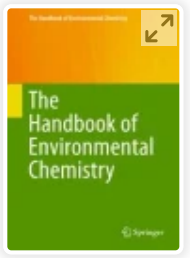

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Covid-19: Survival and Transmission in Wastewater and Sludge

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Abstract

COVID-19 pandemic, considered a disease in the respiratory system, has taken the lives of 4.4 million, around 211 million being infected globally, transmitting the deadly COVID-19 virus through the air from a symptomatic infected person to the other. However, the magnitude of asymptomatic COVID-19 is on the rise and is potentially responsible for spreading the COVID-19 virus among different communities. Excretion of SARS-CoV-2 from the human body, whether mainly in the format of faeces and urine, but either as saliva, sputum, or even body

washings, can get into wastewaters, sewage, or sludge whether the person infected is symptomatic or not. Furthermore, dumping used personal protective equipment including face masks, is another way of spreading COVID-19 which attention needs to be paid. This chapter begins with a description of the SARS-CoV-2 structure and its variants. Next, we will be discussing how COVID-19 virus will be getting into wastewater and sludge and then the mechanism of survival and transmission of this deadly virus in wastewater and sludge. This knowledge will help researchers develop formulas to uncover epidemics in advance and thereby prevent community spreading. The utility of wastewater-based epidemiology (WBE) to monitor, manage, and control the COVID-19 infection cannot be underestimated.

Keywords

COVID-19 **SARS-CoV-2** **Wastewater**

Wastewater-based epidemiology (WBE)

References

1. Zhu H, Li W, Niu P (2020) The novel coronavirus outbreak in Wuhan, China. Glob Heal Res Policy

5(6)

2. Guan W, Ni Z, Hu Y, Liang W, Ou C, He J et al (2020) Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 382(18):1708–1720

3. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J et al (2020) Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. J Am Med Assoc 323(11):1061–1069

4. Yeo C, Kaushal S, Yeo D (2020) Enteric involvement of coronaviruses: is faecal–oral transmission of SARS-CoV-2 possible? Lancet Gastroenterol Hepatol 5

5. Ahmed W, Angel N, Edson J, Bibby K, Bivins A, O'Brien JW et al (2020) First confirmed detection of SARS-CoV-2 in untreated wastewater in Australia: a proof of concept for the wastewater surveillance of COVID-19 in the community. Sci Total Environ 728

6. Grassia R, Testa S, Pan A, Conti CB (2020) SARS-CoV-2 and gastrointestinal tract: the dark side of

the pandemic. Dig Liver Dis 52

7. Sun J, Zhu A, Li H, Zheng K, Zhuang Z, Chen Z et al (2020) Isolation of infectious SARS-CoV-2 from urine of a COVID-19 patient. Emerg Microbes Infect 9(1):991–993

8. Mousavizadeh L, Ghasemi S (2020) Genotype and phenotype of COVID-19: their roles in pathogenesis. J Microbiol Immunol Infect

9. Amirian ES (2020) Potential fecal transmission of SARS-CoV-2: current evidence and implications for public health. Int J Infect Dis 95:363–370

10. Qu G, Li X, Hu L, Jiang G (2020) An imperative need for research on the role of environmental factors in transmission of novel coronavirus (COVID-19). Environ Sci Technol 54

11. Bogler A, Packman A, Furman A, Gross A, Kushmaro A, Ronen A et al (2020) Rethinking wastewater risks and monitoring in light of the COVID-19 pandemic. Nat Sustain 3(12):981–990

12. Ashour HM, Elkhatib WF, Rahman MM, Elshabrawy HA (2020) Insights into the recent

2019 novel coronavirus (Sars-coV-2) in light of past human coronavirus outbreaks. Pathogens 9(3):1–15

13. Dawood AA (2020) Mutated COVID-19 may foretell a great risk for mankind in the future. New Microbes New Infect 35:100673

14. Tai W, He L, Zhang X, Pu J, Voronin D, Jiang S et al (2020) Characterization of the receptor-binding domain (RBD) of 2019 novel coronavirus: implication for development of RBD protein as a viral attachment inhibitor and vaccine. Cell Mol Immunol 17(6):613–620

15. Yan R, Zhang Y, Li Y, Xia L, Guo Y, Zhou Q (2020) Structural basis for the recognition of SARS-CoV-2 by full-length human ACE2. Science 367(6485):1444–1448

