EQA - International Journal of Environmental Quality
ISSN 2281-4485 - Vol. 37 (2020): 40-51
Journal homepage: https://eqa.unibo.it/

published by

Evaluation of physico-chemical water quality treatment efficiency: a case study of Jambussi water headworks in the upper West Region of Ghana

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Article info
Received 12/8/2019; received in revised form 2/12/2019; accepted 11/12/2019.
DOI: 10.6092/issn.2281-4485/9769

Abstract

Water is very important for the sustenance of life and has no substitute and therefore its quality cannot be compromised. This research is to examine the treatment efficiency and the physicochemical quality of drinking water from the Jambussi water headworks from the raw water source to the final consumer at the tap to establish the quality of the water being treated for drinking in the Wa West District and the Wa Municipality, Upper West Region of Ghana. Samples of water were taken from four stages of the treatment processes during the dry season (February-March) and at the onset of the rains in (May-June) 2019. 1.5L bottles properly rinsed, sterilized and labelled were used to take the samples at each point of the process. The samples were then stored in cold ice chest containing ice cubes and transported to the laboratory for analysis within 24 hours. The parameters considered were Temperature, pH, Total Hardness, Ca and Mg Hardness, Manganese, Alkalinity, Turbidity, Colour, Ca^{2+}, Mg^{2+}, NO_3-, NO_2-, Cl^-, F^-, Cu^{2+}, K^+, Al^{3+}, SO_42 and S^-. The results showed that all the parameters analyzed including metals recorded were all below the WHO standards for drinking water at different stages of treatment to the final consumer. Some of the parameters were above the WHO standards at the raw water stage but fall within the standards after treatment. The efficiency of the system was observed to be very good and the quality of the water produced also meets the WHO standards for drinking and other purposes. The research was concluded with recommendations to improve and maintain the water quality for drinking including further research to examine the quality of water produced at other water treatment facilities across the country.

Keywords
water treatment; physicochemical water quality; drinking water; treatment efficiency; WHO Standards

Introduction

Water is very essential for national development and a basic need for all. It is the second most important life support apart from air and useful for both consumptive and non-consumptive purposes. Water quality is also as important as its quantity and accessibility and for this reason, the UN declared "Water for life" programme between 2005-2015 within the Millennium Development Goals compact to halve the number of people without proper access to quality water and basic sanitation by 2015. The Sustainable Development Goal 6 also affirms the need for drinking water quality, safety and affordability by 2030 and to achieve that, adequate investment, provision of infrastructure, sanitation facilities and encourage the protection and restoration of water-related ecosystems would be required (UNDP, 2016). Unfortunately, anthropogenic activities such as

DOI: 10.6092/issn.2281-4485/9769

land use change, over extraction of water resources, high rate of pollution and sedimentation loads will cause freshwater ecosystems to be at risk in Africa. Pollution of river bodies, lakes and streams is mainly as a result of rapid urbanization, industrialization, illegal mining activities and increasing use of chemical fertilizers and pesticides among others (Patel and Shah, 2008). Surface water bodies are mainly exposed to pollution due to human activities from illegal mining, poor agricultural practices, industrial discharges, poor waste management and improper handling of sewage (Pestle, 1997). Naturally, water bodies have the capacity for self-cleansing and purification but due to excessive pollution, such purification process has becomes impossible thus the need for additional treatment. According to Buchholz (1993) pollution of surface water occurs when the quantity of wastes entering a body of water overcomes its capacity to assimilate the pollutants these wastes contain. Thus, the natural cleansing ability of oxygen contained in the water is compromised and the water can no longer breakdown the organic pollutants. Higgins (1975) affirms that surface water bodies such as rivers, lakes and ponds suffer from degradation, chemical and bacterial pollution due to discharges from industries, farm lands and domestic sewage disposal thus affecting the self-purification processes of the water bodies. The deterioration of the water quality is mainly of physical, chemical and biological in nature which affects the oxygen content of the water (Tölgyessy, 1993). The pollution can also add to the nutrient levels of the water resulting in eutrophication which lower the quality of the water. The level of treatment and purification will be determined by the degree of pollution, cost and the intended usage. It is also estimated that about 1.8 billion people get water from a source that is already faecally contaminated, which can cause cholera, enteric fever, and many other acute and chronic diseases. Research shows that about 173 million people get water from untreated surface water and more than 90% of such people live in rural areas. So one of the big problems now is to overcome the gap of proper drinking water supply between urban and rural areas (WHO, 2014). Treated water supply to rural areas is always limited and these rural communities always rely on polluted rivers and dams for their water needs. Rural communities employ traditional method of water treatment such as boiling, filtration, solar disinfection and chlorination to make water safe and reliable for drinking. Until recently, the three northern regions of Ghana relied on boreholes, rivers and dams to meet their water needs but the construction of the Jambussi headworks has brought some relieves especially for the Upper West region. Apart from the surface water being polluted, most of the boreholes were not also safe for consumption as detected by the Community Water and Sanitation Agency (CWSA) in the region. The CWSA annual report showed an elevated level of fluoride in groundwater in 2018 in the three Northern regions of Ghana causing dental effects in children. Besides, many boreholes are also polluted with chemicals such as arsenic and other heavy metals in other parts of the country including the Western region (GWP, 2007). The Black Volta in Upper West region is under increasing threat of pollution in recent years due to increasing population growth, agricultural and illegal mining activities (GNA, 2018). Polluted waters contain significant levels of pollutants, usually at levels above WHO certified drinking water quality standards and these are able to cause significant problems when ingested by humans (Cunningham, 1999). According to WHO, drinking water or potable water is defined as that, having acceptable quality in terms of its physical, chemical, bacteriological and acceptability parameters so that it can be safely used for drinking and cooking (WHO, 2004). Physicochemical and biological quality of raw water is important not only in the assessment of the degree of pollution but also in the choice of the best source and the treatment method needed (WHO, 1984). The SDGs 6.1 requires all countries to achieve universal and equitable access to safe and affordable drinking water for all by 2030 (UN, 2016). The Jambussi water project in the Upper West region was therefore constructed to provide portable water to ease the water challenges for the people in the region. Unfortunately, many people have doubtful perception about the quality of water being supplied from such facilities for drinking. In Ghana, quite a number of Ghanaians do not drink water flowing directly from the tap because of the perceived risk and low quality standard and therefore prefer the sachet and bottled water sold on the streets. Random interviews conducted across the country indicate that majority of Ghanaians have varied reasons for such perception which includes the source of the water for treatment, the capacity of the GWCL to treat water thoroughly for drinking, the amount of chemicals used for treatment, the old distribution lines among others. The problem is not only limited to Ghana but in other African countries. Past studies have shown that people reject tap water mainly because of concerns about health risks. An inspection conducted in 14, 000 centralized and non-centralized sources of water supply revealed that, in major cities, drinking

