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REVIEW ARTICLE

Review of Ghana's water resources: the quality and management with particular focus on freshwater resources

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Abstract

Freshwater resources are continually decreasing in quality and quantity. Approximately, 1% of this freshwater is accessible in lakes, river channels and underground for domestic use. The study reviewed literature on water resources with focus on freshwater, the quality of our freshwater in terms of physical, chemical and biological variables, the main mechanisms of management, and the challenges associated with these mechanisms as well as blending integrated water management with the indigenous or traditional management of water resources for sustainable development and peaceful co-existence. Also the review offered potent recommendations for policy makers to consider sustainable management of freshwater resources. A total of 95 articles were downloaded from Google scholar in water-related issues. The search took place from June to September 2017, and research articles from 1998 to 2018 were reviewed. Basically Ghana is made up of three discharge or outlet systems, namely the Coastal River Systems which is the least and Volta constituting the largest and with the South-Western been the intermediate. Also, freshwater resources usage can be put into two main categories, namely ex situ (withdrawal use) and in situ or in-stream use, and could also be referred to as the consumptive and non-consumptive use, respectively. With the exception of localised pollution engineered by illegal mining and other nuisance perpetuated by indigenes, the quality of water (surface and groundwater) in Ghana is generally better. The review outlined high microbial contamination of water as almost all surface waters are contaminated with either *E. coli*, faecal coliforms or total coliforms or all. However, these contaminations were more prevalent in surface water than groundwater.

Keywords Freshwater · Ghana · IWRM · Water quality · Water use

Introduction

> If there is ever going to be a 3rd World War then it's almost at our door steps and its definitely going to be about water, to curb this we need to take action now (Kofi Annan).

Of all renewable natural resources, water is the most precious of all and it is a basic requirement in the sustenance of all forms of life, complementing our basic needs such as food production, as well as effectively contributing to socio-economic development. Water resources hold great economic potential for agriculture, tourism, irrigation, transport and industry (Nsubuga et al. 2014). It is near impossible to get immediate and/or future replacement for most water uses unlike other resources. Rapid pollution from mining and agricultural activities have compromised water quality making it very expensive to treat for domestic use. However, it is a governable natural resource having the potential of being diversified, transported, stored, reused, and recycled and possibly recoverable (Nsubuga et al. 2014). Water is a naturally circulating resource that is constantly recharged.

Most parts of the world is surrounded by water, but we lack accessibility to this resource especially potable water needed to meet our fundamental needs such as food production, health, sanitation and sustainable development (Owusu et al. 2016). Water constitutes largely over seventy per cent (70%) of the earth's surface and the singular entity to have

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ever existed naturally in all the three (3) states of matter across the globe. It is important to note that of all the water on earth only 2.5% is made up of fresh water and it is distributed all around the world leaving less than one (1%) per cent of fresh water accessible in lakes, river channels and underground (Food and Agriculture Organization of the United Nations 2003; WRC 2005).

In total, the world's water resources are in excess of about 43,750 km^3 per annum, which disperse widely across the world according to the physical features coupled with patchwork of climates. In the world, USA holds the largest portion of the world's total freshwater resources estimated to be about 45%; the second largest is Asia with over 28% of freshwater resources, closely followed by Europe with 15.50% and the other continents with 11.50%. However, in respect of resources per inhabitant in each continent is estimated: 24,000 m^3 per annum, 9 300 m^3 per annum, 5000 m^3 per annum and 3400.1 m^3 per annum in USA, Europe, Africa and Asia, respectively (FAO 2003).

Fifty-two years ago, this indicator attained a supreme value of 4 276 in 1962 as at 2014. In Ghana as at 2014, the renewable freshwater resources per capita were pegged at 1131. Basically, the freshwater resources in Ghana comprise surface water include Volta river system, South-Western and Coastal River Systems (Ghana National Water Policy 2007). Basically due to growing populations and our constant exploitation of this precious resource to meet, our fundamental needs have jeopardised and corrupted the potential use of freshwater resources. Also climate change as well as fiscal factors coupled with environmental pollution from waste (both municipal and industrial waste), leaching of toxic chemicals from fertilisers and pesticides used in agriculture, has further deepen the woes in the potential use of this freshwater resource for our needs. A direct increase in pollution results in a decrease in the amount of operational water (Nsubuga et al. 2014).

Moreover, rapid increase in population across the globe, notably in the developing countries, presents a significant threat to the water resource as well as been a threat to sustainability prompting the need to carefully handle and protect the resource. The term 'water management' broadens over a several sort of activities and disciplines. Water resource management denotes the skilful, efficient as well as effective planning of the limited fresh water resources available for consumption by populace. Water management can be sectioned into three, namely managing water services, then managing the resource and managing the trade-offs needed to equipoise demand and supply (United Nations 2014).

In Ghana, though much has been done on water resources, documentaries, news items and more significantly literature on water resources are more disjointed and not strongly incorporated in policy documents, strategic action plans and reports produced by non-governmental organisations (NGOs), consultants and international entities. The quality of groundwater and surface water resources keeps worsening mainly due to soaring levels of pollution from "galamsey" (illegal mining), waste, leachate from chemical fertilisers and pesticides used in agriculture, chemicals from mining, and use of chemicals in fishing coupled with rapid population growth has entirely left Ghana's water resources ungovernable. The existing water management strategies employed is not robust enough to cover the challenges. Over the past 6 years and counting, Ghana's per capita availability of water resources is reducing daily. The effect of climate change leading to variability in precipitation is one of the challenges our country faces at present, which often result in floods as we recorded the June 3 twin disaster in Accra, Ghana in 2014. The review therefore seeks to assess water resources with focus on freshwater, the challenges, the quality of freshwater in terms of chemical, physical and biological variables as well as blending integrated water management with the indigenous or traditional management of water resources for sustainable development and peaceful co-existence.

The state of water resources in Ghana

Ghana's water resources are categorised into ground water and surface water; however, there are also impoundments or reservoirs. The sources of surface water resources in Ghana are from three river systems, namely the Coastal river systems, South-Western and Volta (Ghana National Water Policy 2007) (Fig. 1).