16. Singh J, Rahman SA, Ehtesham NZ, Hira S, Hasnain SE (2021) SARS-CoV-2 variants of concern are emerging in India. Nat Med 27:1131–1133

17. Quinonez E, Vahed M, Shahraki AH, Mirsaeidi M (2021) Structural analysis of the novel variants of

sars-cov-2 and forecasting in North America. Viruses 13(5)

18. Firestone MJ, Lorentz AJ, Meyer S, Wang X, Como-Sabetti K, Vetter S et al (2021) First identified cases of SARS-CoV-2 variant P.1 in the United States – Minnesota, January 2021. MMWR SurveillSumm 70(10)

19. Hirotsu Y, Omata M (2021) Discovery of SARS-CoV-2 strain of P.1 lineage harboring K417T/ E484K / N501Y by whole genome sequencing in the city, Japan. medRxiv

20. Xiao F, Tang M, Zheng X, Liu Y, Li X, Shan H (2020) Evidence for gastrointestinal infection of SARS-CoV-2. Gastroenterology 158(6)

21. Zhang W, Du RH, Li B, Zheng XS, Lou YX, Hu B et al (2020) Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. Emerg. Microbes Infect 9(1)

22. WHO (2020) Water, sanitation, hygiene and waste management for the COVID-19 virus. World Heal Organisation, pp 1–9

23. Wan Y, Shang J, Graham R, Baric RS, Li F (2020) Receptor recognition by the novel coronavirus from Wuhan: an analysis based on decade-long structural studies of SARS coronavirus. J Virol 94(7)

24. Hamming I, Timens W, Bulthuis MLC, Lely AT, Navis GJ, van Goor H (2004) Tissue distribution of ACE2 protein, the functional receptor for SARS coronavirus. A first step in understanding SARS pathogenesis. J Pathol 203(2)

25. SanJuan-Reyes S, Gómez-Oliván LM, Islas-Flores H (2021) COVID-19 in the environment. Chemosphere 263

26. Poon LLM, Peiris M (2020) Emergence of a novel human coronavirus threatening human health. Nat Med 26

27. Zhang Y, Chen C, Zhu S, Shu C, Wang D, Song J et al (2020) Isolation of 2019-nCoV from a stool specimen of a laboratory-confirmed case of the

coronavirus disease 2019 (COVID-19). China CDC Wkly 2(8):123–124

28. Riou J, Althaus CL (2020) Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020. Eurosurveillance 25

29. Guo YR, Cao QD, Hong ZS, Tan YY, Chen SD, Jin HJ et al (2020) The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak – a n update on the status. Mil Med Res 7

30. Liu Y, Gayle AA, Wilder-Smith A, Rocklöv J (2020) The reproductive number of COVID-19 is higher compared to SARS coronavirus. J Travel Med 27(2)

31. Li R, Pei S, Chen B, Song Y, Zhang T, Yang W et al (2020) Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV-2). Science 368(6490)

32. Hu Y, Shen L, Xu Z, Zhou J, Zhou H (2020) SARS-CoV-2 may persist in digestive tract longer than respiratory tract. Preprints (February)

33. Wu Y, Guo C, Tang L, Hong Z, Zhou J, Dong X et al (2020) Prolonged presence of SARS-CoV-2 viral RNA in faecal samples. Lanc Gastroenterol Hepatol 5

34. Zhang D, Zhang X, Yang Y, Huang X, Jiang J, Li M et al (2021) SARS-CoV-2 spillover into hospital outdoor environments. J Hazard Mater Lett 2

35. Rimoldi SG, Stefani F, Gigantiello A, Polesello S, Comandatore F, Mileto D et al (2020) Presence and infectivity of SARS-CoV-2 virus in wastewaters and rivers. Sci Total Environ 744

36. Ong SWX, Tan YK, Chia PY, Lee TH, Ng OT, Wong MSY et al (2020) Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. JAMA – J Am Med Assoc 323

37. Zhang D, Ling H, Huang X, Li J, Li W, Yi C et al (2020) Potential spreading risks and disinfection

challenges of medical wastewater by the presence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) viral RNA in septic tanks of Fangcang Hospital. Sci Total Environ 741

38. Berendes DM, Sumner TA, Brown JM (2017) Safely managed sanitation for all means fecal sludge management for at least 1.8 billion people in low and middle income countries. Environ Sci Technol 51(5)

