Water treatment technology using MU Static Spiral Perforated Wings (MU – SSPW) ™

~ The Road from Horizontal to Vertical ~

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1. Introduction

Recently, due to the global increase of industrial products and the rapid increase of population mainly in the emerging countries, the water pollution becomes serious in some regions. On the other hand, the sense of crisis of resources and global environment is spreading mainly in developed countries. Development and popularization of water treatment technology are indispensable for the formation of recycling society. Under such background, various water treatment technologies are researched and developed. MU products are unique, realizing space saving, high performance, and maintenance-free simultaneously based on original principle.

This paper first explains the principle of water treatment equipment in our company, and then describes MU-SSPW (MU Static Spiral Perforated Wings), an element that is the core of product performance. This article also introduces MU Aqua Tower, an aerator unit that refines water in air, in contrast to conventional aerators that refine air in water. Finally, we present some applications of MU-SSPW to refine air into fine bubbles in water.

2. Principle of our products for wastewater treatment

In this chapter, we explain the nature of waterfalls, an origin of the principle of core function, MU-SSPW, of our products. Then, we describe the relationship between the waterfalls and the product, followed by the law of MU-SSPW. Finally, we explain the features and applications of the product.

2-1. Physical function of waterfalls

The water is crushed by the interaction of positional energy of a waterfall and roughness of a rock. (**Photo 1**) In other words, the water flow of a waterfall is divided by falling and hitting a rock surface, whereby the running water becomes fine particles and becomes finer by further collisions. In an ordinary waterfall, most of the falling water falls into a waterfall basin, but a part of it becomes fog and stays in the air. The fact that a part of running water changes to fog means that the contact area between gas and liquid and bubble increases constantly.

Photo 1 Nachi Falls

2-2. Relationship between waterfalls and MU Mixing Element

MU Mixing Element embodies the law of nature artificially and efficiently by the refinement of water and its successive expansion of the contact area of liquid-gas phase like waterfalls (**Figure 1**). MU Aqua Tower is a water treatment tower to be installed on the ground. Some layers consisted of MU-SSPW (**Photo 2**) are packed in the tower. When liquid falls through the elements, oxygen in air can be taken into liquid. With regards to the flow of water, firstly, water is pumped up to the top of the tower and then falls down through the MU Mixing Element, which makes water divided into pieces. The division leads to the expansion of the superficial area of water, which promotes the large volume of oxygen dissolved into water. The MU-SSPW in the tower works as the bumpy surface of a rock in waterfalls.

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Fig.1 MU Aqua Tower

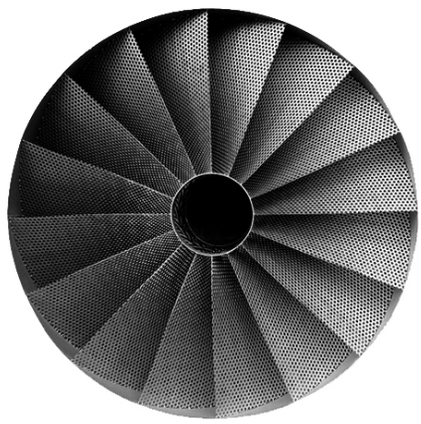

Photo 2 MU-SSPW element

Only using gravitational energy, the tower reproduces the physical function of waterfalls.

2-3. Outline of the principle of MU Aqua Tower

In MU Aqua Tower, the collision energy of falling, brought by the potential energy of the liquid, can be converted into shearing forces in a myriad of directions, which divides liquid into pieces to increase the superficial area of liquid-gas phase. MU-SSPW is the heart of our products. Inside MU Aqua Tower, multiple elements are placed, creating a cylindrical static mixer. Inside the MU-SSPW, multiple perforated wings are placed spirally and the center of the element in an axial direction is void. Because of the spiral placement of multiple perforated wings in an element, every time the liquid passes through the element, the liquid is continuously divided and mixed over time.

