International Low Impact Development (LID) Workshop

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Measures for Conservation of Water Quality by Plants and Soils

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Lake Biwa - Yodo River

Water Quality Preservation Organization

Today's contents

- **Background**

  Water pollution issues of the Lake Biwa watershed

- **Water purification techniques using natural materials**

  Introduction of using plants and soils

- **Results and Application**

  Assess the treatment effect of its removal using soil infiltration (non-biodegradable organic matter in roadway runoff)

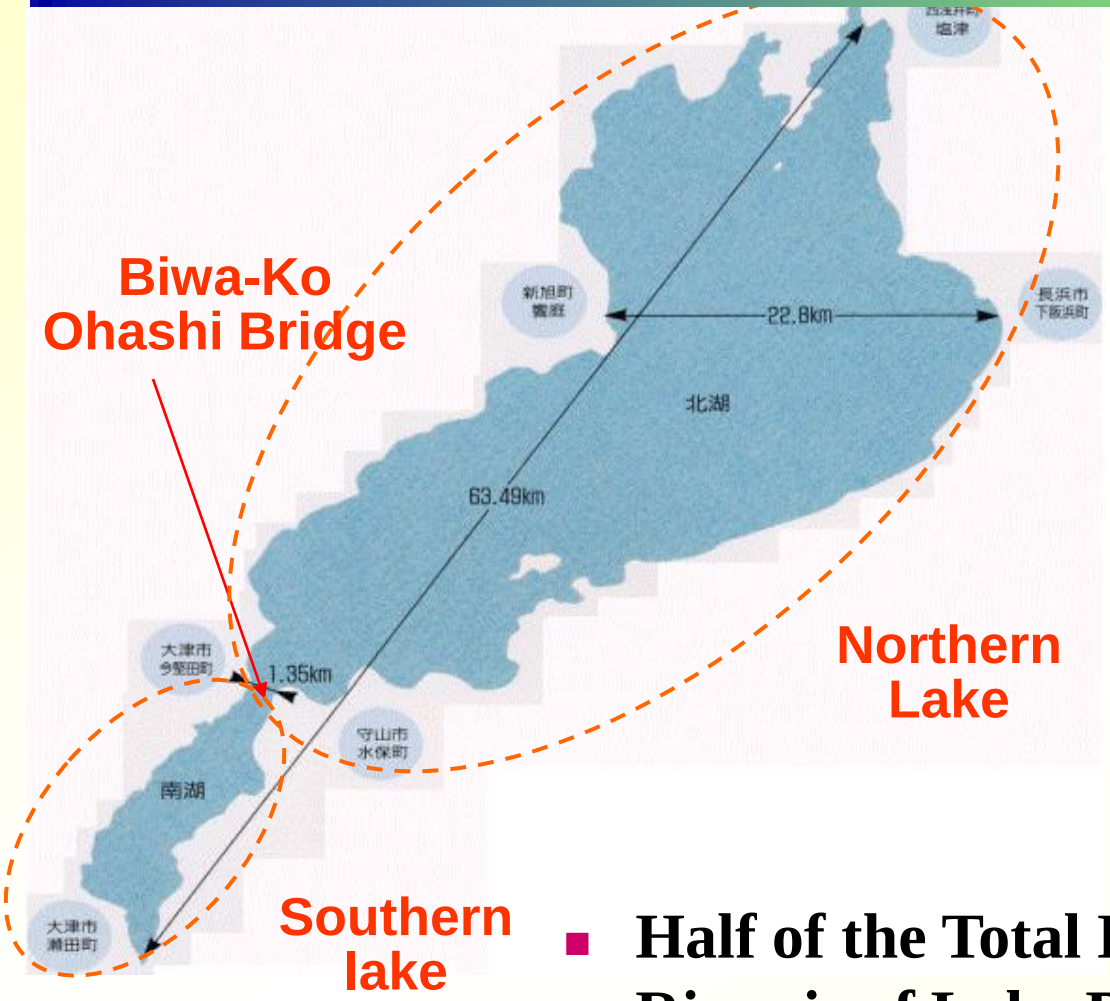
- **Conclusion**

Outlook of Lake Biwa and Yodo River Basin

Characteristics of Lake Biwa-Yodo River Basin

- **Historical Capitals of Japan (Otsu,Nara,Kyoto)**
- **Big commercial and industrial city (Osaka) is located downstream of Yodo River.**
- **Relative small cities are located in upper-stream region surrounding Lake Biwa**
- **Medium-size Historical Japanese Capital (Kyoto) is located in the middle of the Yodo River Basin**
- **-> Almost all population in Kansai Region (14 millions people) depend upon water from Lake Biwa (27.3km^3)**

