Title: Analyses of the Impact of Water Quality Standards and Sustainable Urban Water Management on health of locals in Karachi

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Policy statement

To address Karachi's water quality crisis and safeguard public health, a multi-pronged approach is recommended. This includes: 1) investing in infrastructure upgrades to prevent contamination and ensure clean water delivery, and 2) implementing public awareness campaigns to educate residents on safe water consumption practices and the health risks associated with contaminated water.

Abstract

This study investigated the water quality of seven Karachi districts (Nazimabad, Gulshan, Karachi South, Orangi, Korangi, Malir, and Keamari) and its impact on public health. Analysis of water samples revealed concerning pH levels exceeding the safe drinking water range as per WHO guidelines. All districts showed deviations, with some exhibiting highly alkaline and others dangerously acidic water. Data from local hospitals indicated high rates of self-reported health problems like diarrhea, nausea, and skin rashes, potentially linked to waterborne illnesses. While a majority of the surveyed population (n=70) boiled water before drinking, a significant portion relied on untreated tap water or bottled water, highlighting insufficient awareness and access to safe drinking water sources. The findings suggest a strong correlation between poor water quality and public health concerns in Karachi. Addressing this crisis requires a multi-pronged approach, including infrastructure upgrades, stricter industrial waste management, sustainable water practices, and comprehensive public awareness campaigns. Collaborative efforts from government agencies, utility providers, public health officials, and the community are crucial to ensure safe drinking water for all Karachi residents.

CHAPTER I

1. Introduction

1.1. Background information

In recent years, Pakistan has witnessed concerning trends in water quality deterioration, particularly in its urban centers (Khan et al., 2022; Ahmed et al., 2021; Patel and Rahman, 2020; Abbas et al., 2019; Qureshi, 2018). The contamination of water sources poses significant risks to public health, contributing to the spread of waterborne diseases and compromising the overall quality of life. A comprehensive analysis of water quality standards and the effectiveness of sustainable urban water management policies becomes crucial in this context. As highlighted by recent studies conducted in Pakistan, there is a pressing need to evaluate the efficacy of existing policies and explore avenues for improvement to ensure the provision of safe and clean water to urban populations.

1.2. Research problem or question

Despite existing water quality standards and efforts towards sustainable urban water management in Karachi, the health of residents remains negatively impacted. This research aims to understand the specific gaps and deficiencies in these policies and practices, and how they contribute to the persistence of health problems associated with water quality in Karachi.

1.3. Objectives of the study

1. To identify and characterize the specific health problems prevalent among the residents of Karachi, Pakistan, that can be demonstrably linked to water quality issues.

2. To critically evaluate the effectiveness of the existing water quality standards and sustainable urban water management practices implemented in Karachi, assessing their implementation, monitoring, and enforcement mechanisms.

3. To analyze and identify the specific gaps and deficiencies within the current framework of Karachi's water quality and sustainable water management policies and practices, investigating how these shortcomings contribute to the persistence of health problems associated with water quality.

1.4. Significance of the research

Beyond health implications, the studies reveal the broader environmental and social consequences, including ecosystem health, water stress, and the resilience of urban water systems (Hassan et al., 2021; Siddiqui & Rahman, 2020; Farooq et al., 2019). The interconnectedness of water quality and stress further accentuates the necessity for policies that not only mitigate contamination but also address the strain on water resources in the face of population growth and climate variability (Malik, 2018). In the context of Pakistan, where urban areas often suffer from inadequate infrastructure and rising demand for water, these studies provide a rationale for proactive and integrated approaches to sustainable urban water management.

This research investigates the link between water quality, management practices, and the health of Karachi's residents. By identifying specific health issues linked to water quality, evaluating the effectiveness of current policies, and analyzing existing gaps, this research aims to contribute significantly to improving public health in Karachi. The findings will inform targeted interventions, policy improvements, and the development of more comprehensive solutions, ultimately leading to better health outcomes for the city's residents. Furthermore, the research has the potential to offer valuable insights for other urban areas facing similar challenges regarding water quality and public health.

