

A Sociocultural Study of the Transformative Approaches to Water Preservation

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Abstract

Water is an invaluable solvent that encompasses Earth and its seven continents. All global communities need this nutrient; however, efficient access at safe, quality levels have become increasingly difficult. This condition leads to restricted (or depletion) of this crucial resource. Humankind is dispersed across a series of different continents; therefore, access to water will vary depending on the conditions of each geography. The quality of water sources will vary depending on the environmental conditions; coastal and riverbed regions generally use different forms of purification from their counterparts because the contaminants (pollutants) in areas of scarcity are more hazardous due to operational issues with personal hygiene, wastewater runoff, and cross-contamination from other animal and plant organisms. This research begins by defining water conservation and quality preservation concepts. Next, it examines the ancient civilization technology used by global communities for water conservation. Later, it chronicles the various conditions by which water (supply) access and quality have been compromised within each global community. This is followed by an identification of the contemporary tools and techniques used to protect water quality, giving special attention to a common denominator amongst many communities—the use of animal and plant bioindicators. Next it offers perspectives on how climate change, innovation, and local governance structures support efforts to protect water. It concludes with a discussion of the World Health Organization's efforts as they navigate the challenge of access to clean water for everyone.

Keywords

Water, Bioindicators, Pollution, Robotic Fish, Antimicrobial Resistance

1. Introduction

Planet Earth is comprised mainly of water, and the seven continents are sur-

rounded by the Arctic, North Atlantic, South Atlantic, North Pacific, South Pacific, and Indian oceans. These vast aquatic basins support the existence of both humans and mammals. The human body contains a significant percentage of water, and this composition varies as we age; research indicates it ranges between 62% in our youth and declines to about 55% after age 60 (Lu et al., 2023). Water is a crucial nutrient for humans because it enables our bodies to self-regulate certain functions such as bringing nutrients to cells, getting rid of waste, protecting joints and organs, and maintaining body temperature. In industrial settings, we use water for agricultural development (animal and plant food products). Therefore, access and water quality are crucial to sustaining domestic and industrial water use. Access to water can vary depending on geographic location; coastal or riverbed communities have abundance, and other internal regions with hot, desert-like climates suffer from scarcity. Also, the quality of these sources will vary depending on the environmental conditions; coastal and riverbed regions generally use different forms of purification from their counterparts because the contaminants (pollutants) in areas of scarcity are more hazardous due to operational issues with personal hygiene, wastewater runoff, and cross-contamination from other animal and plant organisms. Some regions use traditional (historical) methods for collecting and monitoring water conditions due to their size and limited budgets; others have cutting-edge tools that use real-time computerized collection, monitoring, and remediation services. Both initiatives matter because the Earth's water is collectively shared among many continents. One area's conditions (climate change, industrial toxins, and wastewater management) could eventually affect others. Therefore, water governance is not a competition; each global community demonstrates social responsibility, using existing capabilities to promote water continuity and safety. This paper seeks to explore the transformative approaches global communities employ to combat the issues of water conservation and water quality preservation.

Water is not a mineral because, in its normal structure (fluid), it does not reach the criteria of a solid mineral until it is frozen as ice. Therefore, water is a naturally occurring solvent that can be transformed. The total amount of water on Earth is relatively stable. However, its structural form changes over time based on climate conditions and location. For example, water takes the form of liquid (ocean), gas (volcano eruption), and solid (glaciers) in different regions of the world.

Water quality follows a more complex journey because the focus on preservation and safety mechanisms has varied in recent decades amongst countries and their government leaders. A common denominator in the deterrents to water quality includes climate change, agricultural and industrial waste, and urban development. Climate change influences disruption in weather patterns, agriculture, and industrial waste introduces contaminants like pesticides and toxins, and urban development removes naturally occurring animal (fish) and plant life (cattails, water hyacinth, duckweed, water mint, and soft rush) that remediates and preserves the quality of water (Sivaranjani & Rakshit, 2016). Variance in geographic conditions prevents standardization (in the employment of specific plant

types) for natural remediation of contamination events. However, there is a commonality in employing animal bioindicators for early detection.

2. Foundational Knowledge

Definitions of water conservation and water quality are necessary to ensure a common understanding of future content within this research. Water conservation refers to efficiently collecting and using naturally occurring solvents and stored supply (reservoir) for human and domestic use. Preservation of water quality involves the suitability of this solvent for intended use. Water used for human consumption should be free of bacteria, particles and pollutants that could compromise the health and well-being of humans and animals. Supplies used for bathing, irrigation, and other non-potable applications must be within published regulations for turbidity (clarity and contamination).

