Water Pollution / Equipment for water pollution control (6)

# Up-flow anaerobic sludge blanket (UASB) method

July 2, 2012

Japan Environmental Management Association for Industry
(JEMAI)

# CONTENT

# 1. Feature of UASB

## 1. 1 Feature of UASB

- The treatment of wastewater containing high strength Organic substance with anaerobic bacteria.
  →Aerobic bacteria can not digest high concentration of COD liquor.
- UASB stands for “Upflow Anaerobic Sludge Blanket”.
- Feature compared with aerobic treatment

Strong point

(a) Energy for aeration is unnecessary.

(b) Generation amount of sludge is small, from 1/2 to 1/5 of activated sludge process.

(c) Methane gas gotten as by-product can be used as energy.

Weak point

(a) Heating is indispensable.

Suitable temp.: Mesophilic fermentation（30～38℃）
Thermophilic fermentation（50～55℃）

(b) Retention time is relatively long: Large volume of equipment
Higher construction cost

# 1．2　Outline of UASB process

- Uses no carrier.
  One time inflow of upflow waste water.
  Mild agitation caused by the rise of produced gas (applying a low shearing force)

  ⬇

  Uses granule sludge (1 ～ 2 mmΦ) generated through self-granulation.

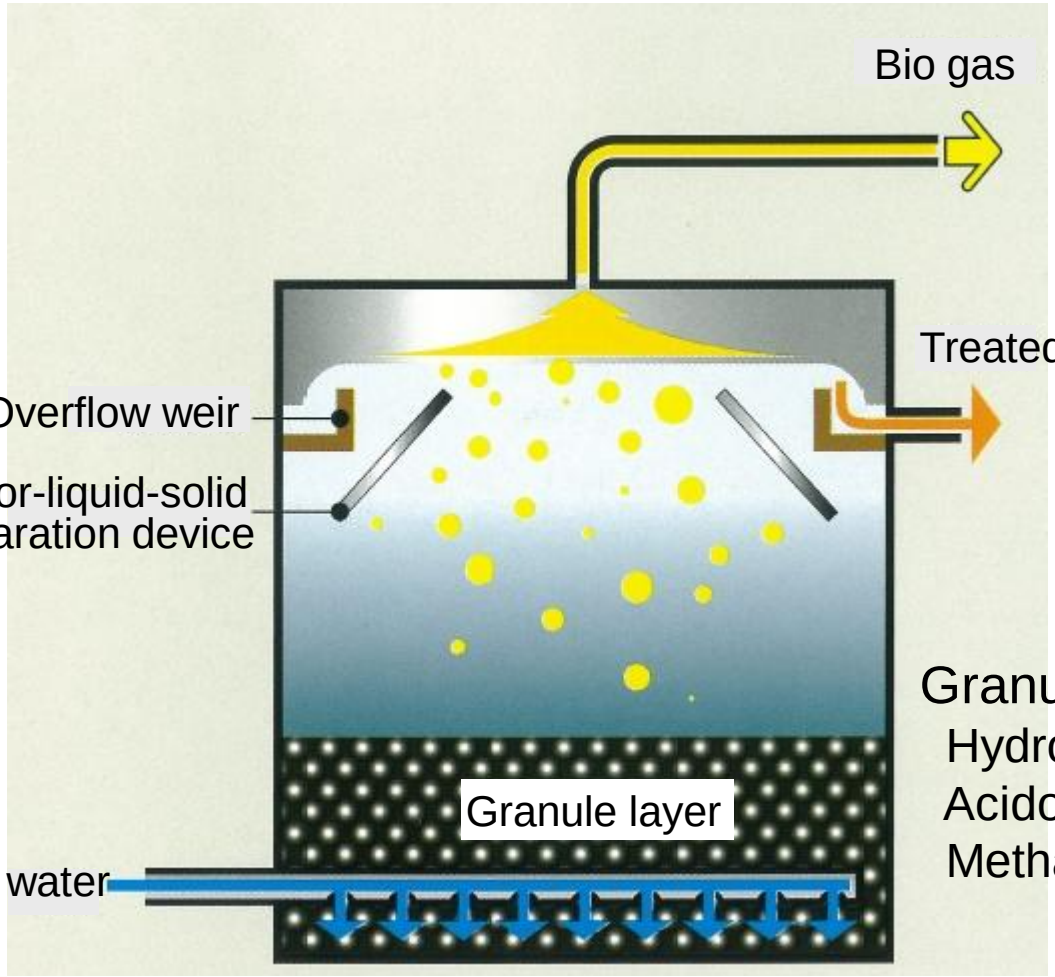
- Sludge concentration in the sludge bed : 50,000 mg/L or more
  → Allows high load treatment of soluble organic waste water.

- Requires at least 2 ～ 3 months to be started up because of self-granulation of flock sludge.
  → Using excessive granule sludge from actual facility can reduce start up time to 2 ～ 3 weeks.

- High sludge settling velocity : 20 ～ 40 m/h
  → The upflow linear velocity of waste water can be increased to around 1.0 ～ 1.5 m/h.

- For high concentration waste water treatment, treated water may be circulated for saving alkaline agent.

