WATER RESOURCE MANAGEMENT – GHANA

VÍZGAZDÁLKODÁS – GHÁNA

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Abstract

Having a tropical climate, Ghana experience high rainfall per year making water resources abundant in the country. The major water resources in the country include; lakes, rivers, streams, ponds and groundwater. Unfortunately, the management of these water resources by ensuring there is sufficient water of adequate quality for drinking and other benefits has been a challenge to government institutions responsible for the planning and execution of policies to manage and sustain these resources. The three major management problem are pollution, flood, and drought. The Government of Ghana in 2022 uses key tracker and indicator as an innovative way of monitoring the progress made in the country's effort to address menace of illegal mining that pollute water resources in Ghana (ENVIRONMENTAL PROTECTION AGENCY, 2023). Dam safety Regulation LI 2236 of 2016 was established as an innovative way safeguarding dams to prevent flooding (WATER RESOURCES COMMISSION, 2021). Small and medium enterprises (SMEs) and consultants use treated sludges and waste water for nursing vegetable seedlings, flash flood forecasting app for detecting early flood warning, using technology to recycle carwash water for re-use. The Environmental Protection Agency (EPA) together with United Nations Framework Convention on Climate Change (UNFCC) through the Capacity Building Initiative for transparency (CBIT) project was aimed at strengthening the effectiveness of Ghana climate ambitious reporting programme for climate action and support (ENVIRONMENTAL PROTECTION AGENCY, 2023). Cooperation in International Waters in Africa (CIWA) a project of World bank, The Sahel groundwater Initiative by CIWA, Transboundary water management in Africa by European union and other initiatives seeks to assist Africa including Ghana with innovation ways in realizing the United Nation Sustainable Development Goals (SDG6) which calls for ensuring the availability and sustainable management of water and sanitation for all by 2030. The government and the institutions responsible for safe guarding the water resources must invest in innovative methods in managing this great resource.

Keywords: *water resource management, Ghana, innovation, pollution, international cooperation*
JEL code: *Q25*

Összefoglalás

A trópusi éghajlaton elhelyezkedő Ghána vízkészlete bőséges, hiszen évente nagy mennyiségű csapadék esik. Az ország főbb vízkészletei a tavak, a folyók, a patakok és a felszín alatti vizek. Sajnos ezeknek a vízkészleteknek a kezelése, vagyis a megfelelő minőségű víz biztosítása ivóvíz vagy egyéb felhasználás szempontjából, kihívást jelentett az ezen erőforrások kezelését és fenntartását célzó intézedések tervezéséért és végrehajtásáért felelős kormányzati szervek *számára. A három fő gazdálkodási probléma a szennyezés, az árvíz és az aszály. Ghána kormánya 2022-ben innovatív módszerként kulcsfontosságú nyomon követési és indikátor mutatókat alkalmaz, hogy kövesse azon erőfeszítések sikerességét, melyeket a ghánai vízkészleteket szennyező illegális bányászat veszélyének kezelésére tett az ország (ENVIRONMENTAL PROTECTION AGENCY, 2023). A gátak biztonságáról szóló 2016. évi LI 2236. számú rendeletet az árvizek megelőzése érdekében a gátak védelmére hozták létre (Water Resources Commission, 2021). A kis- és középvállalkozások, illetve a tanácsadók a kezelt iszapot és szennyvizet zöldségpalánták gondozására, a villámárvíz-előrejelző alkalmazást a korai árvízjelzés észlelésére alkalmazzák. A Környezetvédelmi Ügynökség (Environmental Protection Agency - EPA) az ENSZ Éghajlat-változási Keretegyezményével (UNFCC) közösen, az átláthatóságra irányuló kapacitásépítési kezdeményezés (CBIT) projekt révén céljaként tűzte ki a ghánai éghajlat-változási jelentési program hatékonyságának megerősítését (ENVIRONMENTAL PROTECTION AGENCY, 2023). Az Afrikai Nemzetközi Vízügyi Együttműködés (Cooperation in International Waters in Africa - CIWA), a Világbank célzott projektje, a CIWA által indított Száhel-menti felszín alatti vizekre vonatkozó kezdeményezés, az Európai Unió által indított határokon átnyúló vízgazdálkodás Afrikában és más kezdeményezések célja, hogy segítse Afrikát, köztük Ghánát az ENSZ fenntartható fejlődési céljainak (SDG6) megvalósításában, amely 2030-ig mindenki számára biztosítja a megfelelő minőségű vizet és higiéniát, illetve ezek fenntartható kezelését. A kormánynak és a vízkészletek védelméért felelős intézményeknek innovatív módszerekbe kell befektetniük e nagyszerű erőforrás kezelésében.*

Kulcsszavak: *vízgazdálkodás, Ghána, innováció, szennyezés, nemzetközi együttműködés*

