

Contracted project – 2003  
with Ministry of the Environment, Japan



環境省

Ministry of the Environment

# Treatment of Industrial Wastewater

January 2004

Overseas Environmental Cooperation Center, Japan



# **Industrial Wastewater Treatment**

## **– Food Processing Wastewater–**

### **Committee Members**

**Chairman; Dr. M. Sugahara, Professor, Osaka Sangyo Univ.**

**Members; Dr. H. Tsuno, Professor, Kyoto Univ.**

**Dr. A. Hogetsu, Kobelco Eco-Solutions Co., Ltd**

**Mr. Y. Ogino, (P.E.) Environment Technologies L.P.C.**

**Mr. T. Takemika, (P.E.) EMATEC Kansai**

### **Contents**

- 1. Environment Control & Measures for Industrial Wastewater Treatment**
- 2. Considering Aspects on Wastewater Treatment Plant Design**
- 3. Wastewater Treatment Technologies**
- 4. Examples of 9 Practical wastewater Treatment Plants**

Original sources; Technology Transfer Manual of Industrial Wastewater Treatment, March, 2003, OECC



# 1. Environmental Control & Measures for Industrial Wastewater Treatment

## History

'40's Industrial rehabilitation ('45~'55)

Industrial Pollution

'50's Fisheries damages by paper mills w.w. ('58)

Water Quality Conserv. Law + Control of Effluent Emission from Factory Law ('59)

'60's Basic Law for Environmental Pollution Control ('67)

'70's Water Pollution Control Law ('70)

Inauguration of the Environmental Agency ('71)

Areawide Total Pollution Load Control Law ('78)

Living Environment

'80's Law / Special Measures for Conserv. Of Lake Water Quality ('84)

'90's Practical Environmental Assessment started ('92)

Basic Environment Law ('93)

Environmental Assessment Law ('99)

Global Environment

'00's 5<sup>th</sup> Total Effluent Control System ('02) - - - COD + N, P

1. Environmental Control & Measures for Industrial Wastewater Treatment  
*Measures for Water Quality Conservation (1/3)*

**Laws**

Protecting  
Human Health

Preserving  
Living Standards

**Environmental  
Quality  
Standards**

- 26 items  
Heavy Metals,  
Toxic Sub. Solvents,  
Agriculture chem.  
Nitrogen.....
- Nationwide

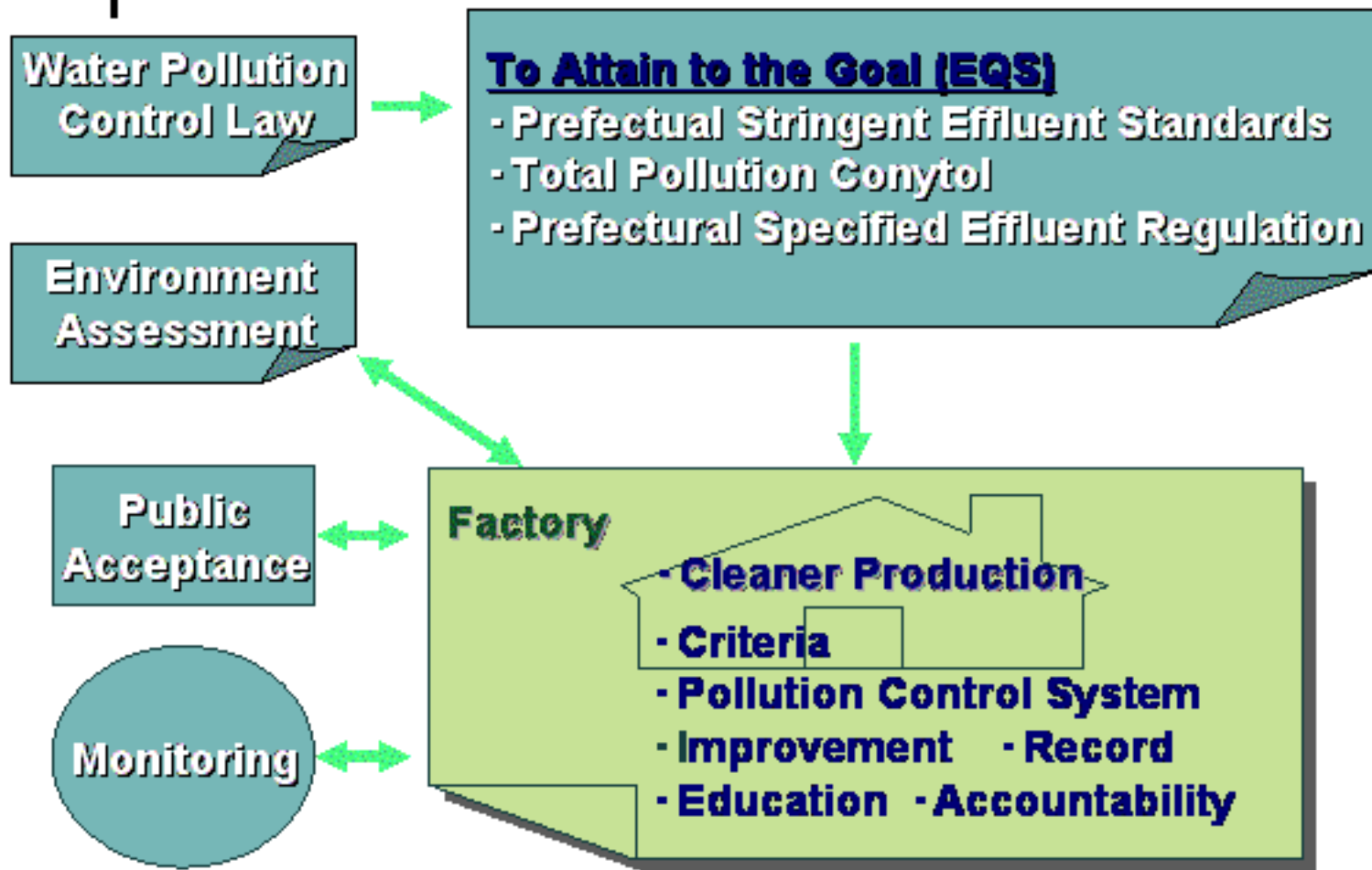
- 9 items  
pH, BOD, SS, DO,  
Oil, T-N, T-P.....
- Lake, Pond, Coast

**Effluent  
Standards**

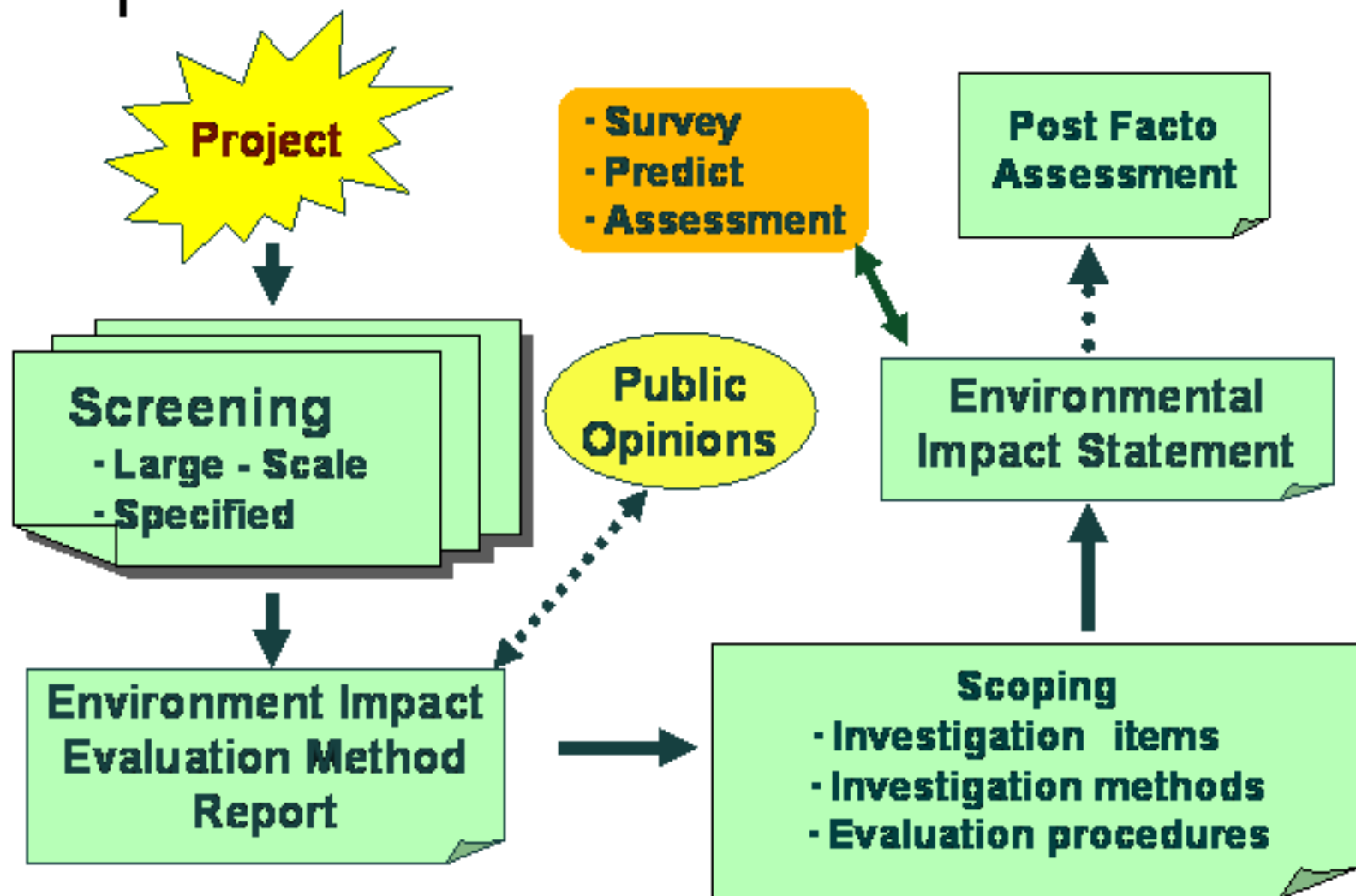
- 27 items  
ditto + Org. P
- Nationwide

- 15 items  
ditto + phenols,  
Cu, Cr, F.....
- Nationwide

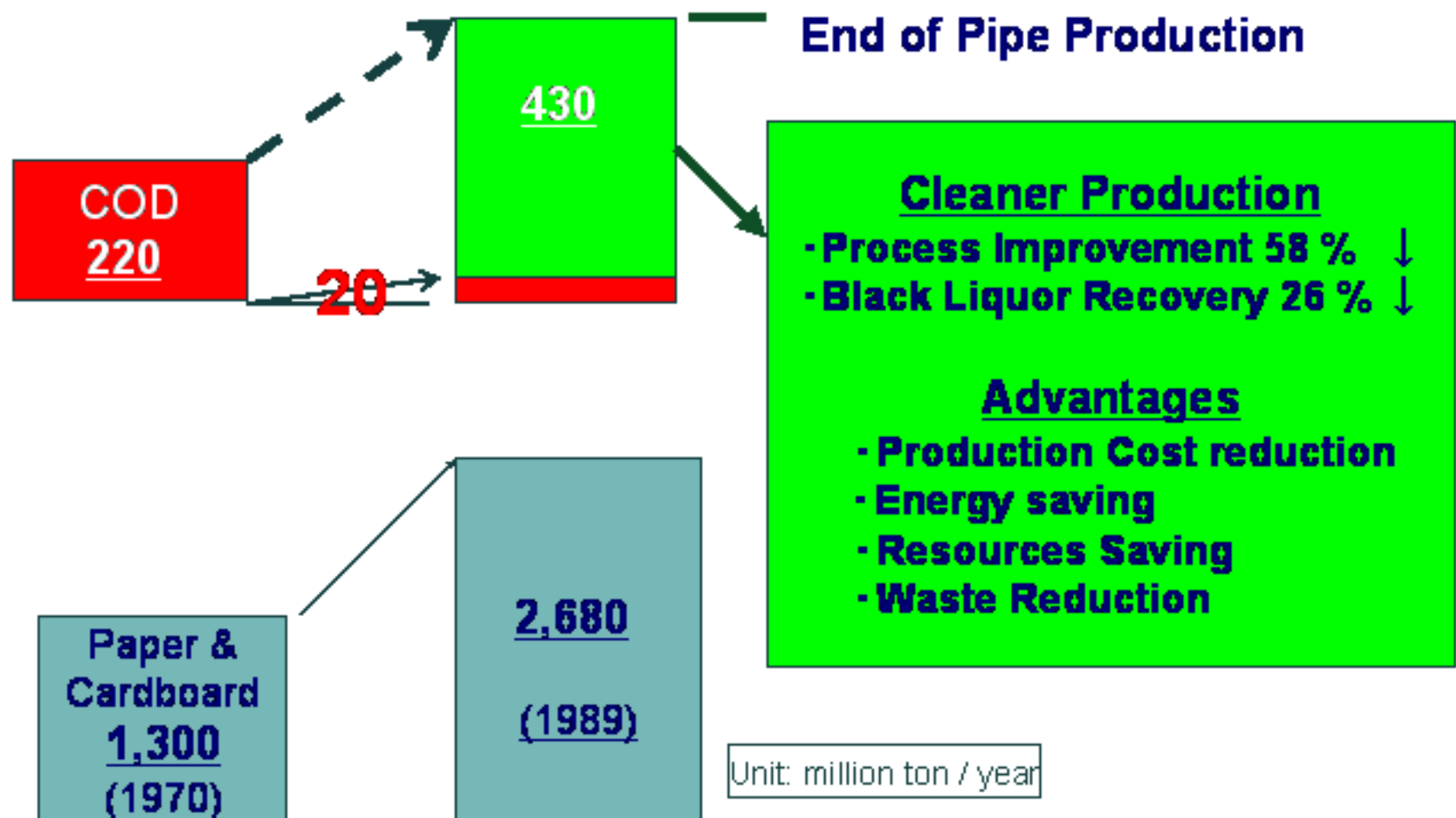
**1. Environmental Control & Measures for Industrial Wastewater Treatment**  
**Measures for Water Quality Conservation (2/3)**  
**Wastewater treatment**



