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Original Research Article

Assessment of dam water quality in three selected communities in Savelugu-Nanton municipality, Ghana

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The study was to assess the quality of dam water in three communities in the Savelugu-Nanton Municipality. Samples were collected three times (in duplicates) from each dam making a total of thirty six (36) samples at two weeks interval in January, 2014. The samples were conveyed to Council for Scientific and Industrial Research-Water Research Institute Laboratory in Tamale for the analysis using standard methods. The study revealed the physico-chemical characteristics of the dam water samples were within World Health Organisation and Ghana Standard Board permissible limits for drinking water except turbidity. Turbidity values obtained ranged from 7 to 46 NTU with a general mean value of 18.06±12.05 NTU. Total coliform count ranged from 2.4 x10^1 to 1.941 x 10^3 cfu/100 ml with general mean valueof 1,088±842.7 cfu/100 ml. Coliform bacteria count of the dam water exceeded the WHO permissible limits for drinking water. Hence, the coliforms contamination implies that the dam water when consume can lead to disease burden. It is therefore recommended that the dam water should be treated against coliform bacteria before using it for drinking purpose.

Key words: Coliform bacteria, dam, turbidity, water quality, Ghana

INTRODUCTION

Water is a basic human need and a precious natural resource for the human wellbeing. It is needed in all aspect of life and health for food production, energy generation and preservation of environment and a substance of life and development (Tiwari, 2000). Historically, man has thrived in water scarcity areas by adapting and modifying water bodies for their suitable use. This is through dam impoundment, dugout wells, canals and among other infrastructure to provide water for the purpose of households potability, drinking source for livestock and irrigation purpose. Access to water is crucial in all aspects of human life as it reflects in the socio-cultural and economic lives of human societies. In arid and semi-arid environments the importance of water is most appreciated due to the straining efforts that are usually required to access it for both socio-economic and household consumption (Bacho, 2001; Ghosh, 2000).

Small and large scale impoundment and distribution of water has been a major factor that has led to tremendous improvement in public health worldwide (UN, 2006). Over 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 major challenge relating to small-scale dams is the potential health hazards resulting from the use of the open water for drinking, bathing, washing of clothes and also production of vegetables associated with faecal contaminated water (Hunter, 2003; Paul and Walton, 2004; UN-Habitat, 2003; WCD, 2000).

Basically, people living in rural areas use the most convenient sources of water in their areas irrespective of quality, due to lack of pipe-borne water and also based on the view that dam water is tasty and ladder with soap (Ministry of People and Environment of Nepel (MOPE), 2001; Pradhan, 2000). Water quality basically refers to the chemical, physical and biological characteristics of water (Diersing, 2009). Water quality measured the condition of water relating to the requirements of one or more biotic species and/ or to any human need or purpose. It is mostly used by reference to a set of standards against which compliance are usually 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). The lack of clean drinking water and proper sanitation systems has led to 70% of diseases which is a crucial public health concern in Ghana. Consequently, households that lack access to clean water are forced to use less reliable and hygienic sources, and often pay high water tariff (OFCD, 2007).

Agricultural activities can cause pollution of water bodies and, over time, cumulative effects can lead to the depletion of water quality (Schilling and Wolter, 2001). Drinking water quality is a major issue in rural areas in the Savelugu-Nanton Municipal. The quality of water is endangered because of anthropogenic activities such as farming (use of agrochemicals), swimming, open defecation, open dumping of waste, washing of cloths among others around the water bodies. The contribution of nutrients and pathogens into streams or via run-off to the dam from livestock faecal waste is therefore expected to be fairly constant in the dams of the study areas, Savelugu-Nanton Municipality. The study was to assess the quality of water for its suitability purpose in the communities.

