Catalogue of Local Wastewater Solutions

Autonomous Oosterwold

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Faculty of Architecture and the Built Environment
Master Track: Urbanism
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Reading Guide

As explained in chapter XX, this catalogue is an overview of the systems that were found in literature and in practice that are applicable for wastewater treatment in Oosterwold. The systems are separated according to their function: wastewater treatment, wastewater collection and wastewater transport. All three functions are necessary in order to produce a fully functioning local wastewater treatment system. Since the wastewater treatment systems are the most important aspects of spatial planning due to their integration within the environment, they are evaluated for their land-use, environmental impact and environmental risks. Additionally, the system structure, landscape integration and reliability are analysed as this information is necessary in order to calculate and integrate essential services within the built environment. In other words, this information is necessary for the maximization studies in chapter 8 and could prove valuable for spatial planners working with local energy provision systems. Wastewater treatment or collection systems that are not applicable in Oosterwold are only discussed in general terms for completeness to limit the scope of this catalogue and provide in-depth information on the systems that matter. According to the following principles systems are excluded from research:

- *The system is novel and not yet applied in practice*
- *When it is not possible to treat wastewater to be self-sufficient considering the wastewater production of a single household in Oosterwold with a plot size of 1600 square meters*
- *If policies or the environment of Oosterwold prohibits the implementation of the system*

Techniques are found using different literature sources. These are literature from universities (TU Delft, Wageningen University), the government (RVO, Unie van Waterschappen) and research institutions (STOWA, RIONED). But, because the consequences of land-use intensity, environmental impact and risks on spatial planning is a relatively new research subject, other sources are used as well. The internet is searched for installation companies, published work of consultants (Groenblauwe netwerken) or NGO's (Saniwijzer, SSWM). For more specific information, installation companies are contacted.

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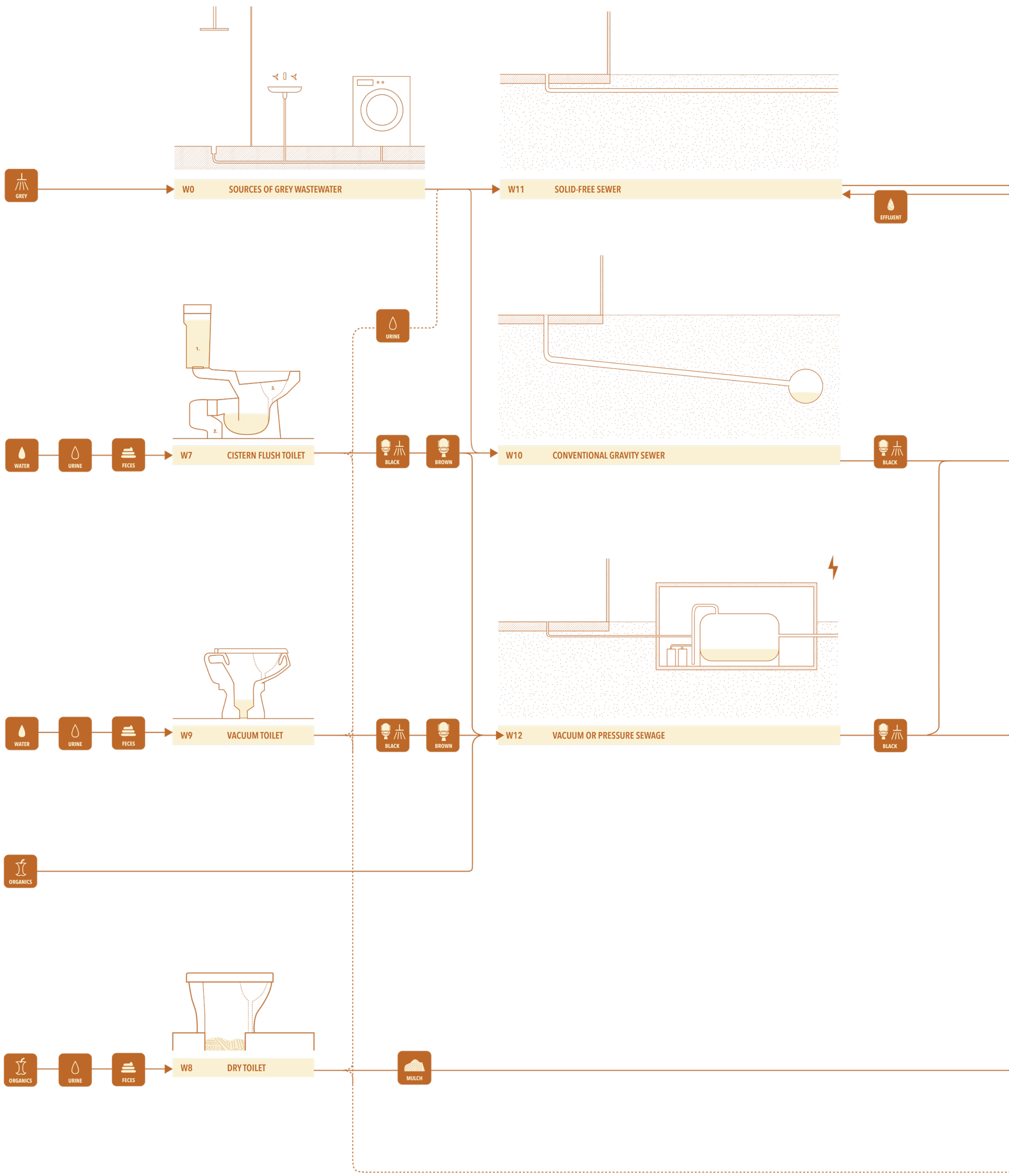
Collection

