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Potable Water: A Regional Viewpoint

Oyelami, A.A. (PhD)
Department of Geography and Environmental Education
Faculty of Social Science,
Emmanuel Alayande University of Education
Oyo, Oyo State, Nigeria
E-mail: oyelamialania@eaueoyo.edu.ng

ABSTRACT

The notion of drinkable water is a backbone of environmental health, policy and sustainable development, though the definition of such water goes beyond the simple everyday definition of drinkable water. In its simplest definition, potable water can be described as a type of water that can be used safely by humans and associated household processes like food preparation and personal hygiene, and will not cause any harm to health when used over a lifetime (Khalmirzaeva, 2022). This definition incorporates various dimensions such as physical, chemical and biological in order to make sure that water that is taken does not lead to acute or chronic illness. Notably, potable water is not considered to be that water which is absolutely pure (i.e., water which consists of H2O solely) but a set of quality criteria such that they are safe regarding human health (Cherkashyna, Sokolova&Brears, 2025). In this respect, drinkable water is a universal health concern and a central objective of international initiatives such as the United Nations Sustainable Development Goals (SDG 6.1) whose objectives include global and equal access to affordable and safe drinking water by 2030. This paper presents some viewpoints on potable water.

Keywords: Water Potability, WHO Standards, Shallow Aquifers, Drinkable Water, SDGs

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1. INTRODUCTION

Traditionally, the idea of potable water was developed along with the invention of technologies of water purification and state health control. Before the inception of the large-scale municipal water treatment system, people used to depend on natural sources like rivers, lakes, and springs, which were usually polluted with runoff, human waste, or pathogens. The understanding that dirty water might spread diseases like cholera, typhoid, and dysentery initiated premature regulation in the 19 th and 20 th centuries to ensure that water quality was controlled. In the modern context, potable water has the legal and scientific connotation whereby it must meet microbial safety standards and chemical contaminant limits a requirement codified in the statutory instruments such as the European Union Drinking Water Directive and national drinking water standards in various countries (EU Directive, 2020; (Cherkashyna, Sokolova&Brears,2025).

In our daily activities, potable water is different as compared to other types of water. As an illustration, non-drinkable water which could be used to irrigate the land, industrial processing or flushing toilets is clearly not safe to drink uncontaminated since it does not meet the health standards of consumable water. Conversely, drinking water should be devoid of dangerous levels of bacteria, coliform and pathogens like Escherichia coli, toxic substances like lead and arsenic, and other pollutants, which may have either short-term or long-term health impacts. These parameters are established in water quality guidelines and regulations, including the Guidelines on Drinking-Water Quality established by the World Health Organization that offer internationally recognized standards to which countries apply to their own situations (Khalmirzaeva, 2022).

Potable water is essential in terms of public health. Safe water averts waterborne diseases and minimizes the general burden of disease among populations. The World Health Organization claims that microbial contamination through water sources that have been contaminated with fecal matter is still a major risk factor in the transmission of disease to humans, and has been associated with millions of deaths due to diarrhea each year especially in children under the age of five and in low-income countries ((Khalmirzaeva, 2022). Potable water reduces this risk through safe drinking and safe preparing of food, and through hygiene measures, like handwashing. The presence of safe drinking water at a location and in a consistent flow can ensure that people do not need to travel far to collect it, which can be cumbersome on a large scale, especially on women and children in resource-strained environments, and can then use the time saved to study and earn income (Rajapakse, Otoo&Danso, 2023).

The technical definition of potable water also addresses the issues of accessibility and reliability, which are formalized by the global monitoring systems. The WHO/UNICEF Joint Monitoring Programme (JMP) considers the definition of safely managed drinking water services as the drinkable water that is on site and accessible as and when required, as well as free of contamination, both microbial and priority chemical contaminants (WHO and UNICEF, 2025). This broadened definition brings to the fore that potable water cannot only be a matter of quality but also physical access and supply chains that sustainably contribute towards water being able to substantively fulfil the needs of human beings. Although there is an improvement, as of 2025 the number of people with no access to safely managed drinking water was still 1 in 4 people on the global level, demonstrating a continued inequality between and among nations.

Rural communities and economically marginalised populations are the most affected by the absence of potable water services since they might resort to unimproved water sources like unprotected wells and untreated surface water that are extremely dangerous to human health. Potable water is known to be a health necessity, as well as a human right, internationally. The UN Human Rights Council and the United Nations General Assembly have stated that the right to safe and affordable drinking water is a right to humans, which cannot be manifested without other human rights, such as the right to health and adequate standard of living (Ncube et al., 2024).
This human rights formulation raises the place of potable water in the technical category to an ethical and legal necessity whereby states and the international community must

provide equitable access, as well as, overcome disparities in water supply. In addition, the definition and even the measurement of potable water are dynamic, based on the progressions of science, the transforming environment, and the policy structures. As an example, several new issues involving antibiotic resistance genes and microplastics in water are influencing the research on the future drinking water standards. Climate change also impacts on the water quality and availability through changing hydrological patterns, augmenting temperature stresses, and amplifying extreme weather conditions that have the potential to damage water infrastructure and safety. In that regard, the notion of potable water needs to evolve so that it would remain a health-saving tool under the influence of such pressures(Ncube et al., 2024).

