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An Analysis of the Effects that South Africa's Informal Settlements have had on the Country's River Systems

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ABSTRACT

The quality of surface water has a significant impact on human health and the entire ecological system. Sewer spillages from the surrounding informal settlements discharging into the river, carrying high concentrations of fecal coliforms, are one of the major causes of extreme pollution in the rivers of South Africa. These informal settlements are common in many developing countries, and they are usually located near waterways to compensate for basic demands for water, sanitation, and recreational space, where municipal infrastructure lags behind urban growth. One major problem has been poor sanitation and poor waste disposal practices in the informal settlements, which has led to the contamination of water resources. This study aims to assess the extent to which poor sanitation in informal settlements impacts the water quality of South African rivers, given the rapid rise in population and unemployment rate. The study also highlights health and environmental issues in the local regions caused by poor sanitation. Contamination of water bodies is associated with serious health problems and fatalities. Therefore, there is a need for frequent monitoring and management of waste products discharged into the neighboring aquatic environments.

INTRODUCTION

One of society's biggest challenges is the scarcity of water which is exacerbated by the pollution of water bodies. The uneven distribution of water across the globe makes it even harder to manage water as some areas have ample water supply, while other areas may range from arid to semi-arid (Oki & Kanae 2006, Bega 2018). The issues of water supply in the latter areas are attributed to factors of low rainfall and high evaporation. Amid these issues are also environmental factors such as floods and droughts that make it hard to manage water, especially since drought and flood events are associated with exacerbating water scarcity and contamination of the water supply. These have subsequently led to the degradation of the quality of water bodies as determined by physical, chemical, and biological criteria (Strydom & King 2015). This degradation is typically measured in terms of the expected use of water, deviation from the norm, and impact on public health and ecology (Strydom & King 2015). For instance, when inefficiently treated wastewater is allowed to flow into the natural water bodies, cumulative impacts lead to the degradation of the water bodies. These impacts range from the degradation of the aquatic ecosystems to the waterborne illnesses, infections, and health complications that man is subjected to as a result of exposure to contaminated water used for irrigation, drinking, or bathing (DEADP 2011).

Contamination of water may originate from point sources or non-point sources. However, this contamination of water supply is not only limited to the direct point sources of inefficiently treated wastewater from the municipality that discharges effluents containing chemical and biological contaminants that are harmful; but it also includes non-point sources that cannot be quantified, such as the agricultural sources (Boardman et al. 2019). It is for this reason that non-point source pollution is difficult to control because it does not originate from a single, easily identifiable source that can be regulated. Instead, it is caused by the scouring effect of rainfall or snowmelt, as well as the dissolved contaminant solids that enter into the receiving water bodies (such as rivers, lakes, reservoirs, and bays) through runoff (Wang et al. 2021). Point sources and non-point sources such as sewage, garbage, and liquid waste coming from households, agricultural lands, and factories are often discharged into these lakes and rivers either directly or indirectly, especially where communities are residing next to the river, thus polluting these water bodies in the process (Barrow 2006, Maphanga et al. 2022, Gqomfa et al. 2022). This, therefore, makes sewage and household wastewater the main causes

of water pollution. Point- and non-point-source wastes may contain harmful chemicals and toxins, making the water poisonous for aquatic ecosystems. Sewage water, agricultural practices, oil spills, and radioactive substances are the most common types of water contamination (WWAP 2017). Therefore, it is clear that point sources and non-point sources are integral in the contamination of water sources. Hence, to mitigate the scarcity of water around the globe, countries have resorted to wastewater treatment plans to supplement water sources (Barceló & Petrović 2011).