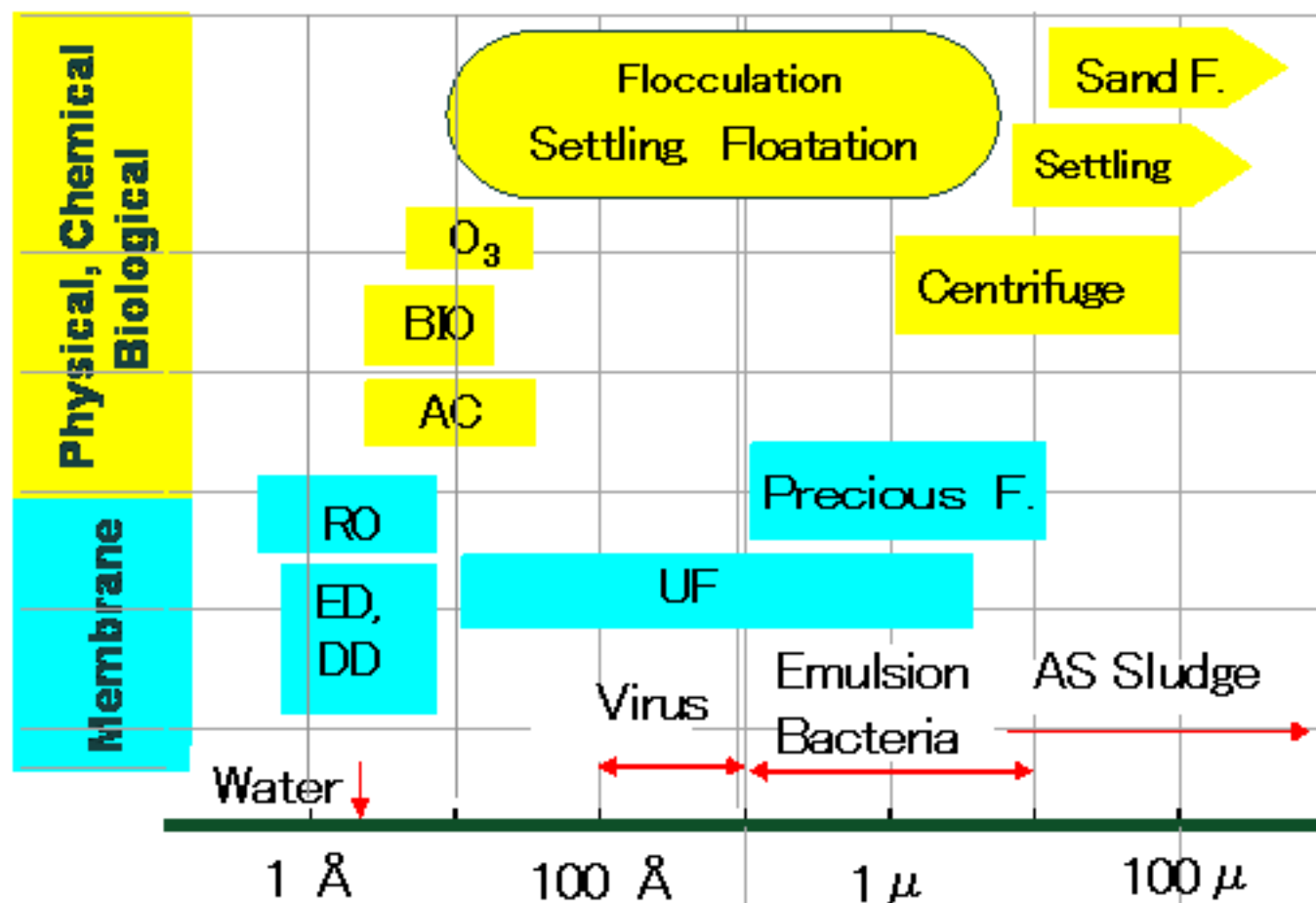
**1. Environmental Control & Measures for Industrial Wastewater  
Measures for Water Quality Conservation (3/3)  
Environmental Assessment System**



## 2. Considering Aspects on W.W. Treatment Plant Design (1) Cleaner Production



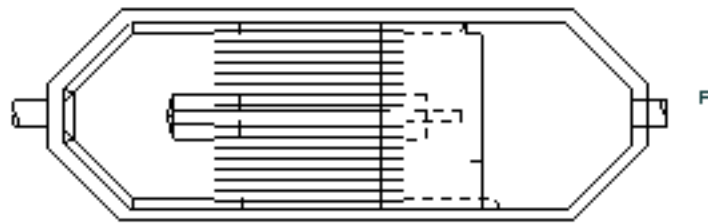
## 2. Considering Aspects on W.W. Treatment Plant Design (2) Selection of Treatment Process



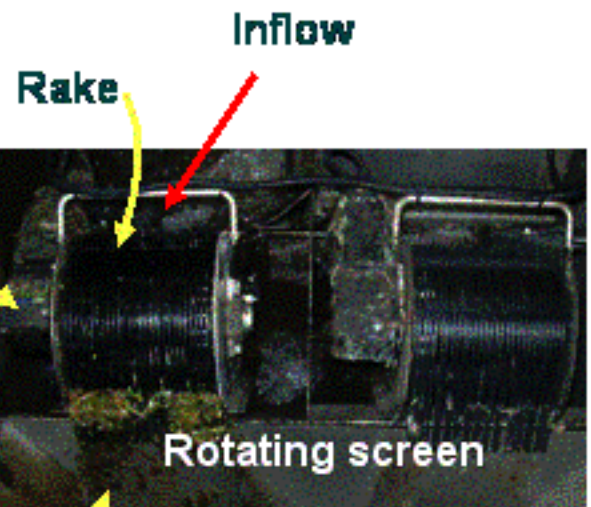
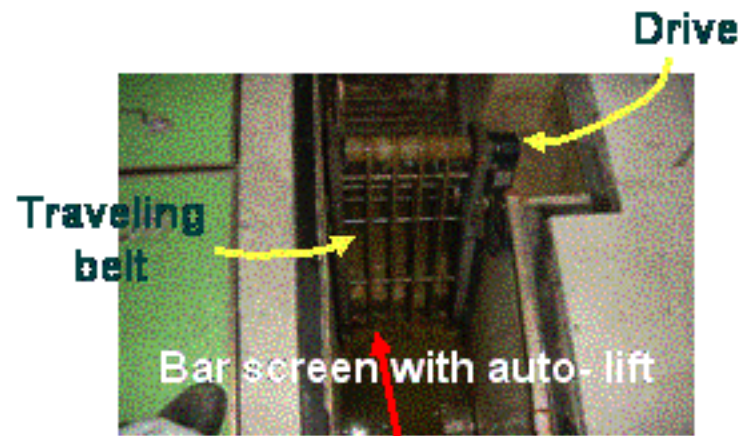
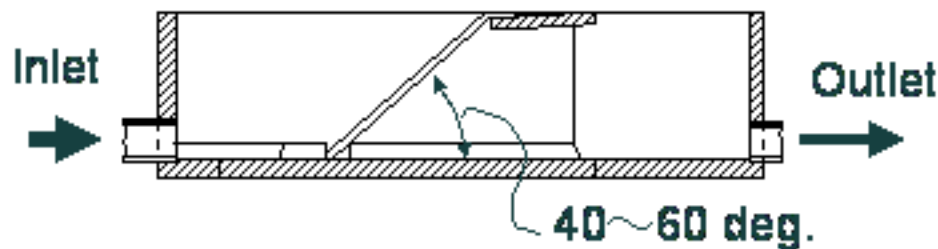


# 3. Wastewater Treatment Technologies

## (1) Screening : Remove Floating Material



Bar Screen



### Grid Effective Spacing

- ◆ Coarse Screen:  $> 50\text{mm}$
- ◆ Normal Screen  $15\sim 50\text{ mm}$
- ◆ Fine Screen  $< 15\text{ mm}$

### 3. Wastewater Treatment Technologies

#### (2) Separation of settling & floating particles

#### Stokes' Law

$$V_r = (g/18 \mu)(P_w - P_o)D^2$$

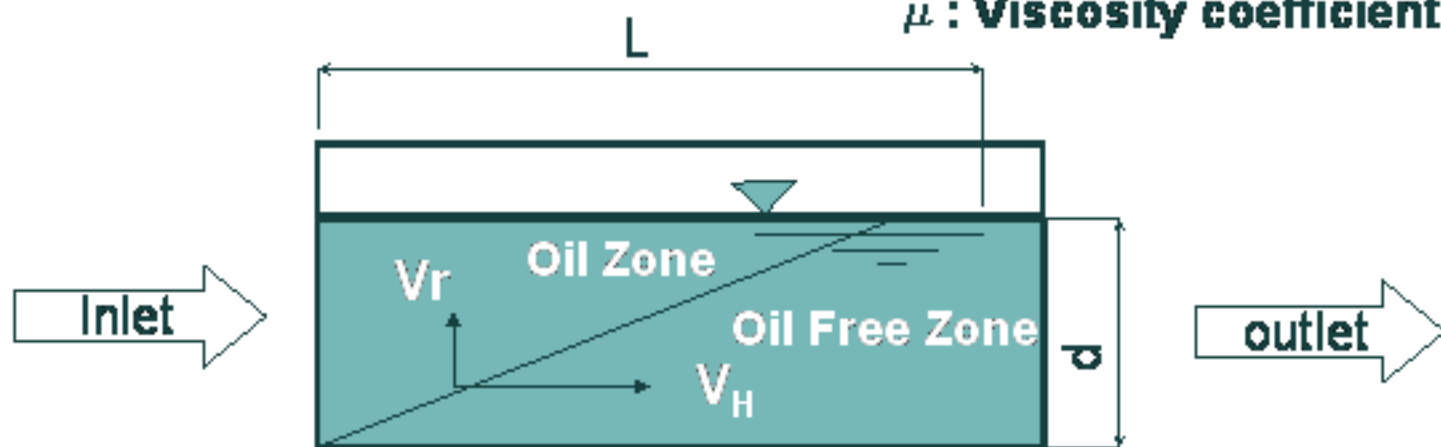
**g:** Gravity,  $m/s^2$

**P<sub>w</sub>:** Water density,  $kg / m^3$

**P<sub>o</sub>:** Oil density,  $kg / m^3$

**D:**  $\phi$  / particle,  $m$

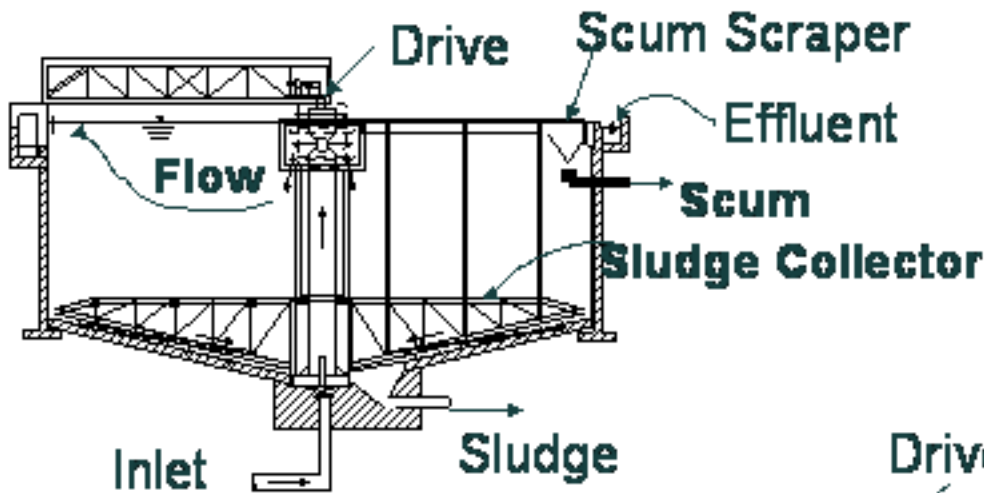
**$\mu$ :** Viscosity coefficient



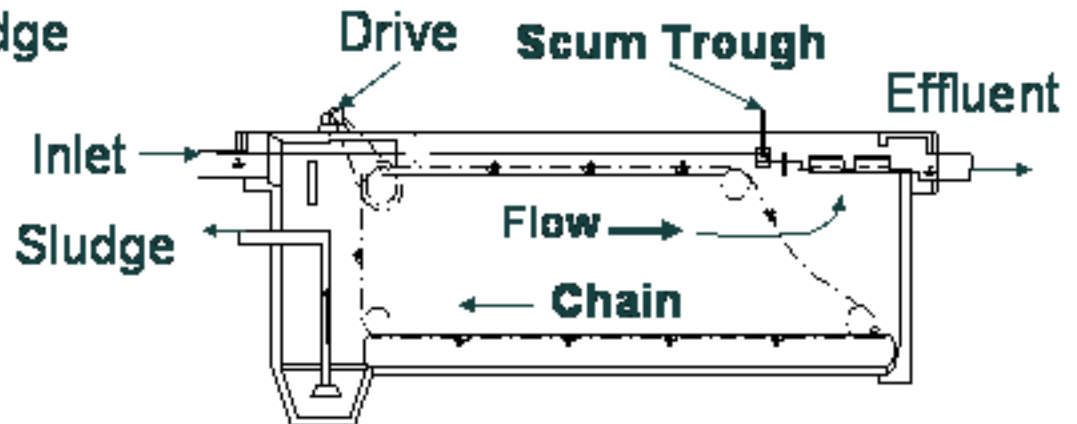
$$L = (V_H / V_r) d$$

### 3. Wastewater Treatment Technologies

#### (3) Sedimentation: Removing SS



**Circular**

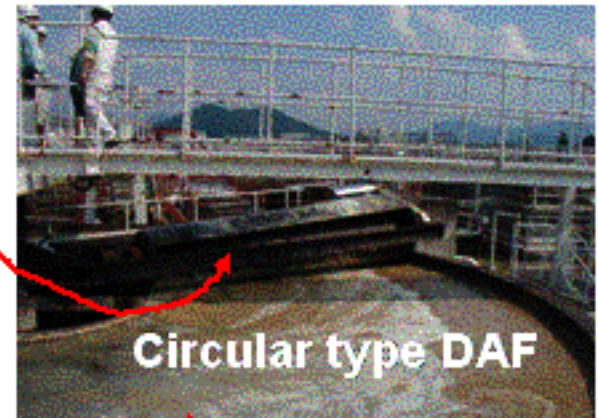
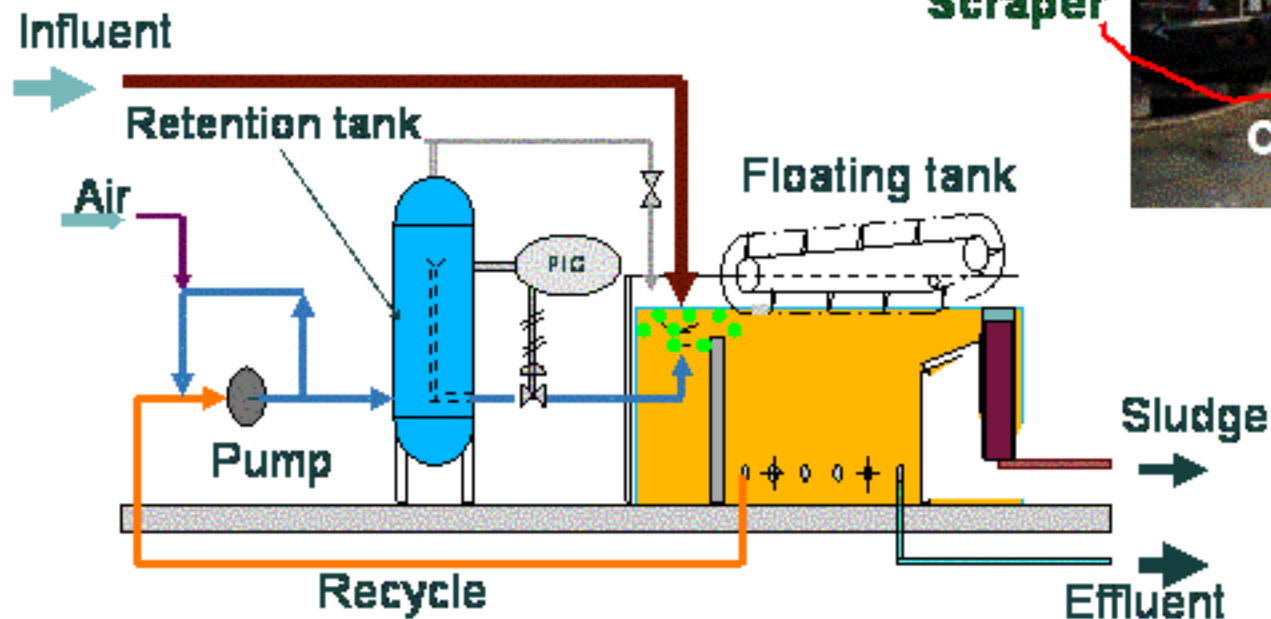


