Figure 1. Inside an Enviro))Septic pipe from a system in operation for 15 years.

We've been saying it for years: System O)) systems based on Advanced Enviro))Septic (AES) technology that were designed, installed and used in compliance to our guides are durable and long-lasting. This technology has existed since 1987. The original systems installed over 30 years ago are still functional, in perfect condition and still treat wastewater with the same efficiency. Two phenomena explain the long lifespan associated with AES technology: the controlled proliferation of a bacteria layer known as a « bio-mat » due to aeration and the treatment of wastewater before it infiltrates into the system sand and natural management of sludge inside the pipes. For the evacuation of septic sludge inside the pipes, many different biological mechanisms pertinent to AES technology allow us to explain this phenomenon.

AEROBIC – ANAEROBIC ALTERNATION

The alternation between aerobic and anaerobic conditions as part of wastewater treatment is a mechanism commonly used as a procedure to reduce the production of septic sludge. This alternation of anaerobic and aerobic conditions upsets the metabolism of bacteria by changing the mechanism of glycolysis between cellular respiration and fermentation. A disruption such as this forces the bacteria to prioritize catabolic pathways, breaking down molecules to ensure the supply of energy needed for survival, as opposed to anabolic pathways associated with biosynthesis, which are responsible for the production of sludge. This phenomenon is known as respiration uncoupling and is one of the main mechanisms involved in the minimal production of sludge in the famous Oxic-Settling-Anaerobic (OSA) process. (Prorot, 2020) (Khursheed,2015).

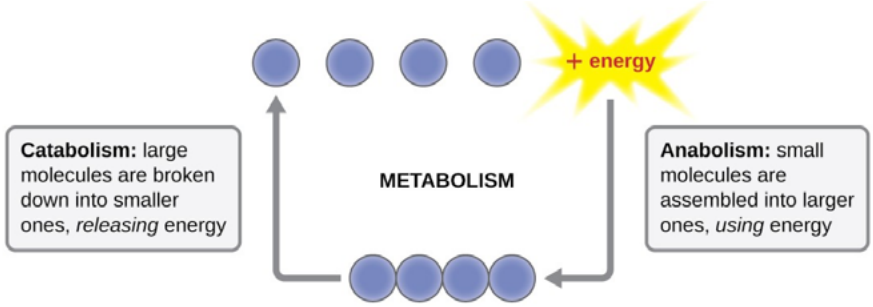

Figure 2. Comparison between catabolic and anabolic pathways (courses.lumenlearning.com)

As part of the AES based systems, an alternation between an aerobic and anaerobic environment occurs multiple times each day, resulting in repetitive respiration uncoupling. Each time water is used in the house, water leaving the anaerobic septic tank spills into the AES pipes.

Depending on the type of supply, the water is more or less agitated allowing a partial aeration. Part of the water becomes an aerobic environment where the first respiration uncoupling occurs. As the oxygen is consumed by the microorganisms, the water becomes progressively anaerobic. It's not until the moment when the water infiltrates completely into the sand that an AES pipe becomes a mainly aerobic environment thanks to the ventilation, causing once again a respiration uncoupling among the microorganisms present inside and around the AES pipes. The pollutants are broken down with the help of the aerobic pathways until partially anaerobic water pours into the pipe and once again changes the environment inside the AES pipe. Due to the change in their environment, the microorganisms need to once again change their glycolysis pathway. This phenomenon occurs each time there is a significant amount of water entering the system.

INTERMITTENT FEEDING

The frequency of the supply of nutrients is equally recognized as an important factor in reducing the production of sludge. In fact, a method that encourages intermittent fasting continuously pushes microorganisms to store energy, in the form of ATM, rather than expending excess energy for reproduction is optimal, always according to the respiration uncoupling principle (Semblante et al., 2014). Being limited to substates that have already been assimilated (endogenic metabolism) due to the absence of external nutrients, during the fasting periods the microorganisms concentrate on catabolic pathways in order to sustain their survival processes.

The systems based on AES technology equally apply this principle, particularly during the night where the microorganisms undergo a long period of fasting. Not only does this fasting period lower the reproduction in microorganisms, the next waves of nutrients are mostly used to rebuild the reserves of energy, once again reducing the production of biomass. The periods of fasting encourage the long-term predominance of slow growing microorganisms that are better adapted to this type of feeding.

