Waste Water treatment by Multi Soil Layering Method

KEC KANATSU ENGINEERING CONSTRUCTION

Background

The use of soil for water treatment has a long history in the world.

Conventional method

Land treatment
Sand filter
Septic systems (EPA)

Some limitations

Low permeability
> need large area
> Risk of clogging

Increase the permeability

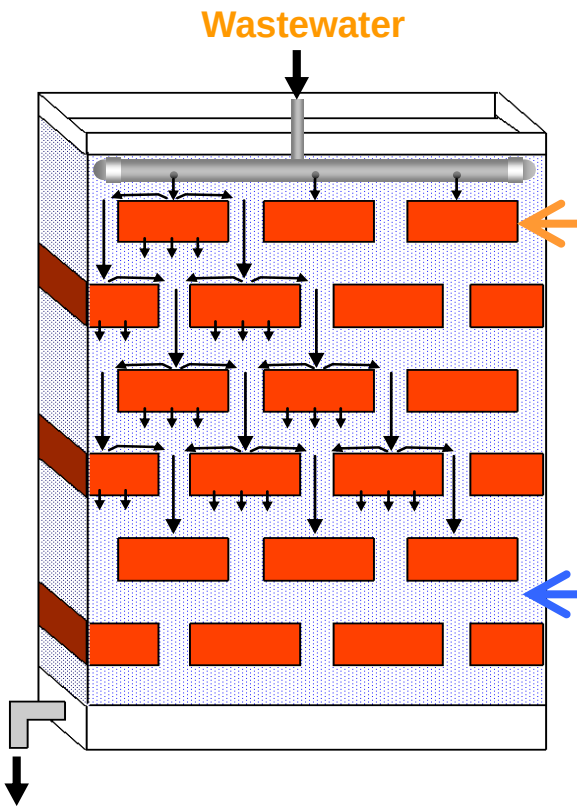
Soil has high purification function,
but is highly depends on properties of each soil type.

Regulation and enhancement of the purification functions

Multi-Soil-Layering (MSL) Method

Multi-Soil-Layering (MSL) Method

The MSL method consists of soil units arranged in a brick-like pattern surrounded by layers of zeolite or alternating particles of homogeneous sizes that allow a high hydraulic loading rate.



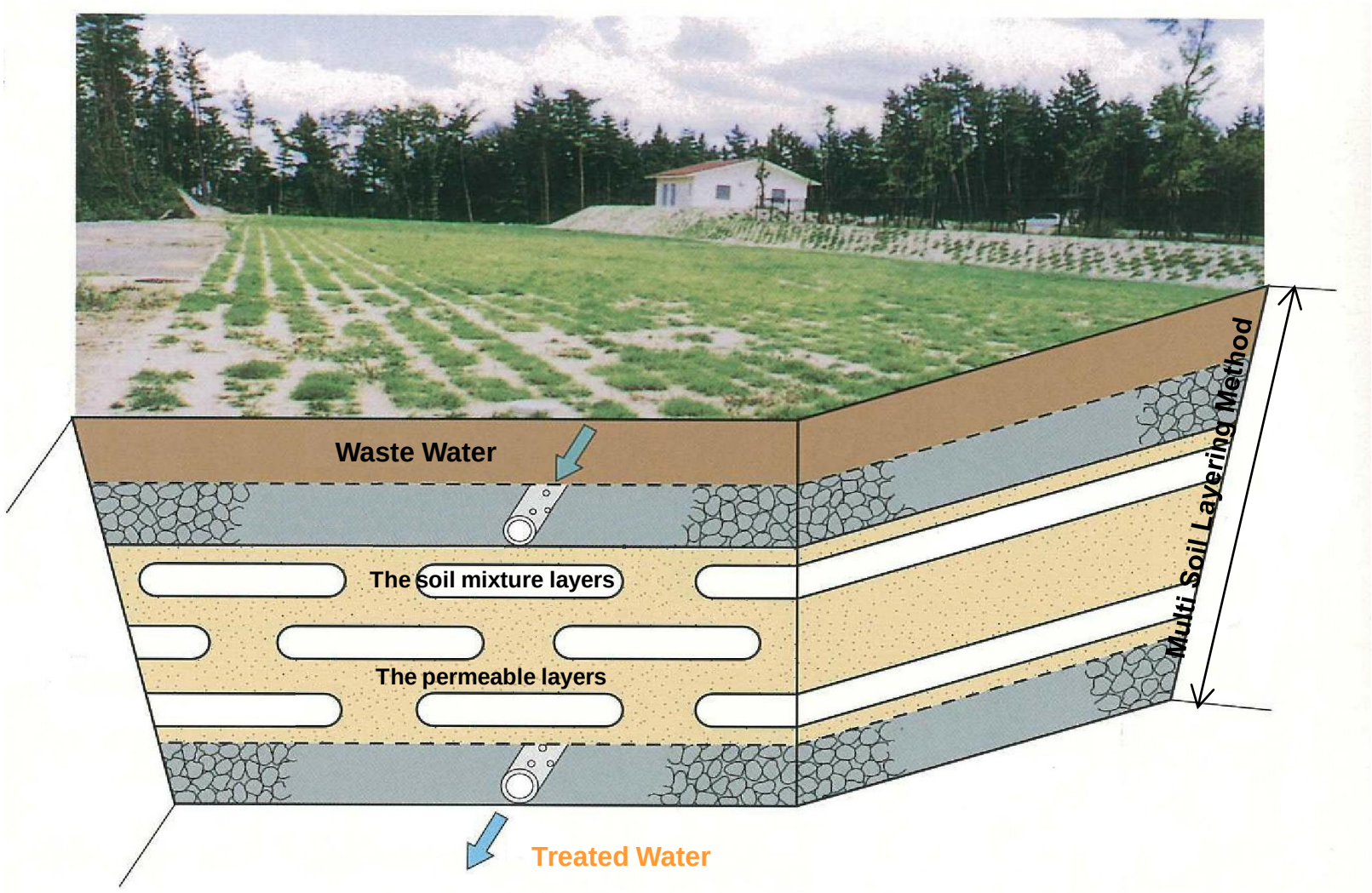
Soil mixture layer (10^{-3} cm sec^{-1})

andisol : high soil aggregate formation, high phosphorus adsorption ability.
sandy soil : large particle size and high permeability
on-site soil: low cost
iron : phosphorus adsorption, reducing agent
charcoal : high porosity, hydrophobic adsorbent, habitat of microorganisms
organic matter : food for microorganisms, electron donor for denitrification

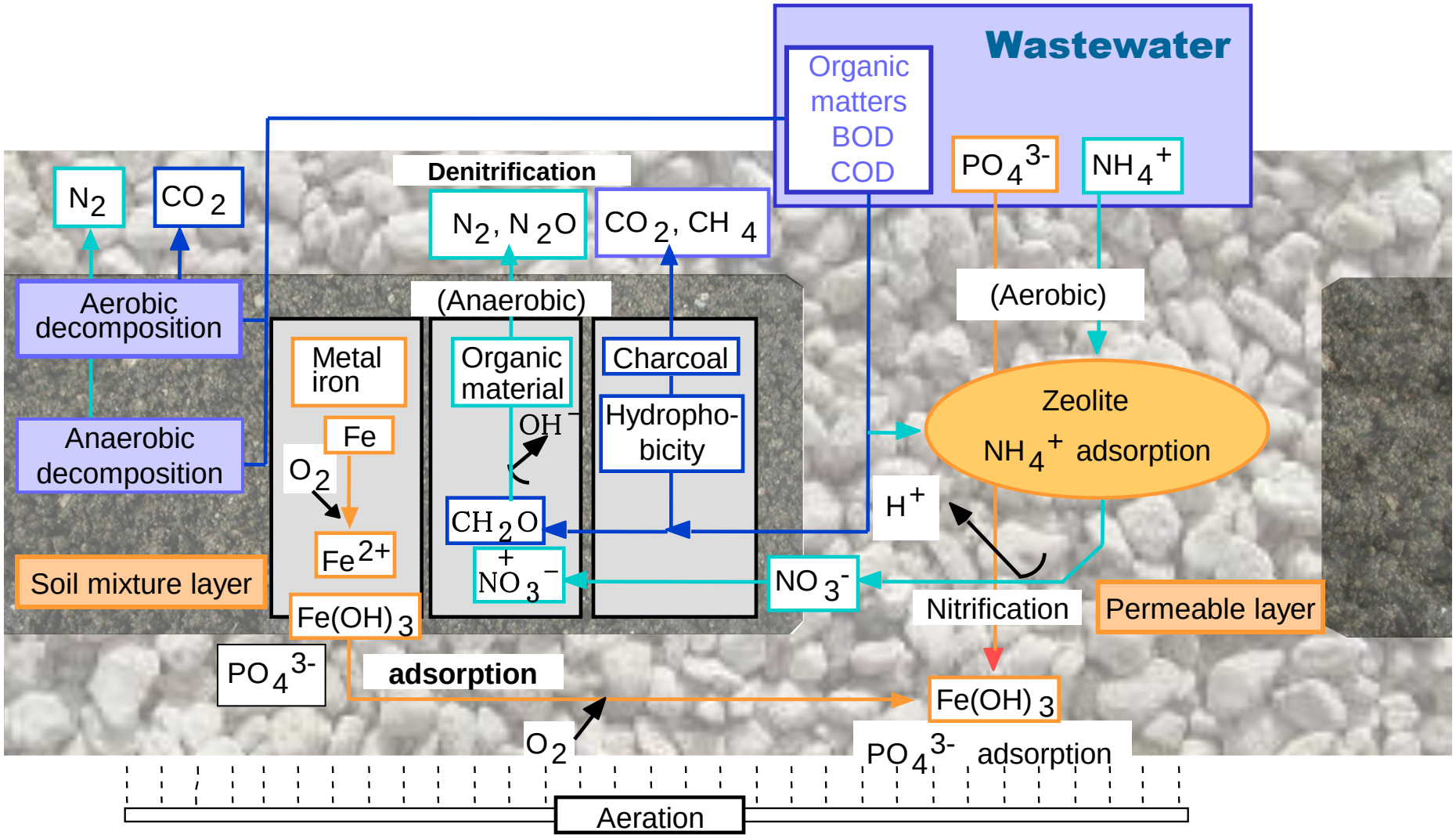
Permeable layer (10^{-1} cm sec^{-1})

