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REVIEW
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Presence of the novel coronavirus (SARS-CoV-2) in sanitary sewages: notes for health surveillance complementary actions in times of pandemic

Presença do novo coronavírus (SARS-CoV-2) nos esgotos sanitários: apontamentos para ações complementares de vigilância à saúde em tempos de pandemia

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ABSTRACT

Introduction: The COVID-19 is caused by the novel coronavirus (SARS-CoV-2), and it's main route of transmission is respiratory. However, recent studies have found genetic material of SARS-CoV-2 in feces of infected individuals and in sanitary sewage samples, pointing to new challenges. **Objective:** Synthesize the evidences on the presence of SARS-CoV-2 in human waste and in sewage, discussing possibilities of alternative transmission routes of COVID-19. **Method:** This is a narrative review, conducted in May 2020, in the platforms Web of Science, CAPES Publications Portal, Scopus and the Virtual Health Library, considering texts in any language. To date, few studies have reported the presence of SARS-CoV-2 in feces, urine and sanitary sewage. **Results:** However, the findings indicate the importance of including this theme in discussions in the current context of the pandemic. In Brazil, given the inability of mass testing, added to underreporting and the existence of asymptomatic cases, it's important to consider alternatives that allow the collective diagnosis to direct actions in regions with higher risk of contagion and circulation of SARS-CoV-2. In this sense, the monitoring of sewage can be an alternative, also presenting economic relevance because it requires less expenditure of public money when compared to other measures – biochemical and molecular tests or other hard technologies. **Conclusions:** Even though this article does not exhaust the discussion of the theme, it advances by bringing data that can be added to the existing information on the forms of dispersion of SARS-CoV-2 in the environment.

KEYWORDS: SARS-CoV-2; COVID-19; Sanitary Sewage System; Sewage System Monitoring; Public Health Surveillance

RESUMO

Introdução: A COVID-19 é causada pelo novo coronavírus (SARS-CoV-2), tendo como principal via de transmissão a respiratória. Contudo, estudos recentes encontraram material genético do SARS-CoV-2 em fezes de indivíduos infectados e amostras de esgotos sanitários, apontando novos desafios. **Objetivo:** Sintetizar as evidências sobre a presença do SARS-CoV-2 em dejetos humanos e esgotos, discutindo possibilidades de vias de transmissão alternativas da COVID-19. **Método:** Trata-se de uma revisão narrativa, conduzida em maio de 2020, nas bases *Web of Science*, Portal de Periódicos da CAPES, *Scopus* e na Biblioteca Virtual em Saúde, considerando textos em qualquer idioma. **Resultados:** Até a data das buscas, poucos estudos reportaram a presença do SARS-CoV-2 nas fezes e nos esgotos sanitários. Todavia, os achados sinalizam a importância de incluir esta temática nas discussões no atual contexto de pandemia. No Brasil, dada a incapacidade da testagem em massa, somada às subnotificações e existência de casos assintomáticos, torna-se importante cogitar alternativas que permitam diagnóstico coletivo para direcionar ações em regiões com maior risco de contágio e circulação do

SARS-CoV-2. Assim, o monitoramento dos esgotos pode ser uma alternativa, apresentando, também, relevância econômica por requerer menos dispêndio de dinheiro público quando comparado a outras medidas – testes bioquímicos e moleculares ou outras tecnologias duras. Apesar das dificuldades relativas ao saneamento no Brasil, os esgotos podem ser mais uma ferramenta capaz de contribuir nas vigilâncias sanitária, ambiental e epidemiológica da COVID-19. **Conclusões:** Reconhece-se que este artigo não esgota a discussão da temática, mas avança por trazer dados que podem ser somados às informações já existentes sobre as formas de dispersão do SARS-CoV-2 no ambiente.

PALAVRAS-CHAVE: SARS-CoV-2; COVID-19; Sistema de Esgotamento Sanitário; Monitoramento do Sistema de Esgoto; Vigilância em Saúde Pública

INTRODUCTION

COVID-19 (Coronavirus Disease 2019) is an infectious disease whose causative agent is the coronavirus called SARS-CoV-2[1,2]. Because the virus was recently discovered, the scientific community has been making efforts to generate knowledge that will promote both the prevention and fight against the disease and the promotion of discussions on the social, economic, and political impacts of the pandemic worldwide[2,3,4,5].

