Water Treatment Technologies

Tetsuo Minami

Global Environment Centre Foundation

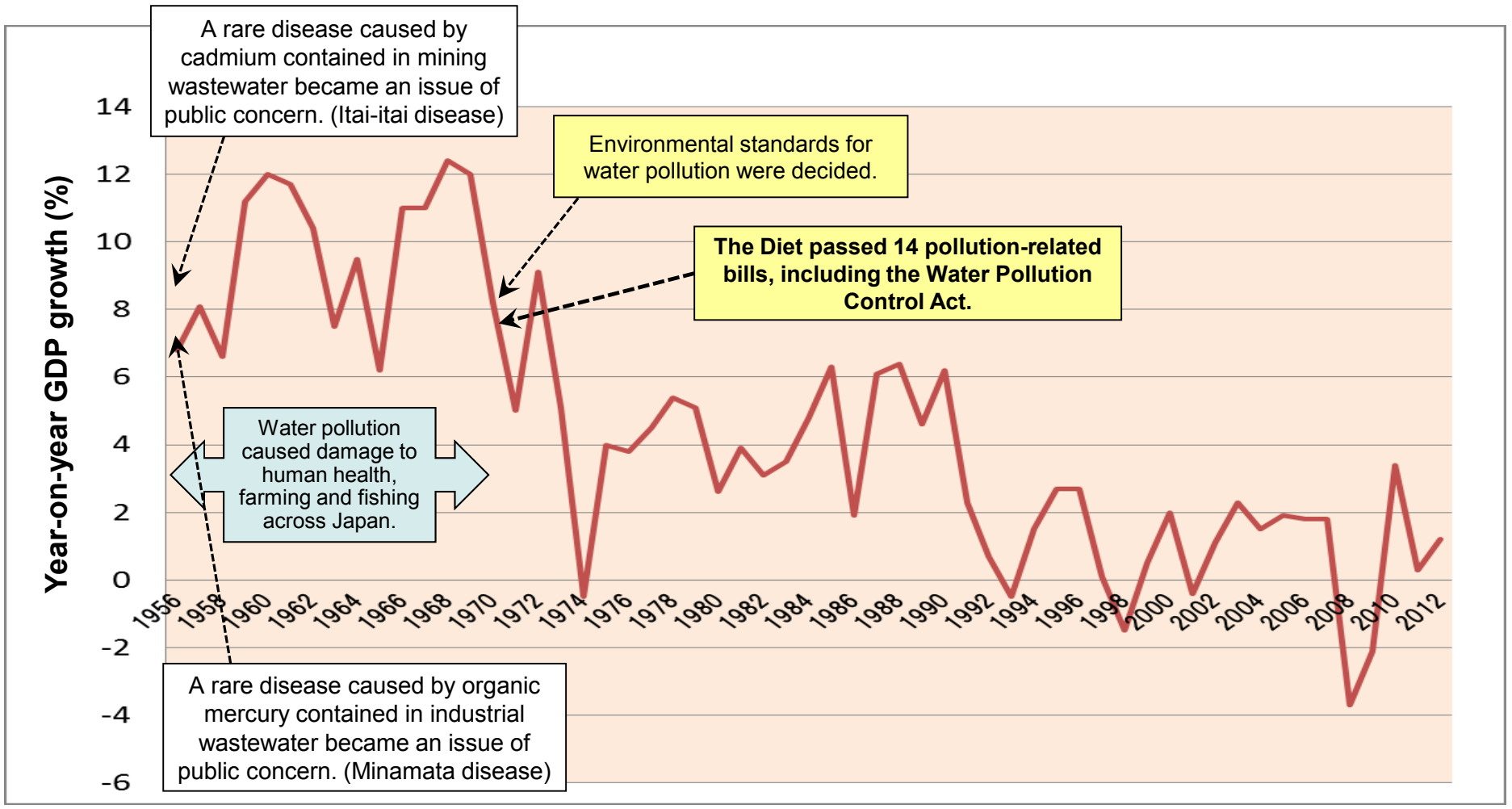
Overview of the Global Environment Centre Foundation (GEC)

- Programs:
  (1) Supporting the activities of the United Nation Environment Programme (UNEP) International Environmental Technology Centre (IETC)
  (2) Offering technical cooperation and other assistance to developing nations in the areas of environmental conservation and measures to address global warming
- Date of founding: January 28, 1992
- Responsible ministries: Ministry of Foreign Affairs, Ministry of the Environment
- Locations
  Headquarters: Ryokuchikoen, Tsurumi-ku, Osaka
  Tokyo Office: Bunkyo-ku, Tokyo

Principal GEC programs

- UNEP IETC projects
- Projects promoting business exchanges with developing nations in the areas of environmental and energy-saving technologies
- Secretariat for the JCM Financing Programme under the commission of Ministry of the Environment, Japan
- JICA training in environment-related fields, etc.

Japan's High Economic Growth and Environmental Pollution



Source: EDMC Handbook of Energy & Economic Statistics in Japan (2014)

Major Water Pollution Incidents in Japan

Niigata Minamata disease (Niigata)

Organic mercury

Itai-itai disease (Toyama)

Cadmium

Osaka Prefecture

Tokyo Metropolitan

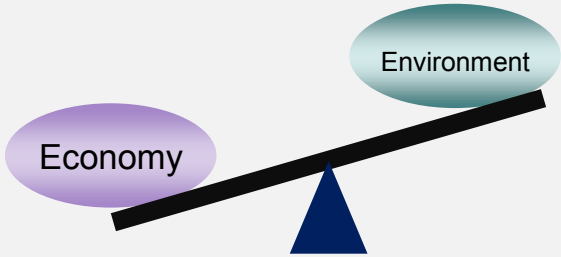
Minamata disease (Kumamoto)

Organic mercury

Damage to local fishing (Chiba and Mie)

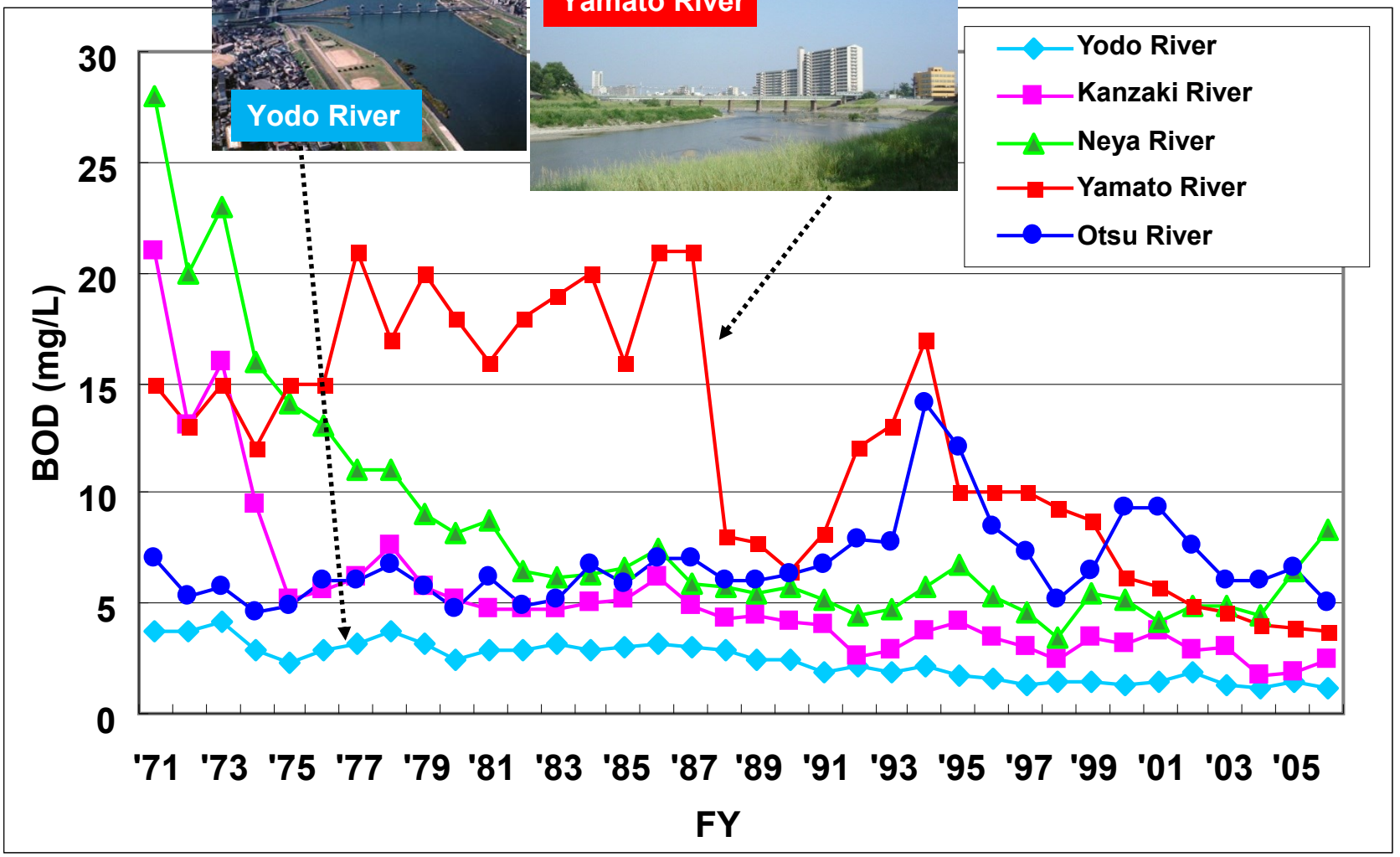
Relationship between Industrial Development and Anti-pollution Measures

- Economy has priority over the environment during a high economic growth period.
- It is difficult to clarify a causal relationship between health damage and environmental pollution.
- It takes a lot of time and cost to restore polluted areas.

