November 22, 2021

JICA Webinar

HOKKAIDO UNIVERSITY

Quantification and Genetic Analysis of SARS-CoV-2 in Wastewater Reveals the Prevalence and Molecular Epidemiology of COVID-19

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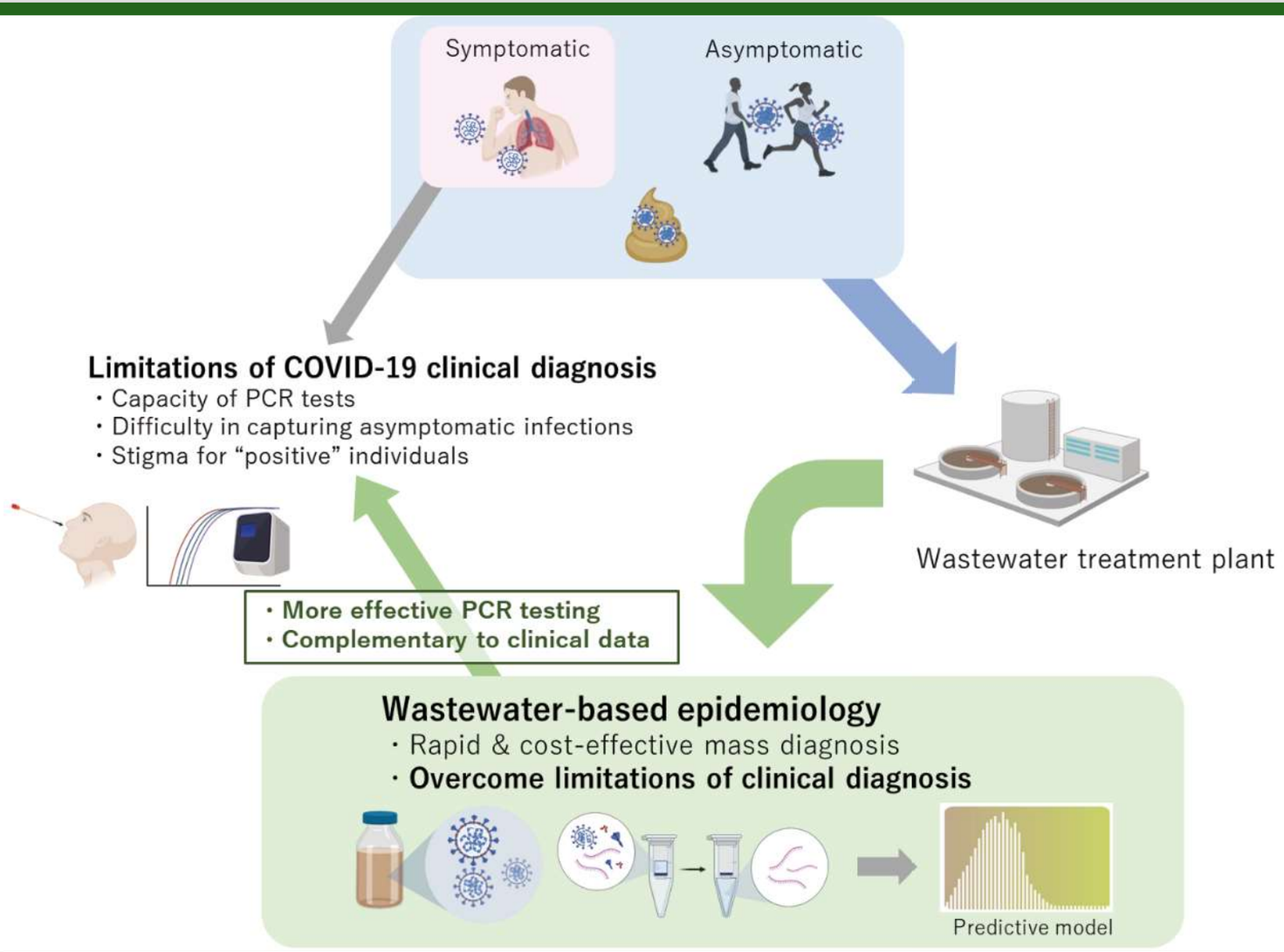
Wastewater-based Epidemiology (WBE)



Hokkaido University press release (May 25, 2020)

✓ Review paper (Kitajima et al., 2020)

Using wastewater to monitor COVID-19

Research Press Release | May 25, 2020

Wastewater could be used as a surveillance tool to monitor the invasion, spread and eradication of COVID-19 in communities.

First Review Paper on WBE for COVID-19

Kitajima *et al.* (2020) Sci. Total Environ. **739**:139076.

