Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Critical role of Hyssop plant in the possible transmission of SARS-CoV-2 in contaminated human Feces and its implications for the prevention of the virus spread in sewage

Sasan Zahmatkesh\textsuperscript{a,\ast}, Jiří Jaromír Klemes\textsuperscript{b}, Awais Bokhari\textsuperscript{b,c,\ast\ast}, Chongqing Wang\textsuperscript{d}, Mika Sillanpaa\textsuperscript{e,f,g}, Mudassir Hasan\textsuperscript{h}, Kassian T.T. Amesho\textsuperscript{i,j}

\textsuperscript{a} Department of Chemical Engineering, University of Science and Technology of Mazandaran, P.O. Box 48518-78195, Behshahr, Iran
\textsuperscript{b} Sustainable Process Integration Laboratory, SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology, VUT Brno, Technická 2896/2, 616 00, Brno, Czech Republic
\textsuperscript{c} School of Chemical Engineering, COMSATS University Islamabad (CU), Lahore Campus, Lahore, Punjab, 54000, Pakistan
\textsuperscript{d} School of Chemical Engineering, Zhengzhou University, Zhengzhou, 450001, China
\textsuperscript{e} Faculty of Science and Technology, School of Applied Physics, University Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia
\textsuperscript{f} International Research Centre of Nanotechnology for Himalayan Sustainability (IRCNHS), Shoolini University, Solan, 173212, Himachal Pradesh, India
\textsuperscript{g} Department of Chemical Engineering, School of Mining, Metallurgy and Chemical Engineering, University of Johannesburg, P. O. Box 17011, Doornfontein, 2028, South Africa
\textsuperscript{h} College of Engineering, Department of Chemical Engineering, King Khalid University, Abha, 61411, Saudi Arabia
\textsuperscript{i} Institute of Environmental Engineering, National Sun Yat-Sen University, Kaohsiung, 804, Taiwan
\textsuperscript{j} The International University of Management, Centre for Environmental Studies, Main Campus, Dorado Park Ext 1, Windhoek, Namibia

** Corresponding author.
\textsuperscript{\ast\ast} Corresponding author. Sustainable Process Integration Laboratory, SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology, VUT Brno, Technická 2896/2, 616 00, Brno, Czech Republic.

E-mail addresses: sasan.zahmatkesh@yahoo.com, sasan-zahmatkesh@mazust.ac.ir (S. Zahmatkesh), bokhari@fme.vutbr.cz, awaisbokhari@cuilahore.edu.pk (A. Bokhari).

The significant issue affecting wastewater treatment is human faeces containing SARS-CoV-2. SARS-CoV-2, as a novel coronavirus, has expanded globally. While the current focus on the COVID-19 epidemic is rightly on preventing direct transmission, the risk of secondary transmission via wastewater should not be overlooked. Many researchers have demonstrated various methods and tools for preventing and declining this virus in

\textbf{GRAPHICAL ABSTRACT}

A novel coronavirus known as SARS-CoV-2 has spread over the world wastewater. It is important to keep an eye out for secondary transmission via wastewater. The significant issue affecting wastewater treatment is human faeces containing this virus. We reported two people tested for 30 d, with written consent, at a hospital in Quchan, Iran.

\textbf{ARTICLE INFO}

Handling editor: Pau-Loke SHOW

Keywords:
SARS-CoV-2
Hyssop plant

\textbf{ABSTRACT}

The significant issue affecting wastewater treatment is human faeces containing SARS-CoV-2. SARS-CoV-2, as a novel coronavirus, has expanded globally. While the current focus on the COVID-19 epidemic is rightly on preventing direct transmission, the risk of secondary transmission via wastewater should not be overlooked. Many researchers have demonstrated various methods and tools for preventing and declining this virus in
Wastewater treatment
Faeces
Respiratory and digestive

1. Introduction

As of January 19, 2019, the World Health Organisation (WHO) has officially declared Coronavirus disease 2019 (COVID-19) (Lai et al., 2020), causing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Pal et al., 2020). The Coronaviridae family includes SARS-CoV-2, an enveloped virus containing a single-stranded RNA genome (Wang et al., 2020). Coronaviridae can cause various symptoms (Roussel et al., 2021), including common colds (Wang et al., 2021) and acute respiratory distress syndrome (Xia et al., 2021). There are two main routes by which SARS-CoV-2 is transmitted (Pavilonis et al., 2021): inhalation of aerosols/droplet (Port et al., 2021) and direct contact (Ng et al., 2021), but currently, evidence suggests that viral RNA can be found in wastewater. The faeces have recently been found to contain this virus (Chen et al., 2020). It can also be found in municipal sewage, spreading it to further areas from inadequately treated effluents; in this way, wastewater monitoring can be effectively implemented (Teymoorian et al., 2021).