2-4. Principle of MU-SSPW

So, why do spirally-twisted perforated wings suit for increasing the superficial area of liquid-gas phase? When the spiral wings have a lot of holes, a part of liquid flowing down along the wings pass through the holes on the wings. By passing through the holes, the different flow arises, together with the swirling current along the surface of the wings. These two different flows promote refinement of the liquid and another split is occurred by hitting each other. Now, when it comes to the form of spiral, the surface curves seamlessly and spirally from the top to the bottom. Now the liquid is flowing along the curving surface, moving spirally, which means that the moving distance from the top to the bottom is longer than the distance of free-falling, the one of vertical straight line. Since the distance of liquid moving on the surface is longer than the one of liquid falling straight down, the time of contacting liquid with gas is also longer than the time of free-falling. Moreover, as there are a lot of holes on the surface, some of the liquid on the surface is falling down from holes onto the lower wings. The moment the liquid is coming on the verge of the hole, its movement and direction are decided by the inertial force along the blade, the viscosity, the strength and direction of force of wind. The very moment the liquid is about to fall down from the hole, the shearing force is brought by the gravity, which promotes the segmentation of the liquid. Inside the cylinder of MU Mixing Element, are several perforated wings set. The wings are set at any regular interval, and the more the area of the surface of wings per volume of the cylinder is, the more often the liquid flowing on the surface of the wings falls down onto the surface of the downer wings through the holes.

The more the area of wings per volume is, the more often liquid passes through the holes on the surface of wings, which means that liquid should be split into pieces more often. The density of area of wings is determined by two index. The one is the number of wings contained in an element. The other is the gentleness of curing of the wings. The more the number of wings is, the more the density of wings per volume is. Likewise, the more gentle the curving of wings are, the bigger the area of the

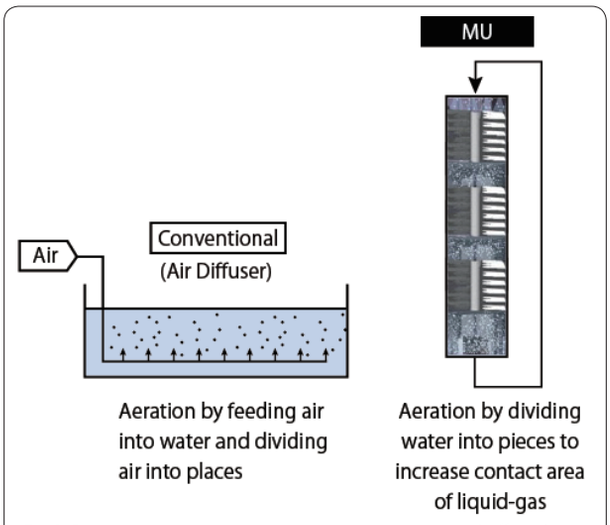

Fig.2 Comparison between horizontal aeration device (diffuser) and vertical aeration device (MU Aqua Tower)

wings is and the more the density of wings per volume is. The value obtained by dividing the area of wings with the volume of the element is defined as the efficiency of gas-liquid phase contact (m^2/m^3). The value is the key factor for scaling up the element.

These multiple wings are set inside MU Mixing Element as mentioned above. With regards to the way the wings are fixed, the inner periphery of the wings is welded onto the rings placed at the center of the circle of the elements. The outer periphery of the wings is also welded on the inner surface of the cylinder covering the whole wings. Since the rings are placed at the center of the element, the void is generated at the center in an axial direction. In the axial hole, there are no obstacle to block the axial flow of fluid. That means that the liquid passing through the hole free-falls and reaches at the bottom of the element. The axial free-fall flow is in a different direction from the spiral flow along the wings. Along the boundary phase between the axial flow through the void and spiral flow along the wings, the forces with different direction also work, which generates the shearing force on the boundary. The shearing forces also urge the liquid to be divided into pieces.

Now, let me wrap up the features of spiral perforated wings consisting of MU Mixing Element. First, the spirally perforated wings add the liquid flowing the wings with some different kinds of shearing force in a various direction. The shearing force is generated when liquid passes through the holes on the surface of the wings and the liquid hit another flow of liquid falling down from the upper hole of the wings, and the axial flow in the center contacts the spiral flow along the perforated wings. These shearing forces with different directions enlarge the contact area of gas-liquid phase. Plus, the curving of the wings makes the flowing distance longer and the contact area bigger, which promote further refinement of the liquid. MU Mixing Element is a highly efficient aeration device backed by the laws of nature, which are geometrically condensed and controlled by perforated spiral form and the difference between axial and spiral flows.

2-5. Features of the MU Aqua Tower

In this chapter, we describe the most important features of the Mu-Aqua tower with MU-SSPW, "No maintenance by self-cleaning action" and "High performance and space-saving."

