SMALL-SCALE DAMS WATER QUALITY AND THE POSSIBLE HEALTH RISK TO USERS OF THE WATER IN THE UPPER WEST REGION OF GHANA

Rev. Dr. Kpieta B. Alfred
Laari B. Prosper
Department of Environment and Resource Studies,
University for Development Studies, Wa Campus, Ghana

Abstract

Small-Scale Dams water quality plays a significant role in water-related disease control among human populations in third world nations. The inadequacy of quality drinking water and the poor management practices of dams in developing countries make these reservoirs' water unsuitable for domestic household uses. The study therefore sought to find out the small-scale dams water quality; and also to find out the extent of health-risk users of these reservoirs water are exposed to in dam communities of the Upper West Region of Ghana Water samples were drawn at different intervals and chemically analysed in the Water Laboratory of Ghana Water Company Limited, Bolgatanga, to find out their suitability for human consumption. The research finding reveals a high level of pollution of the reservoirs. There is a high level of faecal pollution ranging between 10 and 65MPN Index of World Health Organization (WHO) and Ghana Standard Board (GSB). The turbidity levels of almost all the reservoirs are also far above the WHO and GSB Ghana Standard Board (GSB) stipulated drinking water levels. Also, the nitrate and nitrite levels in some of the reservoirs are higher than the WHO and GSB given levels of dam water. The paper concludes that the residents of these dams communities have just become victims of water related diseases due to poor location decision. It is therefore necessary to re-consider the design and construction of small-scale dams to include in the design mechanized hand-dug-wells and boreholes as a component for the drinking water needs of residents in dam communities to forestall health risk.

Keywords: Water quality, reservoirs, residents, communities, health

Introduction

Throughout human history people have adapted and modified water bodies for their use. Water is made available through construction of dams, wells, canals and other infrastructure to provide drinking water for households and livestock and to feed irrigated agriculture. Access to water is critical in all aspects of life as reflected in the socio-cultural and economic lives of human societies. The importance of water is most appreciated in arid and semi-arid environments, where strenuous efforts are usually required to access it for both socio-economic and household consumption. (Bacho, 2001a; Ghosh, 2000).

The impoundment and distribution of water on a small and large scale has been one singular factor that has led to tremendous improvement in public health worldwide (UN, 2006). During the past three decades, water resource development schemes in the world for irrigation, production of energy and the domestic water demands have been greatly expanded (UN-Habitat, 2003). The primary objective of these water resource development projects is to make water available and accessible for the production of more food fibre and to raise the standard of living of people (Judith, 2006; Karim, 2006; UN-Habitat, 2003; Mohan, 1992).

In developing countries, the availability of drinking water in sufficient quantities throughout the year is still very low. Hence, many people depend on water from small-scale dams, ponds and streams though this is rarely suitable for consumption (Duboz et al., 1988 – as cited in Boelee et al., 2009). One of the main challenges relating to these small-scale dams therefore is the potential health hazards resulting from the use of the open water for drinking, bathing, washing of clothes and also production of vegetables using faecal contaminated water (Hunter, 2003, 1992; Paul and Walton, 2004; UN-Habitat, 2003; WCD, 2000). This paper investigate the water quality levels of these small-scale dams and the health risk that users of dams' water are exposed to in the Upper West Region of Ghana.

Study Area

The study area shown in Fig 1 includes: the Wa Municipality, Wa West District and the Nadowli District of the Upper West Region of Ghana. The area covers the south-western parts of the region, stretching from longitude 1° 40'N to 2° 45'N and from latitudes 9° 32'W to 10° 20'W, thus covering an area of approximately 5,899.30 square kilometres. This area is about 32% and 2.56% of the Upper West region and the nation respectively. The area shares boundaries with the Northern Region and Wa East district to the South and North–East respectively, and to the North by Jirapa District and West with Burkina Faso (MTDP-UWR, 2004).

Fig. 1: Map of the Upper West Region Showing the Study Area with Dams

Source: Kpieta et al., 2013.

The Upper West Region, which falls within the guinea savannah zone of Northern Ghana experiences unimodal distribution of rainfall with an intensity of 1000 - 1150 mm/annum. The rain water drains rapidly into the Black Volta leaving the area without standing water bodies in the dry season. The region's average minimum temperature is also 22.6^{o}C and maximum of 39.1^{o}C. The relative humidity of the area ranges between 70% - 90% but falling to 20% in the dry season (Ghana Meteorological Department, Wa - UWR, 2010). As a result of these unfavourable weather conditions, the region faces water stress for both domestic and agricultural activities from November to May, about seven (7) months of dry season in the year. Coupled with the unfavourable weather conditions, the residents of the Upper West Region suffer enduring high levels of poverty where nine (9) out of every ten (10) persons live below the poverty of one dollar a day (GSS,2006). To increase access to water all year round, the Government of Ghana embarked on the construction of small reservoirs in the region to promote dry season irrigation farming, animal watering and domestic use.

Methodology

In Ghana, small-scale dams are common throughout the ten administrative regions. These dams serve the energy and agricultural sector, and the domestic needs of the population. A total of 84 dams and 54 dugouts exist in the Upper West Region (Namara et. al. 2011).

For the purpose of this study, ten (10) small-scale dams and their communities were sampled using both the simple random sampling and the purposive sampling methods from three districts of the Upper West Region as indicated in Fig 1. The sample size of the study includes; three hundred and fifty (350 household heads from the ten (10) sampled dams' communities, and twenty seven (27) focus groups comprising ten (10) focus groups of chief/elders, nine (9) women focus groups and eight (8) youth focus groups. The key informants interviewed included: the Deputy Regional Director - Public Health (GHS); the Regional Director – Ghana Water Company Limited; the Regional Director – Community Water and Sanitation Agency (CWSA); the Regional Director – Ghana Irrigation Development Authority (GIDA); and the Deputy Regional Director – Ministry of Food and Agriculture.

The water quality tests were conducted in three consecutive intervals: the first test was conducted in November, 2010; this period is right after the rainy season, where the dams are inundated. The second test was conducted in May, 2011; this period marks the intensive use of the dam water by farmers for irrigation and animal watering. There is always a high water contact by both humans and animals, leading to high water contamination and diseases transmission within this period. The third test was conducted in June, 2011; this month is the beginning of heavy rains in the area. A lot of human and animal faeces are washed into the dams. There was therefore the need to compare the pollution levels at the three intervals of the water quality test.

The water samples were always drawn from each of the six (6) purposefully sampled dams, two dams from each District and the Municipality. These six dams were selected for the water quality test based on the fact that results from the household head respondents from the dam communities shows that about 77% of residents of these dam communities drink from the dams, thus the need to conduct the water quality test to determine the health implication for drinking from these reservoirs (see Table 1 below).

The sampled dams are:

i. Sankana and Daffiama dams in the Nadowli District;
ii. Busa and Tanina dams in Wa Municipality; and
iii. Siiru and Baleofili dams in the Wa West District.

