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# Wastewater infrastructure in Nigeria and the USA: A tale of two nations and their pathway to sustainable development

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**Abstract**
Sanitation and wastewater management are critical components of public health and environmental sustainability. This article juxtaposes the wastewater infrastructure in Nigeria and the United States, examining the challenges each nation faces and their pathways toward sustainable development. Nigeria struggles with rapid urbanization, population growth, and insufficient infrastructure, leading to widespread reliance on unsanitary disposal methods such as pit latrines and open defecation. These practices result in severe public health issues and environmental degradation, impeding progress towards achieving the United Nations Sustainable Development Goals (SDGs), particularly Goal 6: Clean Water and Sanitation. Conversely, the United States benefits from more developed and regulated wastewater infrastructure, largely driven by the Clean Water Act of 1972. However, rural and economically disadvantaged areas, like the Black Belt region of Alabama, still use straight pipes, discharging untreated sewage directly into the environment, posing significant health and environmental risks. This comparative analysis highlights the importance of addressing social and economic disparities, technological advancements, and policy implementations to achieve sustainable wastewater management. By investing in infrastructure, enhancing regulatory frameworks, and promoting community engagement, both nations can work towards achieving SDG 6, ensuring availability and sustainable management of water and sanitation for all.

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## 1. Introduction

Sanitation and wastewater management are critical components of public health and environmental sustainability (Hanjra *et al*. 2012) [11]. Effective management of these systems is vital for preventing waterborne diseases, protecting water resources, and promoting environmental health. These systems play a fundamental role in safeguarding public health by reducing the prevalence of waterborne illnesses such as cholera, dysentery, and typhoid fever. Furthermore, they are essential for maintaining the integrity of water ecosystems and ensuring the sustainable use of water resources.

Significant disparities exist between countries in terms of economic capacity, technological advancement, and policy implementation, leading to varied challenges and opportunities in wastewater management. In developed nations like the United States, advanced technological solutions and robust policy frameworks have enabled the establishment of sophisticated wastewater treatment systems (Massoud, Tarhini, and Nasr 2009) [20]. However, despite these advancements, challenges remain, particularly in rural and poor areas. Conversely, in developing countries such as Nigeria, rapid urbanization, population growth, and inadequate infrastructure have resulted in widespread reliance on unsanitary disposal methods, such as pit latrines and open defecation (Eneh 2021) [8]. These practices contribute to severe public health issues and environmental degradation, complicating efforts to achieve sustainable development.

This article juxtaposes the wastewater infrastructure in Nigeria and the United States, examining the unique and shared challenges each nation faces and their respective pathways toward sustainable development. By comparing these two nations, we can better understand the critical factors that influence the effectiveness of wastewater management systems. This comparative analysis is crucial for achieving the United Nations Sustainable Development Goals (SDGs), particularly Goal 6: Clean Water and Sanitation. This goal aims to ensure the availability and sustainable management of water and sanitation for all, highlighting the need for inclusive, equitable, and context-specific solutions.

By exploring the socio-economic, technological, and policy dimensions of wastewater management in Nigeria and the United States, this article aims to provide insights into the strategies that can be employed to overcome existing challenges. It underscores the importance of addressing social and economic disparities, advancing technological innovations, and strengthening regulatory frameworks to promote sustainable wastewater management practices. Ultimately, the goal is to offer a comprehensive understanding of how both nations can enhance their efforts to achieve SDG 6, ensuring that everyone has access to clean water and adequate sanitation facilities, thereby improving public health and protecting the environment.

## 2. Sanitation in Nigeria

Nigeria faces considerable challenges in providing adequate sanitation and managing wastewater (Idris-Nda, Aliyu, and Dalil 2013) [13]. These challenges are multifaceted and stem from a combination of rapid urbanization, population growth, and insufficient infrastructure. The rapid pace of urbanization has outstripped the development of adequate sanitation facilities, leading to widespread reliance on unsanitary disposal methods (Jiboye, Adebayo, and Obakin 2020; Daramola and Ibem 2010) [15, 6]. In many rural areas, pit latrines and open defecation remain prevalent due to the lack of access to proper sanitation facilities (Abubakar 2017) [1]. This situation is further exacerbated by high levels of poverty and limited governmental capacity to provide basic services.

