THE HOLISTIC HOSPITAL

AN INTEGRATED APPROACH TO WASTE (WATER) MANAGEMENT

WEGE PRIZE 2016

Current hospital situation and need for change

The volatile price of petroleum, its dwindling nature along with increasing climate change concern and the forecasted population growth have called the plastic industry to adopt more sustainable resource materials. Therefore, there is a need to develop technology aligned with environmental preservation. Furthermore, government's support and consumers' demand for green products are additional factors that drive the development of renewable plastics.

Hospital waste consists mostly of petroleum-based materials and accessories that have been used only once. Strict regulations regarding risk prevention state that these materials may only serve a single application and recycling of contaminated materials is also impeded. With this in mind, it makes sense to switch to a carbon neutral system that maximizes the use of resources.

Conventional materials can only be destroyed or recycled at external facilities through a long chain of processes. For cost reasons these materials are usually destroyed in waste burning facilities at high temperatures. Wastewater is usually disposed of through the sewer system after which it is processed by local water treatment facilities to prevent for example drug pollution. Treatment of both solid waste and wastewater incur high costs for hospitals (up to $3 per day hospital bed, just for solid waste).

Bio-based materials however can be recycled by processing them in an onsite digester at the hospital. The digester converts the bioplastics to biogas which provides energy to power the rest of the waste processing facility and hospital (this is explained in detail below). Although biogas creates CO2, the system itself is neutral. However, future developments could focus on carbon capturing to contribute to an overall reduction of atmospheric CO2 levels.

Facts & Figures

Only 15% of medical waste is hazardous, but due to mixing of waste it contaminates otherwise non-hazardous waste, leading to environmental hazards and higher treatments costs.

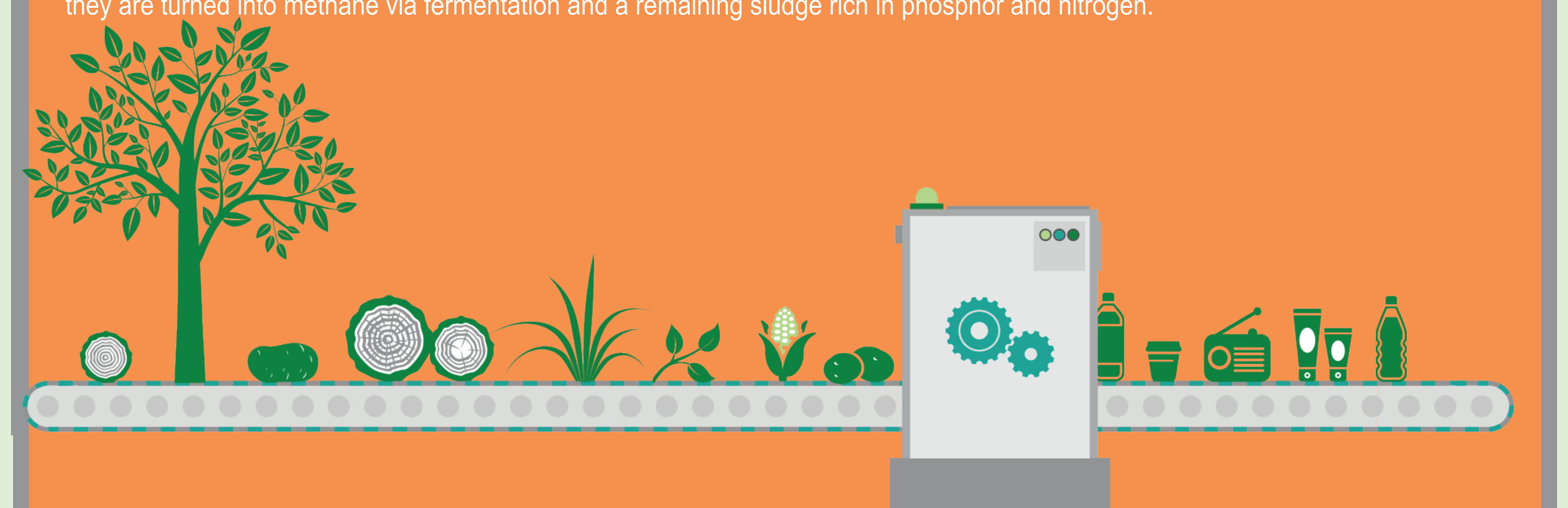
Only 15% of medical waste is hazardous, but due to mixing of waste it contaminates otherwise non-hazardous waste, leading to environmental hazards and higher treatments costs.

