

Waste management beyond the COVID-19 pandemic: Bibliometric and text mining analyses

Original

Waste management beyond the COVID-19 pandemic: Bibliometric and text mining analyses / Ranjbari, M.; Shams Esfandabadi, Z.; Gautam, S.; Ferraris, A.; Scagnelli, S. D.. - In: GONDWANA RESEARCH. - ISSN 1342-937X. - ELETTRONICO. - (2023), pp. 1-14. [10.1016/j.gr.2021.12.015]

Availability:

This version is available at: 11583/2968861 since: 2022-08-01T15:04:55Z

Publisher:

Elsevier Inc.

Published

DOI:10.1016/j.gr.2021.12.015

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23 scientific production to date in the field of WM. In this vein, the performance indicators of the
24 target literature were identified and discussed through conducting a bibliometric analysis. Such
25 conceptual structure of COVID-19-related WM research, including seven main research themes,
26 were uncovered and visualized through a text mining analysis as follows: (1) household and food
27 waste, (2) personnel safety and training for waste handling, (3) sustainability and circular
28 economy, (4) personal protective equipment and plastic waste, (5) healthcare waste management
29 practices, (6) wastewater management, and (7) COVID-19 transmission through infectious waste.
30 Finally, a research agenda for WM practices and activities in the post-COVID-19 era is proposed,
31 focusing on the following three identified research gaps: (i) developing a systemic framework to
32 properly manage the pandemic crisis implications for WM practices as a whole, following a system
33 thinking approach, (ii) building a circular economy model encompassing all activities from the
34 design stage to the implementation stage, and (iii) proposing incentives to effectively involve
35 informal sectors and local capacity in decentralizing municipal waste management, with a specific
36 focus on developing and less-developed countries.

37 **Keywords:** COVID-19, Plastic waste, Healthcare waste, Municipal solid waste, Wastewater,
38 Personal protective equipment.

39 **1. Introduction**

40 The novel coronavirus-caused infectious disease 2019 (COVID-19) pandemic, as the most drastic
41 health calamity of this century (Chakraborty and Maity, 2020), has severely impacted the
42 economic, social, and environmental aspects of the global community and human well-being
43 (Ranjbari et al., 2021c). Disruptions in economic activities and commodity markets (Rajput et al.,
44 2021), limitations in mobility and industrial activities but at the same time, improving the air

45 quality of the cities (Ambade et al., 2021; Gautam et al., 2021; Gautam, 2020; Ravina et al., 2021),
46 and challenges in implementing the 2030 Agenda for Sustainable Development (Bherwani et al.,
47 2021; Ranjbari et al., 2021b) are only a few instances of the pandemic's implications for the global
48 community. This pandemic through posing a significant increase in healthcare waste generation,
49 which is an important transmission medium for the virus, has led to creating critical challenges for
50 waste management (WM) practices globally (C. Chen et al., 2021; Gautam et al., 2022). The
51 dramatic increase of personal protective equipment waste often ends up being treated by traditional
52 disposal methods that have gravely pressured incineration and landfill facilities (Wang et al.,
53 2021). In this vein, the waste generated in the wake of COVID-19, such as masks, gloves, sanitary
54 papers, and clothing materials needs to be considered as medical waste, highlighting the
55 importance of safely handling at the household level, and properly treatments at the municipal
56 level (Musa et al., 2020).

57 However, there are still many uncertainties regarding the effects of the pandemic outbreak on
58 various waste streams generated from a macro lens. On one hand, COVID-19 restrictions and
59 partial lockdowns imposed by governments have decreased some industrial and business activities,
60 which usually generate large amounts of waste (Naughton, 2020). On the other hand, in addition
61 to increased medical waste, some waste streams such as agricultural waste or household wastes
62 may increase due to the high demand for home delivery as well as increasing home cooking in the
63 wake of the pandemic (Dente and Hashimoto, 2020). Consequently, a system thinking approach
64 (Ranjbari et al., 2019; Shams Esfandabadi et al., 2020), as well as more reliable real-time WM
65 data is needed to truly map changes in waste generation in the post-COVID-19 era (Naughton,
66 2020).

67 As a response to the urgent call for action against adverse effects of the pandemic, many COVID-
68 related studies have been conducted within various domains and disciplines. In this regard, a
69 massive amount of research has also been conducted focusing on the effects of the pandemic on
70 WM systems, practices, and different waste streams, such as healthcare WM challenges (de Aguiar
71 Hugo and Lima, 2021), household food waste (Amicarelli and Bux, 2021; Vittuari et al., 2021),
72 effective plastic WM during and post pandemic (Vanapalli et al., 2021), solid waste and
73 environmental impacts (Urban and Nakada, 2021), municipal waste disposal behavior (Vu et al.,
74 2021), face mask waste generation (Torres and De-la-Torre, 2021), reusing COVID-19 face mask
75 as a novel solution to the emerging COVID-19 waste issue (Rehman and Khalid, 2021), solid
76 waste generation and management strategies (Liang et al., 2021), single-use plastic waste (Leal
77 Filho et al., 2021), behavioral impacts on residential food provisioning, use, and waste (Babbitt et
78 al., 2021a), perceptions of people towards household waste management in the wake of the
79 pandemic (Acharya et al., 2021), municipal solid waste management (Yousefi et al., 2021), waste
80 production in households (Filho et al., 2021), and enabling circular economy model in solid waste
81 management as a recovery plan post COVID-19 (Sharma et al., 2021).

82 The increasing interest of researchers and academic communities in contributing to COVID-
83 related WM practices has led to fragmented literature in this domain. As a result, an inclusive
84 landscape of the pandemic challenges for WM is still lacking in the literature. To the best of the
85 authors' knowledge, so far, no research has conducted a comprehensive bibliometric review on the
86 pandemic implications for WM practices. Therefore, to fill this gap, this research aims at providing
87 a comprehensive review of the COVID-related scientific production to date in the WM field. On
88 this basis, bibliometric and text mining analyses are conducted to address the following research
89 questions:

90 **RQ1.** How has the field of research regarding WM in the context of COVID-19 performed?

91 **RQ2.** What are the main research themes of WM in the COVID-19-related scientific production?

92 **RQ3.** What are the potential research gaps and future directions for WM in the post-COVID-19
93 era?

94 The remainder of this research is structured as follows. The methodology is described in Section
95 2. The bibliometric results, including the performance analysis and science mapping of the WM
96 in the pandemic context, are presented and discussed in Section 3. Section 4 provides the research
97 gaps and future research directions to further develop WM practices considering COVID-19
98 implications. And finally, Section 5 concludes the main findings and presents the limitations of
99 the current research.

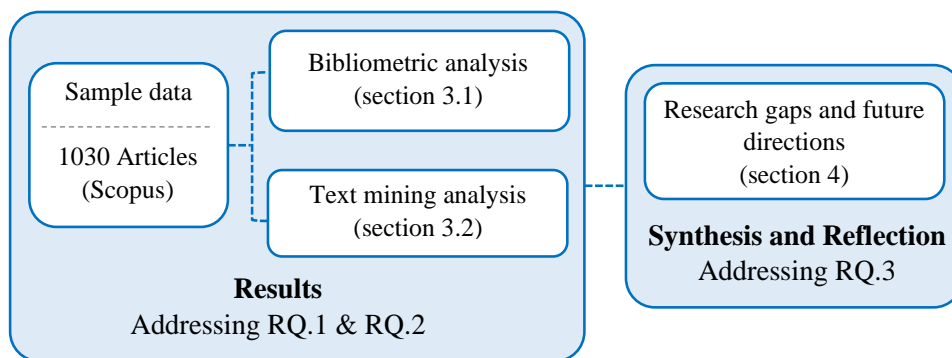
100 **2. Research design and methodology**

101 In this research, an analytical method combining bibliometric and text mining analyses adopted
102 from Ranjbari et al. (Ranjbari et al., 2022, 2021a) was applied to answer the research questions. In
103 this regard, the bibliometric analysis was used to evaluate and map the performance of WM
104 research taking COVID-19 implications into account, corresponding to the first research question.
105 As a part of the bibliometric analysis, bibliographic coupling was conducted, which aggregates
106 articles in different clusters based on the cited references they have in common in their
107 bibliographies. Therefore, the formed clusters in bibliographic coupling are made of the sample
108 articles available in our dataset. On the other hand, a text mining analysis was conducted to
109 discover the main research themes and trends of the WM literature in the context of the pandemic,
110 corresponding to the second research question. The text mining analysis was conducted on the

111 titles and abstracts of the articles within our dataset to extract the noun phrases used by the authors.
112 These phrases are then clustered based on their co-occurrence links (Waltman et al., 2010) to form
113 the main research themes within the studied field of research. Hence, the clusters built in this
114 analysis contain the frequent noun phrases applied in the titles and abstracts of the sample articles
115 in our dataset. Finally, according to the insights provided by the bibliometric and text mining
116 analyses, research gaps and potential avenues for future studies are presented, corresponding to
117 the third research question.

118 Fig. 1 illustrates the main structure of this research approaching the research questions.

119



120

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Fig. 1. The research framework design

122

2.1. Search string and data collection

123 In order to extract as many relevant studies as possible from the target literature, using a well-
124 structured research protocol has been widely highlighted in the literature as one of the most
125 important prerequisites in conducting systematic reviews (Chaudhary et al., 2021; Makrides et al.,
126 2021; Zahedi et al., 2016). On this basis, a structured search string was formulated using different

127 combinations of the keywords "COVID-19" and "waste" as the main two concepts which shape
128 the present review. Consequently, the following search string was constructed to collect articles
129 from the Scopus database: ("COVID-19" OR "pandemic" OR "Coronavirus" OR "SARS-CoV-2")
130 AND "waste".

131 Since this research aims to map all waste streams considering the pandemic effects, we decided
132 not to limit the keyword "waste" with different waste streams, such as municipal solid waste,
133 medical waste, healthcare waste, or plastic waste to cover WM practices for various waste streams
134 as much as possible. The initial run of the search string on the titles and abstracts of articles in the
135 Scopus database returned a total of 1567 articles. Due to the recentness of the COVID-19
136 pandemic, the results were limited to the articles published in 2020 and 2021. Moreover, to ensure
137 the reliability of the sample data, only peer-reviewed journal articles were included in the research
138 leading to excluding other types of documents, such as conference proceedings, book chapters,
139 and editorial notes from the study. Besides, non-English materials were excluded from the
140 remained articles. As a result, a final sample of 1030 articles was selected as the main data for
141 conducting the bibliometric and text mining analyses. Table 1 summarizes the steps taken in this
142 research to construct the final sample.

143 **Table 1.** Steps of the data collection process.

Search string	"COVID-19" OR "pandemic" OR "Coronavirus" OR "SARS-CoV-2" AND "Waste"
Fields mined	Article titles, abstracts, author keywords, and keywords plus

Database	Scopus
Initial Result	1567 articles
Search date	August 8, 2021
Inclusion criteria	Only peer-reviewed journal articles, only English materials, limited to 2020-2021
Final sample	1030 articles

144

145 **2.2. Data analysis**

146 The bibliometric analysis, as a statistical tool to evaluate the performance of an extensive amount
147 of scientific production, has been broadly used for science mapping in recent years. This is due to
148 the capability of the bibliometric analysis in drawing conclusions about the links among articles,
149 journals, authors, keywords, citations, and co-citations networks (Feng et al., 2017), which
150 supports researchers in discovering research themes and trends, and future research directions. In
151 this research, the VOSviewer software version 1.6.16 developed by van Eck and Waltman (2010)
152 was employed to run the bibliometric analysis. Accordingly, the performance of WM research
153 within the COVID-related scientific production was investigated and mapped by presenting
154 bibliometric performance indicators focusing on (i) geographical distribution of publications, (ii)
155 authors' productivity and influence, (iii) core journals, (iv) articles, and (v) keyword-based
156 analysis to unfold research tendencies and hotspots. In this regard, data cleaning, as an essential
157 step in keyword-based analyses to reduce the presence of redundant and useless data (Bresciani et
158 al., 2021; Ranjbari et al., 2020), was performed in a reasonable manner, for instance by (i)
159 unification of the English writing styles, (ii) merging singular and plural as well as full and short

160 forms of the keywords, (iii) excluding general keywords without conveying any specific meaning,
161 such as review or article. Besides, all forms of referring to the COVID-19 pandemic, including
162 Coronavirus, pandemic, and SARS-COV-2 were transformed into "COVID-19" to more
163 accurately assess the occurrence of this keywords.