Scientifically and in regulatory circles, classification of water as potable, requires rigorous monitoring and testing along set parameters of contaminated levels. Such limits are premised on evidence on health matters and risk factors, taking into account chronic exposures and susceptible groups. Indicatively, chemical contaminants such as lead and arsenic are toxic and legally binding to standards of potable water as they are known to be globally agreed as to their health effects. Microbiological standards including the lack of fecal coliforms in a 100 mL sample reveal the evidence of the safety of the water directly in terms of disease-causing organisms.The goal of regulatory compliance to potable water is not only to pass a one-time test but an on-going, certified standard of safety, which is facilitated through the continuous monitoring and management systems (Levin et al., 2024).

The meaning of potable water also crosses over with the socio-economic context. In most developing areas, e.g. in some areas of Sub-Saharan Africa and rural South Asia, communities use water, which is consumed but not fully treated, or guarded against contamination (Levin et al., 2024). This difference between drinking water and potable water is very important. Consumption of water could just imply the presence of water that could be consumed whether it is pure or not but when it comes to potable water, it should imply protection, control, and regulated norms that are meant to avoid health hazards. To conclude, potable water definition is a complex system of characteristics such as safety to be consumed by humans, observance of quality standards, and conformity to human rights and sustainable development objectives. Not only does it taste good or look good but is water that has been properly treated, observed over, and guarded against unfriendly elements, and that can be imbibed without any negative health consequences. The drinkable water has been a focal point of social health, progress, and human rights as the world works to better and enlarge water facilities and water supply. The global issue to attain universal access to potable water demands concerted efforts at the governance, technological, finances, and collective involvement supported by the sense of clear and common understanding of what potable water means in the modern world.

2. CLASSES OF POTABLE WATER

Potable water classification is vital in determining the level of security of drinking water sources, treatment, distribution and management in various socio-economic and environmental settings. Even though there is universal definition of potable water as water that is safe to be consumed by human beings, there are classes in which potable water is represented based on its origin, level of treatment, mode of delivery and the level of its management. Such classes are not just technical differences; rather they are unequal infrastructural systems, government, and environmental differences in the world.

These classifications have also been centralized by international organizations like the World Health Organization (WHO) and UNICEF in order to be monitored and intervened in through policy (Rajapakse, Otoo&Danso, 2023). The drinking water service ladder, as developed by the WHO/UNICEF Joint Monitoring Programme (JMP) is one of the most popular systems of classifying potable water. This model classifies drinkable water services according to quality, accessibility and reliability in preference to source. A safe drinking water which is the top category in this structure is described as drinking water that is of an improved source that is in the premises, readily accessible when it is needed and is not contaminated, especially with fecal contaminants and priority chemicals (Khalmirzaeva, 2022). This category is the international standard of drinking water, since it incorporates health safety with convenience and sustainability. Regulated municipal water or protected water sources are usually provided that are managed safely and whereby the ground water is checked regularly and treated as needed.

Immediately connected to safely managed water is what is referred to as basic drinking water services. This category contains water of better sources like a borehole, a well and a protected well or a public standpipe, though the time taken to collect water must not take more than 30 minutes of a round trip. Although a basic service can provide water that is usually safe, it might not be regularly checked on quality, and it could be prone to periodic water contamination. In most of the low- and middle-income nations, basic drinking water services are the main source through which households obtain drinking water. Even though they are safer compared to the sources that have not been improved, basic services remain dangerous, especially in areas with sanitation coverage that is improper, or in areas where water treatment is inconsistent.

Other significant classes include limited drinking water services that are classified as better sources, consumption of which takes over 30 minutes round trip to get water. Although the water source sources in these resources might be chemically and microbiologically safe upon collection, contamination may happen during extended storage during transportation (Rajapakse, Otoo&Danso, 2023). Limited services emphasize on the fact that potability is not just a designation that is ascertained at the source but can be lost in the course of handling, storage and utilization. In this way, even the limited potable water services tend to be less effective in delivering health and social benefits of greater service levels, although their sources are technically superior.

In addition to the JMP service ladder, potable water may also be sorted by source type, and it has been a common practice in environmental science and water engineering. Surface water based potable water is one of the biggest classes, which is received through rivers, lakes, and reservoirs. Farm runoff, industrial effluents, and urban wastewater have a high likelihood of contaminating surface water and it is recommended to treat the water before it can be considered as drinkable (Pointet, 2022). In the areas where there is high water treatment systems, surface water passes through several steps of treatment such as coagulation, filtration, and disinfection and then distributed. Consequently, treated surface water forms a significant portion of the drinking water in most developed nations despite its predisposed nature.

The other large category is potable water that is produced by groundwater sources comprising of aquifers, boreholes, wells and springs. The soil and rock layers tend to naturally filter groundwater and may reduce the microbial contamination. It is therefore at times regarded as safer than the surface water at the source (Karbalayi et al., 2025). Nonetheless, groundwater cannot be considered uncontaminated; minerals naturally present in the ground, like arsenic and fluoride or mining, agricultural, and waste disposal pollutants, may make groundwater unfit to be used without treatment. .
Groundwater sources built a dependable and robust category of potable water, especially in rural and semi-arid areas where their sources are well secured and supervised. Another category of potable water is rainwater-harvested drinking water, which is being considered more and more of an additive source of potable water, particularly in water stressed areas

and small island states. Rainwater harvesting systems are used to collect and store rain collected on the roof or other surfaces and used domestically. When harvested rain water is collected in a proper structure and maintained, and it is used with proper treatment, e.g., filtration and disinfection, it can comply with the standards of potable water (Khalmirzaeva, 2022).Nevertheless, due to risks of contamination of the roofing materials, storage tanks, and air pollutants, rainwater is usually termed as conditionally potable, under the influence of treatment and monitoring practices.

