Local Recycling of Blackwater and Organic Waste

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Figure 4. Farmer-operated liquid composting reactor

Introduction

Theoretically, the nutrients in domestic wastewater and organic household waste are nearly sufficient to fertilize crops for the world population [1]. In reality, these nutrients are truly wasted, along with potable water. Despite the alarming demands for clean water in our water-scarce age, 20-40% of domestic wastewater is used for flushing toilets [2]. From a sustainable perspective, wasted water must be reduced, wasted nutrients recycled, and waste treatment energy minimised. To achieve these goals a variety of methods and technologies have been developed. Although recycling treatments vary from simple to complex, from centralized to decentralized, and from parochial to innovative, the more successful are based on a rudimentary principle, source separation (Figure 1). Appropriate technologies for dealing with blackwater and organic household waste are discussed.

Abstract

Source separating systems enhance recycling of wastewater. The use of water saving vacuum toilets is beneficial in the separate collection of blackwater. Blackwater (the most nutrient rich wastewater fraction) and organic household waste can be co-processed in a liquid composting reactor to produce a sanitized fertilizer/ soil improver product, heat energy and a financial profit for the plant operator. Applying the fertilizer directly into the soil reduces nutrient loss, odour, and runoff compared with traditional surface spreading.

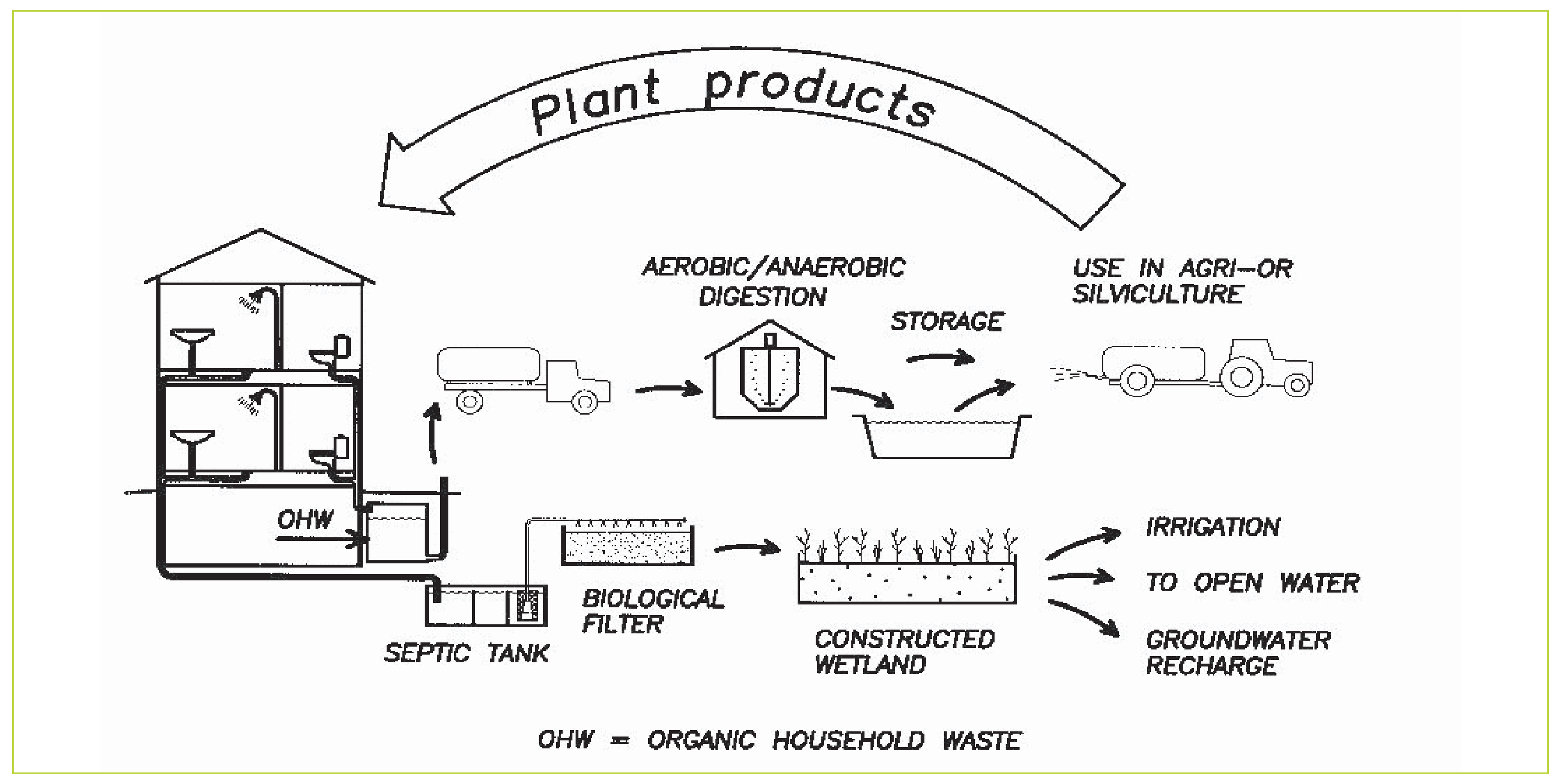

Figure 1. A complete recycling system based on separate treatment.

Results and discussion

Blackwater Collection

Blackwater contains about 90% of the nitrogen, 74% of the phosphorus, 79% of the potassium and 30-75% of the organic matter in wastewater [3,4]. New toilet technologies – such as urine-separating systems, and vacuum or extreme water-saving toilets – facilitate nutrient collection and recycling [5]. Water-saving toilets may reduce the average family volume of blackwater to 6-9 m3 per year. Such volume can be treated locally at an aerobic treatment facility, for example a farm-based liquid composting reactor.

Vacuum toilet and collection systems have been developed for marine use. On-shore the experience with vacuum systems is still limited. In Norway, 4 years experience from two housing developments, 48 and 120 persons respectively, have shown the viability of these systems in ordinary homes. The latest development is vacuum on demand (VOD), i.e., vacuum is generated only when flushing. The system, which is also available in a solar powered version, consumes less energy (<10 kWh/person/year).

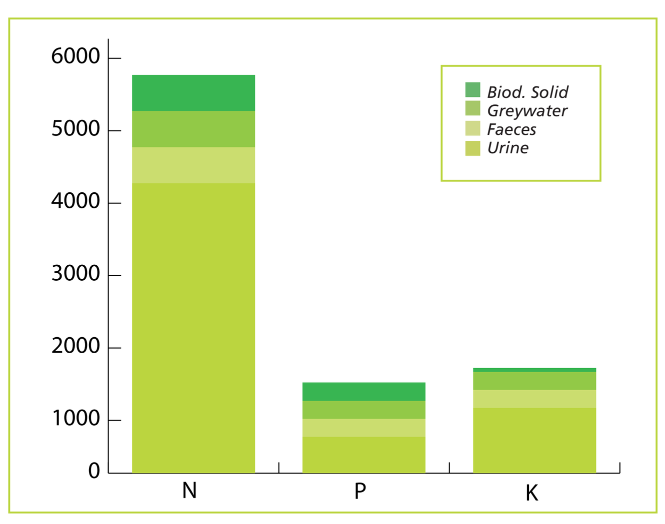

Figure 2. The content of nitrogen (N), phosphorus (P) and potassium (K) in the fractions of biodegradable solid waste and wastewater from households. From Vinnerås [1].