164 In addition to the provided bibliometric indicators, a text mining analysis based on a term co-
165 occurrence algorithm (Van Eck and Waltman, 2011) using the text mining module of VOSviewer
166 version 1.6.16 was also conducted on the manuscripts' titles and abstracts (1030 articles) included
167 in the final sample. As a result, semantic structures and phrase patterns that constructed the main
168 research themes of WM studies post COVID-19 were identified and visualized. A data cleaning
169 step was also taken before text mining analysis by (i) unification of the English writing styles, and
170 (ii) merging full and short forms of the keywords.

171 **3. Results and discussion**

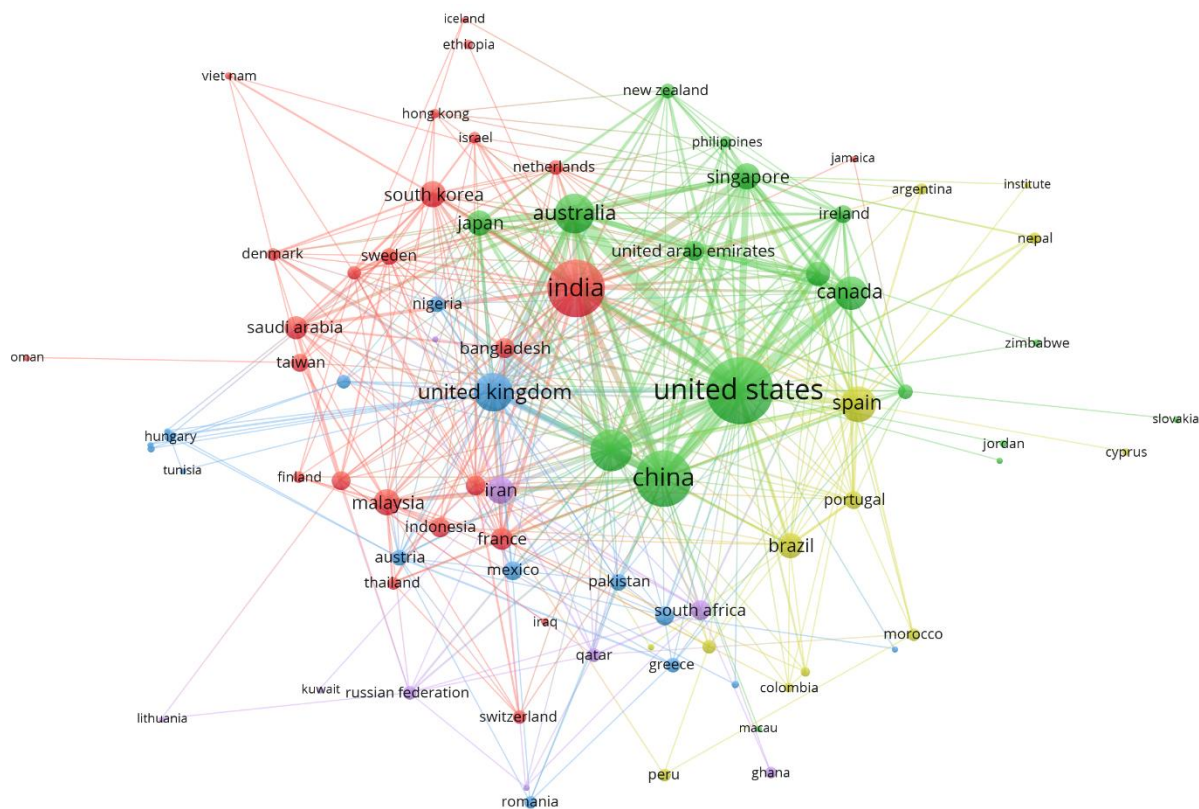
172 In this section, the results of the bibliometric analysis and text mining analysis are presented to
173 address the first and second research questions, respectively.

174 **3.1. Bibliometric results: performance indicators**

175 **3.1.1. Geographical distribution of publications**

176 The spatial and geographic distribution of articles provides insight into the main active countries
177 in terms of publication within the waste context in the COVID-19 era. A total of 91 countries have
178 published articles within our studied field and 82 of these countries are a part of a co-authorship
179 network. Fig. 2 illustrates the countries' co-authorship network of the WM research post-

180 pandemic, consisting of nodes with different sizes corresponding to the number of articles
 181 published by a country, and links with different thicknesses corresponding to the strength of the
 182 co-authorship between each pair of countries. Table 2 provides the list of the top 10 countries in
 183 terms of the number of published articles, number of collaborating countries (number of links),
 184 total number of articles co-authored (total link strength), and the number of cites to their articles.



185
 186 **Fig. 2.** The countries' co-authorship network of WM research post-COVID19 pandemic

187
 188 **Table 2.** Top 10 countries in terms of the number of published articles, number of co-author countries,
 189 total number of co-authorship, and the number of cites to their articles

Rank	Published articles	Number of collaborating countries	Total number of documents co-authored	Citations
1	USA (137)	USA (49)	USA (169)	USA (2080)
2	India (101)	UK (42)	China (132)	Australia (1197)
3	China (98)	China, India (39)	Australia (120)	Japan (1036)
4	Italy (55)	Italy (37)	Italy (108)	Italy (988)
5	Australia (48)	Australia (34)	India (105)	China (840)
6	UK (47)	Singapore (29)	UK (94)	India (754)
7	Spain (39)	Spain (28)	Singapore (84)	Spain (486)
8	Canada (34)	Japan (26)	Canada (72)	UK (448)
9	Iran (23)	South Korea (25)	Spain (54)	Mexico (423)
10	Malaysia (22)	Poland, United Arab Emirates (23)	Japan (53)	Ecuador (357)

190

191 As can be seen in Table 2, the USA with 137 articles, 49 collaboration links, 169 co-authorships,
192 and 2080 citations is ranked first in all four rankings. Although the second and third ranks in these
193 rankings address different countries, Italy is ranked fourth with 55 articles, 37 co-author countries,
194 108 collaborations, and 988 earned citations. UK, China, Australia, India, and Spain also appear
195 among the top 10 countries in all the four lists, but their position differs in each ranking. As the
196 strength of the links in Fig. 2 shows, most of the collaboration of the USA in their publications
197 have taken place with Australia (21 co-authorship), Canada (16 co-authorship), and China (15 co-

198 authorship), which are also the strongest links in this network. The next strong collaboration refers
199 to the co-authorship of Italy with China and the USA, each happening 12 times.

200 3.1.2. Authors productivity and influence

201 Research authors play a key role in the evaluation of the development in an academic field (Guo
202 et al., 2021). A total of 3,348 authors contributed to the research in the field of WM considering
203 the challenges caused by COVID-19, among whom 80 authors have contributed at least in 3
204 articles. Table 3 and Table 4 provide the list of authors with the highest number of articles (most
205 productive authors) and the highest number of citations (most influential authors) in our dataset,
206 respectively, and also the number of their co-authors and co-authorship. Based on the lists provided
207 in these tables, M. Kitajima is the most productive and most influential author among the 3348
208 authors in our dataset.

209 **Table 3.** The most productive authors in WM research post-COVID-19 pandemic

Author	Articles	Citations	Co-authors	Total co-authorship
Kitajima M.	8	848	19	43
Li J.	8	490	22	24
Chen X.	7	24	17	17
Liu Y.	7	72	18	19
Bibby K.	6	714	16	48
Wang J.	6	60	6	9
Wang Y.	6	7	8	8
Zhang L.	6	37	12	16

Ahmed W.	5	713	16	48
Bivins A.	5	538	16	45
Lee J.	5	11	1	1
Li X.	5	18	5	5
Zhang J.	5	132	8	11
Zhang X.	5	103	8	9
Zhang Y.	5	57	6	6

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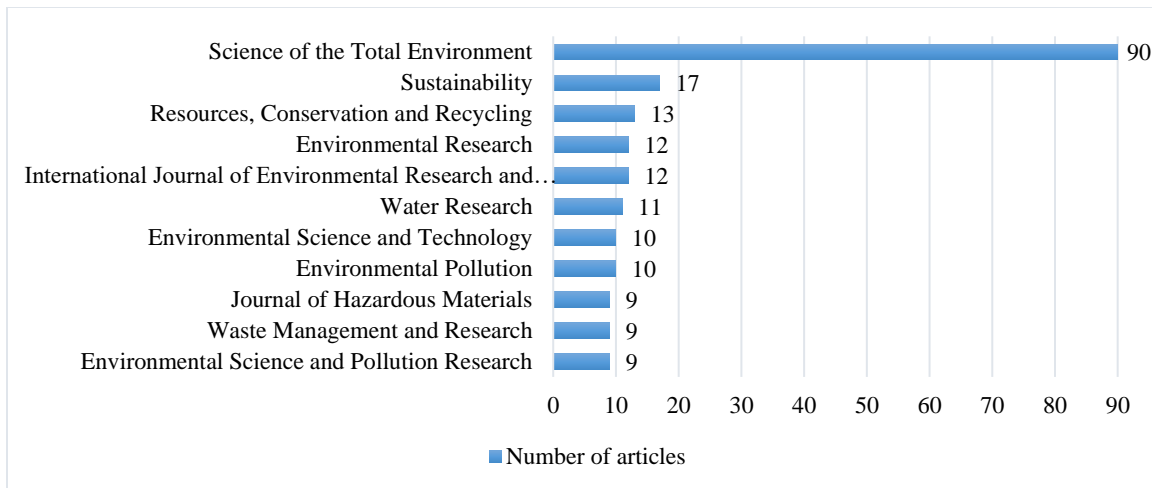
Table 4. The most influential authors in WM research post COVID-19 pandemic

Author	Citations	Articles	Co-authors	Total co-authorship
Kitajima M.	848	8	19	43
Bibby K.	714	6	16	48
Ahmed W.	713	5	16	48
Bivins A.	538	5	16	45
Mueller J.F.	538	4	15	44
Simpson S.L.	538	4	15	44
Thomas K.V.	538	4	15	44
Verhagen R.	538	4	15	44
Smith W.J.M.	521	3	15	35
Li J.	490	8	22	24

212

213 3.1.3. Core journals

214 The 1030 available articles in the WM field of research post COVID-19 within our dataset have
215 been published in 351 journals. Out of this pool of journals, 35 have published at least 3 of the
216 articles in the dataset. Fig. 3 and Fig. 4 focus on the journal publications and show the top ones
217 based on the number of published articles and the number of citations to their articles, respectively.
218 As can be seen in these figures, *Science of the Total Environment* has both the largest share of
219 published articles and the highest number of citations to its articles. Besides, there is a significant
220 gap between this journal and the second-ranked journals both in terms of productivity and
221 influence. In fact, while *Science of the Total Environment* has published 90 articles, *Sustainability*
222 as the next productive journal has published 17 articles, followed by *Resource, Conservation and*
223 *Recycling* that has 13 articles in our database. Moreover, in terms of the citations earned by the
224 published articles, *Science of the Total Environment* is followed by *Water Research and Resource,*
225 *Conservation and Recycling*, with 426 and 297 citations, respectively, which are far away from
226 the 2759 cites received by *Science of the Total Environment*. Therefore, *Science of the Total*
227 *Environment* can be regarded as the leading journal in the field of WM post COVID-19 from this
228 lens of analysis.

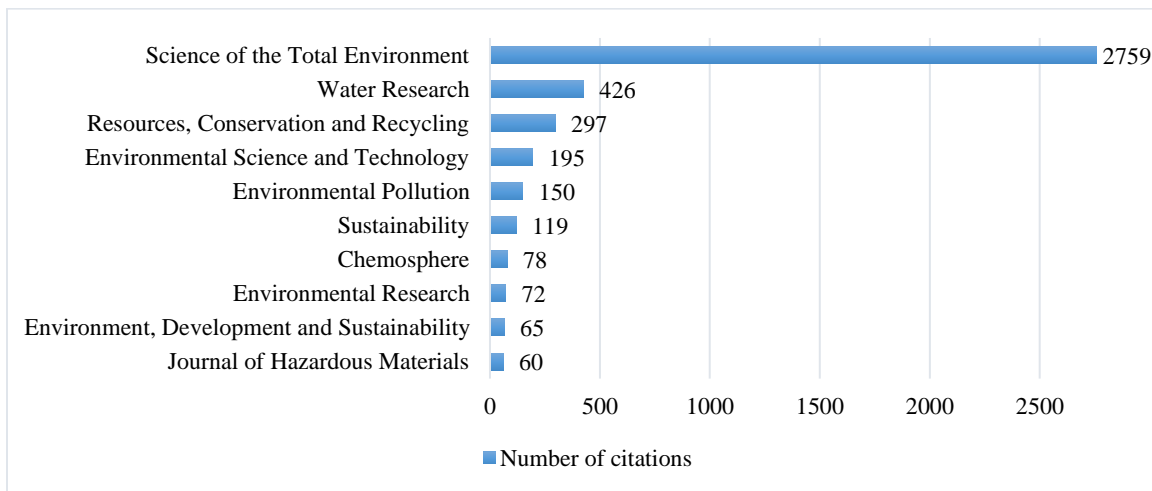


229

Fig. 3. Top productive journals in terms of published articles

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231



232

Fig. 4. Top influential journals in terms of the number of citations to their articles

233

234 **3.1.4. Articles**

235 In this section, two main analyses are conducted on the articles concerning the citations received
 236 by the articles and their bibliographic coupling.