sandy soil: large particle size and high permeability
zeolite : high NH_4^+ adsorption ability, high CEC, high porosity
Pumice : high porosity, low cost than zeolite
charcoal : high porosity, hydrophobic adsorbent, habitat of microorganisms
gravel

Conceptual diagram of Multi-Soil-Layering (MSL) Method



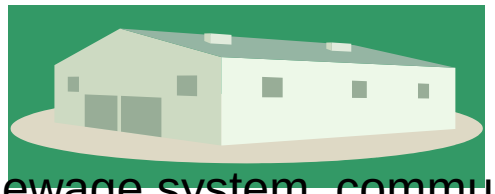
Treatment processes of MSL Method



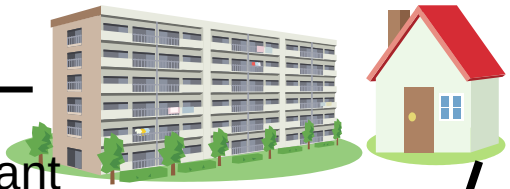
Characteristics of the MSL method

1. High purification ability
2. High removal efficiency of N and P
3. Stable high treatment performance against fluctuation of raw water
4. Low maintenance
5. Reuse of treated water and soil
6. Harmony with the landscape

Application of the MSL Method



Sewage system, community plant



Treated water from wastewater treatment plant

Domestic wastewater

Toilet

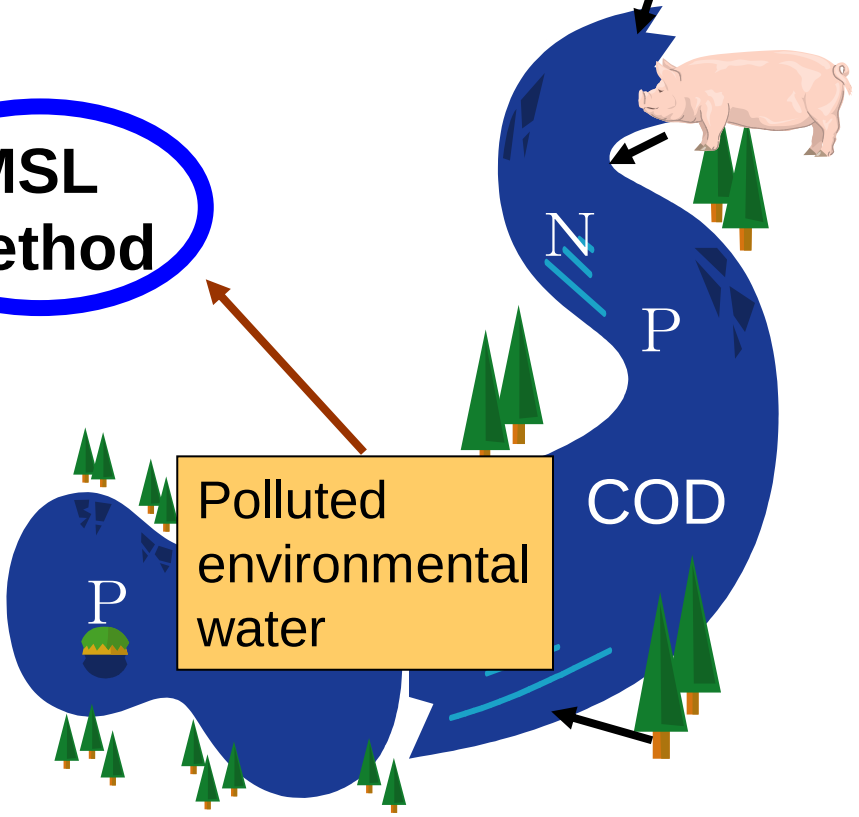
Restaurant

MSL method

remove

N, P, BOD, COD, etc

Treated Water



Polluted environmental water

Application case

Park

Small scale community

Performance of the MSL Method

○Loading rate

BOD、T-N、T-P removal　The standard is 100L m^{-2} day^{-1}.
BOD removal only　It can be increased up to 4000 L m^{-2} day^{-1}

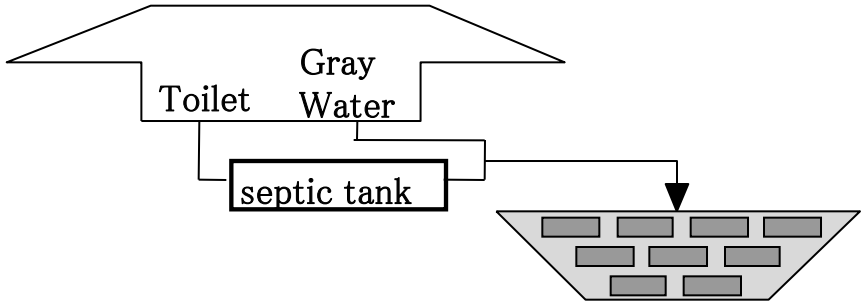
Experimental results (in Shimane University)

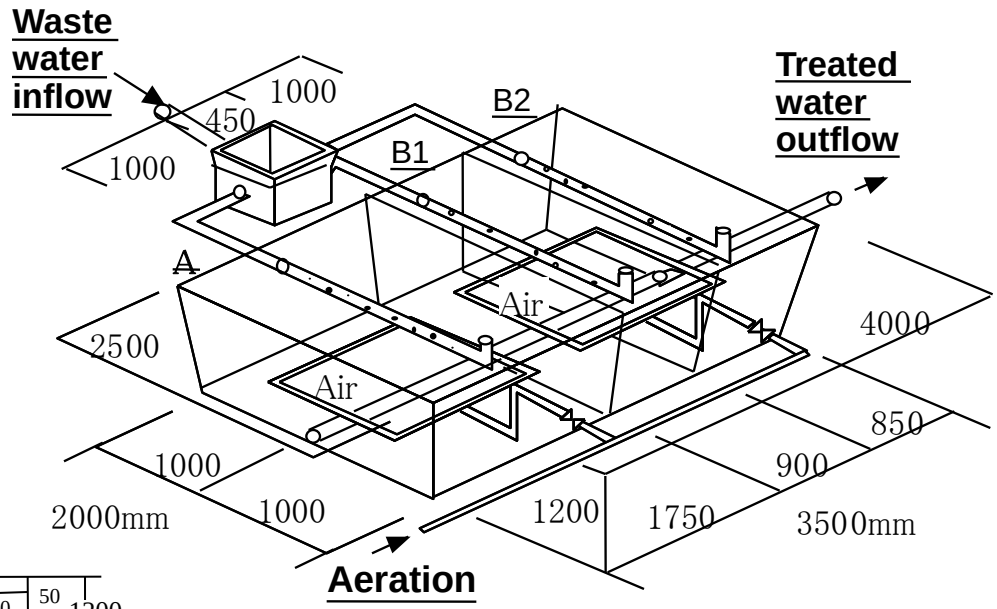
type of water (loading rate)			BOD	T-P	T-N
Ⅰ	river, lake, treated water from wastewater treatment plant (200-5000 L M^{-3} day^{-1})	raw water (mg/l)	25	2.7	12
		treated water (mg/l)	5	1.7	4
		removal rate(%)	77	44	52
Ⅱ	domestic and toilet wastewater (200-2000 L M^{-3} day^{-1})	raw water (mg/l)	190	6.5	58
		treated water (mg/l)	16	1.7	30
		removal rate(%)	91	75	48
Ⅲ	livestock wastewater high polluted water (30-300 L M^{-3} day^{-1})	raw water (mg/l)	1400	40	240
		treated water (mg/l)	47	5.4	92
		removal rate(%)	96	88	61

