

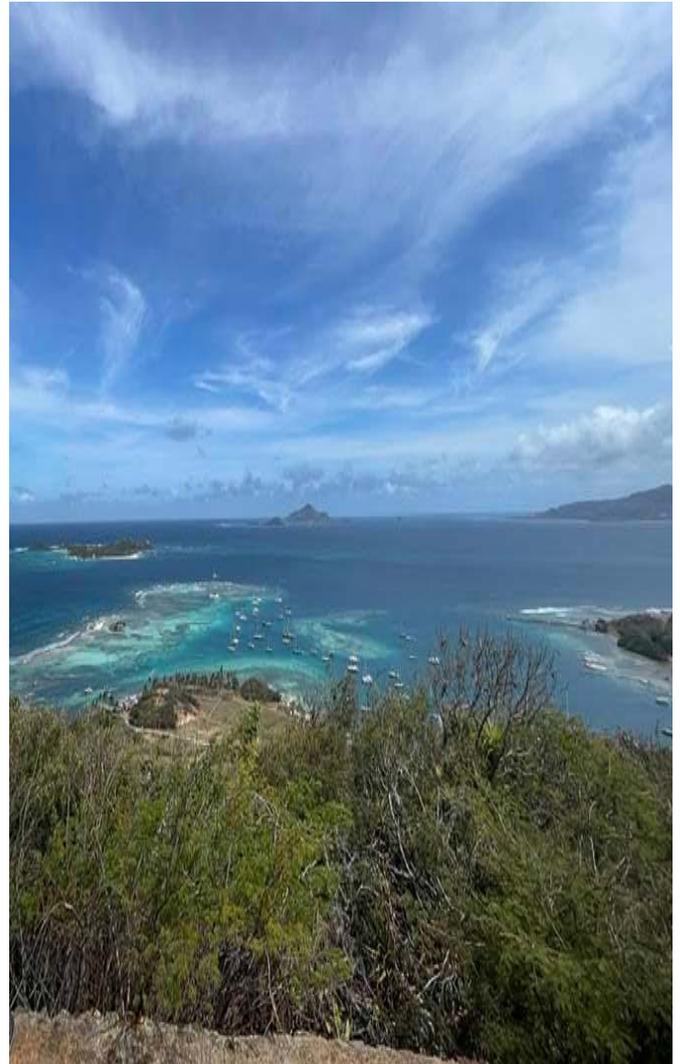


**Clean  
Water  
Wave**



**GOES**

GLOBAL OCEANIC ENVIRONMENTAL SURVEY



**Environmental impact of wastewater on marine ecosystems,  
and decentralised water treatment systems that bring power  
and responsibility back to local communities for cost effective  
and efficient water treatment.**



# Introducing Clean Water Wave's "Eden Cycle System"

- a paradigm shift for genuinely nature-based water and municipal wastewater treatment.

## Background:

1. 80% of the world has no water or wastewater treatment, and wastewater not only pollutes the environment, but it kills plants and animals on land, in our oceans and seriously impacts on public health and economies.
2. More than 80% of all disease in the world is caused by consuming contaminated drinking water, direct exposure to wastewater or when it is used, for example, for irrigation.
3. 90% of cancer is caused by environmental factors, polluted water is a major contributor
4. The wastewater containing micro-plastics toxic chemicals and pharmaceuticals also contributes to the stress and destruction of coral reefs and plankton which impacts on fish populations. The consumption of fish products contaminated by plastic and municipal waste also impacts on public health. It is not possible for conventional municipal wastewater treatment systems or MBR systems to treat the water to a sufficiently high standard. The system generate sludge, and they cannot remove lipophilic toxic chemicals and pharmaceuticals.
5. Microplastic dumped on land from wastewater sludge, even in very small quantities negatively impacts on plant growth
6. Conventional wastewater treatment also generates a huge amount of toxic sludge which is expensive to dump or incinerate. Sludge may then leach toxins back into the water table and pollute drinking water aquifers, rivers or coastal waters.
7. Most water treatment systems are biological but don't give sufficient time for Mother Nature to work. Usually, over a period of 6-12 hours, wastewater travels through a series of concrete tanks with surface mixers, and this adds oxygen. The oxygen supports the growth of bacteria which digest waste in the water. The waste is turned into a bacterial cell biomass/ sludge - (it is like bacteria turning milk into yogurt). This sludge along with many of the toxic chemicals, substances and plastic is then dumped, incinerated, and where possible, isolated from the environment so as not to cause pollution. Sludge ferments, generates methane gas which is a greenhouse gas 150 times worse than carbon dioxide.
8. Governments around the world are trying to take action to mitigate the effects of Climate Change, which is caused, only in part, by the burning of fossil fuels. However, world leaders have recognised that the destruction of nature on land and in the ocean is destroying the very mechanisms that removes carbon dioxide from the atmosphere and, most importantly, from our oceans.
9. All life on earth depends upon marine life in the oceans. If we continue to pollute the ocean at the current level, there will be a total collapse of all marine life within the next 25 years. With the loss of marine life there will be no possibility to stop or reverse climate change – the opportunity to make a step change and deliver 'volume' wastewater treatment, is starting to be recognised as one of our best climate hopes and for the sustainability of Nature and human society.
10. Any lipophilic toxic chemicals and microplastic discharged by industrial or conventional wastewater treatment, will return as rain water with 10 days of discharge. Re climate disruption report