Introduction

Every living thing requires clean water to survive. Fortunately, Ghana can be counted among countries with much water resources. Having a tropical climate, Ghana experience rainfall pretty well per year. However, the rainfall patterns vary from places. Southern and the middle-belt receive more rain than the northern part of the country. The annual rainfall in the south is about 2000 mm while it is a little below 1100 mm in the north. The country has two main weather seasons; rainy and dry seasons. The rainy season is between May and October in the north, April and October in the middle and April to November in the south. The northern part of Ghana also has a higher temperature than the south. The average temperature is between 24°C to 30°C although, sometimes the temperature goes as low as 18°C in the south and as much as 40°C in the north. The country has many rivers and lakes which serves as sources of water for household use, irrigation purposes and industrial use. Water resource management (MRM) defined by the world bank as 'the process of developing and managing water resources in terms of both water quality and quality across all water uses' (COOPERATION IN INTERNATIONAL WATERS IN AFRICA, 2022) continue to be issue to governments globally. The total water area of Ghana is about 8520 km^2. The water resource management is the responsibility of government through various institutions with collaboration with regional and international corporations such as World Bank, UNESCO, UNEP, European Union, Africa Development Bank, FAO, NGOs and others. The Government and these corporations provide innovative way through infrastructure provision such as wastewater treatment, building of dams, dredging of water channels, irrigation infrastructure, distribution of solid waste collection equipment, education of farmers on the effect of agriculture chemical use, remote sensing in monitoring climate change data collection, strengthening of relevant institutions. Effectively managing this natural resource globally can provide benefit to the world. The Council for Scientific and Industrial Research-Water Research Institute predicted Ghana to be water stress by 2025 due anthropogenic activities and climate change (OWUSU et al. 2016). MVULIRWENANDE and WEHN (2020) investigated four innovative projects in Ghana by Small and medium enterprises (SMEs) and water consultants. These projects are; Vegetable nursery using recycled sludge - Produces seedlings using processed sludge and treated waste water, Flash flood forecasting app - Provides early warning for flooding via state-of-the art modelling techniques, EnterWASH: business support for unemployed youth - Enhances the capacity of unemployed youth in the area of WASH and entrepreneurship through training, mentorship and financial support, and Closing the water loop for car washing stations - Develops a technology to recycle wastewater from car washing stations for re-use. Wastewater treatment plants are been built in the country to provide recycled water for re-use. Although the country lacks enough wastewater treatment plants, the governments in collaboration with Zoomlion, a sanitation service provider and a Hungarian company, Pureco recently built a waste water treatment plant in Kumasi which started operation in 2022. Currently, another plant is been built in Takoradi and Tamale to recycle the wastewaters in the western and northern region of Ghana. World bank in collaboration with some European countries through the CIWA project seeks to sustainably manage the natural resources like water to reduce poverty, enhance energy efficiency, and mitigate climate risks in Africa (COOPERATION IN INTERNATIONAL WATERS IN AFRICA, 2022). The Sahel Groundwater Initiative by CIWA seeks in provision of analytical and technical assistance for groundwater use in small-scale irrigation, reviewing the status of groundwater assessment and exploration capacity, facilitating regional cooperation and development of groundwater expertise in western Sahel. Transboundary water management in Africa by European union and other initiatives seeks to help Africa in realizing the United Nation Sustainable Development Goals (SDG6) which calls for ensuring the availability and sustainable management of water and sanitation for all by 2030.

Water Use in Ghana

The major water resource in Ghana include lakes, rivers, groundwater, and rainwater. Water from the lakes and rivers are treated for drinking, domestic and industrial use for most urban cities by the Ghana Water Company Limited (GWCL), provision of electricity by building dams, for irrigation purposes, and animal watering. Some of the lakes and rivers include the Volta river with length about 1500 km and basin area of 407,093 km^2, River Black Volta, White River Volta, River Pra, River Ankobra, River Densu, River Afram, River Ofin and River Todzie (Figure 1). A dam was constructed on the Volta lake to produce hydroelectricity to the country and this remain the major source of electricity to the country since 1963. The Bui dam was also constructed on the River Black Volta as additional hydroelectricity source. In terms of agriculture, the Pwalugu and Bagre dam were constructed on the River White Volta as a source of irrigation water for farmers in the northern Ghana. Although the average temperature is quite high, these rivers always contain enough water for irrigation purposes, hydro-power generation, domestic and industrial use. Groundwater which is major source of drinking water to most of the population especially the rural folks is found in two main rock formation of the country. The sedimentary formation made up of Volta basin which occupies about 43% of total area of Ghana and has yields of 1.0 – 12.0 m^3 ha^{-1} at depth of 20-80 m. The second is the non-sedimentary formation of crystalline basement complex of pre-cambrian origin and occupies 57% of the total area of the country with yields of 1.5-32.0 m^3 ha^{-1} at depth of 20-100 m (ATAMPUGRE et al. 2016).

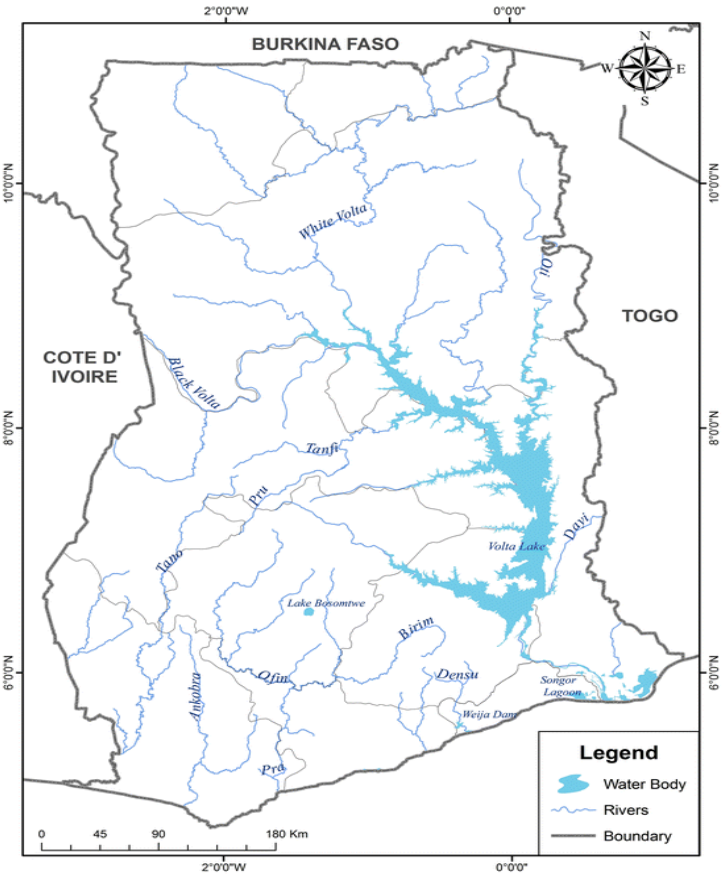


Figure 1. Water resource map of Ghana.
Source: ATAMPUGRE et al. 2016.