# UASB methane fermentation vessel

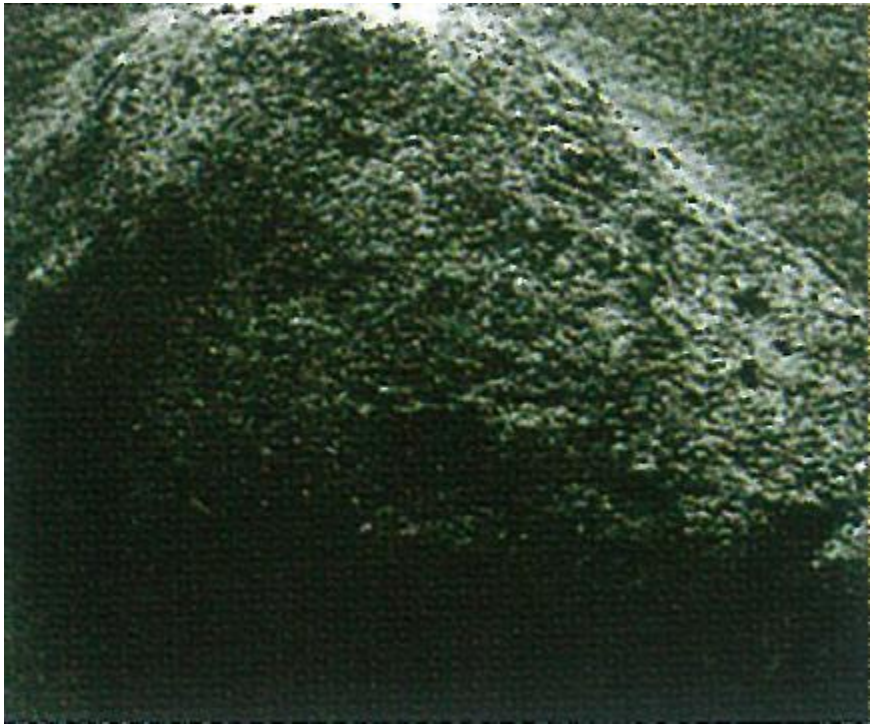



Granule

Hydrolytic bacteria
Acidogenic bacteria
Methanogenic bacteria

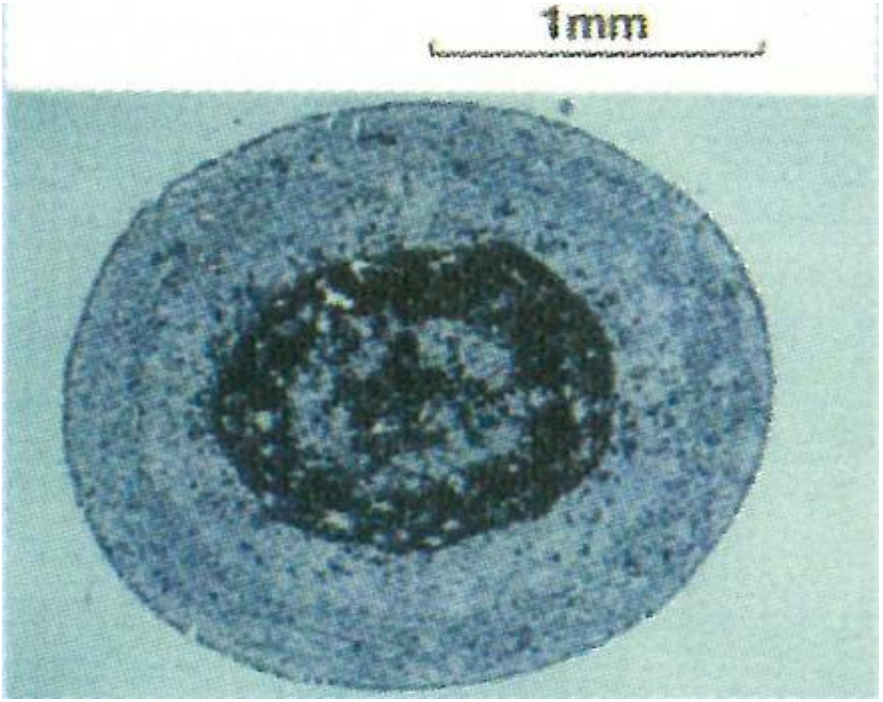
} Granulated aggregate

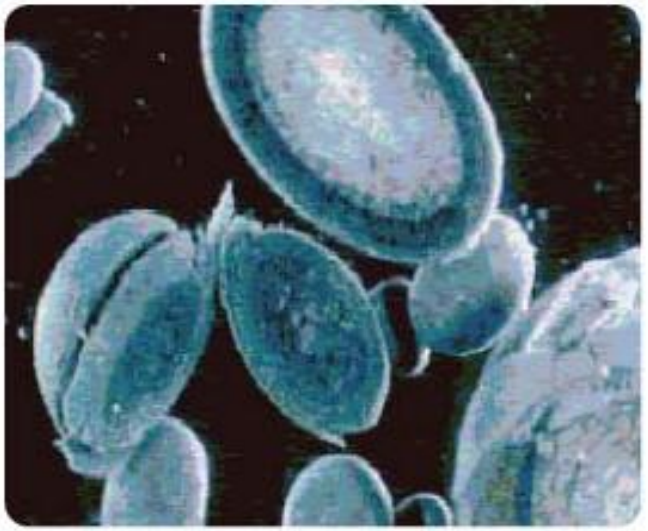
Granule



Surface of granule

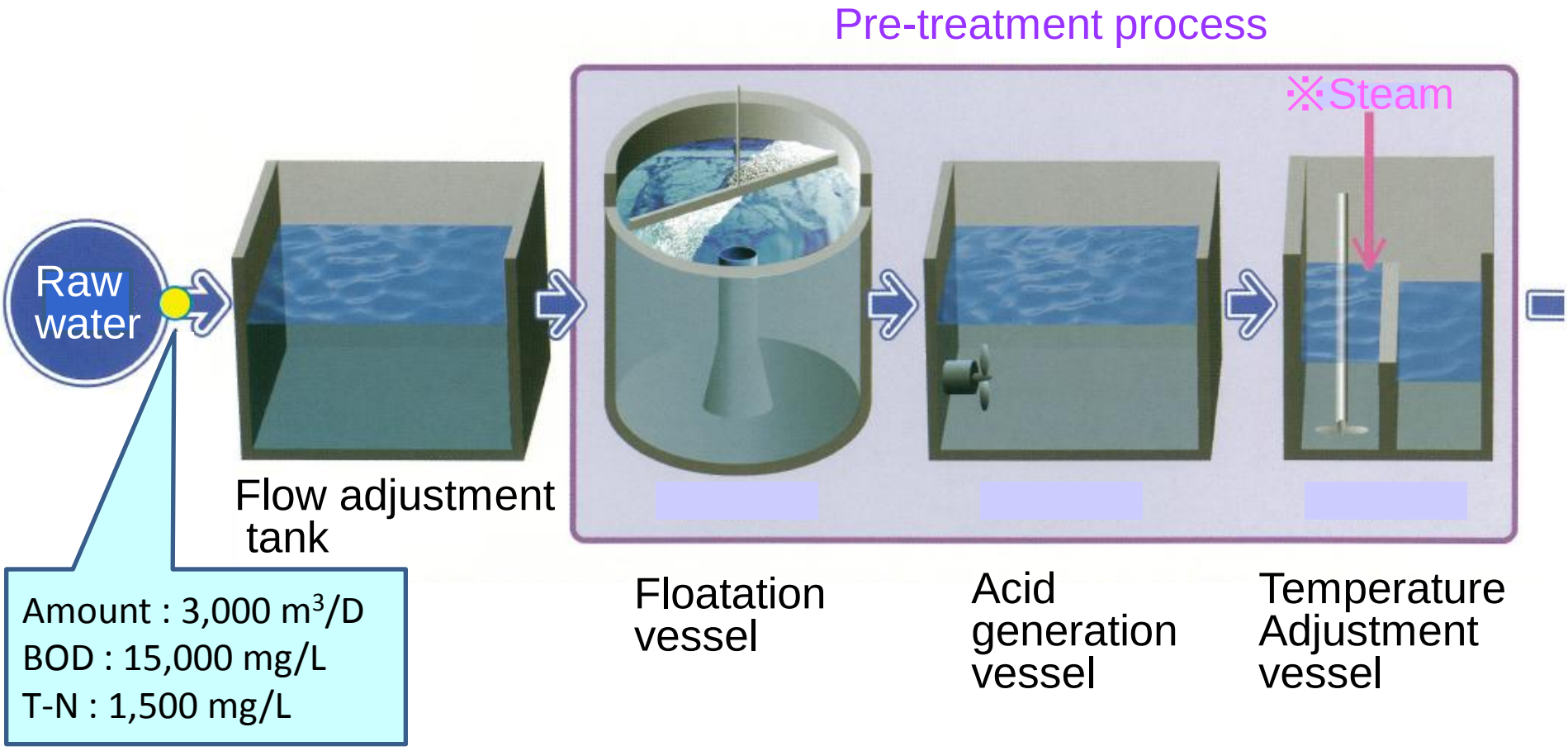
# Cross section of granule



# 1．3　System flow of UASB process

## Example of waste water treatment of starch factory（1/2）



# Example of waste water treatment of starch factory（2/2）

Biogas
$CH_4$ : 65～75%
$CO_2$ : 25～35%

Biological desulfurization equipment

Dry type desulfurization equipment

Gas holder

Boiler

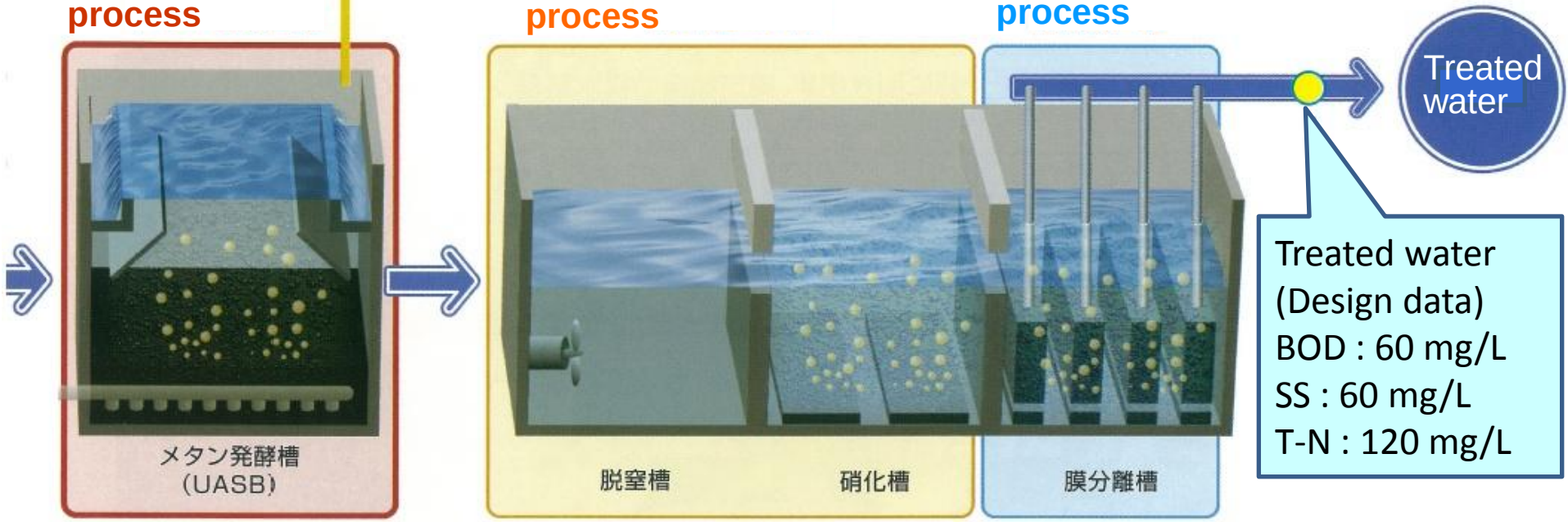
※Steam

**Methane fermentation process**

**Nitrification-denitrification process**

**Membrane separation process**

Treated water




Treated water
(Design data)
BOD : 60 mg/L
SS : 60 mg/L
T-N : 120 mg/L

Methane fermentation vessel (UASB)

