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Water and COVID-19 Pandemic: A Literature Review

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Abstract: ***This literature review provides an analytical examination of the complex dynamic between Water and the extraordinary challenges posed by the COVID-19 pandemic. The critical synthesis and Evaluation of the selected papers reveal a diverse set of techniques and results, contributing to the research knowledge of the complex interplay between the pandemic and water parameters. Drawing on various studies on the topic, the review presents a critical analysis of 15 articles on water demand that span different areas, including water resilience in the United Kingdom and Ireland, water resource disruptions in India, and other relevant contexts. Moreover, the analysis of varying results and methods highlights common patterns and differences, which outlines the general direction of research on such a significant subject. By examining common issues across different editions, the subject matter of the uncertainty involved becomes more precise and complicated. The results highlight that the pandemic has affected multiple facets of Water globally. Each study offers a distinct perspective, from modeling in Saudi Arabia to researching water quality in Hawai'i during lockdowns. While "Water Sector Resilience in the United Kingdom and Ireland: The COVID-19 Challenge" focuses on adaptation strategies, "Changes in Water Use and wastewater generation influenced by the COVID-19 pandemic: A Case Study of China" examines regional variations. The concluding section describes the outcomes and offers suggestions for a broader understanding of the relationship between water and the pandemic.***

Keywords*: *COVID-19, Water, Pandemic, Complex Dynamic

I. INTRODUCTION

The global water problems and the worldwide scope of the COVID-19 pandemic are an exceedingly complex challenge that requires realistic and practical exploration and solutions. A comprehensive rereading of the significant issues arising from the health crisis affecting water resources is underway. The essay presents a problem in three subsections, each arranged to highlight the salient features of the issue.

A. Literature Trends

Reviewing recent trends in research surveys, the main ideas and inquiries identified within extensive water-related studies conducted during the COVID-19 pandemic are presented. Drawing on various studies in the field of literature, we aim in this course to identify common questions and patterns that other researchers have explored at the intersection of environment and health.

B. Scope

Inviting the research investigation is the primary factor that will enable a concise and comprehensive review of the research examination. This sub-theme is explained in detail, which defines the exact zones of the subject of Water during the coronavirus, which will be the object of our study. The literature review will begin with water demand modelling and its implementations in various contexts, and will then proceed to resilience assessment in different geographical contexts. Through this, the literature review can provide a roadmap for readers, familiarising them with the path of the review.

C. Contributions

We advocate for the analysis of this systematic assessment as an academic exercise and a best practice with the potential to further enhance the science we know. This part of the study is closely focused on specifying the objectives of the review, as it is the primary purpose of extracting information that could be valuable for future work. As research on water systems in the context of the COVID-19 pandemic intensifies, this paper focuses on the conclusions and implications of this work, as well as its support for effective resource management. Through this research, the following two sections will present detailed narratives on twelve highly influential publications, each examining a single aspect of the intricate connection between water systems and the profound changes brought about by pandemics. With synthesising, analysing, and critically evaluating these works in mind, the research goal is to produce a depiction of the current state of knowledge, opening the gate for further research in the core of the evolving area facing the most significant challenges.

II. LITERATURE SYNTHESIS

The present study offers some insights, including the introduction of various research perspectives (ranging from views on the relationship between water issues and the progression of the pandemic to the relationship between the nature of water supplies and the spread of COVID-19). At the same time, research from a social housing complex in Brazil is combined with the pre- and post-water consumption patterns to establish more understanding of the regional trends (Cominato et al., 2022, [1]). The extraordinary situation of people confined to their places of residence and the loss of the tourism sector was a remarkable opportunity for some researchers (Garcia et al., 2023, [2]).

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In their paper regarding the tourism situation in the Balearic Islands, Spain.

Their work fills the essential gap in water programs by examining the amount of water used directly or indirectly for tourism in the 2019 and 2020 comparisons.

