龍谷大学
Ryukoku University

7th Workshop on Greenhouse Gas Inventories in Asia

Possibly Co-benefit ? Advanced Wastewater Treatment Process

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Introductory topic on GERF B-071
Upgrading of GHGs Inventory and Evaluation of Countermeasure for Emission Reduction in Waste category

- Joint Research by National Institute for Environmental Studies (NIES), Osaka Univ., Ryukoku Univ.
- Works by Osaka Univ. (Prof. Ike, Prof. Soda)
- Detailed outcome will be presented at 3rd IWA-ASPIRE (Oct. 2009, Taipei)

Emission Estimation

IWWTP, Sewer

$$E = EF \times A$$

E : Amount of CH4 or N2O emitted from sewage treatment plants in conjunction with
domestic/commercial wastewater treatment (kg CH4, kg N2O)
EF : Emission factor (kg CH4/m3, kg N2O/m3)
A : Yearly amount of IWW/sewage treated at a treatment plant (m3)

Domestic Sewage Treatment Plant (mainly septic tanks)

$$E = \Sigma(EF_i \times A_i)$$

E : Emissions of methane and nitrous oxide from the processing of domestic and commercial wastewater at domestic sewage treatment plants (i.e. household septic tanks) (kg CH4, kg N2O）
EFi : Emission factor for domestic sewage treatment plant i (kg CH4/person, kg N2O/person)
A : Population (persons) requiring waste processing at domestic sewage treatment plant i per year

Source category and GHGs emission potential in wastewater sector (2006)

Types of treatment and disposal				CH4 and N2O emission potentials	Comments
Collected	Untreated		River discharge		Rivers with high organics loadings can turn anaerobic.
			Sewers (closed and under ground)	Not a source of CH4/N2O.	Fast moving, clean. (Insignificant amounts of CH4 from pump stations, etc)
			Sewers (open)	Stagnant, overloaded open collection sewers or ditches/canals are likely significant sources of CH4.	Open and warm
	Treated	Aerobic	Centralized aerobic wastewater treatment plants	May produce limited CH_4 from anaerobic pockets. Poorly designed or managed aerobic treatment systems produce CH4. Advanced plants with nutrient removal (nitrification and denitrification) are small but distinct sources of N2O.	Must be well managed. Some CH4 can be emitted from settling basins and other pockets.
					Not well managed. Overloaded.
			Sludge anaerobic treatment in centralized aerobic wastewater treatment plant	Sludge may be a significant source of CH4 if emitted CH4 is not recovered and flared.	CH4 recovery is not considered here.
			Aerobic shallow ponds	Unlikely source of CH4/N2O. Poorly designed or managed aerobic systems produce CH4.	
		Anaerobic	Anaerobic lagoons	Likely source of CH4. Not a source of N2O.	Depth less than 2 metres, use expert judgment.
					Depth more than 2 metres
			Anaerobic reactors	May be a significant source of CH4 if emitted CH4 is not recovered and flared.	CH4 recovery is not considered here.
Uncollected	Septic tanks			Frequent solids removal reduces CH4 production.	Half of BOD settles in anaerobic tank.
	Open pits/Latrines			Pits/latrines are likely to produce CH4 when temperature and retention time are favourable.	Dry climate, ground water table lower than latrine, small family (3-5 persons)
					Dry climate, ground water table lower than latrine, communal (many users)
					Wet climate/flush water use, ground water table higher than latrine
					Regular sediment removal for fertilizer
	River discharge			See above.	