(High performance and space-saving)

The main feature of MU Aqua Tower is the enhanced aeration power brought by the expanded area of liquid-gas phase. The increased area results from the vertically piled up MU-SSPW (**Fig. 2**). A conventional aerator is usually installed in water, but MU Aqua Tower is installed on the ground, not in water. The liquid-gas phase is increased not by sending air into water, but by dividing the target liquid into pieces. This is to say that the oxygen is taken into liquid by dividing water into pieces like waterfalls and wrapping the liquid with the surrounding air, not by infusing air into water. Using this way, aside from taking gas into liquid, when highly volatile substances, such as ammonia, dissolve into liquid, the substance can be efficiently got rid of from the liquid. And, by piling up the elements vertically and putting them inside the tower, a large volume of aeration can be performed only with a small space. Conventional aeration system needs a somewhat large space according to the volume of water. But MU Aqua Tower achieves high efficiency and saving space of the aeration system by making liquid impalpable.

(No maintenance by self-cleaning action)

Another feature of MU Aqua Tower is self-purification. By washing away dirtiness on the surface like waterfalls, the device doesn' t need any maintenance. By the way, when looking into waterfalls carefully, the surface of rocks near the waterfalls is totally different up to how water hits the surface. The areas where the waterfalls always hit and a sheet of spray is created have naked rock surface with no mosses grown. The other areas, where the waterfalls don't hit and mist and moisture are created by the damp of waterfalls, are covered with mosses (**Photo 1**). When water falling down from the upper hit on the surface of a rock, the power with the rocky surface divides the water. On the other side, the falling water is hit on the surface and the water pressurizes the surface, which gets rid of any attachment on it. Water, together with the potential energy, is not only hit into pieces, but also clean the surface, up to the condition of the volume of flow of water, the shape of the surface of a rock, and the angle of water hit onto the rock surface. The fracture of water makes the surface of rock clean. This is true of MU Aqua Tower. When the liquid flows down on the surface of perforated wings of MU SSPW and it moves on the verge of a hole on it, the direction of flow of liquid dramatically changes and the liquid falls down through the hole. When it hit on the edge of a hole, the flow of water is torn by the gravity to divide the water into pieces. Up to the flow of water, velocity, and how the water hit on the edge of a hole, it is decided how water is divided into pieces. In the process of the segmentation of water, the end of a hole is pressured by the force of the segmentation of water, and the force makes the surface of wings clean. Some water falling down through the holes hit on the lower wings and clean the surface. In this way, by dividing water, the perforated spiral wings get clean. For this product, to divide water into pieces is to purify the wings themselves.

2-6. Application of MU Aqua Tower

In this way, features of MU Aqua Tower are a highly efficient and space-saving device due to the vertical type of aeration, and free-of-maintenance. This tower is basically installed on the ground, but this application, due to its high efficiency and saving space, is wider than any conventional aerators. For example, this tower can be installed on the surface of the closed water, such as a pond and lake, and be floating on it by making a structure and putting on it. MU Aqua Tower is originally a device to increase a contact area of the liquid-gas phase to dissolve oxygen with water, but it can strip volatile compound, like ammonia, contained in water into air (Ammonia Stripping). In the next chapter, we will explain how MU Aqua Tower as vertical aerator applies.

3. Application of MU Aerator

In the previous chapter, the mu-aqua tower, which increases the contact interface between gas and liquid by reducing the size of water, was explained. In this chapter, some applications of the mu-aerator, which is an aerator for reducing the size of air, are described.

3-1. Closed cycle aquaculture system

As the demand for fish rapidly increases worldwide as a source of good quality protein, the supply by fishery has hardly increased for the past several 10 years, and the proportion occupied for the culture has increased. Aquaculture plays an important role as a source of protein due to global population growth.

The mainstream of the present aquaculture of marine fish is the aquaculture of small cut net fish. The merit of this culture form is that the initial investment can be reduced, if there are a working ship and a demarcated fishery right. However, the accumulation of organic substances such as nitrogen and phosphorus by the excrement and urine discharged in the process of culture, and the residual feed has a large adverse effect on the water quality of the surrounding sea area. And, there is a demerit that it is easy to be affected by external environment such as red tide.