Wastewater-based epidemiology (WBE) effectively calculates the prevalence, genetic diversity, and geographical distribution of viruses in a given community (Wurzler et al., 2021). In order to build a system for early warning and intervention, the WBE will require the development of a quick analytical approach for the on-site identification of viruses at the wastewater collection point (Hemalatha et al., 2021). An entire region’s faeces can be analysed with the help of wastewater systems (Prado et al., 2021). Many viral infections do not cause symptoms and clinical infections are often misdiagnosed, this method makes it possible to monitor an outbreak of viral infections even if they are not evidently based on clinical surveillance. This is highlighted by the fact that many viral infections are asymptomatic (LaTurner et al., 2021). In addition to the viruses shed via faeces, these limitations restrict other viruses such as norovirus, sapovirus, enterovirus, rotavirus, and hepatitis (Li et al., 2021).

The wastewater surveillance could help measure the spread of disease worldwide, despite limited clinical diagnosis resources and inaccessible or infeasible reporting systems, such as in developing countries (Albastaki et al., 2021). Last but not least, a wastewater surveillance program for SARS-CoV-2 could be beneficial because a wastewater surveillance program would provide up-to-date information about infection trends without affecting availability (Zahedi et al., 2021). In order to implement and interpret this new surveillance tool, practical and technological challenges must be addressed (Hoffmann and Alsing, 2021). An essential aspect of determining the level of this virus is to have an accurate method of measuring it in complicated wastewater matrices requiring specialised equipment and expertise (Wu et al., 2021).

The regularly updated data indicate that SARS-CoV-2 is present in faeces at about 100 ± 10 nm (Elsamadony et al., 2021). SARS-CoV-2 was detected in wastewater samples containing a concentration of up to 200 mL of raw wastewater (Qiu et al., 2021). In order to decrease and prevent SARS-CoV-2 transmissions (Brahim Belhaouari et al., 2021), the water concentration volumes should impact virus detection; 100 mL of untreated wastewater samples are sufficient to detect enteric viruses (Serra-Compte et al., 2021). A primary method for detecting SARS-CoV-2 is RT-qPCR or (nested) RT-PCR. Assays for SARS-CoV-2 that use RT-qPCR and nested RT-PCR are currently available (Zahmatkesh and Sillanpää, 2022).

Evidence shows that viral infections (SARS-CoV and SARS-CoV-2) exhibit many similar pathophysiological processes, including direct lung injury, cytokine storms, immunodeficiency, and other organ harm. SARS in 2003 (an outbreak caused by SARS-CoV) led to the study of many plants (as well as herbal teas and natural compounds) as potential treatments and preventions for Coronavirus infection (Ren et al., 2020). On the basis of the similarities between SARS-CoV and SARS-CoV-2 in epidemiology, genetics, and pathogenic processes, edible and medicinal plants may prove to be beneficial in the management of COVID-19 (Zahmatkesh et al., 2022). On the basis of our existing knowledge of the pathogen, a number of data-driven methods and computational chemical biology techniques (including molecular docking) have been used to screen prospective natural drugs for the management of COVID-19. In a relatively short amount of time, quite a few screenings on a massive scale have been carried out. There have been a lot of discoveries made on natural herbal medicines and dietary bioactive substances (Lin et al., 2021).

In view of the aforementioned new method of preventing SARS-CoV-2 from spreading into sewage, this is a promising new method for preventing it from spreading into faeces. The present work aims to investigate the impact of the Hyssop plant, a highly nutritious plant with various health-preserving secondary metabolites, as a new method for removing SARS-CoV-2 in human faeces. A variety of studies have been conducted on the chemical and biological effects of leaf extracts of Hyssopus officinalis. Researchers have studied its antimicrobial, anti-oxidant, antifungal, insecticidal, and antiviral properties. Pinocamphone, isopinocamphone, and β-pinene, have been associated with the antibacterial and antifungal properties of Hyssop. Several high-molecular compounds in the plant are thought to explain its antiviral activity, including caffeic acid and tannins. This study will lead to a significant advancement in the development of a new medicine that targets Coronavirus removal in human faeces and prevents the spread from wastewater while remaining a sustainable and effective process.