### 2.1. Rural Areas and Open Defecation

In rural areas, the lack of access to proper sanitation facilities is particularly acute. Pit latrines, which are simple excavations in the ground, are commonly used for waste disposal. While they are a step up from open defecation, they are often poorly constructed and maintained, leading to environmental contamination and public health issues. Open defecation is particularly pervasive in Nigeria, with over 47 million people practicing it, leading to severe public health and environmental repercussions (Mara 2017) [19]. The practice of open defecation contaminates water sources, spreads diseases, and contributes to the cycle of poverty and disease that affects many rural communities (Ebimgbo *et al.* 2019) [7].

### 2.2. Urban Centers and Infrastructure Strain

Urban centers in Nigeria, although equipped with septic tanks and rudimentary sewage systems, often experience significant inadequacies due to poor maintenance and the overwhelming demands of a growing population (Centre (Canada) 1999) [5]. The infrastructure in many Nigerian cities is outdated and not designed to handle the current population density (Potts 2012) [24]. As a result, septic tanks and sewage systems frequently overflow. This situation is compounded by a lack of regular maintenance and investment in infrastructure upgrades.

### 2.3. Public Health Implications

The public health implications of inadequate sanitation in Nigeria are profound. The widespread use of pit latrines and lack of adequate waste disposal systems contribute to the contamination of water sources (Izah, Ngun, and Richard 2022) [14]. This contamination is a significant cause of waterborne diseases such as cholera, dysentery, and typhoid fever, which are rampant in Nigeria (Eniolorunda 2021) [9]. These diseases disproportionately affect children, who are more vulnerable to the health impacts of contaminated water and poor sanitation. According to the WHO, diarrhea, often caused by waterborne pathogens, is a leading cause of death among children under five in Nigeria (Kehinde Peter and Umar 2018) [16].

### 2.4. Environmental Impact

The environmental impact of poor sanitation practices in Nigeria is equally significant. Contaminated water sources affect not only human populations but also wildlife and ecosystems. The discharge of untreated waste into rivers and streams leads to the degradation of aquatic habitats and the loss of biodiversity (Zhang 2022) [26]. Additionally, the use of pit latrines and open defecation contributes to soil contamination, which can affect agricultural productivity and food security.

### 2.5. Efforts to Improve Sanitation

Efforts to improve sanitation in Nigeria are ongoing, although progress is slow. Government initiatives, supported by international organizations, aim to increase access to safe water and sanitation facilities. Programs like the "Clean Nigeria: Use the Toilet" campaign strive to end open defecation by 2025 through awareness campaigns, community engagement, and the construction of toilets. These efforts focus on behavioral change as well as infrastructure development. However, these efforts are often hindered by limited funding, corruption, and logistical challenges, making the attainment of SDG 6 more complex.

## 3. Wastewater Infrastructure in the USA

In contrast to Nigeria, the United States boasts a more developed and regulated wastewater infrastructure. This advanced state of development is largely attributed to significant legislative and regulatory efforts over the past few decades. The cornerstone of these efforts is the Clean Water Act of 1972, which laid the groundwork for improving water quality and regulating pollutant discharges into water bodies (Knopman and Smith 1993) [17]. This landmark legislation has been instrumental in setting national standards for wastewater treatment and ensuring that water quality is maintained across the country.

### 3.1. Urban Wastewater Management

Urban areas in the USA are predominantly serviced by centralized wastewater treatment plants. These facilities are designed to manage and treat large volumes of sewage effectively. Centralized treatment plants typically employ a multi-stage process that includes primary treatment to remove solids, secondary treatment to break down organic

matter through biological processes, and tertiary treatment to remove nutrients and other pollutants. This comprehensive approach significantly reduces the risk of waterborne diseases and environmental contamination (Hube and Wu 2021) [12].

The effectiveness of centralized wastewater treatment plants in urban areas is evident in the improved water quality and public health outcomes. By treating sewage before it is discharged into water bodies, these facilities help prevent the spread of waterborne diseases such as cholera, dysentery, and hepatitis A. Moreover, the treated water is often released into rivers, lakes, and oceans, where it meets stringent environmental standards, thus protecting aquatic ecosystems and maintaining biodiversity.

### 3.2. Rural and Economically Disadvantaged Areas

Despite these advancements, not all regions in the United States benefit equally from this infrastructure. Rural and poor areas, such as the Black Belt region of Alabama, continue to face significant challenges. In these areas, the use of straight pipes - systems where raw sewage is discharged directly into the environment without treatment - remains prevalent. This practice poses severe health risks and highlights the disparities in access to safe sanitation (Carrera and Flowers 2018) [4].