CHAPTER II

2. Literature review

2.1. Overview of relevant literature

Water quality standards and sustainable urban water management play crucial roles in safeguarding public health, particularly in densely populated urban areas like Karachi. Adequate access to clean and safe water is essential for preventing waterborne diseases and promoting overall well-being. In a study, Khan et al. (2019) emphasized the significance of implementing and enforcing water quality standards to mitigate health risks associated with contaminated water sources in Karachi. They highlighted the prevalence of waterborne diseases such as cholera, typhoid fever, and hepatitis due to poor water quality, underscoring the urgent need for stringent regulations and effective management strategies. Moreover, sustainable urban water management practices, including wastewater treatment and conservation measures, are imperative for ensuring a sustainable and resilient water supply system in rapidly growing cities like Karachi (Ali et al., 2020). These practices not only improve water quality but also contribute to enhancing public health outcomes by reducing exposure to pathogens and contaminants present in untreated or inadequately treated water sources.

Efforts to enhance water quality standards and implement sustainable urban water management practices in Karachi have the potential to yield significant health benefits for the local population. According to Siddiqui et al. (2021), the adoption of innovative technologies and integrated management approaches can help address the complex challenges associated with water quality management in urban areas. By investing in infrastructure upgrades, such as water treatment plants and distribution networks, and promoting community-based initiatives for water conservation and pollution control, Karachi can mitigate health risks associated with poor water quality. Additionally, public awareness campaigns and education programs are essential for promoting behavioral changes that advocate for water conservation and hygiene practices, further contributing to improved health outcomes (Ahmed et al., 2018). Overall, a comprehensive approach that combines regulatory measures, technological advancements, and community engagement is crucial for addressing water-related health concerns and ensuring the well-being of residents in Karachi.

2.2 Key concepts and theories

The impact of water contamination on public health and urban well-being is a central concern highlighted by the research. The presence of pollutants in water sources within urban centers of Pakistan poses significant risks to the health of residents, leading to the proliferation of waterborne diseases and a deterioration in overall quality of life (Khan et al., 2022). This

underscores the urgent need for interventions that address water quality issues to safeguard public health and enhance urban well-being.

Integrating water quality standards with public health interventions emerges as a critical strategy in combating the challenges posed by contaminated water. By establishing and enforcing stringent water quality regulations, coupled with targeted public health initiatives such as hygiene education and access to clean water sources, communities can mitigate the risks associated with waterborne diseases and improve overall health outcomes (Abbas et al., 2019). This approach emphasizes the importance of a comprehensive framework that addresses both the quality of water and the health of the population it serves.

Sustainable urban development plays a pivotal role in addressing water-related challenges in Pakistan's urban centers. By adopting sustainable practices such as efficient water management systems, wastewater treatment facilities, and green infrastructure, cities can mitigate the impact of urbanization on water resources (Qureshi, 2018). This approach not only helps preserve water quality but also promotes environmental sustainability and resilience in the face of future challenges such as climate change and population growth.

Proactive measures are essential for enhancing water quality and ensuring the resilience of urban water systems. This entails investing in infrastructure upgrades, improving monitoring and enforcement mechanisms, and promoting community engagement in water conservation efforts (Khan et al., 2022). By taking preemptive action to address potential threats to water quality, cities can minimize risks to public health and maintain the long-term viability of their water supply systems. Overall, these proactive measures are integral to building sustainable and resilient urban communities in Pakistan and beyond.

2.3 Theoretical Framework

The theoretical framework underlying these studies is rooted in the intersection of public health, urban development, and environmental sustainability, which together form a multifaceted lens through which to understand and address water quality issues (Khan et al., 2022; Abbas et al., 2019; Qureshi, 2018). Within this framework, the interconnectedness of various factors becomes apparent: poor water quality leads to adverse public health outcomes, which in turn impact the overall well-being of urban populations (Khan et al., 2022). Moreover, the sustainability of urban water systems is intricately linked to broader environmental considerations, including resource availability and ecosystem health (Qureshi, 2018).