Scientific studies have pointed out that the transmission of COVID-19 between humans occurs mainly through the respiratory tract, through droplets expelled by the infected person when they cough or sneeze, and through the contact of the healthy individual with contaminated surfaces and objects, in which the virus may remain viable for a period, depending on the composition of the material and/or surface[1,2,6].

However, in recent weeks, some national and international studies have been released presenting as results the presence of genetic material from the novel coronavirus in the feces of infected individuals (with or without symptoms)[7,8,9], in a urine sample[10], and sanitary sewage samples[11,12,13,14]. Thus, these studies highlight new challenges that need to be recognized and faced by countries.

Even though, until now, the World Health Organization (WHO) has declared that the fecal-oral route is not one of the main ones in the dissemination of COVID-19[15], it becomes relevant, through the Precautionary Principle[16], to discuss the possibility of this path amid of the most serious pandemic of the century. Regarding the Precautionary Principle[16,17], due to the fact that the consequences or reflexes of certain acts are not fully known in the environment, space, and time, necessary measures to avoid future damage (risks) to the environment and health must be adopted. Actions that mitigate possible negative impacts can be taken before a causal link has been established scientifically, this being a determination of the Precautionary Principle[16,17]. Thus, actions to monitor sanitary sewage systems would be important in order to join forces in surveillance mechanisms, especially in countries where cases have been increasing rapidly, such as Brazil.

Thus, in this article, the aim was to synthesize the available evidence on the presence of the novel coronavirus in human waste (feces and urine) and sanitary sewers, discussing the possibilities of alternative transmission routes for COVID-19.

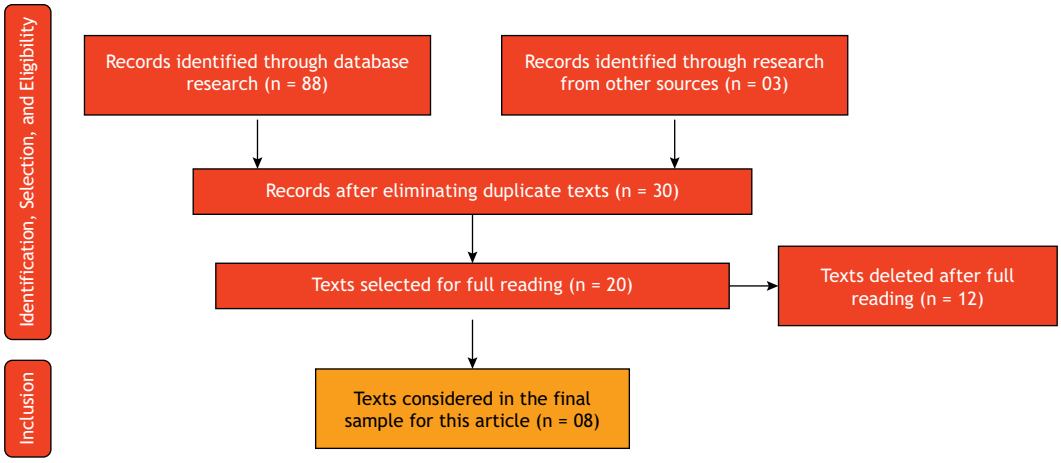
METHOD

This is a narrative review of the literature, based on already established and scientifically accepted protocols[18]. In the first week of May 2020, searches were conducted in the Web of Science, *Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES), Scorpus, and in those indexed by the Virtual Health Library (VHL) databases, as well as repositories of Teaching and Research Institutions in Brazil. The terms used were: "COVID-19"; "SARS-CoV-2"; "Sanitary Sewage System"; *"Wastewater"*; *"Sewage"*; *"Sewage Coronavirus"*; *"Wastewater Coronavirus"*; *"Sewage COVID-19"*; *"Wastewater COVID-19"*; with the assistance of the Boolean operator "AND".

The inclusion criteria were original articles, editorials, technical notes, literature reviews and/or comments; in different languages; available in full electronically; published between December 2019 and May 5, 2020 (the date the searches were conducted). The strategy of consulting the citations of the included texts was also adopted. As exclusion criteria, it was considered: texts with results of experiments made on animals. The Figure shows the representative scheme of the text selection procedures.