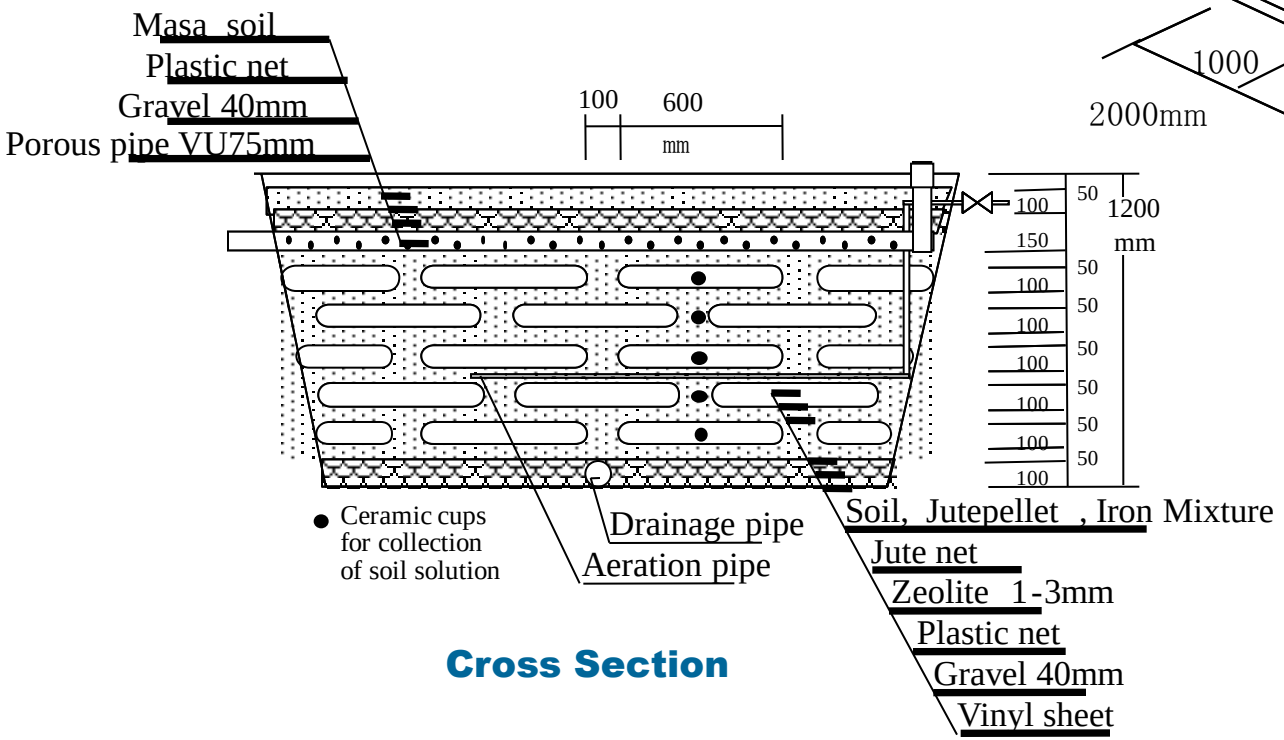
Results of practical use

type of water (loading rate)		BOD	T-P	T-N
[park] a public latrine ($100\ L\ M^{-3}\ day^{-1}$)	raw water (mg/l)	5.4	4.46	39.4
	treated water (mg/l)	0.7	0.04	15.5
	removal rate(%)	81.7	99.1	60.7
[estate,office] a cooperative society office in Osaka ($30\ L\ M^{-3}\ day^{-1}$)	raw water (mg/l)	44.1	4.72	45.8
	treated water (mg/l)	8.5	1.35	13.2
	removal rate(%)	80.7	71.4	71.2
[house] advanced treatment of domestic wastewater ($100\ L\ M^{-3}\ day^{-1}$)	raw water (mg/l)	53.2	7.82	64.8
	treated water (mg/l)	4.8	0.81	5.1
	removal rate(%)	90.9	89.6	92.1
[river] direct river treatment system in Kumazoe River ($4000\ L\ M^{-3}\ day^{-1}$)	raw water (mg/l)	15.7	-	-
	treated water (mg/l)	1.6	-	-
	removal rate(%)	90	-	-

