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Towards Safe and Sustainable Urban Water Management: Lessons from Ghana

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Abstract
This research serves as a wake-up call to policymakers, urban planners, and public health authorities in Ghana and other developing countries grappling with similar challenges. The findings underscore the urgent need for coordinated action to address the root causes of water contamination and ensure the provision of safe and reliable water services to urban residents. One of the key implications of the study is the need for enhanced water quality monitoring and surveillance systems in urban areas. Regular testing and analysis of underground water sources are essential to identify and mitigate potential health risks associated with contamination. This requires investment in laboratory facilities, trained personnel, and data management systems to track water quality indicators over time. Additionally, the research highlights the importance of community engagement and public awareness campaigns to empower residents with knowledge about the risks of using contaminated water sources. By fostering a culture of water conservation and promoting best practices for water storage, treatment, and consumption, communities can play a proactive role in safeguarding their health and well-being. Furthermore, the findings underscore the interconnectedness of environmental, social, and economic factors in shaping water quality outcomes in urban areas. Rapid urbanization, inadequate infrastructure, and informal settlement patterns exacerbate the vulnerability of marginalized populations to waterborne diseases and other health hazards. Addressing these underlying structural issues requires holistic approaches that integrate urban planning, sanitation infrastructure development, and poverty alleviation strategies. Moreover, the research highlights the need for stronger regulatory frameworks and enforcement mechanisms to ensure compliance with water quality standards and regulations. This includes monitoring and enforcement of industrial discharge and waste disposal practices that contribute to water pollution, as well as regulating the use of agrochemicals and fertilizers in agricultural activities that can contaminate groundwater sources. In short, this study underscores the imperative of prioritizing water quality management as a fundamental component of urban development strategies in developing countries. By investing in infrastructure upgrades, capacity building, and community empowerment initiatives, policymakers can work towards ensuring equitable access to safe and clean water for all urban residents, thereby promoting public health, environmental sustainability, and economic prosperity.
Keywords: Water Contamination, Urban Areas, Public Health, Water Quality Monitoring, Community Engagement
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1. INTRODUCTION

In 2003, the United Nations Secretary-General introduced a significant initiative focusing on five critical areas: water, energy, health, agriculture, and biodiversity (WEHAB). This initiative underscored the interconnectedness of these essential sectors and their collective importance for sustainable development. Recognizing the urgent global challenge of freshwater scarcity and pollution, the United Nations General Assembly designated 2003 as the "International Year of Freshwater." This declaration aimed to raise awareness, stimulate action, and promote innovative solutions to address the critical issues related to freshwater resources. The initiative highlighted the necessity for integrated approaches to manage water resources sustainably, ensuring access to clean water for all, and protecting the environment from the adverse effects of water pollution. Studies have revealed alarming statistics regarding global access to safe drinking water. Approximately 1.5 billion people worldwide lack access to safe drinking water, a fundamental human necessity. This deficiency has severe health implications, with at least 5 million deaths per year attributed to waterborne diseases (Frantz and Kifferstein, 2006). These figures underscore the critical need for comprehensive strategies to improve water quality and access, thereby preventing disease and saving lives.

The United Nations has long recognized the significance of this issue. In 2003, the UN Secretary-General launched an initiative focusing on five critical areas: water, energy, health, agriculture, and biodiversity (WEHAB). The same year was declared the "International Year of Freshwater" by the United Nations General Assembly. This initiative highlighted the gravity of the global freshwater shortage and the urgent need to address water pollution. Access to clean water is not just a