39. Usman M, Farooq M, Hanna K (2020) Existence of SARS-CoV-2 in wastewater: implications for its environmental transmission in developing communities. Environ Sci Technol 54

40. Sharif S, Ikram A, Khurshid A, Salman M, Mehmood N, Arshad Y et al (2021, 16) Detection of SARs-CoV-2 in wastewater using the existing environmental surveillance network: a potential supplementary system for monitoring COVID-19 transmission. PLoS One (6)

41. Wu F, Zhang J, Xiao A, Gu X, Lee WL, Armas F et al (2020) SARS-CoV-2 titers in wastewater are higher than expected from clinically confirmed cases. mSystems 5(4)

42. Ahmed W, Bertsch PM, Angel N, Bibby K, Bivins A, Dierens L et al (2021) Detection of SARS-CoV-2 RNA in commercial passenger aircraft and cruise ship wastewater: a surveillance tool for assessing the presence of COVID-19 infected travellers. J Travel Med 27(5)

43. Haramoto E, Malla B, Thakali O, Kitajima M (2020) First environmental surveillance for the presence of SARS-CoV-2 RNA in wastewater and river water in Japan. Sci Total Environ 737

44. Guerrero-Latorre L, Ballesteros I, Villacrés-Granda I, Granda MG, Freire-Paspuel B, Ríos-Touma B (2020) SARS-CoV-2 in river water: implications in low sanitation countries. Sci Total Environ 743

45. Chin AWH, Chu JTS, Perera MRA, Hui KPY, Yen H-L, Chan MCW et al (2020) Stability of SARS-CoV-2 in different environmental conditions. The Lancet Microbe 1(1)

46. Wang W, Xu Y, Gao R, Lu R, Han K, Wu G et al (2020) Detection of SARS-CoV-2 in different types of clinical specimens. JAMA – J Am Med Assoc 323

47. Ho KF, Lin LY, Weng SP, Chuang KJ (2020) Medical mask versus cotton mask for preventing respiratory droplet transmission in microenvironments. Sci Total Environ 735

48. Nzediegwu C, Chang SX (2020) Improper solid waste management increases potential for COVID-19 spread in developing countries. Resour Conserv Recycl 161

49. Mejjad N, Cherif EK, Rodero A, Krawczyk DA, El KJ, Moumen A et al (2021) Disposal behavior of used masks during the covid-19 pandemic in the moroccan community: potential environmental impact. Int J Environ Res Public Health 18(8)

50. Xagoraraki I, O'Brien E (2020) Wastewater-based epidemiology for early detection of viral outbreaks

51. Asghar H, Diop OM, Weldegebriel G, Malik F, Shetty S, El BL et al (2014) Environmental surveillance for polioviruses in the global polio eradication initiative. J Infect Dis 210

52. Hellmér M, Paxéus N, Magnius L, Enache L, Arnholm B, Johansson A et al (2014) Detection

of pathogenic viruses in sewage provided early warnings of hepatitis A virus and norovirus outbreaks. Appl Environ Microbiol 80(21)

53. Orive G, Lertxundi U, Barcelo D (2020) Early SARS-CoV-2 outbreak detection by sewage-based epidemiology. Sci Total Environ 732

54. Heller L, Mota CR, Greco DB (2020) COVID-19 faecal-oral transmission: are we asking the right questions? Sci Total Environ 729

55. Lesté-Lasserre C (2020) Coronavirus found in Paris sewage points to early warning system. Science

56. Medema G, Heijnen L, Elsinga G, Italiaander R, Brouwer A (2020) Presence of SARS-coronavirus-2 RNA in sewage and correlation with reported COVID-19 prevalence in the early stage of the epidemic in The Netherlands. Environ Sci Technol Lett 7(7)

57. Fongaro G, Rogovski P, Savi BP, Cadamuro RD, Pereira JVF, Anna IHS et al (2021) SARS-CoV-2 in human sewage and river water from a remote

and vulnerable area as a surveillance tool in Brazil. Food Environ Virol

58. Randazzo W, Truchado P, Cuevas-Ferrando E, Simón P, Allende A, Sánchez G (2020) SARS-CoV-2 RNA in wastewater anticipated COVID-19 occurrence in a low prevalence area. Water Res 181

