RAW BIOCHEM

NANOTERA: METHOD TO SUPRESS OR REMOVE BLUE-GREEN ALGAE BY THE USE OF MICRO BUBBLES

INTRODUCTION In recent years, water purification using micro bubbles have been developed and recognized as useful for various applications.

There are two basic methods used for the generation of micro bubbles (MB) or micro-nano bubbles (MNB).

The first practical method for the generation of bubbles in large volumes belongs to F. Ohnari, 2002. This entails the hydrodynamic shearing and crushing of the cavity formed in a swirling flow of liquid.

The Nanotera process is defined as the mechanical shearing of the mixture of both liquid and gas with an additional electro-magnetic effect in order to ionize the water that carries micro & nano sized bubbles (MNB).

This process had been demonstrated to be an effective method of generating a large volume of negatively ionized water which contains ionized MNB of the diameter in the range of 200 nm and 3 um.

The Nanotera process has been named as the Nanomiser. It is known that only bubbles are ionized in earlier methods of shearing gases. However, both the water and bubbles are ionized in the Nanotera process.

From the tests carried out at more than 50 sites ranging in size from 200 m in diameter up to 140 hectares in size, it has been proved that the combined ionization of water and bubbles is more effective for the sterilization and purification of polluted aquatic environments than any previous ionization methods.

The principle of this bubble generation process, the structure of the machine as well as several case studies carried out are outlined below. Nanotera's Nanomiser has demonstrably and repeatedly proven that the growth of blue green algae can be suppressed and reversed with minimal capital costs and management oversight.

Features/Benefits

Nanotera's Nanomiser exhibits the following attributes:

1. It will accelerate the natural degradation process of all organic waste types by encouraging greater aerobic activity through a healthy, oxygen rich environment
2. Enhances dissolved oxygen by up to 40% which prohibits the growth of anaerobic bacteria that is the source of odour
3. Ultra-fine bubbles will attach themselves to pollutants for an efficient floating of suspended and settled solids
4. Removes and destructs blue-green algae by prohibiting the growth of limiting phosphorous
5. Low operating costs with minimal electricity consumption which in turn creates a low carbon footprint
6. Significant reductions in the COD, BOD and TP & TN values
7. Odour elimination and control
8. Eliminates the need for solids and toxic bio-sludge removal or commensurate transportation costs
9. Small equipment footprint
10. A reduction in treatment time of up to 50% over alternative technologies
11. No special infrastructure or additional capital infrastructure needed for implementation

Nanomiser AND THE GENERATION OF THE FLOW OF ACTIVATED MNB/W

1.1 The mechanism for the generation of the flow of activated MNB/W Fig. 1 (a) shows a 0.75 kW Nanomiser mounted on a support of metal frame. One air inlet is connected with a plastic tube at its one end. Another end is connected with the air valve which is supported at a position well above the water surface. The water inlets are connected with plastic tubes to the filter cage which blocks out harmful or dangerous objects for the safe operation of Nanomiser which is immersed together with the cage in the water to be cleaned.

Fig. 1 (b) shows an axial section of the whole body of Nanomiser, and (c) an enlarged horizontal section of its main parts in (b). The portion indicated by dotted rectangle in (b) is the basic portion to generate the flow of activated MNB/W. The core parts of Nanomizer units are a stator and a rotor as shown in (b) and (c).