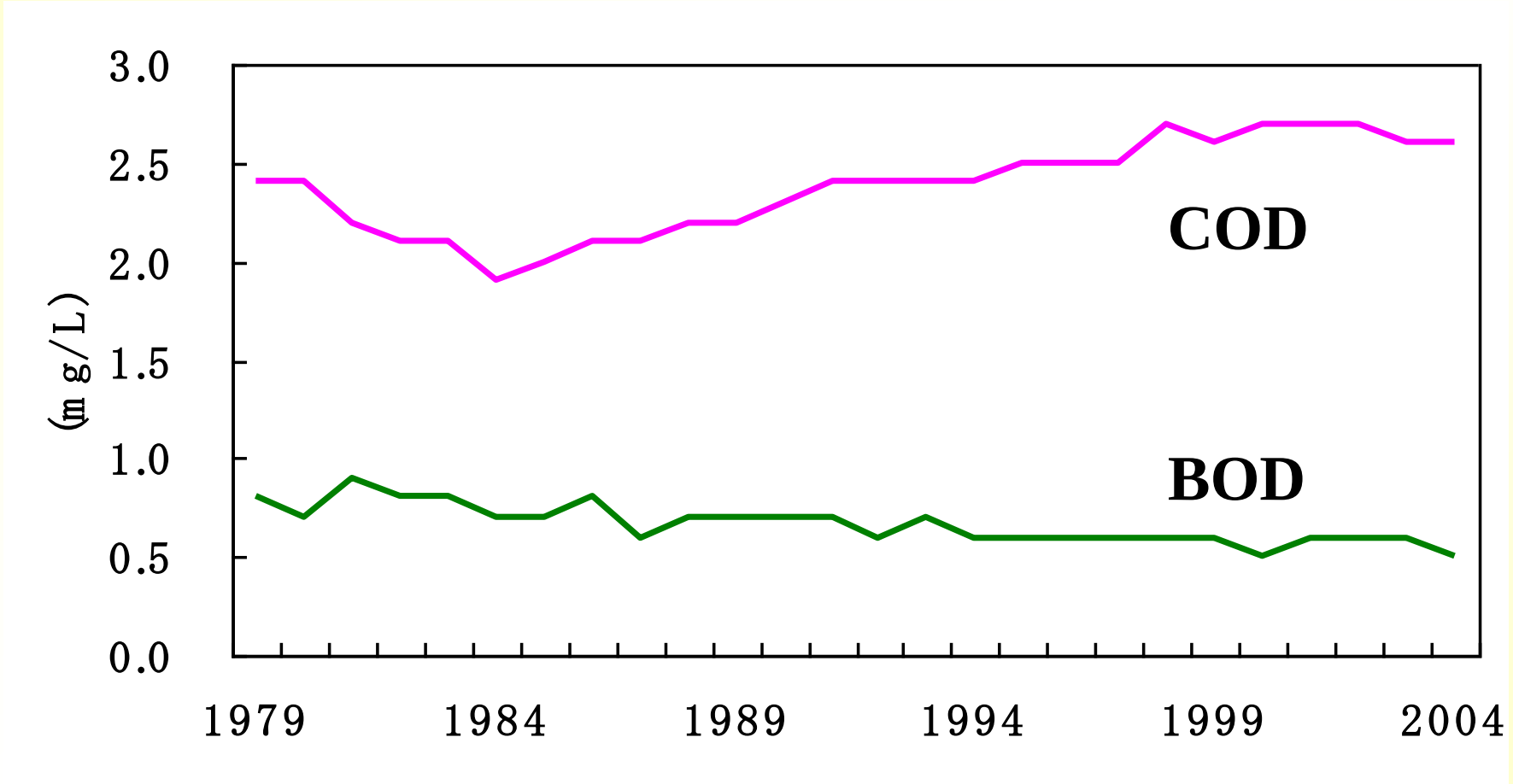
Outlook of Lake Biwa



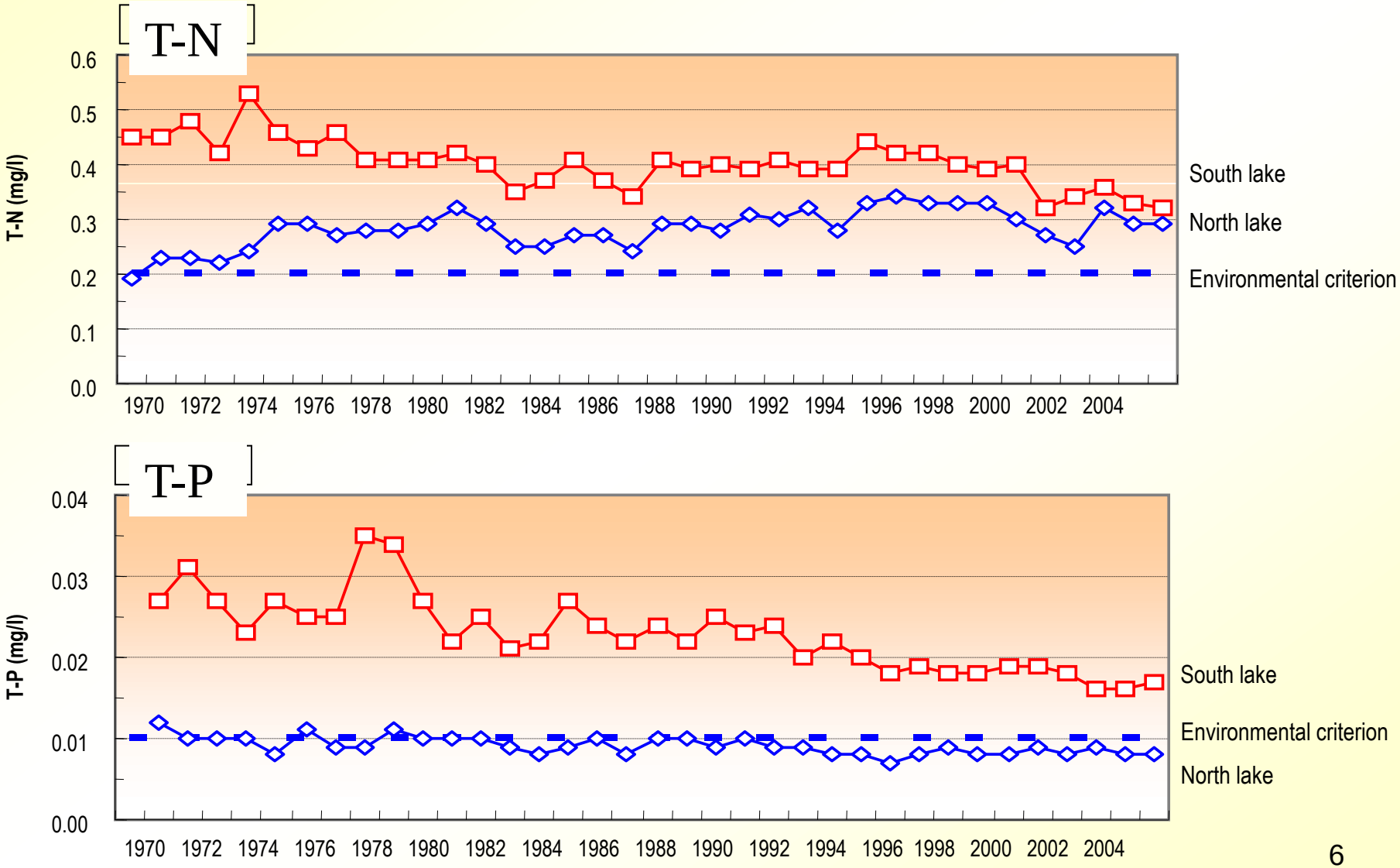
Item	Dimensions, etc.
Lake area	About 674 km^2
Shoreline	About 235 km
Major axis	63.49 km
Max. width	22.80 km
Min. width	1.35 km
Max. water depth	103.58 m
Average water depth	41m
Storage volume	27.5 billion m^3
Basin area	3,848km^2
Water surface altitude	Reference level +84.371 m
Annual average influent volume	5 billion m^3
Annual average rainfall	1,900mm
Number of influent rivers	121 rivers

- **Half of the Total Drainage Area of Yodo River is of Lake Biwa**
- **62% of total discharge of Yodo River comes from Lake Biwa**

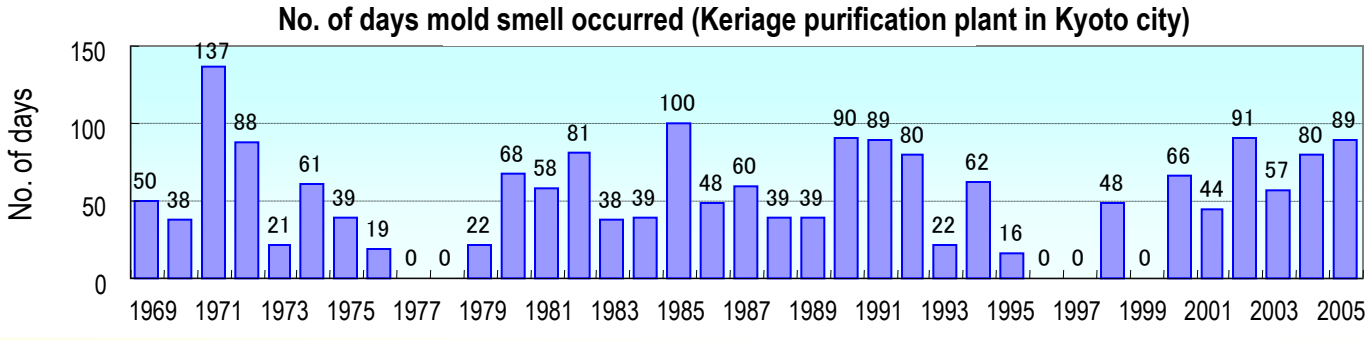
Change in COD and BOD concentration in Northern Lake Biwa



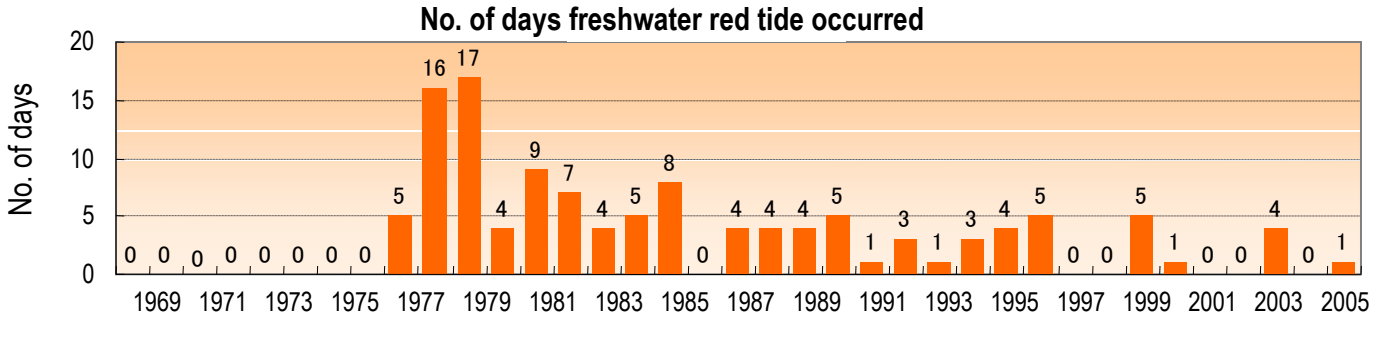
Change in nitrogen and phosphorus concentration in Lake Biwa



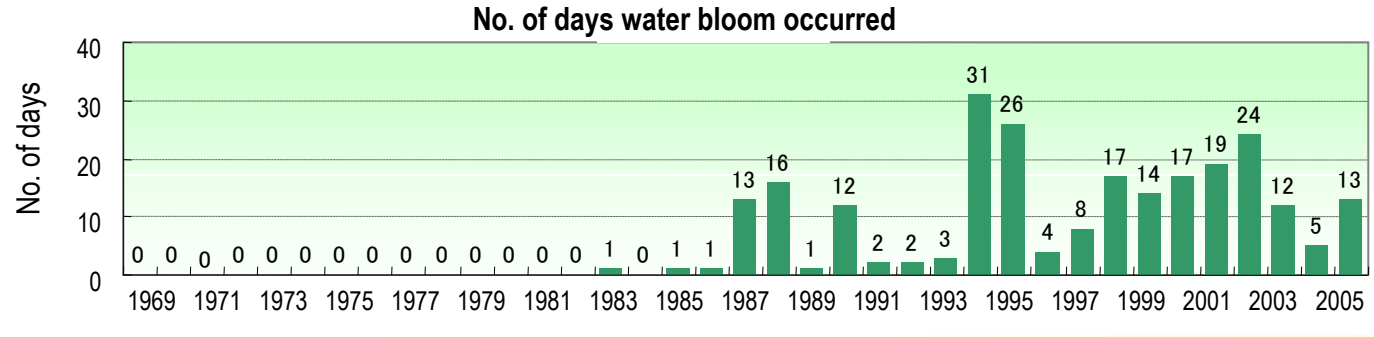
Water problems of Lake Biwa



Mold smell



Red tide



Water bloom

Source: BYQ water environment report

Outline of Biyo center

By experiments for water quality purification, we aim to develop on effective scheme to water environmental preservation.