The texts were analyzed, initially, by the title, then by the analysis of the summary, and for those who did not present enough information to allow their selection or exclusion, vertical readings were conducted. The selection of texts was carried out by all authors, and the differences were resolved by consensus. Lastly, meticulous readings of the selected material were carried out, in an analytical and interpretative way, seeking to gather consensus, without failing to impress discussions on the issues raised, especially in the Brazilian context. Due to the novelty of the theme, the final sample of this review consisted of eight texts, which will be detailed below.

In order to organize the presentation of the results found, first, in the "Results" section, studies found through searches were highlighted. Then, in the "Discussion" section, we present some studies developed in periods prior to December 2019 and that analyzed other coronaviruses in the sewage systems, with emphasis on SARS-CoV (which causes severe acute respiratory syndrome) for presenting structural and genetic characteristics similar to SARS-CoV-2. This option was made in an attempt to better



Source: Elaborated by the authors, 2020.

Figure. Representative scheme of the article selection procedures. Brazil, 05 May 2020.

understand the possibility of the viability of the novel coronavirus, recognizing possible limitations as it is a new pathogen.

RESULTS

Although SARS-CoV-2 was discovered in December 2019, all studies found through electronic database searches were published in 2020. As for the type, original articles and technical notes were found with previous research results.

In a study conducted in China at the Fifth Affiliated Hospital of Sun Yat-sem University, the authors collected respiratory and fecal samples from patients with COVID-19 every one or two days, depending on sample availability, until two consecutive tests were negative. Of the 74 patients investigated, 41 had positive fecal tests for, on average, 27 days, whereas, for breathing tests, the average number of days with positive results was 16 days since the first symptom[7].

Another investigation carried out in China showed that, in the analysis of ten children with positive results for SARS-CoV-2, eight of them presented positive fecal samples with the virus. Furthermore, the authors observed that, after the symptomatic period, fecal samples remained positive even with nasopharyngeal samples indicating a negative result. The researchers reinforce that there is a need for studies that prove the presence of viruses capable of replication in fecal samples[8].

Still concerning feces, another study conducted in China found a strain of SARS-CoV-2 in a fecal sample from a single patient. The authors point out that, in addition to contact with respiratory secretions of infected cases, there would be a possibility that the virus could be transmitted via the oral-fecal route, meaning that the feces could contaminate the hands, food, water and cause infections when invading the oral cavity, respiratory and/or conjunctival mucosa[9]. However, it is necessary to recognize the limitations of this study, mainly in relation to the lack of a representative sample.

It is also worth mentioning a study that managed to isolate the novel coronavirus in the urine sample of a single patient at Guangzhou Heights People's Hospital, in China[10]. It is noteworthy that, despite the limitation of analyzing only one patient, the authors reinforce that such findings increase the importance of precautionary measures to avoid possible transmission through urine[10].

The relationship between the presence of viral ribonucleic acid (RNA) in sewage samples and the number of cases of COVID-19 was also found in an investigation carried out in Paris, France[11]. The authors analyzed samples of raw and treated sewage from the three largest sewage treatment plants (STP) in the French capital. Monitoring was conducted between March and April 2020; and the presence of SARS-CoV-2 was positive in all samples of raw sewage. The presence was also observed in 75% of the treated sewage samples, although it was observed that STP provided a 100-times reduction in viral load. The researchers observed that sewage contamination occurred before the exponential increase in the disease, emphasizing that the increase in the amount of SARS-CoV-2 genetic material in the raw sewage is related to the number of deaths, both in relation to the city of Paris and throughout France. Thus, the study confirmed the validity and importance that monitoring in sanitary sewage has in the detection of the novel coronavirus among population groups in a timely manner[11].

In another study conducted at the Dutch National Institute for Public Health and the Environment, researchers reported the detection of genetic material from the novel coronavirus in samples of wastewater from the Netherlands. The genetic material of SARS-CoV-2 was detected in sewage samples from Amsterdam-Schiphol Airport and the STPs in the cities of Kaatsheuvel and Tilburg, two weeks after confirmation of the first patient with COVID-19[12].

In Brazil, researchers from the Oswaldo Cruz Foundation (Fiocruz) detected genetic material from the novel coronavirus in sewage samples in the city of Niterói, State of Rio de

Janeiro, in April 2020. The researchers used the ultracentrifugation methodology, traditionally used for concentration of viruses in sewers, associated with the reverse transcription technique followed by the polymerase chain reaction (RT-PCR) in real-time, which is indicated by the WHO. It is reinforced that the research is still in progress, with an expectation of expansion, according to the authors[13].