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matter of health, but also of dignity and equity. In many developing countries, the burden of water collection falls disproportionately on women and children, who often spend hours each day fetching water from distant sources. This time-consuming task not only prevents them from engaging in education or economic activities but also exposes them to various health risks. Moreover, water scarcity and pollution are intrinsically linked to other critical global issues such as food security, climate change, and economic development. Agricultural practices, industrial activities, and climate-related changes all significantly impact water availability and quality. Thus, addressing water issues requires a holistic approach that integrates environmental management, sustainable development, and technological innovation. In response to these challenges, various international organizations, governments, and non-governmental organizations have been working to implement solutions. These include developing sustainable water management practices, investing in water infrastructure, promoting water conservation, and enhancing the efficiency of water use in agriculture and industry. Additionally, education and awareness campaigns are crucial in changing consumption patterns and encouraging responsible water use. Technological advancements also play a vital role in addressing water scarcity and pollution. Innovations in water purification, desalination, and recycling can provide new sources of clean water. Moreover, improvements in monitoring and data collection can help manage water resources more effectively, ensuring that water distribution is equitable and sustainable. Recognizing the critical importance of addressing freshwater scarcity in developing nations, ministers from these countries convened at the Water Forum in Kyoto, Japan, to devise strategies for enhancing investment in their water sectors. Given the pressing need to ensure access to safe drinking water for their populations, they turned their focus towards exploring various financing mechanisms. One prominent solution embraced during these deliberations was the adoption of public-private partnerships (PPPs) in water supply initiatives. These partnerships were tailored to align with each country's unique national water policies and developmental priorities. By embracing PPPs, developing countries aimed to leverage the strengths of both public and private sectors to improve water infrastructure and service delivery. The involvement of private entities brought with it expertise, innovation, and financial resources, while governmental oversight ensured accountability and adherence to public health standards. With this collaborative approach, governments sought to overcome financial constraints and accelerate progress towards achieving universal access to clean water. Furthermore, the ministers underscored the importance of implementing stringent measures to safeguard water quality, particularly concerning public health, with a specific focus on vulnerable communities, such as those with low incomes. They emphasized the need for proactive measures to monitor and regulate water sources, treatment processes, and distribution systems to mitigate health risks associated with contaminated water. In essence, the decisions made at the Water Forum reflected a commitment to addressing the multifaceted challenges of freshwater availability and quality in developing countries. By embracing PPPs and prioritizing water quality management, these nations aimed to lay the groundwork for sustainable and equitable access to clean water, essential for improving public health and fostering socio-economic development.

The global policy initiatives aimed at addressing freshwater challenges resonate closely with the constitutional mandate outlined in Article 35(3) of the 1992 Constitution of Ghana. This provision underscores the obligation of the state to ensure reasonable access to essential public facilities and services, including freshwater, for all citizens. In alignment with this constitutional imperative, the government of Ghana took proactive steps to establish the Ghana Water Company Limited (GWCL). The establishment of GWCL marked a pivotal milestone in Ghana's efforts to fulfill its constitutional duty of providing, distributing, and conserving potable water for various societal needs in urban areas. Through the GWCL, the government sought to centralize and streamline water management operations, thereby enhancing efficiency and effectiveness in service delivery. This initiative aimed to address the pressing water needs of urban communities, encompassing domestic, commercial, and industrial sectors. By entrusting GWCL with the responsibility of water provision and distribution, the government demonstrated its commitment to prioritizing access to clean water as a fundamental right of its citizens. This strategic approach not only aligned with constitutional principles but also reflected Ghana's broader development agenda, which emphasizes the importance of infrastructure development and public service provision for national progress. The establishment of GWCL exemplifies Ghana's proactive stance in addressing freshwater challenges and underscores its dedication to ensuring equitable access to this vital resource for its urban population. Through sustained efforts and collaborative initiatives, Ghana endeavors to uphold its constitutional mandate and fulfill its obligations to provide essential services that contribute to the well-being and prosperity of its people. In addition to the Ghana Water Company Limited (GWCL) serving urban areas, the government introduced the Community Water and Sanitation Agency (CWSA) to extend access to freshwater to rural communities. Despite the efforts of these two organizations, the combined output of water they provide falls short of meeting the demand for freshwater in Ghana. This shortfall is particularly pronounced given Ghana's total population, which stood at approximately 24 million in 2010. The insufficient provision of freshwater has compelled many individuals and communities across the country to resort to alternative means of securing water for their households. In rural areas especially, where access to centralized water supply systems may be limited, communities have had to devise innovative solutions to address their water needs. These may include the construction of hand-dug wells, boreholes, or rainwater harvesting systems. However, the reliance on such decentralized water sources comes with its own set of challenges, including issues related to water quality, reliability, and sustainability. Furthermore, the burden of securing water falls disproportionately on vulnerable segments of the population, including women and children, who often bear the responsibility of fetching water from distant sources.