Piped municipal potable water is a very highly controlled category in an urban or peri-urban situation. The type of treatment is usually centralized, there is a large network of distribution, and regular monitoring of quality according to the regulations of national or regional standards. Elsewhere, such as in Europe, piped drinking water systems have to run under the EU Drinking Water Directive that places high standards of quality and consumer protection measures (Ramm, 2022). Potable water in pipes is generally regarded as the most stable and fair type of potable water, although there has been a constant threat in aging pipeline structures and new contaminants even in the wealthiest areas.

The other category that is coming to the fore is packaged potable water which includes bottled water and sachet water. The population of this type of class has increased rapidly in areas where municipal supplies are problematic or perceived to be insecure. Packaged water can be treated and regulated;, however, the quality of packaged water varies widely due to the possibility to impose regulations and the standards of production (Rajapakse, Otoo&Danso, 2023). Sachet water has also enhanced availability of potable water in urban regions in some developing countries, although issues of quality control, affordability and environmental effects of plastic waste continue to be raised. In this regard, packaged water is in a gray area as far as it can be a safe potable water in most instances yet it has not been managed adequately in most instances.

Another specialized category of drinking water is desalinated water, mostly used in arid and coastal areas. Desalination is the process of extracting the salts and other impurities in the sea water or brackish water to be left with fresh water to drink. Recent developments in the membrane technology have brought desalination to become more feasible and even today, nations in the Middle East and even within parts of Europe are now dependent on desalinated drinking water (Pointet, 2022). Although effective, desalinated water is energy-consumptive, and there exist environmental issues, including the problem of brine disposal and carbon emissions, and it cannot be used globally.

Lastly, drinking water may be categorized based on the administration and control and can be formally controlled and informally controlled. The controlled drinking water systems undergo routine monitoring, open disclosure, and standard enforcements, whereas the unregulated ones like the communal operated wells or water delivered by vendors are usually devoid of regular control (World Health Organization, 2023). Although informal systems can offer the necessary access in underserved regions, it is usually conditional and situational whether they can be considered drinkable. Finally, the categories of potable water are indicative of a multifaceted engagement between the source features, treatment procedures, service provision, and government frameworks. To the well-controlled piped supplies to the rainwater collection and packaged water, each category contributes to the global supply of potable water.
Knowledge of such classes is necessary to assess the water safety, determine inequities in access, and come up with effective policies to attain universal access to potable water. With the increased global challenges of climate change, urbanization, and population growth, the capacity to sustainably manage and upgrade all types of potable water has continued to be at the core of the objectives of public health and sustainable development.

3. Physical Qualities of Potable Water

Physical features of potable water are the physical and observable features of water that define its suitability to human consumption and household use. Whereas the physical parameters may not necessarily be a sure sign of the presence of harmful pathogens or other toxic substances, they are quite instrumental in determining the quality of water, since they determine consumer acceptance, functionality of water systems and indirectly, the health status of the people. According to international water quality guidelines, drinking water should be both safe and aesthetically fit to make sure that people repeatedly use and trust water supply systems (Burlingame et al., 2024). In cases of poor physical properties, the consumers are likely to dismiss treated water and use dangerous ones, thus exposing themselves to health hazards.

Colour is one of the greatest physical characteristics of drinkable water. The water to be consumed should preferably be clear or be weakly naturally coloured. Colour in water can be caused by either dissolved organic matter or iron, manganese or industrial pollutants. Although colour is not always a direct health hazard, it can signify the presence of some contaminants that disrupt the disinfection processes or the environmental pollution (Wang et al, 2022). According to WHO guidelines, the colour level of drinking water should not be visible to the consumers since visible colouration tends to create dissatisfaction and suspicion towards the safety of water (Burlingame et al., 2024). In most developing areas, surface or shallow ground water sources are generally coloured water and are related to untreated water or improperly managed water.

Another important physical parameter that is used to determine the quality of potable water is turbidity. It is the turbidity or the haziness of water that is produced by the suspended solids like clay, silt, organic material and microorganisms. The high turbidity is specifically relevant as it may ensure the survival of the pathogens who may be disinfected by the ultraviolet ray or by the use of such disinfectants as chlorine. This is why turbidity is not only a matter of aesthetics, but also a health indicator of the population. Turbidity in drinking water according to international standards is usually kept to a very low level particularly in the piped municipal water supplies so that disinfection and microbial safety may be ensured.

Turbidity is closely connected with clarity that is a measure of how much the water is transparent to the human eye. Even clear water is generally considered to be clean and safe when in reality clear water does not mean that it does not contain harmful contaminants. However, the clarity is also a significant physical attribute since people also think about the water safety by looking at it (World Health Organization, 2023). When the treated water is not clear, people would lose their trust in the water treatment systems and resort to bottled or alternative water which in some cases may not be of a good quality. It is therefore crucial to keep the clarity within the potable water systems to ensure that people come to believe in the water systems. Another characteristic physical characteristic of drinking water is taste. Preferably potable water is supposed to have no taste or a neutral taste that will not discourage the drink.