59. Arora S, Nag A, Sethi J, Rajvanshi J, Saxena S, Shrivastava SK et al (2020) Sewage surveillance for the presence of SARS-CoV-2 genome as a useful wastewater-based epidemiology (WBE) tracking tool in India. Water Sci Technol 82(12)

60. Mallapaty S (2020) How sewage could reveal true scale of coronavirus outbreak. Nature 580

61. Wannigama DL, Amarasiri M, Hurst C, Phattharapornjaroen P, Abe S, Hongsing P et al (2021) Tracking COVID-19 with wastewater to understand asymptomatic transmission. Int J Infect Dis 108

62. Wurtzer S, Marechal V, Mouchel J-M, Moulin L (2020) Time course quantitative detection of

SARS-CoV-2 in Parisian wastewaters correlates with COVID-19 confirmed cases. medRxiv

63. Haas CN, Rose JB, Gerba CP (2014) Microbial agents and transmission. In: Quantitative microbial risk assessment

64. Han MS, Seong M-W, Heo EY, Park JH, Kim N, Shin S et al (2020) Sequential analysis of viral load in a neonate and her mother infected with SARS-CoV-2. Clin Infect Dis

65. Lescure FX, Bouadma L, Nguyen D, Parisey M, Wicky PH, Behillil S et al (2020) Clinical and virological data of the first cases of COVID-19 in Europe: a case series. Lancet Infect Dis 20(6)

66. Woelfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Mueller M et al (2020) Clinical presentation and virological assessment of hospitalized cases of coronavirus disease 2019 in a travel-associated transmission cluster. medRxiv

67. Lee PI, Hsueh PR (2020) Emerging threats from zoonotic coronaviruses-from SARS and MERS to 2019-nCoV. J Microbiol Immunol Infect 53(3)

68. Bivins A, Greaves J, Fischer R, Yinda KC, Ahmed W, Kitajima M et al (2020) Persistence of SARS-CoV-2 in water and wastewater. Environ Sci Technol Lett 7(12)

69. Bibby K, Peccia J (2013) Identification of viral pathogen diversity in sewage sludge by metagenome analysis. Environ Sci Technol 47(4)

70. Kocamemi BA, Kurt H, Sait A, Sarac F, Saatci AM, Pakdemirli B (2020) SARS-CoV-2 detection in Istanbul wastewater treatment plant sludges. medRxiv

71. Peccia J, Zulli A, Brackney DE, Grubaugh ND, Kaplan EH, Casanovas-Massana A et al (2020) Measurement of SARS-CoV-2 RNA in wastewater tracks community infection dynamics. Nat Biotechnol 38(10)

72. Larsen DA, Wigginton KR (2020) Tracking COVID-19 with wastewater. Nat Biotechnol 38(10):1151–1153

73. ANSES (2020) Opinion on the assessment of the risks of reduced physical activity and increased sedentarity levels in lockdown situations (in

French). Maisons-Alfort: French agency for food, environmental and occupational health & safety

74. Lodder W, de Roda Husman AM (2020) SARS-CoV-2 in wastewater: potential health risk, but also data source. Lancet Gastroenterol Hepatol 5(6):533–534

75. Nemudryi A, Nemudraia A, Wiegand T, Surya K, Buyukyoruk M, Cicha C et al (2020) Temporal detection and phylogenetic assessment of SARS-CoV-2 in municipal wastewater. Cell Rep Med 1(6)

76. Sherchan SP, Shahin S, Ward LM, Tandukar S, Aw TG, Schmitz B et al (2020) First detection of SARS-CoV-2 RNA in wastewater in North America: a study in Louisiana, USA. Sci Total Environ 743

77. Westhaus S, Weber FA, Schiwy S, Linnemann V, Brinkmann M, Widera M et al (2021) Detection of SARS-CoV-2 in raw and treated wastewater in Germany – suitability for COVID-19 surveillance and potential transmission risks. Sci Total Environ 751

78. La Rosa G, Iaconelli M, Mancini P, Bonanno Ferraro G, Veneri C, Bonadonna L et al (2020) First detection of SARS-CoV-2 in untreated wastewaters in Italy. Sci Total Environ 736

79. Bar-Or I, Yaniv K, Shagan M, Ozer E, Erster O, Mendelson E et al (2020) Regressing SARS-CoV-2 sewage measurements onto COVID-19 burden in the population: a proof-of-concept for quantitative environmental surveillance. medRxiv