In another Brazilian study, researchers from the Universidade Federal de Minas Gerais (UFMG) collected sewage samples between April 13 and 17; and between April 20 and 24, 2020, in the cities of Belo Horizonte and Contagem, municipalities in the State of Minas Gerais. The results showed that 31% of the 26 samples collected were positive for the presence of SARS-CoV-2. It is noteworthy that the researchers collected samples of untreated sewage and are expected to analyze the exit points of the STPs[14].

DISCUSSION

To date, few studies have reported the presence of SARS-CoV-2 in human waste (feces or urine) and sanitary sewage, with none confirming transmission of COVID-19 via the fecal-oral route.

However, because the structure of SARS-CoV-2 is similar to that of other coronaviruses, some previous studies that analyzed pathogens from the same family brought information that can add to the understanding of the possibilities of transmission of SARS-CoV-2 through routes other than respiratory. In 2003, during an outbreak of Severe Acute Respiratory Syndrome (SARS) caused by a coronavirus called SARS-CoV, researchers reported a rapid spread of the disease in *Amoy Gardens*, a large private apartment complex located in Hong Kong, China. It has been shown that, unlike a typical viral outbreak that spreads through person-to-person contact, the SARS-causing virus has spread, in this case, mainly through the air. The results also showed that high concentrations of viral aerosols from the plumbing of buildings were carried to the bathrooms of the apartments through drains on the floor, contaminating residents, and visitors[19].

In a research carried out in 2005, using *in vitro*, Wang et al.[20] evaluated the persistence of the virus responsible for SARS in tap water without disinfection (addition of chlorine), hospital wastewater, and domestic sewage, checking the virus' permanence in these environments for two days at a temperature of 20°C. This research also demonstrated that SARS-CoV was more susceptible to the disinfection process than *Escherichia coli*. For residual chlorine concentration above 0.5 mg/L, complete inactivation of SARS-CoV was found, whereas complete inactivation was not verified for *E. coli*. The data suggested that standard chlorination practices in the municipal wastewater system could be sufficient to deactivate coronaviruses, as long as utilities monitor available chlorine during treatment to ensure that it has not been depleted. It is also important to monitor the generation of organochlorines in the wastewater chlorination process[20].

In the same SARS outbreak period, researchers from Beijing, China, reported the detection of SARS-CoV coronavirus RNA in previously concentrated sewage samples from two hospitals that received infected individuals. The detection indicated that SARS-CoV was excreted in the feces and urine of these patients. *In vitro* tests were also performed by inoculating SARS-CoV in sewage samples from one of the evaluated hospitals, demonstrating that the virus remained infectious for more than 14 days at 4°C and for two days at 20°C. Furthermore, the RNA of the virus could be detected for 14 days in the sewage samples kept at 4°C and for eight days in those kept at 20°C, suggesting a tendency of inactivation for higher temperatures[21]. In another study also conducted in China, in 2009, the authors identified the persistence of some SARS-CoV-2-like viruses in natural waters and in sewage for more than ten days; reporting the possibility of contamination by droplets (aerosols) from the infected sewage[22].

Thus, adding the studies presented in the Results section with those cited in the Discussion, the data gathered here point to the need to expand the debate on other forms of transmission of the novel coronavirus, with emphasis on the fecal-oral route; as well as the possibility of monitoring the circulation of the virus in populations through the sewage, allowing the relevant measures to be taken in a timely manner. The adoption of these measures becomes valid, mainly, in places where there are economic, logistical, or cultural impossibilities to carry out mass testing[19,23]. In this context, the monitoring of sewage systems can be an important alternative to be included by the State or Public Administration in actions against COVID-19, strengthening health, epidemiological, and environmental surveillance.

The epidemiology of sewage appears in this discussion since it has already been used in the tracking and signaling of early alerts of outbreaks of other viral diseases, such as Hepatitis A, Poliomyelitis, and Gastroenteritis[23,24,25]. Thus, the present article points to this technique as one of the possibilities of offering important information about COVID-19 in Brazil, with sanitary sewers being routes or means capable of determining the scale of the disease outbreak in certain populations.