The following parameters were tested and analysed; Faecal Coliforms, Total Coliforms, Turbidity, pH, Temperature, Total Dissolved Solids, Nitrates and Nitrites, Conductivity, Total Hardness of Water, Ammonium, Sulphate and Manganese.

The water quality test was conducted with the assistance of the Environmental Protection Agency (EPA), Wa - Upper West Region and the

Ghana Water Company Limited, Water Laboratory, Bolgatanga - Upper East Region.

Results and discussion

The Surface Area of the Ten Small-Scale Dams Under-Study

The Global Position System (GPS) Instrument was used to collect the cordinates of each of the ten dams in the field survey. The results were analysed using the ArcGeographic Information System (ArcGIS 9.3) from which the total area of the various study dam reservoirs were calculated as shown in Table 1. The year of construction, and the irrigated land area of each dam was also captured.

Table1: Reservoir Sizes of the Ten Study Dams

No	Name of Dam Community	Reservoir Area m²	Year the Dam Was Constructed	Year the Dam was rehabilitated	Irrigable Land Area (hactares)
1	Sankana	827923.47772	1972	Nill	60
2	Siiru	313670.83063	1989	2001	Uncompleted works
3	Yeleyiri	156887.40217	1959	2003	11
4	Busa	156469.45415	1972	Nil	14
5	Baleofili	136115.83650	1953	2002	16
6	Daffiama	123872.28916	1972	2004	16 (Uncompleted)
7	Takpo	103346.47726	1996	2004	Nil
8	Goli	103294.95822	1996	2004	Uncompleted works
9	Dobile	91341.16793	1999	2008	Uncompleted works
10	Tanina	42007.58155	1967	2003	Undeveloped

Source: Kpieta et al., 2012.

Water Quality

Water quality is the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact and for the health of ecosystems (Diersing, 2009; USA–EPA, 2006).

Results of the Water Quality Test of the Six Reservoirs

The results of the water quality test conducted on the six reservoirs are presented in Tables 2, 3, and 4. All Tests were conducted at GWCL Regional Laboratory from 2010 – 2011. The results show that there is some level of bacteriological pollution in all the six (6) sampled dams. The results of the chemical and physical parameters are within the permissible levels as indicated, but the bacteriological level of the water in all the six (6) dams are far above the permissible level of 0cfu/100ml for drinking water and 10 cfu/100ml for dam water set by the World Health Organization WHO (2008) and the Ghana Standards Boards GSB guidelines for reasonable minimum requirements. The highlighted values in the Tables 2, 3, and 4, are far above the permissible levels of water quality given by the WHO and the GSB.

Table 2: First Phase of Dams Water Quality Test

District		Wa West District Dams' Communities		Wa Municipal Dams' Communities		Nadowli District Dams' Communities	
Community		Balawafiile	Siiru	Tanina	Busa	Daffiama	Sankana
Source		Dam	Dam	Dam	Dam	Dam	Dam
Date Water was Sampled		12/11/2010	12/11/2010	12/11/2010	12/11/2010	12/11/2010	12/11/2010
Time Sampled		10:28am	11:15am	12:10pm	12:50pm	2:55pm	4:05pm
PARAMETERS							
Temperature	(˚C)	31.0	31.3	30.1	32.6	33.1	32.6
Ph		6.59	6.72	6.60	6.75	7.51	6.98
Conductivity	(µs/cm)	**87.2**	**74.4**	**67.6**	**73.5**	**63.0**	**48.8**
Turbidity	(NTU)	1.93	2.33	**7.62**	2.99	7.54	2.84
Nitrates(NO3)	(mg/I)	0.88	0.85	0.95	0.70	0.35	0.75
Nitrite (NO2)	(mg/I)	0.111	0.143	0.194	0.124	0.064	0.099
Ammonium (NH3)	(mg/I)	0.84	0.66	0.74	0.83	0.41	0.5
Sulphate (S04)	(mg/I)	29	18	34	13	31	7
Manganese (Mn)	(mg/I)	<<	0	0.005	0	0.001	0
Total Hardness (CaCO3)	(mg/I)	46	44	40	36	40	38
Total Coliform (cfc)	(cfu/100 ml)	**18**	**12**	**16**	**8**	**18**	**38**
Faecal Coliform (MPN Index)	(cuf/100 ml)	**>16**	**>16**	**>16**	**9.2**	**>16**	**>16**
Total Dissolved Solids	mg/I	34	47	35	33	28	25

Source: Kpieta, 2012.

Table 3: Second Phase of Water Quality Test Results

District		Wa West		Wa Municipal		Nadowli District		WHO, Ghana Standards Board and Ghana Water Company Ltd. Guidelines drinking water
Community		Balawa-fili	Siiru	Tanina	Busa	Daffiam a	Sankana	
Source		Dam	Dam	Dam	Dam	Dam	Dam	
Date Water was Sampled		23/05/11	23/05/11	23/05/11	23/05/11	23/05/11	23/05/11	
Time Sampled		10:05am	11:55am	12:45am	2:14pm	3:55am	4:45pm	
PARAMETERS								
Temperature	(˚C)	29.0	29.0	28.9	29.1	29.0	29.1	None
Ph		7.7	7.5	**8.9**	7.9	6.9	7.7	6.5 - 8.5
Conductivity	(µs/cm)	74.4	88.0	117.6	77.2	66.4	66.4	0 - 1500mg/l
Turbidity	(NTU)	**6.7**	**35.1**	**91.7**	**10.7**	**11.8**	**26.4**	0 – 5.0mg/l
Nitrates(NO3)	(mg/l)	1.6	5.5	**19.0**	1.5	0.351	2.7	0 – 10.0mg/l
Nitrite (NO2)	(mg/l)	**8.0**	**23.0**	**55.0**	**9.0**	**10.0**	**13.0**	0 – 3.0mg/l
Ammonium (NH3)	(mg/l)	0.84	0.66	0.74	0.83	0.41	0.5	0 – 1.5mg/l
Sulphate (S04)	(mg/l)	7.0	17.0	44	7.0	8.0	10.0	0 – 400mg/l
Manganese (Mn)	(mg/l)	0.023	0.112	**0.424**	0.114	0.102	0.163	0 – 0.1mg/l

Total Hardness (CaCO3)	(mg/l)	7.0	10.0	8.0	4.0	6.0	8.0	0 - 500mg/l
Total Coliform (cfc)	(cfu/100 ml)	**>18**	**>18**	**>18**	**>18**	**>18**	**>18**	0 CFU
Faecal Coliform (MPN Index)	(cuf/100 ml)	**19**	**38**	**21**	**31**	**15**	**34**	0 CFU
Total Dissolved Solids	mg/l	35	42	55	36	31	31	0 – 1000mg/l

Source: Kpieta, 2012.