DOI: 10.6092/issn.2281-4485/9769

water does not meet hygienic standards (Hlavinek et al., 2005). Drobenya et al. (2003) also discovered that water supply from Minsk network failed to meet microbiological standards. Even though quality drinking water is generally obtained by complying with specific water quality standards established by governments, the WHO indicated that there was no assurance that people who get water from an approved source will get it free of contamination WHO (2014). Many people therefore are very cautious about the health implication of treated water from certain sources especially in developing countries. These concerns may have arisen as a result of increased awareness about environmental pollution and episodes of waterborne disease outbreaks. The research is therefore to examine the treatment efficiency and the physicochemical quality of drinking water from the Jambussi water headworks from the raw water source to the final consumer at the tap to establish the quality of the water being treated for drinking.

Physicochemical parameters and their characteristics

The source of all continental waters is from the natural water from the atmosphere as precipitation. However, this natural water as it precipitate comes with large amount of aerosols, dissolved gases such as oxygen, nitrogen, carbon dioxide and rare gases and other pollutants such as sulphur dioxide and sulphur trioxide, nitrogen oxides, ammonia, etc. which varies from place to place (Tölgyessy, 1993). Due to the weak mineralization of atmospheric waters and low concentration of hydrogen carbonates, their neutralization capacity is very low and this affect the pH thus atmospheric waters are mainly acidic due to the reaction of Sulphur and Nitrogen oxides. The chemical composition of atmospheric water is (Ca^{2+}, Mg^{2+}, NO_3^- , Cl^-, K^+, SO_4^{2-}, NH_4^-, pH, Na^+) Tölgyessy, 1993.

The chemical composition of surface water is determined first of all by the reaction between atmospheric water and ground water (soil and rocks) which is mostly influenced by anthropogenic activities. Surface waters therefore get mineralized through the above reactions. The presence of dissolved organic matter, agricultural, sewage and industrial wastes affect the quality of surface water bodies. Surface water can therefore be classified as very clean, clean, polluted, seriously polluted, very seriously polluted depending on the amount of oxygen dissolved. The process of determining the qualitative and quantitative composition of surface water bodies involves physical, chemical and biochemical content thus the need for such research to ensure that the water produced meet an acceptable standards. The research analyzed the physico-chemical parameters of water treatment stages from source to point of use of the following (Temperature, pH, Colour, Turbidity, Total hardness, Ca hardness, Mg hardness, alkalinity, Ca^{2+}, Mg^{2+}, NO_3^- , Cl^-, K^+, SO_4^{2-},NO_2^-, Mn^{2+},F^-, Fe^{2+}, Zn^{2+}, Cu^{2+}, Al^{3+}, SO_4^{2-}, S^-).

Temperature: temperature affects the speed of chemical reaction, the rate at which algae and aquatic plants photosynthesize and the metabolic activities of organisms and this can have influence on the water quality. Temperature is one of the most important and influential water quality parameter to life in water.

pH: the pH shows the level of acidity and alkalinity of water. Water at pH of 7 is considered neutral and ideal. WHO (1984) stipulated that drinking water should have pH range of 6.5 to 8.5 with pH value of 7.0 considered the best and ideal. Different sources of water may have varying pH levels due to the level of pollution in the water. Darko-Mantey et al., (2005) discovered that drinking water from different sources has a pH range of 6.1 to 7.2 in some areas.

Colour: water is supposed to be colourless. However, natural colour may be caused by rock fragmentation, decaying leaves, plants, and soil organic matter. Colour is also strongly influenced by the presence of iron and other metals, either as natural impurities or as corrosion products. Even though no health-based guideline value is proposed for colour in drinking-water but water with unusual colour may be rejected even when it is treated.

Turbidity: turbidity is associated with runoff and anthropogenic activities that get their way into water bodies. Although it does not adversely affect human health, turbidity is an important parameter in that it can protect microorganisms from disinfection effects, can stimulate bacteria growth and indicates problems with treatment processes (WHO, 2004).