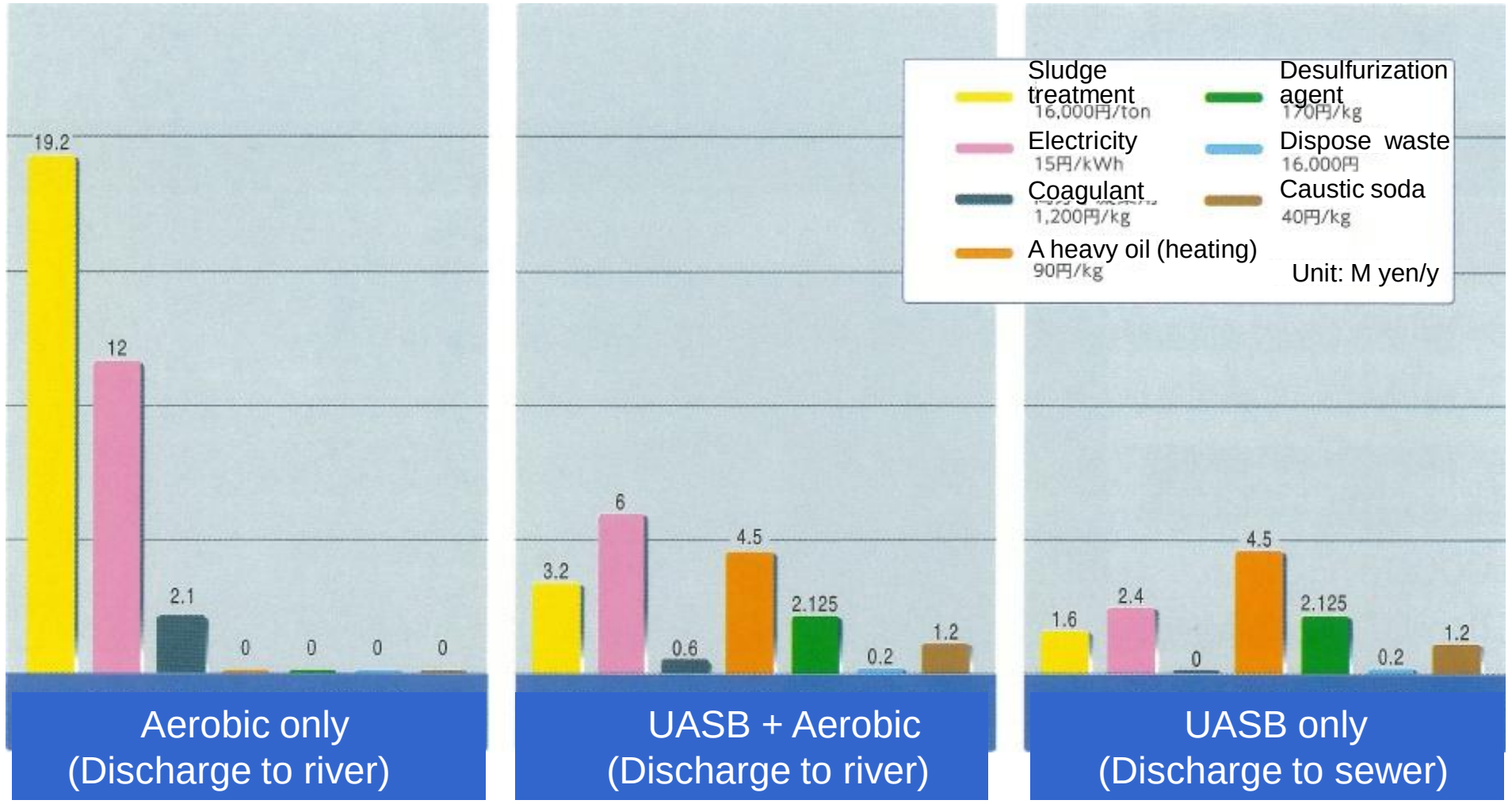
Denitrification vessel

Nitrification vessel

Membrane separation vessel

# 1．4　Decrease of running cost

Condition：Volume of waste water　500m3/D,
BOD　3,000mg/L



# 2. Process flow of waste water treatment of a beer plant

## 2. 1 Production process and kinds of waste water

Malt → Wort → Fermentation

Kinds of waste water

1）Immersion water of barley and filtered water of residue (Lw1)
2）Filtrate of boiled hop (Lw2)
3）Washing water of fermentation tank (Lw3)
4）Washing water of filter for fermented liquor (Lw4)
5）Washing water of bottle and so on. (Lw5)

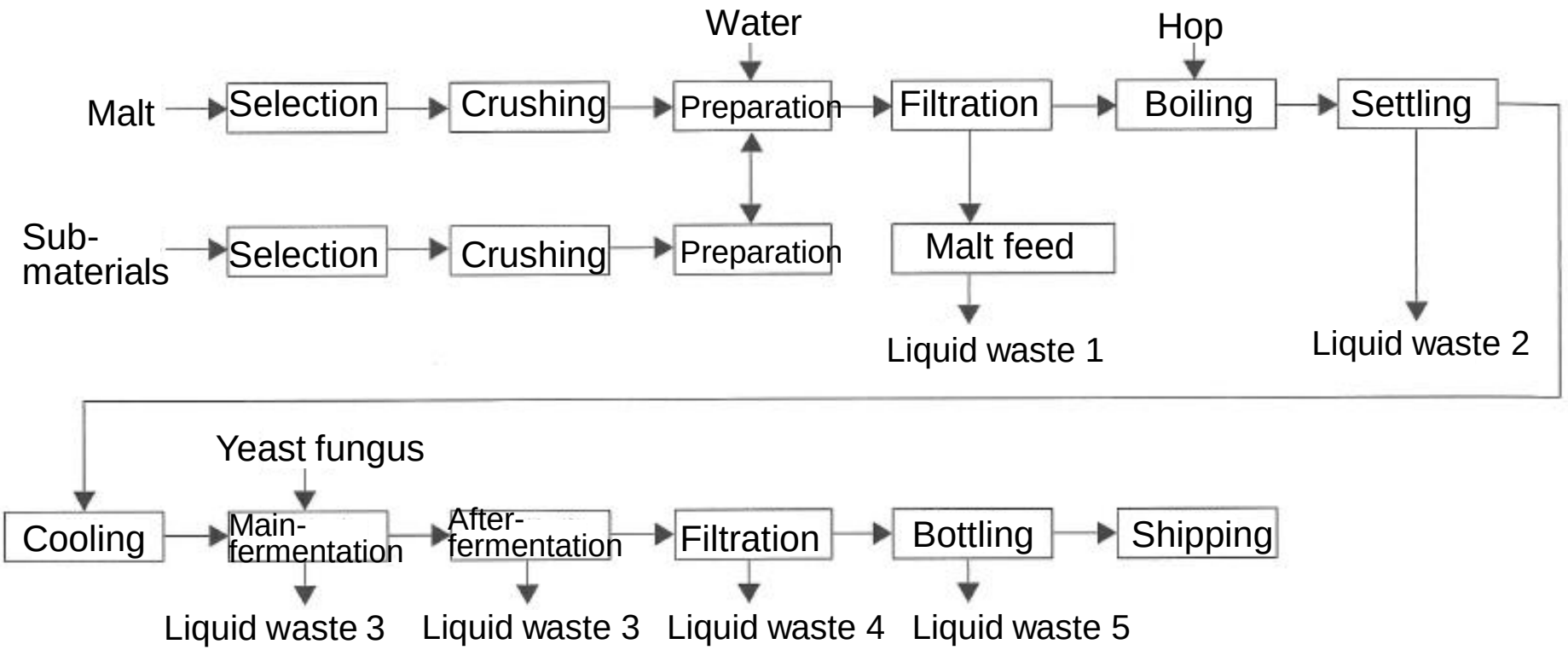
Synthetic waste water treatment
$COD_{Cr}$ 250～1500mg/L
Quantity 2000～7000$m^3$/d