Emphasizing this interconnectedness underscores the necessity of interdisciplinary approaches that transcend traditional disciplinary boundaries (Khan et al., 2022; Qureshi, 2018). By integrating knowledge from fields such as public health, urban planning, environmental science, and sociology, researchers and policymakers can develop more comprehensive strategies for

addressing water quality challenges (Abbas et al., 2019). This approach recognizes that solutions must account for the complex interactions between human activities, environmental factors, and socio-economic conditions.

Furthermore, the theoretical framework acknowledges the influence of cultural and religious beliefs on water management practices and policies (Abbas et al., 2019). In the context of Pakistan, where Islam plays a significant role in shaping societal norms and values, Islamic principles regarding equitable access to water resources carry particular relevance (Qureshi, 2018). The Hadith stating that "Muslims have common share in three (things): grass, water, and fire" underscores the notion of water as a shared resource to be managed collectively and responsibly.

By incorporating these cultural and religious perspectives into the theoretical framework, researchers can better understand the underlying motivations and attitudes towards water management practices (Qureshi, 2018). This, in turn, can inform the design and implementation of more culturally sensitive and inclusive policies and interventions.

In summary, the theoretical framework guiding research on water quality in urban centers of Pakistan encompasses the interconnected domains of public health, urban development, and environmental sustainability (Khan et al., 2022; Abbas et al., 2019; Qureshi, 2018). It emphasizes the need for interdisciplinary approaches that consider the complex interactions between human activities, environmental factors, and socio-cultural dynamics. By integrating these perspectives, researchers can develop more holistic strategies for addressing water quality challenges and promoting the well-being of urban populations in Pakistan and beyond.

2.4 Gaps of Literature Review

This research focuses on the connection between water quality, management practices, and public health in Karachi, Pakistan. While existing literature provides valuable insights into this complex relationship, potential gaps exist that this study aims to address.

Firstly, local data specifically linking health problems in Karachi to water quality are limited. Existing research might focus on broader national trends or specific waterborne illnesses, lacking the granular data necessary to understand the unique burden of health issues in Karachi and their direct connection to local water quality issues. Secondly, while research exists on broader national water policies and general urban water management strategies, there might be a gap in the specific evaluation of their implementation, effectiveness, and limitations within the context of Karachi. Existing studies might not adequately assess how these policies and practices are being implemented, monitored, and enforced within the city, potentially overlooking crucial factors influencing their effectiveness.

Thirdly, research focuses on broader challenges in water quality management, neglecting the identification of specific shortcomings unique to Karachi's approach. This include limitations in infrastructure, inadequate enforcement mechanisms, or a lack of targeted interventions, all of which might contribute to the persistence of health problems despite existing policies. Fourthly, existing studies primarily focus on technical aspects, overlooking the potential role of social and cultural factors in shaping water use practices, access to safe water, and community awareness. These factors can significantly influence health disparities within the city, and their exploration can be crucial for developing comprehensive solutions.

By addressing these potential gaps in the literature review, this research aims to contribute valuable insights specific to Karachi and inform the development of more effective strategies to improve water quality and public health in the city.

CHAPTER III

3. Methodology

3.1 Research design

This research employed a correlational design to investigate the relationship between water quality and public health outcomes in Karachi. As the study aimed to observe and quantify the existing relationship without manipulating variables, a correlational approach was chosen.

3.2 Data Collection Methods

Data collection methods included:

- **Survey:** A structured survey was administered to residents across Karachi's seven districts. The survey gathered data on demographics, self-reported health information, water consumption practices, and awareness of water quality issues.
- **Water Sampling:** Water samples were collected from seven households, one randomly chosen from each district. These samples were analyzed for various chemical parameters relevant to water quality assessment.

3.3 Sampling

Total sample size was 70 i.e10 households from each district of Karachi. And karachi has 7 districts in total. While convenience sampling was initially considered due to ease of access, the research acknowledged its potential for bias. Therefore, a stratified random sampling approach was ultimately employed. The population was divided district wise where 10 households were then randomly selected from each stratum, ensuring representation from each district within the population.