In analyzing the complicated relationships between water resources and the COVID-19 pandemic, "Water sector resilience in the United Kingdom and Ireland: The COVID-19 challenge" makes an essential contribution by diving into the water sector's Resilience (Walker et al., 2023, [3]). This study provides unique insights into the adaptive tactics employed in response to the pandemic's challenges, highlighting the sector's ability to resist and navigate extraordinary change. Furthermore, "COVID-19 Lockdown Disruptions on Water Resources, Wastewater, and Agriculture in India" thoroughly analyzes the broad effects of lockdown measures on several elements of water use in India (Balamurugan et al., 2021, [4]).

"Impacts on water quality" seeks to delve into the indirect consequences that COVID-19 has on water quality, as evident in the association between the pandemic and most environmental variables (Raza et al., 2022, [5]). A new method is being studied, and a natural experiment is being conducted in Hawaii, focusing on water usage for tourism during the COVID-19 pandemic closure period. However, it is a unique insight that is essential while covering the effect of the pandemic on water standards.

Spatially focused, the 'Evaluation of the influence of COVID-19 lockdown on surface water quality in Ireland' utilizes an advanced Irish water quality index model to appreciate the layered dynamics of lockdown impact on the region (Uddin et al., 2023, [6]). Also, the "COVID-19 pandemic lockdown modulation of physicochemical parameters of surface water" affirms COVID-19's influence on the Karamana River, Southwestern India's physicochemical parameters (Prasood et al., 2023, [7]). Investigations of this type offer diverse new perspectives on the specific interactive relationship between the COVID-19 pandemic and water quality, thereby contributing to a deeper understanding of the severe implications for environmental health.

Table 1: Summarize and Synthesize

Study Title	Focus/Area	Methodology	Location	Authors
Indirect effects of COVID-19 on water quality	Indirect consequences on water quality	Study on the association between COVID-19 and environmental variables	USA	Raza et al., 2022, [5]
The Mathematical Modelling Approach for the Wastewater Treatment Process In Saudi Arabia during the COVID-19 Pandemic.	Identifying a coronavirus hotspot through existing wastewater plants in major cities of Saudi Arabia.	Mathematical Modelling Approach	Saudi Arabia	Abdullah et al., S.2022 [15]
Social housing complex in Brazil	Pre- and post-water consumption patterns	Comparative analysis with regional trends	Brazil	Cominato et al., 2022, [1]
Water sector resilience in the United Kingdom and Ireland	Water sector resilience during COVID-19	In-depth analysis of adaptive tactics	United Kingdom, Ireland	Walker et al., 2023, [3]
COVID-19 Lockdown Disruptions on Water Resources in India	Effects of lockdown measures on water use	Comprehensive analysis of the lockdown impact on water use	India	Balamurugan et al., 2021, [4]

III. ANALYZE AND INTERPRET

The selected articles' presentations and reflective interpretations demonstrate a diversity of appreciation for the effects of the COVID-19 pandemic on the world's hydrologic cycle. For instance, in Phuket, Thailand, a pandemic water use pattern is changing due to travel restrictions, high tourism activities, high and low tourism activities, and other more severe effects (Changklom et al., 2022, [8]). The diversity of the approaches, such as modelling techniques in Saudi Arabia and technologically advanced water quality indicators in Ireland, demonstrates the relationship between water fluctuations and the pandemic. "Water quality effects" is an article that deals with the indirect impacts of the pandemic on water quality and demonstrates a clear relationship between COVID-19 and the state of the environment of waters (Raza et al., 2022, [5]). On this note, it is particularly worth mentioning the study's uniqueness, as Hawai'i is an uncommon single-case study examining tourists' water usage during the COVID-19 pandemic shutdown. These studies illustrate the complex relationships between human activities, pandemics, and water quality.

"The study, 'Explain the Effect of Covid–19 Lockdown on Surface Water Quality in Ireland'" at a national level employs a highly developed water quality index model for Ireland. This is one of the research methods that will be used to understand the impacts of water lockdowns, specifically in Irish conditions. Likewise, "The effect of COVID-19 pandemic lockdown on the physicochemical characteristics of surface water in the Karamana River Basin in Southwest India" analyses physicochemical parameters in the Karamana River Basin to reveal how localised effects caused by pandemic-based lockdowns operate.