Source Category in Japan NIR

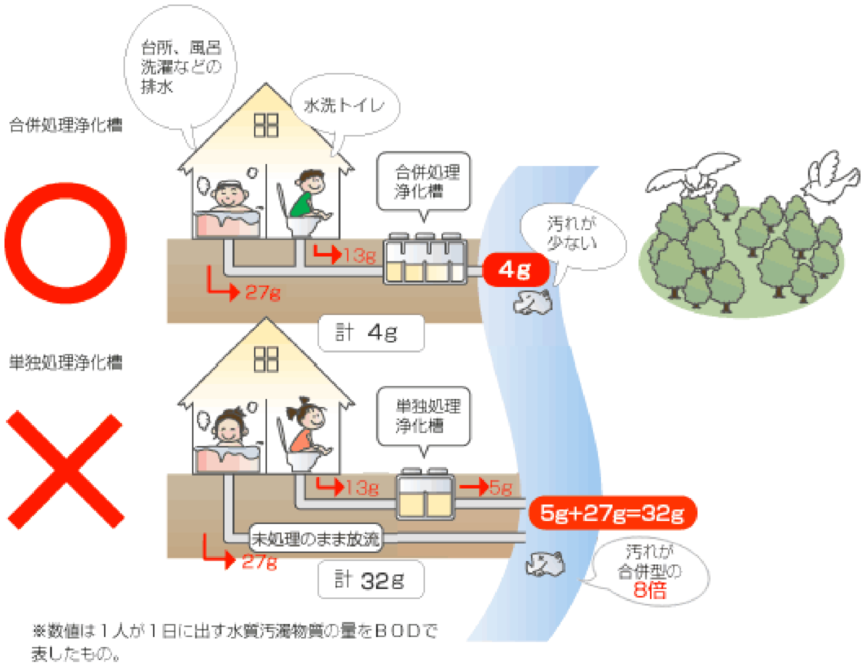
Category	Type Estimated	Forms of Treatment		CH_4	N_2O
6.B.1. (8.3.1)	Industrial wastewater	(Sewage treatment plants)		○	○
6.B.2. (8.3.2)	Domestic/commercial wastewater	Sewage treatment plants (8.3.2.1)		○	○
		Domestic wastewater treatment facilities (mainly septic tanks) (8.3.2.2)	Community plant	○	○
			Gappei-shori johkasou	○	○
			Tandoku-shori johkasou	○	○
			Vault toilet	○	○
		Human waste treatment facilities (8.3.2.3)	High-load denitrification treatment	○	○
			Membrane separation	○	○
			Anaerobic treatment	○	○
			Aerobic treatment	○	
			Standard denitrification treatment	○	
			Other	○	
	Degradation of domestic wastewater in nature (8.3.2.4)	Discharge of untreated domestic wastewater	*Tandoku-shori johkasou*	○	○
			Vault toilet	○	○
			On-site treatment	○	○
		Sludge disposal at sea	Human waste sludge	○	○
			Sewage sludge	○	○

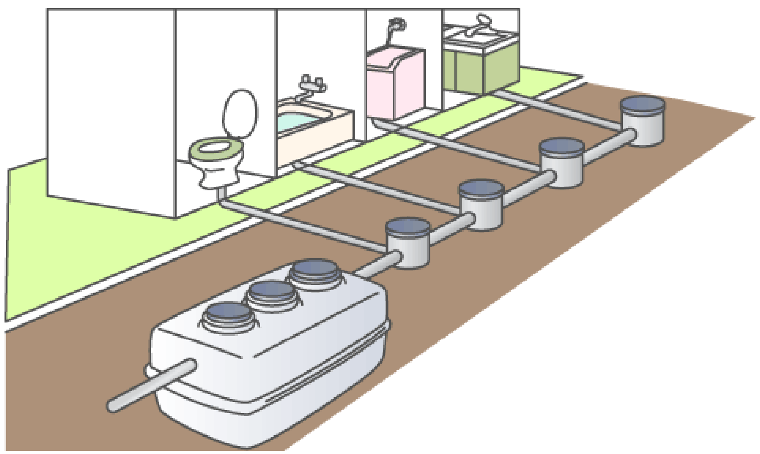
Sewage (miscellaneous)

Human waste (Feces and Urine)

Public sewerage system is spreading from large cities to smaller municipalities and used by 65.5% of the population.
Domestic wastewater treatment systems (e.g. gappei shori jokasou) are being promoted as an effective means of supplementing sewerage systems in smaller municipalities with low population densities and little flat land. In 2006, septic tanks (jokasou) were used by 24.1% of the population, with the remainder being treated after collection or on-site.