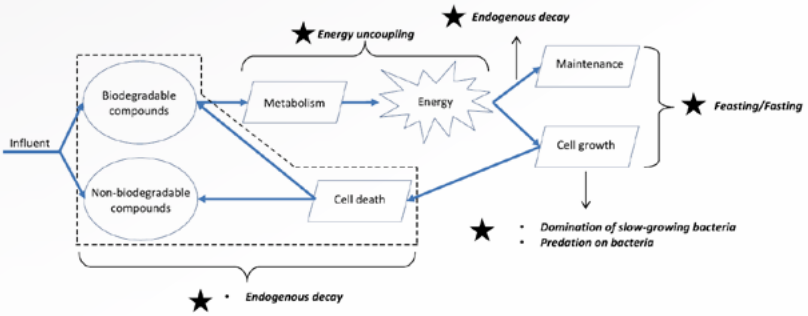

Figure 3. Impact of the different external factors on bacterial metabolism (Semblante et al., 2014)

PREDATION

Predation is a principle that is more and more implemented as a way of reducing the sludge production in wastewater treatment plants. (Prorot, 2008) (Liang et al, 2006). Although bacteria are by far the most numerous organisms present in domestic wastewater, the presence of other microorganisms isn't negligible. In fact, protozoa, rotifers and nematodes are also found in large numbers playing a significant role in wastewater treatment systems. These microorganisms are found higher in the food web than bacteria, consuming both live and dead bacteria. They also integrate minerals excreted by bacteria into their metabolisms. While there is an energy transfer from one trophic level to another, a reduction of living biomass is observed. Knowing that microorganisms reproduce proportionally to the amount of nutrients, a certain equilibrium establishes itself inside the system, allowing the biomass to remain relatively stable. **An advantage of AES technology is that it acts as an ecosystem completely open to nature. A multitude of eukaryotic organisms indigenous to septic systems, such as worms, insects, protozoa, rotifers as well as nematodes, access the AES pipes. These organisms participate in a significant way to the reduction of the biomass, either by transferring energy to higher trophic levels in the food web, or by integrating excreted minerals as part of their metabolic cycles.**

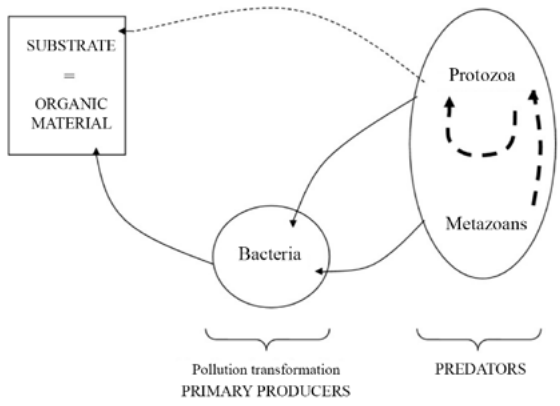

Figure 4. Hierarchical scheme of the trophic levels in domestic wastewater (Prorot, A., 2020)

ELIMINATION OF MINERALIZED BYPRODUCTS

Mineralization is a term used to describe the degradation of organic materials leaving a by-product called minerals. Admittedly, an accumulation of these by-products could be observed over the years under some conditions. However, this isn't the case for a system that is open to the environment.

In fact, these by-products in the form of minerals are excreted during the biodegradation of organic materials. We're most notably talking about CO2, nitrogen compounds, potassium, phosphorus and different metals. Although these are not all necessarily assimilated during the first mineralization, these compounds are always accessible and very useful for different organisms in the ecosystem in which Advanced Enviro))Septic pipes are installed, as discussed in the « Predation » section. Essentially, these minerals are redistributed throughout various metabolic cycles in the organisms (Prorot, 2008). For example, the nitrogen and denitrification processes allow compounds to be easily assimilated by microorganisms, but mainly by the many roots that access the interior of Advanced Enviro))Septic pipes. These roots are also responsible for assimilating the large amount of phosphorus and potassium that would accumulate in the form of minerals. In fact, nitrogen, phosphorus and potassium are elements that are extremely important for plant growth. For example, phosphorus is responsible for around 0.2% of the mass of a plant (Shachtman et al., 2020), and grasses can assimilate up to 5% of their mass as potassium (Arienzo et al., 2009). Figure 1 is an excellent example of the roots that settle throughout the system, who, with the other organisms naturally present in the water and soil, play an extremely important role in the assimilation of organic materials and minerals. The diagram below, explains the process of mineralization and the assimilation of organic and inorganic materials that occur naturally in the soil and is exactly what occurs inside Advanced Enviro))Septic technology.