80. Wang J, Feng H, Zhang S, Ni Z, Ni L, Chen Y et al (2020) SARS-CoV-2 RNA detection of hospital isolation wards hygiene monitoring during the Coronavirus Disease 2019 outbreak in a Chinese hospital. Int J Infect Dis:94

81. Randazzo W, Cuevas-Ferrando E, Sanjuán R, Domingo-Calap P, Sánchez G (2020) Metropolitan wastewater analysis for COVID-19 epidemiological surveillance. Int J Hyg Environ Health 230

82. Hata A, Hara-Yamamura H, Meuchi Y, Imai S, Honda R (2021) Detection of SARS-CoV-2 in wastewater in Japan during a COVID-19 outbreak. Sci Total Environ 758

83. Kumar M, Patel AK, Shah AV, Raval J, Rajpara N, Joshi M et al (2020) First proof of the capability of wastewater surveillance for COVID-19 in India through detection of genetic material of SARS-CoV-2. Sci Total Environ 746

84. WHO (2020) Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). Geneva

85. Hennig K, Drosten C (2020) CORONAVIRUS-UPDATE FOLGE21:1–9

86. Ye Y, Ellenberg RM, Graham KE, Wigginton KR (2016) Survivability, partitioning, and recovery of enveloped viruses in untreated municipal wastewater. Environ Sci Technol 50(10)

87. Brisebois E, Veillette M, Dion-Dupont V, Lavoie J, Corbeil J, Culley A et al (2018) Human viral pathogens are pervasive in wastewater treatment center aerosols. J Environ Sci (China) 67

88. Casanova L, Rutala WA, Weber DJ, Sobsey MD (2009) Survival of surrogate coronaviruses in

water. Water Res 43(7)

89. Goswami K, Bharali S, Hazarika J (2020) Projections for COVID-19 pandemic in India and effect of temperature and humidity. Diabet Metab Syndr Clin Res Rev 14(5)

90. Sidhu JPS, Sena K, Hodgers L, Palmer A, Toze S (2018) Comparative enteric viruses and coliphage removal during wastewater treatment processes in a sub-tropical environment. Sci Total Environ 616–617

91. Amoah ID, Kumari S, Bux F (2020) Coronaviruses in wastewater processes: source, fate and potential risks. Environ Int 143

92. Tran HN, Le GT, Nguyen DT, Juang RS, Rinklebe J, Bhatnagar A et al (2021) SARS-CoV-2 coronavirus in water and wastewater: a critical review about presence and concern. Environ Res 193

93. Whitney ON, Kennedy LC, Fan VB, Hinkle A, Kantor R, Greenwald H et al (2021) Sewage, salt, silica, and SARS-CoV-2 (4S): an economical kit-

free method for direct capture of SARS-CoV-2 RNA from wastewater. Environ Sci Technol 55(8)

94. Barceló D (2020) Wastewater-based epidemiology to monitor COVID-19 outbreak: present and future diagnostic methods to be in your radar. Case Stud Chem Environ Eng 2

95. Yang T, Wang YC, Shen CF, Cheng CM (2020) Point-of-care RNA-based diagnostic device for Covid-19. Diagnostics 10

96. Zaneti RN, Girardi V, Spilki FR, Mena K, Westphalen APC, da Costa Colares ER et al (2021) Quantitative microbial risk assessment of SARS-CoV-2 for workers in wastewater treatment plants. Sci Total Environ 754

97. Dada AC, Gyawali P (2021) Quantitative microbial risk assessment (QMRA) of occupational exposure to SARS-CoV-2 in wastewater treatment plants. Sci Total Environ 763

98. Blanco A, Abid I, Al-Otaibi N, Pérez-Rodríguez FJ, Fuentes C, Guix S et al (2019) Glass wool concentration optimization for the detection of

enveloped and non-enveloped waterborne viruses. Food Environ Virol 11(2)

99. Alexyuk MS, Turmagambetova AS, Alexyuk PG, Bogoyavlenskiy AP, Berezin VE (2017) Comparative study of viromes from freshwater samples of the Ile-Balkhash region of Kazakhstan captured through metagenomic analysis. Virus Dis 28(1)

100. Giacobbo A, MAS R, Zoppas Ferreira J, Bernardes AM, de Pinho MN (2021) A critical review on SARS-CoV-2 infectivity in water and wastewater. What do we know? Sci Total Environ 774

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