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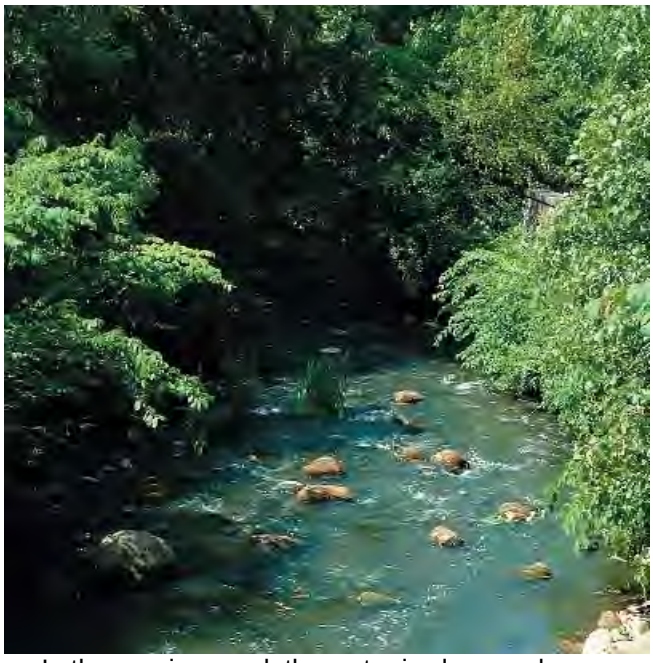
How is sewage water cleaned?

How does nature clean wastewater?

Think of running water in a creek. Here the water is clean and clear. This is because the water is aerated and the natural bacteria have plenty of oxygen. The bacteria here have optimal conditions of growth and they have optimal possibilities to decompose all the organic material. Therefore the water is clean. In a stagnant part of the creek, here the water is green. This is because the bacteria do not get enough oxygen to decompose the nutritional substances. This results in an extreme growth of algae, making the water green.

The key to clean water is to ensure plenty of oxygen to the natural bacteria.

The picture defines the problem.



In the running creek the water is clean and clear. Natural bacteria and microorganisms have decomposed the nutritional substances that otherwise creates algae etc. When the algae die, they will sink to the bottom and decay. With the decaying process the last shred of oxygen is sucked out of the water. Plants will disappear and the fish will die. Normally this is what we call oxygen depletion, and in summertime it can happen in lakes as well as the ocean.

In a BioKube we copy the nature.

To say it uncomplicated; what we do in a BioKube is simply copying nature and recreating the good conditions the bacteria have in the running creek.

We supply the bacteria with a place to live (the BioBlocks), plenty of oxygen and administer their nourishment (the waste water to be cleaned) into the system in precisely timed doses over the 24 hour day cycle. In return the bacteria clean the wastewater to it leaves the system as clean water that can be let into a lake or even be reused.

Different types of cleaning solutions.

A BioKube will clean all types of household waste water. This includes both grey waste water from bath, kitchen and washing machines and black waste water from toilets.

The same technology is also used when creating larger systems to e.g. small villages. If a village needs to establish a local cleaning solution, it will almost always be cheaper with a local solution like a BioKube, instead of choosing a solution of piping sewage water over a big distance from the village to a large municipal wastewater facility.

A BioKube also cleans wastewater from industrial factories that contains organic materials e.g. dairies, slaughterhouses, and marmalade factories.

How clean is the purified wastewater?

When the water leaves the BioKube it is actually cleaner than for instance the Danish governmental requirements for the lakes and streams you can swim in. In countries with shortage of water, reuse of water is essential e.g. for washing our car or watering our garden.

In many parts of the world there is an acute shortage of water, and here treated wastewater from a BioKube can be safely reused, typically after applying ultraviolet lighting to ensure that all potentially harmful bacteria are eliminated.

How does a BioKube clean waste water?

The basic principles in a BioKube.

BioKube cleaning technology is developed so the cleaning process is very simple. BioKube basically use natures own cleaning process and we have simply copied the cleaning process that takes place in the running creek. The Bacteria cleaning the wastewater are also the ones that occur in nature, so a BioKube cleans waste water with aid from natural bacteria and micro organisms only supplied with plenty of oxygen.