For more information watch Clean Water Wave's Technical Director, Dr.Howard Dryden, deliver a 15 minute presentation at COP26 <https://youtu.be/ORGxHr7GqrQ>  
Climate disruption report <https://dx.doi.org/10.2139/ssrn.4210551>

## Supporting websites:

[www.CleanWaterWave.com](http://www.CleanWaterWave.com) | [www.GoesFoundation.com](http://www.GoesFoundation.com) | [www.DrydenAqua.com](http://www.DrydenAqua.com)

## The ideal water treatment system should have the following properties:

- be effective - sustainable, low cost and capable of being easily maintained.
- have product-water quality should be of drinking water standard or capable of being easily turned into drinking water without the requirement to use expensive membranes or large quantities of expensive chemicals
- not generate any waste, methane and, ideally, it should partially desalinate produce water without the requirement to use membranes.
- NOTE: Membranes used for desalination are expensive, and saline reject-water can destroy aquifers, and biodiversity in rivers, and coastal zones with heavy metals as well as osmotic pressure.

The EDEN principle can be used from one house to 10,000 or more people. It is a decentralised means of water treatment, that brings responsibility for the process closer to the community that the system serves. Decentralised systems also negate the requirement for a sewer collection system which can be more expensive than the wastewater treatment systems.

Wastewater treatment systems should deliver wastewater in compliance with drinking water quality standards.

## 1. Eden system, modification for single homes

Many homes are already fitted with soakaways, cesspits, or septic tanks. Soakaways and cesspits cause diffuse pollution and don't treat the wastewater, except for some basic anaerobic fermentation. Septic tanks are anaerobic fermentation tanks. Anaerobic treatment in the tanks is semi effective and under anaerobic conditions they generate methane gas which is 28 to 80 times more of a greenhouse gas GHG than carbon dioxide. Also, with regards to many pharmaceuticals and cosmetics found in domestic wastewater, anoxic fermentation is much less effective than oxidative biological treatment by heterotrophic and autotrophic bacteria.

The following details how to add oxidative biological treatment to a single home, and how to modify an existing septic tank.

### Avoid pollution

The wastewater is treated biologically, either in the water treatment system or by Nature. Any chemicals toxic to nature are also toxic to people so give some thought to the products you use in your home. Do not flush any chemicals down the toilet or use toxic cleaning chemicals. Sodium bicarbonate, vinegar and a small amount of soap are all that you need. If you want to use bleach, then use thin bleach (sodium hypochlorite solution) and use as little as possible.

### Chemicals

Use hard soap, do not use liquid soap, especially if it contains triclosan. Do not use any products that contain triclosan, you might also find it in toothpaste. Sunscreen, cosmetics, shampoo, and many domestic products contain, Oxybenzone, silanes, parabens that are toxic to nature.

### Plastic

A major source of microplastic is from laundry washing. One of the best things you can do to help fight climate change and pollution is not to purchase plastic clothes. The fibres break and millions of microplastic fibres are discharge in wastewater from your washing machine. It is now possible to fit microplastic filters to laundry discharge, or better still, just avoid plastic clothes.

### How to upgrade a septic tank

Aerobic treatment with oxygen is much more effective than anaerobic septic tank treatment. The longer you can give the bacteria to treat the water the better. It is also beneficial to split the system up into 2 or more chambers.