**Rectangle**

### 3. Wastewater Treatment Technologies

#### (4) Flotation: Removing SS & Oil

#### Dissolved Air Flotation



**Scraper**

**Circular type DAF**

**Floated scum**

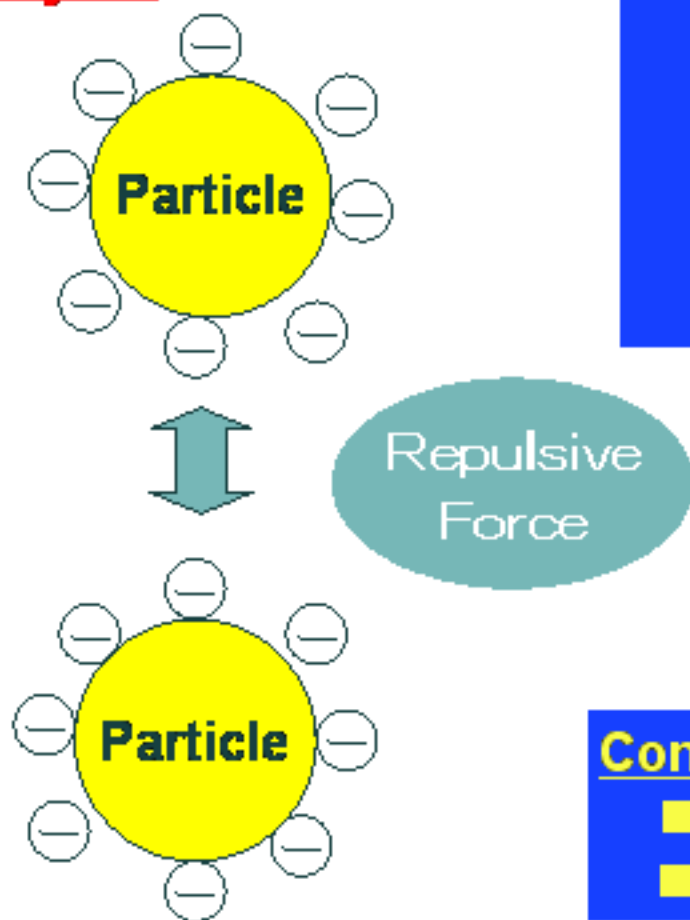
**Sludge**

**Effluent**

### 3. Wastewater Treatment Technologies

#### (5) Coagulation: Enlargement of Particle

Why ?



How to connect ?

- Electric Neutralization
- Bonding opposite Charged Ions
- Physical Adsorption
- Bridging

Coagulants

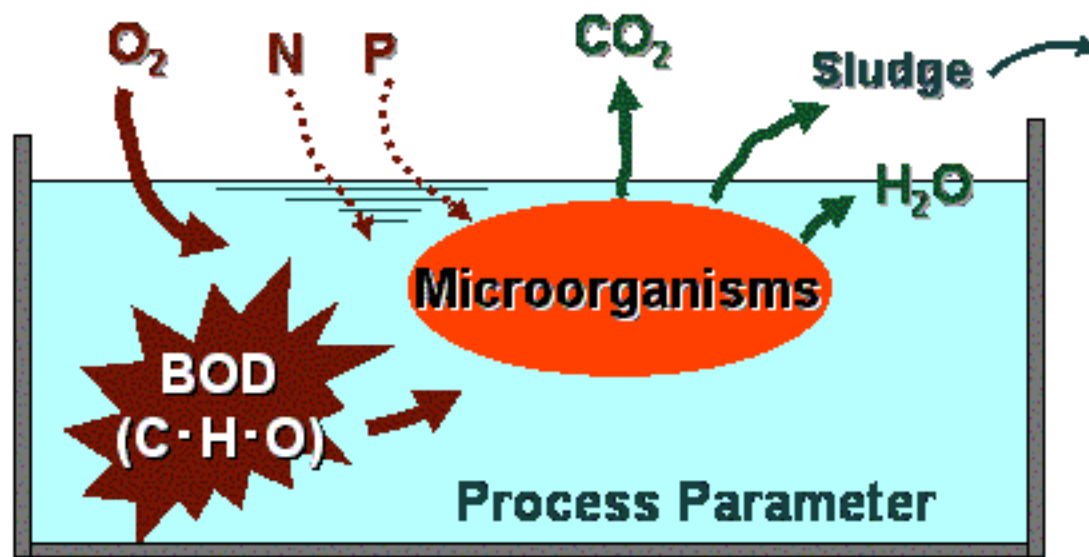
- Electrolyte
- Hydrated Metal Oxide
- Polyelectrolyte

Conditioning

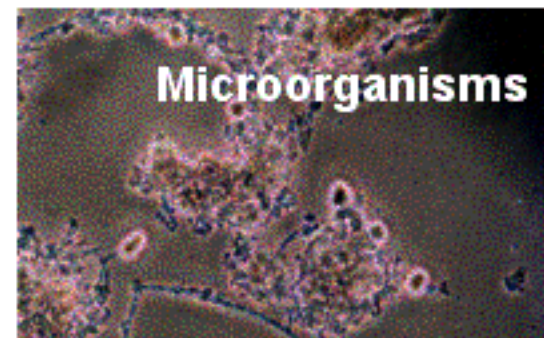
- Mixing
- pH

### 3. Wastewater Treatment Technologies

#### (6) Aerobic Biological process (1/2)



**BOD / MLSS / D**  
0.4  $\hat{=}$  30%  
0.02  $\hat{=}$  SS in Effluent



- Temp : 5~40°C
- pH: ~ 7 ~
- DO: > 0.2~
- BOD:N:P=100:5:1
- BOD /MLSS /D = 0.02~0.4



### 3. Wastewater Treatment Technologies

#### *(6) Aerobic Biological Process (2/2)*

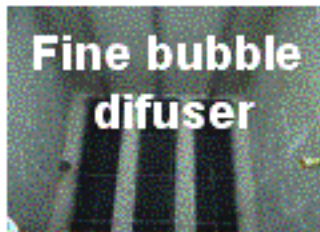
##### Process

- Conventional Activated Sludge
- Modified: Extended Aeration, Lagoon
- Biofilm: Floating Media, Rotating Contactor
- Hybrid: Membrane

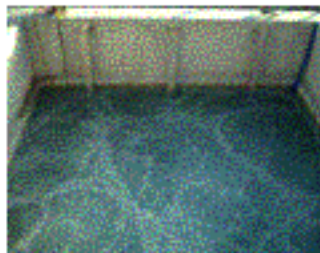
##### Aerators



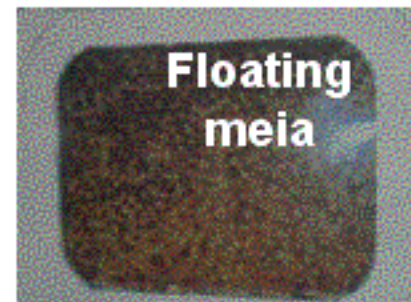
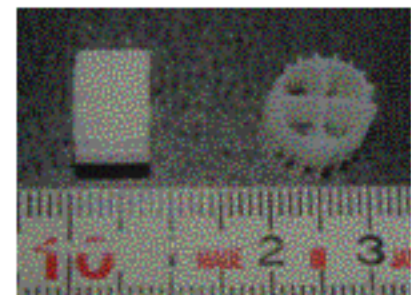
Fine bubble  
difuser



Mechanical aerator  
Fixed bed type



##### Media

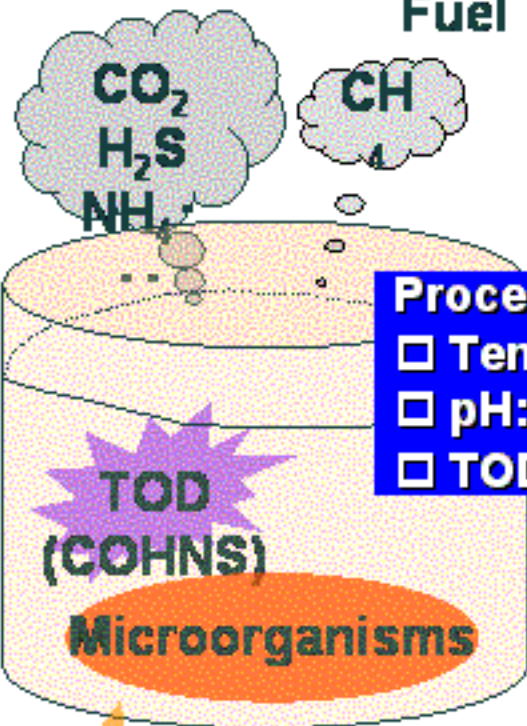


Floating  
meia

### 3. Wastewater Treatment Technologies

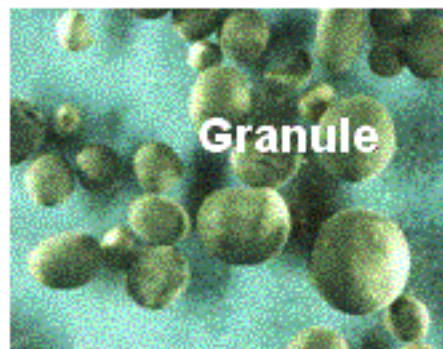
#### (7) Anaerobic Biological Process (1/2)

Fuel 0.35Nm<sup>3</sup> / kg TOD



#### Process Parameter

- Temp:  $\sim 36^\circ\text{C} \sim 55^\circ\text{C}$
- pH: 4.0  $\sim$  7.8
- TOD / VSS / D



Sludge

3~12% / COD Removed

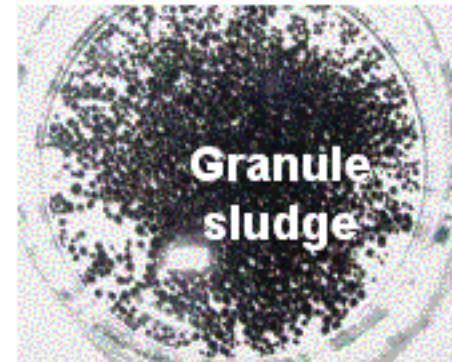
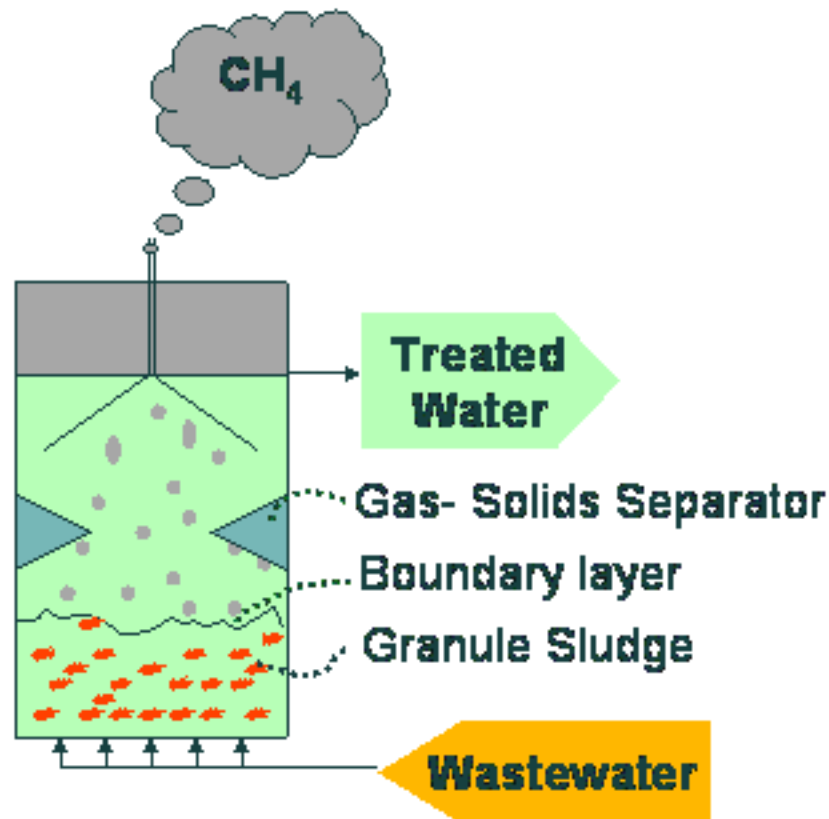