The flow from the household to the BioKube.

Waste water from the toilets, the kitchen and the shower is lead to a pre sedimentation tank. This tank is placed in front of the BioKube. The pre sedimentation tank retains all the sludge that is heavier than water (it sinks) and all sludge that floats (called scum). The two types of sludge stay in the pre sedimentation tank and should be removed once a year to prevent sludge from over flowing into the cleaning units in the BioKube. Between the sludge and the scum there is a water phase, and in rural areas this unclean and polluted waste water often runs directly into a lake or stream. The water that formally was polluting the lakes and streams is now instead cleaned in the BioKube, before it is released in nature.

Optimizing the living conditions for the natural bacteria.

To establish an effective cleaning process it is important that the bacteria – as any other domestic animal – have optimal living condition.

The waste water in a BioKube is cleaned evenly round the clock. Normally a household utilize a lot of water in the morning and not as much the rest of the day. This gives a very uneven flow rate of nutrition to the bacteria. BioKube is the only waste water treatment plant that takes the very irregular water consumption into consideration. BioKube has developed and patented a new kind of controlled measurement system that feeds the BioKube with waste water evenly round the clock. This means that the bacteria are feed regularly, have a better life and therefore cleans the water better than in other sewer systems.

The steps in the bacteriological cleaning process.

The natural micro organisms have optimal life conditions because of the separated biodegradation in the several chambers.

In all cleaning chambers there is a Submerged Aerated Bio filter. The Bio filter is the living place of the bacteria. Beneath the filter there is a frame of pipes filled with holes, also called a diffuser. Air is blown through the diffuser, so the water is aerated. This happens through low-energy blowers.

The aeration has three purposes: aerate the water, so the oxygen level is increased, thereby the working ability of the micro organisms is increased and by that the ability to break down the nutritional substances in the waste water. Furthermore the aeration insures a mixing process in the water, so the polluted water reaches all parts of the bio filter and always has contact with the micro biology.

The micro organisms living on the bio filter will from time to time die and they will die and sink to the bottom. They sink to the bottom in the stagnant part of the bio zone and from here the sediments are regularly pumped return to the sediment tank. If any other sediment has entered the cleaning facility this will, at the same time, be returned to the sediment tank.

How many cleaning chambers?

When considering the size of a BioKube wastewater system, it is important to remember that the cleaning of the sewage water is preformed by natural bacteria. This means that the more stringent the cleaning requirements, the more bacteria (and the therefore the more BioBlocks are required).

1 chamber (or one Jupiter / BioReactor cleaning unit) is required if the cleaning requirements only are COD < 125 mg / litre and SS < 30.

2 chambers (or two Jupiter / BioReactor cleaning unit) are required if the cleaning requirements only are COD < 75 mg / litre and SS < 30.

3 chambers (or three Jupiter / BioReactor cleaning units) are required if the cleaning requirements are COD < 75 mg / litre, NH_4 < 5 mg/l and SS < 20.

Chemicals are harmless to a BioKube.

The Chambers in a BioKube system for 1 house contain approximately 1000 liters of water in each chamber + the pre sedimentation tank. This means that a BioKube can maintain great amounts of polluted water and still be able to clean the waste water completely. A BioKube is also able to sustain chlorine and other tougher cleaning agents.

A BioKube is constructed to endure anything within reason. Therefore it is also able to clean effects and obstacles that people should not throw into their lavatory or sink.

