Physicochemical Qualities of Water in the Reservoir of Bontanga Irrigation Dam in the Guinea Savannah Agro-Ecological Zone of Ghana

ABSTRACT

Fresh water resource is one of the most significant natural assets of a country. Irrigation dams are usually used for irrigation purposes and also often serve as a source of water for domestic use. Due to this, there is a need for proper maintenance, assessment, and sustainable use of irrigation dams. This study assessed the physicochemical properties of the water in the reservoir of Bontanga irrigation dam situated in the Guinea Savannah Agro-Ecological Zone of Ghana. The study assessed three (3) physical and fourteen (14) chemical water quality parameters of the water for irrigation to know whether they are within the acceptable threshold set by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Sampling techniques used in this study were stratified and purposive samplings. The reservoir of the dam was divided into nine (9) strata and in each stratum, 5 samples were taken making a total of 45 samples. Samples taken in each strata were composited making it a total of 9 samples. The water samples were collected into well-labelled polythene bottles and kept in an ice chest with ice cubes. The samples were transported to the Ecological Laboratory of the University of Ghana for analysis. The parameters analyzed were pH electrical conductivity (EC), temperature, chloride (Cl-), sulphate (SO_4^{2-}), bicarbonate (HCO_3-), carbonate, PO_4-P, nitrites/nitrate (NO_3-N), total dissolved solids (TDS), magnesium (Mg^{2+}), calcium (Ca^{2+}), sodium (Na^+), boron, total alkalinity, ammonia (NH_4-N) and potassium (K^+). A greater percentage of the results obtained were within acceptable limits except potassium which was slightly higher. This could be the result of farming activities in the catchment of the dam. In general, the water in Bontanga irrigation dam can be considered suitable for irrigation purposes.

Keywords: *Sustainable irrigation, Physicochemical parameters, Water quality, Bontanga irrigation dam, Surface runoff*

1.0 INTRODUCTION

Across the globe, water is a constraint for agriculture which makes irrigation essential in the field of agriculture to maintain food production and increase yields to improve food security [1]. Therefore, adequate and effective measures to manage and protect water resources (such as irrigation dams, rivers, streams, etc.) are of key importance to ensure the quality of water [2]. In order to use water efficiently in the field of agriculture, there is a need to develop irrigation dams to support crop production and agricultural productivity [3]. Irrigated agriculture makes up 20% of all cultivated land globally but produces 40% of the world's food supply. This type of agriculture is more productive per unit of land compared to rain-fed agriculture, enabling greater intensification of production and more variety in crops grown [4].

Irrigation refers to the artificial process of applying water to the land which aids in crop production [5]. It has been one of the numerous ways to increase agricultural productivity in our modern-day living, due to the uncertainty of rainfall patterns in recent times [6]. The majority of irrigation dams source water from rivers, reservoirs, streams, and rainfall

[7]. These sources greatly impact the purity and efficiency of the water supplied to crops [8]. Regularly assessing irrigation water quality is crucial, as it informs measures to mitigate the negative impacts of high impurity concentrations on crops, animals, and human health [9]. High salinity concentrations interfere with nitrogen uptake in crops, pastures, and trees, reduce their growth, and inhibit reproduction [10].

Some ions such as chloride, lead and arsenic become toxic to plants as the level and concentrations of these ions increase resulting in the poisoning and killing of the plants [11]. A high concentration of impurity in the water has the potential to cause harm to aquatic life and does reduce production and human health is no exception once ingested can be greatly affected [12]. The rate of pollution of surface water in the last century has reached a level where they are no longer safe for crop irrigation [13]. The poor quality of agricultural water sources may result from contamination due to man's activities or by natural phenomena or a combination of the two. Crop production, crop quality, and public health of both farmers and consumers are greatly affected if they are exposed directly to poor quality irrigation [14]. The Northern Region of Ghana often lacks sufficient supplies of optimally pure irrigation water to meet all crop requirements [1].