In 2017, it was estimated that the annual precipitation in volume is about 283.1 billion m^3/year. The total sum of renewable groundwater and surface water was about 56 billion m^3/year with 46% been external sources. Agricultural purpose was measured as the highest use of water in Ghana before municipal and industrial use. The use of water for agriculture increase exponentially over the years from 1970 to 2017. For instant, 52%, 66% and 81% of available water was applied in 1970, 2000 and 2017, respectively. It was estimated in 2015 that about 11.3% of Ghana's population does not have access to potable drinking water (WORLDOMETER, 2023). The total land area equipped for irrigation increase over the years from 31,000 hectares in 2000 to 223,000 hectares in 2020 (SASU, 2023). There are two main ways farmers use agriculture water in Ghana. The natural use of rain-fed and by irrigation. The distribution of these irrigation equipment's varies across the sixteen administrative regions of Ghana. The Upper East, Upper west, Northern regions where the is a prolong dry season have more irrigation facilities than the southern regions.

Water Management Problems in Ghana

Water management is global concern to governments. Climate changes and human activities have affected the quality and quantity of water resources globally. The three major water management problems are; flood, drought and pollution. In Ghana, flooding occurs each year in some parts of the country due to heavy rainfall and/or opening of dams. Water discharge from a dam in Burkina-Faso always causes havoc to residents and agricultural farms in the northern Ghana. Water discharge a dam on the River Densu also causes flooding in Accra and some part of central region which displace residents. Water discharges from the Akosombo dam on the River Volta is not an exception. Flooding in Ghana mostly occur during the raining season (between May and August). Flooding have caused much problems to Ghana in recent years. In 2015, about 152 people lost their lives in Accra due to flooding and gas explosion (OWUSU et al. 2016). Loss of biota and biodiversity, plant lost, reduced yields of agriculture produce, soil loss (organic matter, nutrients) due to erosion (MENSAH et al. 2015). Drought on the other hand does not normally occur in Ghana although the northern part experience some form of harsh weather conditions between October and April. Flood has damage about 780,500,000 USD and killed about 409 lives between 1900 and 2014 in Ghana (ASUMADU-SARKODIE et al. 2015) as compared to 100,000 USD caused by drought in the same period. Accra is a lowland area which has have hills on the northern part. Storm water from those hill-sides all run through Accra-city to the sea. About eight drainage basins are in Accra to direct this rain water to the sea, however, most of these drainages are choked with deposited eroded soil and plastic waste. This blockage of drainage system has and is always the cause of flooding in Accra. Aside the choked drainages, building on water ways, poor construction of drains, poor city planning are some of the causes of flooding in Ghana. Ghana has adopted the 2006 World Meteorological Organization strategy in controlling flood which is shown in table 1. However, the country did little or no effort in implementing such strategies hence the constant flooding in some areas each year. Ghana is active in reaching out to affected areas and providing some relieve items through National Disaster Management Organisation (NaDMO) to people rather than solving the causes of the flooding. The Ghana Hydrological Authority was established in 2021 under the ministry of works and housing for the planning, design, execution, operation and maintenance of flood control mechanisms, drainage improvement works in the country. In combating drought and desertification, the government of Ghana established a sectoral institution called National Action Programme. The institution was to ensure of sustainability of agriculture produce and food security to enhance the livelihood of people and maintain a desirable ecosystem. These programmes are applicable from 2002 to 2027. A National Climate Change Committee (NCCC) policy was established in 2013 with representatives from Ministry of Environment Science Technology and Innovation, Ministry of Finance and Economic Planning, Ministry of Agriculture, Forestry Commission, Ministry of Agriculture, and others to provide strategic directions and coordinate issues regarding climate change in Ghana (MINISTRY OF ENVIRONMENT, SCIENCE, TECHNOLOGY AND INNOVATION, REPUBLIC OF GHANA, 2013).

Table 1. Strategies and Options for Flood Management.
Source: ASUMADU-SARKODIE et al. 2015.

Strategy	Options
Reducing Flooding	Dams and reservoirs Dikes, levees and flood embankments High flow diversions Catchment management Channel improvements
Reducing susceptibility to Damage	Floodplain regulation Development and redevelopment policies Design and location of facilities Housing and building codes Flood proofing Flood forecasting and warning

Mitigating the impacts of flooding	Information and education Disaster preparedness Post-flood recovery Flood insurance
Preserving the Natural Resources of Flood Plains	Floodplain zoning and regulation

Water Pollution

Surface water, handpump on bore/well and wells are the main water sources in most villages in Ghana (Figure 2). Water resource including improved pipe drinking waters have been polluted globally through either anthropogenic or natural causes. Surface water is polluted by excessive nutrients loading. Phytoplankton in the water requires these nutrients to grow and an excessive growth (eutrophication) of these plant-like organisms causes a serious danger to human and other aquatic organisms. Changes in weather patterns and other anthropogenic activities causes depletion of surface waters that can be used for agricultural irrigation. Groundwater use for domestic purposes and agricultural irrigation has become common recently. Most pollutants are filtered out before getting to ground aquifers which may make them safer than surface water However, some groundwater contain high amount of salinity which makes them unsuitable for irrigation (YIDANA, 2010).

Figure 2. Sources of water in most villages in Ghana (A) surface water, (B) handpump on bore/well, (C) well which was contaminated by surface run off.
Source: SCHAFER et al. 2009.