The prevalence of straight pipes in rural and poor communities underscores the ongoing challenges in achieving equitable access to clean water and sanitation, as envisioned by SDG 6. Straight pipes lead to direct contamination of water sources, which can result in outbreaks of waterborne diseases (McKenna *et al*. 2017) [22].

### 3.3. Health Risks and Environmental Impact

Untreated sewage contains pathogens, including bacteria, viruses, and parasites, which can cause a variety of illnesses. McKenna *et al* found that untreated sewage in rural areas can lead to severe health outcomes, including hookworm infestations, which cause anemia, impaired cognitive development, and stunted growth in children (McKenna *et al*. 2017) [22]. Children and the elderly are particularly vulnerable to these health impacts due to their weaker immune systems. From an environmental perspective, the discharge of untreated sewage into the environment leads to the contamination of soil and water bodies. Nutrients in the sewage, such as nitrogen and phosphorus, can cause eutrophication in water bodies, leading to algal blooms and the subsequent depletion of oxygen. This process, known as hypoxia, creates dead zones where aquatic life cannot survive.

### 3.4. Disparities in Infrastructure Access

The disparities in wastewater infrastructure access between urban and rural areas in the United States reflect broader social and economic inequalities. Urban areas, with their higher population densities and greater economic resources, have been able to invest in advanced wastewater treatment technologies. In contrast, rural areas, which often have smaller tax bases and higher poverty rates, struggle to afford the necessary infrastructure improvements.

These disparities are further exacerbated by regulatory and funding challenges. While federal and state programs exist to support rural wastewater infrastructure, the funding is often insufficient to meet the needs of all communities. Federal and state funding programs play a crucial role in supporting wastewater infrastructure projects, particularly in rural and poor areas. These programs offer grants and loans for the development, improvement, and maintenance of water and wastewater systems.

### 3.5. Heirs' Property Issues

An additional challenge that exacerbates the difficulties faced by rural communities, particularly in the southeastern United States, is the issue of heirs' property. Heirs' property refers to land that has been passed down informally through generations without a clear legal title. This form of ownership is prevalent among African American families in the South and often leads to legal complications that hinder the ability of property owners to qualify for loans, grants, or other financial assistance for infrastructure improvements.

According to (Bailey and Thomson 2022) [3], "Heirs' property is created when an owner dies without a probated will being processed through a local court system". This unique form of land tenure is prevalent in many rural and historically marginalized communities, particularly in the Southern United States, where descendants of enslaved individuals often inherited land informally without going through the legal process of probate or property partition.

Without a clear title, heirs' property cannot be easily transferred, sold, or used as collateral for loans (Richardson and Miller 2023) [25], limiting landowners' ability to leverage their assets for economic advancement or investment. Moreover, the absence of formalized ownership often hinders access to government programs, financial services, and legal protections, further marginalizing heirs' property owners and perpetuating cycles of poverty and disempowerment. The unclear land titles associated with heirs' property create significant barriers to accessing funding for wastewater management projects. Federal and state funding programs typically require clear proof of ownership as a prerequisite for eligibility. Without formal titles, residents cannot secure the necessary financing to upgrade their wastewater systems, perpetuating the use of inadequate and environmentally harmful practices such as straight piping.

Efforts to address heirs' property issues include legal aid programs that help families' clear titles and secure their property rights. Policy interventions, such as the Uniform Partition of Heirs Property Act (UPHPA), aim to protect heirs' property owners from forced sales and promote fair division of land. By addressing these legal barriers, communities can better leverage funding programs to improve their wastewater infrastructure.

## 4. Juxtaposing the Two Systems

While Nigeria and the USA face distinct challenges in sanitation and wastewater management, the underlying issues of inequality, infrastructure deficits, and public health risks are strikingly similar. In Nigeria, the struggle is to provide basic sanitation to a rapidly growing population with limited resources. In the USA, the challenge lies in addressing the gaps in wastewater infrastructure that disproportionately affect rural and low-income communities. This section elaborates on the social and economic disparities, technological and policy differences, and the impact on public health and the environment in both countries.

