Advanced Journal of Environmental Sciences
Volume.16, Number 5; May-2025;
ISSN: 2837-3928 | Impact Factor: 9.38
https://zapjournals.com/Journals/index.php/ajes
Published By: Zendo Academic Publishing

RESEARCH ADVANCES ON FACTORS OF CORROSION AND WATER QUALITY IN DAMS: A REVIEW REPORT OF THE PROGRESS

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Article Info

Keywords: Dams, Importance, Water quality, Infrastructural systems, Distribution systems, Corrosion degradation, Influencing factors, Monitoring

DOI
10.5281/zenodo.15439442

Abstract

Corrosion is a natural environmental problem that affects all our industries, products, infrastructures, equipment, systems, etc., and impacts every person, community, nation, and the entire world with shocking cost. Dams are essential for many purposes, including water supply for different uses, but they are subject to many water quality and corrosion issues. This paper reviews the corrosion factors in dams as they relate to water quality and affect the integrity status of the water distribution and infrastructural systems. The paper demonstrates from relevant research information that the quality of dam water is influenced by various chemical and physical factors that need to be monitored and controlled to achieve the required water quality and also avert corrosion of metals like steel and other material types used in dam infrastructures and water distribution systems. Corrosion linked to dam water can lead to issues like leaking in associated pipes and storage tanks as well as the leaching of toxic heavy metals into or the introduction of corrosive substances into the dam water supply, which can all reduce the water quality. The paper demonstrates further that; several factors, including temperature, pH, alkalinity, electrical conductivity, the reaction of dissolved gases (particularly oxygen and carbon dioxide) with metals, reverse osmosis-treated water, and the presence of corrosive ions like chloride, sulfate, and bicarbonate, as well as the turbulence level, flow rates, the natural composition of the water source (such as water from specific geological formations), the presence of microorganisms, changes in land use, pollution in the catchment area, etc., influence both corrosion and water quality in dams. The review information is pertinent for researchers, students, stakeholders, corrosion and quality control strategists, etc., in their varied endeavors to achieve the quality standards of dam waters and preserve the integrity of all system components that must be in service contact with dam waters.

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1.0 INTRODUCTION

Dams are essential for managing water resources, producing energy, and sustaining a range of human endeavors. They are an essential piece of infrastructure for a sustainable and dependable future because of their capacity to store and control water [1, 2]. A closer examination of the significance of dams reveals that they [1-4]:

i. Provide reservoirs for holding water that can be released to satisfy various demands in the industrial, agricultural, and domestic sectors.
ii. Assist control of river flows to guarantee a consistent water supply even during dry spells.
iii. Are essential for preventing floods by holding surplus water during periods of heavy rainfall or snowmelt to restrict floodwaters and release it later, lowering the risk of downstream flooding and safeguarding people and property.
iv. Are used to generate sustainable electricity that can be transmitted to power homes, commercial outfits, and industries by using the flow-controlled river water to turn turbines to produce clean electric energy.
v. Can be used in conjunction with lock systems to enable ships to cross variations in river level and can aid in increasing the depth of water in rivers, facilitating ship, boat, and barge traffic and the transportation of goods.
vi. Store water released for irrigation to help with food production and agriculture in arid and semi-arid regions to ensure food security.
vii. Create reservoirs for recreational activities like boating, fishing, and water sports.
viii. Aid in capturing silt, keeping it from building up downstream and affecting the quality of river water.

Corrosion is a natural environmental problem that affects all our industries, products, infrastructures, equipment, dams, systems, etc., and impacts every person, community, nation, and the entire world with a shocking cost [5-7].This problem has significant impacts on water distribution and infrastructure systems, as well as the quality of water in many dams because of silt buildup, excessive pollution by chemicals from different sources, and the gradual emergence of microbial activity. Concrete, rockfill, and compacted earth fill comprise the majority of dam infrastructures, whereas a range of materials, including concrete, metals like copper, cast iron, ductile iron, and galvanized steel, plastics like PVC, and cross-linked polyethylene (PEX), fiberglass, and wood, are used to build water distribution systems. Depending on the location and construction of the dam, additional materials such as rubber or wood may be used for certain purposes, such as sealing joints or channel lining. Storage tanks, boats, ships, turbines, pumps, and valves are examples of auxiliary infrastructures frequently associated with dams for specific uses. These structures can be made of concrete, aluminum, stainless steel, carbon steel, plastic, and other materials. However, depending on the corrosivity of the dam water, all of these materials are susceptible to different degrees and types of corrosion, which can result in the leaching of heavy metals or other harmful compounds into the dam water [8-10].

When using dam reservoirs as water supply systems, it is important to determine water aggressiveness. Corrosiveness of dam water is a key indicator of its quality, impacting the lifespan and maintenance of infrastructure and potentially impacting water quality and human health [3, 4]. The impacts of corrosive dam water are that it can weaken and damage pipes, tanks, and other infrastructure used for storing and distributing water; it can cause trace metals to leach out of pipes and fixtures, potentially contaminating the water supply; and it can lead to frequent repairs and replacements, increasing maintenance expenses for infrastructure and water systems. Although not a direct health hazard, it can introduce harmful metals into the water, posing a potential health risk. Therefore, information on the corrosivity of dam water is crucial for maintaining the integrity of water infrastructure, ensuring safe and reliable water supplies, and minimizing long-term maintenance costs [2, 4, 8-

10]. Changes in water properties and qualities, such as becoming cloudy, discolored, or bad taste, can be caused by various factors like pollutants or dissolved minerals. These are not considered corrosion but are contributive to corrosion since water itself does not corrode but only deteriorates in quality. The corrosivity and quality of water influence each other, as can be seen, and they are distinct processes that occur simultaneously in most dam environments with crucial effects. There are several factors that affect the corrosion and water quality of dams. Most of the factors vary in types and quantity concentrations from dam to dam and season to season, so they need to be properly investigated, routinely monitored in types and quantity concentrations, and controlled in specific dams through research efforts and practice standards to avoid costly corrosion and water quality issues in dams. The aim of this paper is to present a review report of research information on the monitoring of corrosion factors in dams as they relate to and contribute to the water quality and also harm the integrity of infrastructural and water distribution systems in dams for better knowledge or awareness of properly controlling them in line with standard practices and further research needs of improving structural safety as well as water quality in dams [8-10].

2.0 REPORT OF THE REVIEW

2.1 Methodology

The review information was sourced from various relevant journal articles, books, theses, and conference papers in hard and soft copies and, recapitulated and integrated for better readability and understanding to provide a more comprehensive knowledge on the subject than information from several individual sources.

2.2 Outline of Factors that Affect Corrosion and Water Quality in Dams

The corrosion and quality-affecting factors in dam water and other waters include pH, alkalinity, hardness, and the presence of dissolved minerals and pollutants. These factors can be measured using some indices like the Langelier Saturation Index (LSI) and Ryznar Index (RI), which assess the balance between pH and calcium carbonate saturation. A decrease in pH below 6.5 generally indicates increased corrosivity, whereas an increase in pH above 8.5 leads to greater scaling and incrustation problems [8-12]. High alkalinity can result into corrosiveness, especially in softer water. Soft water, that is, water that is low in calcium and magnesium, can be more corrosive. High levels of total dissolved solids (TDS) can increase conductivity and enhance corrosion. Dissolved oxygen can accelerate corrosion in some cases. Higher water temperatures can increase the rate of corrosion. High levels of chloride or other ion concentrations can also contribute to corrosion. The minerals and organic content in dam water can individually and collectively greatly impact the dam's corrosion-causing capability and water quality. For example, minerals like iron and manganese can lead to water discoloration and scaling, whereas organic matter can contribute to water taste and odor issues and favor bacterial growth. The pH and other chemical parameters can be influenced by certain minerals and organic compounds, which alters the corrosivity level of water. Excessive concentrations of dissolved minerals, especially those associated with acidity, can aggravate corrosion in water pipes and other infrastructural systems [9-12]. Organic compounds, such as those from decaying industrial waste or vegetation, can help to form acidic conditions that aggravate corrosion. The interactions between organic matter and minerals can result in complex chemical reactions that intensify corrosion, especially in the presence of oxygen and other factors. Manganese and iron can cause brownish or reddish discoloration and off-flavors in water, whereas high concentrations of calcium and magnesium in water can result in scaling formation and reduction in soap lathering, with an impact on water quality. Moreover, high concentrations of certain minerals in water can make it unpotable for humans or unsuitable for irrigation. Organic compounds can cause unpleasant tastes and odors in water, making it less palatable. Organic matter can also serve as a nutrient source for microorganisms, leading to bacterial growth and potential health risks. Organic matter, along with suspended solids, can increase the turbidity or cloudiness of water, reducing its aesthetic appeal and transparency. Organic matter can also bind with heavy metals, altering their bioavailability and potentially making them more toxic. The permissible levels of individual mineral and organic components are included in some regulations, such as the Minister of Health and the European Union (EU) directives. According to such directives, the quality of water intended for human consumption should be monitored, consumers should be informed about its quality, and the necessary steps should be taken to ensure that any substances or materials used in conditioning or distribution do not deteriorate its quality and do not directly or negatively affect people's health. Most of the water pollution harmful to health comes from the distribution system and not the water source. Corrosion and the processes of precipitation of corrosion products have a very large contribution here. Corrosion products stimulate the formation of a biofilm layer inside pipelines, resulting in biological contamination of water [3, 4, 8-12].

Water corrosivity is measured using the Langelier Saturation Index (LSI)**.** This index is widely used to assess whether water is probably corrosive or scale-forming. It considers factors like pH, temperature, alkalinity, and hardness to determine the saturation state of calcium carbonate. The Ryznar Index (RI) is another tool for predicting the scaling or corrosiveness potential of water, particularly in relation to calcium carbonate. It also considers the Aggressiveness Index (AI), which can be used to assess the corrosivity of water toward specific materials, like asbestos-cement pipes, and the Water Quality Index (WQI) and Water Stability Index (WSI), which are indices that can be used to assess overall water quality and include factors related to corrosivity [2-4, 8-12].