Most municipal wastewater systems only give the effluent 6 to 12 hours residence time. This generates a toxic waste sludge that is almost impossible to dispose of environmentally, especially on island communities. The systems do not treat or remove the most toxic of chemicals that cause environmental degradation. To treat this waste, you need a 10-to-15-day residence time.

A typical family of 4 people will likely use in the order of 400 to 800 litres of water per day. Try to minimise the amount of water that you use to 150 litres per day per person, this equates to 600 litres per day. The residence time of the wastewater needs to be a minimum of 10 days, so tank capacity should be 6 cubic metres.

If you have an existing septic tank, then you can turn this into an aerobic tank, simply by adding an air diffuser to the primary tank. Leave the secondary tank for sedimentation. If the tank has a volume less than 6 cubic meters you can add a second tank on the system in series to increase the residence time. If you can achieve the 10-day capacity, then the effluent from the tank will be approaching drinking water quality. It will still contain particulate matter and bacteria, which makes it unsuitable to drink, but the water will do no harm when discharged back to the environment. Alternatively, you can use the water for irrigation, there will still be some minerals and nutrients in the water that will be beneficial to most plants and grass.

The figure below shows a typical septic tank modification to make an aerobic aeration tank, with an additional second tank added on to give a 10-day residence time of the wastewater in the system. If you have a 10-day residence time with one tank, then it should give good results, but systems with two or more tanks give greater bacterial species diversity, have less chance of short circuit, and give better results. Up to 4 tanks may be connected in series, or as opposed to tanks 3 and 4, they could be replaced with small wetland ponds as an option. Here will be no smell for the ponds and they can be made to look very attractive.



## Size of aeration system

The size of the aeration system depends upon the number of people (on average) living in the house. For 4 x people, you require a minimum of 1 cubic metres of air per hour to be passed through fine bubble air diffusers.

Number of people	Amount of air required cubic metres per hour
4	1 to 2
8	2 to 4
12	4 to 8

## Air blower

Many different types of air compressor are available, use a linear air compressor for up to 4 people, for larger systems use a rotary vane or sliding vane compressor.

For a small 1 x house system, you may use a linear air compressor, such as the SL44 delivering in excess of 2m<sup>3</sup>/hr of air at 8ft water pressure head.

Air compressor approx. 500usd each

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<https://pentairaes.com/linear-piston-air-pumps.html>

The air compressor sits above ground, fitted onto the compressor is a ½" or 12.5mm flexible polyurethane hose of sufficient length to go to the bottom of the tank. Fit an air diffuser onto the end of the hose. You need an air diffuser capable of passing 1m/hr of air, and to use two or three of these diffusers in the system. The air diffuser is then simply dropped into the tank. This also makes it very easy to remove the diffuser for occasional cleaning. If the water depth in the tank is greater than 8ft then you need to use a rotary vane air compressor to deliver sufficient air pressure to compensate for the water depth.



When the system is first started, there may be a bad smell for around 120 minutes, then it will clear up and there will be no nasty odours from the system, even if you open the tank.

### **Air diffusers**

Many aeration systems just use a pipe with 1mm holes drilled into the pipe, however it is much better to use a fine bubble air diffuser. Air diffusers are available from Clean Water Wave CIC.

Air diffusers are available from CWW, they measure 1 ft in length and are self-ballasted. Diffuser air flow 1 m<sup>3</sup>/hr

Price 160 usd per diffuser



### Additional equipment.

If the water is discharged to a cesspit, or soakaway, this water may end up becoming your drinking water or your neighbours drinking water. It is therefore important to make sure that it is as clean as possible and that you are not transferring toxic chemicals, particles and pathogenic bacteria, parasites or viri.

Initially households may only add an aeration system, then an extra tank to give increased residence time. A CAFÉ filter can also be added, and the water can be disinfected. Each stage provides for an incremental improvement to the quality of the water.

### Tertiary treatment

Mechanical filtration of product water using a CAFE media bed filter to filter the wastewater down to sub-micron level. Back-wash water is returned to first aeration tank.

The photograph shows a CAFÉ 1000 system capable of treating 50 m<sup>3</sup> of water per day. The household system just requires a very small system dealing with up to 1 m<sup>3</sup> of water per day.