This center created on the lakeshore of Lake Biwa in July 1997, and we researched until March 2011.

Four founders:

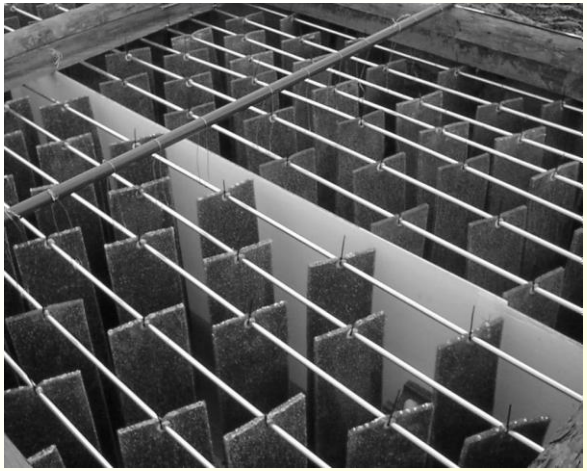
- ✓ **Kinki District Development Bureau of the Ministry of Land, Infrastructure and Transport**
- ✓ **Shiga prefectural government**
- ✓ **Kansai Branch of Japan Water Agency**
- ✓ **Lake Biwa - Yodo River Water Quality Preservation Organization**

1. Research and development of water purification techniques

We are studying the experiments of water purification on River, canal, dam and lake *etc*.








2. Venue for cooperation of different governmental agencies and researchers

- This center is a venue for cooperation aimed at improving water environment, of different governmental agencies and researchers in various fields in Lake Biwa watershed.
- This center is visited 600 to 2000 people per a year and we have discussion on the matter of water environment issue around the world.

3. Providing public information and environmental education

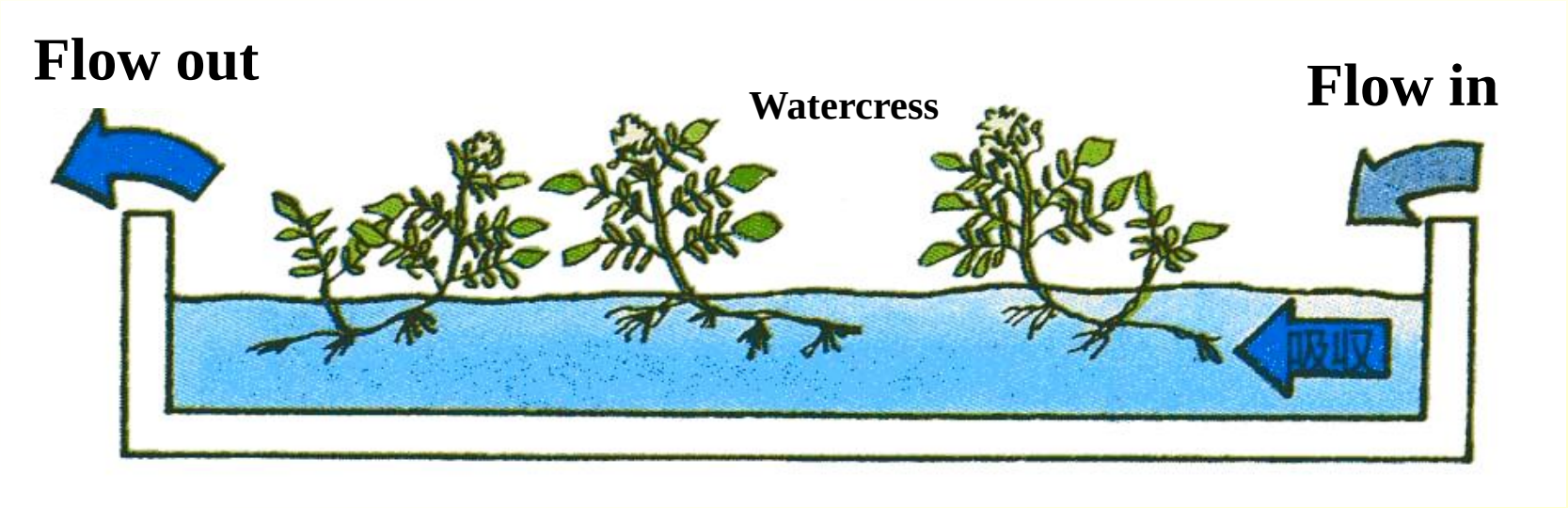
- This center is building a partnership with local citizens and Nonprofit organization, and providing information.
- This center held lectures and symposia in various regions.

Water purification techniques using plants

Actions of purification with vegetation

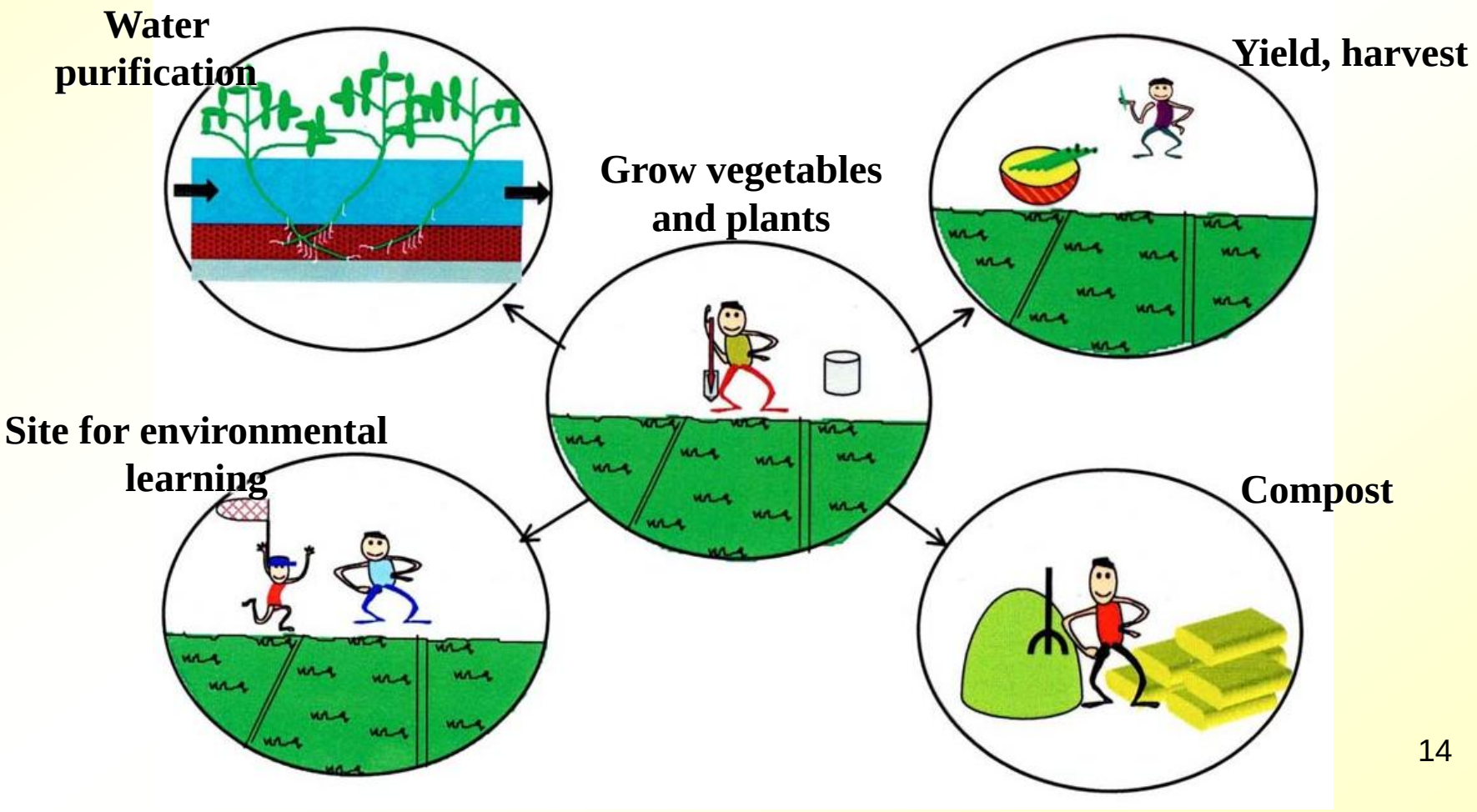
➢ Water purification by using Eco-System

- Sedimentation, filtration by roots and stems of plants
- Adsorption by plant body
- N, P decompose by bacteria and uptake plants
- Biofilms attached to macrophytes and detritus materials
- Biological transformation of organic matter



Objective

Verification of effective in the removal of pollution substances, and approach of maintenance for design plant.

