ESD: Environmentally Sustainable Design

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Indigenous Biomass in underground water tanks.

What is indigenous biomass? Biomass has a few exceptions, one of the most simple ones is: "mass of living biological organisms", it also has a connotation from a renewable fuel source perspective. In any case our first definition encompasses this too. The indigenous component of the term comes from the definition: "Originating and living or occurring naturally in an area or environment." So basically we can say that it is life forms that occur naturally, and in the case of this topic, in underground water tanks.

Having defined the above we can discuss about how we can manage Indigenous Biomass to an advantage, as it can have very good or very bad effects on the quality of water.

Why is this question relevant?
It is a frequent question I get related to what happens in underground water tanks, such as the modular Atlantis (http://www.atlantiscorp.com.au/landscaping/rainwater-harvesting) system being related to appearance of biological matter in the tanks and how it affects the water quality. In addition to this we often get questions associated to the maintenance of the system, in relation to the previous phenomenon. I stress that if a system is properly and correctly designed, it should not require maintenance, this is the first point of a correct Environmental Sustainable Design, if it requires maintenance, it is not sustainable.

Beyond the specific design of a particular project, one obviously needs good components to achieve sustainable outcomes. So once again, we have to look at integral design considerations. In addition to this we have to look at the quality of the water that is going into the system, because no matter how fantastic is our design and the quality of the components, in terms of their functions if we put in water that is beyond the scope of the design we will not have the desired outcomes.

It is often heard and said, that where there is water there will be life. In fact it is not a coincidence that the first thing scientists look for in space exploration, searching for habitable environments, is the presence of water so that it may be able to sustain life.

We can start by saying that water, unless it is contained in sterile conditions, will invariably "generate" biomass. Keeping large amounts of water in sterile conditions is very difficult and not very cost effective. What happens then is a situation that we see very often, water, unless it managed correctly, will become stagnant.

Water as soon as precipitates from the sky, where it is normally free from biological matter, and touches the ground it immediately becomes subject to conditions that can be "good" or "bad" for its quality. The words good or bad are purposefully subjective.

We must first define what is good water quality, this is normally done, among other parameters by presence of Fecal Coliforms (FC), Coliforms, E Coli, pH (acidity), Heterotrophic Plate Count, Turbidity, Heavy Metals, BOD, COD, TN, TP, etc...

To be simple in our explanation we can say that water can be kept in two sorts of environments, one that is entropic or one that is negentropic. As entropy is associated with degradation, in this case of water, we should be looking to create a negentropic environment. I have addressed the subject of [Negentropy from an ESD perspective in a previous blog post](#).

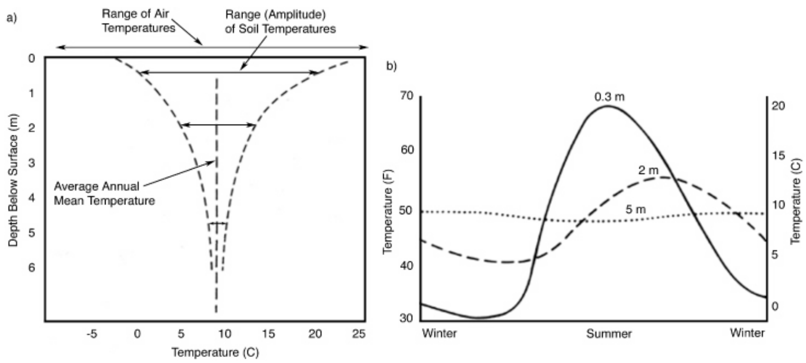
The important thing is that if the water enters a negentropic state or environments it becomes subject to a compounding effect that creates a vicious cycle if you wish.

There are things that are not "too" complicated and achieve several desired outcomes can be things like the following:

Keep water underground

Effects: Keeps water temperature low

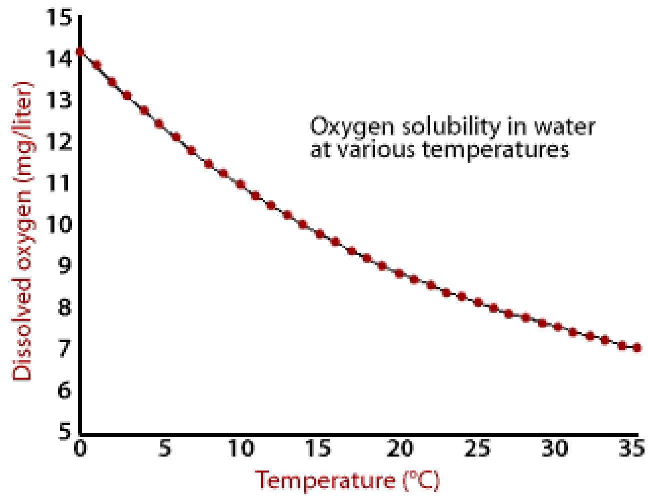
Keeping water underground normally keeps water cool, unless it close to geothermal active area.



source: http://iopscience.iop.org/1748-9326/2/4/044001/fulltext

In the above graph we see how as we get to a depth of 6 meters underground, temperatures have a tendency towards about 9 degrees C. The largest change happens between 0 and 3 metres depth which is where it is most practical and cost effective to install underground tanks. This is will also important from a physical aspect that I will explain in more detail in the section I explain about capillarity.