237 **3.1.4.1. Influential articles**

238 One of the ways to evaluate the influence of an article on a related research area is to consider the
239 number of times it is cited (Merigó et al., 2015). Therefore, Table 5 presents the list of the top 10
240 most cited articles within the WM filed post COVID-19. As shown in this table, two papers share
241 the eighth position by attracting 123 citations. The most influential article in Table 5 with 394
242 citations is a research conducted by Ahmed et al. (2020a) that has focused on the first detection of
243 the COVID-19 virus in untreated wastewater in Australia. Similarly, the first detection of SARS-
244 CoV-2 RNA in wastewater has been considered in Italy (La Rosa et al., 2020) and Japan (Haramoto
245 et al., 2020) in the fifth and eighth most influential articles with 193 and 123 citations, respectively.
246 The existence of SARS-CoV-2 RNA in wastewater treatment plants in Spain and the USA was
247 investigated by Randazzo et al. (2020) and Wu et al. (2020) in the third and tenth influential articles
248 with 274 and 101 citations, respectively. Besides, wastewater-based epidemiology is addressed by
249 Hart and Halden (2020) in the seventh-ranked paper, and a review of the methodologies for the
250 detection and quantification of SARS-CoV-2 in wastewater and the potential of wastewater
251 surveillance regarding the pandemic is presented by Kitajima et al. (2020) in the sixth influential
252 article. Fadare and Okoffo (2020) and Prata et al. (2020) address plastic waste in their research,
253 and finally, Zambrano-Monserrate et al. (2020) and Saadat et al. (2020) analyze the environmental
254 effects of the pandemic, as the eighth, ninth, second and fourth highly cited articles within the
255 studied research area, respectively.

256 Furthermore, considering the journals containing the most influential articles in Table 5, out of the
257 11 available articles, 7 have been published in *Science of the Total Environment*, which was

258 introduced as the most productive and influential journal in the context of WM post pandemic in
 259 section 3.1.3.

260 **Table 5.** Top 10 highly cited articles in the WM research within the COVID19 area

Rank	Author	Title	Journal	Citation
1	Ahmed et al. (2020a)	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	Environmental Science & Technology Letters	394
2	Zambrano-Monserrate et al. (2020)	Indirect effects of COVID-19 on the environment	Science of The Total Environment	356
3	Randazzo et al. (2020)	SARS-CoV-2 RNA in wastewater anticipated COVID-19 occurrence in a low prevalence area	Water Research	274
4	Saadat et al. (2020)	Environmental perspective of COVID-19	Science of The Total Environment	201
5	La Rosa et al. (2020)	First detection of SARS-CoV-2 in untreated wastewaters in Italy	Science of The Total Environment	193

6	Kitajima et al. (2020)	SARS-CoV-2 in wastewater: State of the knowledge and research needs	Science of The Total Environment	175
7	Hart and Halden (2020)	Computational analysis of SARS-CoV-2/COVID-19 surveillance by wastewater-based epidemiology locally and globally: feasibility, economy, opportunities and challenges	Science of The Total Environment	140
8	Haramoto et al. (2020)	First environmental surveillance for the presence of SARS-CoV-2 RNA in wastewater and river water in Japan	Science of The Total Environment	123
	Fadare and Okoffo (2020)	COVID-19 face masks: A potential source of microplastic fibers in the environment	Science of The Total Environment	123
9	Prata et al. (2020)	COVID-19 Pandemic Repercussions on the Use and Management of Plastics	Environmental Science & Technology	113
10	Wu et al. (2020)	SARS-CoV-2 titers in wastewater are higher than expected from clinically confirmed cases	mSystems	101

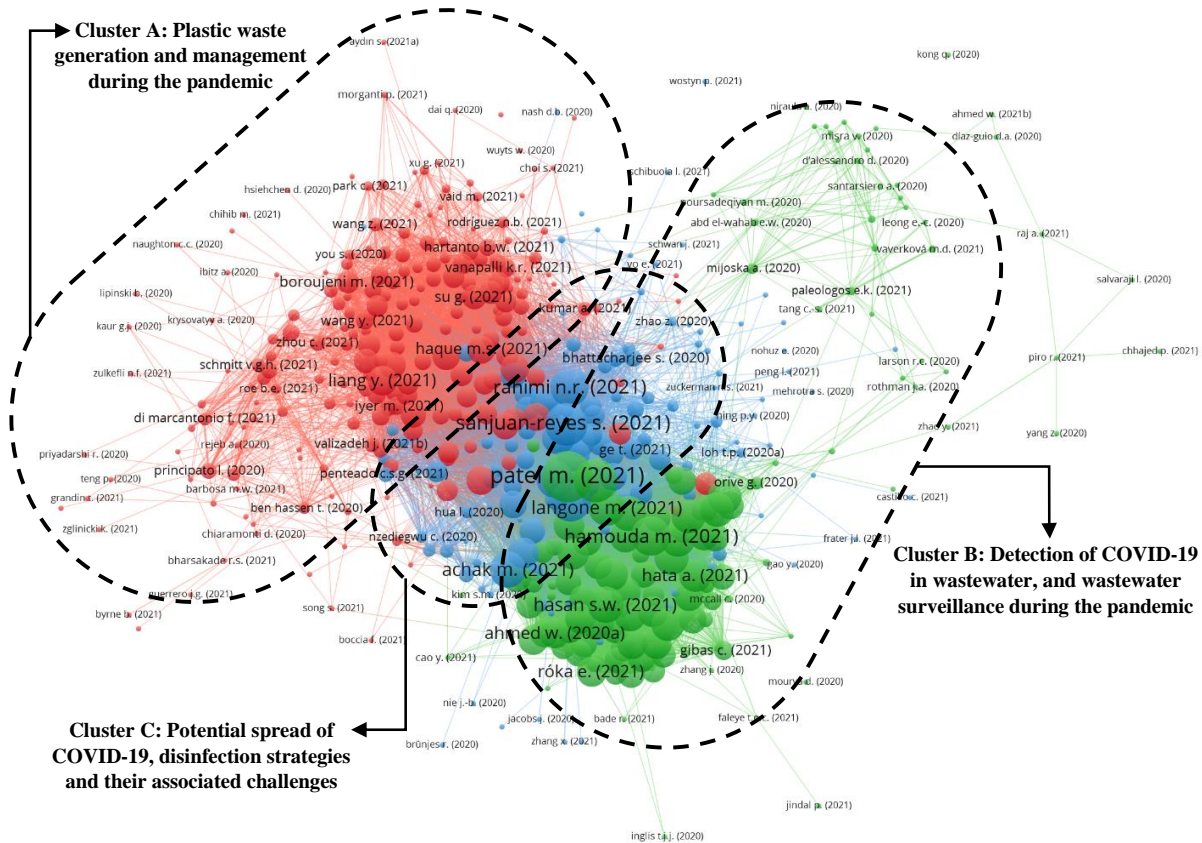
261 **3.1.4.2. Bibliographic coupling of articles**

262 In order to put the articles in relevant categories and show the main themes of the WM research in
263 the COVID-19 era, bibliometric coupling of the articles was conducted based on the references
264 that they share. Out of the 1030 research and review articles in our dataset, only 658 documents
265 had at least one common reference with other documents. Therefore, these 658 articles were
266 considered for the bibliographic coupling in this section. Fig. 5 visualizes the articles grouped in
267 three specific clusters. Each cluster is addressed by a different color and is named based on the
268 main sense of the articles located in it. The size of the bubbles points to the number of citations of
269 the corresponding article and the link between each pair of articles shows their co-occurrence. The
270 top 10 highly cited articles of each category are listed in Table 6.

271 The focus of the majority of the papers in research category A (red color in Fig. 5) is on the
272 generation of plastic waste linked with the usage of face masks (Das et al., 2020; Fadare and
273 Okoffo, 2020) and other personal protective equipment during the pandemic, as well as related
274 management of the generated waste (Prata et al., 2020; Sharma et al., 2020; Vanapalli et al., 2021).
275 This category is supported by articles that share similar references with the plastic waste research
276 but target the management of pandemic-related waste (Ibn-Mohammed et al., 2021; Peng et al.,
277 2020). The unsustainable use of single-use plastics to protect people against the pandemic has
278 exposed ecosystems to several environmental threats by producing a huge amount of plastic
279 pollution (Sarkodie and Owusu, 2021). On one hand, the increase in waste generated, and on the
280 other hand, the reduction in the recycling of used materials have posed serious challenges to water,
281 land, and air (Zambrano-Monserrate et al., 2020). In this regard, the global unprecedented rise of
282 using billions of face masks to slow down the COVID-19 transmission rate has been under intense

283 debate as a critical environmental issue (Fadare and Okoffo, 2020). Replacing common face
284 masks, which are produced from petrochemicals derived raw materials, with degradable bio-based
285 face masks using raw materials that are side-stream products of local industries was proposed by
286 Das et al. (2020) as a sustainable solution for the pandemic WM.

287 Detection of SARS-COV-2 RNA in wastewater (Ahmed et al., 2020a; La Rosa et al., 2021; Orive
288 et al., 2020) is the focal point of research category B, which is shown in green in Fig. 5. This
289 category also includes research on wastewater surveillance post COVID-19 (Daughton, 2020),
290 which highlights the important role of wastewater-based epidemiology as an effective tool to
291 manage the pandemic (Ahmed et al., 2020b) and minimize domino effects of COVID-19
292 restrictions that stress humans and economies (Daughton, 2020). Besides, since wastewater is
293 relatively affordable and can be easily collected and monitored at different population aggregation
294 levels, wastewater surveillance in the COVID-19 outbreak can provide a real-time and cost-
295 effective health assessment rather than case reporting (Thompson et al., 2020). The top 6 papers
296 in this category have been previously reported among the most influential articles in section
297 3.1.4.1. Finally, research category C (blue color in Fig. 5) stands mainly based on the research
298 articles addressing the potential spread of the SARS-COV-2 virus through solid waste (Nzediegwu
299 and Chang, 2020), wastewater (Zhang et al., 2020), environmental matrices and surfaces
300 (Carraturo et al., 2020; Mouchtouri et al., 2020), and water (Carducci et al., 2020), and is supported
301 by research articles addressing preventive measures (Wang et al., 2020) and disinfection strategies
302 (Ilyas et al., 2020).



303

304 **Fig. 5.** Bibliographic coupling of the articles within the field of WM research post-COVID19 pandemic

305 **Table 6.** Highly cited articles within the main identified research categories.

Research category A:	Research category B:	Research category C:
Plastic waste generation and management during the pandemic	Detection of COVID-19 in wastewater, and wastewater surveillance during the pandemic	Potential spread of COVID-19, disinfection strategies and their associated challenges
Article citation	Article citation	Article citation
Reference	Reference	Reference

Zambrano-	356	Ahmed et al.	394	Saadat et al.	201
Monserrate et al.		(2020a)		(2020)	
(2020)					
Fadare and	123	Randazzo et al.	274	Peccia et al.	93
Okoffo (2020)		(2020)		(2020)	
Prata et al. (2020)	113	La Rosa et al.	193	Nzediegwu and	65
		(2020)		Chang (2020)	
Sharma et al.	82	Hart and Halden	140	Zhang et al.	63
(2020)		(2020)		(2020)	
Vanapalli et al.	65	Haramoto et al.	123	Carducci et al.	62
(2021)		(2020)		(2020)	
Mofijur et al.	53	Wu et al. (2020)	101	Carraturo et al.	61
(2021)				(2020)	
Ibn-Mohammed	52	Ahmed et al.	100	Ilyas et al. (2020)	46
et al. (2021)		(2020b)			
Ben Hassen et al.	42	Daughton (2020)	67	Wang et al.	38
(2020)				(2020)	
Das et al. (2020)	38	La Rosa et al.	66	Lacy et al. (2020)	35
		(2021)			
Peng et al. (2020)	33	Orive et al.	66	Ma et al. (2020)	33
		(2020)			

307 **3.1.5. Keyword analysis: research tendencies and hotspots**

308 The analysis of keywords frequency provides a ground for the description of the research domain
309 and the concentration of the collected articles. After cleaning the keywords data, 1765 unique
310 keywords were identified, 119 of which had at least 3 occurrences. Then a heat map was developed
311 for these 119 keywords based on their frequencies in VOSviewer, as illustrated in Fig. 6. As
312 expected, COVID-19 (representing all forms of referring to the current pandemic) is the most
313 frequent keyword, as pictured in Fig. 6, and the next main hot spots refer to wastewater,
314 wastewater-based epidemiology, and personal protective equipment, which are in line with the
315 research categories identified in the analysis of bibliographic coupling in section 3.1.4.2. To
316 facilitate the identification of the most frequent keywords, the author keywords with the
317 occurrence of more than 10 are reported in Table 7.