2. Materials and methods

2.1. Study design

The enrolled patients with SARS-CoV-2 were admitted to Mosa-Ebne-Jafar Hospital of Quchan, Iran, from September 1st to October 9th, 2021 (Fig. S1). All enrolled patients provided written consent. This study was two people testing, and the characteristics of both people were the same; following that, for 30 d, the two patients were tested daily. Two of the participants had pharyngeal swab specimens that tested positive for SARS-CoV-2 RNA when they were analysed using real-time reverse transcription-polymerase chain reaction (RT-PCR). Patients who did not have RT-PCR test findings that were negative for viral RNA in their pharyngeal swabs were ruled out of the study.

Fig. 1. Illustrates the bibliometric analysis mapping created from the Web of Science core collection for the network visualisation of the terms associated with the spread of SARS-CoV-2, which can be transmitted directly from one person to another, or by contact with water, food, or surfaces. This analysis was compiled with the application of VOSviewer software.
2.2. Laboratory examination

Every day, the stool samples from two patients were collected multiple times during the hospitalisation and recovery period, especially during the consumption of hyssop plant. RT-PCR was used to detect the presence of SARS-CoV-2 RNA. Mosa-Ebne-Jafar Hospital’s clinical laboratory confirmed the presence of SARS-CoV-2 RNA. The RT-PCR test was carried out according to the WHO protocol. The safety protocols and precautions from the health ministry have been advised researchers to be exposed to near only two patients for research data collection. The samples collections were taken under proper SOP’s under the supervision of medical staff.

The RT-qPCR kits were used to detect SARS-CoV-2 RNA from Changsha, China, and Shanghai, China. They also used probes and primers to determine the quantitative expression of gene N. For the quantitative analysis. They plotted the standard curve based on different dilutions of in vitro transcription RNA (N gene). According to the manufacturer, the assay targets parts of the SARS-CoV-2 genome. The positive control kit, an internal standard gene fragment (ORF1ab, N gene), and the negative control, namely normal saline, were used for both positive and negative controls.

2.3. Hyssop plants

Hyssop plant is a typical xerophyte that grows well in drought-prone conditions. Hyssop is used in food flavouring as well as sauce formulation despite its bitter taste. Hyssop has a long history of usage as a remedy for coughs, as well as antispasmodic, stomachic, and antifungal properties. According to a study that looked at both the chemical and biological features of the plant, the primary components of hyssop were discovered to be polyphenolic compounds and essential oils. The Hyssop essential oil and extracts exhibit antimicrobial activity, both antioxidant and antifungal, as well as insecticidal and antiviral properties, as indicated in Fig. 2. Finally, using this plant for removing SARS-CoV-2 is effective.

2.4. Hyssop plant application methodology

There are four structural proteins in the mature SARS-CoV-2 particle, namely envelope (E), membrane (M), nucleocapsid (N), and spike (S). S protein is important for antibody-based detection since the surface of the virion exposes the receptor-binding domain (RBD) to the immune system. Thus, antiviral hyssop plants reduce the viral replication cycle and, thus, prolong the time that the immune system has to respond to an infection. Proteins from hyssop plants can act as antivirals, such as carbohydrate-binding proteins (lectins). In addition to binding and inactivating a variety of viruses, lectins also inhibit the production of glycan structures on the surface of the viruses. Finally, the angiotensin-converting enzyme 2 (ACE2) from Hyssop plants can neutralize SARS-CoV-2 because it is fused with human IgG1. Thus, this protein can be used as a potential therapeutic for COVID-19, as indicated in Fig. 3.

