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What do we know about the SARS-CoV-2 coronavirus in the environment?

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**Abstract**

In view of the current situation regarding the Covid-19 disease, a discussion is proposed on the need for research focusing on the presence and evolution of the SARS-CoV-2 virus in water, soils and other environmental compartments, reached through wastewater and sewage sludge spreading. Also, the evaluation of current treatments for wastewater and sewage sludge, as well as the eventual development of new specific techniques, based on sorption, nanotechnology, etc., would be of great interest for controlling the environmental dissemination of these viruses in the current and eventual future outbreaks.

**Keywords:** SARS-CoV-2; wastewater; sewage sludge; environmental compartments; virus survival.

**1. Discussion**

With thousands of people already affected by the Covid-19 disease in various countries around the world, and millions of people controlled regarding displacements in their own countries and/or local geographic areas, it is time to add some comments on related aspects, applicable now and in the coming future.

In fact, it should be taken into account that symptomatic (and maybe also asymptomatic) affected people could spread the viruses through their excreta, which would make appropriate to think on (and evaluate) effectiveness and consequences of related wastewater and sewage sludge treatment and eventual subsequent spreading to environmental compartments. Bowser (2020) has recently reported on the presence of this virus in feces from humans. Also, Pan et al. (2020) published some of the first results in this regard.

If this virus is not eradicated, we should think on further screening focusing on wastewater (Martínez-Puchol et al., 2020) - have recently published a paper dealing with related aspects, but also on sewage sludge (as shown by Nag et al., 2020) - evaluating survival of bacteria and viruses causing different diseases, as well as in previous papers, such as that by Zhao and Liu (2019), soils and sediments (Katz et al., 2018; Nag et al., 2020; Zhao and Liu, 2019), crops (Ahmed et al., 2019; Nag et al., 2020; Zhao and Liu, 2019), animals (Pruvot et al., 2019), surface and ground waters (Corsi et al., 2014; Givens et al., 2016). Further research should also focus on eventual technical treatments, including biosorbents and other materials to retain and/or inactive this and other pathogens circulating in these environmental compartments, before and after going out from wastewater treatment plants (in case of these treatment systems existing, as it could be worse, with spreading of untreated wastes). Some previous papers (such as those by Auffret et al., 2019; Hlongwane et al., 2019) could be considered as reference to program future studies. Also, the “sewage epidemiology approach” could be very useful, as this monitoring concept went from an initial focus on illicit drugs (van Nuijs et al., 2011) to the current view (also called “wastewater-based epidemiology”), covering a broad array of substances in wastewater, including virus particles (Daughton, 2020; Sims and Kasprzyk-Hordern, 2020), and it would allow a drastic reduction in the time needed to develop a wastewater monitoring approach specifically designed for SARS-CoV-2 (Daughton, 2020).

When spread in the environment, some potential steps to be considered for these viruses are transfer from one compartment to another, entering living beings (multicellular, but maybe also unicellular in the future), proliferation, eventual mutation, transmission, ... Currently, it is thought that these coronaviruses can survive for just few days in the environment, out of living cells (Kampf et al., 2020), but it could be enough time to reach other organisms, to mutate and change characteristics, etc. Multiple possible scenarios should be considered for the coming future.

These eventual considerations for the close future would be taken into account as soon as possible, in addition to the already in vigor measures implemented to control direct spreading by the air.

**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.
References

Ahmed, W., Hamilton, K., Toze, S., Cook, S., Page, D., 2019. A review on microbial contaminants in stormwater runoff and outfalls: potential health risks and mitigation strategies. Sci. Total Environ. 692, 1304–1321. https://doi.org/10.1016/j.scitotenv.2019.07.055.

Auffret, M.D., Brassard, J., Jones, T.H., Gagnon, N., Gagné, M.J., Muehlhauser, V., Masse, L., Topp, E., Talbot, G., 2019. Impact of seasonal temperature transition, alkalinity and other abiotic factors on the persistence of viruses in swine and dairy manures. Sci. Total Environ. 659, 640–648. https://doi.org/10.1016/j.scitotenv.2018.12.306.

Bowser, A.D., 2020. Coronavirus may cause environmental contamination through fecal shedding. Medscape Medical News Accessed on March, 9th, at. https://www.medscape.com/viewarticle/926390.