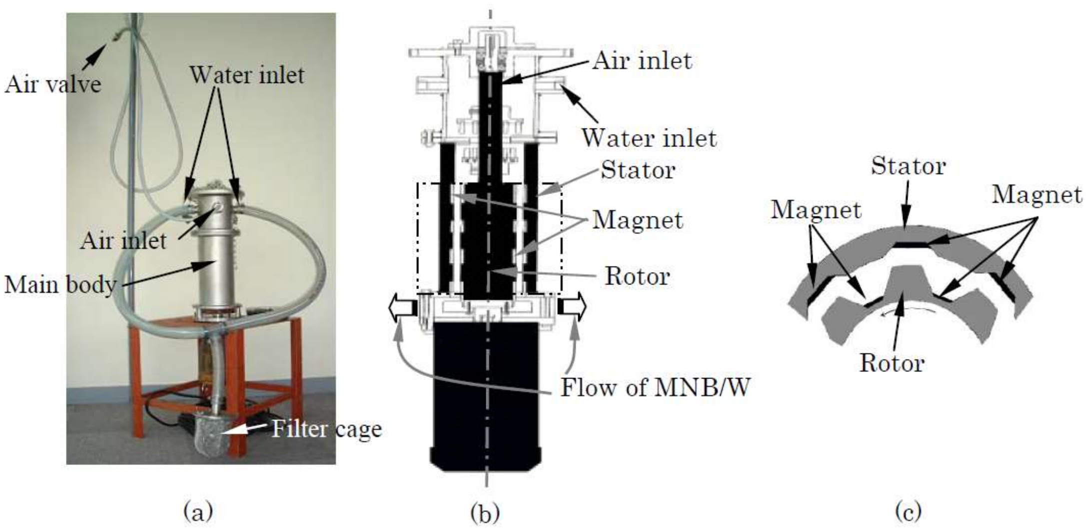


Fig. 1 The basic structure of Nanomizer

The rotor is rotated at a high speed around the fixed axis of the stator by a submersible motor mounted at the bottom of the stator. Trapezoidal grooves are engraved along the axial direction on the inner surface of the stator and also on the outer surface of the rotor.

Permanent magnets are mounted at the bottom of each groove. Water pump is connected with the shaft of the motor at the space between the main parts and the motor. It pumps out the flow of activated MNB/W into the water in all horizontal directions at the site to be cleaned.

1.2 Generation of MNB/W; The Nanomiser unit pumps water and air into the bubble generation aperture through liquid and gas inlets respectively. The mixture of water and air flows down the gap formed between the stator and the rotor.

Concurrently, the mixture which flows down along each groove of the rotor is rotated at the same speed as that of the rotor. Because the axial speed of the flow is negligibly small compared with the rotation speed, the contribution of the axial flow to the generation of bubbles can be neglected. The mixture filling each groove of the rotor is pressurized due to centrifugal force caused by its rotation.

The pressure is transferred to the rest of the flow facing to each groove of the rotor. It is kept high when the grove is not facing to any groove of the stator. It changes to low when the groove faces to that of the stator.

In other words, the pressure of the mixture of air and water in the grooves of stator and rotor is repeatedly compressed or decompressed depending on the periodical change in gap distance. As the solubility of air into water is proportional to the pressure, air is dissolved in water during the compression.

This action creates minute bubbles when the water is decompressed.

In addition, at the moment when this gap abruptly changes, the mixture flow of air and water is mechanically sheared and a large number of much smaller bubbles are generated. Because of such compression, decompression and shearing, bubbles are continuously subdivided and mixed with water. As the mixture always undergoes the same process while it moves down, bubble size becomes smaller and smaller, thus a large number of MNB is generated.

1.3 Activation of Water and MNB Permanent magnets are embedded in each groove on the surface of both stator and rotor. When the magnetic field of each magnet moves relatively to water, electrolysis takes place. (Faraday's law)

This results in the ionization of water and the generation of hydroxyl ion. In this way, the air and water taken into the Nanomiser is converted into a large volume of the flow of activated MNB/W through the powerful action of mixing, shearing and ionization.

It has been known that micro bubbles are negatively charged due to the property of water molecules and frictional charging to the surface of the bubbles. Although theoretical interpretation of the process of ionization is very difficult to analyze, in the case of the Nanomiser, the mutual motion of water and bubbles are made random in the process of the generation of MNB and the activated water that is negatively ionized is proved to be very effective for sterilization and providing useful microbes with good environment.

1.4 The properties of the bubble generated with the Nanomiser; The important factors for the purification of aquatic environments and the extermination of blue-green algae by MNB are the concentration, diameter and stability of bubbles. Fig. 2 shows an example of the distribution of the diameter of bubbles which are contained in the water sampled after 24 hours operation of a unit of 0.75 kW Nanomiser in a tank of 1.5 cubic meters filled with city water.