Nitrate/Nitrite: compounds have demonstrated adverse toxic effects in infants. Due to potential toxicity and widespread occurrence in water, it is regulated and should not exceed 10mg/l in drinking water (WHO, 1984). Common source of NO^{3-}contamination include fertilizer, animal waste, septic tanks, municipal sewage treatment systems, feedlots and decaying plant debris. Surface water bodies must therefore be protected from these sources.

Sulphate: it has frequently been observed that the levels of Sulphate in surface water correlate with the levels of Sulphur dioxide in emissions from anthropogenic

DOI: 10.6092/issn.2281-4485/9769

sources (Keller et al., 1986). Sulphur trioxide (SO_3), produced by the photolytic or catalytic oxidation of Sulphur dioxide, combines with water vapour/ precipitation to form diluted Sulphuric acid, which falls as "acid rain" or snow (Delisle et al., 1977). Dehydration has been reported as a common side effect following the ingestion of large amounts of magnesium or sodium sulphate. Sulphates can interfere with disinfection efficiency by scavenging residual chlorine in the distribution system.

Hardness of water: In areas with hard water, household pipes can become clogged with scale; cause incrustations on kitchen utensils and increase soap consumption. Hard water is thus both a nuisance and an economic burden to the consumer because it does not easily lather with soap. Hard water contains calcium and magnesium in the form of carbonate (CO_3). The degree of hardness in drinking water may be classified in terms of its calcium carbonate concentration as follows: soft, 0 to < 60 mg/L; medium hard, 60 to < 120 mg/L; hard, 120 to < 180 mg/L; and very hard, 180 mg/L and above (Thomas, 1953).

Magnesium ion (Mg^{2+}): Scientists have observed that people in areas with higher levels of magnesium in their drinking water exhibit rates of sudden cardiac related death that are three to four times lower than those of people living in municipalities with the lowest magnesium levels in drinking water (Eisenberg, 1992). The WHO has therefore recommended that areas with low magnesium levels in their drinking water must supplement it with magnesium intake. Magnesium and other alkali earth metals are responsible for water hardness.

Fluorides: may also enter a river as a result of industrial discharges (Slooff, 1988). Many boreholes are also polluted with chemicals such as fluoride and other heavy metals in part of Ghana including Western, Northern and Upper East regions (GWP, 2007). Fluoride is known to have an adverse effect on tooth enamel and may give rise to mild dental fluorosis (prevalence: 12–33%) at drinking-water concentrations between 0.9 and 1.2 mg/litre (Dean, 1942).

Calcium: Calcium is unique among nutrients and increases bone mass which is linearly related to reduction in fracture risk (WHO, 2004). Calcium is an important determinant in water hardness, and it also functions as a pH stabilizer. Hard water may assist in strengthening bones and teeth because of its high calcium concentration. Physicochemical parameters, their significance in water and methods of analysis are therefore outlined in Table 1 below.

Chemical species	Significance in water	Methods of analysis
pH	Water quality and pollution	Potentiometry
Calcium	Hardness, productivity, treatment	Titration, gravimetry, AAS
Magnesium	Hardness	AAS, Titration
Potassium	Productivity, pollution	AAS, flame photometry
Manganese	Water quality (staining)	Photometry, AAS
Nitrate	Algal productivity, toxicity	Photometry, Potentiometry, Polarography
Nitrite	Toxic pollutant	Photometry
Copper	Plant growth	Photometry, AAS, Polarography
Aluminum	Water treatment, buffering	Photometry, gravimetry, AAS
Sulphide	Water quality, water pollution	Photometry, Potentiometry, titration
Sulphate	Water quality, water pollution	Gravimetry, turbidimetry
Chlorine	Water treatment	Photometry, filtration
Fluorine	Water treatment, toxic at high levels	Photometry, gravimetry, AAS, polarography
Zinc	Water quality, water pollution	Photometry, AAS,
Iron	Water treatment, toxic at high levels	Photometry, gravimetry, AAS, Polarography

Table 1. *Chemical parameters and methods of analysis in water supply. Adapted from Tölgyessy, 1993.*

Materials and Methods

Study area description

The Wa West is one of the eleven District Assemblies that make up the Upper West Region of Ghana. The capital is Wechiau and it shares administrative boundaries with the Nadowli to the North, the Wa Municipal to the East, Sawla –Tuna-Kalba to the South and Ivory Coast to the West. It lies within latitudes

DOI: 10.6092/issn.2281-4485/9769

9"049'35"N and longitudes 2"040'51"W. The total population of the district stands at 81,348 representing 11.6 % of the region's population with Male: 49.5% and Female: 50.5% Ghana Statistical service (GSS, 2010). Wa West is where the Jambossi water project is located and provides water for the entire region.

Sampling Method

The research was carried out at Jambussi headworks which supply water to the Wa West districts and other part of the region including the Wa Municipality. Samples of water were taken from four stages of the treatment processes which are the raw water sources, Sedimentation stage, Filtration, and the point of consumption (at the tap). The samples were taken during the dry season (February-March) and at the onset of the rains in (May-June) 2019 at each stage of the treatment process. 1.5L bottles properly rinsed, sterilized and labelled were used to take the sample at each