The construction of an irrigation system has over the years been a step in alleviating poverty and food shortage [15]. In most developing countries, poverty and food insecurity are paramount causes of concern [16]. Hence, prudent as well as pragmatic measures have been undertaken to alleviate challenges associated with agriculture or farming [17]. Given this, large-scale, medium-scale, and small-scale irrigation dams have been constructed to improve food availability [18]. According to a joint report by the Ghana Irrigation Development Authority and the Japan International Cooperation [19], most irrigation dams in Ghana are performing below average, while others have failed entirely. A later study by Namara et al. [8] found that most public irrigation dams in Ghana face significant managerial, socio-economic, technical, and environmental challenges that hinder their performance.

The quality of water used for irrigation has become a critical issue worldwide, due to the challenges of agricultural intensification, climate change, and overexploitation of groundwater from aquifers in arid and semi-arid areas [20]. Suitable irrigation water quality is vital for preserving soil properties, supporting plant growth, and boosting productivity [21]. Most irrigation dams rely on various sources of water which include underground aquifers and surface waters such as dams and rivers [22]. These sources of water may have chemical substances and a substantial amount of salts that could or may have a negative effect on soil fertility and crop yield [23]. According to Zaman et al. [20], the composition and concentration of soluble salt, as well as other physicochemical properties in the water, determines its suitability and quality for irrigation. Tomaz et al. [21] indicated that salt accumulation in the root zone and buildup of other heavy metals limits water availability and uptake, leading to plant stress and subsequently reduced crop yields.

Irrigation water also often contains substances from both anthropogenic and natural sources. The chemical makeup of irrigation water can directly or indirectly impact plant growth through toxicity, deficiency, or by altering nutrient availability. Similarly, certain metals present in irrigation water adversely affect crop production [24]. Examples of trace nutrients and metals include potassium, nitrate, cadmium, mercury, lead, etc. Physical parameters like temperature and turbidity also play a major role in irrigation dams. Under these conditions, farmers must utilize water with acceptable levels of physicochemical properties that will not negatively impact agricultural yield or aquatic life. It is essential to test the physicochemical parameters of water before use for drinking, irrigation, industrial purposes, or any other intended usage. With this in mind, the present study aimed to assess the physical and chemical quality of the water in the Bontanga reservoir for irrigation.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the Bontanga Irrigation Dam, the largest irrigation dam in Ghana's Northern Region, which is managed by the Ghana Irrigation Development Authority (GIDA) (Figure 1). Bontanga is a suburb located 34 kilometers northwest of Tamale in the Tolon-Kumbungu District. It is situated between latitudes 9° 30” and 9° 35” N and longitudes 1° 20” and 1° 04” W. The Bontanga Irrigation Dam's cropping area is divided into upland and lowland sections. The upland is composed of free-draining soils with plots designed for furrow irrigation. The upland area is specifically intended for vegetable production, while the lowland area is for rice cultivation, as its heavy soil texture is often flooded and regulated [25].

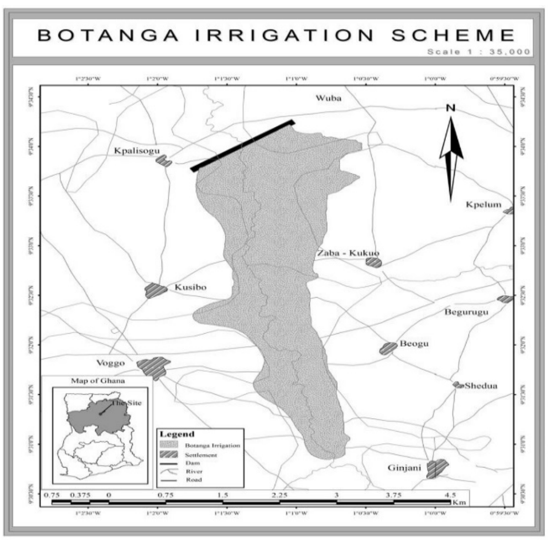

Figure 1. Map of Bontanga irrigation scheme
Source: Sadick et al. [25]

