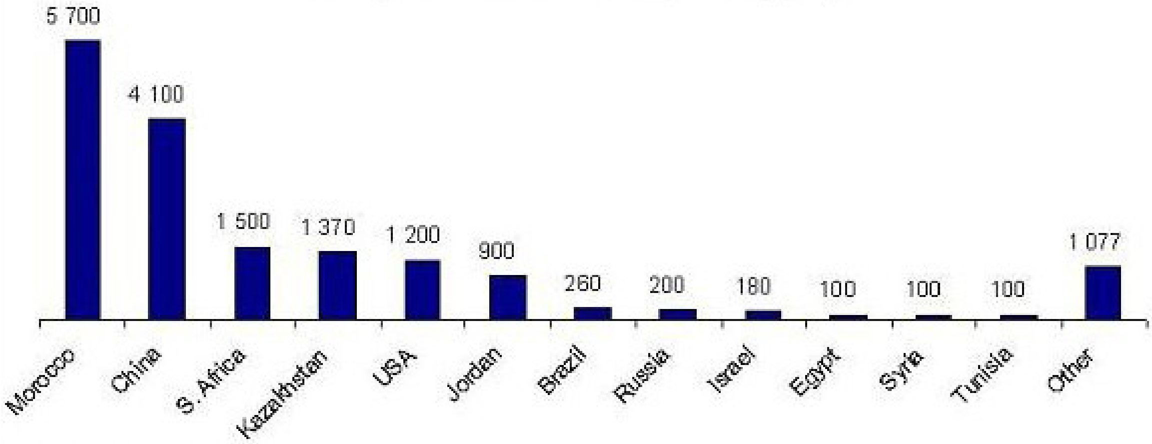

Figure 2: Phosphate rock reserves by country in (Mt), (www.sunkaresources.com)

There are different ways to recover P from wastewater as struvite precipitation (predominant in literature), calcium phosphate precipitation, adsorption e.g. using zeolite or ion exchange and membrane processes.

In conventional WWTP P is mostly removed by precipitation with iron- and alumina salts, which is mostly done simultaneously for improving the sludge settleability.

Anaerobic digestion of concentrated BW, e.g. from vacuum toilets, is a favorable alternative within the context of ecosan, as it gives resource conservation and reuse for the digested effluents. Though the sludge from digested blackwater contains almost most of the nutrients from urine and faeces, utilization via direct land application is often not possible and post treatment is required. Steps of post treatment are thickening, dewatering, composting, heat drying and incineration. The main aim of these phases is the volume reduction which reduces the total disposal costs. A further reduction of the sludge amount is mostly necessary after the thickening. The liquid sludge has to be dewatered and has to conform to a dry and porous form. Because of the substantial volume reduction, liquid-solid separation decreases the capital and operating costs of subsequent handling of solids. Experiments on liquid-solid separation have been conducted considering three different methods:

sedimentation, centrifugation and filtration. Trials were operated on different substrates such as raw black water (RBW), digestate from mesophilic and thermophilic digestion of black water (GRM, GRT), activated sludge (AS) and digested sludge (DS). Different parameters have been determined such as turbidity, SVI, filter resistance, COD, TOC and P-recovery.

All the parameters were measured considering samples from pressure filtration, from sedimentation, from centrifugation and considering several conditioning conditions, adding $Ca(OH)_2$, $Mg(OH)_2$, $MgCl_2$, coagulant a polymer. Results showed that, filtration resistance values, from pressure filtration, are higher if compared to literature ones; In terms of turbidity, sedimentation resulted the worst method for all the substrates. Centrifugation carried out the best results for GRM, while pressure filtration gave the highest turbidity reduction with AS and DS. Regarding phosphorus recovery usage of $MgCl_2$ together with the polymer K255 LXI produced the most efficient results with 81% P-recovery. Good results have been reached also with the usage of $Ca(OH)_2$ considering a molar ratio Ca:P of 1:3 (70% P-recovery).

Figure 3: Precipitation by Ca(OH)2 in RBW. From the picture it is possible to observe the precipitate in the bottom of the Imhoff cone.

In terms of pH, the pH-optimum for P-removal wasn't reached in all the cases and it means that an adjusting of pH is strictly necessary to improve the phosphorus removal and recovery. There is not a single best method which can be used for all the substrates obtaining the same results, but the method has to be chosen depending on the substrate.

Next step of the research can start conditioning the samples with the same concentration of precipitant and additional adjustment of pH towards the optimum for calcium phosphate and magnesium phosphate precipitation.