Jokasou system

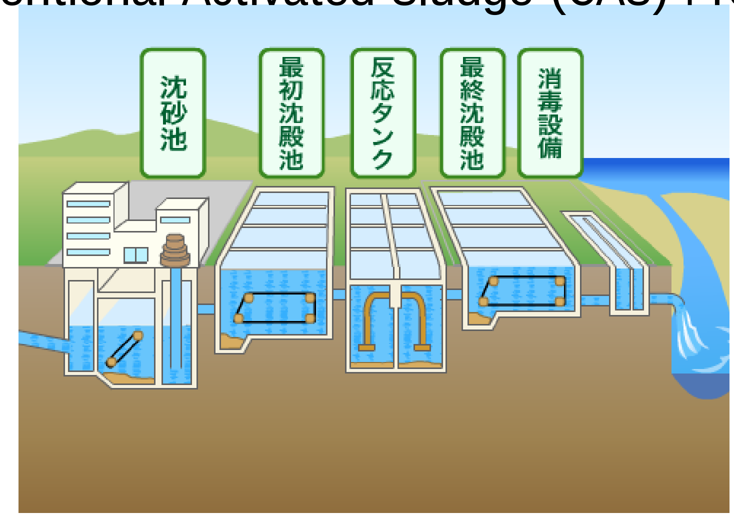




The *gappei-shori* and *tandoku-shori Jokasous are decentralized wastewater treatment facilities installed at an* individual home. The *gappei-shori processes feces and urine and miscellaneous wastewater, whereas tandoku-shori processes only feces and urine. A community plant is small-scale sewage facility where* urine and the miscellaneous wastewater of each region are processed.

Advanced Wastewater Treatment

Conventional Activated Sludge (CAS) Process



Eutorophication in closed water body

N,P removal by advanced treatment

Benefit

Prevention of water pollution
Improvement of public water value

Cost, Energy
Environmental impact

Drawback

Evaluation of Advanced Treatment

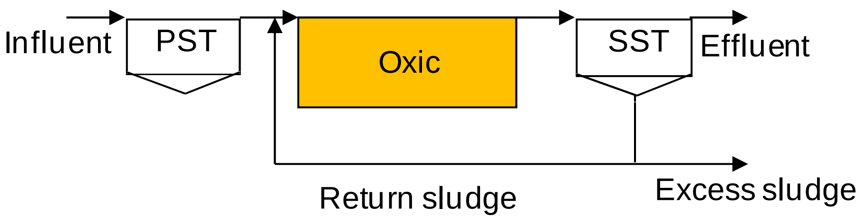
- Eutrophication potential (EP): PO_4eq
  - NOx, T-N, T-P, BOD
- Global Warming Potential (GWP):CO_2eq
  - CO2, CH4, N2O
- Life Cycle Impact Assessment Approach using LIME (JEMAI)

Statistics on 1500 WWTPs (JSWA)

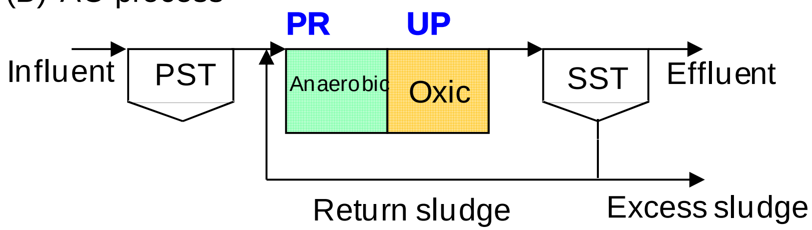
	Number of WWTPs [a] Annual treatment, m^3/y			Planned effluent quality, mg/L [b] (Typical removal, %)		
	$< 10^6$	10^6-10^8	$> 10^8$	BOD	T-N	T-P
CAS	63	282	145	10-15 (90-95)		
AO	14	10	15	10-15		< 3 (75-95)
Recycled nitrification/denitrification	7	6	0	10-15	< 20 (65-75)	
A2O	5	4	2	10-15	< 20 (65-75)	< 3 (75-95)
Nitrification/endogenous denitrification	4	1	0		(75-95)	
Step-feed nitrification-denitrification	0	3	2		(75-85)	
Step aeration	0	4	6	10-15 (90-95)		
Oxygen aeration	1	3	3	(90-95)		
Extended aeration	25	1	0	(90-95)		
Oxidation ditch	459	30	0	(90-95)		