Surface water resources in Ghana

Surface water resources are principally sourced from three river mainstream discharges in Ghana notably: the Coastal River, South-Western and Volta systems. The Red, Black and White Volta Rivers as well as the Oti River comprise of the Volta river systems. The Bia Tano, Ankobra and

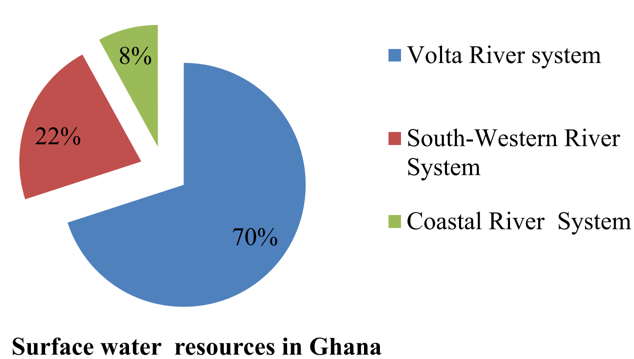

Fig. 1 Surface water resources distribution in Ghana

Pra rivers constitute the South-Western river systems. The Tordzie/Aka, Densu, Ayensu, Ochi-Nakwa and Ochi-Amissah form the Coastal river systems (Ghana National Water Policy 2007). These river systems make up 70, 22 and 8%, respectively, of the total land area of about 240,000 km^2. In addition, the sole natural freshwater lake in Ghana is Lake Bosumtwi. This is a meteoritic crater lake located in the forest zone, with a surface area of 50 km^2 and a maximum depth of 78 m (Ghana National Water Policy 2007; WRC Ghana 2012).

Groundwater resources in Ghana

Ghana's groundwater resources are made up of three geological formations with 54, 45 and 1% for the basement complex (metamorphic rocks and crystalline igneous), the consolidated sedimentary formations, and the Cenozoic and Mesozoic sedimentary rocks, respectively (Ghana National Water Policy 2007). Occurrence of groundwater in the basement complex is linked to the development of secondary porosity hence causing the fracturing, jointing, shearing and weathering. Aquifers depth normally ranged from 10 to 60 m with yields hardly exceeding 6 metres cubic per hour (Ghana National Water Policy 2007; WRC Ghana 2012). The Cenozoic and Mesozoic formations that usually occur in the extreme South Eastern and Western part of Ghana are also limestone aquifers with depth range of 120 to 300 m. The limestone aquifers have an average yield of about 184 cubic metres per hour (Ghana National Water Policy 2007; WRC Ghana 2007).

Impoundments or reservoirs

Reservoirs or dams and impoundments have been created for the purpose of water supply, irrigation, hydroelectric power generation and ecosystem support. In 1964, Akosombo was the first reservoir constructed for hydroelectric power; it was about 100 km from the flowing together of the Sea and the Volta. In the world, one of the largest man-made lakes is Akosombo dam which cover an area of about 8500 km^2 and 148 km^3 water volume capacity (Ghana National Water Policy 2007; Mensah 2010; WRC Ghana 2015). A relatively smaller impoundment was constructed at Kpong with a coverage area of about 40 km^2 thus 17 years thereafter (about 20 km downstream of Akosombo) (WRC 2012; WRC Ghana 2015). The Bui hydroelectric project with capacity of 400 MW in the Black Volta was another impoundment created for the purpose of electricity. If the country were to harness hydroelectric power from Pra River, then we did generate 125 MW from the facility. Other major impoundments in Ghana include the Barekese and Owabi supply (consumptive water for Kumasi Metropolis), the Weija (supply water for Accra), Nawuni (that supply water in and out of the Tamale Metropolis) on the Rivers Densu, Volta and Offin (WRC 2012; WRC Ghana 2015) (Table 1).

Table 1 Characteristics of some major reservoirs or impoundments in Ghana and their estimated annual generation rate or irrigation surface or abstraction rate. *Source*: Ministry of Water Resources, Works and Housing (1998) and WRC (2005)

Location	River	Main basin	Capacity (× 1,000 m^3)	Annual energy generated/irrigation surface/rate of abstraction
Akosombo	Volta	Volta	148 km^3	912 MWh
Abesim	Tano	Tano	7330.06	2,443,353 m^3/y
Barekese	Offin	Pra	89,588.52	29,862,840 m^3/y
Bolgatanga	Yaragaantanga	White Volta	8100.00	2,700,000 m^3/y and 450 ha for irrigation
Bui	Volta	Volta		400 MWh
Daboase	Pra	Pra	29,880.36	9,960,120 m^3/y
Hohoe	Dayi	Volta	2365.20	788,400 m^3/y
Inchaban	Anankwari	Pra	19,973.10	6,657,700 m^3/y
Kwanyako	Ayensu	Coastal	14,931.77	4977.25 m^3/y
Kpong	Volta	Volta		160 MWh and 4000 ha for irrigation
Kpong water works	Volta lake	Volta	232,588.17	77,530,000 m^3/y
Koforidua	Densu	Densu	4966.92	1,655,640 m^3/y
Weija	Densu	Densu	190,000	–
Winneba	Ayensu	Coastal	2484.72	829,572 m^3/y
Tamale	Nawuni	Volta	21,407.16	7,135,721 m^3/y
Tono	Tono	Volta	3,760,286	2500 ha for irrigation
Vea	Vea	Volta	816,000	2,400,000 m^3/y and 1000 ha for irrigation
Owabi	Offin	Pra	15,329.91	5,109,971 m^3/y

Usage of water resources in Ghana

An estimate of actual renewable water resources is 53.20 km^3 per year with 30.30 km^3 year being internally generated. The annual runoff of 56.4 billion m^3 is contributed from all rivers with Volta River contributing a massive 41.6 billion m^3. The mean annual runoff of 38.7 billion m^3 is from the Volta basin in Ghana thus about 64.70% of the total annual runoff. The annual runoff contribution from Volta is 64.70%, 29.20% from South-Western and 6.10% from Coastal system in Ghana (Ghana National Water Policy 2007; Ministry of Water Resources, Works and Housing 2012). In terms of freshwater resources usage, the two main categories are ex situ (withdrawal use) and in situ or in-stream use and could also be referred to as the consumptive and non-consumptive use, respectively.