2.3 Monitoring of Corrosion and Water-Quality Factors in Dam Water

Chemical analysis, physical testing, and biological analysis are common techniques for monitoring corrosion and water quality in dams [12, 13]. These techniques help in assessing the factors of corrosion and water quality to understand the water dynamics in dams for control or various uses. Chemical analysis is achieved by laboratory sampling using advanced techniques such as multivariate analysis, colorimetry, HPLC, and other complex methods. Chemical analysis is concerned with the measurement or determination of factors such as pH, dissolved oxygen (DO) as a contributor to biological activity and corrosion rates, total dissolved solids (TDS) as an indicator of the amount of dissolved minerals and salts in the water and a contributor to corrosion rate, conductivity as a measure of dissolved solids in the water as well as the presence level of ions in the water and the water's capability to conduct electricity, and detection and quantification of heavy metals such as mercury, cadmium, and lead, which can contaminate the water and influence its quality. Chemical tests include organic compounds, pesticides, and other pollutants. The natural chemical composition of water based on its geological origin only and its interaction with the surrounding environment, including the breakdown of organic pollutants and leaching of reactive aquifer constituents, is also important in chemical analysis. The physical tests for water quality are its color, odor, and turbidity for visual and sensory assessments of its quality and temperature as an influencer of chemical reactions and corrosion rates. Biological monitoring is achieved by microbial analysis to identify bacteria and other microorganisms that contribute to water contamination and corrosion, as well as bioindicators, which provide insights into water quality and assess the health of aquatic ecosystems [12, 13-15].

A number of manual and automatic monitoring techniques that involve corrosion rate determination are used for assessing changes in corrosion rates over time, such as ultrasonic testing, which employs ultrasonic waves to detect corrosion in structures; use of electrical, electrochemical, and magnetic sensors to detect corrosion rates or various levels of physical, chemical, and biological entities that influence corrosion and water quality; sand erodibility tests to evaluate the potential of the water to erode materials; statistical analysis to analyze data from various monitoring techniques and identify trends and patterns; and water quality index (WQI), a simplified method for evaluating water quality based on multiple parameters [12, 13].

Advanced monitoring techniques such, as remote sensing which uses satellites or aircraft to monitor water quality and changes in the surrounding environment. Real-time data collection, analysis, and administration are made possible by the Internet of Things (IoT) technology to significantly enhance water quality monitoring. The pH, temperature, dissolved oxygen, turbidity, and conductivity of water can all be continuously monitored by IoT devices equipped with various sensors. These sensors transmit the monitored information to centralized systems, where it is examined to identify contaminants, predict instances of pollution, and ensure that environmental laws are followed. For instance, smart sensors in water bodies can identify and notify authorities of biological contamination or chemical spills, enabling quicker mitigation and reaction measures. Moreover, by offering real-time information on the effectiveness of the filtration and purification phases, IoT-enabled devices can enhance water treatment operations and guarantee the delivery of safe drinking water. In addition to improving the precision and effectiveness of water management techniques, the application of IoT in water quality monitoring supports public health and environmental sustainability. Other advanced or emerging technologies applicable to corrosion and water quality monitoring in dams with much greater advantages than traditional monitoring techniques include artificial intelligence (AI), which has the capability of machine learning, fiber optics and wireless monitoring technology [13-16].

However, all the monitored values of the corrosion and water quality-affecting factors in dams need to be analyzed in accordance with standard designations of the values by reputable authorities based on the intended use of the water, such as drinking, agriculture, recreation, in-stream, and industrial uses [15-20]. Water quality standards for various uses are developed by many national and international organizations. National standards are frequently based on guidelines provided by the World Health Organization (WHO) on a global scale. Furthermore, standards for water quality for various uses, such as industrial water, drinking water, and water sampling, are published by the International Organization for Standardization (ISO). Many countries also have their own national authorities, such as the Nigerian Standard for Drinking Water Quality (NSDWQ) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) in Nigeria, the Bureau of Indian Standards (BIS) in India, the Ministry of Ecological Environment (MEE) and the Ministry of Water Resources (MWR) in China, and the Environmental Protection Agency (EPA) in the United States, that set and enforce standards for water quality in the domains of their respective jurisdictions. Regional organizations such as the European Union have also established their directives and standards for water quality within their member countries [12, 13-18]

2.4 Research Report on Corrosion and Water Quality Monitored Factors in Dams for Control Purposes

Frequent monitoring of corrosion-causing or water-quality-affecting parameters in dam waters and counteracting or controlling them to acceptable or safe conditions is the first crucial step to avert catastrophic structural failures and health issues in the usage of any dam water for specific purposes [19, 20]. Some research or practices from the literature on controlling factors of dam water corrosivity and quality show that:

Irenosen et al. [21] analyzed composite water samples taken from Owena Multi-purpose Dam in six sampling campaigns covering the wet and dry seasons for physicochemical and microbial characteristics using standard methods for the examination of water and wastewater jointly published by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Results showed significant ($p < 0.05$) seasonal variations in most measured parameters, with few showing significant spatial variation. The characteristics of the water from the dam lake revealed acceptable quality for most measured parameters with a low chemical pollutant burden compared with drinking water standards and water quality for aquaculture. However, high values of turbidity, color, iron, manganese, and microbial load were recorded compared with drinking water standards, which call for proper treatment of the water before distribution for public consumption.

According to Ezugwu [22], Nigeria has a large number of surface water bodies and suitable dam locations that could be used to build reservoirs for a range of water uses, such as groundwater recharge, hydropower production, flood control, water supply, irrigation, navigation, tourism, sanitation, and the development of fish and wildlife. The effects of disasters and dam construction on people and the environment were investigated. Flooding is severely damaging several areas of our nation. The effects of dams and previous dam failures were also described. Numerous reasons for dam failure were listed. Also included were suggestions on how to prevent dam catastrophes in our nation in the future.

Ojelabi et al. [23]. Stated that Eleyele Dam water was abstracted by the Oyo State Water Corporation at Eleyele Treatment Works for the treatment and supply of potable water to Ibadan city. The dam is exposed to flooding and pollution by human and industrial activities within the city metropolis. The quality of the water samples taken along the course of the dam was assessed. The samples were examined for physical, chemical, and bacteriological parameters using standard procedures. The results showed high concentrations of alkalinity, hardness, and bacteriological and heavy metal contaminants (lead and iron) compared with the World Health Organization (WHO) and the Standard Organization of Nigeria quality standards for drinking water. The high concentration of contaminants calls for great attention because inadequate water treatment before human consumption can result in the bioaccumulation of heavy metals and result in a public health concern. The study recommends that the dam should be prevented from flooding and human and industrial activities, while proper and adequate water treatment of the dam's water should be ensured before its supply to the metropolis.

According to Mohseni-Bandpei et al. [24], one of the most crucial concerns in managing water supply resources and demand is the water quality pattern, which is influenced by the input regime and site specification. The study evaluated the water quality of Latyan Dam, a significant reservoir that provides Iran's capital city of Tehran with drinking water. Water samples were collected every month at the four dam depths. Temperature, pH, turbidity, total dissolved solids (TDS), electrical conductivity (EC), hardness, silica, ammonium, nitrate, nitrite, total phosphorus (TP) concentrations, and other physical and chemical characteristics of the water were tracked between May 2014 and January 2017. The statistical analysis's findings showed that the depth had an impact on the dam's water quality based on five variables: turbidity, pH, EC, SO_4^{2-}, and TP ($p < 0.05$). Furthermore, seasonal fluctuation analyses revealed that eleven of the seventeen variables—EC, turbidity, TDS, Ca^{2+}, K, Cl^-, SO_4^{2-}, silica, nitrate, and TP—were statistically significant ($p < 0.05$). By comparing the mean readings, it was possible to determine that the slightly higher wintertime levels of EC, TDS, Ca^{2+}, K^{2+}, Cl^-, and SO_4^{2-} were likely caused by the diluting effects of seasonal precipitation. During the spring, nutrient-like distribution of nitrate, TP, and silica were much greater, indicating eutrophication and strong diatom activity. Compared with the other seasons, which also showed the impacts of rainfall, turbidity was higher in the autumn. In comparison with other seasons, the aggressiveness index (AI) evaluation indicates that winter water is both noncorrosive and mildly corrosive. Furthermore, based on the research findings and a comparison with national and international water quality standards and regulations, it can be concluded that the water quality of Latyan Dam throughout the study period was suitable for use as a drinking water source. However, a precise and ongoing assessment of the water quality in the reservoir is considered essential because of the alterations in phosphate and nitrate, as well as the widespread emergence of the eutrophication issue.

Youdeowei et al. [25] presented a paper that focused on the effectiveness of various dams in Nigeria with respect to configuration and purpose, size, lifespan, and sustainability. The paper outlined the causes of dam failures were outlined, and their lifespans were compared to their configuration, location, and objectives. The results obtained from the study show that Nigeria has large, medium, and small dams that are also single-purpose. The dam structures will live out their lifespan effectively and sustainably as estimated from the designs, except for the action factors such as changes in the hydrology of the dam location, changes in the design criteria, and natural disasters. The need to know the degree to which dam structures achieve the directed result or purpose, the lifespan of each dam before rehabilitation, and the sustainability of the dams in Nigeria, bringing the attention of the government and private owners to the need for construction and maintenance, was the basis of their paper.

Ogbodo et al. [26] conducted a study on the assessment of physicochemical parameters and the overall water quality index of the Lower Usuma Dam water during the rainy and dry seasons in a cycle (year 2019). Parameters such as temperature, pH, sulfates, nitrates, phosphates, total hardness, turbidity, and color were determined using respective standard methods, and the overall water quality index for the period under review was determined using the weighted arithmetic method. The results showed that optimum water quality for the dam is obtainable during the dry season, whereas poor water quality was observed during the rainy season. The water from the dam was observed to have an overall WQI value of 72.02 (grade C), indicating that it is suitable for irrigation and industrial use but requires treatment before drinking. The data obtained were analyzed using one-way analysis of variance (ANOVA), and significant differences were accepted at $p \leq 0.05$. There was an observed statistical difference in the physicochemical properties of water in the rainy and dry seasons.

