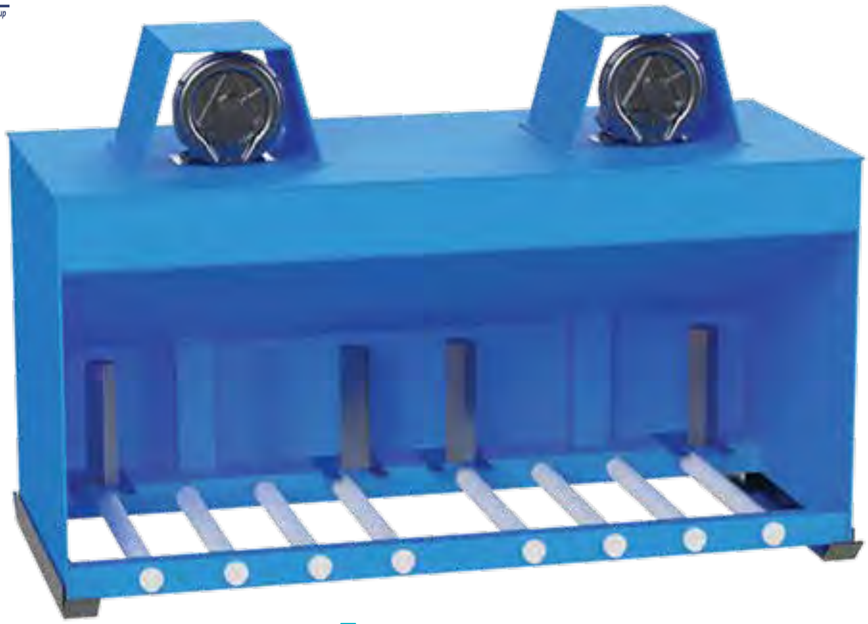


Kuh-kai Lagoon Aerator

A new aeration concept for wastewater lagoons and algae control

The use of wastewater treatment lagoons, or stabilisation ponds, is a common practice for rural municipalities and industrial facilities. Through the years there have been numerous designs for these ‘sludge settling basins,’ ranging from facultative, partial aerated, and fully aerated systems. But the primary reason for these systems is to utilise relatively shallow earthen ponds, or lagoons, for the purpose of sludge settling and stabilisation. Over the years, the technologies for these lagoons has changed little except to line them to protect groundwater from contamination and the addition of multi-celled lagoon systems for the purpose of adding mechanical oxidation for quicker treatment and effluent water polishing.

The other things that have changed are the encroachment of growing populations and plant expansions that often pose problems for both the lagoons and the populations around them. Noxious odours, which are caused by the insufficient digestion and buildup of the sludge on the bottom of aerated lagoons, become a primary problem. Space limitations become a major problem as populations grow, and new, or larger, cells are required in the lagoon system. The efficiency of these lagoons is dependent on a myriad of conditions that range from environmental to design limitations. Sludge reducing bacteria populations must constantly be assessed, sludge depth and water temperatures are usually in constant flux and aeration equipment and the energy to run them is expensive and causes ever increasing maintenance and maintenance costs. Post the treatment lagoon, in the effluent holding ponds, blue green algae (BGA) is often a problem in warmer areas. The use of a Royce Lagoon Aerator in this pond can de-stratify the lagoon and make it difficult for the BGA to exist.

The Lagoon Aeration Process

In the more advanced waste lagoon systems there is an aeration process that is supposed to:

1. Provide oxygen to aerobic bacteria that convert and oxidise the organic material in the wastewater.
2. Provide mixing in order to distribute dissolved oxygen and bring aerobic organisms into contact with organic sludge.
3. Provide enough mixing to allow solids to become suspended for quicker digestion and oxidation by the aerobic bacteria. If this does not take place, solids will build up on the bottom, eventually requiring the very expensive process of sludge removal from the lagoon bottom.

Over the years the methods of aerating these lagoons has changed little. The primary aeration techniques used for earthen waste lagoons are:

- Hose bubbler systems that utilise large, housed, industrial blowers.
- Diffused air grids that also utilise large industrial blowers.
- Low horsepower spray aerators.
- Paddle-wheel, or brush, aerators.
- Large circular surface mixers.
- Floating air induction aerators.
- Solar powered mixers.

There are other less-used technologies found in waste lagoons for the purpose of providing dissolved oxygen and mixing, but these are so seldom used that they will not be addressed here.

The primary positives and negatives of the above listed aeration technologies are:

- Hose bubbler systems are very common in lagoon aeration because of their relatively low initial cost, and initially they seem to work fine. But, the blowers required

to drive these systems are very expensive to operate and maintain; the hoses themselves require occasional replacement for optimum efficiency, and finally, but most importantly, their inefficiency in mixing and getting dissolved oxygen into the sludge, especially in older lagoons, allow for sludge buildup and the eventual cost of sludge removal.