The most anthropogenic sources of water pollution are mining, leaching of fertilizers and other chemicals used on agricultural farms, indiscriminate disposal of solid and liquid waste, deforestation which may cause soil erosion that may be deposited in lakes and rivers. Deforestation can also increase the evaporation on lakes and rivers causing dryness during dry seasons. Macrophytes and phytoplankton may receive more light when the vegetation along lakes and rivers are destroyed. Natural phenomenon can also influence the pollution of water bodies. The geology of surface water and groundwater can contribute to their pollution. The variation of inorganic contaminants detected in surface waters and groundwaters may be due to natural variation in geology, human mining and industrial activities (SCHAFER, 2010). JAJI et al. (2007), another study of water quality of the River Ogun in the south-west of Nigeria shows all physiochemical, bacteriological parameters, all pollution indicators and trace metals are above WHO limits. Pesticides, Escherichia coli, hydrocarbons, phosphate, heavy metals among others were reported to be major contaminants of surface and ground waters in west and central African countries (PARE and BONZI-COULIBALY, 2013). In areas where agricultural activities are on large scale, large amount pesticides and fertilizers are found in the surface and ground waters. Extensive agricultural practices, urbanization and settlements of over increasing population along surface water bodies has increased the deterioration of surface water qualities through the effluents of waste water from industrial, and domestic sources (GROGA et at., 2012). A groundwater study by EYANKWARE and EPHRAIM (2021) also observed a high percentage of faecal coliform. The presence of faecal coliform in water confirm its contamination with faecal material of human or animals (KUMPEL et al. 2016). Similar pollution of water bodies was reported in other African countries including Nigeria, Senegal and Burkina-Faso (GROGA et al. 2012). The different uses of contaminated water have a potential of growing health and environmental concerns in Africa. Dealing with these concerns will require an appropriate policy including monitoring of surface water quality, wastewater control, and reducing of agricultural fertilizer applications (GROGA et al. 2012). Using Lake Taabo in Ivory Coast as case study, BROGA et al. (2012) suggested that human pressure and climate change may have effect on the lake functions. High nutrients concentration especially, phosphorus and nitrogen occur mostly in the raining season through leaching agriculture farms. Loading surface waters with wastewaters, fertilizers may become source of nutrients for exponential growth of phytoplankton. This may also cause the conductivity of the water to rise, reduce dissolved oxygen posing danger to aquatic organisms in the water. Another source of surface water pollution is the gradual evolution of sediment (ANOH et al. 2012) and this may require dredging to restore its depth. Iron ore mining in Liberia and India was found to be potential contamination of surface water and groundwater (GLEEKIA and SAHU, 2016).

In the case of drinking water quality, KUMPEL et al. (2016) studied the water monitoring policies of, how water quality varied from sources, and the institutional responsibility from seven Sub-Sahara African countries. They noted from their study that majority of population do not have access to improved pipe water (5% in Uganda, 12% in Ethiopia, 16% in Zambia, and 22% in Kenya). They found 4% of samples from pipes to plots, 2% from public/standpipes, 22% from harvested rain water, 31% from boreholes, 39% from springs (rivers), 65% from dug wells to contain some level of faecal indicator bacteria which poses health hazard to people. They noted that regulatory institutions in monitoring water quality mostly focus on pipe water to homes and industries and less on surface water and groundwater. They therefore proposed expansion of water quality monitoring to other sources of water and not only on pipe water. Identification of lakes vulnerability areas of pollution can help in taking immediate steps to curb the pollution (ANOH et al. 2012). NARE et al. (2011) suggested community participation in the monitoring and management of rivers and lakes. This will let information flow between the locals and the responsible national agencies on the status of rivers and lakes always. BHANDARI (2014), also suggested intensive education of farmers on the use of agrochemicals and their residues. This will allow farmers to use these chemicals within FAO standards hence not causing problem to the environment. In assessing the anthropogenic impact and health status of aquatic ecosystem, north-America and Europe mostly uses diatoms due to their rapid response to change in their environmental conditions and also it is cost-effective compared to other methods (DALU and FRONEMAN, 2016) and therefore Africa and other developing countries must resort to this method in monitoring their surface waters. In Ghana, water from rivers and lakes are treated by the Ghana Water Company Limited for household use in the major cities of the country. However, majority of the population especially those in the rural areas depends on untreated water from rivers, lakes, wells and boreholes for drinking and domestic use. Unfortunately, majority of these sources of water has been polluted through anthropogenic activities such as mining activities, indiscriminate disposal of both solid and liquid waste and agricultural activities. Turbidity of the surface waters increases nowadays due to soil erosion and mining activities in the catchment areas. The main source of surface water pollution of the River Birim in south-east part of Ghana is mining and domestic activities (ANSAH-ASARE and ASANTE, 2000). Study by KARIKARI and ANSA-ASARE (2006) indicated a low level of trace metal in River Densu between 2003 to 2004. However, they noted that microbial activities of the water were poor due to the contamination of the river. These observations can be generalized to other polluted water bodies. The government and some NGOs provide boreholes for communities without portable drinking water. However, the expenses of maintaining these boreholes are borne by the communities. Communities that are not able to repair a malfunctioning equipment seek other sources of drinking water. Majority of household in the country depends on sachet water or “Pure water” as they are normally called for drinking. Pipe-water for domestic use for those in the cities. Due to intermittent of pipe water flows, citizens turn to use untreated well water or from unhygienic water vendors for drinking and domestic use. These water sources are believed to be contaminated and hence contribute to children under five mortality (MARCHDAR et al. 2013).

To evaluate the variation of surface water quality in the Aby lagoon in the western part of Ghana between wet and dry season, a study by MIYITTAH et al. (2020) found water temperature, electrical conductivity, nitrate, dissolved oxygen, pH, and turbidity to vary significantly between the two seasons. However, phosphate was found to be statistically not significant. This they believe was as a result of municipal waste disposal throughout the year. Anthropogenic waste disposal and up-stream flow of rivers are the major sources of pollution of their study area (Aby lagoon). Another study by ABDUL-RAZAK et al. (2003) shows River Oti in the north-eastern part of Ghana which the residents use for domestic use was considered unsuitable for human direct use due to high count of faecal coliform and total coliforms. EYANKWARE and EPHRAIM (2021) noted that faecal coliform and total coliform have higher mean in surface water than open well.

Drinking Water Contamination in Ghana

Preceding studies in Ghana and other countries such as Portugal and Spain found package water to be responsible for the outbreak of typhoid and cholera (OSEI et al. 2013) although they are considered to be safer than other source of drinking water.