The data was taken with a flow type particle analyzer (APSS) developed by Sysmecs Inc. Diameter is distributed within 0.2 um and 2.2 um so that all the bubbles belong to MNB. Peak value is approximately 6 M/mL and located at 1.3 um. The total number of the bubbles was about 60M/mL. As 0.2 um is the resolution limit of the optics of the analyzer, the distribution less than 0.2 um cannot be measured.

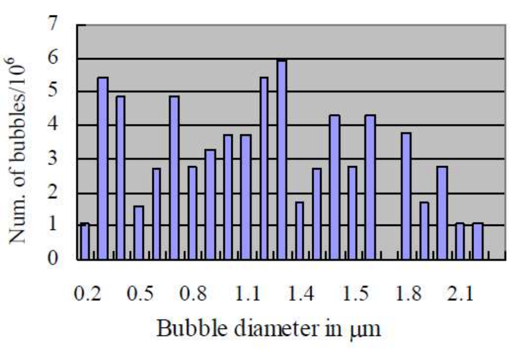


Figure 2 Distribution of Bubble Diameter

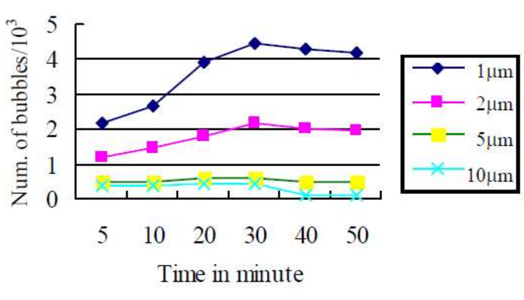


Figure 3 Variation in Bubble Population

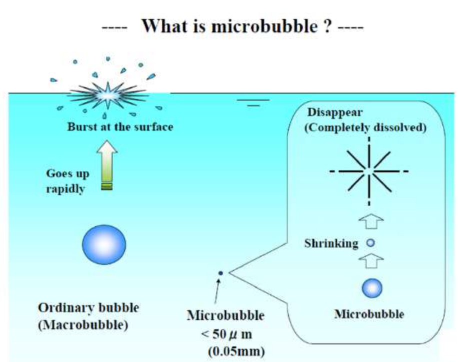
Fig. 3 shows the dependence on temporal variation of the number of bubbles for each diameter of 1, 2, 5 and 10 um during and after the operation of Nanomiser.

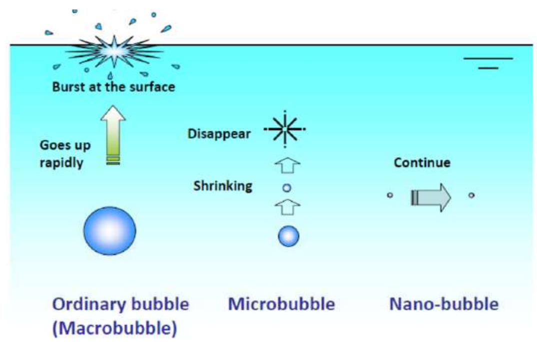
A smaller type of Nanomiser with controllable rotational speed was used for this purpose. It was operated for 30 minutes and then stopped.

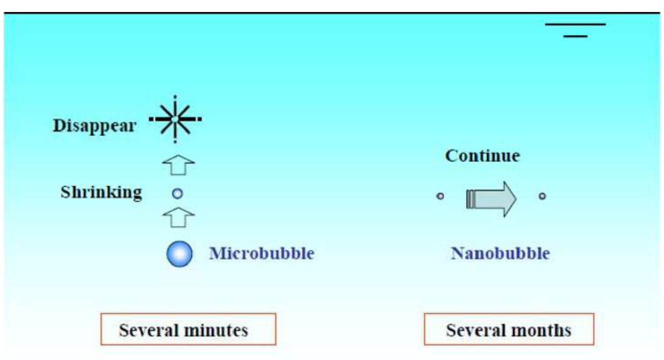
The variation of the number of bubbles was recorded for 20 minutes after the stop of operation together with the first 30 minutes during the operation. The number is kept almost constant in case of 5 and 10 um within the first 30 minutes, while it continues to increase in case of 1 and 2 um.