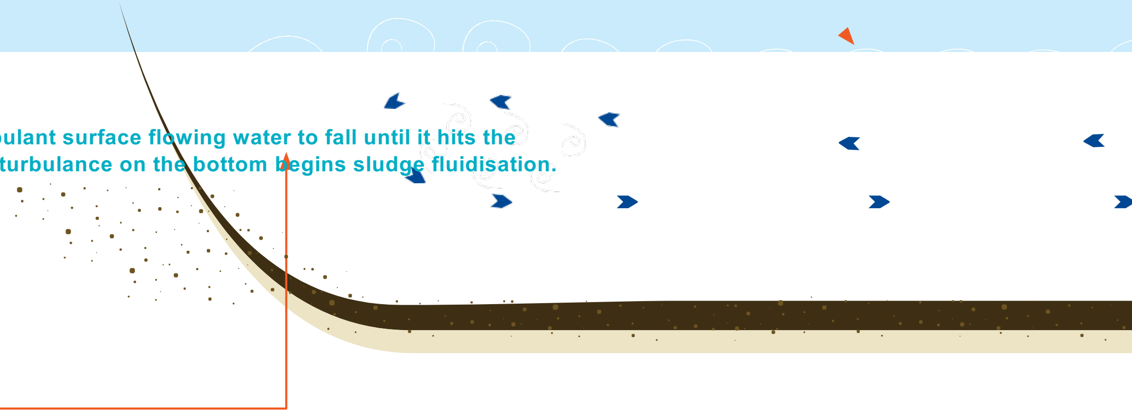
- Diffused air grids are used in an effort to make the waste lagoon work like the extended aeration process commonly used in urban municipal wastewater systems. These are expensive installations, especially when manmade liners are utilised. The blowers are very expensive to operate and maintain, and finally, the diffusers used cannot be located as efficiently as extended aeration designs because of their cost and expense of sludge removal when sludge depths rise above the diffuser heads.
- Spray aerators are inexpensive to install and do not use much energy, but their efficiency in providing mixing and dissolved oxygen to the sludge is minimal.
- Paddlewheel, or brush aerators, are simple and inexpensive to install, but they are quite expensive to operate and their continual maintenance requirements are costly. These aerators do move water, so they will mix bottom sludge, but their cost of operation is always their major drawback.
- Large surface mixers, or aerators, were initially introduced in extended aeration plants in the first half of the 20th century, and are primarily used in large industrial waste lagoon systems. They are very expensive to acquire, and take large amounts of energy to run. But these aerators, if properly designed, do mix the bottom sludge and will allow dissolved oxygen to provide the oxidation of suspended solids that is required to reduce solids buildup on the lagoon bottom.
- Floating air induction aerators do move water well and they do add dissolved oxygen somewhat efficiently, but they are restricted to deeper and lined lagoons. They also possess an inefficient water moving capability so many are required for even small lagoons.
- Solar powered mixers are the newest entry to the lagoon aeration market. But, due to the very low amount of energy available, via solar panels, effective mixing, especially in older lagoons, is deficient. They are very costly and soon require as much maintenance as other devices mentioned above. Ragging of the impellor is a frequent problem.

A New & Better Lagoon Aerator

The idea of 'blended aeration' was conceived in 2004 in order to improve the aeration and growth conditions of fish being raised in earthen ponds. The idea of the blended aerator was to allow the fish to return to its genetically coded preference of living in moving water. Moving water provides the organisms that live there with:

- A flow that usually cleans the bottom of noxious sediments.
- The ability of the fish to get to the bottom to scavenge for food.

LAGOON AERATOR



Quiescent water forces turbulant surface flowing water to fall until it hits the sludge on the bottom. This turbulance on the bottom begins sludge fluidisation.

Opposite shores turns water back toward the intake of the model Lagoon Aerator, which pulls 37,000 cubic metres of water through itself per day. This flowing water completes the fluidisation of the sludge.

How the Lagoon Aerator is different from other surface aerators

- A relatively constant level of dissolved oxygen throughout the water column.
- And, recent studies have identified that a fish that swims into a current experiences a more efficient food conversion ratio.

One concept that must be recognised in attempting to understand the blended aerator is that water is a heavy natural material. Once a measure of water begins to move, it is very hard to stop and will take a long time to do so on its own. During the process of moving, the water will naturally fall to the lowest level it can reach, normally moving anything lighter than itself in the process – like sludge.

The Royce Lagoon Aerator is a second generation of the aerator used for the fish farming industry. Due to the corrosive nature of many wastewaters there are no metals used in the construction. Some use a metal frame or submersible components. The Royce Lagoon Aerator is made from ridged and durable recycled HDPE without any submerged metal components. One Royce Lagoon Aerator effectively recycles 4,500 2L milk bottles or 34,450 plastic shopping bags.