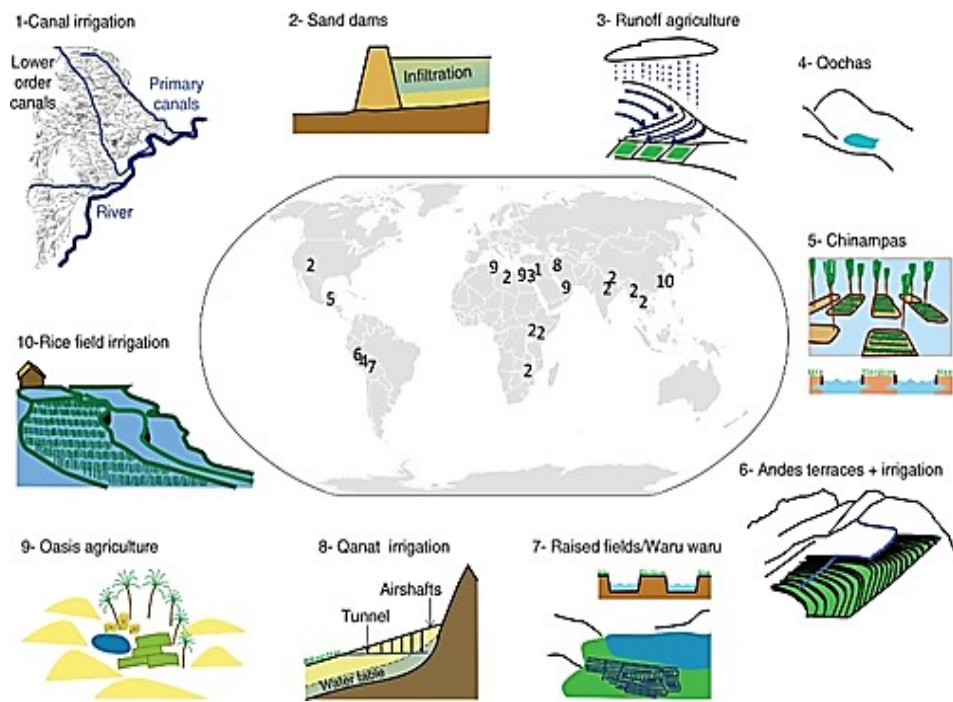
2.1. Water Conservation

Each continent possesses (see **Figure 1**) unique physical characteristics that can define or limit water availability in a naturally occurring solvent form.

2.2. Water Quality

Antarctica water manifests as a solid mineral in the northern continent, ice. The temperatures of this solidified mineral reduce the opportunity for contamination from external sources, more so than in other continents. Water contamination and pollution can occur in warmer environments due to human intervention, industrial waste, and climate change. Historical research in these regions reveals contamination from the lack of proper infrastructure within European cities that caused their biological waste to overflow and contaminate the natural resources (Lack, 1999). Typhoid and plague ravaged these communities between 1840 and 1940 as the government struggled to acquire funding to resolve the issues of cross-contamination within one of the region's largest reservoirs, the Thames River (Vanderslott et al., 2019). American cities seemed to replicate the plight of their UK counterparts, "waterborne diseases were responsible for almost 25% of reported deaths from infectious diseases in major US cities, which were experiencing rapid immigration, industrialization, and overcrowding" (Cutler & Miller, 2005: p. 16).

Crossing the Atlantic Ocean, on the continent of Africa, the lack of water (in some parts of the region) prevented people from having access to proper hygiene, which increased the occurrences of cross-contamination in natural resources from water runoff from other diseased areas (WHO Africa, n.d.). Moving into Asia in 1850, unprecedented flooding that did not subside caused profound water stagnation, resulting in cross-contamination due to its integration with sanitary sources for domestic human use and agriculture irrigation (WHO Viet Nam, n.d.). Finally, in Australia, typhoid fever flourished in 1890 caused by unsanitary conditions due to overcrowding, which manifested itself in cross-contamination of domestic supply systems, creating waterborne disease; cases began to decline, and normality returned in 1910 (Government of Western Australia, n.d.).



Technique	Description	Earliest Introduction	Location
Canal Irrigation	Creation of an artificial waterway or passage between natural resources to facilitate crop irrigation	1000 BC	Zerqa Triangle in the Jordan Valley
Sand Dams	Creation of a concrete wall across a riverbed that collects water seasonally.	400 BC	African regions, India Nepal, Myanmar Thailand, North America
Runoff Farming	Collect runoff water from uncropped areas to farming areas for irrigation purposes.	Byzantine Period (500-700 AD)	Negev Desert of Israel
Qochas	Creation of water reservoirs from rain or runoff accumulating in naturally occurring land depressions.	500-800 BC	Peru Bolivia
Chinampas	Creation of an island within a lake or pond using soil and twigs to produce gardens.	1000 AD	Mexico, Central America (Belize, Cost Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama)
Andean Terraces	Creation of farming areas by carving flat surfaces into mountainous terrain to preserve rainfall for soil consumption	2000 BC	Peru, Chile, Argentina Colombia, Venezuela Ecuador, Bolivia
Raised Fields/Waru	Creation (and connection) of raised fields or gardens connected by canals to increase soil fertility.	300 BC	Peru Bolivia
Qanat Irrigation	Creation of underground tunnels and shafts that collect water and channel it to new domestic use and farm irrigation locations.	1000 BC	Iran Iraq Türkiye
Oasis Agriculture	Natural water sources in a desert area provide irrigation for farming and vegetation.	3500-3700 BC	Ein Gedi, in the Judean Desert, Jerusalem, Israel Egypt, Tunisia United Arab Emirates
Rice Field Agriculture	Creation of irrigation strategy for rice fields that use basin (flooding), furrows (creation of trenches), or surface (runoff from gravity).	6000 BC	China

