Contract project-2003
With Ministry of the Environment, Japan

環境省
Ministry of the Environment

Measures against Lake Eutrophication

January 2004

Overseas Environmental Cooperation Center, Japan

Committee Members

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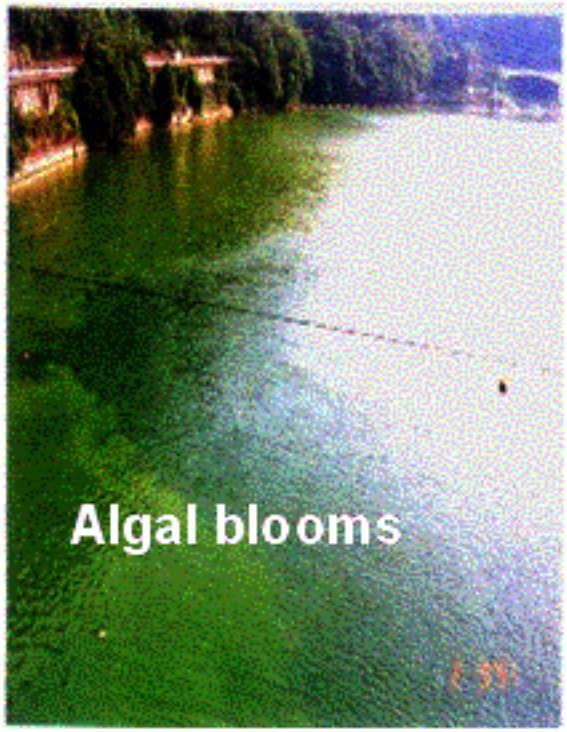
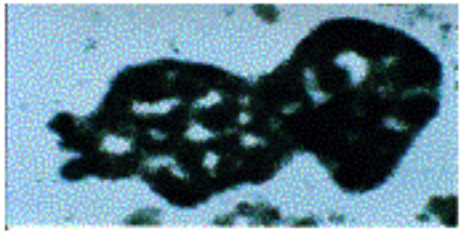
Contents

Original source

Dr. Y. Inamori, et al; Technology Transfer Manual on Measures against Lake Eutrophication, March, 2003, OECC

1. Eutrophication Phenomenon





Microcystis 3~7 μm ϕ

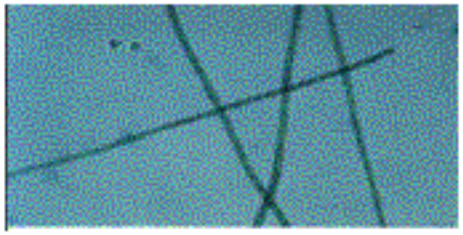
Cyanobacteria, amorphous

gelatinoid colonies

Anabaena 4.5~10 μm ϕ

Cyanobacteria

Round colonies / coiled filaments



Oscillatoria 2~5 μm length

Filamentous cyanobacteria

Cyanobacteria forms *blooms* in eutrophic waters

2. Damages caused by Eutrophication

Water supply

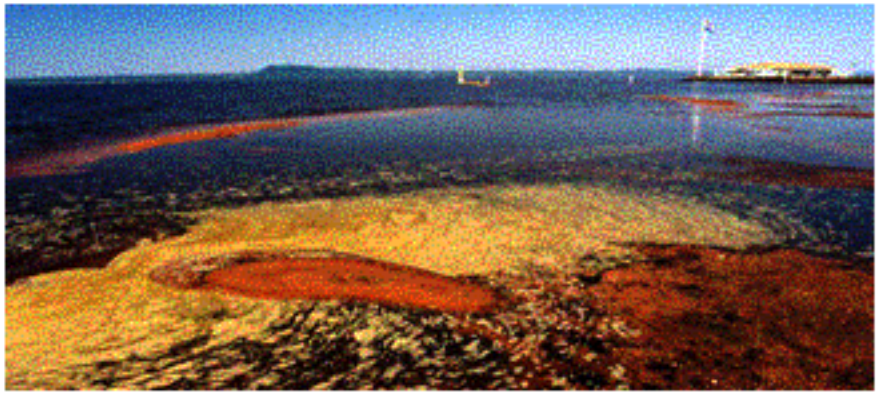
1. SS, pH up → Inhibiting coagulation → Much coagulant, hard settling
2. Pre-chlorination required → Trihalomethane production (carcinogen)
3. Clogging in filter media and screen
4. Production of 2-MIB, geosmin →Offensive odors
5. Anoxic zone created by dead algae → Eluting Iron and manganese

Agricultures and Fisheries

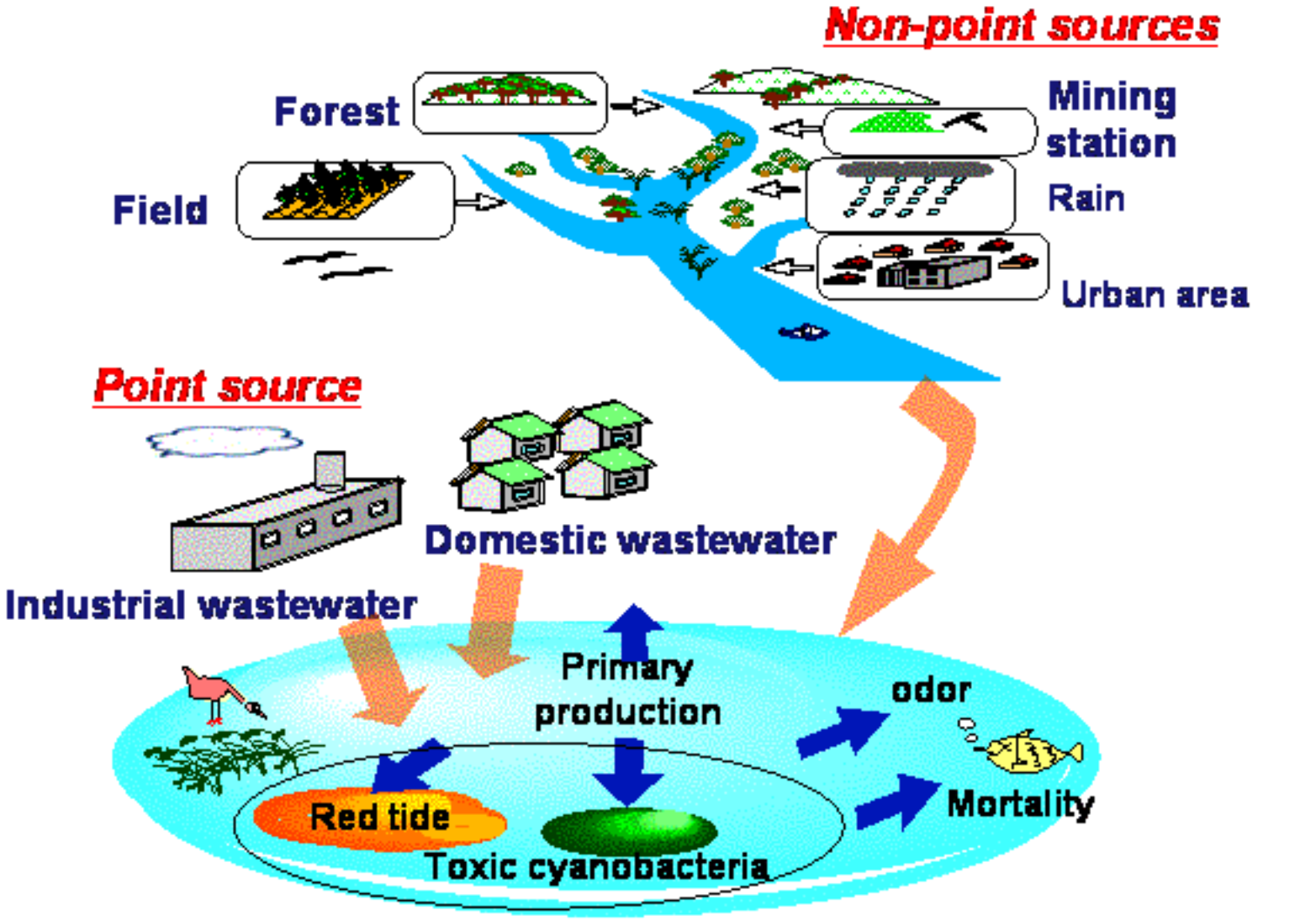
1. Changing aquatic life
2. Irrigation by eutrophicated water → Crop production decreasing
3. Toxigenic cyanobacteria → Health disorder of livestock
4. Anoxic zone – Fish killed