Brazil is already considered one of the countries with the highest number of infected – 584,016 confirmed cases until June 3, 2020[26], and with the increase in the virus circulation in the population, it must be recognized that this will increase the viral load in the sewage systems of cities[13,22]. Thus, discussions about alternative routes of transmission of COVID-19, with emphasis on fecal-oral, need to be considered in the media, to think of a structure that guides new research with this focus[27].

From another perspective, collecting information about the occurrence and fate of SARS-CoV-2 in the sewage can allow you to discover areas with a greater presence of the virus, predicting possible unexpected increases and contributing to regionalized (localized) actions that optimize service responses without overburdening them, especially the Unified Health System (SUS).

Given the inability to perform tests for the entire population in Brazil, it is important to think of alternatives that have the potential to collectively discover and target regions with the highest risk and circulation of SARS-CoV-2, mainly because, in addition to the possibility of underreporting of the cases, there are many infected people who are asymptomatic but have the potential for transmission. And, in this sense, sewage monitoring can be one of these alternatives, even presenting economic relevance, as it may require less expenditure of public money when compared to other measures – biochemical and molecular tests or other hard technologies.

In Brazil, the option of monitoring sewage can be considered by federal, state, and municipal managers, as sewage collection is an existing service in the country. However, it is necessary to recognize the limitations regarding the ideal coverage in all cities, areas, and regions, even if the country has the Brazilian National Plan for Basic Sanitation (PLANSAB)[28] – which refers to universalization processes of these services. According to the National Sanitation Information System (SNIS)[29], the average percentage of services provided by sewage collection networks is 60.9% in the urban areas of Brazilian cities, especially in the Southeast region, with an average of 83.7%. Regarding sewage treatment, it is observed that the country's average index is 46.3% for the estimate of the generated sewage and 74.5% for the sewage that is collected[29].

However, even in the face of these difficulties, sewage appears as another topic to be considered in this pandemic moment, presenting itself as a tool that can provide a collective diagnosis, especially in the largest cities that already have a sewage system with a collection that serves a percentage above 50% of the population. However, it is essential that the State expand the sewage system, including also access to quality water[30], guaranteeing the right to better living conditions for the population, with a direct impact on health.

It is noteworthy that, for each R$ 1.00 invested in sanitation, R$ 4.00 is saved in health[31]. Thus, considering the surveillance of sewage systems is also considering actions that involve collective health[25,31,32], valuing the specificities of the territories and their population dynamics, while considering social control as an instrument of fighting to guarantee the right to sanitation[28] and health[33].

CONCLUSIONS

Although, to date, no research has confirmed the transmission of COVID-19 via the fecal-oral route, the studies presented here signal the importance of including this topic on the agenda of discussions in the face of the pandemic. In Brazil, even with the difficulties related to sanitation, sewage can be another tool capable of contributing to the efforts of health, environmental, and epidemiological surveillance. The State must expand the sewage system for the population, in addition to adopting measures that encourage and require companies providing sanitation services to align their actions, with the need for them to have control over the systems, so that quality data is provided and that is also capable of guiding preventive measures of contagion and mitigation of the risks of illness.

Lastly, it is recognized that this article does not exhaust the discussion of the theme but advances in the sense of presenting data that add to the existing information on the ways of dispersion of SARS-CoV-2 in the environment. Investigations in different cities in Brazil need to be conducted, considering regional disparities, in order to have greater clarity on the viability of the virus in raw and treated sewage and on the viability of fecal-oral contamination, so that the monitoring of sewage systems strengthen itself as an auxiliary tool in the surveillance of diseases and conditions such as COVID-19.