South Africa's freshwater supply is under increasing pressure due to rapid urban population growth that has subsequently overloaded the wastewater systems such as sewerage, leading to the collapse of wastewater treatment infrastructure (Phungela et al. 2022) and compromising both health and the environment, given that the sewage is just flowing directly into the river (Bega 2021). Sewer spillages from the surrounding informal settlements discharging into the river, carrying high concentrations of fecal coliforms, are one of the major causes of extreme pollution in the river (Bega 2021). According to Statistics South Africa, informal settlements are "unplanned settlements on land that have not been surveyed or proclaimed as residential, consisting primarily of informal dwellings (shacks"). In 2013, it was estimated that 2.1 million South African households lacked access to basic housing services such as running water, electricity, and other amenities (Morole et al. 2022). South Africa is a semi-arid country with high water stress because of low rainfall volumes and high evaporation (Adewumi et al. 2010). Water safety measures, general health, and well-being education, and overall hygiene are prevalent issues in informal settlements. These issues go neglected because of a lack of information, support, and resources, resulting in sickness and harmful living circumstances. Greywater channels, which are wastewater streams that do not include sewage waste, pass through neighborhoods, fostering bacteria and many ailments (Radingoana et al. 2020). Toilet facilities are badly managed and filthy, resulting in a hazardous and unhygienic living environment (Cape Town Project Center 2014). Water pollution coupled with climate change makes matters around the informal settlements worse. There are also concerns that the stress on the water will worsen because of the current climate change projections. These projections tend to show uncertain after-effects for aquifer systems and the related groundwater goods and services (Knuppe 2011). The water sources and the health of the environment depend on sustainable rainfall patterns.

South Africa has an average rainfall of about 464mm per year (Mtengwana et al.2020). However, because of both local and global climate change, the country has witnessed fluctuating rainfall patterns, resulting in financial, economic, and ecological consequences, particularly when water supplies are under severe strain (Schulze 2005). Although water resources are scarce, even the available water is not evenly distributed. With changes in legislation (National Water Act 36 of 1998) from the apartheid era to the democratic dispensation, South Africa has tried to correct this anomaly. During the last decades of the apartheid period in South Africa, the Department of Water Affairs and Forestry (DWAF) was responsible for ensuring that the water needs of those chosen by the government, such as white farmers, were met. The democratic dispensation in South Africa brought change as the DWAF now ensures that all its citizens have access to safe water and basic water sanitation (Seward 2010). Despite this, South African households generally still lack adequate sanitation facilities, especially in informal settlements.

According to a Saturday Star report by Bega (2018), the Vaal River in South Africa is highly polluted, and the major contributors have been indicated as a high level of saline acid mine drainage effluent that is pumped into the river. Raw or partially treated sewage from local wastewater treatment plants is a major pollutant that creates serious health risks. The presence of *E. coli* is also an indication of fecal existence in the water. *E. coli* counts of 200-400 per 100 mL of water signify a major risk of gastrointestinal disorders(Bega 2017). Due to high pollution levels, the Vaal River has turned green, and a lot of fish have been found dead on the riverbanks. The community of Parys, located on the banks of the river, has suffered immensely due to such pollution (Bega 2018). The consequent water pollution poses a major threat to the well-being of both the environment and the population. Although several factors are associated with water pollution around informal settlements, insufficient studies have looked at the impacts of informal settlements on water quality in South Africa. This study aims to determine how inadequate sanitation and waste collection in informal communities affect the water quality of South African rivers. The report also emphasizes health and environmental problems in the local communities because of poor sanitation. This study is important as it will raise awareness of the impacts of informal settlements on river pollution, identify different sources of pollution, and help in understanding surface water quality such that the environment is protected and the water is safe for human use.

LITERATURE REVIEW METHODS

The literature search included English peer-reviewed articles and relevant reports. All information used in the evaluation and review was collected from extensive project reports, published papers, and websites. The Google Scholar database and Web of Science were used to identify all the relevant

articles and reports. The criteria for selection included the following: (1) the impact of informal settlement on water quality; (2) monitoring the influence of urban sprawl on water pollution (3) the impact of rapid population and urbanization on water pollution; (4) the effect of shacks or informal settlements and different land uses on water quality; (5) contributors of surface water pollution in South Africa; and (6) the link between informal settlement and rate of water pollution just to mention few. However, the literature search focused on informal settlements, water pollution, and the destruction of river catchments around information settlements. Each article was assessed according to the accuracy of its results, and the systematic review and meta-analyses used for the selection of articles are included in our discussion.