From a chemical point of view the importance of temperature is relevant as the cooler the water, the higher the Dissolved Oxygen (DO) capacity that it has.



source: http://www.cotf.edu/ete/modules/waterq3/WQassess3f.html

The oxygen content is important because, the lower the DO, the higher the probability that anaerobic activity should occur, though paradoxically one could say that this an inevitable consequence anaerobic activity or digestion occurs once the dissolved oxygen has been consumed, which is a consequence of aerobic activity rather than anaerobic, however it can also be observed that aerobic digestion also reduces Biological Oxygen Demand (BOD), which is something positive.

Aerobic digestion, is often associated to composting, which is a process that creates practically immediately usable by product without any undesirable by products, which is not the same situation with anaerobic digestion which creates sludge and methane. Recent and more modern process have made plants that use this process more efficiently, the methane, which is a green house gas, can be used for heating either to dry sludge or for power generation or even both, but the burning of the methane, produces carbon dioxide too. The management of sludge is also quite a complex process and there is an entire industry dedicated to it, in best cases when process it can be used as fertilizer, or worst case burned, creating a lot of pollution or buried and lost. Aerobic digestion in water treatment also serves to reduce BOD as well as pathogens and other desirable outcomes.

Why is all of this relevant to underground tanks? Very simply because all of these process can occur in underground tanks.

The very temperature also has an effect from a biological perspective on what types living matter can exist in water, in addition to this, the cooler the water the longer that water can remain in better conditions as biological metabolisms are directly affected by temperature, as such the colder the temperature the slower the reproductive cycle.

Effects: Keeps water dark
The effect of keeping water dark is very important, apart from the presence of light being associated with heat, in this case the darkness is important to protect the water from plants that perform photosynthesis. Though photosynthesis can normally considered something positive as

it is an oxygen producing process, however this also implies that the plant metabolic process that also requires some measure of oxygen as the plant apart from to photosynthesising also performs cellular respiration, which consumes oxygen, instead of producing it. Aside from this a very common form of algae that may become present in water exposed to light is what is generally named Blue Green Algae or Cyanobacteria, this type of algae poses two main situations that are of interest, one is that it produces toxins which are know as Cyantoxins, which undoubtedly poison water. The other interesting aspects within their robustness is that they are also able to exist not only in aerobic conditions, but also anaerobic conditions, which then presents the problems we had mentioned in the previous point.

The best thing then is to avoid light.

Provide high surface area to volume ratio
Providing a high surface area to volume ratio does mainly two interesting things.
Effects: More surface area for beneficial biomass
The more surface area one provides the more ability there is to form biofilm. Biofilm is a form of biomass. Biofilm necessarily exists attaching it self to surfaces, hence the more surface area we provide in a determined volume the better it is. If we have the presence of "good" biofilm.

Above is a photo of excavated modular tanks, that where taken out of the ground after 6 years. The tanks were excavated because within the scheme of the Australian Economic Stimulus Plan for schools, this school received funding to construct an additional building and as such relocated the position of the tanks. The case study for the original installation that was done in 2004 can be seen here. What is impressive about these tanks is that having been removed from the ground that they are in impeccable conditions.

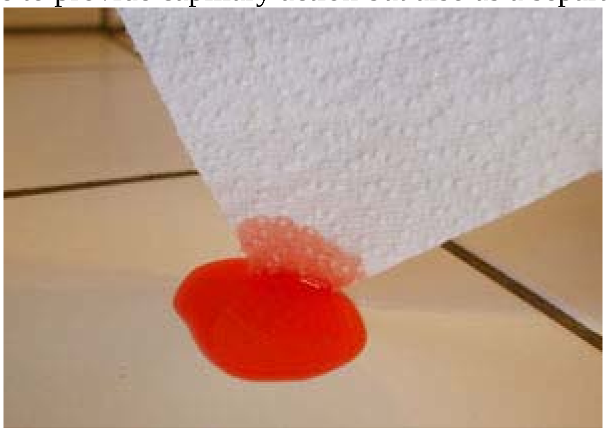
What is important then is to explain why the presence of biofilm is good and beneficial for an underground tank system.

