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Application of Wastewater-based Epidemiology in Suffolk County, NY: Surveillance of SARS-CoV-2, Antiviral Drugs, and More

Mian Wang, Ph.D.
Cheng-Shiuan Lee, Ph.D.

2022 Clean Water Symposium

June 17th, 2022

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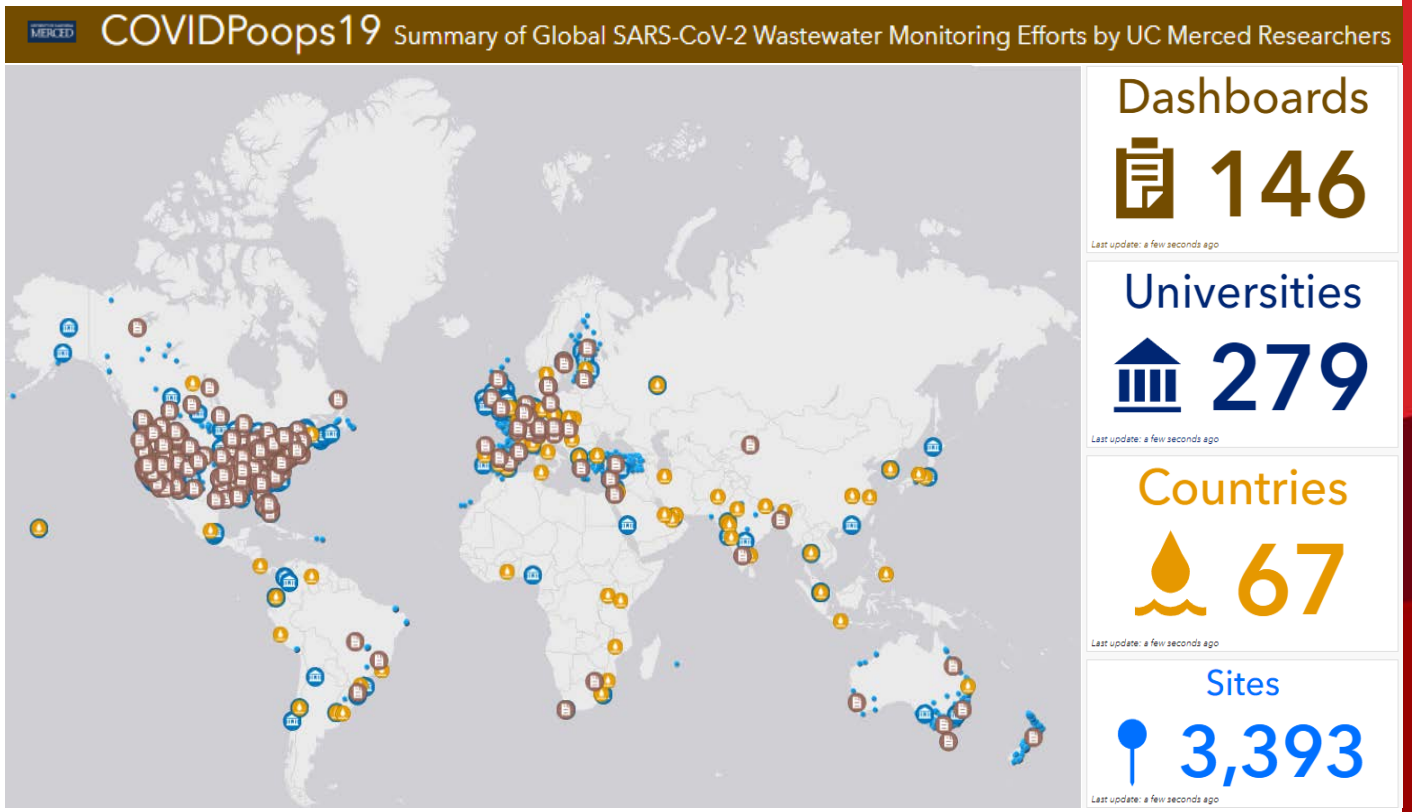
Wastewater-based Epidemiology (WBE)

- **WBE (wastewater surveillance):**
  - provide information on the risk factors and health status of a population through analysis of their wastewater
- Historically used in the 1990's to fight polio
- Adopted to monitor illicit drug use, antibiotic resistance, and pathogens
- Unbiased and non-invasive population health assessment tool
- Used globally to monitor SARS-CoV-2 in wastewater
  - U.S., Canada, Europe, Australia, etc.



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Ref: Ahmed, Warish, et al. *Science of the Total Environment* 805 (2022): 149877.
https://ucmerced.maps.arcgis.com/apps/dashboards/c778145ea5bb4daeb58d31afee389082

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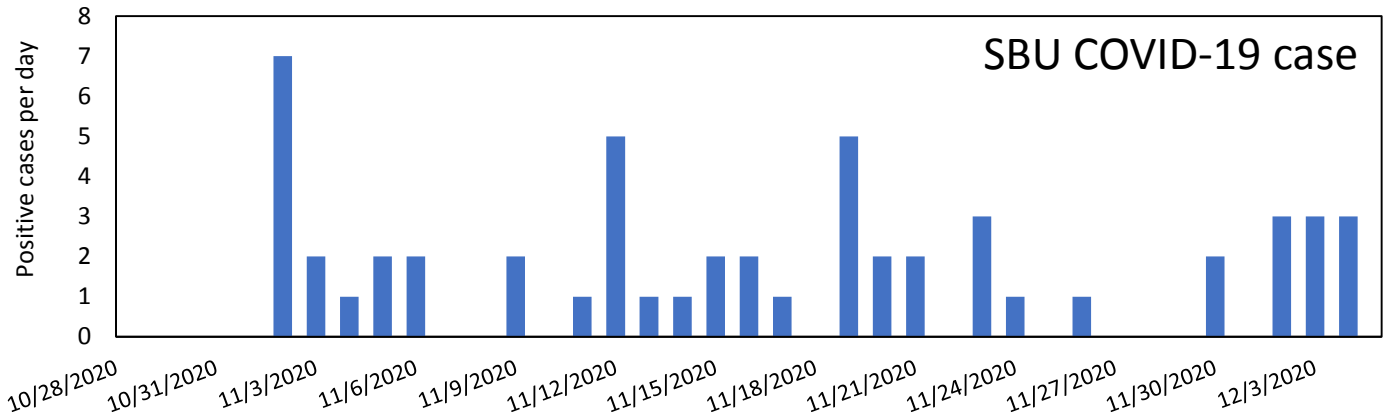
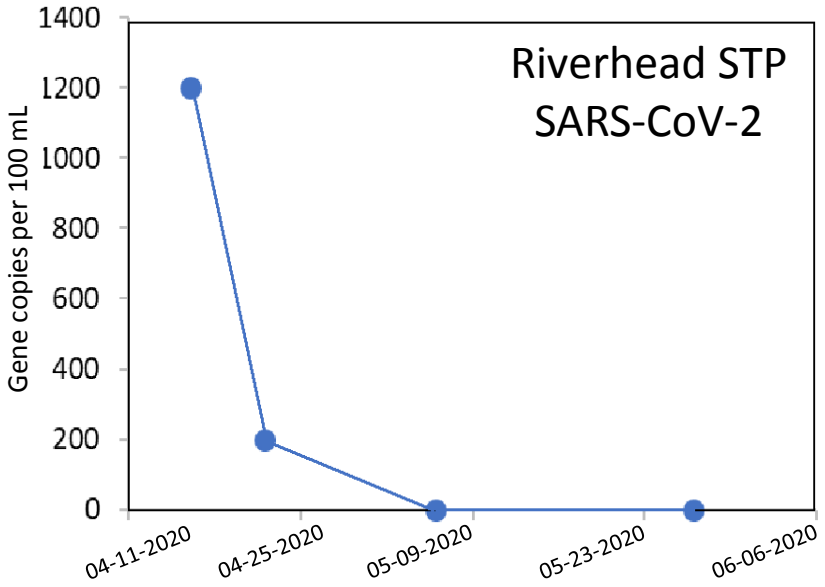
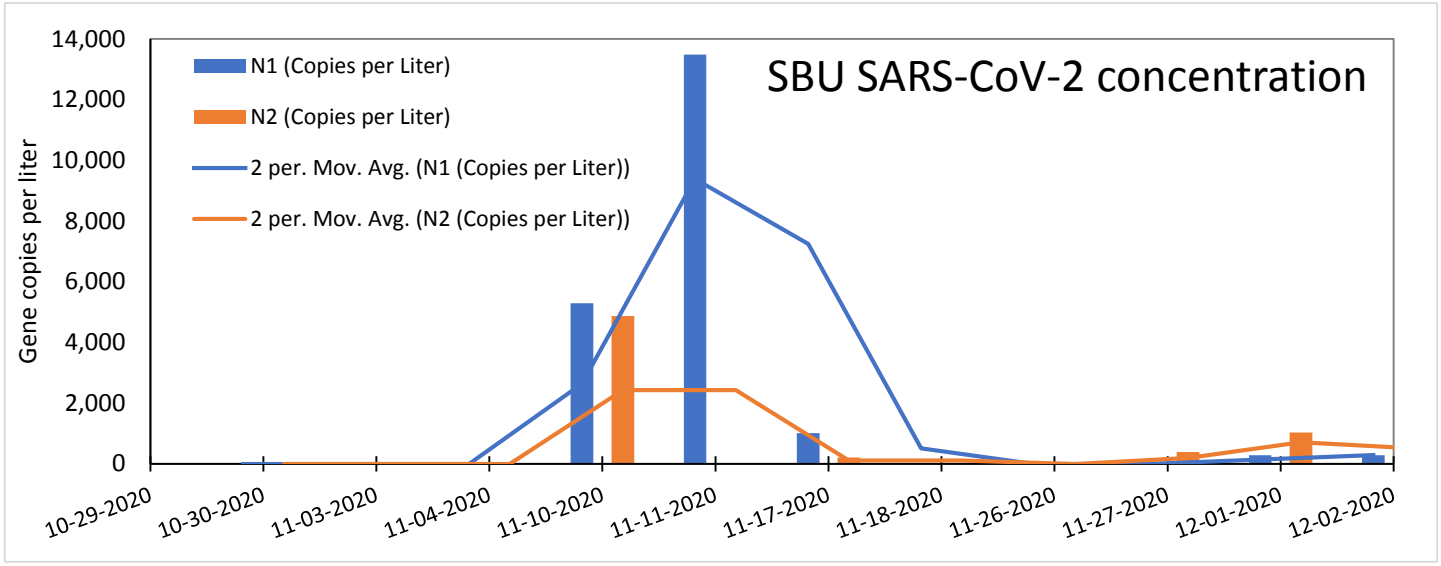
First efforts of wastewater surveillance