Landscape and Recreation

1. Reducing transparency
2. Coloring (green, brown)
   Bloom & fresh water red tide
3. Smelling
4. Toxins release



3. Mechanisms of Eutrophication (1/2)



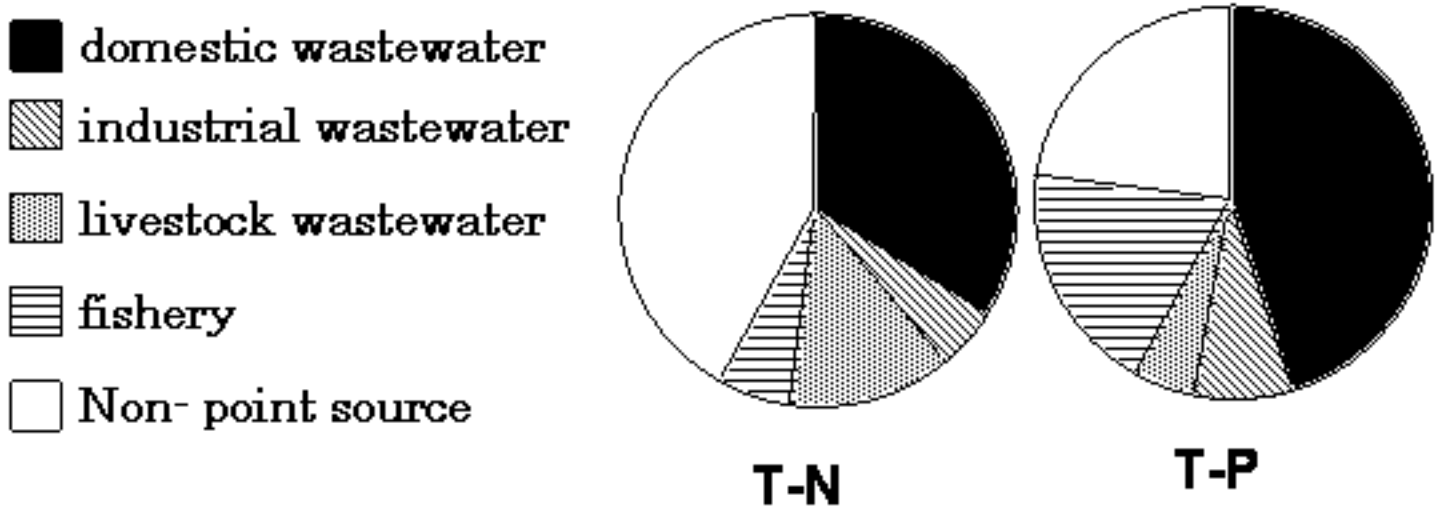
3. Mechanisms of Eutrophication (2/2)

Basic unit loads *(per capita and adult farm animal)*

	BOD (g/ d)	N (g/ d)	P (g/ d)
Human excrement	13	8	0.6
Household effluent※	27	2	0.4
Pig	130	37	14.7
Cattle	800	290	54

※ domestic wastewater exclusive of excrement

Pollution sources of Lake Kasumigaura



4. Eutrophication in Lake Biwa and Measures (1/2)

Water area; 670 km2
Volume; 27,500 million m3
Water depth; max. 130 m ave. 42 m
Population density ; 44 / million m3
Population density per basin area; 381 / km2
Average retention time; 5.5 years

1970s; eutrophication spread
1977; red tide
1979; Ordinance for eutrophication prevention in lake Biwa
1983; algal-bloom
1985; General wastewater standard for N and P
1989; mass multiplication of picoplankton

Water quality in Southern Lake (mg/L)

	COD	T-N	T-P
Env. Std.	1.0	0.20	0.010
1996	3.0	0.42	0.018
2001	4.2	0.32	0.016

Env. Std.; Environment Standard

4. Eutrophication in Lake Biwa and Measures (2/2)

Measures were taken !

- Control of effluent COD, N and P
- Water quality conservation facilities improvement project
- Domestic wastewater joint treatment plant installation project
- Small ww treatment facilities in agricultural village improvement project
- Waterweed harvesting project
- Enforcement of ordinance to reed community preservation
- So on・・・・・・・・・・・・・

Water quality hasn't been improved yet ----- Why ?

1. Long retention time (about 5 years)
2. Underestimation for load amount from agricultural land
3. Increasing N and P by shifting from pit latrine to septic tank
4. Possible increase of residential pollutant load
5. Time lag of sediment sludge decomposition
6. Lack of integrated management of environment

5. Eutrophication Study Methods and Considerations

(1) Purposes; Restoration of Eutrophication Lake

Characteristics of bioassay

(1) Ecological Index:

a) biotic characteristics, species composition, individual numbers
b) characteristics of dominant species
c) diversity of community
d) substance metabolism, nutrition, oxygen demand, etc. in one system

(2) Physio-biochemical Index:

a) oxygen demand of individual creature or mixture community
b) reaction of cell / organization of individual creature
c) growth condition of specific creature
d) change of specific bio-materials / life substance

Indicators

5. Eutrophication Study Methods and Considerations

(2) Survey Methods -Procedures

Procedures at surveying

1. Confirming objectives of study
2. Discussion
3. Research plan
4. Preliminary research
5. Full research
6. Discussion
7. Concluding results
8. Reports

Preliminary studies

1. Information of lake
2. Targeted biotic communities
3. Study location & objectives
4. Observation of lake
5. Correcting schedule

Sampling Timing & Intervals

Animals - reproduction, hatching, eclosion· · · ·

Phytoplankton - doubling time – 7 days

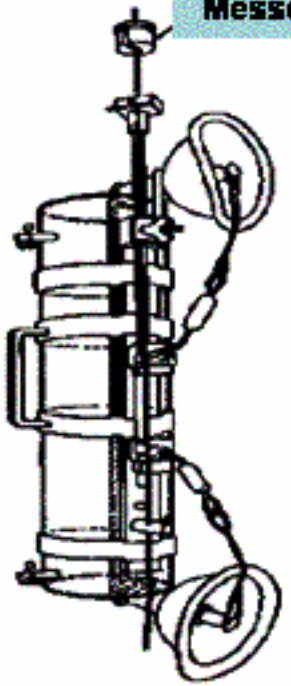
Dominant species - seasonal changes

5. Eutrophication Study Methods and Considerations

(2) Survey Methods - Apparatuses and devices

Sampling Devices

Plankton net



Vandon water sampler

Microscopic Observation

Optical microscope

Stereomicroscope

5. Eutrophication Study Methods and Considerations

(2) Survey Methods - Apparatuses and devices – N, P Analysis

N, P - - - - -essential for microbes to propagate

T-N (mg/L)		0.03		0.2
	← Oligotropic		Mesotropic	Eutropic →
T-P (mg/L)		0.003		0.02

Analytical items

N analysis T-N, NH_4-N, NO_2-N, NO_3-N

P analysis T-P, PO_4-P

Analytical methods

Official methods

Auto Analyzer

Handy analytical kit (pack test)