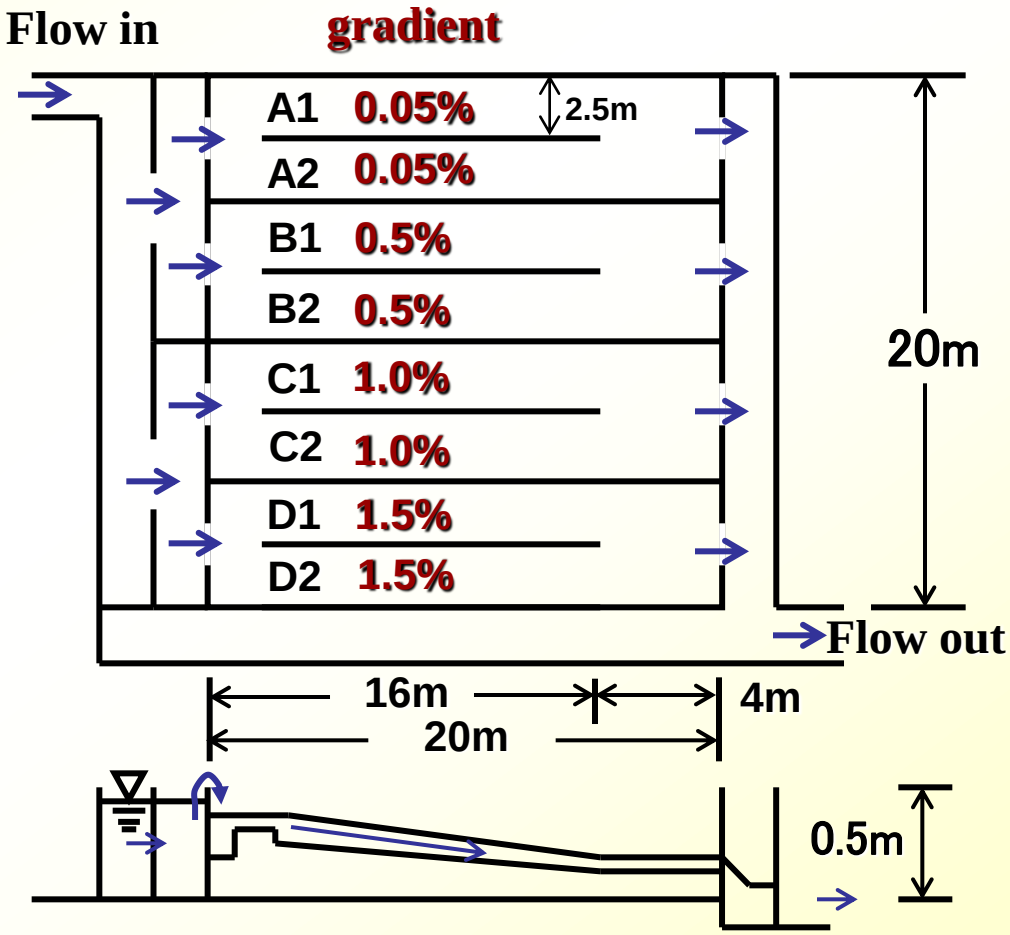


Experimental contents

- **Experimental period：1997～2001**
- **Testing agency：Shiga prefectual government, BYQ**
- **Experimental item：**

- ✓ **Water quality survey**
- ✓ **Plant growth survey**
- ✓ **Microbial survey**
- ✓ **Safety test**
- ✓ **Composting method**
- ✓ **Form of resident participation**
- ✓ **Other hydroponics plants**
- ✓ **Maintenance of facility**

Experimental condition



(JP patent No.1689108)

Raw water SS 5～40mg/L
COD 4～10mg/L
T-N 1.0～2.5mg/L
T-P 0.1～0.3mg/L

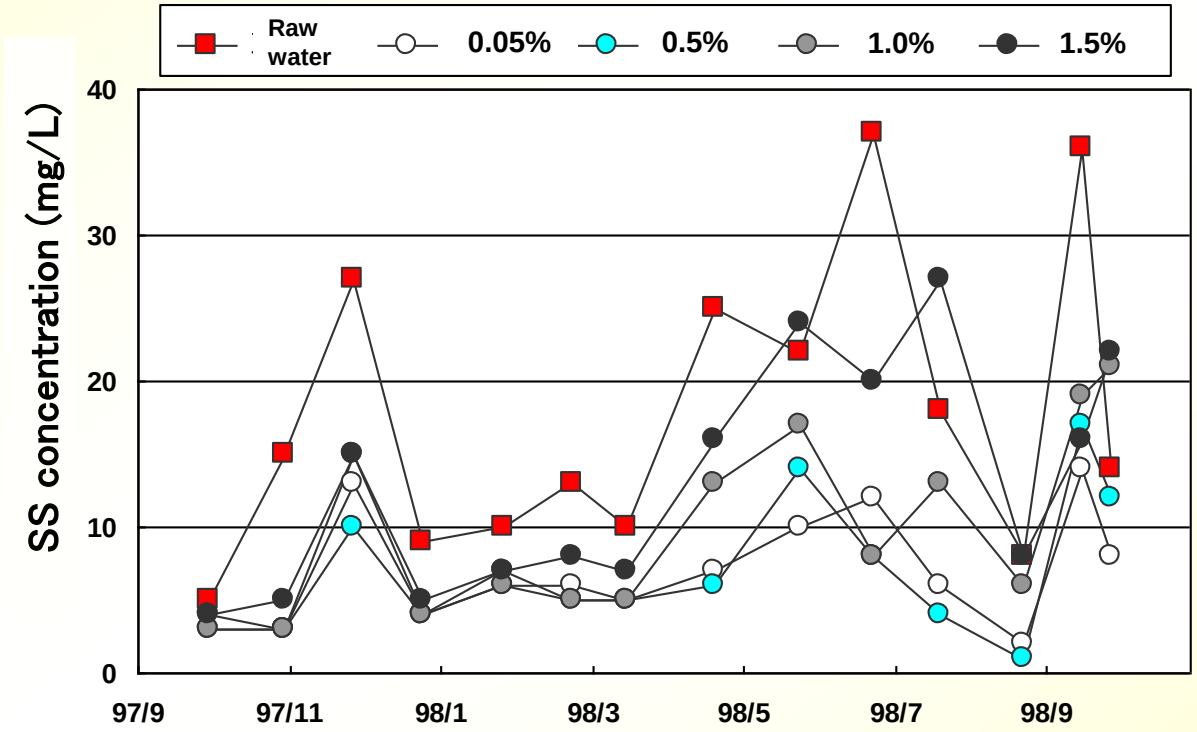
Flow rate：79.3m³/day

Water depth (av.)：5cm

Retention time：app. 40 min

Purification effect vs. gradient *(1997.9-1998.9)*

- **0.5% gradient was gotten best result of removal ratio for Suspended solid.**



Notes: More than 10 cm upper part of the plant was cut off when the plant height reached to higher than 25 cm from water surface, then one third of the plants was thinned out.

Plant Comparison

➢ **Experimental materials : Ornamental Plants**

Watercress

•Evergreen and edible
•Propagation power is very strong.

Lysimachia

•Yellow flower in March to May
•Propagation power is strong.