To solve these disadvantages, onshore aquaculture was created. As systems, there are water stop breeding, flowing water pouring, semi-

	Marine	On-shore			
Type	Small net portation	Stop breeding	Flowing water pouring	Semi-circulation breeding	Closed circulation
Exchange water?	No	No	Yes	Partly yes	No
Purify water?	No	No	No	Yes	Yes
Features	・Subject to external environment ・Need a working ship and demarcated fishnery right	・Easy aquaculture ・Accumulated harmful substances ・Low productivity	・Easy aquaculture ・Low bad effect on environment ・Need a large amount of pouring water, which limit the location for installation ・High risk of disease ・High warming/cooling cost	・Low bad effect on environment ・Low risk of disease ・Low warming/cooling cost ・Limited location for gaining water ・Need water purification devices	・No location limit ・High productivity ・Low risk of disease ・Low bad effect on environment ・High initial cost ・Difficult water management

Our aquaculture system reduces initial cost and streamlines water management!

Table 1 Comparison of aquaculture systems

circulation breeding, closed circulation type, etc., and these features are summarized in **Table 1** together with the small cut net fish tank system of marine culture. Among them, closed circulating type aquaculture which is excellent in environmental conservation, capable of high-efficient productivity, low disease risk, and not specified in the place is attracting attention.

(Advantages and Disadvantages of Closed Circulating Type Aquaculture)

The advantages and disadvantages of closed circulating type aquaculture are as follows.

[Advantages]

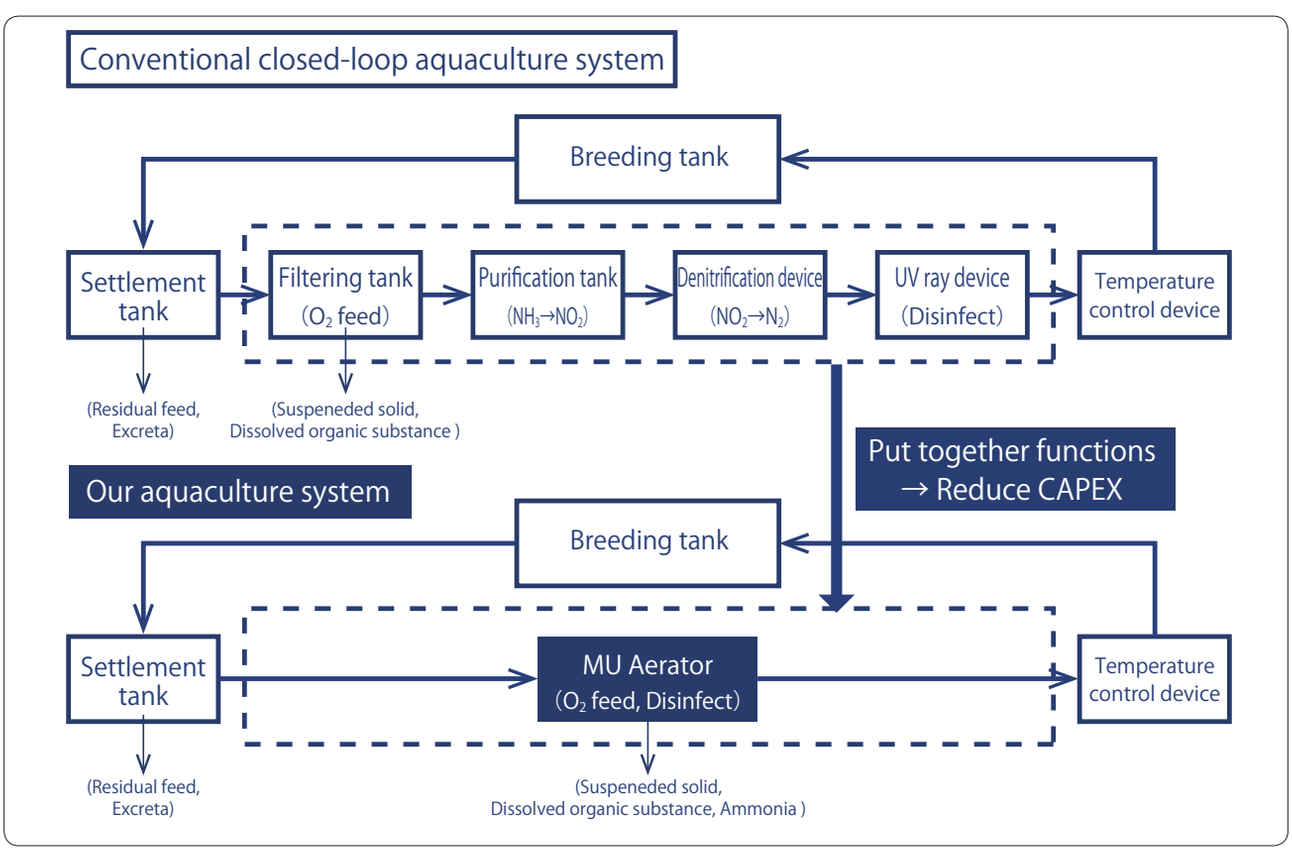

Fig. 3 Differences between conventional closed-loop circulation aquaculture system and MU water purification system