Addressing the gap between freshwater demand and supply in Ghana requires a multifaceted approach that encompasses both infrastructure development and policy interventions. This includes continued investment in water infrastructure to expand coverage and improve service reliability, as well as initiatives to promote water conservation and sustainable management practices. Furthermore, there is a need for enhanced coordination and collaboration among government agencies, private sector stakeholders, and local communities to ensure equitable access to freshwater resources across the country. By adopting a comprehensive and inclusive approach to water management, Ghana can work towards achieving its goal of universal access to safe and reliable water for all its citizens, in line with its constitutional mandate and international commitments. As the extraction of underground water through drilling of deep and shallow wells becomes increasingly prevalent, it is imperative to assess the quality of this water source to safeguard public health. To address this need, a research study was conducted to evaluate the quality of underground water in a rapidly expanding suburb of the Accra Metropolis. The study focused on analyzing microorganisms and chemical elements present in sampled underground water to determine their potential impact on human health. By isolating and examining these contaminants, the research aimed to assess the overall safety and suitability of underground water for consumption and domestic use within the community. Through rigorous analysis and testing procedures, the study sought to identify any potential risks associated with the presence of harmful microorganisms or chemical pollutants in the underground water sources. By quantifying the levels of these contaminants and evaluating their potential health effects, the research aimed to provide valuable insights into the quality and safety of underground water resources in the study area. The findings of this research are expected to contribute to informed decision-making and policy development aimed at ensuring access to clean and safe drinking water for residents of the suburb. By identifying areas of concern and potential sources of contamination, the study may also inform strategies for mitigating risks and improving water quality management practices in similar urban settings. The availability of underground water relies heavily on the presence and characteristics of an aquifer—a geological formation consisting of saturated layers capable of supplying water to wells for various purposes (Hoch, Ed. 2009). When precipitation occurs, water infiltrates into the ground and percolates through porous rock or soil layers, eventually recharging the aquifer. Aquifers play a crucial role in storing and transmitting groundwater, serving as natural reservoirs that can sustain water availability over extended periods. The ability of an aquifer to store and release water depends on factors such as its porosity, permeability, and geological structure.

Understanding the dynamics of aquifers is essential for managing water resources effectively, as they often serve as primary sources of freshwater for drinking, irrigation, industrial processes, and other human activities. Proper management of aquifers involves monitoring water levels, recharge rates, and quality to ensure sustainable utilization and prevent overexploitation or contamination. By studying the characteristics and behavior of aquifers, scientists and water resource managers can develop strategies for sustainable groundwater management, including measures to protect recharge areas, control abstraction rates, and mitigate pollution risks. Through integrated approaches that consider hydrological, geological, and environmental factors, it is possible to maintain the long-term viability of aquifer systems and ensure continued access to groundwater for future generations. Research has shown that wells relying on shallow underground water exhibit fluctuations in depth, typically ranging between 1.5 and 6.5 feet, which correlate with seasonal variations (Mazari-Hiriart et al., 2005). For instance, a study conducted in Mexico City, North America, found that during the rainy season, 19 percent of groundwater samples exceeded recommended levels for both total and fecal coliforms, compared to 16 percent during the dry season. These findings underscore the impact of seasonal changes on groundwater quality and highlight the need for comprehensive monitoring and management strategies to ensure the safety and sustainability of underground water sources.