Domestic wastewater treatment





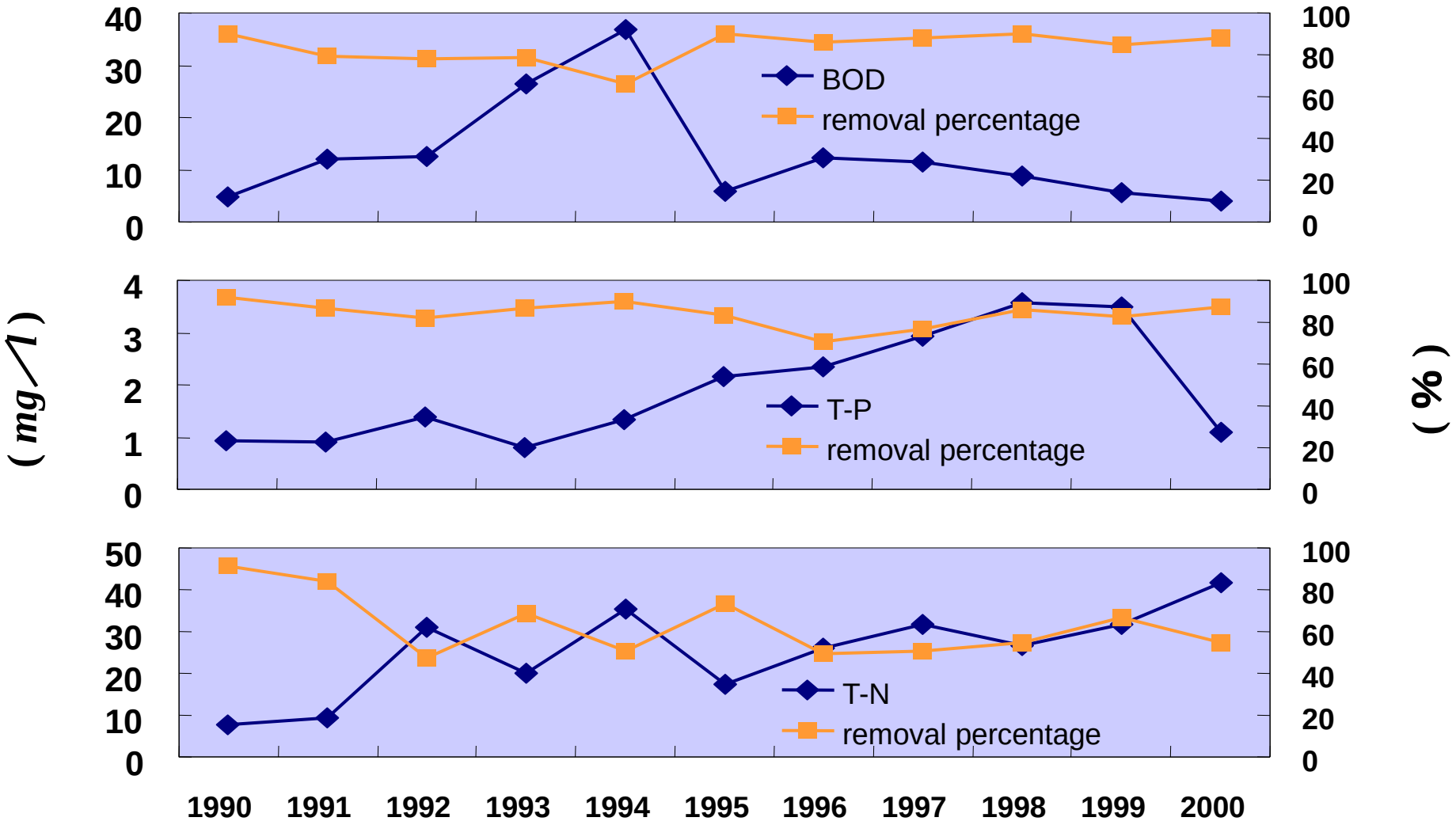


Cross Section

Plan of treatment quantity:1m³/day

Actual loading rate: 100～250L/m²/day

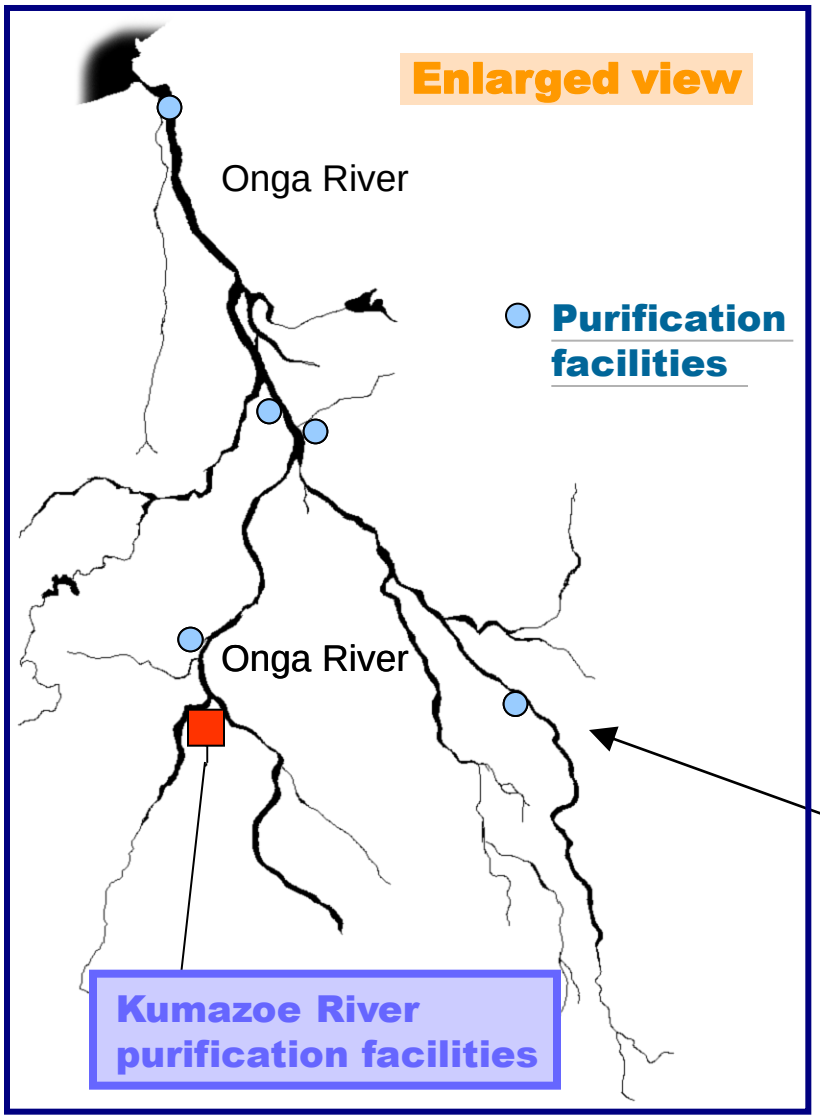
Evaluation of system performance during the 10years operation

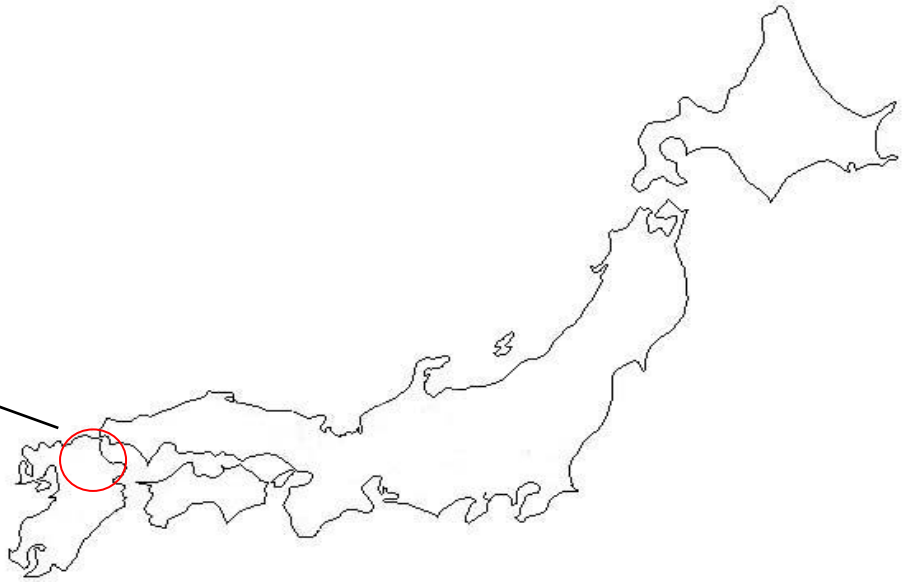


Change of BOD,T-P,T-N concentration and removal percentage of treated water

Application case:
Treatment of Polluted River Water by the MSL Method

Kumazoe River purification project





location of Kumazoe River and situation of the watershed

Kumazoe River basin

The general situation of Kumazoe River

The catchment area	2.5km^2 (the urban area: about 80%)
Length of river channel	1.2km
River flow	average of winter: 7000m^3 day^{-1} average of summer: 28000 m^3 day^{-1}
Quality of the river water	average BOD concentration of winter 55mg L^{-1} average BOD concentration of summer 9 mg L^{-1}

The contents of the project

The design parameters of the MSL method

Targeted quantity of the river water: 7000m^3 day^{-1} (the target is mean river flow of winter)
Targeted quality of the river water: BOD 15.7 mg L^{-1} (on the average)
BOD 50 mg L^{-1} (on the maximum)
Targeted quality of the treated water: less than BOD 1.6mg L^{-1}
(BOD removal rate: 90%)

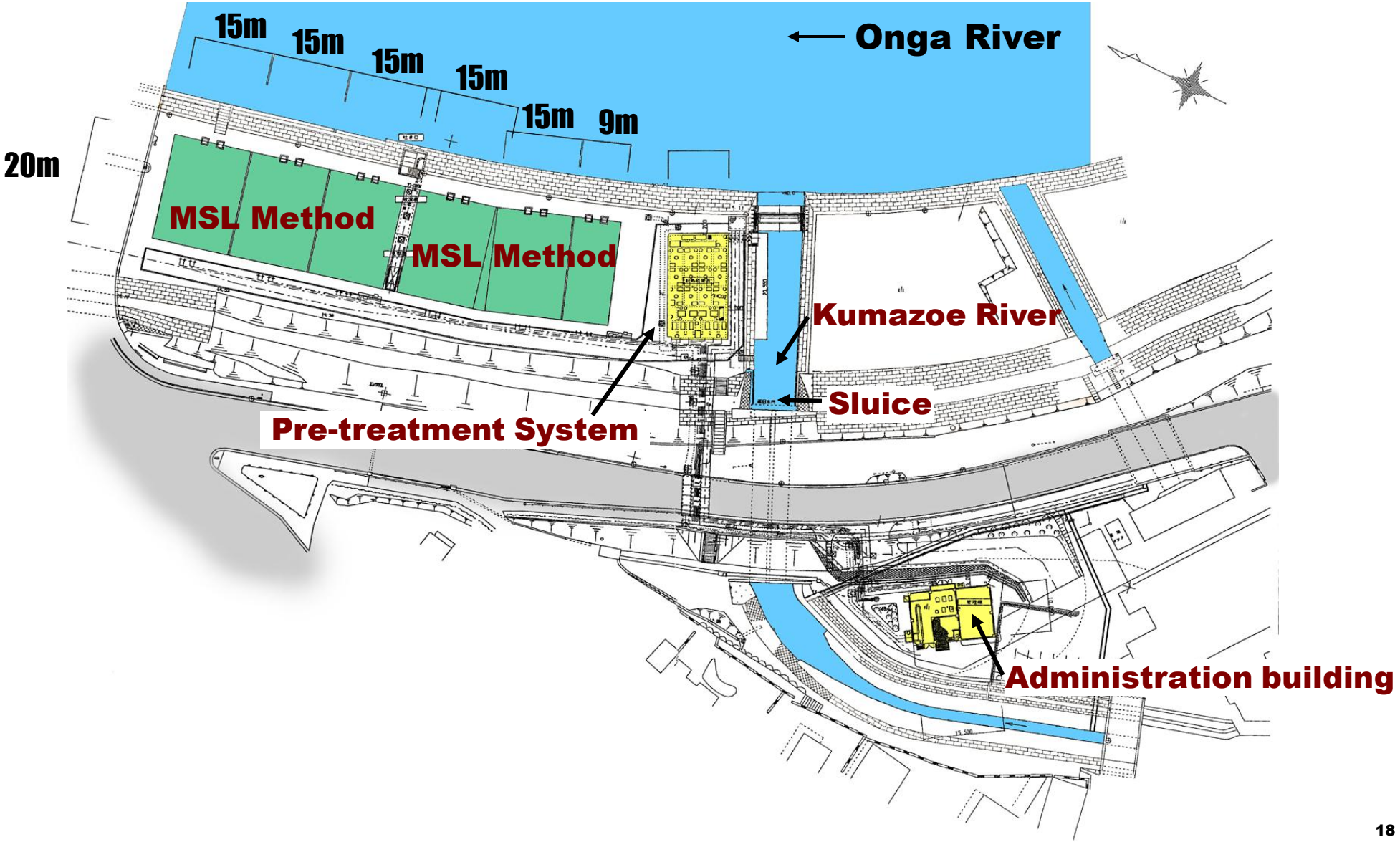
The scale of the MSL method

Site area: the MSL method 1750m^2
total 6 series: 5 series of 6 series are always alternate operations.
: pre-treatment system for SS removal (a contact oxidation system)