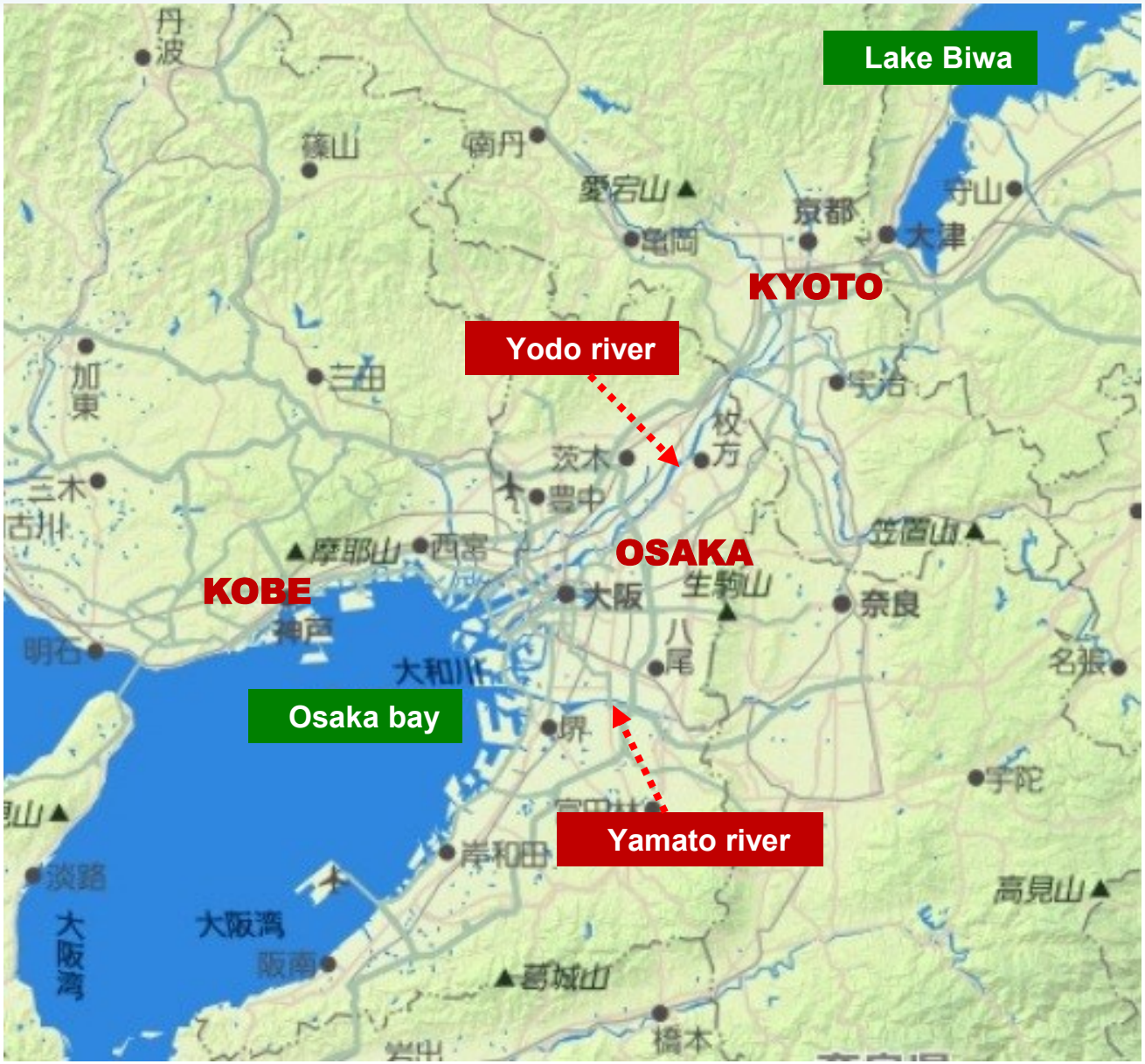


It is important to establish and properly operate necessary laws to prevent environmental pollution.

Improvement of Water Quality by Sewerage Improvement and Drainage Control (Osaka)



Watershed of Yodo river and Yamato river



Current situation of Yodo river in Osaka

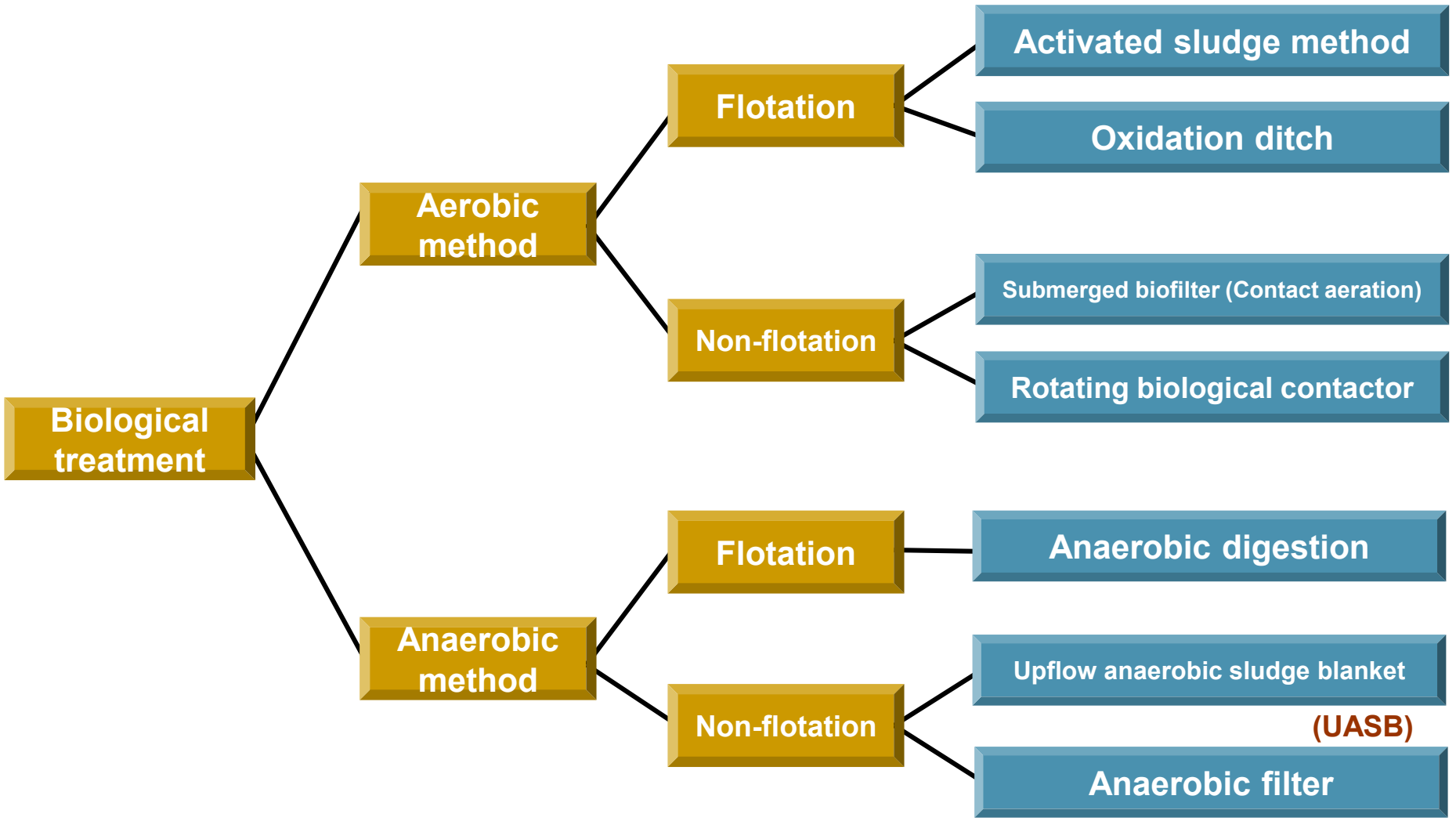
Organic wastewater qualities and their treatment methods

Biological treatment using activated sludge method that utilizes microbiological activity is commonly applied for treatment of wastewater that contains high level of organic matters.

Business category	Wastewater quality (before treatment)	Treatment method/remarks
■ **Starch manufacturing** (Starch, corn starch, etc.) Wastewater discharge: 100 – 3,000 m^3/day	• pH: 6 - 8 • BOD: 500 – 20,000 mg/L • SS: 5,000 mg/L • T-N: 100 - 200 mg/L	• UASB Method, Anaerobic treatment method, Activated sludge method <Remarks> pH change due to putrefaction
■ **Animal and vegetable oils and fats manufacturing** (Animal and vegetable oils and fats) Wastewater discharge: 100 – 2,000 m^3/day	• pH: 4 - 9 • BOD: 100 – 2,000 mg/L • SS: 400 – 1,000 mg/L • T-N: 20 - 30 mg/L	• Flotation treatment method, Activated sludge method <Remarks> Separation of emulsified oil
■ **Pharmaceutical manufacturing** (Synthetic drugs, vaccine, vitamins, etc.) Wastewater discharge: 1,000 – 3,000 m^3/day	• pH: 2 - 11 • BOD: 40 – 2,500 mg/L • SS: 200 - 600 mg/L • T-N: 80 - 100 mg/L	• Activated sludge method, Neutralization precipitation method <Remarks> Discoloration, odor
■ **Daily products manufacturing** (Butter, cheese, yogurt, milk, ice cream, etc.) Wastewater discharge: 1,000 – 6,000 m^3/day	• pH: 6.5 - 11 • BOD: 50 – 1,000 mg/L • SS: 70 - 150 mg/L • T-N: 30 - 40 mg/L	• Flotation treatment method, Activated sludge method <Remarks> Residual chlorine

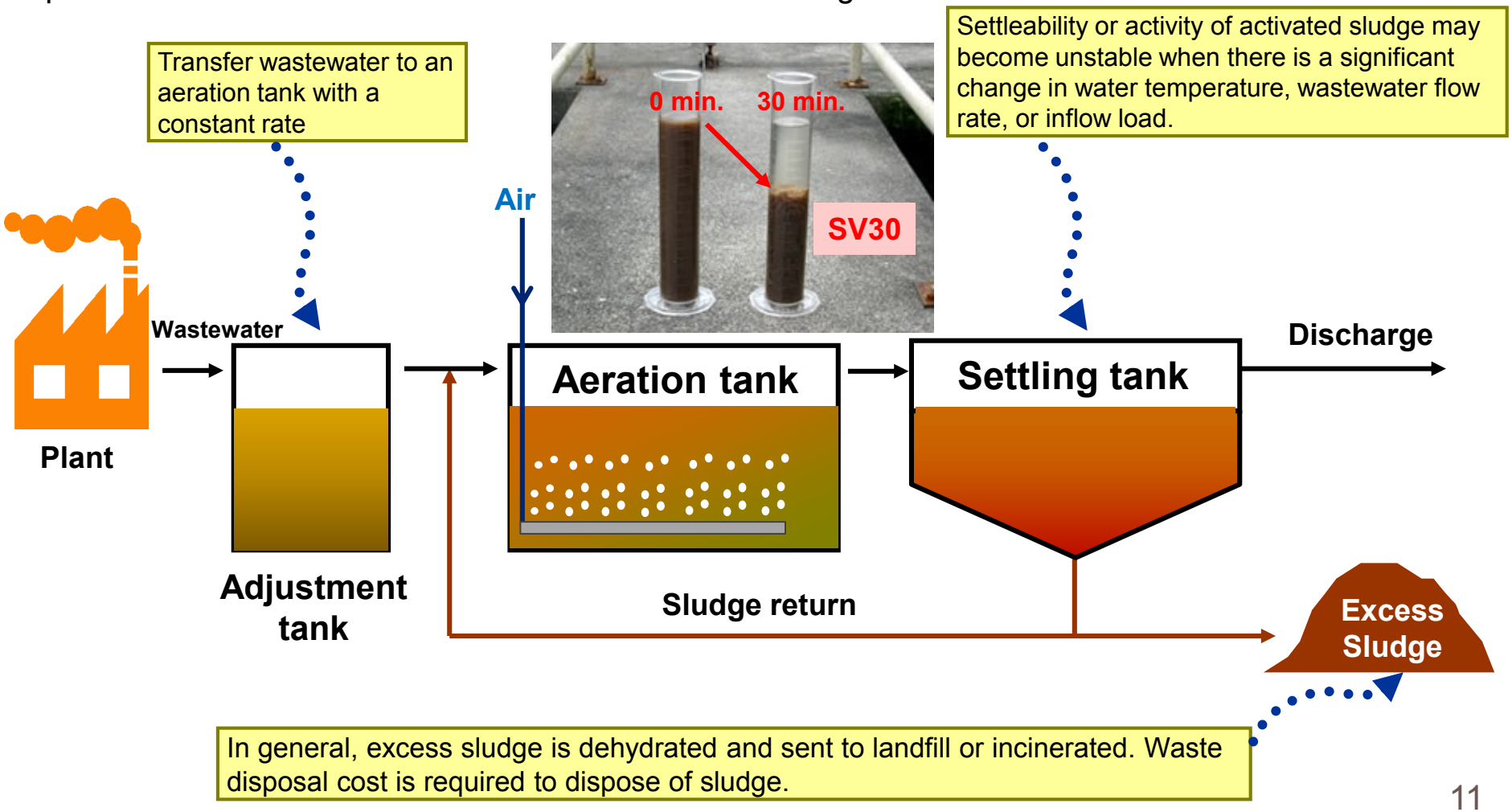
Source: Prepared based on information from Japan Environmental Management Association for Industry or research data from foreign countries.