Figure 1. Ancient Water Management. Source: Kaptijn (2018).

Global communities employ many methods to detect contaminants or pollutants in water supply; they often vary depending on budgets, technology, and cultural preferences. Early civilizations used techniques such as boiling water (to eliminate germs), filtering (passing water through the filter using sand, cloth, or charcoal) to remove impurities and particles, or sedimentation (using time to allow large debris to settle at the bottom of the container before removing above water). Eventually, chlorine (bleach) integration was introduced as a more effective and efficient method to purify water and reduce the effects of cross-contamination and pollution (National Resource Council, 1977).

3. Contemporary Methods

3.1. Water Quality

The best deterrent to remediating water contamination (pollution) is avoidance, and introducing bioindicators (techniques used to detect the presence of pollutants in our environment) has been notably efficient in this endeavor. Detecting mechanisms can exist in various forms and often depend on the unique characteristics of each community or continent. Animal and plant techniques are the most used bioindicators in contemporary society. Since each community has unique characteristics, such as terrain, water temperature, salinity, and ecosystem, the most practical common denominator towards standardization for detecting water pollutants is fish, native to their culture.

3.2. Animal Bioindicators

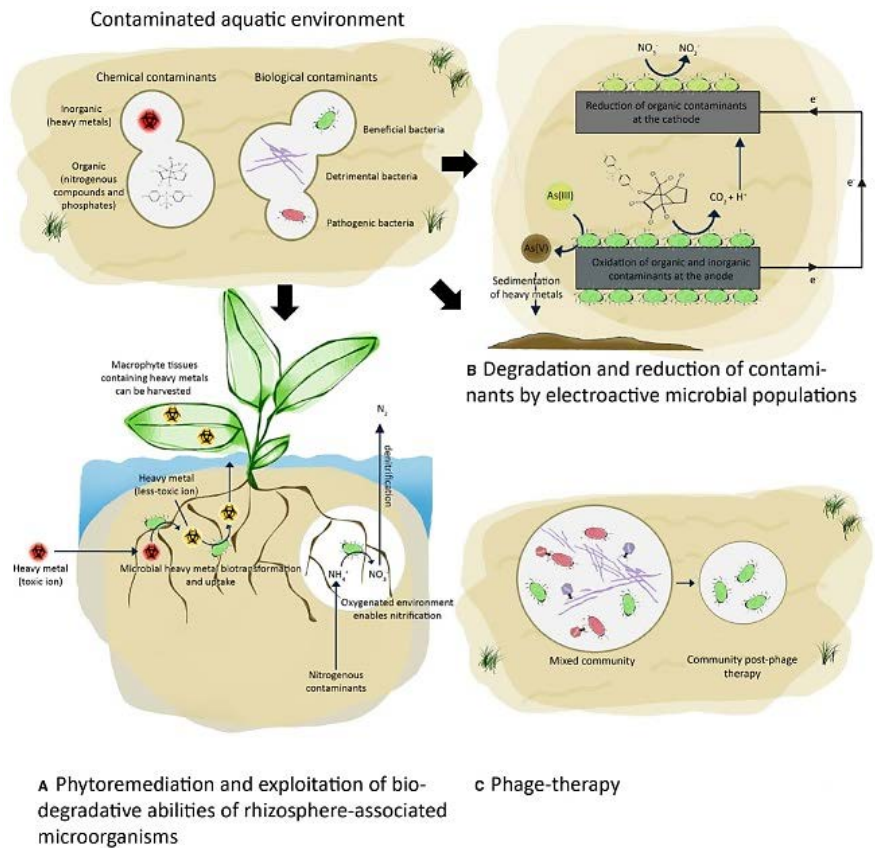
Fish are excellent sensitivity analysis tools because they follow certain patterns of behavior that inform scientists of their mental and physical state (Sun et al., 2022). For example, fish sensitive to certain conditions (water temperatures, toxicity, presence of predators, etc.) are not likely to accumulate or nest in certain areas. Fish act as bioindicators in their ability to report the presence of toxins in their skin and organs; they are also inclined to reflect deviation in behavioral patterns, which reflect adversity to water conditions (Sun et al., 2022). These behavioral deviations can alert researchers to abnormalities in the ecosystem. See **Table 1** for the types of fish species used for certain testing sequences.