Iris ensata var. spontanea

•Purple flower in June to July
•Mother variety of iris

Result of removal ratio

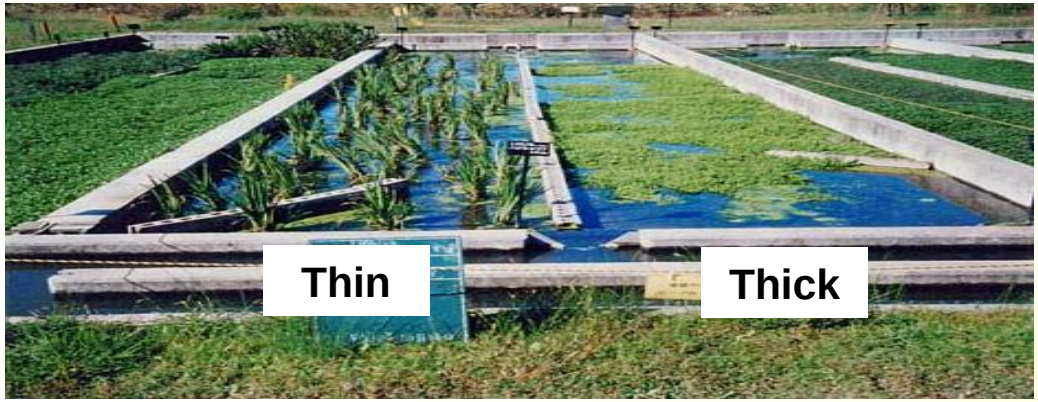
- **The removal ratio of *Lysimachia* was almost same in *Watercress*.**

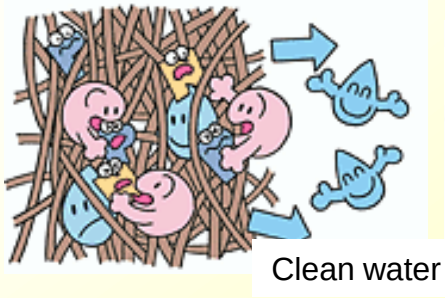
Removal ratio (%)	T-N	T-P	COD	SS
Watercress	10.7	29.7	10.7	61.3
Lysimachia	11.7	18.5	12.9	44.0
Iris ensata var.	8.0	14.3	9.1	34.0

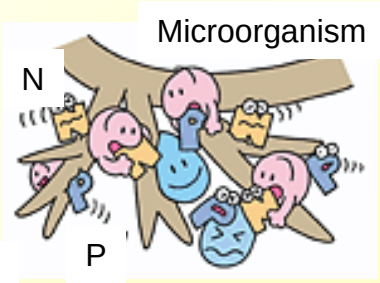
- ***Watercress*** **: average of 1997.9 - 1998.9 and 1999.10 - 1999.12**
- ***Lysimachia*****,** ***Iris ensata var*****. : 2000.6 - 2001.1**

Actions of purification with vegetation

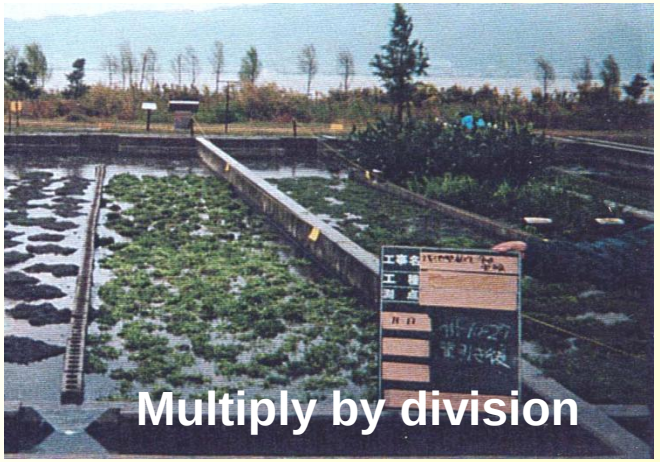
- **Elimination of particulate portion (SS, P-COD, P-TN etc.) was given effect filtration by growing thickly.**







Workability of maintenance



- **Moisture content of plant body was average 87%.**
- **Drying was able to improve workability of maintenance.**

Landscape of Hydroponics Purification

Forget-me-nots ***Watercress*** ***Lysimachia*** ***Mint***

Utilization of the results achieved up to now

Hydroponics Purification (Ashikari park)

Manager ; Shiga pref.

Water purification techniques using soil

Red globular soil

Purification-with-soil test facility

➢ **This is an actual-field type test facility simulating purification using the soil percolation system that has filtration, adsorption, ion-exchange etc.**

- **Physical action:**

  → filtration

- **Chemical action:**

  → adsorption,
  ion exchange

- **Biological action:**

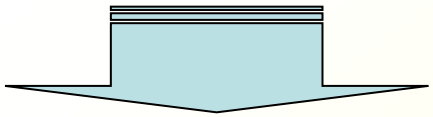
  → decomposition,
  ingestion by microorganisms

Objective

- **Problems to put the facility to practical use**
  - **Wide land area is necessary** → **It is difficult to get enough land.**
  - **Low speed loading** → **Pollution reduction percentage increases.**

  → **However, the rate of pollution removal per a unit time decreases.**

- **Necessity to find the practical water purification velocity**
  - **High speed loading** → **Space-saving facility can be realized.**



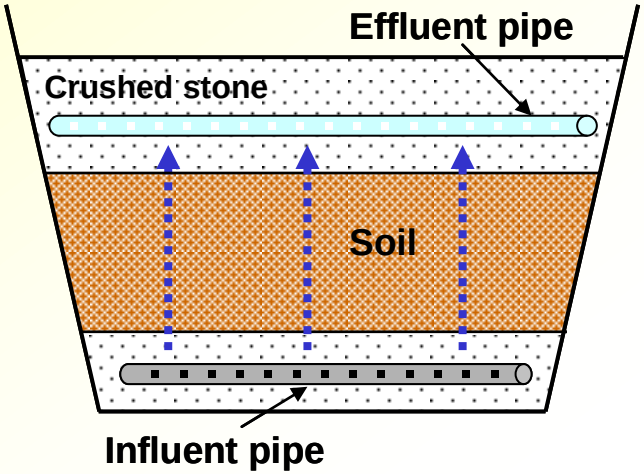
The marginal water infiltration velocity and the optimum processing speed should be found in order to increase the processing efficiency.

Experimental contents

- **Experimental period：1997～2011**
- **Testing agency：Kinki District Development Bureau of the Ministry of Land, BYQ**
- **Experimental item：**
  - ✓ **Water quality survey**
  - ✓ **Structure of facility → Necessary thickness of soil layer and effective life of soil to adsorb phosphorus should be found.**
  - ✓ **Operation conditions in order to increase the processing efficiency**
    - **: Direction of water infiltration (Upward flow or Downward flow)**
    - **: Method of water infiltration (Spraying system or Flooding system)**
    - **: Velocity of water infiltration (to find the Optimum processing speed)**

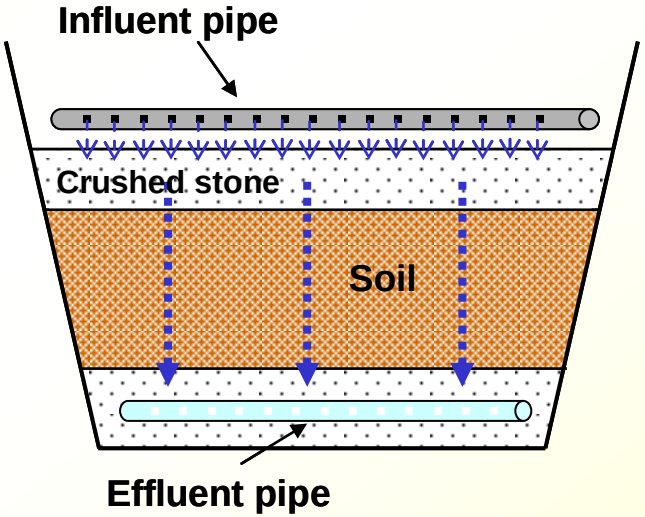
Water flow in the soil purification facilities

Upward flow



- **Purification performance is relatively stable compared to the downward flow.**
- **Clogging may occur in the lower part of the soil layer. In such a case, soil shall be entirely replaced.**