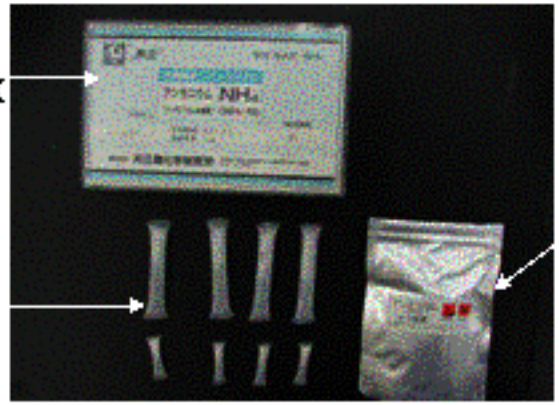
+ pH, COD

5. Eutrophication Study Methods and Considerations

(2) Survey Methods - Apparatuses and devices - N, P, others Analysis

NP Auto Analyzer

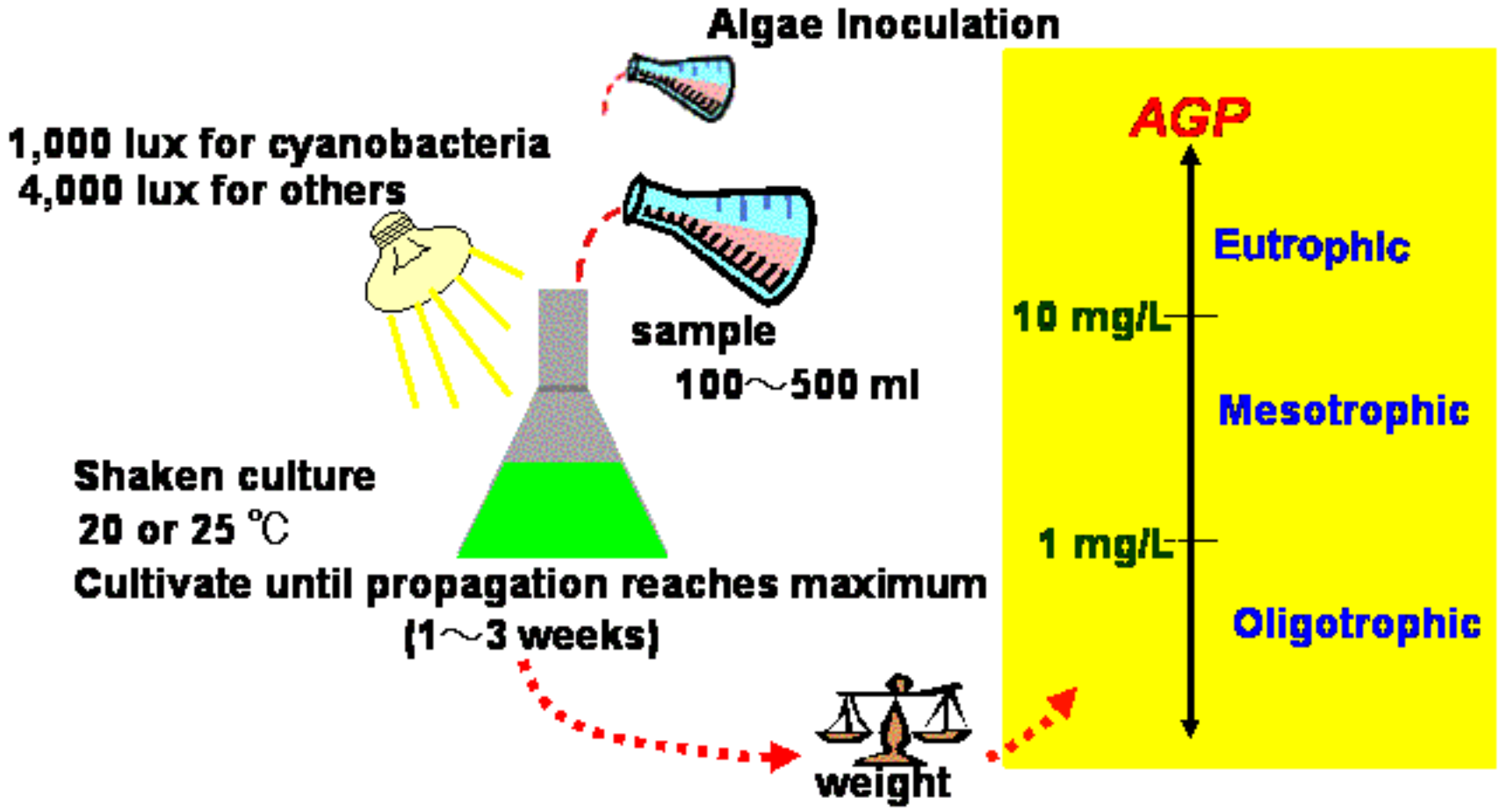
Handy Analytical Kit (Pack Test)



Pack Tester for NH_3

5. Eutrophication Study Methods and Considerations

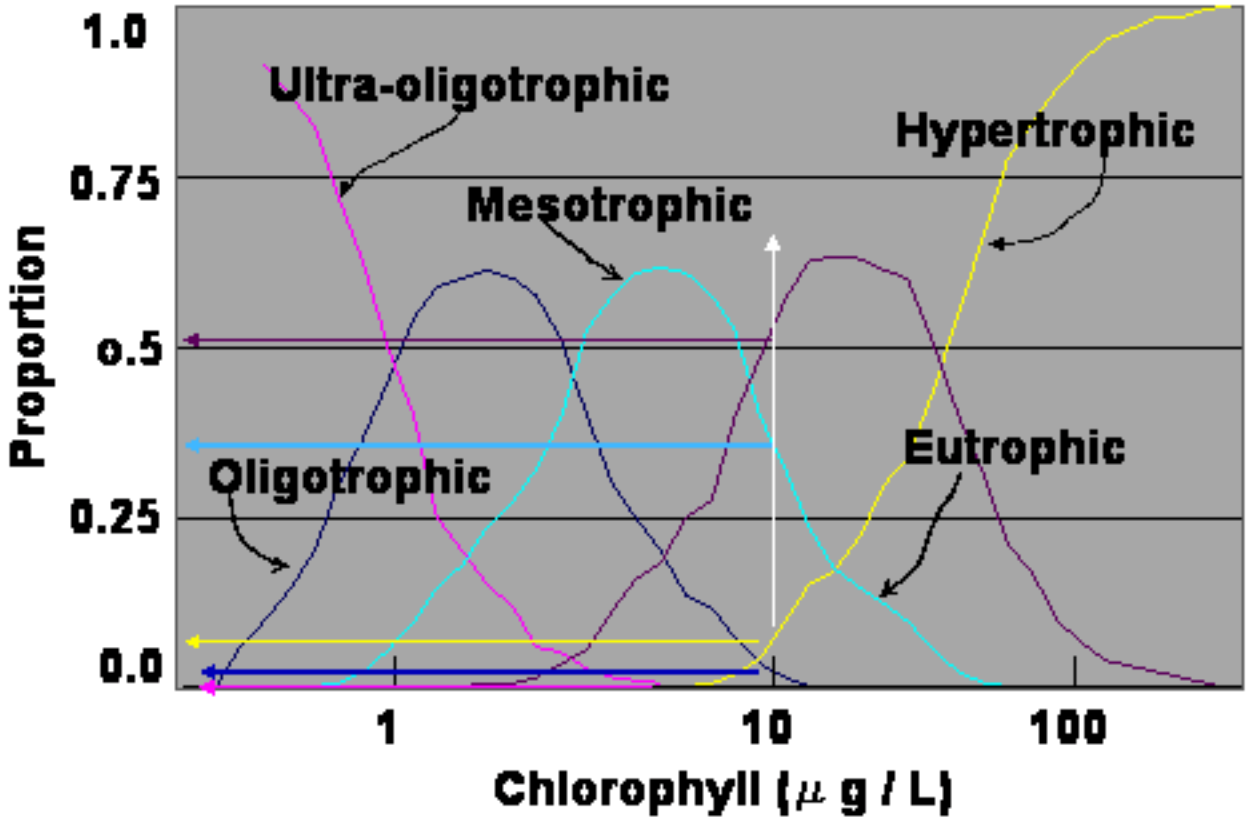
(3) Evaluation - Algal Growth Potential



5. Eutrophication Study Methods and Considerations

(3) Evaluation - Chlorophyll

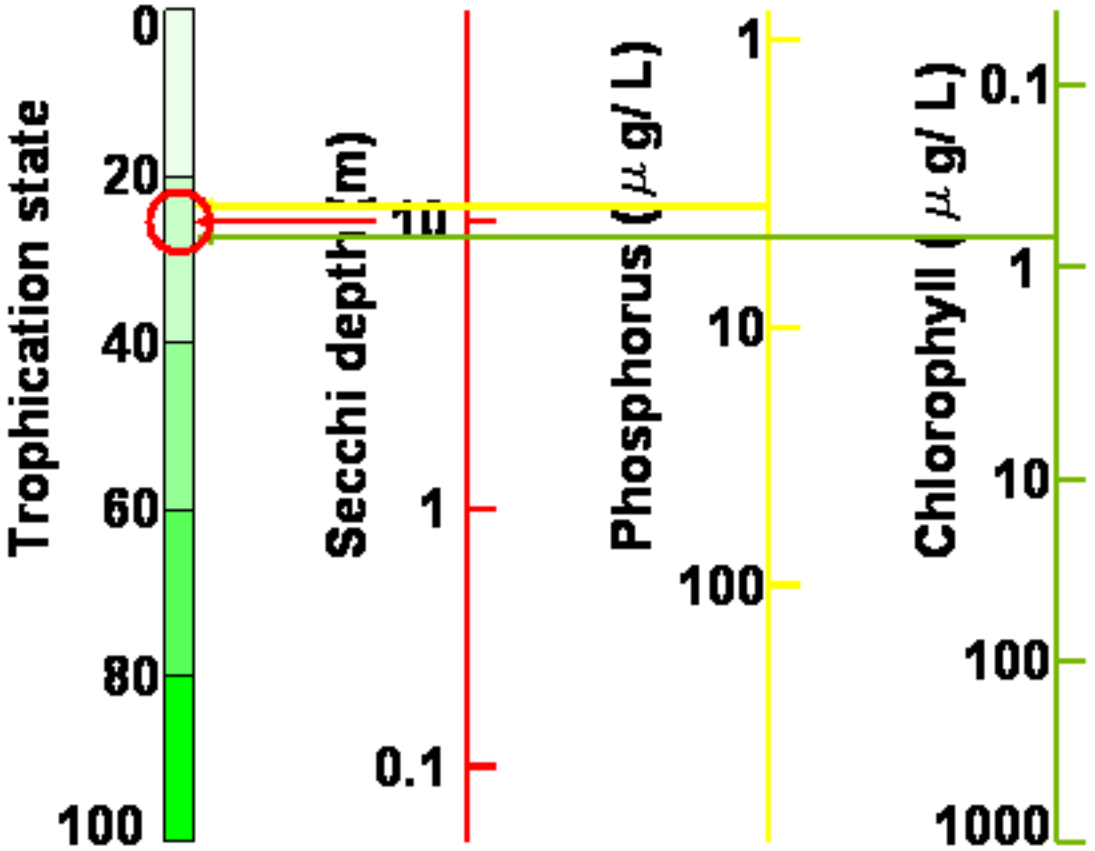
Probability distribution for chlorophyll related to trophic state