2.2 Water Sample Collection

Water samples collection was done early at 7 am (GMT). The materials used for the sampling include polythene bottles (50 ml storage capacity), a permanent marker (for labelling), ice-chest and ice cubes (for keeping the water samples safe and fresh), and a canoe. The “dam king” selected one native to assist in water sample collection by being in charge of steering the canoe (stern paddler). Water sampling was done following methods outlined in a study by [26]. The sampling methods used were stratified sampling, purposive sampling, and composite sampling methods. The dam was divided into nine (9) strata and five (5) Sampling Points were purposively selected (Plate 1). Five (5) samples were collected from each stratum and were combined (composited) to give one sample each in each stratum reducing the number of samples from forty-five (45) to nine (9) (Plate 1). The sampling began at the lower section, then to the middle section, and finally to the upper section or the receiving point. The sampling was done in this way to avoid contamination or mixing of particulate matter from the upper section. Also, a field blank consisting of deionized water was added to the samples. To identify errors and contamination during sample collection and analysis, the pH and temperature of the samples were measured at the University of Ghana's Ecological Laboratory prior to statistical analysis. The nine (9) samples were carefully labelled using permanent marker and stored in an ice chest with ice cubes. The ice chest was securely sealed shut using duct tape. The samples were kept at approximately 4°C and transported to the Ecological Laboratory of the University of Ghana for analysis of 17 parameters including 3 physical parameters and 14 other nutrient and chemical parameters.

Plate 1. Water Sampling in the Reservoir of the Bontanga Irrigation Dam

2.3 Physical Parameters Analysis

The physical parameters tested and analyzed across the nine samples were pH, electrical conductivity, and total dissolved solids. These parameters were assessed using the methods published by APHA [27]. pH was measured on a standard pH scale (PHS-25, Bante, China). Total dissolved solids were measured by gravimetric analysis and conductivity methods (Table 1), using a TDS meter (HQ14D, Hach, USA). The recorded levels of the physical parameters were compared against standards from the World Health Organization (WHO) and Food and Agriculture Organization (FAO) [1].

2.4 Chemical Parameters Analysis

The chemical parameters tested in the nine samples were nitrate, PO_4-P, ammonia, SAR, sulphate, bicarbonate, carbonate, total alkalinity chloride, sodium, potassium, magnesium, calcium, and boron following the American Public Health Association [27]. In irrigation, the type of water used is very important as poor water quality may result in different types of problems such as salinity, water infiltration, hardness, and toxicity [28]. All laboratory analysis was done at the Ecological Laboratory of the University for Development Studies. Chemical parameters were analyzed using Perkin Elmer PIN Accle 900T GRAPHITE Atomic Absorption Spectrophotometer (AAS), (Waltham, United States of America). The methods to test/analyze the chemical parameters of the water samples are listed in Table 1.

Table 1. Physicochemical parameters and methods of analysis

Physicochemical Parameters	**Methods**
pH and Temperature	pH meter method
Electrical Conductivity (μS/cm) (EC)	Conductivity meter method
Total Dissolved Solids (mg/L)	Gravimetric method
Nitrate, NO_3 as NO_3-N (mg/L)	Hydrazine reduction method
PO4-P	Ammonium molybdate
Ammonia, as NH_{4-N}	Colorimetric method
SAR	Used Richard (1954) formula method
Sulphate (SO^4) mg/L	Barium chloride method
Biocarbonate as ($CaCO_3$) (mg/L)	Titrimetric method
Carbonate (CO_3)	Titrimetric method
Total Alkalinity (mg/L)	Strong acid titration
Chloride (Cl^-) (mg/L)	Titration method
Sodium (Na^+) (mg/L)	Flame photometric method
Potassium (K^+) (mg/L)	Flame photometric method
Magnesium (Mg^{2+}) (mg/L))	Titration method (Standard EDTA)
Calcium (Ca^{2+}) (mg/L)	Titration method (Standard EDTA)
Boron (B) (mg/L)	Spectrophotometry

2.5 Data Analysis

The data obtained were computed and analyzed using Microsoft Excel 2019 and XLSTAT 2018. The standard deviation, range, and mean were computed for each parameter and compared to the permissible limits of FAO [29] and WHO [30]. The data were also analysed using descriptive statistics. Graphs were generated to depict the levels of the parameters to give a comprehensive understanding of the results obtained.

3.0 RESULTS AND DISCUSSION

The levels of electrical conductivity, temperature, and total dissolved solids were measured and analyzed in water samples taken from nine (9) different locations labelled A through I within the area of study and are discussed in the proceeding sections.