*It is not easily affected by typhoons and global warming, and artificial management of rearing environment is possible.
*Branding can be promoted, because non-use of chemicals and improvement in quality can be attempted.
*Since there is no restriction of the fishery law and regulations, the installation place can be freely chosen.
*It is connected with the employment promotion of old people, etc., because the work can be done on the land.
*The effect of excrement on the environment can be reduced.
[Disadvantages]
*It can easily wipe out fish.
*Inadequate backup systems in the event of power failure or other problems.
*There is a problem in productivity due to initial investment and production cost.

(Structure of closed-loop aquaculture systems)

This time, it is considered that the initial investment which is one of the above demerits can be substantially reduced by using our product for this system. The existing standard closed cycle aquaculture system and the system using our products are shown in **Fig. 3**. As shown in the figure, the replacement of the conventional physical filtration layer, biological purification tank, denitrification equipment, and ultraviolet irradiation equipment with MU Aerator is considered to drastically reduce the initial equipment cost and the operating cost.

In the closed-loop aquaculture system, solid removal, floating pollutant removal, oxygen supply, ammonia removal, nitric acid removal, sterilization disinfection, water temperature adjustment are treated. As a general example of the present system, a sedimentation tank is used for the removal of solid matter such as residual feed and excreta, a physical filtration tank is used for the removal of floating pollutants and oxygen supply, an aeration device is used for oxygen supply, a biological purification tank is used for changing ammonia into nitric acid, a denitrification device is used for changing nitric acid into carbon dioxide, an ultraviolet irradiation device is used for sterilization, and a temperature control device is used for water temperature adjustment.

On the other hand, only MU Aerator can replace the above four devices (physical filtration tank, biofiltration tank, nitriding device, and ultraviolet irradiation device). Oxygen is supplied by MU Aerator, which mixes gas and liquid to generates microbubbles. And, it is possible to separate and remove the floating pollutant from the water using the property in which the pollutant adsorbs and concentrates in the gas-liquid interface of the bubble of the microbubbles. In other words, it can perform the same function as a physical filtration tank. In addition, the aerator is a powerful generation equipment of microbubbles, and has a track record of stripping ammonia in water directly into air. In the conventional equipment, ammonia is nitrified to nitric acid in a biological purification tank, and nitric acid is treated to carbon dioxide in a stepwise manner in a denitrification apparatus, but this aerator can treat them all at once. Furthermore, it is known that when microbubbles collapse in water, OH radicals are generated. The OH radical has been confirmed to have a bactericidal effect similar to that of ozone.[1] Therefore, the sterilization effect can be expected in MU Aerator which generates a large amount of microbubbles.

As described above, this aerator can remove floating pollutants, supply oxygen, remove ammonia, remove nitric acid, and sterilize and disinfect the closed circulation type aquaculture system, and it can play the roles of physical filtration tank, biological filtration tank, denitrification equipment, and ultraviolet irradiation equipment. Therefore, MU Aerator is expected to play a role in the popularization of the closed circulation type aquaculture system in the future.

3-2. Radon stripping device in pure water

MU Reactor with MU-SSPW has been used as a radon radiator at the Super-Kamiokande, Institute for Cosmic Ray Research, the University of Tokyo. Super-Kamiokande is the world's largest water Cherenkov cosmic particle observation system, operated by Institute for Cosmic Ray Research in

