AIT, Thailand

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Health risk monitoring and management for sustainable urban environment

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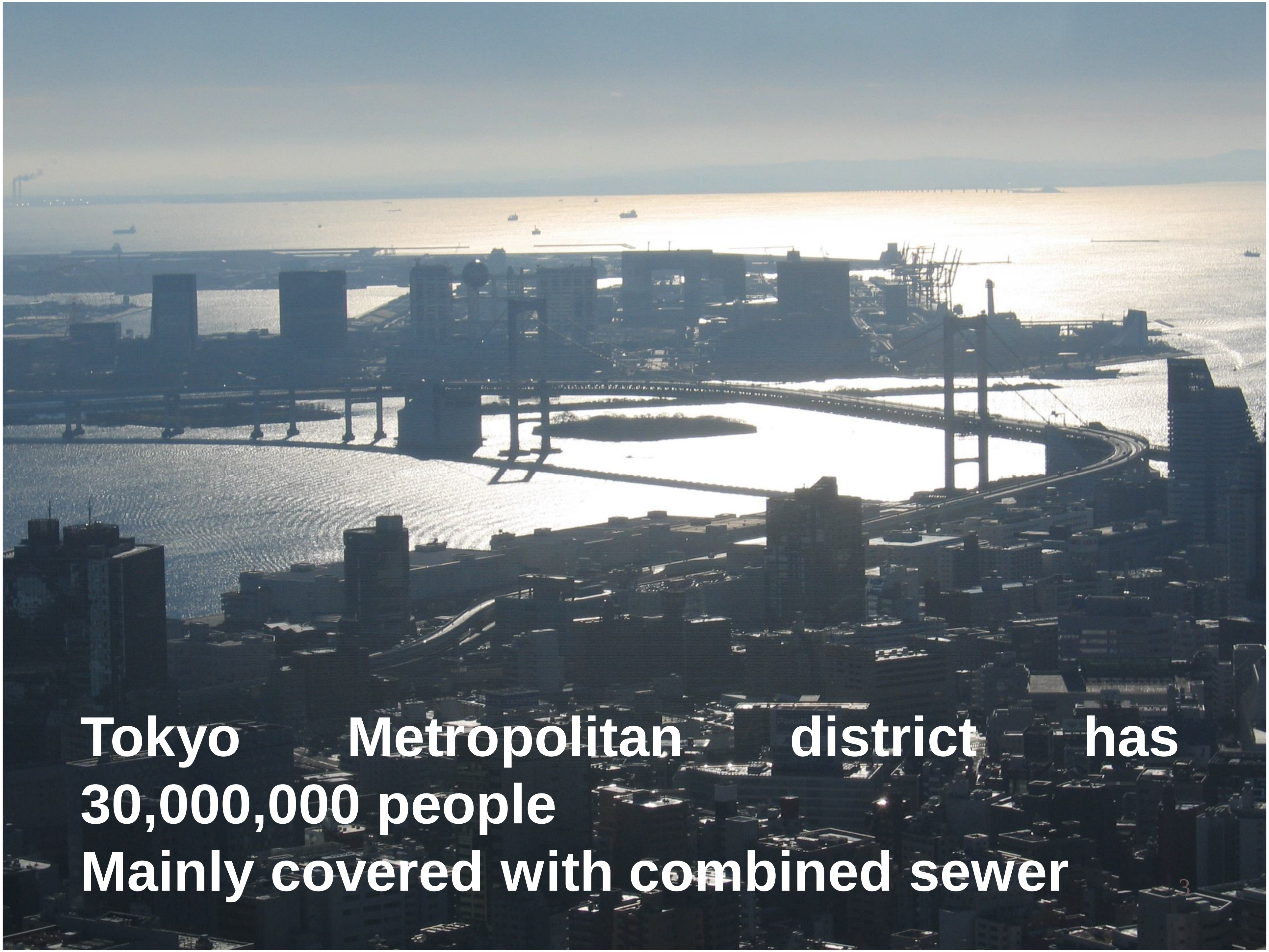
THE UNIVERSITY OF TOKYO

Tokyo bay monitoring

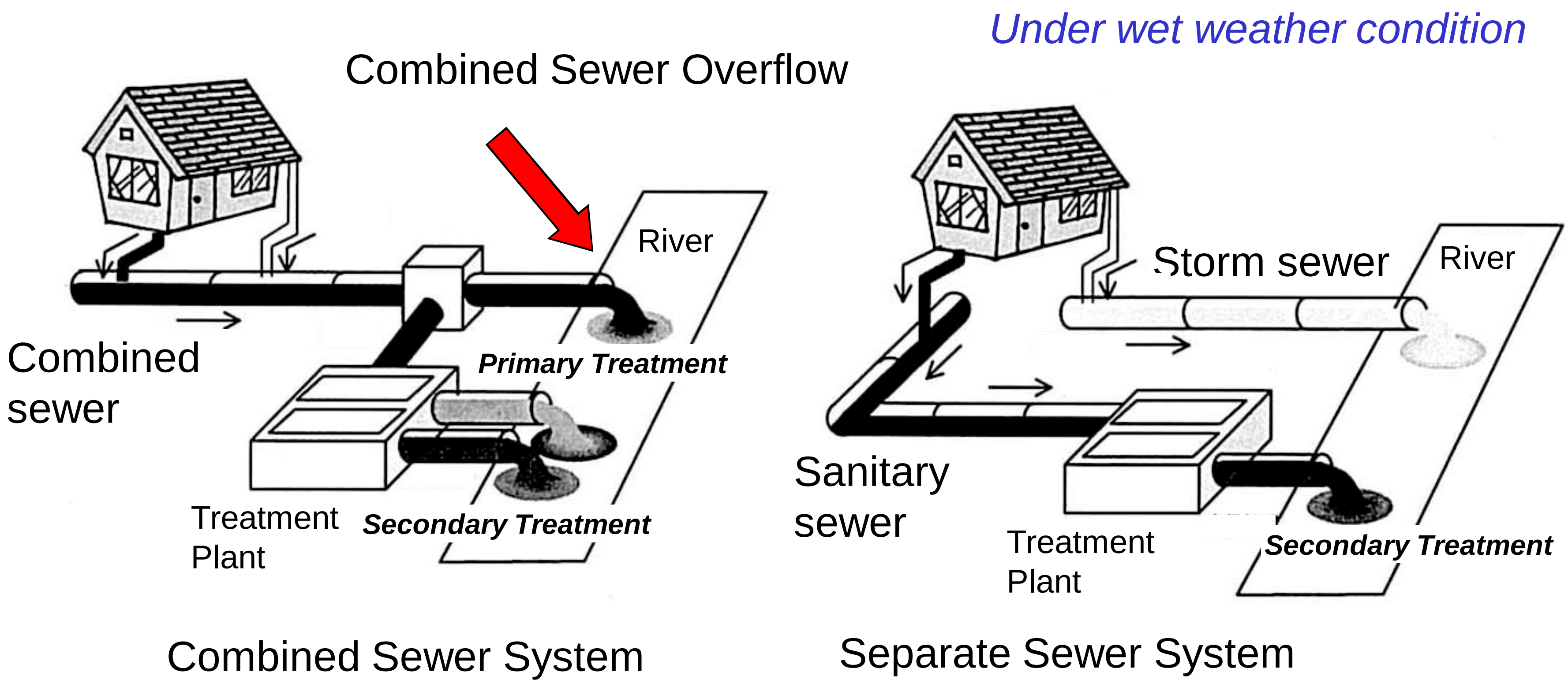
Combined sewer overflow
increase viruses in water



Tokyo Metropolitan district has 30,000,000 people

Mainly covered with combined sewer

Problem in Urban sewer system



Combined sewer systems (CSS) are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe.

What is CSO ?

Combined Sewer Overflow

Dry weather

Wet weather

Importance of Pathogens in CSO

- Microbial risk is accumulation of daily risk, which cause acute disease.
- Chemical water quality standard is based on chronic disease.
- Chemical contamination level varies linearly but microbial level exponentially. In the extreme event microbial risk should be cared.

Tokyo Olympic Games 2020

- Triathlon at Odaiba Beach
- Water quality standard

E. coli <250cfu/100ml

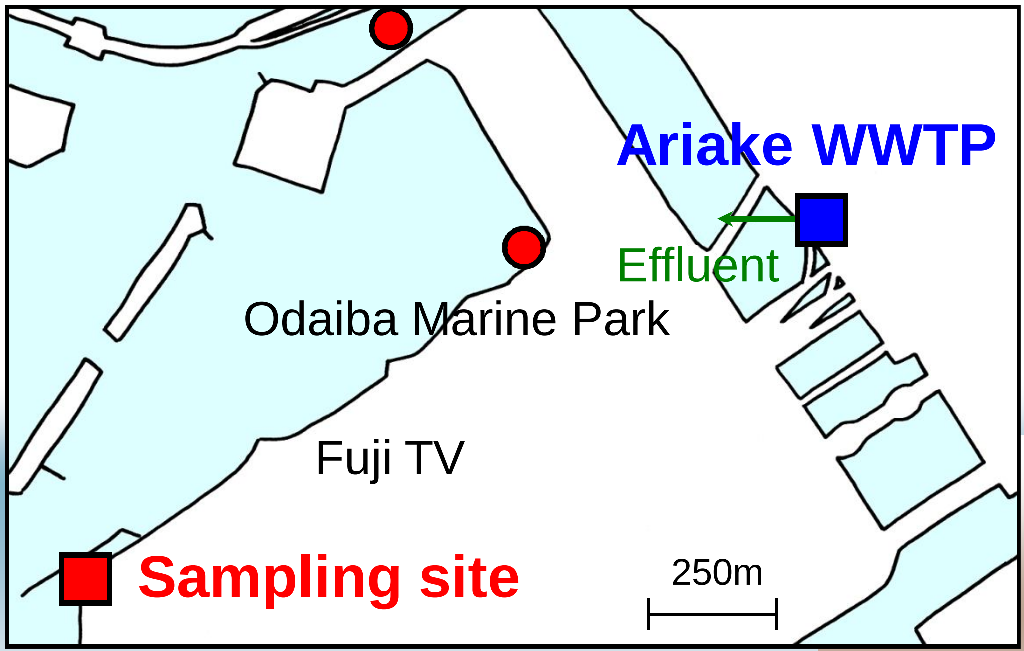
Tokyo's Olympic hopes run into polluted waters

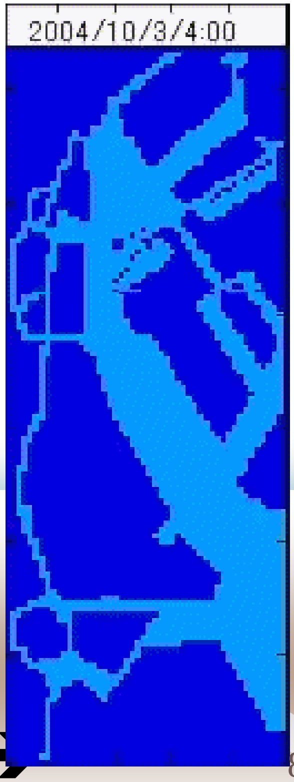
London 2012's triathletes had cleaner water than may be expected in Tokyo

Triathlon competition (Aug 2010 in Copenhagen, Denmark) held shortly after a CSO resulted in an outbreak (Andersen et al. 2013).