- In **April 2020**, began collecting raw wastewater samples from **Riverhead STP**
- During **fall 2020**, began sampling effluent from the **Stony Brook University** dorms







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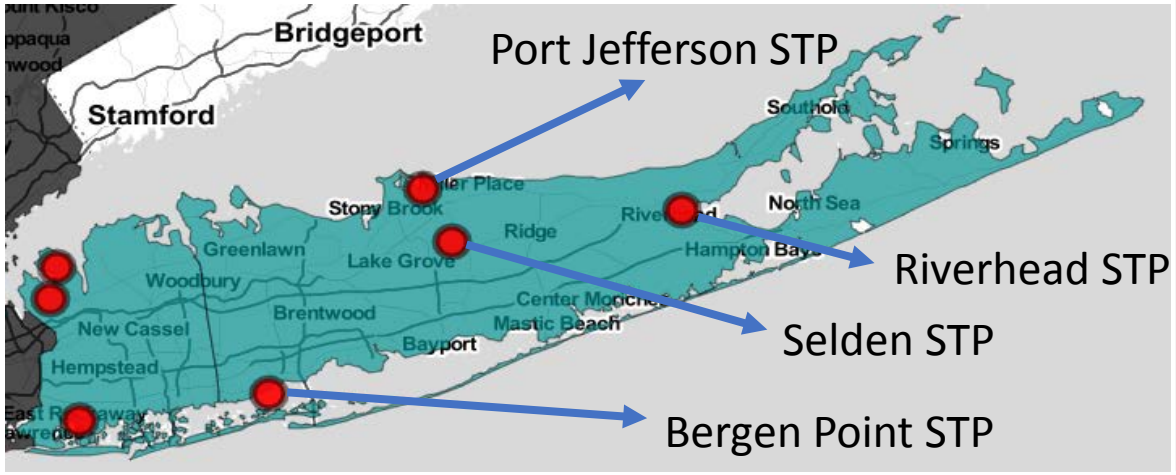
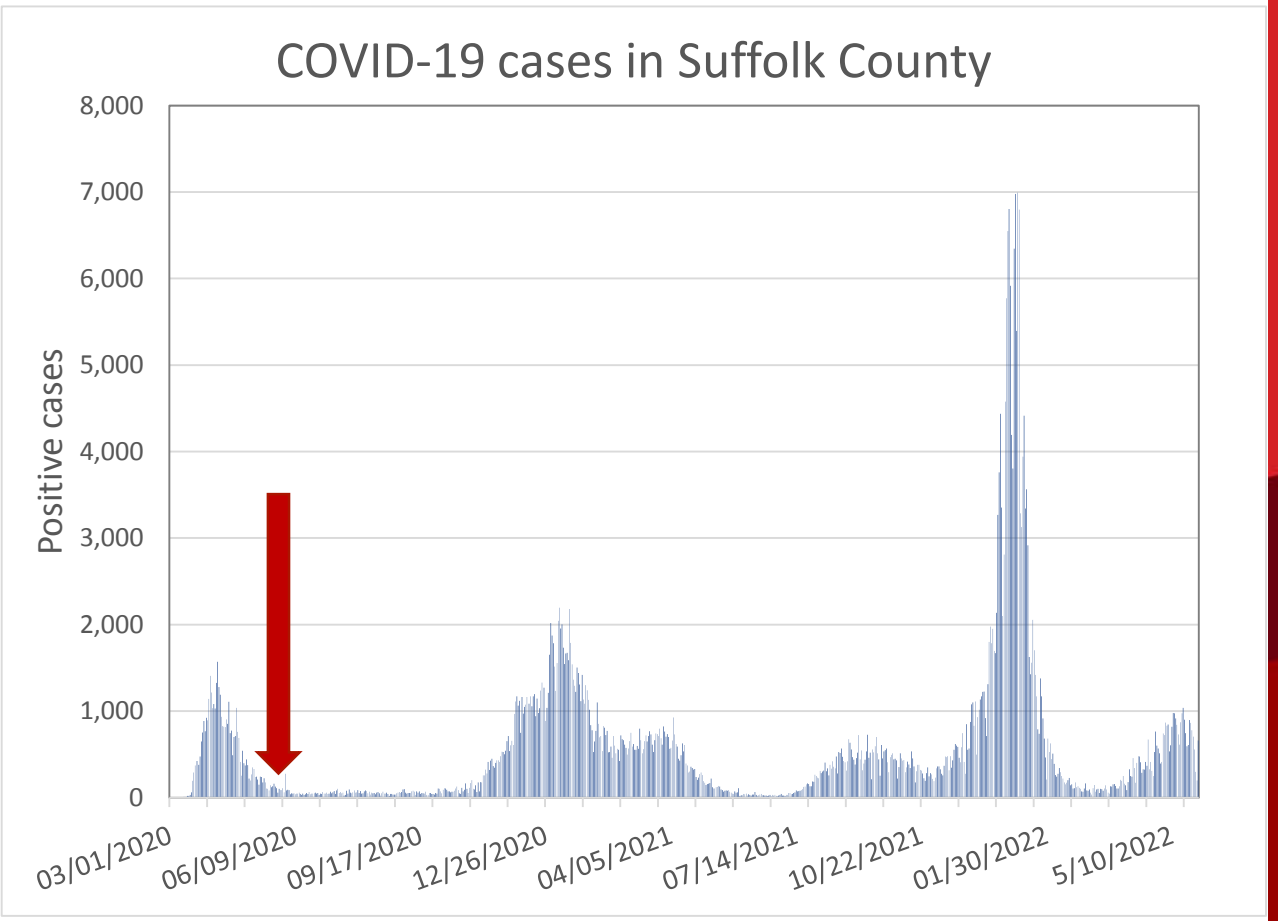
Wastewater Surveillance of SARS-CoV-2 in Suffolk County

- **June 2020**: raw wastewater samples from the Bergen Point STP, largest STP in Suffolk County
- **April 2021**: Selden STP
- **February 2022**: Port Jefferson STP
- **May 2022**: Riverhead STP





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Sampling

- Overview of Sampling Strategy
  - Collect **untreated wastewater** from STPs
  - Sampling **upstream** from **pump stations**
- Frequency of Sampling
  - **Two/three times weekly sampling** to provide actionable and timely data regarding changes in COVID-19 transmission
  - **A series of multiple samples** taken from the same point reveal trends in viral transmission
- Types of Samples
  - **Composite samples**: take a small quantity of wastewater continuously to create a composite sample over 24 hours

WWTP name	Population served	Capacity (MGD)
Bergen Point STP	278,775	30.5
Selden STP	24,147	2.4
Port Jefferson STP	3,349	1.15
Riverhead STP	7,741	1.3

Composite Autosampler

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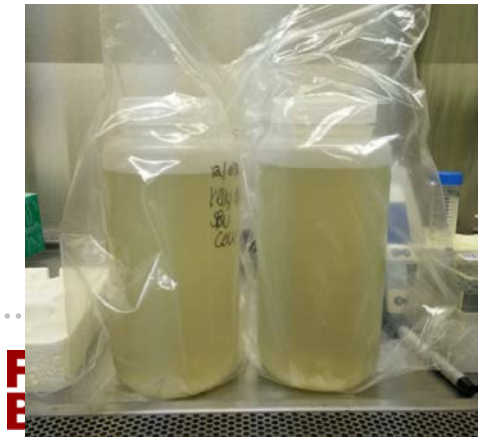
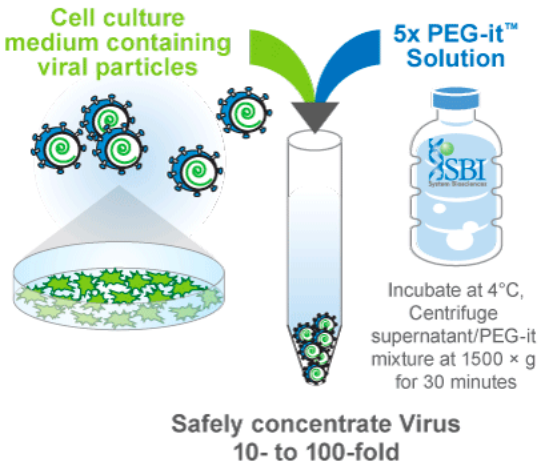
Analytical workflow