Table 4: Third Phase of Water Quality Test Results

District		Wa West		Wa Municipal		Nadowli District		WHO, GSB & GWCL Guidelines
Community		Balawafiile	Siiru	Tanina	Busa	Daffiama	Sankana	
Source		Dam	Dam	Dam	Dam	Dam	Dam	
Date of Sampled		15/06/2011	15/06/2011	15/06/2011	15/06/2011	15/06/2011	15/11/2011	
Time Sampled		10:28am	11:15am	1:10pm	2:50pm	04:55pm	05:05pm	
PARAMETERS								
Temperature	(˚C)	29.9	30.0	30.0	29.4	29.9	30.0	None
Ph		7.2	7.2	7.6	7.6	7.6	7.1	6.5 - 8.5
Conductivity	(µs/cm)	69.9	80.0	116.2	82.9	62.7	66.0	0 - 1500mg/l
Turbidity	(NTU)	4.45	**33.1**	**99.3**	**8.77**	**13.0**	**19.9**	0 – 5.0mg/l
Nitrates (NO3)	(mg/l)	0.6	2.5	**10.1**	1.1	1.5	2.8	0 – 10.0mg/l
Nitrite (NO2)	(mg/l)	**5.0**	**13.0**	1.72	**4.0**	**8.0**	**15.0**	0 – 3.0mg/l
Ammonium (NH3)	(mg/l)	0.27	0.65	**1.76**	0.34	0.36	0.49	0 – 1.5mg/l
Sulphate (S04)	(mg/l)	1	10	50	6.0	8.0	12	0 – 400mg/l
Manganese (Mn)	(mg/l)	0.082	0.123	**0.548**	0.167	0.117	0.192	0 – 0.1mg/l
Total Hardness (CaCO3)	(mg/l)	6.0	4.0	24.0	6.0	6.0	14	0 - 500mg/l
Total Coliform (cfc)	(cfu/ 100ml)	**>18**	**>18**	**>18**	**>18**	**>18**	**>18**	0 CFU
Faecal Coliform (MPN Index)	(cuf/100ml)	**24**	**44**	**60**	**46**	**40**	**65**	0
Total Dissolved Solids	mg/l	24	44	60	46	40	65	0 – 1000mg/l

Source: Kpieta, 2012.

The pH of the Reservoirs Water in the Study Area

pH is a measure of the acidity or alkaline of an aqueous solution. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C (77 °F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. pH is related in several different ways to almost every water quality parameter; pH values higher than 8.5 favours viral hepatitis, a growth in water (WHO, 2008). The WHO and the Ghana Standards Board recommended levels for dam water pH is between 6.5 and 8.5. As shown in Tables 2 and 3, both the first and second phases of the pH results were within the given range of 6.5 and 8.5 which is the acceptable levels. However the third phase of the test results presented in Table 3, which was conducted in June 2011, shows Tanina dam water pH at 8.9 which could be favouring the prevalence of infectious hepatitis in the community and the region at large.

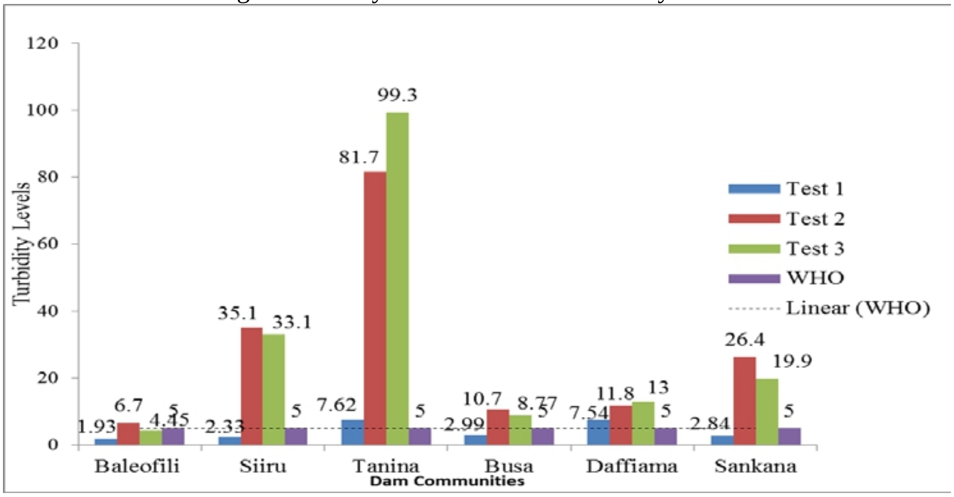
The Turbidity (NTU) of the Six Dams Reservoirs

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. It is primarily a measure of the concentration of finely divided matter (colloidal solids), which affects the water's appearance and may contain micro-organisms. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU). The measurement of turbidity is a key test of water quality.

Turbidity in open water may be caused by growth of phytoplankton. However, human activities that disturb land, such as construction, can lead to high sediment levels entering water bodies during rain storms due to storm water runoff. In drinking water, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases. In water bodies such as lakes, rivers and reservoirs, high turbidity levels can reduce the amount of light reaching lower depths, which can inhibit growth of submerged aquatic plants and consequently affect species which are dependent on them, such as fish and shellfish. (USA-EPA, 2009, 2005 U.S.A – EPA, 2005).

The WHO (2008) recommended level of water turbidity is 0 – 5mg/l; the first phase of the water quality test carried out in November 2010 shows four out of the six sampled reservoirs turbidity levels where within the acceptable range of 0 – 5mg/l; however, Tanina and Daffiama dams' water turbidity levels were a little above the given range. As shown highlighted in Table 2 and then represented in Fig 2, the dams water turbidity levels were at 7.62 and 7.54mg/l respectively. The reason for the low levels of the turbidity was that all the dams were inundated after the heavy raining season from June to October ending, thus, the dams were full and overflowing making the water purer and clear.

Fig 2: Turbidity Levels of Six of the Study Dams



Source: Kpieta, 2012.

