# FEATURES OF THE DAIICHI UNIVERSITY WATER RECYCLING SYSTEM: VITAL TO THE PRESERVATION OF THE HYDROLOGICAL CYCLE

*Isao Isii, *Mitsunori Tanaka and *Etsuko Okabayasi

# 第一工大方式水浄化システムの特長

*石井　勲　*田中　光徳　*岡林　悦子

**ABSTRACT**

The wastewater can purify highly efficient by the Daiich university water recycling system. The velocity inside the aeration tank is 6.7m/min on average, with a minimum of 2.8/min being achieved. The average velocity using Yakultfilter is only 0.3m/min. This slow velocity is well suited to the adhesion of bio-films and contributes to the purification of wastewater. There is a range of DO (Dissolved Oxygen) emission inside the filter from zero to saturation. Thus various types of microorganisms can multiply inside those.

Characteristics of this sewerage system are as follow. ①The treated BOD comes close to zero. ②Nitrogen removal capability ③Disposal water contains minute coliform groups. ④Minimal sludge production ⑤Ease of maintenance ⑥Recycling of effluent.

## 1. Maintains a Treatment Standard of BOD 1ppm

To begin with, it is necessary to discuss the principle of the Ishii Water Recycling System. This system mimics the river's self-purifying process and is efficient in removing wastewater contamination. Yakult containers (contact media) placed in this system function like stones in a river. They are dispersed randomly throughout the aeration tanks producing a suitable environment for microorganisms to live and multiply. Yakult is a very popular lactic acid drink and therefore empty containers can be easily obtained, recycled and utilized in the system.

There are two essential conditions that must be present in order to purify wastewater biologically:

a) Breeding of microorganisms; and

b) Continuous maintenance and breeding of microorganisms.

Focusing on theses two conditions will enable a more efficient and accelerated purification process. Each microorganism flourishes in its preferred environment of dissolved oxygen tange. The sulfur bacterium prefer to inhabit areas with low dissolved oxygen concentrations (DO). They favour an eonvironment with a DO of 0.03mg/l, whereas protozoans, such as Vorticella, requite a DO of greater than 4mg/l. As the range of DO is varied from zero to saturation

* 土木工学科（第一工業大学環境衛生開発研究所）

throughout the aeration chambers, the various types of microorganisms breed in their preferred cnvironments within the chamber.

In the conventional activated sludge process, wastewater containing oxygen is completely mixed making the DO constant throughout the tank. Consequently, only microorganisms suited to that specific DO are able to multiply and prosper.

Living things need a place to rest. For instance, human beings work during the day and sleep during the night. Likewise, birds rest on twigs when they are not flying in the sky. In the activated sludge process of sewage treatment, microorganisms in the tank keep moving from their birth to death without any rest. Just as human beings do not perform well without rest, these microorganisms become very unhealthy.

Empty Yakult-containers with the bottoms removed are set into the aeration tank. The irregular shape of the contact media causes the retention time and the wastewater flow inside the tank to be irregular (ex: sharp, straight, obtuse).

In addition, a variation of DO (named DO gradient) between the filter beds is formed. As a result, various biotas accompanied by a variety of DO concentration and water quality appear. Furthermore, wastewater inside the Yakult-containers which are situated perpendicular to the flow of wastewater are subject to an almost anaerobic environment.

On the other hand, if the filters are set parallel to the flow of the wastewater the DO concentration increases to nearly saturation. Therefore, the various concentrations of DO are distributed in the aeration chamber.

In general, the aeration chamber is filled with Yakult contact media (a relatively small sized contact media with a rough surface) which obstructs the flow, enabling microorganisms to adhere to the surface creating an anaerobic environment.

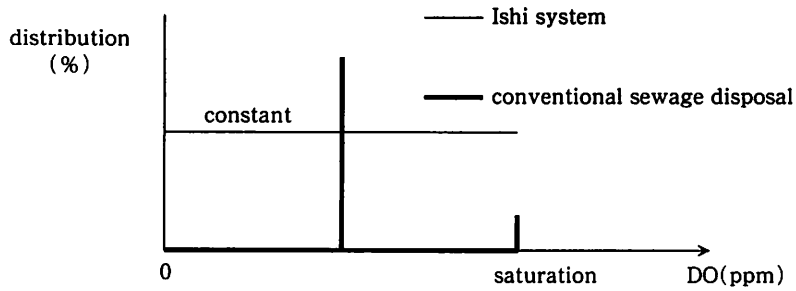
On the other hand, other types of contact media (which are larger and have a smoother surface) increases the flow which does not allow microorganisms to adhere as easily and thus creates an aerobic environment.