Causes of Water Pollution Around the Informal Settlements

Human beings are often responsible for being the main cause of water pollution, mostly due to an increase in anthropogenic activities, especially in the informal settlements where there is a general lack of basic municipal services. One of the central problems faced by residents in informal settlements is the lack of a proper system for waste management. As a result of a lack of established collection points, heaps of waste are scattered in and around residential zones, which leads to environmental and health problems. However, a minority of residents choose to burn or bury their waste near their residences(Ameyibor et al. 2003). Approximately 15 million people in South Africa lack adequate sanitation. Every citizen has a right to basic services, and municipalities are responsible for providing such services. However, the provision of basic services is a challenge and is aggravated by growing unemployment and the sprawling of unplanned informal settlements (Cousins 2004). According to a Stats SA (2016) media release, 45.6% of households in South Africa have no access to toilet facilities inside their homes, and less than 50% of households have a toilet outside of their residence.

Of the remaining 75.5% of people with access to sanitation, 12.2% have pit latrines, and 60.6% are connected to a sewerage system. In some informal settlements, toilets are shared (Stats SA 2016). As a result of these issues, residents have been forced to employ several alternative sanitation practices. Through interviews, observation, and focus group discussions in five informal settlements in the Western Cape, South Africa, 383 randomly selected respondents identified factors that shape their sanitation practices and how these practices impact access to and sustainability of sanitation services in the policy context of the Free Basic Sanitation (FBSan) (Muanda et al. 2020). Residents utilize buckets, porta-potties, plastic bags, and existing facilities within and outside their communities for defecating or dumping bucket contents and open defecation. For instance, in the Ezindlovini informal settlement in Khayelitsha, more than 20,000 people share 380 communal toilets. Some of the residents do not have toilet facilities at all. There have been protests and cries against the local government for help in addressing this problem (Anonymous 2016). This case is similar to that of Dunoon informal settlements in Cape Town, where a large number of residents share few toilets, which are normally dirty and blocked. The residents have opted to defecate in open spaces close to the river (Gqomfa 2020).

A study conducted at the Apies River in Pretoria sampled the river at ten distinct locations (Abia 2020). These locations were upstream and downstream, exposed to various human activities. Several sewage treatment facilities damaged the river by directly discharging effluent into it. Due to system failure or overloading, the discharged effluent was sometimes not treated or partially treated. The river also receives waste from informal settlements close to the riverbank, directly through dumping or indirectly through surface runoff during heavy rains. The informal and rural settlements discharge their garbage, including feces, directly into the river (Abia 2020). The study also discovered that the number of bacteria isolated before the water traveled through informal settlements was lower than the number isolated after the river passed through the informal settlements. The residents were forced to use the river as a toilet due to a lack of facilities in the area.

Urbanization and Poor River Systems

As stated by Worldometer (2020), South Africa's population in rural areas exceeded the population of urban areas by 10% in the year 1955. However, this is not the case anymore. In 2019, the South African population in urban areas was 66.3%, and it was estimated to rise to 66.7% in 2020(Worldometer 2020). Fig. 1 shows the rapid increase in the number of people moving from rural areas to urban areas. Although the urban population has been increasing, the rural population remained lower from 1955 to 1975 compared to the urban population. From 1980 to 2020, the urban population was higher than the rural population. In 2020, 66.7% of the population of South Africa lived in urban areas.

Urbanization is a major cause of the rapid spread of informal settlements. Many people migrating from rural areas cannot afford houses; they are compelled to construct shacks in the most vulnerable areas, such as wetlands, riverbanks, etc. Barrow (2006) corroborates that due to affordability, informal settlements are sometimes erected