Indeed, the quality of water sourced from aquifers can be compromised by a variety of factors, stemming from both natural processes and human activities. Natural pathways, for instance, can provide conduits for stormwater to infiltrate from the earth's surface into an aquifer, potentially introducing contaminants along the way. Human actions, including the excessive use of fertilizers, agrochemicals, and untreated wastewater leakage, can also contribute to groundwater pollution. Moreover, activities such as excavation for highway construction and mining operations can disturb the natural soil layers, reducing the filtration and purification capacity of the soil and exposing the water table to potential pollutants. Regardless of the specific mechanisms of contamination, underground water that becomes polluted poses significant health risks to consumers who rely on it for drinking and other domestic purposes. Efforts to safeguard underground water quality require a multifaceted approach, encompassing measures to mitigate pollution sources, enhance monitoring and surveillance systems, and implement appropriate remediation strategies where contamination has occurred. By addressing both natural and anthropogenic factors contributing to groundwater pollution, it is possible to protect this vital resource and ensure its continued availability for present and future generations.

2. METHODOLOGY

The research employed a purposive sampling method, focusing specifically on households with wells, which constituted the target population for the study. While the initial sample comprised 126 houses, ultimately 120 households participated in the research, yielding an impressive response rate of 95 percent. A systematic approach was adopted for data collection, involving the sampling of water from 22 wells. Samples were collected into appropriately labeled one-liter bottles and preserved in a light-proof insulated container equipped with ice-packs to maintain optimal conditions during transportation for subsequent analysis. The locations of the sampled wells within the various compounds were determined using a hand-held Global Positioning System (GPS) receiver, with the coordinates accurately recorded for each site. Additionally, the presence and positions of septic tanks within the households were identified using the same instrument, and the distances between the wells and septic tanks were carefully measured. It is noteworthy that data collection occurred during the same season, ensuring consistency and minimizing the influence of seasonal variations on the results obtained. This approach enhances the reliability and validity of the findings, as any observed patterns or trends can be confidently attributed to factors other than seasonal fluctuations.

3. RESULTS AND DISCUSSIONS

The data provided in Table 1 illustrates the utilization of underground water by residents across various categories of usage. For drinking water, 54.2% of the respondents reported using underground water, indicating a significant reliance on this source for potable water. This suggests that a substantial portion of the population depends on underground water as a primary source of drinking water, which could have implications for water quality and public health. In contrast, the usage of underground water for cooking, bathing, and laundry is universal among the respondents, with 100% reporting its utilization for these purposes. This highlights the widespread dependency on underground water for daily household activities, reflecting its importance in meeting basic needs. Interestingly, the category labeled as "Others" shows a lower percentage of underground water usage at 37.5%. This suggests that while underground water is extensively utilized for essential activities like drinking and household chores, its usage may be less common for other purposes not explicitly mentioned in the survey. Overall, the data underscores the significance of underground water as a vital resource for residents, particularly for essential activities such as drinking, cooking, bathing, and laundry. Understanding the patterns of underground water usage is crucial for water resource management and ensuring sustainable access to clean water for communities.

Table 1: Utilization of Underground Water by Residents

Type of Usage	Number	Frequency	Percentage (%)
Drinking	120	65	54.2
Cooking	120	120	100
Bathing	120	120	100
Laundry	120	120	100
Others	120	45	37.5

Table 2 outlines the frequency of water quality checks conducted by property owners. The data suggests variations in the frequency of these checks, with two distinct categories: yearly checks and checks at irregular intervals. Of the respondents, only 6 individuals (27%) reported conducting yearly checks on water quality. This indicates a relatively low proportion of property owners who adhere to an annual schedule for assessing the quality of their water supply. Conversely, a significant majority of respondents (73%) reported conducting checks at irregular intervals. This suggests that the practice of monitoring water quality is more commonly carried out on an ad-hoc basis rather than following a structured yearly schedule. The disparity in frequency between yearly checks and checks at irregular intervals underscores potential gaps in water quality monitoring practices among property owners. While some may prioritize regular assessments, others may only perform checks sporadically, which could impact their ability to identify and address water quality issues promptly. Enhancing awareness about the importance of regular water quality checks and promoting consistent monitoring practices could contribute to better water management and ensure the provision of safe and clean water for residents.