Evaluation Target Process:
Advanced Treatment for Nutrient removal

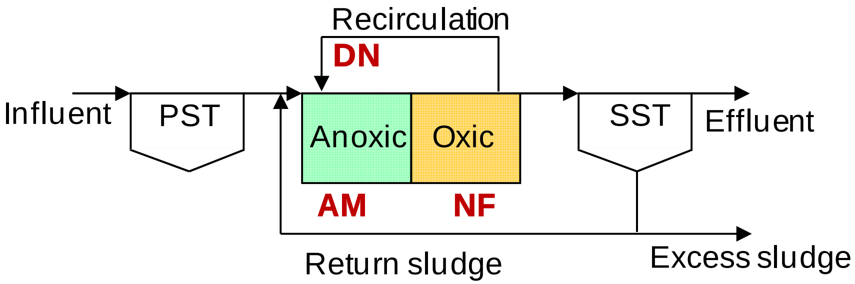
(A) CAS process



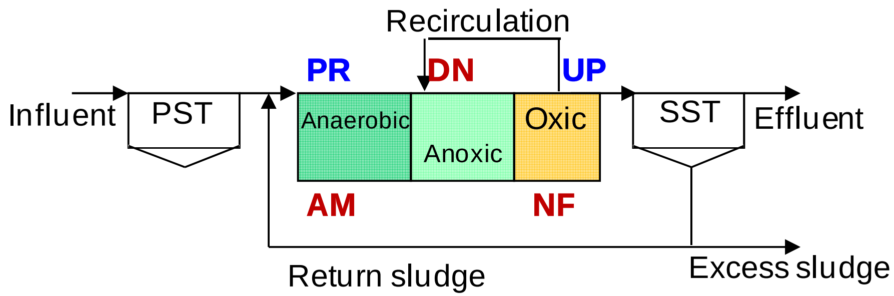
(B) AO process



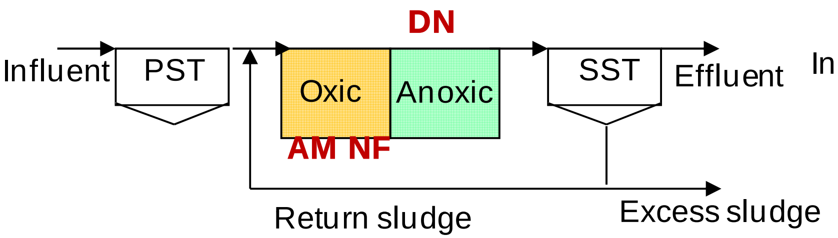
(C) Recycled nitrification/denitrification process