The construction details of the MSL method

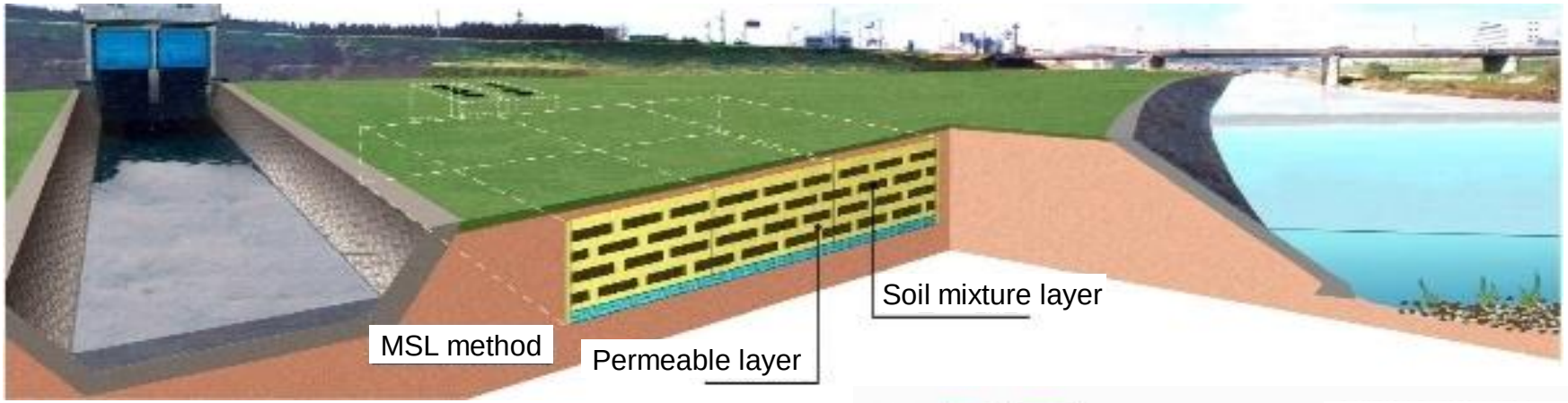
The construction period: September,2002 ~ March,2005 (start: April,2005~)
The cost of construction: 7.7 hundred million yen
110 thousand yen per 1m^3 day^{-1} of the water quantity

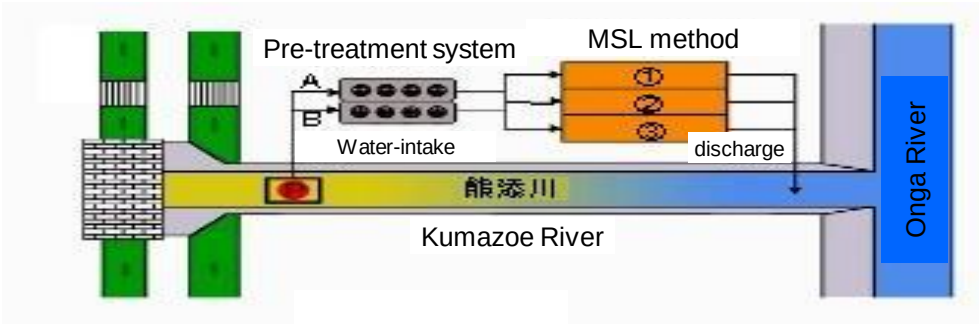
A plan for Kumazoe River purification project



Kumazoe River purification facilities (the MSL method)

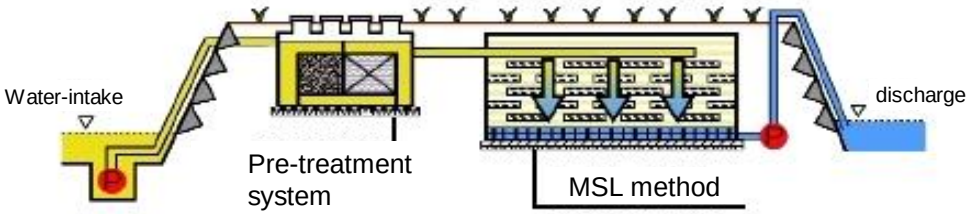
The demonstration experiment of pilot scale on the site for Kumazoe River purification project



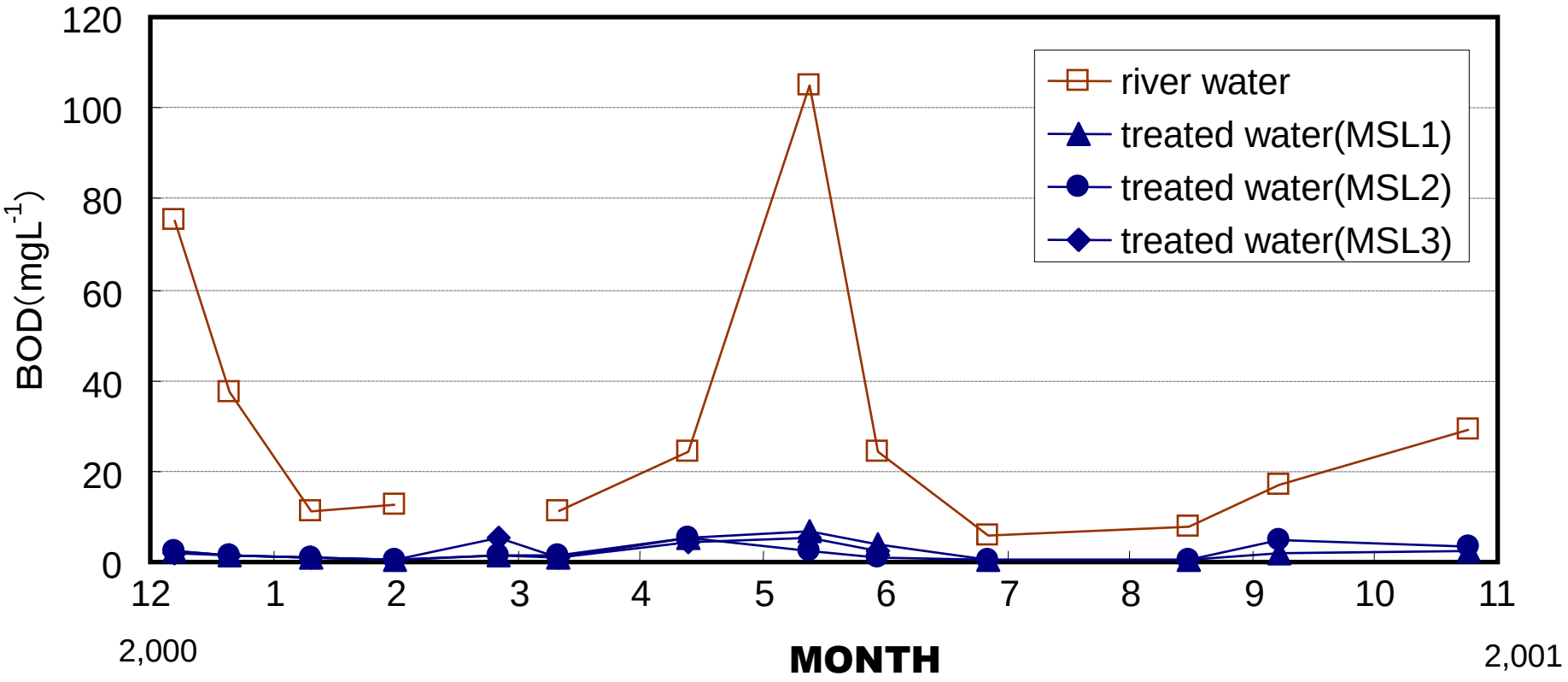


The scale of the system

Water quantity for treatment		$144m^3day^{-1}(4m^3m^{-2}day^{-1})$
(Loading rate)	Pre-treatment system	$72m^3day^{-1}\times2$
	The MSL method	$48m^3day^{-1}\times3$