Consumptive use or ex situ use

With the consumptive use, basically water is withdrawn or taken from its main source. "Water intake" refers to the quantity withdrawn, usually some part of this water is consumed or lost and the remaining quantity seeps into the original source. The quantity of water that does not returned to the water body is commonly referred as the "water consumption"

The most consumptive uses of water in Ghana are municipal use (water supply) 37%, 48% for agricultural use (livestock watering and irrigation) and 15% for industrial use. For surface water resources alone, it is projected that consumptive water demand would reach 5 billion m^3 by 2020, that is equivalent to 12% of the total surface water resources (WRC 2005) (Fig. 2).

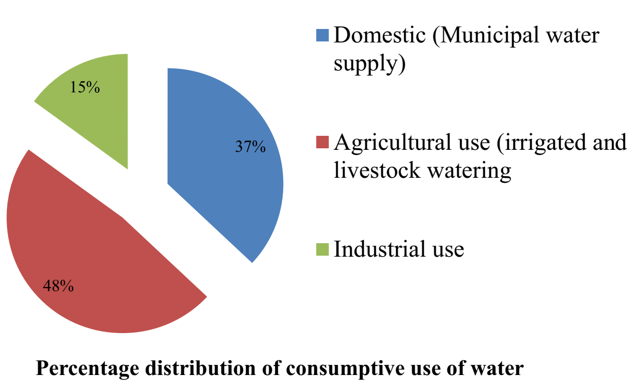

Fig. 2 Distribution of consumptive or ex situ use of freshwater resources

Non-consumptive or in situ use

Unlike consumptive water use, non-consumptive water or in situ use is linked to activities that require no withdrawal of water from its main source.

The major non-consumptive uses of water include water transport, inland fisheries, hydropower generation and tourism (recreational activities like waterfalls) as well as ecosystem support services. Reservoirs and impoundments are constructed to facilitate potable water, create platform for irrigation and the core been hydroelectric power generation. Since, water is not withdrawn for these uses, it is practically impossible to estimate the actual quantity of water required. However, It is projected that by 2020 Ghana will require supply of 1,733,380 cubic metres of non-consumptive use of water, of which 378,430 cubic metres would be used for hydropower generation (Ghana National Water Policy 2007; Ministry of Water Resources, Works and Housing 2012) (Table 2).

Freshwater quality

The quality of naturally occurring surface waters and groundwater some years back was generally good except until the recent phenomenon of localised pollution due to the discharge of sewage into water bodies from industrial and domestic activities, leaching of fertilizers and pesticides used in agriculture, with the most recent and alarming canker being illegal artisanal mining denoted ('galamsey') (USAID 2011). This has become a constant menace as almost all water resources located close to mining areas are seriously polluted. The alarming rate of this destruction has prompted the government of Ghana under the hospices of the Ministry of Lands and Natural Resources to designate special task force to fight this menace and safeguard our water resources. Also use of chemicals in fishing coupled with rapid population growth has entirely left our water resources ungovernable (Nsubuga et al. 2014). Discharges of untreated sewage from municipal waste have resulted in serious pollution of water in most urban settings. Lagoons and Rivers situated near industrial areas are gradually perishing due to the discharge of untreated municipal waste from domestic and industrial effluent that causes odour and nutrient enrichment leading to algal bloom. An example of such a polluted lagoon in Ghana is the Korle Lagoon in Accra (WRC 2015). Water quality is an embodiment of all aspect of physical, chemical and biological features. The main water quality characteristics of streams, rivers and lakes include the physical, chemical and biological features which are of prime importance to water engineers (Owusu et al. 2016).

Table 2 Estimated values for consumptive and non-consumptive use of freshwater resources from 2000 to 2020 *Source*: Ministry of Water Resources, Works and Housing (1998) and WRC (2005)

Demand	Year			
	2000 (million m^3)	2010 (million m^3)	2020 (million m^3)	% Withdrawals
Rural centres	166.6	231.9	321	0.6
Urban centres	320.6	523.6	616	1.2
Domestic/industrial water	487.2	755.5	937	1.8
Other sectors				
Hydro-energy	37,843	37,843	37,843	90.2
Irrigated agriculture	617.45	2132.42	4114.42	5.46
Livestock	31.9	49.1	74.8	0.12
Freshwater resources	53,200	–	–	–
Fishing	–	–	–	–
Mining	–	–	–	–
Water Transport	–	–	–	–
Tourism	–	–	–	–
Cumulative use of domestic and industrial water	487.24	755.45	937	1.76
Cumulative demand	38,979.59	40,779.79	42,969.22	

Physical variables

Physical properties of groundwater

Saana et al. (2016) study reported temperature as part of the physical variable which ranged between 28.80 and 32.80 °C. The study also revealed that turbidity and true colour of the water samples ranged between 0.13–105 NTU and 5–130 Hz, respectively. Sarpong (2014) in a study indicated that temperature and turbidity vary in concentration in relation to required standards. Cobbina et al. (2010) reported the colour of water which ranged from 5 to 750 Hz with a mean 175 Hz, turbidity from 0.65 to 568 NTU with a mean 87.9 NTU.

Physical properties of surface water

Ansa-Asare and Gordon (2012) reported the mean turbidity levels in Densu Basin were higher than that of Ayensu and Birim basins and exceeded WHO standards for domestic use. The low turbidity indicates higher primary productivity of Ayensu Basin. Leslie (2010) in a study revealed pollution of Aboabo River since colour, odour, turbidity and taste levels exceeded WHO stipulated limits for potability. Asamoah-Boateng (2009) indicated high turbidity and total suspended solids values exceeded WHO and Ghana Standard Authority standard for potability and were attributable to mining activities.

Karikari and Ansa-Asare (2006) reported high levels of turbidity which was attributed to poor farming practices that lead to saltation of the river during runoff. Goski (1999) reported that physically, the quality of water in the Densu River basin can be said to be poor as suggested by the high colour value (30–90 TCU against a guideline value of 15 TCU) and turbidity (6–54 NTU against a guideline value of 5 NTU).