According to Warda et al. [27], the agricultural industry at Cheffia Dam, which is situated in the El Tarf region, relies heavily on water to meet the demands of multiple civilizations. Irrigation water must have physicochemical characteristics that crops can tolerate. The aim o their study was to assess the water quality of the Cheffia Dam. Over the course of three months—February, March, and April 2019—three sampling spots were chosen in order to ascertain the water's physicochemical and bacteriological characteristics. Water samples were subjected to analyses of several physicochemical parameters and heavy metal concentrations, including T, pH, EC, DO, salinity, turbidity, Cl^-, Ca^{2+}, Mg^{2+}, NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, and Fe^{2+}. Total germs, fecal coliforms, and fecal streptococci were the main subjects of the samples collected for the bacteriological investigation. The study findings show that for drinking and irrigation water, most physicochemical parameters in Cheffia Dam were within or near the WHO and Algerian acceptable limits. The obtained bacteriological data show that fecal streptococci, fecal coliforms, and total coliforms were present in substantial amounts. The runoff and unsanitary practices in the study area may have contributed to the elevated loads of these pathogens throughout the study period. The microbiological contamination index computation verifies that there is no deterioration in the quality of water when contamination is zero. Although leaching, challenges in moderately permeable soils, and drainage should be taken into consideration, the surface waters under study were of good quality for agriculture and may be used to irrigate most crops.

Sey and Belford [28] argued that heavy metal pollution from tailing dams has become a major global concern due to its toxicity, persistence, and accumulative potential, with detrimental effects on public health and environmental receptors. In a bid to determine the contamination status of a decommissioned tailing storage facility (TSF 2) from Chirano Gold Mine Limited (CGML), scoops of mine tailing samples were collected down to a depth of 20 cm from nine sampling sites within an 810000 m² grid. The concentrations of As (0.7 to 3.3), Pb (1.3 to 2.2), Cr (0.9 to 1.9), Cd (2.0 to 2.6), Cu (5.5 to 6.5), Zn (2.4 to 3.6), and Fe (4.5 to 12) mg/kg were below the FAO/WHO permissible limits at the sampling sites ($p < 0.05$). The geo-accumulation index and contamination factor revealed that F2 was uncontaminated with As, Pb, Cr, Cu, Zn, and Fe. However, the mine tailings were significantly enriched with Cd and thus likely to pose an ecological risk to the surrounding environment. In general, the tailings dam is not progressively deteriorating in accordance with the pollution load index. Findings of this study will contribute to the environmental database of gold mine tailings at CGM to assist future remediation of the tailings storage facility.

According to Winton et al. [29], although environmental scientists frequently debate the effects of major dams, they frequently overlook the significance of changed water quality as a cause of biological repercussions. This is partially due to the paucity and fragmentation of data regarding the connection between dams and water quality, particularly in low-latitude developing nations where dam construction is currently centered. They examined and summarized data on how damming affects water quality in their study, paying particular attention to low latitudes. They discovered that thermal stratification in reservoirs and the trapping of sediments and nutrients are the two main physical mechanisms that cause the majority of changes in water quality. They compiled data and literature on the 54 largest low-latitude reservoirs to evaluate their mixing behavior using three classification schemes because stratification emerges as a significant driver, and there is ambiguity in the literature regarding the stratification behavior of water bodies in the tropics. The majority of low-latitude reservoirs, if not all are likely to stratify on at least a seasonal basis, according to direct observations in the literature and classifications based on morphometry and/or climate. According to this research, low-latitude dams may release cooler, anoxic deep water, which could harm ecosystems downstream by changing their temperature regimes or producing hypoxic stress. Many of these reservoirs can also effectively retain sediments and bed load, changing or destroying downstream habitats, including deltas and floodplains. There are several ways to lessen the effects of sediment entrapment and stratification on water quality, but implementation often encounters financial or practical obstacles. The water quality of tropical and subtropical rivers will change because of the thousands of proposed low-latitude dams that are about to be built. Improved baseline data and more advanced reservoir stratification behavior predictions are needed to better understand these changes and the related environmental implications. Both current and possible future effects could be reduced with improved dam designs and environmental impact studies.

Fashagba et al. [30] found that dams are crucial pieces of structure that store water for irrigation and municipal uses. Given their vital role, a dam's water quality assessment is considered an important criterion that requires constant monitoring. In their research, they attempted to use two water quality indices (WQIs) methods to assess the water quality of the Keddara Dam, which is located on the Boudouaou River, Algeria, using 11 water quality parameters (temperature, pH, conductivity, turbidity, total suspended solids (TSS), full alkalimetric title (TAC), hydrometric title (TH), nitrite ions (NO_2^-), nitrate ions (NO_3^-), ammonium ions (NH_4^+), and phosphate ions (PO_4^{3-})) for data recorded from 29 December 2018 to 3 June 2021. Application of the Canadian Council of Ministers of the Environment (CCME) WQIs and the Weighted Arithmetic Method (WAM) indicated that the Keddara Dam's water quality parameters were within the WHO's permissible level, except for the conductivity and turbidity values. The results of the CCME WQI ranged from acceptable (81.92) to excellent (95.08) quality, whereas the WAM WQI ranged from 9.52 to 17.77, indicating excellent quality. This demonstrates that the Keddara Dam is appropriate for agriculture and municipal use. The water quality indices (WQIs) methods are recommended as valuable tools that allow both the public and decision-makers to comprehend and manage the water quality of any aquatic environment by providing flexibility in choosing variables.

Shahady and Cleary [31] stated that as dam structures age, climate-driven precipitation patterns change, and ecological uplift becomes desirable, dam removal is becoming a common practice for stream restoration in the United States. However, these dams may function as retention basins in densely urbanized watersheds, eliminating pollutants and reducing hydrological change. Elimination might be more beneficial to the environment and economy, but sediment and pollution removal methods might be more effective at preserving water quality and averting destructive flooding. An urbanized sub-watershed (>20% impervious surface, comprising 37.8% of the total watershed land surface) that flows through an 18-hectare reservoir and a rural sub-watershed (<5% impervious, comprising 63.2% of the total watershed land surface) situated in the James River and Chesapeake Bay watersheds were compared in Central Virginia. It is planned that this reservoir will soon be removed. According to the data comparisons, the confluence has a water quality that is more similar to that of the rural and minimally impermeable sub-watershed, whereas parts of the urbanized watershed appear to be degraded. Data gathered after an unanticipated dam overtopping in August 2018—when the reservoir was briefly drained because of safety concerns—further supported this view. Following draining, the confluence's water quality reverted to that of the urbanized sub-watershed instead of the rural one. Most notably, the quality of the water entering the James River rapidly and dramatically declined from good to deteriorating. According to this case study, reservoirs in heavily urbanized watersheds may be important infrastructure for improving water quality; thus, their removal as part of a stream restoration plan needs careful thought.

Abualhaija and Mohammad [32] conducted a study to evaluate the physicochemical quality of surface water from the Kufranja Dam (KD) in northern Jordan during the summer and winter. Dissolved oxygen, conductivity, temperature, pH, major anions, major cations, and heavy metals were determined in the samples. The majority of the physicochemical characteristics showed a comparable geographical distribution, with the lowest concentrations being noted at the dam's end and the highest concentrations being observed near the dam's entry. This suggests that the same factors—such as weathering products, agricultural practices, natural discharges from nearby catchment regions, and wastewater effluents that reach the dam through Wadi Kufranja—affect their incidence and distribution. Apart from the EC values, which were higher than the WHO drinking requirements, all other physicochemical characteristics and heavy metal quantities in KD water were below the maximum acceptable levels according to the Jordanian and international standards for drinking and irrigation. The study posited that KD water requires appropriate treatment before use and that it is chemically unfit for human consumption based on the water quality index (WQI). Although the EC results and the USSL diagram demonstrated that the dam's water is acceptable for irrigation and falls into the good to permissible categories for irrigation, the irrigation indices (SAR, Na%, and MH) showed that the KD water is chemically suitable for irrigation. As a result, most soils can be irrigated with KD water (with the exception of those that have a limited tolerance for salt). It may be necessary to address salinity specifically, and crops with high salt tolerance are recommended.

Sharma [33] observed that dams are constructed on rivers to meet various requirements for power, irrigation, drinking water, and flood control. The foremost consequence of a dam project is the creation of a reservoir submerging large tracts of land and a substantial amount of vegetation and biomass, which undergoes decomposition, taking on average eight to ten years to degrade the initial stock. The change of the aquatic system from a riverine to a lacustrine environment is therefore obvious. There is a consequent effect on the water quality due to alterations in the dynamics of the oxygen transfer mechanism in river water. In impoundments with large depths, thermal stratification occurs, dividing the vertical profile of the river into distinct zones known as epilimnetic and hypolimnetic zones. The water quality of the impounded river is characterized by impacts along the longitudinal profile of the river, both upstream and downstream of the dam. The quality of water deteriorates toward the reservoir bed and also upstream and downstream of the reservoir due to several factors, such as storage duration, nutrient load, reservoir depth, turbidity, and temperature. Sharma's study was carried out to assess the variation in water quality due to dams. For the purpose of this study, three dams with different design features were selected to assess the water quality along the vertical profile of the impoundments and along the longitudinal profile of the rivers upstream as well as downstream of the dams. Depletion of dissolved oxygen content was observed in both the vertical and longitudinal water quality profiles of the river. Similarly, metals such as lead, copper, zinc, manganese, and iron showed increased concentrations in bed-level samples compared to samples of flowing water.

Dębska et al. [34] published a paper on the effects of a dam reservoir in Komorów on water quality in the Utrata River. The implementation of the adopted objective involved a comparison of water quality at two points: above and below the reservoir. The Utrata River is polluted with biogenic compounds throughout the section studied. The COD content also indicates significant contamination exceeding the permissible limits. A positive effect of the reservoir on the river water quality was also observed in terms of the dissolved oxygen content, with the concentration increasing below the reservoir. The reservoir had a positive effect on reducing the total phosphorus concentration in the water. Water in the Utrata region below the reservoir had higher values of chemical oxygen demand (CODMn) than above the reservoir. There were no differences in the concentration of NH_4^+ and NO_3^- ions in the water before and after the reservoir.