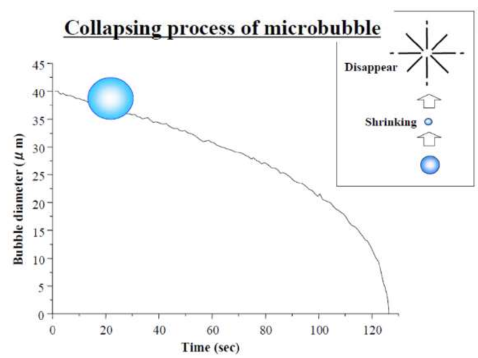
It is because large bubbles are always converted into smaller ones by means of the mechanical shear as already mentioned. It deceases during the next 20 minutes in case of 10 um in diameter.

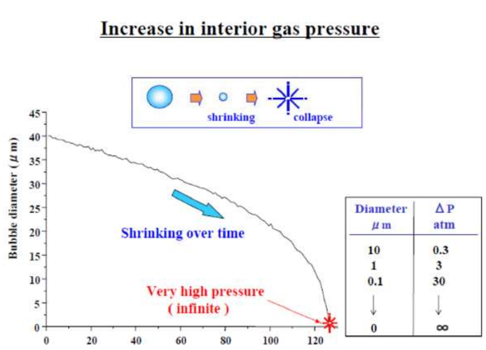
This means that larger bubbles are more instable. In the case of smaller diameters, it keeps an almost constant value. This supports the well-known property of MNB that enables it to stay stable in water. The large amount of stable MNB and water, both of them are activated, are powerful means for the improvement of BOD and COD or the restoration of good aquatic environment from the pollution caused by eutrophication.

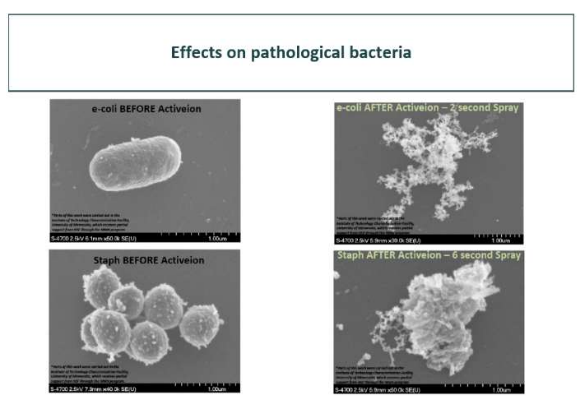


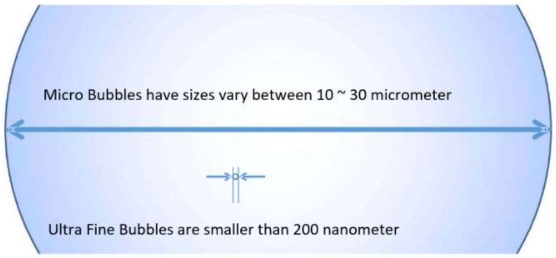






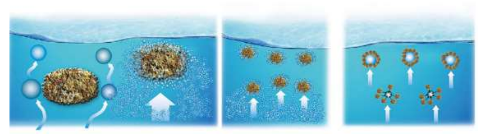






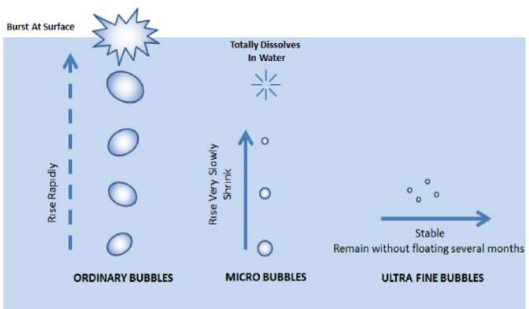
Properties of Ultra Fine Bubbles

Flotation Efficiency



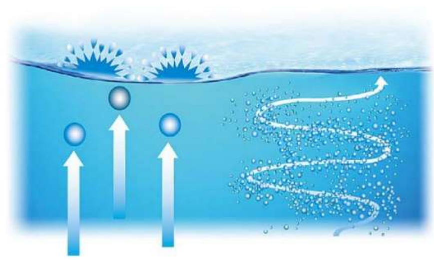
- Bubbles float up to the surface, they catch solids (**contaminants**) and bring them up to the surface
- Large bubbles often fail to catch and bring them up to the surface
- UFB can **penetrate into small dents** of a contaminant and enclose it entirely in a ball of tiny bubbles