Chemical variables

Chemical properties of groundwater

Saana et al. (2016) reported the mean concentrations of 0.06 mg/l for iron, 22.11 mg/l for calcium, 29.84 mg/l for magnesium, 13.97 mg/l for chloride, 0.00 mg/l for fluoride, 0.00 mg/l for aluminium, 0.00 mg/l for arsenic, 0.01 mg/l for ammonium, 2.09 mg/l for nitrate and 0.26 mg/l for nitrite. In addition, the mean total hardness value was 178.07 mg/l, 55.28 mg/l for calcium hardness and 122.79 mg/l for magnesium hardness. Also, 6.14 to 7.50 pH units for pH, 48 to 240 mg/l for total alkalinity, 80.10 to 524 mg/l for TDS and 131 to 873 µS/cm for electrical conductivity.

Affum et al. (2015) reported toxic elements, hardness and salinity pollution as the main factors affecting the quality of groundwater. Mineral dissolution, cation exchange and silicate weathering influenced the quality of groundwater. The order of major ions of the water was $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ and $Cl^- > SO_4^{2-} > HCO_3^-$. Piper plot and the hydrogeology of study showed a water type of 86% of sodium chloride and 14% of sodium hydrogen carbonate and sodium carbonate. The As and Cd concentration of 79 and 43%, respectively, exceeded the WHO guideline limits of 10 µg/L and 3 µg/L for potability exception of Hg.

Sarpong (2014) reported pH, conductivity, alkalinity and amount of oxygen that varied in concentrations. Mean conductivity ranged from 68.36–581.22 µS/cm, with the alkalinity, DO and pH values within WHO and Ghana

Standards Authority permissible limits. Asante (2012) reported groundwater pH ranged between 5.77 and 6.56 and electrical conductivity ranged between 360.17 and 957.12 µS/cm. Also, contaminants resulting from mining detected in water samples were: As (< 0.001–0.002 mg/l), Cn (0.002–0.036 mg/l), Mn (0.100–0.72 mg/l) and Fe (0.32–3.035 mg/l). Cobbina et al. (2010) reported total iron that ranged from 0.07 to 7.85 mg/l (mean 1.0 mg/l) and manganese from 0.03 to 1.59 mg/l (mean 0.50 mg/l). Also, Nkansah et al. (2010) reported pH that ranged between 6.30 and 7.0 pH units, 46–682 µS/cm for electrical conductivity, 0.67–76.00 mg/l for PO_4^{3-}, 0.20–0.80 mg/l for F^-, 0.0–0.97 mg/l for NO_3^-, 0.0–0.06 mg/l for NO_2^-, 3.00–7.00 mg/l for SO_4^{2-}, 0.0–1.20 mg/l for Fe and 0.0–0.02 mg/l for Mn.

Chemical properties of surface water

A study by Asante (2012) reported surface water pH levels that ranged between 6.57 and 7.14 pH units and 451.67–774.72 µS/cm for electrical conductivity. However, mining-related contaminants detected in water samples were: As for < 0.001–0.002 mg/l, Cu for 0.002–0.04 mg/l, Mn for 0.10–0.72 mg/l and Fe for 0.32–3.04 mg/l. Ansa-Asare and Gordon (2012) reported that all the pH values for the rivers ranged between 6.5 and 8.5 pH units. The electrical conductivity levels followed the order: Densu > Ayensu > Birim of the River basins; the order was much depended on the human activities in the basin. Also, Ammonia–nitrogen followed this order in terms of the river basins: Ayensu (0.16 mg/l) < Birim (0.27 mg/l) < Densu (0.36 mg/l). The basins had NO-N concentration that ranged from 0.01 to 3.96 mg/l (1.89 mg/l) for Densu, 0.21–6.48 mg/l (2.55 mg/l) for Birim and 0.001–8.17 mg/l (2.63 mg/l) for Ayensu. TDS and total hardness also showed a similar pattern of Birim < Ayensu < Densu. This was due to frequent domestic use impacting on Densu basin as compared to the other basins.

Asamoah-Boateng (2009) indicated clearly that arsenic, iron and lead were the most predominant mining-related metallic pollutants found in all the water bodies. This was attributable to the perceived natural climatological and geological conditions. Karikari and Ansa-Asare (2006) reported that the pH of the water was in 7.20–7.48 pH units range and seasonal variation did not affect the water. The study revealed that river waters were moderately soft to slightly hard (91.20–111 mg/l $CaCO_3$ of hardness). High nutrient loads were observed in the basin and the study attributed it to agricultural, domestic and industrial activities. The general ionic dominance pattern of the water was Na > Ca > Mg > K, and $HCO_3 > Cl > SO_4$ which is an intermediate between freshwater system and sea water system. The chloride dominance over sulphate was due to activities, fertilizer use, household effluents and other anthropogenic point sources. The study showed low metal contamination of the river as the trace metal levels were low concentrations.

Goski (1999) revealed that pH ranged from 7.50 to 8.40 pH units and conductivity (162–681 µS/cm). Also, high phosphate level of the Densu River ranged from 0.01 to 1.20 mg/l, iron had values ranging between 0.20 and 1.59 mg/l, which exceeded the WHO guideline value of 0.30 mg/l, and chloride had values within 9.20–112.0 mg/l. Also, BOD levels ranged from 0.77 to 9.90 mg/l and dissolved oxygen levels ranged from 1.60 to 9.40 mg/l.

Biological variables of water resources

Biological variables of groundwater

Saana et al. (2016) reported that 14% out of the total water samples collected tested positive for faecal coliforms and exceeded WHO guidelines limit of zero colony-forming unit/100 ml for drinking water. Affum et al. (2015) reported the absence of *E. coli* in the water sampled, but wells contained total coliforms (*Enterobacter* species) that was 36%. All but one of the hand-dug wells and boreholes showed faecal contamination with levels above WHO and GSA guidelines. The counts of the total coliform, faecal coliform and the *E. coli* differed significantly ($p = 0.005$) between the various water sources sampled. Cobbina et al. (2010) reported coliform counts in water from all the dugouts in both wet and dry seasons were, however, above the recommended limits for drinking water. Faecal and total coliforms ranged between < 1–19,000 cfu/100 ml (mean of 1310 cfu/100 ml) and 125–68,000 colony-forming units/100 ml (mean of 10,623 cfu/100 ml), respectively. Nkansah et al. (2010) indicated *E. coli* and total coliform were below the minimum detection limit of 20 MPN per 100 ml in the samples.