→ $COD_{Cr}$ 3000～4000mg/L

→ $COD_{Cr}$ 300～500mg/L

(“ Lw” stands for “Liquid waste”. see next sheet)

# Process flow of beer production



## 2. 2　Waste water treatment of beer brewery (two step treatment)

- BOD of Synthetic waste water：400～1200mg/L （Biodegradable）
  Activated sludge treatment
- In 1970s　Upflow Anaerobic Sludge Blanket (UASB) process
  Holland, Wageningen Univ. of Agriculture　Lettinga et al
- Combination process of UASB and activated sludge process

  （UASB）　（Activated sludge）

  Raw water $COD_{Cr}$ 1500mg/L ⟶ 200mg/L ⟶ 20mg/L
- Effect of introduction of UASB

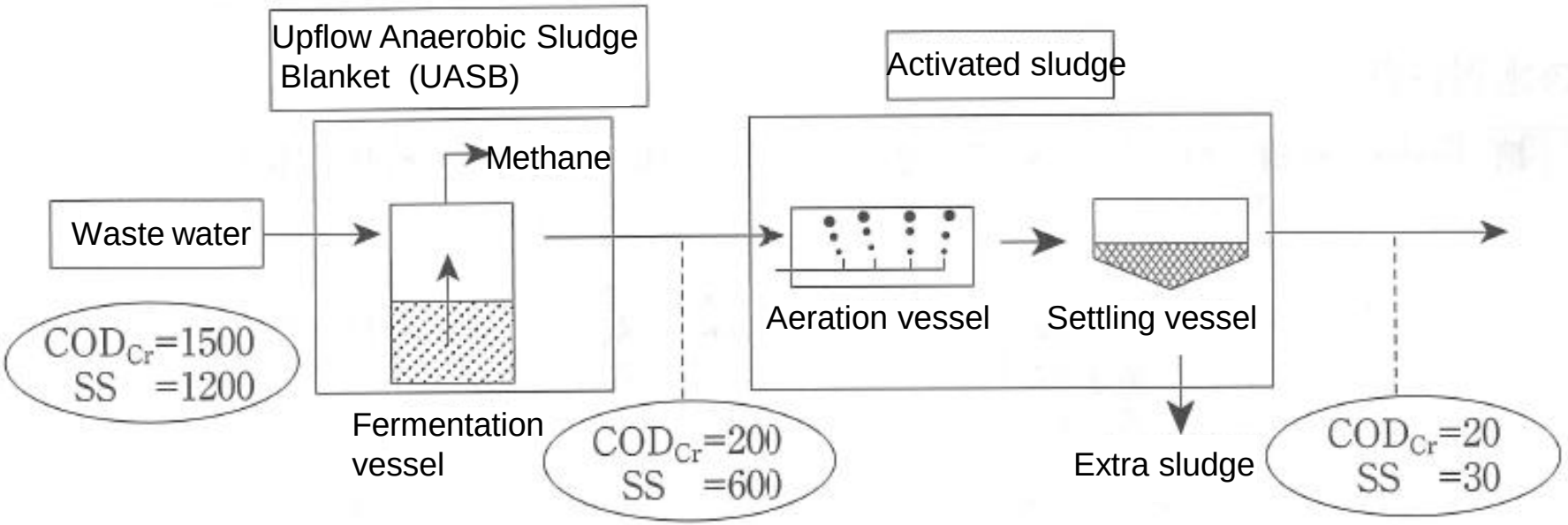
| | Activated sludge | UASB + Activated sludge |
|---|---|---|
| Unit consumption of electricity | 45.5 kWh/kL | 15.8 kWh/kL (1/3) |
| Quantity of excess sludge | 41.0 kg/kL | 22.0 kg/kL (1/2) |
| Chemicals cost (neutralization of organic acid) | 200 ¥/kL | 360 ¥/kL (1.8) |

Load reduction <u>by introduction of UASB</u>

→ Aeration power consumption : about 1/3

Excess sludge amount : about 1/2

# Waste water treatment flow of beer production



# 3. High speed UASB equipment

## 3. 1 High speed UASB equipment（Mitsubishi IC reactor）

### (1) Feature

① Feature of UASB treatment equipment

- Energy saving ： Consumption of electricity 1/8～1/15 （against aerobic treatment）
- Low excess sludge generation ：Sludge generation 1/5～1/15 （ against aerobic treatment ）
- Energy recovery ： Methane gas → Fuel of boiler（Recovery of steam and electricity）

② Feature of IC Reactor（Internal Circulation)

- Two step settler（Gas-Liquid separator）

  → Install settlers separately at upper and lower parts of a reactor. Both parts have different function to strengthen effective collection of methane gas and the power of retaining granule.
- Internal circulation ： Consumption of alkaline 1/3 or less Prevent granule enlarge.

  → By using gas lift effect of methane gas generated in a reactor granules circulate then the power of pump is unnecessary.

② Feature of IC Reactor（Internal Circulation)（contd.）

・Ultra high load treatment ： Volumetric loading 20～30 times

→ Because of special type inlet distributor and unique internal circulation system the contacting efficiency between organic matters and granule is raised. Then volumetric loading of 20～35kgCOD/m³・D is achieved.

It is 20～30 times larger than that of aerobic treatment and 2～3 times larger than existing UASB equipment.

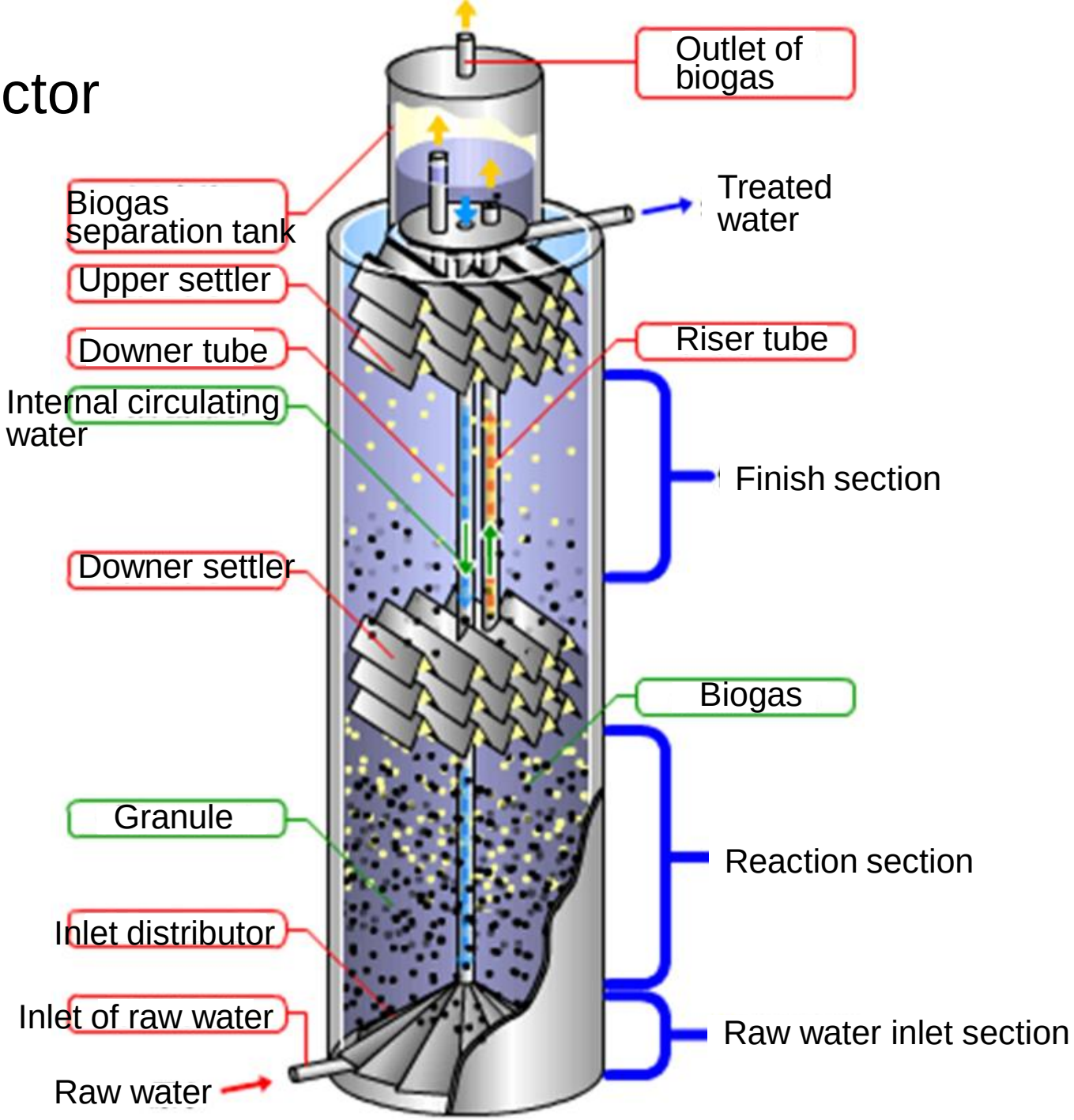
・Space saving structure ： Installation area 1/10 or less

→ High load treatment is achieved by adopting tower type reactor.