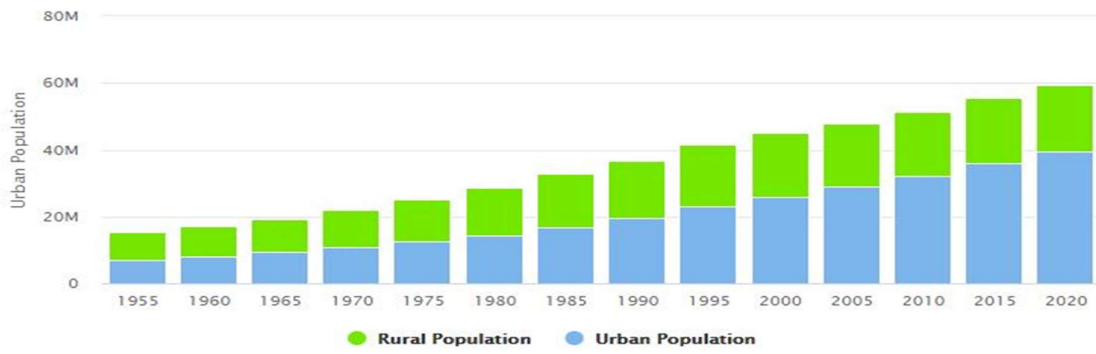

Fig. 1: South African urban vs rural population from 1955 to 2020 (Worldometer 2020).

in the most unfavorable conditions, such as those close to water bodies.

According to Barnes (2003), a study conducted in Cape Town showed that much of the water pollution is derived from human waste in informal townships where the municipality has not put appropriate sewerage systems or does not have adequate maintenance in place. In some parts of the settlements, untreated sewage leaks into storm water drains and flows into the water bodies. Barnes (2003) research work included the analysis of water samples for six years from the Plankenbrug River in Stellenbosch, which flows into the Eerste River(Barnes 2003). Samples from the river were taken, and interviews at Kayamnandi informal settlements were conducted. The results revealed that the river was excessively contaminated with hazardous levels of feces, which could adversely affect the health of all citizens who may come into contact with the water. The tests also revealed the presence of 13 million Escherichia coli per 100 ml of water. However, not all fecal contamination originated from Kayamnandi. Large amounts of fecal contamination occasionally entered the river near farming areas and Water Treatment Works areas below Kayamnandi (Barnes 2003).

Trends on Rivers Water Quality in South Africa

Although after 1994, revisions to South Africa's water law and regulatory frameworks were acknowledged for their emphasis on social and environmental sustainability, it is commonly acknowledged that the country's water quality is deteriorating. It is vital to comprehend what changes in water quality have occurred to analyze how management changes may have affected the resource (Abia 2020, Phungela et al. 2022). The Crocodile River in Mpumalanga and the Olifants River in Mpumalanga and Limpopo are used as examples for the investigation, which looks at trends in a number of water quality indices in these two catchments (Maphanga et al. 2022). The first is somewhat stressed and has previously been identified as water-stressed, whereas the second is severely impacted and has recently attracted a lot of attention in relation to water quality.

Overall, temporal trends frequently demonstrate declining water quality at locations in the mid to lower catchments, whereas locations in the high catchment may only experience minor changes. Sites that were impacted at the beginning of the data recording typically still exhibit that impact, though some have improved. In general, consequences are caused by increasing levels of orthophosphate (although recent studies indicate this trend has stopped at many locations), pH, salinity, and, for sites in the Olifants River, raised or increased sulfate and calcium levels. Compared to sulfate impacts, some locations displayed higher chloride levels indicative of salinization. Microbial levels were also high; however, no trend was visible (WRC Report 2014). A river system that has experienced human influence over time is the Eerste River. This study looked at the Eerste River's water quality between 1990 and 2005, looking for temporal and geographic patterns. The City of Cape Town (CCT) and the Department of Water Affairs and Forestry (DWAF) collected data at eight sample stations along the Eerste River's course and one on its tributary, the Plankenbrug, and it was analyzed to find the trends. Chemical oxygen demand (COD), pH, electrical conductivity (EC), nitrogen, and phosphorus were the water quality parameters analyzed (COD). Because they are regarded as important indicators of water quality, these measures were specifically chosen.