UTILIZATION OF BLACKWATER

Before utilizing blackwater as a crop fertilizer it is necessary to sanitize and stabilize it. This can be achieved by, e.g., composting. Even when the amount of toilet flush water is only 1 litre, the dry matter in the blackwater is less than 1%. Therefore organic matter (such as organic household waste or manure) must be added in order to achieve appropriate treatment of the blackwater by liquid composting [4]

Aerobic Treatment by liquid composting

Liquid composting yields two products: (1) sanitized fertilizer suitable for agriculture, and (2) energy in the form of heat. A Norwegian liquid composting system has been developed which is farmer-operated [6]. Waste from 700 homes is treated in a thermophilic reactor of working volume 32 m3. The finished liquid compost is sanitized, stabilized and sufficient for spreading to 30-40 hectares of the farmer's own land. The plant generates a profit of ca. 27 000 p.a. Currently, 7 plants are in operation on Norwegian farms.

Direct ground injection (DGITM)

A tractor-mounted injection system has been designed for the purpose of applying liquid fertilizer (Fig 3) [7]. The device does not penetrate the ground; rather, high pressure injects the sanitized slurry into soil. Compared with traditional surface spreading methods, DGI makes nitrogen 80% more plant available and reduces run-off, odour, and air pollution by 20%. Moreover, crop yields from liquid compost are similar to mineral fertilizer.

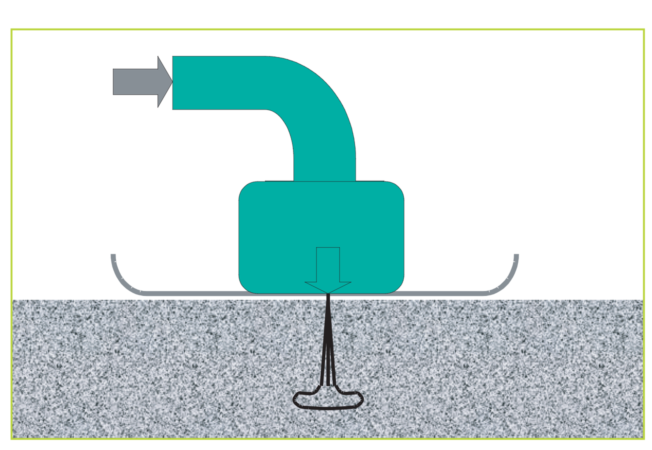

Figure 3. Slurry injected under pressure beneath DGI skid plate.

FUTURE AREAS OF RESEARCH

Small-scale bio-gas reactor for cold climates: Development of an economical bio-gas reactor. This will operate in the thermophilic range in order to achieve hygienization of the blackwater/organic waste. Degradation of pharmaceutical residues: Investigate potential of thermal hydrolysis to degrade pharmaceutical residues in blackwater.

Algal processing of wastewater: Use of algae or bacteria cultured on wastewater for a range of purposes, such as generation of hydrogen energy; production of fine chemicals or proteins and lipids for use as dietary supplements in fish and animal feeds; sequestration of heavy metals or other toxic substances.

Combining solid and liquid waste

It is feasible to combine treatment processes into a synergistic system that further mitigates emissions (Figure 5). The objective of the system is to generate three products – biogas energy, usable water, and fertilizer – with minimal environmental impact. To achieve this goal, source-separated waste, i.e., solid organic household waste (OHW), blackwater and manure, are treated using different methods.

The lower-left corner (Figure 5) shows fuel preparation for bio-fuel pellets or briquettes. An option also exists for plastic baling of 200 – 400 kg solid fuel, which may be stored for more than a year. Since the bales are hermetically enclosed there is no odour.