Therefore, the Yakult filter which holds 65 ml is the most suitable size and shape for allowing good distribution of DO in which varied microorganisms can inhabit.

Thus, the retention time and the movement of the wastewater is various. For example, the DO grade of the wastewater inside the filters that is parallel to the flow of the wastewater is very small and almost zero. But the anaerobic water inside the filters becomes aerobic later because it is driven out by the inflow from outside of the filter. Repetition of this cycle many times varies the biota upward and downward inside the tank. Moreover it activates the food chain process in order to encourage the presence of biota's which are accompanied by a variety of water quality.

Thus, mixing relatively different conditions of wastewater during the process to purify the wastewater provides highly efficient purification.

Using conventional contact media, the velocity inside the aeration tank is 6.7m/min on average, with a minimum of 2.8m/min being achieved. The average velocity using Yakult-filters is only 0.3m/min. This slow velocity is well suited to the adhesion of bio-films and contributes to the purification of wastewater. Further comparison of Yakult-filters with conventional contact media found that the quality of the material was one of the reasons for accelerated purification. The material of conventional plastic contact media contains poisonous Styrene monomers that are used to facilitate the plasticity. Using this conventional plastic contact media, there is an inherent danger that this poison will be present in the effluent and therefore, the microorganisms may not adhere to the filters. On the other hand, Yakult-containers contain non-poisonous rubbers, and have surfaces that are very rough. This is favorable to the adhesion of microorganisms to the filters.




conventional sewage disposal

## 2. Nitrogen Removal Capability

It is necessary to convert the Nitrogen in wastewater to nitrate nitrogen as an essential condition to breed denitrification-bacillus. This system, unlike similar ones has this attribute. Consequently, savings in energy costs, a low level of BOD and denitrification are all possible at the same time. In the other denitrifying systems nitrogen removal is accomplished through the addition of methanol.

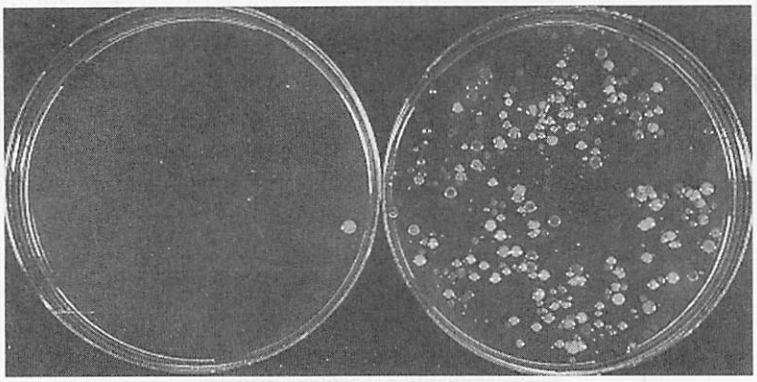
| Date | Time | Tr (cm) | pH | DO (mg/l) | BOD (mg/l) | NH4-N (mg/l) | NO2-N (mg/l) | NO3-N (mg/l) | T-N (mg/l) | T-N' (mg/l) | Re (%) | Aer (hr) | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| '97. 5.15 | 9:00 | 100 | | 7.3 | 1.3 | 10.6 | 0.9 | 24.0 | 48.9 | 65.3 | 25.1 | 24 | Aerobic |
| '97.10.29 | 16:00 | 100 | 5.6 | 8.1 | 2.1 | 10.4 | 0.1 | 40.0 | 53.0 | 70.0 | 24.3 | 24 | Aerobic |
| '97.11.13 | 10:30 | 100 | 5.8 | 6.9 | 3.3 | 6.4 | 0.2 | 27.3 | 35.4 | 60.6 | 41.7 | 12 | Anaerobic |
| '97. 8.23 | 16:30 | 100 | 6.8 | 6.8 | 1.2 | 10.0 | 0.1 | 26.6 | 38.3 | 50.8 | 24.6 | 9 | Aerobic |
| '97. 9.25 | 14:00 | 100 | 6.3 | 2.0 | 3.3 | 10.8 | 0.2 | 13.4 | 24.8 | 56.6 | 56.2 | 6 | Anaerobic |

Tr: Transparency
T-N': T-N in the fermentation tank
Re: Ratio of nitrogen removal
Aer: Aeration time
Con: the natural condition

### 3. Disposal Water Contains Minute Coliform Groups

According to some installation experiments, the number of coliform is less than 50 groups/ml (current regulation 3,000 group/ml)

1) Coliform bacteria in the effluent from on-site treatment system



Left: Ishii Water Recycling System

Right: Treatment system from another company

～ Photo - 1 ～

(Inoculated Coliform bacteria of 100ul on Desoxycholate Culture Medium)

2) A comparison of the number of coliform bacteria between the A sewage treatment facility and the Ishii Water Recycling System installed in the Republic of Palau.