3. Results and discussion

Between September 1 to October 9, 2021, two COVID-19 patients admitted to Mosa-Ebne-Jafar Hospital were tested. The median age was 55; both were men, and patients had a smoking history and the most prevalent symptoms were fever, dry cough, weariness, and lethargy. In patients with SARS-CoV-2, faeces showed a 40% positive result. The patients’ stool specimens were collected multiple times during their hospitalisation. For the first time, one plant test on Human faeces contaminated with SARS-CoV-2; including utilising Hyssop plants; which is to prevent Corona reduction in Corona patient faeces, as well as prevent it from spreading in the sewage; moreover, antiviral, antifungal, antimicrobial, antioxidant, and insecticidal properties Hyssop have been found to protect against SARS-CoV-2. Many compounds found in Hyssop are thought to contribute to its antibacterial and antifungal properties, including pinocamphone, isopinocamphone, and β-pinene. The plant has three phytochemicals responsible for the antiviral properties: caffeine, tannins, and an unidentified high-molecular compound. Besides, in this test, two people were tested based on their usage of the Hyssop plant over 30 d; however, one person uses it three times a day,
By drinking Hyssop three times a day, it was shown that this plant could decrease Corona in the stool after 10 d. There are a variety of bioactive compounds in the stem of this plant, including limonene, rosemary, caffeic acid, flavonoids, and merobins. Hyssop extracts and essential oil (E.O.) have been studied for their medicinal properties as well as their antiviral and antibacterial properties; moreover, the E.O. of Hyssop is antiseptic, antimicrobial, antiviral (especially against HIV), antitumor, antispasmodic, and antioxidant; it also improved the lung function of the patient (Charles, 2012). Hyssop is commonly used for medicinal, aromatic, and culinary purposes. The advantage of this plant is that Xanthophyll, which is found in the herb, contains fat, sugar, choline, tannins, carotene, and volatile oil; following that, Hyssop is used for many digestive and intestinal ailments, such as stomach pain, gas, colic, and a loss of appetite. It has been used for coughs, colds, respiratory infections, sore throats, and asthma.

Excessive consumption of Hyssop can cause harm and side effects: 1) Blood pressure is increased by this plant, so people with high blood pressure should avoid it. 2) Excessive consumption may cause seizures. 3) Excessive consumption of Hyssop is harmful to the liver (Jangi et al., 2021).

In this research, SARS-CoV-2 was detected in specimens of two patients for the decline in SARS-CoV-2 in faeces humans and prevention of faeces in sewage; notably, due to the fact that these two people (out of 500 people hospitalised due to SARS-CoV-2) were chosen because this plant was, for the first time, tested on people (Flow Chart1). This study revealed that stool samples from laboratory-confirmed COVID-19 patients tested positive for SARS-CoV-2 RNA; neither symptoms of gastrointestinal illness nor severity of illness was associated with this finding. Upon testing two persons, the person who consumed the...
A negative test after 25 d based on cyclic and oral PCR; however, a stool test still showed positive results. Our study results pointed out that testing SARS-CoV-2RNA in faeces may be useful for diagnosing the infection and that considering SARS-CoV-2 transmission via the faecal-oral route should be given serious consideration.

As shown in Fig. 5, recent research conducted in a variety of countries has demonstrated that SARS-CoV-2 RNA can be identified in stool samples taken from COVID-19 patients. RNA from SARS-CoV was detected in gastrointestinal tissue samples taken endoscopically from a COVID-19 patient. An abundant amount of the Angiotensin-converting enzyme 2 (ACE2), which plays a role in the cellular entry of SARS-CoV-2, was found in the epithelia of a SARS-CoV-2 patient’s gastric, duodenal, and rectal linings. This finding was made possible by the fact that ACE2 is highly expressed in these tissues. The S1 domain of SARS-CoV-2 is responsible for the binding of the virus to the cellular receptor ACE2 on host cells. As soon as the virus entered the cell, the cytoplasm was able to produce viral-specific RNA and proteins, which led to the formation of additional virions that were then released into the gastrointestinal tract. Xiao et al. (2020) identified infectious SARS-CoV-2 in stool, indicating that infectious virions were released into the gastrointestinal tract.
SARS-CoV-2

Decline faeces containing SARS-CoV-2

Method of decline

Hysop plant

Yes

This plant can almost 31–40% decline SARS-CoV-2 in human faeces, causing preventing SARS-CoV-2 from a spread to sewage

This plant increases blood pressure.

Diagnose before use

It does not eliminate SARS-CoV-2 in human faeces.

No

End

Flow Chart 1. A new way to detect SARS-CoV-2 in human faeces.

gastrointestinal tract. Human faeces contain SARS-CoV-2, which is a significant problem these days; however, using Hysop showed many antioxidants in this plant that are effective for respiratory, digestive, and immune system health. The SARS-CoV-2 in the stool was reduced by 30% by consuming this plant.