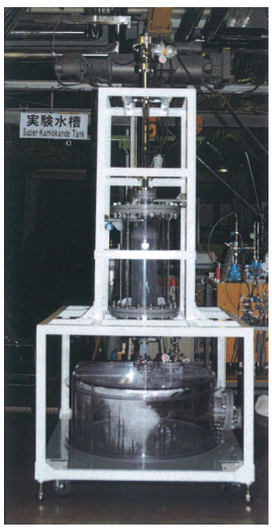

Photo 3 Radon stripping device

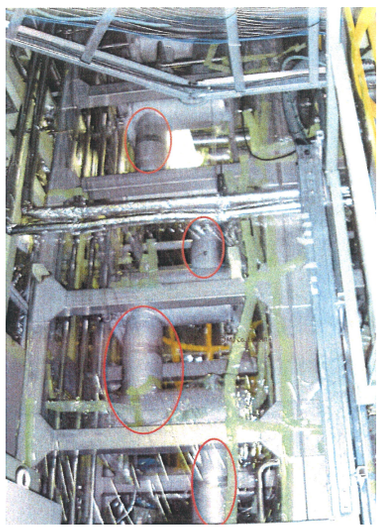

Photo 4 KamLAND vacuum deaeration device

the University of Tokyo, installed in the former Kamioka mine, Kamioka-cho, Hida City, Gifu Prefecture. It is used for the measurement of radon (Rn) concentration in ultrapure water in the neutrino observation equipment "Super Kamiokande (Super-K)" in the underground of the former Kamioka mine. That is, it is used in the process of dissipating (deaeration) Rn contained and accumulated in ultrapure water by pure air (Radon Free Air). Specifically, ultrapure water in the observation equipment is supplied from the upper part of MU Reactor, pure air is supplied from the lower part, and gas-liquid mixture is conducted by MU-SSPW in the equipment of the Reactor, and Rn in the ultrapure water is diffused (deaeration) as radon gas and supplied to the Rn measurement equipment (**Photo 3**). By highly efficient gas-liquid mixed contact using microbubbles, it was possible to dissipate extremely low concentration (0.8 mBq/m^3) of Rn contained in ultrapure water at almost vapor-liquid equilibrium value, and to measure Rn concentration in ultrapure water in the observation equipment at low level.

The size of the gas-liquid mixing part of MU Reactor is 34 mm in outer diameter, 600 mm in length, and 60 to 120 l/h of ultrapure water can be diffused. As the performance of MU Reactor, Rn in the ultrapure water can be dissipated at almost 100% vapor-liquid equilibrium value, and the liquid mass velocity is 1.4 x 10^5 kg/m^{2}h, the gas mass velocity is 2.4 x 10^2 kg/m^{2}h, and the column efficiency is 20 to 25%. The diameter is 1/6, the volume (gas-liquid contact area) is 1/50, and the gas-liquid contact time is 3/100 in comparison with the filling tower system of the conventional technology, and it is proven that the Reactor is high-efficient. The purification equipment attached to Super Kamiokande has a processing capacity of 70 m^3/hr.

3-3. Radioactive rare gas distillation device in pure oil

MU Reactor is also used in KamLAND, which is an antineutrino detector in Research Center for Neutrino Science in Graduate School of Science and Faculty of Science, Tohoku Univ. Super-Kamiokande uses a large amount of water to detect neutrino reactions, while KamLAND uses a liquid scintillator, a mixture of purified oils. Our product is used for vacuum degassing equipment of Rn and Kr in pure oil used for liquid scintillator. In order to lower the background and improve the detection sensitivity, radioactive noble gases such as Rn and Kr existing in the pure oil in the equipment are degassed and used to purify the pure oil (**Photo 4**). By gas-liquid mixed contact of micro bubbles, it is possible to dissipate Rn and Kr of ultra-low concentration (0.1 to 30 mBq/m^3) contained in pure oil at almost gas-liquid equilibrium value.

3-4. Radon measuring device in seawater

MU Reactor is also mounted on "Mirai", a marine earth research vessel (marine research vessel) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and is used for continuous measurement of radon (^{222}Rn) in sea water. "Mirai" is the largest oceanographic research vessel in Japan and one of the most powerful oceanographic research vessels in the world with the latest oceanographic observation equipment. The dynamic action of the MU-SSPW's helical 180 degrees twisted blade enabled the continuous measurement