Biological treatment technologies



Outlines of activated sludge treatment method

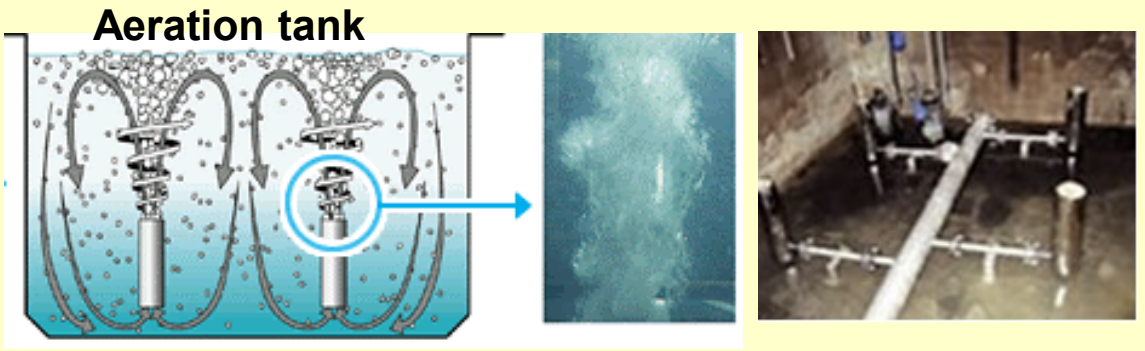
Organic matters contained in wastewater that flows into an aeration tank is decomposed by aerobic microorganisms in the presence of oxygen by aeration, and the mixed solution is then transferred to a settling tank where the solution is separated into sludge and clear water (solid-liquid separation). The supernatant water is considered as treated water and sludge is sent back to an aeration tank.

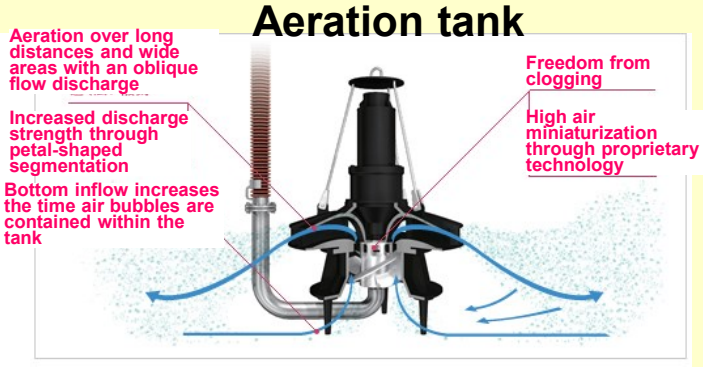


Aeration technology for activated sludge method

There are various aeration techniques to supply oxygen for aerobic microorganisms. Besides the followings, a surface agitation system is also available.

Aeration using micro bubbles generated by strong water stream created by agitation and circulating system

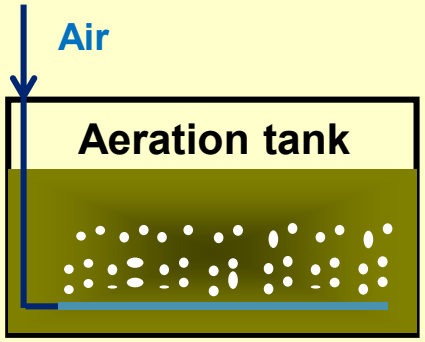




Aeration using micro bubbles generated by strong water stream created by agitation and circulating system

Source: Osaka Prefectural Government water-related technologies website

Aeration technology for activated sludge method

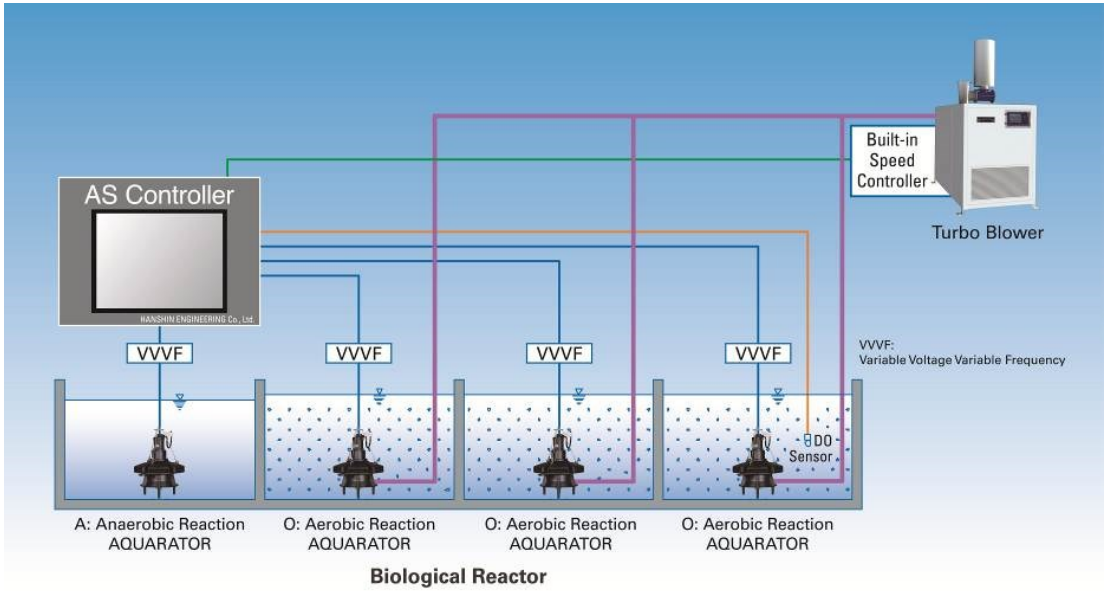


Aeration by micro bubbles using diffuser equipment (tube type, panel type, etc.)

Source: Osaka Prefectural Government water-related technologies website

Submerged Mechanical Aerator/Agitatior

Hanshin Engineering Co.,.Ltd.



Features

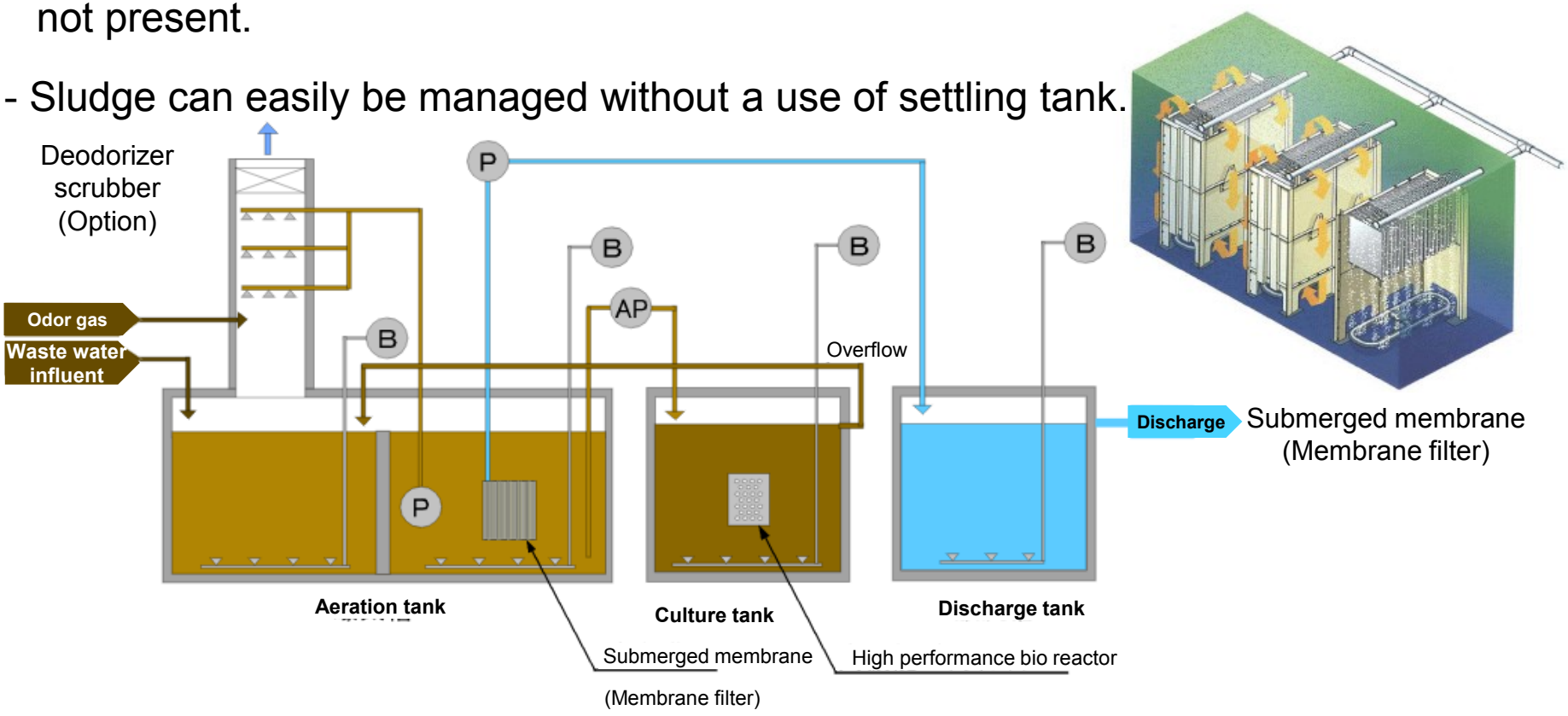
- High oxygen dissolution efficiency and high energy efficiency.
- Slude condition can be mantained good condition and it can not accumlate on a tank bottom so that the treatment is able to be stable.
- Maintenance is not necessary frequently and easy. No need to remove sludge from a tank and clean there during the maintenance.