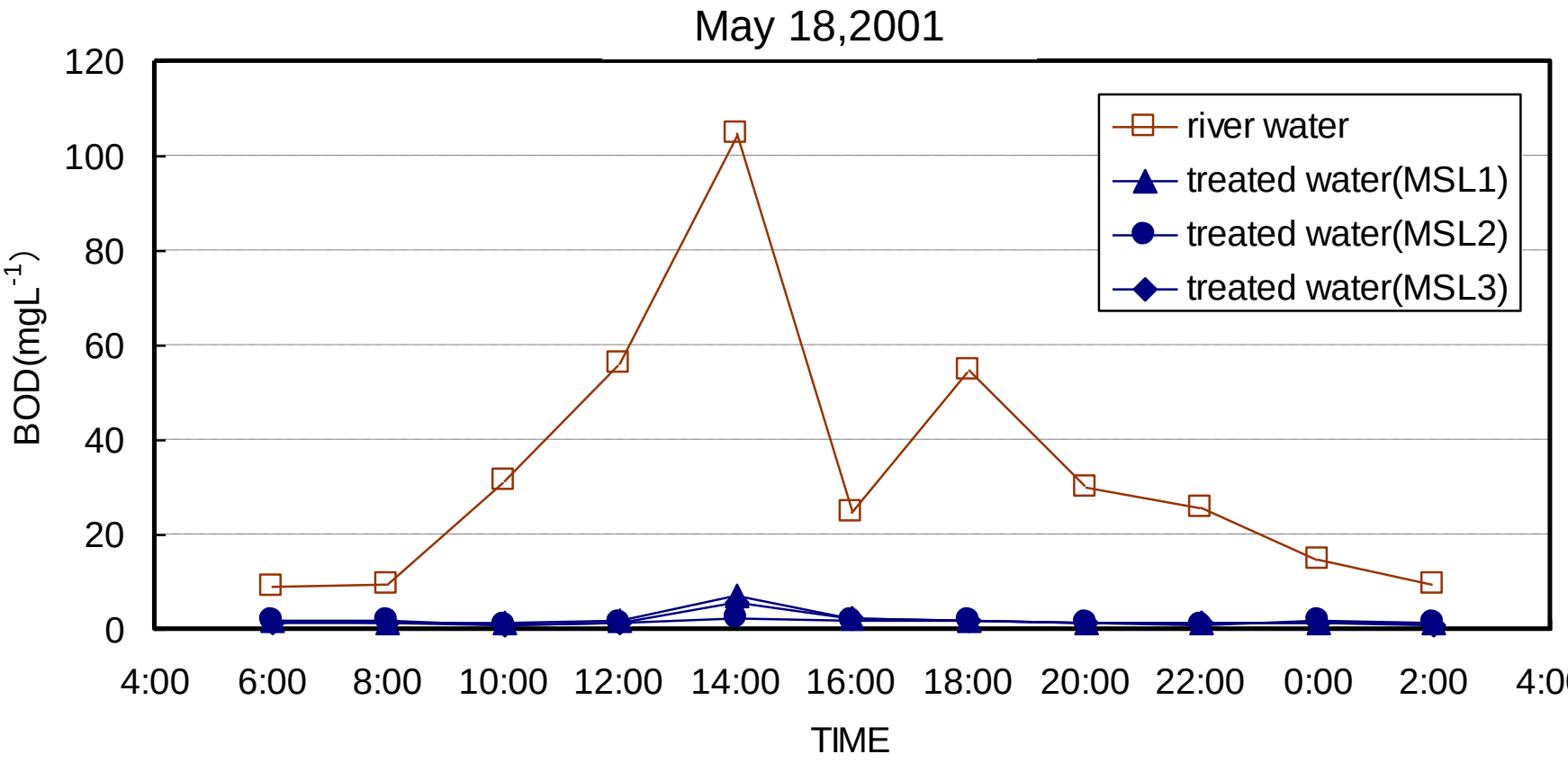


A performance of demonstration experiment



source: survey by Ministry of Land, Infrastructure and Transport

Seasonal change of BOD concentration in the demonstration experiment



source: survey by Ministry of Land, Infrastructure and Transport

Dairy change of BOD concentration in the demonstration experiment

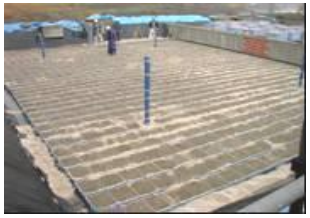
The comparison of performance and cost

	MSL system	contact oxidation system by gravel with aeration	contact oxidation system by gravel and various types of plastic modules with aeration	advanced contact oxidation system by gravel with aeration
BOD of influent water (mgL^{-1})	55	55	55	55
BOD of effluent water (mgL^{-1})	5	14	10	10
site area (m^2)	2,300	2,400	1,200	1,000
construction cost (million yen)	440	512	1,031	440
maintenance cost (thousand yen)	6,000	6,600	18,000	6,000

Source: The above construction cost are used as an example, and so are difficult to the real cost.

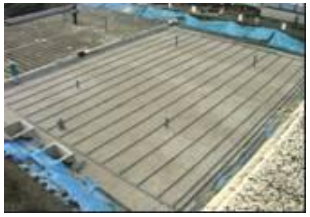
The construction processes of the MSL method

In making of the soil mixture layers, a nonwoven fabric was laid in the plastic cage and the mixed soil was filled up in it.



These blocks were laid like left picture.

The void spaces (permeable layers) between each block and block sides were filled with pumice.

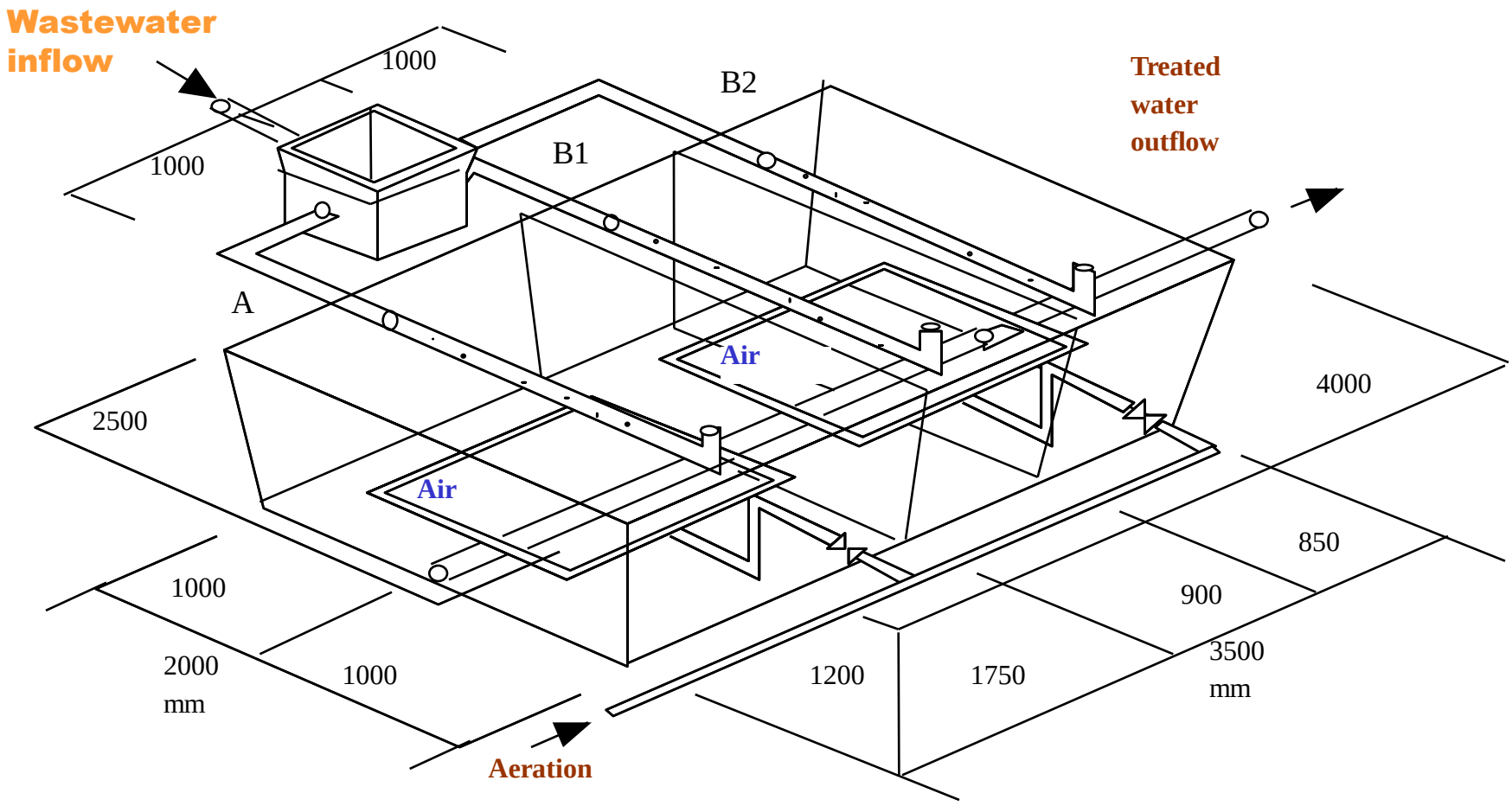


The inlet pipe was installed at the top of the system.