The Royce Lagoon Aerator uses one 1.5kW regenerative blower to move over 37,000 cubic metres of water through itself in a 24 hour period. Once that surface water begins to move it will fall to the bottom, on a continual basis, bringing the bottom sediments, or sludge, into the water column where the nutrients will oxidise and aerobic organisms will thrive. A second 1.5kW regenerative blower feeds into industrial grade fine bubble diffusers for the addition of dissolved oxygen, and this blower can be automatically controlled to turn on only when DO is required.

This aerator design can be customised for your lagoon system and manufactured in Brisbane, QLD.

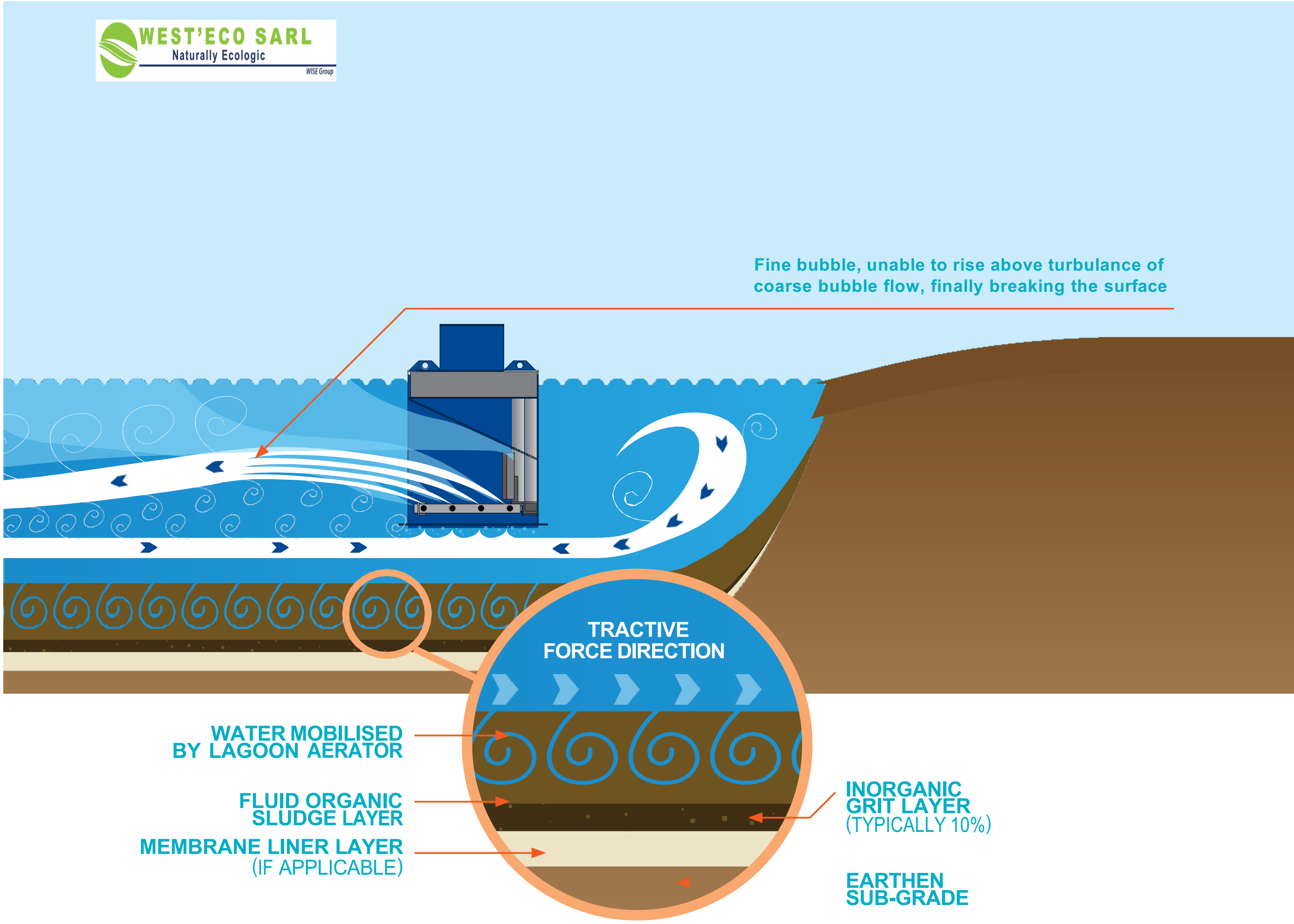
Features

- Only 3kW at maximum energy use
- No propellers or shafts to foul
- No belts or gearboxes to break or require maintenance
- Non-corrosive materials of construction - Anodized aluminum, HDPE, Stainless Steel
- The addition of up to 9.0kg O_2/hr

Benefits

- Continuously moves the lagoon or pond water via vertical mixing, for complete destratification, algae bloom reduction, and natural sludge digestion.
- Delivers more dissolved oxygen to the water per hour
- Lowers energy costs by up to 80%
- Practically maintenance free for years
- Eliminates trapped nitrogen and ammonia gases, and improves BOD/COD counts