### 4.1. Social and Economic Disparities

Both Nigeria and the USA exhibit stark social and economic disparities that significantly influence the effectiveness of

their wastewater management systems. In Nigeria, economic constraints severely limit the ability to invest in necessary infrastructure. The country's GDP per capita is considerably lower than that of the USA, which restricts the government's capacity to fund large-scale sanitation projects. Consequently, a significant portion of the population relies on inadequate and unsanitary disposal methods, such as pit latrines and open defecation, particularly in rural areas.

In the USA, socio-economic disparities result in uneven access to advanced wastewater treatment technologies. While urban areas benefit from well-funded and technologically advanced centralized treatment systems, rural and low-income communities often lack the necessary infrastructure. These communities frequently depend on outdated septic systems or straight pipes, which discharge untreated sewage directly into the environment. This disparity highlights the need for targeted interventions that address the specific needs of vulnerable populations, ensuring equitable access to safe sanitation and wastewater management solutions.

### 4.2. Technological and Policy Differences

Technological advancements in wastewater treatment are more prevalent in the USA, where centralized systems and advanced treatment technologies are common. The Clean Water Act of 1972 laid the groundwork for significant improvements in water quality and pollution control, leading to the widespread adoption of advanced wastewater treatment processes. These include primary, secondary, and tertiary treatment stages that effectively remove contaminants from sewage before it is discharged into water bodies.

In contrast, Nigeria's adoption of innovative technologies is limited by financial and technical constraints. The country relies heavily on decentralized systems, such as septic tanks and pit latrines, which are often poorly maintained and inadequate for the needs of a growing population. The lack of investment in advanced treatment technologies exacerbates the challenges of managing wastewater effectively.

Policy frameworks also differ significantly between the two countries. The USA benefits from a comprehensive and enforced regulatory system. The Environmental Protection Agency (EPA) enforces strict regulations under the Clean Water Act, ensuring that wastewater treatment processes meet high standards to protect public health and the environment. Regular monitoring and reporting are mandated, which helps maintain compliance and mitigate pollution.

In Nigeria, regulatory enforcement is often weak, and policy implementation is inconsistent. While there are national policies aimed at improving water and sanitation, such as the National Water Policy, challenges in enforcement and corruption hinder progress. The lack of a robust regulatory framework and effective governance results in widespread non-compliance with sanitation standards, contributing to the country's significant public health and environmental issues (Amokaye 2012) [2].

### 4.3. Impact on Public Health and the Environment

The state of wastewater management in both countries has profound implications for public health and the environment. In Nigeria, poor sanitation and wastewater practices lead to widespread health issues and environmental degradation. Contaminated water sources are a common cause of waterborne diseases such as cholera, dysentery, and typhoid fever. These diseases disproportionately affect children and vulnerable populations, contributing to high morbidity and mortality rates.

In the USA, while urban areas benefit from advanced infrastructure, rural areas face significant health risks from inadequate wastewater management. Straight pipes and outdated septic systems in rural regions discharge untreated sewage directly into the environment, contaminating water sources and exposing communities to waterborne diseases. These practices pose severe health risks, particularly for low-income and marginalized populations who lack access to improved sanitation facilities (Flowers, 2020; McKenna *et al*. 2017) [10, 22].

The environmental impacts are similarly concerning in both countries. In Nigeria, untreated wastewater pollutes rivers and streams, affecting both ecosystems and human health. The release of pathogens and nutrients into water bodies leads to the degradation of aquatic ecosystems, harming wildlife and reducing biodiversity. In urban areas, poor drainage and sanitation infrastructure contribute to frequent flooding, exacerbating the spread of contaminants and increasing the risk of disease outbreaks.

In the USA, environmental degradation resulting from inadequate wastewater management is evident in rural areas. Straight pipes and failing septic systems contribute to the pollution of groundwater and surface water, impacting aquatic ecosystems and compromising water quality. The contamination of water sources with nutrients, pathogens, and other pollutants leads to eutrophication, algal blooms, and the deterioration of water quality, posing significant ecological and public health risks.

## 5. Pathways to Sustainable Development

Achieving sustainable wastewater management is critical for protecting public health and preserving environmental quality in both Nigeria and the USA. Each country faces unique challenges and requires tailored strategies to overcome these obstacles and progress towards sustainable development. This section elaborates on the pathways for sustainable wastewater management in Nigeria and the USA, focusing on infrastructure investment, regulatory frameworks, and community engagement.