Sample preparation → Sample concentration → RNA extraction → RNA measurement

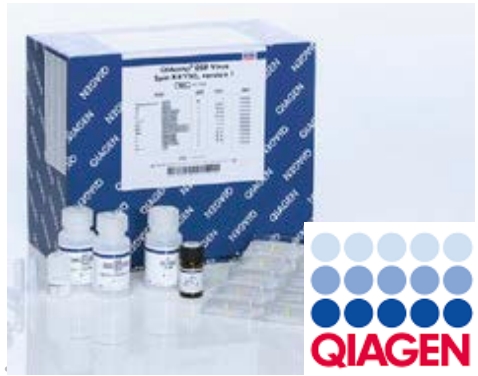
Process within 24 hours by centrifugation to remove large solids



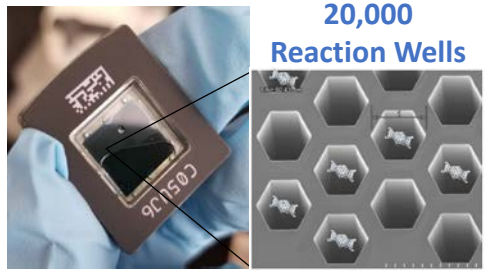
Polyethylene glycol (PEG) precipitation



From the suspension by an extraction kit



RT-digital PCR: detection and quantification method



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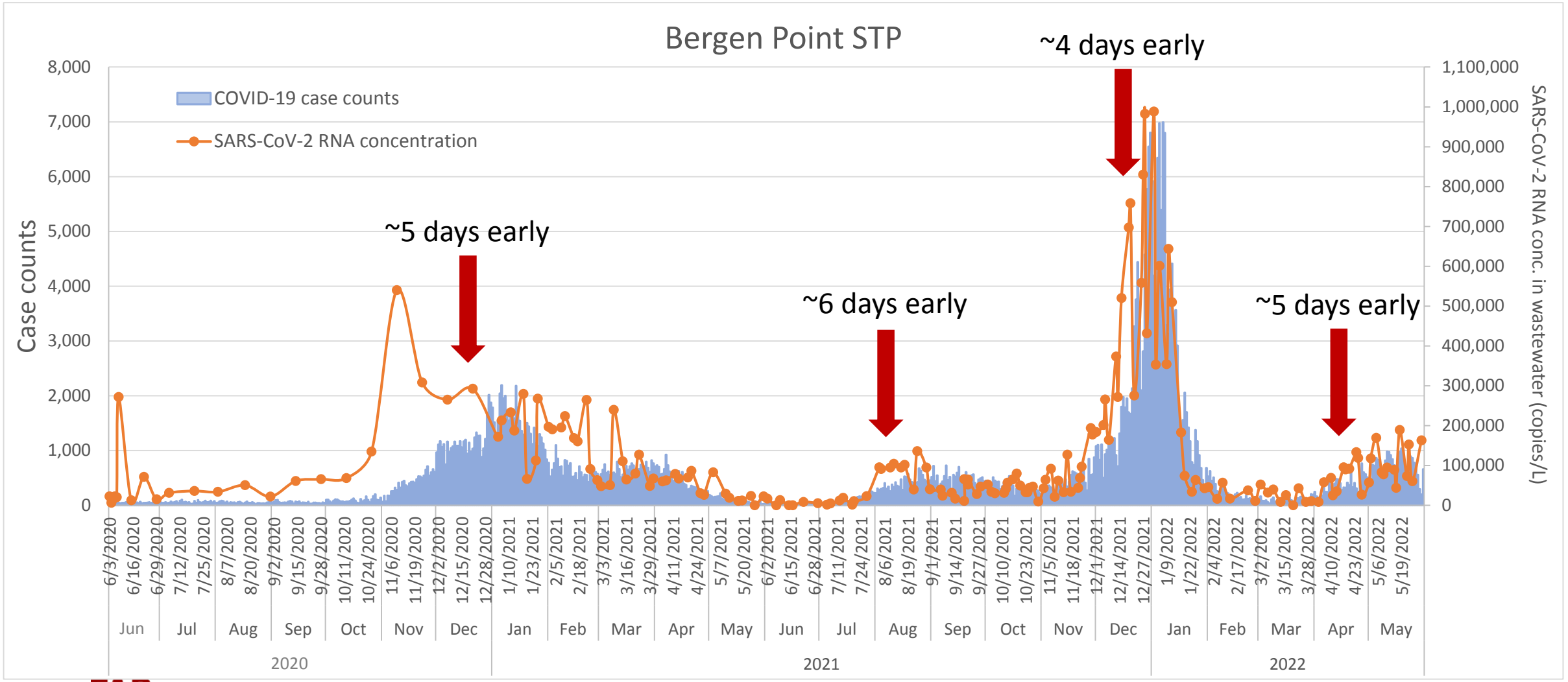
COVID-19 wastewater data in Suffolk County



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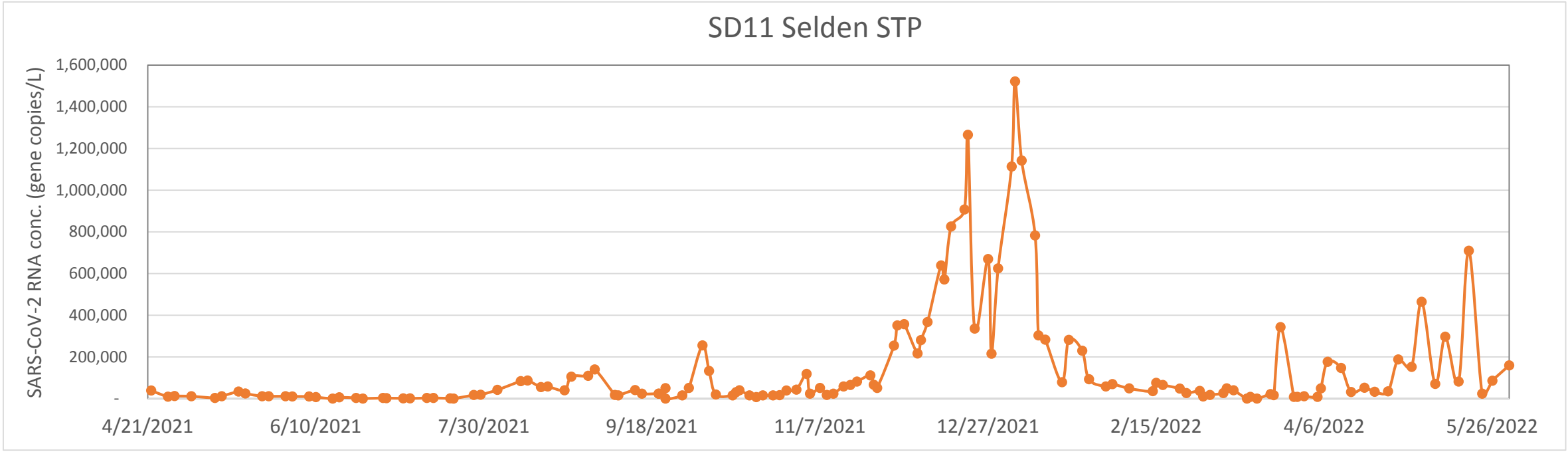
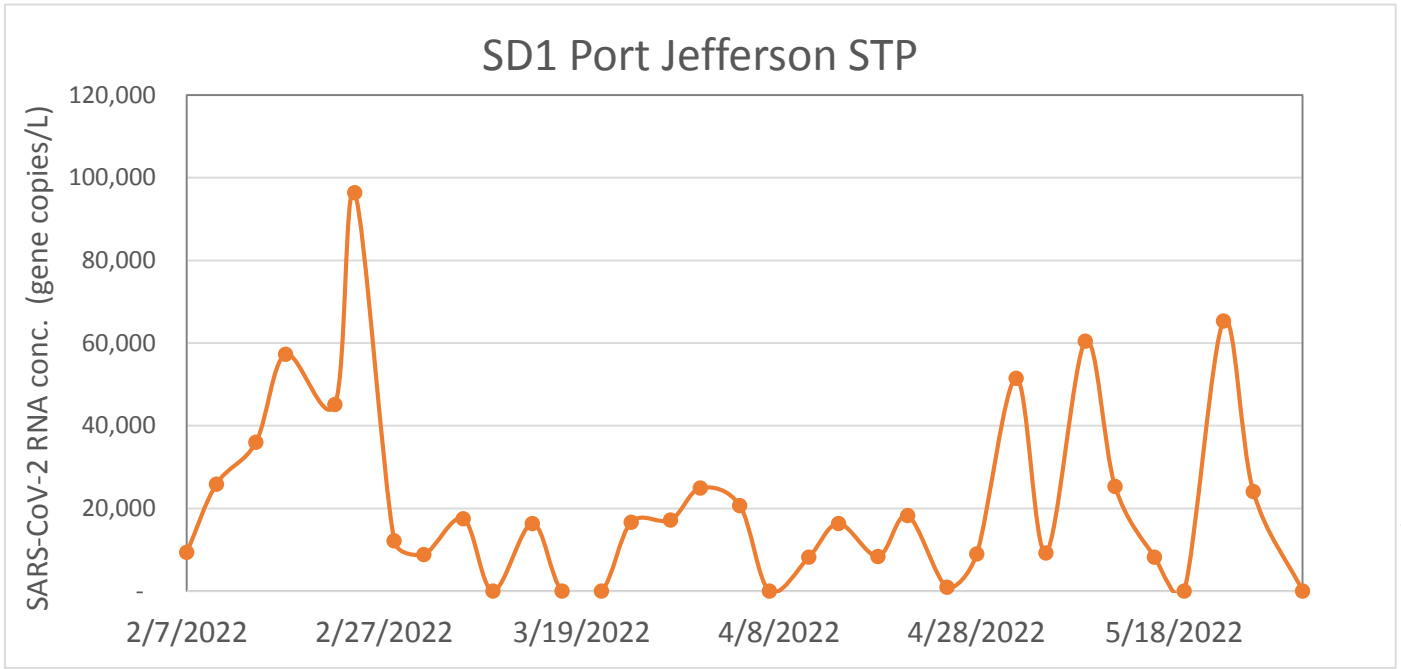
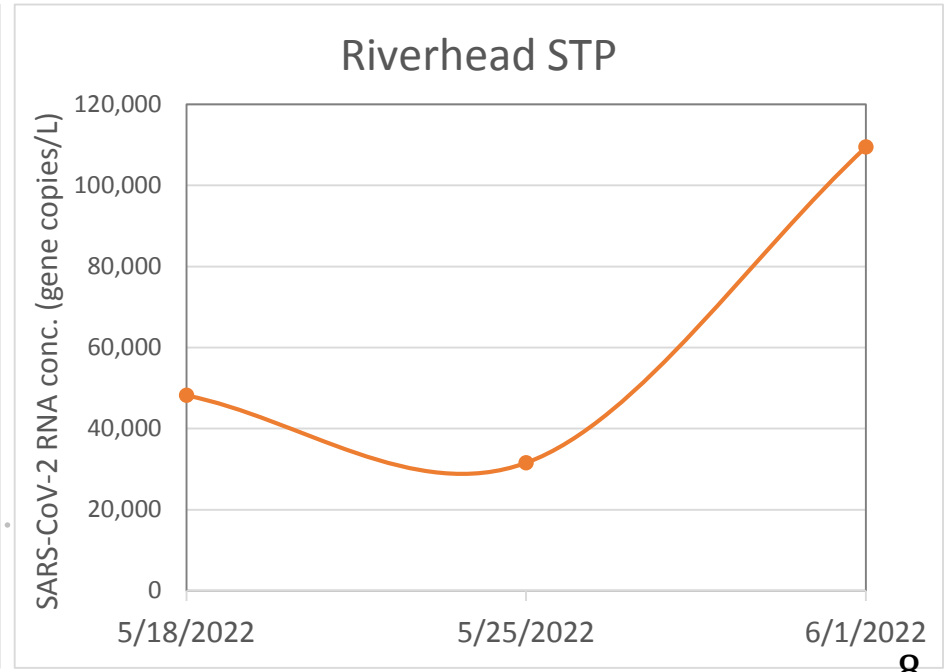