3.3. Plant Bioindicators

The earliest scientific detection of pollutants in water (using plant bioindicators) dates back to (Kolkwitz & Marsson, 1902) in the study of algae blooms in stagnant water. “Algal blooms are harmful because they produce elevated toxins and can increase bacterial growth” (Aracic et al., 2015: p. 3). These types of contaminants resulted in earlier episodes of cholera and typhoid fever. Plants can also remediate these pollutants, returning water supply reservoirs to safe levels for human consumption. Studies have shown that contamination levels decrease when plant foliage (a floating bed of perennial grasses) is integrated into contaminated aquatic environments (see **Figure 2**).

Table 1. Common fish species used for bioindicators.

Fish Species	Bioindicator Type	Description	Research
Bluegill Sunfish, Zebrafish, Cichlids (African lakes), Sculpin, White Suckers, Minnows, Crayfish, Mussels	Changes in ecosystem (general)	Used for abundance studies due to the high sensitivity of any general water conditions	Ali et al. (2020) Ngor et al. (2023) Chovanec et al. (2003)
Trout Salmon Coral Reef fish	Changes in ecosystem (temperature sensitivity)	Used for abundance studies due to climate change	Alfred Wegener Institute & Helmholtz Centre for Polar and Marine Research (2020)
Zebrafish	Water Quality (Toxins) Arsenic, Cadmium, BPA, Nitrates	Used sensitivity to heavy metals and toxins	Chahardehi, Arsad & Lim (2020) Paul et al. (2019)
Bass, White Suckers, Killifish, Bullhead, Trout, Perch, Mudminnow	Water Quality (pH)	Used to assess pH levels in lakes and ponds	Nierzwicki-Bauer et al. (2010)
Medaka, Mummichog, Zebrafish	Transgenic Fish	Genetically altered fish that reflect visual traits when water is polluted.	Winn (2001)



Types	Description
Chemical	- Inorganic (heavy metal)
Contaminants	- Organic (nitrogenous compounds and phosphates)
Biological	- Beneficial bacteria
Contaminants	- Detrimental bacteria
	- Pathogenic bacteria
	A. Phytoremediation and exploitation of biodegradable abilities of rhizosphere-associated micro-organisms.
	Description: Both toxic and non-toxic heavy metals attach to the roots of the aquatic plants. Macrophyte tissues containing heavy metals can be harvested. Oxygenated environment enables nitrification.
	B. Degradation and reduction of contaminants by electroactive
Remediation	microbial populations.
	Description: Oxidation or organic and inorganic contaminants at the anode. This leads to a reduction of organic contaminants at the cathode.
	C. Phage-therapy
	Description: The resultant is a mixed community of contaminants (both threats and benefactors) which eventually reduce to only beneficial bacteria.

Figure 2. Demonstration of plant bioindicator and remediation of harmful contaminants in water. Source: [Aracic \(2015\)](#).

The plants remediated harmful contaminants using “an environmentally friendly strategy for removing excess nutrients, organic pollutants, and heavy metals” ([Aracic et al., 2015](#): p. 4). This bioremediation strategy for treating contaminated water has an added benefit because harvested macrophytes can be processed into biomaterials such as biogas ([Ahalya et al., 2003](#)) and animal feed ([Li et al., 2012](#)). The protein and fiber content of macrophytes meet the national feed thresholds, and the content of toxic heavy metal ions is below the critical levels for animal feeds ([Li et al., 2012](#)).

4. Views on Climate Change, Innovation and Governance

4.1. Climate Change

Climate Change refers to the impact that artificial and natural forces have on the ecosystems and environment around the world. Examples of artificial influences include things like deforestation ([National Geographic, n.d.](#)), conversion of fossil fuels ([Stanford University, 2023](#)), industrial waste ([Ejaz et al., 2024](#)), and erosion of marshland ([Lu et al., 2024](#)). The erosion of arctic layers causes sea levels to rise and produces extensive flooding ([Khojasteh et al. \(2023\)](#)). It is often viewed as a hybrid of natural and artificial forces that extensively damages the economies and ecosystems of coastal victims. [Jun, Salhab, & Jafino \(2022\)](#) posits:

“Regionally disaggregating global exposure headcounts, it becomes apparent that flood risks are particularly prevalent in certain regions. At 668 million people, the East Asia and Pacific region has the highest number of people exposed to significant flood risk, corresponding to about 28% of its total population. In South Asia, 576 million people are exposed to significant flood risk (about 30.4% of the

population). Between 9% - 20% of the regional populations of Sub-Saharan Africa, Europe and Central Asia, Middle East and North Africa, Latin America, and the Caribbean, and the United States and Canada are exposed to high flood risk” (Jun, Salhab & Jafino, 2022).