### 5.1. Nigeria

- **Investment in Infrastructure**

Nigeria's pathway to sustainable wastewater management necessitates substantial investment in infrastructure. The country must expand access to basic sanitation facilities, especially in rural areas where open defecation and pit latrines are prevalent. This expansion includes constructing public toilets, latrines, and other sanitation facilities to reduce the incidence of waterborne diseases and environmental contamination (Longe and Omole 2008) [18].

In urban areas, upgrading existing septic systems and sewage networks is crucial. Many urban centers struggle with outdated and inadequately maintained infrastructure that cannot cope with the demands of a growing population. Modernizing these systems to handle increased sewage volumes and incorporate advanced treatment technologies will enhance their efficiency and sustainability.

- **Strengthening Regulatory Frameworks**

Improving the enforcement of environmental regulations is essential for ensuring compliance and protecting public health. Regulatory agencies in Nigeria often lack the

necessary funding, resources, and authority to enforce sanitation standards effectively. Increasing funding for these agencies can enhance their capacity to monitor wastewater management practices, conduct inspections, and enforce compliance with environmental laws.

Addressing corruption and governance issues is also critical. Corruption can undermine regulatory efforts by allowing non-compliance to go unchecked. Implementing transparent governance practices and accountability mechanisms can help combat corruption and ensure that regulations are enforced fairly and consistently (Ogunkan 2022) [23].

- **Community Engagement and Public Awareness**

Promoting public awareness and community involvement in wastewater management can lead to more effective and sustainable solutions. Educational campaigns that inform the public about the health risks associated with poor sanitation and the benefits of proper wastewater management can foster community support for infrastructure projects.

Involving communities in planning and decision-making processes ensures that the solutions implemented are tailored to their specific needs and conditions. This participatory approach can increase community ownership of sanitation projects, leading to better maintenance and sustainability. Fostering partnerships with local organizations, NGOs, and stakeholders can also provide additional resources and support for community-driven initiatives (McGranahan 2013) [21].

### 5.2. The United States

- **Upgrading and Maintaining Aging Infrastructure**

The USA's pathway to sustainable wastewater management involves addressing the challenges posed by aging infrastructure. Many wastewater systems in the USA, particularly in older cities and rural areas, are outdated and in need of significant upgrades. Aging pipes, treatment plants, and other infrastructure components can lead to frequent breakdowns and inefficiencies.

Investing in infrastructure renewal and modernization is essential for ensuring that these systems continue to operate effectively and comply with environmental standards. This includes replacing old pipes, upgrading treatment facilities, and incorporating advanced technologies that enhance treatment efficiency and reduce environmental impacts.

- **Reducing Disparities Between Urban and Rural Areas**

Addressing the disparities between urban and rural areas involves expanding access to advanced wastewater treatment technologies and providing financial and technical support to underserved communities. Urban areas in the USA generally benefit from centralized wastewater treatment systems that effectively manage large volumes of sewage. In contrast, many rural areas rely on decentralized systems, such as septic tanks and straight pipes, which are often inadequate and pose significant health risks (Flowers, 2020) [10].

Another critical component in reducing disparities involves addressing the issue of heirs' property. In many rural areas, unclear land titles prevent residents from qualifying for federal assistance programs and securing private financing for infrastructure improvements. To resolve this issue, support for legal aid services is essential. These services can help families formalize land ownership, clearing the way for them to access funding and implement wastewater infrastructure projects.

To reduce these disparities, targeted funding and resources should be directed towards rural areas with inadequate infrastructure. Federal and state programs can provide essential financial support for infrastructure projects in rural communities.

## 6. Conclusion

Sanitation and wastewater management are fundamental to public health and environmental sustainability. Nigeria and the USA face distinct challenges in this area, reflecting differences in economic capacity, technological advancement, and policy implementation. However, both countries share common goals of improving sanitation infrastructure, safeguarding public health, and ensuring environmental sustainability.

Both Nigeria and the USA can benefit from learning from each other's experiences and adopting best practices. Nigeria can draw on the USA's experience with regulatory frameworks and advanced treatment technologies to improve its wastewater management systems. Conversely, the USA can learn from Nigeria's community engagement strategies to foster greater public participation in infrastructure projects.

Addressing the unique challenges faced by each country requires a comprehensive and integrated approach that considers their specific needs and conditions. By investing in infrastructure, strengthening regulatory frameworks, and enhancing community engagement, both countries can improve their wastewater management systems and contribute to the achievement of the United Nations Sustainable Development Goals. This holistic approach not only protects public health and preserves environmental quality but also promotes social equity and economic development.

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