SD11 Selden STP
SARS-CoV-2 RNA conc. (gene copies/L)
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
4/21/2021
6/10/2021
7/30/2021
9/18/2021
11/7/2021
12/27/2021
2/15/2022
4/6/2022
5/26/2022


SD1 Port Jefferson STP
SARS-CoV-2 RNA conc. (gene copies/L)
120,000
100,000
80,000
60,000
40,000
20,000
-
2/7/2022
2/27/2022
3/19/2022
4/8/2022
4/28/2022
5/18/2022


Riverhead STP
SARS-CoV-2 RNA conc. (gene copies/L)
120,000
100,000
80,000
60,000
40,000
20,000
0
5/18/2022
5/25/2022
6/1/2022

Statewide participation summary [1]

55	99	4,750,009
Participating counties	Participating WWTPs	Population covered

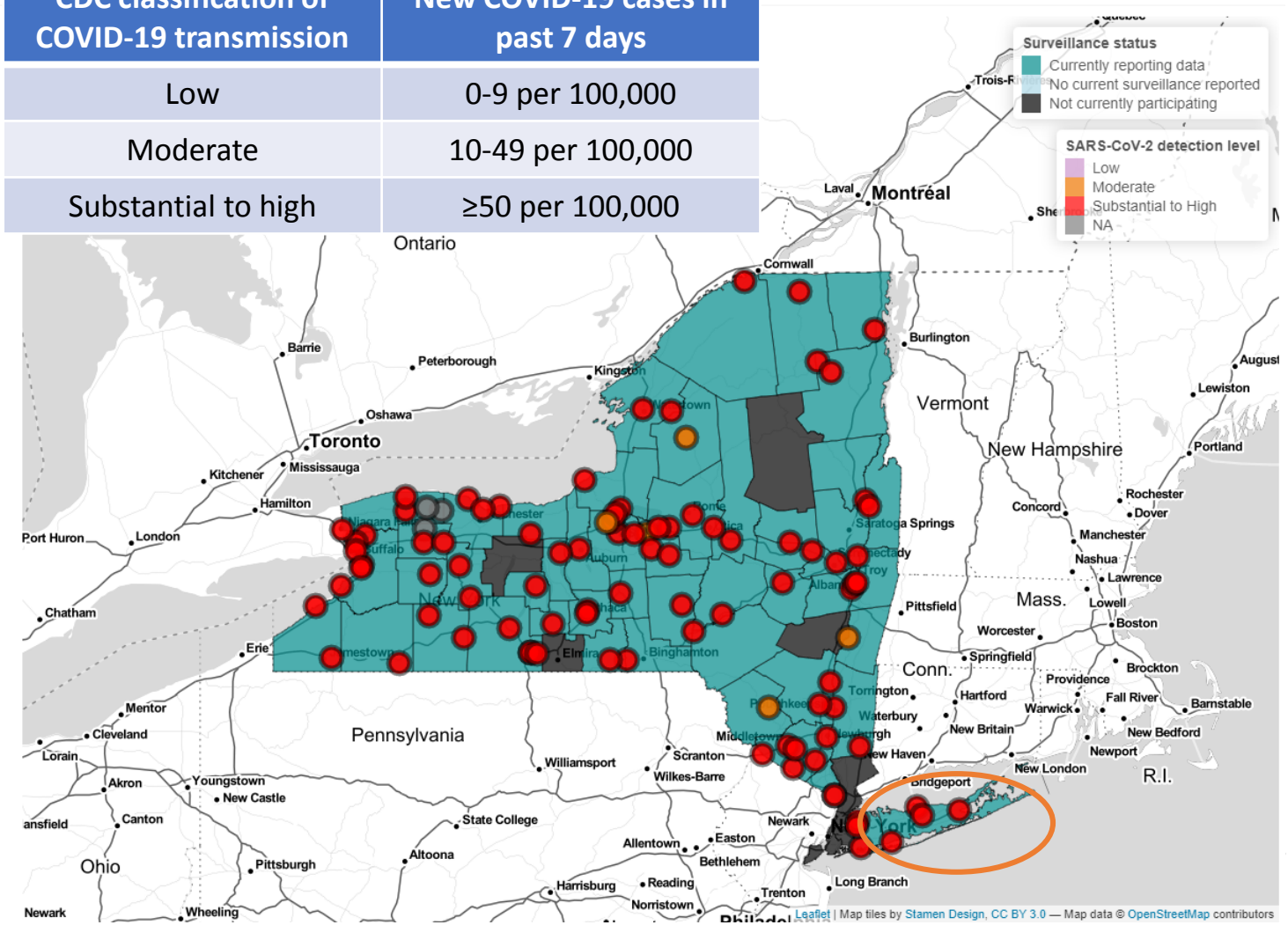
[1] Participation as of Jun 14, 2022

State Dashboard
Resources and toolkit
Information

Wastewater trend
- SARS-CoV-2 intensity
- Gene copies

Cases data
- New cases
- Active cases
- Test positivity

CDC classification of COVID-19 transmission	New COVID-19 cases in past 7 days
Low	0-9 per 100,000
Moderate	10-49 per 100,000
Substantial to high	≥50 per 100,000



https://mbcolli.shinyapps.io/SARS2EWSP/#

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Antiviral drugs in wastewater

- Monitor antiviral drugs and other licit and therapeutic drugs
  - Complement and strengthen RNA-based method
  - Understand the impact of the pandemic on pharmaceutical consumption

#	Compound	Abbrev.	Note
1	Chloroquine	CQ	Antiviral
2	Hydroxychloroquine	HCQ	Antiviral
3	Remdesivir	REM	Antiviral
4	Desethyl Chloroquine	DCQ	Metabolite
5	Desethyl Hydroxychloroquine	DHCQ	Metabolite

- FDA Emergency Use Authorization (EUA):
  - CQ and HCQ (March 28, 2020)
  - Remdesivir (May 1, 2020)

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https://www.fda.gov/news-events/press-announcements/fda-approves-first-treatment-covid-19

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Pharmaceuticals in wastewater