Table 2: Frequency of Water Quality Checks

Check on Water Quality	Property Owners	Frequency	Percentage (%)
Yearly	22	6	27
Irregular intervals	22	18	73

Table 3 presents various physio-chemical parameters of the water samples collected. These parameters offer insights into the quality and composition of the water under examination. The turbidity of the water samples ranged from 0.54 NTU (Nephelometric Turbidity Units) to 1.59 NTU. The mean turbidity was calculated to be 0.93 NTU, with a relatively low variance of 0.08 NTU and a standard deviation of 0.29 NTU. Turbidity measures the cloudiness or haziness of water caused by suspended solids, indicating the clarity of the water. The pH levels of the water samples varied between 3.89 and 6.80. The average pH level was found to be 5.11. The pH of water is a measure of its acidity or alkalinity, with values below 7 indicating acidity, and values above 7 indicating alkalinity. The variance and standard deviation of pH were 0.62 and 0.79, respectively, indicating moderate variability in pH levels among the samples. The concentration of total coliform bacteria in the water samples ranged from 0 to 651 colony-forming units per 100 milliliters (CFU/100ml). The mean concentration of total coliform bacteria was 107.68 CFU/100ml. Total coliform bacteria are indicators of water quality and can originate from fecal matter, indicating potential contamination. The variance and standard deviation for total coliform concentrations were notably high, indicating significant variability among the samples. Overall, the physio-chemical parameters provide valuable information about the quality of the water samples, with turbidity, pH, and total coliform concentrations serving as important indicators of water safety and suitability for various purposes such as drinking, recreational activities, and agricultural use. Analyzing these parameters helps in assessing water quality, identifying potential sources of contamination, and implementing appropriate measures to ensure safe water supply for various needs.

Table 3: Physio-Chemical Parameters

Parameters	Number	Minimum	Maximum	Mean	Variance	Standard Deviation
Turbidity	22	0.54	1.59	0.93	0.08	0.29
pH	22	3.89	6.80	5.11	0.62	0.79
Total Coliform (100ml)	22	0	651.	107.68	43097.8	207.63

Table 4 presents the values of various divergent chemical parameters found in the water samples collected. These parameters provide insight into the composition and chemical characteristics of the water. The TDS levels ranged from 532 mg/L to 1216 mg/L, with a mean of 625 mg/L. TDS represents the total concentration of dissolved substances in water, including inorganic salts, organic matter, and other dissolved solids. The variance and standard deviation were 20721.60 and 143.95, respectively, indicating significant variability in TDS levels among the samples. Sodium concentrations varied from 27 mg/L to 270 mg/L, with an average of 137.7 mg/L. Sodium is an essential mineral but high levels can be detrimental to health, particularly for individuals with hypertension or cardiovascular issues. The variance and standard deviation were 3469.2 and 58.9, respectively. Calcium levels ranged from 6.7 mg/L to 80.2 mg/L, with a mean concentration of 21.49 mg/L. Calcium is vital for various physiological functions and is also important for water hardness. The variance and standard deviation were 379.4 and 19.48, respectively. Chloride concentrations varied widely from 132 mg/L to 516 mg/L, with a mean of 249.73 mg/L. Chloride is essential for maintaining electrolyte balance but elevated levels can indicate contamination or salinity issues. The variance and standard deviation were notably high at 84,548.85 and 92.46, respectively. Sulphate levels ranged from 1.64 mg/L to 133 mg/L, with a mean concentration of 27.79 mg/L. Sulphate is naturally present in water and elevated levels can result from industrial or agricultural activities. The variance and standard deviation were 547 and 23.39, respectively. Nitrate concentrations varied widely, with some samples having undetectable levels up to 39 mg/L. Nitrate contamination can result from agricultural runoff or sewage discharge and poses health risks, particularly for infants. The variance and standard deviation were 66.9 and 8.18, respectively. Total alkalinity ranged from 6.0 mg/L to 274 mg/L, with a mean of 39.18 mg/L. Alkalinity measures the water's capacity to resist changes in pH and is influenced by bicarbonates, carbonates, and hydroxides. The variance and standard deviation were 5,014 and 70.81, respectively. Magnesium concentrations ranged from 7.7 mg/L to 47.8 mg/L, with a mean of 0.9 mg/L. Magnesium is an essential mineral for human health and is also important for water hardness. The variance and standard deviation were 114.7 and 10.71, respectively. These chemical parameters provide valuable information about the composition, quality, and potential uses of the water samples, aiding in assessing water suitability for various purposes such as drinking, agriculture, and industrial processes. Analyzing these parameters helps in identifying potential sources of contamination and implementing appropriate measures for water treatment and management.