Contents lists available at ScienceDirect

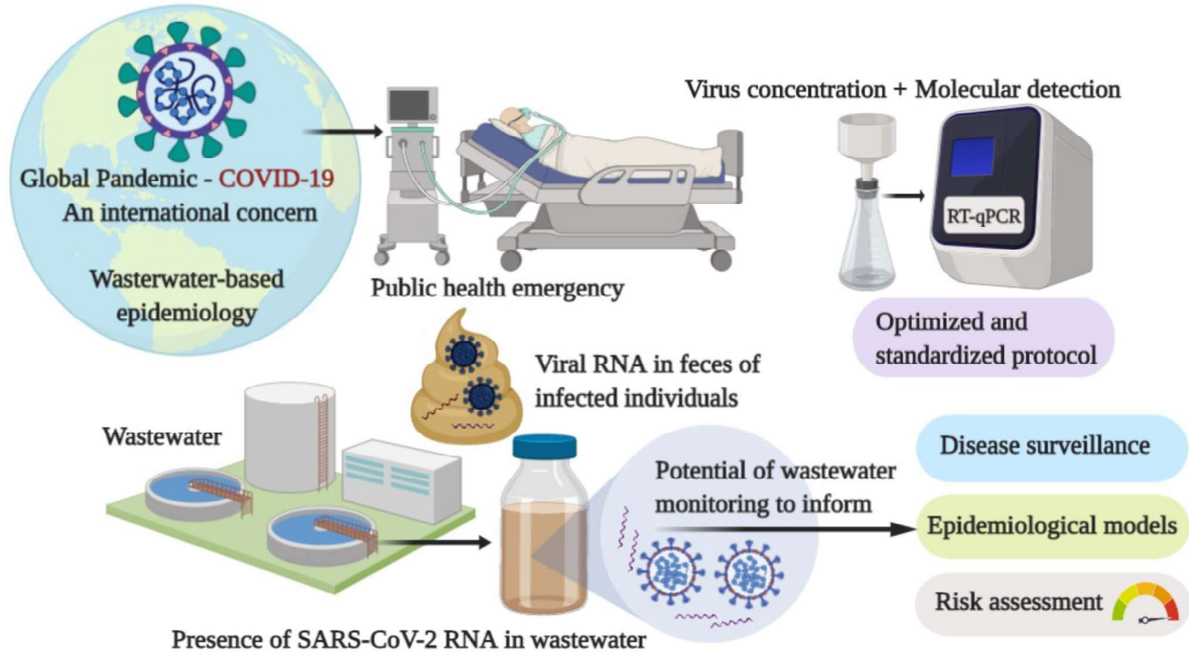
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

SARS-CoV-2 in wastewater: State of the knowledge and research needs

Masaaki Kitajima [a,*], Warish Ahmed [b], Kyle Bibby [c], Annalaura Carducci [d], Charles P. Gerba [e], Kerry A. Hamilton [f], Eiji Haramoto [g], Joan B. Rose [h]



Proposed the importance and potential of WBE to better understand the disease prevalence

- Gastrointestinal symptoms in COVID-19 and shedding of SARS-CoV-2 in excreta
- Evidence for the presence of SARS-CoV-2 and related CoVs in wastewater
- Understanding COVID-19 epidemiology through wastewater surveillance
- Methods for SARS-CoV-2 detection in wastewater
- Survival and inactivation of CoVs and enveloped surrogate viruses in water and wastewater matrices
- Respiratory viruses in wastewater and the occupational risk
- Quantitative microbial risk assessment (QMRA) for respiratory viruses and SARS-CoV-2
- Dose-response of SARS-CoV-2 and relevant respiratory viruses

First Detection of SARS-CoV-2 RNA in Wastewater in Japan

Haramoto *et al.* (2020) *Sci. Total Environ.* **737**:140405.

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

First environmental surveillance for the presence of SARS-CoV-2 RNA in wastewater and river water in Japan

Eiji Haramoto [a,*], Bikash Malla [a], Ocean Thakali [b], Masaaki Kitajima [c]