# 3. Wastewater Treatment Technologies

## (7) Anaerobic Biological Process (2/2)

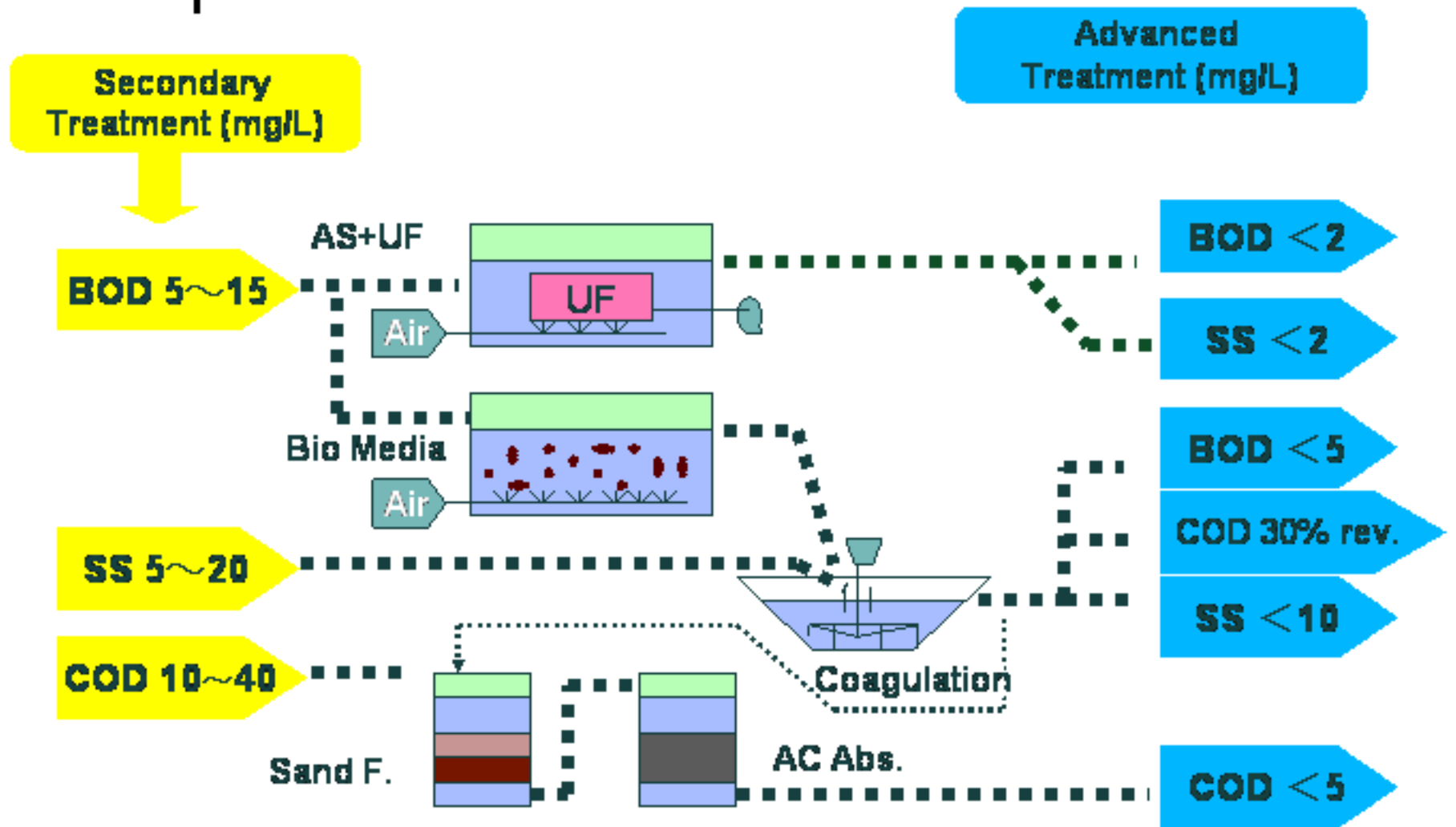
### UASB

Upflow Anaerobic Sludge Blanket



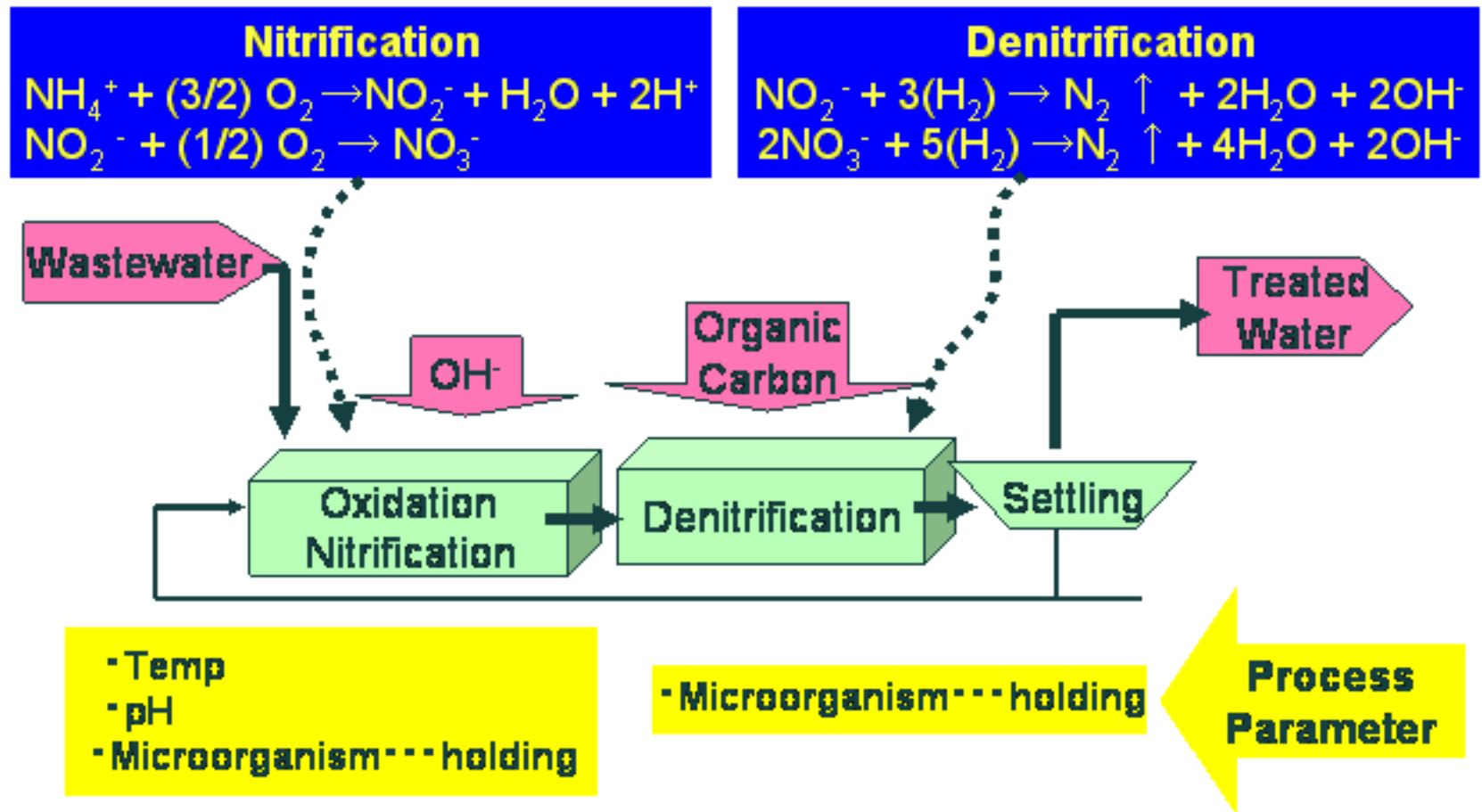
### 3. Wastewater Treatment Technologies

#### (8) Advanced Treatment – BOD, COD, SS



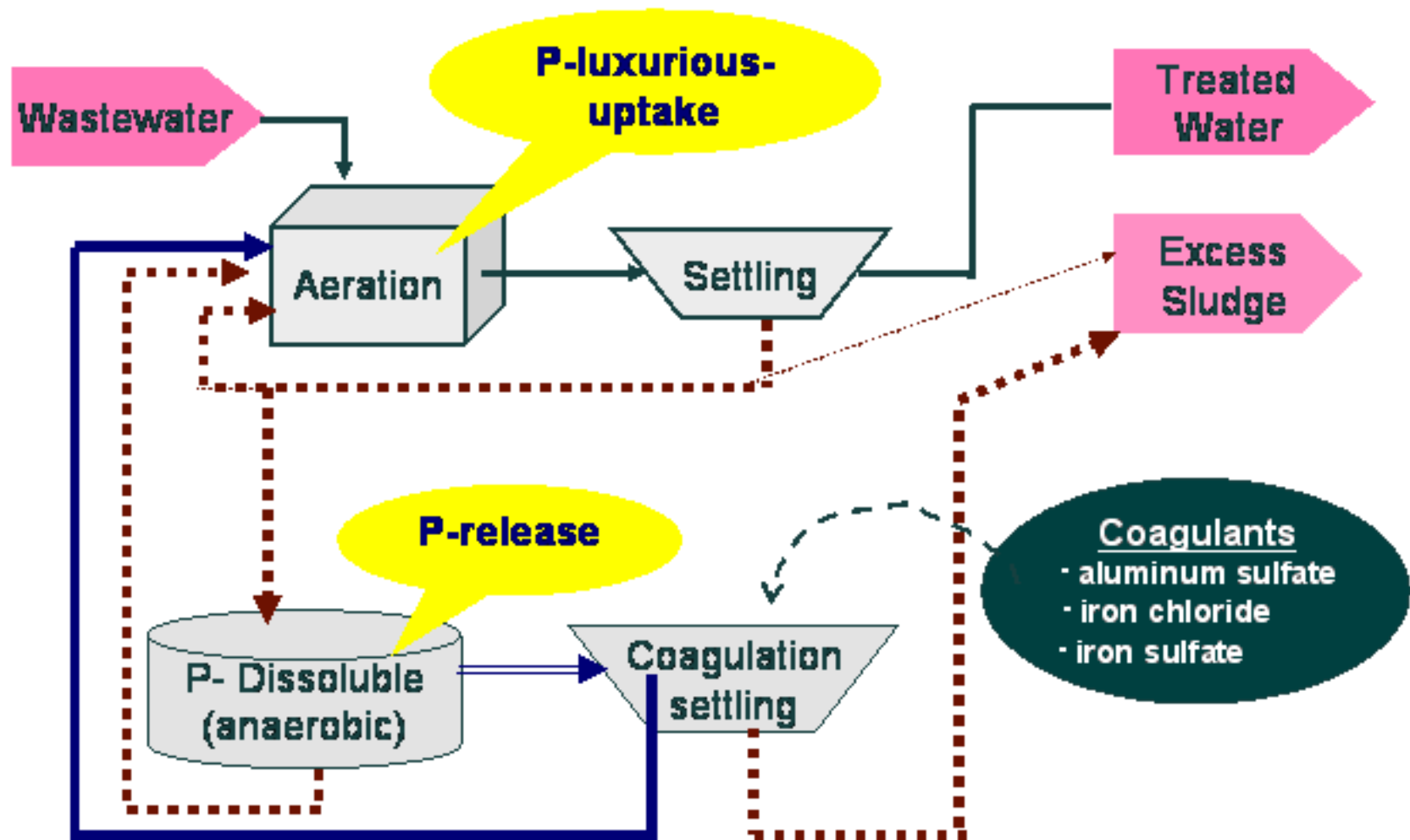
### 3. Wastewater Treatment Technologies

#### (8) Advanced Treatment – N Removal



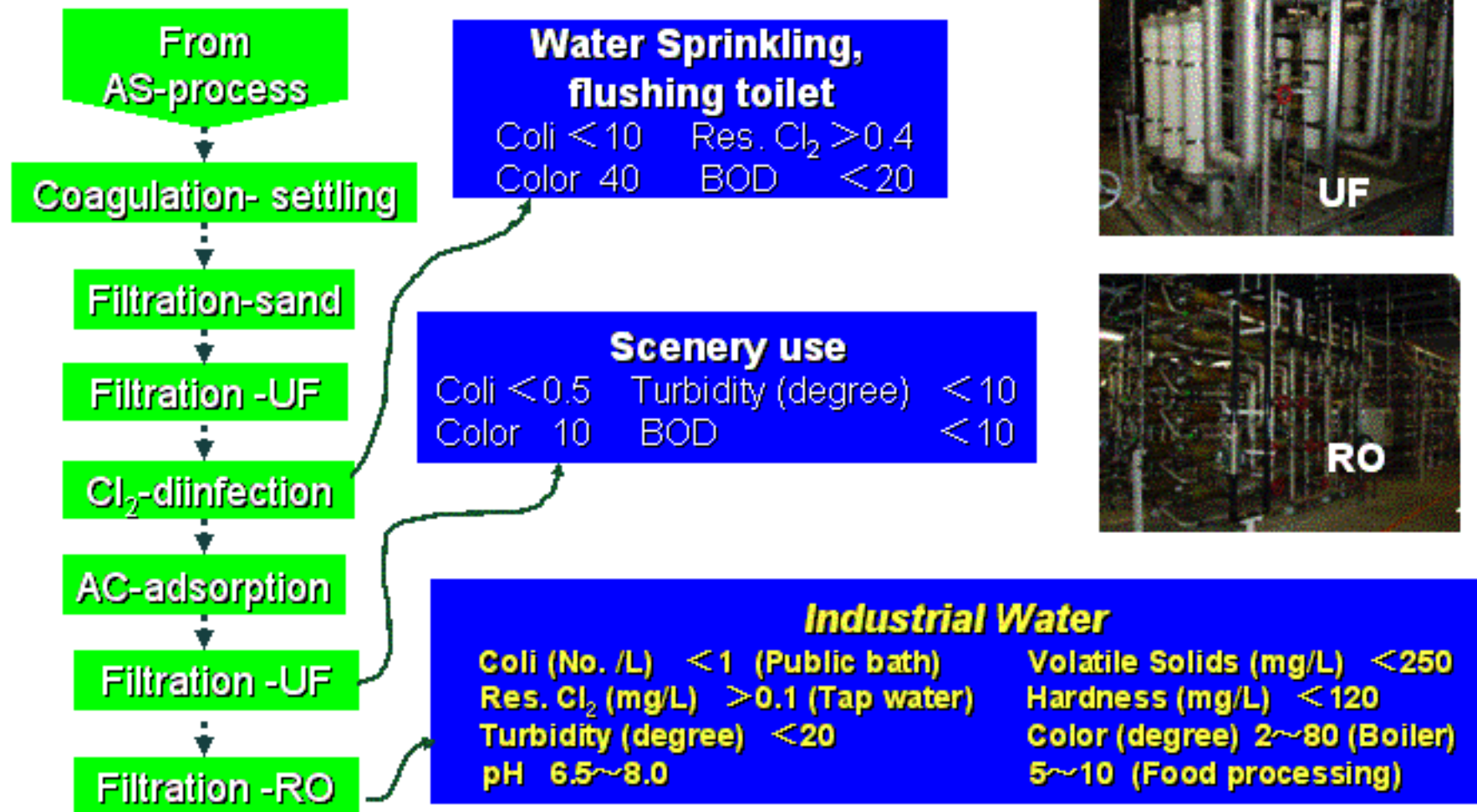
### 3. Wastewater Treatment Technologies