Table 4: Values of Divergent Chemical Parameters

Variable	Frequency	Minimum	Maximum	Mean	Variance	Standard deviation
Total Dissolved Solids	22	532	1216	625	20721.60	143.95
Sodium	22	27	270	137.7	3469.2	58.9
Calcium	22	6.7	80.2	21.49	379.4	19.48
Chloride	22	132	516	249.73	84,548.85	92.46
Sulphate	22	1, 64	133	27.79	547.	23.39
Nitrate	22	-	39	10.08	66.9	8.18
Total Alkalinity	22	6.0	274	39.18	5,014	70.81
Magnesium	22	7.7	47.8	0.9	114.7	10.71

4. CONCLUSION

The insufficiency of potable water in urban areas of developing nations underscores a broader challenge stemming from inadequate investment and infrastructure. Due to limited financial resources, governments often struggle to establish and maintain robust systems for water treatment, distribution networks, and conservation measures. As a consequence, many urban dwellers are left without reliable access to safe drinking water, exacerbating health risks and perpetuating cycles of poverty and inequality. Addressing this multifaceted issue requires coordinated efforts to mobilize funding, implement sustainable solutions, and prioritize the needs of marginalized communities. The true cost of inadequate access to clean water extends far beyond economic considerations. The toll on human lives and well-being due to waterborne diseases is immeasurable and often disproportionately affects vulnerable populations. While curative medicine is crucial for addressing immediate health concerns, preventive measures such as ensuring access to safe drinking water are equally essential for safeguarding public health in the long term. Redirecting attention and resources towards proactive strategies for water provision and sanitation can ultimately lead to significant improvements in overall health outcomes and contribute to sustainable development goals. Investing in preventive measures like environmental sanitation and freshwater provision can yield significant long-term benefits for emerging cities. Beyond the immediate health advantages of reducing waterborne diseases, such initiatives contribute to broader social and economic development. Improved public health means fewer medical expenses for individuals and governments, freeing up resources for other critical areas like education and infrastructure. Furthermore, prioritizing freshwater provision demonstrates a commitment to sustainable urban development. Access to clean water is not only a basic human right but also a cornerstone of environmental stewardship. By safeguarding water resources and investing in efficient water management systems, cities can mitigate the risks of water scarcity and contamination, ensuring a more resilient future in the face of climate change and population growth. Moreover, promoting environmental sanitation fosters a sense of civic responsibility and community well-being. Clean, well-maintained public spaces enhance residents' quality of life and pride in their surroundings. This, in turn, can bolster social cohesion and strengthen community bonds, leading to safer and more vibrant neighbourhoods. Overall, prioritizing freshwater provision and environmental sanitation is not just a matter of public health but a strategic investment in the long-term prosperity and sustainability of emerging cities. By allocating resources wisely and adopting a proactive approach to urban management, city leaders can create healthier, more resilient communities that thrive in the face of future challenges.

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