(W.K.Dodds,Fresh Water Ecology,p.339, Academic Press ,2002)

5. Eutrophication Study Methods and Considerations

(3) Evaluation –Water clarity, P, Chlorophyll



(W.K.Dodds,Fresh Water Ecology,p.339, Academic Press, 2002)

6. Administrative Countermeasures in Japan

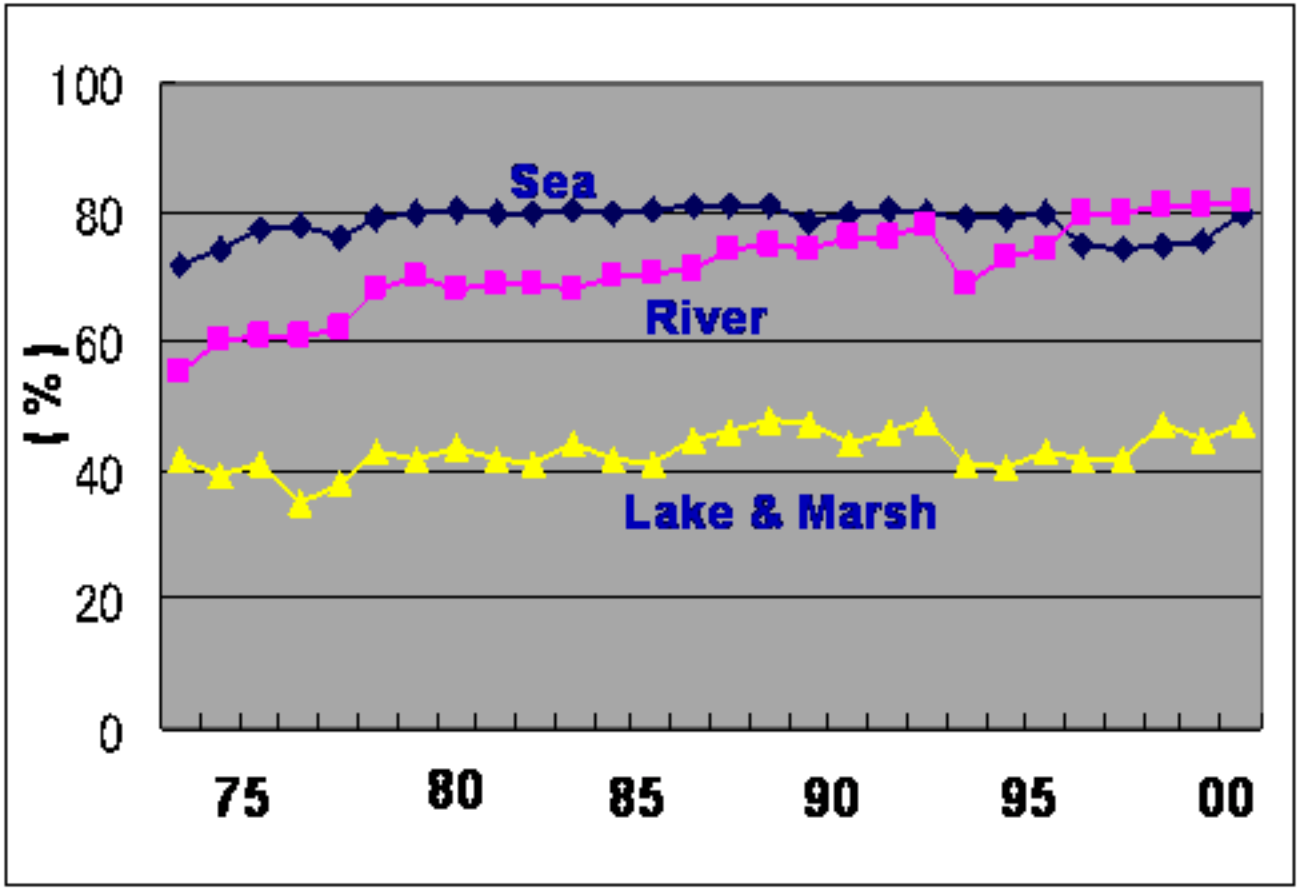
(1) Administrative measures

1967	Basic Law for Environmental Pollution Control
1970	Water Pollution Control Law
1971	Inauguration of the Environmental Agency
1984	Special measures for conservation of lake water quality
1985	Setting effluent standards for N & P related to lakes and marshes
1990	Systemization of measures against household wastewater
2002	Fifth Total Effluent Control System + N & P

6. Administrative Countermeasures in Japan

(2) *Changes in environmental conditions*

Succession of achievement ratio for environmental standard



River; BOD, Sea, Lakes and marsh; COD

7. Improvement Technology for Water Quality of Lake & Marsh

Preventing Lake & Marsh from Eutrophication

N & P Reduction

1. In Premises measures
- Industrial Wastewater
- Domestic Wastewater

→
- *Removal Processes*
- *Cleaner Productions*
- *Management of WW Facility*
- *Life Cycle Assessment*

2. On Site Measures
- Lake, Marsh

→
- Aquaculture Purification
- Aquatic Plant Cultivation
- Aerated Circulation
- Lagoon System

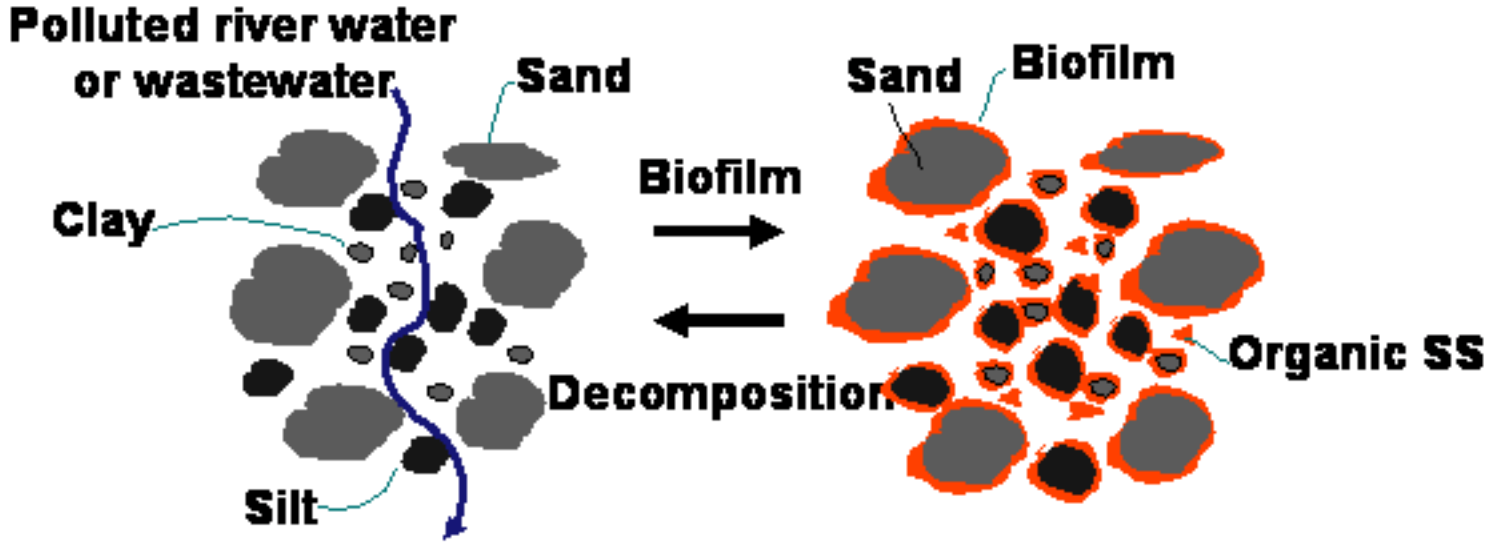
3. Household Waste Load Reduction

→
- Residential Participation

7. Improvement Technology for Water Quality of Lake & Marsh

(1) High-rate multilayer soil treatment method (1/3)