3.1 Electrical Conductivity

The average value for electrical conductivity across the nine (9) strata was seventy-seven (77) with a standard deviation of 2.24 (Table 2). The electrical conductivity levels ranged from a maximum of 81 μS/cm to a minimum of 74 μS/cm across the strata, as depicted in

Figure 2. As defined by Hassan [31], the electrical conductivity (EC) of water measures its capacity to conduct electric charge or current. Across the strata, the electrical conductivity values ranged from 74 to 81 µS/cm, with a mean of 77 µS/cm and a standard deviation of 2.24. According to Hassan [31], conductivity over 1000 µS/cm means that the water is polluted and unsafe for crop cultivation as well as human consumption. Analysed water samples from Bontanga irrigation dam had EC levels of 82 µS/cm being the highest indicates that the water from Bontanga irrigation dam is within the permissible limits for irrigation. According to WHO [32] standards, the permissible limit for electrical conductivity in irrigation dams is 600 dS/m. Compared to this standard, the electrical conductivity values of the Bontanga irrigation dam water ranging from 74-81 µS/cm fall well below the permissible limit, indicating suitability for drinking and irrigation as per WHO guidelines [32]. Fianko and Korankye [33] further categorized electrical conductivity values below 700 µS/cm as safe for irrigation and human consumption, which the Bontanga values aligned with.

Figure 2. Levels of electrical conductivity of water in the Bontanga irrigation dam

3.2 Total Dissolved Solids (TDS)

Total dissolved solids (TDS) include inorganic salts like bicarbonates, sodium, and chlorides, as well as some dissolved organic matter [34]. Elevated TDS levels in drinking water do not necessarily indicate a health risk, but may signify chemical pollution. TDS levels ranged from 48 to 52 mg/L across the strata, with a mean of 49.89 mg/L and standard deviation of 1.36 (Table 2). Figure 3 shows the TDS levels for each stratum of the Bontanga dam. TDS forms from water's capacity to dissolve salts and minerals, producing an unpleasant taste [35]. The WHO TDS standard is 500 ppm [32]. Thus, the dam's TDS levels are within safe levels for irrigation and domestic use per WHO guidelines. The water samples analyzed displayed low salinity, ideal for unfettered irrigation given the acceptable, low EC and TDS levels.

Figure 3. Levels of total dissolved solids in the water of the Bontanga irrigation dam

3.3 Temperature

Temperature plays a pivotal role in water quality [36]. According to [31], the temperature of the water determines processes of biosorption of toxic metals in water bodies, biological and chemical oxygen demand, viscosity, palatability, odour as well as chemical reactions. The temperature recorded for the samples collected and analysed were between 24 and 25°C at room temperature (Table 2). This temperature is good for irrigation purposes and domestic usage. Dallas and Ross-Gillespie [37] indicated that most aquatic organisms live in a very tampered temperature range and can easily perish when the temperature of the water becomes too high or too low. Also, the rate of photosynthesis of phytoplankton is affected by temperature [38]. This can determine whether there would be an algal bloom or not [39]. At higher temperatures, pollutants dissolve easily and quickly into water and also become more toxic. According to [31], temperature determines the viscosity, palatability and solubility of toxic metals as well as affecting chemical processes.

Table 2. Physical parameters of water in the reservoir of the Bontanga irrigation dam

Sampling Point	Temperature (°C)	Electrical Conductivity (μS/cm)	Total Dissolved Solids (mg/L)
A	24	79	52
B	24	81	52
C	25	77	50
D	25	74	48
E	24	75	49
F	24	75	49
G	24	76	49
H	25	78	50
I	25	78	50
Mean	24.4444	77	49.8889
SD	0.5270	2.2361	1.3642
FAO Acceptable levels (1985)	24 -25	0-3000	0-2000

3.4 pH

The pH levels across the strata had a mean of 6.46 and standard deviation of 0.05, with a minimum of 6.40 and maximum of 6.50 (Figure 4), spanning a range from 6.40 to 6.50 (Table 3). The Bontanga dam water was slightly acidic. The pH values did not vary substantially between sampling points. The highest pH was 6.50 and the lowest 6.40 (Figure 4). Recommended irrigation water pH ranges from 6.5-8.5 [29]. Water outside this range can cause nutritional imbalances since pH affects metal leaching, toxicity, and bioavailability [40]. Lower pH can leach metal ions harming aquatic life and crops [24]. As the recorded pH levels fall within irrigation recommendations, the Bontanga dam water is suitable for irrigation, aligning with findings by [40] that pH between 6.5-8.5 is optimal. pH variations occur due to shifts in carbon dioxide, carbonates and bicarbonates [41], impacting parameters like metal solubility and toxicity [42]. Water treatment can increase pH whereas corrosion lowers it into acidic levels [43]. Similar pH values were obtained by [44] and [45] in African dams.