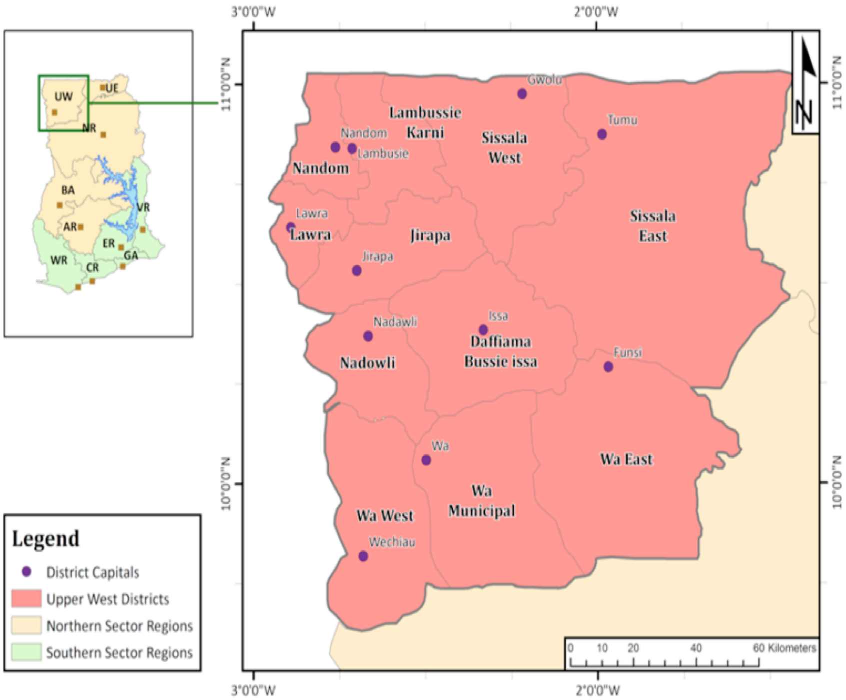

Figure1. *Map of Upper West region indicating Wa West District.*

point of the process to prevent contamination and exchange. The samples were then stored in cold ice chest containing ice cubes to prevent microbial contamination. The samples were transported to the laboratory for analysis within 24 hours.

Instruments, materials and methods used

Portable pH meter (370 Jenway), Photometer DR 6000, filtration instrument, Whatman 1 filter paper, Aquachek©Nitrate / Nitrite (Hach USA) test kit, conical flasks, thermometer, hydrochloric acid, burette, pipette. Electrometric, Potentiometric, Gravimetric, Titrimetric methods were employed in the analysis.

The above instruments and the materials were used for the analysis of the various physicochemical parameters such as Temperature, pH, Colour, Turbidity, Ca hardness, Mg hardness, alkalinity, Ca^{2+}, Mg^{2+}, NO_3^- , Cl^-, K^+, SO_4^{2-},NO_2^-, Mn^{2+}, F^-, Fe^{2+}, Zn^{2+}, Cu^{2+}, Al^{3+}, $SO_4^{2-}$and S^- for both wet and dry seasons. The analysis was conducted under strict environmental conditions to avert contamination and error. Recommended Standard procedure for the laboratory test and analysis were followed in detailed (APHA, 2005). The results of each of the analysis were recorded.

<u>Results</u>

The research carried out during the dry and wet season shows variations in most of the parameters tested. During the wet season, parameters such as turbidity, colour, nitrate, calcium and sulphide show increasing trends in the water sources as indicated in figures 2a and 2b.