3	Wastewater-based epidemiology	36	13	Disinfection	12
4	Personal protective equipment	30	14	Environmental impact	11
5	WM	28		Plastic pollution	11
6	Food waste	23		Transmission	11
7	Sewage	22	15	Environmental pollution	10
8	Medical waste	20		Face mask	10
9	Sustainability	19		Public health	10
10	Lockdown	16		Virus	10
11	Biosafety	14			

323

324 Since the keyword COVID-19 has a significantly higher frequency (422 occurrences) in
325 comparison with the second most frequent keyword (wastewater with 47 occurrences), it has a co-
326 occurrence with many of the keywords. Based on Table 8, COVID-19 has a pivotal role and
327 appeared alongside wastewater, wastewater-based epidemiology, and personal protective
328 equipment in the author keywords list of 43, 31, and 24 articles, respectively. However, to provide
329 a clearer picture of the most frequent pairs of keywords, without considering “COVID-19”
330 keyword, the most frequent pairs of keywords ignoring “COVID-19” are provided in Table 9.
331 Personal protective equipment and WM, and also wastewater and wastewater-based epidemiology,
332 both are the most frequent pairs of keywords with 7 occurrences. Circular economy and
333 sustainability, and virus and wastewater both are ranked as the second most frequent pairs each

334 appearing in 6 documents. The third rank goes to 4 pairs, including biosafety and laboratory,
 335 consumer behavior and food waste, sewage and wastewater, and wastewater and water, each with
 336 5 occurrences.

337 **Table 8.** The most frequent pairs of author keywords considering COVID-19 as the pivotal keyword

Keyword 1	Keyword 2	Frequency
COVID-19	Wastewater	43
COVID-19	Wastewater-based epidemiology	31
COVID-19	Personal protective equipment	24
COVID-19	WM	22
COVID-19	Sewage	19
COVID-19	Food waste	15
COVID-19	Lockdown	15
COVID-19	Medical waste	15
COVID-19	Biosafety	14
COVID-19	Sustainability	13

338

339

340 **Table 9.** The most frequent pairs of author keywords excluding COVID-19 from the list of keywords

Keyword 1	Keyword 2	Frequency
Personal protective equipment	WM	7

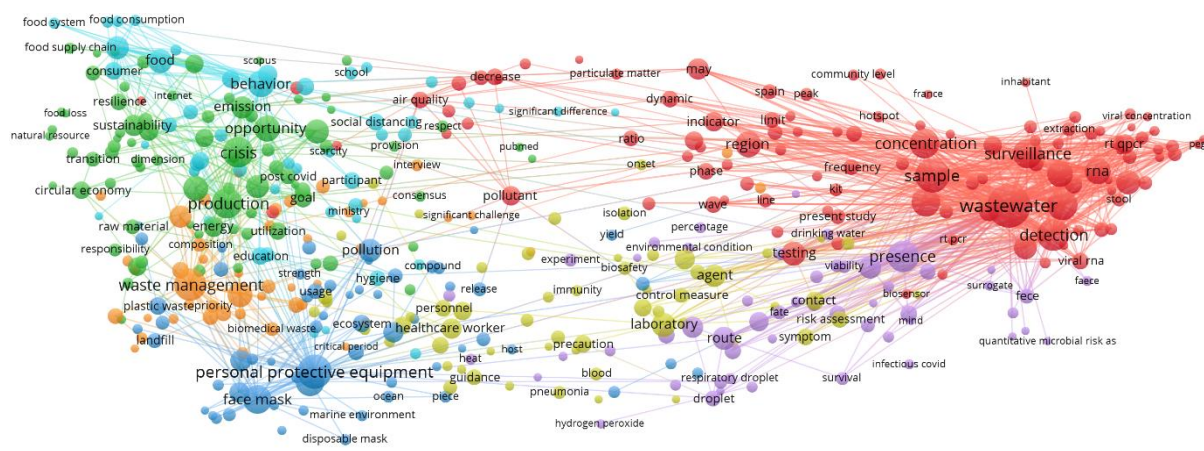
Wastewater	Wastewater-based epidemiology	7
Circular economy	Sustainability	6
Virus	Wastewater	6
Biosafety	Laboratory	5
Consumer behavior	Food waste	5
Sewage	Wastewater	5
Wastewater	Water	5

341

342 **3.2. Text mining results: thematic conceptualization**

343 The text mining analysis was conducted on the titles and abstracts of the 1030 collected peer-
344 reviewed journal articles of our sample to uncover hidden semantic structures and research themes.
345 After cleaning the data, 16,345 unique noun phrases were identified. In order to base the analysis
346 on the sufficiently frequent terms, a minimum of 5 occurrences was considered as a criterion for
347 the selection of phrases, leading to the selection of 853 noun phrases. Then, to remove the general
348 terms (e.g. article, research, etc.) and focus on the main topic of this research, the 60% most
349 relevant identified terms were considered in the analysis based on the statistical method applied in
350 the VOSviewer software (Van Eck and Waltman, 2011). The obtained list of 512 terms was then
351 checked manually to remove the remaining general terms, which do not point to a specific research
352 theme, such as COVID-19 pandemic, coronavirus-caused infectious disease, and Middle East
353 respiratory syndrome. As a result, 454 unique phrases remained, which were used to build clusters
354 based on the co-occurrence of the terms to reveal the research themes in the WM research post
355 COVID-19 era. The seven major themes identified include (1) household and food waste, (2)

356 personnel safety and training for waste handling, (3) sustainability and circular economy, (4)
 357 personal protective equipment and plastic waste, (5) healthcare waste management practices, (6)
 358 wastewater management, and (7) COVID-19 transmission through infectious waste. Fig. 7
 359 presents the thematic structure of the COVID-related WM research. Similar to Fig. 6, the size of
 360 the circles and the links between them show the occurrence of identified terms and their co-
 361 occurrence, respectively.



362

- | | | | |
|------------|--|------------|--|
| Cluster #1 | ■ Household and food waste | Cluster #5 | ■ Healthcare waste management practices |
| Cluster #2 | ■ Personnel safety and training for waste handling | Cluster #6 | ■ Wastewater management |
| Cluster #3 | ■ Sustainability and circular economy | Cluster #7 | ■ COVID-19 transmission through infectious waste |
| Cluster #4 | ■ Personal protective equipment and plastic waste | | |

363 **Fig. 7.** Major research themes in COVID-related WM research

364 The first cluster refers to the household and food waste (cluster #1) considering the pandemic
 365 effects on the waste generated, consumer behavior and lifestyle, and food systems. The main terms
 366 in this research theme are behavior, food, food waste, consumer, household, food consumption,
 367 food system, lifestyle, sanitizer, and household waste. On this basis, the pandemic has highly
 368 impacted the food consumption and purchasing habits of people (Pappalardo et al., 2020) leading
 369 to create many challenges for food systems and businesses all around the world. In this vein, the

370 changes in food consumption behavior in the post-COVID era may be related to price increase
371 concerns, food waste awareness, and safety (Güney and Sangün, 2021). This research theme has
372 been mainly focused on stockpiling and food waste during the COVID-19 pandemic (Brizi and
373 Biraglia, 2021), food waste reduction in times of crisis (Malefors et al., 2021), household food
374 waste behavior (Qian et al., 2020), food waste generation (Heikal Ismail et al., 2020), and safety
375 and food packaging (Kitz et al., 2021). Babbitt et al. (2021b) showed that the increased food
376 purchasing behavior of households to gain self-sufficiency during the pandemic has increased
377 waste through bulk purchasing and stockpiling. In another study, Filho et al. (2021) denoted that
378 the COVID-19 lockdowns have resulted in higher consumption levels of take-away food and
379 packaged products. Based on their research evidence, 45–48% of the participants reported
380 consumption growth of fresh food, packed food, and food delivery due to longer stays at home.
381 Nevertheless, despite the potential increase in food waste generated during the pandemic, Vittuari
382 et al. (2021) showed a considerable reduction in declared household food waste due to uncertainty
383 and increased availability of time at home by Italian households. Moreover, the research conducted
384 by Ben Hassen et al. (2021) revealed that although the pandemic has increased the consumption
385 levels of local food products due to food safety concerns, it has improved the awareness of people
386 towards food, leading to food waste reduction.

387 The second identified research theme focuses on personnel safety and training for waste handling
388 (cluster #2). The main terms included in this cluster are healthcare worker, infectious disease, staff,
389 diagnosis, personnel, professional, training, medical staff, and the healthcare system. The critical
390 role of healthcare sector staff in providing adequate infection control and proper medical WM
391 procedures was underlined by Aleanizy and Alqahtani (2021) to highlight the importance of
392 knowledge and awareness regarding COVID-19 infection control and WM activities in healthcare

393 facilities. In addition to healthcare personnel, workers in other sectors, such as wastewater
394 treatment plans (Zaneti et al., 2021), and municipal waste centers need to be trained regarding
395 safely handling the medical waste generated due to the pandemic outbreak. Sustainability and
396 using the potentials of the circular economy (cluster #3) has constructed the third research theme
397 of WM research taking COVID-19 into account in the target literature. The circular economy
398 approach, as a tool to promote sustainable development at the local and global scales, has gained
399 momentum (Shevchenko et al., 2021c, 2021a). In this regard, sustainability, supply chain,
400 recycling, circular economy, resilience, raw material, reuse, and sustainable development goal
401 have appeared frequently within the context of research in this area. Developing circular networks
402 and creating circularity to reduce waste, and to return resources to the production cycle was
403 proposed by Alonso-Muñoz et al. (2021), as a cure to make the supply chains resilient against the
404 pandemic adverse effects. Designing eco-design process of face masks based on circularity and
405 life cycle assessment (Boix Rodríguez et al., 2021), recycling of the materials of the disposable
406 filtering masks (Battezzore et al., 2020), the potential of agri-food loss and waste to contribute
407 to a circular economy (Osorio et al., 2021), blockchain-based forward supply chain and WM
408 practices for COVID-19 medical equipment and supplies (Ahmad et al., 2021), safe WM during
409 the pandemic and circular economy implementation (Pikoń et al., 2021), and the interplay of
410 industry 4.0 and circular economy for developing a smart healthcare waste disposal system
411 (Chauhan et al., 2021) have constructed the bottom line of this research theme. In this regard, smart
412 cities with a special focus on using smart technologies, such as Internet of Things, big data
413 analytics, and cyber-based decision support systems can better support solving WM problems
414 (Shevchenko et al., 2021b).

415 Personal protective equipment and plastic waste (cluster #4) has been identified as one of the
416 prominent research clusters in COVID-related WM research. The major keywords and terms in
417 this research themes are mask, face mask, plastic, plastic waste, landfill, contaminant, plastic
418 pollution, surgical mask, polymer, and disposable mask. The high demand for personal protective
419 equipment such as face masks, as the main equipment to protect humans against the pandemic, has
420 led to approximately 1.6 million tons/day of plastic waste worldwide (Boix Rodríguez et al., 2021).
421 Consequently, the disposal of such an unprecedented amount of personal protective equipment has
422 posed significant challenges to WM practitioners and societies (Nowakowski et al., 2020), such as
423 environmental pollution (Lee et al., 2021), recycling difficulties (Maderuelo-Sanz et al., 2021),
424 redesigning and reduction of single-use plastics and personal protective equipment (Patrício Silva
425 et al., 2020), and threat to the marine environment and coastal regions (Chowdhury et al., 2021;
426 Dharmaraj et al., 2021). Rizan et al (2021) reported a total of 106,478 tonnes of CO₂ emission as
427 the carbon footprint of distributing personal protective equipment during the first six months of
428 the COVID-19 pandemic in England. Their scenario modeling of environmental mitigation
429 strategies showed that UK manufacture would have reduced the carbon footprint by 12%, reusing
430 gowns and gloves by 10%, eliminating gloves by 45%, and maximal recycling by 35%. However,
431 imposing strict regulations for the public to properly dispose of face masks has become a
432 significant challenge for governments worldwide (Dharmaraj et al., 2021). This highlights the
433 importance of proposing effective and innovative solutions for face mask WM (Rehman and
434 Khalid, 2021), such as using biodegradable materials in face mask production, recycling by
435 obtaining liquid fuels through pyrolysis, and encouraging reusable and washable masks (De-la-
436 Torre et al., 2021; Haddad et al., 2021).