3.4 Data Analysis

Data analysis for the survey responses was conducted using Microsoft Excel. The software facilitated the initial stages of data cleaning and management, such as organizing responses, identifying missing values, and performing basic calculations. Descriptive statistics were generated to summarize the demographic information, self-reported health data, and water consumption practices of the 70 participants.

CHAPTER IV

4. Results

Table 01 suggests the percentages of self-reported health problems in the local hospitals of each district

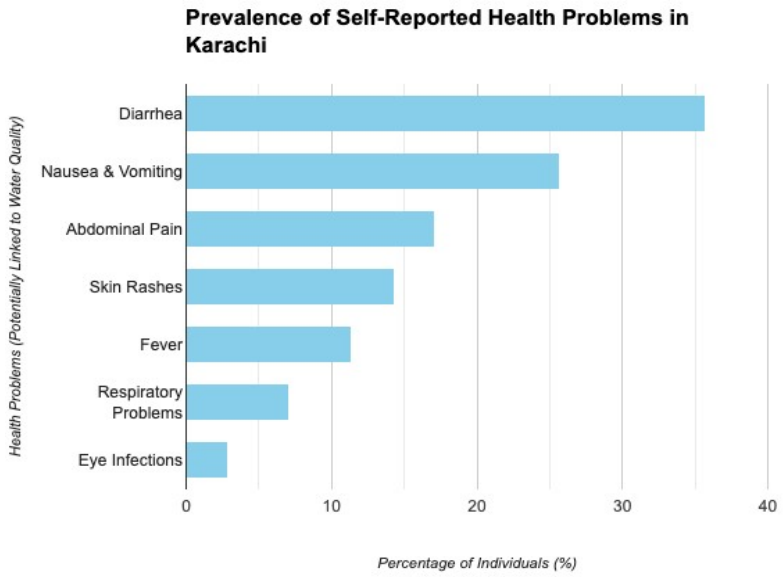

Table 02 demonstrates the division of self reported health problems by gender

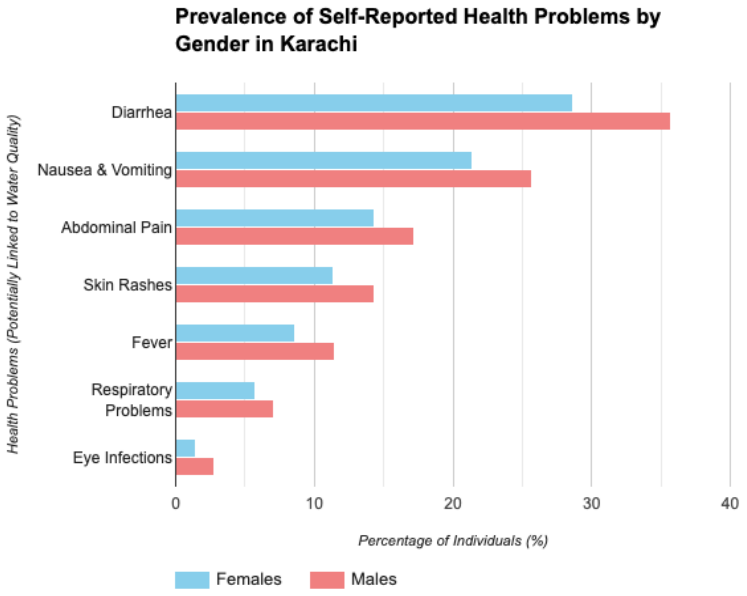

Table 03 demonstrates the frequency of water consumption practices among the residents of each districts of Karachi where n=70