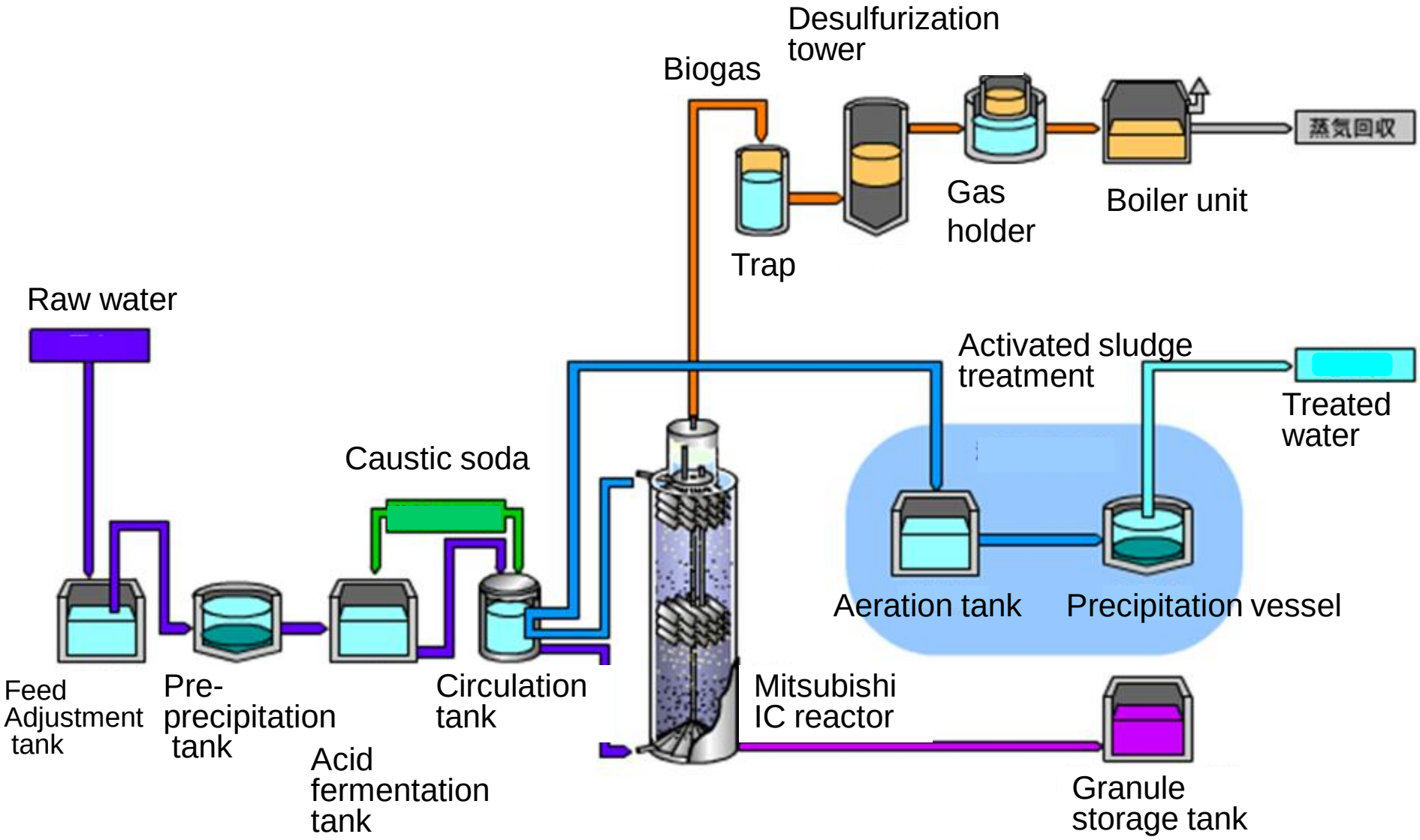
It 1/10 or less of aerobic treatment and 1/3 or less of existing UASB equipment.

(2) Treatment flow

# IC Rector


Outlet of biogas
Biogas separation tank
Treated water
Upper settler
Riser tube
Downer tube
Internal circulating water
Finish section
Downer settler
Biogas
Granule
Reaction section
Inlet distributor
Inlet of raw water
Raw water inlet section
Raw water

# Waste water treatment flow sheet
# （Two-phase fermentation system）

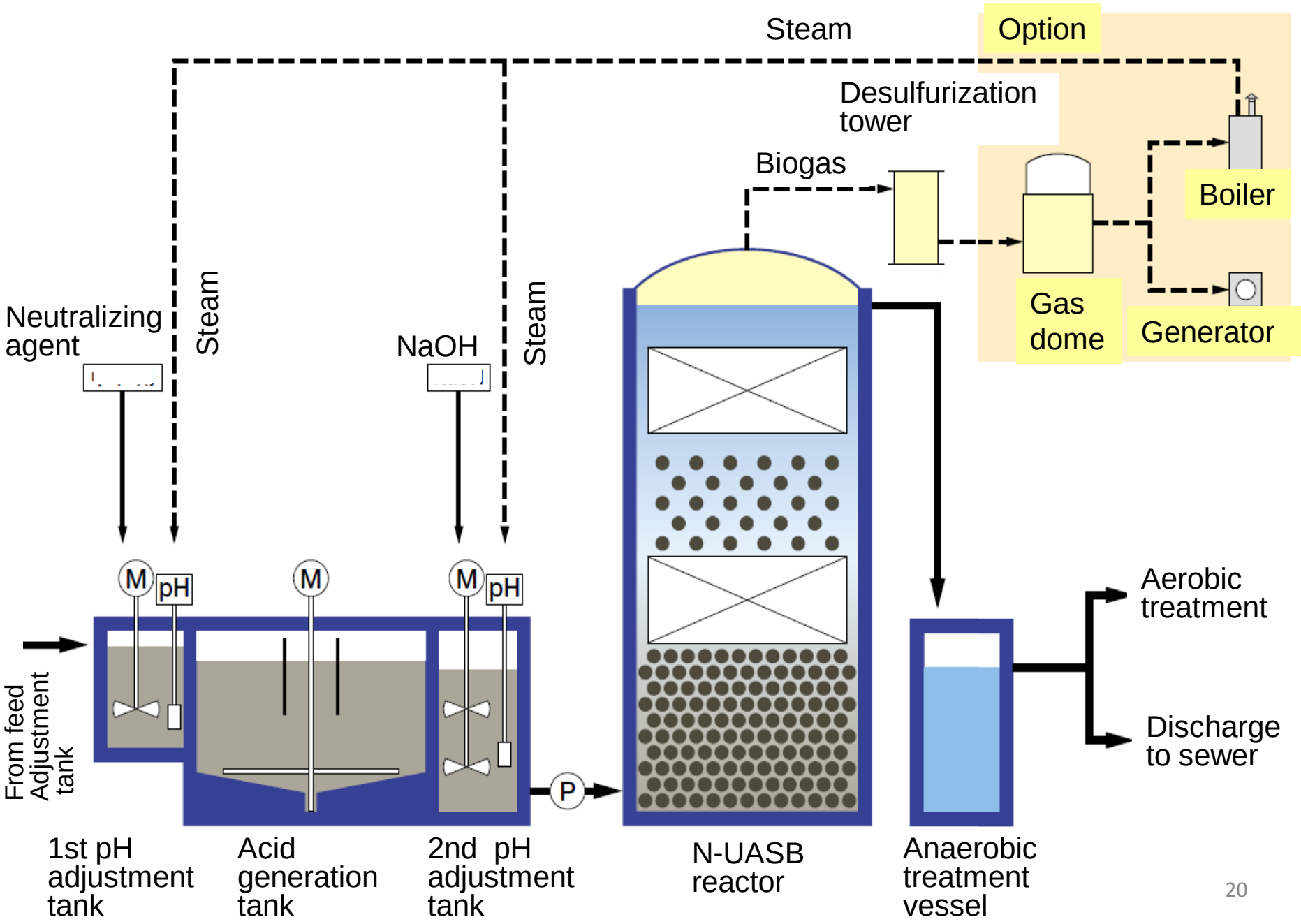


## 3. 2　N-UASB process（NEO-UASB）（ Nishihara Neo Co.,Ltd. ）

### (1)　Feature

- Diameter of granule　：　1～5 mm
- Realize high speed digestion by increasing contact efficiency between liquid and granules by generating turbulence of liquid by circulation in vessel where granules are highly packed.
  → Upper part of vessel　：　laminar flow
  Lower part of vessel　：　turbulence
  Wide range of load and space-saving waste water treatment equipment
- Aeration process is unnecessary.
  →　Low consumption of electricity.
- About 70 % of organic matter is converted to methane gas.
  → Very much reduction of waste treatment cost of sludge compared with aerobic treatment.
- Concentration of $COD_{Cr}$ in raw liquid is 1,000～40,000 mg/L.
  Volumetric loading of COD is 10～30 kg/$m^3$・D.