Price of systems on request

### Disinfection Electrolytic chlorinator

The chlorinator will produce 2 to 4mg/l of free chlorine from chloride in the water. This level of chlorine will disinfect the wastewater and should eliminate all pathogens. It will depend upon the quality of the discharge water, but after 10 days of aerobic digestion the water quality will be very good. Ideally the chlorinator should be located after the CAFÉ filter. It is not ideal, but it could also be placed after the last aeration tank, in-line with the discharge water

In line chlorine generator, 12v dc supply of 110-220v ac supply.

Cost of equipment, budget cost 600 usd



## 2. Eden system for 10 to 10,000 people.

“The Eden Cycle” is a complete Life Support System for treating all municipal wastewater from 10 to 10,000 people and delivers the same amount of water back to the community for consumption and sanitation. The system is a scalable, decentralised water treatment network. This nature based and inspired system can also be used for fish production, and to grow vegetables and herbs for local consumption. The system bio-desalinates water and helps to maintain or recover the health of aquifers. Using nature, we can return a contaminated, polluted environment back to EDEN.

### How it works

1. The Eden Cycle system passes wastewater through a series of 4 lagoons (concrete tanks could be used but is more expensive and less attractive to the eye.)
2. The residence time of the wastewater in the lagoons is 15 days (or more) in total
3. Oxygen is added by using fine bubble air diffusers – these are 5 times more efficient than surface aerators. This residence time allows nature to go to work – the bacteria will evolve and adapt to treat the wastewater.
4. Fish, shrimp, and plant cultivation can become part of the water treatment as an optional add-on to the process and revenue generator. The system could be deployed in cities and peri-urban locations to bring “The Eden Cycle” into our way of life for everyone in all countries.
5. After 15 days, the waste will be totally treated, and towards the end of the process the bacteria will run out of food, so they start eating each other. This is called endogenous respiration - bacteria are turned back into water, carbon dioxide and nitrogen gas, so no sludge is produced and because the digestion is done aerobically, no methane is formed.
6. At the end of the system, water quality will be very high, and ready for polishing to remove any remaining bacteria or other organisms that may remain. Water is polished by filtering it using AFM, which is the world’s most advanced filtration media.
7. The Eden Cycle was inspired by Clean Water Wave’s Clean Aqua for Everyone filter (CAFE) and this is used to house the AFM. CAFE filters are low energy, high performance filters which use AFM rather than sand to maximise their sustainability. AFM is manufactured in Scotland and Switzerland by up-cycling coloured glass bottles, resulting in a water filtration media which is ten times better than sand in most conditions.
8. The CAFÉ filter operates at a very slow water flowrate which means that coagulants and flocculants such as aluminium chloride or poly aluminium chloride are not required. This is critical because if you want to use the water for irrigation or aquifer replenishment the water must not contain high concentration of metals.
9. After being polished in the CAFE, the water will be better than any other wastewater treatment system. The water, having been nominally filtered down to less than 1µm, is now of an extremely high quality and may be used for class 1 irrigation, aquaculture and hydroponics and then used again for irrigation, or injected into the ground to replenish aquifers without causing salination.
10. If drinking (potable water) is required, the water should be polished a second time in the CAFE filter(s), followed by either UVc or chlorine, and this ensures that there is no living bacteria or pathogen in the water. The produce water provided by the system can also be sold back to the community at a sustainable price that covers the cost of operating the Eden Cycle system.

**The Eden Cycle System has the possibility of being a revenue generator and zero cost solution for the ultimate in water treatment**

## Our Eden cycle is both nature inspired and nature based solution:

Clean Water Wave has combined tried and tested technologies - lagoons, AFM, fine bubble diffusers, constructed wetland edging, CAFE filters and effective disinfection to deliver a zero discharge/ zero impact water treatment.

Almost 100% of the wastewater can be reused or returned to the local environment without the use of membranes or overly sophisticated technology that will require ongoing expensive replacements. The cost of Clean Water Wave's Eden Cycle process is therefore up to 50 times lower than conventional wastewater treatment, and it will deliver better water quality, with systems that can be easily managed. All water, including municipal and other wastewater, is a valuable resource and the costs should not be prohibitive to turn it into water suitable for irrigation or potable water.

The Eden Cycle systems are self-contained, 100% sustainable, and carbon neutral. They are highly functional, simple, and look good. Ideally, they can and should become part of a community. As the biology develops, they can become a meeting point with a pleasant, natural ambiance where fish and other produce from the system can be purchased.