MATERIALS AND METHODS

Study Area

The research was carried out in Libga dam in Mogulaa Area Council, Zieng Buntanga dam in Nanton Area Council and Bunlung dam in Savelugu urban centrein Savelugu-Nanton Municipal Assembly, Northern Region of Ghana. It shares boundaries with West Mamprusi district to the north, Tamale Metropolitan Assembly to the south, Karaga district to the east and Kumbungu district to the west. The vegetation in the Municipality is Guinea Savannah with a single rainy season and a prolonged dry season.

Samples Collection

Samples were collected three times (induplicates) from each dam making a total of thirty six (36) samples at two weeks interval in January, 2014. Each duplicate is either used for physico-chemical analysis or the bacteria analysis. Care was taken to ensure that samples are representative of dam examined and that no accidental contaminations occurred during sampling. Samples were collected into clean water bottles and stored in cool ice chest (at 4 °C) and transported to Council for Scientific and Industrial Research-Water Research Institute Laboratory, Tamale for analysis.

Determination of the Physico-chemical and Coliform Parameters of the Water Samples

A Jenway model 4020 conductivity meter was used to determine the conductivity and TDS of the samples. A pH meter (Jenway model) and combination electrode was used to determine the pH level of the water samples. A turbidimeter (hatch model) was used to determine turbidity levels of water samples. Sample was vigorously shake and poured into turbidimeter sample cell to at least $^2/_3$ full. An appropriate range was selected using the range knob. The turbidity value was then read. Nitrate, phosphate, fluoride and sulphate in dam water were determined by hydrazine reduction method, reaction with ammonium molybdate and ascorbic acid, spadns method, turbidimetric method respectively using UV/ Visible spectrophotometer in accordance with APHA 4500. Potassium and sodium were analysed with flame atomic absorption spectrophotometer (FAAS) in accordance with APHA (1998).

Filter membrane technique was used for the determination of coliform bacteria in accordance with APHA (1998). Membrane filtration technique was used to determine total coliforms and faecal coliforms in accordance with APHA 9222A and 9222D. Filtration unit comprising of Erlenmeyer flask, vacuum source and porous support were assembled and with the aid of a flame-sterilized forceps, a sterile membrane filter (0.45µm Millipore) was placed on the porous support. The upper funnel was placed in position and secured with appropriate clamps in a Millipore machine. 100 ml of sampled well water was aseptically poured into the upper funnel and suction applied to create a vacuum. After the sample was passed through the membrane filter, the filtration unit was taken apart and with the aid of a sterile forceps the membrane filter was placed in the Petri dish containing selective media for various parameters: M-Endo for total coliform and M-FC for faecal coliform. Clamps, forceps were usually sterile prior to use for the next sample. All plates were incubated in inverted position at 37±2 °C (total coliform) and 44±2 °C (faecal coliform) for 18-24 hours. SPSS version 16 software was used to determine the correlation matrix of the parameters using Pearson's correlation at two tailed.

RESULT AND DISCUSSION

Table 1 presented the physico-chemical and coliform bacteria characteristics of water samples from the dams, whilst Table 2 shows correlation between the parameters. The physico-chemical parameters obtained from the water samples fell within the World Health Organisation (WHO) (2008) and Ghana Standard Board stipulated limits for drinking water except turbidity. Generally, pH values recorded from the samples ranged from 6.02 to 7.20 with a general mean value of 6.49±0.39 pH-unit. Similar pH values were reported by Preeti et al. (2009) and Kpieta and Laari (2014) in their assessment of water quality in Kerwa dam for drinking purpose, and small-scale dams water quality and the possible health risk to users of the water in the Upper West Region of Ghana respectively. Although pH has no direct impact on consumers, it is one of the most important operational water quality