Oiganji et al. [35] conducted a study in order to evaluate physicochemical parameters at various locations within the Shere Hills Dam reservoir located in the Jos North Area of Plateau State. Three separate locations—the upper, center, and lower sections—were used to gather water samples, which were then examined at the Bauchi State Water Quality Laboratory. The turbidity and color of the tested parameters were excessive for drinking, but they fell within the acceptable limits for irrigation when compared to the standard water quality of NESREA (2011) and NSDWQ (2015). Although turbidity and color have little bearing on the growth and development of plants, they must be treated with an activated carbon filter and alum flocculation before being consumed by people. Periodic quality assessments of drinking and irrigation water are required.

According to Kalaitzidou et al. [36], seasonal water sampling and analysis are required to assess water quality and to identify the degradation of clean water. During the dry and wet seasons of 2022, the monitoring of surface and dam water samples were monitored in several regions of Greece, such as the Eastern Thermaikos Gulf, Mouriki, and Marathonas basins. The orthomosaic mapping of the dam reservoirs was also recorded for monitoring. All the analyzed dam water samples and the samples from the Mouriki area had good water quality in terms of physical and chemical features, according to the samples' classification based on the Canadian Council of Ministers of Environment Water Quality Index (CCME WQI). However, the high amounts of $Na+$ and $Cl-$ in some samples from the Eastern Thermaikos Gulf and Marathonas basins indicate seawater incursion, whereas the increasing quantities of $NO3-$ indicate anthropogenic activity. Furthermore, geothermal fluids were responsible for the elevated arsenic (As) concentration in samples from the Eastern Thermaikos Gulf. The sensitivity analysis also confirmed the significance of Cl^-, NO_3^-, and As presence in water quality in the analyzed regions, highlighting the need for sustainable management.

Wanjari and Tanpure [37] stated that freshwater resources like dams, reservoirs, lakes, streams, rivers, etc., are chiefly used for drinking, irrigation, and industrial and domestic purposes. The Adol reservoir is a freshwater resource present in the Washim district of India. It provides water for drinking and irrigation purposes to many villages and is also a good source of fishery. Their study was a primary attempt to evaluate the water quality of the Adol Reservoir. For evaluating water potability, physical and chemical parameters of the water were analyzed over the period of 5 months (August to December 2018). The results of their study indicated that all parameters were in the standard range as stipulated by the World Health Organization (WHO). For the sustainability of the reservoir, the participants advised that water wasted in irrigation should be avoided.

Gyasi et al. [38] stated that large dams play an important role in promoting economic and social development in many countries. However, the construction of such dams can have a detrimental effect on the environment. The aim of this study was to investigate perceptions of drinking water quality among the inhabitants of selected communities within the Bui Dam environs. With the help of questionnaires, 100 respondents from the communities around the dam were randomly selected and interviewed. Their responses were compared with another 100 respondents selected from remote communities near the dam. These were supplemented in-depth interviews, focus group discussions, and personal observation. Analysis of the results showed that there were greater proportions (31%) of the participants who lived in the surrounding communities within the age category 20-25 years compared to 19% of their remote-community counterparts. There were significantly greater proportions of female respondents in the communities surrounding the dam (57%) than in the remote communities (52%). The study further showed that the perception of risk of consuming contaminated drinking water was more common among remote communities (odds ratio = 4.57). The perception of water quality based on physical properties was investigated as part of the study. Analysis of the results showed that a significantly greater proportion of remote communities (35%) perceived their water had an objectionable smell compared to 7% of inhabitants of their other counterparts (p-value = 0.001). The study further showed that a significantly greater proportion of the study participants in the remote communities perceived that their water had color (65%), and they did not drink water from any other source (63%) apart from their stream. The study demonstrated that generally, inhabitants within the study communities perceived the construction of the Bui Power Project to have negatively affected their drinking water quality.

Bakobie et al. [39] conducted their study to assess the quality of dam water in three communities in the Savelugu-Nanton Municipality. Samples were collected three times (in duplicate) at 2-week intervals in January 2014 from each dam, giving 36 samples. The samples were conveyed to the Council for Scientific and Industrial Research (Water Research Institute Laboratory, Tamale) for analysis using standard methods. The study revealed the physicochemical characteristics of the dam water samples were within the World Health Organization and Ghana Standard Board permissible limits for drinking water, except for turbidity. The obtained turbidity values ranged from 7 to 46 NTU, with a general mean value of 18.06±12.05 NTU. The total coliform count ranged from 2.4 x 101 to 1.941 x 103 cfu/100 ml, with a general mean value of 1,088 ± 842.7 cfu/100 ml. The coliform bacterial count in the dam water exceeded the WHO permissible limits for drinking water. Hence, coliform contamination implies that when consumed, the dam water can lead to disease burden. Therefore, it is recommended that the dam water be treated for coliform bacteria before use for drinking.

Tiwari and Tiwari [40] stated that Bhagirathi is a Himalayan River that flows into the Uttrakashi district in Uttarakhand state. It is one of the most important streams of the Ganga River. This river is famous for dam construction and fisheries development. The fish of commercial importance in cold water are the Mahaseer and Snow Trout. Fish production depends on the physical, chemical, and biological qualities of water. In their study, water quality evaluation and dams in the sustaining fish population dynamics were reviewed to make fish culturists and environmentalists aware of the water quality factors that influence the health of a pond and to increase the fish yields to meet the growing demands of the present-time scenario in that country. The construction of dams causes water quality problems, and the discharge of water from dam wall systems indirectly affects fish populations. In their study, the authors also reviewed some important impacts associated with dams and recommended mitigation measures. They noted that dams have a negative impact on fish population dynamics, especially for downstream habitats, and water quality is measured by temperature, turbidity, carbon dioxide, pH, alkalinity, hardness, BOD, TDS, and turbidity. The maximum oxygen content of water was recorded in January at 13.02 ± 0.166 mg l^{-1}, and the minimum was 9.4 ± 0.05 mg l^{-1} in July in Site I (before the reservoir dam wall). In Sites II and phase I (after the dam), the maximum DO was observed in the month of January at 12.1 mg l−1 and the minimum in July at 8.93 mg l−1. This is because the water level is minimized at Site II and is almost dry in winter. The CO_2 of the Maneri Bhali Phase I—Site I (before dam) was recorded at a maximum in April at 3.10 ± 0.012 mg l^{-1}. In Maneri Bhali Phase I—Site II (after the dam), the CO_2 was recorded at a maximum of 3.01 ± 0.003 mg l^{-1} in the month of July. The river of the Garhwal Himalaya harbors a rich aquatic diversity; the most common endemic fish species that inhabit this fresh water are the *Schizothorax* species. The maximum number of fish was observed in winter and the minimum in monsoon season. At present, the production of these fish from streams is very poor and is not well managed from a recreational and conservation point of view. If such is developed properly, it can have revenue potential for our state government. Sports, fisheries, and tourism should be promoted.

Abdus-Salam et al. [41] stated that potable water is becoming progressively scarce due to anthropogenic pollution, and it has necessitated monitoring of the water quality of rivers and dams as a subject of ongoing concern and research. Their study assessed the quality of water collected from four different dams (Agba, Igbaja, Oloru, and Omu-Aran) in Kwara State, Nigeria, using standard procedures. Water and sediment samples were collected at three different spatial locations on the dams. The average values of most physicochemical parameters like pH, temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Dissolved Solid (TDS), Total Hardness (TH), alkalinity, some nutrients such as chloride (Cl-), sulfate (SO42-), phosphate (PO43-), nitrate (NO3-), and some heavy metals such as Cu and Zn have values that were within World Health Organization (WHO) guidelines for drinking water for each of the dams, while Cd and Fe concentrations were observed to be much higher than WHO guidelines for drinking water. This could be a result of anthropogenic input. The sediments of the dams analyzed for heavy metals showed that Mn, Zn, and Cd were high in the dams, which can be easily washed into the water body through leaching, thereby causing detrimental effects to the consumers.

Ahmed et al. [42] stated that the Water Quality Index (WQI) is a unique and effective rating technique for assessing the quality of water. Nevertheless, most of the indices are not applicable to all water types, as these are dependent on core physicochemical water parameters that can make them biased and sensitive toward specific attributes, including time, location, and frequency for data sampling and number, variety, and weight allocation of parameters. Therefore, there is a need to evaluate these indices to eliminate the uncertainties that make them unpredictable and that may lead to manipulation of the water quality classes. Their study calculated five WQIs for two temporal periods: June to December 2019, obtained in real time (using the Internet of Things (IoT) nodes) at the inlet and outlet streams of Rawal Dam; and 2012–2019, obtained from the Rawal Dam Water Filtration Plant, and collected through GIS-based grab sampling. The computed WQIs categorized the collected datasets as 'Very Poor,' primarily owing to the uneven distribution of the water samples, which led to class imbalance in the data. Additionally, their study investigated the classification of water quality using machine learning algorithms, namely, decision tree (DT), k-nearest neighbor (KNN), logistic regression (LogR), multilayer perceptron (MLP), and naive Bayes (NB), based on parameters including pH, dissolved oxygen, conductivity, turbidity, fecal coliform, and temperature. The results demonstrate that the proposed DT algorithm outperformed other models with a classification accuracy of 99%. Although WQI is a popular method used to assess water quality, there is a need to address the uncertainties and biases introduced by the limitations of data acquisition (such as specific location/area, type and number of parameters, or water type), leading to class imbalance. This can be achieved by developing a more refined index that considers various other factors, such as topographical and hydrological parameters with spatial temporal variations, combined with machine learning techniques to effectively contribute to the estimation of water quality for all regions.

According to Onyedim [43], expanding human development activities that overuse and contaminate water resources has made water quality a serious concern. Water samples were collected from four different places for this investigation, and water from the National Root Crop Research dam in Umudike, Ikwuano Local Government of Abia State was subjected to physicochemical analysis to determine its appropriateness for irrigation. Every parameter in this investigation, including TDS, pH, alkalinity, total hardness, fluoride, nitrate, sulfate, chloride, calcium, and magnesium, was determined to be within FAO and WHO acceptable ranges. The dam water's pH readings are marginally below the FAO and WHO acceptable ranges. The electrical conductivity and chloride values of the dam water samples fell inside the medium salinity zone. As a result, irrigation can be performed using the water from these dams.