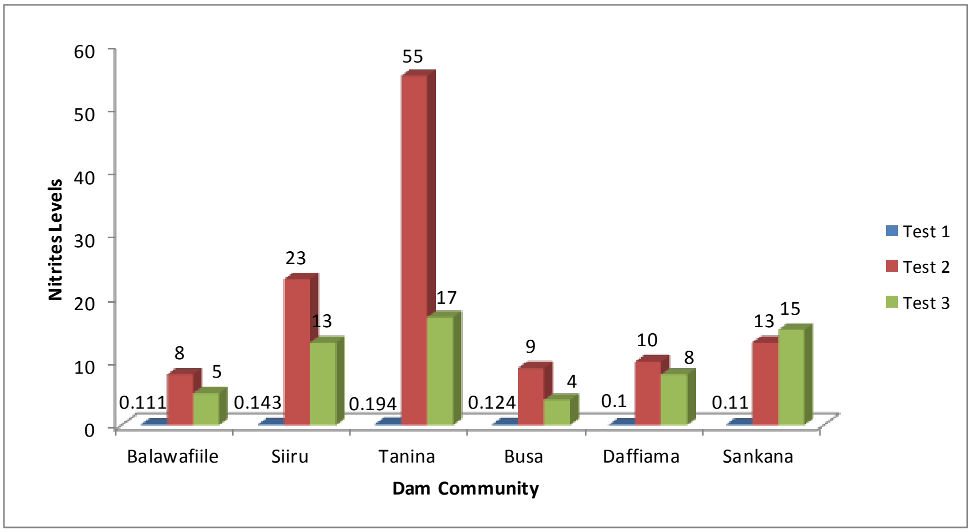
The second and third phases of the water quality test conducted in May and June 2011, rather shows heavy cloudiness of all the dams with Tanina dam being the worse, having its water turbidity levels at 81.7mg/l and 99.3mg/l units of turbidity (NTU) – these figures are well above the WHO and the Ghana Standards Board acceptable levels 5 NTU. The reason for the heavy cloudiness of all the reservoirs is as a result of the farming activities in and around the dam's catchment areas. These anthropogenic forces are causing considerable environmental degradation of the vegetable cover around these dams. Subsequently, the water bodies of these dams become reservoirs for human/animal waste that entered with surface runoff from the rains. This level of pollution according to Boelee et. al. (2009) even harms the fish population in the reservoirs.

Nitrates (NO3) and Nitrites (NO2) Levels of the Six Reservoirs

WHO Guideline Value for Nitrate in drinking water is 10mg/litre and for Nitrite are 3mg/litre. Nitrates enter water from the breakdown of natural vegetation, the use of chemical fertilizers in modern agriculture and from the oxidation of nitrogen compounds in sewage effluents. In the body, Nitrates are converted to Nitrites; the nitrites react with haemoglobin in the red blood cells to form methaemoglobin, affecting the blood's ability to carry enough oxygen to the cells of the body. Bottle-fed infants less than three months of age are particularly at risk. Drinking water containing excessive amounts of nitrates can cause methoemoglobinaemia in bottle-fed infants (blues babies) (New Hampshire Department of Environmental Services, 2010).

The three phases of the water quality test results displayed in the Tables 2, 3, and 4, showed very negligible nitrate and nitrite levels in the dams in November 2010 when the test was first conducted. However, the second and the third phases of the test results as depicted in Figure 3 shows a significant increase in the nitrite levels in all the dams with Tanina dam again having the worse contamination as represented in Figure 3. Meanwhile this particular dam water is seriously used by the residents for bathing, washing of clothes and watering of vegetables. Again, the consumption of water and vegetables produced from this dam irrigation has a serious public health-risk in the region.

Fig 3: Nitrite Levels of Six of the Study Dams Water



Source: Source: Kpieta, 2012.

Coliform Bacteria

Coliform bacteria are organisms that are present in the environment and in the faeces of all warm-blooded animals and humans. Coliform bacteria will not likely cause illness, however, their presence in drinking water indicates that disease-causing organisms (pathogens) could be in the water system. Most pathogens that can contaminate water supplies come from the faeces of humans or animals. There are three different groups of Coliform Bacteria; each has a different level of risk. Total Coliform, Faecal Coliform, and *Escherichia coli* are all indicators of drinking water quality. The Total Coliform group is a large collection of different kinds of bacteria. Faecal Coliforms are types of total Coliform that mostly exist in Faeces. *E. coli* is a sub-group of Faecal Coliform (Lika et. al. Undated; WHO 2004, 2006).

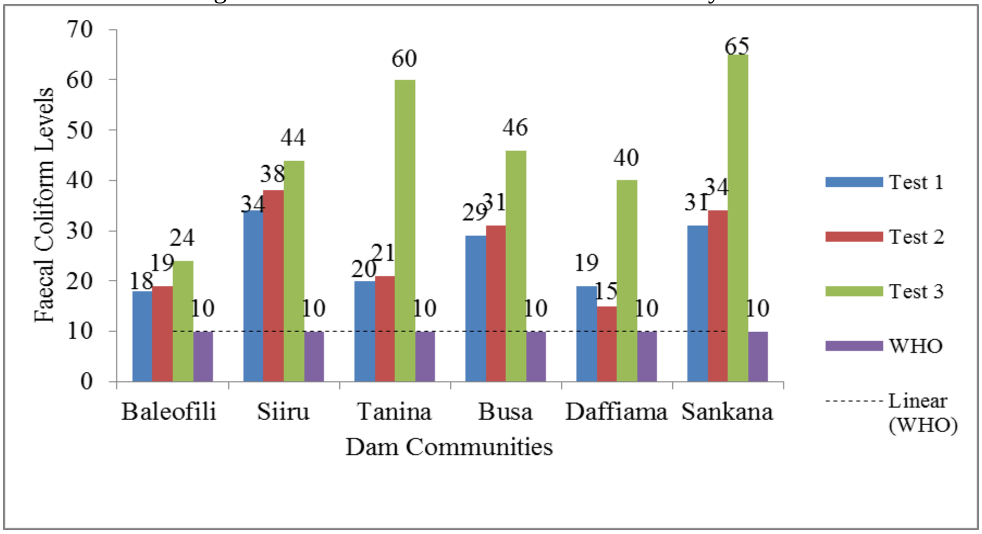
Total Coliform (CFC) Levels in the Reservoirs

Total Coliforms include organisms that can survive and grow in water. Total coliform bacteria (excluding *E. coli*) occur in both sewage and natural waters. Some of these bacteria are excreted in the faeces of humans and animals, but many coliforms are heterotrophic and able to multiply in water and soil environments. Total coliforms are generally measured in 100ml samples of water (WHO 2004, 2006; Washington State Department of Health, 2010).

The three phases of the water quality test for Total Coliform levels in the dams as highlighted in the Tables 2, 3, and 4, has shown very high levels of total coliform in the reservoirs. Three dams – Siiru, Busa and Tanina dams had their levels of coliform below 18cfc/100L during the first phase of the test, but the subsequent tests rather revealed an increase in the Total Coliform levels far above 18cfc/100L. All the six sampled reservoirs are showing high Total Coliform levels signifying high levels of faecal contamination of the reservoirs and the possible presence of disease causation pathogens in the water.

Faecal Coliform (MPN Index)

Fig 4: Faecal Coliform Levels of Six of the Study Dams



Source: Source: Kpieta, 2012.

Faecal Coliform bacteria are a sub-group of total coliform bacteria. They appear in great quantities in the intestines and faeces of humans and animals. The presence of faecal coliform in water sample often indicates recent faecal contamination, meaning that there is a greater risk that pathogens are present. For water to be considered as no risk to human health, the faecal coliform and E. coli counts/100mL should be zero (World Health Organization 2004).