Table 1. Present summary results of the dams waters samples

Parameter	Unit	MEAN	MIN	MAX	Standard deviation	WHO/GSB limit
TDS	µg/l	36,680	2,790	55,540	12,840	1,000,000
Conductivity	µS/cm	60.2	36.37	91.78	21.23	-
pH	pH-unit	6.5	6.02	7.2	21.23	6.5-8.5
Alkalinity	µg/l	29,780	16,000	44,000	10,740	1,000,000
Sulphate	µg/l	7,690	5,290	10,600	2,020	400,000
Chloride	µg/l	7,410	3,000	19,900	4,970	250,000
Nitrate	µg/l	160	10	410	150	10,000
Phosphate	µg/l	70	10	127	40	2,500
Fluoride	µg/l	100	10	150	60	1,500
Calcium	µg/l	5,070	1,600	12,800	3,490	200,000
Magnesium	µg/l	2,480	1,000	4,360	1,010	150,000
Sodium	µg/l	12,590	5,200	65,000	19,660	200,000
Potassium	µg/l	2,600	2,000	3,900	600	30,000
Silica (SiO4)	µg/l	16,930	8,300	25,700	6,520	-
Tot. Hardness	µg/l	22,890	8,000	50,000	12,530	500,000
Turbidity	NTU	18.06	7	46	12.05	5
Temp	ºC	26.76	25.9	28.1	0.75	-
Total coliform	cfu/100ml	24	1,941	1,088	842.66	0
Faecal coliform	cfu/100ml	0	35	17.33	12.28	0

Table 2: Correlation Analysis of Parameters of the sampled dam water

Parameter	TDS	EC	pH	Alk	SO_4	F	Ca^{2+}	Mg^{2+}	Na	K	TH	Turb
TDS	1											
EC	1.0**	1										
pH	0.2	0.2	1									
Alk	0.9**	0.9**	0.1	1								
SO_4	0.9**	0.9**	0.1	0.5	1							
F	0.2	0.2	-0.1	0.5	-0.1	1						
Ca^{2+}	0.9**	.9**	0.4	0.8*	0.8*	0.0	1					
Mg^{2+}	0.8*	0.8*	0.8*	0.6	0.7	-0.1	.9**	1				
Na	0.0	0.0	0.7*	-0.2	0	-0.1	0.1	0.4	1			
K	0.8*	0.8*	0.5	0.6	0.7*	0.0	1.0**	.9**	0.0	1		
TH	0.9**	0.9**	0.6	0.8*	0.8*	0.0	1.0**	0.9**	0.2	0.9*	1	
Turb	-0.2	-0.2	-0.2	-0.4	0	-0.7*	-0.1	-0.2	0.0	0.0	-0.1	1

**Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

parameters. Extremes of pH can affect the palatability of water but the corrosive effect on distribution systems is a more urgent problem (IEPA, 2001). pH showed very strong positive correlation with magnesium and sodium at 5% significance level that implies they have a common source of contamination or interacts effectively in the dam water.

The minimum mean value of turbidity was recorded from Libga dam whilst the maximum was from Bunglung dam (Figure 1). The values recorded were all above the WHO (2008) and Ghana Standard Board stipulated limit of 5 NTU for drinking water. When compared to that of Kpieta and Laari (2014) who studied small-scale dams water quality and the possible health risk to users of the water in the upper west region of Ghana, the presented study turbidity values are extremely higher. This increased in turbidity levels irrespective of the location and/or season, may have detrimental effect on the visual quality of the water. The high level of turbidity in the dam water could be due to accumulation of particulate matter through runoff from increased precipitation. However, in the dry season, insufficient mixing or flow, stagnation and increased biogenic activity may have contributed to the observed turbidity levels (Cobbina et al., 2009). Turbid water in particular, may contain suspended and colloidal matter with the tendency to accommodate disease-causing microorganisms. High turbidity might also affect growth of aquatic organisms in the dams. Biological activities such as the growth of phytoplankton in the dams probably contributed to the high turbidity recorded (Cobbina et al., 2009). However, turbidity revealed negative correlation with sulphate at 5% significant level contrasting their