### Large Scale water treatment

Large scale water treatment systems require an extensive sewer network to transport the wastewater to the effluent treatment plant or to long sea out-falls. The cost of these installations is often more expensive than the water treatment system, and under no circumstances should we continue to dump wastewater at sea. This is not an option, it is seriously damaging to the marine environment, economies of coastal communities, public health, and climate change.

The Eden Cycle System gives you a new concept in water treatment and decentralised processing that negates the cost of large-scale sewer networks. Local decentralised systems provide local solution and applications to use the product water

### Clean Water Wave a scalable system:

- The Eden Cycle system is scalable from 10 to 10,000 or more people. If more water treatment is required, then more systems are installed
- The water may be discharged back into the environment with zero risk, it could be used for aquifer replenishment without causing salination or heavy metal including boron issues
- The water may be used for irrigation or treated for drinking water supplies.
- Eden Cycle is a closed loop water treatment process that allows for the continuous use of the same water.

### Stage 1 - screening

- Raw wastewater is screened to remove the solid matter, which may also include macro plastic. The waste is used for composting or, is dried and used for Biochar. If the waste contains plastic the pyrolytic process could return this back into fuel.
- The carbon/biochar would be used as soil in the aquaponics process and, may also be sold as one of the outputs from the process.

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## Stage 2: lagoons

- The screened water enters a series of 4 or more ponds or lagoons connected in series. The lagoons may be clay lined or sealed using a recycled geotextile membrane. DIRD in Dhaka Bangladesh produce a plastic membrane by recycling plastic bottles. The lagoons are sealed using HDPE high density polyethylene 2.4mm or thicker.
- The lagoons are constructed to hold a water depth of 3 - 5m and, and a volume of water sufficient for a 4 days residence time for each of the 4 lagoons making 16 days in total
- Each lagoon in the series of 4 will have the same hydraulic capacity.
- The water in lagoons 1 and 2 are strongly aerated, this is the most intensive part of the process. 60% of the energy is used in the first two lagoons
- For every 100 PE (people equivalents) a minimum of 10 m<sup>3</sup>/hr of air is required, water flow per 100 people will depend on the country but typically this could be 15m<sup>3</sup>/day. The system is then scaled according to these ratios. For example, 10,000 people system requires, 1000m<sup>3</sup>/hr air blowers (2 x 25kw blowers), 1500m<sup>3</sup>/day of water and 4 x lagoons each with a volume of 6000m<sup>3</sup>.

### Equipment required for a 10,000 PE system

- 2 x 500m<sup>3</sup>/hr air blowers, roots type air blowers should be used
- 100 x air diffusers each rated at 10m<sup>3</sup>/hr of air such as [www.DrydenAqua.com](http://www.DrydenAqua.com)
- 40 tonnes of AFM in CAFÉ filters or pressure sand filters operating at 2m/hr as a filtration velocity
- 4 x 4000m<sup>3</sup> lagoons 3 to 5m in depth
- Air ring main 125mm diameter around the perimeter of each lagoon. Use steel pipe in tropical and sub-tropical countries, HDPE pipe may be used in temperate countries