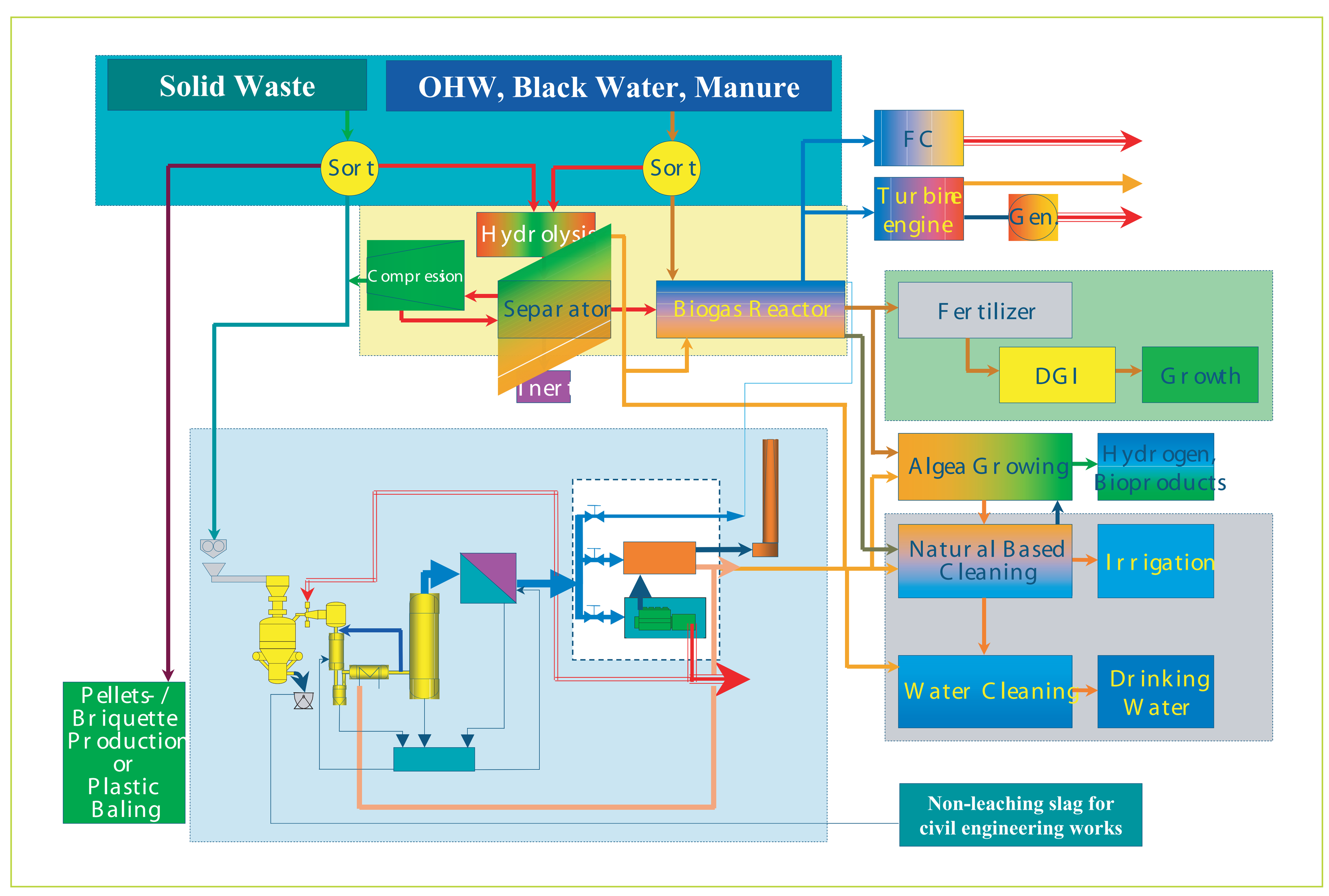

Figure 5. A combined plant with water purification systems that produces hydrogen, bio-energy and fertilizer.

Conclusion

Experience from Norway shows that wastewater recycling is enhanced by source separation. Blackwater has value as a crop fertilizer because of its content of major plant nutrients, however, blackwater must be sanitized and stabilized before re-using.

Blackwater can be beneficially co-processed with organic household waste to produce a stable, sanitized liquid compost product. In addition, heat energy and a financial profit for the plant operator are also generated.

By using DGI, the liquid compost may be injected into the ground and fertilize the soil with less aerial emissions, runoff, and nutrient loss than traditional surface spreading.

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