Activated sludge method using membrane technology (MBR)

- MBR(Membrane Bio Reactor) uses membrane (membrane filter) to achieve solid-liquid separation for the activated sludge treatment process, so settling tank is not necessary. (space saving)

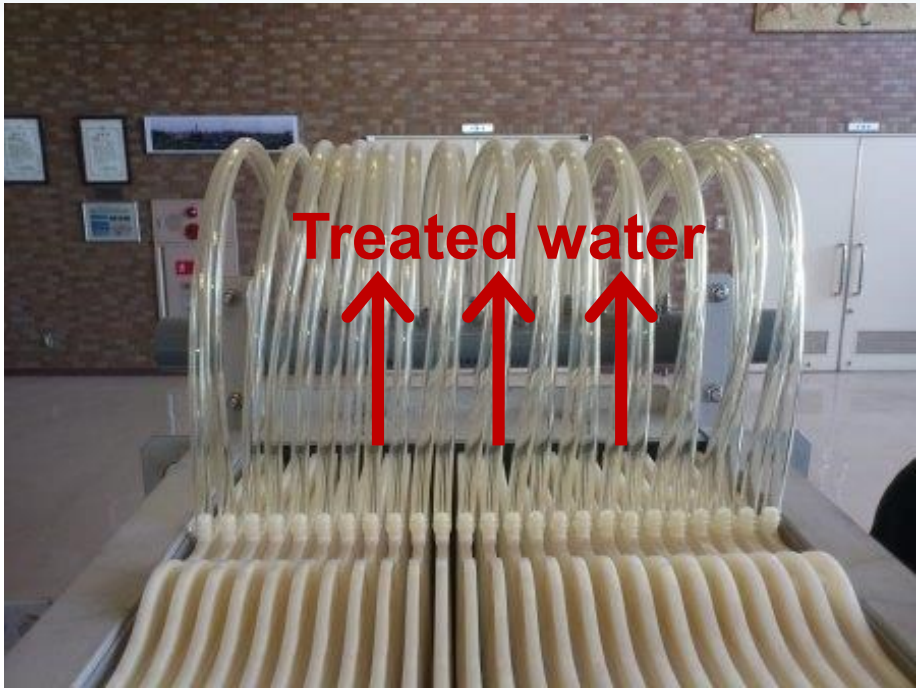
- Since the treated water passes through membrane (MF membrane, etc.), SS are not present.

- Sludge can easily be managed without a use of settling tank.

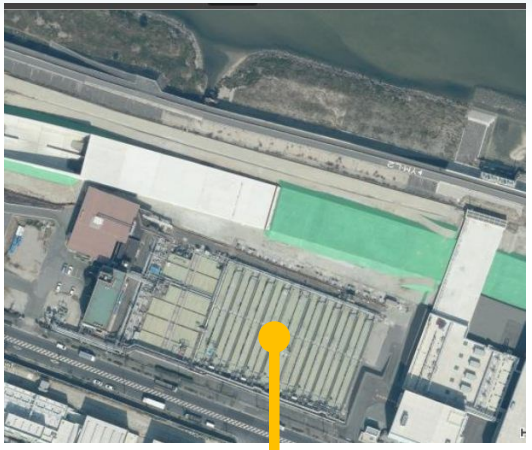


Source: Osaka Prefectural Government water-related technologies website (partly)

Example of usage of an activated sludge method using membrane technology (MBR)



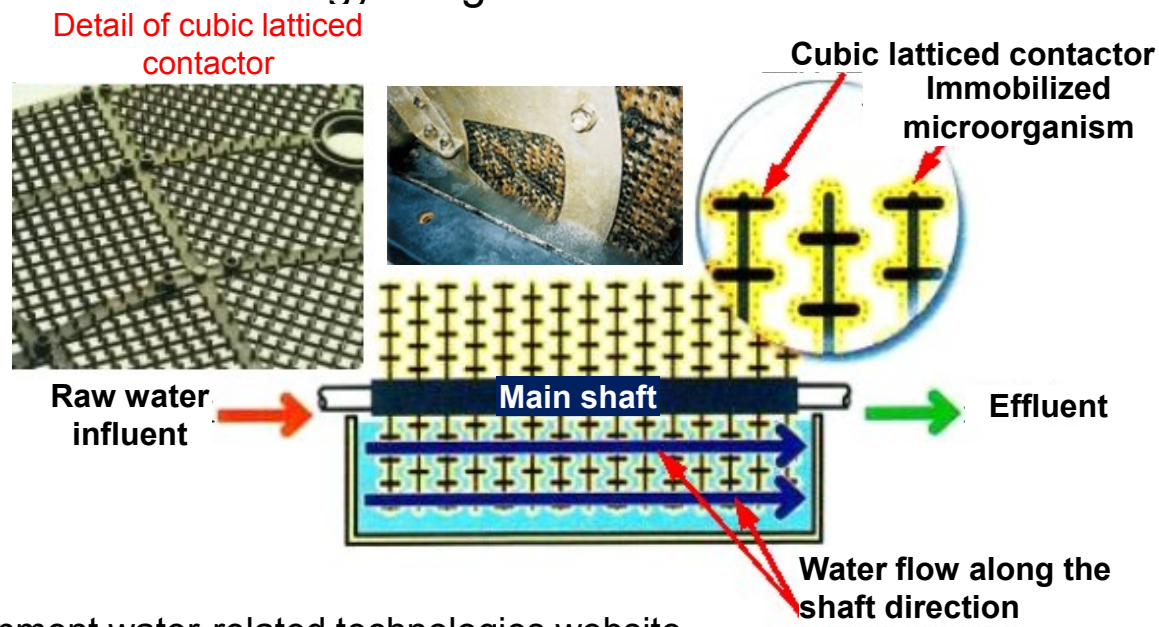
Top of membrane filter unit



Installation of MBR at sewage treatment plant

Outlines of a treatment technology using rotating biological contactor

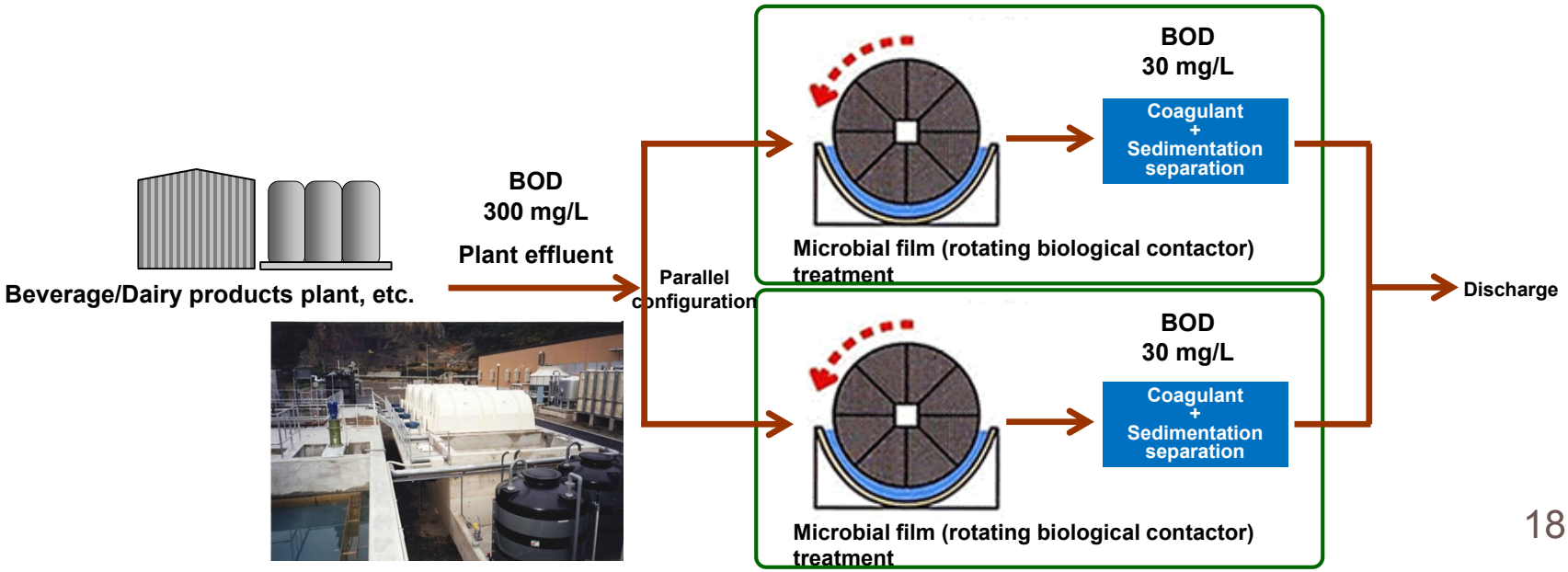
- This system purifies wastewater using a microbial film adhering to a cubic latticed contactor.
- The contactor slowly rotates in a condition that a part of the contactor is submerged in the wastewater. In the way, the unit can absorb oxygen from the air and pollutants from the wastewater to decompose the pollutants in an aerobic condition.
- While the number of microorganisms continuously increase during the decomposition process, those with decreases activity level drop off the contactor and settled in the settling tank.
- Since the system consumes lower power than activated sludge method which uses an aeration blower, the operation-related energy usage can be reduced.



Source: Osaka Prefectural Government water-related technologies website

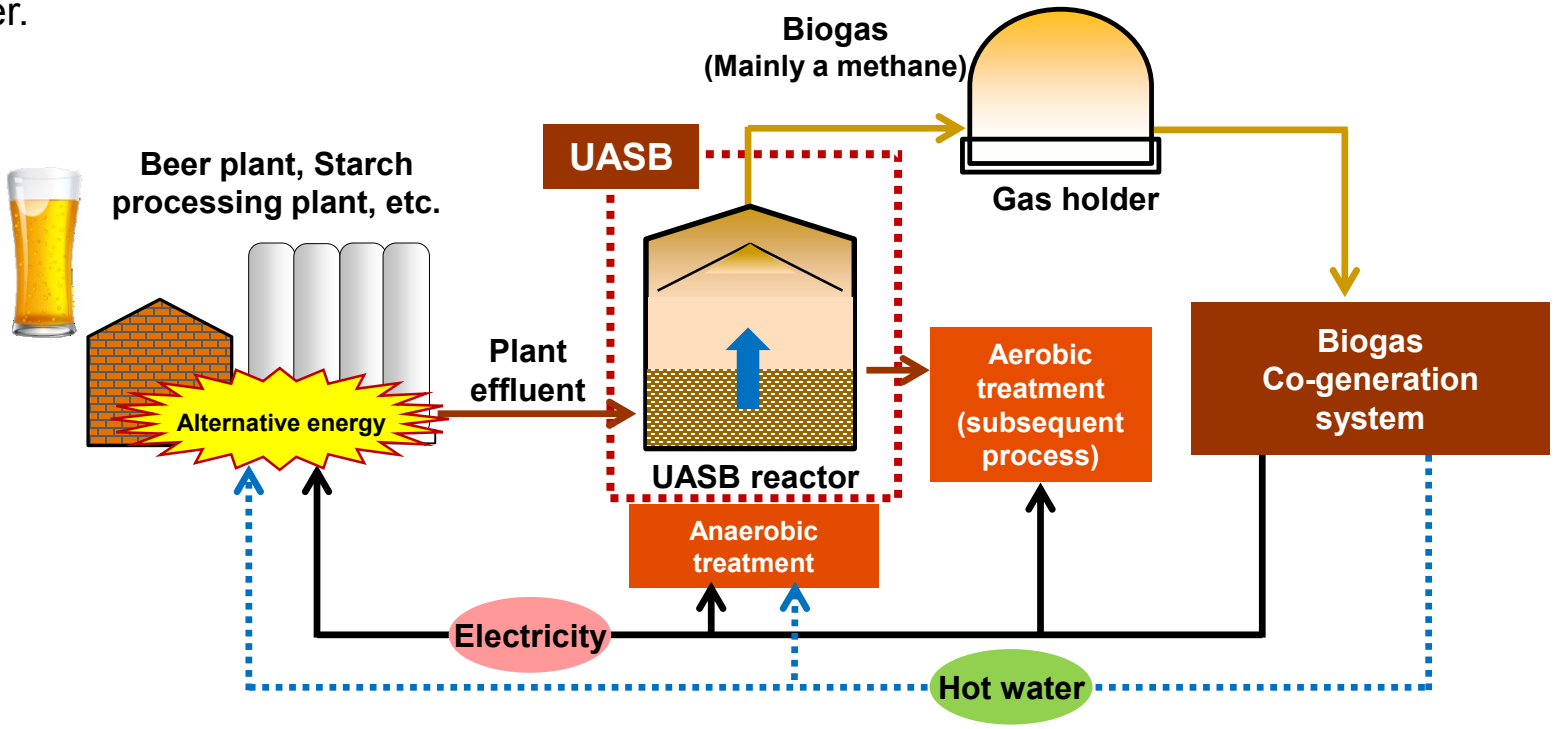
Example of usage of a treatment technology using rotating biological contactor

- Wastewater generated through activities involved in productions of dairy products, beverages, or noodles usually contains relatively low level of organic substances. For these industries, it would be beneficial to use a microbial film (rotating biological contactor), an aerobic treatment method, to treat their wastewater as the plant can reduce energy consumptions and minimize sludge generation.
- If strict discharge standards must be fulfilled due to any specific reasons such as because the plant discharges the effluent into a river, etc., stable wastewater treatment and effluent quality can be maintained when the units are installed in a parallel configuration to disperse the load, and the processed water is further treated by a sedimentation separation using coagulant that is added to enhance efficiency of sludge sedimentation after the microbial film treatment. Additionally, it helps to avoid water quality deterioration caused by bulking that occurs due to a load variation influence during the activated sludge process.