The faecal coliform levels highlighted in the results presented in Tables 2, 3, and 4 shows an alarming levels of faecal contamination of the reservoirs far above the permissible level of 10 MPN Index by WHO and GSB. The faecal coliform levels of the six dams represented in Fig 4 shows that the pollution levels increases from the first phase of the water quality test conducted in November 2010. As depicted in Fig 4, Sankana and Tania reservoirs are heavily polluted with 65 and 60 MPN respectively. This level of faecal pollution of the reservoirs poses a high risk of outbreak of infectious diseases in the area because the months of May/June is a period where farmers spend most of their working hours in the farms preparing the land for sowing. Working under the scorching sun's heat makes the farmers consume lots of water from these contaminated reservoirs. Also the health-risk of an outbreak of E. coli in the region is very high as farmers continue to use the highly contaminated waters to produce vegetables which are sold to the public in the various markets in the region.

Escherichia Coliform (E. coli) is a sub-group of the faecal coliform group; this bacterium is harmless bacteria and is found in great quantities in the intestines of people and warm-blooded animals. However, in other parts of the body, *E. coli* can cause serious disease, such as urinary tract infections, bacteraemia and meningitis.

The presence of *E. coli* in water samples almost always indicate recent faecal contamination, meaning there is a greater risk that pathogens are present. Its presence in water or on the surfaces is used as an indicator of faecal contamination. The human health effects of EHEC stereotypes, such as *E. coli* O157:H7 and *E. coli* O111, causes diarrhoea that ranges from mild and non-bloody to highly bloody and potentially fatal. Livestock, such as cattle and sheep, and to a lesser extent, goats, pigs and chickens, are a major source of EHEC strains. The latter have also been associated with raw vegetables, such as bean sprouts (Morgan, 1991; WHO, 2011 (www.who.int/mediacentre/factsheets/fs125/en/E.coli, retrieved on 24/2/11).

The level of faecal coliform and streptococcal bacteria present in all the analysed water samples taken from the six dams makes these reservoirs water unsuitable for human consumption. Meanwhile, it is this same water that is used for horticulture and for human consumption in these dams' communities. During the field survey, it was observed that residents of these dam communities were fetching the reservoirs water for bathing, washing, and watering vegetables. The consumption of vegetables produced with such polluted water may be endangering the health of consumers with gastrointestinal diseases and skin infections which are actually among the reported Ten Top OPD Diseases in the Upper West Region (GHS Reports, UWR, 2000 -2010).

Other parameters also tested and the results presented in the Tables 2, 3, and 4 are Ammonium (NH_3), Sulphate (S04), Manganese (Mn), and Total Hardness ($CaCO_3$). These parameters results are all within the permissible levels in open water by the WHO and the GSB.

Sources of Drinking Water in the Dam Communities

The source of water for drinking and cooking is seriously inadequate in the small-scale dams' communities. The main source of quality water in these dam communities is the boreholes as shown in Table 5. The challenge however is the increasing populations in these dam communities, resulting in increasing pressure on the boreholes for drinking water, thus, the frequent breakdowns of the boreholes and the usual long queues of women and children waiting for their turn to fetch quality water. The yield of a number of these boreholes has therefore reduced considerably while others dried up completely. Out of the 5 boreholes in Tanina community only 2 are functioning; Goli community has only 3 out of the 7 boreholes functioning; and only 4 out of the 8 boreholes in Sakana are currently working. Gengieri – a suburb of the Sankana community with eight compounds has no borehole, the people drink from the dam instead of walking about 1 kilometre or more to queue at the nearest borehole for safe water.

Communities such as Yeleyiri, Siiru and Baliefili are dispersed settlements with each family settling on their farm land. The provision of a single borehole in these dam communities makes it difficult for some families to travel the long distance to fetch water when the dam is just close by. It is only Busa and Daffiama communities that have a small-town water system operated by the mechanization of some boreholes which reaches a few compounds.

Table 5: Dam Communities Environmental Setting

District	Community	Population		Total Population	Sources of water	Toilet facilities available
		Male	Female			
Wa Municipal	Busa	1195	1362	2557	7 stand pipes, 8 wells, and 2 boreholes	3 KVIP, but not in use
	Dobile-Wa	-	-	-	-	-
	Tanina	907	906	1873	2 boreholes	3 KVIP, but all are out of use
Wa West District	Siiru	87	84	171	1 borehole	None
	Yeleyiri	116	128	245	1 borehole	None
	Baliefili	234	265	499	1 borehole, 1 hand-dug well	None

Nadowli District	Sankana	1060	1349	2409	8 bore holes, 2 wells	1 KVIP, but is out of use
	Takpo	1388	1452	2840		1 KVIP, but is out of use
	Goli	589	722	1311	3 boreholes	1 KVIP, but is out of use
	Daffiama – Dakyie	407	535	932	1 boreholes, 2 wells	1 KIVP, but is out of use

Source: Kpieta, 2012

Many of the households (91.7%) as shown in Table 6 indicated that their households use the borehole water at home for cooking while 8.1% said they use the dams and hand-dug wells water. However, 7.1% of the households clearly stated that they do not have access to boreholes as such they use the dam water to cook and drink. While 66% of respondents said they use the dam water for bathing and washing, others said it is the hand–dug wells and streams water they use for cleaning. The source of farm water to residents of these dam communities could be the most likely cause of increasing risk of infections with water-related diseases.

About 96% of the 350 household head respondents of the survey are subsistent farmers and spend most of their working hours in the farm. And as shown in Table 6, about 77% of these respondents drink from the dams when they are on their farms working. The remaining 20.1% said they drink from hand-dug wells and streams in the farm. The health-risk facing these residents of dam communities is the fact that the respondents said that they don't treat (boiling the water, chemical treatment) the reservoirs water before drinking. Majority (98.9%) of household respondents indicated that they do not treat their water before using it. During the focus group discussions, the general response to why the dam water is not treated before drinking is that: *"Kuong ba taa zieng, nubo mang kpi la kuong kye ka ba nyu"* –'water has no poison, people die in water and yet we drink it and nothing happens'.

An elder stated at Male FGD at Sankana:

"How can I always walk pass water to go to my farm and return home to fetch water from a borehole to drink? Just look at the distance from our farm back home to fetch water from a borehole and see how our farms are beyond the dam, where is the time to do that?"

Table 6: Sources of Households Domestic Water Use in the Area

District	Borehole water used for cooking at home	Borehole water used for Bathing and washing clothes	Dam water used for cooking at home	Dam water used for bathing and washing clothes	Borehole water used on the farm for drinking	Dam water used on the farm for drinking
Wa Municipal	76.2	23.8	2.9	57.1	32.4	63.8
Wa West District	99.0	1.0	8.3	95.2	9.5	93.3
Nadowli District	97.9	2.1	7.0	50.7	7.9	74.3
Total	91.7	8.3	7.1	66	15.7	76.9

Source: Kpieta, 2012.

The women also said during the Female FGD's that they would have wished to always fetch the borehole water and take along to the farm, but they have to carry the prepared food from home to the farm for the day's work.