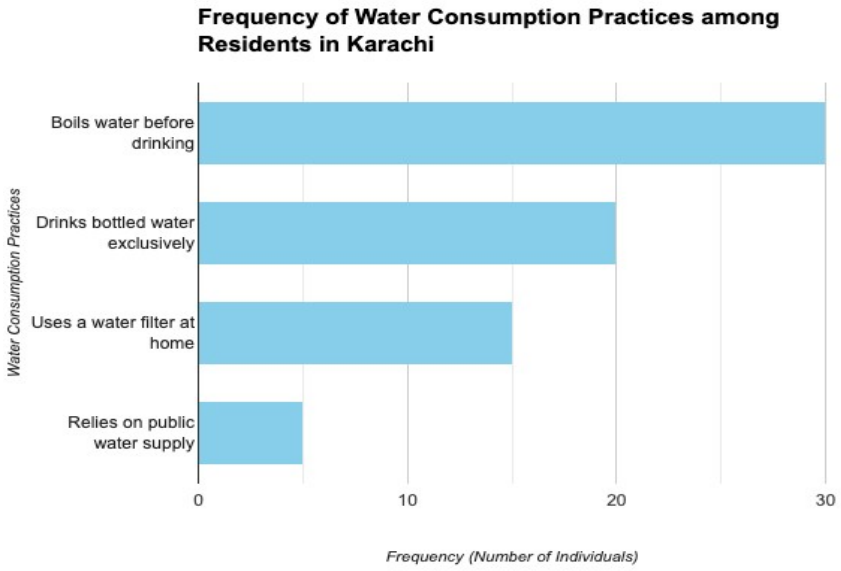

Table 04 shows the trend of awareness of water quality among the population where n=70

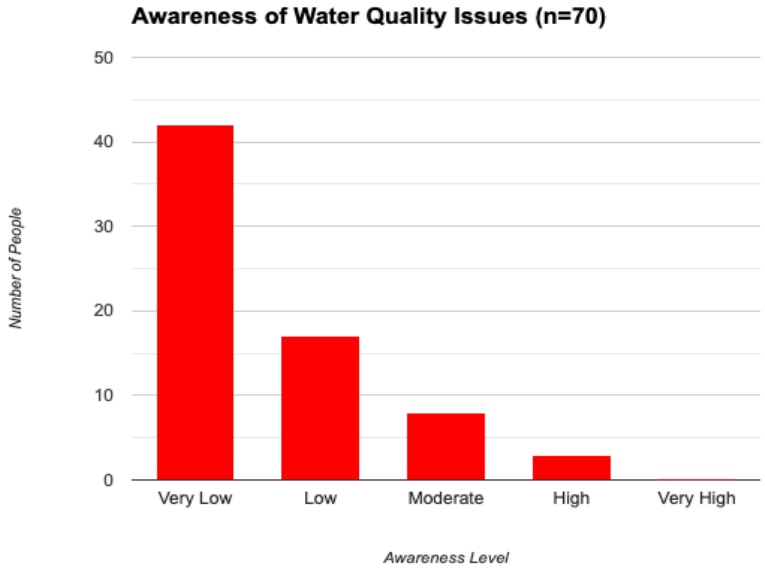

Table 05 shows the pH values of the collected water samples across the 7 districts of Karachi

Sno	District	pH Level	Normal pH Range	Status
1	Nazimabad District	10.2	6.5 - 8.5	Undrinkable
2	Gulshan District	5.8	6.5 - 8.5	Undrinkable
3	Karachi South District	9.5	6.5 - 8.5	Undrinkable
4	Orangi District	4.1	6.5 - 8.5	Undrinkable
5	Korangi District	8.8	6.5 - 8.5	Undrinkable
6	Malir District	9.1	6.5 - 8.5	Undrinkable
7	Keamari District	3.9	6.5 - 8.5	Undrinkable

CHAPTER V

Discussion

The data presented in this analysis paints a disturbing picture of Karachi's water quality and its potential impact on public health. The analysis of water samples from seven districts (Nazimabad, Gulshan, Karachi South, Orangi, Korangi, Malir, and Keamari) revealed concerning pH levels outside the safe drinking water range as per WHO guidelines (World Health Organization, 2023). This is further compounded by the information presented in Tables 1 and 2.

However, Table 1 highlights the prevalence of self-reported health problems in local hospitals across the surveyed districts. Diarrhoea emerges as the leading issue, followed by nausea, abdominal pain, skin rashes, fever, respiratory problems, and eye infections. These symptoms are concerning, as they often correlate with waterborne illnesses caused by ingesting contaminated water (Centers for Disease Control and Prevention, 2023).