#### (8) Advanced Treatment – P Removal



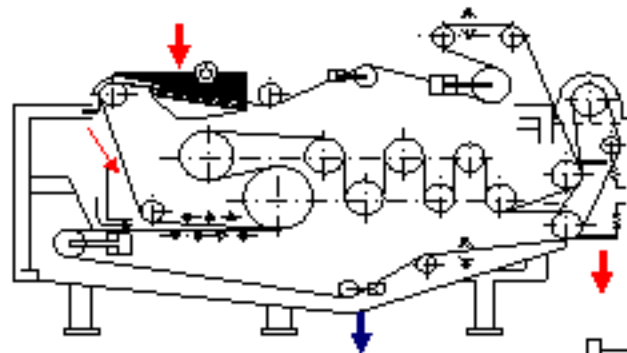
# 3. Wastewater Treatment Technologies

## (9) Reusing Treated Water

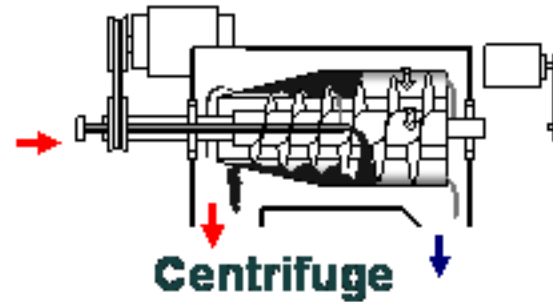


# 3. Wastewater Treatment Technologies

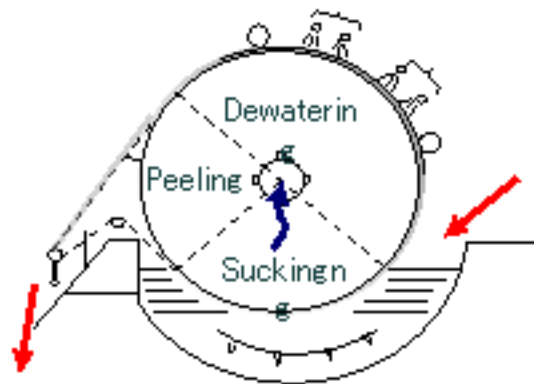
## (10) Dehydration - Dehydrators



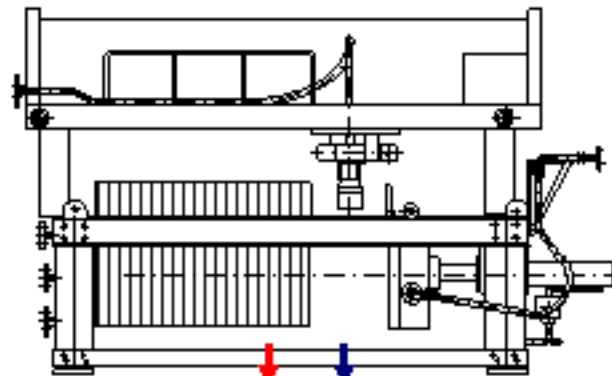
**Belt Press**



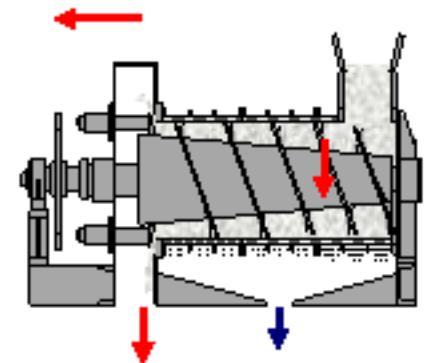
**Centrifuge**



**Vacuum filter**



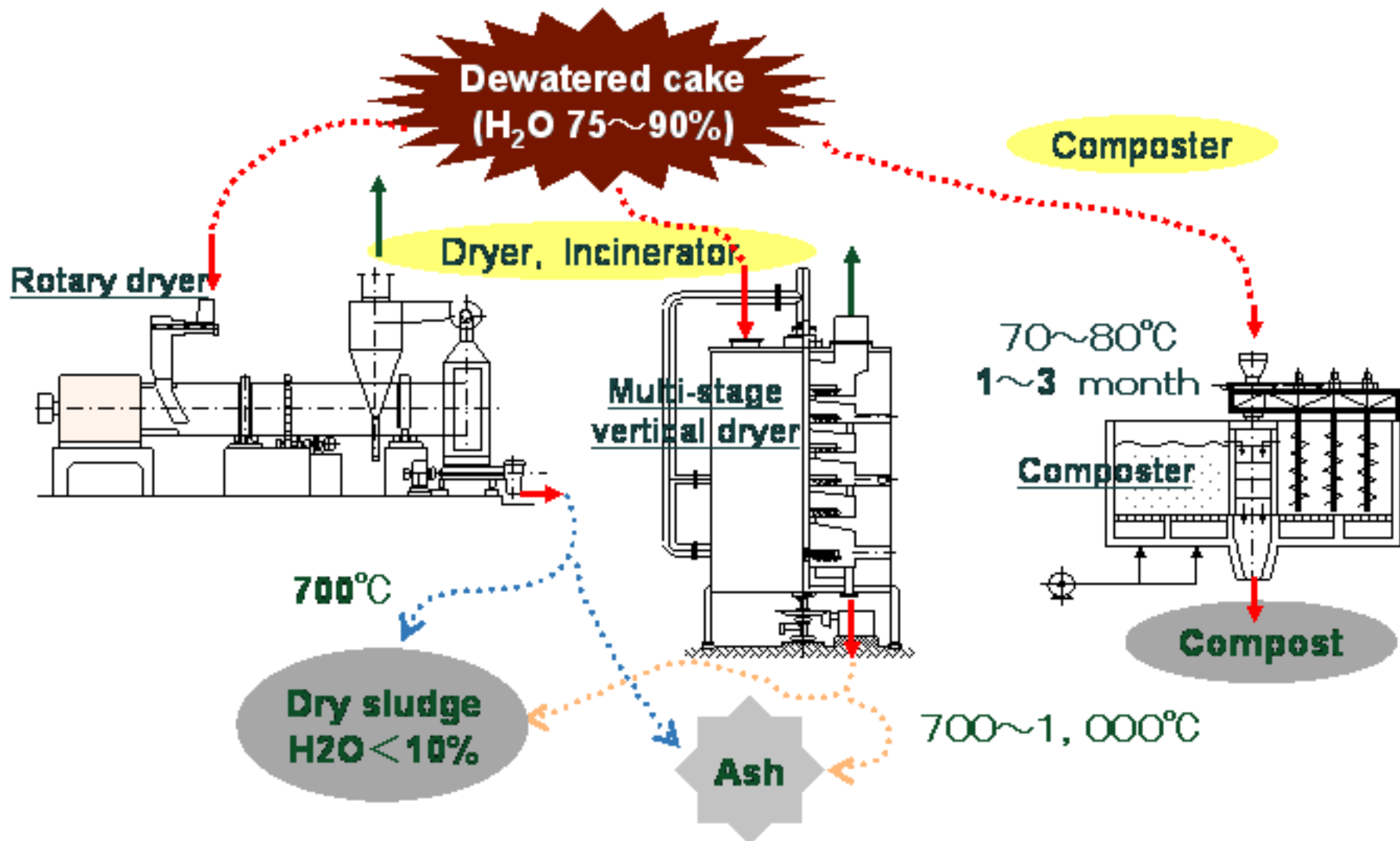
**Filter press**



**Screw press**

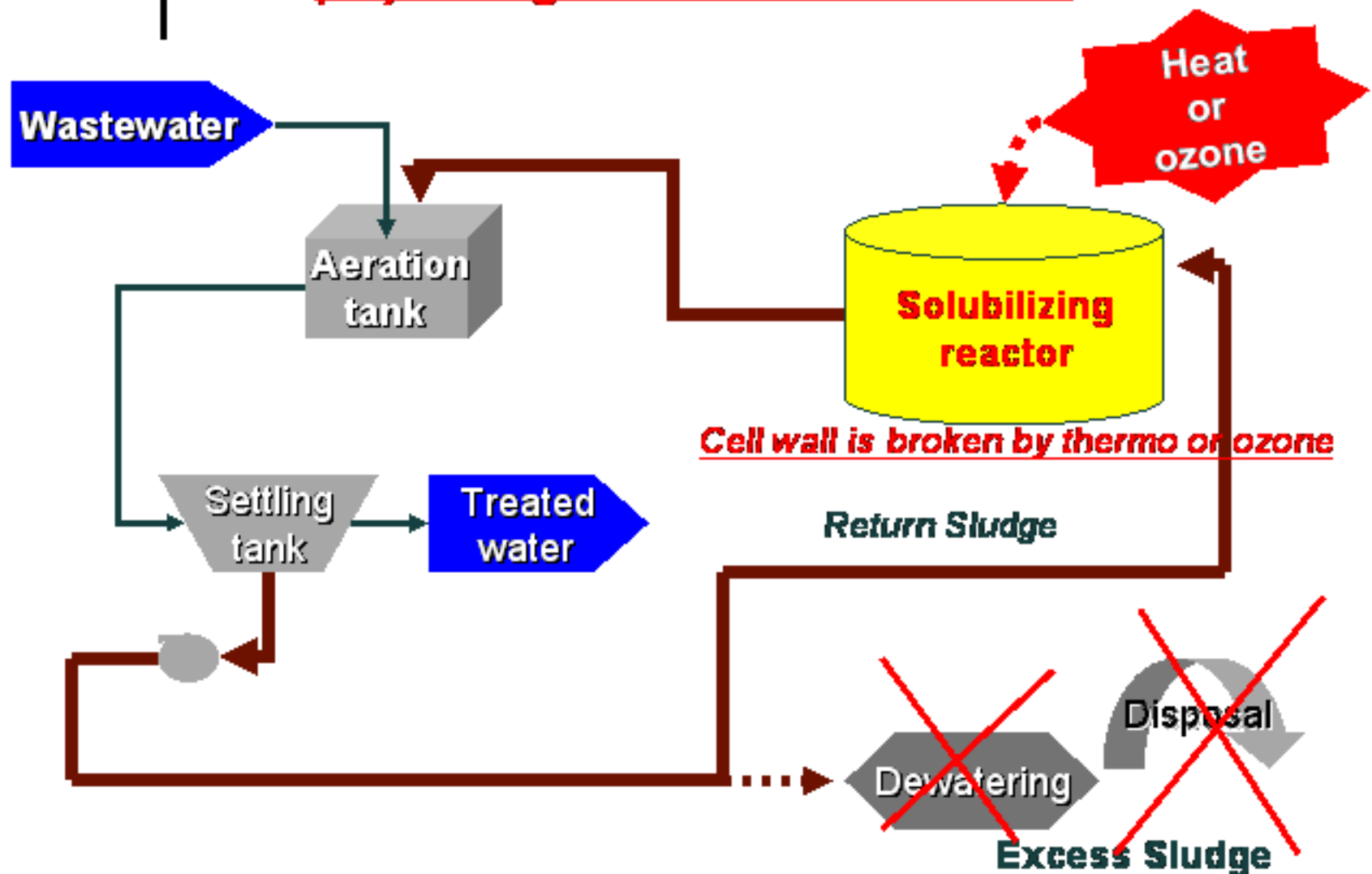
### 3. Wastewater Treatment Technologies