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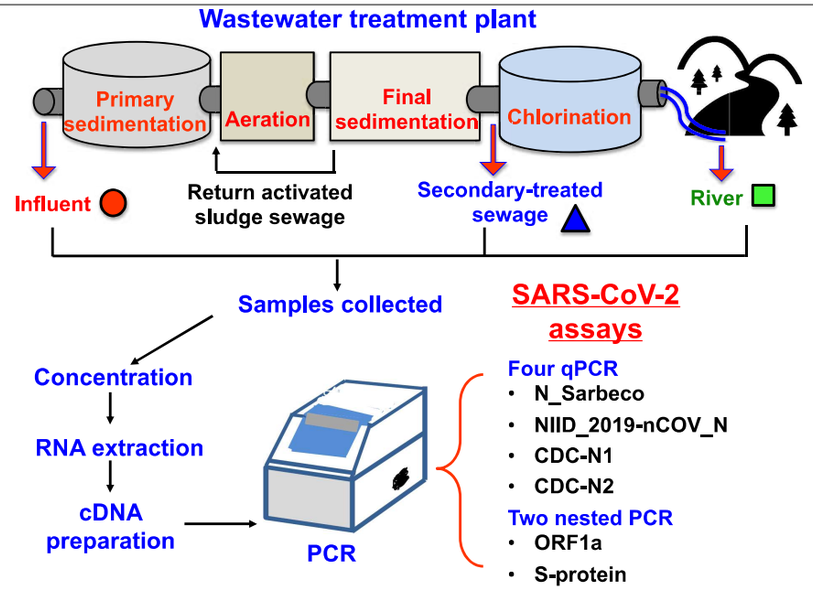

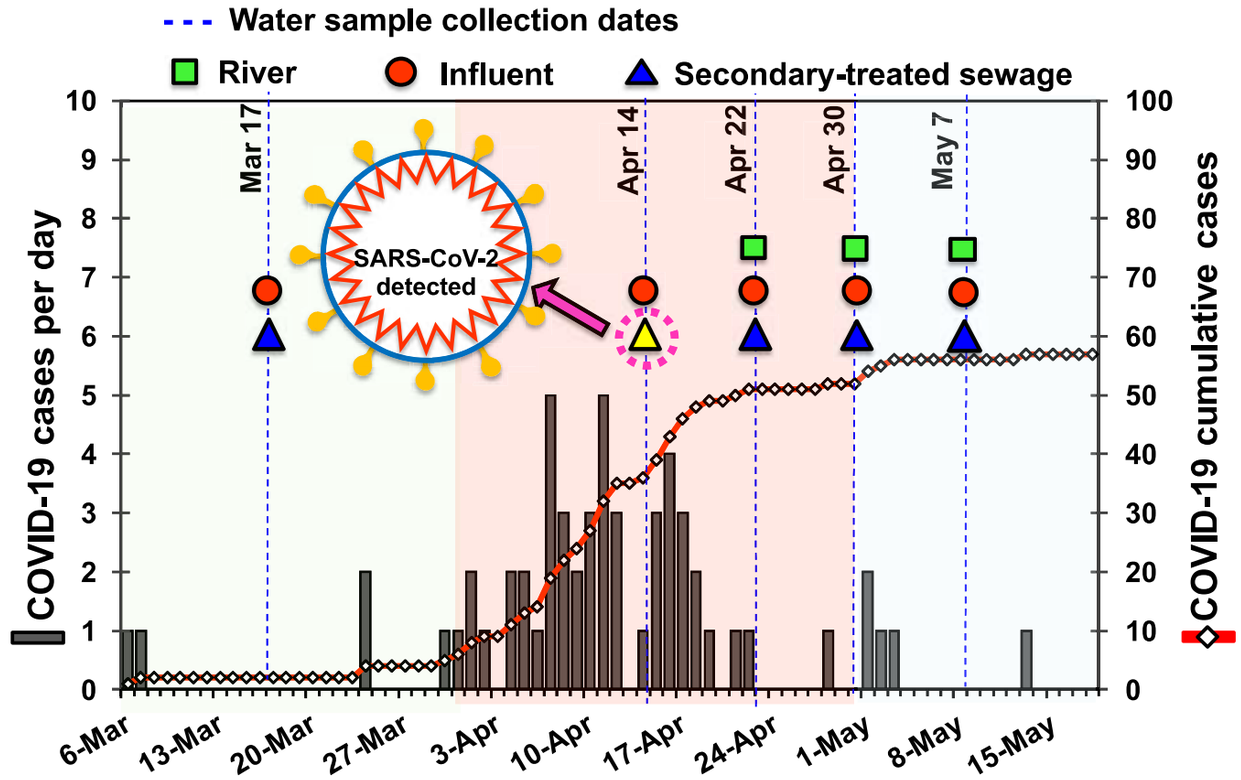

Detection of SARS-CoV-2 RNA in a secondary-treated wastewater sample

First Detection of SARS-CoV-2 RNA in Wastewater in North America

Sherchan *et al.* (2020) *Sci. Total Environ.* **743**:140621.