According to (Chen et al., 2020), SARS-CoV-2 RNA was found in oral swabs, anal swabs, and blood samples; however, at a later stage of infection, anal swabs were more commonly positive than oral swabs. Although respiratory samples turned negative (Li et al., 2020), was reported that a stool sample from a COVID-19 patient remained positive for 33 consecutive days. As a result of the fact that viral replication in the gastrointestinal tract may be different from that in the respiratory tract, it is possible that viruses can be transmitted from the gastrointestinal tract to the oral cavity even after the respiratory tract has cleared viral particles. This may even be the case when the respiratory tract has eliminated all viral particles. It is unethical to release a patient only on the basis of negative results from an RT-PCR test for viral RNA that was performed using pharyngeal swabs as samples. The detection of viral RNA in COVID-19 patients’ anal swabs or stool samples should be performed routinely during hospitalisation and recovery until the patient has tested negative for the viral RNA in faeces. This should continue until the patient has tested negative for the viral RNA in faeces (Table 1).

In terms of wastewater, correct wastewater management must necessarily begin with the sampling. High levels of viruses may be found in hospital and isolation centre wastewater and domestic wastewater from areas of contamination, which require special attention. Nevertheless, sewage systems should be monitored for leaks to prevent disease and contamination of the water supply. The typical secondary activated sludge treatment is a popular biological treatment method for eliminating pathogens because of the combined effects of wastewater aeration, biological activity of biomass, and secondary sedimentation. Inactivation of viruses can be aided by a variety of circumstances, including the length of time spent in treatment tanks and exposure to sunshine. This final step, disinfection, is essential in preventing the growth of viruses. Using secondary treatments followed by disinfection, WWTPs have proved to be effective. Although, the disinfection process is not available at all WWTPs due to differences in population equivalent (P.E.). Despite this, in light of SARS-CoV-2’s high susceptibility to disinfection and to prevent the virus from spreading, it might be sensible to apply a disinfection treatment for all WWTPs and small WWTPs only during epidemic outbreaks.

4. Conclusion

The prevention of direct transmission of SARS-CoV-2 and the treatment of persons who have been infected are the primary focuses of the medical and public health professionals who are working on this outbreak. The secondary transmission is not something that should be disregarded. In the event that this does not occur, secondary transmission has the potential to put at risk the gains that have been so painstakingly achieved via the use of existing transmission control mechanisms and may even contribute to the reemergence of COVID-19. During the SAR-CoV-2 pandemic, many research projects were conducted in water and wastewater, to remove human faeces from sewage with various technological and methodological means. Test results indicate that after 10 d of consuming this plant, the stool of the person who consumed this plant reached almost 35%, and finally, at the end of the 30th d, the stool reached 10%. Due to its antioxidant properties, this plant reduced the SARS-CoV-2 levels in the stool and improved the patient’s acute respiratory.

These results in this study could be of particular importance for developing countries, as they have suffered from comparatively underprivileged public sanitation environments, which might contribute to the rapid upsurge in SARS-CoV-2 infection. The results in this study can be of wide-ranging interest and applied somewhere else. This study can provide a new solution that can control the spread of SARS-CoV-2 via wastewater, particularly during the global pandemic. This investigation will lead to important progress in developing a new medicine that targets Coronavirus removal in human faeces and prevents the spread from wastewater while remaining a sustainable and effective process.

Credit author statement

Sasan Zahmatkesh: Collected the research articles, analysed, testing, and prepared the first original draft, screened, Software, and

| Human Faeces (%) | Treatment for SARS-CoV-2 in | Reference |
|------------------|-----------------------------|-----------|
|                  | human faeces                |           |
| 29               | Not any way to decline      | Wang et al., (2020b) |
| 47.7             | Not any way to decline      | Lin et al., (2020)   |
| 53.4             | Not any way to decline      | Xue et al., (2020)   |
| 80               | Not any way to decline      | Wu et al., (2020)    |
| 55               | Not any way to decline      | Cheung et al., (2020) |
| 15.3             | Not any way to decline      | Cheung et al., (2020) |
| 48.1             | Not any way to decline      | Cheung et al., (2020) |
| 40%              | Hysop plants can decline human faeces containing SARS-CoV-2 | This paper |

The prevention of direct transmission of SARS-CoV-2 and the treatment of persons who have been infected are the primary focuses of the medical and public health professionals who are working on this outbreak. The secondary transmission is not something that should be disregarded. In the event that this does not occur, secondary transmission has the potential to put at risk the gains that have been so painstakingly achieved via the use of existing transmission control mechanisms and may even contribute to the reemergence of COVID-19. During the SAR-CoV-2 pandemic, many research projects were conducted in water and wastewater, to remove human faeces from sewage with various technological and methodological means. Test results indicate that after 10 d of consuming this plant, the stool of the person who consumed this plant reached almost 35%, and finally, at the end of the 30th d, the stool reached 10%. Due to its antioxidant properties, this plant reduced the SARS-CoV-2 levels in the stool and improved the patient’s acute respiratory.