Can also be used with
Kuh Kai Water Aerator on page 82



	BLOWER 1 - KUH KAI	BLOWER 2 - FINE AIR DIFFUSERS	
Power Consumption (kW)	*1.50*	*1.50*	kWatt Consumption of each Blower
Airflow (l/h)	*155,000.00*	*155,000.00*	Airflow from 1.5kW Blower
Oxygen Supplied (l)	*32,550.00*	*32,550.00*	Airflow x 21% of Oxygen in Air Average
Bubble Path length (M) - Due to unique shape	*3.00*	*3.00*	Estimated minimal horizontal distance that the air travels from bottom to surface (+-20%)
Kuh Kai total uptake (%)	*6.00*		
Mass of dissolved oxygen transferred (kg) (SOTR)	*2.57*	*6.51*	
O_2kg/kW/hr of delivery	*1.71*	*4.34*	
Total O_2kg/kW/hr	*3.03 +-20%*		
Total O_2kg/hr (SOTR)	*9.08 +-20%*		

Unique Design causes longer Sub Surface Bubble Travel Time = Increased Contact Time of Diffused Air with Water. Design of Aerator can be considered an Air-Water Interface Generator for Oxygen Transfer Enhancer in Diffused Aeration System - Passaworn Warunyuwong & Tsuyoshi Imai et al.

WEST'ECO SARL
Naturally Ecologic
WISE Group

Kuh Kai Water Aerator

Unique design creates both coarse, fine and micro-bubble aeration

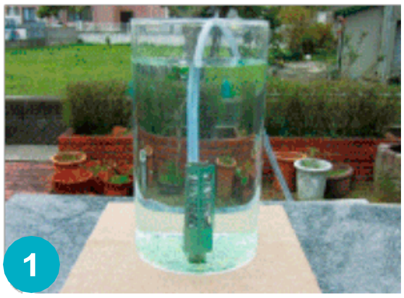
KUH KAI is an innovative product that collides, stirs and breaks down sludge and air into fine particles in a pentagonal cylinder 65cm in length, to accelerate the purification of waste water. Air jetted from a pentagonal cylinder diffuses and radiates outward while eddying in a non-conventional approach.

Features

- Applicable when the water is 1m or deeper
  - Applicable to existing or new equipment as long as the water tank or lagoon pond is 1m or deeper.
- No clogging (Pentagonal tube opening 80mm × 130mm)
  - No need to worry about clogging due to the large-diameter opening particularly with intermittent processes during denitrification.
- Power cost reduction (20% to 40%)
  - With a small pressure loss between the air in-take and discharge, power costs can be substantially reduced.
- No sludge flocculation on the tank bottom and the oxygen transfer rate is high due to its "air lift effects".
  - Sludge on the tank bottom is drawn into the pentagonal cylinder and the sludge and air are broken down into fine particles which increases the oxygen transfer rate while colliding, being stirred, and rotating. This how the KUH KAI effectively purifies the water.
- Easy maintenance and management due to its simple structure
  - The main body is made of stainless steel and the inside is made of molded resin = Virtually maintenance free. Also, the main body material and the installation method can be changed according to needs.

Can also be used with Lagoon Aerator on page 82.

MIXING DEMONSTRATION IN A CLEAR WATER TANK



Whole tank volume: 170L

Sludge drawn into a cylinder rises and rotates while colliding against and being mixed with air.

Sludge stirred in the cylinder churns in a spiral and circulates in the tank for purification.

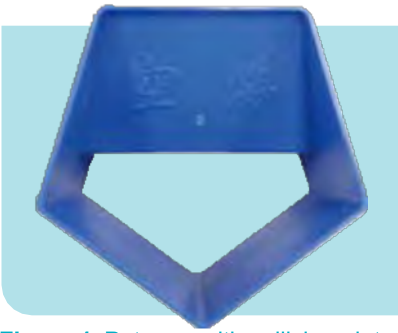


Figure 1 Petagon with collision plates

Discharge of Air

Operation in a aeration tank running condition

DEVELOPMENT

Treatment of Organic Waste using the Activated Sludge Method with micro-organisms has become a standard method in wastewater treatment. In recent years, there has been an increase in technology to reduce the footprint of Wastewater Treatment Plants whilst still maintaining and improving the efficiency of the process.

One area where there can be an improvement relates to higher efficiency of the Aerator (air diffuser). Some current systems use the bubble type generation utilizing porous materials that can clog through deposits of sludge due to the restrictions on their location and positioning. Often, a large vortex flow utilizing a large amount of energy is required to prevent this occurring.

An Aerator was required to prevent the depositing of sludge clogging the Aerator pores without using large amounts of energy. The Kuh Kai Pentagonal Air Lift Aerator was developed to fulfill this need.