I have listed below 2 interesting and relevant points from the wikipedia article on biofilm:

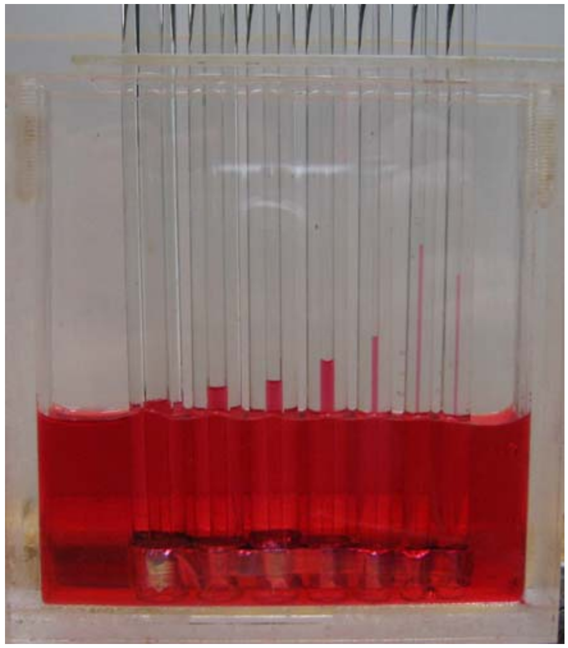
- Biofilms can also be harnessed for constructive purposes. For example, many sewage treatment plants include a treatment stage in which waste water passes over biofilms grown on filters, which extract and digest organic compounds. In such biofilms, bacteria are mainly responsible for removal of organic matter (BOD), while protozoa and rotifers are mainly responsible for removal of suspended solids (SS), including pathogens and other microorganisms. Slow sand filters rely on biofilm development in the same way to filter surface water from lake, spring or river sources for drinking purposes. What we regard as clean water is a waste material to these microcellular organisms since they are unable to extract any further nutrition from the purified water.

- Biofilms can help eliminate petroleum oil from contaminated oceans or marine systems. The oil is eliminated by the hydrocarbon-degrading activities of microbial communities, in particular by a remarkable recently-discovered group of specialists, the so-called hydrocarbonoclastic bacteria (HCB).

Effect: Increased capillary action
Capillary action is present for several reasons in correctly designed underground tanks, because of several components that contribute to it.
Sand: Sand has capillary action that occurs because of the granularity of sand. A tank that is correctly designed should be surrounded by an "envelope" of sand. The sand in this case also provides a situation that has a filtration effect that is not only mechanical and physical, but also biochemical as stated from the effect the biofilm has on the sand.
Geotextile: Geotextile as a fabric has capillary action. Below is a photo that shows this effect. A geotextile is a fabric that is made of plastic polymers, that for practical effects, does not biodegrade with time, especially if it is being kept underground. Geotextile should cover the modular tanks so that the sand surrounding the tanks does not enter the tank. In this case it not only serves as the purpose to provide capillary action but also as a separation and filter media.



source: http://www.sciencebuddies.org/science-fair-projects/project_ideas/PlantBio_p033.shtml
Tank components: Modular tanks, such as the Atlantis ones, have flat sides, these flat sides when placed together also creates capillary action. The closer the plates are together, the more pronounced this effect is.



source: http://webapps.lsa.umich.edu/physics/demolab/controls/imagedemobg.aspx?picid=1102

Capillary action has several effects the main one is that it moves water. As capillary action moves the water upwards, against the force of gravity, it eventually reaches a stage where it can not go up any more, at the same time it has more water molecules below it that are pushing up, as they are subject to the same forces of capillarity, however the difference with the situation of the tubes shown in the above photo, is that water in the sand, in the geotextile or between the modules, can "fall off" the tube, or be subject to a situation where as the cooler water from the bottom of the tank which is more dense, enters an area where the water is warmer and hence less dense, this cooler denser water will naturally descend again, until it gets to it's level of homeostasis, and again be subject to the effect of capillary action. This constant movement of water, by definition eliminates the possibility of the water stagnating. In association with this, as water would reach the water surface, it will also be subject to air and as such become aerated, once more increasing the Dissolved Oxygen level.

Proof

All of this theory sounds very good, however what evidence is there that what all of the above says in relation is true, please see some examples and case studies below with independent test results.

Case study examples:

Bondi Beach Stormwater Harvesting

Powels Creek East Concord Road Stormwater Harvesting

Comparisons with different types of underground tanks

Having said the above we can say we have found a situation where were create practically ideal conditions for the conservation or storing of water. So one could say that as long as one puts water underground then it should be acceptable. Not so much so, traditionally one of the most common types of underground water storage tanks have been cisterns made of concrete, these can be strong, but have the observation that the have an extremely low surface area to volume ratio, as such, unless external power consuming agitation, aeration devices or chemicals are used the water will go stagnant. The same is true of similar plastic or fibreglass cisterns. Recently there have also been a number systems that use "half pipes" providing void volumes, these have a larger footprint as they cannot be stacked, and are infilled between the half pipe rows with crushed rock or similar, this we could say is better that a traditional concrete cistern, as they are comparatively providing a slightly higher surface area to volume ratio.

As such having made the above analysis, we can see that to have indigenous biomass that is aerobic and beneficial for the water quality we also have to provide a good environment for it to exist. If this is done it can even be said that the quality of water while it remains in such a type of environment will improve with time.