In their paper, Cymes and Glińska-Lewczuk [44] aimed to demonstrate the potential of various benefits of two water quality indices used to assess four dammed lakes in a lowland area of northeastern Poland: the Sodium Adsorption Ratio (SAR), which is advised by the US Salinity Laboratory Department of Agriculture and used in the assessment of water for irrigation, and the Water Quality Index (WQI), which was created by the Scottish Development Department and used in the assessment of water potential for human consumption, industries, fisheries, and recreation. Their study was based on the results of a water quality monitoring program in which the pH, dissolved oxygen, electrical conductivity, biological oxygen demand, chemical oxygen demand, NH_4^+, NO_3^-, Cl^-, SO_4^{2-}, Na^+, Ca^{2+}, Mg^{2+}, and HCO_3^- had been analyzed. On a 5-degree WQI scale, the water quality metrics were found to vary among the research reservoirs and to indicate a medium and bad class. The water class in the study reservoirs was I, and the SAR was less diverse. The findings demonstrated that all of the reservoirs' water was safe for irrigation without endangering the soil structure and could be used to raise fish that can withstand less water aeration. Although it was advised not to directly come into contact with the water, it was assumed that it could also be recreationally used. The water quality indices (WQI and SAR) show great potential when evaluating water for multipurpose use. It was determined that the WQI and SAR are great instruments for providing a summary of the general water quality conditions throughout time and space. When combined, they may also be used to provide planners and managers with more easily understandable information about specific water uses.

Cantalice et al. [45] posited that in semi-arid Brazilian regions, underground dams can efficiently store water under possible scenarios of climate change. However, the annual humidity vector in these regions is vertical, and annual evapotranspiration exceeds annual rainfall, resulting in the accumulation of salts in groundwater reservoirs. Their study investigated over the course of two agricultural years the hydrologic behavior, soil moisture, and seasonal behavior of electrical conductivity (EC) of irrigation water from an underground dam constructed in the Jacu watershed in a Brazilian semiarid region. The underground dam retained more soil moisture than other nearby areas during the rainy season; however, during dry periods, its storage capacity was reduced by evapotranspiration occurring inside and outside of the groundwater dam, and after rainfall, the same level of evaporation occurred from soil as from the dam. During the dry season, the underground dam raised the concentration of salts in the irrigation water, which was categorized as C4, corresponding to the far too saline irrigation water; however, in subsequent rainy seasons, the electrical conductivity of irrigation water decreased to be included in a group of low salinity of 0.95 dS m-1 (C1). The irrigation water sodicity changed from the risk of sodium accumulation to the category of without sodium risk.

According to Gorde and Jadhav [46], water plays the most significant role in forming terrain and controlling climate. It is one of the most significant substances that have a significant impact on life. The physical, chemical, and biological properties of water are typically used to describe its quality. Water quality is declining, and aquatic biota is depleted because of extensive and diverse contamination in aquatic ecosystems brought on by rapid industrialization and the careless use of chemical pesticides and fertilizers in agriculture. Waterborne diseases affect the human population as a result of drinking tainted water. As a result, it is essential to periodically check the quality of water. Temperature, pH, turbidity, salinity, nitrates, and phosphates are among the parameters that can be measured. Evaluation of aquatic macroinvertebrates can also indicate water quality.

Sayyad [47] estimated the physicochemical parameters of the Jayakawadi Dam from February 2015 to January 2016 to assess the suitability of the dam water quality for aquaculture. Several parameters, like pH, dissolved oxygen (DO), alkalinity, nitrate, nitrite, phosphate, and sulfate, were studied. The physicochemical parameters were analyzed for assessment of the water quality status of the Jayakawadi Dam. These parameters revealed that fluctuations in water were within the desirable limits for aquaculture, and high levels of phosphate needed to be modified in order to favor aquaculture.

Garde et al. [48] investigated the physicochemical characteristics of surface water at various Sarfa Dam stations in Shahdol, Madhya Pradesh, India. According to the usual procedures advised by APHA, water samples were taken from several stations and analyzed for a number of parameters, including pH, temperature, electrical conductivity, TDS, TS, turbidity, TS, COD, calcium hardness, total hardness, alkalinity, BOD, and chloride. Findings from their study showed that all physicochemical parameters, besides turbidity and total solids, were within the BIS-recommended acceptable range. Accordingly, the findings demonstrated that the Sarfa Dam water sample is safe for drinking without any negative effects on the environment or human health.

Joshua [49] argued that surface water bodies are potential pathways to waterborne diseases, primarily due to their susceptibility to contamination. In addition, rural communities in many developing countries use surface water as part or the sole means of water supply without treatment due to the ease and proximity to water supply. His study assessed the reservoir water quality and the health risk impact of the Kin Dam. Water samples were collected from 52 sampling points along the reservoir. The results showed that color (23.2 mg/L), turbidity (19.35 mg/L), nitrate (124.40 mg/L), lead (0.11 mg/L), potassium (1.61 mg/L), phosphorus (0.07 mg/L), coliform count (13.86 cfu m/L), and E. coli (6.47 cfu m/L) were significantly above stipulated standards. In addition, human health risks showed severe risks for adults, children, and infants, with nitrate constituting over 70% of all non-carcinogenic health risks. The correlation indicates that pH is strongly correlated with nitrate, potassium, phosphate, calcium, lead, iron, coliform count, and E. coli. In addition, a strong positive correlation was observed between turbidity color, coliform count, and E. coli. The outcome suggests poor water quality, resulting in severe health concerns, particularly for children and infants. Surface water monitoring is therefore recommended, particularly within areas that rely solely on unprotected drinking water sources.

Buta et al. [50] conducted a study to assess the spatio-temporal evolution of eutrophication and water quality of the Turawa Dam reservoir, located in southwestern Poland on the Mała Panew River; to identify the location and relationship between potential sources of physicochemical pollution related to the progressing process of eutrophication; and to determine the trophic status and water quality indices of the selected research object. The analysis (Mann–Whitney U test, PCA, HCA, Spearman correlation matrix) showed a high susceptibility of the reservoir to eutrophication processes, especially due to the influence of dangerous loads of compounds emerging from areas with high tourist intensity and pollutants flowing from the Mała Panew River. The parameters causing deterioration in the ecological status were TP, DO, BOD5, and COD. Considering the cumulative results of the water quality indices for the period of 1998-2020, the average water quality was classified as Class II or III. A noticeable deterioration in water quality was observed in the years 2016–2020, which proves the progressing eutrophication in the Turawa reservoir. In 1998–2020, the reservoir was classified as eutrophic or mesotrophic based on the three calculated trophic status indices. The research article can help develop a strategy for dealing with water blooms, a reliable system for monitoring pressures causing eutrophication, and optimal technologies for the reconstruction of multifunctional reservoirs.

According to Ewuzie et al. [51], managing water resources depends on the proper collection and processing of data on water quality. Therefore, the purpose of published articles on water-quality monitoring and assessment is to provide the public, decision-makers, students, researchers, and water-quality specialists with pertinent and trustworthy information. It follows that such information must come from data collected and examined in a current, scientifically sound way. As a result, improper data analysis and reporting methods may produce false findings and undermine efforts to draw conclusions free of errors. In order to identify the anticipated trends in water quality research with regard to data collecting, data processing, and reporting for physicochemical, bacteriological, and trace organics parameters, the study makes use of the findings on water quality assessment in Nigeria over the previous 20 years. A total of 123 Web of Science papers that were quartile graded (Q1–Q4) and dealt with the evaluation of water quality in Nigeria were examined. The findings revealed flaws in some data analysis and reporting areas. In order to demonstrate preferable methods for evaluating, reporting, and visualizing several frequently used descriptive and inferential statistics of water quality indicators, simulated heatmaps and graphs were employed. Finally, several areas of deficit that require attention for better water quality research were noted and alternate approaches to commonly used water quality evaluation methods in Nigeria were proffered.

Ahmad [52] claimed that building massive dams has been a crucial part of the development of global infrastructure, with major benefits that include guaranteeing water storage, lowering the risk of flooding, and generating around 20% of the world's electricity through hydropower, despite environmental implications. With a focus on four primary areas—fish biodiversity, riparian vegetation, sediment deposition, and water quality—their investigation objectively examines the environmental effects of big dams. By analyzing data from more than 145 major rivers worldwide and analyzing case studies from throughout the world, the study calculated the extent of these effects. Their study concluded that the world's freshwater storage capacity has decreased by 0.5–1% per year due to dam-induced silt deposition alone. The study also highlights the substantial decline in fish biodiversity, with species fragmentation observed in over 70% of dam-affected rivers, and the severe degradation of riparian vegetation and water quality, which has resulted in a rise in eutrophication and hypoxia. Although dams are essential for supplying fundamental human requirements, their impact on the environment and water resources necessitates a reevaluation of existing dam structures and a cautious approach to the construction of new dams. The integration of an all-encompassing, global perspective that highlights the importance of integrating environmentally sustainable practices into dam operations is their study’s contribution to this field. Their assessment is an essential tool for environmental scientists, engineers, and policymakers to assist the preservation of river ecosystems while weighing the advantages of development.

According to Alla and Liu [53], dams are crucial for generating energy and supplying drinking water; however, water quality, aquatic ecology, land use, terrestrial wildlife, flora, and air quality are all significantly harmed by dams. To reduce these detrimental effects on the ecosystem, mitigation strategies should be employed. For instance, sediment control drains should be built to lessen the effect on water quality. Containers for chemical waste should be available in order to reduce chemical contamination. Clearing vegetation before filling reservoirs is crucial in terms of climate and greenhouse gas emissions. Because of the numerous operations involved in building, filling, and maintenance of reservoirs and dams, dams generally have a negative impact on the physical and biological environment.