# （2）Waste water treatment flow sheet（ Two-phase fermentation system）



# Example of waste water of seasoning production

| Item \ Sample | N-UASB | |
|---|---|---|
| | Before introduction | After introduction |
| BOD (mg/ℓ) | 7,600 | 322 |
| CODcr (mg/ℓ) | 9,900 | 429 |
| SS (mg/ℓ) | 580 | 250 |

Application： Waste water of ,

Food processing, Textile industry, Soft drink, Smelting・dyeing,
Fermentation, Oil and fat industry,
Drug industry, Pulp and paper, Chemical industry

## 3. 3　EGSB reactor（Superbiosaver – R, Kurita Water Industries Ltd）

（EGSB：Expanded Granular Sludge Bed）

### (1)　Feature

・Apply to high-load anaerobic treatment（EGSB）for waste water of beer production.

・Pocess

Waste water from beer plant → Rough sepeation screen → High speed pre-precipitation（Removal of SS, up flow velocity about 6m/h）→ Acid generation vessel → EGSB eactor

・Specification of reactor

Inlet concentation of $COD_{Cr}$　4400mg/L

Capacity of eactor　525 $m^3$ × 2

（floor space 35m2 × height 15m × 2 vessels）

Retention time　4.2 hr

Maximum volumetric loading of total CODcr　about 24 $kg/m^3 \cdot D$

- Feature of reaction vessel

  The shape of the Vertical

  Improve volumetric efficiency by increasing volume of sludge zone over 60～70 % or more by eliminating dead space at bottom.

  Reducing area of cross section

  → Increase water rising velocity（LV）and gas rising velocity（GV）

  Require high performance settler

- Better effect compared with aerobic treatment

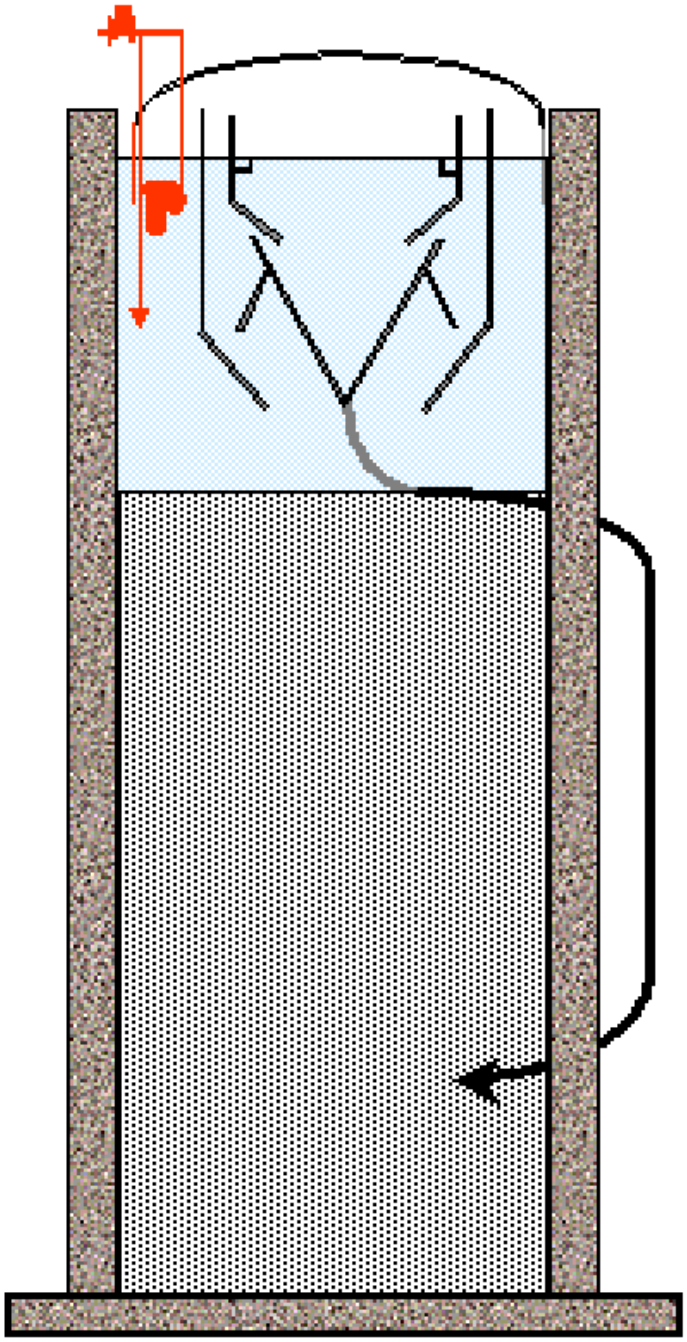
  Electricity cost　53 %　reduction

  Sludge generation　57 %　reduction

  Steam recovery（Incineration of methane gas）

  Chemicals cost　increase

  } Totally about 55 % reduction.