EQUIPMENT DESCRIPTION

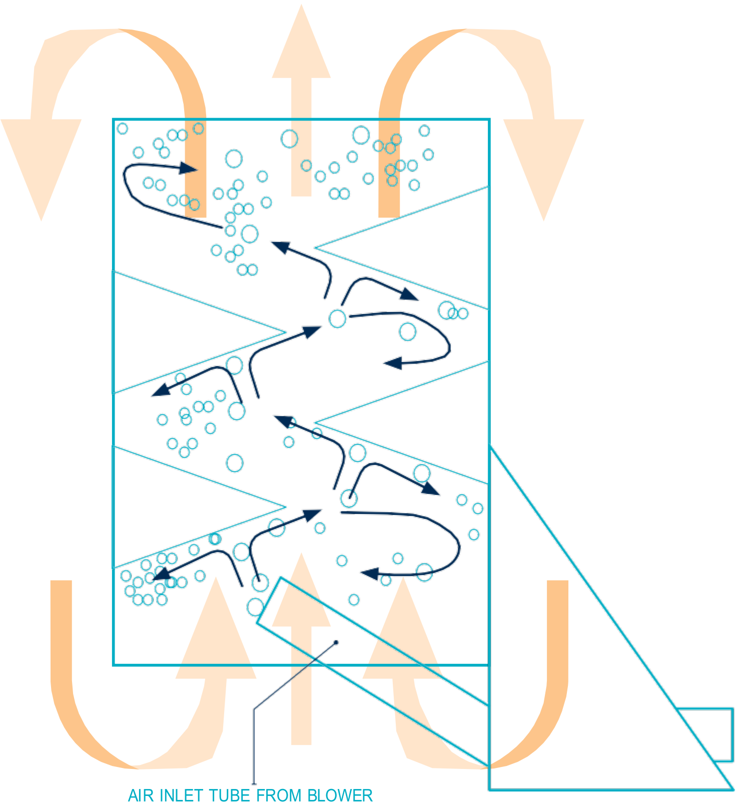
This system, in which the waste water and solids or gases are mixed, was introduced with a view to efficiently dissolve oxygen into wastewater as well as completely mixing it. A pentagon was developed whereby each pentagon section could be placed on top of one another in multiple stages in a vertical direction (**Figure 1**) with an opening impingement plate, and having a clearance between the cylindrical portion and the gas ejection nozzle with an Air inlet in a location at the bottom of the tube (**Figure 3** on the next page).

The effects of the aerator are shown in **Figure 3** and **Figure 4** (on the next page) with the discharge of actual air. It rises in the cylindrical body while colliding with the collision plate and the liquid and then forcibly discharging due to the increased pressure of the gas in the cylinder. As a result, the three parties to complete mixing - liquid, gas and solid coexist inside the cylindrical body, with the gas stage being finer due to the effects of the collision plates.

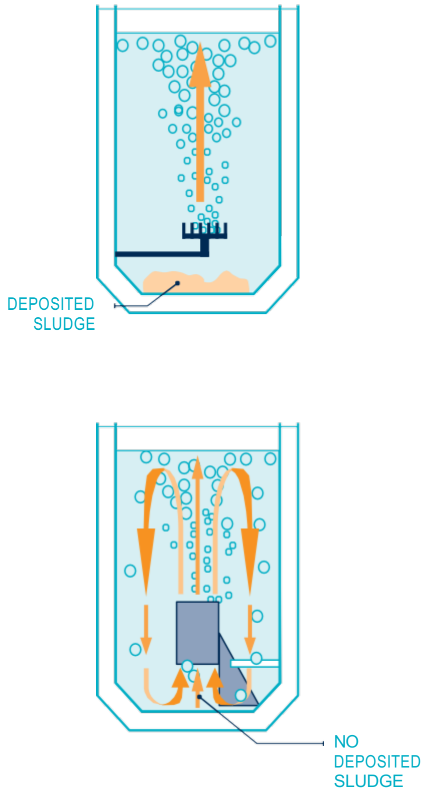
If a collision plate shown in **Figure 1** was a shape close to a circle, due to the fluid flowing along the circumference, turbulent flow in the circumferential direction would be less likely to occur. If you have polygonal shape, turbulence is likely to occur due to flow impinges on each side. On the other hand, the flow itself in the circumferential direction does not generate a large enough resistance when you use a square shape such as a triangle, and the flow would be short-circuited and only go upwards. A Pentagon has been determined as the optimum shape as a result. Moreover, from results of a study of the flow in the vertical direction for the number of stages of the impingement plate, the optimum number of stages was determined to be five stages.

SELECTION CRITERIA OF THE AERATOR IN WASTEWATER TREATMENT FACILITIES IS AS FOLLOWS:

In the aeration tank, the primary objective is the provision of adequate oxygen to activate the sludge. Design criteria is usually 2% - 17% depending on the depth, of the oxygen dissolution efficiency. The Kuh Kai aerator, is a deviation from typical design criteria due to its efficiency of oxygen and agitation capabilities as can be seen from these results. In an activated sludge aeration tank, these methods are shown in the **Figure 4** (on the next page) comparing typical porous aerator versus the Kuh Kai aerator.