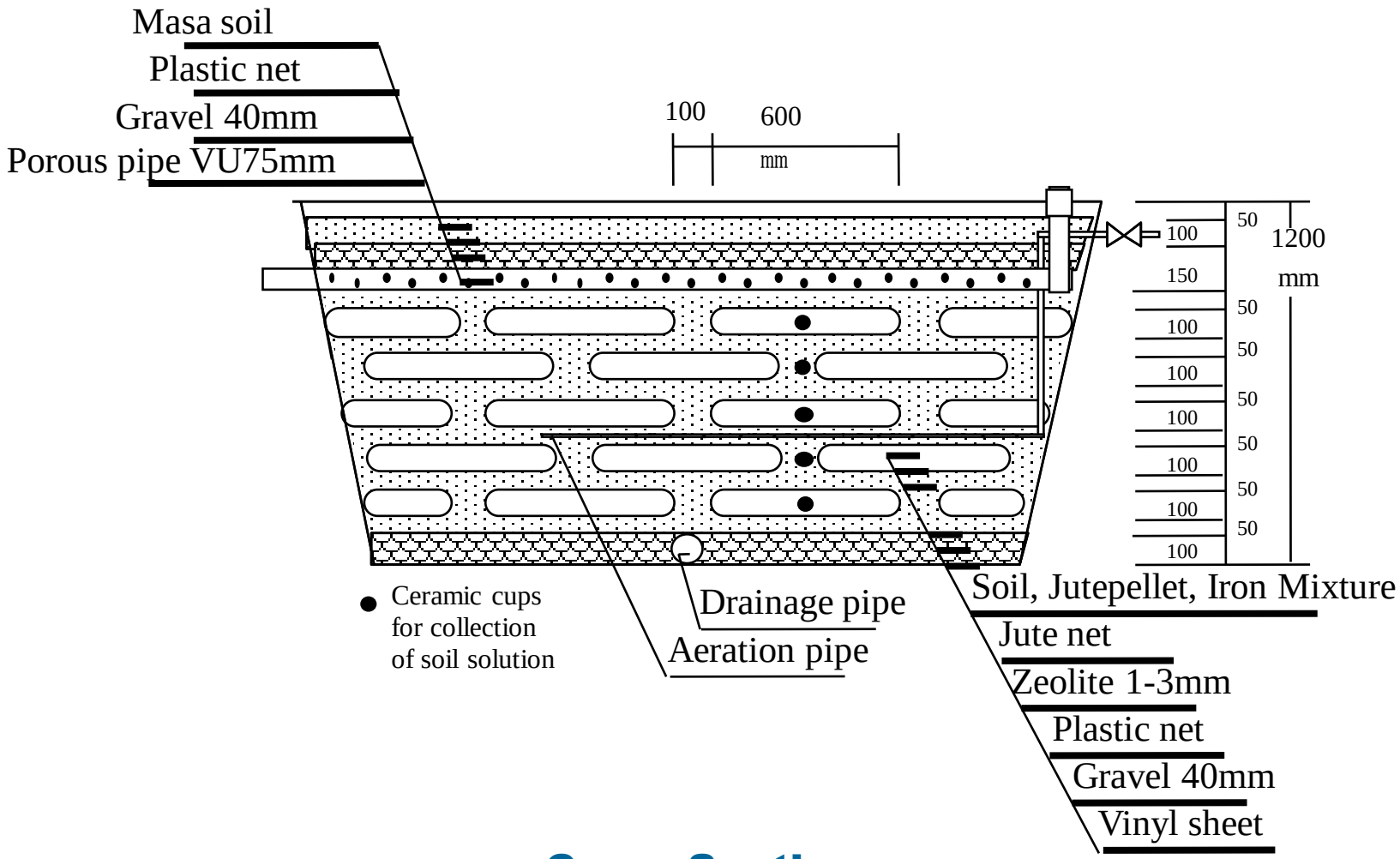
Soil is covered on the surface of the system.