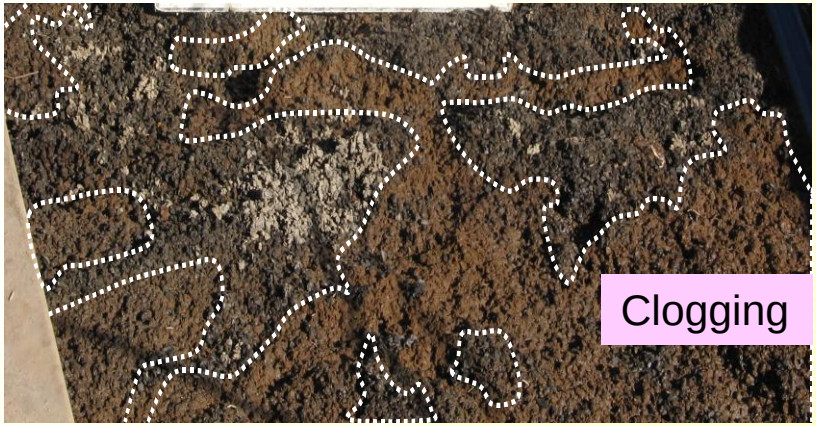
Downward flow



- **Clogging may occur in the upper part of the soil layer. So it is not necessary to entirely replace the soil layer.**

Results

- **It is necessary to put the material, which has a buffer or percolation effect, at the upper part of red globular soil layer.**
- **Clogging at the influent holes can be avoided when the influent pipe is not buried.**
- **Spraying system is effective to avoid the clogging.**
- **Our result that the experimental surface loading rate is 5 m^3/m^2/day at the soil layer thickness of 1 m demonstrated that the effective life of soil to adsorb phosphorus is long time.**
- **However, the facility was clogging before it.**
- **Therefore it is very important to prevent of the clogging for the surface loading .**



Downward flow

Treated effluent (Purification-with-soil)

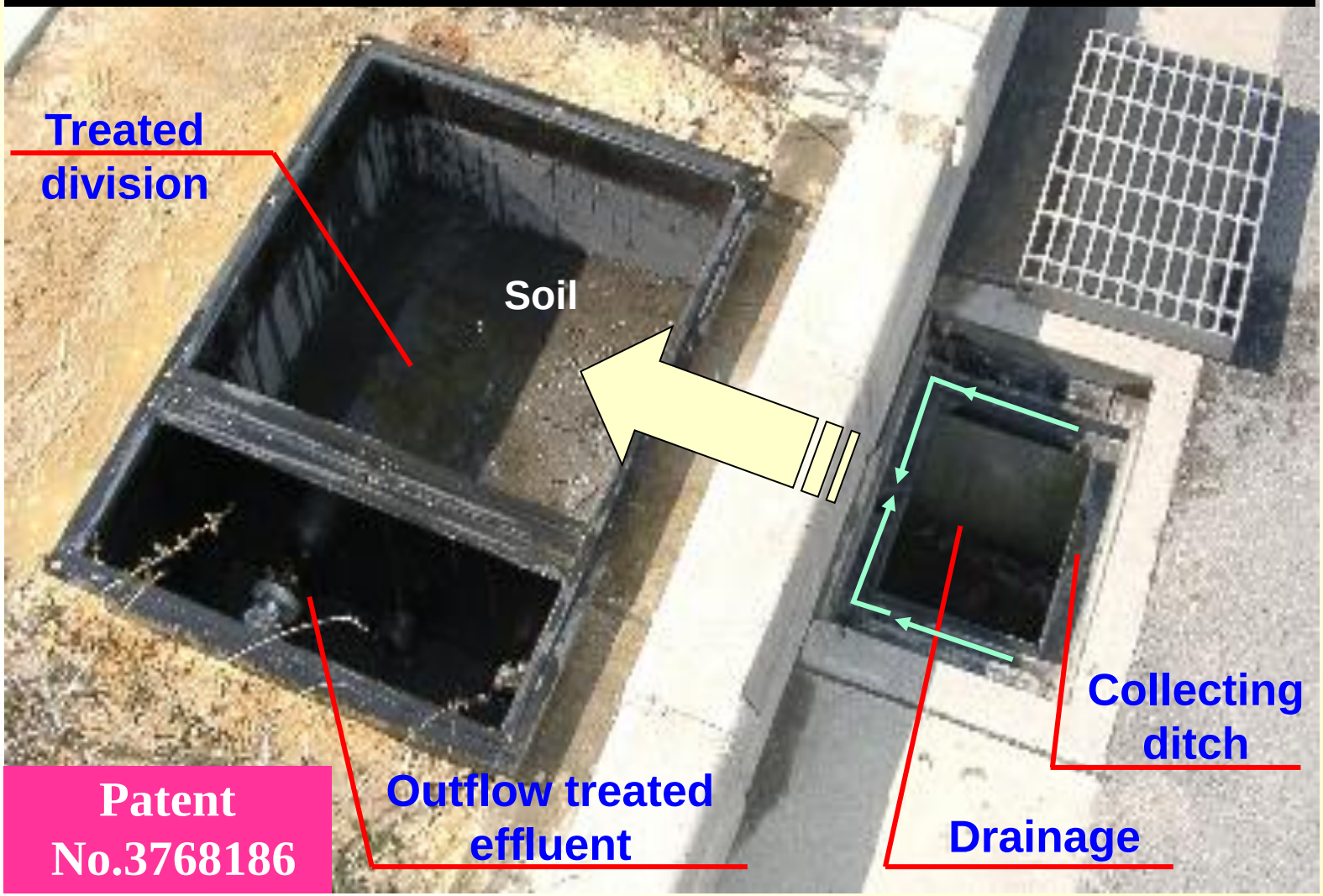
Utilization of the results achieved up to now

Water Purification using soil

Manager ; Ministry

The example of the practical application of the technology and applied research

Facility of separate and water purification for road runoff

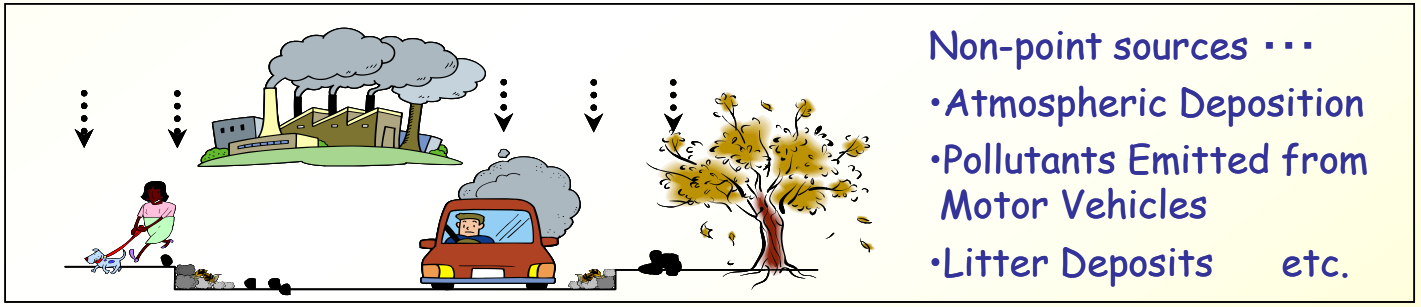


Patent No.3768186

Background

Water issue of Lake Biwa watershed

- Nonpoint sources from urban roadways of the Lake Biwa watershed have increased with an increase in traffic due to urban development and the impervious land surface.
- Organic matter such as stormwater runoff from urban roadways are increasing their contribution to the whole COD pollution load.



Meanwhile,

- The soil infiltration is able to effectively reduce pollutant loads (phosphorus).