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

First detection of SARS-CoV-2 RNA in wastewater in North America: A study in Louisiana, USA

Samendra P. Sherchan [a,*], Shalina Shahin [a], Lauren M. Ward [a], Sarmila Tandukar [b], Tiong G. Aw [a], Bradley Schmitz [c], Warish Ahmed [d], Masaaki Kitajima [e]

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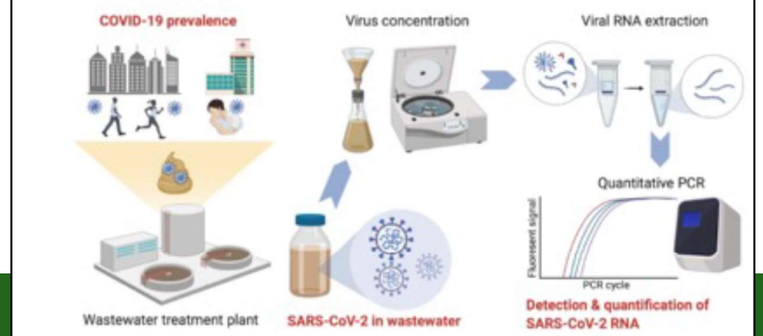
Hokkaido University press release (Aug. 26, 2020)

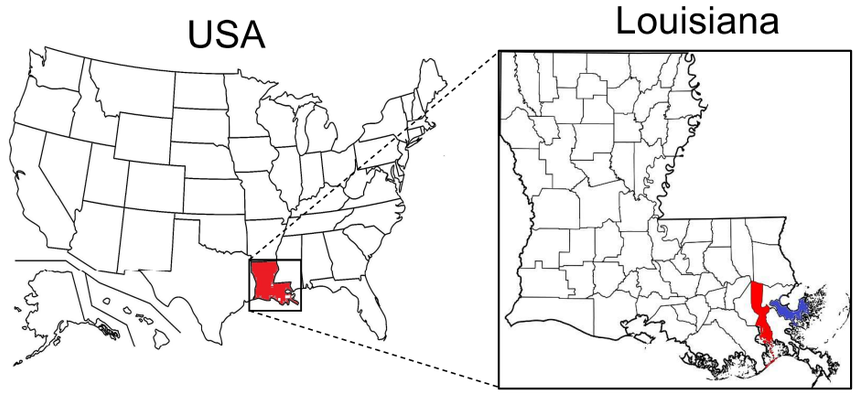
SARS-CoV-2 RNA detected in untreated wastewater from Louisiana

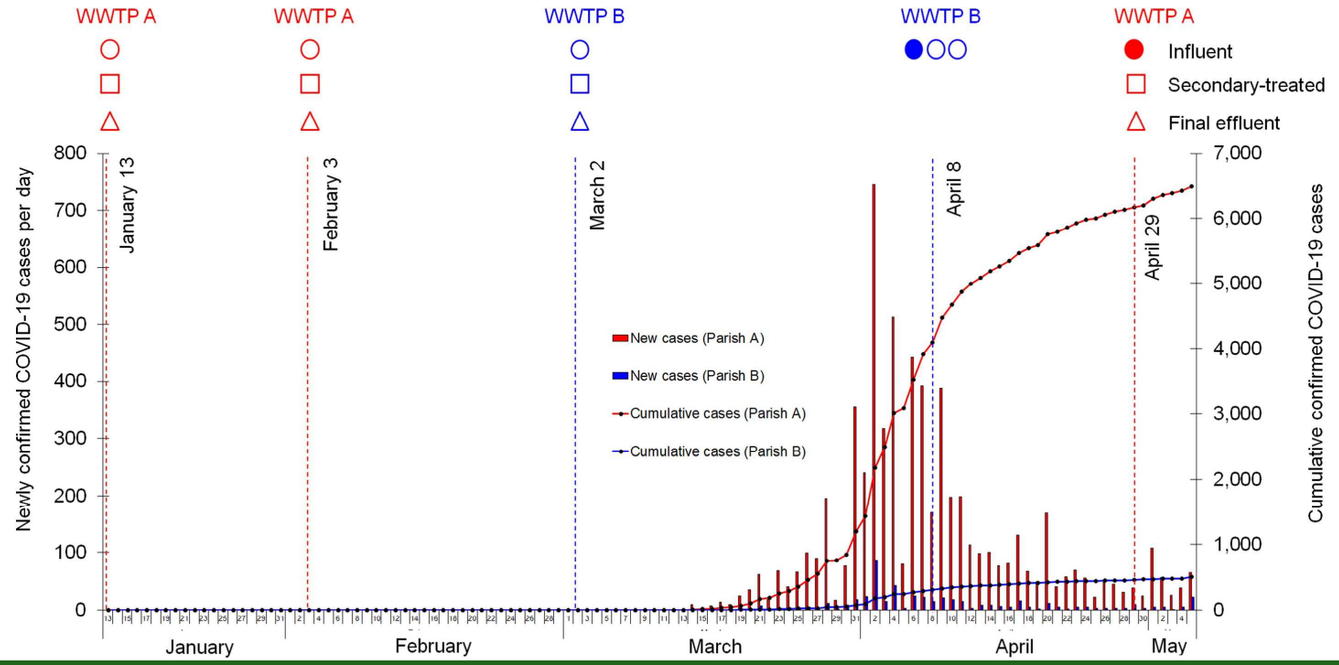
Research Press Release | August 26, 2020

A group of scientists have detected genetic material from SARS-CoV-2 in untreated wastewater samples collected in April 2020 from two wastewater treatment plants in Louisiana, USA.