Taste in water could be caused by presence of naturally occurring minerals, gases or treatment chemicals like chlorine.Although having a certain amount of mineral content may enhance taste, its high concentration of certain substances such as iron, sulfates, or chlorides may render water unpleasant (Burlingame et al., 2024). Water with a bad taste can make people consume lower amounts of water or drink other sources, which could put them at risk of water having poor quality. This is why taste is regarded as a significant operation parameter in drinking water management, although taste is not commonly regarded to have direct health impact at acceptable levels.

On the same note, smell is another important physical attribute of drinking water. The drinking water must not have any offensive or unusual smell. The odours can be as a result of biological activity (growth of algae), chemical contamination or gases such as hydrogen sulfide. Though odour does not necessarily imply health risks, it can be one of the indicators of ineffective source protection or inefficiency in treatment (Pointet, 2022). The long-term presence of unpleasant smells may compromise the drinking water systems and cause households to switch to other water supplies, which raises the chances of health complications among the population. Odour control is therefore a significant factor in the control of potable water quality.

Another physical property with influence on the acceptability and safety of drinking water is climate. Water is usually more enjoyable to drink at low temperatures and under high temperatures, this can stimulate microbial growth and a quicker rate of chemical reaction in the water distribution systems. The ambient temperature in tropical areas is high and this makes it difficult to maintain proper water temperature, especially in surface water systems and storage facilities. Even though temperature is not controlled under strict numerical boundaries in most regulations, it is considered as a key determinant that affects taste, microbial activity as well as water quality in general.

Potable water also has its physical quality, which depends on the presence of total dissolved solids (TDS). TDS is the total salty content of inorganic salts and low level of organic materials that are dissolved in water. Although TDS can be considered a parameter associated with chemicals, its impact on the water taste and appearance makes it a part of the discussion of physical properties. Water, which has a very high level of TDS, usually has a salty or bitter taste and can also lead to scaling of pipes and other household appliances (Karbalayi et al., 2025). On the other hand, very low amounts of TDS may lead to flat or unpleasant taste. The acceptable TDS limits contributes to satisfaction of the consumers and sustainability of the water supply infrastructure.

The other significant physical feature is the formation of foam. The foaming in drinking water can result because of the presence of detergents and organic matter or industrial pollution. Foam is not necessarily toxic, but it can be an indication of wastewater contamination or industrial waste discharge, and creates a question of the overall well-being of the water source World Health Organization, & United Nations Children's Fund(2022). The potable water standards dictate that water should not have visible foam because it compromises on aesthetics and confidence of the population.

Physical quality is also associated with the conductivity of water which implies the capacity of water to conduct electrical current. The higher the concentrations of dissolved ions, the greater the conductivity and this is commonly a rapid measure of mineralization and salinity. Conductivity is a health risk measurement that is not directly related to health hazards, but the unusual values can indicate pollution or alterations in the qualities of the water source that could be investigated further. Conductivity monitoring also assists water managers to take care of consistent water quality, and identify possible occurrences of pollution.
The importance of physical qualities does not only limit to aesthetics and consumer perception but has wider implications on the health and administration of the population. Physical poor quality may disrupt the process of water treatment, escalate the functioning expenses, and decrease the efficiency of disinfection. As an illustration, turbidity levels should be high, which means that they require more disinfectants/filtering capacity, whereas too much colour might complicate treatment activities (World Health Organization,

2023). Besides this, physical properties affect the social behavior; people will tend to take water more often and use it when it looks clean, clear, and attractive.

Finally, it is important to note that the physical characteristics of drinkable water such as colour, turbidity, clarity, taste, odour, temperature and other parameters are part of essential elements used in the evaluation of drinking water quality. Although these properties do not necessarily translate to chemical or biological safety, they are crucial in ensuring acceptability of the product by the consumer, effective treatment procedures, and confidence in water supply systems. The international standards acknowledge that potable water should uphold safety and aesthetic standards to be really fit to be consumed by humans. With the increasing demands on water resources due to major global issues like climate change, urbanization and pollution, the physical quality of potable water will continue to be a key concern of the health of the people, water management as well as sustainable development.

4. CHEMICAL QUALITIES OF POTABLE WATER

The chemical qualities of potable water mean the nature and the concentration of dissolved chemical substances in water that define the safety, suitability and acceptability of the water to be consumed by human beings. Contrary to physical properties, which determine aesthetic perception to the greatest extent, chemical properties have both immediate and remote-term effects on human health, the strength of infrastructure, and the sustainability of the ecosystem. Chemical constituents in potable water should be in limits that do not render them acutely or chronically harmful to the health of individuals, but still cannot upset the chemical balance of potable water allowing it to be palatable and to be treated (Mitchell &Frisbie, 2023). As a result, the standard of chemical is one of the most important tenets of drinking water standards in the world.

PH is one of the most basic chemical parameters of potable water that indicates the level of acidity or alkalinity of water between 0-14. According to most drinking water recommendations, the pH of drinking water must be in the range of between 6.5 and 8.5 to guarantee safety and acceptability. Very low PH of water may be corrosive and result in the leaching of metals like lead and copper in the pipes and highly alkaline water may produce scaling and decrease the effectiveness of disinfection. Even though pH per se is not directly a health hazard in the normal range, it has a profound effect on the behavior of other chemical contaminants and on the stability of the water supply system on the whole.