A woman remarked at Siiru Female FGD:

"*If the farm workers are many how can I keep walking back home to fetch drinking water from a borehole for all of them to drink when the dam is just nearby? Even if I return home to fetch from the borehole no one will be at home that will help me carry the basin of water, we all leave for our farms and return in the evening*."

These findings in this study agree with Boelee et. al. 2009, that in developing countries, clean water availability in sufficient quantities throughout the year for drinking and other household uses is still very insufficient. Thus, many people depend on water from small-scale dams, ponds and streams though this is rarely suitable for human consumption.

The health implications on households drinking directly from these highly contaminated dams and at the same time using it to produce most of the vegetables consumed in the region is a primary factor for the increasing infectious disease burden on households reported at the various hospitals and clinics (OPDs) in the study area. These small reservoirs may have an unquestionable potential health hazards and long term impact on human health and development in the area. Again it has corroborated with other research findings such as Hunter (2003, 1992), Paul and Walton (2004), UN-Habitat (2003) and WCD (2000) that the uses of the contaminated small-scale dams water for drinking, bathing, washing of clothes and also production of vegetables increases water-related diseases in the given area.

Spatial Variation of Water-Related Diseases Burden in the Study Area

Both the household head respondents and the focus group discussants indicated that malaria is the disease that afflicts them most often than all other water-related diseases in the area. About 95% of respondents, as indicated in Table 7, mentioned malaria as the top disease burden throughout the year. This is confirmed by the Ghana Health Service Regional Reports (2000-2010), showing malaria as the Top Ten Diseases in the Upper West Region.

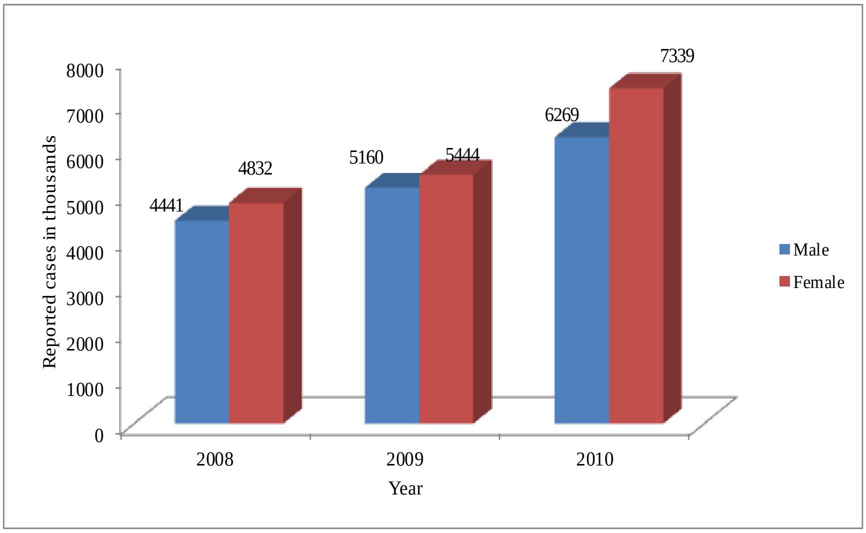
Table 7: Spatial Variation of Water Related Disease Burden on Households

District	Malaria (%)	Skin Diseases (%)	Schistosomiasis (%)	Diarrhoea (%)
Wa Municipal	90.5 (95)	42.9 (45)	1.9 (2)	17.1 (18)
Wa West	94.3 (99)	18.1 (19)	57.1 (60)	23.8 (25)
Nadowli District	98.6 (138)	12.9 (18)	0.7 (1)	12.1 (17)
Total	94.9 (332)	23.4 (82)	18 (63)	17.1 (60)

Source: Kpieta, 2012.

Diarrhoeal Diseases

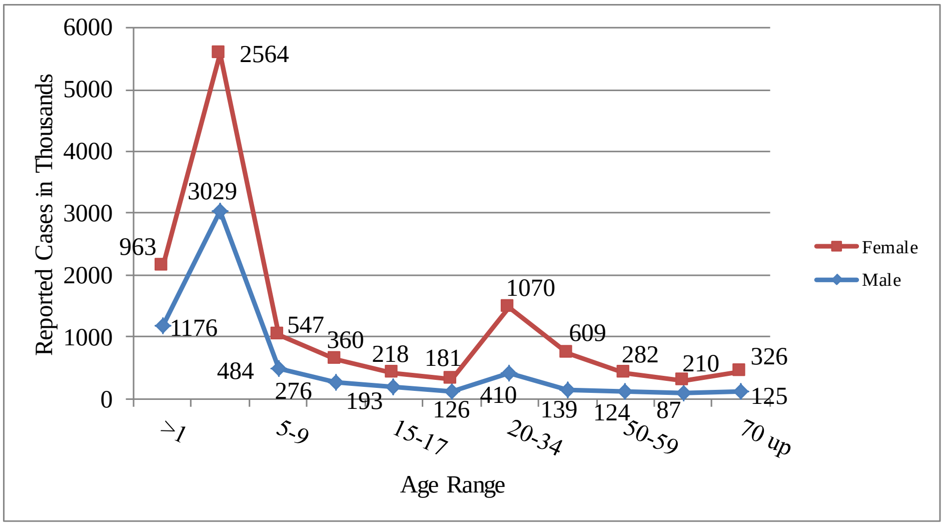
Fig 5: Reported OPD Diarrhoea Cases, 2008-2010



Source: Analysed GHS Data, UWR January 2011.

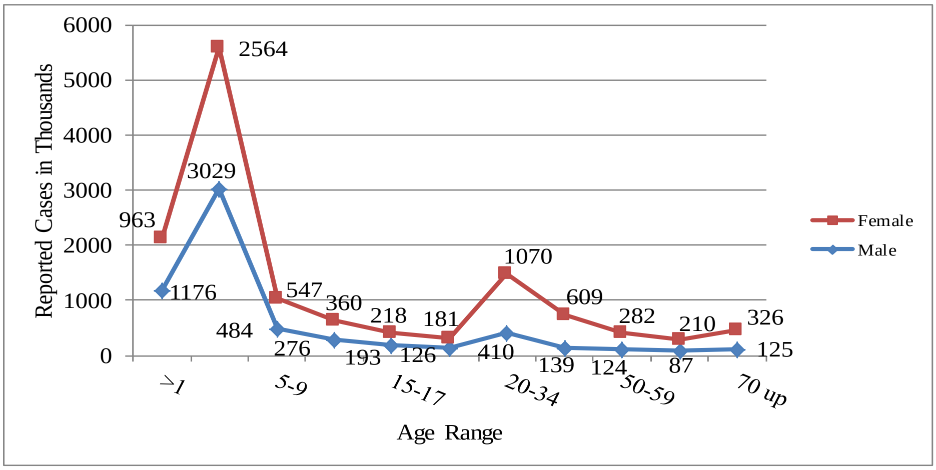
The reported cases of diarrhoea disease burden from 2008–2010 in the Upper West Region are represented in Fig 5. It is showing an increasing trend of the disease. Women appear to be suffering more from the disease than men. The percentage increase of 16% of the disease burden on women from 2008-2009 and 35% increase from 2009–2010 is very high. The percentage increase of the disease on men showed 12% increase from 2008-2009 and 13.3% increase from 2009-2010. The age specific analysis of the disease indicated in Fig 6 and Fig 7 also shows the age ranges from >1 to 4 years group to be suffering the highest disease burden in the region.