The lower parts of the Diep River (including the Milnerton Lagoon sites) and the Mosselbank River have declined over the past five years due to phosphorus enrichment, which has been a problem in the Diep watershed rivers historically (Gqomfa 2020, Ggomfa et al. 2022). The catchments in this area that perform the worst right now include. From 1995 to 2020, the Diep River catchment has been monitored. Fecal contamination: E. coli measurements recorded at river sites in the Sand catchment have deteriorated moderately over the monitoring period (1990-2020), indicating that conditions

are not entirely suitable for informal recreational activities (Inland 2019). Illegally establishing informal settlements on property deemed inappropriate for housing is one of the issues connected to the improper management and disposal of human waste. Due to the difficulty in providing services, homeowners often dump their domestic trash, greywater, and sewage into the environment, which leads to rapid contamination and the deterioration of occasionally significant waterbodies. Poorly maintained informal settlements and backyard residents in the Salt catchment are also sources of river water pollution (e.g., Joe Slovo, Kanana, Valhalla Park, Vygieskraal informal settlements). Additionally, backyard houses contaminate the Diep River in formal settlements like Fisantekraal as well as in informal settlements in the basin, such as Dunoon and Joe Slovo (Inland 2019).

The Contribution of Informal Settlements in Different Provinces to River Pollution

Unplanned urbanization has contributed to the ongoing rise in informal settlements. The number of households living in informal settlements has grown since 1995, going from 1 170 902 to 1 294 904 by 2011. More than 2,700 informal settlements were nationwide (Stats SA 2016). According to government data, the number of informal settlements in South Africa increased to 2225 between 2002 and 2016 (Stats SA 2016). According to assessments and records, there were reportedly roughly 3200 informal settlements as of May. Approximately five million people live in informal settlements in and around the major urban areas (Mbanga 2020). This growing trend of informal settlements compromises the river systems. Rivers and other freshwater resources in South Africa are becoming stressed due to the country's rising economy and population. Additionally, due to increased pollution brought on by industry, urbanization, afforestation, mining, agriculture, and power generation, the water quality of these resources has deteriorated (Ashton et al. 2016).

The fast growth of informal settlements is mostly due to urbanization coupled with rapid population growth and a high unemployment rate, forcing people to migrate to urban areas (Morole et al. 2022). The most vulnerable sites, such as marshes and riverbanks, are where many people coming from rural areas establish shacks because they are unable to purchase homes. Informal settlements are sometimes in unfavorable conditions, such as those close to water bodies (Tsenkova 2010). Along South Africa's riverbanks, informal settlements dump rubbish into the rivers as well. When there is significant rainfall, this is transported by dumping and surface runoff (Maphanga et al. 2022). These informal settlements were not constructed per the necessary laws and lacked suitable waste disposal facilities (Gqomfa et al. 2022). Table 1 gives an overview of the water quality of South Africa's rivers and the informal settlements as contributors to their pollution.

The declining river water quality affects all of Africa, not just South Africa. For instance, low-income populations, especially those who reside in informal settlements, frequently use Kenya's Nairobi River as a source of water for cleaning, washing, and watering crops (Mbui 2019). Furthermore, because many homes lack toilet facilities, the river is also used to dump human and domestic waste.

Impacts of the Environmental Pollution Caused by Informal Settlements on the South African River Systems

Table 1: Overview of the water quality of South Africa's rivers and the informal settlements as contributors to their pollution.

Provinces	Rivers	Impacts of River Pollution & Sources
Kwazulu Natal	Umgeni River	The catchment areas vary in size and land use, ranging from dense informal settlements to primarily agricultural. Phosphorus input and bacterial contamination were both monitored. It was discovered that the watershed with the greatest proportion of informal settlements also had the greatest levels of non-point source pollution (Gangoo 2003).
Western Cape	Diep River, Black River	The informal community of Island in Site C, Khayelitsha, includes a river that is largely blocked by trash, smells noxious, and serves as a home for rats. Diep River and Black River, amongst other things, have also been polluted largely by Informal settlement waste and open defecation (Gqomfa et al. 2022, GroundUp 2018).
Mpumalanga/ Northern Cape/Gauteng	Olifant River	The Olifant River is close to a variety of informal settlements. Along with informal settlements polluting the catchment, sewage treatment facilities also contributed to microbiological contamination and related diseases (Ecosystem Health 2011).
Eastern Cape	Umtata River	According to 2001 research, contamination from residential waste from multiple riverbank informal communities is the cause of the high coliform counts and nutritional levels that are over permitted limits (Fatoki et al. 2001)
Gauteng	Jukskei Hennops, Klip, Apies Rivers	The rivers in Gauteng revealed that the main human activities that impact, alter, and contaminate rivers like the Jukskei, Hennops, Klip, Apies, and numerous tributaries are poorly maintained sewage systems, treatment plants, and informal settlements built along the banks of the rivers (Liebenberg 2019)