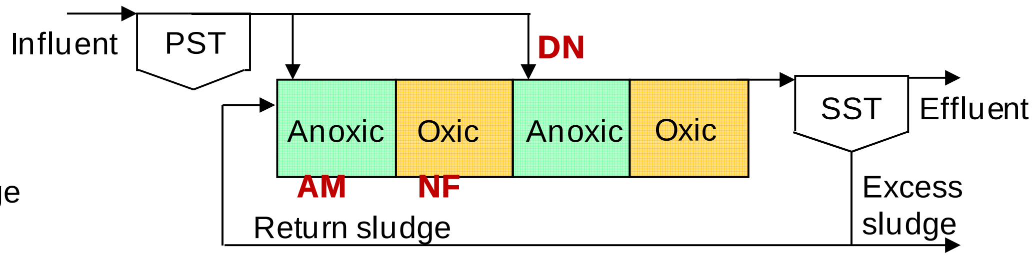
(D) A2O process



(E) Nitrification/endogenous denitrification process



(F) Step-feed nitrification-denitrification process

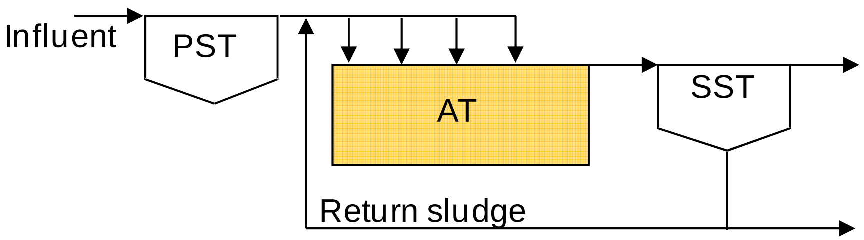


AM:ammonification
NF:nitrification
DN:denitrification

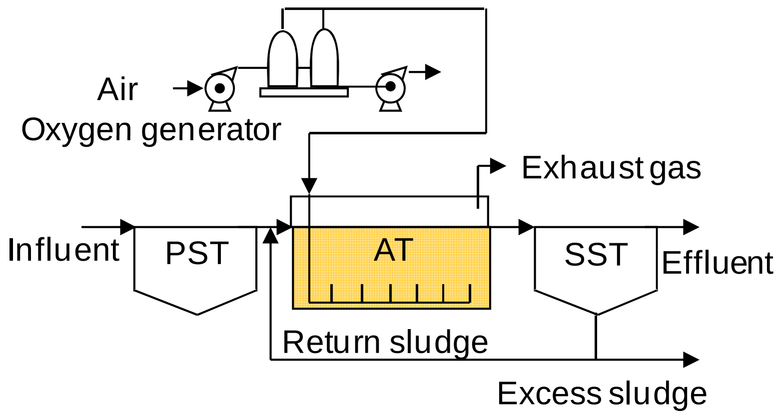
PR:phosphorus release
PU:phosphorus uptake