The significant table, which helps in clearly sorting methodology and results observed from various research papers, highlights the usefulness of the findings. Now, this comparison is not just about underscoring the similarities and differences, but also serves as a vehicle for more specific trends to emerge in the articles. Through these studies, the pandemic further highlights the complexities of water movement problems, serving as a basis for environmental health studies and water management programs worldwide.

Table 2: Analyze and Interpret

Study title	Focus	Methodology	Location	Authors
Social housing complex in Brazil	Pre- and post-water consumption patterns	Comparative analysis with regional trends	Brazil	Cominato et al., 2022, [1]
Water sector resilience in the United Kingdom and Ireland	Water sector resilience during COVID-19	In-depth analysis of adaptive tactics	United Kingdom, Ireland	Walker et al., 2023, [3]
COVID-19 Lockdown Disruptions on Water Resources in India	Effects of lockdown measures on water use	Comprehensive analysis of the lockdown impact on water use	India	Balamurugan et al., 2021, [4]
Evaluation of the influence of the COVID-19 lockdown in Ireland	Lockdown impact on surface water quality	Utilizes an Irish water quality index model	Ireland	Uddin et al., 2023, [5]
COVID-19 pandemic lockdown modulation of physicochemical parameters	Influence on Karamana River physicochemical parameters	Analysis of lockdown modulation on river parameters	Southwestern India	Prasood et al., 2023, [7]

IV. RESULTS AND FINDINGS

This discovery reveals the inconsistencies that on-ground research shows in the dynamics of water systems, which are critical aspects as the pandemic progresses. As an illustration, "Water Demand Profile Before and During the

COVID-19 Pandemic in a Brazilian Social Housing Complex" is in complete contrast to the first one. Instead of presenting dissenting facts, it shows how water demand profiles have changed before and during the pandemic. Although COVID-19 lockdowns have impacted water demand differently worldwide, Resilience has become a priority, and actors in the existing food system are expected to show adaptive behaviors that may allow them to cope with either threats or opportunities (Zurek et al., 2022, [9]). The procedure acknowledges that implementing resilience enhancements involves ethical dimensions and ultimately necessitates negotiations among various interest groups.

During the COVID-19 pandemic, many positive and negative changes occurred; it allowed for the release of an enormous amount of medical waste, while on the other hand, it also helped improve air and water quality worldwide. Air quality data from remote sensing showed an apparent decline in pollutants, especially around waste centres like Wuhan, Italy, Spain, and the US during the lockdowns (Kazak et al., 2021, [10]). This set of changes, which also occurred on the beach and in its surroundings, created a quieter and cleaner environment. The literature represents the complex ways in which the SARS-CoV-2 pandemic has affected water resources. It emphasises the importance of integrating studies that fully timeline the effects of the pandemic on water resources. The pandemic's undeniable impact on water flow cannot be overstated, and it has led to changes in demand patterns, water quality, and the resilience of the water sector. The Articles "Water Sector Resilience in the United Kingdom and Ireland: For instance, the papers "The COVID-19 Challenge" and "COVID-19 Lockdown Disruptions on Water Resources, Wastewater and Agriculture in India" taken from the United Kingdom, Ireland and India, stand to exhibit the most expansive influence of pandemic-causing lockdown restrictions on the provision of Water and the management of wastewater and the agriculture field (Balamurugan, et al.,2021, [4]) Through these researches one can see that public health work inextricably links hospital aquatic rehabilitation to global dilemmas in water management, stressing the worldwide interdependence between water and environmental problems to social and economic fate of the world. This leads to the formulation of adaptively flexible policies, creating a robust framework that can withstand global challenges both now and in the future.

According to the literature review, a comprehensive and complete picture of the multifaceted impacts of the COVID-19 pandemic on water dynamics is elucidated. The conclusions of the integration synthesis are undoubtedly clear: health and environmental management are interdependent at different levels. Thus, opponents of adaptive policies require a more profound understanding of the link between the two. This literature brings to the foreground myriad themes, trends, ironies, and gaps, which will form the basis for more intensive investigation in the future. The basic information about this issue serves as the starting point necessary for officials, scientists, and practitioners to process data concerning the water space and respond to global water challenges and environmental and human health concerns accordingly.