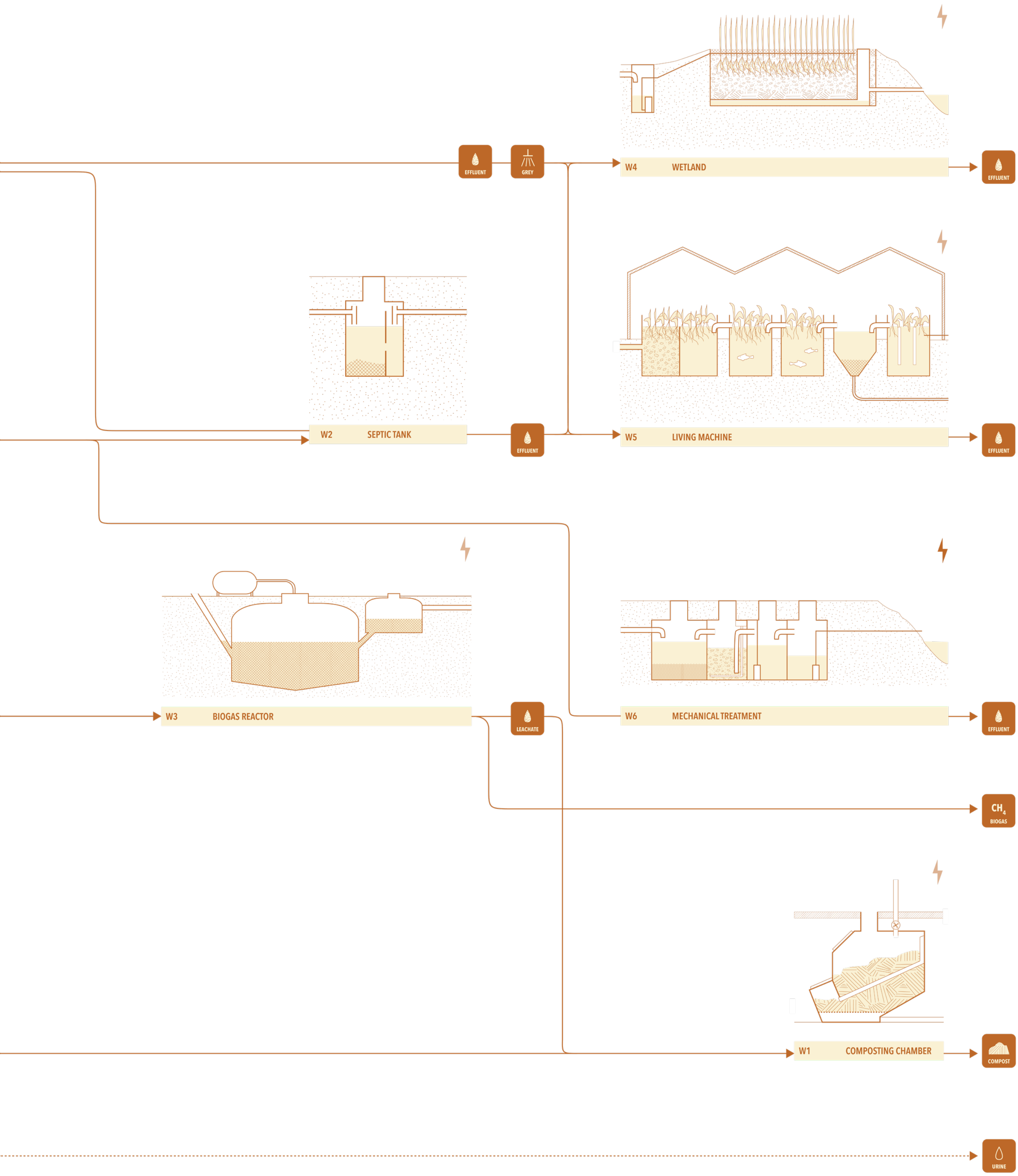
Transport



Storage & Treatment

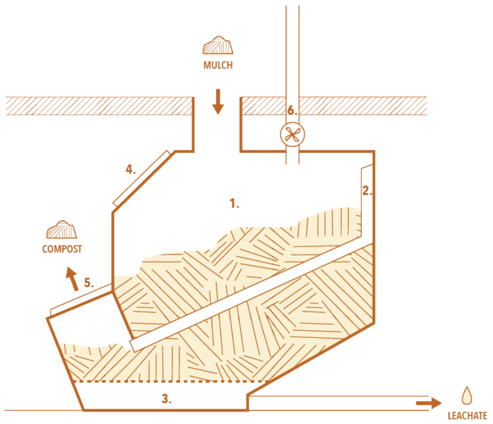
primary

secondary & tertiary



W1 Composting chamber

A composting chamber can convert excreta and organic waste into compost using the decomposing abilities of microorganisms under aerobic conditions or in other words biological treatment. To create the appropriate conditions for this to happen, sufficient oxygen, moisture, temperature and carbon-nitrogen levels need to be applied. This can be done either by adjusting input (less water, more carbon etc.) or changing the amount of ventilation. In practice these conditions are hard to maintain properly and often the compost needs to be treated again (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014). The efficiency of the chamber can be increased by diverting urine.



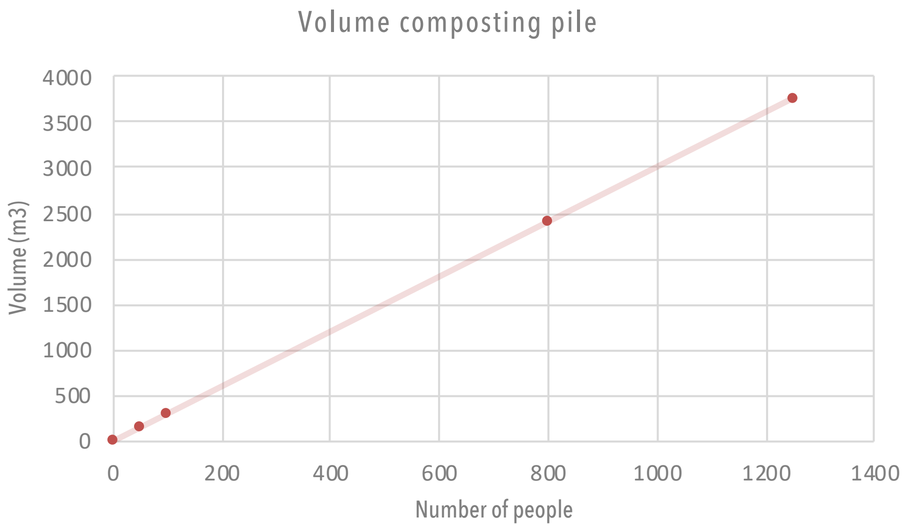
1. System structure composting chamber

1.1 System structure

The chamber is designed using a storage chamber (1.), air ducts for aeration (2.), a leachate collection system (3.), an access door for maintenance and the adding of waste (4.), a door to collect the finished compost (5.) and an optional ventilation unit (6.). There is only a small negligible amount of electricity required for the ventilation unit. The input (faeces, urine and organic waste) needs to be as dry as possible for the creation of high-quality compost and the reduction of odour. It is therefore only possible to combine a composting chamber with a dry toilet. A 1000 kg of raw material (faeces and organic waste) will produce around 400 kg of compost (Elferink & Vlaar, 2010).

1.2 Land-use and land-use intensity

The required chamber volume is around 300 litre per person per year (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014). The chamber can be placed under a dry toilet for direct collection or in a central place where faeces and organic waste is collected. It is necessary to construct an outside composting pile or bin for further treatment as the compost still contains pathogens after leaving the compost chamber. In other words, around twice the dimensions are necessary in order to treat the compost. Another important aspect to recognize in composting is the amount of land necessary for the usage of compost. The Netherlands has strict policies regarding the amount of nitrogen or phosphorus (highly present in compost from faeces) that can be used on land depending on the type of crop or function of the land.



2. Volume of a composting chamber calculated according to data from Tilley et. al, 2014

1.3 Landscape integration

Composting chambers can only be integrated in buildings. Further treatment within a compost pile can be combined with a natural or agricultural landscape.

1.4 Environmental impact

Landscape	Impact	Explanation
Road	Not applicable	-
Buildings	Low	A compost chamber can emit odour, especially if the composting is not done according to regulations (Reinink & Kempener, 2001).
Agriculture	Low	There is no impact on agriculture due to composting.
Water	Not applicable	-
Nature	Low	There is no impact on nature due to composting.