Biological variables of surface water

Leslie (2010) reported that faecal coliforms count for water sampled at all stations were above 300×10^4/100 ml and had exceeded the WHO guidelines of 0/100 ml for domestic use. Asamoah-Boateng (2009) revealed high microbial counts in all the water bodies that suggested high bacterial pollution making the water unwholesome for domestic use. Karikari and Ansa-Asare (2006) attested that the microbial quality of the river water was poor and far below the standard for domestic use. The finding was attributable to direct contamination by human and animal excreta and other activities such as washing of clothes and swimming. The River water cannot be used for domestic purposes without any form of treatment. Goski (1999) reported that total coliform and faecal coliform counts ranged from 100 to 1940 count/100 ml and this indicated poor sanitary conditions in the Basin.

Fresh water pollution and looming crises in Ghana

More of the population could have safe drinking water facilities if the ongoing anthropogenic activities in Ghana are gapped with the great efforts made by the traditional and local government authorities in Ghana. About 60% of water bodies in Ghana are polluted with most of them in critical condition (Ampomah 2017). The quantity and quality of fresh water are still a major problem in most countryside of Ghana as people have to use rainwater, surface water, and shallow groundwater as their drinking water sources. Due to the persistent widespread in illegal mining activities, pollution of water bodies occurs mostly in the south-western parts of Ghana. According to Ampomah (2017) industrial waste, illegal mining, farming and household disposals are the major causes of water pollution in Ghana; hence traditional and local government authorities need to help in the protection of water bodies. There is urgent need to improve the quality of fresh water bodies in those areas.

It is indisputable fact that fresh water resources in Ghana are under threat as water resources are running dry and increasingly becoming scarce by the day. Managers of water treatment plants in Ghana are forced to shut down due to pollution that is making cost of water treatment of water bodies very expensive.

According to Mantey (2017) fresh water bodies in the following regions of Ghana have been polluted due to illegal mining activities. River Pra, Daboase, and River Ankobra that are the main water bodies in the Western Region have been polluted. Birim in the Eastern Region as the main water body has been polluted. Due to that water treatment plants in Kyebi were forced to shut down due to pollution of the river which is beyond treatment. This challenge has compelled the Ghana Water Company to construct boreholes which will serve smaller masses.

The problem extends to the new Juaben communities and Koforidua where fresh water bodies around those communities have been polluted due to fishing activities. Mantey (2017) asserted that they use to use very minimal chemicals in treating the water from Volta River, but currently the chemical usage is high due to gradual increase in pollution. The Densu River in the Greater Accra Region, which draws its water source from Western Accra that is situated around the Weija dam, has been polluted due to industrial waste and farming activities. This has complied Ghana Water Company to use chemicals to address the pollution issue.

In the Central Region, some water bodies particularly in Cape Coast have been polluted due to galamsey activities (Mantey 2017). The situation is not different in Brong Ahafo if not worse, as residents have been blocking the course of the river at definite intervals which prevents water from flowing into some areas in the Region (Mantey 2017). The recent lack of water in Sunyani was not due to equipment but farming activities, where the residents blocked the river course in order to irrigate farms (Mantey 2017).

The Black Volta in the Upper West Region is also polluted. This coupled with rapid population growth has engineered Ghana Water Company to set up a new water treatment plant in order to compliment the production of safe drinking water (Mantey 2017). The Ashanti Region is battling with the same pollution problem. According to Mantey (2017), the Enu River which serves residents at Konogo in the Ashanti Region is polluted due to illegal mining activities. The basic activity causing pollution of water bodies in the Northern Region is sand winning, whilst galamsey activities are responsible for water bodies' pollution in some regions (Mantey 2017). The Nawuni River in the Northern region of Ghana has experienced massive sand winning activities and that has continously altered the color of the River (Mantey 2017). Globally, water pollution has become a problem now a days this call for evaluation of water resource policy to counter this pollution problem.

Water resource management

Water resource is one of the most permeate natural resources previously viewed as a free good with unlimited quantity (Ghana National Water Policy 2007). However, water as a resource is increasingly becoming scares and low in quality as a result of rapid population growth, urbanisation and diversified use such as fisheries, irrigation, industrial processes, hydropower generation and ecosystem support services (Ghana National Water Policy 2007). Shaw (2005) estimated that, globally, 12 million deaths can be attributed to water scarcity in many given years stressing even the need for appropriate water resources management. Water resource management denotes the skilful, efficient and effective planning of the fresh water resources that are scarce for efficient use by all living organisms. These resources are made up of all groundwater and surface water that can be treated for purpose of human use. Water resources management in Ghana can be broadly put into three categories, namely customary laws and practices (traditional approach), statute law or legal dimension (constitutional approach) and the most recent been the integrated water management (interdisciplinary approach).

Traditional approach to water resources management

Water is the most treasured natural resource in the Ghana culture. It is a traditional resource used to perform various functions like pouring libation aside from the domestic use (Ofori-Boateng 1977). The main supplies of water in the customary regime are springs, streams, rivers and wells though there are proliferation of dams and boreholes in the new age of the twenty-first century. However, with the availability of these sources of water supplies there is entirely no institution or office mandated or tasked under the customary regime to provide water for indigenes (Mensah 1999). This could be attributable to the fact that water is a common resource (tragedy of the common) with no clear ownership though that mandate is vested on the chiefs and the traditional authorities.

Water in its natural state cannot be privately owned. There is no clear distinction as to ownership of water in the customary practice; it varies from community to community. Surface water is considered as a public property in most communities in Ghana; for others, the onus lies on the king or chief and his kinsmen. The fact is that the king or chief holds the water in trust for his people therefore; the chiefs and their kinsmen control manage and regulate the use of water resources. In some communities in the northern part of Ghana, chiefs and queens are assigned to specific stream, rivers and wells (Opoku-Agyeman 2001).

Customary law, however, evolved rules that ensure equitable use and quality of water resources is maintained and standardised in the communities.