#### (11) Drying, Incineration, Composting



### 3. Wastewater Treatment Technologies

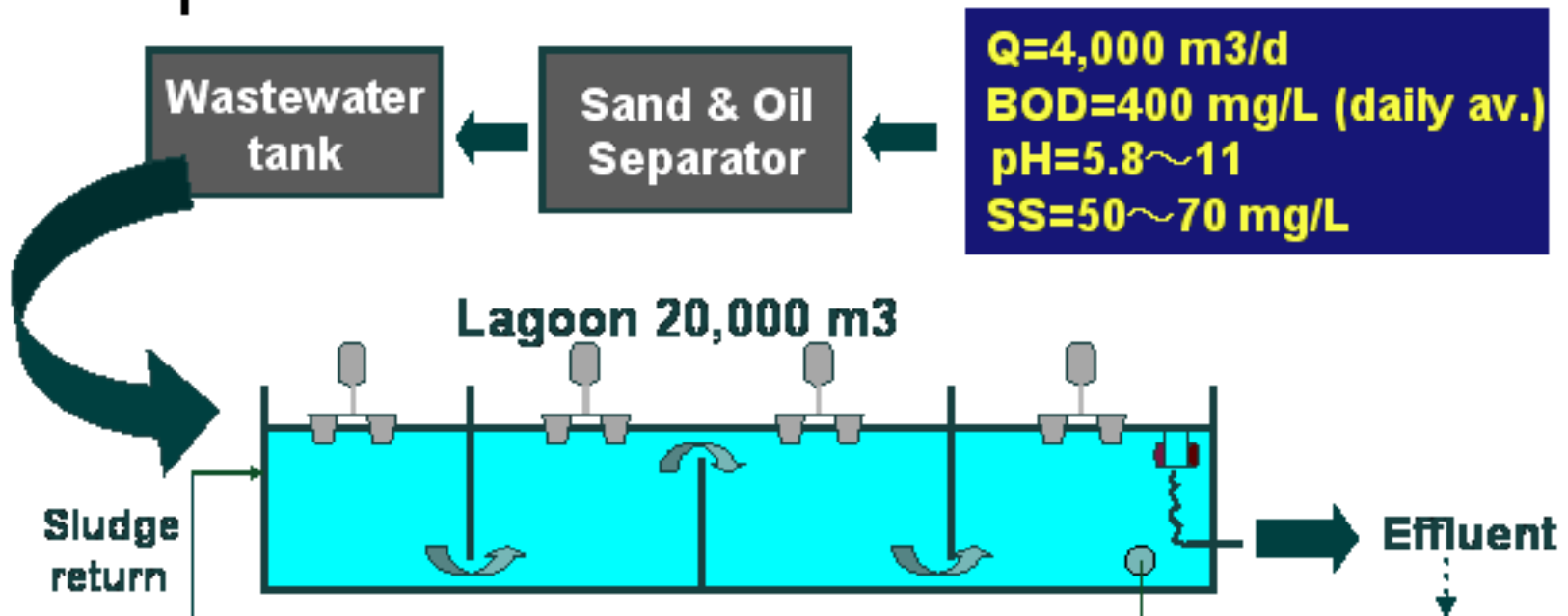
#### (12) Sludge Reduction Process





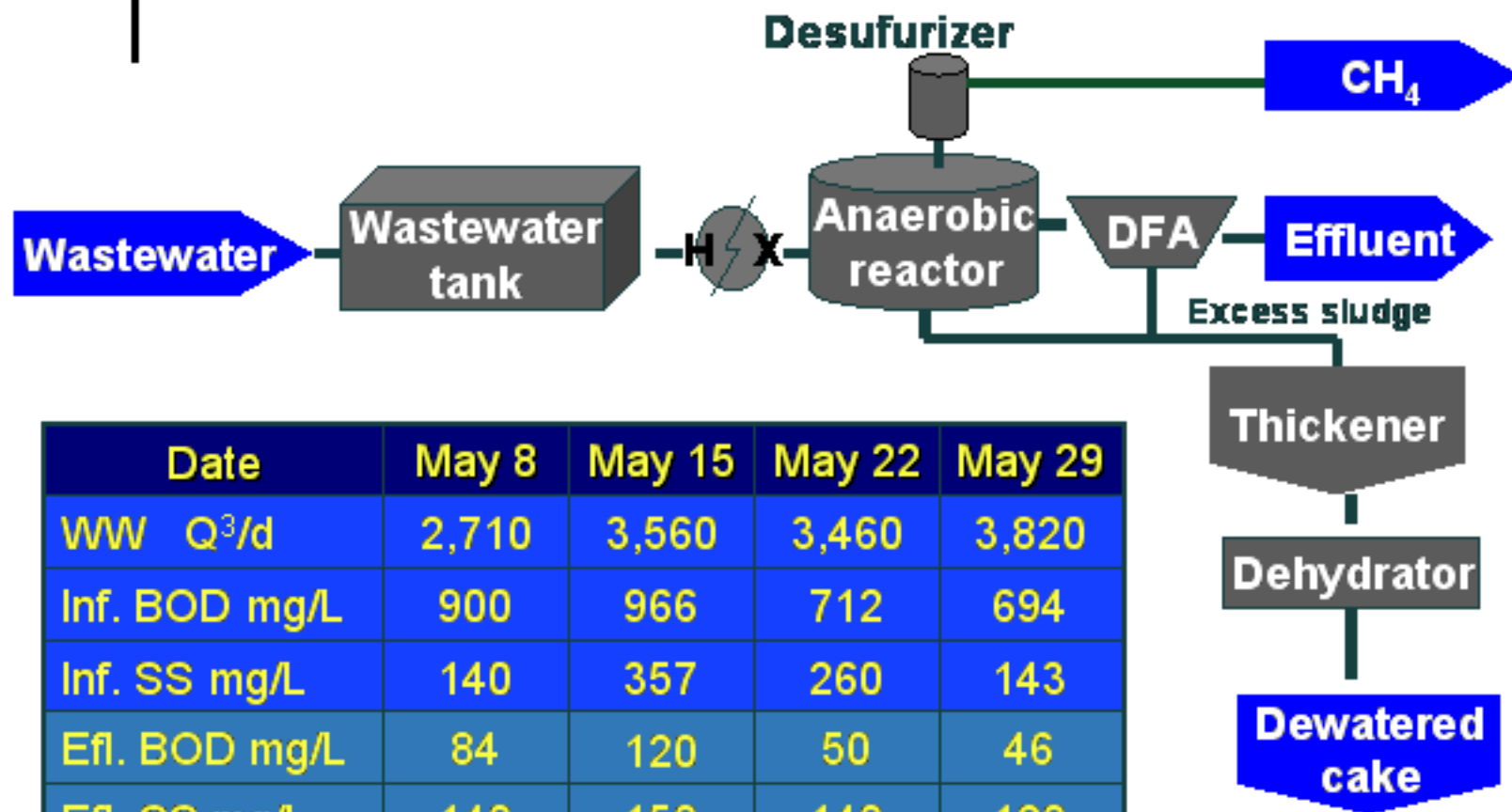
## 4. Examples of Food Processing WW Treatment

### (1) Beverage -----Coke



Yearly	Temp. (°C)	Water (°C)	pH	BOD (mg/L)	DO (mg/L)	SS (mg/L)	Trsp. (cm)
Av.	10.7	16.7	9.0	2.6	4.5	4.3	40
Max	33	25.4	11.3	5.4	9.2	11.3	50
Min	-15	7.1	7.8	1.6	1.7	2.4	20

## 4. Examples of Food Processing WW Treatment (2) Breweries — Beer (1/3)



Date	May 8	May 15	May 22	May 29
WW $Q^3/d$	2,710	3,560	3,460	3,820
Inf. BOD mg/L	900	966	712	694
Inf. SS mg/L	140	357	260	143
Efl. BOD mg/L	84	120	50	46
Efl. SS mg/L	140	150	140	120
$\text{CH}_4$ $m^3/d$	1,100	1,210	924	969

WW: Wastewater, weekly average

## 4. Examples of Food Processing WW Treatment

### (2) Breweries — Beer (2/3)

#### Cost comparison – Anaerobic vs. Aerobic

Item	Price ¥	Anaerobic + DAF		Aerobic process	
		Cons. /d	¥ /d	Cons. /d	¥ /d
Power	18/kWh	3,200kWh	57,600	6,800kWh	122,400
Steam	3/kg	12,000kg	36,000	-	-
45% NaOH	40/kg	1,600kg	64,000	-	-
Coagulants	1,400/kg	4kg	5,600	15kg	21,000
Desulfer	170/kg	4.2kg	714	-	-
Sludge disp.	10,000/m <sup>3</sup>	1.5m <sup>3</sup>	15,000	6m <sup>3</sup>	60,000
CH <sub>4</sub>	28,000/kL	2kL	▲56,000	-	-
<b>Total</b>			<b>122,914</b>		<b>203,400</b>
<b>Economics</b>		<b>+ ¥ 80,486/ d</b>			

DAF: dissolved Air Floatation unit, CH<sub>4</sub>: converted to A-heavy oil

## 4. Examples of Food Processing WW Treatment

### (2) Breweries — Beer (3/3)

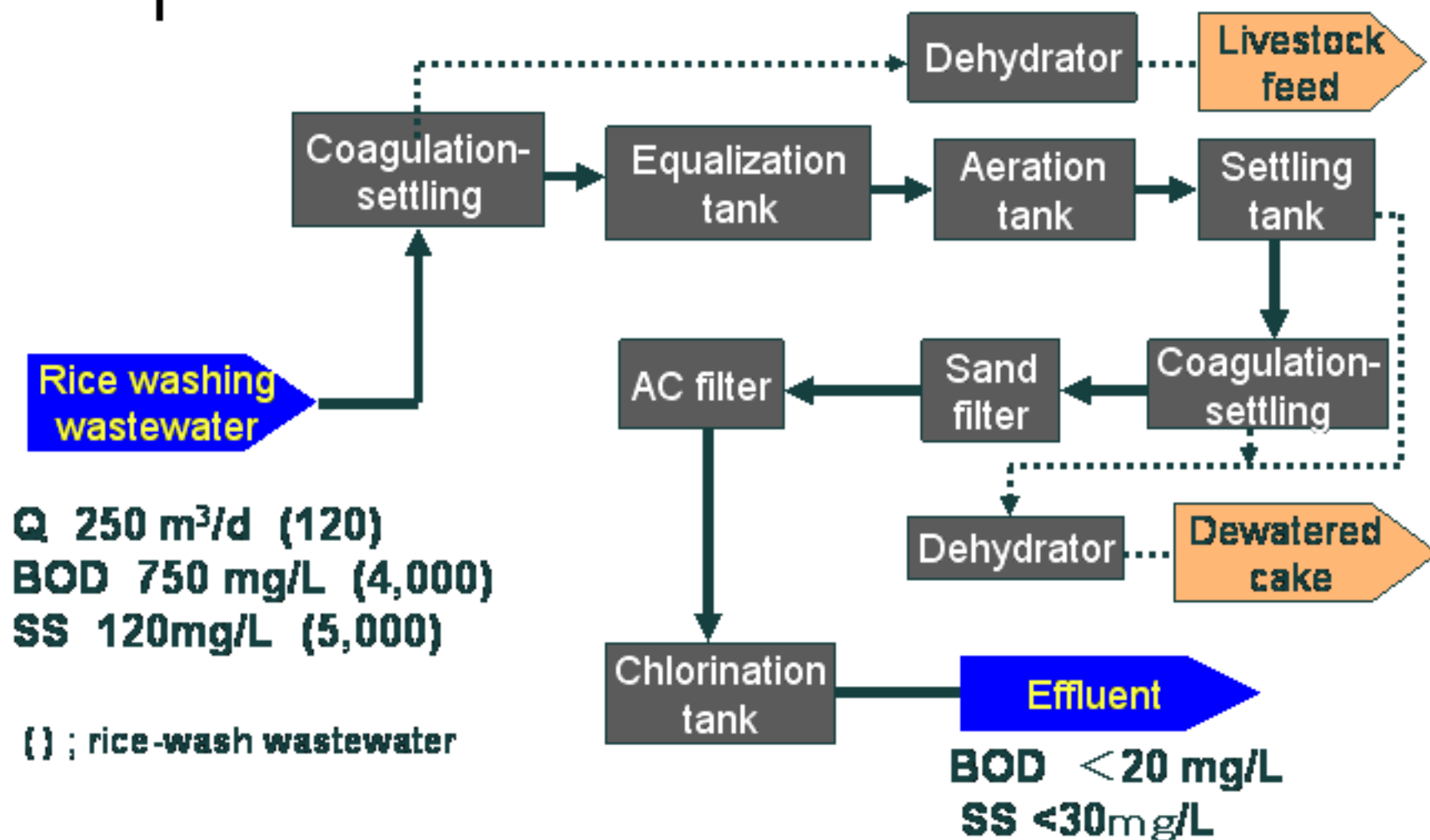


Centrifuge  
dehydrator



## 4. Examples of Food Processing WW Treatment

### (2) Breweries — Sake (1/2)

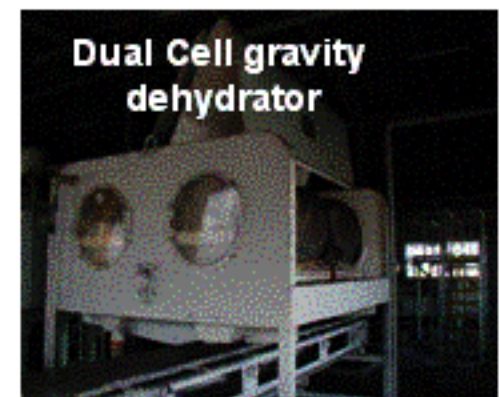


## 4. Examples of Food Processing WW Treatment (2) Breweries — Sake (2/2)

### Purification of rice-washing wastewater by coagulation

	pH	SS (mg/L)	BOD (mg/L)
<b>Raw WW</b>	<b>6.6</b>	<b>717</b>	<b>1,250</b>
<b>Effluent</b>	<b>6.8</b>	<b>&lt; 30</b>	<b>185</b>

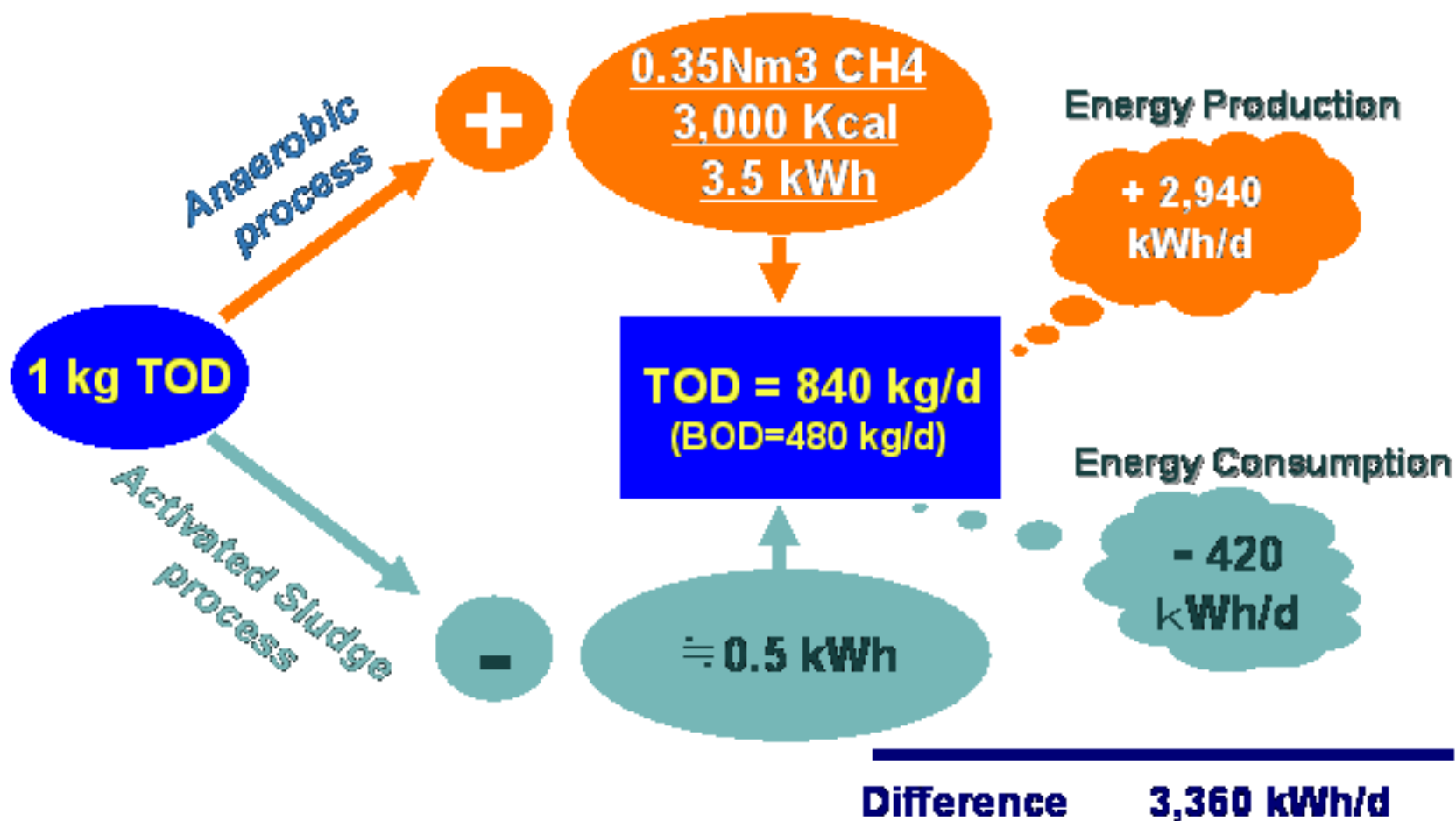
Coagulants: alum; 1,000 NaOH; 365 Polymer; 10 (mg/L)