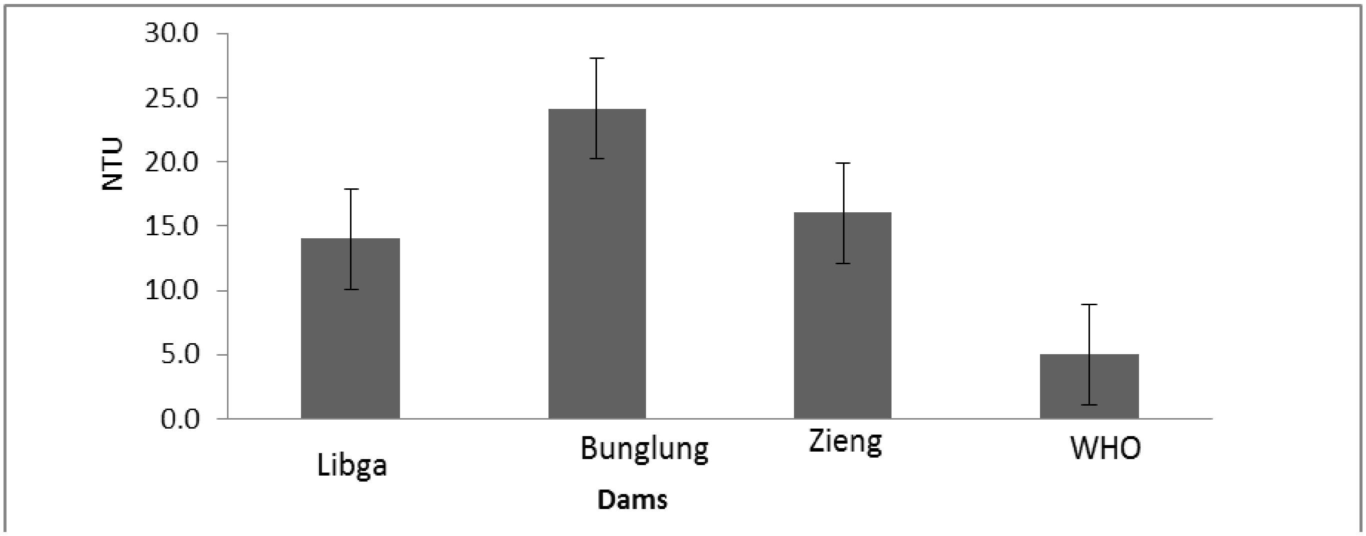

Figure 1: Mean turbidity values of the dam water

common source of pollution or do not interact effectively in the dam water.

Total Dissolve Solids (TDS) levels indicate the general nature of salinity of water. It signifies the inorganic pollution load of water system (Usha et al., 2008). The study recorded TDS that ranged from 2,790 to 55,540 µg/l with a general mean value of 36,700±12,840 µg/l. Generally, the study recorded TDS values were within WHO (2008) and GSB stipulated limits for drinking water. However, the TDS values recorded in this study are bit higher than that of Kpieta and Laari (2014) who studied small-scale dams water quality and the possible health risk to users of the water in the upper west region of Ghana. TDS shows a strong positive correlation with alkalinity, sulphates, calcium, and total hardness at 1% significance level and 5% significance level with magnesium and potassium implying that they have common source of contaminants or interact effectively in the dam water.

Electrical conductivity (EC) values measured from the various dams' ranged from 36.37 to 91.78 µS/cm with a general mean of 6.02±21.23 µS/cm. EC values recorded in this study are similar to that of Kpieta and Laari (2014) who studied small-scale dams water quality andthe possible health risk to users of the water in the upper west region of Ghana. EC is considered to be a rapid and good measure of dissolved solids. The higher the value of dissolved solids, the greater the amount of ions in water (Bhatt et al., 1999). The EC had a strong positive correlation with total alkalinity, sulphates, calcium and total hardness at 1% significant level and magnesium and potassium at 5% significant level implying they have same source of contamination or interact effectively in the dam water.