(By Yaeko Masuchi, Associate Professor, University of Tokyo and Takashi Someya, Associate Professer, Saga University. April 1, 1998)

Microbiological analysis on coliform bacteria in treated water samples

| Effluent from sewage treatment facility | Effluent from Ishii-type sewage treatment system Ebcrdong's house, Koror |
|---|---|
| Numbers of coliform bacteria/ml | |
| 2,600,000 | 33 |

3) Date from the installations in Canada:

Reference Date: Quality of treated water in the systems installed in Canada

| City | Test Date | BOD5 | TSS | Fecal Coliform | Comments |
|---|---|---|---|---|---|
| Abbotsford | 97/05/07 | <2 | 5 | <2 | 1 month test |
| Aldergrove | 97/05/15 | <2 | 7 | <2 | 1 month test |
| Langley | 96/12/13 | 3 | 8 | <2 | 1 month test |
| Langley | 97/05/15 | <2 | <4 | <2 | 6 month test |
| Maple Ridge | 97/01/15 | <2 | <4 | <2 | 1 month test |
| Pitt Meadows | 97/03/19 | <2 | 4 | <2 | 1 month test |
| Pitt Meadows | 97/01/15 | <2 | <4 | <2 | 1 month test |
| Surrey | 97/12/13 | 2 | <4 | 30 | 1 month test |
| Surrey | 97/05/15 | <2 | <4 | <2 | 6 month test |
| Surrey | 97/02/15 | 5 | <4 | <2 | 3 month test |
| Surrey | 97/05/15 | <2 | <4 | <2 | 6 month test |

## 4. Minimal Sludge Production

As biomass (mixed liquor suspended solids, MLSS) exceed the certain amount, the excess of MLSS is molecularized and changed into methane, carbon dioxide, water, sulfur and so on.

As the following figures on sludge show, it has been mathematically proven that there is a certain limit of MLSS (but the details about that are so specialized that it is omitted.) For example, the experimental installation in my home has not been taken care of at all for 13 years. Another one, used by 7 people, has been in the same condition as mine since it was installed in December of 1983. Both of them have been working until now.

## 5. Ease of Maintenance

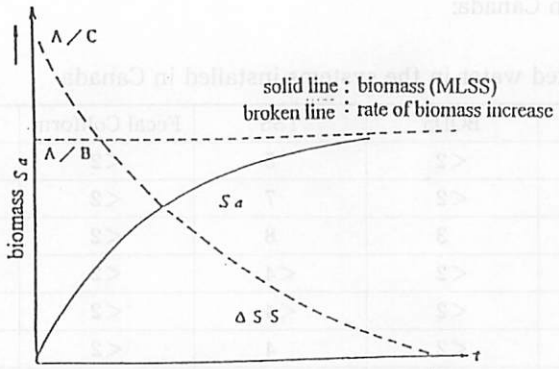
Maintenance of this system is very easy for the following reasons:

a) The production of sludge is extremely small.
b) Same particular troubles such as limitation of MLSS expansion and dissolution that are common in the activated sludge process are not encountered with this system.

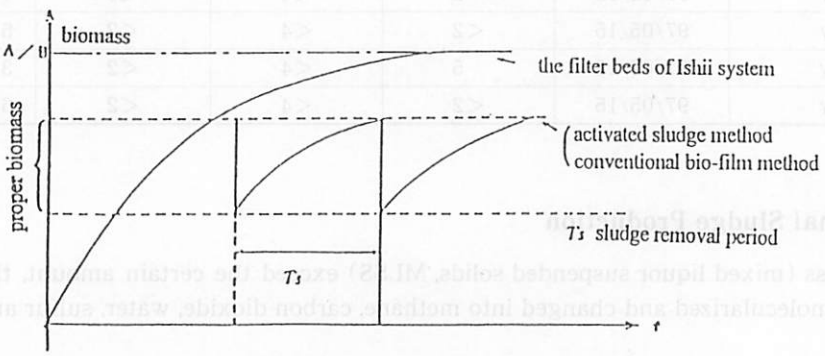
The only major upkeep required for this system is maintenance of the blower. Every two years or so blower components wear out and must be replaced.

## 6. Recycling of Effluent

The effluent from this system is ideally suited for watering plants, flushing toilets and washing laundry. Furthermore, this system is an efficient and suitable addition to help preserve the hydrological cycle and the environment, especially in cities where water resource are limited.