Geographic regions differ in their adoption, beliefs, and prioritization of remediation techniques, and sometimes, these variations are divided along economic and political ideology. Smaller countries are always vulnerable because they need access to funding or innovation necessary to reduce or avert these threats.

4.2. Technology and Innovation

Early detection is the prevalent denominator in this research towards water conservation and preservation of water quality. Three (3) notable new technologies are present to assist in these goals. Most of these items fall under aquaculture, which entails realtime monitoring of aquatic environments and ecosystems to ensure proper water conditions that do not harm lakes, ponds, or marine life. The items are Aquasend Beacon, Bionic Robotic Fish, and SeaRAS Realtime Aquasense System.

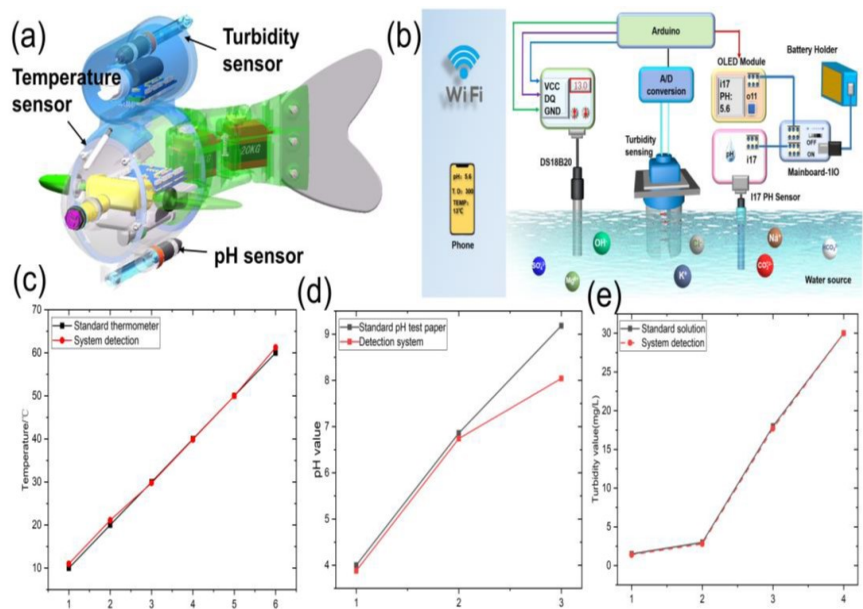
4.2.1. Case Study 1: Aquasend Beacon

Hawaii is known for its luscious rainforests nestled in between massive volcanic structures. However, most people do not know they are experiencing significant ecosystem loss. “Prior to Hawaii’s statehood, there were nearly 500 natural fishponds; over time, it has decreased to less than 100; therefore, restoring this rich cultural and natural heritage (Waikalua Loko I’a) is crucial to the aquaculture industry” (Aquasend, n.d.). As noted in other countries, stagnant water, due to erosion and runoff, has created mass algae blooms, reducing fish’s viability to remain in the pond due to loss of oxygen levels. Ancestral keepers of the ponds created walls and gates to contain the fish in a safe environment; with proper oxygen levels, these are no longer effective and must be augmented to save the ecosystem. Aquasend employed three beacons to detect water conditions and proactively remediate them by integrating native mullet and milkfish because they consume algae and sediment, naturally remediating the water quality (Moriarty, 1976).

4.2.2. Case Study 2: Bionic Robotic Fish

Robotic fish have been studied for the last two decades, beginning in 2004 with Lauder & Drucker and most recently with the introduction of three-dimensional autonomous devices in MicroMachines (Chen et al., 2023). The earliest usage was to study fish behavior; however, it has since expanded to monitoring water quality, observing and tracing industrial waste (oil spills), and patrolling harbors and coastlines (Tan, 2011). The newest model has expanded capability, enabling the bionic robotic fish to detect multiple parameters, such as water temperature, pH value, and turbidity in aquatic environments, in a more efficient manner completing testing with a lake on underwater navigation and data collection of water quality parameters (see **Figure 3**), of pH, temperature, and turbidity sen-

sitivity (Tan, 2011).



Components	Description
A	Temperature Sensor Turbidity Sensor pH Sensor
B	Schematic of the configuration to support Wi-Fi network and iPhone Application
C	Graph plot of standard thermometer and system detection
D	Graph plot of standard pH test paper and detection system
E	Graph plot of standard solution and system detection

Figure 3. Bionic Robotic Fish. Source: Chen et al. (2023: p. 9).