The other important chemical parameter is total dissolved solids (TDS), which is the sum total of inorganic salts (calcium, magnesium, sodium and potassium) and low traces of organic substances dissolved in water. TDS impacts on the taste, hardness and aesthetic acceptability of drinkable water. Water that is highly salty or salty and water with extremely low TDS water will be perceived as unpalatable or salty to sensitive people and may cause gastrointestinal unpleasure, respectively (Li et al., 2025). Global standards point to the fact that the reasonable TDS concentrations will lead to consumer satisfaction and structural durability.

Another chemical property of drinking water that is significant is the water hardness which is mainly due to the dissolved calcium and magnesium ions. Extremes of hardness have not been shown to be harmful to health but moderate levels of hardness have been described as helpful since calcium and magnesium are necessary minerals (Mitchell &Frisbie, 2023). Nevertheless, too much hardness may lead to scale formation in pipes, boilers and domestic appliances, augmenting maintenance and efficiency of the system.

On the other hand, water that is extremely soft could be corrosive, which helps in leaching metals used in pipes. As such, a range of hardness should be operated and maintained at the optimum levels due to health and operational factors.

Major inorganic ions that include sodium, chloride, sulfate and bicarbonate also affect the chemical quality of potable water. High sodium levels can be an issue to people with hypertension or kidney disease, whereas high chloride amounts can add a salty flavor and lead to corrosion of metal pipes. When found in large quantity, sulfates may result in bitter taste and laxative effects especially among people who are not used to drinking water with a lot of sulfates. As a result of these reasons, global and national standards establish values of safety and acceptability of these ions through guideline values.

One of the most important issues of chemical quality is the management of toxic heavy metals in drinking water. Lead, arsenic, mercury, Cadmium, and chromium are some of the metals that have raised a significant issue of concern among the general population because they are toxic at low levels. Examples of these include lead exposure, which is linked to neural damage, particularly in children, and arsenic pollution which is linked to lesions of the skin, heart diseases, and multiple cancers (WHO, 2023). These are contaminants that can be introduced to drinking water as a result of natural geological processes or as a result of human activities like mining, industrial discharge and corrosion of plumbing systems. Consequently, drinking water standards set very high concentrations of heavy metal, which is an indication that whatever is added to drinking water that contains heavy metals has to be regulated by very strict limits to protect and safeguard the health of the population throughout their lifetime.

Another chemical group, which is strictly followed in drinking water, is the presence of nitrates and nitrites. These chemicals are usually found in agricultural runoff, septic, and wastewater discharge. Methemoglobinemia or the so-called blue baby syndrome, which is a potentially deadly disease in infants, is linked to a high amount of nitrate in drinking water and makes the blood incapable of transporting oxygen (Kono et al., 2025). There are also enhanced risks of some cancers that are caused by long-term exposure of high nitrate levels. Thus, the levels of nitrates and nitrites are one of the most stringently applied chemical guidelines in the drinking water regulation.

Chlorine and chloramine are residual disinfectants, which are deliberately added into the drinking water to manage the microbial contamination of water during distribution. Although the substances are necessary in ensuring the safety of microbiology, their level has to be strictly regulated to reduce the possible health risks and taste disturbance. High amounts of chlorines may create bad taste and smell and result in the generation of disinfection by-products (DBPs) with the reaction of organic matter in water. Trihalomethanes and haloacetic acids (DBPs) are linked to high risks of cancer and reproductive effects, and their control is a major factor in chemical water quality control. Organic contaminants of potable water are also chemical quality and consist of pesticides, herbicides, industrial solvents, and petroleum products. These chemicals can be introduced into water bodies (agricultural activities), industrial wastes, or improper disposal of wastes. Some organic chemicals are extremely harmful to health because of their carcinogenic or endocrine-disruptive nature even at very low concentrations World Health Organization, & United Nations Children's Fund(2022).
The development of analytic technology has led to the enhancement of the detection of trace organic compounds in drinking water, and thus the current guidelines on potable water have undergone constant changes to accommodate new chemical hazards. One of the new issues in the sphere of chemical water quality is the occurrence of emerging pollutants, e.g., pharmaceuticals, personal care products, and microplastics. Despite the fact that regulatory requirements of these substances are in the process of development,

the presence of those in the drinking water systems has cast doubt on the long-term health consequences and the efficiency of their treatment (Wang et al., 2022). Although it is evident that levels are typically low, the fact that certain new contaminants are persistent and bioaccumulative explains the importance of ongoing research and dynamic regulation.

Chemical qualities are not only important to human health, but also to the performance of the infrastructure and the environmental sustainability. Pipes and storage facilities may be damaged by chemically aggressive water, which results in greater leakage and contamination and losses of money. On the other hand, chemically unbalanced water can be expensive to treat to fit the drinkable requirements. Due to these reasons, water plants and utilities across the globe invest massively in chemical monitoring and management to achieve safety and efficiency of the system (Kono et al., 2025). To sum up, chemical properties of drinking water are at the core of safety, acceptability, and sustainability of drinking water. The chemical integrity of drinking water is defined by parameters that include the following; pH, dissolved solids, hardness, major ions, nutrients, heavy metals and organic contaminants. There is clear safeguarding of the health of the populace, the ability to sustain dependable water systems, in addition to boosting the confidence that a consumer would have in the drinking water systems. With the current environmental stresses, industrialization and climatic changes that are affecting the water resources, sustaining and enhancing the chemical quality of the potable water will become a major challenge in the world and a pillar of sustainable development.