Although data from Ghana Water Company Limited (GWCL) regarding the water quality at the outlet of the treatment plant compiled with the standard (no *E. coli* detection in 100 ml), re-contamination occurs in the distribution process from leakages, low pressure, and biofilm growth in the pipes (MACHDAR et al. 2013). GWCL has in recent years complain much in the level of water pollution across the country. The cost of water processing for drinking has increased due to high pollution of surface water bodies. In assessing the microbiological quality of package water and water treatment, WHO use Heterotrophic Plate Count bacteria (HPC). Most tap and sachet water sampled in Accra shows HPC level above the recommended limit by WHO of <500 CFU mL^{-1} (OSEI et al. 2013). Their study also finds some protozoa including rotifers in tap and sachet water but none in bottle water sampled. They concluded by suggesting that bottle water is safe for drinking than the commonly used sachet and tap water in Ghana.

Other study by ROSSITER et al. (2010) analysed various sources of drinking water in Ghana and found out most chemicals; fluoride, assess nitrate and manganese present in the drinking waters are above the WHO standard. They also found groundwater in the mining areas to be contaminated with heavy metals such as lead, arsenic and uranium. Similar finding was found by SCHAFER et al. (2009) analysing chemical contaminants of surface water and groundwater. SCHAFER et al. (2009) found aluminium, iron and manganese at high concentration in Volta Region, fluoride concentration is high in Northern and southern part of Ghana. Boron concentration is high in the northern. High salt concentration and high pH in the coastal regions due to seawater intrusion. Periodic environmental studies need to conducted in the mining areas to ensure sustainable operations compliance with the regulations relating to mining by the companies (GLEEKIA and SAHU, 2016). Another study by AKOTO et al. (2019) found nitrate, chlorine, cadmium, and lead in some groundwater samples in the coastal area of the Volta region to be above WHO recommended concentration in drinking water.

Contamination of Irrigation water in Ghana

Some communities have a clean water for irrigation through the government provision of small dams for agricultural purposes. However, most communities lack such amenities and thereby result to the use of other sources for their irrigation. Contaminated water from rivers, streams, household effluents, dug wells are such sources (Figure 3). Most farmers may have little or no knowledge about the consequence of using contaminated water for irrigation. Contaminated water used in agricultural irrigation may threaten the development of crops as well as human health. A study in Ghana by AMUAH et al. (2022) indicated that total faecal coliform and *E. coli* were present in most of the water used in irrigation. They also detected *Ascaris lumbricoides* and *Trichuris trichiura* in vegetables. These findings, they believe were as a result of contaminated water used in irrigation of crops. Some pesticides such as chlorpyrifos, diazinon, hexachlorocyclohexane, 1,1-dichloro-2, lambda-cyhalothrin, were detected in water used in irrigation. Other compounds such as chromium, cadmium, copper, zinc, lead, iron, nickel and manganese were also detected in their sample.

Figure 3. Contaminated water used in irrigation.
Source: AMUAH et al. 2022.

Heavy metals found in Ghana waters

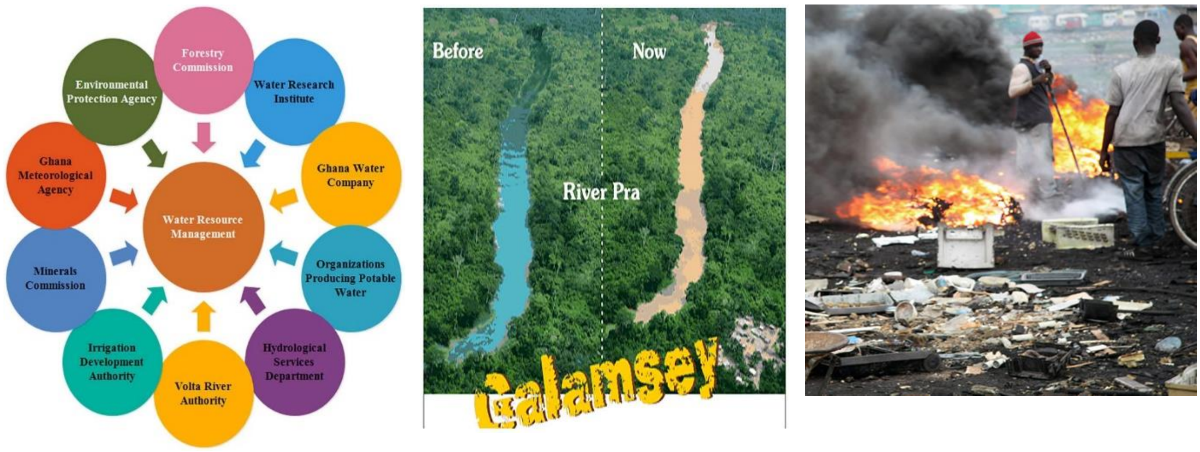
With the development of many economies around the globe, both types and content of heavy metal in the soil have increase in recent years causing the deteriorating of the environment (SU, 2014). There are several sources of heavy metal contaminants in the environment; agricultural and food waste, atmospheric deposition, municipal waste and sludge, fertilizers, industrial waste among others. The presence of heavy metals in the environment may not be recognise in a short term since their effects are felt in a long time. Remediation of heavy metal polluted air and water may be easier than polluted soil (SU, 2014). Dilution and self-purification can be used to reverse the contamination of water and air by blocking the source. However, it is mostly inapplicable to reserve a contaminated soil and these metals can stay for about 200 years in the soil to be remediated (SU, 2014). Several heavy metals and other compounds were found in Ghana surface water, groundwater, and drinking water. The concentration of such contaminants can be posed a great danger to the population. The major heavy metals found in surface water, groundwater and soil include; cadmium, mercury, lead, copper, arsenic and manganese (ARMAH et al. 2010). Cadmium was reported by JÄRUP (2003) to have negative effect on human health. Kidney damage, skeletal damage, and cardiovascular diseases are few effect of cadmium to people exposed to it. Cadmium enters the human system through many ways. Such as cigarette smoking and through food. Plants uptake cadmium from the contaminated soil through waste sludge used on agriculture farms. Lead can reach humans through food chain when airborne lead is deposited on the soil and surface water. Like cadmium, plants take lead from the soil then transfer it to secondary and tertiary consumers. Humans that depends on contaminated water for drinking and domestic use may also be exposed to its danger. It is mainly distributed through the environment by manufacturing and fusil fuel burning. Lead may cause brain damage in children and may also affect the functioning of the brain in adults with symptoms such as headache, abdominal pain and other symptoms related to nervous system. Some amount of arsenic concentration was found in the mining areas in Ghana. Arsenic concentration in the rural areas in UK were found to be >1 to 4 ng m^{-3} and may be as high as 200 ng m^{-3} in the cites and >100 ng m^{-3} near the industrial areas, and approximately 10 µg L^{-1} in water concentration (JÄRUP, 2003). Arsenic compounds can be present in groundwater through rock weathering and leaching from manufacturing and agriculture farm lands as well as in food through the food chain. Arsenic exposure to the population through drinking water show high risk of mortality from lung, bladder, kidney cancer skin cancer and other skin lesions (JÄRUP, 2003), and about 50 – 100 ug L^{-1} of arsenic in drinking water has resulted in lung and skin cancer. Most of this contaminants entre the human body through ingestion. Dermal absorption of this contaminants was found to be negligible by AKOTO et al. (2019). KPAN et al. (2014) found three heavy metals to be of high concentration in groundwater and soil in a gold mining community in Ghana. The allowable concentration of lead, mercury and copper in drinking water are 0.01 mg L^{-1}, 0.001 mg L^{-1} and 2 mg L^{-1} respectively (WHO, 2004). They found in their samples the mean concentration of lead 95.13 mg kg^{-1} in soil and 190.27 mg L^{-1} in groundwater, 140.87 mg kg^{-1} and 211.31 mg L^{-1} of mercury in soil and groundwater respectively. Soil and groundwater concentration for copper were 63.26 mg kg^{-1} and 75.92 mg L^{-1} which are by far above the recommended limits.