#	Compound	Note	OTC	#	Compound	Note	OTC
1	Acetaminophen	Analgesic/Antipyretic	Y	14	Nifedipine	Antihypertensive	N
2	Atenolol	Antiarrhythmic	N	15	Primidone	Anticonvulsant	N
3	Carbamazepine	Anticonvulsant	N	16	Propranolol	Antiarrhythmic	N
4	Cimetidine	Antihistamine	Y	17	Ranitidine	Antihistamine	Y
5	Diclofenac	Anti-inflammatory	N	18	Salbutamol	Antiasthmatic	N
6	Diltiazem	Antiarrhythmic	N	19	Sulfamethoxazole	Antibiotic	N
7	Diphenhydramine	Antihistamine	Y	20	Trimethoprim	Antibiotic	N
8	Fenofibrate	Anticoagulant	N	21	Venlafaxine	Antidepressant	N
9	Fluoxetine	Antidepressant	N	22	Warfarin	Anticoagulant	N
10	Ketoprofen	Anti-inflammatory	N	23	Caffeine	Stimulant	-
11	Lamotrigine	Anticonvulsant	N	24	Paraxanthine	Metabolite of caffeine	-
12	Metoprolol	Antiarrhythmic	N	25	Nicotine	Stimulant	-
13	Naproxen	Anti-inflammatory	Y	26	Cotinine	Metabolite of nicotine	-

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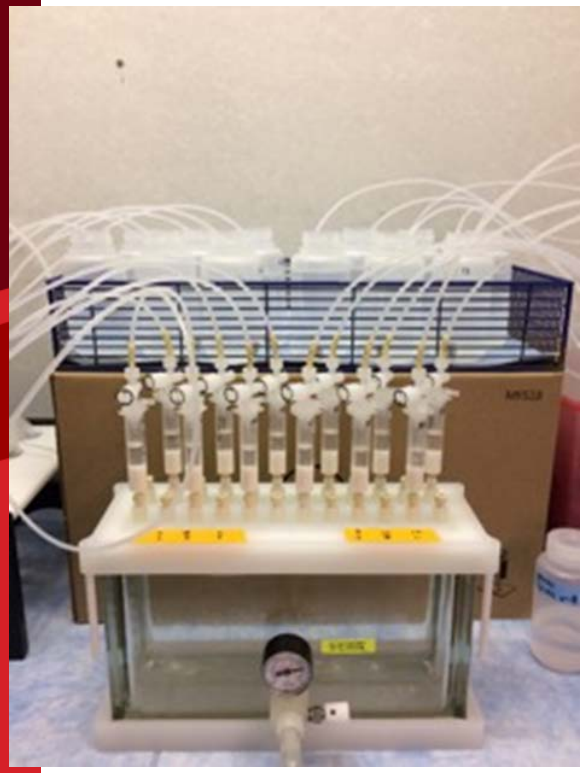
Analytical method



100 mL wastewater sample

↓

Add isotopically labelled standard

↓

Solid phase extraction (HLB cartridge)

↓

Add internal standard

↓

LC-MS/MS analysis

Agilent 6495B LC-MS/MS system

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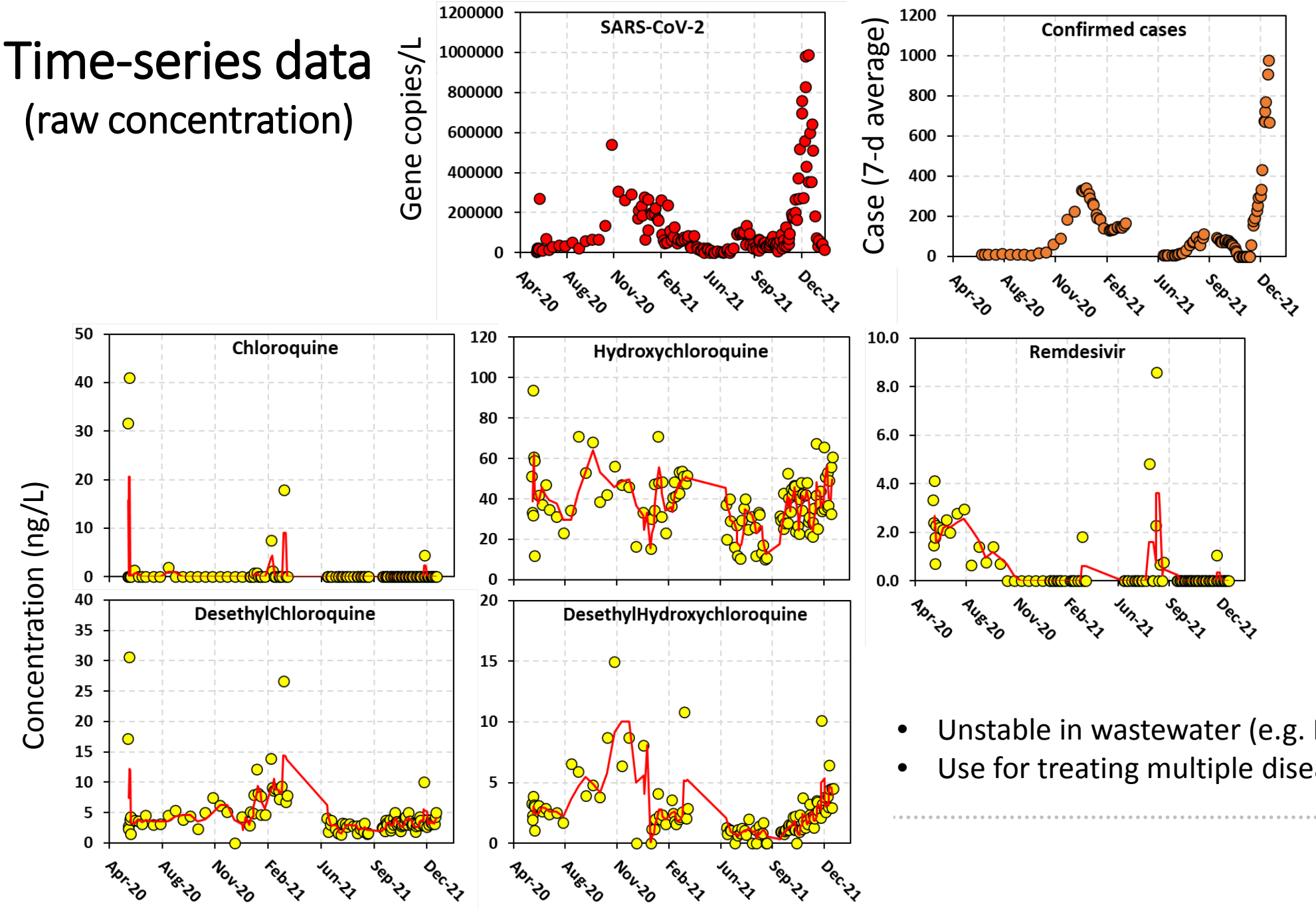
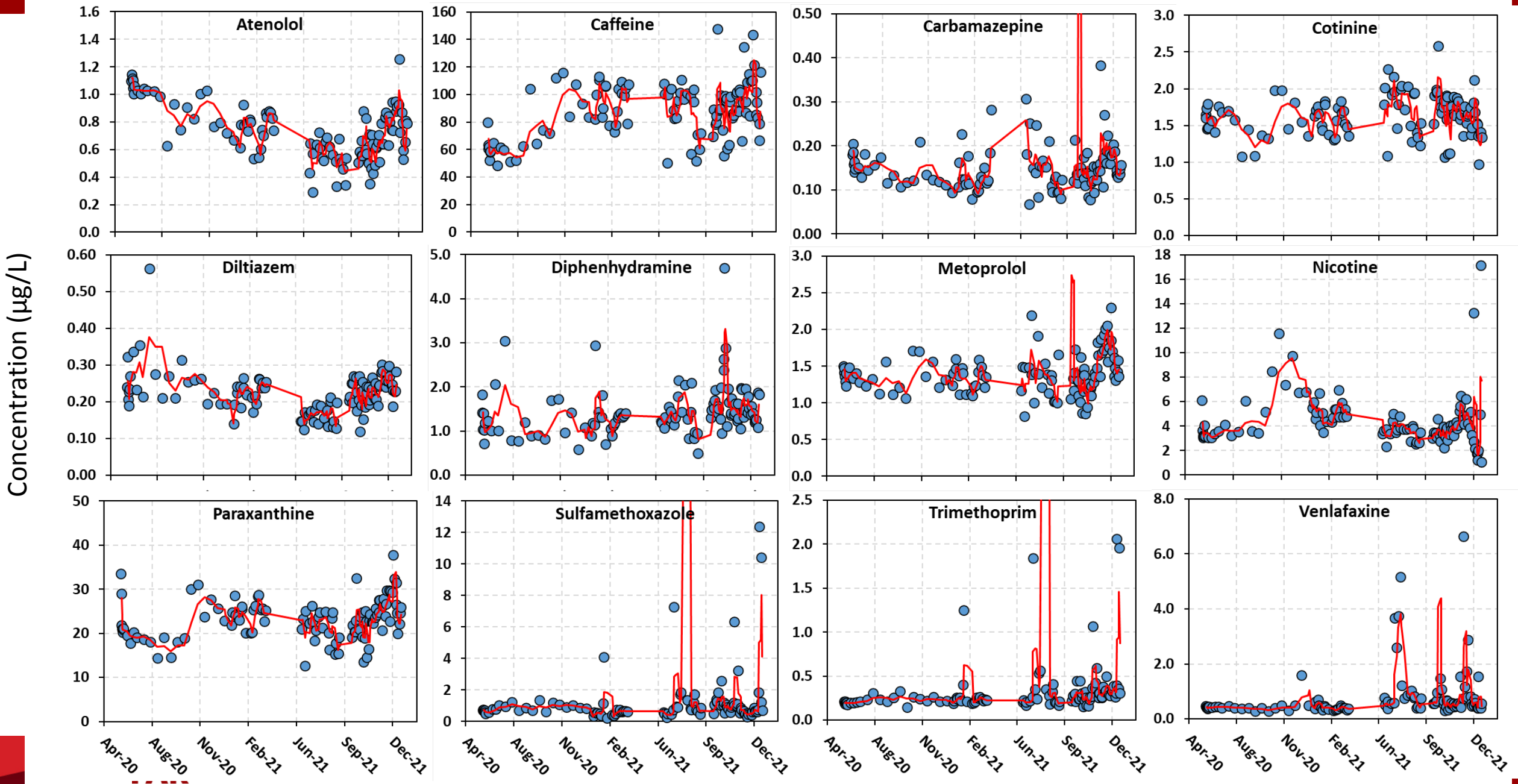
Time-series data
(raw concentration)