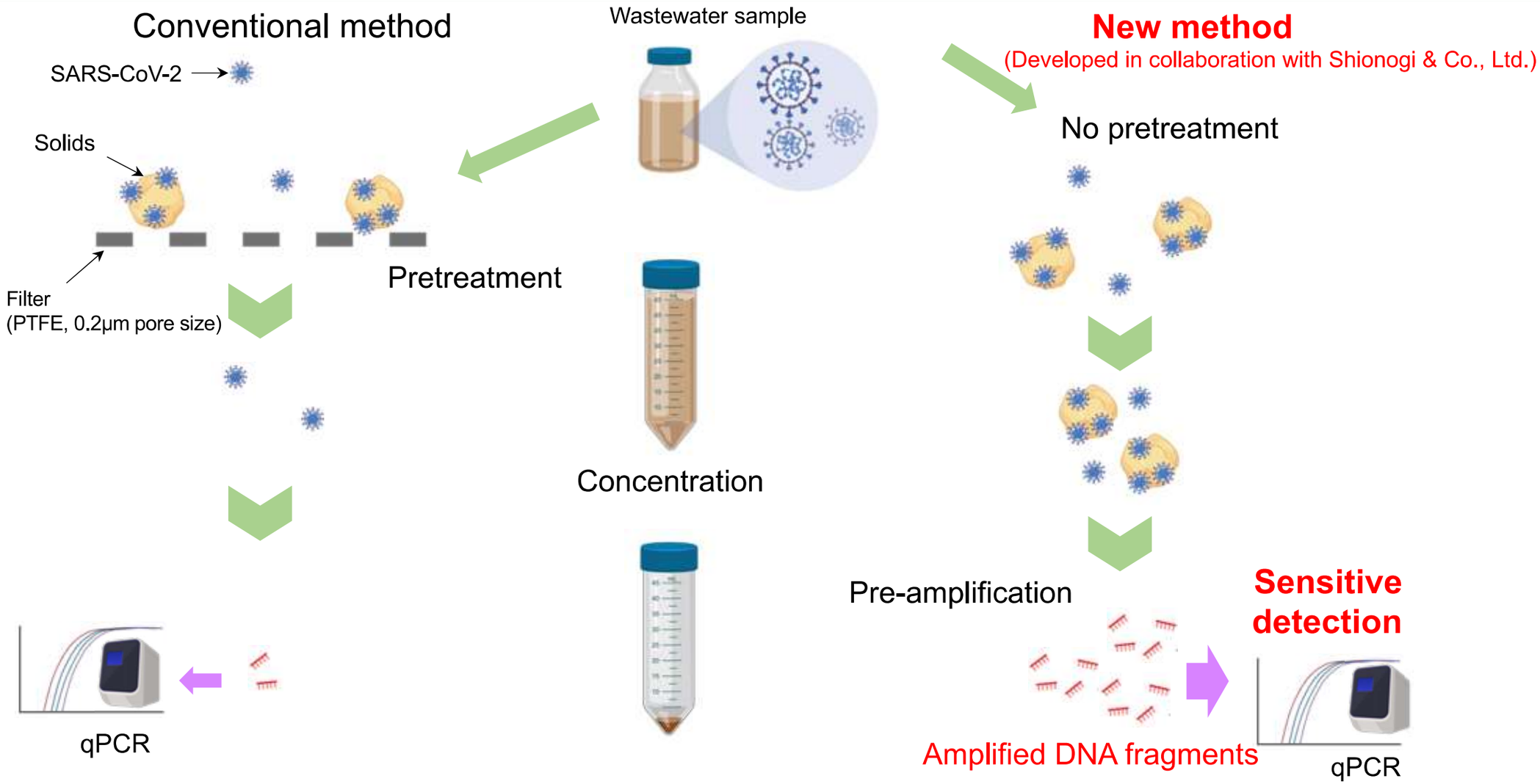


The role of Wastewater-Based Epidemiology in the detection of SARS-CoV-2 (Masaaki Kitajima/Biorender).