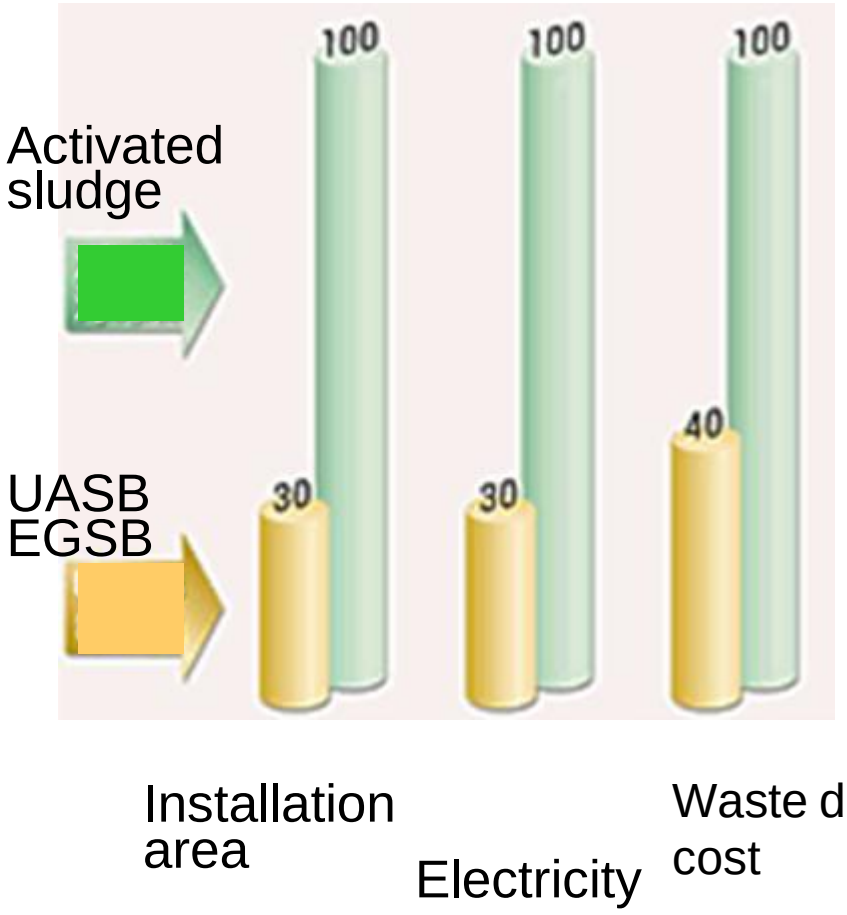
# Inner structure of Superbiosaver – R

# 3．4　UASB/EGSB reactor（Daiki Ataka Engineering Co.,Ltd.）

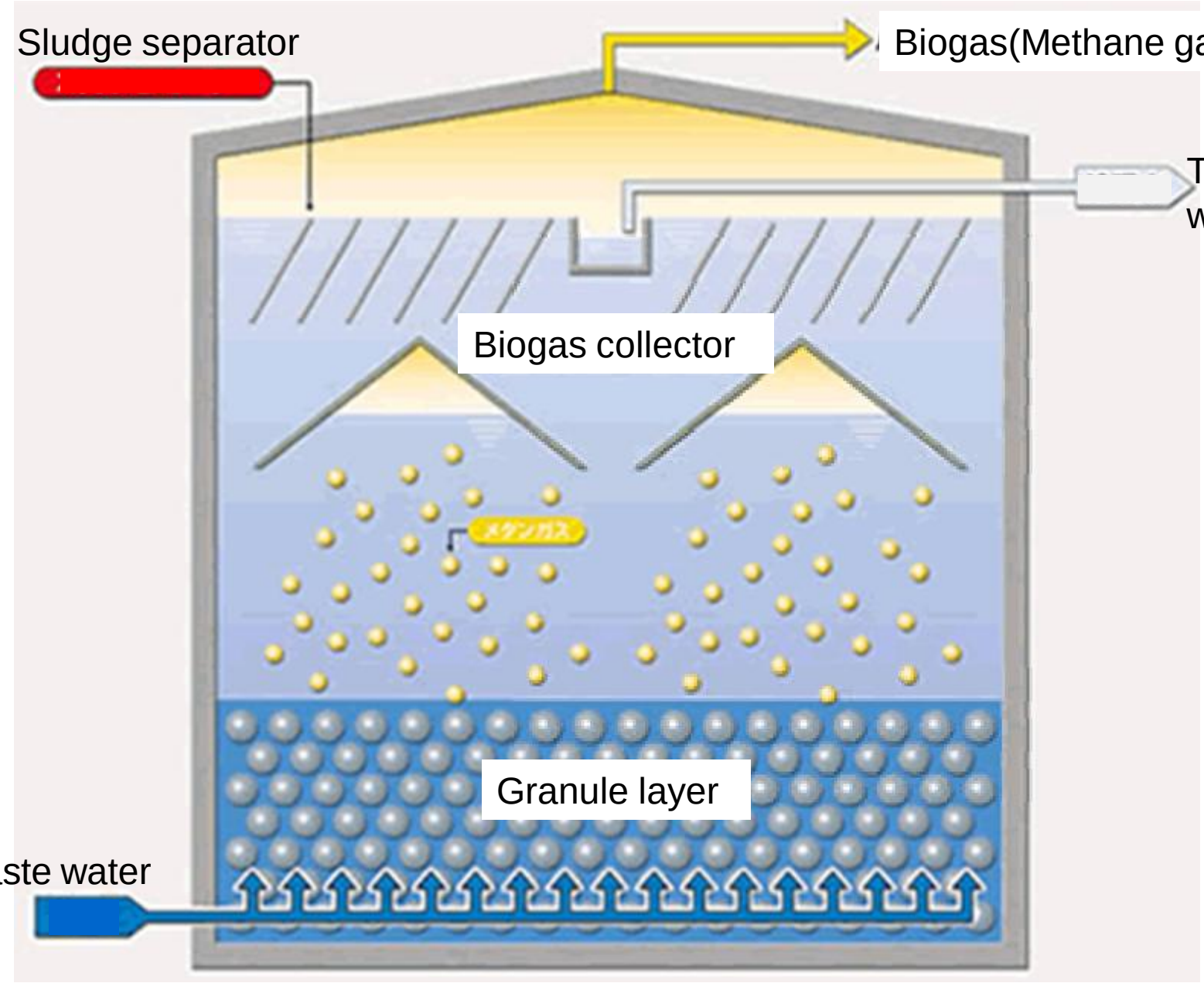
(1)　Feature

- Low running cost
- Low excess sludge generation
- Decrease installation area
- Recovery of energy
- Easy maintenance