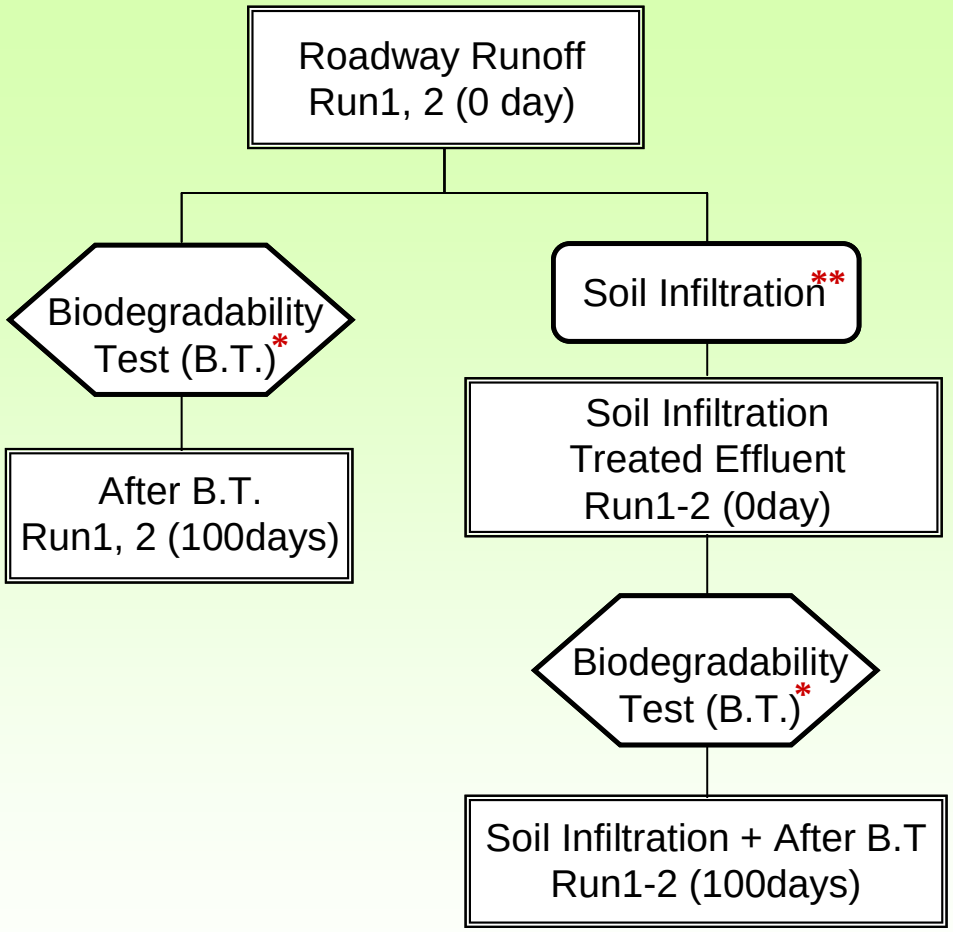
Objective

- We focused on the non-biodegradable organic matter* as chemical speciation of the first flush runoff from urban roadways.
- Increase in the non-biodegradable organic matter will have a significant impact on the lake ecosystem.

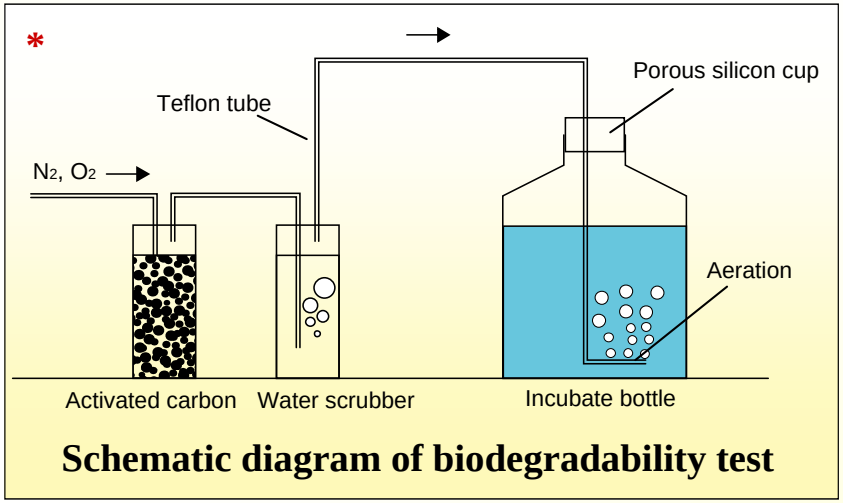
* "biodegradable" was defined as degradable by microorganisms under the best environment for their activity.
The "non-biodegradable" material was the remaining material after one hundred days incubation .

- **To estimate Non-biodegradable organic matter in roadway runoff**
- **To assess the treatment effect of its removal using soil infiltration**

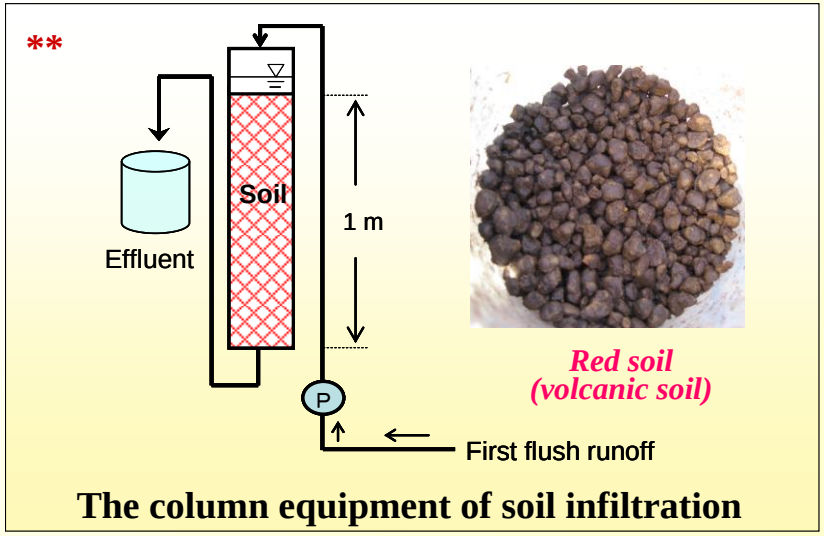
Methods and Materials



Experimental scheme



Schematic diagram of biodegradability test

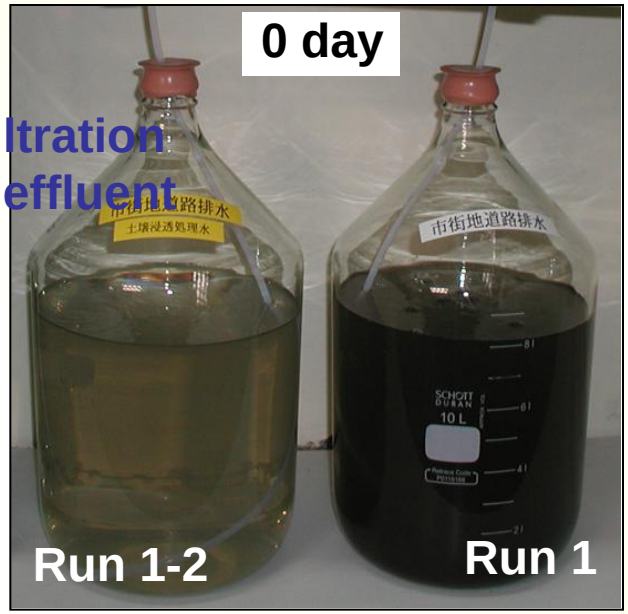


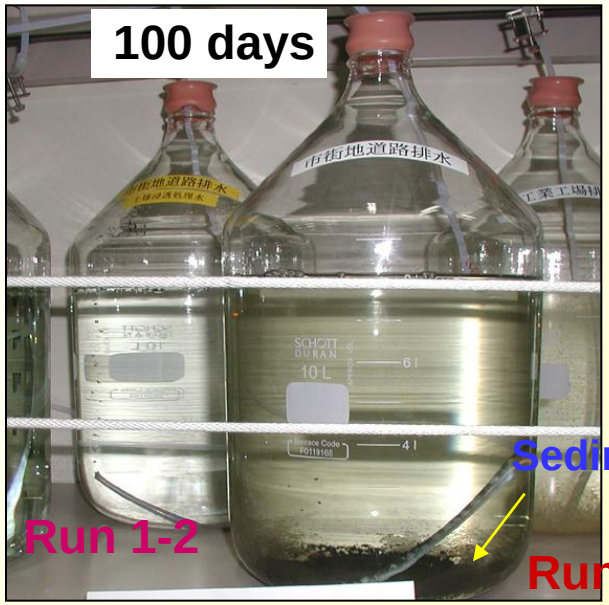
The column equipment of soil infiltration