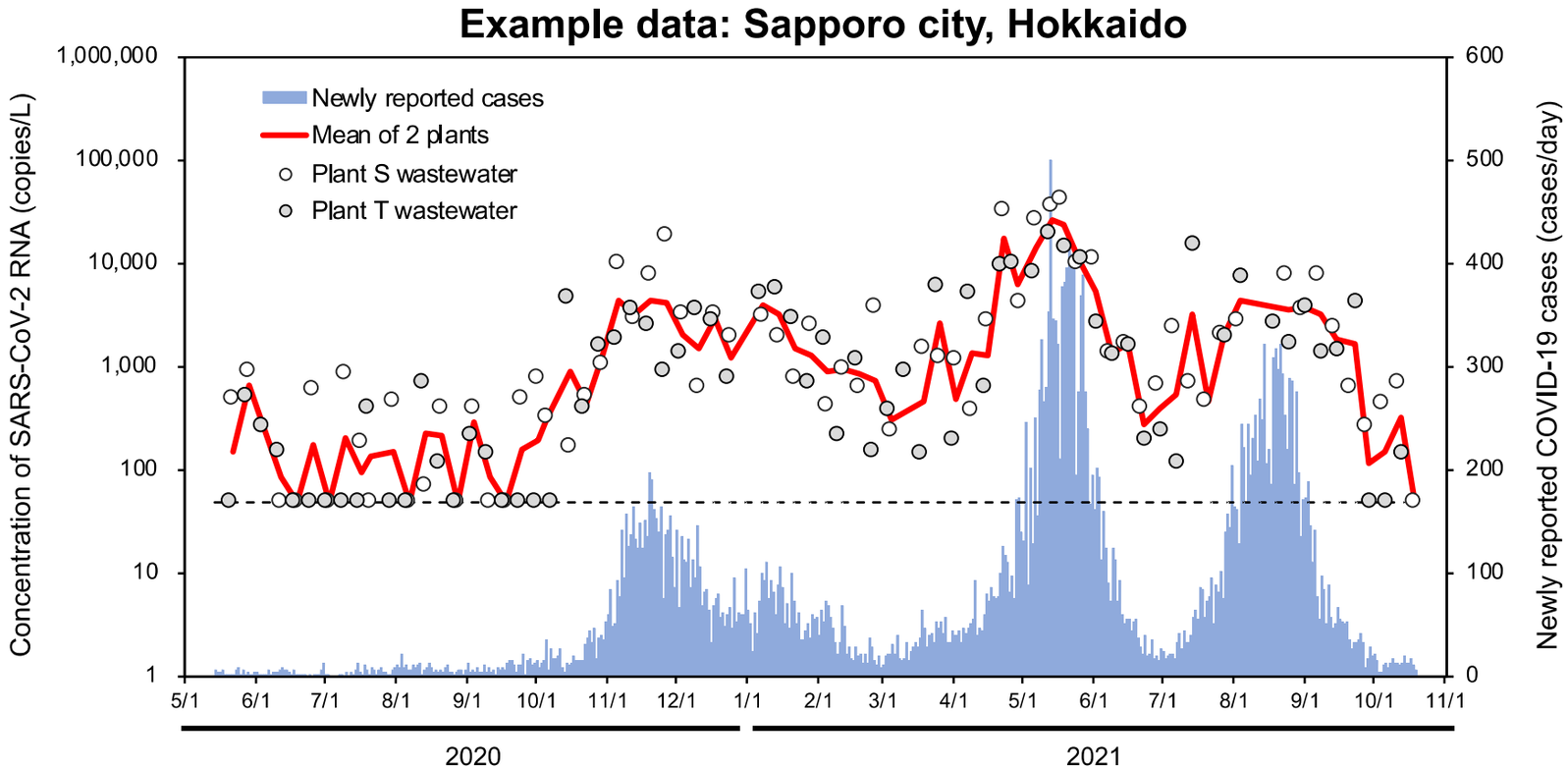


Technological Innovation in WBE - 1: Development of a Highly Sensitive SARS-CoV-2 RNA Detection Method



Innovative Method Enables Quantification of Low-level SARS-CoV-2 RNA in Wastewater