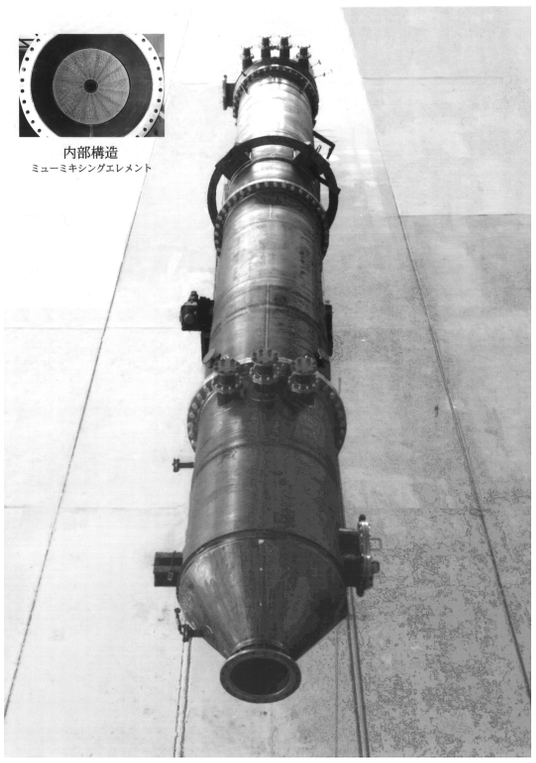

Photo 5 Vacuum distillation column

of radon 222 without losing the stripping function, even if the ship tilts 30 degrees in the turbulent Antarctic Ocean. This proof was a great achievement.

3-5. Wastewater treatment equipment containing organochlorine compounds

MU-SSPW is used to treat wastewater containing organochlorine compounds discharged from chemical plants. The wastewater includes Ca/Mg compound and organochlorine compound. The amount of wastewater is 600 m^3/hr. The inlet concentration of chlorine compounds is 200 to 500 wtppm. In the vacuum distillation column (**Photo 5**) equipped with MU-SSPW, water vapor is supplied from the lower part of the distillation column, and waste water from the upper part is supplied to the MU-SSPW to carry out gas-liquid contact, mixing, and diffusion in counterflow, and substances are transferred from liquid to gas phase. The tower is a free-standing tower of 1500mm in diameter and 18 m in height. The number of theoretical calculation stages was 8, but actually 5. In addition, there is no clogging by Ca and Mg system compounds, and it has been operated without maintenance for more than 20 years. The stripping efficiency of MU-SSPW is 85 to 95%.

3-6. Treatment equipment for radioactive contaminated water

The storage tanks for contaminated water generated by the explosion at the Fukushima nuclear power plant are increasing every day. The fission products of ultrafine particles expected to be contained in this contaminated water are ^{239}Pu, ^{238}U, ^{235}U, ^{90}Sr, ^{87}Rb, ^{93}Zr, ^{135}Cs, ^{129}I, ^{144}Nd and ^{147}Sm. 2)[(2)] The methods of treating these fission products are as follows:

1) Evaporative concentration method
2) Adsorption methods (As adsorbents, there are ion exchange resin, active carbon, molecular sheep, etc. At present, ALPS created by Toshiba is in use.)
3) Floating separation method (Using MU-SSPW)
4) Liquid-liquid extraction method (Using MU-SSPW)
5) Dilution method

and so on. Among them, 3) and 4) using MU-SSPW are briefly described below. In flotation separation method of (3), the contaminated water is treated by arranging the aeration tank or the diffusion tower with MU-SSPW in series in multiple stages. Ultrafine radioactive materials in the vent gas discharged from each aeration tank are collected and recovered by MU Scrubber. The floating radioactive material is condensed and disposed as a solidified body. The advantage is that new radioactive waste is not increased. That is to say, this is a proposal of the system which does not fall into "infinite circulation". In the liquid-liquid extraction method as (4), the liquid waste is made into a heavy liquid, the organic solvent as an extraction liquid is made into a light liquid, and the heavy liquid is supplied from the upper part of the extraction column and the light liquid is supplied from the lower part of the extraction column, respectively. In the MU-SSPW located in the center of the extraction tower, the heavy and light liquids are contacted and mixed by counterflow, and the radioactive material is transferred from heavy to light liquid, and the light liquid is discharged from the upper part of the extraction tower and the heavy liquid is discharged