3. Environmental impact of a ccomposting chamber

1.5 Reliability

The composting process develops faster in warm climates and therefore also faster in summer. For optimal composting in the Netherlands it is necessary to leave the compost for at least two years (Reinink & Kempener, 2001).

1.6 Environmental risks

To mitigate risks associated with composting it is important to separate the composting process from the environment and to ensure there is no contact between humans and the compost. This can be done by separately composting within a container and wearing protection when working with the compost. Furthermore, to ensure a proper treatment process, the temperature, moisture, oxygen and the carbon versus nitrogen level need to be monitored (Reinink & Kempener, 2001).

Hazard	Risk	Explanation
Pathogen release	Medium	Due to improper handling of compost, pathogens might be released and impose a danger on public health. [1]
Contamination of groundwater	Low	If the compost comes into contact with the groundwater this can cause pollution. [1]

[1] (Reinink & Kempener, 2001)

4. Environmental risks due to composting

1.7 Composting in Oosterwold

Composting is an interesting system for in Oosterwold as it is a relatively cheap method of wastewater treatment and does not require a sewer system which is difficult to implement with bottom-up urban development.

Challenges

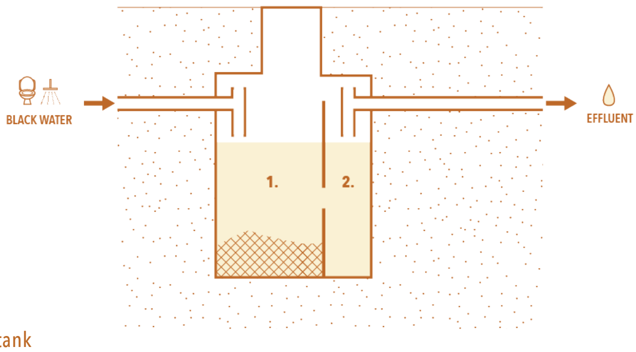
- *Care needs to be taken considering the pollution of groundwater as this would be a serious issue in Oosterwold due to the abstraction of potable water from the area*
- *Composting is in need of maintenance which is considered to be a 'dirty' task*
- *Composting differs from the conventional wastewater treatment in the Netherlands*
- *Inhabitants need to be trusted with the safe and proper handling of compost to prevent groundwater or public health issues*

Opportunities

- *Cheap method of wastewater treatment*
- *No need for a sewer system*
- *Possible to use the compost in agricultural processes*

W2 Septic tank

A septic tank is a simple watertight chamber which performs primary treatment for grey or black water. It uses a combination of physical and biological treatment and is composed of at least two chambers separated by a baffle to prevent scum and solids from escaping with the effluent. The tank filters around 50% of solids and removes 30-40% of BOD (when well-designed and maintained).
A septic tank is applied in 21.500 households in the Netherlands (Esch & Eem, 2015). For most households it is the only treatment before wastewater is deposited as effluent into the environment.



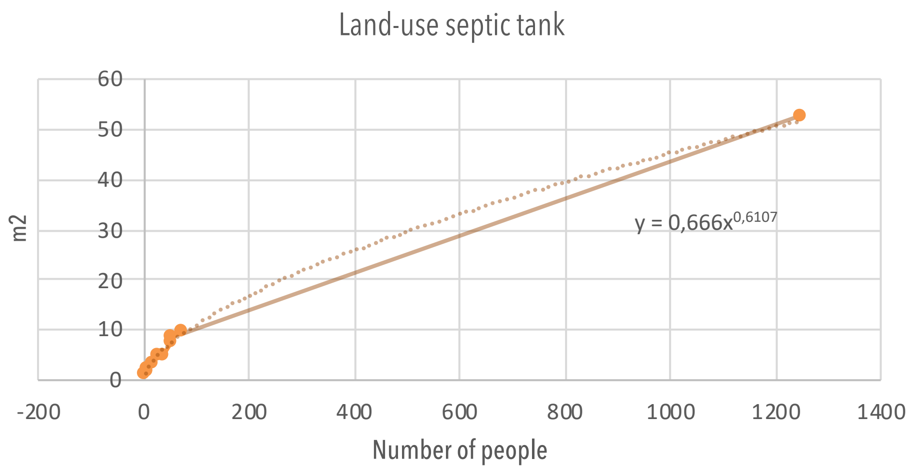
5. System structure of a septic tank

2.1 System structure

A septic tank consists of a sedimentation zone (1.) where gravity separates solids from the wastewater forming a sludge at the bottom of the tank. In the second chamber (2.) the solid-free effluent is collected and transported for further treatment or disposed in the environment.

2.2 Land-use and land-use intensity

The size of a septic tank depends on the amount of wastewater which in turn depends on the number of inhabitants or households connected to the tank. The more households are connected to the septic tank the lower the amount of volume needed for treatment due to the averaging effect and increased efficiency of treatment. The different sizes for a septic tank according to the number of inhabitants are shown below (Septische-put.be, 2019).



6. Land-use of a sepetic tank calculated using data from septischeput.be

2.3 Landscape integration

A septic tank needs to be reachable for maintenance and sludge removal through a small valve. Other than that, the tank is placed underground and out of sight. The tank can be integrated within the agricultural and natural landscape. It is only possible to place small vegetation or crops on the septic tank.

2.4 Environmental Impact

Landscape	Impact	Explanation
Road	Not applicable	-
Buildings	Low	There can be an odour release through the maintenance and aeration valve (D.Butler & Payne, 1995).
Agriculture	Low	There is no known impact on agriculture.
Water	Not applicable	-
Nature	Low	There is no known impact on nature.

A. Environmental impact due to septic tanks

2.5 Reliability

The reliability of septic tanks does not change according to different weather patterns. They do have an optimal functioning temperature of 35 degrees but still function at least from an average of 10 degrees (A.Luostarinen & A.Rintala, 2005).

2.6 Environmental Risks

Hazard	Risk	Explanation
Contamination of groundwater	Low	Due to clogging of the system, faulty installation or pumping failure systems can overflow and cause pollution due to the improper treatment of wastewater (D.Butler & Payne, 1995).

7. Environmental risks due to a septic tank

2.7 Septic tanks in Oosterwold

A septic tank is, together with the biogas reactor, the only primary treatment possible in Oosterwold.