5. WHAT MAKES A DIFFERENCE IN POTABLE WATER ACROSS THE GLOBE?

The global variation in quality, access, and reliability of potable water is a complicated combination of natural, socio-economic, technological, political as well as environmental aspects. Though potable water is a universally recognized definition of water which is safe to be used by human beings, there is an enormous difference between availability of potable water as perceived by region, country and even communities within country. These inequalities affect the health outcomes of the population, economic progress and equity, and potable water is a key concept in global development discourse (Bwire, 2022).

Economic development is one of the most influential agents of differences in potable water all over the world. The high-income countries typically have well-developed water infrastructure, such as sophisticated treatment plants, comprehensive systems of distribution, and powerful monitoring systems. Such investments allow providing clean drinking water of high quality on a regular basis (Bwire, 2022). On the contrary, a number of low- and middle-income nations are financially constrained, which restricts their capability to construct, repair, and renovate water infrastructure. This leads to more poorer areas depending more on unimproved or partially improved sources of water exposing them more to waterborne diseases (UNICEF, 2025). Intimately associated with economic ability is infrastructure availability and state. Physical structures used to provide potable water systems include dams, boreholes, treatment facilities, pipelines and storage reservoirs. Poor maintenance, aging infrastructure, and limited coverage in the majority of the developing areas causes intermittent supply and contamination during the distribution process.

Where the source of water is treated to drinking quality, leaks and changes in pressure levels can cause the entry of pathogens and pollutants into the system. On the other hand, those nations that have well-developed infrastructure that is not old will be in a better position to maintain water quality as it flows to the consumers. The political systems and regulation laws are also crucial determinants of variations in drinkable water in the world. Good water governance entails legal clarity, enforcement of laws, institutional harmony as well as transparency. In other nations such as Europe, the quality has strict limits set through extensive laws including the Drinking Water Directive that obliges to monitor the quality and to publish the results on a regular basis (Ramm, 2022). As a contrast, water quality control and water management responsibility lack in a number of countries due to weak regulatory capacity and divided institutional responsibility. The water systems can also not provide safe drinking water on a regular basis where the governance of the nation is feeble even when the water systems are technically correct.

Water source availability and natural endowment is another significant determinant. The availability of raw water to be used as drinking water is highly affected by the geographic and climatic conditions. The nations that have plenty freshwater access, including biggest rivers, lakes, and renewable ground water systems, usually have less restriction in supplying drinkable water compared to arid or semi-arid areas (Karbalayi et al., 2025). Areas that are scarce in water usually rely on groundwater sources that are scanty, desalination, or water transfer over long distances, all which adds to the cost and technical complications. Deficit of natural water therefore enhances inequity in accessibility of potable water across areas.

Climate change has become one of the significant factors in the world making differences worse on potable water. Alterations in the rainfalls, increased temperatures, extended drought and increased floods have a direct impact on the availability and quality of water. Floods may enter sanitation systems and pollute sources of drinking water, and droughts decrease water supply and increase the concentration of pollutants. Most of the effects are experienced in low-income nations, where the infrastructure is often ill-equipped to withstand climate disasters and adapt to them (outstanding existing inequalities in safe drinking water access) (Desbureaux et al., 2022).

Another important issue that affects the difference of potable water across the world is the quality of sanitation and waste management systems. Lack of sanitation means that human waste will get to water sources and cause biological contamination, which will affect the potability. Areas that have high ratios of sanitation and wastewater treatment systems that are safely managed tend to have better results regarding the quality of drinking water. On the other hand, it is very difficult to have biologically clean drinking water in places where open defecation, poorly constructed latrines, or untreated wastewater are prevalent. This water nexus of sanitation-water gives rise to the fact that the increases in the quality of potable water are often subject to parallel investments in sanitation infrastructure.

Innovation and technological capacity also vary the availability of drinkable water throughout the world. Owing to sophisticated methods of treatment, like membrane filtration, ultraviolet disinfection, and real-time control of water quality, high-quality potable water can be obtained even with the polluted or saline water (Desbureaux et al., 2022). The high-income countries tend to apply such technologies with more probability as there are more financial and technical resources. On the contrary, simpler treatment modalities or household-based interventions are practiced in many developing areas and may prove to be less dependable or replicable. The gaps in technology are therefore a major cause of inequality in the quality of potable water around the globe.
Social and demographic factors are also involved. The high rate of population growth and urbanization exerts vital pressure on the available water systems and especially in the cities in the Global South. The population in informal settlements can grow more rapidly than the supply of infrastructure, and millions of people are deprived of the possibility to get access to safely managed drinking water (UNICEF, 2025). Conversely, other countries where the rate of urbanization is less rapid and where there is a planned urban development are more capable of matching the water infrastructure development to the

demand. Population dynamics, however, play a role in determining the sustainability of the drinkable water services besides accessibility.