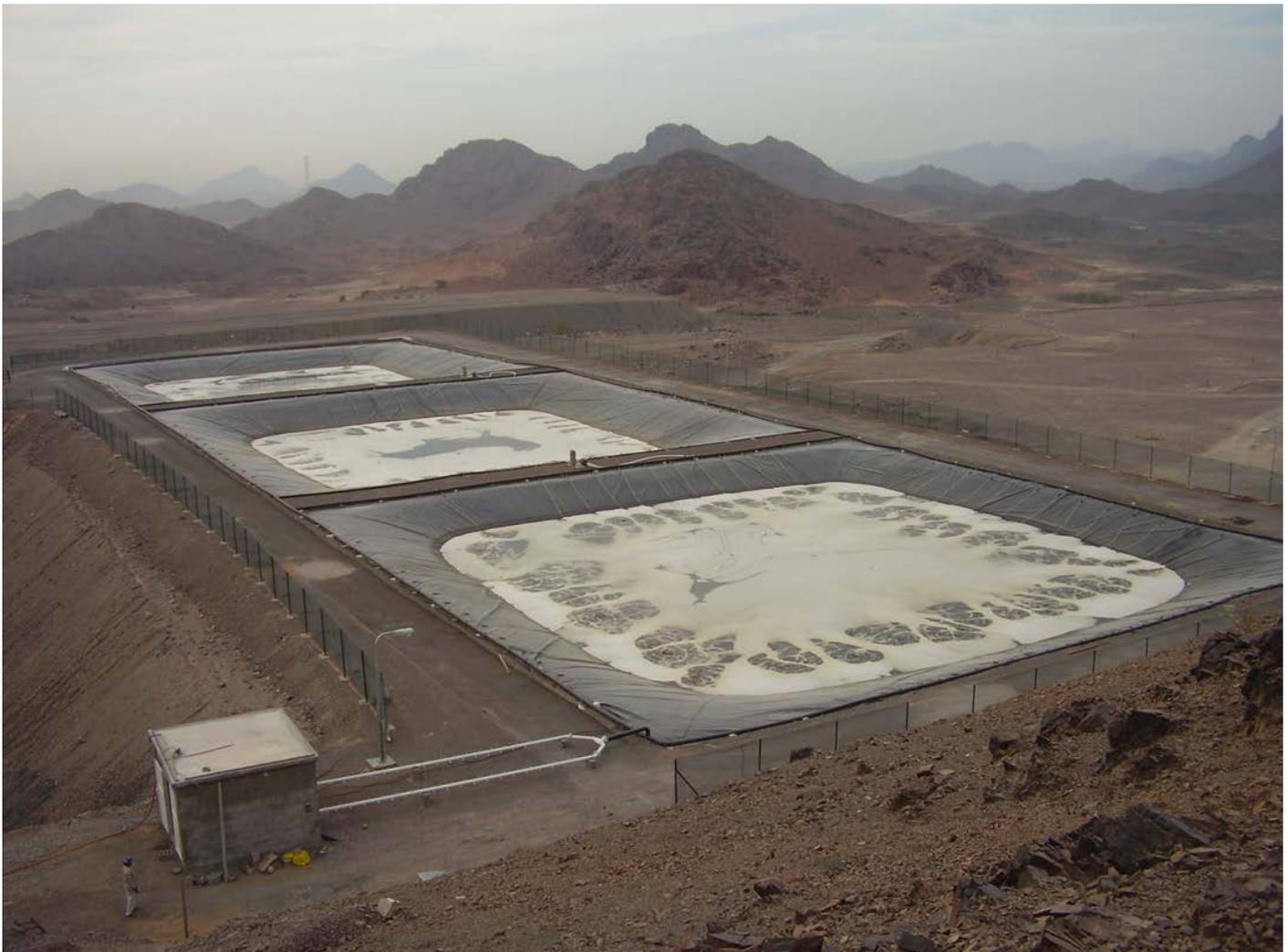
There will be other items required but the above covers the main components.

### Lagoon 1:

The water in the first lagoon will have a high BOD (Biochemical Oxidation Demand) due to a high concentration of ammonium and organic matter. This water needs most of the oxygen delivered by air blowers to allow bacteria to complete the digestion of food consumed by people.

The water will appear dark to light brown and will have an earthy smell. The oxygen concentration is maintained above 2 mg/l, and there will be no objectionable odours. The residence time of the water in this lagoon is 4 days. The water will then overflow to lagoon 2. The reason for having a number of lagoons in series, is to increase the species diversity of bacteria and other organisms in the water.

The BOD of the water entering lagoon 1 will be 200 to 500 mg/l. The BOD of the water by the time it enters lagoon 2 will be <20 mg/l.



### Lagoon 2:

The lagoon water will appear light brown in colour, the bacteria will be forming large stable bacterial floc. The concentration of protozoan, rotifers and many other organisms will become established. The dissolved oxygen content of the water will be >4mg/l. The BOD and ammonium concentration of the water in the lagoon will be <1 mg/l. The wastewater will have been digested and converted into bacterium cell biomass. Some of the bacteria will also have been digested to an end point of water, carbon dioxide and nitrogen gas. The nitrogen will be discharge as nitrogen gas to atmosphere as well as to nitrate in solution.

### Lagoon 3:

Water entering lagoon 3 will have a low BOD and ammonium level but a high concentration of solids in the form of bacteria and, both single celled and small, multi-cellular organisms. The organisms now have no food to eat, so they start attacking and eating each other. This is called endogenous respiration, and the bacterial cell biomass and other organics are converted to water, carbon dioxide and nitrogen gas - meaning no sludge is produced that would then require expensive transport or disposal.

