※ 注意：全部題目均請作答於試卷內之「非選擇題作答區」，請標明題號依序作答。

Please refer to the following paper for question 1-4

Letter to the Editor: Wastewater-Based Epidemiology Can Overcome Representativeness and Stigma Issues Related to COVID-19

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Environ. Sci. Technol. *2020, 54, 5311- 5311*

We read with great interest the Viewpoint by Mao et al., "Can a Paper-Based Device Trace COVID-19 Sources with Wastewater-Based Epidemiology?"[1] We agree regarding the benefits of a wastewater-based epidemiology (WBE) approach in predicting the spread of the COVID-19 infection by analyzing the presence of the virus in wastewater. Concentrations of the norovirus in wastewater samples collected every week accurately reflect the infection in the watershed, suggesting that this approach can serve as a warning of a public outbreak.[2] We suggest additional advantages to this approach and call for a wastewater collection campaign involving international cooperation between environmental researchers, wastewater workers, and public health specialists, aimed at preventing the spread of COVID-19.

The WBE approach to testing for COVID-19 has potential advantages over testing the public. First, virus concentrations in wastewater represent the overall status of the watershed, while the number of COVID-19 cases involving infected people is possibly biased. Testing of the public seldom involves complete enumeration or even randomized sampling, because these sampling methods tend to overwhelm or collapse the medical care system, have the disadvantage of false-positives, and are time and labor intensive. The WBE approach is effective in identifying temporal changes in the infection status in the watershed without selection bias. Its second advantage relates to the issue of the stigma that can result from a COVID-19 outbreak. Infected people, or those diagnosed with a false-positive, together with their families, are potentially harmed by stigma and discrimination as well as social isolation.[3] This is one of the disadvantages of testing in complete enumeration or randomized sampling of the entire population. So far, WBE may not have been preferred due to potential regional stigma; however, WBE has proved its value by avoiding individual stigmatization. By contrast, in the current context of a worldwide outbreak of COVID-19, details of the number of cases in a particular region, and sometimes identifying details of infected individuals, are already being broadcast.

Detection of SARS-CoV-2 in urban wastewater has been reported in The Netherlands where RT-qPCR tests have been used,[4] although these tests still need more careful investigation regarding their sensitivity and specificity. The necessary analytical techniques must be developed, and in the meantime, wastewater samples should be collected and frozen regularly for future validation of the method and reconstruction of the temporal trends of the infection. Meeting this challenge could provide a perspective on preventing the continuing spread of the COVID-19 pandemic.

https://dx.doi.org/10.1021/acs.est.0c02172 Environ. Sci. Technol. 2020, 54, 5311−5311

Wastewater-based epidemiology (WBE) is a method to estimate the consumption, or exposure to chemicals/pathogen in a population. Chemicals/pathogen can be excreted from our body, go through sewages and eventually to the wastewater treatment plants. Therefore, by measuring the concentrations of chemicals/pathogen in wastewaters and through the back-calculation, the total usage or exposure can be estimated. WBE has commonly being used to monitor illicit drug use in the communities and has also recently being used for COVID-19.

1.(10%) What type of water pollutant is COVID-19?

a. Infectious agents
b. Organic chemicals
c. Inorganic chemicals
d. Radioactive materials

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2.(10%) This back-calculation equation below has been used in Australia to get the total consumption (doses per day per 1000 people) of illicit drugs used in the community, where **concentration** (**analyte**) of illicit drugs is measured in the wastewaters. Assuming that we can use similar equation to estimate the exposure to COVID-19 in the community, in the case where we don't have "Flow volume" and "Catchment population in 1000's" data, what other data can be used instead? In other words, which parameters in the wastewaters can be used as biomarkers to represent/indicate wastewaters that were originated from human usage instead of other sources (i.e. rain water, industrial wastewaters, etc)? (Please select the **least appropriate** or the **least suitable** biomarker)

$$\textit{Total consumption (dose per day per 1000 people)} = Analyte\left(\frac{ng}{L}\right) \times \left(\frac{Flow\ volume(ML/day)}{Catchment\ population\ in\ 1000's}\right) \times \left(\frac{Mw\ ratio}{Excretion\ factor}\right)$$

a. BOD (Biological Oxygen Demand)
b. Ammonia Nitrogen
c. Total Nitrogen
d. Total Phosphorus
e. Total Carbon

3.(10%) Please explain your choice for Question 2

4.(20%) In addition to the parameters listed in the back-calculation equation above, what other factors do you need to consider in order to improve the use of WBE for estimating the exposure of COVID-19/ or consumption of illicit drug? In other words, what other important variables are not considered in the equation? Please explain.

Please refer to the following statements for question 5-8

In 2020, Taiwan recorded the first flood season (May to November) without any single typhoon since 1964. As a result, reservoirs across the island saw unexpected low water storages, halting the irrigation in some regions. Several measures were planned by the government to improve the situation, including more extensive wastewater recycling and seawater desalination. In fact, even under normal circumstances, the annual average amount of water available per capita in Taiwan is around 4000 m^3, lower than the global average.

5.(10%) The average annual rainfall in Taiwan is around 2500 mm, about 2.6 times higher than the global average. Given the high rainfall, explain why Taiwan has a lower-than-average annual per capita amount of water.

6. (10%) What are the major freshwater uses in Taiwan and globally? Rank these uses from high to low.

7. (10%) Please propose a treatment train for indirect portable water reuse for domestic wastewater.

8. (20%) Water Resources Agency plans to build a seawater desalination plant in Hsinchu. Please discuss its pros and cons considering all social, economic and environmental implications.

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