4.2.3. Case Study 3: SeaRAS Aquasense

SeaRAS (Lien et al., 2022) is specifically designed to detect the presence of one very dangerous toxin in society, Hydrogen sulfide (H₂S). This toxin can occur in various environments, some of which are as simple as a decaying well system, a fish farm exposed to decaying soil and rocks, or the byproduct of offshore oil drilling. In either scenario, hydrogen sulfide is recognized as one of the most toxic threats to all aquacultures; this toxin accounts for a significant amount of the Norwegian salmon population annually (Somerset et al., 2020). Fish farms exist worldwide, so the SeaRAS AquaSense system (AQS) has many potential applications in aquaculture:

“AquaSense system(AQS) is a mobile, wireless-based, and realtime monitoring system for measuring water quality parameters such as carbon dioxide, dioxygen, hydrogen sulfide, pH, salinity, temperature, total gas pressure, and turbidity. The sensors of this highly sophisticated machinery are not directly exposed to water, ensuring low maintenance and high levels of accuracy.

AQS was designed to assist researchers, experts, and fish farmers in achieving timely and accurate gas formation mechanisms to employ the best possible mitigation strategies to reduce contamination and salmon loss in fish farms” (Lien et al., 2022).

5. Governance

Water conservation and quality preservation should be at the forefront of every country’s government sector. Many have experienced profound impacts from flooding or scarcity, compromising human health and well-being. As a result, many countries (as published by [Jacque et al., 2024](#)) have worked individually and collectively to develop governance measures to avert forecasted issues:

“For instance, member states of the European Union are required by the Water Framework Directive to protect and restore their waterbodies to ensure sufficient water is available to support wildlife and human needs (European Commission, n.d.). Similar policy frameworks also exist at the national scale, such as the Canada Water Act (Environment and Climate Change Canada, 2023), Australia’s National Water Initiative (Productivity Commission, 2021), the Water Law of the People’s Republic of China (FAO, 2023b), or India’s National Water Policy (Ministry of Water Resources, 2012). Internationally, the United Nations (UN) has committed to ‘ensure availability and sustainable management of water and sanitation for all’ (United Nations Department of Economic and Social Affairs, n.d.) through its 6th Sustainable Development Goal. They also publish the annual UN World Water Development Report, prepared by the UNESCO World Water Assessment Programme, (United Nations World Water Assessment Programme, n.d.), which aims to provide ‘an authoritative and comprehensive assessment of the overall state, use, and management of the world’s freshwater resources’ and support decision-makers to establish sustainable water policies” ([Jacque et al., 2024](#): p. 572).

These efforts represent significant strides toward the mutual goals of water conservation and preservation in society. There is no quick, single solution because these complex problems are cumulative and take many years to manifest. Therefore, it will likely take an equitable amount of time to resolve; however, diligence in collaboration and communication can propel society forward to an amicable and efficient resolution.

6. Findings

6.1. North America

Several waterways border the physical continent of North America; these include the Arctic Ocean, Hudson Bay, Great Lakes, Labrador Sea, Atlantic Ocean, Caribbean Sea, Gulf of Mexico, Pacific Ocean, Gulf of Alaska, Bering Sea, and Beaufort Sea. Within the land mass are the forty-nine states of the U.S., the Canadian

Shield, the Appalachian Mountains, Coastal Plan, Sierra Madres, Sierra Nevada, Rocky Mountains, Cascades, West Coast Range, Alaska Range, Brooks Range, and Great Plains. The region is also shared with Alaska, Canada and Mexico. This massive assortment of geographic regions includes freshwater and saltwater bodies, lakes, ponds, canals, and rivers. Some are directly sourced from (cyclical phases of freezing and melting water) the Arctic layers, which trickle down from the mountainous regions through rivers, gorges, and canals until they reach the coastal plain and ranges on the western and eastern sides.

Early America enjoyed clean water and streams with minimal instances of pollution and contamination; however, as it matured and expanded industrialization, aggressive development produced toxins that spread and began to compromise its sources and contributors. Aging infrastructure (inadequate maintenance) can create issues within metropolitan cities that can produce hazardous environments for everyone because when plumbing fails, treated water mixes with raw sewage or general run-off, creating unsanitary conditions. In rural and suburban areas, human negligence (removal of marshlands or industrial waste) also produces contamination of lakes and ponds or reduces their ability to perform natural remediation through fish and plants.

Fortunately, several regions within America have developed governance structures to remediate known problems with protective measures for natural wildlife preservation, protected marshlands, and penalties for illegal dumping and toxic spills. Many philanthropic groups within the states have funded organizations that monitor and track large and small bodies of water such as forges, lakes, ponds, and rivers to ensure they are clean, safe, and self-sustaining using both animal and plant bioindicators facilitated by a society of riverkeeper and waterway protectors.