The water turns clear in Lagoon 3 and algae become established. The algae mop up any residual phosphate and nitrates. They will also consume the carbon dioxide from the respiration process. Dissolved oxygen levels will increase to greater than 6mg/l during the day and drop to 4mg/l at night. Algae concentration starts to increase and zooplankton such as daphnia will start to appear.

#### Lagoon 4:

This lagoon may have constructed wetland edges, algal concentrations will be high, and zooplankton concentration will be high.

The water in the lagoon will be of sufficient quality to permit the cultivation of fish such as tilapia. These fish are not for human consumption as there may be some toxins and plastic in the fish, so they are left to breed and to produce juveniles. These will be harvested from the system and transferred, as required, to the aquaculture part of the process.

In addition to fish, shrimps are also introduced to lagoon 4, for example, the freshwater Macrobrachium shrimp or freshwater crayfish. Again, juveniles will be cropped to stock the aquaculture system.

The aquaculture part of the process is not essential, it is an add-on that can be incorporated as part of the process.

Lagoon 4 is fitted with a simple inclined tube clarifier and here a CAFÉ filter pump(s) is located.

#### Stage 3 CAFÉ filtration

The product water from lagoon 4 is filtered by a CAFÉ filter incorporating AFM filtration media. The advantage of the CAFÉ filter over a conventional sand filter is the simplicity of the process. There are no PLC control systems, valves or actuators. The CAFÉ filter is a siphon filter and essentially it looks after and back-washes itself. The back-wash water is sent to lagoon 1.

Each CAFÉ filter can process 2 m<sup>3</sup>/hr of water, CAFÉ filters are therefore added in parallel to achieve the desired water flow. If larger systems are required, then RGF gravity flow sand filters or pressure filters with AFM media may be used as an option. The product water from



the CAFE filters will be of potable water quality, however, to be sure, the water should be filtered down to less than 1 um by a cartridge filter and then chlorinated to 0.5mg/l, or irradiated by UVc (ultra violet) filter at more than 40mj/cm<sup>2</sup>/sec. If the water is not filtered and chlorinated it may be used for the following.

1. Irrigation water
2. Aquifer injection
3. Zero impact discharge to the environment
4. Feed water for membrane plant for ultra pure water
5. Any application where you require clean freshwater.
6. Aquaculture and Aquaponics



### Stage 4 Aquaculture

The aquaculture system is an optional revenue earner for the water treatment system.

Aquaculture systems are often designed to maximise the production of the fish or cultivated animals. Tilapia are herbivorous fish so, feed for the Tilapia could be produced by the Aquaponics part of the process. Macrobrachium shrimps could also be cultivated in the same system to maximise the use of the feed and waste from the tilapia



### Stage 5 Aquaponics.

Pure aquaponics follows the aquaculture system and here vegetables/herbs can be produced using the tried and tested aquaponic methods: (i) thin film water, (ii) earth based using biochar produced by the system, and (iii) deep water. A balance between the aquaculture and the aquaponics systems is maintained to negate the need for any additional fertiliser or, energy input to the system. The Eden Cycle is nature based, everything is balanced, self-contained and self-maintaining. The discharge water from the aquaponics is recycled back to the aquaculture system.

*Note: In many parts of the world the use of reverse osmosis systems for water treatment and a lack of aquifer replenishment of the ground water has been destroyed by a rising concentration of salts. The cultivation of any plants in the water, will reduce the salt content of the water by around 25%. This is called bio-desalination.*

In cases where the salt content of the water is too high for human consumption, it may be pumped out of the ground and



mixed with some wastewater. The Tilapia and shrimps will be okay in the saline water, however different plants will need to be selected that can survive in water up to approx 10g/l salt. The system would then be used for bio-desalination and aquifer recovery. Halophytic plants such as quinoa, mustard, and safflower may be cultivated, in fact there are 10,000 different types of salt tolerant plants.



### Stage 6 - 2nd stage CAFE Filtration

The water from the aquaponics system will be close to WHO potable water standards,

but it will contain a few solids, bacteria and possibly parasites. After passage through a CAFÉ filter the product water may be used for the following applications;

1. Irrigation water
2. Aquifer injection
3. Zero impact discharge to the environment
4. Feed water for membrane plant for ultra-pure water
5. Filtered by 1 um cartridge filter, chlorinated, or UV irradiated and used as drinking water