Figure 0. Levels of pH of water in the Bontanga irrigation dam

3.5 Nitrate (NO_3 or NO_3-N)

The nitrate (NO_3 or NO_3-N) levels ranged from 0.9 to 1.2 mg/L across the strata, with a mean of 0.989 mg/L and standard deviation of 0.105 (Table 3). The highest nitrate level recorded was 1.2 mg/L in stratum B (Figure 5). The primary sources of nitrates (NO_3-) in water bodies are human and animal waste, fertilizers, and industrial effluent. In this study, nitrate levels showed little variation across samples, with the maximum at 1.2 mg/L and minimum at 0.9 mg/L, aligning with previous research [46]. Nitrate signifies complete oxidation of organic matter [47] through nitrification in water originating from farming and wastewater [48]. The permissible limit for irrigation water is 10 mg/L nitrate [29]. The obtained values ranging from 0.9-1.2 mg/L nitrate meet irrigation standards and indicate the Bontanga dam water can be safely used for irrigation and other domestic purposes.

Figure 5. Levels of nitrate (NO_3) in the water of the Bontanga irrigation dam

3.6 Phosphate

The phosphate-phosphorus (PO_4-P) levels ranged from 0.2 to 0.6 mg/L across the strata, with a mean of 0.344 mg/L and standard deviation of 0.142 (Table 3). The maximum PO4-P recorded was 0.6 mg/L, while the minimum was 0.2 mg/L (Figure 6). According to [31] and [30], natural background phosphate-phosphorus (PO_4-P) levels in river water range from 0.005 to 0.05 mg/L. The PO_4-P levels recorded across all Bontanga dam samples from 0.2 to 0.6 mg/L exceed this background range but remain below the 2 mg/L permissible limit for irrigation water per FAO guidelines [31]. Thus, while elevated compared to natural background river levels, at below the permissible maximum, the Bontanga dam PO_4-P levels indicate irrigation water of acceptable quality that can be utilized for irrigation purposes.

Figure 6. Levels of PO_4-P in the water of the Bontanga irrigation dam

3.7 Ammonia

The ammonia (NH4-N) levels ranged from <0.01 to 0.1 mg/L, with a mean of 0.023 mg/L and standard deviation of 0.034 (Table 3). The maximum ammonia level was 0.1 mg/L (Figure 7), while results below <0.01 were not depicted graphically. The Sodium Adsorption Ratio (SAR) levels spanned 0.01 to 0.1 mg/L, with identical mean and standard deviation values of 0.023 and 0.034 respectively (Table 3). The ammonia concentrations in rivers and bays are usually less than 6 mg/L; higher levels may indicate anthropogenic pollution. Unpolluted waters contain a small amount of ammonia and ammonia compounds, usually <0.1 mg/L as nitrogen, according to [49]. Also, according to the guideline values [31], the permissible limit for irrigation is 5 mg/L. The total concentration of ammonia recorded from the samples indicated low levels of ammonia. This implies that the water used for irrigation at Bontanga irrigation scheme is of a safe standard.

Figure 7. Levels of Ammonia in the water of the Bontanga irrigation dam

3.8 Sulphate

The values obtained from the analysis of sulphate were <0.1. There were no variations amongst the samples and it can be said that the level of sulphate is below the detection limit. According to [31], sulphate does not pose any high environmental health risks or human health problems. Gulumbe et al. [44] obtained similar results in Aliero dam water in Nigeria, and in dam of Mexa in northeast Algeria by [45].