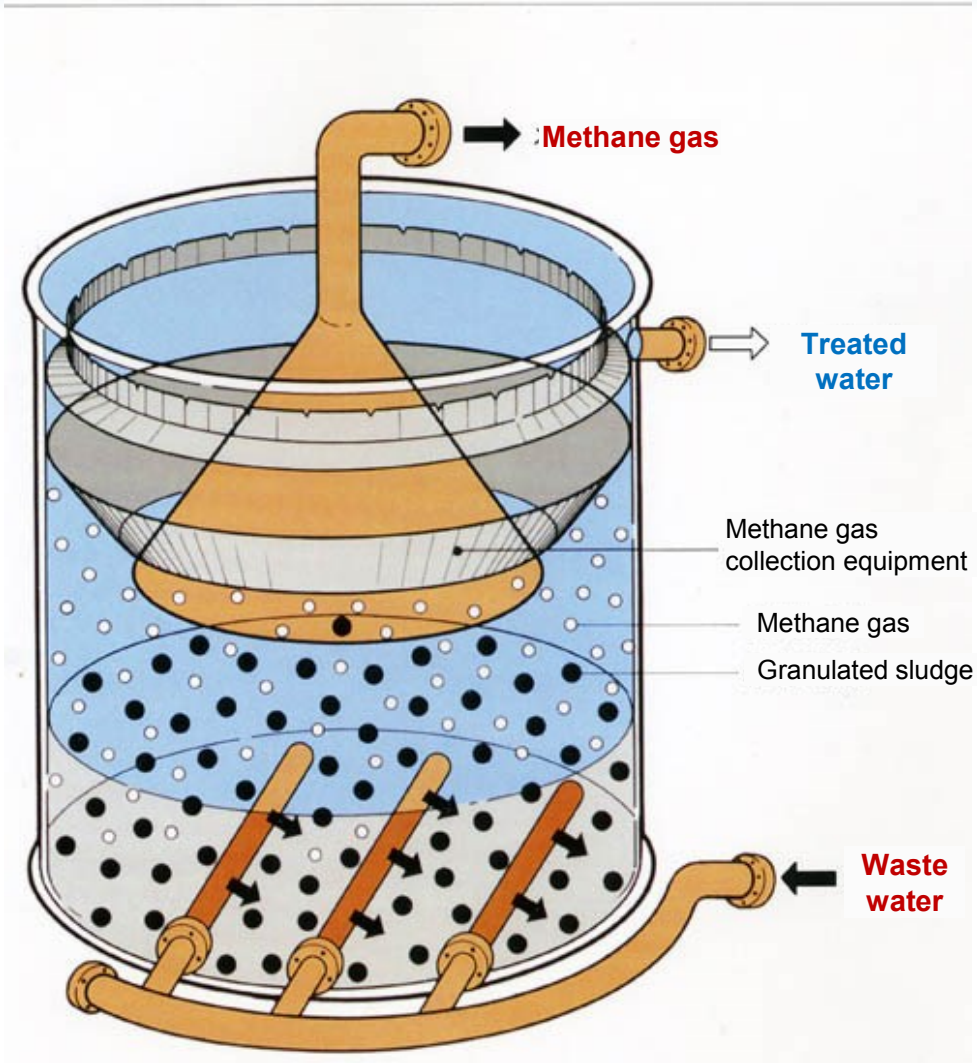
Outlines of a treatment technology using Upflow Anaerobic Sludge Blanket (UASB)

- An anaerobic digestion system that utilizes microbiological activities is an effective treatment technique for wastewater that contains high level of organic substances with no presence of hazardous substances.
- UASB becomes functional when the temperature inside the reactor is setup at about 35 – 40°C to maintain stable methane fermentation. In Japan, heating may be required in a low temperature season. In a tropical zone, this system has an advantage as a heating process is not required.
- The biogas generated from UASB system is utilized as an alternate energy source for the plant operations, which include fuel supply for co-generation system (generates electricity and hot water) or boiler.



Example of energy system using biogas at beer plant

Typical Upflow Anaerobic Sludge Blanket (UASB) system



- Untreated wastewater flows into the system through a pipe located at the bottom
- Wastewater is decomposed by anaerobic microorganisms inside the reactor, while it is slowly mixed by upward flow created along with the generation of methane gas or carbon dioxide.
- By the mixing effect, anaerobic microorganisms form into granules and become sludge to enhance solid liquid separation.
- Wastewater is further processed by decomposition as it moves up through the sludge formation layer. The treated water is discharged from the upper level of the unit and methane gas is reused as a heat source.

(Source: APEC Virtual Center for Environmental Technology Exchange website)

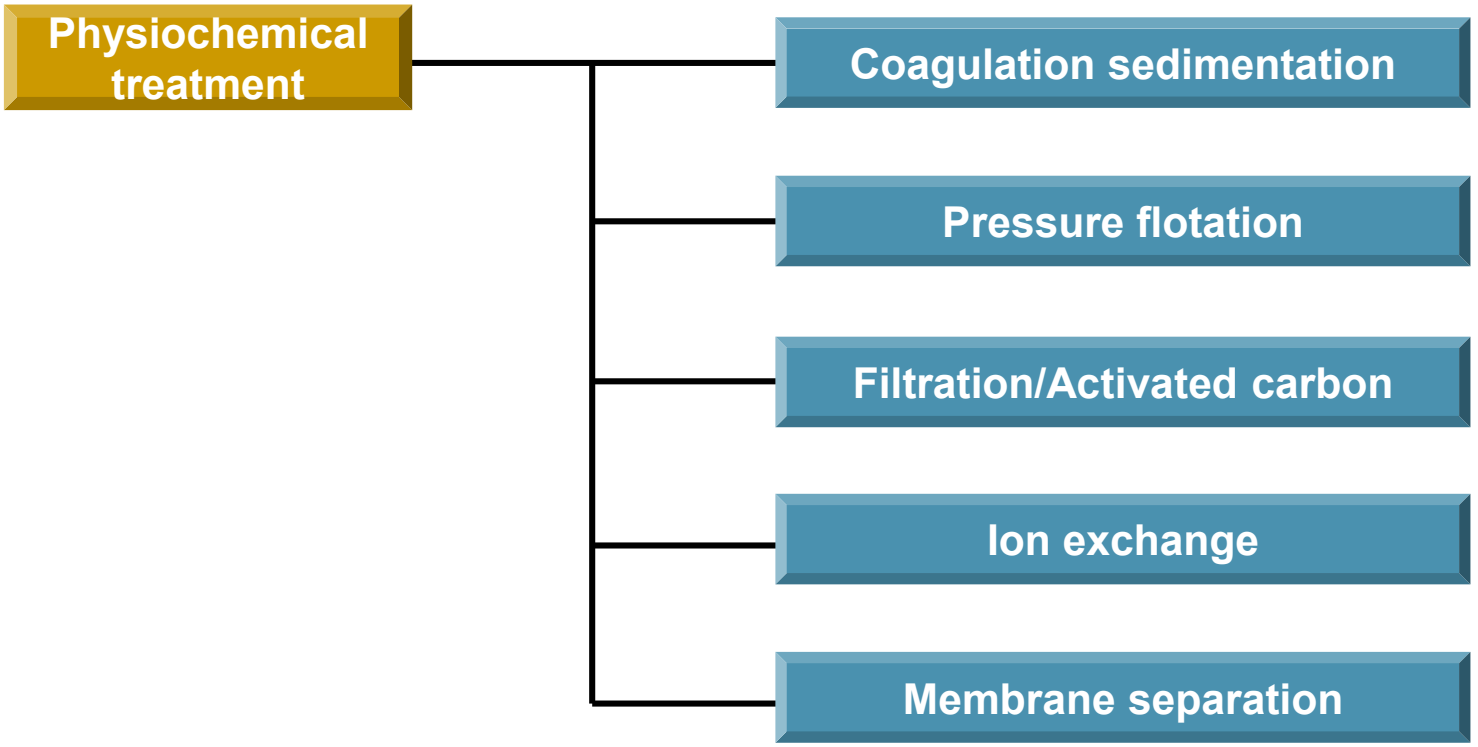
Qualities and treatment methods of Wastewater containing inorganic materials such as metals

For inorganic wastewater that contains metals, the chemical treatment methods including coagulation sedimentation or neutralization treatment is applied based on the concentration of metals

Business category	Wastewater quality (before treatment)	Treatment method/remarks
■**Non-ferrous metal manufacturer** Rolled copper, drawn wire, rolling for aluminum, etc) Discharge volume: 200 – 10,000 m^3/day	• pH: 2 - 7 • SS: 70 - 200 mg/L	• Neutralization treatment, etc. <Remarks> Handling of heavy metals
■**Electroplating manufacturing** (Electroplating) Discharge volume: 10 – 100 m^3/day	• pH: 1 - 2 • CN: 20 – 200 mg/L • Cr: 40 - 150 mg/L • Also contains Cu, Cd, Zn, etc.	• Coagulation sedimentation method, etc. <Remarks> Variation of wastewater characteristics, handling of heavy metals, etc.
■**Inorganic industrial product manufacturer** (Caustic soda industrial products)	• Contains Hg	• Ion exchange, chemical treatment
■**Glass manufacturing** (Optical glass, specialized glass)	• Contains heavy metals such as Cd, etc.	• Coagulation sedimentation method, filtration method

Source: Prepared based on information from Japan Environmental Management Association for Industry