Principle



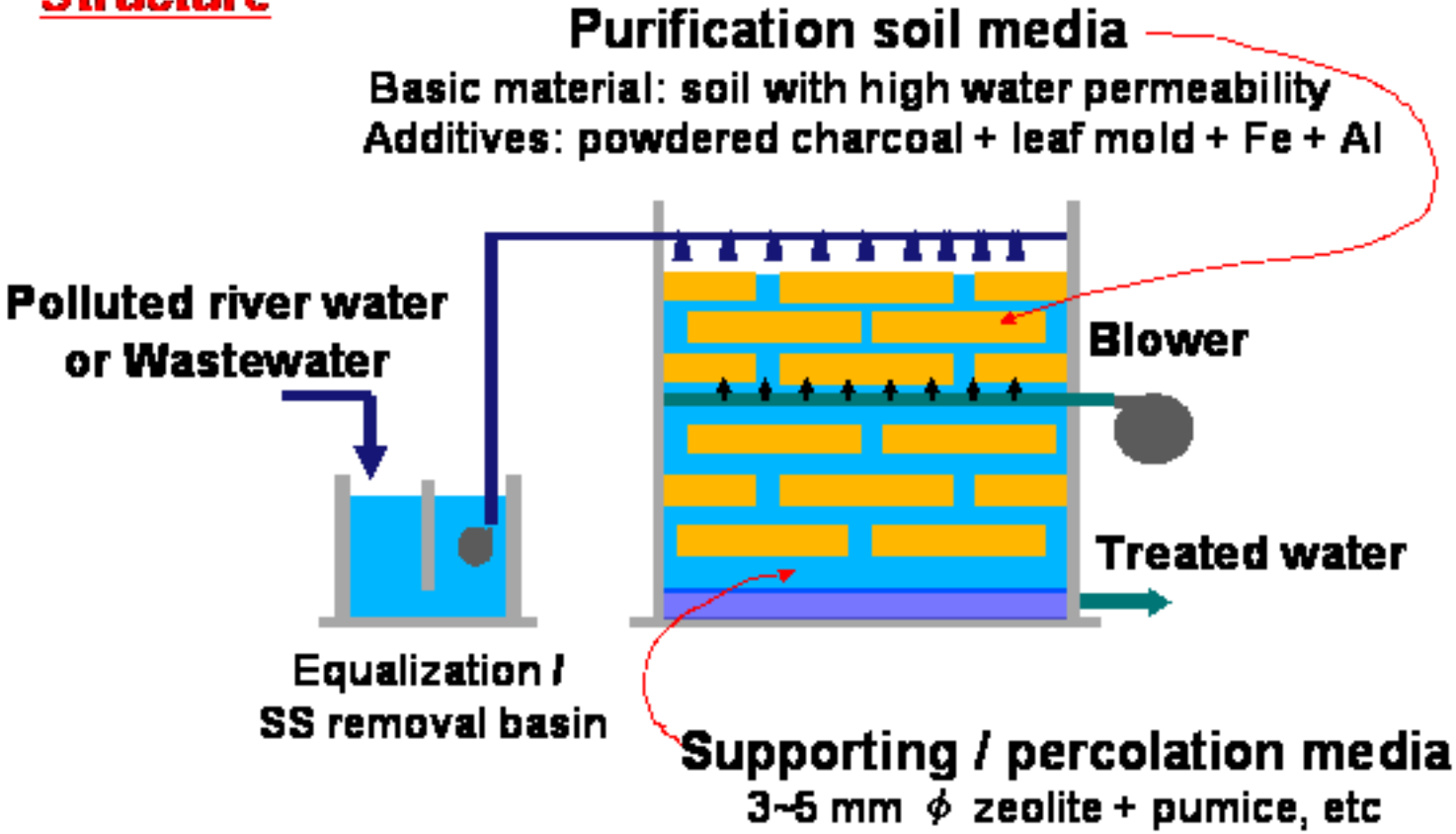
Operation

- Shift operation ; 3-momth operation, 1-month halt
- Intermittent operation ; 3-hr operation, 4-hr halt
- Long term operation halt; 3~4-month every 2- year

7. Improvement Technology for Water Quality of Lake & Marsh

(1)High-rate multilayer soil treatment method (2/3)

Structure



7. Improvement Technology for Water Quality of Lake & Marsh

(1) High-rate multilayer soil treatment method (3/3)

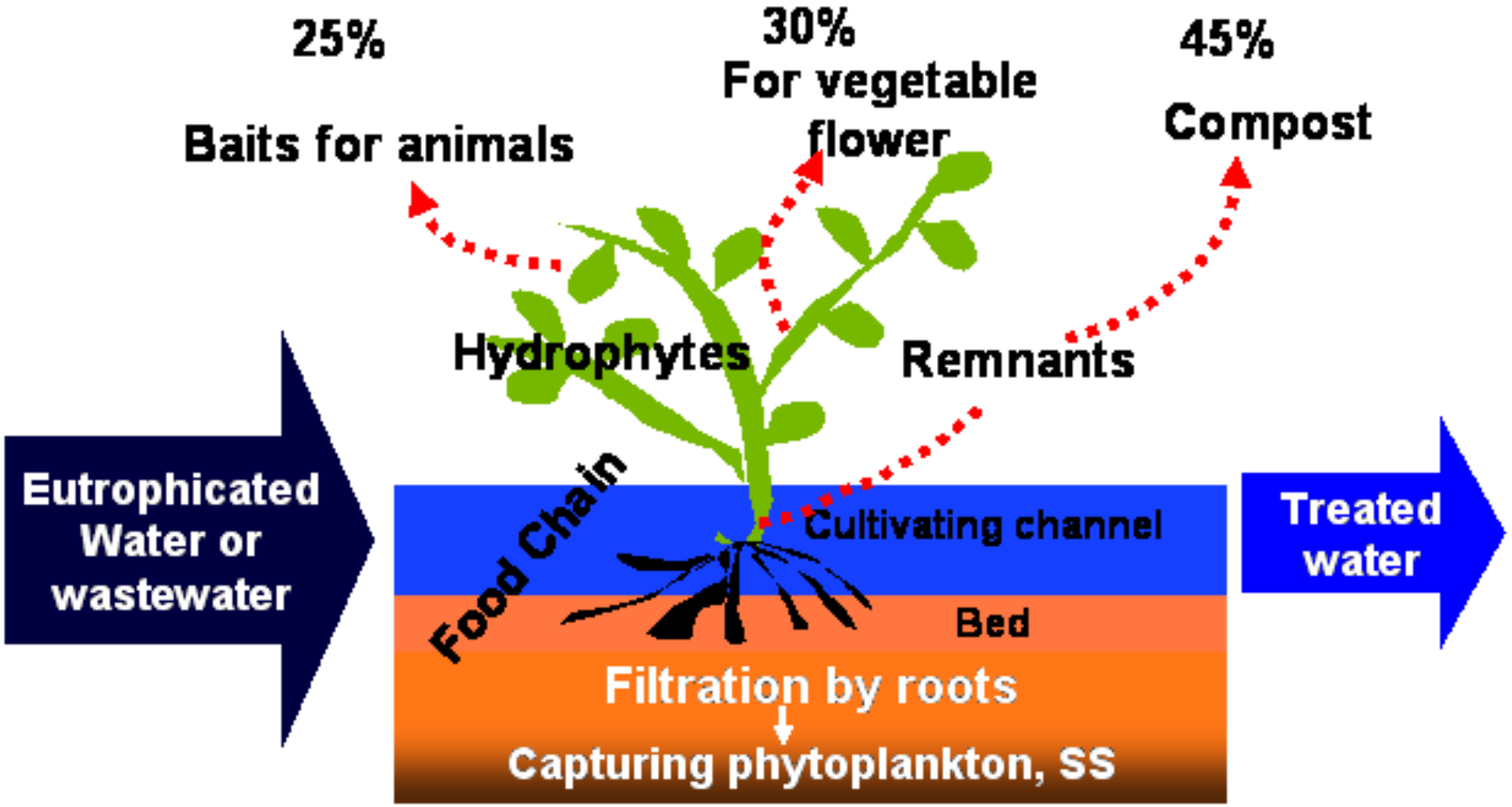
Specifications for 12,000 m^3/d

Performance	Loading rate	4 $m^3/m^2/d$	8 $m^3/m^2/d$
	Inf. (mg/L)	BOD 60 SS 40	BOD 20 SS10
	Efl. (mg/L)	BOD 3 SS 2	BOD 3 SS 2
	P- removal (%)	60	15
	N- removal (%)	40	10
Dimension	Stages of soil media	6	10
	Size / soil media (cm)	40X40X10	20X40X5
	Area of tank (m^2)	4,000	2,000
	Depth of media (cm)	125	105
	Water pit depth (cm)	30	50