Evaluation Target Process: AT for other purpose

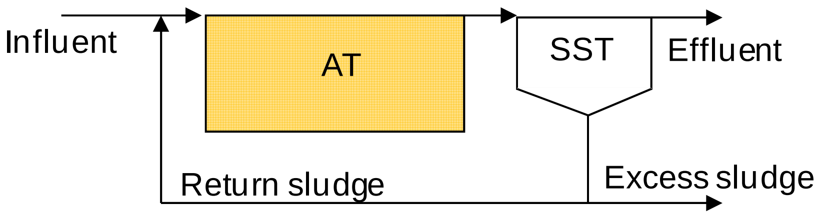
(A) Step-aeration process



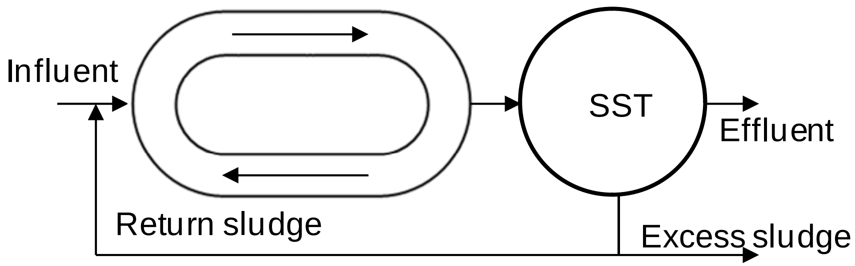
(B) Oxygen aeration process



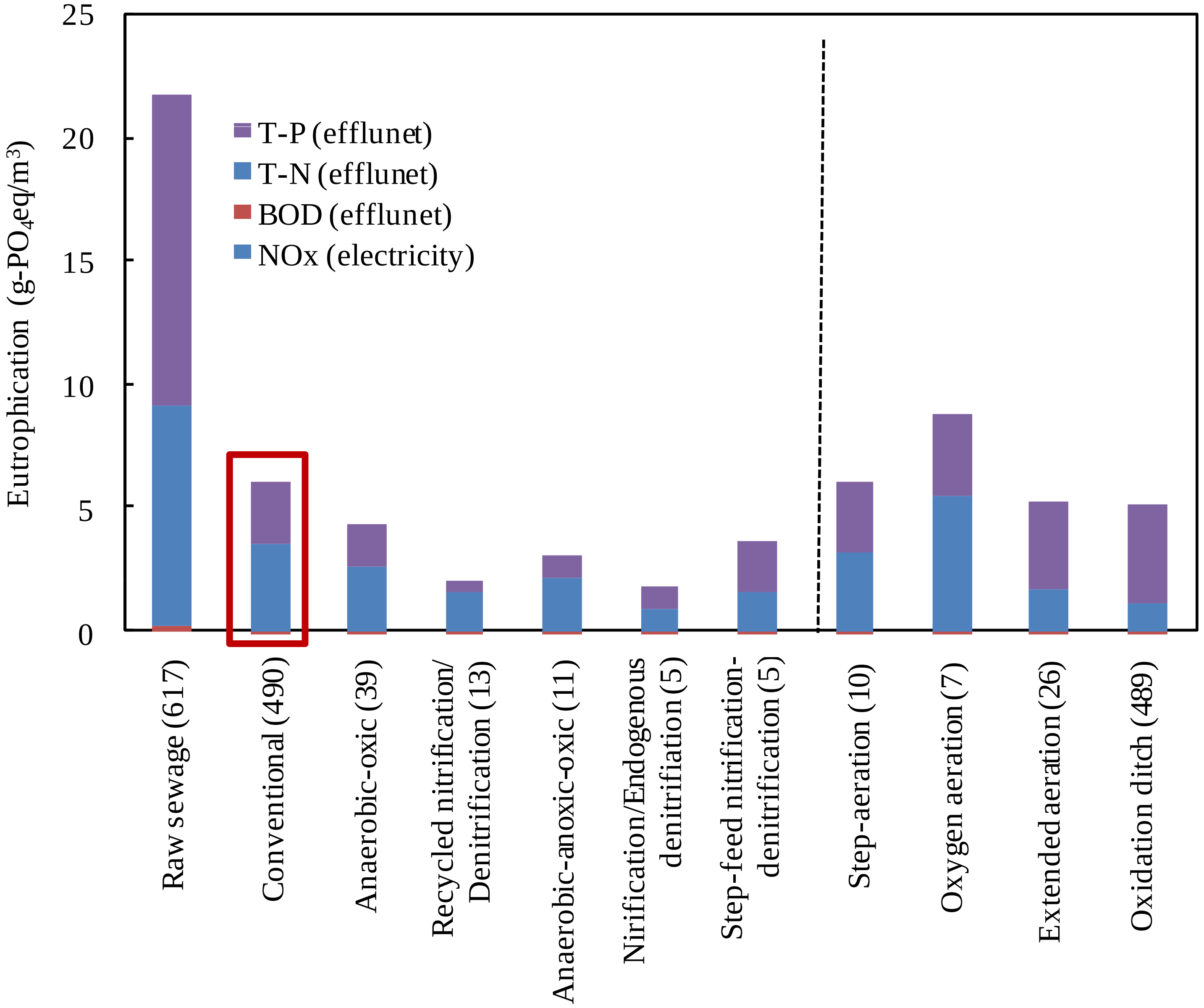
(C) Extended aeration process