Another study by HADZI et al. (2018) found iron, aluminium, manganese, arsenic, lead, and chromium to be higher than WHO recommendation limits in rivers in the mining and pristine areas in Ghana. Arsenic, lead and chromium dominated the heavy metal concentration in most mining areas under study hence they pose environmental threats to residents. Nickel, copper, zinc and other heavy metals were found to be within the permissible limits. The concentration of heavy metals in mining areas is on increase. OBIRI (2007) studied heavy metal concentration in boreholes in a miming area in Ghana and found only manganese and arsenic to be above the

WHO recommended limit. Iron, lead, cadmium, zinc, cobalt and chromium were within the permitted limits. Although manganese and arsenic concentration were considered not permissible, they are much lower than the current situation. This gives a much concern to the health of residents in mining areas. Of five heavy metals studied by COBBINA et al. (2015) in borehole, dug-out, wells in two mining communities in the northern region of Ghana, only zinc (0.002 mg L^{-1} to 0.034 mg L^{-1}) was found to be below the WHO limit of (3 mg L^{-1}). However, mercury (0.038 to 0.064 mg L^{-1}, arsenic (0.03 to 0.031 mg L^{-1}), lead (0.031 to 0.250 mg L^{-1}) and cadmium (0.023 to 0.534 mg L^{-1}) were above the WHO limits. These concentrations do not deviate much from WHO limits as compared to current reported values. NYANTAKYI et al. (2019) found River Tano in Ghana and its sediment to be most polluted with heavy metals in the rainy season than dry season except for lead and cadmium. Copper was only detected in sediment samples. Downstream of the river was found to be heavy polluted with the metals than mid-stream and source. All metals detected in the water samples were above the WHO permissible limit except zinc. However, mercury, cadmium and chromium in the sediment sample were found to be above WHO limit. As a result of the river pollution downstream, residents at the source of the river are safer to use the water for domestic purposes than those at the mid-stream and downstream.

Ghana Water Resource Management Institutions

In the planning and management of water resources in Ghana, a number of representatives from various institutions was constituted by act of parliament (ACT522 of 1996). Water Resource Commission (WRC) was then formed to manage and coordinate government policies regarding water resources in the country. Prior to the colonial era, chiefs and high priest were responsible for the maintenance of the water bodies and laws such as farming closer to water bodies are prohibited, people are not allowed to fetch water on some specific days other than for domestic use OWUSU et al. (2016). These and other laws were to prevent the pollution of water bodies. However, the colonial and post-colonial era has giving the government a complete responsibility for the management of the water resources. The traditional leaders were not involved in the planning and execution of government policies regarding the water resources. These has turned the previous clean water bodies to highly polluted water bodies. Government has over the years instituted several agencies to manage the water resources (Figure 4A) however, the management of the water resources is always hindered by some activities by locals. Illegal mining (Figure 4B), pollution, improper agricultural activities, proliferation of aquatic weeds, and climate change are few challenges the WRC encounter in water resource management. In 2015, the WRC needed about 4 million USD in order to clear the River Volta of aquatic weeds (OWUSU, 2016). Illegal mining has recent years destroyed what used to be clean surface waters in the mining areas of Ghana. The felling of trees used for charcoal, indiscriminate burning of electronic waste (Figure 4C) and other organic waste releases greenhouse gases into the atmosphere which affect the climate change globally.



A B C

Figure 4. A: water resource management institutions, B: effect of mining on River Pra in Ghana, C: indiscriminate burning of solid and e-waste.
Source: OWUSU et al. 2016, THE BORGEN PROJECT 2023.

Conclusion

The water crises in Ghana has recent years is more of a governance issue rather than physical availability of water resources. Government agencies mostly failed to implement policies that will protect these water resources from being polluted. In view of the challenges in water resource management, the government of Ghana through the appropriate authorities must provide a comprehensive and innovative methods in mitigating the challenges posed to water resources. It is therefore recommended that proper ways of mining are to be encouraged. Citizens are to be continually be educated of the effect of climate change to reduce the emission of greenhouse gases into the atmosphere through burning of solid and e-waste. Best agriculture practices must be encouraged through the use of clean water for irrigation, farmers must continuously be educated on fertilizers, herbicides and pesticides use since these chemicals are leached into the groundwater. The traditional way of water resource management should be incorporated into the western and scientific ways to realize the sustainability of these resources. Ghana must take the opportunity of water resource management initiatives by World bank, European union, and other international cooperation to providing technical, educational, infrastructure support, investment and strengthening of institutions to protect and manage its resources to achieve the SDGs related to water. More wastewater treatment plants should be built in all regions in the country.