Virus survey in Tokyo bay

- Date…2004 Aug 4 ~ Oct 15
- Samples…47times each for 3 location, collected in the morning
- Parameters…Norovirus, Adenovirus, Total coliforms, *E. coli*
  - Volume used for virus concentration ：1,000mL

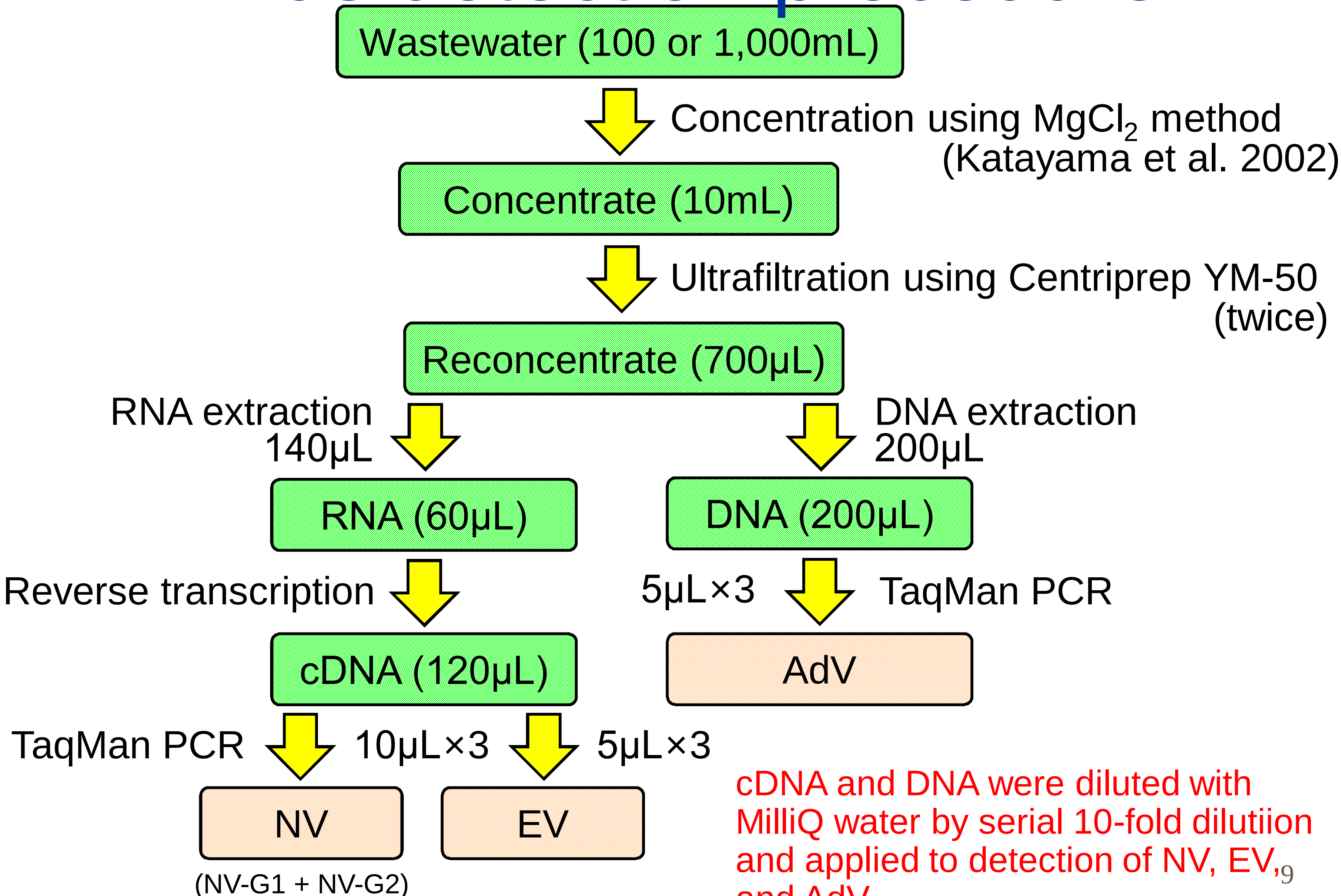




CSO Simulation （10/3 ~ 10/5）→

By Yukio Koibuchi

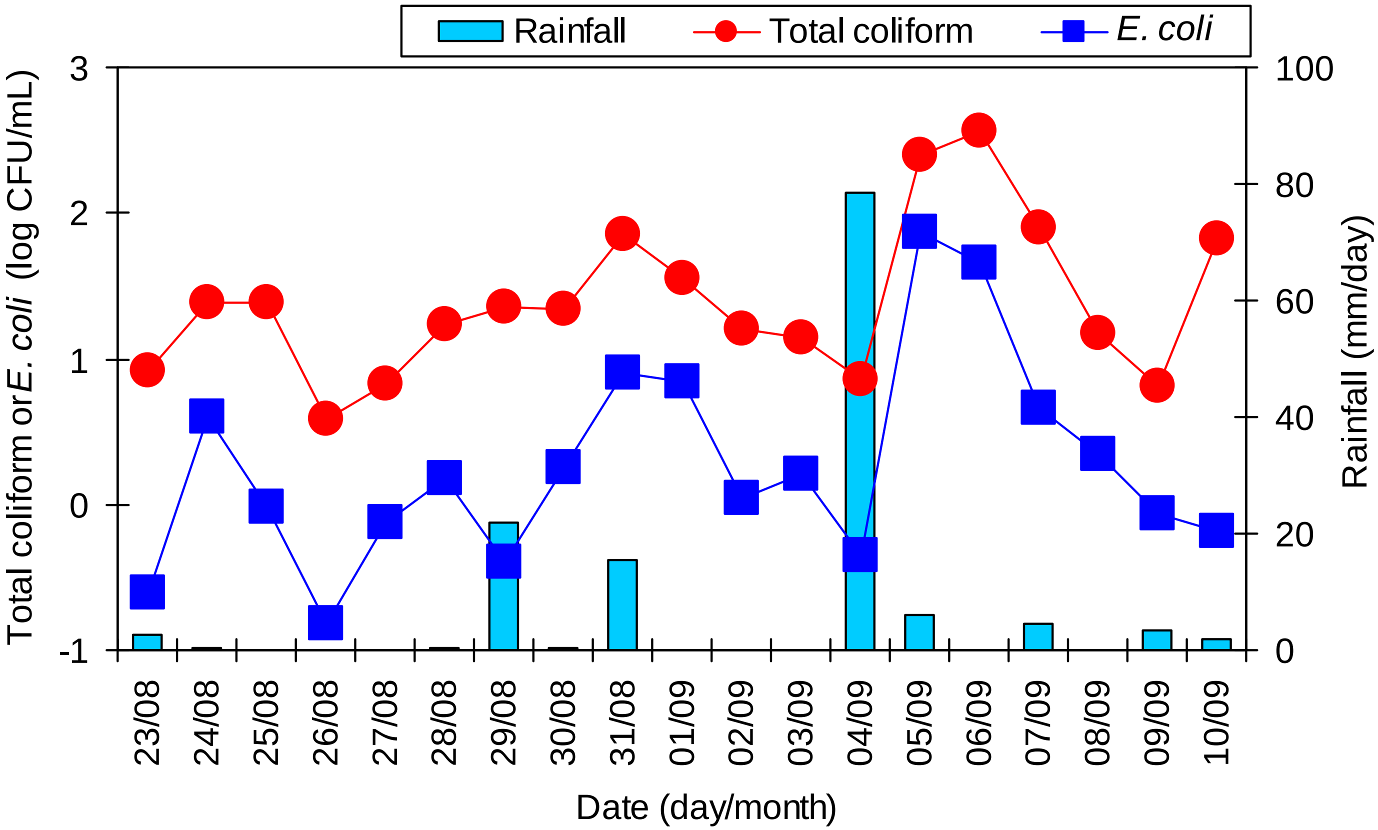
Virus detection procedure



cDNA and DNA were diluted with MilliQ water by serial 10-fold dilutiion and applied to detection of NV, EV, and AdV

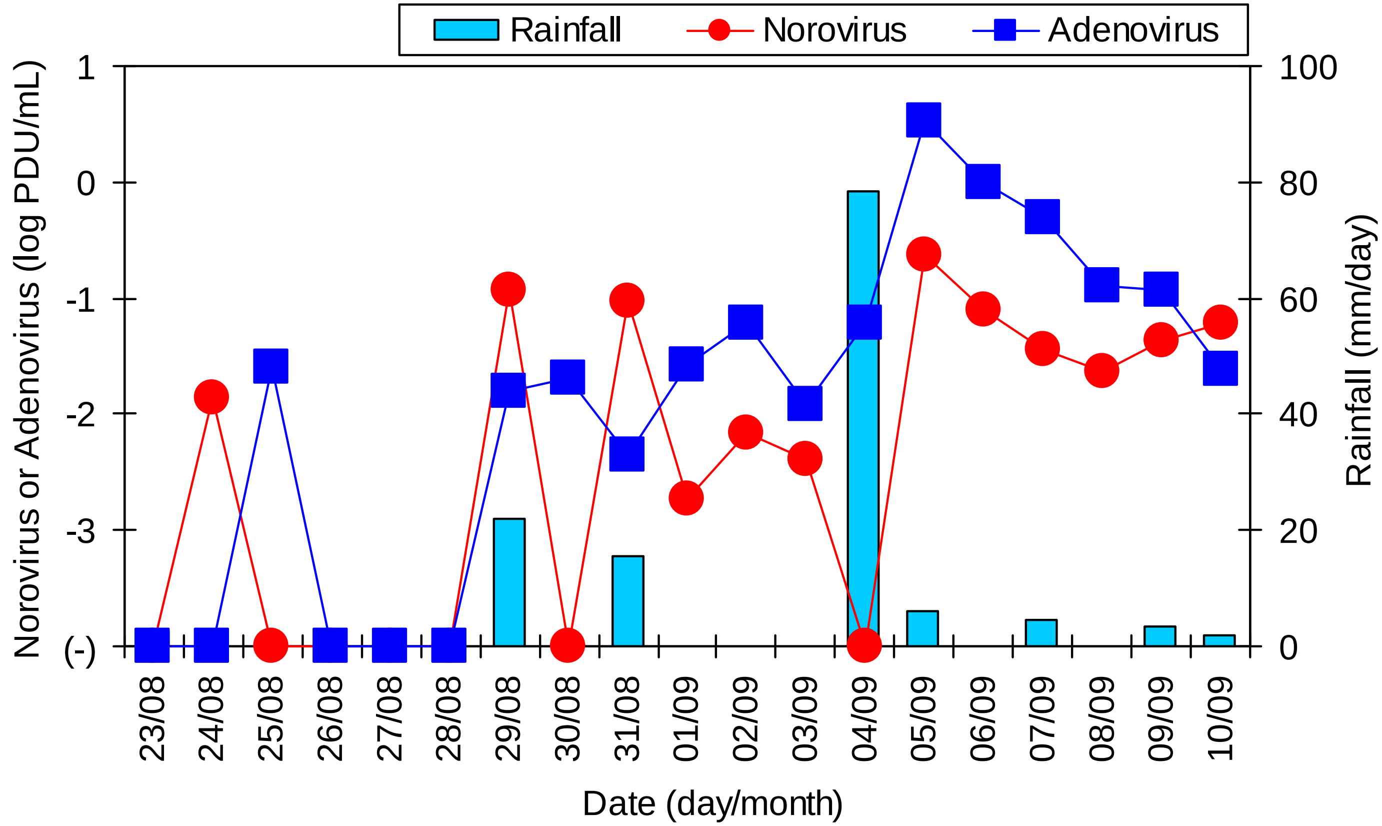
Profile of Total coliforms and *E. coli*

- Increased after rain event, gradually decrease for several days.
- Increase on Sep 4 （ rain : 84.5mm ）
  - Total coliforms…1.55 log
  - *E. coli*…2.22 log



Profile of Norovirus and Adenovirus

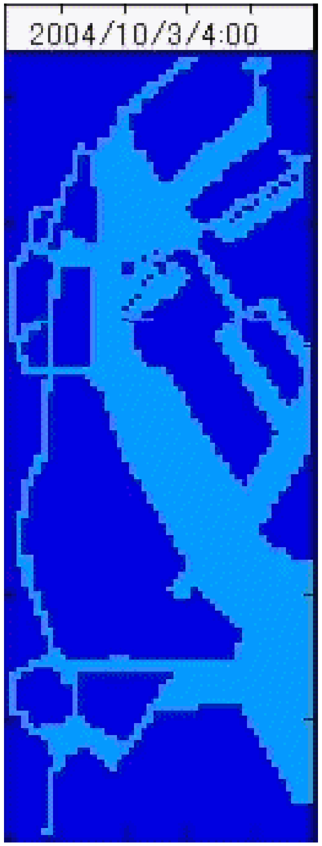
- Virus also increased by rain event
- Decrease rate of viruses were less than those of coliforms.