Informal settlements in South Africa lack essential amenities and, as a result, turn to environmental degradation, such as trash dumping, the loss of vegetative cover, and water contamination. Many informal communities are located near water sources, particularly rivers (Gqomfa 2020). Due to the lack of sanitation, many people in these communities make shallow pit latrines, other natural resources, and riverbanks. As a result, the potential for water contamination is quite significant in these communities (Gangoo 2003, Kretzmann 2019). The river's water quality is impacted by pollution caused by dumping, trash, loss of vegetative cover, and raw sewage run-offs (Mbui 2019). Therefore, the pH and conductivity of the water are altered. The term "water quality" is used in this paper to express water's suitability to sustain various uses or processes. Any specific use will possess some requirements for the physical, chemical, or biological characteristics of water; for instance, limits on the concentrations of toxic substances for the use of drinking water or temperature and pH range restrictions for water that supports invertebrate communities (Bartman & Ballance 1996, Liebenberg 2019). Water quality also describes how suitable the water is for maintaining recreational, domestic, agricultural, and industrial or aquatic ecosystem processes (DEADP 2011). In general, the quality of natural water differs from one place to another, subject to seasonal changes, soil and rock type, and the surface through which it flows. The quality of water is considerably changed by various human activities like mining and recreation, urban and industrial development, and agriculture (Kretzmann 2019). The quality is also altered extensively within the spatial catchment area.

When the environment deteriorates as a result of the depletion of resources such as air, water, and soil, it leads to environmental degradation (Choudhary et al. 2015). The process of environmental degradation compromises the natural environment, reducing biological diversity and negatively impacting the general health of the environment (Mbonambi 2016). The environment may also deteriorate due to urban growth-related challenges in developing and developed countries; for example, water and air pollution, refuse disposal, and loss of farmlands and natural areas (Barrow 2006). Cape Nature compiled a river report as part of the Western Cape River Health Programme, sponsored by the Department of Water Affairs and Forestry, and aimed at investigating the quality, quantity, and ecosystem health in the Western Cape. The report revealed that, in general, only a small number of Cape Town's rivers are still in good condition (Gosling 2007). This clearly shows that the quality of water in the rivers has been deteriorating due to several reasons, amongst them being informal settlements (Gangoo 2003). The deterioration of the water quality of rivers in South Africa has brought about challenges such as microbiological contamination and eutrophication, just to name but a few (Strydom & King 2015). Microbiological pollutants from sewage often lead to contagious diseases that infect drinking water, affecting land and water life (Mbui 2019). Water supplies that have been inadequately treated will have noticeable levels of total coliform bacteria and fecal coliforms due to the presence of *E. coli*. *E.coli* indicates fecal pollution from humans and warm-blooded animals (Strydom & King 2015).

Furthermore, there is a link between fecal pollution and eutrophication. Rivers and streams are impacted by these pollutants, which cause eutrophication, move sediments, and introduce harmful bacteria when transported by rain runoff (Bianco et al. 2020). Eutrophication is excessive nutrient enrichment, increased growth of microscopic floating plants, and algae, and the formation of floating plants in water bodies (Smith & Schindler 2009, Mbonambi 2016). It also tends to cause suffocation of fish and water organisms. Eutrophication is characterized by too much plant and algal growth as a result of the increased availability of one or more limiting growth factors needed for photosynthesis, such as sunlight, carbon dioxide, and nutrient fertilizers (Schindler 2006, Bianco et al. 2020). The pH of water can also change to acidic due to sulfate particles from acid rain. This can cause damage to aquatic life, resulting in a high number of deaths within an environment (Khan & Ansari 2005, Kretzmann 2019). The growth of photosynthetic plants and microorganisms can also be disrupted because of suspended particles that tend to reduce the amount of sunlight penetrating the water (Strydom & King 2015). As the water quality has deteriorated, causing eutrophication, therefore eutrophication will cause alteration in the species composition within the aquatic ecosystem.