- Unstable in wastewater (e.g. Remdesivir)
- Use for treating multiple diseases (e.g. HCQ)


Concentration (µg/L)
Atenolol
Caffeine
Carbamazepine
Cotinine
Diltiazem
Diphenhydramine
Metoprolol
Nicotine
Paraxanthine
Sulfamethoxazole
Trimethoprim
Venlafaxine
Apr-20
Aug-20
Nov-20
Feb-21
Jun-21
Sep-21
Dec-21

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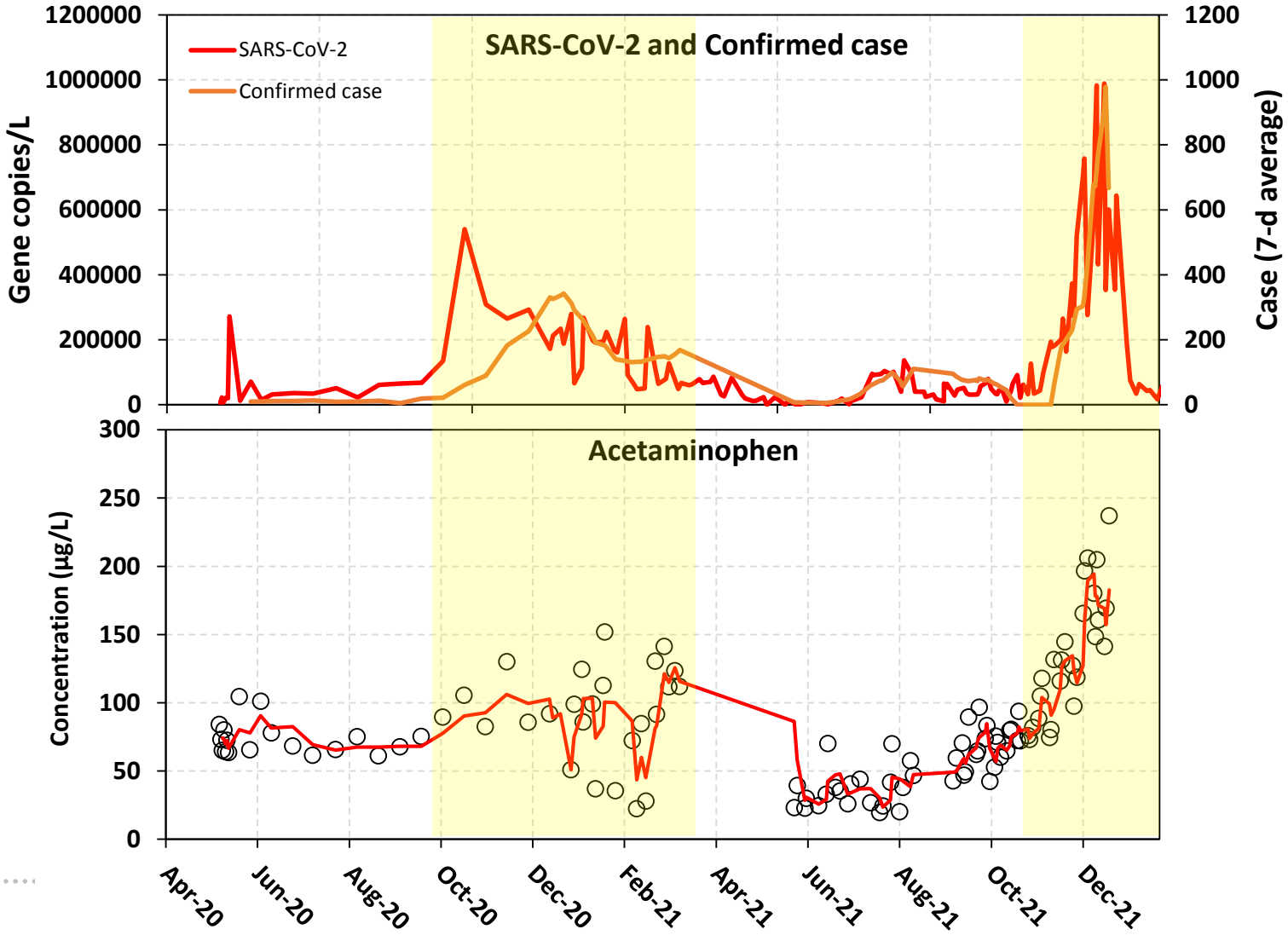
Time-series data



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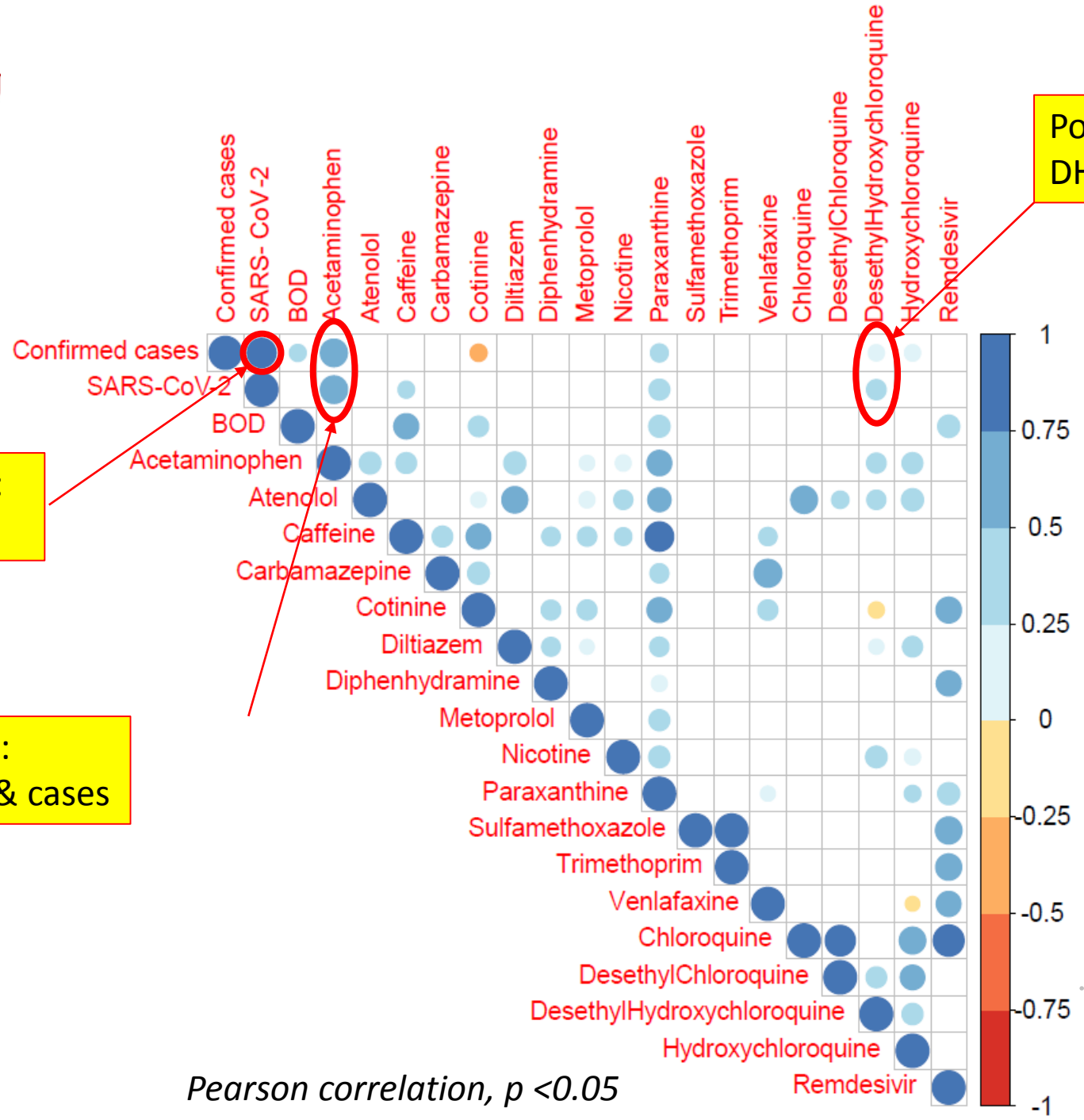
Positive correlation:
DHCQ vs. virus & cases