reference data

Structure of Multi Soil Layering Method

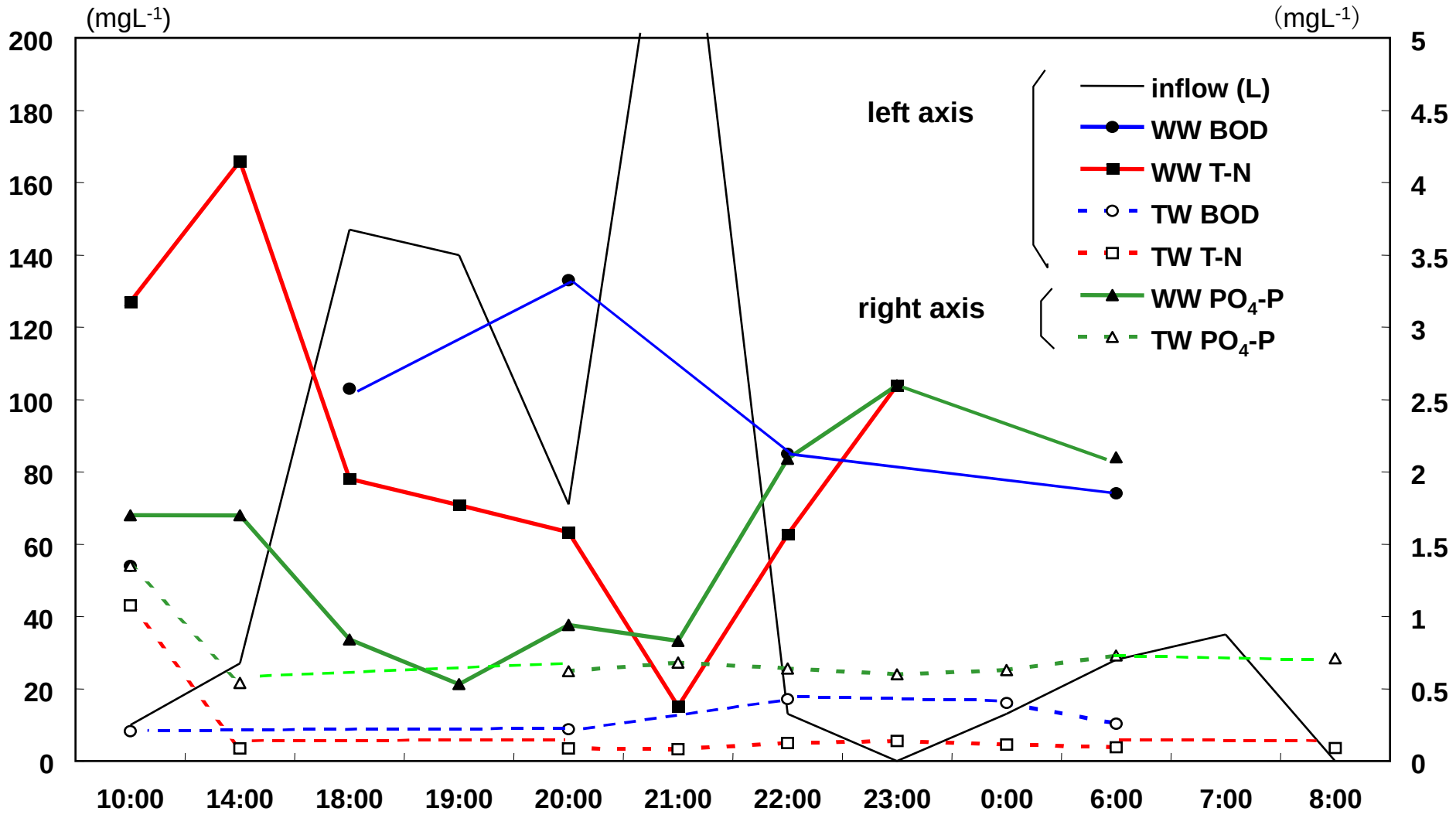


Perspective figure



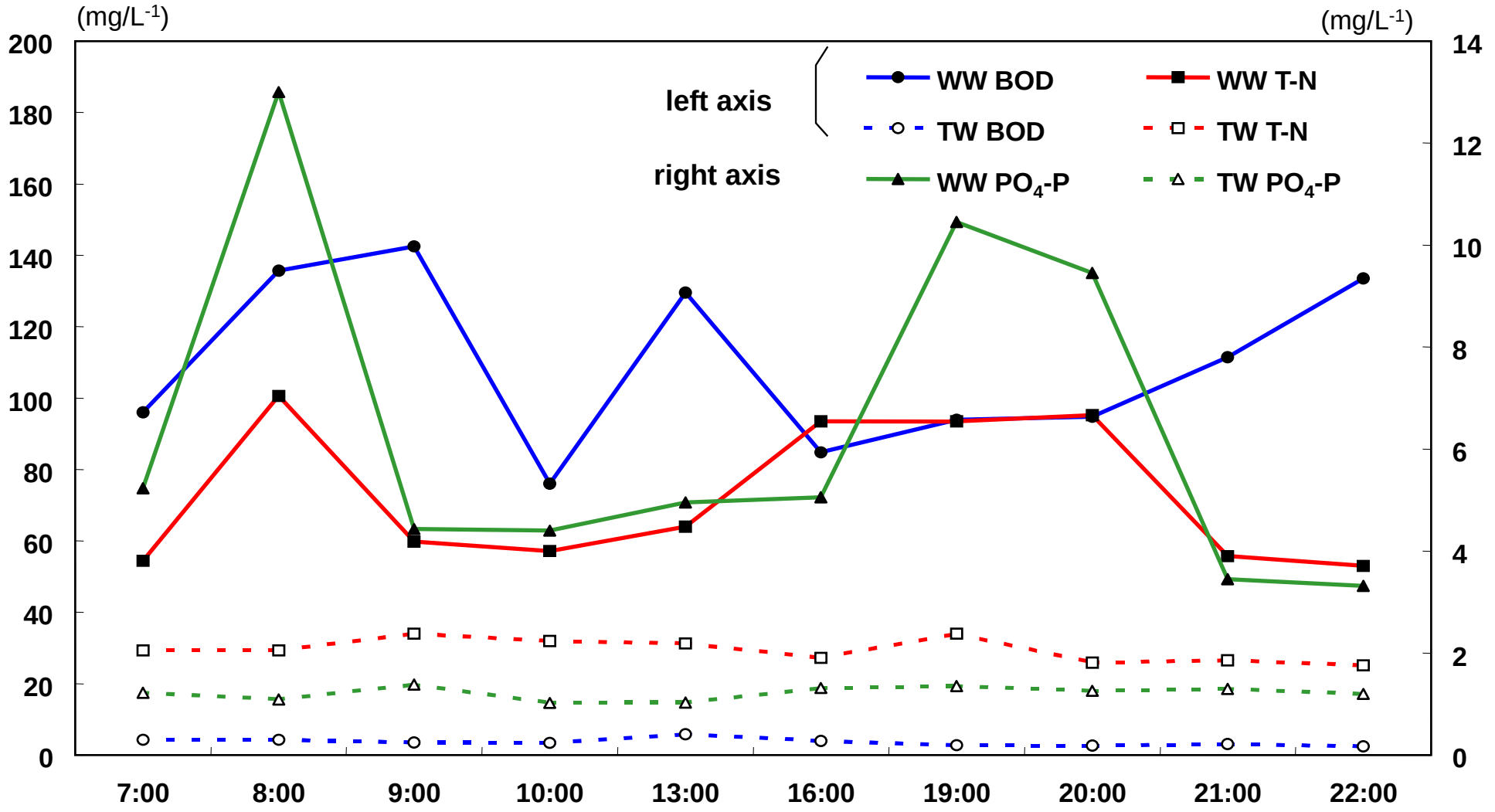
Cross Section

Evaluation of system performance during the 10years operation



Daily fluctuation of waste and treated water（1991/2/13-14）

Evaluation of system performance during the 10years operation



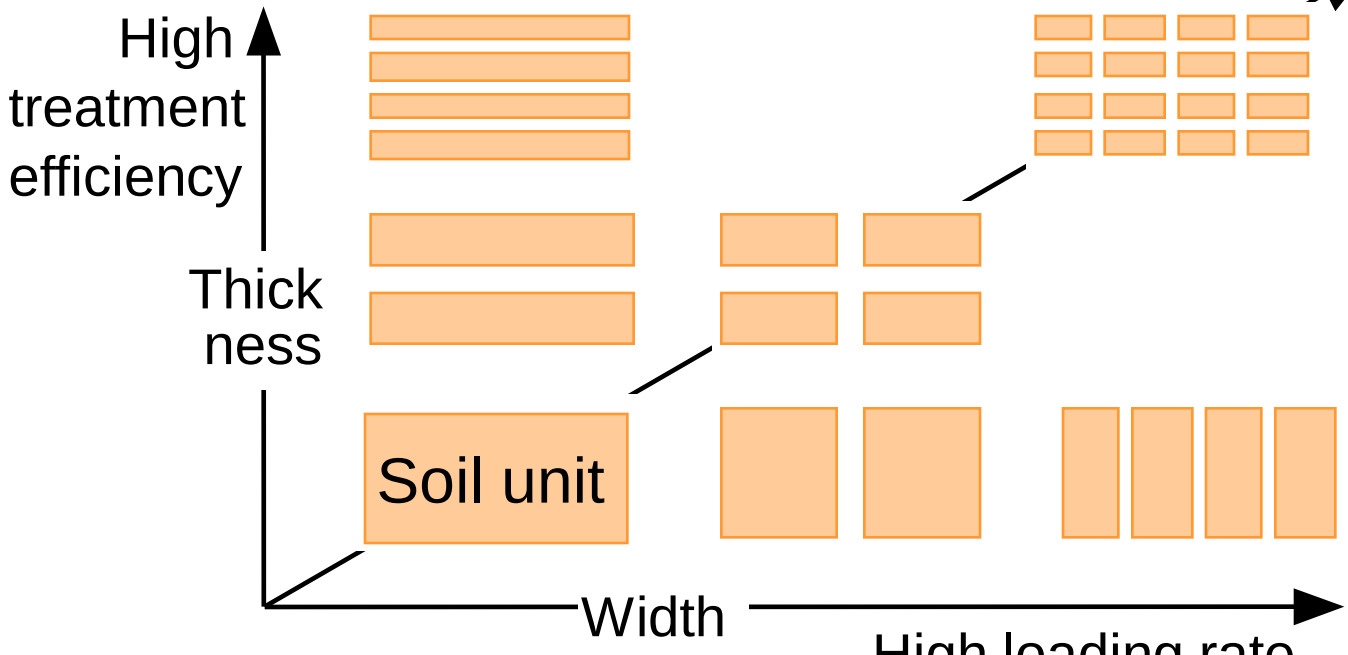
Daily fluctuation of waste and treated water（1999/12/22）

MSL structure and type of water treatment

Heavily polluted water
Low loading rate

Moderately polluted water
High loading rate

Toilet, Restaurant ww treatment



Advanced treatment of sewage or domestic ww

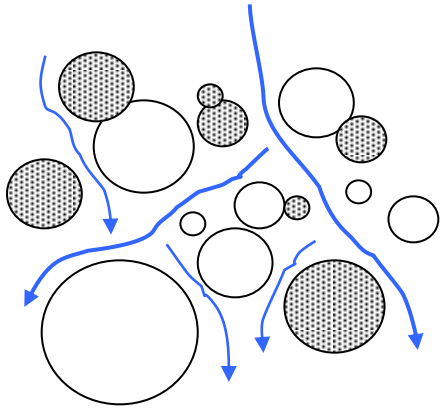
Less polluted water
High loading rate

Direct treatment of polluted river water

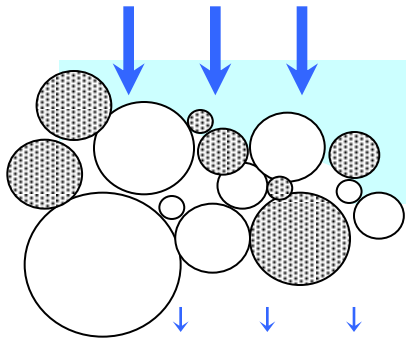
Unit size is decided depending on the degree of treatment needed.

Prevention mechanisms of clogging and shortcut in the MSL method

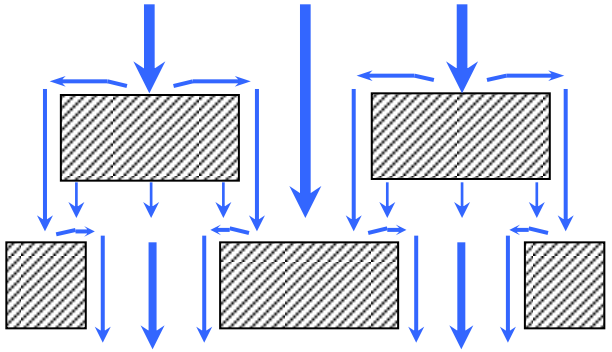
Lack of uniformity



Clogging



(1)Water flow in soil



Improvement of contact efficiency and filtration function

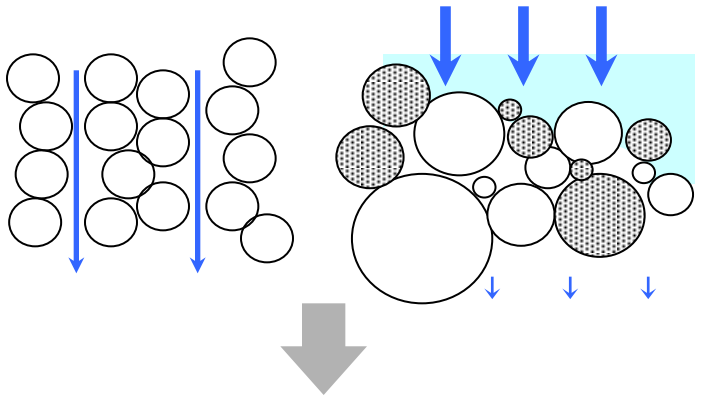
↓

Improvement of PO_4-P, COD, SS removal

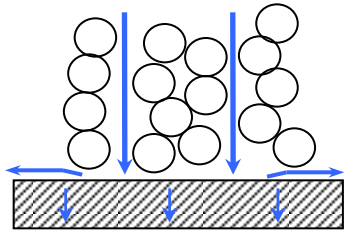
(2)Water flow in the MSL method

(a) Shortcut

(b) Clogging



(c) Prevention effect by MSL method



(3)Difference of water flows by various materials