Education and general awareness plays a indirect role in discrepancies in potable water results. The more educated the community, the more likely that it will be aware of the risks of water quality, will demand that service providers are accountable and will implement safe water handling practices (Bwire, 2022). Even the available potable water can be contaminated in places where there is low awareness by means of unsafe storage and handling. Social capacity and behavior therefore determine the effectiveness of potable water systems in the real world. Inequality in the countries is another determinant and this reflects international disparities on a smaller scale. The urban elites tend to have piped, potable water of good quality, whereas the rural communities and the urban poor have to use distant or unsafe sources of water. It is a type of internal inequality that is observed in most places such as Sub-Saharan Africa, South Asia, and even Latin America. The disparity in potable water on the world level is thus not merely international but it is also deep-rooted in the national and local level.

International cooperation and development assistance also have a role to play in global disparities in potable water. Multilateral projects, technical aid and development aid have contributed to the increase in access to potable water in most of the low-income nations. Nevertheless, lack of equal aid distribution, the shortness of project cycles, and lack of local capacity can make it less effective in the long term (UNICEF, 2025). The nations that have an established investment and good relations are more likely to achieve a higher degree of universal access to safe drinking water. Summing up, economic ability, infrastructure, governance, natural circumstances, climate change, sanitation networks, technology, population trends, and social justice are not individual factors that make a difference in potable water in the global context, but a set of factors

These determinants are interrelated because certain regions experience universal access to safe and reliable drinking water and others remain at a constant for chronic shortage and health hazards. Social and technological innovation, good governance, and social inclusion are important strategies to use in reducing global inequalities in potable water. With the world shifting to the attainment of Sustainable Development Goal 6, such differences are still important in determining policies and interventions that provide safe drinking water to everyone.

6. Categories of Potable Water in Africa

The availability of potable water in Africa is influenced by various environments, socio-economic and infrastructural influences and consequently lead to various categories of potable water that differ substantially across geographical regions and populations. In contrast to most high-income areas where water is only supplied in centralized and regulated system, Africa has a wide range of sources of water and access to services. To offer a standard concepts of these differences, international bodies especially the World Health Organization (WHO) and UNICEF categorize drinkable water based on the Joint Monitoring Programme (JMP) drinking water service ladder that is broadly used in African nations (Kono et al., 2025). These classifications are not only based on the origin of water but also on the quality of water, its availability, and consistency.
In Africa, the top most sought after and safe category of potable water is the drinking water services which are managed safely. This type denotes a better source of water, which is on-site, on demand, and without fecal and priority chemical contamination. In Africa, the safest potable water is found mostly in large cities and capital towns, where the municipal water companies have piped systems of distribution. It is however under-covered as compared to the world averages. In the early 2020s, less than a half of the African population has a connection to the safe drinking water, and rural regions are especially

poorly served (Kono et al., 2025). This category is the standard of potable water safety and sustainability in the continent though it has a limited reach.

The group of safe drinking water services shares a close relation with the basic drinking water services. This category also covers water that is sourced through better means that include boreholes, protected wells, protected springs, and public standpipes when the collection time does not exceed 30 minutes round trip. The access to basic services is one of the most common types of potable water access in Africa particularly in the peri-urban and rural communities. Although these sources of water tend to be safer than unimproved sources, they are not always consistently available or sufficiently monitored, which puts the risk of sporadic contamination at a higher level. However, basic drinking water services are an important advancement of unsafe sources and are important in eliminating disease burdens due to water.

The other significant category is limited drinking water services which alludes to better water sources which take above 30 minutes of round trip to acquire water. In most rural areas of Africa, families are using boreholes or closed wells that are technically considered improved sources but put users at a great time and physical cost (Bwire, 2022). But even though the water collected by the sources can even satisfy the minimum criteria on potability upon collection, the water stored on transport and in the home can become contaminated over a long duration. Limited services thus emphasize on the inter-relationship of water quality and access thus stating the fact that potable water needs to be both safe and convenient to access so that it provides all the health benefits.

In addition to the JMP service ladder, the classified African potable water may be discussed according to the type of source, which is also highly applicable as the continent depends on the natural water sources. A significant group is the potable water that is based on groundwater, i.e., is a borehole, well, or a protected spring. Groundwater is an essential drinking water source in Africa especially in arid and semi-arid areas where surface water is limited (Li et al., 2025). Groundwater, when properly treated and guarded, can be a relatively stable and also microbiologically harmless drinking water. Nonetheless, it may be compromised in its safety in certain areas by natural contaminants, e.g., fluoride and arsenic, mining and agricultural pollution, and thus requires treatment and monitoring.

Another category of water that is important in Africa is surface water derived potable water. Many urban areas and rural societies access drinking water through rivers, lakes and reservoirs. Surface water is highly exposed to wastewater discharge, agricultural runoff, open defecation, and thus needs a lot of treatment before it can be considered potable World Health Organization, & United Nations Children's Fund(2022). In urban areas where water has been treated in an efficacious treatment facility, the supply systems of the municipalities are based on treated water surface water. Conversely, in towns and those locations that have no or limited surface water treatment, sometimes the water that is untreated or slightly treated is consumed, which hides the boundary between potable and non-portable water and endangers people.

Another category of drinking water in Africa that is different and gaining significance is rainwater-collected drinking water. Rain water collection systems are used to collect rain in rooftops or other surfaces and store it to be used domestically. In different areas receiving seasonal rainfall and with poor ground water sources, rainwater harvesting serves a supplementary source of drinkable water, especially at the community and home scales (Bwire, 2022). Harvested rain water can be of quality equal to drinking water, when it is appropriately designed, maintained and treated. Nevertheless, risks of contamination by roofing materials, storage tanks, and poor maintenance imply that rainwater will usually be considered conditionally drinkable, based on measures of treatment.