Strong positive correlation:
virus conc. vs. cases

Good positive correlation:
acetaminophen vs. virus & cases



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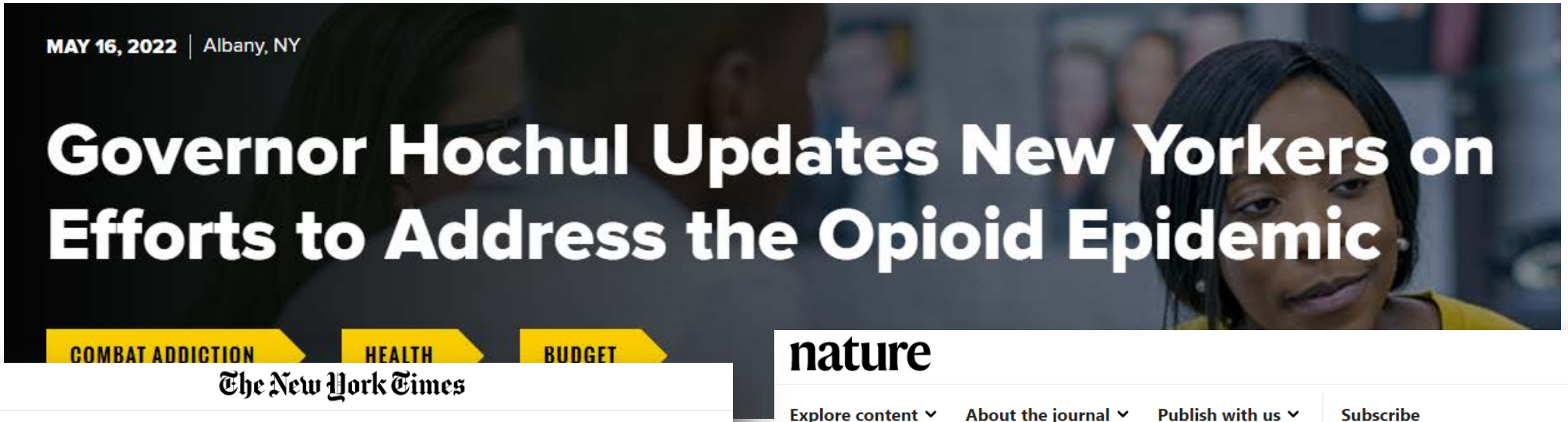
Pearson correlation, p <0.05



The New York Times

Fentanyl Tainted Pills Bought on Social Media Cause Youth Drug Deaths to Soar

Teenagers and young adults are turning to Snapchat, TikTok and other social media apps to find Percocet, Xanax and other pills. The vast majority are laced with deadly doses of fentanyl, police say.

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NEWS | 01 June 2022

Mega-model predicts US opioid deaths will soon peak

The crisis is projected to claim more than half a million more lives from 2020 to 2032, although yearly deaths are on course to start falling before 2025.

Naloxone
Naltrexone
(±)-Methadone
EDDP
Meperidine
Buprenorphine
Dihydrocodeine

alcohol

WSJ | OPINION

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Fentanyl Overdose Rates Are Rising Fast

The drug will continue killing Americans until Biden decides to get control of the border.

By Joseph Grogan and Casey B. Mulligan
May 18, 2022 6:22 pm ET

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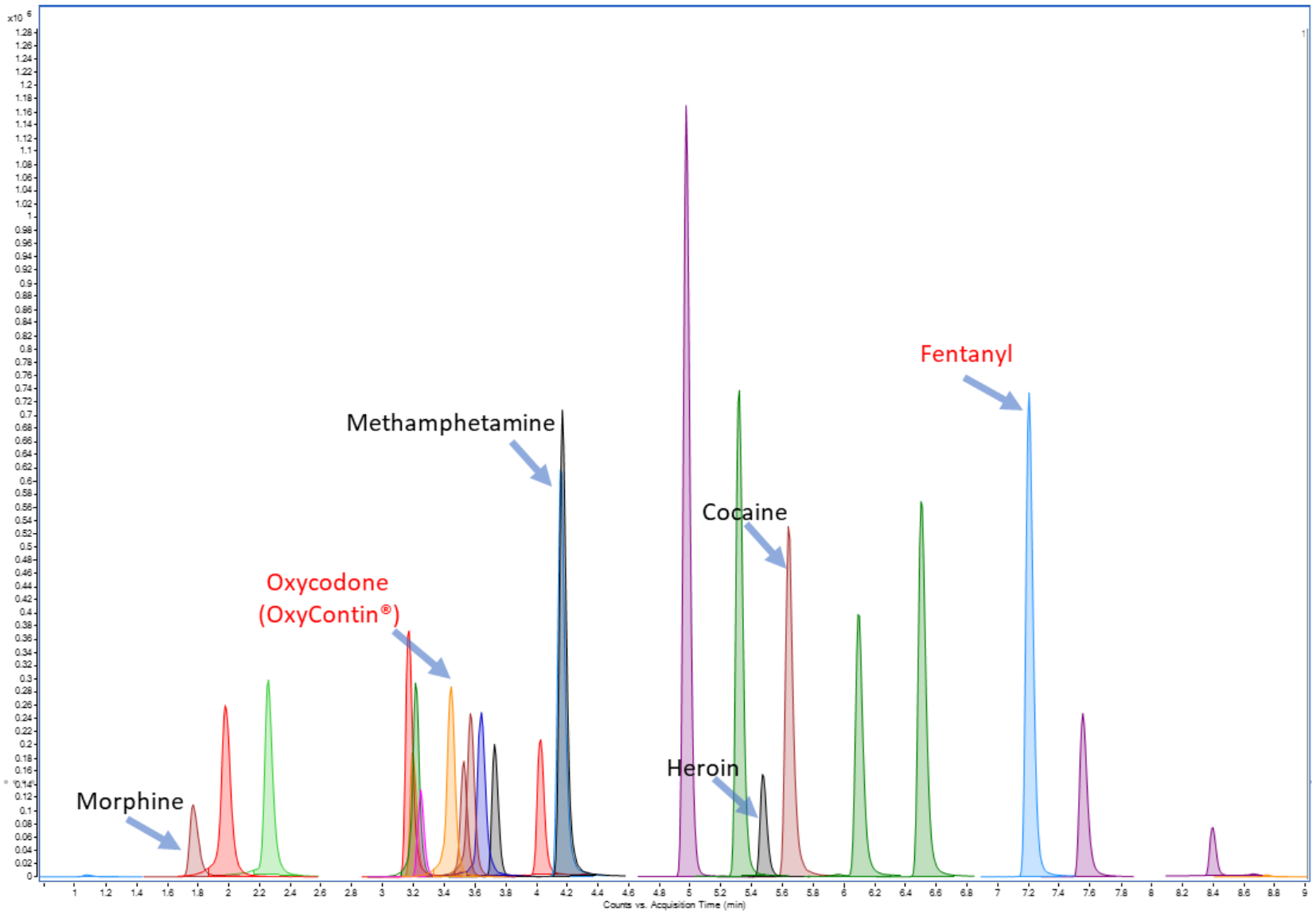
Wastewater surveillance of opioids



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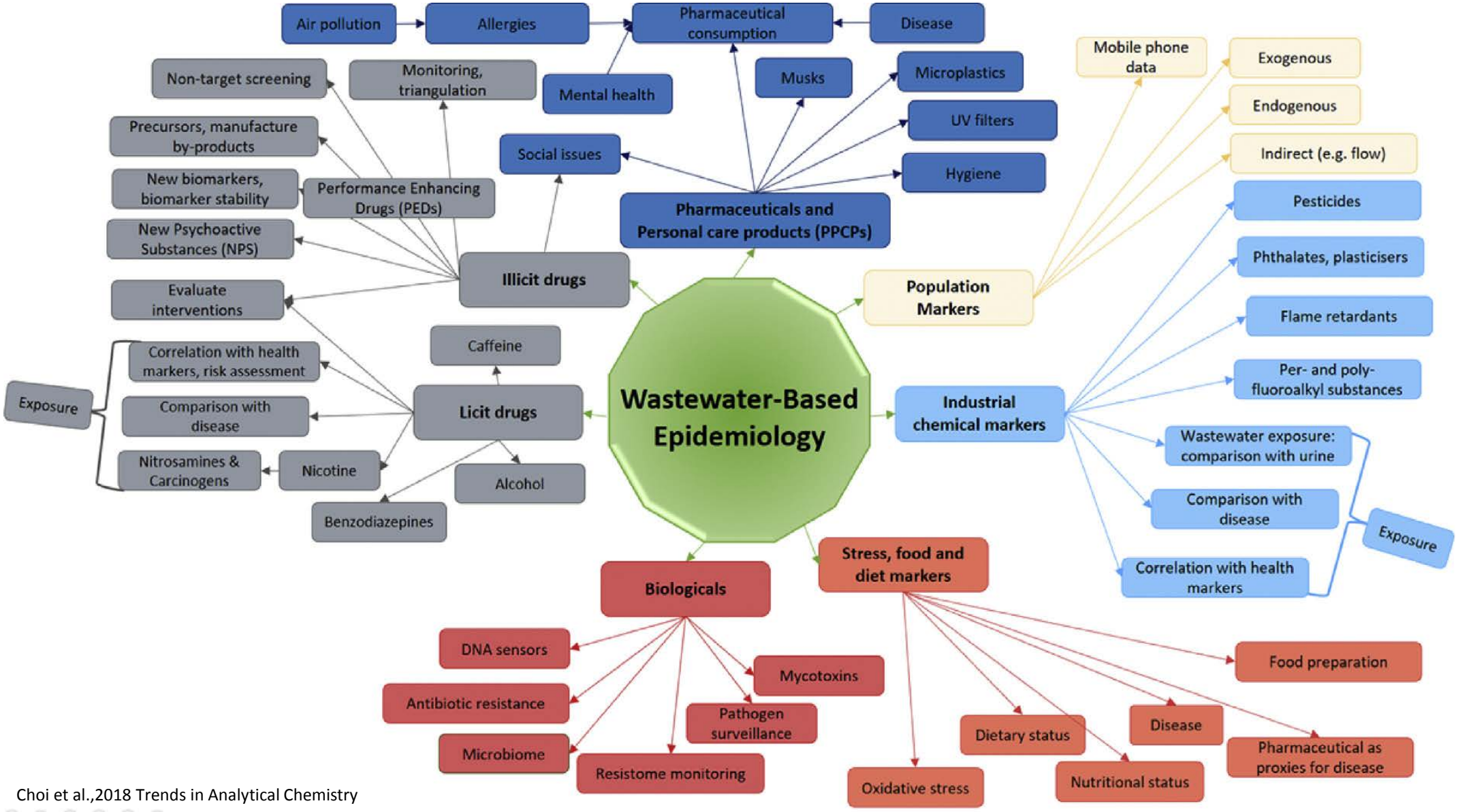
Future of wastewater surveillance