DOI: 10.6092/issn.2281-4485/9769

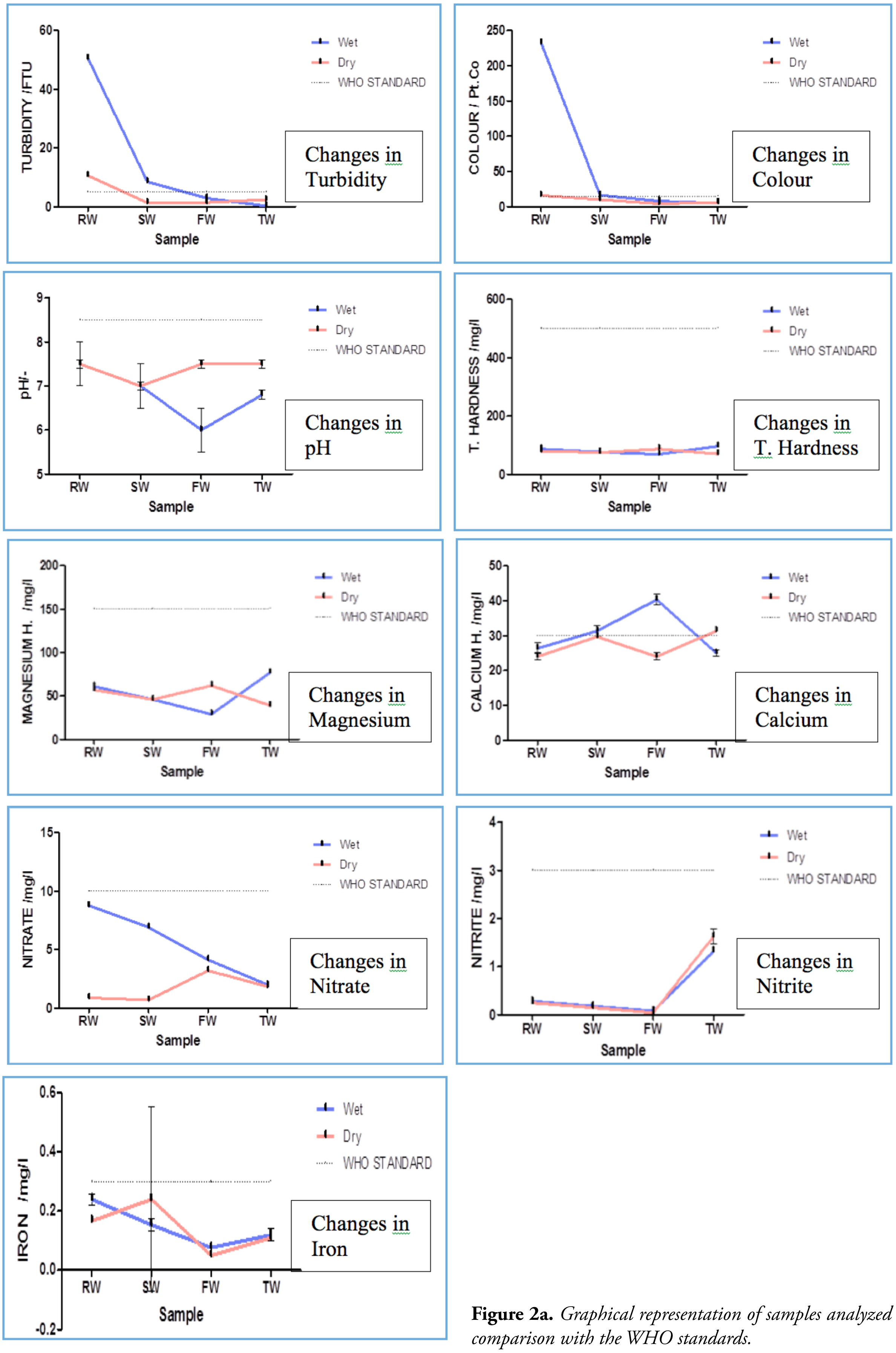

Figure 2a. *Graphical representation of samples analyzed in comparison with the WHO standards.*

DOI: 10.6092/issn.2281-4485/9769

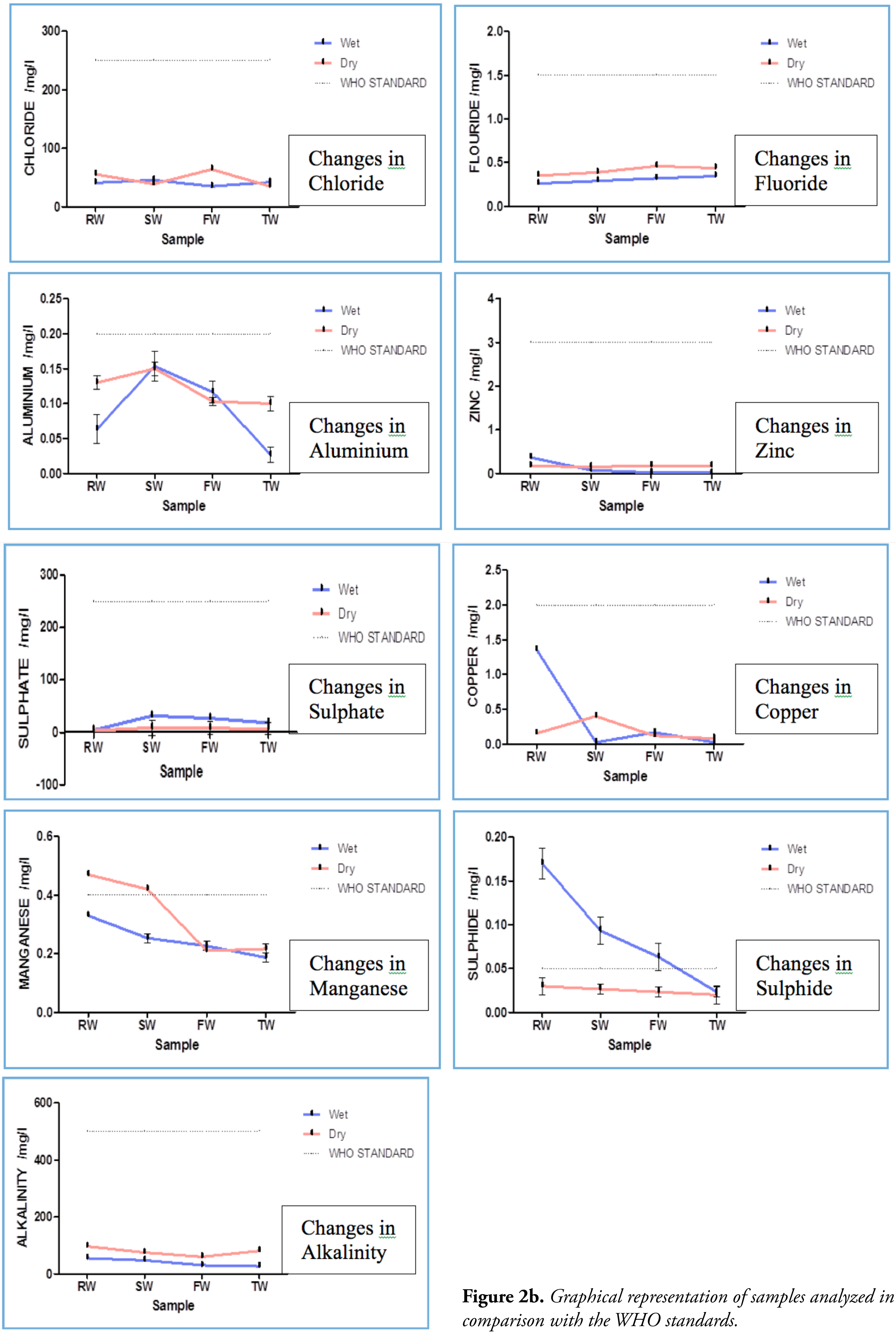

Figure 2b. *Graphical representation of samples analyzed in comparison with the WHO standards.*

DOI: 10.6092/issn.2281-4485/9769

This is as a result of runoffs from non-point sources of the water shed as well as dilution of certain chemicals which lowers the concentration in the water. On the other hand, during the dry season, parameters such as pH, Manganese, temperature, fluoride among others depict increasing trend of concentration as shown in Table 2 and 3. The mean and standard deviation of the parameters were also determined and the results from the analysis are presented graphically as shown in Figure 2a and 2b.