Behaviour of Bubbles in Water



Properties of Ultra Fine Bubbles

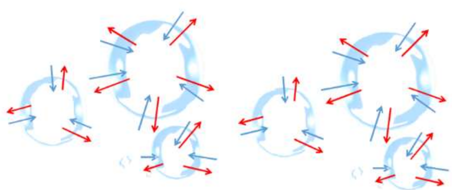
Slow Rising Speed - Longer Retention



- Due to their size **UFBs have smaller buoyancy**
- Able to survive underwater longer than larger bubbles
- **Effective difusion of gases** in the gas/liquid interface

Properties of Ultra Fine Bubbles

Self-pressurizing Effect

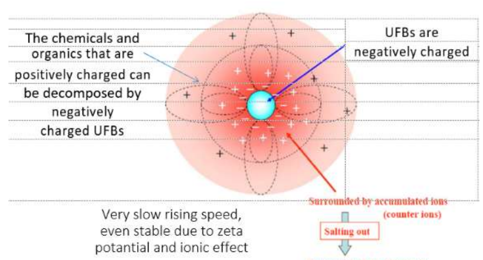


- The **smaller the bubbles**, the **higher the inner pressure** due to surface tension
- Pressurization promotes **dissolution of gas into the water**

Gas dissolves → The bubble shrinks → Internal pressure rises → Gas dissolves

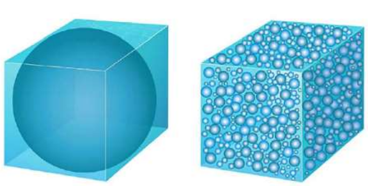
Properties of Ultra Fine Bubbles

Surface Potential - Stability



Properties of Ultra Fine Bubbles

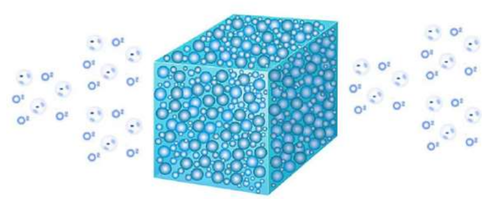
Enhanced Aerobic Activity



- **Larger contact area** between air and liquid
- The increase in the contact area dramatically enhances **aerobic bacteria activities** in the liquid
- The **efficiency of chemical reactions** between the supplied gas and liquid ingredients

Properties of Ultra Fine Bubbles

High Solubility of Gases



- Ability to **dissolve a very high amount of gas efficiently** in a liquid
- This is due to the **high contact surface area** between the gas and the liquid, and also to the **high pressure in the bubbles**

Appendix
Case Studies

Algae Removal in Reservoirs

Location: Municipality Reservoir, Kyuragi-machi, Japan
Objective: Oxygen/Ozone UFB for control of algae spread and improvement of water transpacency and stabilization of pH
Treatment period: In use for 15 years
Total Treatment Capacity; 4,000 tons
Water content: Drinking Water

Results:

1. Enhanced aeration (up to 40%)
2. Maintained continuously high levels of dissolved oxygen
3. Provided oxygen to support aerobic microbiology population growth
4. Stimulated and enhanced natural biological treatment process
5. Significant improvements in COD & BOD
6. Removed blue green algae including destruction of algae and floatation of dead cells
7. Prohibited the growth of algae by limiting phosphorous
8. Removed odours
9. Improved water clarity

Appendix
Case Studies

Algae Removal in Reservoirs

Location: Marugame Park, Kagawa Prefecture, Japan
Objective: Treatment of Blue-Green Algae
Treatment period: March 2010 – June 2010
Total Treatment Capacity; 78,000 Cubic Meters
Water content: Algae Bloom