Infection risk was shown to be higher for a few days after rain.

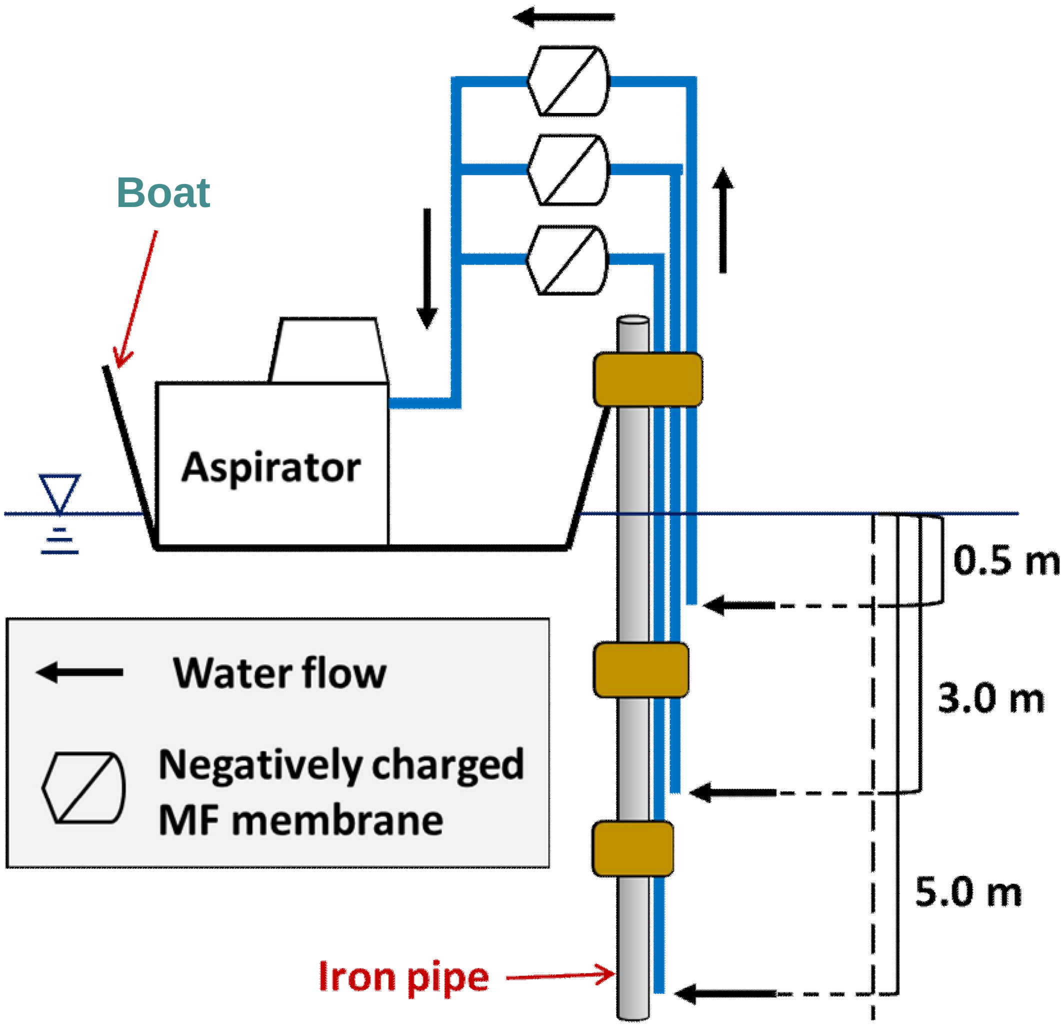
Materials and Methods (Sampling site)

- Sumida
  Mouth of Sumida river
- Meguro
  Mouth of Meguro river
- Sea Lane
  Regularly used route for vessels
- Odaiba
  Port, Inlet



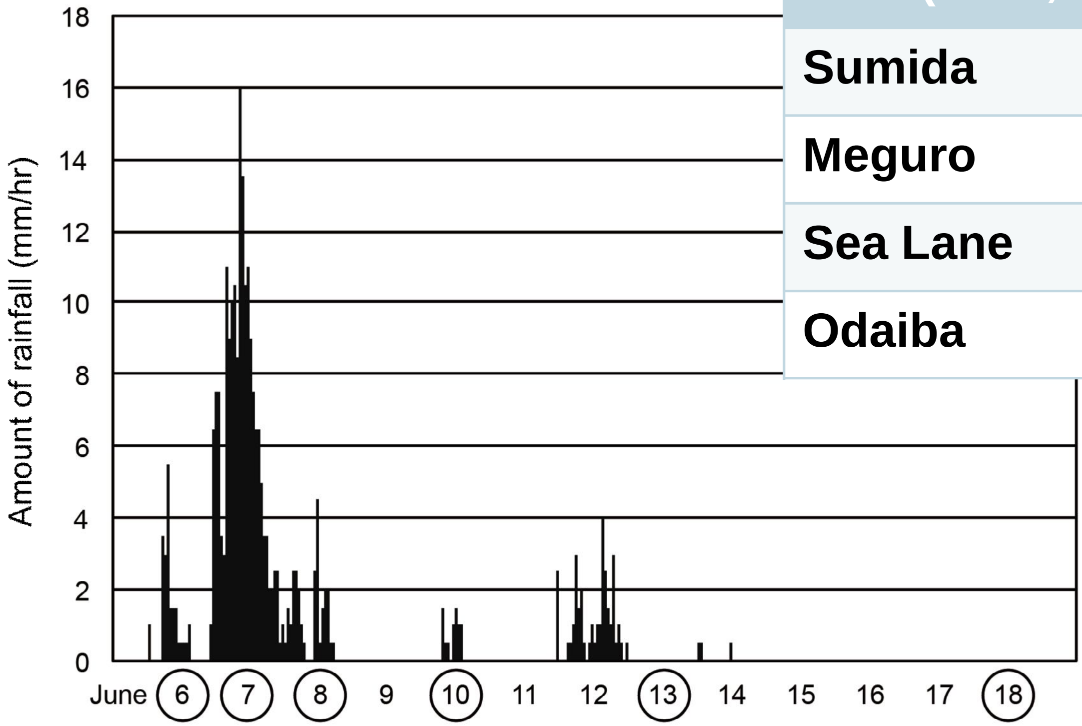
Materials and Methods

- Water samples were collected at three different depths (0.5, 3 and 5 m) at 4 sites, using a special sampling device.



Materials and Methods

- Water samples were collected from Tokyo Bay on 1, 2, 3, 5, 8, 13 days after the first rainfall observed in June 2014.



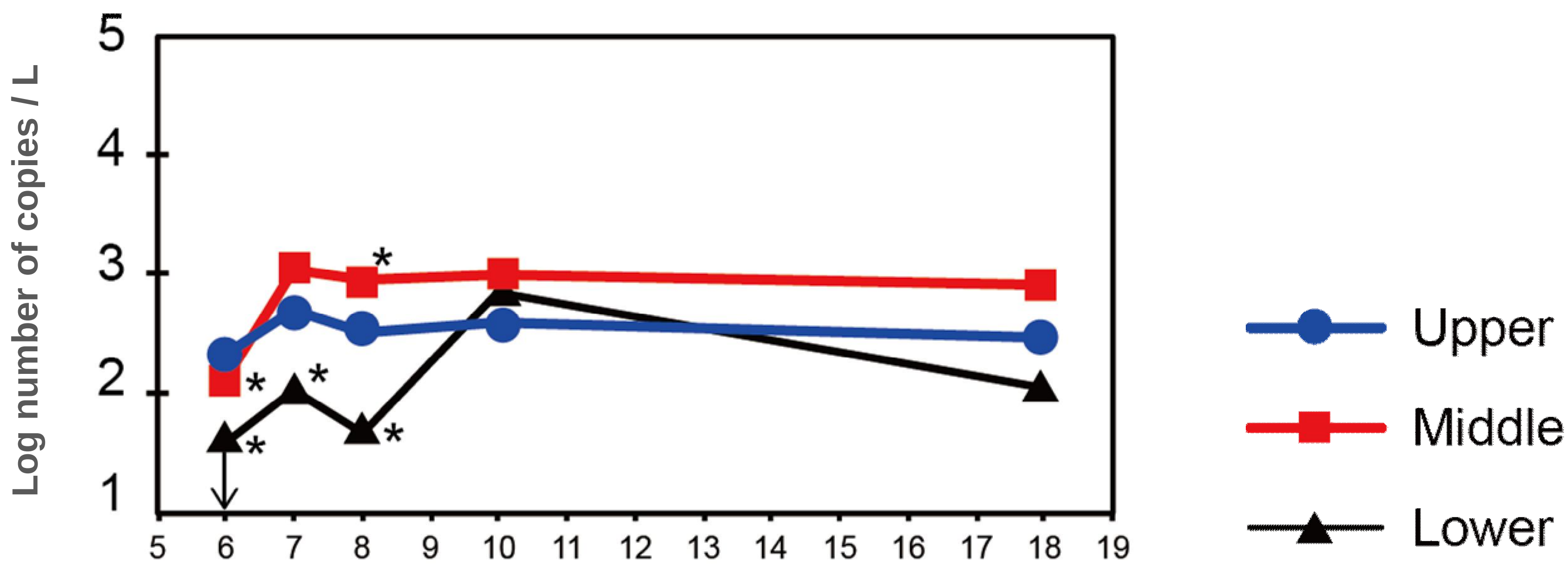
Date (June)	6th	7th	8th	10th	13th	18th
Sumida	○	○	○	○	×	×
Meguro	○	○	○	○	×	×
Sea Lane	○	○	○	○	○	○
Odaiba	○	○	○	○	×	○

Total rainfall amount
247 mm

The rainfall profile and timing of sample collection.