Challenges

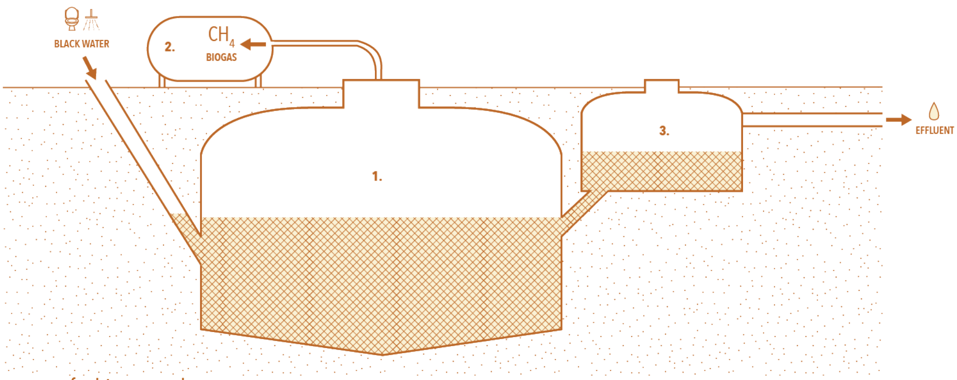
- *Proper maintenance and desludging is important for optimal performance*
- *Septic tanks do not catch fats and oils, an extra grease trap should be installed in case there is a lot of fat release, for example from from cooking*
-

Opportunities

- *The sludge can be used as fertilizer when further treated*

W3 Biogas Reactor / Digester

A biogas reactor uses biological methods (anaerobic degradation) to treat blackwater, sludge or organic waste and can be used as an alternative to a septic tank. The output is an odourless digestate rich in organics and nutrients while pathogens are reduced and biogas. This digestate can be used as fertilizer (if further treated and pathogens are completely removed) and biogas can be used for the generation of energy (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014).



8. Systems structure of a biogas tank

3.1 System structure

When wastewater collects in the large chamber the fermentation process starts and creates biogas as a by-product. This creates a higher pressure within the chamber and pushes the digestate towards the expansion chamber and into an outlet for further treatment (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014). The produced biogas generally consists of 62% methane, 37% carbon dioxide and 1% different gasses and has a calorific value of 19 MJ per m3 (SenterNovem, 2008). The technique works best with a high content of nutrients and low soap content. Grey water should therefore not be added.

3.2 Land-use and land-use intensity

Biogas reactors can be constructed above or below the ground. The volume of the tank depends on the amount of black water and the retention time in the tank. The retention time depends on the temperature, a low temperature means a high retention time and a high temperature results in a low retention time. Heating can therefore be applied to reduce the amount of space needed for the reactor. The average retention time of a simple biogas reactor is 40 days (Grant, 2014). In total a biogas reactor can produce around 25 m3 biogas per year if organic waste is also added to the mixture.

3.3 Biogas in Oosterwold

It is possible to generate biogas in Oosterwold using black water and additional organic waste. However, the amount of biogas production is too little (around 25 m3) and mainly produced in summer to provide a sufficient means of energy production (around 200 kWh which is just enough for cooking). However, if a biogas system is used on a communal scale the amount of biogas could potentially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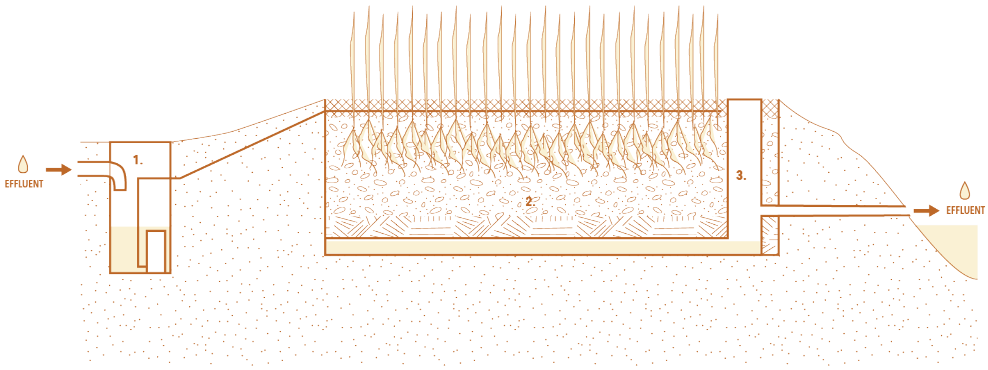
provide sufficient for some form of heating or electricity production.

W4 Wetland

A wetland uses physical and biological treatment to clean wastewater. The inflow of water is filtered using sand or other material and simultaneously treated by bacteria that are present in the roots of plants living in the sand layer (Potz, 2012). Roughly there are two types of wetlands, one where the water flows vertically and one where the water flows horizontally. A horizontal can be subdivided into a surface flow technique where wastewater is in direct contact with the environment and a sub-surface flow technique where waste water is filtered below the surface (Kilian Water, 2019). Only the second technique is possible for the purification of household wastewater due to the odour coming from surfaced wastewater. To increase efficiency in both vertical and horizontal wetlands extra aeration can be added.



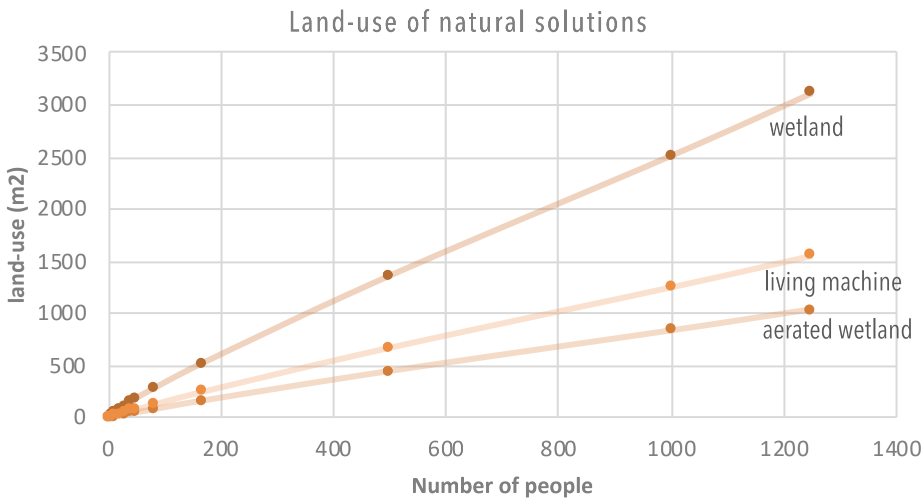
9. System structure of a wetland

4.1 System structure

Solid-free wastewater is dumped in a collection tank (1.) from where the wastewater is pumped to the actual filter (2.). Wastewater passes the filter vertically passing several filtering layers and plant roots which decompose any pollutants. It is important to pump wastewater in intervals to make sure there is enough time for the biological processes to dispose of pollutants. Wastewater leaves the filter through piping at the bottom. Often a control tank (3.) is installed in order to monitor the quality of effluent (Potz, 2012).

4.2 Land-use and land-use intensity

The height of a (vertical) wetland is always 60 centimetres but the footprint depends on the amount of wastewater and the average pollution rate. Wetlands are sized according to their treatment capacity in winter which is usually around 10% of their full capacity (Spoelstra & Truijen, 2010, p. 79). When extra aeration is added the amount of necessary space is almost halved (Potz, 2012). When properly maintained odour should not be present around the wetland.



10. Land-use of wetland, aerated wetland and a living machine calculated according to data from Wetlantec, Tilley et. al, 2014 and Potz, 2012.