6.2. South America

The Caribbean Sea, North Atlantic Ocean, South Atlantic Ocean, and South Pacific Ocean border South America. The land mass consists of the Andes Mountains on the western edge, the Amazon rainforest in the North, a large central lowland area, and the Brazilian and Guiana Highlands. It contains Venezuela, Guyana, Suriname, French Guiana, Brazil, Uruguay, Argentina, Paraguay, Bolivia, Chile, Peru, Ecuador, and Colombia. This continent has unique characteristics: polarities, a lush rainforest in the North, and one of the driest deserts on the western coast. Although South America contains some of the driest areas in the world, river waterways still exist here, and these include Paraguay, Purus, Rio de Plata, Sao Francisco, Tocantins, Parana, Uruguay, Japura, Jurua, Orinoco, Rio Negro, and the famous Amazon River.

Like many other countries, Early South America experienced growing pains because infrastructure was insufficient to support its growing needs. Argentina's water issues are well known because of the diverse accumulation of events in the country. There are desert-like geographic parts, which create challenges for basic

hygiene and hydration for humans and animals. Inadequate hygiene in the operation of small wells can result in unintended contamination, and ground run-off during seasonal flooding contaminates city water supplies because their aging or inadequate infrastructure is incapable of supporting this load of untreated sewage. South America employs a series of bioindicators using aquatic macroinvertebrates to help address these concerns.

6.3. Eurasia

Eurasia consists of the regions of Europe and Asia; it is one of the largest land masses in the world. The Atlantic Ocean, Arctic Ocean, Pacific Ocean, Indian Ocean, North Sea, Baltic Sea, Black Sea, Caspian Sea, Aranian Sea, Norwegian Sea, Barents Sea, Kara Sea, Laptev Sea, Eastern Siberian Sea, Chukchi Sea, Sea of Okhotsk, Sea of Japan, Yellow Sea, East China Sea, South China Sea, Philippine Sea, Mediterranean Sea, Red Sea, and Bay of Bengal border it. The land mass is bordered by the Arctic Circle in the North, Japan, North Korea and South Korea, and the Taiwan Region of China in the East. Vietnam, Cambodia, Thailand, Myanmar, Bangladesh, India, Sri Lanka, Pakistan, Iran, United Arab Emirates, Oman, and Yemen border the Southern region. Norway, Sweden, Denmark, Netherlands, Portugal, Spain, France, Germany, Italy, Greece, Serbia, Romania, Bulgaria, Türkiye, Syria, Lebanon, Israel, Bahrain, and Saudi Arabia border the Western region. The longest rivers navigating within the land mass include the Yangtze, Yellow, Mekong, Volga, Euphrates, and Danube.

Eurasia is the most diverse environment on Earth's planet. This group of inhabitants has the greatest span of polarization in country size, economic and technological capability, culture, religion, politics, and societal structure (open and closed community). There are also unique characteristics across the region; some areas have abundant unencumbered natural resources, and others have scarcity, with challenges in access to water for human use and irrigation systems – there is no standardization. In this environment, using central authority helps identify, prioritize, and facilitate humanitarian efforts and societal maintenance. However, this is complicated because of the prior divisions in governance structures, as some areas are intentionally private and protected rather than open and fluid to everyone.

Many countries within Eurasia experience water quality themes like those in other continents, like over-crowding (poor hygienic issues), failing infrastructure (plumbing), and contamination (run-off of decaying matter and sewage) due to repetitive flooding events. Those who are more affluent can develop or purchase solutions for remediation, while others rely on the philanthropic initiatives of the various divisions of the World Health Organization (WHO) to develop programs in re-action or prevention of water crises. Both animal and plant bioindicators are currently employed in Eurasia; some are manually monitored in small rural communities, and others are automatically monitored or tracked with technology.

6.4. Africa

The Mediterranean Sea, Red Sea, Gulf of Aden, Somali Basin, Mozambique Channel, Natal Basin, Cape Basin, Angola Basin, Guinea Basin, Gulf of Guinea, Sierra Leone Basin, Canary Basin, Indian Ocean, North Atlantic Ocean, and South Atlantic Ocean border the continent of Africa. The land mass is bordered in the North by Morocco, Algeria, Tunisia, Libya, and Egypt. Sudan, Ethiopia, Somalia, Kenya, Tanzania, and Mozambique are on the Eastern side. Western Sahara, Mauritania, Senegal, Guinea, Cote D'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Gabon, Congo, Angola, and Namibia on the Western side, with South Africa bordering the Southern coastline. The major rivers within Africa include the Nile, Congo, Niger, Zambezi, and Orange.

Africa has a diverse culture, including metropolitan cities, deserts, jungles, volcanos, villages, flatlands, and coastal ports. The continent has severe polarization of resident type and economic conditions, and it shares the common themes of other continents regarding water collection, purification, and cross-contamination issues. Many of the humblest constituents of Africa still live in villages, following their ancestral cultures (like those in Native Mexico) because they do not wish to adopt new technology. Africa uses animal and plant bioindicators where possible, and its operations include manual and automated collection methods.