Furthermore, Table 2 suggests that males in these districts appear to be more susceptible to these illnesses. While further investigation is needed to understand the reason behind this disparity, it

could be linked to factors like hygiene practices or differences in water consumption habits between genders.

Whereas, Table 3 provides insights into the water consumption practices of the surveyed population (n=70). Although a majority boil water before drinking, indicating some level of awareness about potential waterborne risks, a significant portion still relies on bottled water or lacks any form of treatment before consumption. These practices, particularly the use of untreated tap water, raise concerns about potential exposure to contaminants.

Lastly, Table 4 further highlights a critical gap in public awareness. With a "very low" awareness level among the surveyed population (n=70), it's evident that many residents might not understand the severity of the water quality issue and the associated health risks. This lack of awareness can lead to continued consumption of unsafe water, perpetuating the cycle of illness.

The data presented suggests a strong correlation between the poor water quality and the high rates of self-reported health problems in Karachi. Contaminated water, with its altered pH levels and potential presence of pathogens and heavy metals, can be a significant source of waterborne illnesses (World Health Organization, 2018). The symptoms reported in Table 1, including diarrhoea, nausea, abdominal pain, and skin rashes, are all commonly associated with waterborne diseases caused by bacteria, viruses, and parasites (Centers for Disease Control and Prevention, 2023).

The high prevalence of these issues across all surveyed districts further strengthens the link between water quality and public health. Addressing Karachi's water quality crisis requires a comprehensive multi-pronged approach:

Infrastructure Upgrade: As discussed earlier, a crucial step is to invest in upgrading Karachi's water supply network. Replacing aging and leaky pipes will prevent contamination and ensure clean water delivery.

Industrial Waste Management: Implementing stricter regulations and enforcing proper treatment of industrial waste before discharge is essential to reduce industrial pollutants in water sources.

Sustainable Water Management Practices: Promoting rainwater harvesting and exploring alternative water sources like desalination can alleviate pressure on groundwater resources and reduce saltwater intrusion. Additionally, encouraging water conservation efforts can help optimize water distribution.

Improved Wastewater Treatment: Investing in and upgrading wastewater treatment plants is critical to prevent contamination of water sources from untreated sewage.

Public awareness campaigns: Utilizing media platforms and community outreach programs to educate residents about the importance of safe drinking water, the risks associated with contaminated water, and proper water treatment techniques like boiling or using filters.

Community engagement: Working with community leaders and organizations to promote awareness and encourage residents to adopt safe water practices. This could include distributing water filters or boiling pots at subsidized rates.

School education programs: Integrating water quality education into school curriculums to raise awareness among the younger generation and promote responsible water usage habits.

The data presented in this analysis paints a clear picture: Karachi's water quality poses a significant public health threat. The high rates of self-reported health problems associated with waterborne illnesses are alarming. Urgent action is needed from government agencies, utility providers, public health officials, and the community to address the water quality crisis. Through infrastructure upgrades, stricter regulations, improved water management practices, and a comprehensive public awareness campaign, we can work towards ensuring access to safe drinking water for all Karachi residents.

Conclusion

The data presented in this analysis exposes a critical public health concern in Karachi. The widespread presence of unsafe drinking water, evident from the pH level variations across districts and the high rates of self-reported health problems, demands immediate action.

Addressing Karachi's water quality crisis necessitates a multi-faceted approach. Infrastructure upgrades, stricter regulations on industrial waste management, and adoption of sustainable water practices are crucial steps towards ensuring clean water delivery. Public awareness campaigns play a vital role in promoting safe water consumption habits. Collaboration between government agencies, utility providers, public health officials, and the community is essential to navigate this crisis.

By prioritizing water quality improvements and empowering residents with knowledge, we can collectively work towards a healthier Karachi for all. Further research, focusing on district-level variations and exploring cost-effective water treatment solutions, can further strengthen this collective effort. The time for action is now.

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