Result

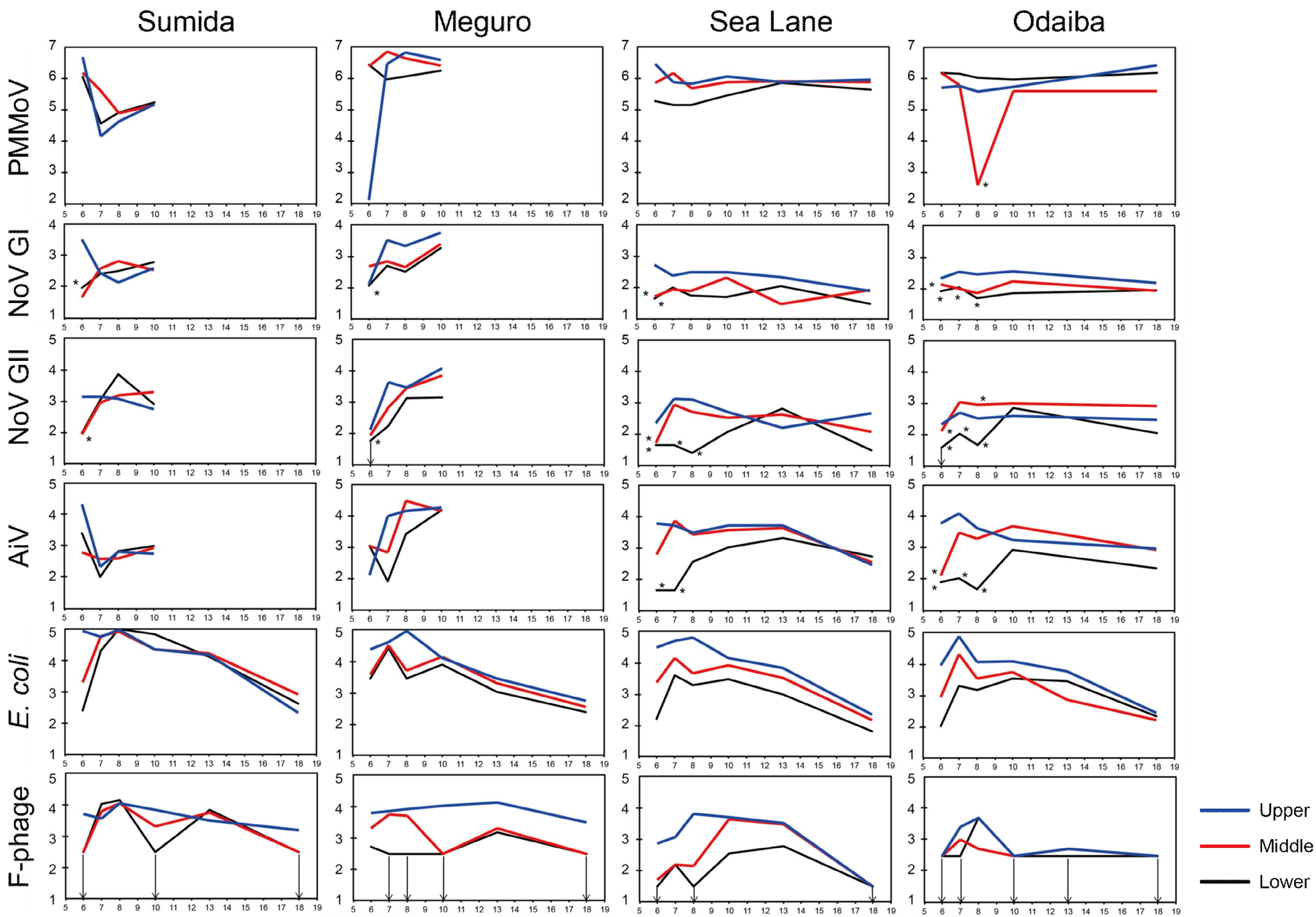
<u>Norovirus GII at Odaiba</u>



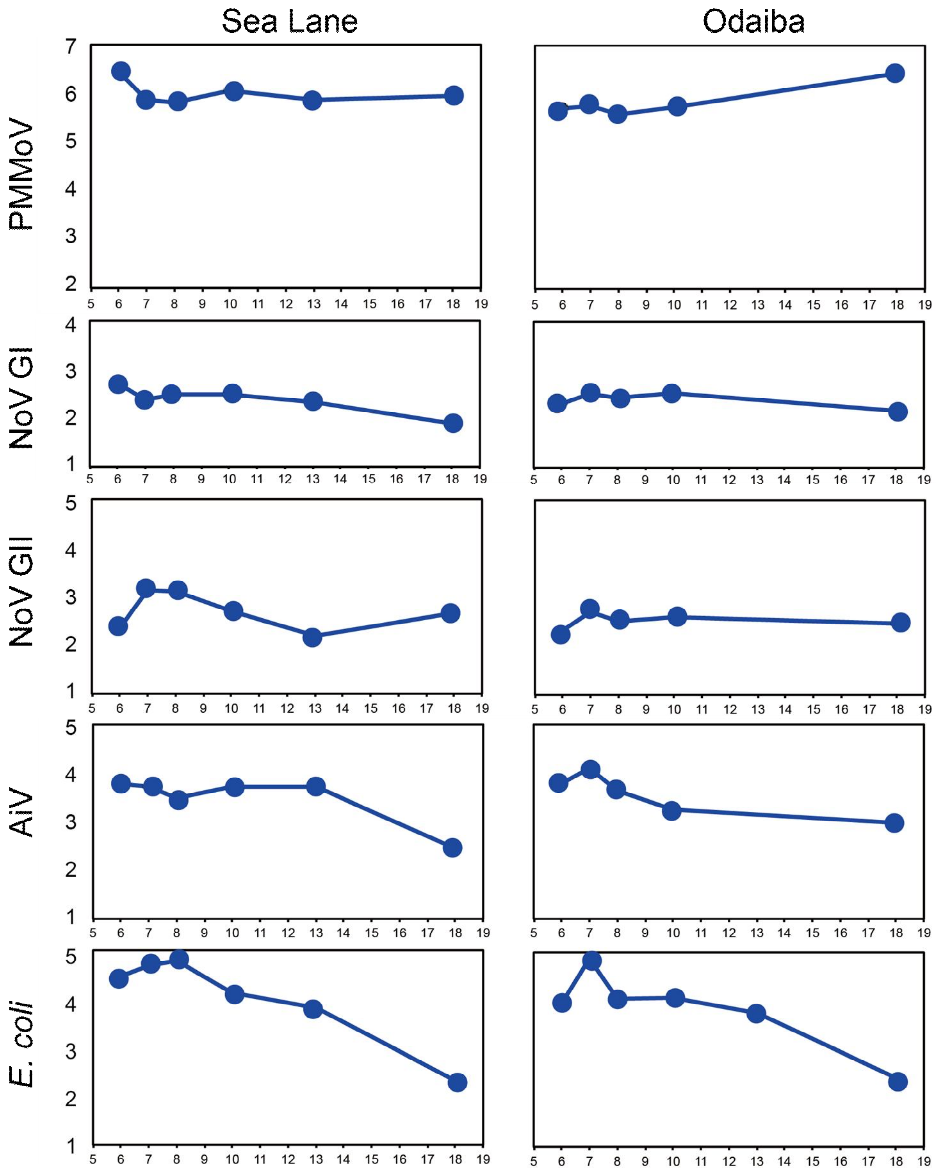
* : Detection efficiency was lower than 10%.

↓ : Under detection limit

Results of all samples



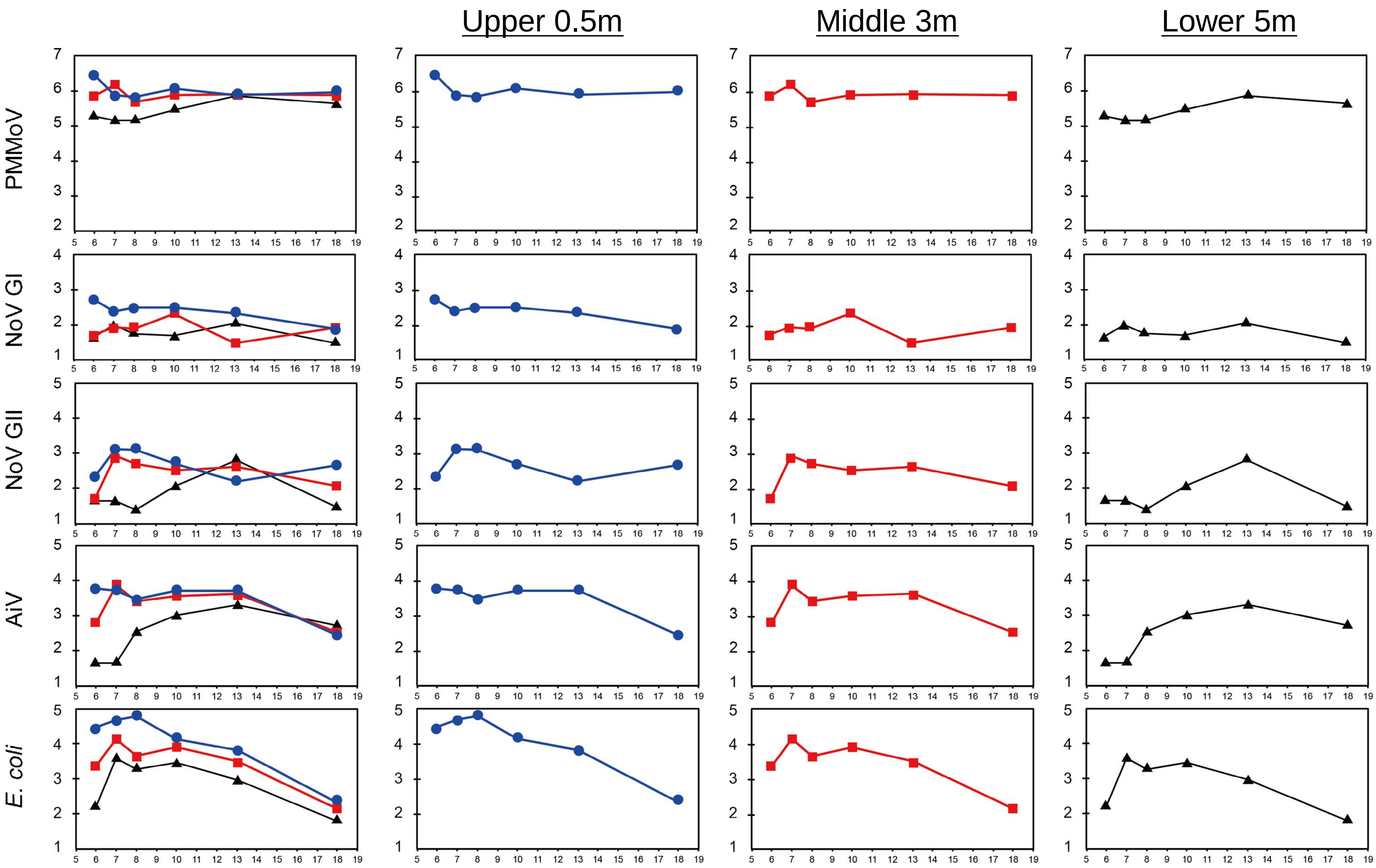
Results of upper layers



The high concentration of E.coli is a clear evidence of CSO.

Impact of CSO on virus occurrence was not clear.

Results of Sea Lane samples



Summary

◆Concentrations of *E.coli* were higher at upper layer on the first day, and clearly decreased during the sampling period (18 days).

◆PMMoV stayed high concentration throughout the sampling period.

◆Fluctuations of PMMoV and NoVs concentrations are limited, and impact of CSO seems limited.

⇒ Maybe because of too heavy rain?

A Rapid Coagulation Treatment during wet weather period

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Need of Compact Treatment for municipal wastewater

- Most of the treatment systems were developed assuming ordinal condition
- Impact of extreme events (Rain fall, Electricity shortage, Tsunami) should be taken into account.