References

ABDUL-RAZAK, A., ASIEDU, A. B., ENTSUA-MENSAH, R. E. M., & DE GRAFT-JOHNSON, K. A. A. (2010). Assessment of the water quality of the Oti River in Ghana. West African Journal of Applied Ecology, 16(1). https://doi.org/10.4314/wajae.v16i1.55868.

AKOTO, O., TEKU, J. A., & GASINU, D. (2019). Chemical characteristics and health hazards of heavy metals in shallow groundwater: case study Anloga community, Volta Region, Ghana. Applied Water Science, 9(2), 1–9. https://doi.org/10.1007/s13201-019-0914-z.

AMUAH, E. E. Y., AMANIN-ENNIN, P., & ANTWI, K. (2022). Irrigation water quality in Ghana and associated implications on vegetables and public health. A systematic review. Journal of Hydrology, 604, 127211. https://doi.org/10.1016/j.jhydrol.2021.127211.
ANOH, K. A., JOURDA, J. P., KOUAMÉ, K. J., KOUA, T. J. J., EBA, A. E., & LAZAR, G. (2012). Demarcation of protection perimeters for surface waters of Taabo (Ivory Coast) watershed using GIS and multicriteria analysis. Environmental Engineering & Management Journal (EEMJ), 11(12). https://doi.org/10.30638/eemj.2012.264.
ANSAH-ASARE, O. D., & ASANTE, K. A. (2000). The water quality of Birim River in South-East Ghana. West African Journal of Applied Ecology, 1(1), 23–34. https://doi.org/10.4314/wajae.v1i1.40567.
ARMAH, F. A., OBIRI, S., YAWSON, D. O., ONUMAH, E. E., YENGOH, G. T., AFRIFA, E. K. A., & ODOI, J. O. (2010). Anthropogenic sources and environmentally relevant concentrations of heavy metals in surface water of a mining district in Ghana: a multivariate statistical approach, Journal of Environmental Science and Health, Part A, 45:13, 1804–1813, https://doi.org/10.1080/10934529.2010.513296.
ASUMADU-SARKODIE, S., OWUSU, P. A., & JAYAWEERA, M. (2015). Flood risk management in Ghana: A case study in Accra. Available online: 04.08.2023. Source: https://www.primescholars.com/articles/flood-risk-management-in-ghana-a-case-study-in-accra.pdf.
ATAMPUGRE, G., BOTCHWAY, D. V. N., ESIA-DONKOH, K., & KENDIE, S. (2016). Ecological modernization and water resource management: A critique of institutional transitions in Ghana. GeoJournal, 81, 367–378. https://doi.org/10.1007/s10708-015-9623-9.
BHANDARI, G. (2014). An overview of agrochemicals and their effects on environment in Nepal. Applied Ecology and Environmental Sciences, 2(2), 66–73. https://doi.org/10.12691/aees-2-2-5.
COBBINA, S. J., DUWIEJUAH, A. B., QUANSAH, R., OBIRI, S., & BAKOBIE, N. (2015). Comparative assessment of heavy metals in drinking water sources in two small-scale mining communities in Northern Ghana. International Journal of Environmental Research and Public Health, 12(9), 10620–10634. https://doi.org/10.3390/ijerph120910620.
COOPERATION IN INTERNATIONAL WATERS IN AFRICA (2022). Annual report. Available online: 04.08.2023. Source: https://www.ciwaprogram.org/rcv1/ciwa-annual-report-2022-english/.
DALU, T., & FRONEMAN, P. W. (2016). Diatom-based water quality monitoring in southern Africa: challenges and future prospects. Water SA, 42(4), 551–559. http://dx.doi.org/10.4314/wsa.v42i4.05.
EPA (2023). EPA supports organisations to enhance climate data collection. Available online: 04.08.2023. Source: http://www.epa.gov.gh/epa/media/news/epa-supports-organisations-enhance-climate-data-collection.
EYANKWARE, M. O., & EPHRAIM, B. E. (2021). A comprehensive review of water quality monitoring and assessment in Delta State, Southern Part of Nigeria. Journal of Environmental & Earth Sciences, 3(1). https://doi.org/10.30564/jees.v3i1.2900.
GLEEKIA, A. M. G. D., & SAHU, H. B. (2016). Impacts of iron ore mining on water quality– a comparative study of India and Liberia. In Conference paper: 6th ASIAN MINING CONGRESS 236(34). Available online: 04.08.2023. Source: https://www.researchgate.net/publication/299397410_IMPACTS_OF_IRON_ORE_MINING_ON_WATER_QUALITY_-_A_COMPARATIVE_STUDY_OF_INDIA_AND_LIBERIA.
GROGA, N., OUATTARA, A., DA COSTA, S., DAUTA, A., BEAUCHARD, O., MOREAU, J., & LAFFAILLE, P. (2012). Water quality and water-use conflicts in Lake Taabo (Ivory Coast). Open Journal of Ecology, 2, 38. https://doi.org/10.4236/oje.2012.21005.

HADZI, G. Y., ESSUMANG, D. K., & AYOKO, G. A. (2018). Assessment of contamination and health risk of heavy metals in selected water bodies around gold mining areas in Ghana. Environmental monitoring and assessment, 190(7), 1–17. https://doi.org/10.1007/s10661-018-6750-z.

JAJI, M. O., BAMGBOSE, O., ODUKOYA, O. O., & AROWOLO, T. A. (2007). Water quality assessment of Ogun River, South West Nigeria. Environmental Monitoring and Assessment, 133(1), 473–482. https://doi.org/10.1007/s10661-006-9602-1.