4.3 Landscape integration

Wetlands are easy to combine with a natural landscape as they are composed of natural vegetation. It is not possible to use the reed for agricultural purposes or in the garden as these can be contaminated with harmful substances.

4.4 Environmental impact

In general, the environmental impact of wetlands is low meaning they are easy to place and integrate within the landscape.

Landscape	Impact	Explanation
Road	Not applicable	-
Buildings	Low	There is a conception that wetlands can attract mosquitos or cause odour, however, research of wetlands in practice discards this theory (Spoelstra & Truijen, 2010).
Agriculture	Low	There is no known impact on agriculture from wetlands.
Water	Not applicable	-
Nature	Low	There is no known impact on nature from wetlands.

11. Environmental impact due to a wetland

4.5 Reliability

Wetlands are in general reliable methods of wastewater treatment, however, their ability to treat wastewater decreases when the temperature decreases (Roest, 2018). This means wetlands should be constructed according to a winter situation.

D. Shared wetland (photo by author, Oosterwold) ▶

4.6 Environmental risks

Hazard	Risk	Explanation
Pollution of groundwater due to incomplete treatment, construction mistakes or use of chloride	Low	The quality of the effluent depends on the construction, surface area, retention time of the wastewater (prone to fluctuations) and quality of incoming wastewater (which also depends on the method of primary treatment and the use of harmful substances by users). When one of these aspects is does not function correctly or the influent of wastewater is prone to fluctuations, this can cause insufficient treatment.
Absorption and release of contaminations by reed	Medium	If the reed of wetlands is cut and spread into the environment pollution can take place (Rijksoverheid, 2020).

12. Environmental risks due to wetlands

4.7 Wetlands in Oosterwold

Wetlands are a good wastewater treatment solution for Oosterwold and can, if correctly used and constructed, reach the correct quality effluent within the restrictions.

Challenges

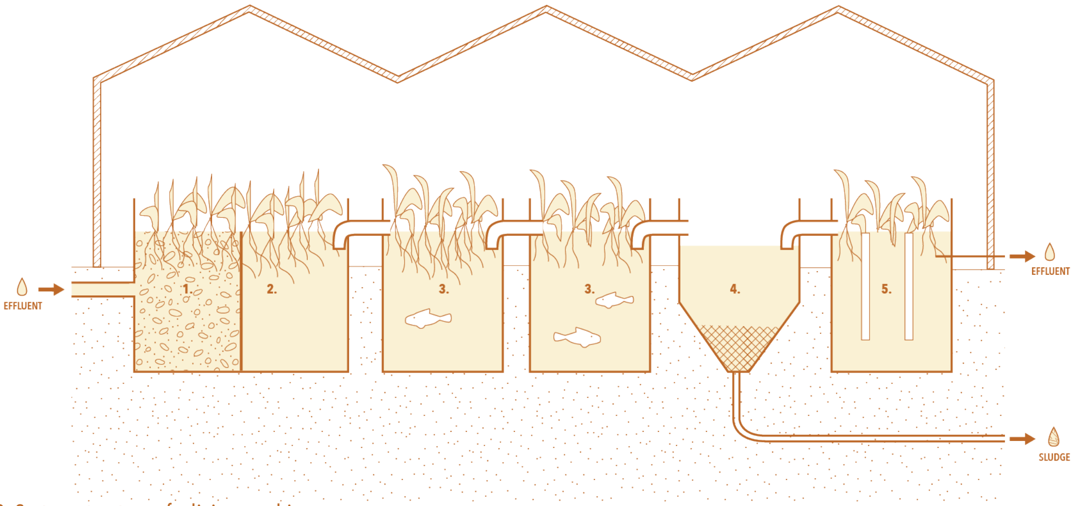
- *Proper handling and correct use of the system (abstaining from harsh chemicals)*
- *High fluctuations in wastewater influent*

Opportunities

- *Abundance of land for the implementation of wetlands*
- *Adds to the natural character of Oosterwold*

W5 Living machine

A living machine uses a variety of floating plant ponds in order to produce a clean effluent from wastewater. The system is often enclosed by a greenhouse to create the right conditions for the specific type of plants or fish that live within the ponds and to prevent the water from freezing in colder climates. The different ponds treat wastewater biologically through the use of floating plants and physically through sedimentation (similar mechanism as wetlands). The plants that are used are selected for their long root systems since this provides the necessary bacteria to clean the wastewater. Fish can be added to the ponds to control algae and mosquito populations or for harvest and consumption. In this case sufficient fresh water has to be added in order to dilute the wastewater and temperatures must be monitored to create healthy living conditions for the fish. The living machine has high removal rates of BOD and suspended solids and mechanical aeration can be applied to improve overall efficiency. To prevent problems, plants need to be maintained and the pond needs to be desludged periodically (Potz, 2012).



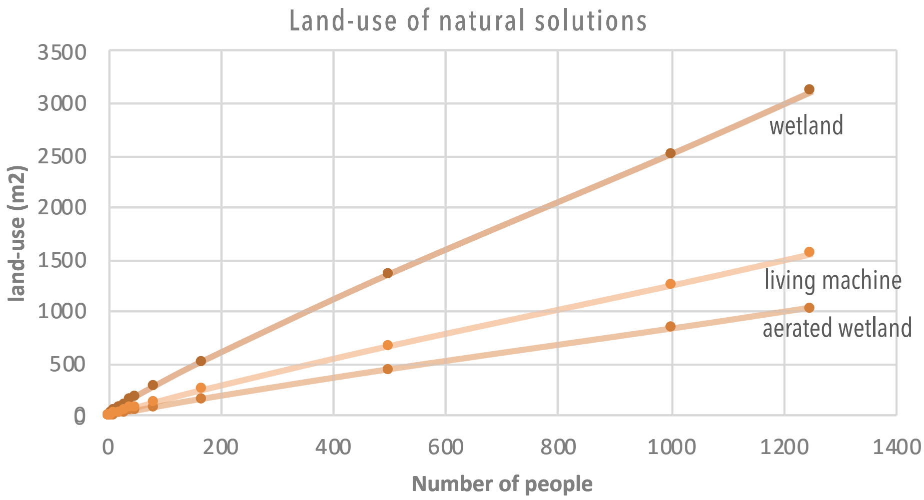
13. System structure of a living machine

5.1 System structure

Both black and grey water are treated in a living machine. Often the system needs a minimum amount of water, especially if fish are also used. In a living machine wastewater passes an anoxic reactor (1.), a closed aerobic reactor (2.) a set of open aerobic reactors (3.), a sedimentation tank to further clarify the wastewater (4.) and a (horizontal) wetland for final treatment (5.). Often only solid-free wastewater is used to prevent clogging of the system which entails installing a form of primary treatment such as a septic tank when black water is treated as well. Heating does not have to be applied as incoming sunlight and hot grey water will be enough to prevent ponds from freezing. However, if one of these sources is not available or tropical plants are used, extra heating might have to be applied (Ottel & Schellekens, 2017).