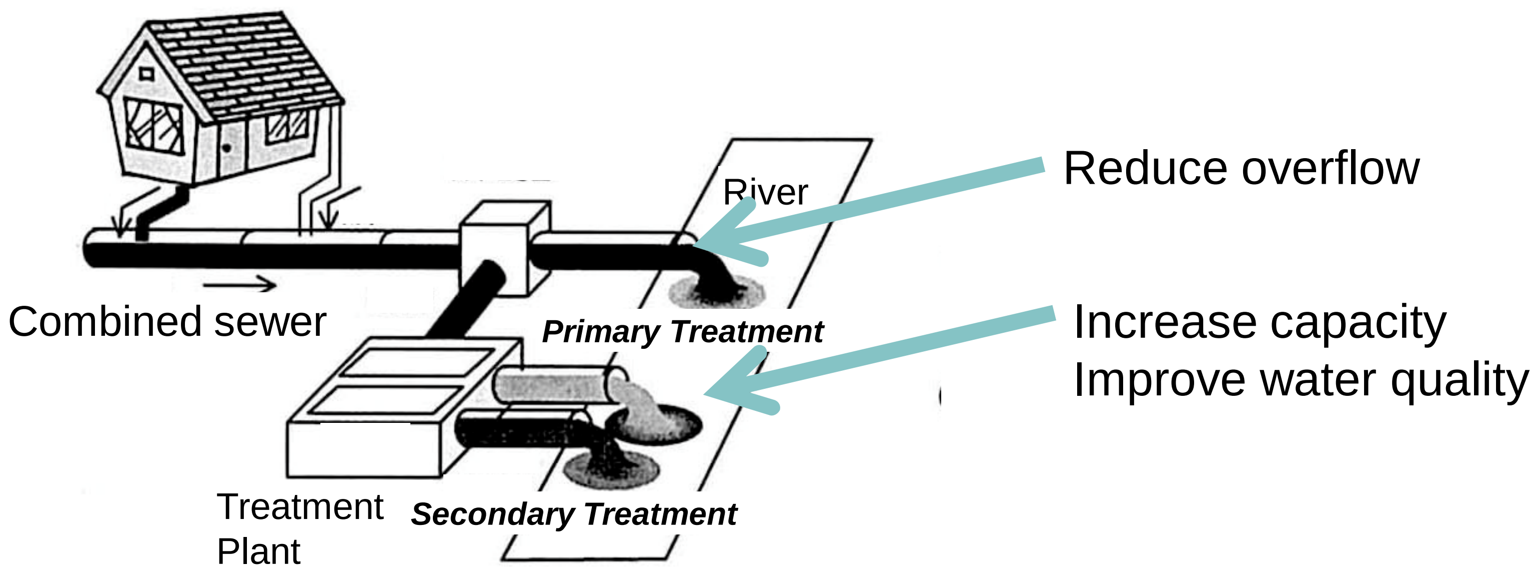
Need of Tentative treatment

- No established treatment system before full recovery of WWTPs.
- What should be prioritized?
  - BOD, N, P
  - Pathogens,
  - Heavy metals, Chemcals
- Should consider the receiving water body

Reducing CSO problem

Under wet weather condition

Combined Sewer Overflow



Combined Sewer System

Primary treatment should be more developed.

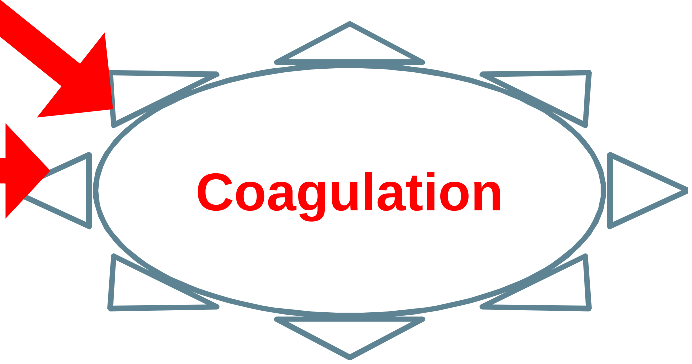
Disinfection of Pathogens in Wastewater

Chlorination in WWTPs

- **Effective for E. coli and coliforms** （Tree et al., 2003)
- **Not effective against bacteriophages under high ammonium condition** （Tree et al., 2003, 2005; Armon et al., 2007）
- **Factors** ： **pH, ammonia、SS、Organic Matter**

UV irradiation

- **Effective to all microbes**
- **Easy maintainance**
- **Factors**： **UV absorbance**



Problem may be caused by the use of coliforms as the single microbial indicator in the water management

Coagulants

- Chitosan: as a cheap material in local use in developing country
- Al : Used world wide. Some concern in residual Al on health issues.
- Fe : Seawater lacks Fe for ecosystem

  good performance of coagulation

Polyferrite : Effective for Odor treatment

Used in the wastewater industry

Obtained from Iron industry

Objective

Development and Evaluation of Compact treatment of wastewater using polyferrite

- **Efficiency as treatment of pathogens are evaluated using E. coli, coliforms and bacteriophages as indicators.**
- **Several sets of condition of Coagulation/Chlorination**
- **UV absorbance was also measured to assess the effectiveness of UV treatment**

Bacteriophages were used as the indicator of enteric viruses

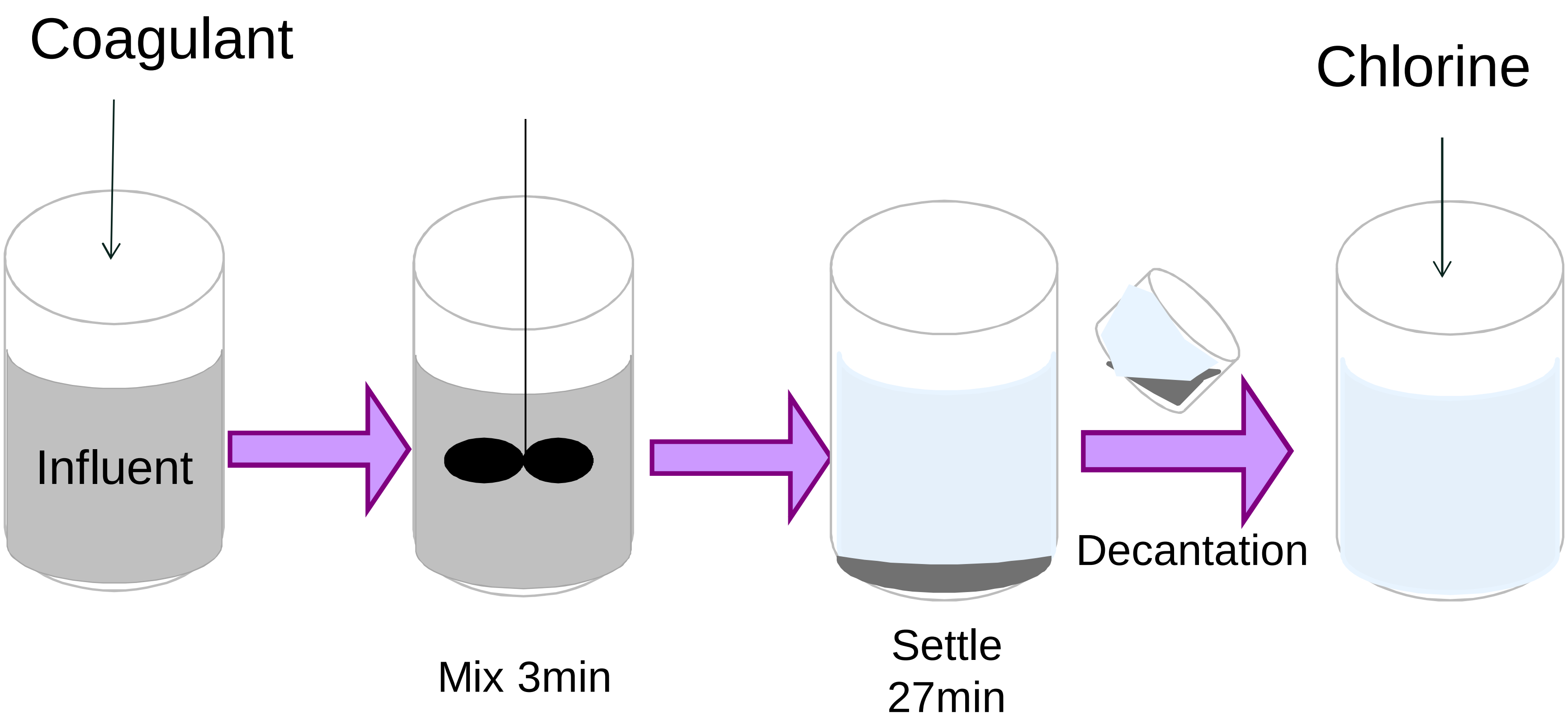
Indegenous microbes were evaluated

Rapid 60

Slow 60

Disinfection study

- PolyFe was selected due to good removal of phages.



Coagulation condition

Coagulation	PolyFe Dose (mg/L)	2sec Rapid mixing*	3min Slow mixing
[redacted]			
Slow 60	**60**	×	○
[redacted]			
Rapid 60	**60**	○	○

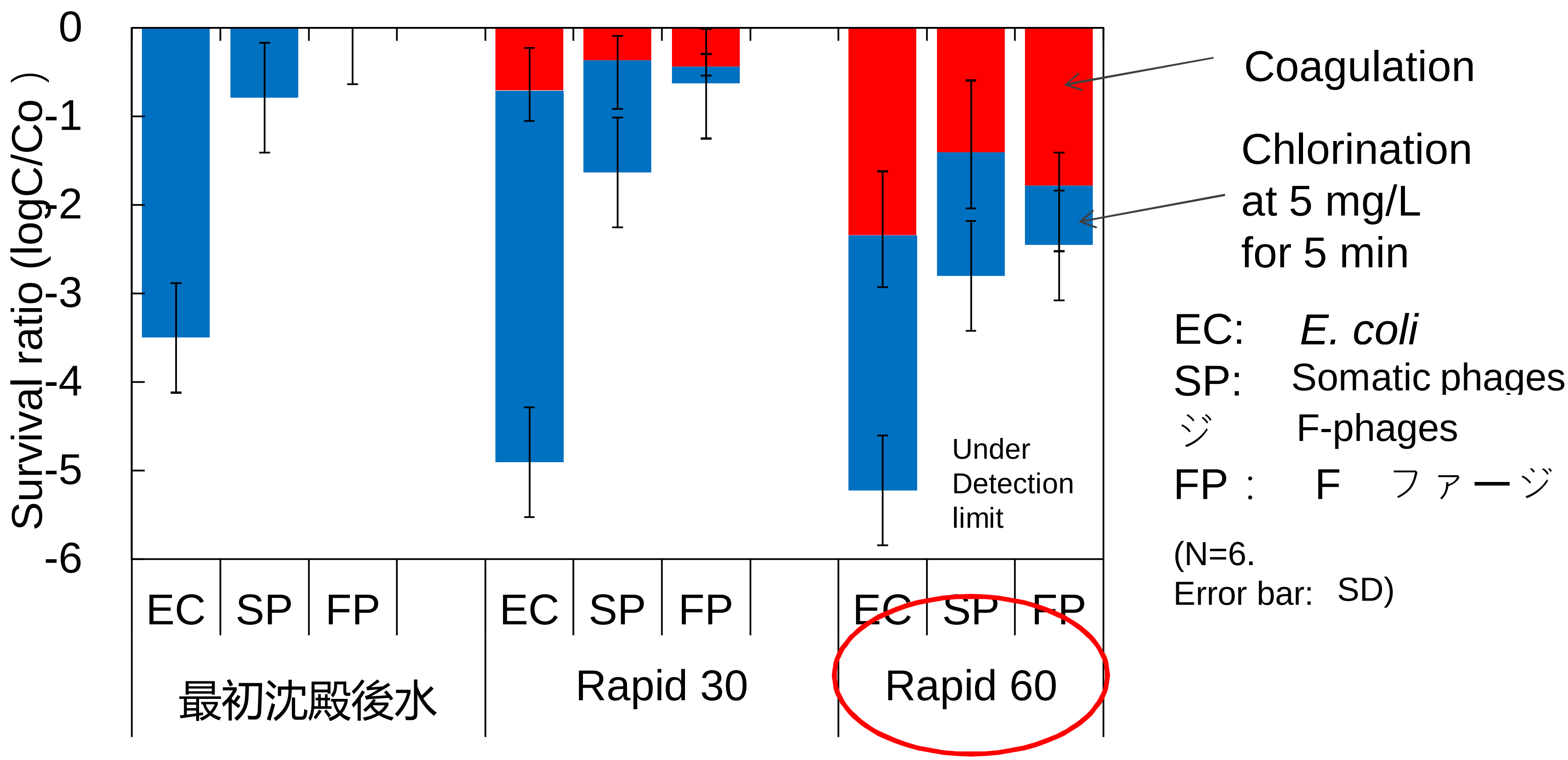
*: Spike coagulant befor pump up ⇒ 2 sec rapid mixing