Aerator Internal Gas-liquid mixing in **Figure 3**



Sludge Deposit Effects in **Figure 4**

AERATOR PERFORMANCE COMPARISON

CATEGORY	ITEM	AIR BUBBLE TYPE	MECHANICAL TYPE	KUH KAI
Oxygen transfer rate	No clogging of porous diffusers in intermittent processes during settling (denitrification)	×	✓	✓
	Complete mixing of water column of solids, liquids and air	×	×	✓
	No sludge flocculation on the tank bottom	×	×	✓
	Efficient uptake by micro-organisms by using full Biomass available	×	×	✓
Maintenance	Power saving (small pressure loss)	×	×	✓
	Facility Cost savings (easy installation and piping)	×	×	✓
	Easy Operation and Maintenance (parts replacement)	×	×	✓
	Proven Long Life Durability	×	×	✓

DATA

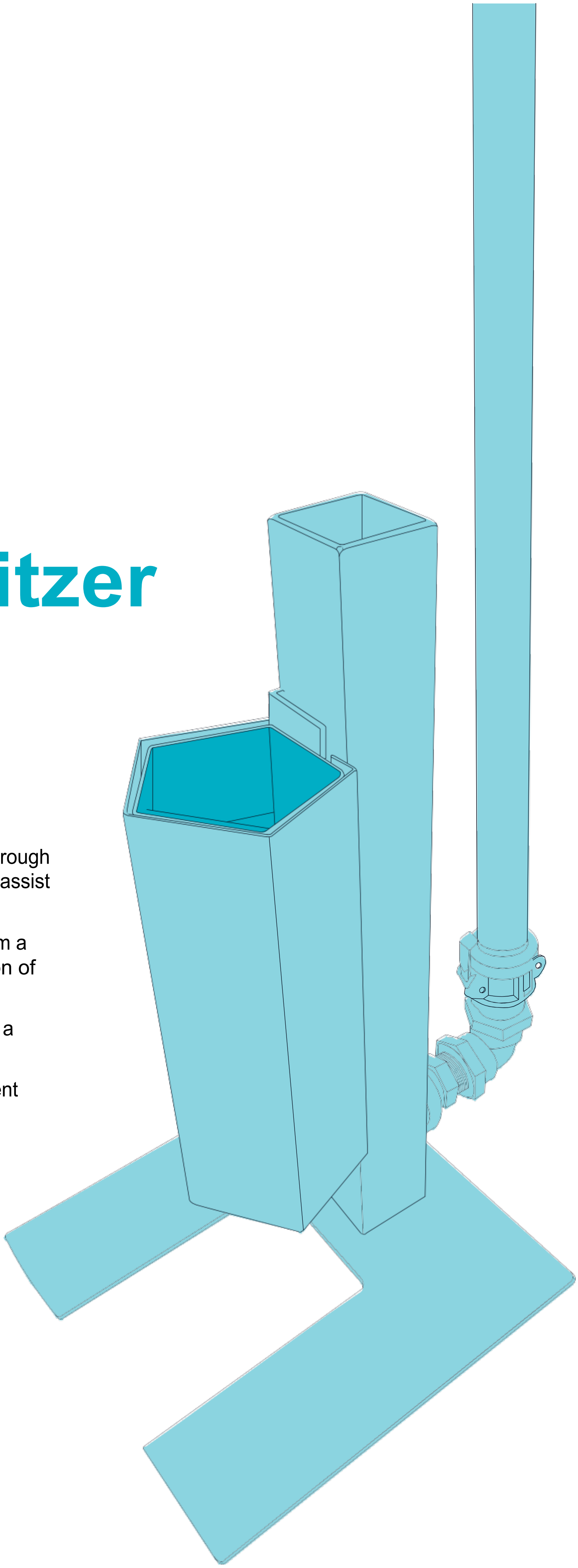
MODEL	MATERIAL		CONNECTION	WEIGHT	AIR SUPPLY VOLUME [M^3/MIN]			COVERED AREA [M^2]	ADAPTABLE WATER DEPTH [M]
	MAIN BODY	PIPING			LOWER LIMIT	SUGGESTED	UPPER LIMIT		
KA-L	Stainless steel (POM)	SUS	40A	7.2	0.4	1.1	1.5	6~12	1~
KA-M	Stainless steel (POM)	20A	20A	4.8	0.1	0.3	0.5	4~5	1~

WEST'ECO SARL
Naturally Ecologic
WISE Group

Assists in removing FATS, OILS, GREASES and odour from wet wells and pump lift stations.