Parameters	RAW WATER		SETTLED WATER		FILTERED WATER		TREATED WATER		WHO STAND
	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	
TEMPERATURE / °C	27.3	0.10	27.8	0.15	28.2	0.15	27.8	0.10	30.5
PH	7.50	0.10	7.00	0.10	7.50	0.10	7.50	0.10	8.50
COLOUR / Pt.Co	16.0	1.00	10.0	1.00	4.17	0.76	6.00	1.00	15.0
TURBIDITY /FTU	10.6	0.37	1.30	0.04	1.40	0.61	2.40	0.10	5.00
T. HARDNESS /mg/l	80.0	5.00	75.0	5.00	86.7	2.89	70.0	5.00	500
CALCIUM H. /mg/l	24.0	1.00	29.7	0.58	24.0	1.00	31.3	0.58	30.0
MAGNESIUM H. / mg/l	57.0	3.61	46.0	1.00	62.0	1.00	39.0	1.00	150
CALCIUM /mg/l	9.60	0.10	12.2	0.15	9.60	0.10	12.4	0.10	200
MAGNESIUM /mg/l	13.7	0.16	10.9	0.04	14.61	0.19	9.47	0.03	150
ALKALINITY /mg/l	97.0	2.00	75.0	1.00	60.0	5.00	81.0	1.00	500
CHLORIDE /mg/l	55.7	1.53	39.0	1.00	64.0	1.00	35.0	1.00	250
NITRITE /mg/l	0.25	0.04	0.15	0.03	0.04	0.02	1.63	0.15	3.00
NITRATE /	0.88	0.03	0.69	0.02	3.20	0.10	1.84	0.08	10.0
FLOURIDE /mg/l	0.35	0.01	0.39	0.02	0.46	0.01	0.44	0.01	1.50
IRON /mg/l	0.17	0.02	0.24	0.31	0.05	0.01	0.11	0.01	0.30
ZINC /mg/l	0.17	0.01	0.15	0.01	0.18	0.01	0.17	0.01	3.00
COPPER /mg/l	0.15	0.02	0.40	0.01	0.12	0.02	0.08	0.01	2.00
POTASSIUM /mg/l	4.23	0.06	4.40	0.10	4.10	0.10	4.30	0.10	30.0
ALUMINIUM /mg/l	0.13	0.01	0.15	0.01	0.10	0.01	0.10	0.01	0.20
SULPHATE /mg/l	3.10	0.10	8.83	14.9	7.49	12.57	7.13	12.01	250
SULPHIDE /mg/l	0.03	0.01	0.03	0.01	0.02	0.01	0.02	0.01	0.05
MANGANESE /mg/l	0.47	0.01	0.42	0.01	0.21	0.01	0.22	0.02	0.40

Table 2. *Results of dry season water analysis for the four treatment stage.*

DOI: 10.6092/issn.2281-4485/9769

Parameters	RAW WATER		SETTLED WATER		FILTERED WATER		TREATED WATER		WHO STAND
	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	
TEMPERATURE / °C	26.8	0.10	26.4	0.10	26.7	0.10	26.8	0.10	30.5
PH	7.50	0.50	7.00	0.50	6.00	0.50	6.80	0.10	8.50
COLOUR / Pt.Co	233	3.06	16.3	1.53	8.00	1.00	5.00	1.00	15.0
TURBIDITY /FTU	50.5	0.35	8.50	0.30	2.90	0.06	0.28	0.03	5.00
T. HARDNESS /mg/l	87.0	2.00	76.7	1.53	68.7	1.53	97.0	2.00	500
CALCIUM H. /mg/l	26.3	1.53	31.3	1.53	40.3	1.53	25.0	1.00	30.0
MAGNESIUM H. /mg/l	61.0	1.00	46.0	1.00	29.0	1.00	77.0	2.00	150
CALCIUM /mg/l	10.8	0.76	12.6	0.78	16.7	0.76	9.80	0.20	200
MAGNESIUM /mg/l	14.7	0.16	11.6	0.20	7.83	0.68	18.5	0.57	150
ALKALINITY /mg/l	55.0	1.00	48.0	1.00	30.5	0.50	27.0	1.00	500
CHLORIDE /mg/l	41.0	1.00	45.7	0.58	35.0	1.00	42.0	1.00	250
NITRITE /mg/l	0.28	0.01	0.18	0.02	0.08	0.02	1.32	0.03	3.00
NITRATE /	8.76	0.14	6.91	0.15	4.13	0.05	1.99	0.05	10.0
FLOURIDE /mg/l	0.26	0.02	0.29	0.01	0.32	0.01	0.34	0.02	1.50
IRON /mg/l	0.24	0.02	0.15	0.02	0.08	0.02	0.12	0.02	0.30
ZINC /mg/l	0.37	0.02	0.07	0.02	0.02	0.01	0.01	0.01	3.00
COPPER /mg/l	1.36	0.03	0.02	0.01	0.17	0.02	0.02	0.01	2.00
POTASSIUM /mg/l	6.57	0.50	4.37	0.15	6.00	0.50	5.10	0.20	30.0
ALUMINIUM /mg/l	0.06	0.02	0.15	0.02	0.12	0.02	0.03	0.01	0.20
SULPHATE /mg/l	4.00	1.00	31.7	1.53	27.0	1.00	18.0	1.00	250
SULPHIDE /mg/l	0.17	0.02	0.09	0.02	0.06	0.02	0.02	0.01	0.05
MANGANESE /mg/l	0.33	0.01	0.25	0.02	0.23	0.02	0.19	0.02	0.40