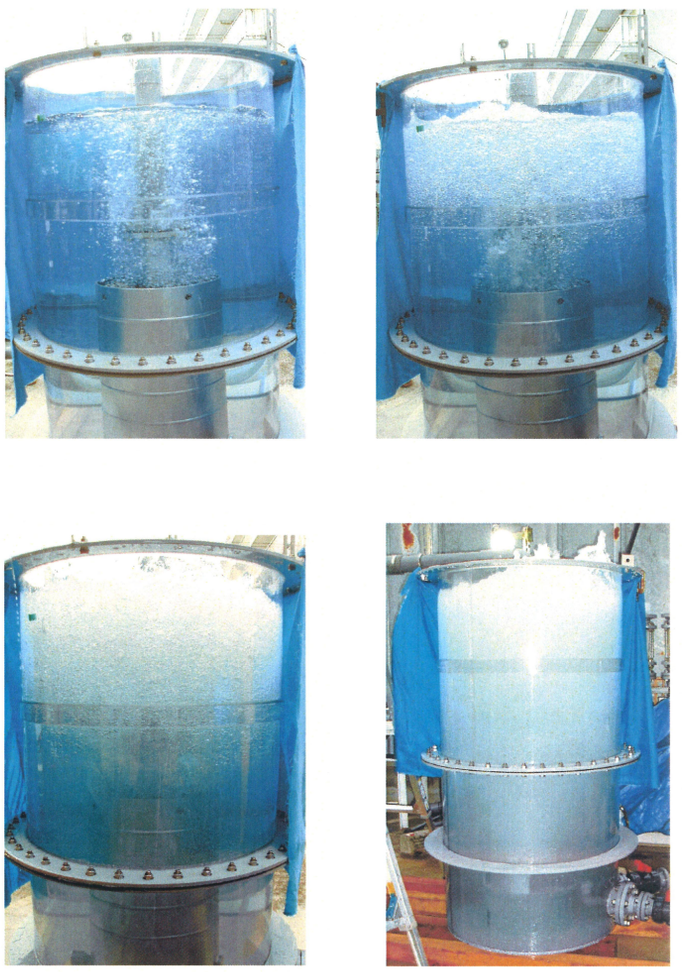

Photo 6 In a state of aeration as a model of liquid-liquid extraction

from the lower part. Light liquid is distilled and concentrated, and solidified as highly concentrated radioactive waste. TBP + kerosene is considered as an extract. Advantages of this system are as follows: (1) no mechanical movable part in the extraction column, (2) maintenance-free, (3) high performance, (4) space saving, and (5) the critical reaction can be prevented beforehand by making the center of the extraction column hollow, which is equivalent to the center of MU-SSPW, and by arranging the neutron absorber in the space. **Photo 6** shows a model of the mixing state of heavy and light liquids. Air was assumed as a light liquid and water as a heavy liquid. The biggest problem in the treatment method of radioactive contaminated water is that the detoxification of "chemical pollution" by organochlorine compounds, organofluorine compounds, organomercury, arsenic, etc. is possible by chemical and physical methods, for example, incineration, burial, decomposition, conversion of chemical formula by element combination, etc. On the other hand, in "radioactive contamination" by radionuclides, (1) conversion and shortening of half life by nuclear reaction are attempted by irradiating nuclides with neutrons, and (2) radioactive decay is waited. The nuclear reaction of (1) requires energy consistent with various nuclides. Because it is constrained by a philosophy of $E = mc^2$ that Einstein's mass and energy are equivalent. Is it possible to find a new solution?

4. Prospect

This paper describes the application of MU-SSPW to water treatment. However, it can be understood from our website (http://mu-company.com/) that MU-SSPW is an element with applicability in a wide range of fields. The results of radiation of radon under severe conditions, which were impossible by conventional treatment methods, were one of the great results. In light of this, we are working diligently with our customers toward even higher hurdles.

We would like to see the effectiveness of this system by promoting its use in the direct cleaning system of reaction, dust removal, and gas, which can be operated only with MU-SSPW. At the same time, we would like to prove that MU-SSPW can be used to break down the traditional equipment that has been frequently cleaned for many years due to dirt and clogging. It is recognized that these are the breakthrough of the traditional methods, the challenge to tray and filling with the history of 100 years. Our history of challenge is only 35 years. It has just begun. We intend to continue our challenge with the joy that favorable results are produced from the leased test equipment and improvement is realized one by one. And, we believe that the

contribution is possible by "Improvement of the global environment" which is MU's mission, i.e., 1) “Energy saving by high performance MU-SSPW”, 2) “Resource and space saving by compactness of equipment”, and 3) “Maintenance free by elimination of dirt and clogging.”

5. Conclusion

We have described the results and applications of MU-SSPW. We have described in detail the conversion of wastewater treatment technology from horizontal to vertical. He also gave a trial discussion on the treatment technology of radioactive contaminated water, which will become a problem in the future. If MU-SSPW, an innovative technology that has never existed before, can contribute to solving these problems, there will be no more joy as an engineer or as a human being. With the cooperation and guidance of all of you, we will continue to walk steadily, step by step, in a spiral fashion, to provide "delicious water" "safe water" and "a refreshing atmosphere" to all living things on the earth.

What do we see and what do we seek in the deep underground temple constructed with immortal high dose radioactive waste?

“Sakura Sakura Waga Shiranui ha Hikari Nagi”
(Michiko Ishimure, "Ten")

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