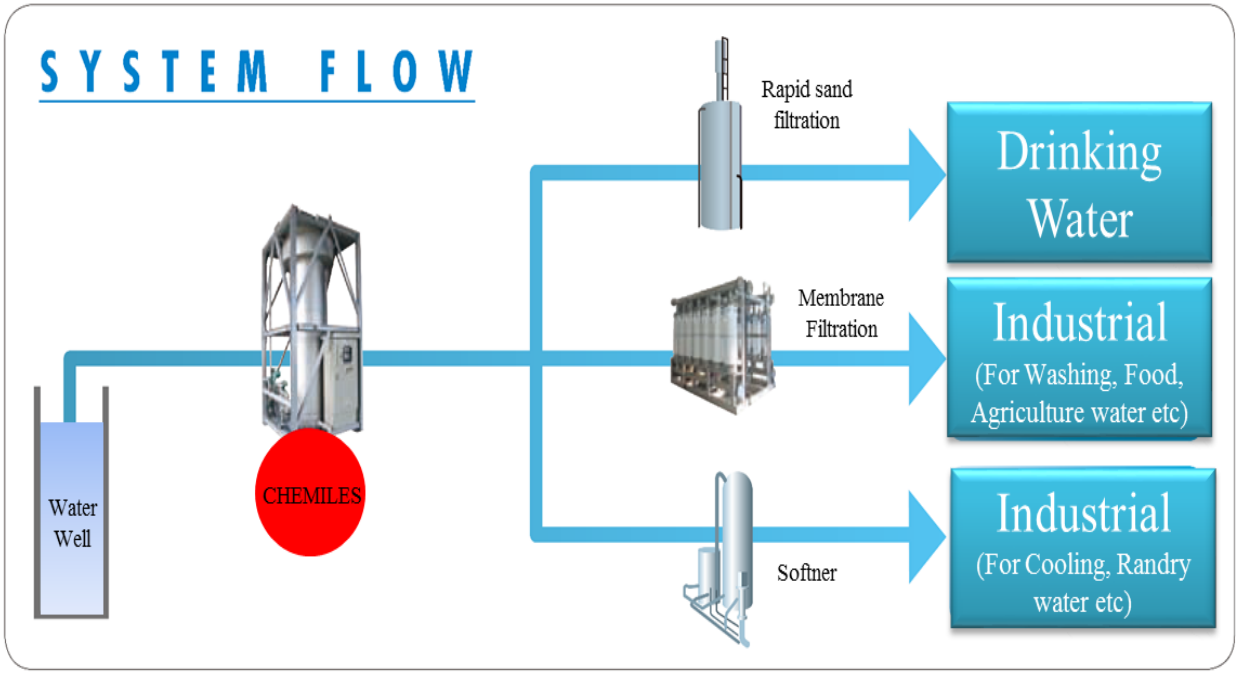
Physiochemical treatment technologies



Chemical-less Groundwater Treatment System

Nagaoka International Corp.

“CHEMILES” remove iron, manganese, ammonium nitrogen and arsenic without any chemicals.



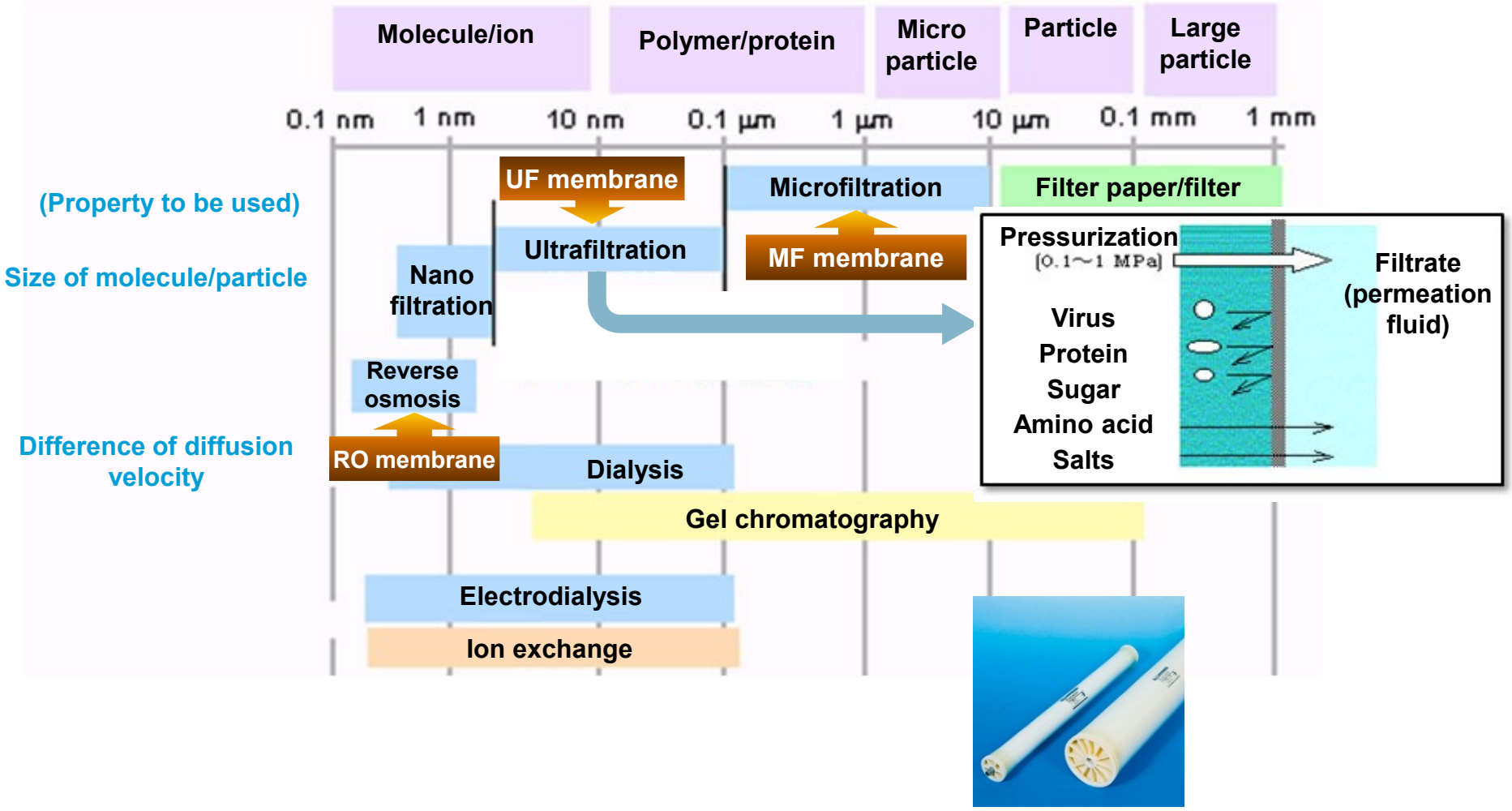
Features

【No chemilcals】 Chemiles is easy maintenance and low running cost because no chemicals are used.

【High speed 】 Liner velocity is 500m/D because of adapting contact oxidation and biological treatment. So Chemiles need minimum footprint.

【Highly concentration】 Chemiles were adapted in high concentration raw water site (ex.Fe:max40mg/L,Mn:max4mg/L, NH4:max4mg/L)

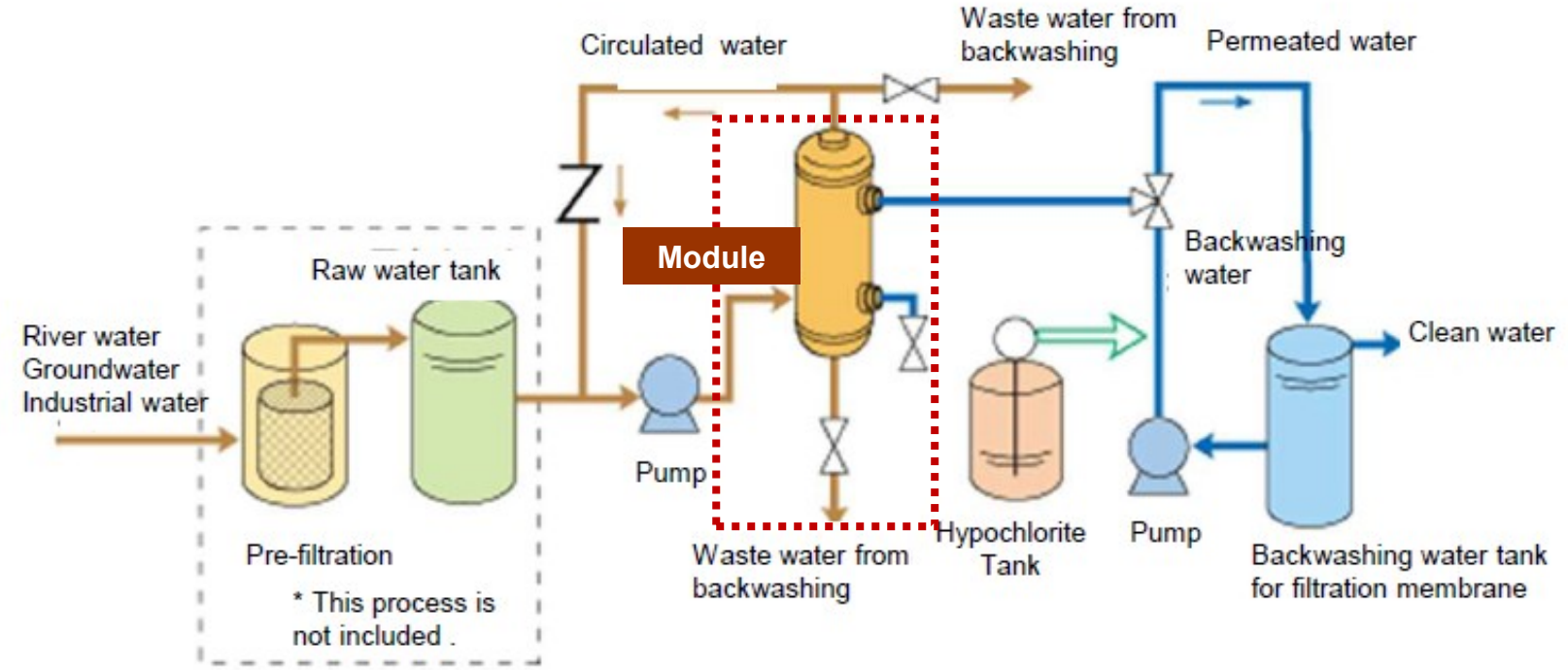
Types and target substance of high performance membrane



Membrane module

Source: Data from Japan Science and Technology Agency, etc.