According to Adusei et al. [54], surface water quality mapping and estimation are essential for inland reservoir planning and sustainable management. Their study used different models like multiple linear regression (MLR), support vector machines (SVM), and random forests (RF) to analyze and obtain the water quality information of the Owabi Dam reservoir from satellite data collected by Sentinel-2 (S2) and Landsat 8 (L8). The parameters measured in water samples from 45 systematic plots were pH, turbidity, alkalinity, total dissolved solids, and dissolved oxygen. A repeated k-fold cross-validation process was used to examine the performances of all three models in terms of the adjusted coefficient of determination (R2.adj) and root mean square error (RMSE). In order to assess the water quality, model-assisted estimates of WQPs were calculated using pixel-level forecasts and compared with WHO reference values. In general, S2 yielded more accurate findings than L8 for all three models. In terms of recovering WQPs from the Owabi Dam reservoir, S2 performed 67% better than L8 on average, according to the inter-sensor relative efficiency. S2 provided MLR with the lowest accuracy (R2.adj value of 55–91%, RMSE value of 0.03–3.14) and RF with the greatest (R2.adj value of 95–99%, RMSE value of 0.02–3.03). SVM produced findings for S2 that were comparable to those of RF, although with somewhat larger RMSEs of 0.03–3.99. With the exception of the turbidity value of 33.49 mg/L, which was higher than the reference levels, the estimated pH value of 7.06, total dissolved solids value of 39.19 mg/L, and alkalinity value of 179.60 mg/L were all within acceptable bounds. The surface water quality of the Owabi Dam reservoir should be monitored using the S2 and RF models.

Ndekezi et al. [55] asserted that sand dams are one of the most successful rainwater-harvesting methods and have been adopted in most arid and semi-arid lands (ASALs) of Kenya to secure domestic water supply and micro-irrigation. The ability of these dams to maintain acceptable water quality under extreme climatic conditions such as recurrent droughts and floods is of paramount public health concern, as various pollutants easily find their way into the dams. Their study assessed the suitability of sand-dam water abstracted via scoop holes (SCHs) and shallow wells (SHWs) in Kitui-West, South-Eastern Kenya. Water quality compliance checks were performed using the specifications of the Kenyan Bureau of Standards (KEBS) for natural potable water and the World Health Organization's (WHO) drinking-water quality guidelines, where applicable. A total of 48 water samples, comprising 33 SCHs and 15 SHWs, were collected during the dry period (February 8 and 28, 2018) and the wet season (March 23, April 20, and May 19, 2018) in three sand dams using clean plastic bottles and transported in cooler boxes to the laboratory for storage and analysis. The water samples were analyzed for pH, temperature, total dissolved solids (TDS), total hardness (TH), biochemical oxygen demand (BOD), trace metals (Cu, Fe, Mn, Zn, and Cr), Escherichia coli (E. coli), and total coliforms (TCs). Results of the analyses showed that the majority of the assessed physicochemical parameters and trace metals complied with KEBS limits at rates of more than 90%, except for turbidity, Cu, and Fe, which complied with low overall scores of 44%, 56%, and 35%, respectively. These three parameters behaved differently in both abstraction methods, as their mean values (compliance rates) exceeded KEBS limits in SCHs, that is, 297 NTU (18%), 1.7 mg/L (48%), and 2.22 mg/L (9%), and were below limits in SHWs, that is, 3.1 NTU (100%), 0.89 mg/L (73%), and 0.21 mg/L (87%), respectively. E. coli compliance levels were 48% in SCHs and 87% in SHWs with maximum counts as 300 CFU/100 ml, while TCs were detected at high rates of 94% and 47%, respectively, with maximum counts as 2,500 CFU/100 ml. Therefore, these results demonstrated that water extracted via SCHs is more unsafe than water from SHWs, but both provide water that is microbiologically unfit for direct human consumption. Shallow-well water was found to be physiochemically fit and only requires disinfection, whereas scooped water needs first to be purified with homemade water filters and then chlorinated with available disinfection by-products (DBPs) to increase its potability. Continuous monitoring of sand-dam water quality was recommended so that public awareness should be raised on time when new contaminants emerge or existing ones become intense to avoid possible health risks that can result from unnoticed long-term exposure.

Ayaz et al. [56] conducted a study to determine the water quality of Rawal Dam, Islamabad. Three water samples were collected from different sites of Rawal Dam, namely, Sohan, Lake View, and Barha Kahu. Different determined parameters of the water samples during the study included sulfates, hardness, alkalinity, nitrates, total solids (TS), dissolved oxygen (DO), chloride, turbidity, pH, taste, odor, and temperature. All three water samples were separately analyzed to obtain the results, which were compared with the water quality standards prescribed by the World Health Organization (WHO). From the results, all the parameters were found to be hygienic and safe for agricultural purposes. It was recommended that dam water be filtered more often before drinking; otherwise, it may cause different infectious diseases. The analysis was limited to the physical and chemical analysis of some parameters. However, some more parameters were suggested for testing the quality of Rawal Dam, Islamabad water for drinking.

Al-Khashman and Alnawafleh [57] conducted a study to assess the physicochemical and chemical quality of Tannur Dam water in southern Jordan. The water samples were collected in two intervals, the first in May 2015 and the second in September 2015. All samples were analyzed for temperature, electrical conductivity, dissolved oxygen, pH, major cations (Ca2+, Mg2+, K+, and Na+), and major anions (Cl-, NO3-, HCO3-, and SO42-). Hydro-geochemical analyses of 36 water samples collected from the dam water during the two intervals were used to determine their properties and types. The ion concentration in the water samples was found to be due to the dissolution of carbonate rocks and ion-exchange processes in clay. The general chemistry of the water samples was typical of alkaline earth waters with prevailing bicarbonate chloride. The PHREEQC Hydrogeochemical modeling was used to obtain the saturation indices of specific mineral phases, which might be related to interactions with water and aquifers, and to identify the chemical species of the dissolved ions. Calcite and dolomite solubility were assessed in terms of the saturation index, where positive values indicated oversaturated SI > 0. Hydro-geochemistry behavior is rather complicated and is affected by anthropogenic and natural sources. The positive correlation values between the various parameters indicate that most of the ions originated from the same lithological sources. The abundance of major ions in the dam water samples was in the following order: $HCO_3^- > Ca^{2+} > Cl^- > NO_3^- > SO_4^{2-} > Na^+ > Mg^{2+} > K^+$… It was also found that the water samples from the Tannur Dam are generally very hard, very high in saline, and medium alkaline in nature. Total high hardness (TH) and total dissolved solids (TDS) in some samples indicate that they are permissible for domestic and irrigation purposes. From the residual sodium carbonate, SAR, and electrical conductivity values, it was found that the dam water is suitable for agricultural purposes.

In their study, Lekwot et al. [58] examined the effects of human activities on water quality at Lamingo Dam. They carried out a field study to ascertain how human activities affect the water quality of the dam between 2013 and 2014. The analysis included physicochemical analysis. Surveys were carried out to find out from the inhabitants their daily occupation and other activities normally undertaken around the reservoirs that may affect water quality. The survey identified some undertaken activities as farming, fishing, cement block molding, cattle rearing, and car washing. The laboratory test results of the collected water samples from the dam revealed that the levels of total suspended solids (TSS), total dissolved solids (TDS), pH, dissolved oxygen (DO), chemical oxygen demand (COD), temperature, electrical conductivity, turbidity, hardness, benzene, cyanide, mercury, and cadmium in the dam water were quite high. With the exception of pH, all other measured physicochemical parameters were between 100% and 120% higher and exceeded the maximum permissible limit given by the Nigerian National Standard Water Quality and World Health Organization (WHO). The presence of some of these pollutants at various points of the dam was observed, and their quantitative levels were found to be at varying degrees. These parameters and the high levels of some of them were attributed to poor sanitation, improper farming methods such as excess fertilizer use, improper fishing practices, and domestic waste discharge into the dam.

Singh and Kataria [59] asserted that it is important to make an assessment of water resources, their magnitude, distribution, and scope of use. It is also important to have an idea of the present and future demands for water for various uses, such as industrial, irrigational, and domestic purposes, from a public health point of view. In their study, they attempted to assess the water quality of the 'Kaliasot Dam' for a period of one year, 2007-08, in monsoon, winter, and summer seasons. Water samples were collected from different points to cover the complete dam area. The parameters observed in the samples for water-quality assessment of the dam were temperature, pH, electrical conductance, turbidity, total solids, TDS, SS, nitrates, phosphate, chloride, and alkalinity, as well as the total hardness, Ca-H, Mg-H, D.O., BOD, COD, Na, K, sulfate, and fluoride, and all physicochemical parameters.

Jamil et al. [60] asserted that water quality is critically important because of its impact on human health and aquatic systems. In their study, the water quality parameters of Simly Dam, which supplies drinking water to Islamabad and Rawalpindi, were determined, and the water quality index (WQI) was calculated using the arithmetic weighted method. Water samples were collected from different locations of the dam, and filtration plants were installed in the facility. Twelve physicochemical parameters of the dam water, including pH, electrical conductivity (EC), total dissolved solids (TDS), alkalinity, hardness, biological oxygen demand (BOD), dissolved oxygen (DO), total chloride, calcium, nitrates, potassium, and sodium (Na), were measured to estimate the sediment and water quality from the dam. The WQIs of both raw and filtered dam water was determined using the World Health Organization (WHO) standards for drinking water. The WQI of the raw and filtered dam water was 62,79 and 49.43, respectively. The WQI of the raw dam water was found to be in class C, which is the poor category, while that of the filtered dam water falls in class B, which is the good category, according to the water quality index categories. They concluded that regular monitoring of the dam water quality is recommended to ensure its safe supply to consumers.

Sarhat et al. [61] reported that in summer 2021, water at the Bawashaswar Dam turned red as a result of drought, a decreasing water supply, and the presence of a high number of anthropogenic pollutants. This strange situation had not previously happened in the region, raising concerns among water users. In this study, 12 samples were collected from various locations inside the reservoir. The selected physicochemical parameters included turbidity, pH, dissolved solids (TDS), electrical conductivity (EC), total hardness (TH), magnesium (Mg^{+2}), calcium (Ca^{+2}), sulfate ($SO4^{-2}$), dissolved oxygen (DO), biological oxygen demand (BOD), iron (Fe^{+2}), and fluoride (F^{-}), which were analyzed and were also used to determine the water quality index (WQI). The results were obtained using the weighted arithmetic index (WAI) method. Therefore, the water quality parameters were found to be very high, exceeding the limit range. This indicates that the water in the reservoir has poor quality and cannot be used for drinking, irrigation, or fish culture.