## 4. Examples of Food Processing WW Treatment

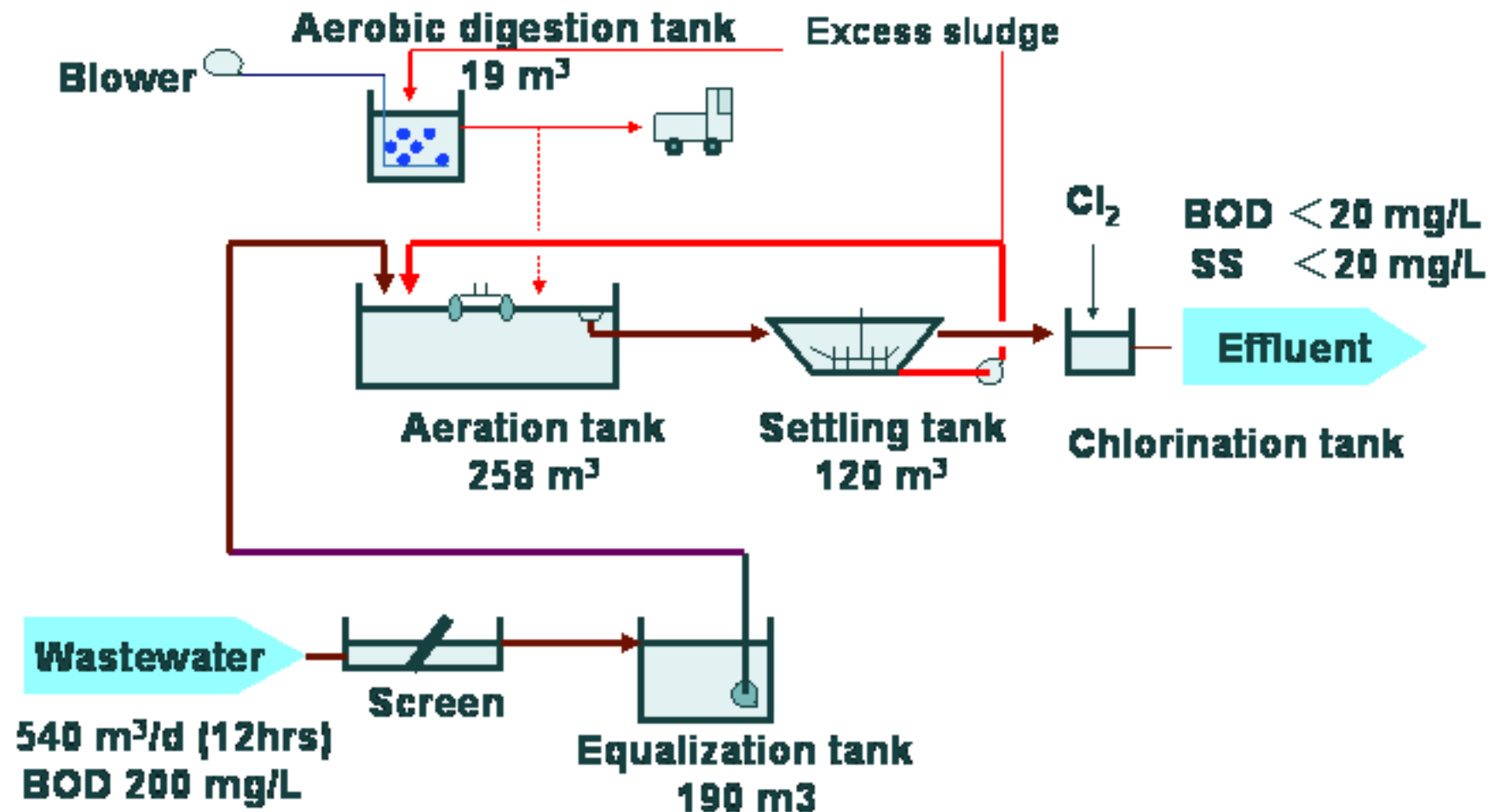
### (3) Oil & Fat (2/2)





## 4. Examples of Food Processing WW Treatment

### (4) Milk & Dairy Product (1/2)



## 4. Examples of Food Processing WW Treatment

### (4) Milk & Dairy Product (2/2)

## Sludge Bulking

Wastewater

- Low molecular hydr. C
- Reduced sulfur
- Shortage-N, P & Fe
- Toxic materials

Temporarily measure: **Coagulant**

Causes

Operation

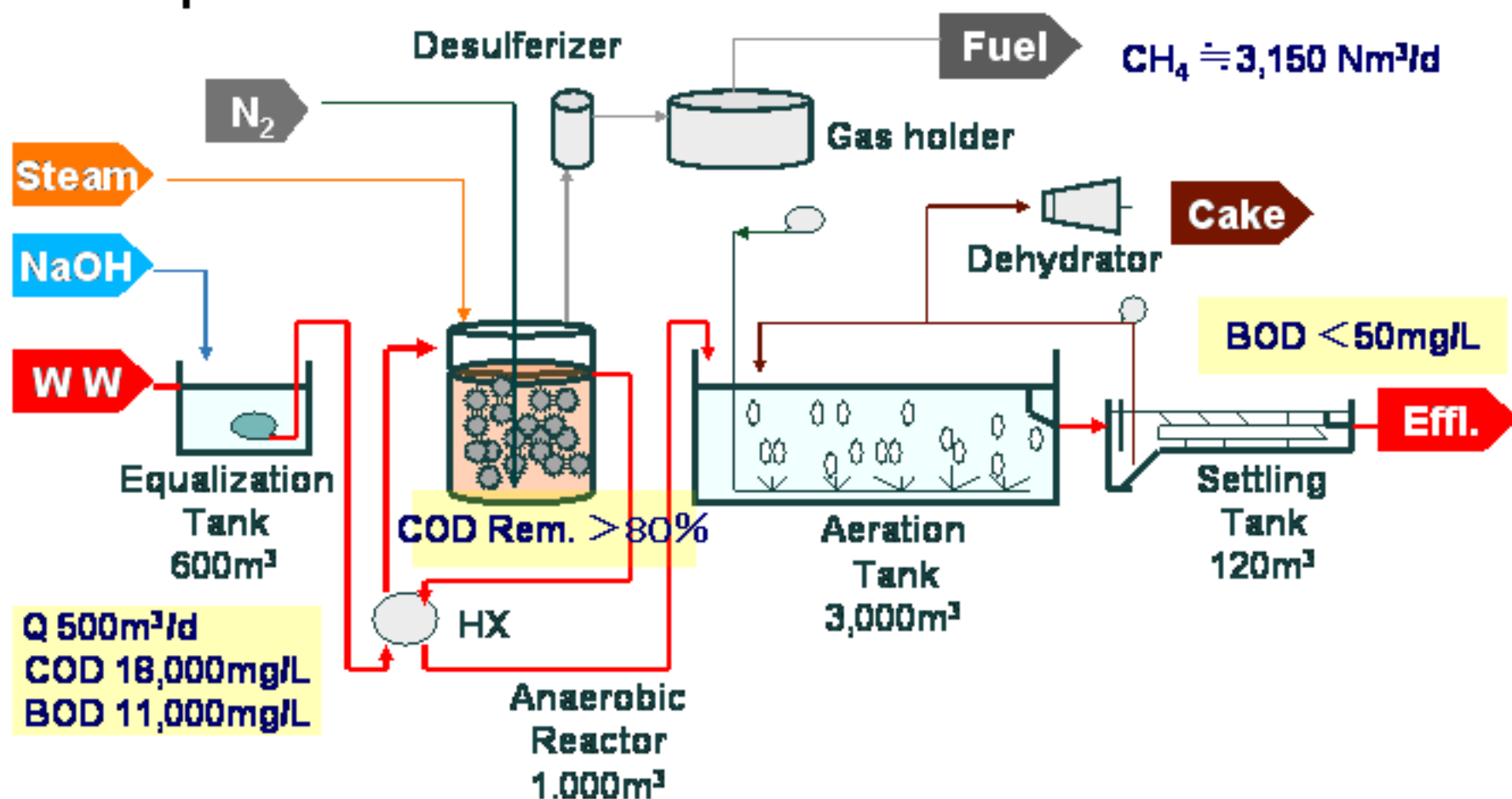
- Low load < 0.2kgBOD/kg SS/d
- High load > 0.4kgBOD/kg SS/d
- Low DO < 0.2mg/L
- Abnormal pH < 6.5 ~ 8 <
- Short SRT

**For Chronic bulking:**

- ✓ **Plug-flow**
- ✓ **Batch-wise operation**
- ✓ **Pre-treatment-Anaerobic process**

## 4. Examples of Food Processing WW Treatment

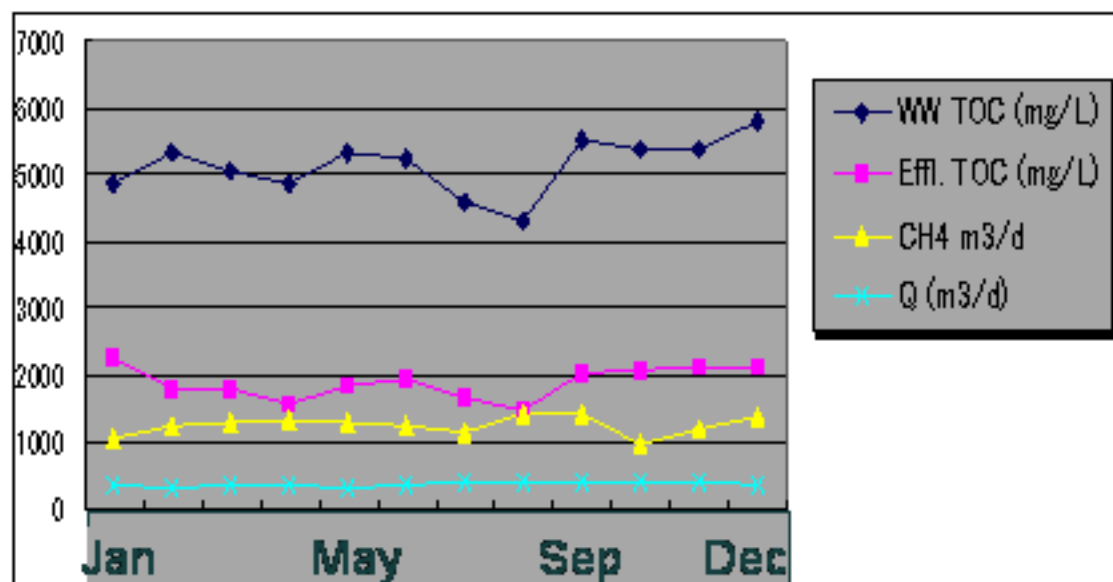
### (5) Wheat Starch (1/2)



## 4. Examples of Food Processing WW Treatment

### (5) Wheat Starch (2/2)

#### Anaerobic Process Performance (Monthly av.)



Oper. parameter

**Anaerobic**

WW Volume  
 °C in reactor  
 Gas volume  
 CH<sub>4</sub> Conc.  
 pH  
 SS

**Aerobic**

MLSS  
 pH  
 °C in AT  
 DO

### Advantages of Anaerobic Treatment

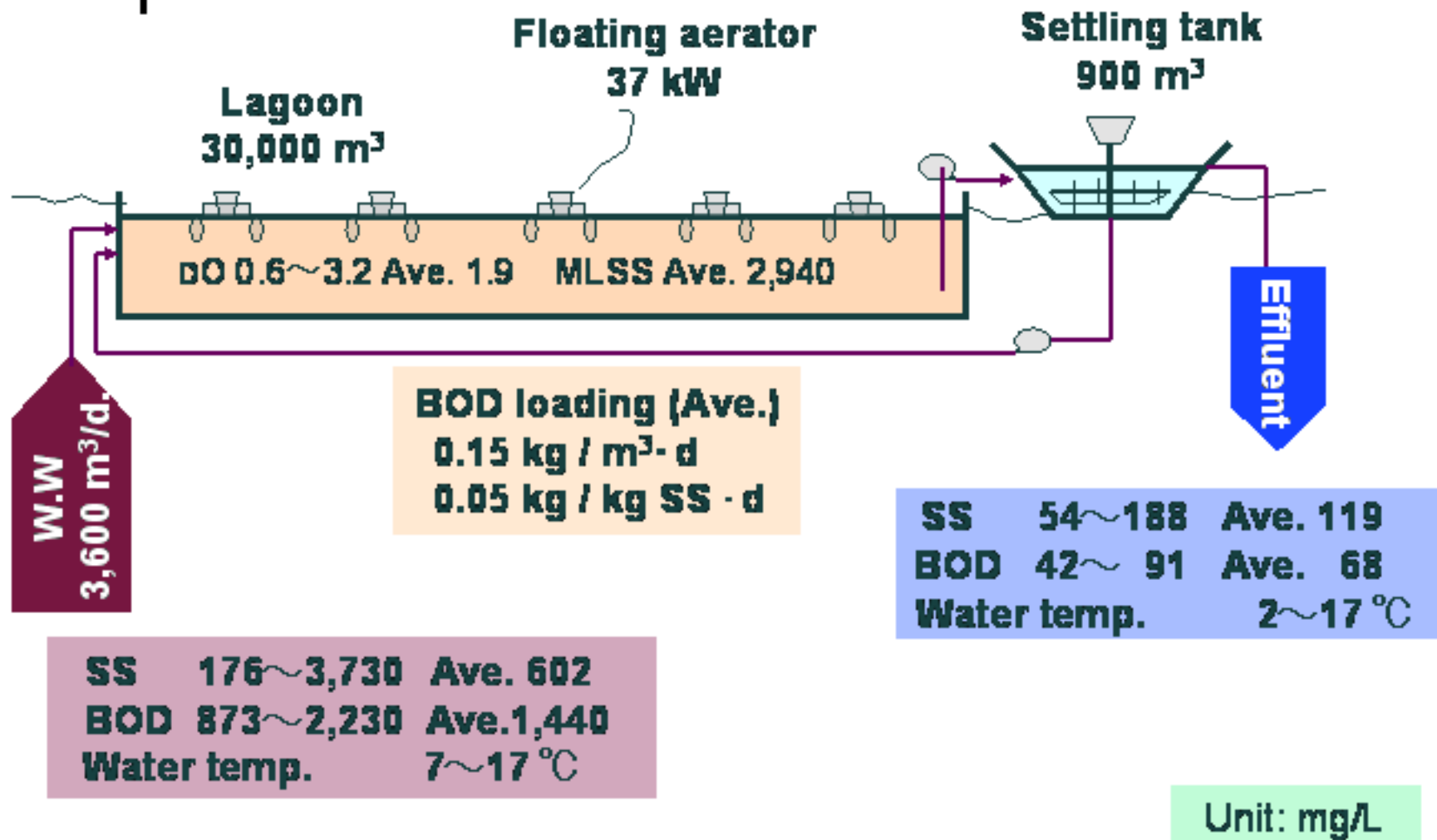
CH<sub>4</sub> → Fuel for Starch drying process