V. CRITICALLY EVALUATE

The analysis of the selected studies reveals a complex context, where strengths and limitations are highlighted, leading to a deeper understanding of the diverse changes in water dynamics during the COVID-19 period. "Understanding Household Water-Use Behaviour and Consumption Patterns during COVID-19 Lockdown in Saudi Arabia", how the online questionnaire survey spatial approach can dependably evaluate the water demand effects. Although a case study within Saudi Arabia would help illuminate the Saudi Arabian movement, the findings may not present a generalizable application. Just like that, "Water demand profile at the eve of the COVID-19 pandemic and during the COVID-19 pandemic in a Brazilian Social Housing complex" is the study that analyses the pre- and post-pandemic water demand profiles.

Nevertheless, implementing the VILA system in urban environments other than favelas may require revision.

The role of water security in the immediate global arena is a foremost matter, especially in the Pacific region, which is highly exposed to climate change factors. World statistics on this issue are alarming, showing that 600 million people lack access to clean drinking water, and approximately 2.4 billion lack proper sanitation. Thus, the situation is urgent. Coinciding with the significance of climate change on water sources is the situation in a state like Hawaii, where most of its groundwater is used (DeMaagd et al., 2022, [11]). Although petite on a global scale, the tourism sector still poses a significant problem in water-intensive areas; for example, in Hawaii, hotels and resorts account for a disproportionately high rate of water demand. The direct and indirect links between tourism growth, water scarcity, and climate change are examined using Bali as a case study of unsustainable local aquifer exploitation, which is closely tied to the tourism industry.

Over the years, the COVID-19 Pandemic Has Led to changes in lifestyle, production methods, and trade routes, which have in turn impacted water consumption and pollution. Already a massive problem worldwide, water scarcity will become more severe with multiple consequences for volume and quality (Jia et al., 2022, [12]). Pathogenic viruses in Water and sewage networks can transfer diseases. Therefore, patients in hospitals or healthcare-suffocated buildings face the danger of contamination and hazards, hence the need for intelligent sanitation systems.

Within the context of water sector resilience, "Water sector resilience in the United Kingdom and Ireland: The document 'COVID-19 confrontation'" presents a detailed analysis. The strengths of Stretch Studio include reminding us that it is of utmost importance to consider the distinctions between the two locations. Still, we need to pay more attention to these differences.

The COVID-19 pandemic has negatively impacted the global industrial supply chain, with China serving as the principal manufacturing centre for raw materials. In 2020, Chinese coastal regions, including Fujian Province, implemented strict lockdown policies. Consequently, the drivers of sectoral trade were severely shaken. Despite the global economic crisis, water quantity and quality were the winners in the aftermath of the pandemic lockdown management, which the global ecology had achieved (Yu et al., 2023, [13]). This research aims to explore the case of Fujian Province, which combines the three components of wasteful and polluting Water: physical, virtual, and total. The study found a drop in the quantity of natural Water and an increased level of local water quality when the lockdown was lifted.

In the study of water quality dynamics, "Impacts on water quality" makes a significant contribution by investigating the indirect impacts of COVID-19, enhancing the literature with nuanced findings. However, difficulties separating these impacts from other environmental elements may bring complexity that undermines the study's validity. On a separate point,

"Tourism water use during the COVID-19 shutdown: A natural experiment in Hawai'i" provides an interesting perspective. Nonetheless, the potential constraint in generalizability due to the unique Hawaiian environment cautions against applying these findings to other contexts, underscoring the need for more studies in different geographical locations to achieve a comprehensive understanding.

"Evaluation of COVID-19 lockdown effect on surface water quality in Ireland" differentiates primarily in applying Ireland's water quality index, enabling a deeper assessment (Uddin et al., 2023, [6]). Nonetheless, the study's focus on Ireland alone may be a limiting factor in its applicability to cases in other geographic regions. Similarly, the "COVID-19 pandemic lockdown affected the physico-chemical parameters of surface water in the Southwest India" showed that the study provides SWN with essential insights (Prasood et al., 2023, [7]). Nevertheless, ascertaining the exact relationship between the observed physicochemical variances and the prevailing pandemic impacts remains complex, underscoring the need for a comprehensive dataset that provides a thorough understanding of all environmental phenomena in the study area.