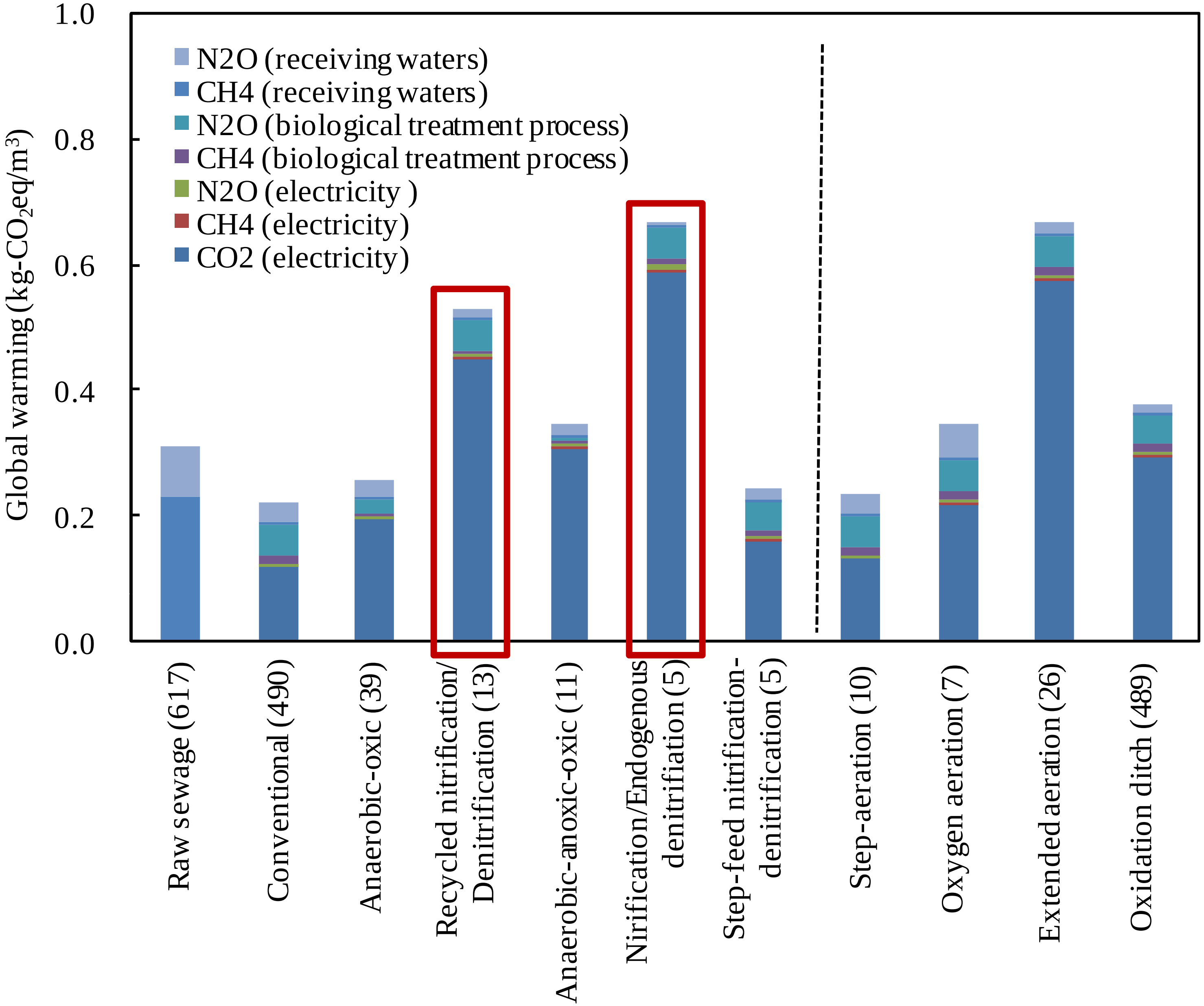
(D) OD process



Eutrophication Potential

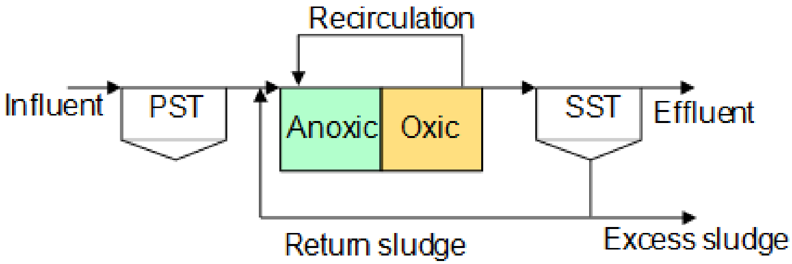


Global Warming potential



Electricity Consumption

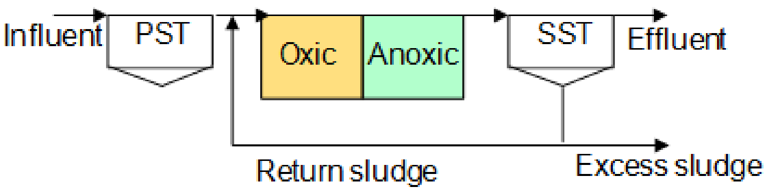
(C) Recycled nitrification/denitrification process