No specific measures to remove N and P by adding Fe/Al balls

7. Improvement Technology for Water Quality of Lake & Marsh

(2) Biopark Aquaculture Purification - - - - Principle



7. Improvement Technology for Water Quality of Lake & Marsh

(2) Biopark Aquaculture Purification - - - - Features

- Removal; BOD, COD, SS, P, N
- Providing safe & comfortable space
- Harvest; vegetables, flowers, fish & compost
- Environmental education for the public

Fish

Kibagata

Tsuchiura

Swamp cabbage

7. Improvement Technology for Water Quality of Lake & Marsh

(2) Biopark Aquaculture Purification - - - - Performance

Annual average of nutrients removal

※ $g \cdot (d \cdot m^2)^{-1}$

Pollutant	Place	Influent (mg/L)	Effluent (mg/L)	Removal Rate(%)	Removal Amount ※
COD	Tsuchiura	9.6	8.3	14	4.3
	Kibagata	8.2	5.6	32	7.8
SS	Tsuchiura	20.9	9.6	54	50.0
	Kibagata	16.0	3.3	79	38.1
T-N	Tsuchiura	3.7	3.1	15	1.9
	Kibagata	1.7	1.1	36	1.8
T-P	Tsuchiura	0.12	0.09	27	0.16
	Kibagata	0.13	0.07	47	0.18

7. Improvement Technology for Water Quality of Lake & Marsh

(2) Biopark Aquaculture Purification - - - - Performance

Treatment of water containing water-blooms (Tsuchiura)

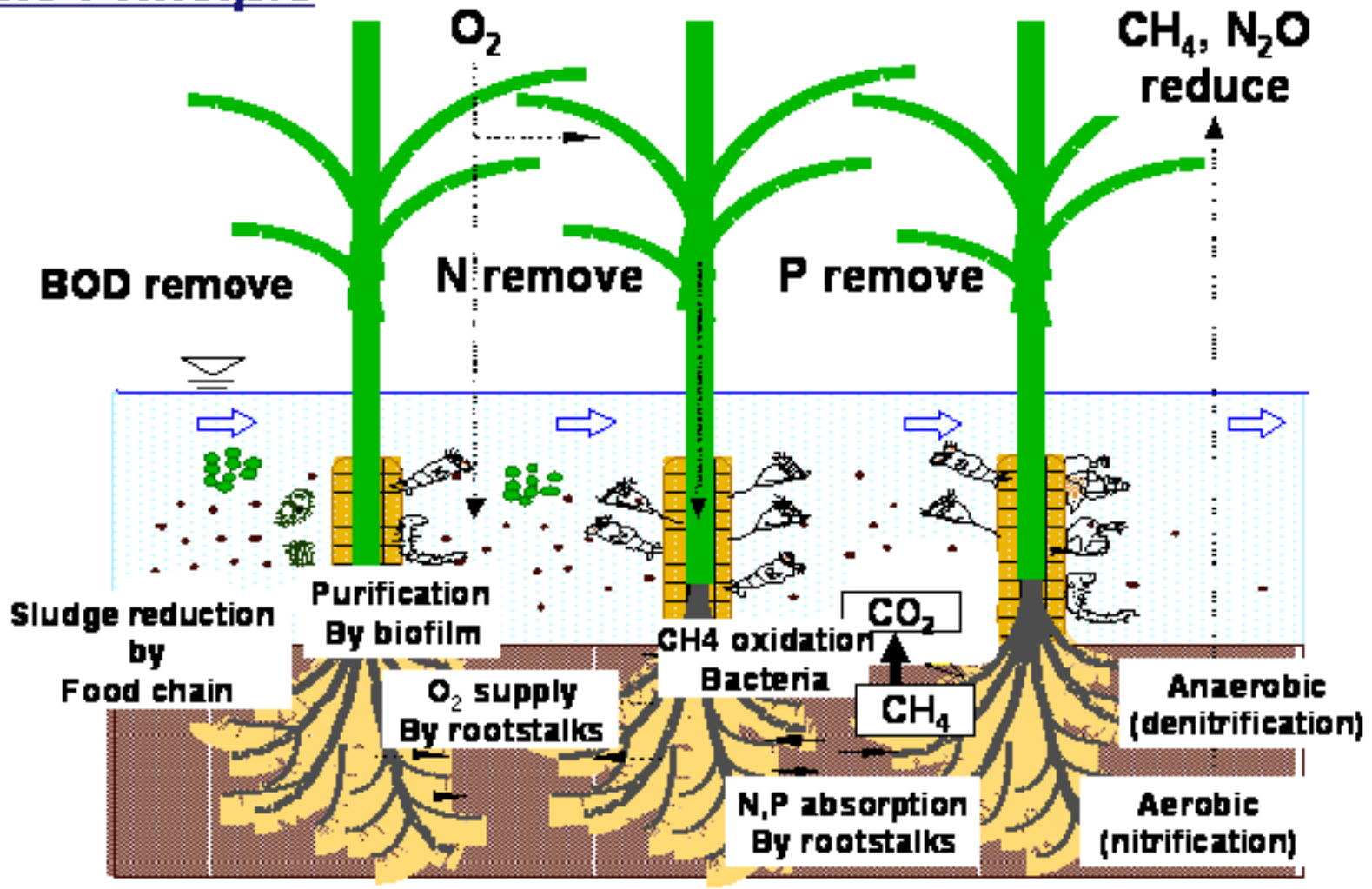
Pollutants	Influent (mg/L)	Effluent (mg/L)	Removal Rate (%)	Removal $g \cdot (d \cdot m2)^{-1}$
SS	56	14	75	148
T-N	6.5	3.5	46	10.6
T-P	0.41	0.15	64	0.93

Assuming; H_2O **content of water- blooms = 98%**
Removal velocity; 7.4 kg water- bloom / m^2 /d

7. Improvement Technology for Water Quality of Lake & Marsh

(3) Purification by Aquatic Plant Cultivation

Basic Principle



7. Improvement Technology for Water Quality of Lake & Marsh

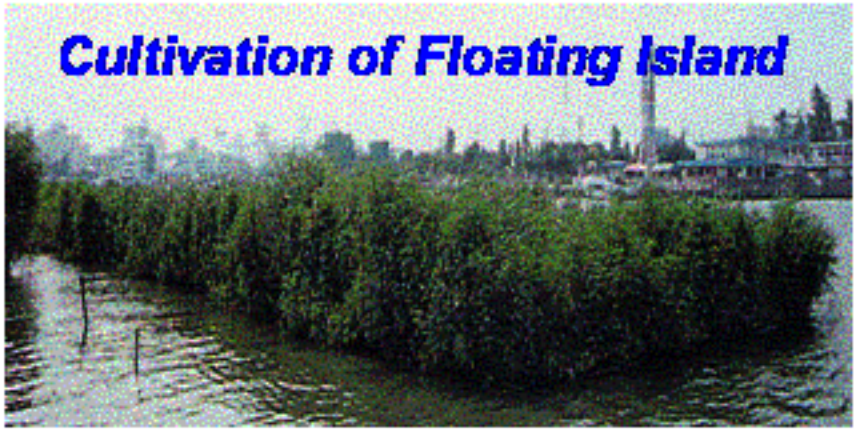
(3) Purification by Aquatic Plant Cultivation