Primary Challenges:

1. Thick layer of Blue Green Algae covering the pond
2. High Chemical Oxygen Demand
3. Bad odour from anaerobic bacteria

Results:

1. Blue Green Algae layer fully decomposed
2. 10% improvement in COD levels
3. Dissolved oxygen levels improved by 40%
4. Bad odour disappears within 2 weeks of treatment process beginning

Algae/Sludge Removal

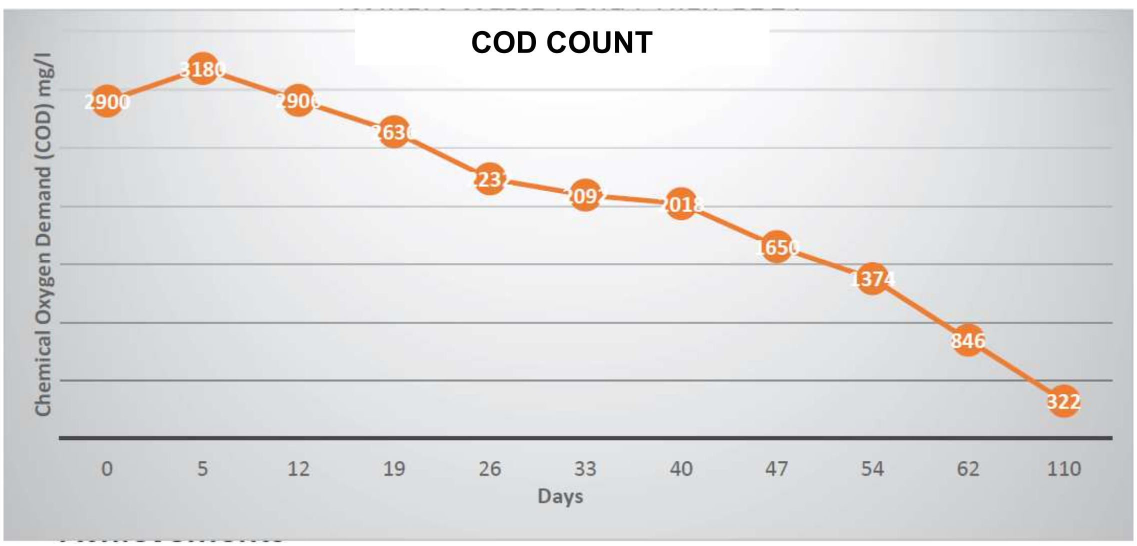
Location: Tulbagh Winery, Porterville, Capetown, South Africa
Objective: Treatment of Winery Waste Water
Treatment period: Sept 16, 2015 to Jan 6, 2016
Total Treatment Capacity; 500,000 litres
Water content: High loads of organic residue from wine-making process

Primary Challenges

1. High Chemical Oxygen Demand (COD)
2. Bad odour through elevated organic content and active anaerobic bacteria
3. High Total Suspended Solids (TSS) and Turbidity due to the high organic load and sludge at bottom of pond

Early Stages of UFB Treatment
(after one week)

After UFB Treatment
(after 2 months)



Results:

1. COD Levels drop from 2,900 mg/l to 322 mg/l within 4 months
2. Bad odour disappeared
3. pH levels rose from 4 to 7.4 in 2 months
4. After 2 weeks of treatment, bird life returned to the pond.