Enough nitrification needs Long SRT

Electricity for recirculation of nitrified liquor

(E) Nitrification/endogenous denitrification process

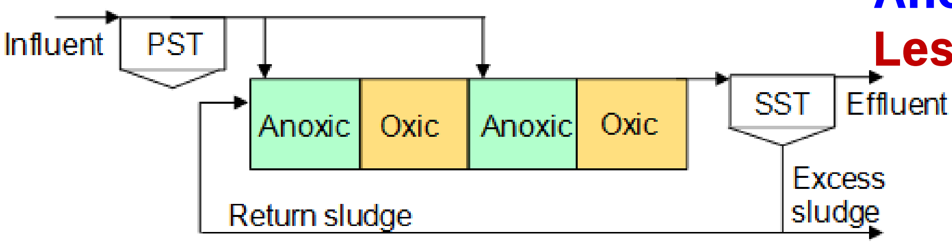


Enough denitrification needs Long HRT

Appilication to small scale plant

Electricity per unit must be uneffective

(F) Step-feed nitrification-denitrification process

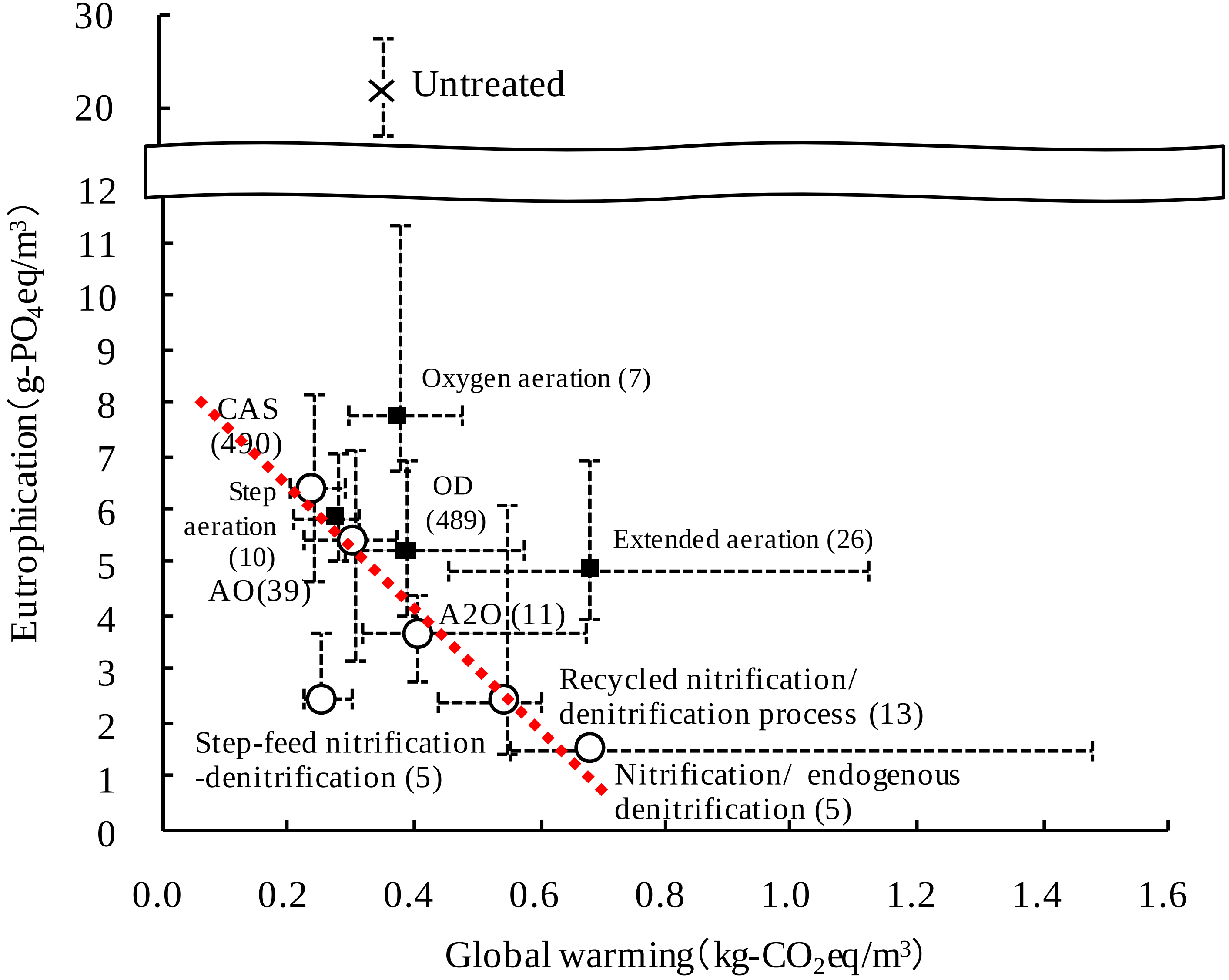


No recirculation of nitrified liquor

Anoxic tanks in the process

Less electricity than full-aeration tanks

Trade-off Relationship



Conclusion

- Importance of **Operation-related GHGs** (especially electricity) on GWP evaluation
- **Negative correlation** between **EP** and **GWP** values of the nutrient removal processes
  - Endeavours to reduce the EP value of 1.0 mg-PO_4eq compensate with increase in the GWP of 86.5 g-CO_2eq.
- **Step-feed nitrification-denitrification process**
  - only exception of the trade-off among the nutrient removal processes
  - possible candidate for co-benefit process.