3.9 Bicarbonate

The level of bicarbonate in the Bontanga irrigation dam ranged from 39.01 to 43.89 mg/L with an average and standard deviation of 40.773 and 2.208 respectively (Table 3). The maximum level of bicarbonate was 43.89 mg/L which was in strata D (Figure 8). The variations of bicarbonate content among the samples are very little with the highest being 43.89 mg/L and the lowest 39.01 mg/L. Bicarbonate exists in water due to the presence of carbonate minerals such as limestone, magnesite, and dolomite. This may have an effect on the pH of the water [50]. According to the guideline values [31], the permissible limit of bicarbonate for irrigation is 10 mEq/L but converting the mean which is 40.77mg/L to mEq/L is 0.66 mEq/L. with the values obtained from the analysis, it can be said that the level of bicarbonate content is considered very good for irrigation.

Figure 8. Level of bicarbonate in the water of the Bontanga irrigation dam

3.10 Carbonate

The results obtained for carbonate (CO_3) ranged from 3.44 to 3.87 mg/L with an average of 3.60 and a standard deviation of 0.19 (Table 3). The maximum value obtained for carbonate was 3.87 mg/L with the minimum value being 3.44 mg/L (Figure 9). The values obtained for carbonate ranges from 3.44 to 3.87 mg/L with a mean of 3.5956 mg/L and little variation among samples taken as indicated in Table 3, according to the authors. The highest value obtained was 3.87 mg while the lowest was 3.44 mg. According to guideline values [31], the permissible level of carbonate for irrigation is within 0-1 mEq/L, but converting the recorded value of 3.5956 mg/L into mEq/L gave 0.120 mEq/L. The values obtained can be said to be of an acceptable level for irrigation. This finding is consistent with the findings reported [46].

Figure 9. Levels of carbonate in the water of the Bontanga irrigation dam

3.11 Total Alkalinity

Results obtained for total alkalinity range from 32 to 36 mg/L (Figure 10) with a mean of 34.11 and a standard deviation of 1.6915 (Table 3).

Figure 10. Levels of total alkalinity in the water of the Bontanga irrigation dam

3.12 Sodium

Results obtained for sodium ranges from 0.002 to 0.013 mg/L (Figure 11) with their means and standard deviations being 0.0056 and 0.0039 respectively (Table 3). Alkalinity is often reported as mg/L of calcium carbonate [51]. It can originate from carbonates or bicarbonates that dissolve from the rock where the groundwater is stored (e.g., rainwater dissolving limestone), according to the passage [52]. While the separate carbonate and bicarbonate alkalinity test results are helpful in understanding the source of the alkalinity and the potential for other contaminants in the water, from an irrigation perspective the total alkalinity is the most important water test result. The ideal range for total alkalinity is approximately 30 to 100 mg/L but levels up to 150 mg/L may be suitable for many plants, according to the [32]. High alkalinity above 150 mg/L tends to be problematic because it can lead to elevated pH of the growth media which can cause various nutrient availability problems (e.g., iron and manganese deficiency, calcium and magnesium imbalance), according to the [32]. Low alkalinity (below 30 mg/L) provides no buffering capacity against pH changes. This is especially problematic where acid fertilizers are used, according to [31]. Alkalinity in pond water can vary greatly throughout the day if photosynthetic algae and plants are present, according to [31]. The values obtained from the analysis of sodium were very low. According to the guideline values [31] the permissible limit of sodium of irrigation water from 0 – 40 mEq/l. The present study recorded an average level of sodium of 0.0056 mg/L (0.00025 mEq/L) from the analysis of the water in the Bontanga irrigation reservoir. Therefore, it can be said that the sodium level of the Bontanga irrigation dam is acceptable for irrigation.

Figure 11. Levels of sodium in the water of the Bontanga irrigation dam

3.13 Sodium Adsorption Ratio

The values of sodium absorption ratio (SAR) content obtained from the analysis of the sample range from 0.0008 to 0.0088 mg/L (Figure 12) with a mean of 0.0044 (Table 3). SAR is used to assess the relative concentrations of sodium, calcium, and magnesium in irrigation water and provide a useful indicator of its potentially damaging effects on soil structure and permeability, according to the passage. Sodium adsorption ratio (SAR) is a parameter in irrigation water quality that is often tested to assess the quality of water [53]. This parameter is often employed in the careful management of soils affected with sodium, according to [54]. SAR serves as an indicator of the suitability of water to be used for irrigation purposes [53]. According to [54], SAR is employed as a diagnostic water parameter for soil sodality hazard. SAR index is increased by high carbonate (CO_3^-) and bicarbonate (HCO_3^-) levels (approximately >3-4 mEq/L or >180-240 mg/L). Typically, a SAR value below 2.0 is considered very safe for plants especially if the sodium concentration is also below 50 mg/L. Also, according to the guideline values [31], the permissible limit of SAR for irrigation is > 0.7 to 2.9 mg/L. Thus, with the values obtained from the analyzed sample, it can be said that the water is safe for irrigation purposes.