JÄRUP, L. (2003). Hazards of heavy metal contamination. British Medical Bulletin, 68(1), 167–182. https://doi.org/10.1093/bmb/ldg032.

KARIKARI, A. Y., & ANSA-ASARE, O. D. (2006). Physico-chemical and microbial water quality assessment of Densu River of Ghana. West African Journal of Applied Ecology, 10(1). https://doi.org/10.4314/wajae.v10i1.45701.

KUMPEL, E., PELETZ, R., BONHAM, M., & KHUSH, R. (2016). Assessing drinking water quality and water safety management in Sub-Saharan Africa using regulated monitoring data. Environmental Science & Technology, 50(20), 10869–10876. https://doi.org/10.1021/acs.est.6b02707.

KPAN, J. D., OPOKU, B. K., & GLORIA, A. (2014). Heavy metal pollution in soil and water in some selected towns in Dunkwa-on-Offin District in the Central Region of Ghana as a result of small-scale gold mining. Journal of Agricultural Chemistry and Environment, 3(02), 40. https://doi.org/10.4236/jacen.2014.32006.

MACHDAR, E., VAN DER STEEN, N. P., RASCHID-SALLY, L., & LENS, P. N. L. (2013). Application of quantitative microbial risk assessment to analyze the public health risk from poor drinking water quality in a low-income area in Accra, Ghana. Science of the Total Environment, 449, 134–142. https://doi.org/10.1016/j.scitotenv.2013.01.048.

MENSAH, A. K., MAHIRI, I. O., OWUSU, O., MIREKU, O. D., WIREKO, I., & KISSI, E. A. (2015). Environmental impacts of mining: a study of mining communities in Ghana. Applied Ecology and Environmental Sciences, 3(3), 81–94. https://doi.org/10.12691/aees-3-3-3.

MIYITTAH, M. K., TULASHIE, S. K., TSYAWO, F. W., SARFO, J. K., & DARKO, A. A. (2020). Assessment of surface water quality status of the Aby Lagoon System in the Western Region of Ghana. Heliyon, 6(7), e04466. https://doi.org/10.1016/j.heliyon.2020.e04466.

MVULIRWENANDE, S., & WEHN, U. (2020). Dynamics of water innovation in African cities: Insights from Kenya, Ghana and Mozambique. Environmental Science & Policy, 114, 96–108. https://doi.org/10.1016/j.envsci.2020.07.024.

NARE, L., ODIYO, J. O., FRANCIS, J., & POTGIETER, N. (2011). Framework for effective community participation in water quality management in Luvuvhu Catchment of South Africa. Physics and Chemistry of the Earth, Parts A/B/C, 36(14-15), 1063–1070. https://doi.org/10.1016/j.pce.2011.08.006.

NYANTAKYI, A. J., AKOTO, O., & FEI-BAFFOE, B. (2019). Seasonal variations in heavy metals in water and sediment samples from River Tano in the Bono, Bono East, and Ahafo Regions, Ghana. Environmental Monitoring and Assessment, 191(9), 1–14. https://doi.org/10.1007/s10661-019-7744-1.

OBIRI, S. (2007). Determination of heavy metals in water from boreholes in Dumasi in the Wassa West District of western region of Republic of Ghana. Environmental Monitoring and Assessment, 130(1), 455–463. https://doi.org/10.1007/s10661-006-9435-y.

OSEI, A. S., NEWMAN, M. J., MINGLE, J. A. A., AYEH-KUMI, P. F., & KWASI, M. O. (2013). Microbiological quality of packaged water sold in Accra, Ghana. Food Control, 31(1), 172–175. https://doi.org/10.1016/j.foodcont.2012.08.025.

OWUSU, P. A., ASUMADU-SARKODIE, S., & AMEYO, P. (2016). A review of Ghana's water resource management and the future prospect. Cogent Engineering, 3(1), 1164275. https://doi.org/10.1080/23311916.2016.1164275.

PARE, S., & BONZI-COULIBALY, L. Y. (2013). Water quality issues in West and Central Africa: present status and future challenges. Understanding Freshwater Quality Problems in a Changing World Proceedings of H04, IAHS-IAPSO-IASPEI Assembly, Gothenburg, Sweden, July 2013, IAHS Publ. 361, 87–95. Available online: 04.08.2023. Source: https://www.academia.edu/4615436/Water_quality_issues_in_West_and_Central_Africa_present_status_and_future_challenges.
ROSSITER, H. M., OWUSU, P. A., AWUAH, E., MACDONALD, A. M., & SCHÄFER, A. I. (2010). Chemical drinking water quality in Ghana: Water costs and scope for advanced treatment. Science of the Total Environment, 408(11), 2378–2386. https://doi.org/10.1016/j.scitotenv.2010.01.053.
SASU, D. D. (2023). Area equipped for irrigation in Ghana. Available online: 04.08.2023. Source: https://www.statista.com/statistics/1356797/area-equipped-for-irrigation-in-ghana/.
SU, C. (2014). A review on heavy metal contamination in the soil worldwide: Situation, impact and remediation techniques. Environmental Skeptics and Critics, 3(2), 24. https://doi.org/10.1080/15320383.2019.1592108.
THE BORGEN PROJECT (2023). The environment affects impoverished communities. Available online: 04.08.2023. Source: https://borgenproject.org/tag/natural-resource-availability/.
WORLD HEALTH ORGANIZATION (2004). Guidelines for drinking-water quality (Vol. 1). Available online: 04.08.2023. Source: https://apps.who.int/iris/handle/10665/42852.
WORLDOMETER (2023). Ghana Water Use, Resources and Precipitation. Available online: 04.08.2023. Source: https://www.worldometers.info/water/ghana-water/.
WATER RESOURCES COMMISSION (2021). Ghana Annual report. Available online: 04.08.2023. Source: https://www.wrc-gh.org/documents/reports/.
YIDANA, S. M. (2010). Groundwater classification using multivariate statistical methods: Southern Ghana. Journal of African Earth Sciences, 57(5), 455–469.

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