Only 15% of medical waste is hazardous, but due to mixing of waste it contaminates otherwise non-hazardous waste, leading to environmental hazards and higher treatments costs.

No pharmaceuticals that are harmful to the aquatic environment will leave the treatment plant.

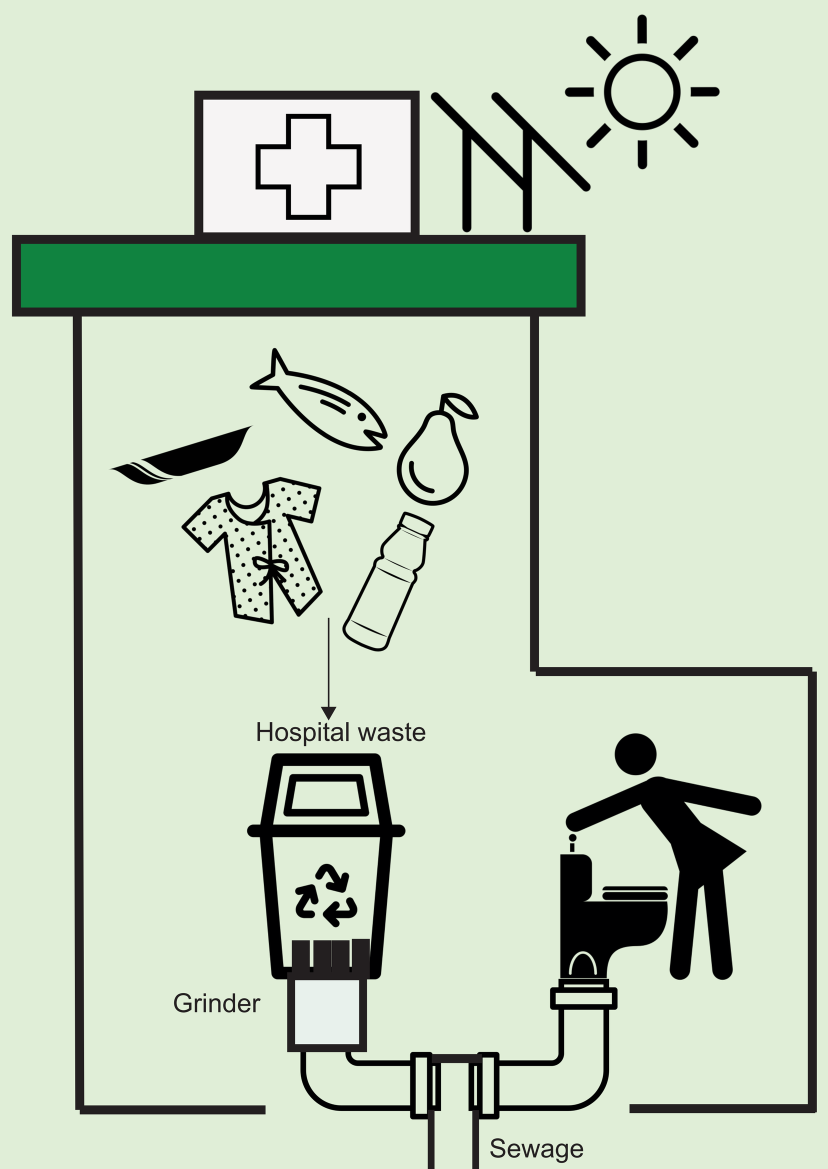
Bioplastics

Bioplastics is an ambiguous term, meaning that the definition is used for both biodegradable and bio-based plastics. These two groups do not necessarily overlap. The bioplastics to which are referred in this project are biodegradable bio-based plastics, i.e. made directly or indirectly from naturally occurring compounds and able to be chemically broken down by microbes or other biological means. Bio-based plastics can for example be made from starch (as is the case for PLA), which is a common by-product for any potato processing facility. Considering the entire life cycle of bioplastics, natural materials are needed to produce them and after use they are turned into methane via fermentation and a remaining sludge rich in phosphor and nitrogen.