Chlorination

Chlorine dose : 5mg/L, 10mg/L

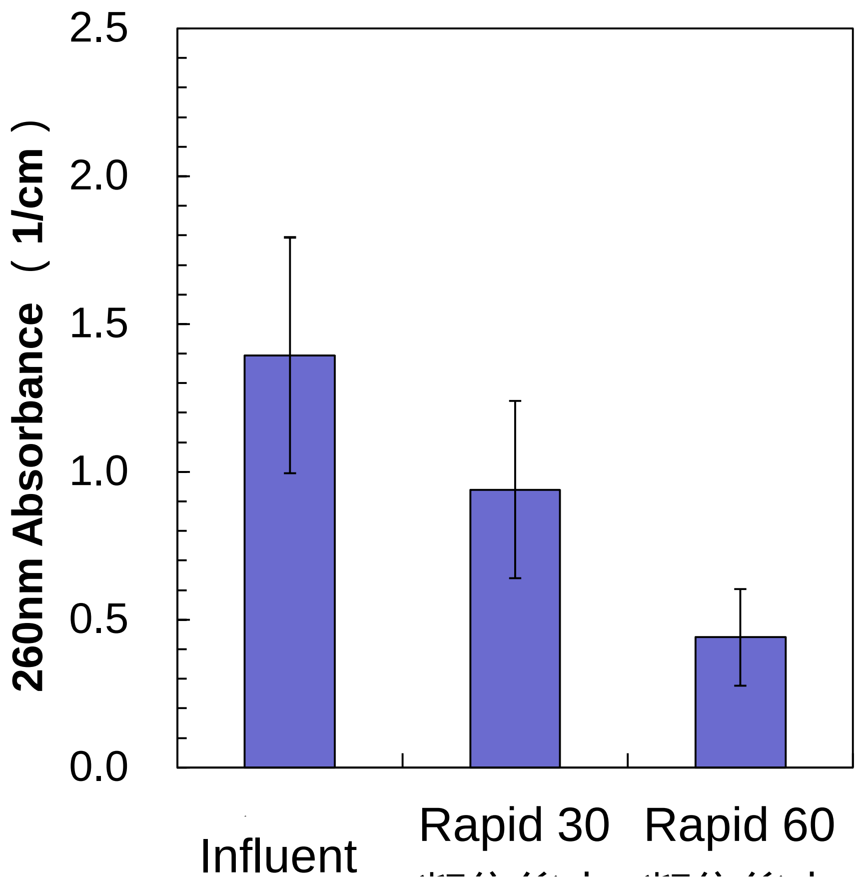
Contact time : 1min, 5 min, 30 min

Efficiency of PolyFe on Removal of Microbes



- **PolyFe dose at 60mg/L** most effectively removed all indicators.

Absorbance after treatment



（N=6. Error bar: SD）

- **E260 decreased by the PolyFe treatment especially by Rapid 60**
- **UV treatment may be effective after the treatment.**

Conclusion

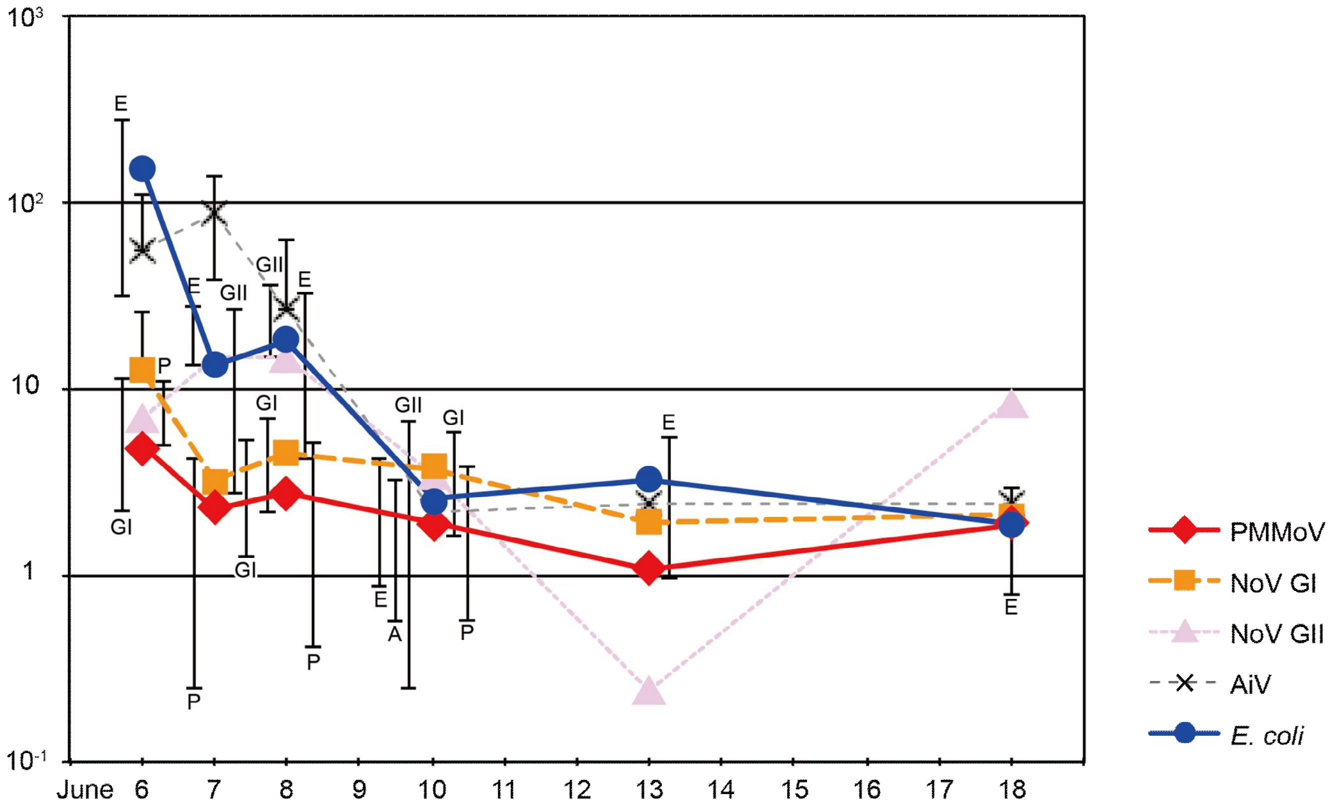
1. Rapic mixing enhanced the treatment efficiency even a short time (2 sec)
2. PolyFe dose at 60mg/L achieved most effective removal of all indicators tested.
3. Supernatant of the treated water at 60mg/L with rapid mixing had low E260.
4. Coagulation may be a good option to treat combined sewer in a short retention time.

Acknowledgement

- Miyagi Prefecture,
- Ministry of Land, Infrastructure, Transport and Tourism
- Ministry of Environment
- AGS, University of Toyo
- Steel Foundation for Environmental Protection Technology

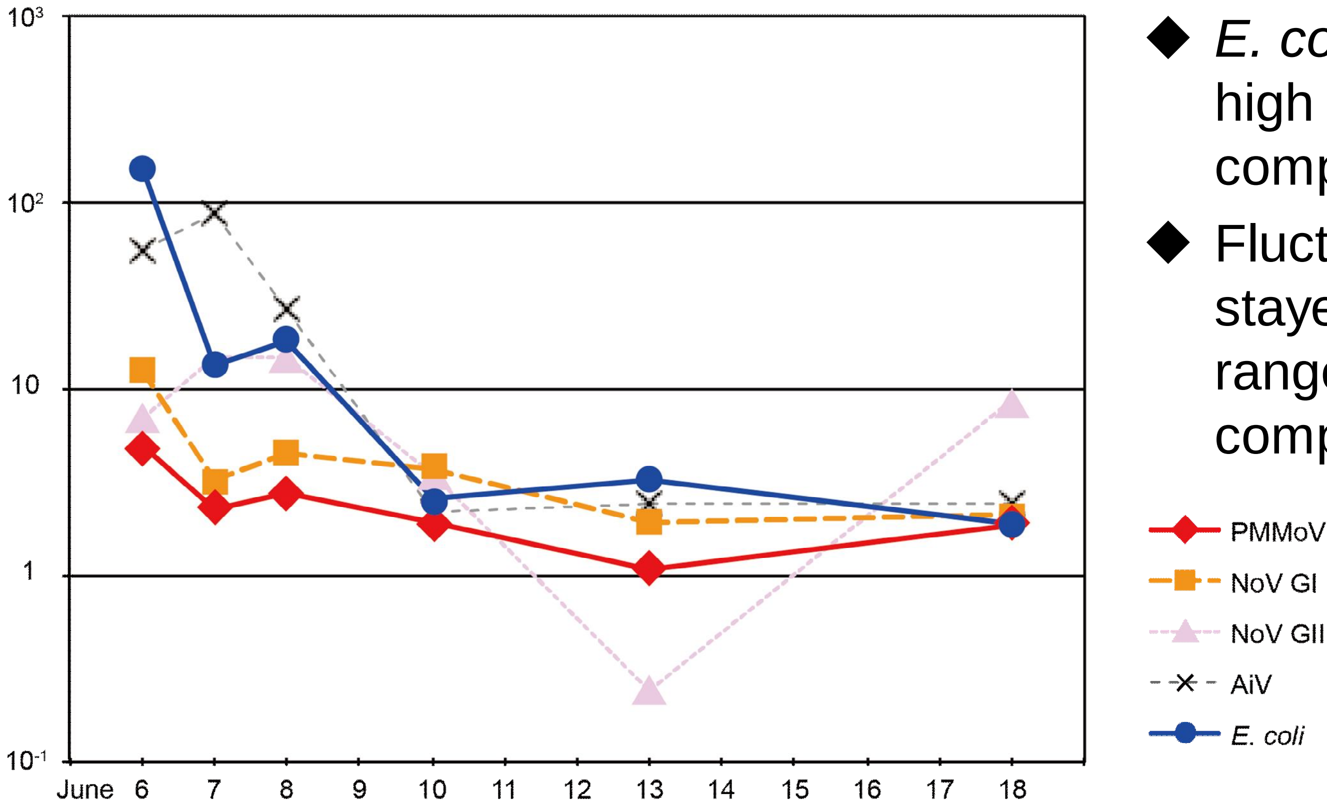
Discussions

Comparing the diffusion of viruses and *E.coli*
(Upper / lower layer ratio of concentrations)



Discussions

Comparing the diffusion of viruses and *E.coli*
(Upper / lower layer ratio of concentrations)



- *E. coli* showed relatively high ratio on the first day compared with the viruses.
- Fluctuations of the viruses stayed within a narrow range during CSO event compared with *E. coli.*

- Pollution dynamics of indicator bacteria and viruses may reflect their different behaviors in diffusion and settling after CSO events.