Piped municipal potable water is also another category, which is supplied by centralized distribution systems by local government or private utilities. Most common in urban African regions, the rate of service coverage and reliability is not consistent across countries and cities (UNICEF). Most of the time, centralized water facilities treat piped water to drinking standard but irregular supply, aging facilities and unauthorized connections may affect water quality during delivery. Consequently, even treated water that is potable at the source may not be potable upon use, thus the obstacles in ensuring that this category of water is maintained within the continent.

packaged potable water, such as bottled water and sachet water, has become an important category in most African nations, especially in cities and on the urban periphery. Sachet water is a commonly packaged product in small plastic bags that is consumed so often because it is affordable and convenient (UNICEF). Although treatment and control of various packaged water are exercised, the levels of quality standards are not fully enforced resulting in mixed levels of safety. In other senses, bottled water has enhanced the availability of clean drinking water in areas where the water mains are not dependable; although, there are persistent fears of poor quality control and pollution by plastics.

Another category of importance in the case of emergency and humanitarian is the water that is distributed and transported by trucks and is consumed by people. Tankers deliver water to populations impacted by the war or natural calamities or damaged infrastructure. Such water can be treated to provide minimum drinking water standards but its quality relies on the protection of its source, the hygiene of the tankers and the conditions of storing the water. The category can be regarded as a temporary one and it points out the vulnerability of potable water supply in the regions of crisis in Africa.

The management and governance structures are also apparent in the categorization of the drinkable water within the African continent. Formally controlled sources of water like piped supply of water in municipalities are put under the control of nationally recognized standards and monitoring whereas the control of informally controlled sources like community wells and water supplied by vendors is not consistently regulated. This governance gap affects the water safety and equity because the population dependent on informal systems is more prone to water contamination and disruption of services.

Conclusively, the types of potable water in Africa vary widely and these types mirror the diverse environmental factors, the infrastructure capacity, and socio-economic realities of Africa. Out of the safely controlled piped supplies, simple, constrained and source based water like ground water, surface water, rainwater collection and packaged water, each category contributes to the aspect of satisfying drinking water demands. The identification of these categories is crucial in assessing the progress of achieving universal access to safe drinking water and formulating specific interventions that will mitigate disparities in access to safe and quality water. With Africa going through the process of urbanization, with increasing climatic and population pressures, empowering and increasing higher standards of potable water will be an important development agenda.

7. CONCLUSION

Potable water is among the most basic needs to human survival, the public health, and sustainable development, but its accessibility and quality continue to be a wide problem in the world. This paper has shown that, potable water is not characterized by its human consumption suitability only but a complex of physical, chemical, biological, and environmental characteristics that need to be managed carefully to achieve safety. The international standards established by other organizations, including the World Health Organization, focus on the fact that drinkable water should be devoid of toxic substances, visually pleasing, and consistently available to people in an unlimited supply.

The comparison of classes and characteristics of potable water shows that water safety is a complex phenomenon. Acceptability is dependent on physical characteristics (color, turbidity, taste and temperature) and chemical characteristics (pH, dissolved solids and toxic substances) directly affect the health outcomes. The focus on preventing waterborne diseases and a disproportionate impact of these conditions on susceptible groups in low- and middle-income countries has been based on biological properties, especially the absence of pathogenic microorganisms. Environmental attributes also highlight the need to guard water sources against pollution, land degradation, and stressors that occur in the climate creating the need to have integrated water resource management.

Regional analysis indicates that availability of drinking water is determined by geography, infrastructure, governance and socio-economic capacity. In Africa, the types of potable waters include safely controlled piped water supplies, basic and limited supply, ground water, harvesting of rainwater, packaged water, and emergency distributions. These types of categories are a manifestation of innovation and inequality because the communities continue to rely on sources that are only conditionally drinkable. Europe, in its turn, enjoys a well-developed centralized infrastructure, robust regulatory frameworks, and sophisticated treatment technologies, which allow becoming more covered with safely treated potable water (Ramm, 2022).These variations represent the role of political commitment, institutional strength, and investment capacity having a great impact on the outcome of potable water.

Inequality in accessible water is a globally dependent variable with interrelated aspects, such as economic growth, quality of infrastructure, good governance, natural potable water supply, climatic changes, hygiene facilities, and technological capabilities. The problem of climate change has aggravated water insecurity, in particular, by causing droughts, floods, and low water quality, which disproportionately impact areas with low adaptive capacities (Desbureaux et al., 2022). These are further increased by population growth, fast urbanization and inequality within countries, which leaves rural communities and urban poor with no access to safe drinking water that they can depend on.

Conclusively, to make potable water universal it does not just involve finding safe sources but it is more on long-term investment in infrastructure, governance, environmental protection, technological advancement, and educating the people. The realization of Goal 6 of Sustainable Development of clean water and sanitation to everyone will rely on the global and local differences in attaining this goal through coordinated policies and inclusive strategies. With the increasing demands of climate change and population increase, the fortification of potable water is going to continue playing a vital role not only in the health of the people but also in their economies, social justice, and sustainability in the long term across the globe.

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