Ibrahim and Ibrahim [62] used the Average Score Per Taxa (ASPT) and Biological Monitoring Working Party (BMWP) Score evaluation techniques to evaluate the water quality of Jakara Dam from January to October 2016. They gathered and identified 10, 631 macroinvertebrates from 15 families and three phyla-Mollusca, Arthropoda, and Annelida species using standard methodology. During the sampling period, ASPT values and BMWP scores were noted at each site (A, B, C, and D). All the sites had poor water quality according to the data, with ASPT values below 4 and BMWP scores below 100. The most common species found during the sampling period were annelid worms (Tubifex tubifex), dipteran larvae (Chironomus sp.), and gastropods (Melanoides tuberculata). The presence of pollution indicator species such as Melanoides tuberculata, Chironomus sp., Hirudo medicinalis, and Tubifex tubifex confirmed that the Jakara Dam is polluted. It was therefore recommended that further studies be conducted to validate the use of the BMWP/ASPT score as an index of organic pollution.

Ardarsa and Surinta [63] asserted that arid land, hazardous compounds in water, and a rising climate are some of the major issues facing water resource management. The management of water resources should be immediately addressed. The primary focus of their research paper was on water quality monitoring at the Lam Pa Thao dam in Chaiyaphum, Thailand. Because they raise fish in floating fish cages, the farmers in the area are directly impacted by the dam's water quality. They should be able to keep an eye on and manage the variables influencing the water quality in order to stop fish farming losses. As a result, the farmer is able to keep an eye on the quality of the water, and the monitoring system can promptly report back to the farmer. In this instance, researchers created Internet of Things buoys to gather data from the Lam Pa Thao dam in order to monitor water quality. A total of 13,608 cases of water quality data were gathered by researchers between January and March of 2021. Five critical parameters—temperature, pH, total dissolved solids, electric conductivity, and dissolved oxygen—were acquired. The researchers chose not to use dimension reduction because of the sheer number of parameters, and they suggested grouping the water data into suitable clusters for these tests using K-means clustering methods. For the K-means algorithm, the silhouette coefficient was calculated to analyze the effectiveness of cluster separation. The best cluster that was grouped using the K-means algorithm achieved a silhouette score of 0.6839. Further to these, the researchers evaluated the K-means algorithm on the Charles River and Fitzroy River datasets. The silhouette scores were 0.5489 and 0.6589, respectively.

Sunday et al. [64] collected and analyzed the physicochemical properties of water, such as pH, temperature, conductivity, total dissolved solids, total suspended solids, alkalinity, dissolved oxygen, chloride, turbidity, hardness, sulfate, chemical oxygen demand, and biochemical oxygen of the three major dams and rivers in Zamfara State, using standard analytical methods. The influence of seasonal variability on the parameters was also considered. Bacteriological assessment was also conducted to determine the bacterial load in the water bodies. The total bacterial counts obtained during the wet season (3.6 x 106 to 8.9 x 106) were generally higher than those obtained during the dry season (2.4 x 105 to 7.9 x 105). The microbial values recorded in the dam, which ranged from 2.4 x 105 to 7.4 x 106, and in the rivers, which ranged from 5.2 x 105 to 8.9 x 106, represent high bacteria loads compared to the recommended standards for drinking water (WHO, 2008; EPA, 2010; USEPA, 2002). The results of the physicochemical parameters revealed marked variations and non-uniform distribution from one season to another during the two years of study. The results further showed that pH, temperature, EC, TDS, TSS, alkalinity, DO, BOD, COD, Cl, and SO_4 have values that fall below the USEPA standard limit for drinking water, with the exception of turbidity (88.67 mg/l), which has a value higher than the recommended standard limit. Analysis of variance of the collected data revealed significant differences ($P < 0.05$) between the parameters based on location and season. Multiple range tests conducted on the parameters also revealed significant differences between the wet and dry seasons. The combined mean of the parameters further revealed a significant difference between the years.

According to Sunardi et al. [65], reservoirs are strategically important for sustainable energy supply. Unfortunately, complex contaminants from activities in the catchment and within the reservoir are causing water quality degradation in most of the reservoirs. The study evaluated the degree of water degradation in terms of corrosivity and to investigate its effects on hydropower operation and capacity. Information was collected from 2007 to 2016 on water quality (temperature, calcium, bicarbonate, pH, and total dissolved solids) from 20 sampling stations in the Cirata Reservoir. The information indicates that the river water is already corrosive (LSI = -0.21 to -1.08) and that the corrosiveness increases as one enters the reservoir (LSI = -0.52 to -1.49). Water corrosivity reduces manufacturing capacity and damages hydromechanical equipment. Complex human activities, including agriculture, land conversion, and urban and industrial discharge, are all part of the catchment's external environment, and they have all contributed significantly to the water's corrosiveness. Meanwhile, the issue has got worse due to the inside environment, such as aquaculture in floating net cages. The upkeep of the hydro-mechanical facilities has increased in tandem with the corrosiveness of water. Since the existing state of affairs undoubtedly poses a threat to the sustainability of hydroelectric operations and, consequently, energy supply, strategies must be implemented.

Albaggar [66] conducted a study to evaluate the quality of water in selected dams in the Albaha region, Kingdom of Saudi Arabia. Water samples from eight dams were submitted to physical, chemical, and bacteriological testing using established protocols for conductivity, total dissolved solids, ions, acidity, alkalinity, and EC Blue 100 coliform detection. The acceptable limits for pH, total dissolved solids, turbidity, Mn, and NO_3 established by Saudi standards were surpassed by around 75% of the water samples from rivers. Fe, Mn, SO_4, NO_3, NO_2, and total dissolved solids had average concentrations of 3065.00, 0.10, 0.89, 68.25, 17.91, and 0.016 mg/L, respectively. However, the average pH of the water samples, however, was 7.95 ± 0.66, which is within the range considered acceptable by both national and international criteria. In addition, the total dissolved solids in the irrigation water exceeded the Food and Agriculture Organization‘s (FAO) regulatory level. With no discernible spatial variation across dams and locations as groups, coliform bacteria were found in 37.5% of the dam’s Coliform bacteria and turbidity, pH and NO_3, SO_4 and NO_3, and coliform bacteria and NO_2 levels were all correlated. Agricultural practices, as well as human and animal wastes dumped into dams by flash floods and rainfall, may be the cause of elevated concentrations of the evaluated parameters in dams. The dams must be properly treated before use for irrigation or consumption.

Smatti-Hamza et al. [67] provided a study evaluation of the heavy metal content of sediment from the Koudiet Medouar Dam for use in agriculture and drinking water production. From 2012 to 2014, 216 sediment samples were collected at nine points upstream and downstream of the dam to determine the extent of hazardous metal contamination. In parallel, the physicochemical parameters of the sediments and physical properties of the water were identified. According to the mean ± standard deviation, the water temperature was 15.5 ± 7 °C, its conductivity was 1125 ± 228 µS/cm, and its hydrogen potential was 8.05 ± 0.36. The hydrogen potential for sediments is 8.55 ± 0.22, the conductivity is 730 ± 347 µS/cm, the carbonates are 49.18 ± 18.1%, the proportion smaller than 63 µm is 27.06 ± 6.95%, and the organic matter is 3.02 ± 1.2%. The order of trace metal concentrations was Mn > Zn > Cr > Cu > Co > Ni > Pb > Cd. The significant link between trace metals suggests that silted sands are associated with these elements, indicating that they share common sources. Two or more elements dominate the polymetallic contamination, with Cd, Cr, and Cu being the most concerning elements according to the geo-accumulation index, contamination factors, degree of contamination, and sediment pollution index. High levels of trace metals were found in the sediments upstream of the dam, particularly in the village's second station, which is close to the dam. The study findings show the impact of human-induced cadmium, chromium, and copper inputs from agricultural practices through soil erosion, runoff water, and household water discharges.

Anbarsouz et al. [68] investigated how water quality affected the concrete structures of the Voshmgir dam and its irrigation system in order to determine the possibility of chemical damage resulting from water quality. Water sampling from the dam and its network, as well as a field survey, was conducted in June 2022 in this respect. The results of water quality tests were examined using internationally recognized standards and soft water aggression indices to assess the degree of water chemical aggression on concrete. Additionally, using the information obtained from the Golestan water authority, the temporal variations of water chemical aggressiveness were examined. According to the June 2021 Langelier and Ryznar indices for dam water, which are -0.6 and 8.6, respectively, the water is corrosive and extremely corrosive, and the spillway's concrete structure is vulnerable to a significant soft water attack. There was an aggressive risk of at least one concrete-damaging agent in every month under study. The Ryznar index was 8.49 in December 2021, and the concentrations of magnesium and sulfate were 400 and 199 mg/liter, respectively. Three factors—soft water, sulfate, and magnesium—have been linked to the probability of concurrent aggressiveness. A five-month evaluation of the Voshmgir Dam's water quality revealed that it is corrosive in four months and that there is a two-month risk of sulfate and magnesium ion reactions with concrete. Epoxy coatings are therefore advised in order to shield the concrete structure of the spillway and the lining of irrigation canals from corrosive dam water leaching and damage resulting from the reaction of sulfate and magnesium ions with concrete.

According to Hamzah et al. [69], corrosion and scaling issues are frequent occurrences in water cooling systems, particularly open cooling systems. The purpose of this study was to assess the water quality at the Temenggor Dam hydropower plant intake and tailrace. The water samples underwent laboratory analysis and in-situ monitoring. Temperature, pH, specific conductivity, dissolved oxygen (DO), total dissolved solids (TDS), turbidity, and chlorine content were the seven parameters that were assessed in situ. A water sampler was used to collect surface and one- to three-meter-deep water samples at three different places close to the intake area. An identical method was also used to collect data from two places at the tailrace. For additional examination, the samples were returned to the UiTM, Shah Alam laboratory. Alkalinity, total suspended solids (TSS), and the amounts of Ca^{2+}, Mg^{2+}, and Fe^{2+} are all included in the laboratory analysis. To predict the scaling and corrosion tendency, the LSI, RSI, and PSI were computed based on the data. Given the supporting elements, the index indicates a strong propensity for corrosion to occur in the cooling system.