This circular waste (water) treatment system was designed specifically to deal with hospital waste (water) in a manner that minimizes environmental impact and maximizes resource recovery at a cost-effective rate, while at the same time adhering to the increasingly strict regulations that apply to the medical sector, now and in the future. The system is essentially a collection of proven waste (water) treatment processes wrapped in a concept that is feasible for on-site placement at hospitals without the necessity of extensive modifications to existing infrastructure. By using bioplastics as the basis for single-use materials in hospitals, this system is capable of effectively processing waste in such a way that waste output is minimized with 90% and at the same time energy and potable water is produced in a carbon neutral way.

How to implement?	Strengths	Benefits for stakeholders
- Find a suitable sludge treatment facility ✓ - Find hospitals to implement this system ✓ - Further develop regulations in cooperation with local and regional governments	- Cheaper than outsourcing - Lower electricity need and cost - CO2 Neutral - Minimizing environmental impact - Output is cleaner water than tap water	- Direct and future cost reductions for hospitals - Government has less pollution from pharmaceuticals in water - New value stream for waste treatment facilities - No environmental impact
Threats - Local regulations vary - System is not patentable (could also be an opportunity) - Market volatility of bio-based products	**THE HOLISTIC HOSPITAL** SWOT ANALYSIS	**Opportunities** - Water Scarcity - Financially feasible from start - Healthcare sector and waste will grow - Regulations are expected to become stricter in the future
Biggest risks - Needs third party for the sludge - People might wrongfully think that the water is not clean - Investment climate changes	**Weakness** - Initial Investment - Structural change sewage system - Effectiveness dependent on regulations - Bioplastics are a system-requirment	**Challenges** - Convincing hospitals to change procurement - Substantial investment required - Still in pioneering phase



Steps System

Grinder
Each floor/hallway will be outfitted with a grinder. Specific hospital waste, urinals, leftovers and dishes are grinded to pieces that are small enough to be disposed through the existing wastewater sewage system. The sewage system does not need extensive modification. The only modification necessary entails connecting the grinders to the sewage pipes.

Sewage
The existing sewage system transports both the grinded waste as well as conventional hospital wastewater. This wastewater is rich in hormones, bacteria, nutrients and pharmaceuticals. The sewage system leads to the waste processing which is located on-site in a separate building. After this phase we can discern two separate streams: solid waste (SW) and wastewater (WW).

Screening (SW)
Upon entering the waste processing facility the solid waste is filtered out by a screening system and transported to another grinder where it is grinded to even smaller pieces. These smaller pieces are then transported to a collection tank (discussed later). The remaining wastewater is transported to the bioreactor with activated sludge.

Bioreactor: Activated Sludge (WW)
Activated sludge in the bioreactor removes heavy metals, phosphates and nitrogen from wastewater by binding . This sludge is still present in the outflow stream of the bioreactor.

Membrane (WW)
The outflow stream from the bioreactors goes through a membrane that filters out sludge from the previous step, bacteria and viruses. The holes in this membrane are so small that only water can pass through. Pharmaceuticals and hormones dissolved in water are not (yet) removed. The sludge that is filtered from the water is collected in the same collection tank that contains the solid waste.

Oxidation (WW)
The oxidation phase removes the majority of the pharmaceuticals and hormones that are dissolved in the water. The oxidant employed is ozone gas and is considered one of the most aggressive oxidative agents available. An added benefit of this method is that it produces no dangerous side products. These products are, however, still present in the outflow stream.