Table 3. *Results of wet season water analysis for the four treatment stages.*

Discussion

Water quality, quantity and accessibility are very important and a human right issue since it is for the sustenance of life and has no substitute. Due to pollution of most of the water bodies, water treatment has become very necessary to provide water for the masses. However, the cost of treatment of water is directly proportional to the level of quality of the raw water and thus protection of such water bodies from pollution is very paramount. Unfortunately, no natural water is absolutely free from pollution and for that reason, the WHO has set minimum standard to make water drinkable without any health implication and therefore any water purported for drinking must meet that standard as indicated by WHO (2004). The research to establish the quality of water delivered to the public from the Jambussi head works to meets the WHO standards for drinking and other purposes gave very interesting results. The raw water was found that it was not severely polluted and that most of the parameters analyzed at the laboratory showed that the mean values were within the WHO standards prior to treatment and that there were no significant differences at the various levels of treatment. This is because the water source was far from settlement and thus pollution from anthropogenic activities was hardly present. This was observed during the field observation that the water was sourced from a point far from human settlement and that is why the raw water was fairly good as compared to one closed to settlement. This is an indication that anthropogenic activities could affect the quality of water close to human settlement, industrial sites and farming communities. Despite the appreciable quality of the raw water, most of the parameters were above the WHO standards prior to treatment either in the dry or wet season. Turbidity and Colour were observed to be higher in the raw water during the wet season than the dry season and this was possible due to runoff and erosion of sediments, organic matter, plants and animal residues, agricultural residues and some inorganic particulate as suggested in (Higgins, 1975; Pestle, 1997). Notwithstanding, there were variations between wet and dry seasons for some of the parameters. For instance,

DOI: 10.6092/issn.2281-4485/9769

Nitrate, Iron, Copper, Zinc, Calcium, etc. were higher during the wet season than the dry season and this may be as a result of the introduction of certain pollutants from runoffs into the river. Potassium and Temperature have an accepted consumable concentration prior to subjecting to treatment. The concentration of K^+ in the water samples were within the WHO standards in both dry and wet season. The temperature in the dry season was readily above the wet season throughout the four treatment stages due to high solar radiation that occurs during such periods.

Calcium and Magnesium will make water hard as indicated by Thomas (1953). The level of calcium was higher in the wet season than dry season. Water at the tap also recorded higher levels of calcium hardness in the dry season whereas the wet season recorded levels below the WHO standards. Calcium hardness may have the benefits for the people as it is known to strengthen bones especially in children (WHO, 2004) even though it will increase the cost of soap application. The level of magnesium hardness went slightly higher in the dry season of the filtered stage and in the final stage during the wet season. The WHO recommends supplementing drinking water with magnesium because of related cardiovascular risk factor when the level of magnesium is low in drinking water (Eisenberg, 1992). The mean concentrations of Nitrate and Nitrite were recorded to be lower from the various treatment stages in the dry and wet seasons and were within the WHO standards. High concentration may give rise to potential health risks particularly in pregnant women and bottle-fed infants (Kempster et al., 1997).

Fluoride and Iron were both within the WHO standards but Iron is slightly higher in wet season than dry season. For Fluoride, concentrations above 1.5mg/l carry an increasing risk of dental fluorosis, and much higher concentrations lead to skeletal fluorosis as indicated by GWP (2007). However, Low concentrations provide protection against dental caries, especially in children (WHO, 1984). Drinking water must therefore be tested for Fluoride before consumption. For Chlorine, Alkalinity, Copper, Zinc, Aluminium, and Sulphate are all within the WHO standards. Sulphide and Manganese levels were higher in the raw water but became low after treatment and within the WHO standards. However, some parameters such as colour, turbidity, calcium hardness, Calcium and Manganese were all above the WHO standard at the raw water stage. The higher levels at the raw water may be as a result of runoff from agricultural fields and chemical discharges (Patel and Shah, 2008). After treatment, the laboratory analysis of the water from the taps for consumption showed that all the parameters were within the WHO acceptable standards for drinking and thus the water produced from the Jambussi is good. The results also show that the efficiency of the system can also be trusted as indicated by the quality of the output. Tap water from the Jambussi headworks is therefore good for direct consumption.

Conclusion and recommendations

The cost of treatment of water is directly proportional to the level of quality of the raw water. No natural water is absolutely free from pollution and for that reason, the WHO has set minimum standard to make water drinkable without any health implication. All the parameters analyzed including metals recorded were all within the acceptable standards at different stages of treatment to the final consumer. The research has therefore established the quality of the water produced at the Jambussi headworks to meet the standards for drinking. The efficiency of the system was observed to be very good thus the quality of the water produced. It was also observed that the source of the raw water was also fairly good and this will reduce the cost of production and sustain the efficiency of the machines. Highly polluted water will affect both the efficiency and cost and subsequently affect the regular supply of water to the populace. The water sources must therefore be protected from activities such as illegal mining, industrial discharges, poor waste management, over use of fertilizers and chemicals around the facility which pollute surface and underground water bodies during heavy rains.