Creation and Control of Aquatic Plant-Growing Environment

Creation and Control of Aquatic Plant-Growing Environment

Performances

N	27%
P	6%
Chlorophyll	57%



Performances

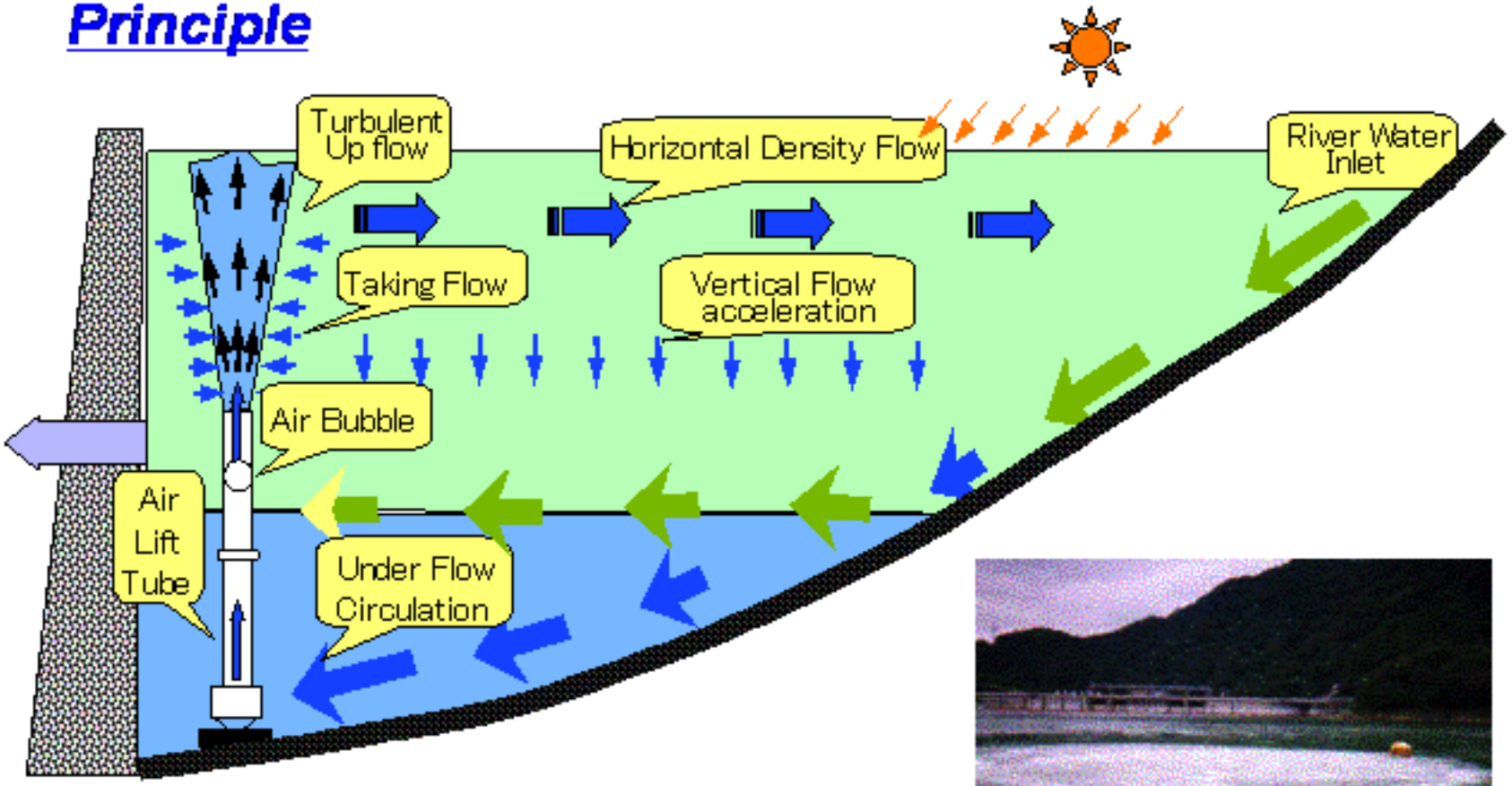
N 0.4 g $(d \cdot m^{2})^{-1}$

P 0.02 g $(d \cdot m^{2})^{-1}$

7. Improvement Technology for Water Quality of Lake & Marsh

(4) Purification by Aerated circulation System

Principle



Surface above air lift tube

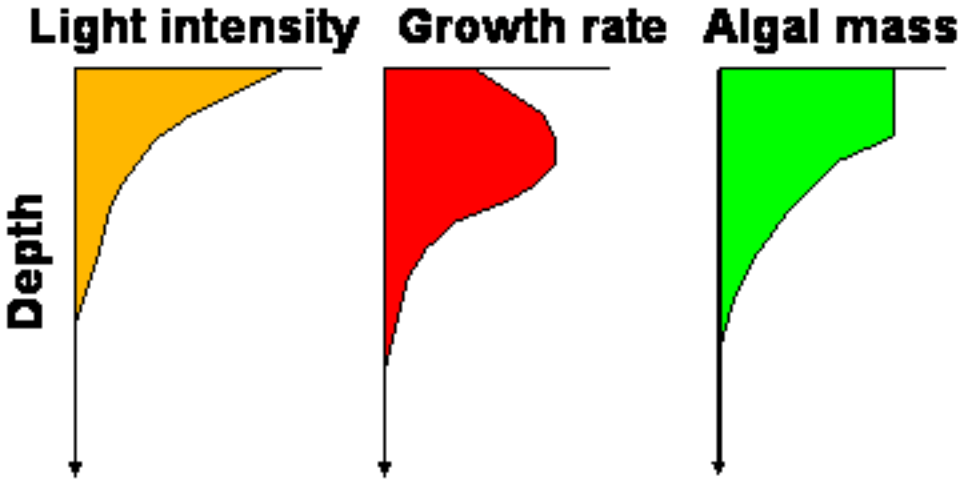
7. Improvement Technology for Water Quality of Lake & Marsh

(4) Purification by Aerated circulation System

Effects of aerated circulation

- Light control------restraining phytoplankton
- Surface layer water-----shortening detention time → 2-3 days
- Improving lower water DO------Preventing elution of Mn, NH_3 etc
- Sedimentation promotion-------sedimentation of phytoplankton

	Transparency (m)	productive layer (m)
Hypertrophic	<1	<2
Eutrophic	1-1.5	2-3
Mesotrophic	1.5-2	3-4
Oligotrophic	>3	>5