Kuh Kai Wet Well FOG Blitzer

Water Aerator



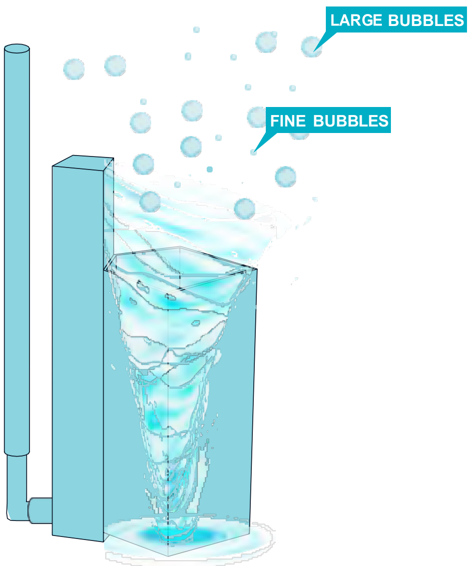
- Helps Dissolve FOG within hours
- Helps Eliminates odours
- Simple to Install

Utilising both coarse and fine Aeration bubbles through the patented Kuh Kai Aerator, the coarse bubbles assist in breaking up the FOG "scum" in the well.

The fine micro bubbles activate aerobic bacteria to form a healthy colony of bacteria that enable biodegradation of organic matter and thus also eliminating odours.

The Kuh Kai Wet Well FOG Blitzer is easy to install by a suspension chain and air hose.

A low energy Blower can also be supplied to compliment the System Package.



We can build a custom Aerator for your application!

Sonication

- Improve Denitrification Process by using sonicated sludge as carbon source
- Increase Biogas in Anaerobic Digesters
- Reduce Foaming in Activated Sludge Processes and Anaerobic Digesters

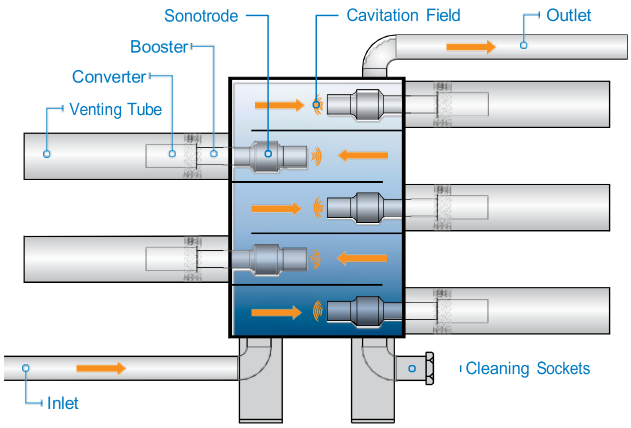
The Ultrawaves Sonication System

World Leading Technology using High-power ultrasound to break down biomass through cavitation

The principle

Ultrasound is sound with frequencies beyond audible sound, i.e. from 20 kHz up to the megahertz range. In aqueous media ultrasound waves cause periodic compression and extension of the water phase. High-intensity ultrasound is necessary to tear apart water molecules during the rarefaction phase, which results in the formation of microscopically small voids in the liquid. These voids become bubbles filled with water vapour or gas. They grow in extension phases and shrink in compression phases, until they implode.

This event is called cavitation, a process under extreme (adiabatic) conditions. On a micro scale, pressures of 500 bar and a temperature of 5,000°C are produced. Particularly large cavitation bubbles are produced within the frequency range from 20 to 100 kHz; when these bubbles collapse they cause extreme mechanical shear forces. These forces produced by ultrasound are capable of destroying even the most robust surfaces.



How it works

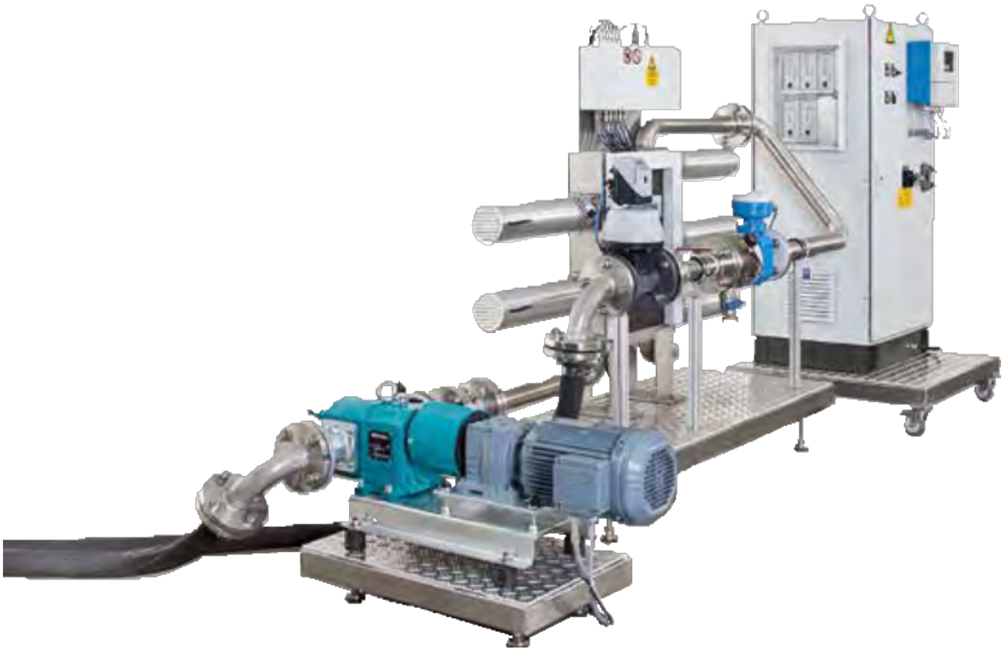
Extensive empirical studies have led to the development of a patented high-power ultrasound system, which is optimally tuned to the disintegration of biomass. Our ultrasound reactors operate as a plug flow system. Ultrasound within the lower frequency range (20 and 35 kHz) and high intensity is applied. Our ultrasound systems can be used for volumetric flow rates of up to 2 m3/h, which means that the resulting sonication time for the medium is very short viz. only one minute. It is not necessary to recirculate the medium. The flow rate can even be higher for less concentrated suspensions.