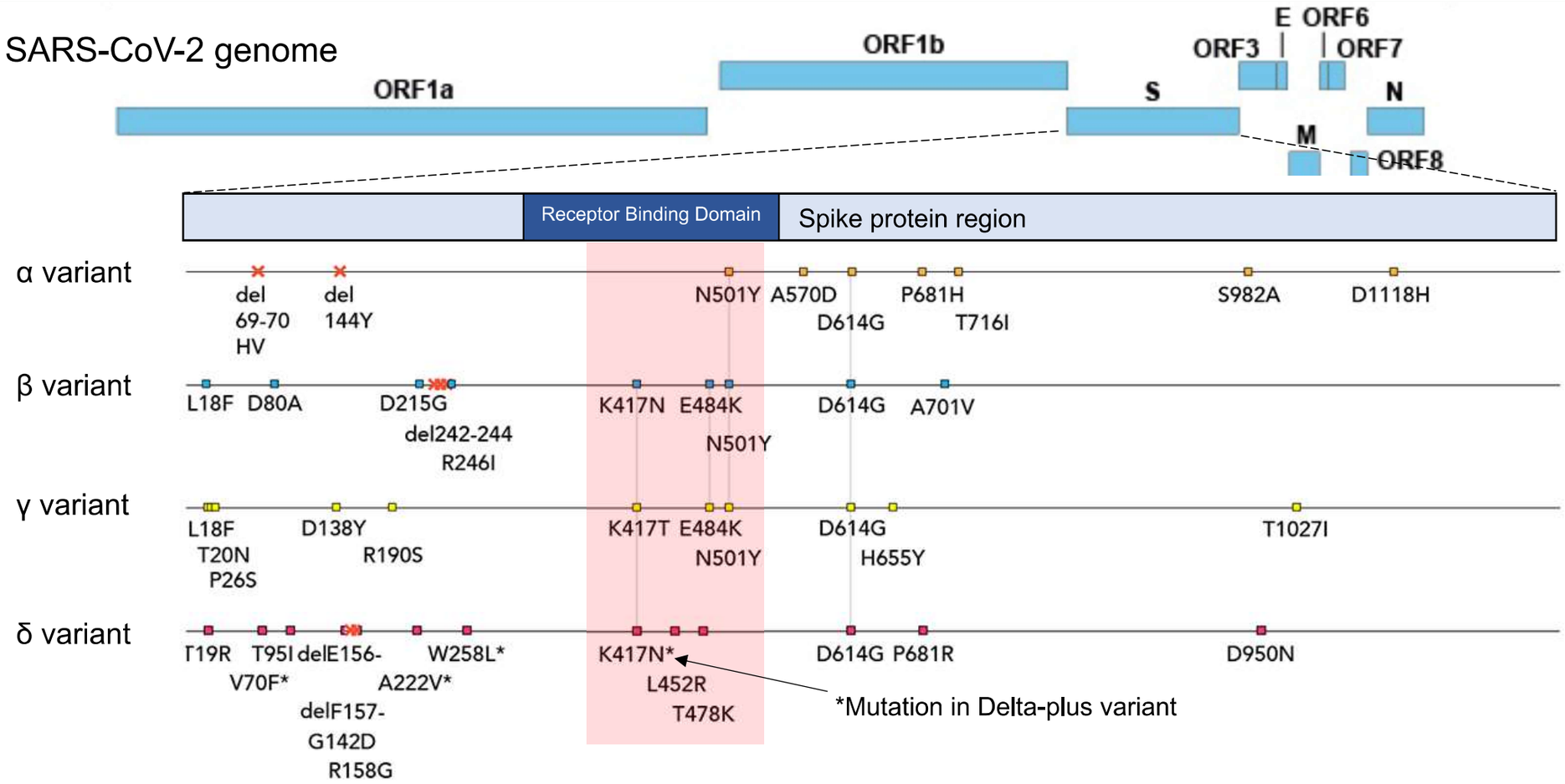
- Long-term quantitative monitoring of SARS-CoV-2 at wastewater treatment plants in major cities in Japan using **the highly senstive detection method**

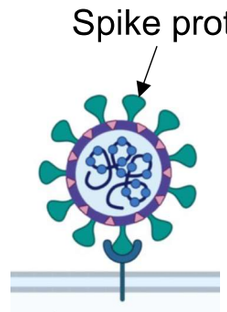


- Similarity in trends of reported cases and SARS-CoV-2 concentrations in wastewater

➔ **SARS-CoV-2 RNA quantification in wastewater can track the dynamics of COVID-19 prevalence**

Technological Innovation in WBE - 2:
Development of Variant Detection Method Based on Genomic Analysis





Next-generation sequencing (MiSeq)

- Established **variant detection protocol** based on genomic analysis
  - Collaboration with Shionogi & Co. Ltd. and the Institute of Medical Science, The University of Tokyo

Established Protocol Enables City-level Variant Monitoring via WBE

❑ Continuous monitoring of variants at wastewater treatment plants in a city

Reference: Wuhan (NC_045512)
✓ Variant call (VAF > 0.05)

First report of **α variant** from clinical surveillance in the city **2021 March**

First report of **δ variant** from clinical surveillance in the city **2021 June**