437 The next research theme belongs to healthcare waste management practices (cluster #5) which is
438 in line with the previous research theme. The main focus of the research included in this cluster is
439 on challenges imposed by the pandemic outbreak on the healthcare facilities. In this vein, terms
440 such as medical waste, waste generation, waste disposal, incineration, infectious waste,
441 transportation, biomedical waste, healthcare waste, and hazardous waste have occurred frequently
442 within the titles and abstracts of the research articles. In this cluster, the importance of proper
443 healthcare waste management has been highlighted by many scholars in terms of controlling the
444 environmental transmission of COVID-19 (Shammi et al., 2021), perception and attitudes towards
445 medical waste disposal (Islam et al., 2020), water, sanitation, hygiene, and waste disposal practices
446 as COVID-19 response strategies (Islam et al., 2021), energy generation from hazardous waste
447 during the pandemic (Valizadeh et al., 2021), selection of the best healthcare waste disposal
448 techniques (Manupati et al., 2021), bio-medical waste incineration (Thind et al., 2021), assessment
449 of healthcare waste disposal technologies in terms of energy, environment, and economy (Zhao et
450 al., 2021), and healthcare waste separation behavior (F. Chen et al., 2021). Wastewater
451 management (cluster #6) and COVID-19 transmission through infectious waste (cluster #7) are
452 considered as the mainstream research frontier regarding the prevention of SARS-CoV-2
453 transmission. The main terms within the wastewater management research theme are wastewater,
454 detection, surveillance, concentration, wastewater treatment plant, and sewage. On the other hand,
455 presence, route, exposure, particle, surface, droplet, sludge, and aerosol are some of the main terms
456 in the research theme of COVID-19 transmission through infectious waste. The research in these
457 clusters have principally investigated the concentration of SARS-CoV-2 in wastewater (Cao and
458 Francis, 2021), wastewater surveillance (Róka et al., 2021), Monitoring changes in COVID-19
459 infection using wastewater-based epidemiology (Pillay et al., 2021), SARS-CoV-2 transmission

460 channels (Abd El-Wahab et al., 2020), and occupational exposure to SARS-CoV-2 in wastewater
461 treatment plants (Dada and Gyawali, 2021).

462 **4. Research agenda: gaps and potential avenues**

463 According to the performance indicators and thematic structures provided in the previous section
464 through the bibliometric and text mining analyses, to address our third research question, we
465 identified the following main research gaps and potential directions as the research agenda for WM
466 post COVID-19:

467 • ***Adopting a system thinking approach for WM practices.*** As highlighted by Naughton (2020),
468 there is a need for more real-time WM data and systems thinking approach regarding COVID-
469 19 effects on waste generation and composition. However, due to the causal-effect links of the
470 interconnected challenges imposed by the pandemic on WM activities, there is still a significant
471 gap in the literature. This requires establishing a systemic framework to monitor and properly
472 manage the pandemic crisis implications for WM practices as a whole. Accordingly, modeling
473 and simulating the long-term effects of COVID-19 on waste generation and formulating
474 appropriate policies are highly recommended for future research. The outputs of such research
475 not only are helpful for COVID-19-recovery plans but also can be generalized and used as a
476 guideline for handling similar crises in the future.

477

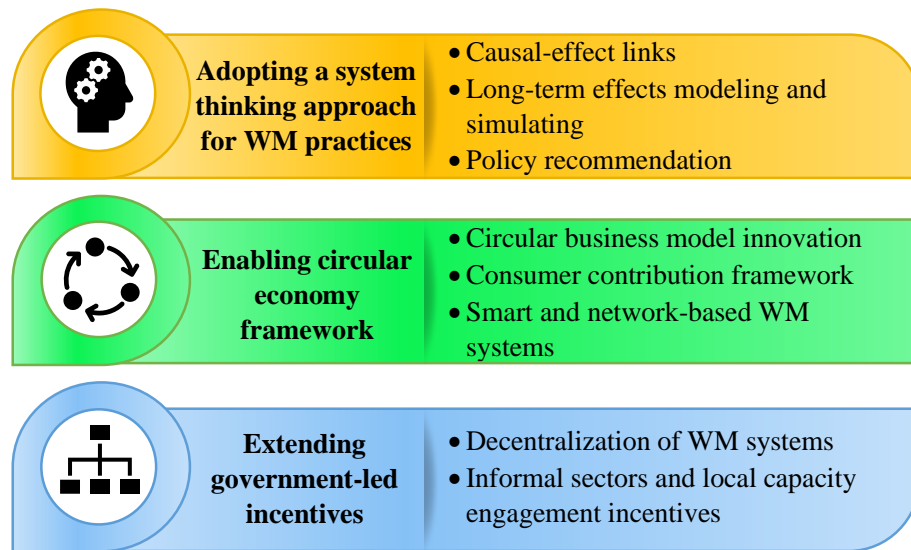
478 • ***Enabling circular economy framework.*** On one hand, the outbreak of the COVID-19 pandemic
479 has led to an unprecedented demand for using personal protective equipment, in particular face
480 masks, which generate a huge amount of waste across the globe. On the other hand, due to the
481 infectious nature of the generated healthcare waste, reusing, repairing, and recycling programs

482 of such waste have faced serious challenges. Although limited research has been conducted on
483 the potential of circular economy approaches to mitigate the effects of the pandemic on waste
484 (Kumar et al., 2021; Pikoń et al., 2021; Sharma et al., 2021), research in this area is still in its
485 immaturity stage and so far from practice and implementation in the real world. Therefore,
486 building a circular economy framework from the design stage to the implementation stage is of
487 high importance to effectively deal with COVID-related waste. On this basis, (i) innovative
488 solutions to keep materials and products within the cycle as long as possible, (ii) consumer
489 contribution to the circular economy transition in the healthcare industry, and (iii) developing
490 smart and network-based WM systems to support WM activities towards a circular economy
491 focusing on waste prevention and reduction, are proposed as potential avenues for further
492 research in WM research agenda post COVID-19.

493

494 • ***Extending government-led incentives.*** In line with the research conducted by Sharma et al.
495 (2021), decentralization of WM systems and practices with a bottom-to-top approach is
496 recommended for policy-makers and authorities to better manage the newly emerged waste post
497 the pandemic. We believe that there is no better time than now to plan for involving local
498 communities in the WM activities. In this regard, developing encouraging plans and incentives
499 to effectively involve informal sectors and local capacity in municipal waste management,
500 especially in developing and less-developed countries, remarkably deserves to be deeply
501 investigated in future research.

502 Fig. 8 summarizes the main directions for future research on WM practices in the wake of the
503 pandemic.



504

505

Fig. 8. Future research agenda for WM research post COVID-19 era.

506

5. Conclusion

507

This study provided an inclusive map of the WM research in the context of the COVID-19

508

pandemic by conducting bibliometric and text mining analyses on a total of 1030 peer-reviewed

509

journal articles in the Scopus citation database. As a result, the performance of the COVID-related

510

scientific production in the WM field was mapped through analyzing and discussing bibliometric

511

performance indicators, including (i) geographical distribution of publications, (ii) authors

512

productivity and influence, (iii) main contributing journals and publications, and (iv) keyword-

513

based analysis to unfold research tendencies and hotspots. Besides, by conducting bibliographic

514

coupling, the following three main clusters of research in WM post COVID-19 were identified:

515

(a) plastic waste generation and management during the pandemic, (b) detection of COVID-19 in

516

wastewater, and wastewater surveillance during the pandemic, and (c) potential spread of COVID-

517

19, disinfection strategies and their associated challenges. The salient research themes of the target

518

literature were also identified by conducting text mining analysis on the titles and abstracts of the

519 articles as follows: (1) household and food waste, (2) personnel safety and training for waste
520 handling, (3) sustainability and circular economy, (4) personal protective equipment and plastic
521 waste, (5) healthcare waste management practices, (6) wastewater management, and (7) COVID-
522 19 transmission through infectious waste.

523 The provided insights support researchers and policy-makers to better understand the effects of the
524 pandemic on generating various waste streams and emerged challenges for WM practices and
525 activities. As such, a research agenda based on the main research gaps was proposed for further
526 studies, focusing on (i) system thinking approach to properly manage the pandemic crisis
527 implications for WM practices as a whole, (ii) building a circular economy model from the design
528 stage to the implementation stage, and (iii) proposing incentives to effectively involve informal
529 sectors and local capacity in decentralizing municipal waste management, especially for
530 developing and less-developed countries. Nevertheless, there are some limitations to this research.
531 First, the sample data was retrieved from the Scopus database. Therefore, incorporating other
532 databases, such as Web of Science, may enhance the reliability of the present research and further
533 extend the findings. Second, non-English documents were excluded from our search, potentially
534 missing some specific studies and practices in WM at a micro-level.

535 **References**

- 536 Abd El-Wahab, E.W., Eassa, S.M., Metwally, M., Al-Hraishawi, H., Omar, S.R., 2020. SARS-CoV-2
537 Transmission Channels: A Review of the Literature. *MEDICC Rev.* 22, 61–69.
538 <https://doi.org/10.37757/MR2020.V22.N4.3>
- 539 Acharya, A., Bastola, G., Modi, B., Marhatta, A., Belbase, S., Lamichhane, G., Gyawali, N., Dahal, R.K.,
540 2021. The impact of COVID-19 outbreak and perceptions of people towards household waste

541 management chain in Nepal. *Geoenvironmental Disasters* 8, 14. [https://doi.org/10.1186/s40677-021-](https://doi.org/10.1186/s40677-021-00188-w)
542 00188-w

543 Ahmad, R.W., Salah, K., Jayaraman, R., Yaqoob, I., Omar, M., Ellahham, S., 2021. Blockchain-Based
544 Forward Supply Chain and Waste Management for COVID-19 Medical Equipment and Supplies.
545 *IEEE Access* 9, 44905–44927. <https://doi.org/10.1109/ACCESS.2021.3066503>

546 Ahmed, W., Angel, N., Edson, J., Bibby, K., Bivins, A., O'Brien, J.W., Choi, P.M., Kitajima, M.,
547 Simpson, S.L., Li, J., Tscharke, B., Verhagen, R., Smith, W.J.M., Zaugg, J., Dierens, L.,
548 Hugenholtz, P., Thomas, K. V., Mueller, J.F., 2020a. First confirmed detection of SARS-CoV-2 in
549 untreated wastewater in Australia: A proof of concept for the wastewater surveillance of COVID-19
550 in the community. *Sci. Total Environ.* 728, 138764. <https://doi.org/10.1016/j.scitotenv.2020.138764>

551 Ahmed, W., Bertsch, P.M., Bivins, A., Bibby, K., Farkas, K., Gathercole, A., Haramoto, E., Gyawali, P.,
552 Korajkic, A., McMinn, B.R., Mueller, J.F., Simpson, S.L., Smith, W.J.M., Symonds, E.M., Thomas,
553 K. V., Verhagen, R., Kitajima, M., 2020b. Comparison of virus concentration methods for the RT-
554 qPCR-based recovery of murine hepatitis virus, a surrogate for SARS-CoV-2 from untreated
555 wastewater. *Sci. Total Environ.* 739, 139960. <https://doi.org/10.1016/j.scitotenv.2020.139960>

556 Aleanizy, F.S., Alqahtani, F.Y., 2021. Awareness and knowledge of COVID-19 infection control
557 precautions and waste management among healthcare workers. *Medicine (Baltimore)*. 100, e26102.
558 <https://doi.org/10.1097/MD.00000000000026102>

559 Alonso-Muñoz, S., González-Sánchez, R., Siligardi, C., García-Muiña, F.E., 2021. New Circular
560 Networks in Resilient Supply Chains: An External Capital Perspective. *Sustainability* 13, 6130.
561 <https://doi.org/10.3390/su13116130>

562 Ambade, B., Sankar, T.K., Kumar, A., Gautam, A.S., Gautam, S., 2021. COVID-19 lockdowns reduce
563 the Black carbon and polycyclic aromatic hydrocarbons of the Asian atmosphere: source
564 apportionment and health hazard evaluation. *Environ. Dev. Sustain.* <https://doi.org/10.1007/s10668->

565 020-01167-1

566 Amicarelli, V., Bux, C., 2021. Food waste in Italian households during the Covid-19 pandemic: a self-
567 reporting approach. *Food Secur.* 13, 25–37. <https://doi.org/10.1007/s12571-020-01121-z>

568 Babbitt, C.W., Babbitt, G.A., Oehman, J.M., 2021a. Behavioral impacts on residential food provisioning,
569 use, and waste during the COVID-19 pandemic. *Sustain. Prod. Consum.* 28, 315–325.
570 <https://doi.org/10.1016/j.spc.2021.04.012>