The analysis of water dynamics, "Driving forces and variation in water footprint before and after the COVID-19 lockdown in Fujian Province of China," and "COVID-19 water sector responses in Europe: The primary 'scoping review of preliminary recommendations for governmental interventions' can also be considered (Antwi et al., 2021, [14]). Nevertheless, the latter can be drivers of water cycles. Therefore, it may refer to a more direct causation analysis that will limit the development of a complete set of mechanisms responsible for water footprints' fluctuation. On the one hand, a recommender analysis of European countries' governmental initiatives may have limitations due to the need to select only a few of them and monitor them. Stressing these considerations highlights the need for further research on whether an established connection exists and, if so, what the most effective intervention would be for that specific case.

A significant part of this critical review is related to the fact that both positive and negative characteristics of each paper should be taken into consideration, the differences in methodology should be discussed, as well as the details regarding the geographic location of the study; in general, the sum of all papers of this kind extended the global knowledge of the complex connection between COVID epidemic and the world water problem.

Identifying the strengths and locating the gaps unveiled here will be instrumental in formulating more comprehensive and enlightened programs that guide the research activities of the given field. This activity is crucial for developing effective strategies to protect water resources, as the world continues to face numerous global challenges in the future.

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Table 3: Critical Evaluation

ARTICLE TITLE	STRENGTH	WEAKNESS
Walker et al., 2023, [3]	Provides in-depth analysis of water sector resilience in the United Kingdom and Ireland.	Limited emphasis on potential variations between the two regions.
Balamurugan et al., 2021, [4]	A comprehensive examination of pandemic-induced disruptions on water resources in India.	It may need to address regional disparities within India thoroughly.
Raza et al., 2022, [5]	Explores indirect effects of COVID-19 on water quality, adding depth to the literature.	Potential challenges in isolating indirect effects from other environmental factors.
DeMaagd et al., 2022, [11]	Presents a unique natural experiment in Hawai'i, contributing an unconventional perspective.	Generalizability may be limited due to the uniqueness of the Hawaiian context.
Uddin et al., 2023, [6]	Utilizes an advanced Irish water quality index model for nuanced assessment.	The focus on Ireland might limit broader applicability. |
Prasood et al., 2023, [7]	Investigation of pandemic-induced modulation of physico-chemical parameters in Southwest India.	Potential challenges in attributing changes solely to pandemic effects.
Yu et al.,2023, [13]	Examines driving forces and variations in water footprint in Fujian Province, China.	It may lack direct causation analysis between driving forces and variations.
Antwi et al., 2021[14]	A scoping review offers a preliminary understanding of governmental interventions in Europe.	A more in-depth analysis of the effectiveness of interventions may be needed.
Kazak et al., 2021, [10]	Explores changes in water demand patterns in a European city.	Limited generalizability to diverse urban contexts globally.
Jia et al., 2022, [12]	Case study of changes in China's water use and wastewater generation during the pandemic.	Limited focus on potential regional variations within China.

VI. CONCLUSION

Ultimately, this literature review provides a comprehensive examination of the COVID-19 pandemic's impact on global water dynamics. The critical synthesis and Evaluation of the selected papers reveals a diverse set of techniques and results, contributing to the research knowledge of the complex interplay between the pandemic and water parameters. Each study offers a distinct perspective, from modeling in Saudi Arabia to researching water quality in Hawai'i during lockdowns. While "Water Sector Resilience in the United Kingdom and Ireland: The COVID-19 Challenge" focuses on adaptation strategies, "Changes in Water Use and wastewater generation influenced by the COVID-19 pandemic: A Case Study of China" examines regional variations.

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval or consent to participate, as it presents evidence that is not subject to interpretation.
Availability of Data and Materials	Not relevant.
Authors Contributions	I am the sole author of the article.

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