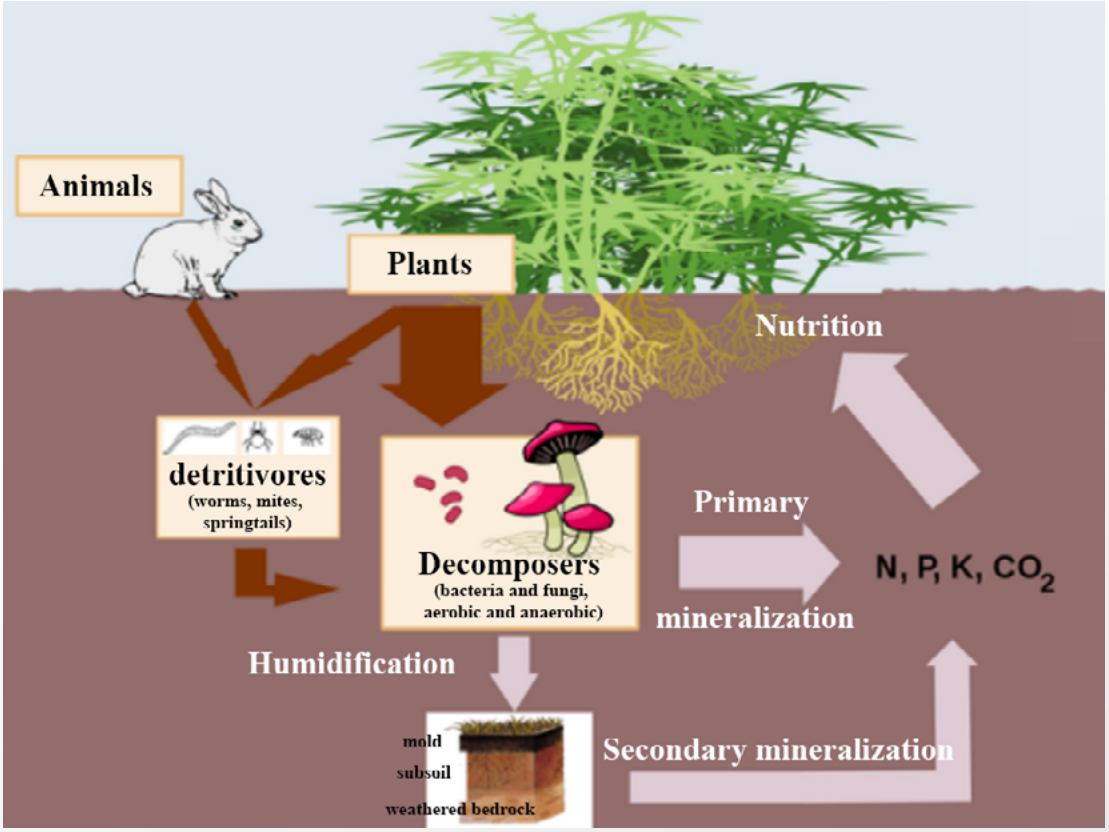

Figure 5. Decomposition and mineralisation processes (https://commons.wikimedia.org/wiki/File:Cycle_azote_fr.svg)

CONCLUSION

« Nothing is lost, nothing is created, everything transforms », Antoine Laurent Lavoisier. This famous quote summarizes perfectly what occurs naturally in the ecosystem created by AES pipes. **While every wastewater treatment system will create by-products, it's not every system that is able to harmoniously reintroduce them into nature's cycles.**

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Decomposition and mineralisation processes : https://commons.wikimedia.org/wiki/File:Cycle_azote_fr.svg