As part of the management strategies adopted by the local authorities, implements or containers used to fetch water are also regulated and monitored. The local authorities outline specific rules to manage water resources usually engineered by fetish priestesses and priests though these may slightly vary depending on the location. Containers such as calabashes, earthenware pot, and lately buckets are accepted for the drawing water. Also, some communities generate commonsensical rules banning the use of dirty bucket for collection of water and prevention of women from fetching water during menstruation period especially in rivers. Generally, there are particular days set aside for people not to go into the river or the sea. Also, there is prohibition of farming along river banks as they are considered as resting abode for river gods. Sanctions for rules violation are by slaughtering of sheep to sanctify the gods or ancestors, payment of fines to community elders or the provision of schnapps, local chief or the priests or priestesses (Sarpong 1993-1995; Mensah 1999; Opoku-Agyeman 2001).

Aside from penal sanctions like infliction of fines and sacrifices, religious and cultural beliefs, norms and values are also crucial means of ensuring compliance with the customary rules on water supply. Pronouncement made by chiefs, priestesses and priests is strongly adhered to and disobedience of such edicts is prone to grave repercussion with the worst been death sentences for victims. Customary rules laid the foundation for enforceable regulations and rules to evolve which were used for the water resource management and conservation (Opoku-Agyeman 2001).

However, conflicts that emanate from water resources use were squarely handled by traditional authorities. They drove their wisdom from past experience and prevailing rules and regulations as well as authoritative command specified by the chiefs and elders. The judgment made by these tribunals was abided by due to the fear for the fetish priestesses and priests. The power of enforcement exercised by chiefs included the power to ostracise an offender from the community for non-compliance to any verdict (Sarpong 1993–1995; Mensah 1999; Opoku-Agyeman 2001).

Due to colonisation and the advent of dynamism in culture as well as the proliferation of western religions, the venom of customary rule has significantly diminished and ineffective for water usage rules enforcement. This has also substituted the traditional authorities' powers with that of the governor and successively the executive after independence and laws imposed by the colonial power or ordinances enacted or by the legislature have replaced customary edicts propounded by traditional authorities. Customary law for the enforcement of norms on water usage has now paled into irrelevance and is practices only in rural communities.

Statutory laws (legal acts) on water resources management

The birth of the 1992 constitution paved way for establishment of legislative instrument, and the enactment of laws though these laws did not spell out any establishment of an institutional basis for water resources regulation. However, related resources such as fisheries, forestry and land were establishment of Fisheries, Minerals and Lands Commissions tasked to manage and coordinate policy in connection with these resources. These Commissions activities have, however, impacted the water resources sector. Water resources commission pursuant to the Water Resources Commission Act, 19961 for proper management of Ghana water resources, inter alia. The Act is the main instrument that directs water use and its management in Ghana.

Water acts and regulations for water resource management in Ghana

The major Acts enacted by the State in the quest to manage Ghana's water resources include:

Dam safety regulation 2016, (LI 2236),
Riparian buffer zone policy, 2011,
Drilling license and groundwater regulation 2006, (LI 1827),
Water use regulation 2001, (LI 1692),

Water resource commission Act 19961, Act 522.

Regulatory institutions in Ghana

Institutions mandated to direct control and manage the standard of water include:

Water Resources Commission (WRC),
Environmental Protection Agency (EPA),
National Environmental Action Plan (NEAP),
Public Utilities Regulatory Commission (PURC).

Integrated water resources management (IWRM)

For sustainable, equitable and efficient water resources use, there is the need for fully implementation of IWRM which is an integrated approach. Basically the customary and statutory laws have failed to address challenges associated with water resources management, hence the need to adopt efficient and robust approach to arresting the menace. IWRM referred to a process that promotes the coordination of management and development of land, water and related resources, in order to maximise the social welfare and resultant economic in an equitable way without cooperating the vital ecosystems sustainability (Global Water Partnership 2000). Operationally, IWRM approaches involve application of diverse knowledge from disciplines and insights from stakeholders to devise and implement equitable, efficient and sustainable solutions and development problems of water (GWP 2000). IWRM is a means of achieving three thematic objectives of efficiency, equity and sustainability.

Implementation of IWRM in Ghana by Water Resources Commission (WRC)

Ghana followed the formal international recommendations (WSSD Plan of Implementation) and conventions made on developing IWRM by the ECOWAS through national planning. However, since the manifestation of IWRM in 1990, Ghana has ever since put in laudable legal, political, and institutional frameworks as effort to sustain the implementation of IWRM.

The IWRM Plan document provides summaries of the current baseline situation of the bio-physical context, the socio-economic context, water demands, water resources potential, the water sharing among the neighbouring countries along with the current framework management as specified by the legal instruments and roles and functions of water institutions.

Management of water resources concerns is cross cutting in order to achieve the outcomes of the plan will necessitate a collective effort to influence some other sectors. Undoubtedly, successful implementation of the IWRM plan will be depended on existing institutions and structures. High levels of collaboration among stakeholders and agencies have already been developed by WRC; this will be maintained and further strengthened. NGOs/Community-Based Organisations, MMDAs, and other civil society groups at the decentralised level that work together within a water resource are usually tasked to take charge and coordinate management of water resources activities by deploying the management at the lowest level. Finally, in the IWRM implementation plan monitoring and evaluation are very key element. As progress towards objectives and goal can be pursued and draw lessons for performance improvement.

Challenges of WRM in Ghana

It is worth acknowledging that a lot have been done for the development of legal, political and institutional framework for management of water resource in Ghana and even beyond. However, the country still faces numerous challenges in its quest to meet the current and future needs. Some of the gaps in water resources management (thus customary laws and practices, statutory and IWRM) in Ghana include

- Existing water laws and regulations are not properly enforced; hence they are not robust enough to address the menace.
- The acts do not provide mechanisms to reconcile customary law and practices with statutory laws in the constitutional discourse. Thus, the enactment of these acts has dully denied traditional authorities the mandate. The local authorities should be empowered and given constitutional mandate to prosecute or apply customary laws and practices in the water resources management.
- Lack of involvement of community in decision making as the top-down approach is still more prevalent. These resources are located in these communities; hence its management should be bottom-up approach where community members as well as traditional authorities can take part in decision making regarding water resources management.
- Lack of regulations on surface water especially dam safety and control of domestic and industrial effluent discharge and sewage outfalls
- Climate change and climate variability impacts on water resources are inadequate and often insufficiently incorporated described in sectoral management strategies of water (National IWRM Plan–Water Resources Commission 2015).
- Early warning systems and mitigation of effects of droughts and floods are insufficient (National IWRM Plan–Water Resources Commission 2015).