Example of purification system using high performance membrane



Components of equipment mounted on purification system

Example of purification system using high performance membrane

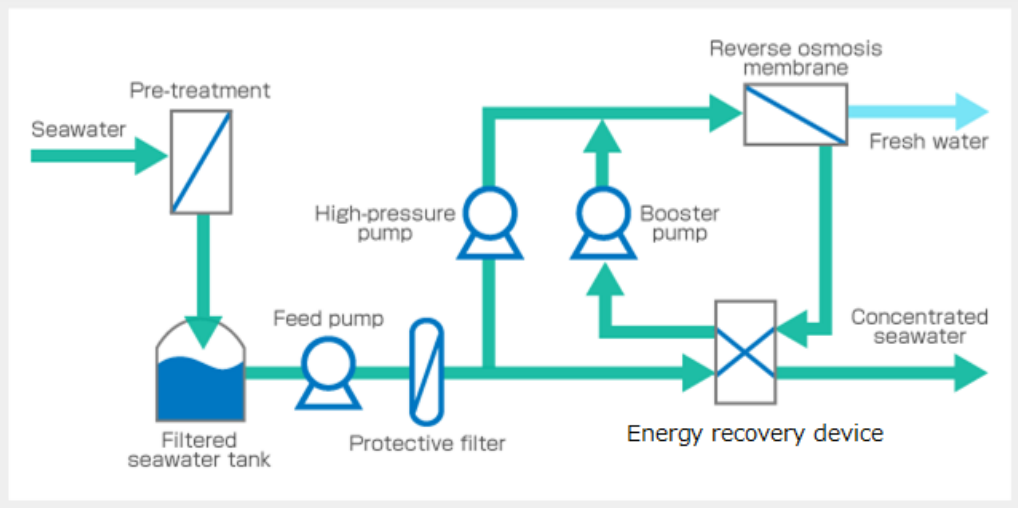
UF membrane module mounted on purification system

RO membrane module mounted on purification system

Hollow Fiber RO Seawater Desalination System

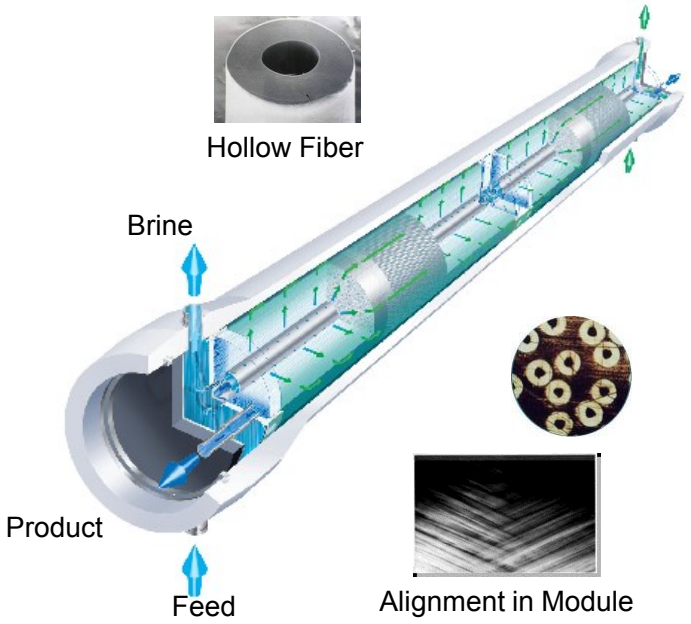
Toyobo Engineering Co., Ltd.

Seawater Desalination System with low running cost and stable operation



Process flow（with Energy recovery）

Hollow Fiber RO Membrane Module-HOLLOSEP®

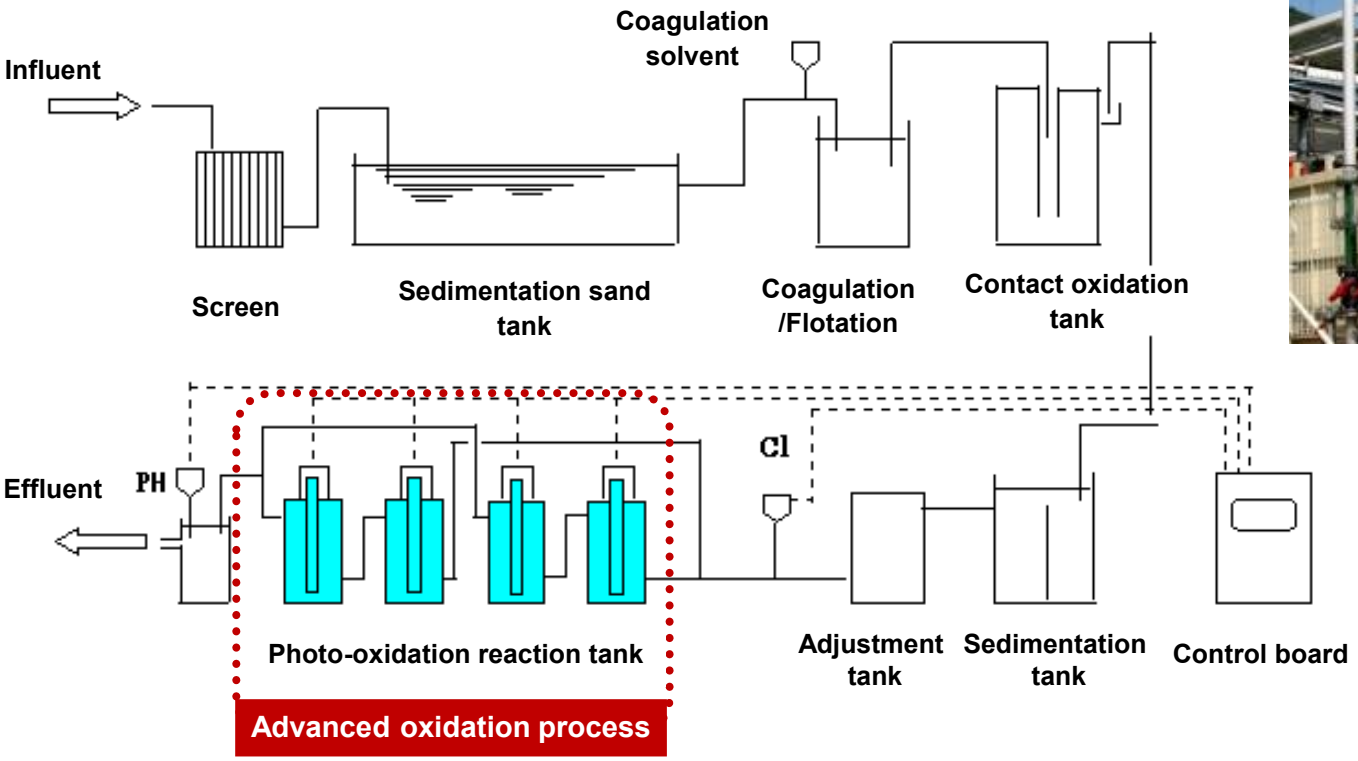


Features

-Employs Toyobo HOLLOSEP®, a highly functional and reliable reverse osmosis membrane that has been used in large-scale seawater desalinization systems around the world and in Japan.
-Can also be used to produce demineralized water of pure-water quality from salt-contained well water.
-Can save energy consumption by utilizing Energy recovery device

Advanced oxidation process for water purification

- Water purification by oxidative decomposition of pollutant after generating hydroxyl-radical with strong oxidation power using oxidation solvent and UV-C with high energy



Flow diagram of treatment system for dying wastewater

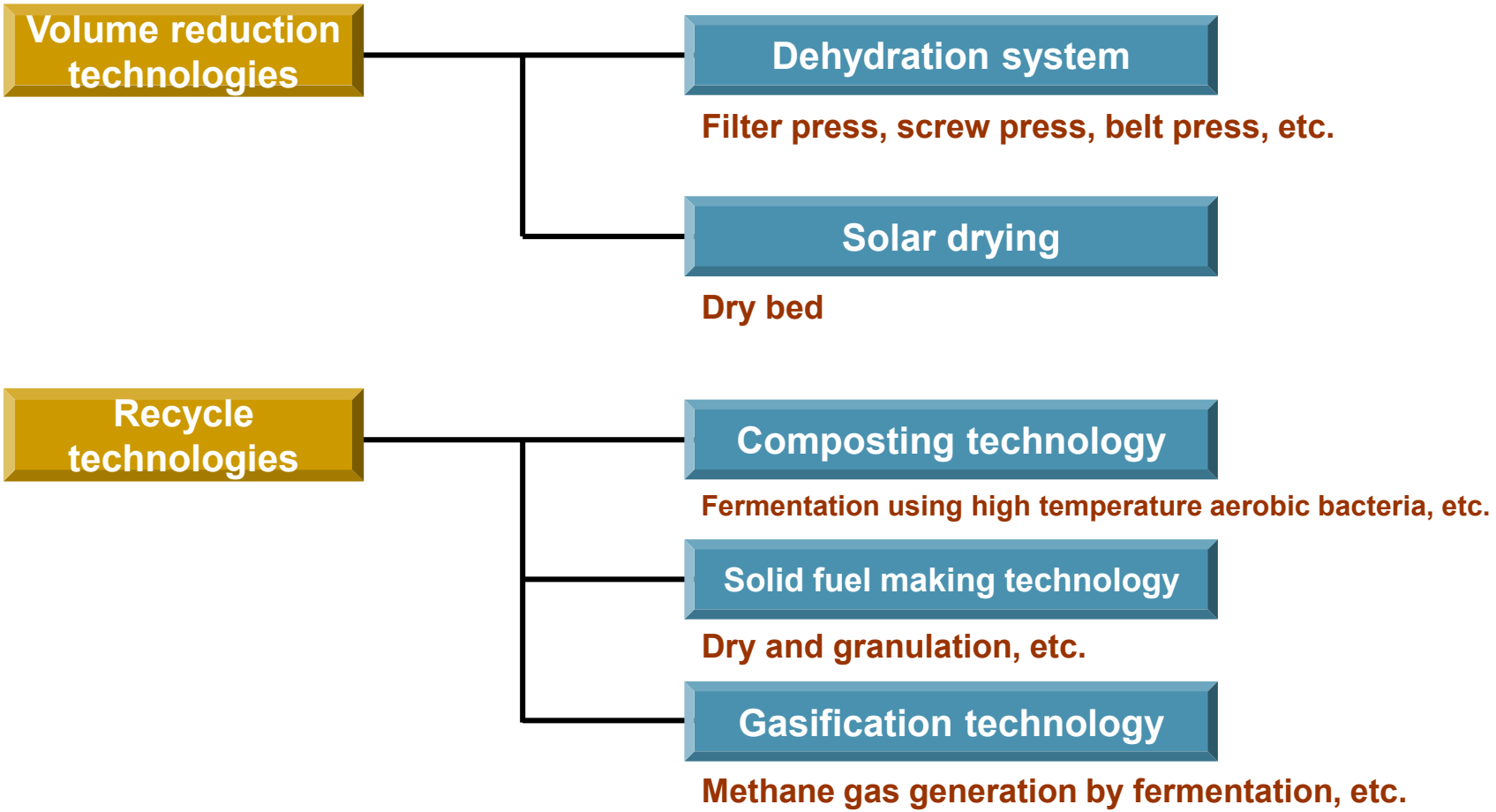
Light: *Raw water*
Middle: *After contact oxidation tank*
Right: *After advanced oxidation process*

Source: Osaka Prefectural Government water-related technologies website

Example of advanced oxidation process for water purification

Purification plant for groundwater
(Removal of ammonia, ferrous, manganese)