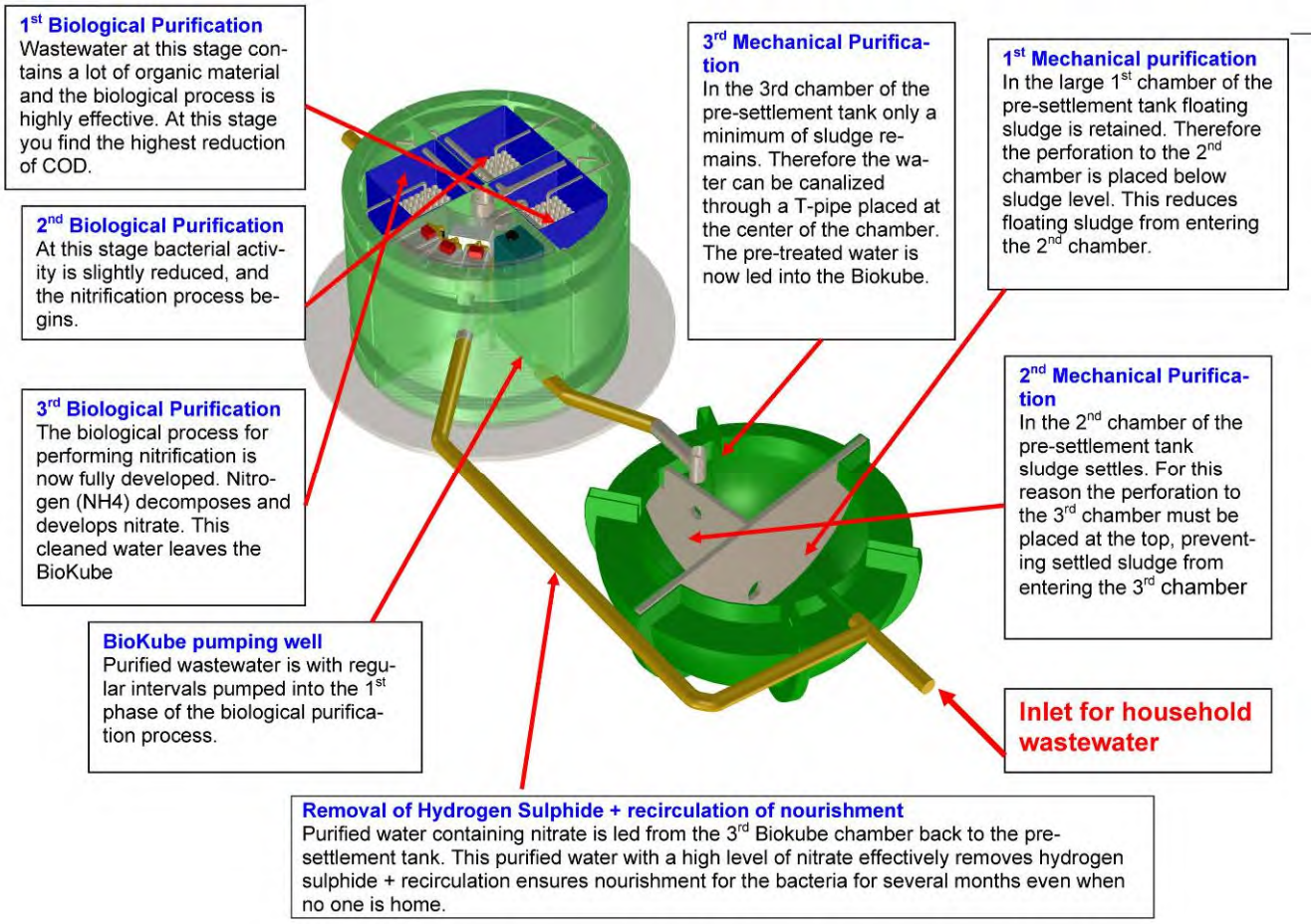
When testing our cleaning facility it has been subject to loads of the many different chemicals, which is utilized in a modern household – and the answer is clear – the BioKube sure walks the distance.

Illustration of the BioKube cleaning process

It is a central part of the BioKube cleaning process, that it is integrated with the pre settlement tank.

The reason is simple; it is always cheaper and more efficient for the bacteria if as many particles as possible are removed in the pre settlement tank before the waste water to be treated enters the cleaning chambers.

Below is an illustration of the BioKube cleaning process.



A BioKube Mars used in the illustration above will clean wastewater to below the following cleaning requirements: COD < 75 mg/litre, NH_4 < 5 mg/litre and SS < 20. This will normally require 3 cleaning chambers. The first two reduce organic material to below COD < 75 mg/litre. The third chamber will reduce NH_4 to below < 5 mg/litre. This process (nitrification) is only possible as a stable process if organic material is reduced to below COD < 75 mg/litre.

A BioKube Pluto only reduces organic material to below COD < 125mg/litre. This can be done with only one cleaning chamber.