REFERENCES

1. Liu J, Liao X, Qian S, Yuan J, Wang F, Liu Y et al. Community transmission of severe acute respiratory syndrome coronavirus 2, Shenzhen, China, 2020. Emerg Infect Dis. 2020;17(26):1320-3. https://doi.org/10.3201/eid2606.200239
2. World Health Organization – WHO. Coronavirus disease 2019 (COVID-19). Geneva: World Health Organization; 2020 [acesso 10 maio 2020]. Disponível em: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200326-sitrep-66-COVID-19.pdf?sfvrsn=9e5b8b48_2
3. Yuen KS, Ye ZW, Fung SY, Chan CP, Jin DY. SARS-CoV-2 and COVID-19: the most important research questions. Cell Biosci. 2020;10:1-5. https://doi.org/10.1186/s13578-020-00404-4
4. Lai CC, Shih TP, Ko WC, Tang HJ, Hsueh PR. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease 2019 (COVID-19): the epidemic and the challenges. Int J Antimicrob Agents. 2020;55(3):1-9. https://doi.org/10.1016/j.ijantimicag.2020.105924
5. Brito SBP, Braga IO, Cunha CC, Palácio MAV, Takenami I. Pandemia da COVID-19: o maior desafio do século XXI. Vigil Sanit Debate. 2020;8(2):54-63. https://doi.org/10.22239/2317-269x.01530
6. Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med. 2020;382(16):1564-7. https://doi.org/10.1056/NEJMc2004973
7. Wu Y, Guo C, Tang L, Hong Z, Zhou J, Dong X et al. Prolonged presence of SARS-CoV-2 viral RNA in faecal samples. Lancet Gastroenterol Hepatol. 2020;5(5):434-5. https://doi.org/10.1016/S2468-1253(20)30083-2