According to Bergal et al. [70], water is a natural resource vital to life and a necessary resource for all human endeavors. They conducted the current investigation in order to determine the water's aptitude at the Mexa Dam in northeast Algeria. They conducted a physicochemical and bacteriological investigation of the basin's waters in 2020 to assess the quality of the Mexa Dam to support specific natural activities as well as the supply of drinking water, irrigation, and industry. To ascertain the water's physicochemical and bacteriological characteristics, three sampling locations were chosen over a two-month period. Water samples were examined for a number of physicochemical characteristics and heavy metal concentrations, including T, pH, EC, TDS, DO, salinity, turbidity, durability, Cl–, Ca2+, Mg2+, NO2, NO3–, and NH4+. Total germs, fecal coliforms, and fecal streptococci were the main subjects of the samples collected for the bacteriological investigation. Most of the Mexa dam's physicochemical parameters were found to be within or near the WHO and Algerian acceptable limits for drinking and irrigation water, according to the results. The results were validated by creating the Mexa Dam's water suitability map for irrigation. Significant amounts of both total and fecal coliforms were found in the bacteriological data. Runoff and unsanitary behavior in the research area may have contributed to the elevated load of these bacteria during the study period.

According to Sul et al [71]., a considerable amount of unscheduled downtime on longwall equipment was caused by the early corrosion-induced failure of armored face conveyor (AFC) chains. Wet coal and water were found in continual touch with the AFC chains. Since longwall top-coal caving was introduced with its added AFC, the problem of AFC chains failing too soon has gained greater attention. It is unknown how reverse osmosis (RO), a common water treatment technique for lowering dissolved particles and salinity, affects the corrosion of AFC chains. The purpose of this study was to investigate how RO water directly affects AFC chain corrosion. The AFC chain steel was immersed in two water samples: treated water from an RO treatment facility and untreated dam water, for an immersion test. Four corrosion indices were evaluated for each of the two water samples, and elemental analysis was performed. Even though the dam water has far higher quantities of calcium, chloride, sulfate, sodium, and magnesium, the RO water dissolves calcium carbonate scales more forcefully, which increases the corrosion of the AFC chains. The primary alkaline component of water that gives it the ability to buffer acids is bicarbonate ions. Reduced scaling tendencies and strong corrosivity are the results of decreasing alkalinity in water without balancing other ions.

Okunlola et al. [72] observed that water transfer from an area of excess to an area of scarcity is now becoming an accepted option, especially for regional water supply. They noted that the Gurara water transfer provides for the transfer of raw water from the Gurara Dam in Kaduna State to the Lower Usuma Dam in the Federal Capital Territory (FCT), Abuja, through a 75 km conduit pipeline to augment the water supply to the FCT as a result of rapid population growth. The purpose of their research is to provide baseline conditions in terms of the quality of raw water at the Gurara Dam before transfer and after mixing at the Lower Usuma Dam. The Water Quality Index (WQI) was used to assess the quality of the water for overall, drinking, aquatic, recreation, irrigation, and livestock use. Twenty water samples from both dams were collected, some at predetermined depths, and subjected to physicochemical analysis using APHA standard methods of analysis for both wet and dry seasons. The overall WQI was poor for drinking and aquatic, but fair for recreation and livestock, and good for irrigation. These were due to high COD, BOD, total hardness, turbidity, Ca2+, K+, Mg2+, Cd+, Pb+, and Fe2+ concentrations. The results of the analysis, when compared with the Nigerian Standard for Drinking Water Quality (NIS 544:2007) and World Health Organization (WHO) permissible limits, showed that the Gurara Dam and Lower Usuma Dam were polluted and that the water was not safe for drinking. Variations in the constituent concentrations were observed in terms of water depth and season. Regular monitoring of water quality should be carried out because the watershed is currently rural but may face potential urbanization in the coming decades.

Zamdayu et al. [73] pointed out that Kiri Dam was constructed on the River Gongola to supply the needed water for the projected 12000ha of land for sugarcane cultivation on the typical soil of the Lower River Gongola. The water quality in the dam was investigated by collecting water samples at the dam inlet, main dam, and canal and analyzing them for physical, chemical, and biological contaminations. Their study results showed that most values were within permissible limits; however, the canal had elevated anions and cations. In the canal, Escherichia coli levels increased by 15.7% and; total coliforms increased by 17.1%. From the water quality calculations, the water was unfit for human consumption but moderately good for agriculture.

According to Danbauchi [74], dams represent a physical attempt by humans to store water for distribution during times of scarcity. Lower Usuma Dam was built in order to satisfy the residents of FCT, Abuja's need for a high-quality water supply. The Lower Usuma Dam's water quality for residential use was assessed in their study. Ten samples covering particular points of procurement, processes, and delivery of a quality water supply were collected using a qualitative research design. Standard measures for physical, chemical, and bacteriological factors were then used to analyze and evaluate the Lower Usuma Dam’s water quality with the samples in a laboratory in accordance with the National Standard for Drinking Water Quality (NSDWQ). The findings indicated that although the bacteriological parameters had high concentrations exceeding the NSDWQ’s maximum recommendation, the physical and chemical parameters were generally acceptable. Therefore, the water quality at Abuja's Lower Usuma Dam is fit for various domestic uses but falls short of the standards needed for casual drinking.

Torabi Jorjafki et al. [75] conducted a quality evaluation of the physical and chemical indices of seasonal river dam water (case study, Kerman Ghadruni Dam) in order to investigate water pollution in the Ghadruni Dam basin, a seasonal river dam reservoir, and provide management recommendations to reduce its pollution. They looked at the quality regulation of water parameters in seasonal rivers to develop future management plans. The Ghadruni Dam Basin has a unique geographic location and is one of the sources of drinking water for the two cities, with the possibility that pollution might soon infiltrate the reservoir as a result of the region's industrialization and subsequent population growth. They anticipated that runoff from agricultural lands that flow into seasonal watercourses would have a greater impact on the water quality of these watercourses than permanent rivers because of the extensive use of chemical fertilizers in the areas surrounding the seasonal rivers. The two rivers (Hotkan and Ghadruni) were close to rural residential areas. Six sites in the dam-feeding streams and the reservoir itself were sampled for the research purpose. They took measurements of the water's chemical and biological characteristics because the introduction of agricultural runoff could alter them. For a year, they recorded dissolved solids, temperature, EC, pH, turbidity, ammonium, DO, COD, nitrogen, nitrite, nitrate, sulfate, and chloride, among other chemical and biological indicators. The acquired results were assessed and examined. According to the research findings, the main causes of pollution in the Ghadruni Dam basin were the effects of household and industrial sewage as well as agricultural effluents left in the system. At the sampling stations, parameters like EC (dissolved solids, nitrite, nitrate, sulfate, and chloride) exhibited comparatively high values. Additionally, significant differences were observed in the water temperature and pH values. A water resource management plan in this basin and cooperation among reputable organizations can address the pollution issue in the dam, which receives water from the Ghadrun and Hotkan rivers.

3.0 CONCLUSION

A review report of research information from various literary sources on factors that affect corrosion and water quality in dam waters and the monitoring of these factors has been presented for better knowledge or awareness of properly controlling them in line with standard practices and for further research needs for improving structural safety as well as water quality in dams. The review shows that:

i. Dams are crucial for meeting our water requirements for various purposes at various locations around the globe, but they are subject to significant corrosion and water-quality issues due to excessive concentrations of several factors that cause corrosion and also reduce water quality therein compared to water from wells and freely flowing rivers, streams, canals, etc. due to their exposure to excessive pollution from various sources, greater silt formation on their beds, attracting greater microbiological activities, and less intermingling of their water flows.

ii. Corrosion and water-quality negation are serious issues that must be contended with in individual dams, especially those at different geological locations around the world.

iii. The quality of water is a different issue from the corrosion issue in dams and other water environments, but all the factors that affect water quality, such as pH, dissolved oxygen, temperature, total dissolved solids including mineral and organic matter, biological activities, pollutants like pesticides, hardness, turbidity, etc., also affect corrosion and vice versa, and corrosion itself affects water quality by causing deleterious or corrosive substances from the dam-water associated materials or systems to leach into it.

iv. To contend with corrosion and water quality in a dam, there is a need for continuous or frequent routine monitoring and analysis of corrosion and water quality-affecting factors in the dam for controlling the factors to acceptable levels in line with the water quality standards for drinking, agricultural, industrial, and recreational uses by chemical analysis, physical testing, and biological analysis.

v. We can keep good track of factors that affect corrosion and water quality in dams by chemical analysis, physical testing, and biological analysis, etc., using available or affordable techniques like multivariate analysis, colorimetry, HPLC, and other complex methods such as advanced laboratory technologies as well as automated sensors and advanced monitoring techniques such as remote sensing and the Internet of Things (IoT). Other advanced or emerging technologies, such as artificial intelligence (AI) with its capability in machine learning, fiber optics techniques, wireless monitoring technology and. water quality index (WQI), a simplified method for evaluating water quality based on multiple parameters, are also applicable to monitoring the factors with several advantages.

vi. Monitored factors that can affect water corrosion and quality in dams can be analyzed and controlled to acceptable values using standards designated by credible international, regional, and national authorities or organizations such as the World Health Organization (WHO), the International Organization for Standardization (ISO), the European Union, the Nigerian Standard for Drinking Water Quality (NSDWQ), the National Environmental Standards and Regulations Enforcement Agency (NESREA), the Bureau of Indian Standards (BIS), the Ministry of Ecological Environment (MEE), the Ministry of Water Resources (MWR), and the Environmental Protection Agency (EPA) based on the intended use of the water.

vii. Accurate quantitative monitoring of all factors that cause corrosion and also reduce water quality in various dams for optimally controlling the factors to safety-level requirements for various dam water uses poses serious technological challenges with costs and has continued to attract more research and practice attention over the years to date, as demonstrated by 55 out of several research outputs from the literature on the subject for routine or continuous practice for meeting the standard safety requirements of dam water for various uses.

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