Purification of a pond polluted by blue-green microbes in Amusement park

Area 3,800 m , Depth 1.5 m, Water 5,700 ton

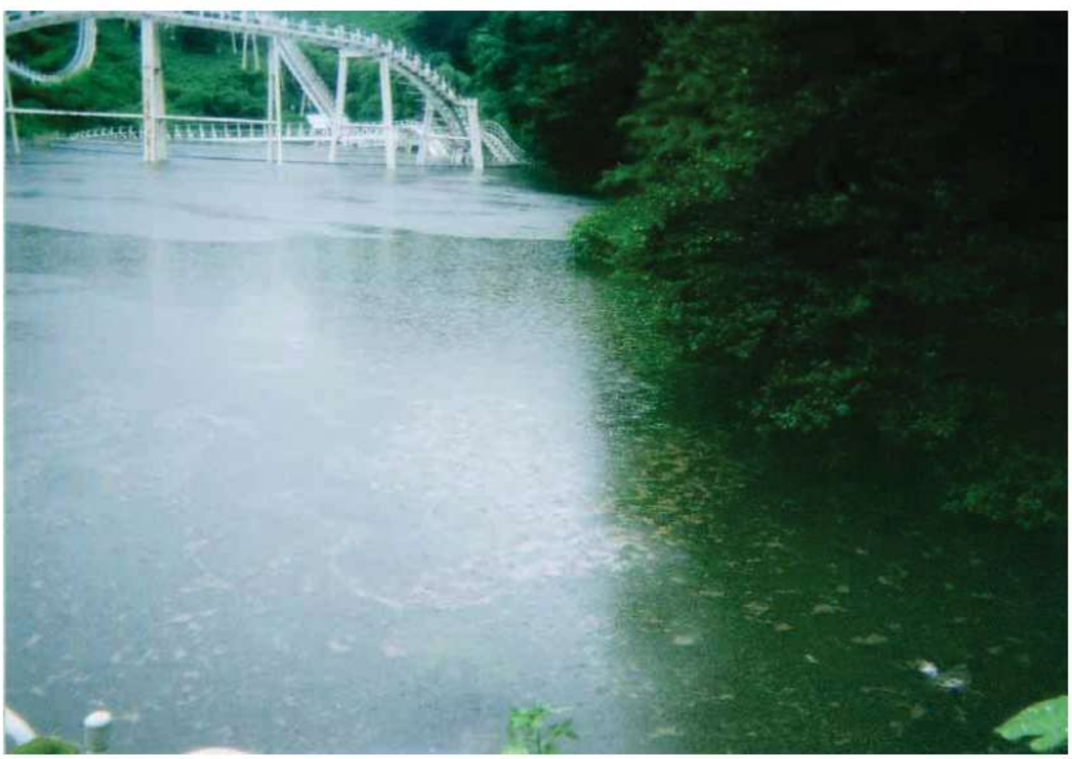
Blue-green microbes dead and floated

Floated-condensed microbes

Condensed and floated blue-green microbes

Air inlet and top portion of UFB SYSTEM is Indicated by red arrow.

Lumps floated to the surface, after condensed with sludge at the bottom of the pond

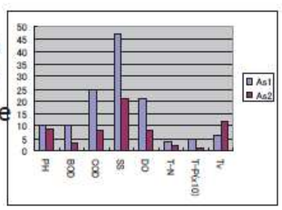


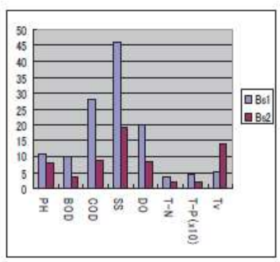
Floated matters together with viscous bubbles

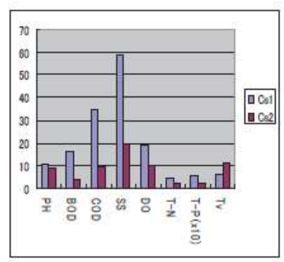
Reddish purple color suggests chemical compounds

Evaluation of Purification , 8/7 and 9/10 2002

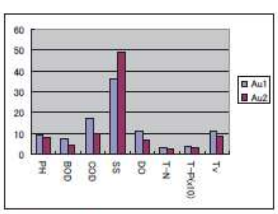
At 1 m below Surface



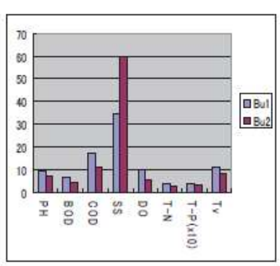




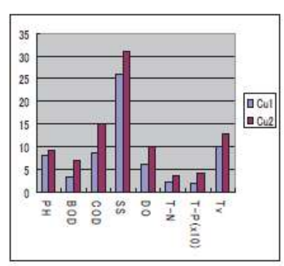
Below 1 m from surface



Point A



Point B



Point C