Corsi, S.R., Borchardt, M.A., Spencer, S.K., Hughes, P.E., Baldwin, A.K., 2014. Human and bovine viruses in the Milwaukee River watershed: hydrologically relevant representation and relations with environmental variables. Sci. Total Environ. 490, 849–860. https://doi.org/10.1016/j.scitotenv.2014.05.072.

Daughton, C., 2020. The international imperative to rapidly and inexpensively monitor community-wide Covid-19 infection status and trends. Sci. Total Environ. 138149.

Givens, C.E., Kolpin, D.W., Borchardt, M.A., Duris, J.W., Moorman, T.B., Spencer, S.K., 2016. Detection of hepatitis E virus and other livestock-related pathogens in Iowa streams. Sci. Total Environ. 566–567, 1042–1051. https://doi.org/10.1016/j.scitotenv.2016.05.123.

Hlongwane, G.N., Sekoai, P.T., Meyyappan, M., Moothi, K., 2019. Simultaneous removal of pollutants from water using nanoparticles: A shift from single pollutant control to multiple pollutant control. Sci. Total Environ. 656, 808–833. https://doi.org/10.1016/j.scitotenv.2018.11.257.

Katz, A., Peña, S., Alimova, A., Gottlieb, P., Xu, M., Block, K.A., 2018. Heteroaggregation of an enveloped bacteriophage with colloidal sediments and effect on virus viability. Sci. Total Environ. 637–638, 104–111. https://doi.org/10.1016/j.scitotenv.2018.04.425.

Kampf, G., Toft, D., Plaender, S., Steinmann, E., 2020. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. J. Hosp. Infect. 104 (3), 246–251. https://doi.org/10.1016/j.jhin.2020.01.022.

Martínez-Puchol, S., Rusiñol, M., Fernández-Cassí, X., Timoneda, N., Itarte, M., Andrés, C., Antón, A., Abril, J.F., Ciriones, R., Rofill-Mas, S., 2020. Characterisation of the sewage virome: comparison of NGS tools and occurrence of significant pathogens. Sci. Total Environ. 713, 136604. https://doi.org/10.1016/j.scitotenv.2020.136604.

Martínez-Puchol, S., Rusiñol, M., Fernández-Cassí, X., Timoneda, N., Itarte, M., Andrés, C., Antón, A., Abril, J.F., Ciriones, R., Rofill-Mas, S., 2020. Characterisation of the sewage virome: comparison of NGS tools and occurrence of significant pathogens. Sci. Total Environ. 713, 136604. https://doi.org/10.1016/j.scitotenv.2020.136604.

Nag, R., Whyte, P., Markey, B.K., O’Flaherty, V., Bolton, D., Fenton, O., Richards, K.G., Cummins, E., 2020. Ranking hazards pertaining to human health concerns from land application of anaerobic digestate. Sci. Total Environ. 710, 136297. https://doi.org/10.1016/j.scitotenv.2019.136297.

Pan, Y., Zhang, D., Yang, P., Poon, L.L.M., Wang, Q., 2020. Viral load of SARS-CoV-2 in clinical samples. Lancet Infect. Dis. https://doi.org/10.1016/S1473-3099(20)30113-4.

Pruvot, M., Khammanvong, K., Milavong, P., Philavong, C., Reinharz, D., Mayxay, M., Rattanavong, S., Horwood, P., Dussart, P., Douangneun, B., Theppangna, W., Fine, A.E., Olson, S.H., Robinson, M., Newton, P., 2019. Toward a quantification of risks at the nexus of conservation and health: The case of bushmeat markets in Lao PDR. Sci. Total Environ. 676, 732–745. https://doi.org/10.1016/j.scitotenv.2019.04.266.

Sims, N., Kasprzyk-Hordern, B., 2020. Future perspectives of wastewater-based epidemiology: monitoring infectious disease spread and resistance to the community level. Environ. Int. 105689. https://doi.org/10.1016/j.envint.2020.105689.

van Nuijs, A.L.N., Castiglioni, S., Tarcomnicu, I., Postigo, C., Alía, Lopez de, Neels, M.H., Zuccato, E., Barcelo, D., Covaci, A., 2011. Illicit drug consumption estimations derived from wastewater analysis: a critical review. Sci. Total Environ. 409 (19), 3564–3577. https://doi.org/10.1016/j.scitotenv.2010.05.030.

Zhao, Q., Liu, Y., 2019. Is anaerobic digestion a reliable barrier for deactivation of pathogens in biosludge? Sci. Total Environ. 668, 893–902. https://doi.org/10.1016/j.scitotenv.2019.03.063.