Choi et al.,2018 Trends in Analytical Chemistry

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Acknowledgments

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- Ann Marie Famularo, Hannah Winslow, Timothy Wong
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- Thank you to Stony Brook University, NYS, Suffolk County, Bergen Point STP, SCDHS, DOH for support
- Thank you for your attention.

- Follow us on Twitter: @nysccwt
- https://www.stonybrook.edu/cleanwater/
- Sign up for our email list: ccwt@stonybrook.edu

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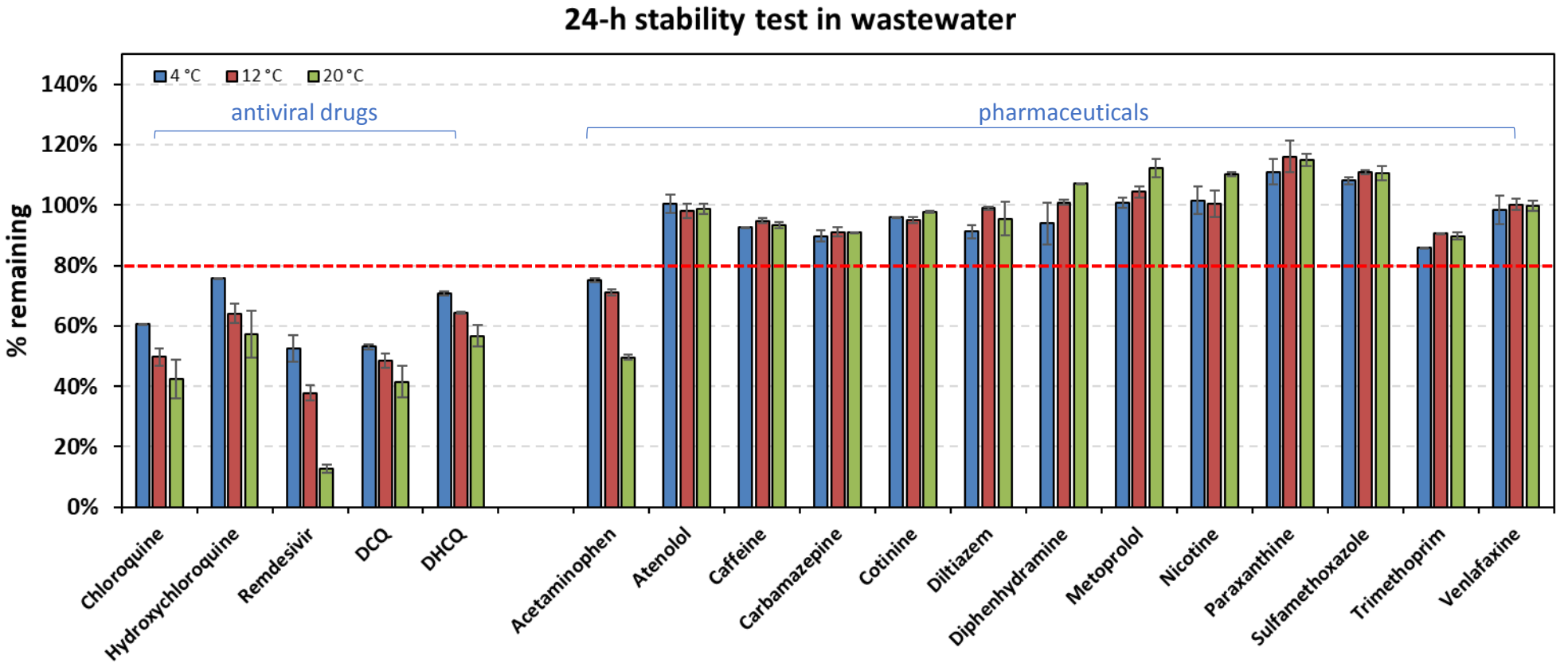
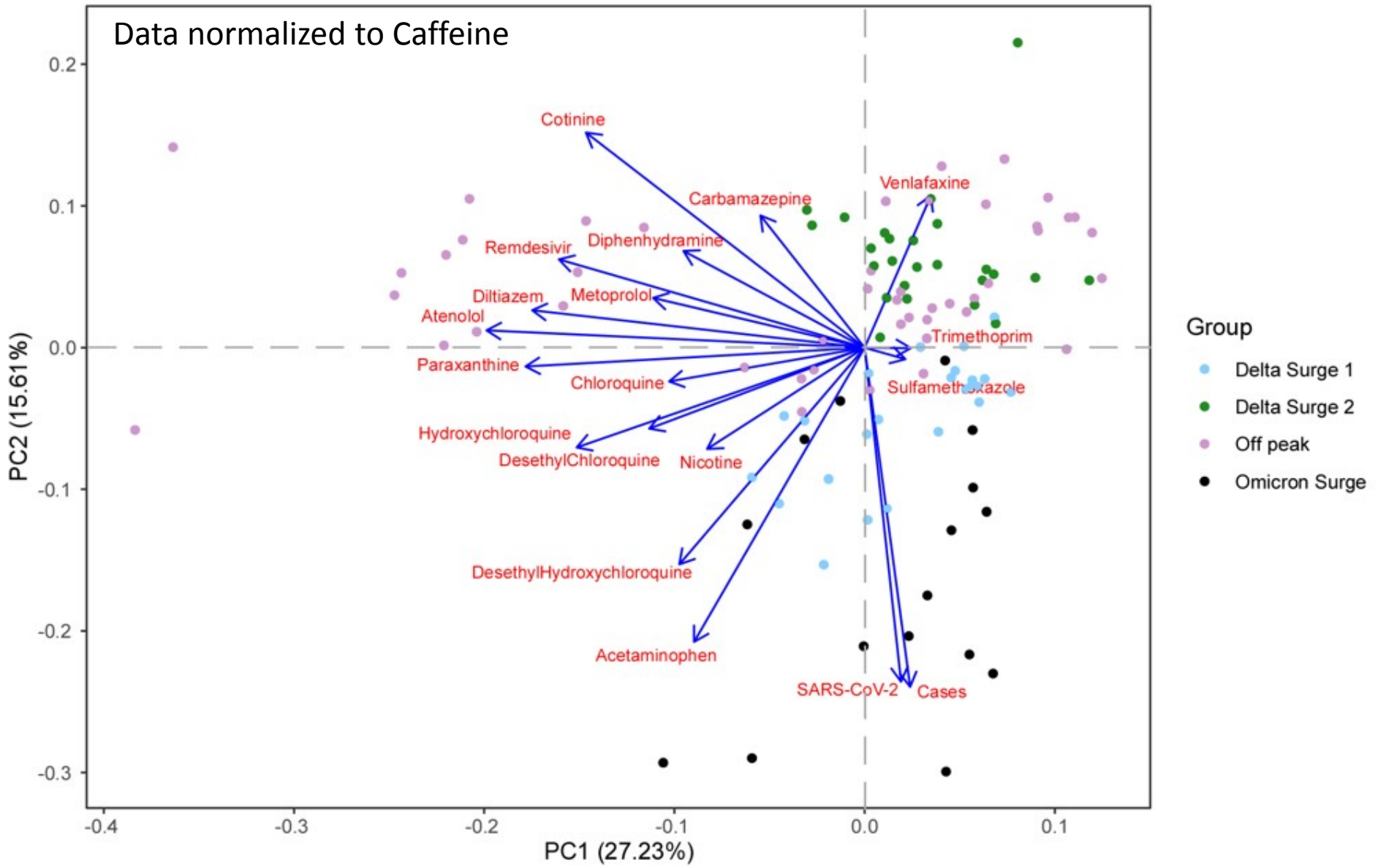
Influent concentration (ng/L or µg/L) → *WW flow* / *attenuation* → **Daily mass load (mg/day)** → *population* / *metabolic rate* / *excretion rate* → **Daily consumption (mg/capita/day)**

- Bergen Point STP
  - Influent temperature underground: 10−11 ˚C (winter) and 18−20 ˚C (summer)
  - Average travel time in sewer lines: 40 minutes to 8 hours
  - Composite sample: collecting every 15 min at <6 ˚C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