These results in this study could be of particular importance for developing countries, as they have suffered from comparatively underprivileged public sanitation environments, which might contribute to the rapid upsurge in SARS-CoV-2 infection. The results in this study can be of wide-ranging interest and applied somewhere else. This study can provide a new solution that can control the spread of SARS-CoV-2 via wastewater, particularly during the global pandemic. This investigation will lead to important progress in developing a new medicine that targets Coronavirus removal in human faeces and prevents the spread from wastewater while remaining a sustainable and effective process.

Credit author statement

Sasan Zahmatkesh: Collected the research articles, analysed, testing, and prepared the first original draft, screened, Software, and
analysed the key findings; Jiri Jaromir Klemes: Supervision, Writing-review & editing, Validation, Funding; Kassian T.T. Amesho: Writing-reviewing, editing. Awaiss Bokhari & Mudassir Hasam: Writing-review & editing, Chongqing Wang: Writing - original draft, Mika Sillanpää: Writing - review & editing, Supervisor, 

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The support from the project “Sustainable Process Integration Laboratory-SPIL” funded by EU CZ Operational Programme Research and Development, Education, Priority1: Strengthening capacity for quality research (Grant No. CZ.02.1.01/0.0/0.0/15_003/0000456) is acknowledged. Work was also supported by the Deanship of Scientific Research at King Khalid University, Abha-KSA, for funding this research through General Research Project under grant number (R.G.P. 2/189/43).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chemosphere.2022.135247.

References

Albastaki, A., Naji, M., Looth, R., Almeheiri, R., Almulla, H., Almarri, I., Alreyami, A., Aden, A., Alghaffal, R., 2021. First confirmed detection of SARS-COV-2 in unveeted municipal and aircraft wastewater in Dubai, UAE: the use of wastewater based epidemiology as an early warning tool to monitor the prevalence of COVID-19. Sci. Total Environ. 760, 143350.

Brahim Belhaouari, D., Wurtz, N., Grimaldier, C., Lacoste, A., Pires de Souza, G.A., Amesho, K.T., Sillanpaa, M., Wang, C., 2022. Integration of renewable energy and wastewater epidemiology to assess the impact of COVID-19 and inactive SARS-CoV-2 in wastewater treatment. Clean. Chem. Eng.: 100037.

The detection of mercury (II) ions using fluorescent gold nanoclusters on a portable paper-based device. Chem. Eng. J. 133070.

Li, X., Zhang, S., Shi, J., Luby, S.P., Jiang, G., 2021. Uncertainties in estimating SARS-COV-2 prevalence by wastewater-based epidemiology. Chem. Eng. J. 129039.

Lin, J.-H., Chen, S.-J., Lee, J.-E., Chu, W.-Y., Yu, C.-J., Chang, C.-C., Chen, C.-F., 2021. The detection of mercury (II) ions using fluorescent gold nanoclusters on a portable paper-based device. Chem. Eng. J. 133070.

Pavilionis, B., Ierardi, A.M., Levine, L., Mirer, F., Kelvin, E.A., 2021. Estimating aerosol transmission risk of SARS-CoV-2 in New York City public schools during reopening. Environ. Res. 195, 110805.

Ren, J.R., Vinda, C.K., Owebu, I.O., Holbrook, M., Fischer, R., Bushmaker, T., 2021. SARS-COV-2 sequence prevalence and transmission risk factors among high-risk close contacts: a retrospective cohort study. Lancet Infect. Dis. 21, 333–343.

Pal, M., Berhanu, G., Desalegn, K., 2020. Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2): an update. Cureus 12 (3).

Pavilionis, B., Ierardi, A.M., Levine, L., Mirer, F., Kelvin, E.A., 2021. Estimating aerosol transmission risk of SARS-CoV-2 in New York City public schools during reopening. Environ. Res. 195, 110805.

Lai, C.C., Shih, T.P., Ko, W.C., Tang, H.J., Hsueh, P.R., 2020. Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2): an update. Cureus 12 (3).

Pavilionis, B., Ierardi, A.M., Levine, L., Mirer, F., Kelvin, E.A., 2021. Estimating aerosol transmission risk of SARS-CoV-2 in New York City public schools during reopening. Environ. Res. 195, 110805.

Zahmatkesh, S. and M. Sillanpaa (2022). Review of a method and new tool for decline and inactive SARS-CoV-2 in wastewater treatment. Clean. Chem. Eng.: 100037.