Figure 12. Levels of SAR in the water of the Bontanga irrigation dam

3.14 Chloride

Results obtained for chloride ranges from 0.27 to 0.55 mg/L (Figure 13) with its means and standard deviations being 0.348 (Table 3). According to the [31] guideline values, the permissible limit of chloride for irrigation is 1100 mg/L. Thus, it can be said that the level of chloride obtained in the analyzed sample is of acceptable level for irrigation. The limit of Cl (mg/L) concentration level is 250–1000 according to the Bontanga irrigation scheme standard, 200 is the determined acceptable limit, and 600 is the optimum allowable limit for the specification of drinking water [32].

Figure 13. Levels of chloride in the water of the Bontanga irrigation dam

3.15 Potassium (K^+)

The results obtained for potassium (K^+) range from 2.733 to 3.853 mg/L (Figure 14) respectively with its respective means being 3.033 (Table 3). The ammonia levels obtained from the water samples were below the 6 mg/L threshold, which as [55] research indicates the water is likely free of human-caused pollution. Osei et al. [49] stated that ammonia content higher than 0.1 mg/L (as nitrogen) is atypical in uncontaminated waters. Additionally, agriculture organization FAO's guidelines list 5 mg/L as the maximum ammonia level suitable for irrigation. Given the low ammonia concentrations found, we can conclude the water poses no issues for agricultural use around Bontanga. The carbonate quantities ranged from 3.44 to 3.87 mg/L, averaging 3.6 mg/L between samples, with little fluctuation as shown in Table 3 written by the authors. The highest recorded amount was 3.87 mg/L compared to a minimum of 3.44 mg/L. Per FAO's (1985) recommendations, appropriate carbonate levels for irrigation fall in the 0 to 1 mEq/L window – converting the found mean level equates to 0.12 mEq/L. Thus, the detected quantities are deemed permissible for irrigation.

Figure 14. Levels of potassium in the water of the Bontanga irrigation dam

3.16 Magnesium (Mg^+)

The results obtained for magnesium (Mg^+) ranged from 2.692 to 3.066 mg/L respectively (Figure 15) with their respective means being 2.7888 (Table 3). Magnesium ions play a crucial role in proper cell functioning and enzyme activation [56]. However, research by [57], has found that magnesium at excessive levels can also act as a laxative, causing unwelcome diarrhoea. Furthermore, inadequate magnesium intake or bodily levels can lead to negative structural and performance changes in people. The FAO [31] guideline values indicate that the permissible level of magnesium for irrigation ranges from 0 – 5 mEq/L. The average result obtained for magnesium is 0.229 mEq/L (2.7888 mg/L). This level of magnesium in the dam falls into the acceptable limit as indicated by [31] standards. Hence the magnesium level in the Bontanga irrigation dam is safe for irrigation purposes.

Figure 15. Levels of magnesium in the water of the Bontanga irrigation dam

3.17 Calcium

The results obtained for calcium ranges from 2.806 – 3.427 mg/L (Figure 16) respectively with an average of 3.0301 (Table 3). According to the guideline values [31], the permissible limits of calcium for irrigation ranges from 0-5 mg/L. Calcium, as calcium pectate, plays a vital role in preserving the structure of plant cell walls, according to [58]. When calcium levels are deficient, new plant tissues like root ends, developing leaves, and shoot extremities frequently display malformed development stemming from flawed cell wall creation [59]. Calcium is also employed to turn on enzymes and transmit signals enabling cells to synchronize operations [60]. While calcium overabundance rarely transpires, [54]) note it remains a possibility that calcium toxicity could manifest under certain conditions. The values obtained for calcium in this study after analysis were in the permissible limits. This implies that the level of calcium in the water in Bontanga irrigation dam is good for irrigation purposes.