Sludge bulking in activated sludge process → Disappeared

Excess sludge generation → Reduced to about 1/5

## 4. Examples of Food Processing WW Treatment

### (6) Potato starch(1/2)



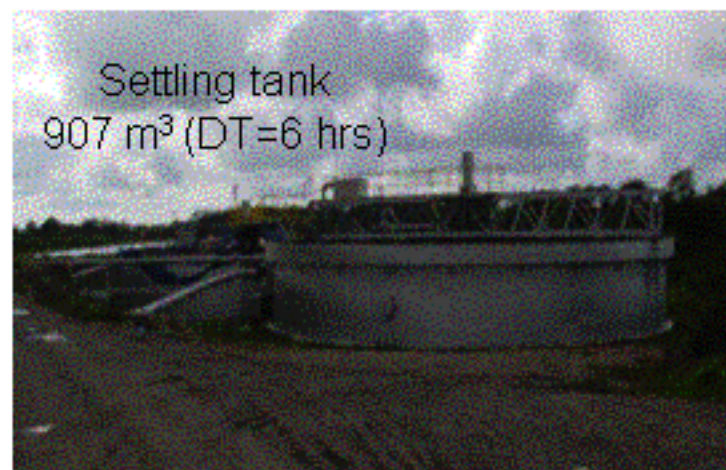
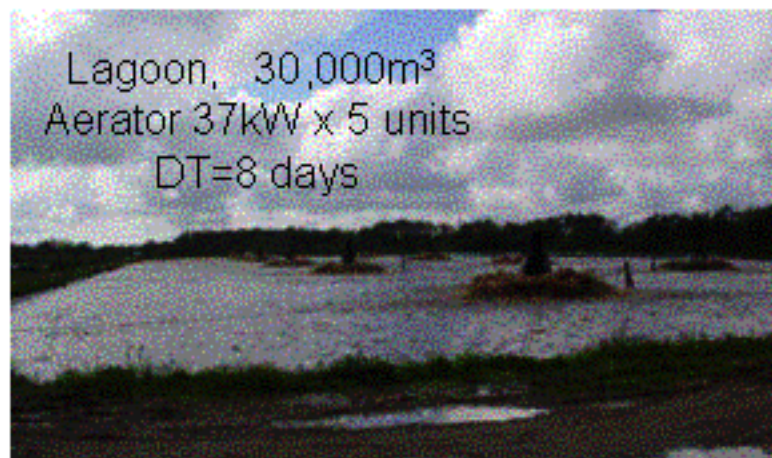
## 4. Examples of Food Processing WW Treatment

### (6) Potato starch(2/2)

**Operation: End of summer ~ early of winter**

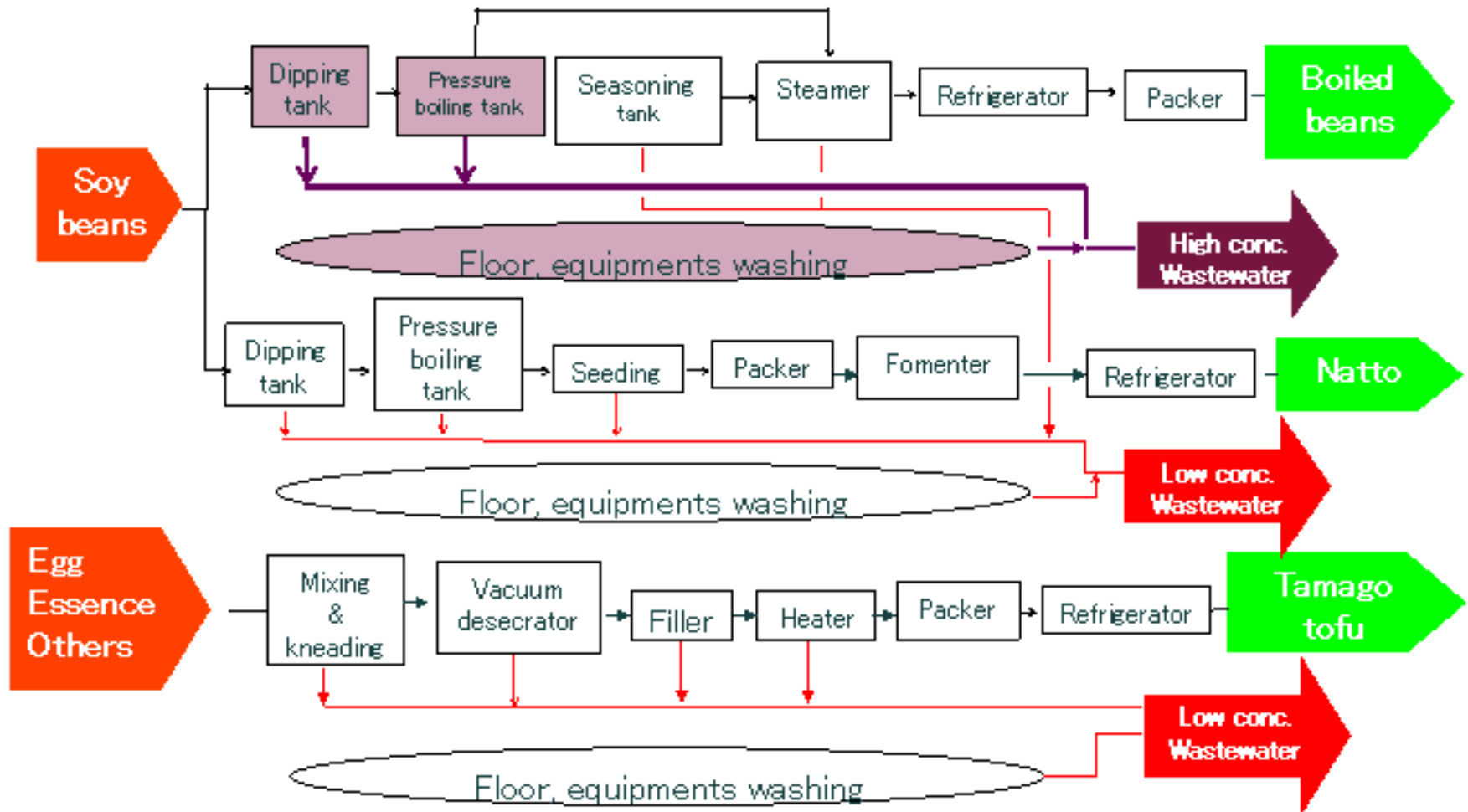
**Problem at restart-up: filamentous bacteria bulking**

- **Maintain sludge activity** → Intermittent wastewater feed
- **Dispersing AS** → coagulants feed
- **New sludge seeding** → from sewage treatment plant
- **Control of sludge septicity** → minimum aeration



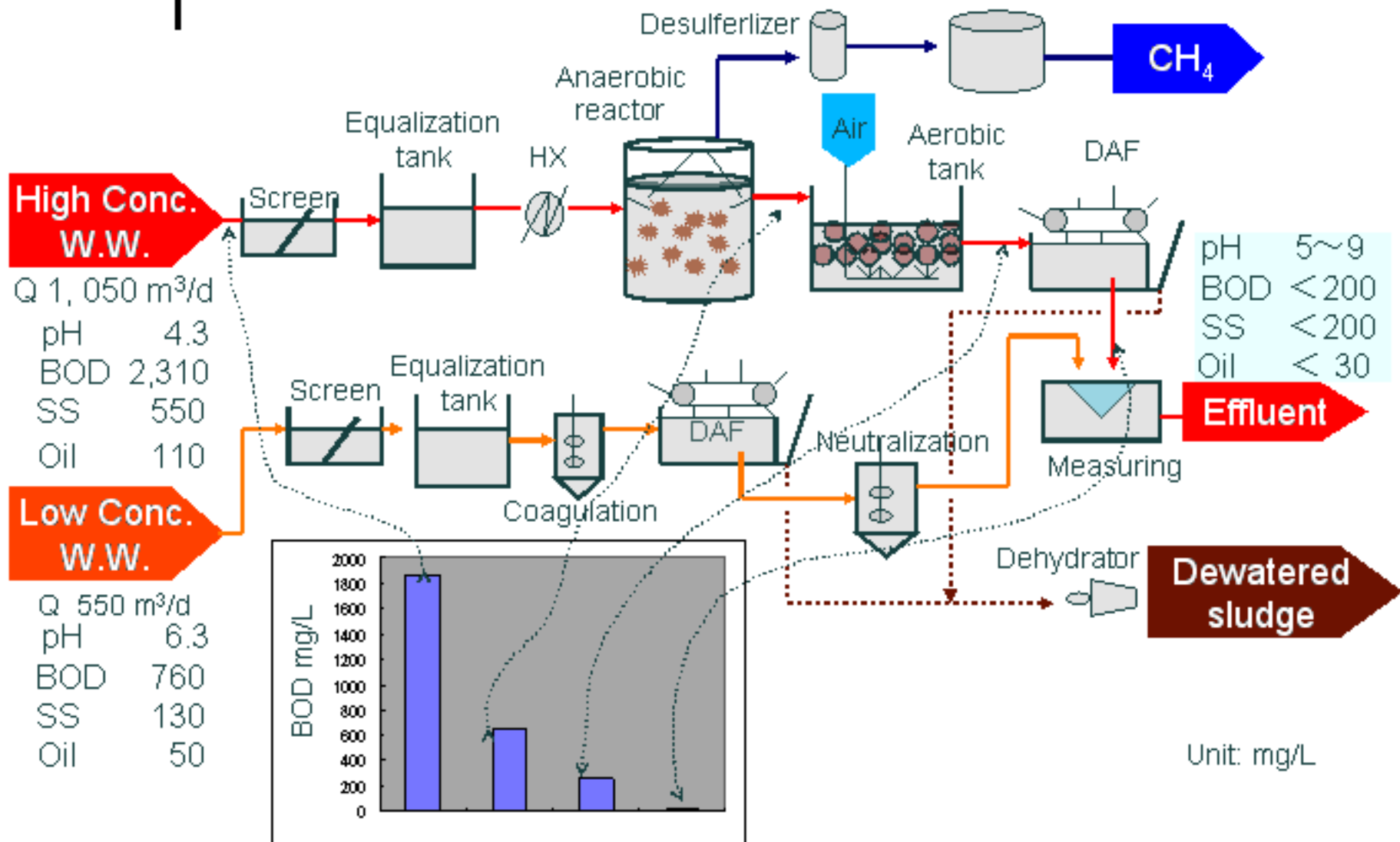
## 4. Examples of Food Processing WW Treatment

### (7) Takeout dishes (1/2)



## 4. Examples of Food Processing WW Treatment

### (7) Takeout dishes (1/2)

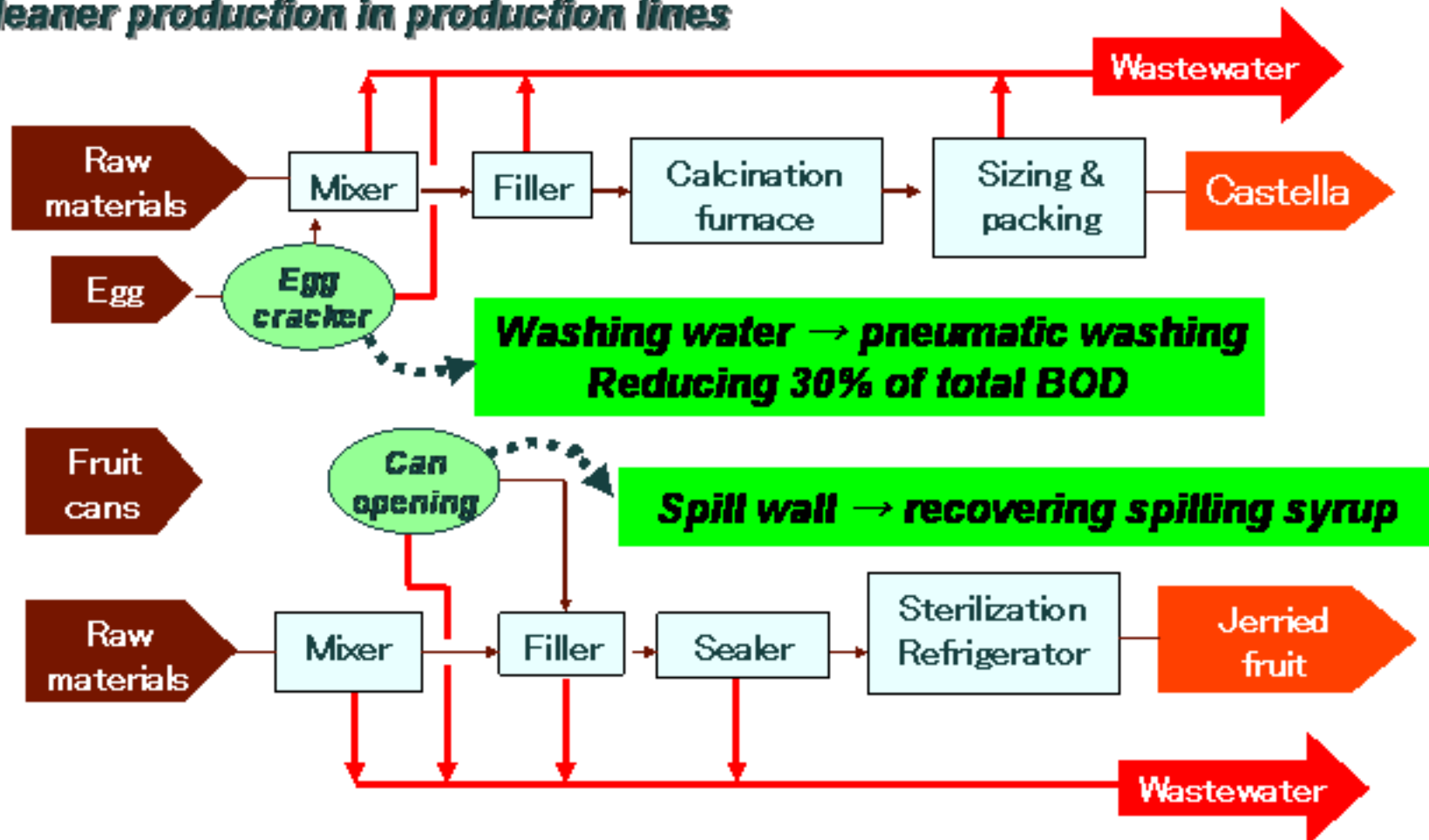




## 4. Examples of Food Processing WW Treatment

### (8) Confectionaries (1/2)

#### Cleaner production in production lines



## 4. Examples of Food Processing WW Treatment

### (8) Confectionaries (2/2)