Major technologies to achieve volume reduction and recycle of sludge

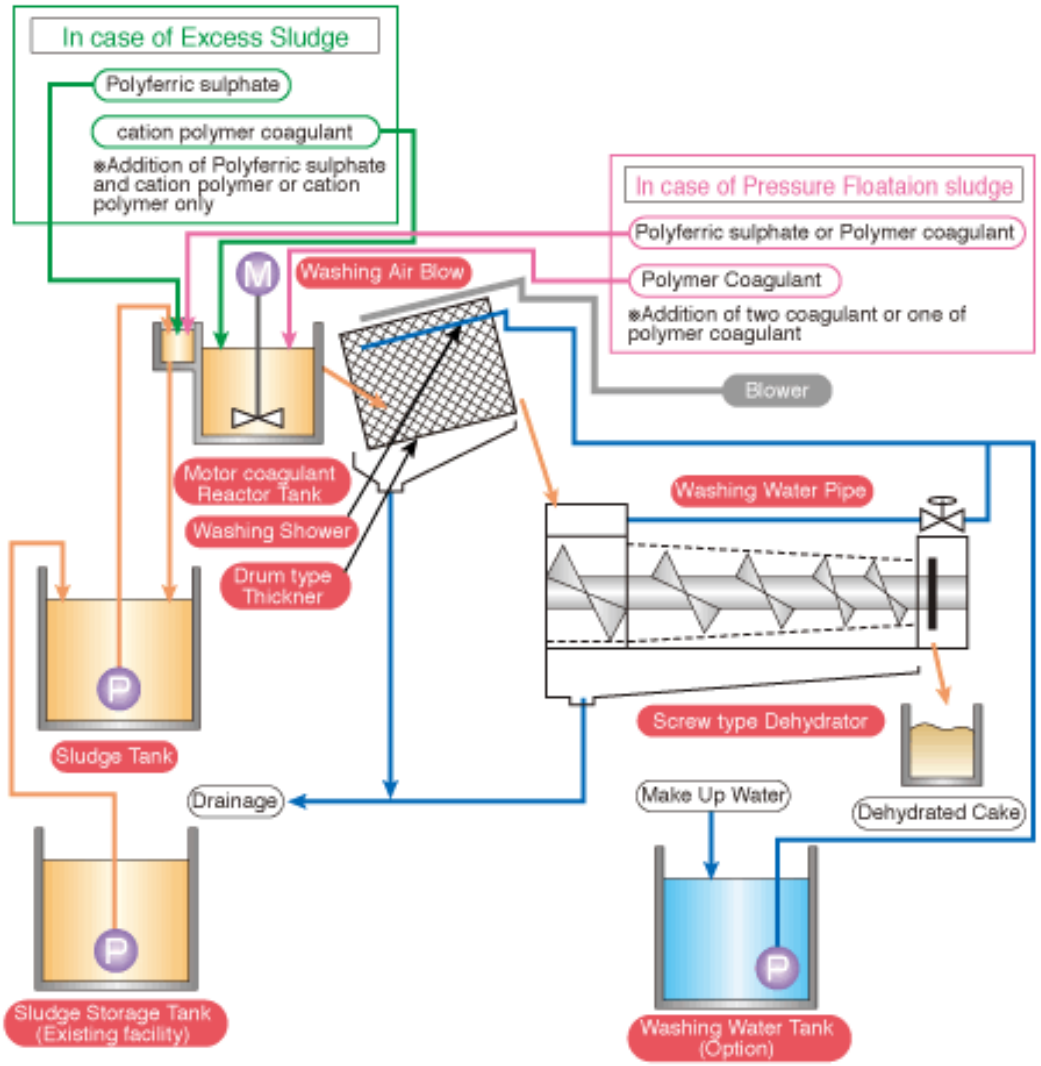


Sludge dehydration system, Example

- Sludge is generated from treatment facility using activated sludge method or coagulation sedimentation process
- For activated sludge method, dehydration is processed to remove water from the sludge usually at approximately **80%** of water content

Example of screw press process flow is shown, right

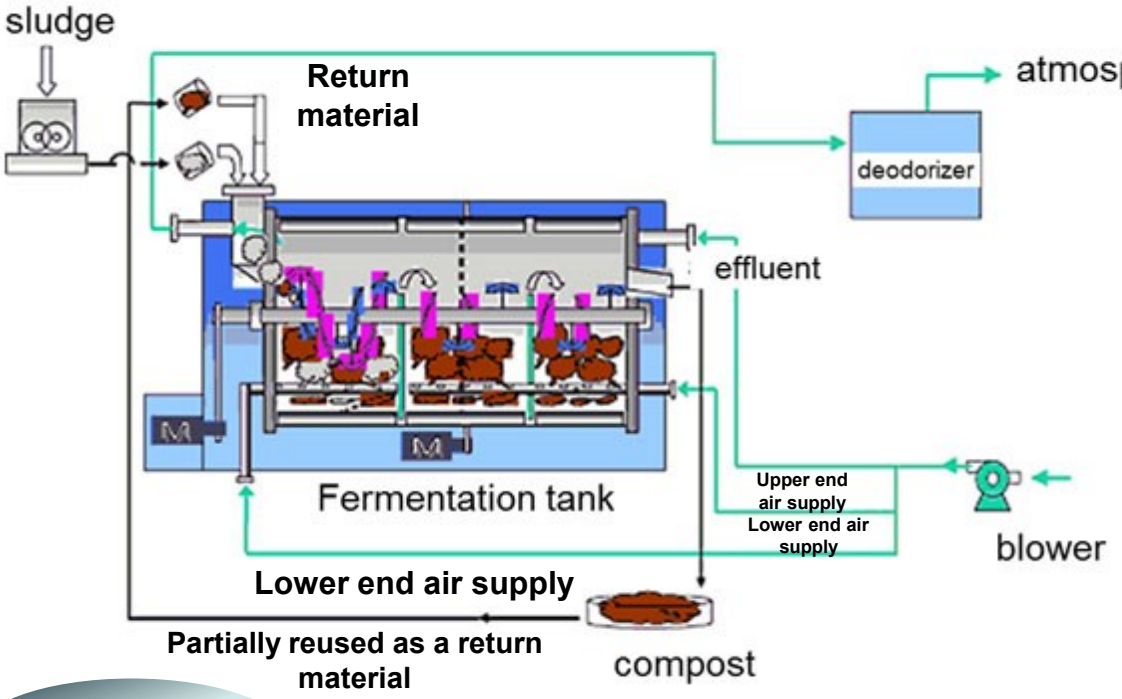
As the sludge moves further into the compression zone by the screw, the compression force is increased and dehydration is further achieved



Source: Osaka Prefectural Government water-related technologies website, and etc.

Sludge composting process technology

Composting is processed using aerobic bacteria and aeration.
The dry sludge generated can be used as a compost for agriculture use.



Fermentation tank

Point !

- Sludge that is rich in nitrogen or phosphate and does not contain any hazardous substance can be reused as organic fertilizer through composting process.

Source: Global Environment Centre Foundation "NETT21" website

Water quality monitoring in factory

Example

Monitoring COD emission load in factory

Automatic
COD analyzer

COD emission load (L)

$L = C \times Q \times 10^{-3}$ (kg/day)

C: COD conc.(mg/L)
Q: Flow rate (m^3/day)

sampling

Waste
water

Treated
water

Measurement
of flow rate

discharge

Factory

Wastewater
treatment

River/Sea

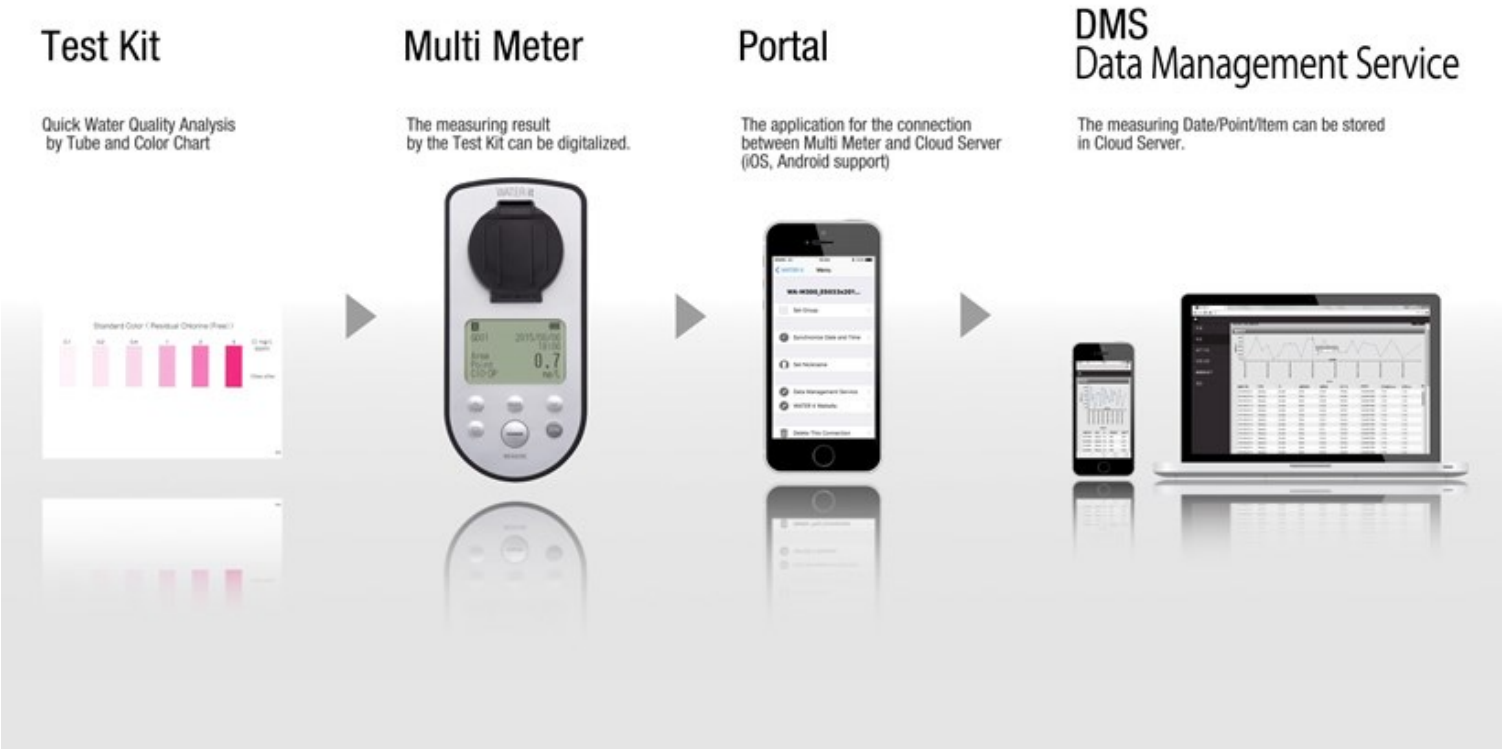
Check the condition
of wastewater
treatment process

Check the condition
of measuring
equipment

Quick Water Quality Measurement

OPTEX CO., LTD.

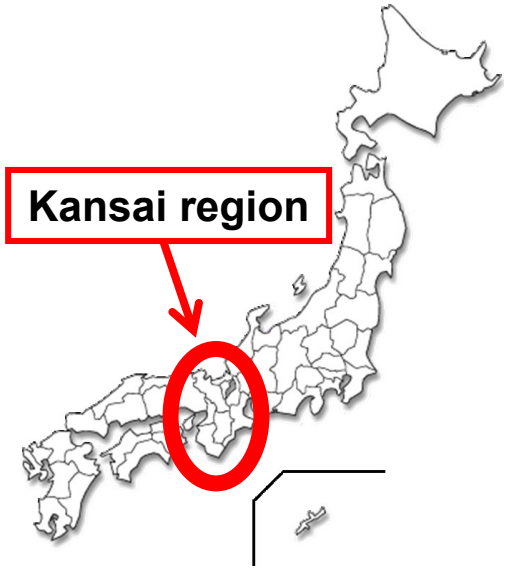
“WATER it” is the best solution of Quick Water Quality Measurement on site!



Features

Quick measurement of water quality on site become available.
Anyone can check the water quality by simple processes.
Using OPTEX DMS (Data Management Service), the measurement results can be checked on website.

Thank you for kind attention!



"Team E-Kansai" consists of about 170 companies and organizations that possess exceptional environmental and/or energy-saving technologies and wish to develop their businesses in Asia

URL : http://team-e-kansai.jp/en/