The technical explanation.
6 step cleaning Process with Denitrification

Pre cleaning

The first step in the cleaning process is always pre cleaning to remove as many particles from the incoming sewage water as possible.

In a system for a few houses this is done via a septic tank or a pre sedimentation tank. The size of the septic tank depends on the number of people and how often it is emptied. Each person produces 1½ litre of sludge pr. day and the septic tank must be big enough to contain this and still have enough still standing water to make the incoming sewage water separate particles; if the incoming water rushes too fast, it will carry particles into the cleaning chambers.

In big systems the separation will often be done mechanically via flotation, filters or flocculation possible combined with flotation / filters.

As the system increases in size, it becomes cheaper with mechanical separation (flotation / filters/ than simple sedimentation in a septic tank.

Reduction of organic material.

Organic material in sewage water is typically measured in BOD_5 (Biological Oxygen Demand over 5 days or COD (Chemical Oxygen Demand).

Incoming BOD_5 will in household sewage water typically be > 400 mg/l (COD 800 mg/l).

It is possible to reduce the organic material to BOD < 2 mg/l.

Reducing organic material is basically only a question of the amount of Bio Blocks / oxygen / retention time in the cleaning chambers.

The bacteria that reduce organic material are called heterotrophic. They are quite aggressive and grow very fast.

If the only requirement is reduction of BOD_5 / COD then this can be done in a cleaning system with only one cleaning chamber such as a Pluto.

Reduction of NH_4 (Ammonium).

In some countries there is also a requirement for reduction of NH_4 (called Ammonium).

In the incoming sewage water there is typically 100 – 300 mg/l of NH_4.

In the process of reducing NH_4, it is changed to NO_3 (called nitrate).

This process is called Nitrification. The bacteria that perform Nitrification are called Autotrophic.

NH_4 can be reduced to < 0,5 mg/l.

Since the Autotrophic bacteria grow perhaps 10 times slower than the Heterotrophic bacteria that degrade organic material, the two kinds of bacteria should be separated in two separate chambers. If the system contains only one chamber, reduction of Ammonia will not be stable if there are fluctuations in the amount of incoming organic material. The Heterotrophic bacteria will if there is only one chamber “grow over” the Autotrophic bacteria.

Nitrification therefore requires minimum two chambers to be stable. A BioKube Venus, which can also reduce Ammonium, therefore has two chambers. In larger systems we recommend 3 chambers when Nitrification is required as this makes the process more stable when there are fluctuations in the amount of incoming sewage water.

Reduction of NO_3 (Nitrate)

NO_3 (Nitrate) acts as a nourishment to plants in water and in some areas there is therefore an additional requirement that it be removed. This is often described as limiting the total amount of total Nitrogen in the out flowing water.

NO_3 can be reduced to NO_2 (Nitrite) if

1. The environment is void of oxygen (anaerobic) – which it is in the septic tank
2. There is free carbon – which there always is in a septic tank with household sewage water.
3. NO_3 then is transformed to NO_2
4. NO_2 is transformed to $N_2 + H_2O$

This Process is called Denitrification.

Denitrification is accomplished by recalculating cleaned sewage water from the last chamber to the septic tank.

The recirculation will be - depending on requirements for NO_3 reduction – be 2 to 3 times the daily amount of water to be cleaned.

Additional recirculation will require a bigger septic tank for the sludge to settle since more water will be flowing through the septic tank.

Vacation periods / no inhabitants in the house.

If there is no one home in the house as is the situation when the family is on vacation, then there is no sewage water produced to give nourishment to the bacteria.

This situation is handled by recirculation of cleaned sewage water back to the septic tank as described above. Tests have documented that there is enough nourishment in the sludge in the septic tank for the bacteria to live for more than 12 months and still be active immediately the family comes home and starts to produce sewage water.

Reduction / elimination of H_2S

Hydrogen Sulphide (H_2S) is a powerful poison that always develops in still standing sewage water void of oxygen as in a septic tank. And it smells very bad.

H_2S is prevented from forming by recirculation of cleaned sewage from the last chamber back to the septic tank.

The recirculated cleaned sewage water will be oxygen rich preventing H_2S from forming.