Way forward (future prospect) in Ghana's Water Resource Management

Aside from the managerial gaps in water resources management, other constraints of WRM include illegal mining, bad or improper agricultural practices (the new phenomenon of chemical farming) leading to eutrophication, waste disposal and management, clearing of the forest (timber extraction) and climate change.

What can be done to ameliorate the situation, thus looking for possible ways or solutions towards management of Ghana's water resources?

Incorporating customary water management

Until 1996 where the WRC was established and task with the constitutional mandate to manage water resources in the country, the customary laws and practices were the best bet for effective water resources management in Ghana. This customary laws and practices did not disappoint though there were gaps in terms of equity as the traditional authorities could not make water resources more accessible to all but evolved rules that ensures quality and equitable use of water resources among communities.

Co-existence between the customary laws and practices as well as the statutory laws

There should be a need for a reconciliation of the traditional management (customary laws) and statutory laws to effectively address water resources management problems. Thus, judicial mechanism should be developed for settling conflicts, disputes that arise from water resources management.

Sensitisation and education on the menace of illegal mining and creating alternative livelihood activities for victims

Illegal mining have taken a toe in the limited water resources, destroying a lot of fresh water bodies in Ghana. Severally governments have made attempts to mitigate or if possible arrest the problem, but the problem still persists to date. Government has often times deployed task force and security agents for instance the military to visit these site and have culprits arrested yet people still go back. The menace has been evident through the loss of live through collapse of pits that ended up killing some of their members and even the security as we recently witness in the loud cry of Captain Mahama's death. There is a need to increase awareness of illegal mining menace to these illegal operators and the risk it poses to future generations. It is only until change in attitude towards environmental sustainability occurs that the problem of illegal mining will be a thing of the past. Attitudinal change cannot ensue overnight; however well-planned awareness creation and proper advocacy as well as behavioural change public services to these miners can make the currently situation better. Moreover, education must be intensified especially when giving license to small-scale mining operators as well periodic monitoring of their operation to ensure their operations are in conformity with the established standards. Nevertheless, alternative jobs or livelihood should be created by the government to get their miners engaged.

Specific roles or responsibilities must be assigned to stakeholder or the architects in water resources management

Most of water resources in Ghana are situated in rural areas. Hence, it is best to appropriately assign specific duties to various stakeholders in the community as to how they can help in the governance of water resources and its related ecosystems by the roles assigned to them. In order to effectively and efficiently carry out this mandate, they should be adequately equipped with materials needed to do so. Moreover, the traditional authorities should be task with the responsibility of improving communities' sanitation as this would also help protect fresh water bodies.

Adopting renewable energy sources

Climate change has eluded local, regional and national concerns and has become to be can a renowned global issue that has a toil on water resources. Concerted efforts have constantly been made through the adoption of various international protocols like the Montreal, Kyoto among others to mitigate this global canker. In Ghana, climate change is evident through the irregular rainfall patterns that have led to various floods that have recently wreaked havoc and the drought pattern experienced some countryside. This phenomenon is mostly stimulated by anthropogenic activities that have increase the levels of greenhouse gases resulting in global warming and eventually climate change.

Most of the rural communities in Ghana are entirely dependent on trees as their primary sources of energy through felling of trees for timber, fuel wood, charcoal among others and this has been the main contribution to climate change. Though there are sophisticated technologies to address the release of GHG's from fuels used in vehicles, the increase in number of these cars in the system is worrying.

In addressing this, the minimal usage of charcoal is encouraged and replaced with liquefied petroleum gas by former President John Mahama of Ghana (in his administration) tried to achieve by giving out some cylinders to some rural people since, they rely a lot on wood for cooking. Also, another viable means of mitigating climate change is through the use of hydroelectric power to meet energy needs which Ghana as a country is using though there are current challenges with the hydropower system. This has not limited the use of more renewable sources of energy to meet current energy demand as the venture into new emerging forms of energy sources such as wind and solar. The country has what it takes to harness this, as there is abundance of sun particularly in northern Ghana, the only challenge could probably be finance (cost).

Conclusion

Notably, freshwater resources are continually decreasing in quality and quantity. The review aimed at assessing the water resources with focus on freshwater, the quality of our freshwater resources in terms of physical, chemical and biological variables, the main mechanisms of management, and the challenges associated with these mechanisms as well blending integrated water management with the indigenous or traditional management of water resources for sustainable development and peaceful co-existence. Ghana freshwater resources are made of surface and groundwater bodies. Ghana is drained by the South-Western, Volta, and Coastal River Systems. Also, freshwater resources usage can be put into two main categories, namely ex situ (withdrawal use) and in situ or in-stream use and could also be referred to as the consumptive and non-consumptive use, respectively.

The review outlined high microbial contamination of surface water as almost all surface waters were contaminated with either *E. coli*, faecal coliforms, total coliforms or all. However, this contamination was more prevalent in the surface water than groundwater. Moreover, the physical parameters of water quality had decreased considerably making surface waters more turbid, with total suspended solids coupled with bad odour and colour. However, the trend was different from groundwater. Fe, Mn, or both were present in 20% of borehole supplies with As level been high in most of the surface waters.

Customary laws and practices, statutory laws and IWRM have been the major management mechanisms employed to manage Ghana's water resources over the years and now. Challenges that emerge from these management mechanisms include: weak enforcement of Acts, mechanisms to reconcile customary law and practices with statutory laws in the constitutional discourse were not provided, top-down approach to decision making that has sideline the community members, lack of regulations for surface water, climate variability and others. In addressing these aforementioned challenges, the following recommendation should be taken into consideration, readopting customary water resources management, co-existence between customary laws and practices and statutory laws, sensitisation and education, assignment of specific role as well as adopting renewable sources of energy. The adoption and implementation of these suggestions will bring about effective and efficient water resources management for sustainable development and peaceful co-existence. The water resources will be able to support current generations in quality and quantity as well as future generations.