8. Xu Y, Li X, Zhu B, Liang H, Fang C, Gong Y et al. Characteristics of pediatric SARS-CoV-2 infection and potential evidence for persistent fecal viral shedding. Nat Med. 2020;26(4):502-5. https://doi.org/10.1038/s41591-020-0817-4
9. Zhang Y, Chen C, Zhu S, Shu C, Wang D, Song J et al. Isolation of 2019-nCoV from a stool specimen of a laboratory-confirmed case of the coronavirus disease 2019 (COVID-19). China CDC Week. 2020;2(8):123-4. https://doi.org/10.46234/ccdcw2020.033 shu
10. Sun J, Zhu A, Li H, Zheng K, Zhuang Z, Chen Z et al. Isolation of infectious SARS-CoV-2 from urine of a COVID-19 patient. Emerg Microbes Infect. 2020;9(1):991-3. https://doi.org/10.1080/22221751.2020.1760144
11. Wurtzer S, Marechal V, Mouchel JM, Maday Y, Teyssou R, Richard E et al. Time course quantitative detection of SARS-CoV-2 in parisian wastewaters correlates with COVID-19 confirmed cases. medRxiv. 2020:1-13. https://doi.org/10.1101/2020.04.12.20062679
12. Medema G, Heijnen L, Elsinga G, Italiaander R. Presence of SARS-coronavirus-2 in sewage. medRxiv. 2020:1-9. https://doi.org/10.1101/2020.03.29.20045880
13. Ferreira V. Fiocruz divulga estudo sobre a presença do novo coronavírus em esgotos sanitários. Fiocruz Notícias. 28 abr 2020[acesso 11 maio 2020]. Disponível em: http://portal.fiocruz.br/noticia/fiocruz-divulga-estudo-sobre-presenca-do-novo-coronavirus-em-esgotos-sanitarios
14. Pró-reitoria de Assuntos Estudantis - PRAE. Coronavírus é identificado em esgotos. UFMG Notícias. 6 maio 2020[acesso 11 maio 2020]. Disponível em: http://www.ufmg.br/prae/noticias/coronavirus-e-identificado-em-amostras-de-esgoto
15. Representação da Organização Pan-Americana da Saúde no Brasil - OPAS Brasil. COVID-19 (doença causada pelo novo coronavírus). Folha Informativa. 2020 [acesso 11 maio 2020]. Disponível em: http://www.paho.org/bra/index.php?option=com_content&view=article&id=6101:covid19&Itemid=875
16. Rossoni HAV, Rossoni FFP, Soares AFS. Aspectos legais institucionais da restauração fluvial. In: Baptista M, Pádua VL, editores. Restauração de sistemas fluviais. Barueri: Manole; 2016. p. 221-58.
17. Milaré E. Direito do ambiente. 10a ed. São Paulo: Revista dos Tribunais; 2015.
18. Rother ET. Revisão sistemática X revisão narrativa. Acta Paul Enferm. 2007;20(2):5-6. https://doi.org/10.1590/S0103-21002007000200001
19. Mckinney KR, Gong YY, Lewis TG. Environmental transmission of SARS at Amoy Gardens. J Environ Health. 2006;68(9):26-30.
20. Wang XW, Li JS, Jin M, Zhen B, Kong QX, Song N et al. Study on the resistance of severe acute respiratory syndrome-associated coronavirus. J Virol Methods. 2005;126(1-2):171-7. https://doi.org/10.1016/j.jviromet.2005.02.005
21. Wang XW, Li J, Guo T, Zhen B, Kong Q, Yi B et al. Concentration and detection of SARS coronavirus in sewage from Xiao Tang Shan Hospital and the 309th hospital of the chinese people's liberation army. Water Sci Technol. 2005;52(8):213-21. https://doi.org/10.2166/wst.2005.0266
22. Casanova L, Rutala WA, Weber DJ, Sobsey MD. Survival of surrogate coronaviruses in water. Water Res. 2009;43(7):1893-8. https://doi.org/10.1016/j.watres.2009.02.002
23. Mao K, Zhang H, Yang Z. Can a paper-based device trace COVID-19 sources with wastewater-based epidemiology. Environ Sci Technol. 2020;54(7):3733-5. https://doi.org/10.1021/acs.est.0c01174
24. Levican J, Levican A, Ampuero M, Gaggero A. JC polyomavirus circulation in one-year surveillance in wastewater in Santiago, Chile. Infect Genet Evol. 2019;71:151-8. https://doi.org/10.1016/j.meegid.2019.03.017
25. Paiva RFPS, Souza MFP. Association between socioeconomic, health, and primary care conditions and hospital morbidity due to waterborne diseases in Brazil. Cad Saude Publica. 2018;34(1):1-11. https://doi.org/10.1590/0102-311X00017316
26. Ministério da Saúde (BR). COVID-19: painel coronavírus. Brasília: Ministério da Saúde; 2020 [acesso 19 maio 2020]. Disponível em: http://covid.saude.gov.br/
27. Heller L, Mota CR, Greco DB. COVID-19 faecal-oral transmission: are we asking the right questions? Sci Total Environ. 2020;729:1-3. https://doi.org/10.1016/j.scitotenv.2020.138919
28. Brasil. Lei Nº 11.445, de 5 de janeiro de 2007. Estabelece diretrizes nacionais para o saneamento básico; altera as leis Nº 6.766, de 19 de dezembro de 1979, Nº 8.036, de 11 de maio de 1990, Nº 8.666, de 21 de junho de 1993, Nº 8.987, de 13 de fevereiro de 1995; revoga a lei Nº 6.528, de 11 de maio de 1978; e dá outras providências. Diário Oficial União. 8 jan 2007.
29. Ministério de Desenvolvimento Regional (BR). Diagnóstico dos serviços de água e esgotos. Brasília: Sistema Nacional de Informações Sobre Saneamento; 2018[acesso 19 maio 2020]. Disponível em: http://www.snis.gov.br/diagnostico-anual-agua-e-esgotos/diagnostico-dos-servicos-de-agua-e-esgotos-2018
30. Soares AFS, Souza e Souza LP. Contaminação das águas de abastecimento público por poluentes emergentes e o direito à saúde.Rev Dir Sanit. 2020;20(2):100-33. https://doi.org/10.11606/issn.2316-9044.v20i2p100-133
31. Trata Brasil. Saneamento: principais estatísticas no Brasil. São Paulo: Trata Brasil; 2015[acesso 19 maio 2020]. Disponível em: http://www.tratabrasil.org.br/saneamento/principais-estatisticas/no-brasil/saude
32. World Health Organization - WHO. Investing in water and sanitation: increasing access, reducing inequalities. Geneva: World Health Organization; 2014[acesso 19 maio 2020]. Disponível em: https://www.who.int/water_sanitation_health/publications/glaas_report_2014/en/

33. Brasil. Lei Nº 8.142, de 28 de dezembro de 1990. Dispõe sobre a participação da comunidade na gestão do sistema único de saúde (SUS) e sobre as transferências intergovernamentais de recursos financeiros na área da saúde e dá outras providências. Diário Oficial União. 31 dez 1990.

Author's Contributions

Soares AFS - Conception, planning (study design), acquisition, analysis, data interpretation, and writing of the work. Souza e Souza LP, Nunes BCR, Costa FCR, Silva LFM - Planning (study design), acquisition, analysis, data interpretation, and writing of the work. All authors approved the final version of the work.

Conflict of Interests

The authors inform that there is no potential conflict of interest with peers and institutions, politicians, or financial in this study.