Biodegradability test

Advanced sewage treatment effluent

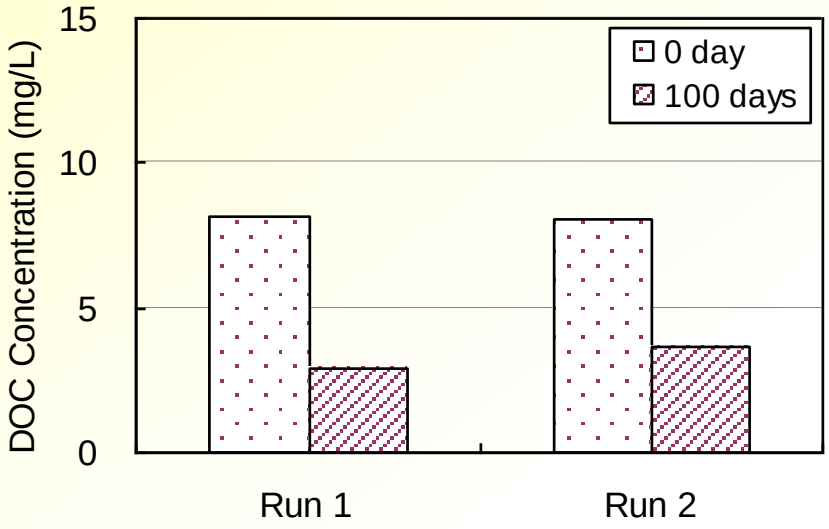
Soil infiltration treated effluent

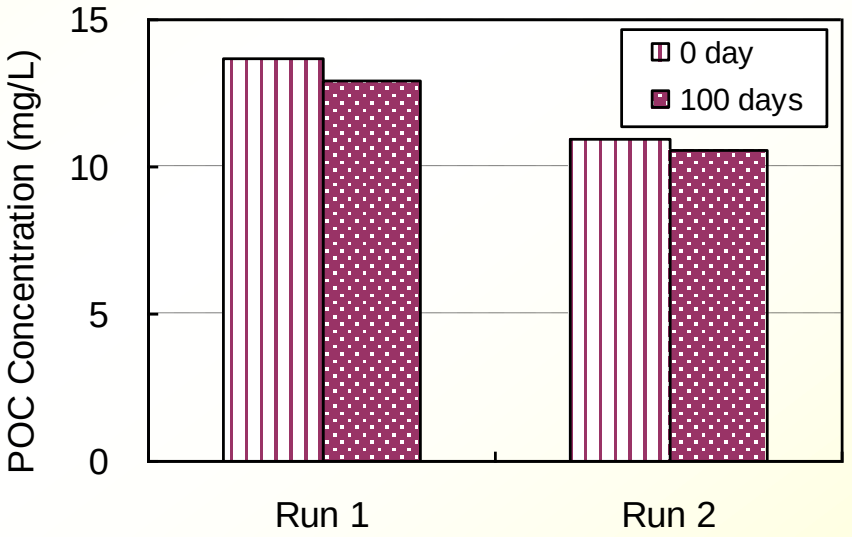




Results and Discussion

1. Non-biodegradable organic matter in roadway runoff

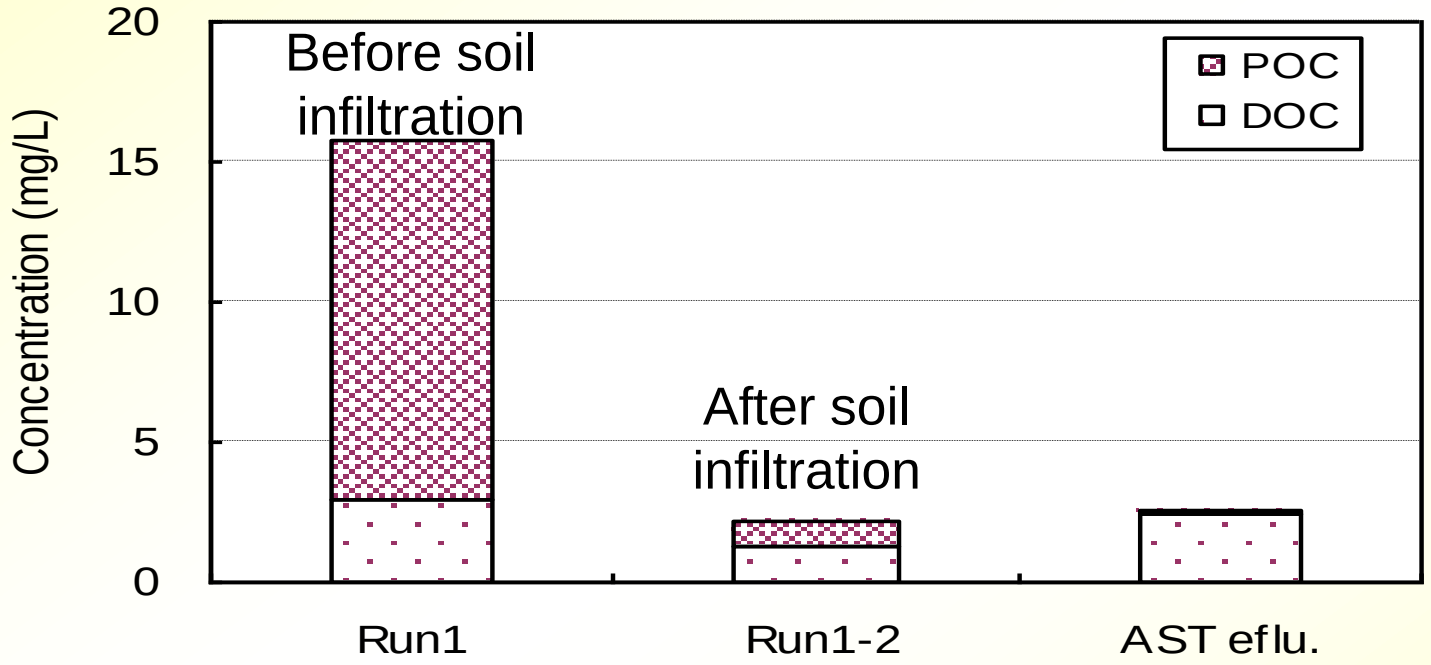




- Around 60% of DOC was reduced by microorganisms and 40% of that was non-biodegradable.
- POC was found to be extremely non-biodegradable and refractory because of more than 90%.
- Non-biodegradable organic matter accounted for 74% of initial TOC.

Results and Discussion

2. Soil infiltration treatment



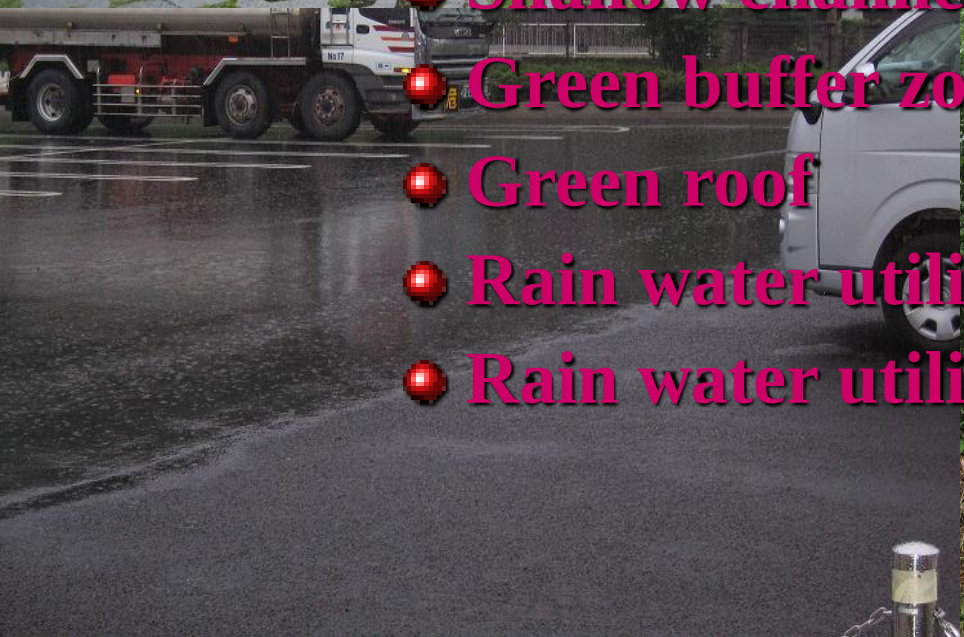
- Non-biodegradable removal efficiency of TOC, POC and DOC were 86%, 93% and 55%, respectively. DOC was lower than the concentration in sewage treatment water.
- Very high removal efficiency of POC was presented that soil infiltration was effective for non-biodegradable countermeasure.

Soil Infiltration ~ Low Impact Development ~

Low Impact Development

at City Planning Stage (Eco city),

- **Pervious road**
- **Shallow channel collection**
- **Green buffer zone**
- **Green roof**
- **Rain water utilization on road**
- **Rain water utilization on roof**



Conclusions

- Water purification techniques using plants is preferred landscape and effective in doing educational activity.

- The facility of this system shows a new form of resident participation in public works for water preservation.

- The removal efficiency of water purification techniques using soil has revealed not only phosphorus causing eutrophication, but also non-biodegradable organic matter from roadway runoff.

- This soil infiltration processing can be put to practical use in a variety of situations.

Acknowledgments

The field surveys were financially supported by Ministry of Land, Infrastructure, Transport and Tourism and Shiga prefecture.