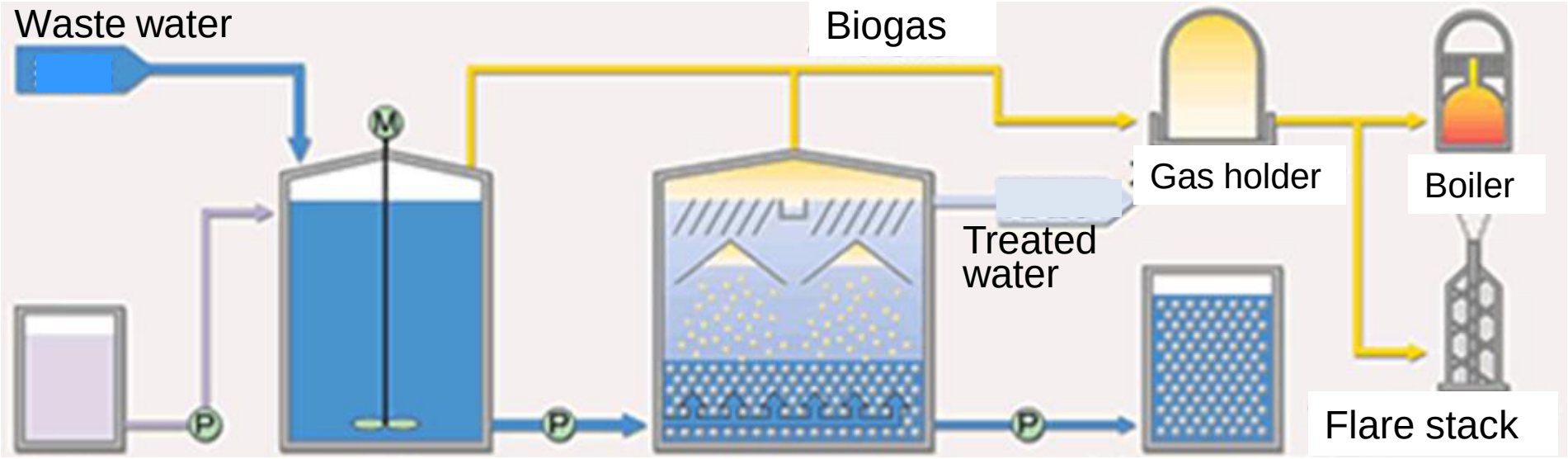
Comparison of cost



# UASB/EGSB Reacror



# System flow sheet



# 3. 5　ECOUS SYSTEM（Eco Creative Japan.Co.,Ltd.）

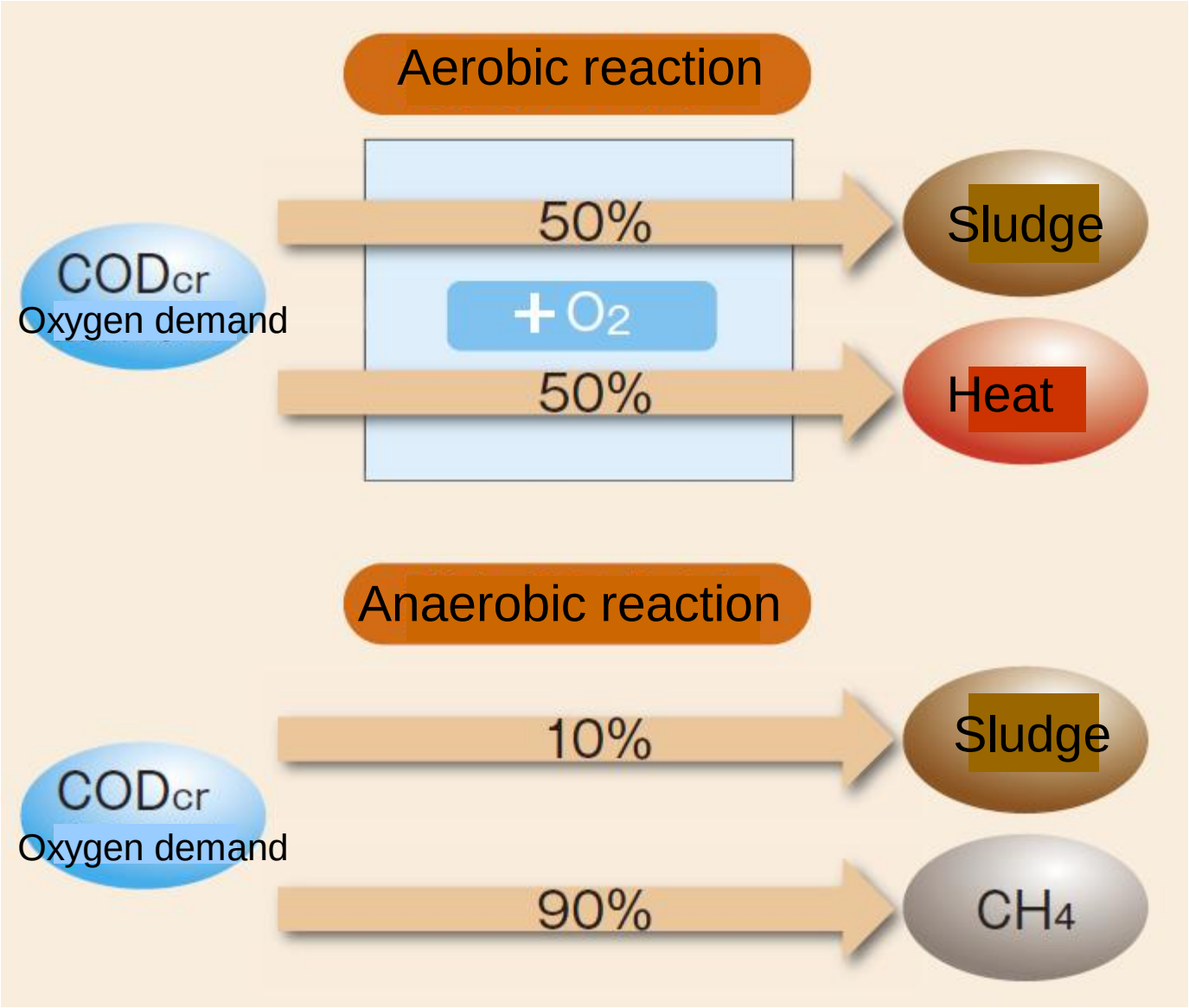
## (1) Feature

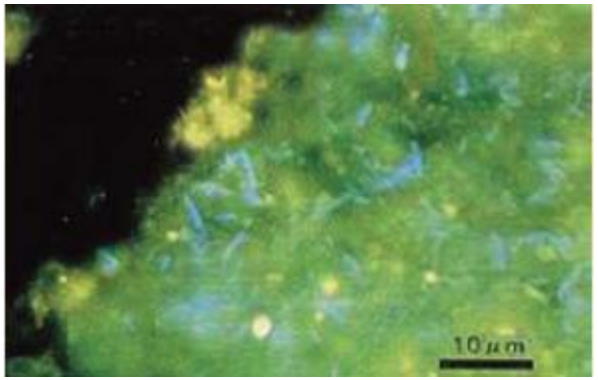
- Improve injection and recycling of raw waste water to contact with sludge granule by expanding coagulated bacteria
- Much reduce of digestion time.
- Much educe of generation of excess sludge.
- Wide availability of operation condition caused by seasons.

→ Anaerobic bacteria can endure for long term stop.

| Relative item | Std. activated sludge process | UASB process | EGSB process |
|---|---|---|---|
| Excess sludge | Large (10) | Small (1) | Small (1) |
| Sludge conc,（MLSS) | 5000～8000mg/L | 50,000～150,000 mg/L | 100,000～200,000 mg/L |
| Denitrification rate | Almost no effect | 60~70% | 90% or more |
| Loading (kg-COD/m³・D) | 0.6kg-COD/m³・D | 10~15kg-COD/m³・D | 20~30kg-COD/m³・D |
| Install space | 10 | 3 | 2 |
| Running cost | 10 | 2 | 1 |

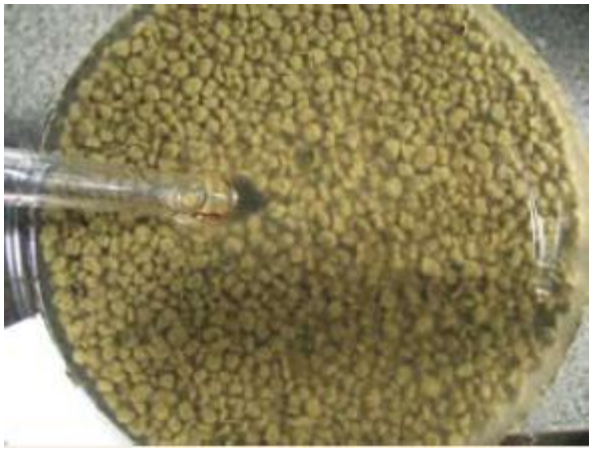
# (2) Principal of ECOUS SYSTEM





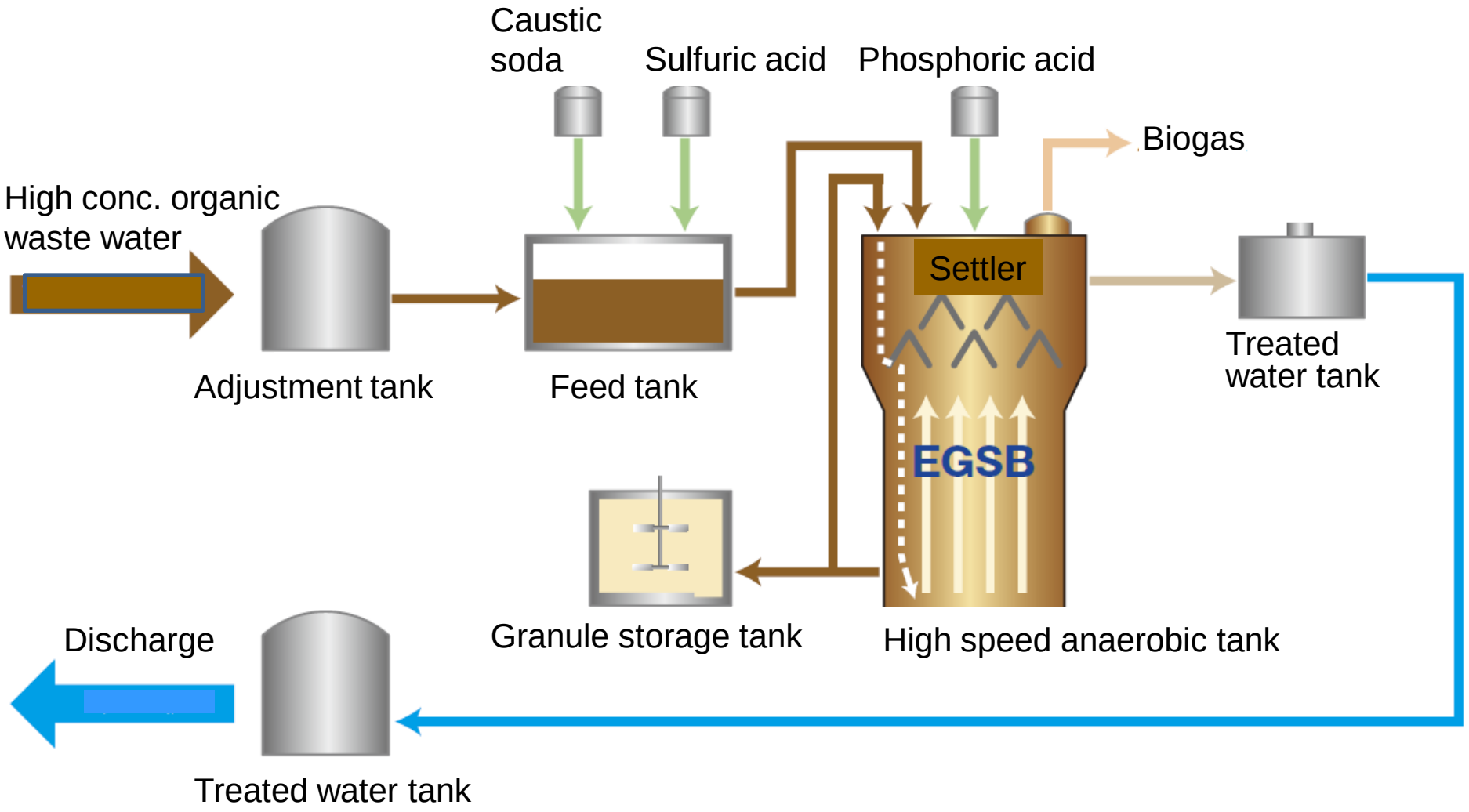

Blue shining methanogenic bacteria in granule

Granule (Lump of anaerobic bacteria)  2～3 mm



High density granule

# (3) Basic treatment flow



# (4) Actual example of EGSB