Figure 16. Levels of calcium in the water of the Bontanga irrigation dam

3.18 Boron

The results obtained for boron ranges from 0.004 to 0.014 mg/L (Figure 17) respectively with an average of 0.0099 for boron (Table 3). The highest value of boron obtained was 0.011 mg/L and lowest was 0.004 mg/L. There were little variations among the samples. According to the [31] guideline values, the permissible limit of boron content for irrigation water ranges from 0 – 2 mg/L. According to [32] boron is a very good crop nutrient that facilitates their growth. However, when they are in excess in irrigation water, they can be toxic. Also, higher concentrations of boron even in the soil can be extremely toxic to the crop as it can lead to a decrease in productivity [31]. The values obtained from the analysis show boron levels are within the permissible limits. Thus, the water in Bontanga irrigation dam is very good for irrigation purposes.

Figure 17. Levels of Boron in the water of the Bontanga irrigation dam

Parameter	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Mean**	**STDV**	**FAO**
Nitrate (mg/L)	1	1.2	1.1	0.9	1	0.9	1	0.9	0.9	0.99	0.1054	0-
PO_4-P (mg/L)	0.4	0.6	0.5	0.2	0.4	0.3	0.2	0.3	0.2	0.344	0.1424	0-
Ammonia	0.01	0.01	0.01	0.01	0.1	0.01	0.01	<0.01	<0.01	0.023	0.03402	0-
SAR	0.0088	0.0051	0.0109	0.0025	0.0041	0.0025	0.0016	0.0008	0.0034	0.004	0.0034	0-

Sulphate (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	0-
Bicarbonate (mg/L)	39.01	41.45	39.01	43.89	42.67	43.89	39.01	39.02	39.01	40.77	2.2078	0-
Carbonate (CO_3)	3.44	3.66	3.44	3.87	3.76	3.87	3.44	3.44	3.44	3.595	0.19456	0-
Total Alkalinity (mg/L)	32	34	32	36	35	36	32	35	35	34.11	1.6915	30-
Chloride (Cl-) (mg/L)	0.33	0.33	0.27	0.27	0.33	0.55	0.51	0.27	0.28	0.349	0.1066	0-
Sodium (mg/L)		0.006	0.013	0.003	0.005	0.003	0.002	0.003	0.004	0.006	0.0039	0-
Potassium (mg/L)	2.815	2.934	3.076	3.853	2.733	2.896	2.98	3.011	2.998	3.033	0.32497	0-
Magnesium (mg/L)	3.1	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	0.1	0-
Calcium (mg/L)	3.1	2.8	2.99	3.1	3.3	2.8	2.9	2.9	3.4	3.0	0.21	0-
Boron (mg/L)	0.01	0.01	0.01	0.01	0.01	0.004	0.01	0.01	0.01	0.01	0.004	0-

Table 3. Chemical Parameters of Water in the Bontanga Irrigation Dam

STDV-Standard Deviation

4.0 CONCLUSION

Irrigation dam water must be treated to meet WHO, and FAO standards before they can be used for drinking and irrigation**.** Both physical and chemical parameters of the water in the Bontanga irrigation dam were analysed. These parameters include; the pH, Temperature, Total Dissolved Solids (TDS), Electrical Conductivity, Nitrate (mg/L), PO_4-P (mg/L), Ammonia, SAR, Sulphate (mg/L), Bicarbonate (mg/L), Carbonate (CO_3), Total Alkalinity (mg/L), Chloride (Cl-) (mg/L), Sodium (mg/L), Potassium (mg/L). Magnesium (mg/L), Calcium (mg/L) and Boron (mg/L). These parameters are within the permissible and acceptable levels of irrigable water as established by the [32] standards as well as [31] irrigable water guidelines values and standards, except for potassium which was higher than the permissible limits. The high potassium levels obtained may have resulted from the surface runoffs carrying chemical fertilizer into the dam from the surrounding farms. Generally, the water in Bontanga irrigation dam proved to be of good quality. Although the Bontanga irrigation dam currently can be classified as good for irrigation based on the findings of this present study, careful maintenance needs to be undertaken to prolong the safety of the irrigation dam and to promote sustainable irrigation as the problematic issues relating to irrigation water quality often occur over time.

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