Informal settlements are also susceptible to ruin by the natural elements and easy to destroy by fire. Fires may cause air pollution, and, in turn, the particles from air pollution may pollute the water bodies (SERI 2018). Inadequate planning regarding drainage or sewage systems exposes informal settlements to flooding and risk of diseases because of still water and waste that is not collected but blocking drainage around the rivers or the river. This, in turn, degrades the ecosystems and their inhabitants (SERI 2018). Many rivers across the country are facing these challenges. For example, an informal settlement of Site C in Khayelitsha in South Africa is situated at the edge of the river. The river is regularly blocked with litter, and odors of toxins and has become a safe harbor for rodents. A lot of the litter is dumped by the residents of Site C into the river (Green 2018). Fig. 2 shows the Langa informal settlement constructed in the most vulnerable area, on the edge of the

Fig. 2: Langa informal settlement and pollution of Black River (Gqomfa 2020).

Black River. These settlements are prone to floods during rainy seasons. Residents dispose of their waste into the river, thus contaminating it (Mbanga 2020). Waste disposed of close to the river also enters the river, thus contaminating it through runoffs during rainy seasons.

The methods used to dispose of waste in informal settlements, such as dumping, pits, and burning waste, are harmful to the environment. The groundwater and surface water are also polluted due to the use of these disposal practices in informal settlements, as waste from the land surface can move through the soil and end up in groundwater (Mbanga 2020). As a result, pesticides, fertilizers, and waste disposed of in waste pits and landfills can pollute groundwater (Barrow 2006).

Waste management in underdeveloped nations is often characterized by unregulated dumping of waste, which is frequently accompanied by open burning (UNEP 2018). Carbon dioxide is the principal gas generated by rubbish burning, with an estimated 40 to 50 percent of waste being made up of carbon by mass. Other worldwide sources of carbon dioxide emissions, such as autos and power plants, account for just 5% of the total global CO_2 emissions. Dumping waste in informal settlements causes decay, leading to unpleasant odors. Consequently, dust, methane, and greenhouse gases are produced as a by-product of organisms decomposing organic waste (Ferronato & Torretta 2019).

On the other hand, the increasing amount of human involvement with the earth's climate system, caused by the continual growth in greenhouse gases, is producing imbalances in the earth's atmosphere, resulting in a variety of local and regional effects. These effects have shown themselves in a variety of ways, including changes in precipitation patterns, droughts, vegetative patterns, crop production changes, and so on. According to the IPCC (2018), the world has until 2030 to cut human-caused carbon dioxide emissions in half and reduce other greenhouse gases to have a 45% chance of avoiding the worst impacts of climate change.

DISCUSSION AND RECOMMENDATIONS

The impact of Erecting Informal Settlements on Water Quality

The physical disturbance of the land due to the construction of informal settlements alters land use, leading to environmental impacts (Gqomfa et al. 2022). For instance, the alteration of land use due to urbanization and agriculture causes precipitation to run off quickly, resulting in severe erosion, flash flooding, reduced groundwater, recharge, and wildly fluctuating streamflow. This poor use of land leads to nutrient over-enrichment and sediment-contaminated water, which harms fish, plankton, and aquatic plants and may slit up channels, lakes, and reservoirs (Barrow 2006, Bianco et

al. 2020). One of the major challenges that emanate from informal settlements existing along riverbanks is that people tend to do laundry in the river, as is the case with one of the Alexandra informal settlements called Stjwetla, closest to the Jukskei River in Gauteng (Mawela 2008). Phosphate salts are included in a wide variety of laundry detergents in concentrations ranging from 35 to 75%. Phosphates may contaminate water in a variety of ways, including limiting the biodegradation of organic matter. Non-biodegradable chemicals cannot be removed by either public or private wastewater treatment systems. Phosphate-based detergents can also cause eutrophication, and phosphate enrichment can cause algae and other plants to overgrow in bodies of water (Abia 2020). Eutrophication depletes available oxygen in the water, causing other species to die (Senapati 2021). The aquatic organisms are also critically impacted by pollution, erosion, and sedimentation generated by the construction of these informal settlements, which use up the dissolved oxygen content in the environment and decrease the total biodiversity of the area(Owusu-Asante & Ndiritu 2009). Furthermore, as a result of the large population, there are sewage problems time and again, which find their way into the river (Mawela 2008).