5.2 Land-use and land-use intensity

The footprint of a living machine is only slightly larger than the footprint of an aerated wetland (Potz, 2012). Sufficient space for maintenance and routing has to be taken into account in the size of the greenhouse. The absence of examples makes it hard to determine the economy of scale but since the mechanism of a living machine is similar to those of a wetland, similar economies of scale can be expected. Nuisances such as odour or light are not present in living machines making them easy to integrate into the environment (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014).



14. Land-use of wetland, aerated wetland and a living machine calculated according to data from Wetlantec, Tilley et. al, 2014 and Potz, 2012.

5.3 Landscape integration

Living machines are shielded by a greenhouse to protect the tropical plants against cold weather. Furthermore, fish can be harvested for consumption. This makes it easy to integrate living machines with an agricultural landscape. It is also possible to attach living machines to a home or built it in nature. For obvious reasons it is not possible to integrate a living machine in roads or water bodies.

5.4 Environmental impact

The largest impact of living machines is the possible odour formation or attraction of mosquitos. These can be mitigated by balancing the ecosystem (e.g. adding fish which eat the mosquito larvae) (Todd & Josephson, 1996).

Landscape	Impact	Explanation
Road	Not applicable	-
Buildings	Low	There is a conception that wetlands can attract mosquitos or cause odour, however, research of wetlands in practice discards this theory (Spoelstra & Truijen, 2010).
Agriculture	Low	There is no impact on agriculture.
Water	Not applicable	-
Nature	Low	There is no impact on nature.

15. Environmental impact of a living machine

5.5 Reliability

Heat is added to living machines which reduces the fluctuations in wastewater treatment capacity between winter and summer. This means there are no fluctuations in wetlands and reliability is high (if care is taken for proper maintenance).

5.6 Environmental risks

Hazard	Risk	Explanation
Pollution of groundwater due to incomplete treatment, construction mistakes or use of chloride	Low	The quality of the effluent depends on the construction, surface area, retention time of the wastewater (prone to fluctuations) and quality of incoming wastewater (which also depends on the method of primary treatment and the use of harmful substances by users). When one of these aspects is does not function correctly or the influent of wastewater is prone to fluctuations, this can cause insufficient treatment.
Pathogen release	Low	The open water can potentially release pathogens if contact is made with the water.

16. Environmental risks due to a living machine

5.7 Living machines in Oosterwold

Living machines are suitable for the treatment of wastewater as long as enough energy is generated to sustain treatment capabilities and quality of effluent.

Challenges

Regular maintenance is necessary for optimal functioning

Possible attraction of mosquitos and emittance of odour

Opportunities

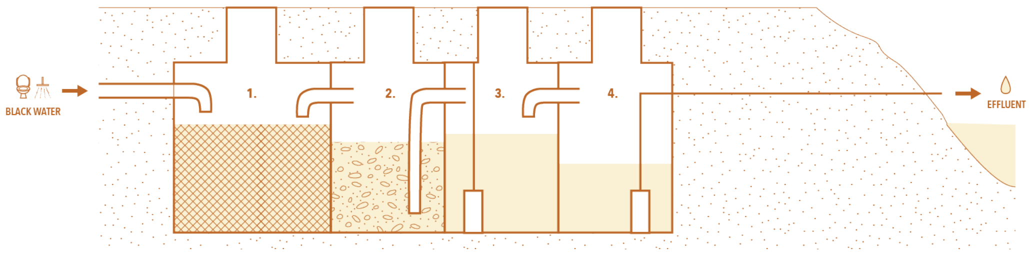
Combination of food production (fish) and wastewater treatment

Reduced land-use compared to (non-aerated) wetland

Merges easily with the agricultural landscape of Oosterwold

W6 Mechanical treatment or activated sludge

A mechanical treatment system uses a set of tanks where wastewater is circulated and cleaned. Both biological and physical treatments is used in order to treat wastewater. Conditions in the tanks are mechanized through aeration and wastewater is often recirculated in order to maintain a fixed population of micro-organisms for the biological treatment. A considerable amount of energy is used in order to create these conditions. This results in a lower land-use and the fact that tanks can be built underground. However, mechanical treatment systems are less robust when it comes to large fluctuations in wastewater production compared to more natural treatment systems such as wetlands (Kilian Water, 2019).



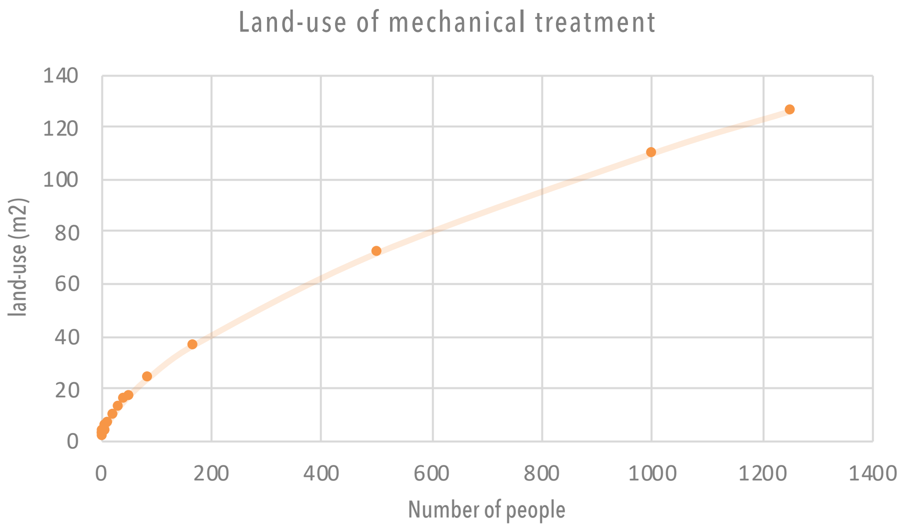
17. System structure of mechanical treatment

6.1 System structure

Wastewater is first collected in a sedimentation tank (similar to a septic tank) for physical treatment, to separate solid waste from liquid waste (1.). In the second tank wastewater is treated biologically through the use of micro-organisms (2.). This tank is aerated to create the right conditions for these micro-organisms which form the so-called 'activated sludge'. This requires a continuous source of electricity. The next tank acts as a clarifier removing the newly formed sludge from the treated wastewater (3.). From here wastewater is often recirculated (depending on the incoming flow of wastewater) to keep the microorganisms alive and well fed. The last tank collects the treated wastewater and releases it into the environment (4.).

6.2 Land-use and land-use intensity

Mechanical treatment requires a small area for the treatment of wastewater and can take place underground making it an easily integrated technique. It is therefore one of the most widely used techniques. The tanks can be easily combined with other practices and functions.



18. Land-use of mechanical treatment calculated according to data from AkaNova

6.3 Landscape integration

Mechanical treatment is relatively easy to integrate within the environment as it is placed underground. The scales found for an underground system range from around 2 to 200 persons (Copierwater, 2020). From around 1000 persons the system is built above ground and is similar to conventional large-scale wastewater treatment. This system is not taken into account since this is outside the scope of this research but still counts as local wastewater treatment.