571 Babbitt, C.W., Babbitt, G.A., Oehman, J.M., 2021b. Behavioral impacts on residential food provisioning,
572 use, and waste during the COVID-19 pandemic. *Sustain. Prod. Consum.* 28, 315–325.
573 <https://doi.org/10.1016/j.spc.2021.04.012>

574 Battegazzore, D., Cravero, F., Frache, A., 2020. Is it Possible to Mechanical Recycle the Materials of the
575 Disposable Filtering Masks? *Polymers (Basel)*. 12, 2726. <https://doi.org/10.3390/polym12112726>

576 Ben Hassen, T., El Bilali, H., Allahyari, M.S., 2020. Impact of covid-19 on food behavior and
577 consumption in qatar. *Sustain.* 12, 1–18. <https://doi.org/10.3390/su12176973>

578 Ben Hassen, T., El Bilali, H., Allahyari, M.S., Karabašević, D., Radosavac, A., Berjan, S., Vaško, Ž.,
579 Radanov, P., Obhodaš, I., 2021. Food behavior changes during the covid-19 pandemic: Statistical
580 analysis of consumer survey data from bosnia and herzegovina. *Sustain.* 13, 1–11.
581 <https://doi.org/10.3390/su13158617>

582 Bherwani, H., Gautam, S., Gupta, A., 2021. Qualitative and quantitative analyses of impact of COVID-19
583 on sustainable development goals (SDGs) in Indian subcontinent with a focus on air quality. *Int. J.*
584 *Environ. Sci. Technol.* <https://doi.org/10.1007/s13762-020-03122-z>

585 Boix Rodríguez, N., Formentini, G., Favi, C., Marconi, M., 2021. Engineering Design Process of Face
586 Masks Based on Circularity and Life Cycle Assessment in the Constraint of the COVID-19
587 Pandemic. *Sustainability* 13, 4948. <https://doi.org/10.3390/su13094948>

588 Bresciani, S., Ciampi, F., Meli, F., Ferraris, A., 2021. Using big data for co-innovation processes:

589 Mapping the field of data-driven innovation, proposing theoretical developments and providing a
590 research agenda. *Int. J. Inf. Manage.* 60, 102347. <https://doi.org/10.1016/j.ijinfomgt.2021.102347>

591 Brizi, A., Biraglia, A., 2021. “Do I have enough food?” How need for cognitive closure and gender
592 impact stockpiling and food waste during the COVID-19 pandemic: A cross-national study in India
593 and the United States of America. *Pers. Individ. Dif.* 168, 110396.
594 <https://doi.org/10.1016/j.paid.2020.110396>

595 Cao, Y., Francis, R., 2021. On forecasting the community-level COVID-19 cases from the concentration
596 of SARS-CoV-2 in wastewater. *Sci. Total Environ.* 786, 147451.
597 <https://doi.org/10.1016/j.scitotenv.2021.147451>

598 Carducci, A., Federigi, I., Dasheng, L., Julian R, T., Marco, V., 2020. Making waves: Coronavirus
599 detection, presence and persistence in the water environment: State of the art and knowledge needs
600 for public health. *Water Res.* 179, 115907. <https://doi.org/10.1016/j.watres.2020.115907>

601 Carraturo, F., Del Giudice, C., Morelli, M., Cerullo, V., Libralato, G., Galdiero, E., Guida, M., 2020.
602 Persistence of SARS-CoV-2 in the environment and COVID-19 transmission risk from
603 environmental matrices and surfaces. *Environ. Pollut.* 265, 115010.
604 <https://doi.org/10.1016/j.envpol.2020.115010>

605 Chakraborty, I., Maity, P., 2020. COVID-19 outbreak: Migration, effects on society, global environment
606 and prevention. *Sci. Total Environ.* 728, 138882. <https://doi.org/10.1016/j.scitotenv.2020.138882>

607 Chaudhary, S., Dhir, A., Ferraris, A., Bertoldi, B., 2021. Trust and reputation in family businesses: A
608 systematic literature review of past achievements and future promises. *J. Bus. Res.* 137, 143–161.
609 <https://doi.org/10.1016/j.jbusres.2021.07.052>

610 Chauhan, A., Jakhar, S.K., Chauhan, C., 2021. The interplay of circular economy with industry 4.0
611 enabled smart city drivers of healthcare waste disposal. *J. Clean. Prod.* 279, 123854.
612 <https://doi.org/10.1016/j.jclepro.2020.123854>

613 Chen, C., Chen, J., Fang, R., Ye, F., Yang, Z., Wang, Z., Shi, F., Tan, W., 2021. What medical waste
614 management system may cope With COVID-19 pandemic: Lessons from Wuhan. *Resour. Conserv.
615 Recycl.* 170, 105600. <https://doi.org/10.1016/j.resconrec.2021.105600>

616 Chen, F., Lou, J., Hu, J., Chen, H., Long, R., Li, W., 2021. Study on the relationship between crisis
617 awareness and medical waste separation behavior shown by residents during the COVID-19
618 epidemic. *Sci. Total Environ.* 787, 147522. <https://doi.org/10.1016/j.scitotenv.2021.147522>

619 Chowdhury, H., Chowdhury, T., Sait, S.M., 2021. Estimating marine plastic pollution from COVID-19
620 face masks in coastal regions. *Mar. Pollut. Bull.* 168, 112419.
621 <https://doi.org/10.1016/j.marpolbul.2021.112419>

622 Dada, A.C., Gyawali, P., 2021. Quantitative microbial risk assessment (QMRA) of occupational exposure
623 to SARS-CoV-2 in wastewater treatment plants. *Sci. Total Environ.* 763, 142989.
624 <https://doi.org/10.1016/j.scitotenv.2020.142989>

625 Das, O., Neisiany, R.E., Capezza, A.J., Hedenqvist, M.S., Försth, M., Xu, Q., Jiang, L., Ji, D.,
626 Ramakrishna, S., 2020. The need for fully bio-based facemasks to counter coronavirus outbreaks: A
627 perspective. *Sci. Total Environ.* 736. <https://doi.org/10.1016/j.scitotenv.2020.139611>

628 Daughton, C.G., 2020. Wastewater surveillance for population-wide Covid-19: The present and future.
629 *Sci. Total Environ.* 736, 139631. <https://doi.org/10.1016/j.scitotenv.2020.139631>

630 De-la-Torre, G.E., Rakib, M.R.J., Pizarro-Ortega, C.I., Dioses-Salinas, D.C., 2021. Occurrence of
631 personal protective equipment (PPE) associated with the COVID-19 pandemic along the coast of
632 Lima, Peru. *Sci. Total Environ.* 774, 145774. <https://doi.org/10.1016/j.scitotenv.2021.145774>

633 de Aguiar Hugo, A., Lima, R. da S., 2021. Healthcare waste management assessment: Challenges for
634 hospitals in COVID-19 pandemic times. *Waste Manag. Res. J. a Sustain. Circ. Econ.* 39, 56–63.
635 <https://doi.org/10.1177/0734242X211010362>

636 Dente, S.M.R., Hashimoto, S., 2020. COVID-19: A pandemic with positive and negative outcomes on

637 resource and waste flows and stocks. *Resour. Conserv. Recycl.* 161, 104979.
638 <https://doi.org/10.1016/j.resconrec.2020.104979>

639 Dharmaraj, S., Ashokkumar, V., Hariharan, S., Manibharathi, A., Show, P.L., Chong, C.T.,
640 Ngamcharussrivichai, C., 2021. The COVID-19 pandemic face mask waste: A blooming threat to
641 the marine environment. *Chemosphere* 272, 129601.
642 <https://doi.org/10.1016/j.chemosphere.2021.129601>

643 Fadare, O.O., Okoffo, E.D., 2020. Covid-19 face masks: A potential source of microplastic fibers in the
644 environment. *Sci. Total Environ.* 737, 140279. <https://doi.org/10.1016/j.scitotenv.2020.140279>

645 Feng, Y., Zhu, Q., Lai, K.-H., 2017. Corporate social responsibility for supply chain management: A
646 literature review and bibliometric analysis. *J. Clean. Prod.* 158, 296–307.
647 <https://doi.org/10.1016/j.jclepro.2017.05.018>

648 Filho, W.L., Voronova, V., Kloga, M., Paço, A., Minhas, A., Salvia, A.L., Ferreira, C.D., Sivapalan, S.,
649 2021. COVID-19 and waste production in households: A trend analysis. *Sci. Total Environ.* 777,
650 145997. <https://doi.org/10.1016/j.scitotenv.2021.145997>

651 Gautam, A.S., Kumar, S., Gautam, S., Anand, A., Kumar, R., Joshi, A., Bauddh, K., Singh, K., 2021.
652 Pandemic induced lockdown as a boon to the Environment: trends in air pollution concentration
653 across India. *Asia-Pacific J. Atmos. Sci.* <https://doi.org/10.1007/s13143-021-00232-7>

654 Gautam, S., 2020. COVID-19: air pollution remains low as people stay at home. *Air Qual. Atmos. Heal.*
655 13, 853–857. <https://doi.org/10.1007/s11869-020-00842-6>

656 Gautam, S., Setu, S., Khan, M.G.Q., Khan, M.B., 2022. Analysis of the health, economic and
657 environmental impacts of COVID-19: The Bangladesh perspective. *Geosystems and*
658 *Geoenvironment* 1, 100011. <https://doi.org/10.1016/j.geogeo.2021.100011>

659 Güney, O.I., Sangün, L., 2021. How COVID-19 affects individuals' food consumption behaviour: a
660 consumer survey on attitudes and habits in Turkey. *Br. Food J.* 123, 2307–2320.

661 <https://doi.org/10.1108/BFJ-10-2020-0949>

662 Guo, Y.-M., Huang, Z.-L., Guo, J., Guo, X.-R., Li, H., Liu, M.-Y., Ezzeddine, S., Nkeli, M.J., 2021. A
663 bibliometric analysis and visualization of blockchain. *Futur. Gener. Comput. Syst.* 116, 316–332.
664 <https://doi.org/10.1016/j.future.2020.10.023>

665 Haddad, M. Ben, De-la-Torre, G.E., Abelouah, M.R., Hajji, S., Alla, A.A., 2021. Personal protective
666 equipment (PPE) pollution associated with the COVID-19 pandemic along the coastline of Agadir,
667 Morocco. *Sci. Total Environ.* 798, 149282. <https://doi.org/10.1016/j.scitotenv.2021.149282>

668 Haramoto, E., Malla, B., Thakali, O., Kitajima, M., 2020. First environmental surveillance for the
669 presence of SARS-CoV-2 RNA in wastewater and river water in Japan. *Sci. Total Environ.* 737,
670 140405. <https://doi.org/10.1016/j.scitotenv.2020.140405>

671 Hart, O.E., Halden, R.U., 2020. Computational analysis of SARS-CoV-2/COVID-19 surveillance by
672 wastewater-based epidemiology locally and globally: Feasibility, economy, opportunities and
673 challenges. *Sci. Total Environ.* 730, 138875. <https://doi.org/10.1016/j.scitotenv.2020.138875>

674 Heikal Ismail, M., Ghazi, T.I.M., Hamzah, M.H., Manaf, L.A., Tahir, R.M., Mohd Nasir, A., Ehsan
675 Omar, A., 2020. Impact of Movement Control Order (MCO) due to Coronavirus Disease (COVID-
676 19) on Food Waste Generation: A Case Study in Klang Valley, Malaysia. *Sustainability* 12, 8848.
677 <https://doi.org/10.3390/su12218848>

678 Ibn-Mohammed, T., Mustapha, K.B., Godsell, J., Adamu, Z., Babatunde, K.A., Akintade, D.D., Acquaye,
679 A., Fujii, H., Ndiaye, M.M., Yamoah, F.A., Koh, S.C.L., 2021. A critical analysis of the impacts of
680 COVID-19 on the global economy and ecosystems and opportunities for circular economy
681 strategies. *Resour. Conserv. Recycl.* 164, 105169. <https://doi.org/10.1016/j.resconrec.2020.105169>

682 Ilyas, S., Srivastava, R.R., Kim, H., 2020. Disinfection technology and strategies for COVID-19 hospital
683 and bio-medical waste management. *Sci. Total Environ.* 749, 141652.
684 <https://doi.org/10.1016/j.scitotenv.2020.141652>

685 Islam, S.M.D.D.-U., Mondal, P.K., Ojong, N., Bodrud-Doza, M., Siddique, M.A.B., Hossain, M.,
686 Mamun, M.A., 2021. Water, sanitation, hygiene and waste disposal practices as COVID-19 response
687 strategy: insights from Bangladesh. *Environ. Dev. Sustain.* 23, 11953–11974.
688 <https://doi.org/10.1007/s10668-020-01151-9>