Sustainable Development and Water Quality

The Brundtland Commission made sustainable development popular and placed it in context, defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Barnaby 1987). The commission focused on economic, socio-political, and ecological/environmental conditions. The concept of sustainable development advocates setting up strong measures to stimulate economic and social development, especially for people in developing countries, as well as making sure that the integrity of the environment is sustained for upcoming generations. Principles of International Environmental Law and Policymaking (e.g., Stockholm and Rio Declarations and Agenda 21) have been adopted by South Africa (Fuggle & Rabie 2015). Again, South Africa has hosted important international conferences such as the 2002 World Summit on Sustainable Development. Such summits are essential; hence, they support urban water sustainability, including access to safe drinking water, wastewater management for improved public health, and protection against flooding (Larsen et al. 2016).

The real achievements of sustainable urban development are still inadequate because of challenges, even though it has drawn interest for many years(Rathnayaka et al. 2016). Changes implemented to create greener water and improve wastewater management have drawn attention and proposals. This is because the growth of the integrated urban water system is understood to play a key role in urban water sustainability (Capodaglio et al. 2016). Sustainable development requires that outputs, such as waste and pollution, and inputs be handled effectively in urban or rural environments. Some of the urban challenges that take priority are water supply, refuse, sewage disposal, energy, informal settlements, and transport (Barrow 2006, Abia 2020). In the transition towards sustainable development, it is important to include the public in decisions regarding water management. This helps to encourage practitioners to develop a more viable management practice (Rabadán & Sáez-Martínez 2017). The responsibility for water and waste management should be shared between government authorities and businesses. Even so, there is difficulty in determining where public responsibility ends, and corporate responsibilities begin (Rabadán & Sáez-Martínez 2017).

To attain the goal of sustainable development, precautionary and proactive measures need to be taken because humans seem to be more exposed (Barrow 2006). These measures are intended to monitor the handling and disposal of hazardous substances that could negatively and irreversibly destroy the environment. Certain substances pose major risks to the environment due to their toxicity, persistence, and capacity to bioaccumulate. In cases where the behavior of a particular substance is barely known, that substance is presumed to be a threat. A system that could be used to identify this type of pollutant has not yet been established in South Africa, particularly relative to discharge into water resources (Strydom & King 2015).

CONCLUSION

The water demand continues to rise, and this calls for improved management of supplies. Indeed, rivers are sensitive and important ecosystems that have been extensively damaged globally and locally. This paper briefly reviewed the impact of informal settlements on the quality of water in South African rivers. The paper showed that the quality of water is affected mostly by anthropogenic activities and is declining due to the rise of urbanization, population growth, industrial production, climate change, non-compliance of wastewater treatment plants, agricultural waste, and other factors. Attempts to provide general coverage for water and sanitation continue to face challenges in South Africa, and the most vulnerable and poor communities are largely affected by this failure. The overcrowded informal settlements with inadequate sanitation are a major problem, coupled with the lack of other services like waste collection. Due to a lack of such services, human health is negatively impacted by water-related diseases as the water bodies are extensively polluted. Using polluted water from rivers for washing, swimming, drinking, and cooking

has spread water-related diseases. The subsequent water pollution poses a major threat to the well-being of both the environment and the population. Even though South African laws are meant to ensure that water resources are protected and managed sustainably and equitably to benefit all its citizens, there is a challenge with enforcement and compliance. To promote sustainable development, it is vital to incorporate the populace in decisions about water management. This may assist in encouraging experts to develop feasible management practices. Water and waste management is understood to be a mutual responsibility of government authorities, businesses, and all stakeholders.

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