		"3rd wave"			"4th wave"						"5th wave"		
Wastewater Treatment Plant		**'20/11/19**	**'20/12/4**	**'21/1/7**	**'21/5/14**	**'21/5/17**	**'21/5/19**	**'21/5/21**	**'21/5/28**	**'21/5/31**	**'21/7/28**	**'21/7/30**	**'21/8/2**
Plant A					WT-like	α(10.6%) WT-like			α(99.8%)		δ(99.8%)	δ(76.4%) WT-like	α(37.5%) δ(57.2%)
Plant B	Facility no.1						α(6.1%) δ(6.6%) WT-like			WT-like	δ(89.7%) WT-like	WT-like	δ(24.6%) WT-like
	Facility no.2	WT-like[1]		α(12.4%) WT-like	α(92.8%) WT-like		α(12.0%) WT-like	α(100.0%)			α(98.7%)	δ(100.0%)	γ(39.6%) WT-like
Plant C	Facility no.1		α(5.9%) WT-like		α(9.1%) WT-like	α(98.1%)					α(51.5%) δ(30.4%) γ(5.5%)	δ(100.0%)	δ(97.6%)
	Facility no.2						α(6.0%) WT-like				α(24.8%) δ(61.8%) WT-like	δ(100.0%)	α(6.0%) δ(92.2%)

Not analyzed

(※ Results of amplicon NGS analysis; Percentage indicates relative abundance of the variant in total numbers of SARS-CoV-2 reads.)
([1]WT-like: wild-type-like sequences)

■ Possibilities of (1) **early detection** of variants and (2) tracking **molecular epidemiological dynamics**.

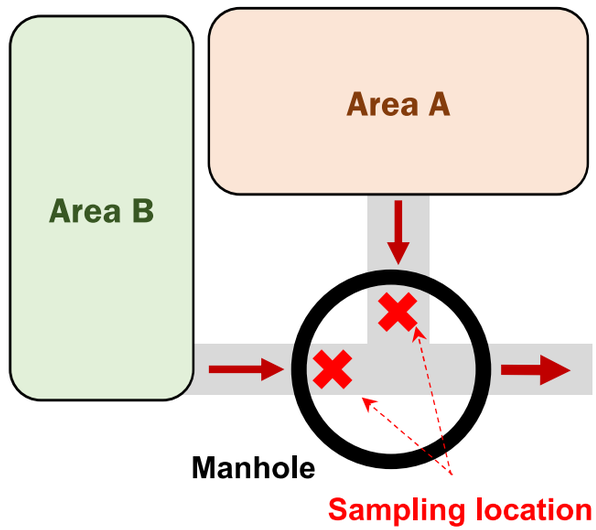
Applicability of WBE to Facility-level COVID-19 Monitoring

❑ Wastewater surveillance implemented in the Tokyo 2020 Olympic and Paralympic Village

✓ To better understand COVID-19 incidence

1. SARS-CoV-2 RNA was **detected in a number of wastewater samples** (even in the areas where no positive case was identified via mandatory daily clinical testing among residents).
   - ✓ The "Hokudai-Shionogi method" is so sensitive that viral RNA excreted from noninfectious postquarantine patients and asymptomatic patients with low viral shedding was detected.
2. When SARS-CoV-2 RNA was not detected via passive sampling of wastewater in a given area for 3 consecutive days, clinical tests almost never identified positive cases in that area.
   - ✓ **Wastewater testing provides information beneficial for optimizing clinical testing schemes** (e.g., prioritizing and determining the need for exhaustive tests)
3. Genomic analysis confirmed the presence of the SARS-CoV-2 genome and **identified variants** in the wastewater samples.

Image of sampling locations in the village



Wastewater samples collected from **7 distinct areas** comprising the entire residential buildings.

Reference: The Tokyo Organising Committee of the Olympic and Paralympic Games. The roundtable meeting with experts for countermeasures against COVID-19 (review), September 28, 2021 [*in Japanese*]

Summary and Potential of WBE

❑ Summary - usefulness of WBE

- ✓ **Cost-effective frequent monitoring** of community-level prevalence
  - Wastewater contains viruses shed from a number of infected individuals
- ✓ Viruses shed from **asymptomatic patients** can also be detected
  - Monitoring of actual prevalence including asymptomatic infections
- ✓ Virus discharge into sewer preceds symptom, diagnosis, and reporting
  - Early estimation of newly reported cases – **leading indicator**

❑ Potential of WBE - identification of epicenters

① Wastewater treatment plant
② Pumping station
③ Manhole

Proof of concept and social implementation of WBE became possible owing to the innovation in SARS-CoV-2 detection method

Image of epicenter identification