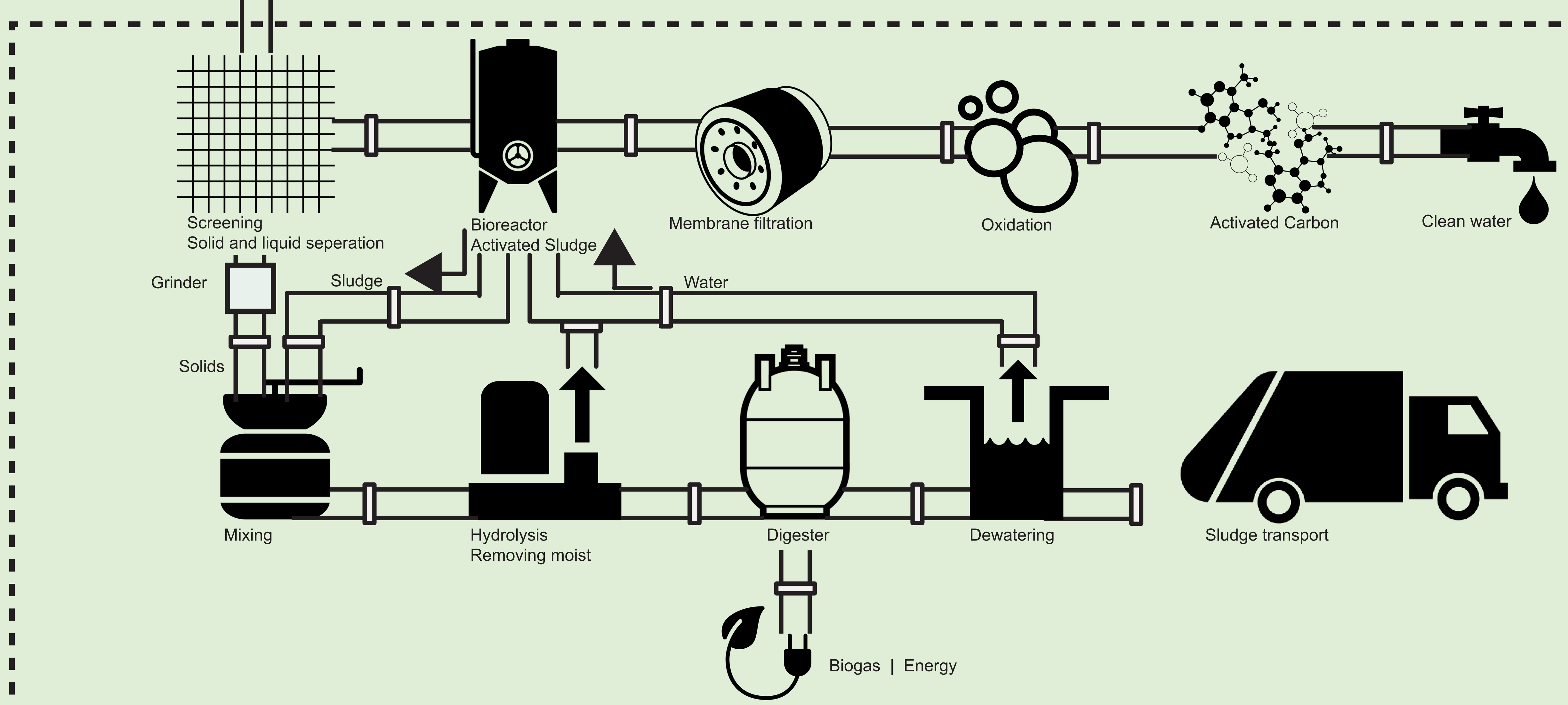
Active Carbon (WW)
The activated carbon (AC) system consists of a reactor with a surface of active carbon. This carbon binds to any remaining particles in the wastewater. After having passed through the AC system the water is 99% free of pollutants meaning that it is cleaner than tap water.

Mixing (Sludge + SW)
In the collection tank sludge and solid waste are gathered and mixed. The mixing is intended to equalize the composition of the contents of the tank as far as possible. A more equal composition ensures a better digestion process later on.

Hydrolysis (SW)
Before the material can enter the digester, water content must be diminished. This is done through the process of hydrolysis. After this the waste is transported to the digester.

Digester (SW)
The solid waste is collected in the digester. In the digester 90% of the waste is converted to biogas. The remaining 10% is converted to sludge during the process, and has to be collected and treated at an external location by a third party. The available biogas is sufficient to power the waste treatment facility, allowing for a CO2 neutral process. The digestion process is such that it succeeds in eliminating pathogens, bacteria, pharmaceuticals and hormones. In depth information on how this process functions is provided elsewhere.

Heavy metal recovery from sludge
With prices for raw materials increasing, new methods for recovery of valuable resources from waste and sludge have become economically feasible.



Meet the team

'Spaak' is Dutch for 'spoke'. Spokes give structure to the wheel. The wheel stands as a symbol for our heritage – the Dutch bikes, standing for freedom and independence- but it is also a symbol for circular design. With our design we added a new spoke to the wheel of the circular economy, increasing its strength and firmness.

Dan Mulder
Josephine Nijstad
Livio Bod
Martijn Savenije

SPAAK circular solutions