Pollution will always increase the cost of water production thus it is paramount that water bodies are protected from severe runoffs from polluted sites, intensive agricultural communities and waste disposal sites. Authorities in charge of water bodies must constantly or regularly monitor the catchment areas to avoid severe pollution of these water bodies to ensure good water quality standards are achieved. Most importantly, government must resource the water treatment companies with state-of-the-art equipment for the treatment of water for drinking. To have a reliable and quality water supply, government must also provide adequate funding for research and development of water resources in the country. Workers at the treatment facilities must also ensure that recommended water treatment procedures are followed to the letter. The general public especially those close to the water sources must be educated to protect the water bodies

DOI: 10.6092/issn.2281-4485/9769

from pollution. Above all, further research in other water treatment facilities across the country must also be examined to confirm the quality of the water produced. If such measures are taken, it will increase public confidence in the quality of the water produced by the Ghana Water Company Limited.

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Évaluation de l'efficacite du traitement physico-chimique de la qualite de l'eau: étude de cas de la centrale hydraulique de Jambussi dans la region de l'extreme ouest du Ghana.

Résumé

L'eau est très importante pour la subsistance de la vie et n'a pas de substitut. Par conséquent, sa qualité ne peut être compromise. Cette recherche a pour but d'examiner l'efficacité du traitement et la qualité physico-chimique de l'eau potable des embouchures d'eau de Jambussi, de la source d'eau brute au consommateur final au robinet, afin d'établir la qualité de l'eau traitée pour la boisson dans le district de Wa West et dans les Municipalité de Wa, région supérieure ouest du Ghana. Des échantillons d'eau ont été prélevés à quatre stades des processus de traitement pendant la saison sèche (février-mars) et au début des pluies en (mai-juin) 2019. Des bouteilles de 1,5 L correctement rincées, stérilisées et étiquetées ont été utilisées des échantillons à chaque étape du processus. Les échantillons ont ensuite été stockés dans une glacière contenant des glaçons et transportés au laboratoire pour analyse dans les 24 heures. Les paramètres considérés étaient la température, le pH, la dureté totale, la dureté en Ca et Mg, le manganèse, l'alcalinité, la turbidité, la couleur, le Ca^{2+}, le $Mg^{2+,}$ le NO_3^-, le NO_2^-, le F^-, le Cu^{2+}, le K^+, le Al^{3+}, le SO_4^{2-} et le S^-. Les résultats ont montré que tous les paramètres analysés, y compris les métaux enregistrés, étaient tous inférieurs aux normes de l'OMS pour l'eau potable à différentes étapes du traitement par le consommateur final. Certains des paramètres dépassaient les normes de l'OMS au stade de l'eau brute mais étaient conformes aux normes après traitement. L'efficacité du système a été jugée très bonne et la qualité de l'eau produite répond également aux normes de l'OMS en matière de consommation et autres. La recherche s'est conclue par des recommandations visant à améliorer et à maintenir la qualité de l'eau destinée à la consommation, notamment des recherches supplémentaires pour examiner la qualité de l'eau produite par d'autres installations de traitement de l'eau à travers le pays.

Valutazione dell'efficienza del trattamento della qualità dell'acqua chimico-fisica: un caso di studio di headworks sull'acqua di Jambussi nella regione occidentale del Ghana

Riassunto

L'acqua è molto importante per il sostentamento della vita e non ha sostituti e quindi la sua qualità non può essere compromessa. Questa ricerca è volta a esaminare l'efficienza del trattamento e la qualità fisico-chimica dell'acqua potabile proveniente dai serbatoi dell'acqua Jambussi dalla fonte di acqua grezza al consumatore finale al rubinetto per stabilire la qualità dell'acqua trattata per bere nel distretto di Wa West e Comune di Wa, regione dell'ovest del Ghana. Campioni di acqua sono stati prelevati da quattro fasi dei processi di trattamento durante la stagione secca (febbraio-marzo) e all'inizio delle piogge nel maggio-giugno 2019. I contenitori da 1.5 L utilizzati per il campionamento sono stati preventivamente risciacquati, sterilizzati ed etichettati, I campioni sono stati quindi conservati in una camera fredda contenente e sottoposti ad analisi entro 24 ore dal prelievo. Sono stati considerati temperatura, pH, durezza totale, durezza Ca e Mg, manganese, alcalinità, torbidità, colore, Ca^{2+}, $Mg^{2+,}$ NO_3, NO_2^-, F^-, Cu^{2+}, K^+, Al^{3+}, SO_4^{2-} e S^-. I risultati hanno mostrato che tutti i parametri analizzati, inclusi i metalli registrati, presentano valori al di sotto degli standard dell'OMS per l'acqua potabile nelle diverse fasi del trattamento. Alcuni dei parametri risultavano al di sopra degli standard dell'OMS nelle acque che precedevano il trattamento, per poi rientrare al di sotto dei limiti. L'efficienza del sistema può considerarsi molto buona e la qualità dell'acqua trattata soddisfa anche gli standard dell'OMS a fini potabili e per altri usi. La ricerca si è conclusa con raccomandazioni per migliorare e mantenere la qualità dell'acqua potabile, comprese ulteriori ricerche per esaminare la qualità dell'acqua prodotta in altri impianti di trattamento delle acque in tutto il paese.