689 Islam, S.M.D.D.-U., Safiq, M.B., Bodrud-Doza, M., Mamun, M.A., 2020. Perception and Attitudes
690 Toward PPE-Related Waste Disposal Amid COVID-19 in Bangladesh: An Exploratory Study.
691 *Front. Public Heal.* 8, 1–6. <https://doi.org/10.3389/fpubh.2020.592345>

692 Kitajima, M., Ahmed, W., Bibby, K., Carducci, A., Gerba, C.P., Hamilton, K.A., Haramoto, E., Rose,
693 J.B., 2020. SARS-CoV-2 in wastewater: State of the knowledge and research needs. *Sci. Total*
694 *Environ.* 739, 139076. <https://doi.org/10.1016/j.scitotenv.2020.139076>

695 Kitz, R., Walker, T., Charlebois, S., Music, J., 2021. Food packaging during the COVID-19 pandemic:
696 Consumer perceptions. *Int. J. Consum. Stud.* ijcs.12691. <https://doi.org/10.1111/ijcs.12691>

697 Kumar, N.M., Mohammed, M.A., Abdulkareem, K.H., Damasevicius, R., Mostafa, S.A., Maashi, M.S.,
698 Chopra, S.S., 2021. Artificial intelligence-based solution for sorting COVID related medical waste
699 streams and supporting data-driven decisions for smart circular economy practice. *Process Saf.*
700 *Environ. Prot.* 152, 482–494. <https://doi.org/10.1016/j.psep.2021.06.026>

701 La Rosa, G., Iaconelli, M., Mancini, P., Bonanno Ferraro, G., Veneri, C., Bonadonna, L., Lucentini, L.,
702 Suffredini, E., 2020. First detection of SARS-CoV-2 in untreated wastewaters in Italy. *Sci. Total*
703 *Environ.* 736, 139652. <https://doi.org/10.1016/j.scitotenv.2020.139652>

704 La Rosa, G., Mancini, P., Bonanno Ferraro, G., Veneri, C., Iaconelli, M., Bonadonna, L., Lucentini, L.,
705 Suffredini, E., 2021. SARS-CoV-2 has been circulating in northern Italy since December 2019:
706 Evidence from environmental monitoring. *Sci. Total Environ.* 750, 141711.
707 <https://doi.org/10.1016/j.scitotenv.2020.141711>

708 Lacy, J.M., Brooks, E.G., Akers, J., Armstrong, D., Decker, L., Gonzalez, A., Humphrey, W., Mayer, R.,

709 Miller, M., Perez, C., Arango, J.A.R., Sathyavagiswaran, L., Stroh, W., Utley, S., 2020. COVID-19:
710 Postmortem diagnostic and biosafety considerations. *Am. J. Forensic Med. Pathol.* 41, 143–151.
711 <https://doi.org/10.1097/PAF.0000000000000567>

712 Leal Filho, W., Salvia, A.L., Minhas, A., Paço, A., Dias-Ferreira, C., 2021. The COVID-19 pandemic and
713 single-use plastic waste in households: A preliminary study. *Sci. Total Environ.* 793, 148571.
714 <https://doi.org/10.1016/j.scitotenv.2021.148571>

715 Lee, A.W.L., Neo, E.R.K., Khoo, Z.-Y., Yeo, Z., Tan, Y.S., Chng, S., Yan, W., Lok, B.K., Low, J.S.C.,
716 2021. Life cycle assessment of single-use surgical and embedded filtration layer (EFL) reusable face
717 mask. *Resour. Conserv. Recycl.* 170, 105580. <https://doi.org/10.1016/j.resconrec.2021.105580>

718 Liang, Y., Song, Q., Wu, N., Li, J., Zhong, Y., Zeng, W., 2021. Repercussions of COVID-19 pandemic
719 on solid waste generation and management strategies. *Front. Environ. Sci. Eng.* 15, 115.
720 <https://doi.org/10.1007/s11783-021-1407-5>

721 Ma, Q.X., Shan, H., Zhang, C.M., Zhang, H.L., Li, G.M., Yang, R.M., Chen, J.M., 2020.
722 Decontamination of face masks with steam for mask reuse in fighting the pandemic COVID-19:
723 Experimental supports. *J. Med. Virol.* 92, 1971–1974. <https://doi.org/10.1002/jmv.25921>

724 Maderuelo-Sanz, R., Acedo-Fuentes, P., García-Cobos, F.J., Sánchez-Delgado, F.J., Mota-López, M.I.,
725 Meneses-Rodríguez, J.M., 2021. The recycling of surgical face masks as sound porous absorbers:
726 Preliminary evaluation. *Sci. Total Environ.* 786, 147461.
727 <https://doi.org/10.1016/j.scitotenv.2021.147461>

728 Makrides, A., Kvasova, O., Thrassou, A., Hadjielias, E., Ferraris, A., 2021. Consumer cosmopolitanism
729 in international marketing research: a systematic review and future research agenda. *Int. Mark. Rev.*
730 ahead-of-p. <https://doi.org/10.1108/IMR-12-2020-0304>

731 Malefors, C., Secondi, L., Marchetti, S., Eriksson, M., 2021. Food waste reduction and economic savings
732 in times of crisis: The potential of machine learning methods to plan guest attendance in Swedish

733 public catering during the Covid-19 pandemic. *Socioecon. Plann. Sci.* 101041.
734 <https://doi.org/10.1016/j.seps.2021.101041>

735 Manupati, V.K., Ramkumar, M., Baba, V., Agarwal, A., 2021. Selection of the best healthcare waste
736 disposal techniques during and post COVID-19 pandemic era. *J. Clean. Prod.* 281, 125175.
737 <https://doi.org/10.1016/j.jclepro.2020.125175>

738 Merigó, J.M., Mas-Tur, A., Roig-Tierno, N., Ribeiro-Soriano, D., 2015. A bibliometric overview of the
739 *Journal of Business Research* between 1973 and 2014. *J. Bus. Res.* 68, 2645–2653.
740 <https://doi.org/10.1016/j.jbusres.2015.04.006>

741 Mofijur, M., Fattah, I.M.R., Alam, M.A., Islam, A.B.M.S., Ong, H.C., Rahman, S.M.A., Najafi, G.,
742 Ahmed, S.F., Uddin, M.A., Mahlia, T.M.I., 2021. Impact of COVID-19 on the social, economic,
743 environmental and energy domains: Lessons learnt from a global pandemic. *Sustain. Prod. Consum.*
744 26, 343–359. <https://doi.org/10.1016/j.spc.2020.10.016>

745 Mouchtouri, V.A., Koureas, M., Kyritsi, M., Vontas, A., Kourentis, L., Sapounas, S., Rigakos, G.,
746 Petinaki, E., Tsiodras, S., Hadjichristodoulou, C., 2020. Environmental contamination of SARS-
747 CoV-2 on surfaces, air-conditioner and ventilation systems. *Int. J. Hyg. Environ. Health* 230,
748 113599. <https://doi.org/10.1016/j.ijheh.2020.113599>

749 Musa, H., Musa, T.H., Musa, I.H., Oderinde, O., 2020. Letter to Editor COVID-19 outbreak and medical
750 waste: Challenge in hand. *Int. J. Public Heal. Sci.* 9, 153. <https://doi.org/10.11591/ijphs.v9i3.20523>

751 Naughton, C.C., 2020. Will the COVID-19 pandemic change waste generation and composition?: The
752 need for more real-time waste management data and systems thinking. *Resour. Conserv. Recycl.*
753 162, 105050. <https://doi.org/10.1016/j.resconrec.2020.105050>

754 Nowakowski, P., Kuśnierz, S., Sosna, P., Mauer, J., Maj, D., 2020. Disposal of Personal Protective
755 Equipment during the COVID-19 Pandemic Is a Challenge for Waste Collection Companies and
756 Society: A Case Study in Poland. *Resources* 9, 116. <https://doi.org/10.3390/resources9100116>

757 Nzediegwu, C., Chang, S.X., 2020. Improper solid waste management increases potential for COVID-19
758 spread in developing countries. *Resour. Conserv. Recycl.* 161, 104947.
759 <https://doi.org/10.1016/j.resconrec.2020.104947>

760 Orive, G., Lertxundi, U., Barcelo, D., 2020. Early SARS-CoV-2 outbreak detection by sewage-based
761 epidemiology. *Sci. Total Environ.* 732, 139298. <https://doi.org/10.1016/j.scitotenv.2020.139298>

762 Osorio, L.L.D.R., Flórez-López, E., Grande-Tovar, C.D., 2021. The Potential of Selected Agri-Food Loss
763 and Waste to Contribute to a Circular Economy: Applications in the Food, Cosmetic and
764 Pharmaceutical Industries. *Molecules* 26, 515. <https://doi.org/10.3390/molecules26020515>

765 Pappalardo, G., Cerroni, S., Nayga, R.M., Yang, W., 2020. Impact of Covid-19 on Household Food
766 Waste: The Case of Italy. *Front. Nutr.* 7, 1–9. <https://doi.org/10.3389/fnut.2020.585090>

767 Patrício Silva, A.L., Prata, J.C., Walker, T.R., Campos, D., Duarte, A.C., Soares, A.M.V.M., Barcelò, D.,
768 Rocha-Santos, T., 2020. Rethinking and optimising plastic waste management under COVID-19
769 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal
770 protective equipment. *Sci. Total Environ.* 742, 140565.
771 <https://doi.org/10.1016/j.scitotenv.2020.140565>

772 Peccia, J., Zulli, A., Brackney, D.E., Grubaugh, N.D., Kaplan, E.H., Casanovas-Massana, A., Ko, A.I.,
773 Malik, A.A., Wang, D., Wang, M., Warren, J.L., Weinberger, D.M., Arnold, W., Omer, S.B., 2020.
774 Measurement of SARS-CoV-2 RNA in wastewater tracks community infection dynamics. *Nat.*
775 *Biotechnol.* 38, 1164–1167. <https://doi.org/10.1038/s41587-020-0684-z>

776 Peng, J., Wu, X., Wang, R., Li, C., Zhang, Q., Wei, D., 2020. Medical waste management practice during
777 the 2019-2020 novel coronavirus pandemic: Experience in a general hospital. *Am. J. Infect. Control*
778 48, 918–921. <https://doi.org/10.1016/j.ajic.2020.05.035>

779 Pikoń, K., Poranek, N., Czajkowski, A., Łązniewska-Piekarczyk, B., 2021. Poland’s Proposal for a Safe
780 Solution of Waste Treatment during the COVID-19 Pandemic and Circular Economy Connection.

781 Appl. Sci. 11, 3939. <https://doi.org/10.3390/app11093939>

782 Pillay, L., Amoah, I.D., Deepnarain, N., Pillay, K., Awolusi, O.O., Kumari, S., Bux, F., 2021. Monitoring
783 changes in COVID-19 infection using wastewater-based epidemiology: A South African
784 perspective. *Sci. Total Environ.* 786, 147273. <https://doi.org/10.1016/j.scitotenv.2021.147273>

785 Prata, J.C., Silva, A.L.P., Walker, T.R., Duarte, A.C., Rocha-Santos, T., 2020. COVID-19 Pandemic
786 Repercussions on the Use and Management of Plastics. *Environ. Sci. Technol.* 54, 7760–7765.
787 <https://doi.org/10.1021/acs.est.0c02178>

788 Qian, K., Javadi, F., Hiramatsu, M., 2020. Influence of the COVID-19 Pandemic on Household Food
789 Waste Behavior in Japan. *Sustainability* 12, 9942. <https://doi.org/10.3390/su12239942>

790 Rajput, H., Changotra, R., Rajput, P., Gautam, S., Gollakota, A.R.K., Arora, A.S., 2021. A shock like no
791 other: coronavirus rattles commodity markets. *Environ. Dev. Sustain.* 23, 6564–6575.
792 <https://doi.org/10.1007/s10668-020-00934-4>

793 Randazzo, W., Truchado, P., Cuevas-Ferrando, E., Simón, P., Allende, A., Sánchez, G., 2020. SARS-
794 CoV-2 RNA in wastewater anticipated COVID-19 occurrence in a low prevalence area. *Water Res.*
795 181, 115942. <https://doi.org/10.1016/j.watres.2020.115942>

796 Ranjbari, M., Morales-Alonso, G., Shams Esfandabadi, Z., Carrasco-Gallego, R., 2019. Sustainability and
797 the Sharing Economy: Modelling the Interconnections. *Dir. y Organ.* 68, 33–40.
798 <https://doi.org/10.37610/dyo.v0i68.549>

799 Ranjbari, M., Saidani, M., Shams Esfandabadi, Z., Peng, W., Lam, S.S., Aghbashlo, M., Quatraro, F.,
800 Tabatabaei, M., 2021a. Two decades of research on waste management in the circular economy:
801 Insights from bibliometric, text mining, and content analyses. *J. Clean. Prod.* 314, 128009.
802 <https://doi.org/10.1016/j.jclepro.2021.128009>

803 Ranjbari, M., Shams Esfandabadi, Z., Scagnelli, S.D., 2020. A big data approach to map the service
804 quality of short-stay accommodation sharing. *Int. J. Contemp. Hosp. Manag.* 32, 2575–2592.