Fig 6: Diarrhoea Prevalence among Age Groups in 2008



Source: Analysed GHS Data, UWR January 2011.

Fig 7: Diarrhoea Prevalence among Age Groups 2010

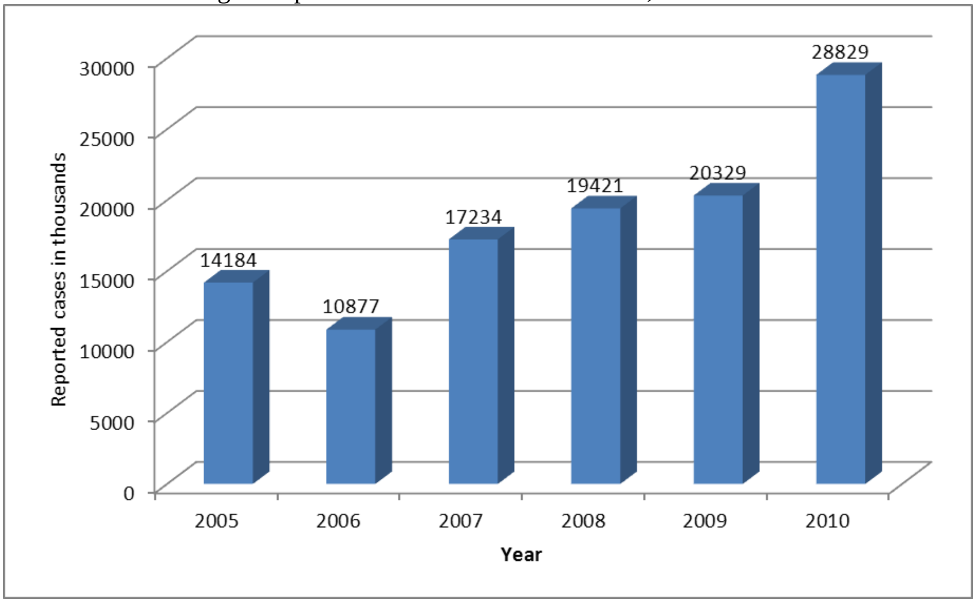


Source: Analysed GHS Data, UWR January 2011.

The high diarrhoea diseases burden on children and women may be having a negative effect on agricultural production and development as a whole in the region. The reason has been that women form the core of agricultural labour force in the region.

Skin Diseases Prevalence

Fig 8: Reported OPD Skin Diseases Cases, 2005–2010



Source: GHS, UWR, January, 2011.

The reported OPD skin disease cases in the region from 2005–2010 shows a very high incidence of the disease. As indicated in Fig 8, the year 2007 reported the highest disease burden of 46,008 cases in the region. There was a significant decline in reported cases in 2008 and then gained a steady increase in 2010. Bathing of the highly contaminated dams water as indicated in Table 6, may be accounting for the increasing skin disease prevalence in the area.

Conclusion and recommendations

Small-scale dams water quality is becoming an issue that needs urgent attention by all stake holders because of the increasingly public health-risk associated with the uses of the dam water by residents of the dam communities. The problem is aggravated by the water stress in the region during the seven months dry season period lasting from October–to-May ending each year. The shortage of quality water for household uses puts the populations at risk as people resort to drinking the highly contaminated water from the dams. These polluted waters are also the only source of water for vegetable production and animal watering in the region. The households living in close proximity to these dams are at the greater health-risk of infectious and parasitic diseases. Findings from this survey shows that the citing of small-scale dams in water stress region like the Upper West Region without adequate boreholes for the drinking water needs of households is a recipe for increasing water-related disease burden on the people. It is imperative for the Government of Ghana to re-consider the design and construction of small-scale dams to include in the design mechanized hand-dug-wells and boreholes as a component for the drinking water needs of residents in dam communities. Also, the fencing of the reservoirs to keep animals away from having direct contact with the water bodies may help reduce the pollution of the reservoirs. Additionally, there is the need for effective environment management in the dam communities in the area.

References:

Abdul-Korah GB (2006). “Where is not home? Dagaaba migrants in the Brong Ahafo Region, 1980 to present.” African Affairs, 106, 71-94.

Arnedo-Pena A, Bellido-Blasco J, Puig-Barbera J, Artero-Civera A, Campos-Cruañes JB, Pac-Sa MR, Villamarín-Vázquez JL, Felis-Dauder C (2007). "Domestic water hardness and prevalence of atopic eczema in Castellon (Spain) school children."

Salud Publication Mex.492 (4): 295–301. doi: 10.1590/S0036-36342007000400009. PMID 17710278. http://ezinearticle.com/? Total Hardness-and-water-Quality&id=516135).

Awumbila M (2007). “Internal migration, vulnerability and female porters in Accra.” A Paper presented at the Population Association of America Conference, New York, March 29-30, 2007.

Bacho ZLF (2001a). From a gift of Nature to an Economic Good. Changing the Perceptions and Management of Drinking Water. Spring Research Series, Published by Spring Centre, University of Dortmund. House. Pall Mall. London.

Boelee E, Cecchi P, and Koné P (2009). “Health Impacts of Small Reservoirs in Burkina Faso.” Colombo, Sri Lanka: International Water Management Institute. 50p. (IWMI) Working Paper 136). doi:10.3910/2009.202 http://www.iwmi.cgiar.org/Publications/Working_Papers/working/wp136.pdf.

Cleveland DA (1991). “Migration in West Africa: A savanna village perspective.” Journal of the International African, 61(2), 222-246.

Corvalan C, and Kjellstrom T (1995). Health and Environment Analysis for Decision. Making, World Health Statistics Quarterly, vol. 48, No.2.

Diersing N (2009) “Water Quality: Frequently Asked Questions.” PDA. NOAA. (http://floridakeys.noaa.gov/pdfs/wqfaq.pdf, retrieved 2009-08-24).

Eigtveds PC (2006). “Water Reform and Access to Water for the Rural Poor.” Short country review of recent water reform, undertaken by Claus Aagaard Pedersen, DII in preparation of the Danida – DWF-Research – DIIS Conference. http://www.glowa-volta.de/publications/ printed/van_edig_etal_2003.pdf).