Methodology

Raw sewage water collected from wastewater treatment plant in Kanto area, Japan(stored at 4℃)

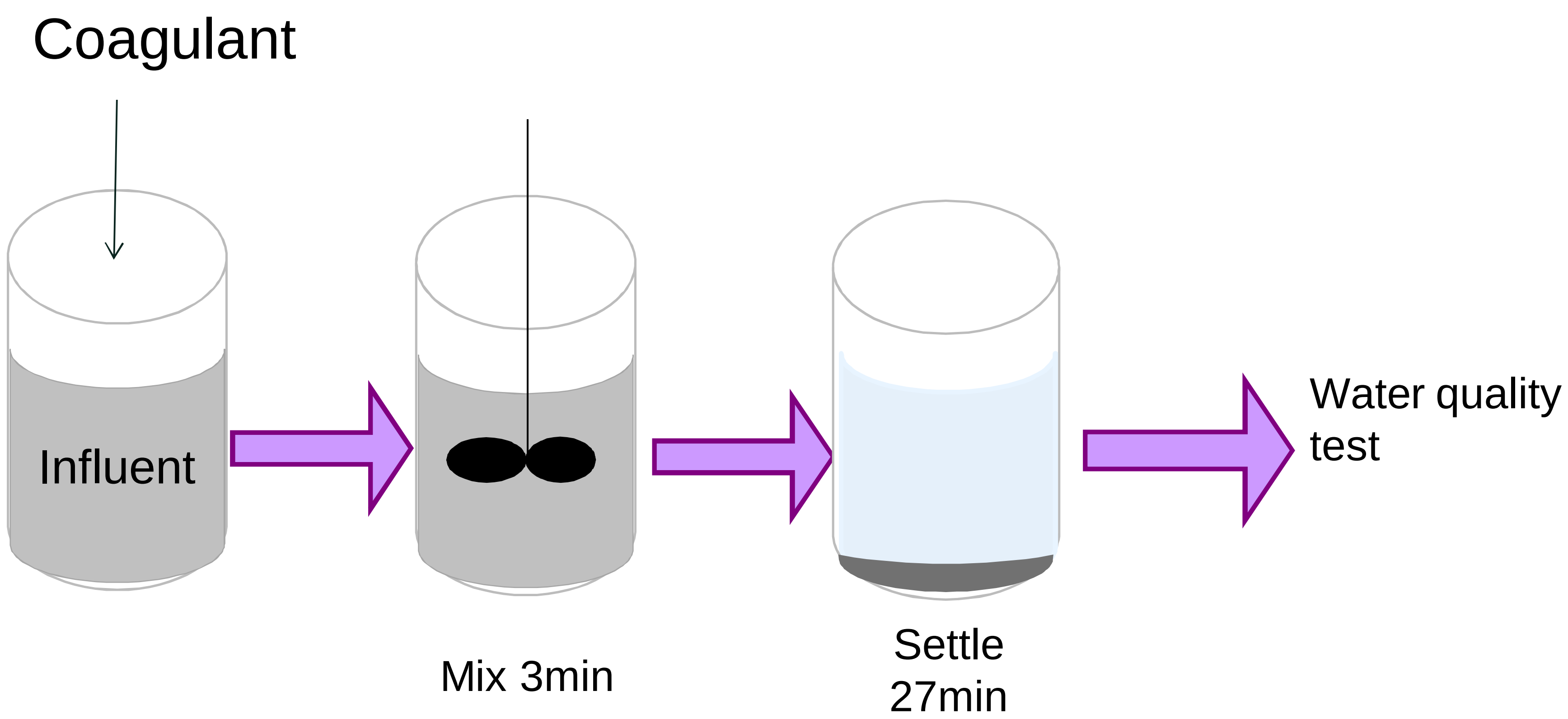
<u>Perform the coagulation process by using Jar-test</u> with

1.Polyaluminium chloride(PAC);
dose 15, 30 and 60 mg/L
2. Polyferric sulphate (PF);
dose 10, 30, 60 and 90 mg/L
3. Chitosan (CT);
dose 5, 10 and 30 mg/L

- Mixing speed: 1200 rpm
- Mixing time :2 sec. and 20 sec.
- Settling time : 10 mins

- <u>Physico-chemical test</u>
  - pH
  - SS
  - Turbidity
  - UV254
  - BOD5
- <u>Biological test</u>
  - *E.coli* and total coliform
  - Bacteriophage
    - ✓F-specific phage
    - ✓Somatic phage

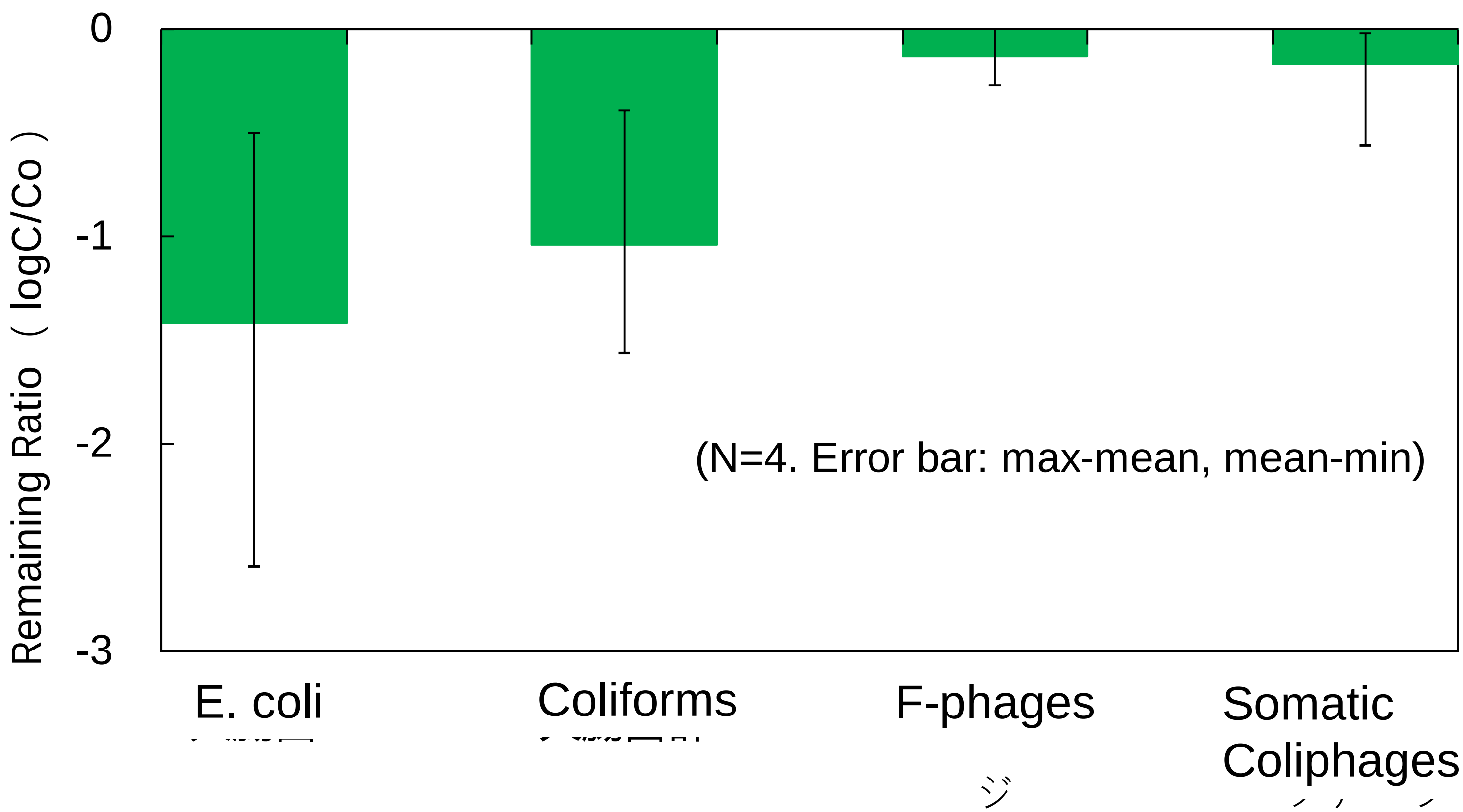
Outline of Treatment



Samples used

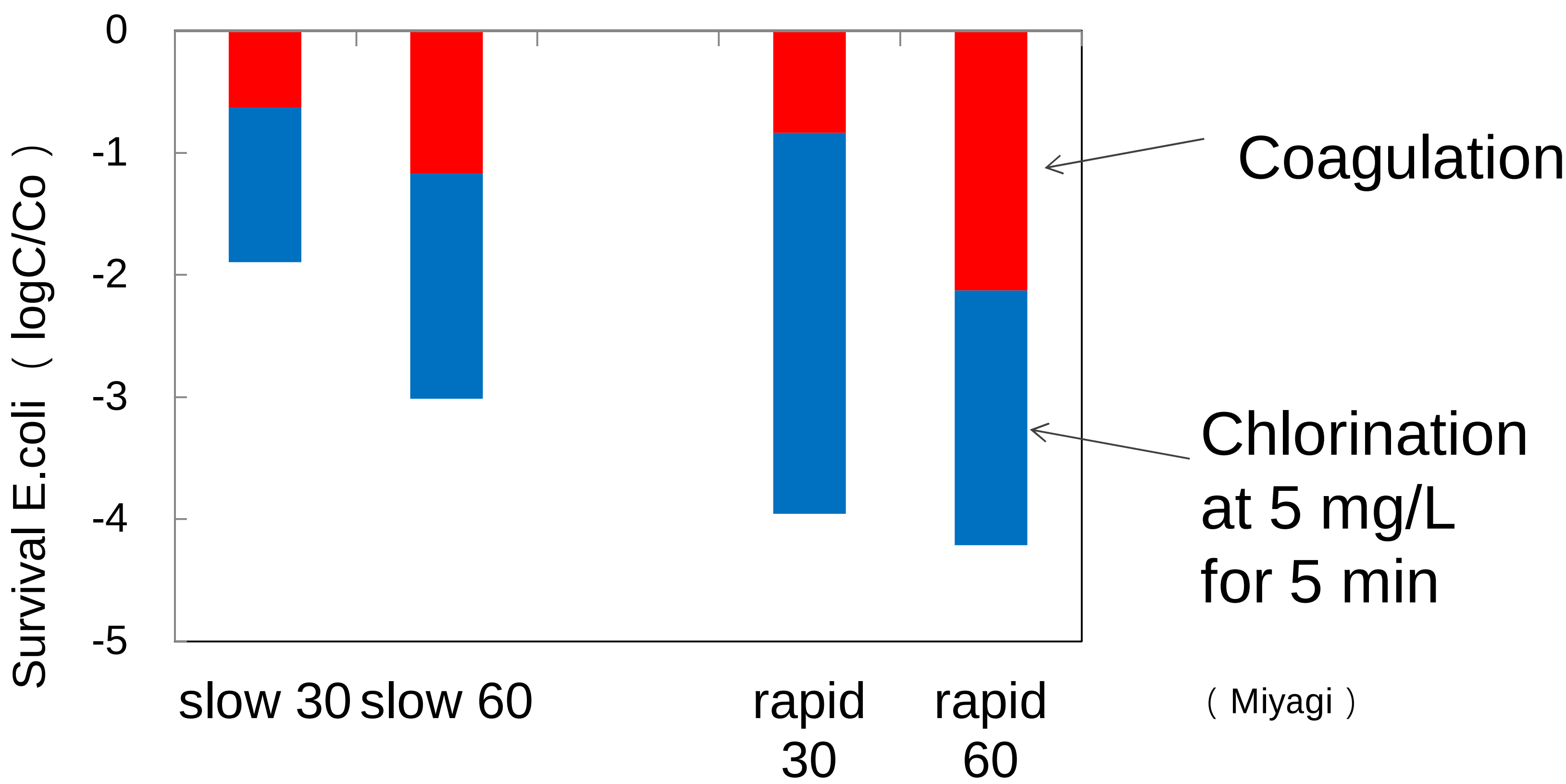
2011/9/29	Miyagi	Influent, Primary treated, effluent
10/29	Miyagi	Influent, Primary treated, effluent
12/28	Kanto	Influent, Primary treated,
2012/1/11	Kanto	Influent, Primary treated,
1/19	Kanto	Influent, Primary treated,
1/25	Miyagi	Influent, Primary treated, effluent
1/27	Miyagi	Influent, Primary treated, effluent