805 <https://doi.org/10.1108/IJCHM-02-2020-0097>

806 Ranjbari, M., Shams Esfandabadi, Z., Scagnelli, S.D., Siebers, P.-O., Quatraro, F., 2021b. Recovery
807 agenda for sustainable development post COVID-19 at the country level: developing a fuzzy action
808 priority surface. *Environ. Dev. Sustain.* <https://doi.org/10.1007/s10668-021-01372-6>

809 Ranjbari, M., Shams Esfandabadi, Z., Shevchenko, T., Chassagnon-Haned, N., Peng, W., Tabatabaei, M.,
810 Aghbashlo, M., 2022. Mapping healthcare waste management research: Past evolution, current
811 challenges, and future perspectives towards a circular economy transition. *J. Hazard. Mater.* 422,
812 126724. <https://doi.org/10.1016/j.jhazmat.2021.126724>

813 Ranjbari, M., Shams Esfandabadi, Z., Zanetti, M.C., Scagnelli, S.D., Siebers, P.-O., Aghbashlo, M., Peng,
814 W., Quatraro, F., Tabatabaei, M., 2021c. Three pillars of sustainability in the wake of COVID-19: A
815 systematic review and future research agenda for sustainable development. *J. Clean. Prod.* 297,
816 126660. <https://doi.org/10.1016/j.jclepro.2021.126660>

817 Ravina, M., Esfandabadi, Z.S., Panepinto, D., Zanetti, M., 2021. Traffic-induced atmospheric pollution
818 during the COVID-19 lockdown: Dispersion modeling based on traffic flow monitoring in Turin,
819 Italy. *J. Clean. Prod.* 317, 128425. <https://doi.org/10.1016/j.jclepro.2021.128425>

820 Rehman, Z. ur, Khalid, U., 2021. Reuse of COVID-19 face mask for the amelioration of mechanical
821 properties of fat clay: A novel solution to an emerging waste problem. *Sci. Total Environ.* 794,
822 148746. <https://doi.org/10.1016/j.scitotenv.2021.148746>

823 Rizan, C., Reed, M., Bhutta, M.F., 2021. Environmental impact of personal protective equipment
824 distributed for use by health and social care services in England in the first six months of the
825 COVID-19 pandemic. *J. R. Soc. Med.* 114, 250–263. <https://doi.org/10.1177/01410768211001583>

826 Róka, E., Khayer, B., Kis, Z., Kovács, L.B., Schuler, E., Magyar, N., Málnási, T., Oravecz, O., Pályi, B.,
827 Pándics, T., Vargha, M., 2021. Ahead of the second wave: Early warning for COVID-19 by
828 wastewater surveillance in Hungary. *Sci. Total Environ.* 786, 147398.

829 <https://doi.org/10.1016/j.scitotenv.2021.147398>

830 Saadat, S., Rawtani, D., Hussain, C.M., 2020. Environmental perspective of COVID-19. *Sci. Total*
831 *Environ.* 728, 138870. <https://doi.org/10.1016/j.scitotenv.2020.138870>

832 Sarkodie, S.A., Owusu, P.A., 2021. Impact of COVID-19 pandemic on waste management. *Environ. Dev.*
833 *Sustain.* 23, 7951–7960. <https://doi.org/10.1007/s10668-020-00956-y>

834 Shammi, M., Behal, A., Tareq, S.M., 2021. The Escalating Biomedical Waste Management To Control
835 the Environmental Transmission of COVID-19 Pandemic: A Perspective from Two South Asian
836 Countries. *Environ. Sci. Technol.* 55, 4087–4093. <https://doi.org/10.1021/acs.est.0c05117>

837 Shams Esfandabadi, Z., Ravina, M., Diana, M., Zanetti, M.C., 2020. Conceptualizing environmental
838 effects of carsharing services: A system thinking approach. *Sci. Total Environ.* 745, 141169.
839 <https://doi.org/10.1016/j.scitotenv.2020.141169>

840 Sharma, H.B., Vanapalli, K.R., Cheela, V.S., Ranjan, V.P., Jaglan, A.K., Dubey, B., Goel, S.,
841 Bhattacharya, J., 2020. Challenges, opportunities, and innovations for effective solid waste
842 management during and post COVID-19 pandemic. *Resour. Conserv. Recycl.* 162, 105052.
843 <https://doi.org/10.1016/j.resconrec.2020.105052>

844 Sharma, H.B., Vanapalli, K.R., Samal, B., Cheela, V.R.S., Dubey, B.K., Bhattacharya, J., 2021. Circular
845 economy approach in solid waste management system to achieve UN-SDGs: Solutions for post-
846 COVID recovery. *Sci. Total Environ.* 800, 149605. <https://doi.org/10.1016/j.scitotenv.2021.149605>

847 Shevchenko, T., Kronenberg, J., Danko, Y., Chovancová, J., 2021a. Exploring the circularity potential
848 regarding the multiple use of residual material. *Clean Technol. Environ. Policy* 23, 2025–2036.
849 <https://doi.org/10.1007/s10098-021-02100-4>

850 Shevchenko, T., Saidani, M., Danko, Y., Golysheva, I., Chovancová, J., Vavrek, R., 2021b. Towards a
851 Smart E-Waste System Utilizing Supply Chain Participants and Interactive Online Maps. *Recycling*
852 6, 8. <https://doi.org/10.3390/recycling6010008>

853 Shevchenko, T., Vavrek, R., Danko, Y., Gubanova, O., Chovancová, J., 2021c. Clarifying a Circularity
854 Phenomenon in a Circular Economy under the Notion of Potential. *Probl. Ekorozwoju* 16, 79–89.
855 <https://doi.org/10.35784/pe.2021.1.09>

856 Thind, P.S., Sareen, A., Singh, D.D., Singh, S., John, S., 2021. Compromising situation of India’s bio-
857 medical waste incineration units during pandemic outbreak of COVID-19: Associated
858 environmental-health impacts and mitigation measures. *Environ. Pollut.* 276, 116621.
859 <https://doi.org/10.1016/j.envpol.2021.116621>

860 Thompson, J.R., Nancharaiyah, Y. V., Gu, X., Lee, W.L., Rajal, V.B., Haines, M.B., Girones, R., Ng, L.C.,
861 Alm, E.J., Wuertz, S., 2020. Making waves: Wastewater surveillance of SARS-CoV-2 for
862 population-based health management. *Water Res.* 184, 116181.
863 <https://doi.org/10.1016/j.watres.2020.116181>

864 Torres, F.G., De-la-Torre, G.E., 2021. Face mask waste generation and management during the COVID-
865 19 pandemic: An overview and the Peruvian case. *Sci. Total Environ.* 786, 147628.
866 <https://doi.org/10.1016/j.scitotenv.2021.147628>

867 Urban, R.C., Nakada, L.Y.K., 2021. COVID-19 pandemic: Solid waste and environmental impacts in
868 Brazil. *Sci. Total Environ.* 755, 142471. <https://doi.org/10.1016/j.scitotenv.2020.142471>

869 Valizadeh, J., Aghdamigargari, M., Jamali, A., Aickelin, U., Mohammadi, S., Khorshidi, H.A.,
870 Hafezalkotob, A., 2021. A hybrid mathematical modelling approach for energy generation from
871 hazardous waste during the COVID-19 pandemic. *J. Clean. Prod.* 315, 128157.
872 <https://doi.org/10.1016/j.jclepro.2021.128157>

873 van Eck, N.J., Waltman, L., 2010. Software survey: VOSviewer, a computer program for bibliometric
874 mapping. *Scientometrics* 84, 523–538. <https://doi.org/10.1007/s11192-009-0146-3>

875 Van Eck, N.J., Waltman, L., 2011. Text Mining and Visualization using VOSviewer. *ISSI Newsl.* 7, 50–
876 54.

877 Vanapalli, K.R., Sharma, H.B., Ranjan, V.P., Samal, B., Bhattacharya, J., Dubey, B.K., Goel, S., 2021.
878 Challenges and strategies for effective plastic waste management during and post COVID-19
879 pandemic. *Sci. Total Environ.* 750, 141514. <https://doi.org/10.1016/j.scitotenv.2020.141514>

880 Vittuari, M., Masotti, M., Iori, E., Falasconi, L., Gallina Toschi, T., Segrè, A., 2021. Does the COVID-19
881 external shock matter on household food waste? The impact of social distancing measures during
882 the lockdown. *Resour. Conserv. Recycl.* 174, 105815.
883 <https://doi.org/10.1016/j.resconrec.2021.105815>

884 Vu, H.L., Ng, K.T.W., Richter, A., Karimi, N., Kabir, G., 2021. Modeling of municipal waste disposal
885 rates during COVID-19 using separated waste fraction models. *Sci. Total Environ.* 789, 148024.
886 <https://doi.org/10.1016/j.scitotenv.2021.148024>

887 Waltman, L., van Eck, N.J., Noyons, E.C.M., 2010. A unified approach to mapping and clustering of
888 bibliometric networks. *J. Informetr.* 4, 629–635. <https://doi.org/10.1016/j.joi.2010.07.002>

889 Wang, J., Pan, L., Tang, S., Ji, J.S., Shi, X., 2020. Mask use during COVID-19: A risk adjusted strategy.
890 *Environ. Pollut.* 266, 115099. <https://doi.org/10.1016/j.envpol.2020.115099>

891 Wang, Z., Guy, C., Ng, K.T.W., An, C., 2021. A new challenge for the management and disposal of
892 personal protective equipment waste during the covid-19 pandemic. *Sustain.* 13, 3–6.
893 <https://doi.org/10.3390/su13137034>

894 Wu, F., Zhang, J., Xiao, A., Gu, X., Lee, W.L., Armas, F., Kauffman, K., Hanage, W., Matus, M., Ghaeli,
895 N., Endo, N., Duvallet, C., Poyet, M., Moniz, K., Washburne, A.D., Erickson, T.B., Chai, P.R.,
896 Thompson, J., Alm, E.J., 2020. SARS-CoV-2 Titers in Wastewater Are Higher than Expected from
897 Clinically Confirmed Cases. *mSystems* 5. <https://doi.org/10.1128/mSystems.00614-20>

898 Yousefi, M., Oskoei, V., Jonidi Jafari, A., Farzadkia, M., Hasham Firooz, M., Abdollahinejad, B.,
899 Torkashvand, J., 2021. Municipal solid waste management during COVID-19 pandemic: effects and
900 repercussions. *Environ. Sci. Pollut. Res.* 28, 32200–32209. <https://doi.org/10.1007/s11356-021->

901 14214-9

902 Zahedi, M., Shahin, M., Ali Babar, M., 2016. A systematic review of knowledge sharing challenges and
903 practices in global software development. *Int. J. Inf. Manage.* 36, 995–1019.
904 <https://doi.org/10.1016/j.ijinfomgt.2016.06.007>

905 Zambrano-Monserrate, M.A., Ruano, M.A., Sanchez-Alcalde, L., 2020. Indirect effects of COVID-19 on
906 the environment. *Sci. Total Environ.* 728. <https://doi.org/10.1016/j.scitotenv.2020.138813>

907 Zaneti, R.N., Girardi, V., Spilki, F.R., Mena, K., Westphalen, A.P.C., da Costa Colares, E.R., Pozzebon,
908 A.G., Etchepare, R.G., 2021. Quantitative microbial risk assessment of SARS-CoV-2 for workers in
909 wastewater treatment plants. *Sci. Total Environ.* 754, 142163.
910 <https://doi.org/10.1016/j.scitotenv.2020.142163>

911 Zhang, D., Ling, H., Huang, X., Li, J., Li, W., Yi, C., Zhang, T., Jiang, Y., He, Y., Deng, S., Zhang, X.,
912 Wang, X., Liu, Y., Li, G., Qu, J., 2020. Potential spreading risks and disinfection challenges of
913 medical wastewater by the presence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-
914 CoV-2) viral RNA in septic tanks of Fangcang Hospital. *Sci. Total Environ.* 741, 140445.
915 <https://doi.org/10.1016/j.scitotenv.2020.140445>

916 Zhao, H.-L., Wang, L., Liu, F., Liu, H.-Q., Zhang, N., Zhu, Y.-W., 2021. Energy, environment and
917 economy assessment of medical waste disposal technologies in China. *Sci. Total Environ.* 796,
918 148964. <https://doi.org/10.1016/j.scitotenv.2021.148964>

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921

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924