Erlanger TE, Keiser J, Caldas De Castro M, Bos R, Singer BH, Tanner M, Utzinger J (2005). "Effect of water resource development and management on lymphatic filariasis, and estimates of populations at risk." American Journal of Tropical Medicine and Hygiene 73: 523-533.
Ghana Health Service Annual Reports (2000 – 2010), Upper West Region of Ghana.
Ghana Living Standard Survey Report (GLSS, 2005).
Ghana Poverty Reduction Strategy (2003 - 2005). An Agenda for Growth and Prosperity.
Ghana Statistical Service (2000). Population and Housing Census 2000. Preliminary report on population census. Accra. UNFPA Funded Project, (GHA/01/P070), Ghana Statistical Service. Accra, Asante and Hittscher Press limited.
Ghana Statistical Service, (2005). Population and Housing Census: Analysis of District Data and Implication for Planning. Upper West Region, pp. 24-37.
Ghana Statistical Service (1995a). Migration Research Studies in Ghana. International Migration, Volume 1.
Ghana Statistical Service (1995b). Migration Research Studies in Ghana. International Migration, Volume 2.
Ghana Statistical Service Report - Wa, Upper West Region (2006).
Ghosh G (2000). Some observations on water policy reforms hydro-politics. WSSCC (ed) 200: vision 21: Water for People, Water Supply and Sanitation Collaborative Council Publication, Switzerland.
Hart A (2007). Total Hardness and Water Quality. http://www.healthydrinkingwaterblog.com/
http://ezinearticles.com/?expert=Anna_Hart
Hunter MJ (2003). "Inherited burden of disease: Agricultural dams and the persistence of bloody urine (Schistosomiasis haematobium) in the Upper East Region of Ghana, 1959–1997." Social Science and Medicine 56: 219-34.
Hunter MJ (1992). "Elephantiasis: A disease of development in north-east Ghana." Social Science and Medicine 35: 627-645.
Judith AR (2006). "Urban Water and Sanitation Services; an IWRM Approach. Global Water Partnership Technical Committee (TEC)." TEC Background Papers No.11.
Karim AA (2006). "Serious Environmental and Public Health Impacts of Water Related Diseases and Lack of Sanitation on Adults and Children." Washington, DC.
Kpieta BA (2012). Health Implications of the Construction of Small-Scale Dams on Households in Three Districts of the Upper West Region of Ghana. Un-Published PhD Thesis.

Kpieta BA, Owusu-Sekyere E, and Bonye ZS (2013). Reaping the benefits of small-scale irrigation dams in North-Western Ghana: Experiences from three districts in the
Upper West Region. *Research Journal of Agriculture and Environmental Management. Vol. 2(8), pp. 217-228, August, 2013. ISSN 2315 – 8719 ©2013 Apex Journal.*
Lika M, Daka A, and Monkolli H (Undated). Microbilogic Examinations of Some Natural Water Sources. Nutura Mantenegrina, Padgorica, 7(2): 505-510.
Medium Term Development Plan (MTDP), Upper West Region (2004).
Meteorological Department (2010): Regional Report, Wa Upper West Region (1960-2009).
Mohan M (1992): Water Supply and Environmental Management: Developing World Applications. Westview Press, Inc. USA.
Morgan P (1991): Rural Water Supplies and Sanitation. Published by Macmillan Education Ltd, London.
Morris G, and Jiahua F (1998). "Reservoir Sedimentation Handbook." McGraw-Hill Publishers.
Namara, RE, Horowitz L, Nyamadi B, Boubacar B (2011). "Irrigation development in Ghana: past experiences, emerging opportunities, and future directions, Accra, Ghana." International Food Policy Research Institute (IFPRI), Ghana Strategy Support Program (GSSP). 43p. (GSSP Working Paper 0027). IWMI.
New Hampshire Department of Environmental Services (2010): Environmental Fact Sheet. 29 Hazen Drive, Concord, New Hampshire 03301 • [603] 271-3503 • www.des.nh.gov
Oram B (2010). "Total Dissolved Solids and Water Quality." Water Research Centre. B.F. Environmental Consultants Inc. 15 Hillcrest Drive, Dallas, PA 18612. (http://www.water – research.net/totaldissolvedsolids.htm - retrieved 22/02/11.
Paul and Walton, (2004): Core concepts in Health, 9th edt. Published by McGraw Companies, Inc 1221 Avenue of Americas, New York, and NY100020.
United Nations World Water Development Report 2, (2006). "Water a shared responsibility". [Online]. Available: www.unesco.org/water/wwap.
UN-Habitat (2003). Water and Sanitation in the World's Cities. Local actions for Global Goals. United Nations Human Settlements Programme. Earthscan Publications Ltd 120 Pentonville Road, London, NI 9JN, UK.
USA - Environmental Protection Agency, Washington, DC (2006): "Water Quality Standards Review and Revision." (http://en.wikipedia/wiki/Turbidity).

USA Environmental Protection Agency, Washington, (2009). “Drinking Water Contaminants.”

USA Environmental Protection Agency (EPA), Washington, D.C. (2005). “National Management Measures to Control Non-point Source Pollution from Urban Areas.” Chapters 7 and 8. Document No. EPA 841-B-05-004.

U.S.A Environmental Protection Agency (EPA). Washington, DC (2008). "Analytical Methods Approved for Drinking Water Compliance Monitoring under the Total Coliform Rule."

Valent F, Little D, Bertollini R (2004). Burden of disease attributable to selected environmental factors and injury among children and adolescents in Europe. Lancet, Vol. 363: 2032-2039.

Wa District Assembly, (2004). Wa District Profile.

Water Resource Commission of Ghana, (2006). Status of Integrated Water Resources Management in Ghana (1999- 2007).

Washington State Department of Health (2010). Coliform Bacteria and Drinking Water. Division of Environmental Health Office of Drinking Water.

Washington State Department of Health, Division of Environmental Health, office of Drinking Water (2011). “Coliform Bacteria and Drinking Water.”

World Commission on Dams (2000). Dams and Development: A New Framework for Decision-Making. Earthscan Publications Ltd, London and Sterling, VA.

WHO (2011): “Diarrhoea." http/www.who.int/diarrhea/en/ - retrieved 8/9/11).

WHO (2011): “Enterohaemorrhagic Escherichia coli (EHEC).” Media Centre Fact sheet N°125. (www.who.int/mediacentre/factsheets/fs125/en/ E.coli, retrieved on 24/2/11).

WHO Library Cataloguing-in-Publication Data (2008): “Guidelines for drinking-water quality.” [electronic resource]: incorporating 1st and 2nd addenda, Vol.1, Recommendations, 3rd ed.

World Health Organization (2004). Water Supply and Sanitation Collaborative Council and. Sanitation and Hygiene Promotion Guide. Switzerland.

World Health Organization (2006). Preventing disease through healthy environments:

Towards an estimate of environmental burden of disease. Prüss-Usten A and Corvalan C, World Health Organization, Geneva.