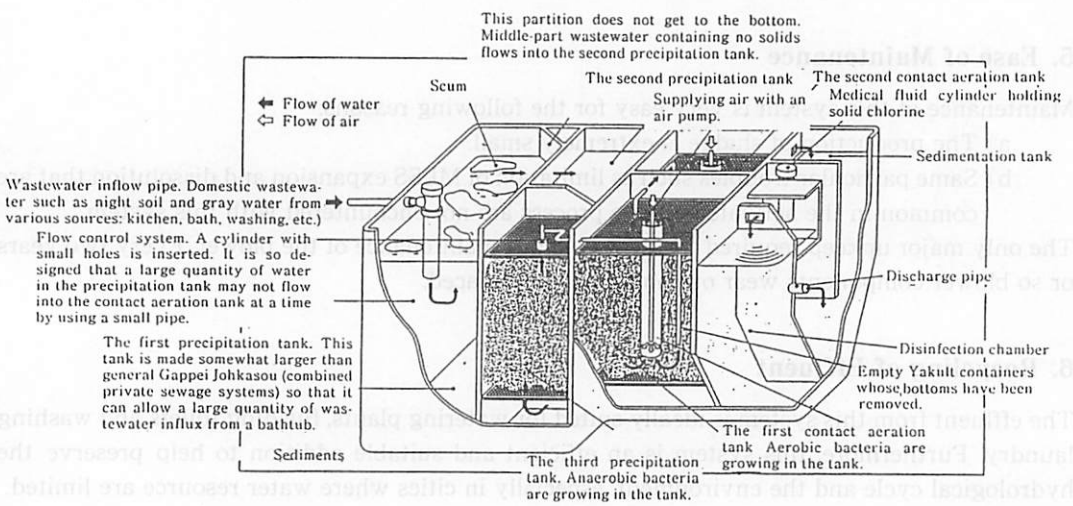



biomass (MLSS), rate of biomass increase




the fact of sludge removal in bio-treatment process

Construction of the Water-Recirculated System by the DAI-ICHI UNIVERSITY Method



FEATURES OF THE DAIICHI UNIVERSITY WATER RECYCLING SYSTEM:

## The Ishii Water Recycling System and Reuse of Effluent

Photo-2 Training of engineers from South East Asia

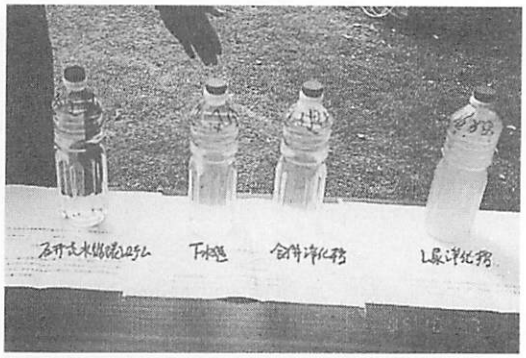


Photo-3 Comparison of effluent from various treatment systems


Photo-4 Watering plants and car washing

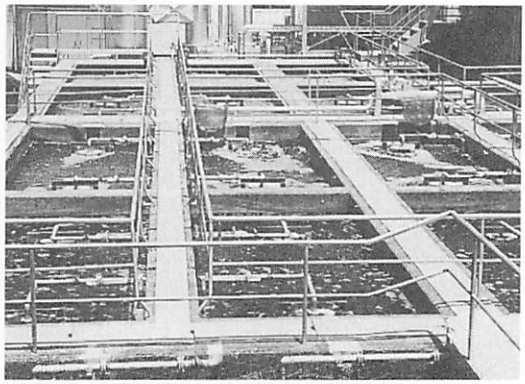


Photo-5 Overflow water purifier of Nagara-river estuary dam

Photo-6 Treatment of contaminated river in Adachi-ku, Tokyo

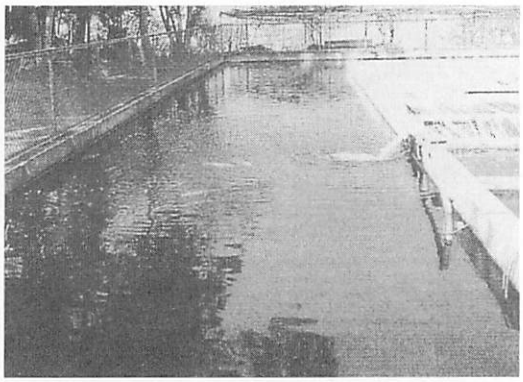


Photo-7 Effluent from seniors' home reused for pond landscaping