6.4 Environmental impact

Landscape	Impact	Explanation
Road	Not applicable	-
Buildings	Medium	Mechanical treatment can omit odour and/or noise (Stowa, 2019).
Agriculture	Low	There is no impact on agriculture due mechanical treatment.
Water	Not applicable	-
Nature	Low	There is no impact on nature due mechanical treatment.

19. Environmental impact of a mechanical treatment system

6.5 Reliability

The reliability of the system is dependent on a continuous source of electricity and workings of an operation unit. There is no large difference in the treatment capacity in winter or summer.

6.6 Risks

F. Mechanical treatment system waiting for implementation)photo by author, Oosterwold) ▶

Hazard	Risk	Explanation
Groundwater pollution	Medium	Mechanical systems are prone to complicated mechanical and microbiological problems or possible electricity outages resulting in possible groundwater pollution (SSWM, 2018).

Environmental risks of mechanical treatment

6.7 Mechanical treatment in Oosterwold

Mechanical treatment is possible in Oosterwold if care is taken considering the fluctuations in influent and adequate measures are taken when a malfunction presents itself.

Challenges

- *Requires a constant source of electricity*
- *Is less able to absorb fluctuations compared to natural systems*
- *Requires expertise for maintenance and operating*
- *Can emit odour and noise*

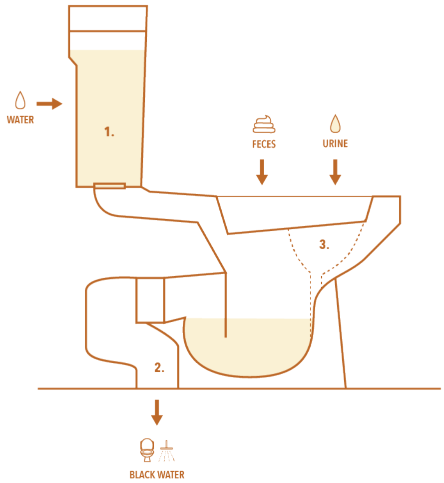
Opportunities

- *Low land-use*
- *Can be placed underground reducing the visibility*
- *Can be operated at a range of organic and hydraulic loading rates*

G. Ponds in which effluent of different types of wastewater treatment is discharged (photo by author, Oosterwold)

W7 Cistern Flush Toilets

The cistern toilet is the most commonly used toilet in the Netherlands and uses water to flush down urine and feces. Modern versions use about 6-9 liters of water however low-volume flush toilets can use as little as 3 L (SSWM, 2018). This means the cistern toilet must always be connected to a constant source of water and a storage or treatment technology for black water (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014).



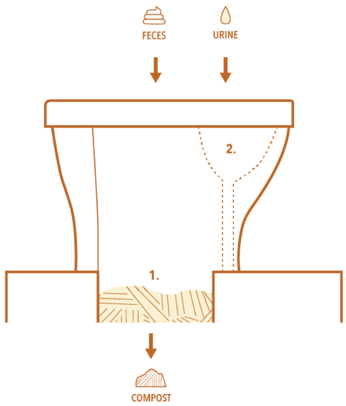
20. System structure of a cistern flush toilet

7.1 System structure

A flush toilet consists out of a 1. water tank, 2. drainpipe, and 3. a possible installation for urine diversion. Faeces and urine are collected and flushed away using water. This is usually connected to a sewer which transports the black water towards a treatment facility. In case of seperate urine collection it is possible in later phase to efficiently abstract valuable resources such as potassium and phosphorus (Wilsenach, 2005).

W8 Dry toilet

The dry toilet operates without flush water, excreta is simply collected. This toilet is often used in remote areas or in areas with water scarcity (SSWM, 2018). There are three different dry toilets: a compost toilet, a burning toilet and a chemical toilet. A compost toilet simply collects excreta for further treatment and compost creation, sometimes (but rarely) with the usage of foam and very small amounts of water in order to 'guide' excreta and reduce smell. In a burning toilet excreta is heated and transformed to ash (using considerate amounts of energy) which can be used as a form of compost.
A chemical toilet uses chemicals in order to prevent the decomposition of excreta and accompanying smells. The created product is simply thrown away periodically and cannot be used as fertilizer (Stowa, 2019).



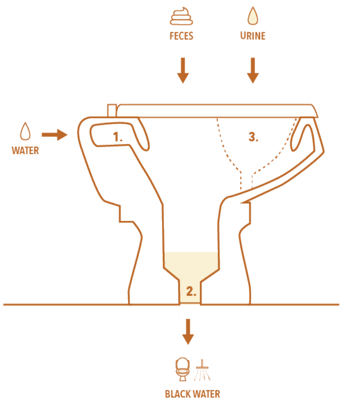
21. System structure of a dry toilet

8.1 System structure

The system illustration represents the most simple and common form of a dry toilet: the compost toilet. Here excreta is simply collected (1.) without the usage of chemicals or electricity. Again, there is the possibility for separate urine collection (2.). The mulch or pre-compost can be used for further treatment and development of compost that can be used as fertilizer.

W9 Vacuum or pressure toilet

A vacuum toilet uses suction and a small portion of water (0.5-1.5 L per flush) to collect urine and faeces (SSWM, 2018). Using less water results in a higher content of organic matter which means a higher potential for resource recovery (such as biogas or compost). A vacuum toilet creates negative air pressure to transport excreta while a pressure toilet uses pressure to transport excreta.



22. System structure of a vacuum toilet

9.1 System structure

To create a vacuum or pressure energy (electricity) is needed. This is not included in this part of the calculations but can be found in the next chapter ‘W2 Transport’. A small water supply (1.) makes sure excreta is neatly transported through opening the vacuum valve (2.) and again separated urine collection (3.) is an option.

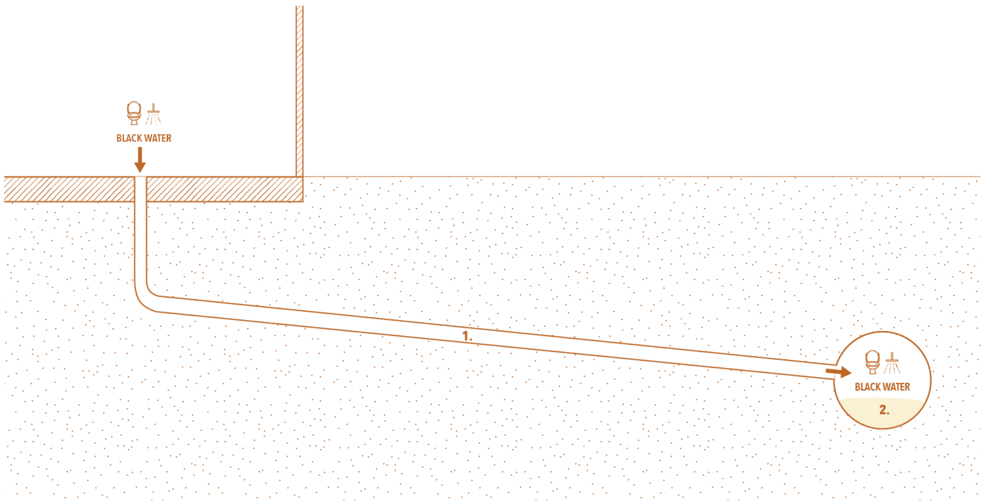
I. Dry composting toilet with seperate urine collection in Ritthem (photo by author)