6.5. Australia

The continent Australia is the smallest land mass; the Indian Ocean, Timor Sea, Arafura Sea, Gulf of Carpentaria, Coral Sea, Pacific Oceans, Tasman Sea, and Indian Ocean surround it. The Great Sandy Desert, Barkly Tableland, Great Dividing Range, Australian Alps, Nullarbor Plain, and Australian Shield border it. The major rivers include Murray, Darling, Murrumbidgee, Lachlan, Cooper Creek, Flinders, and Diamantina. This continent has a unique mineral composition; the economy is driven by mining for iron, coal, oil, and gold. Early Australia suffered some of the same challenges with water-borne disease (as other continents), primarily due to overcrowding and poor hygienic care during the height of mining efforts. Australia uses various animal and plant bioindicators to assess water and soil conditions to protect its human and animal inhabitants and rainforests, cattle, and winery businesses.

6.6. Antarctica

Antarctica is the coldest land mass on the planet; nearly 98% of it is covered with ice and snow. The temperature stays near freezing or below most of the year. The Atlantic Ocean, Indian Ocean, Pacific Ocean, Wendell Sea, Ross Sea, Amundsen Sea, and Bellingshausen Sea border it. The land mass consists of Ellsworth Land, Queen Maud Land, East Antarctica, Wilkes Land, Victoria Land, Marie Byrd Land, and West Antarctica. Current research is underway to determine the viability of an ancient river beneath the ice sheet that dates to 34 million years ago (Jammieson et al., 2023). Antarctica doesn't have any substantive water conservation

issues other than premature glacier melting due to increased temperatures (climate change) because the entire continent is covered in water (solvent) in its frozen state (ice). Water quality is considered excellent, and animal and plant bioindicators are used to assess these conditions.

7. Conclusion

Planet Earth relies upon water to survive, and its inhabitants (animals and humans) require this crucial nutrient within their internal biology to support proper functioning. Therefore, the abundance and quality of this nutrient are crucial within society. Every continent on this planet has some form of access to water. However, the quality of that water varies depending on the process used to collect and distribute it between the source and recipient. Many communities still rely on the collection and purification methods taught by ancestral generations; others have migrated to newer techniques with the introduction of computerized systems. The delineation remains aligned with the community's geographic size and economic conditions (wealth).

Many disparate communities share cyclical behaviors and experiences in water conservation and purification. Industrialized areas like cities have modern access through internal plumbing systems. However, these items need to be adequately maintained, and the lack of prioritization in these areas keeps extending this maintenance. This fails when heavy flooding occurs, creating cross-contamination with sewage and run-off over unsanitized areas. Coastal areas still enjoy abundant water access, and some add desalination techniques (as appropriate) coupled with traditional animal and plant bioindicators to detect pollutants. Inland areas with water scarcity due to desert-like climates have challenges associated with the basic hygiene of small-well operators, leading to cross-contamination. Communities in these areas also have primitive (historical) methods for collection of rainwater for domestic use, and collection of ground run-off over unsanitary areas for agriculture and irrigation, and this leads to further contamination which triggered the historic water-borne illnesses of years past (typhoid, cholera, plague) worldwide.

The World Health Organization (WHO, 2015) characterizes this as “water-stress” because it entails the complex challenges that exist for many small, poor countries because their sources are seriously compromised because they lack standardized water treatment services, which keeps them in a perpetual mode of water-borne illnesses and water scarcity.

The United Nations Environment Programme, Convention on Biological Diversity, and World Health Organization published a set of perspectives on several critical issues involving society titled *Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review* (WHO, 2015). This research reveals a broad spectrum of global concerns that affect every continent, noting current and proposed strategies for overcoming these challenges. Section II of this document, titled “Thematic areas in Biodiversity and Health”, focused on fresh-

water, wetlands, biodiversity, and human health. The contents of the discussion demonstrated a profound knowledge of the depth and breadth of the situation worldwide, noting the struggles of each continent along with the historical and current technology tools employed to remediate these problems and their limitations.

The report reveals many complex perspectives related to ecosystems and human health that are well beyond the scope of this research. The most challenging issue involves escalating specific water treatment techniques to address the contents of processed and unprocessed water sources. The newest dilemma involves how to reduce the amount of 1) commonly anticipated pathogens (sewage, fertilizers, pesticides, herbicides, and bacteria) and 2) unexpected pathogens (pharmaceutical and recreational drugs, toxic hospital wastes, heavy metals, and mercury poisoning) that are creating antibiotic-resistance outcomes (Xu et al., 2022) in vulnerable populations of people that desperately need medicine to survive. The WHO recognizes and supports animal and plant bioindicators to assist in environmental and water quality monitoring; the team is knowledgeable about these problems and needs more funding and resources to accomplish the goals.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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