Removal of Indicators in WWTP (Miyagi)



- **Phages** remain and not inactivated effectively
- **E. coli and coliforms** were reduced by the treatment

Treatment efficiency under different coagulation condition



Rapid mixing (2 sec) enhanced the treatment efficiency

Result and discussion : SS and BOD5

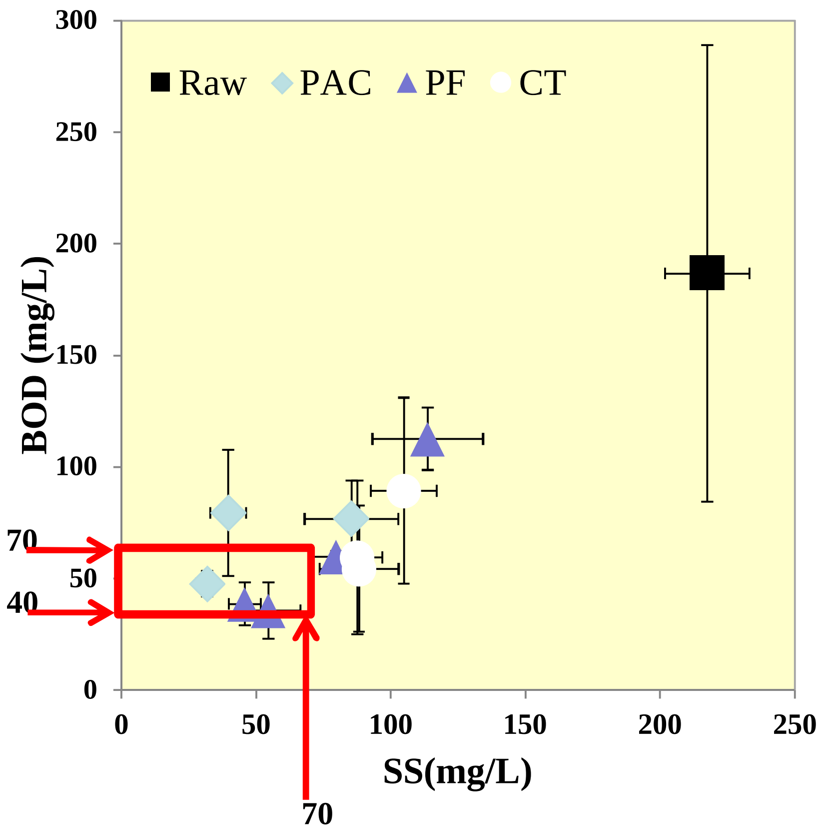
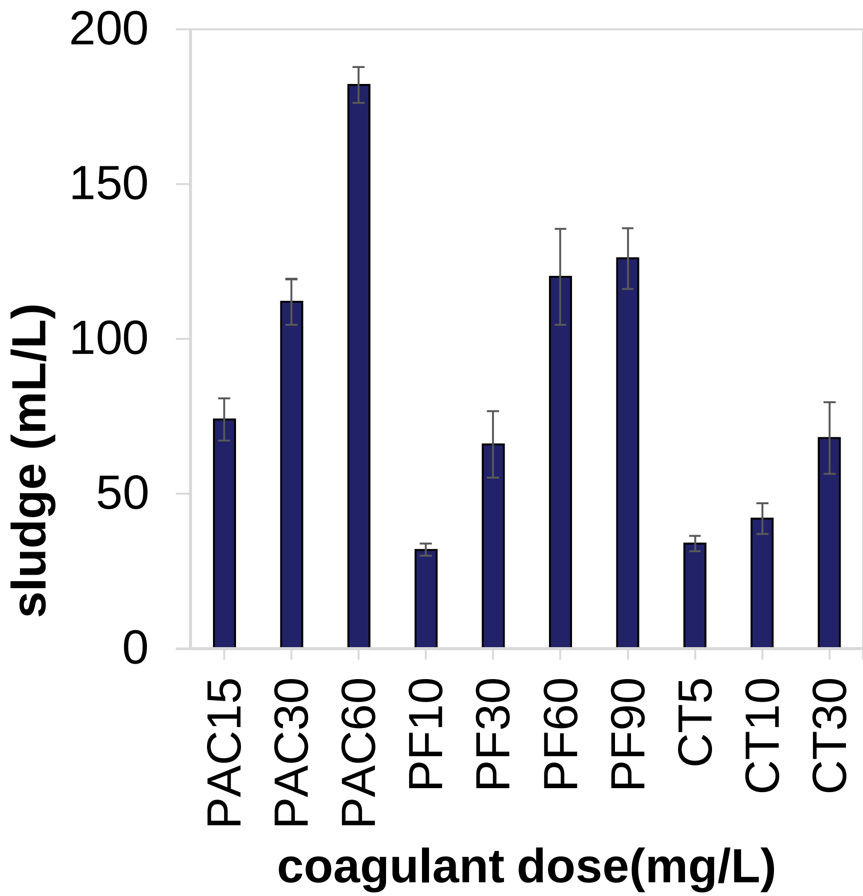


Fig.1 The amount of sludge after coagulation(N=5)

- Coagulation process has effectively removed the BOD and SS from wastewater.
- Coagulation with PAC and PF at optimized condition(PAC15,PAC 30, PF60 and PF90 mg/L) can remove high particles.
- From this point, microorganisms which is attached to SS particles were also removed together by coagulation process.
- The BOD value was low when the SS is less.

** BOD and SS was set as a technical practice for company by wastewater works at BOD 40-70 mg/L and SS at 70

Result and discussion : Sludge production



Amount of sludge after coagulation(N=5)

- Sludge production are inverse variation to turbidity.
- The use of PAC and PF at high dose has higher amount of sludge than the use of chitosan.
- PAC and PF has high Electrical charge provide the chance to bind with other particles than CT
- After the coagulation process and sedimentation process. The sludge treatment will considered.

Result and discussion : *E.coli* and total coliform

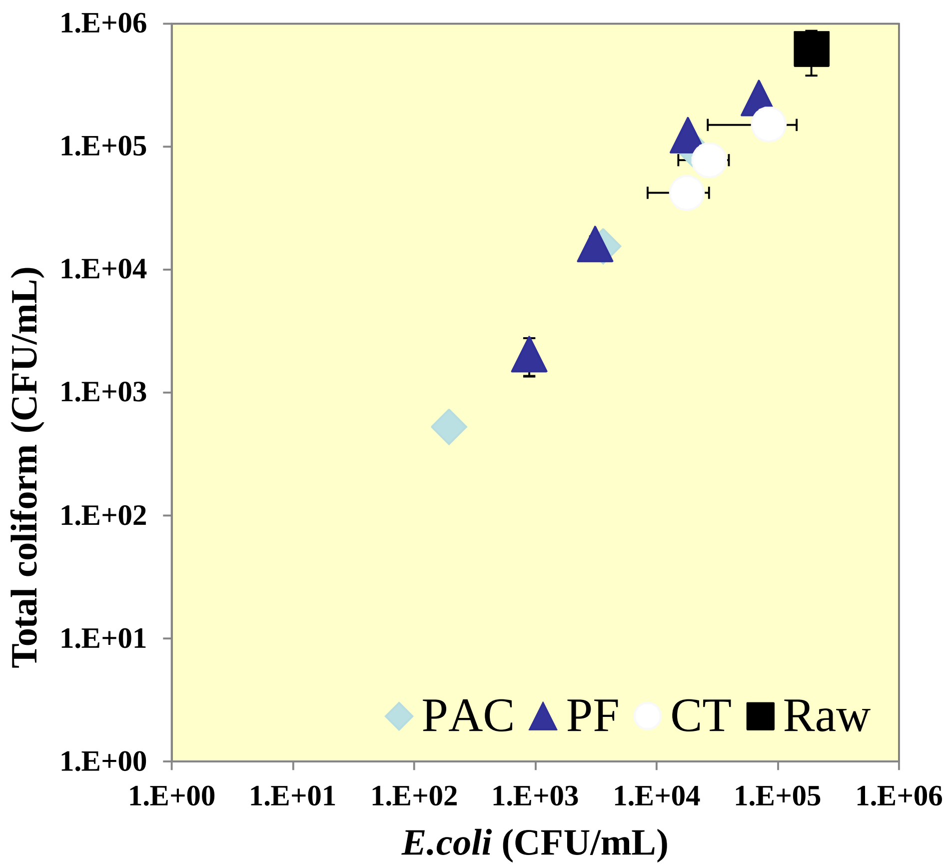


Fig.3 The correlation between the log remaining of *E.coli* and total coliform(N=5)

❖ This Fig. shows the relationship between the remaining of *E.coli* and total coliform

➢ *E.coli* and total coliform were removed by coagulation with PAC60 mg/L by 3 log.

➢ And PF90 mg/L can also remove *E.coli* and total coliform by 3 log.

➢ Coagulation with CT at various dose are not effectively remove both *E.coli* and total coliform.

Result and discussion : Bacteriophage (somatic phage and F-phage)

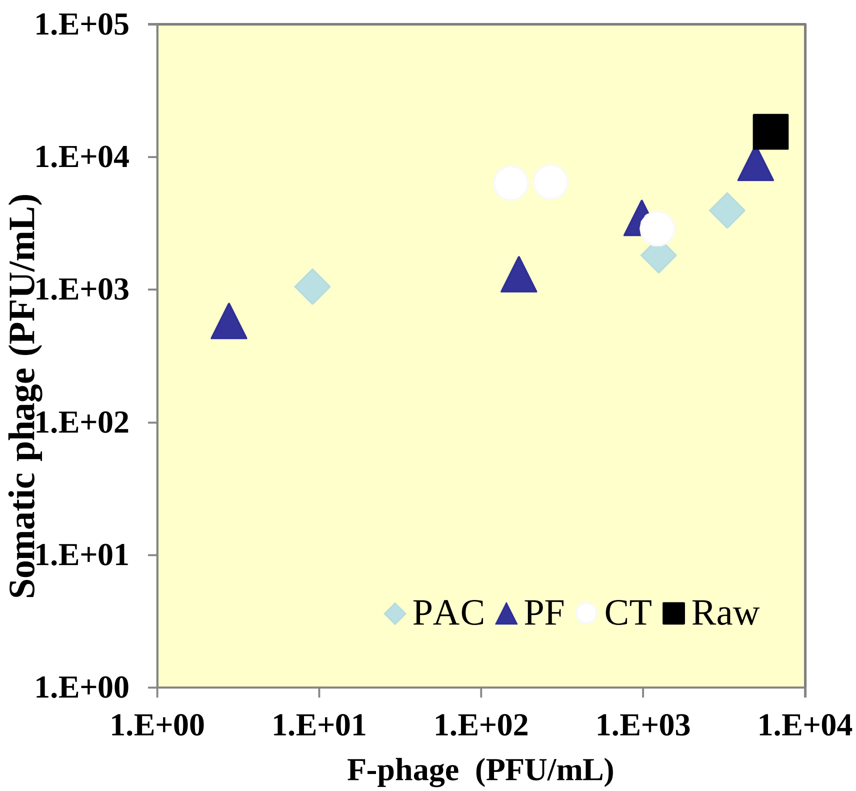


Fig.4 The correlation between the log remaining somatic phage and F-specific phage(N=5)

❖This Fig. shows the relationship between the remaining of bacteriophage ; somatic phage and F-specific phage.

➢ *E.coli* and total coliform were removed by coagulation with PAC60 mg/L by 3 log.

➢ Coagulation with PF90 mg/L can also remove *E.coli* and total coliform by 3 log.

➢Coagultion with CT at various dose are not effectively remove both *E.coli* and total coliform.

➢