J. Vacuum toilet in the 'Casa Vita' building in Deventer (photo by Helder Makelaars, 2019)

H. Urine diverting toilet in the Waterboard building in Meppel (photo by E. v. Münch, 2006)

W10 Conventional sewer

Conventional gravity sewers use gravity and additional pumps to transport wastewater. The gravity sewer is designed with a slope to maintain a self-cleaning velocity when wastewater (as well as rainwater in many cases) runs through the sewer. This mechanism only works when enough water is generated and therefore the gravitational sewer works best with a flush toilet. If a slope is not possible additional pumping stations are needed. The disadvantage of a gravity sewer is the large diameter and sometimes deep construction which contribute to its inflexibility (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014). The diameter of a conventional gravitational sewer is around 250 mm when only household wastewater is transported and requires a minimum inclination of around 0,4 cm per meter in order to reach a minimum self-cleaning velocity (VPB, 2008).



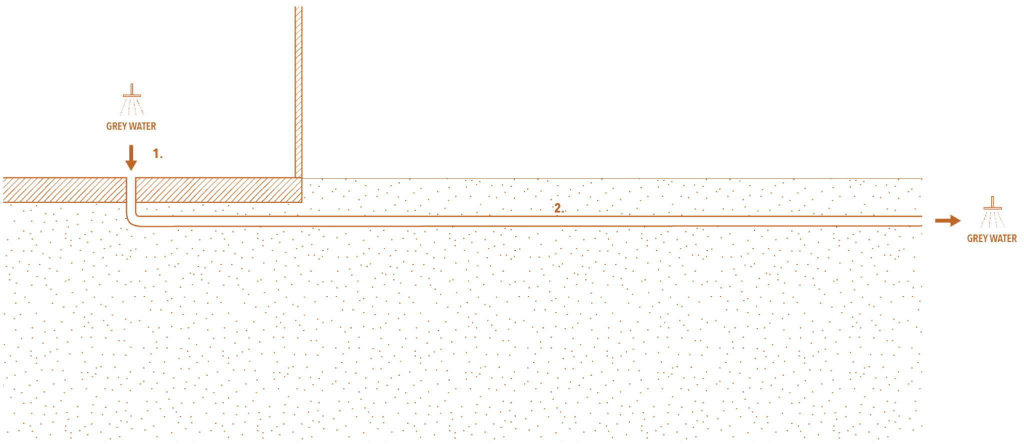
23. System structure of a conventional sewer

10.1 System structure

A conventional gravitational sewer transports black or grey water and, in most cases, also rainwater, however, in recent versions of the gravitational sewer rainwater is often not included or dismantled. A sufficient amount of water is necessary to transport wastewater maintaining the self-cleaning properties. The system drawing shows the most common form of a gravity sewer with 1. transport of black or grey water under a certain inclination and 2. a main sewer also with a certain inclination, this can also simply be a point of collection or treatment technique. Often the usage of pumps and therefore energy is needed in order to transport wastewater from lower to higher points. The usage of electricity depends on the efficiency of the pump (roughly 70% for small electric pumps), the height difference (due to the inclination) and amount of wastewater (dependent on the number of households) (Duurzaam MKB, 2019).

W11 Solid-free gravitational sewer

Solid free sewers are small-diameter pipes (minimum of 75 mm) that use gravity or pumps to transport pre-treated wastewater or solid-free wastewater (such as grey-water). Due to the solid-free wastewater the self-cleaning velocity of sewers can be lower and therefore require no inclination. This makes solid-free sewers easier to place and maintain as well as very flexible compared to conventional gravity sewers (Stowa, 2019).



24. System structure of a solif-free gravitational sewer

11.1 System structure

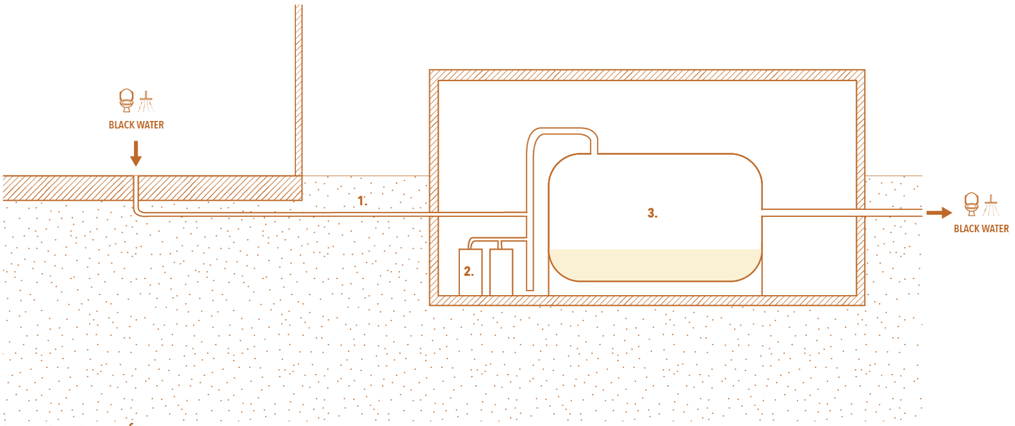
Since solid-free water is more easily transported and therefore does not require a self-cleaning velocity and accompanying gradient, electricity needs for pumping are reduced to a minimum (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014).

L. Conventional (seperated) gravitational sewer (photo by ACA VZW)

K. Pumping station of a vacuum sewer (photo by Dieks)

W12 Vacuum sewer

A vacuum sewage system uses suction to transport wastewater or organic waste. It is often applied in low-density areas since the implementation cost are lower, pipes are smaller and there is no required inclination. On top of that it is easier to recycle nutrients as the amount of water necessary is very minimal and therefore has wastewater has a high nutrient density. Vacuum sewers do require more electricity to keep a constant negative air pressure in order to transport wastewater (SSWM, 2018). Furthermore, a vacuum sewer requires a pumping station which has to be spatially integrated and can omit noise or odour. Around 4% of Dutch households is connected to a vacuum sewer (Wit, R. de Graaf, & Debucquoy, 2018).



25. System structure of a vacuum sewer

12.1 System structure

Vacuum sewers require a constant source of electricity in order to create negative air pressure (around -0.6 bar) using air pumps (2.) (SSWM, 2018). The electricity demand can vary from 0,2 - 0,7 kWh per m3 of wastewater (Mohr, Iden, & Beckett, 2016). When a valve opens (either in a vacuum toilet or later along the sewer system) wastewater is sucked in and transported (1.) to a collection tank (3.). From here on wastewater is treated or resource recovery can take place.

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