References

Affum AO, Dede Osae S, Nyarko BJB, Afful S, Fianko JK, Akiti TT, Adomako D, Acquaah SO, Dorleku M, Antoh E, Barnes F, Affum EA (2015) Total coliforms, arsenic and cadmium exposure through drinking water in the Western Region of Ghana: application of multivariate statistical technique to groundwater quality. Environ Monit Assess. https://doi.org/10.1007/s10661-014-4167-x

Ampomah B (2017) 60% of Ghana's water bodies polluted—Water Resources Commission. Executive Secretary of the Commission at a workshop in Ho, Source: GNA, May 13, 2017

Ansa-Asare OD, Gordon C (2012) Water quality assessment of Densu, Birim and Ayensu rivers in the Okyeman area. West Afr J Appl 20(3):53–64

Asamoah-Boateng EK (2009). Physico-chemical and microbiological quality of surface waters within the Newmont Ghana Gold Mining concession areas. A thesis submitted to the Department of Theoretical and Applied Biology, College of Science and Technology, in partial fulfillment of the requirements for the degree of Master of Arts, Kwame Nkrumah University of Science and Technology

Asante FG (2012) Physico-chemical quality of water sources in the gold mining areas of Bibiani. A thesis submitted to the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology In partial fulfillment of the requirements for the degree of Master of Science

Cobbina SJ, Anyidoho LY, Nyame F, Hodgson IOA (2010) Water quality status of dugouts from five districts in Northern Ghana: implications for sustainable water resources management in a water stressed tropical savannah environment. Environ Monit Assess 167(1–4):405–416

Food and Agriculture Organization of the United Nations (2003) Review of world water resources by country. Report. ISSN 1020-1203

Global Water Partnership (GWP) (2000) Integrated Water Resources Management, Technical Advisory Committee, TEC Background Paper No. 4

Goski BNW (1999). The quality of water of the Weija Dam and the Densu River. A thesis submitted to the Department of Nutrition and Food Science University of Ghana, Legon, in partial fulfillment of the requirement for the award of M.Phil degree in Food Science. University of Ghana http://ugspace.ug.edu.gh

Karikari AY, Ansa-Asare OD (2006) Physico-chemical and microbial water quality assessment of Densu river of Ghana. West African J Appl Ecol. https://doi.org/10.4314/wajae.v10i1.45701

Leslie D (2010). The causes and health effects of river pollution: A Case Study Of The Aboabo River, Kumasi. A thesis submitted to the Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree of Master of Arts

Mantey S (2017) Galamsey, pollution destroying water bodies in Ghana—Water Company, March 22, 2017. The Head of Communications at the Ghana Water Company

Mensah K (1999) Water law, water rights and water supply (Africa); Ghana—study country report. DFID KaR Project R7327

Mensah F (2010) Integrated water resource management in Ghana: past, present, and future. Paper presented at the proceedings from the world environmental and water resources congress

Ministry of Water Resources Works and Housing (2005) Access to water supply and sanitation, country status overview, Accra

Ministry of Water Resources Works and Housing. (2012) National integrated water resources management (IWRM) plan. Water Resources Commission

Ministry of Water Resources Works and Housing. (2015) National drinking water quality management framework for Ghana; "Prevention is better than cure"

Ministry of Water Resources, Works and Housing, Ghana. (2007). Ghana national water policy

Ministry of Works and Housing, Ghana (1998) Water resources management (warM) study—information building block. Accra, Ghana

Nkansah MA, Boadi NO, Badu M (2010) Assessment of the quality of water from hand-dug wells in Ghana. Environmental Health Insights 2010:4 7–12. http://www.la-press.com

Nsubuga FNW, Namutebi EN, Nsubuga-Ssenfuma M (2014) Water resources of Uganda: an assessment and review. Journal of Water Resource and Protection 6:1297–1315. https://doi.org/10.4236/jwarp.2014.614120

Ofori-Boateng J (1977) Environmental law, Ghana water laws, review of Ghana law, Accra

Opoku-Agyeman M (2001) Shifting paradigms: towards the integration of customary practices into the environmental law and policy in Ghana. Paper presented by the Water Resources Commission at the conference on securing the future organized by the Swedish Mining Association, 25 May–1 June 2001, Skelloste, Sweden

Owusu AP, Asumadu-Sarkodie S, Ameyo P (2016) A review of Ghana's water resource management and the future prospect. Cogent Engineering 3:1164275

Saana SBBM, Fosu SA, Sebiawu GE, Jackson N, Karikari T (2016) Assessment of the quality of groundwater for drinking purposes in the Upper West and Northern regions of Ghana. SpringerPlus 5:2001. https://doi.org/10.1186/s40064-016-3676-1

Sarpong GA (1993–1995) From Stockholm to Rio: some Ghanaian responses to the problems of the environment, (1993–95) 19 U.G.L.J, pp 53–82

Sarpong V (2014). Potability of water from boreholes and hand-dug wells in two peripheral communities of Jacobu in the Amansie Central District, Ghana. A thesis submitted to the Department of Theoretical and Applied Biology in partial fulfillment of the requirements for the award of the degree of Master of Science of Environmental Science

Shaw WD (2005) Water resources economics and policy. Edward Elgar Publishing, Cheltenham

United Nations (UN) (2014) Water resources management. Retrieved June 2016, from http://www.unwater.org/topics/water-resources-management/en

USAID (2011) Biodiversity and tropical forests environmental threats and opportunities assessment. Retrieved from http://www.encapafrica.org/documents/biofor/ETOA_Ghana_FINAL.pdf

Water Resource Commission Ghana (2005) Water users geo-reference survey

Water Resources Commission (2007) Annual Report. WRC, Accra

Water Resource Commission Ghana (2012) National integrated water resources management (IWRM) plan. Water Resources Commission Ministry of Water Resources Works and Housing

Water Resource Commission Ghana (2015) Basins. Retrieved December 2017, from http://www.wrc-gh.org/basins/

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