7. Improvement Technology for Water Quality of Lake & Marsh

(4) Purification by Aerated circulation System

Kamafusa Impounding Dam

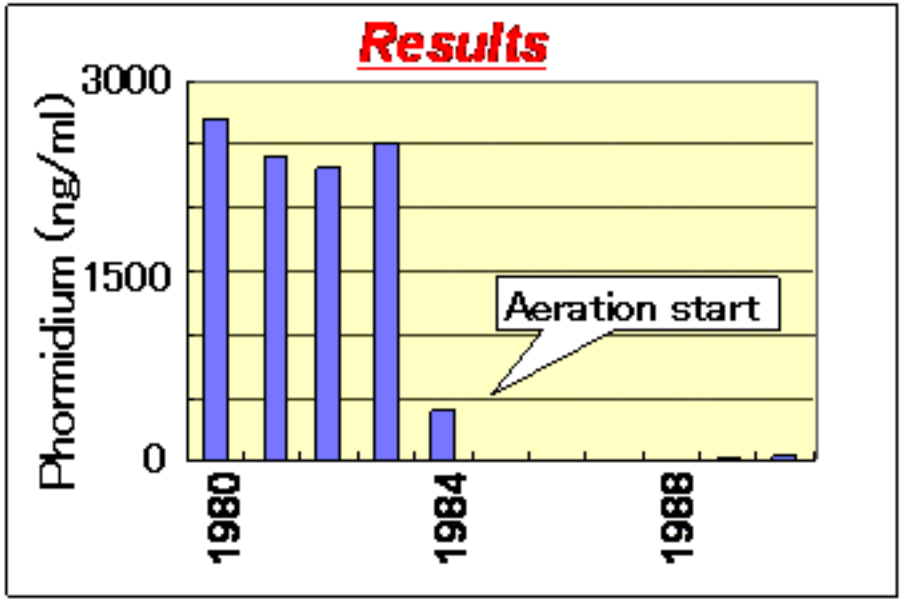
V=45.3 million ton

A=3.7 km^2

Air-lift Pipe 7.5kWx5, 22kWx1

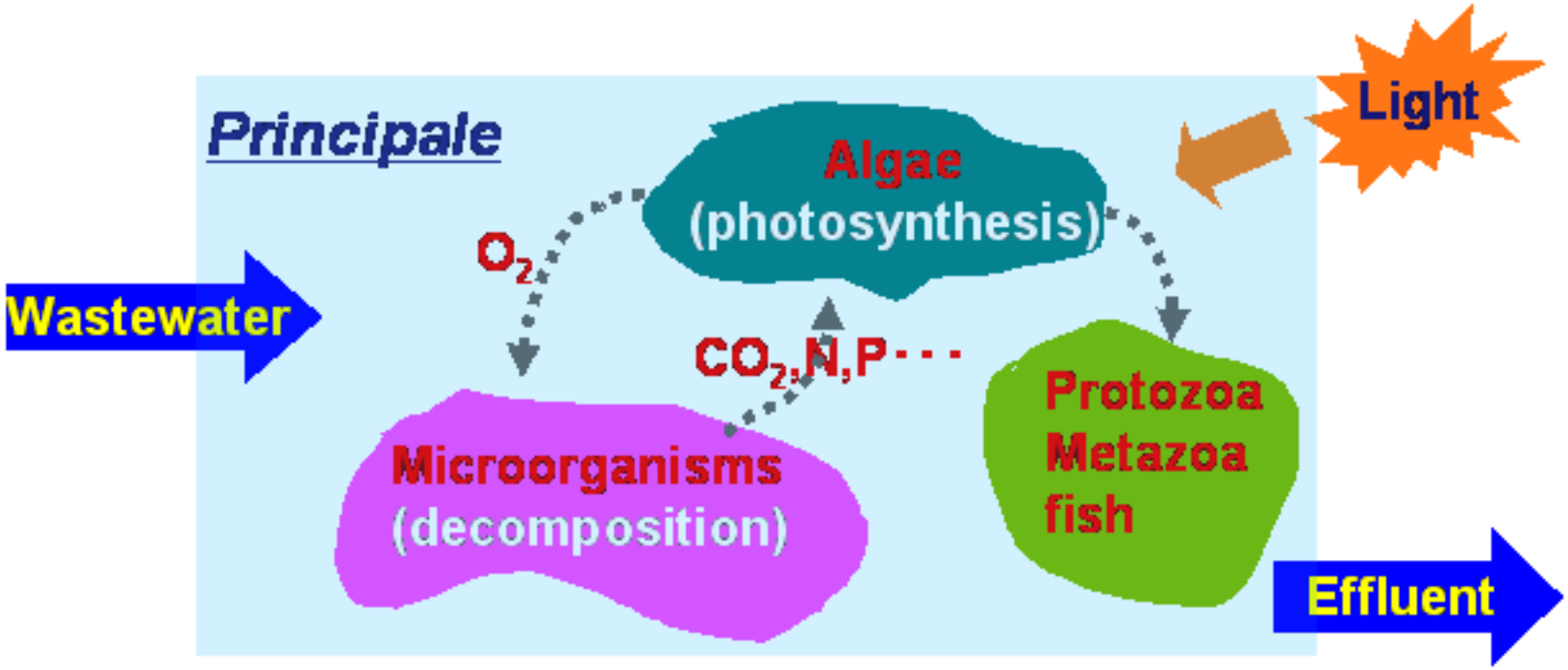
Purpose: multipurpose

Phormidium / blue-green algae→ musty odor



7. Improvement Technology for Water Quality of Lake & Marsh

(5) Purification by Lagoon System



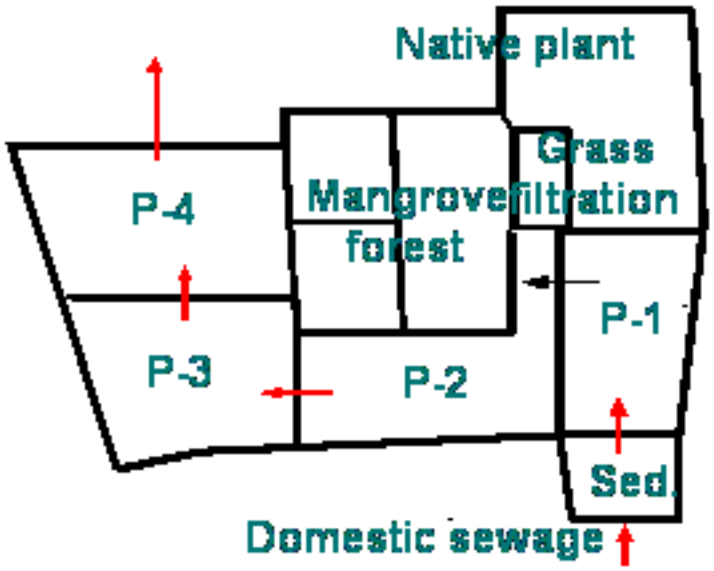
Lagoon	Water depth (m)	Detention time (days)	BOD removal ($g / m^2 / d$)
Facultative pond	0.7- 1.5	10- 50	2- 6
High-rate pond	0.2- 0.3	2- 6	10- 30

7. Improvement Technology for Water Quality of Lake & Marsh

(5) Purification by Lagoon System

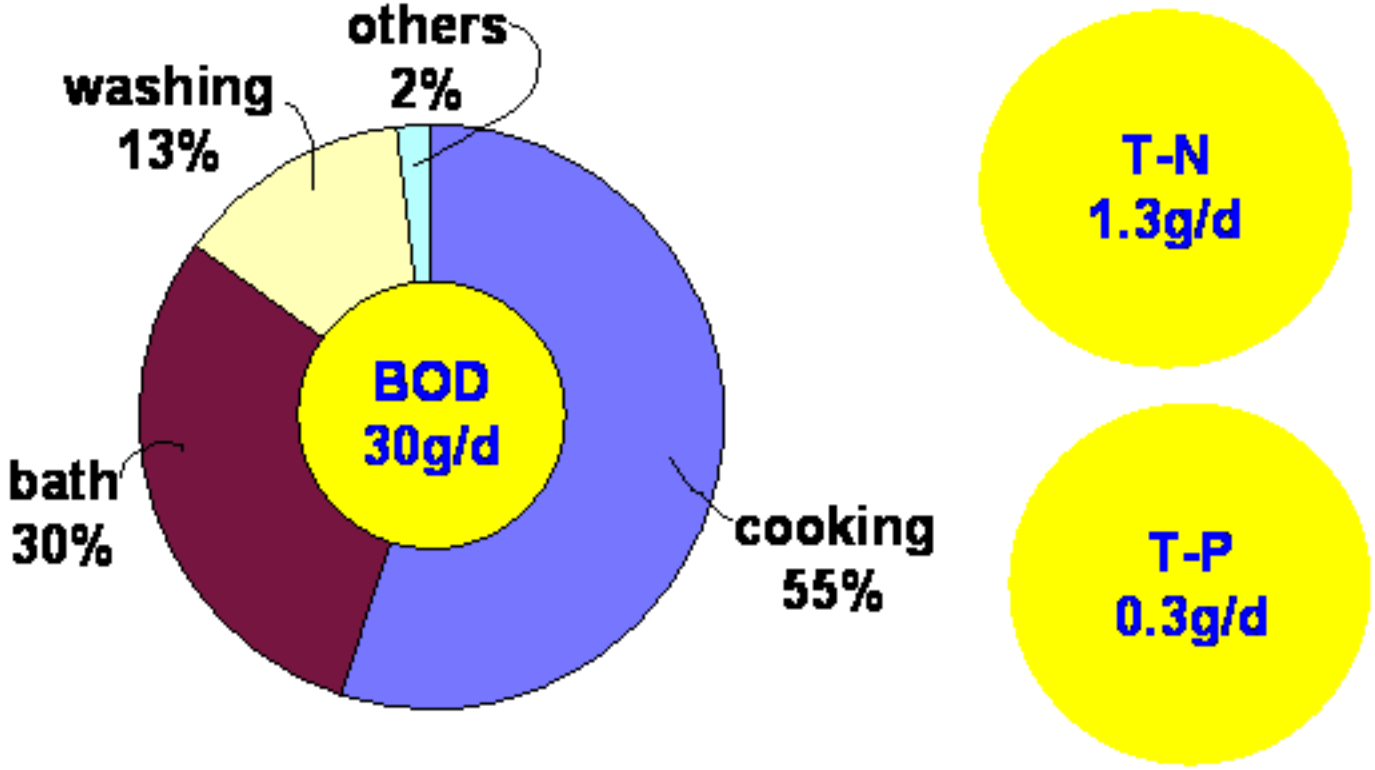
Performance result; Phetchaburi, Thailand

	Depth (m)	Area (m2)	Vol (m3)	BOD (mg/l)	T-N (mg/l)	T-P (mg/l)
WW	-	-	-	145	22	3.8
SD	2.3	10,217	23,499	45	19.5	3.5
P-1	2 .0	30,408	60,816	31	11.8	3.1
P-2	1.9	34,898	66,306	21	7.5	1.4
P-3	1.8	35,422	63,763	12	6.8	0.7
P-4	1.7	43,132	73,324	14	6.1	0.5
			Rmv. Rate(%)	90	72	86



7. Improvement Technology for Water Quality of Lake & Marsh

(6) Resident Participation Measures at Kitchen



House hold wastewater load / capita

7. Improvement Technology for Water Quality of Lake & Marsh

(7) Resident Participation Measures at Kitchen

Pollutant load reduction

A. Kitchen

1. Control cooking refuse

- Cook just enough, no leftovers
- Collection of solids and food left over
- Rice washing water→ plants
- Wipe sauce, oil, dressing, etc before washing
- Don't dump soup, beer, etc

2. Properly dispose of used oil

- Use up cooking oil each time you cook
- Absorb used oil to paper or solidifier

3. Properly dispose of collected materials

- Garbage disposal or bury underground

B. Bath

Use proper amount and type of detergent

C. Laundry

Use used water for laundry or other purposes