Sludge treatment

Degradation of the organic sludge fraction by conventional anaerobic sludge stabilisation is limited by the rate-determining hydrolysis step. Degrees of volatile solids degradation of 50% are rarely achieved. The cause of this lies in the difficult to access and degrade bacterial biomass of the waste activated (excess) sludge. By applying the high- power Ultrawaves ultrasound technology this limiting hydrolysis step is overcome. Therefore the sonicated excess sludge biomass is more readily available for the subsequent biological enzymatic degradation process.

Ultrasound causes disintegration of the sludge floc structure and release of exo-enzymes even with small energy inputs. This also creates more interface between the solid and liquid phase and there- fore facilitates the enzymatic attack of the active micro-organisms. A higher energy input results in the breakdown of bacteria cells, causing the cell contents and endo-enzymes to be released. These enzymes further accelerate the degradation process. The entire digestion process is intensified and the organic fraction is further degraded. An important advantage from this is a significantly increased production of biogas and reduction in the quantity of residual sludge to be disposed of. As a result of the smaller quantity of residual organic matter, the dewaterability of the digested sludge is also facilitated (less flocculent addition) and increased (higher degree of dewatering).

This disintegration of the sludge reduces its viscosity.



This is important for practical operation, as this facilitates mixing the fermenter content, which in turn results in noticeable energy savings. With the help of ultrasound technology, digesters which are at the limit of their capacity can easily continue to be operated long-term. In new installations the digesters can be designed with a shorter retention period.

Bulking sludge and foam

Seasonal bulking sludge problems often occur in wastewater treatment plants. These are usually caused by filamentous organisms. Foaming in digester tanks is also a familiar occurrence and can cause substantial operational problems.

Sonication of a small quantity of the return activated sludge or returned excess sludge exposes this bacterial biomass to permanent stress through cavitation and fluctuating pressure in the liquid medium. Ultrawaves has proven that this process causes filamentous micro-organisms to particularly suffer and therefore forces them to be permanently eliminated. Use of high-power ultrasound can therefore prevent the formation of bulking sludge and stable wastewater treatment plant operation is maintained again.

Wastewater Treatment

Nitrogen degradation: The biological nitrogen degradation takes place through nitrification and denitrification. A successful degradation process requires an additional carbon supply to be provided for the denitrification stage. Normally, methanol or another external carbon source is bought in and added to the process for this purpose.

Sonication of the excess sludge with ultrasound breaks down the biomass. This releases the cell contents - i.e. ideal carbon carriers - which are then available as an internal source of carbon in the denitrification stage. Biological nitrogen degradation in the wastewater treatment plant can therefore be maintained or even intensified. If part of the sonicated sludge is returned to the biological phase, the quantity of sludge to be disposed of is automatically reduced. Use of ultrasound for the degradation of nitrogen was successfully tested in practice and, for example, has been in operation in Bünde municipal wastewater treatment plant since 2006.

Reduction in greenhouse gas emissions - Positive CO_2 balance due to ultrasound

Electricity produced from biogas is climate-neutral, which is particularly positive for the greenhouse gas balance. Therefore, by using the Ultrawaves ultrasound systems, the CO_2-neutral energy production can be further increased.

The mathematical model drawn up by Ultrawaves calculates the emission reduction achieved by using ultrasound, as the following example shows: In a wastewater treatment plant with 100,000 p.e. ultrasound achieves a 10% relative increase in anaerobic sludge degradation. As a further consequence the dewaterability of the digested sludge is increased by 4% (relative). These effects result in a reduction in the annual greenhouse gas emissions by 1.5 kg CO_2 equivalents per p.e. This corresponds to a reduction of around 150 tonnes CO_2 equivalents per year for this wastewater treatment plant.

Further and more detailed descriptions of case studies as well as our reference list are presented on our website.

Royce Water Technologies Pilot Plant used for Trials

Royce Water Technologies has placed a significant investment into a Pilot Plant to introduce this technology to the Australian Wastewater market and invites progressive engineers and stakeholders at waste water facilities to partner us in this endeavor.