Nitrates values recorded from the samples ranged from 10 to 410 µg/l with a general mean value of 6,490±0.15 µg/l. The nitrate values recorded from all the three dams were within the WHO (2008) and GSB stipulated limit of 10,000 µg/l. Similar nitrates levels were reported by Kpieta and Laari (2014) who studied small-scale dams water quality andthe possible health risk to users of the water in the upper west region of Ghana. High nitrate levels in drinking water will render them hazardous to infants as they induce methaemoglobinaemia ("blue baby" syndrome) (WHO, 2008). The nitrate itself is not a direct toxicant but is a health hazard because of its conversion to nitrite, which reacts with blood haemoglobin to cause methaemoglobinaemia (WHO, 2008). However, the low nitrate levels can cause long-term exposure as low levels between 2,000 to 4,000 µg/l in community water supplies has been linked to bladder and ovarian cancer (Weyer et al., 2001). Hence, indigenes continue consumption of the dam water might not be free from disease burden.

Fluoride content is an important factor for the development of normal bones and teeth. The required level is 1,000 to 1,500 µg/l for drinking purpose (Preeti et al., 2009). The present study recorded fluoride levels that ranged from 10 to 150 µg/l with a general mean value of 100±60 µg/l that were below the WHO (2008) and GSB stipulated limit of 1500 µg/l for drinking water. Fluoride shows strong negative correlation with turbidity at 5% significant level implying that their different source of contamination and non-interacting in the dam water.

High concentration of chloride is considered to be the indicator of pollution due to organic wastes of animal origin, regarded harmful to aquatic life and troublesome in irrigation water (Rajkumar et al., 2004). Chloride concentrations recorded ranged from 3,000 µg/l to 19,000 µg/l with a general mean of 7,410±4,970 µg/l (Table 1) that were below WHO (2008) and GSB stipulated limit of 250,000 µg/l for drinking water. There is a strong positive correlation between chloride concentration and temperature at 5% significance level implying they have common source of contaminant or interact effectively in the dam water.

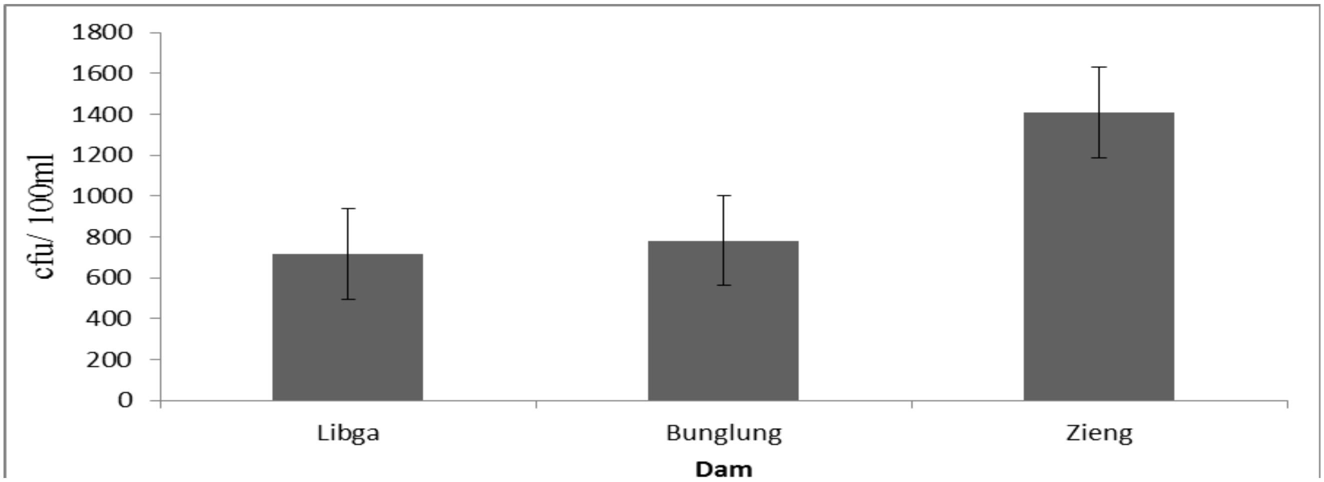

Figure 2: Mean total coliform count from the dams

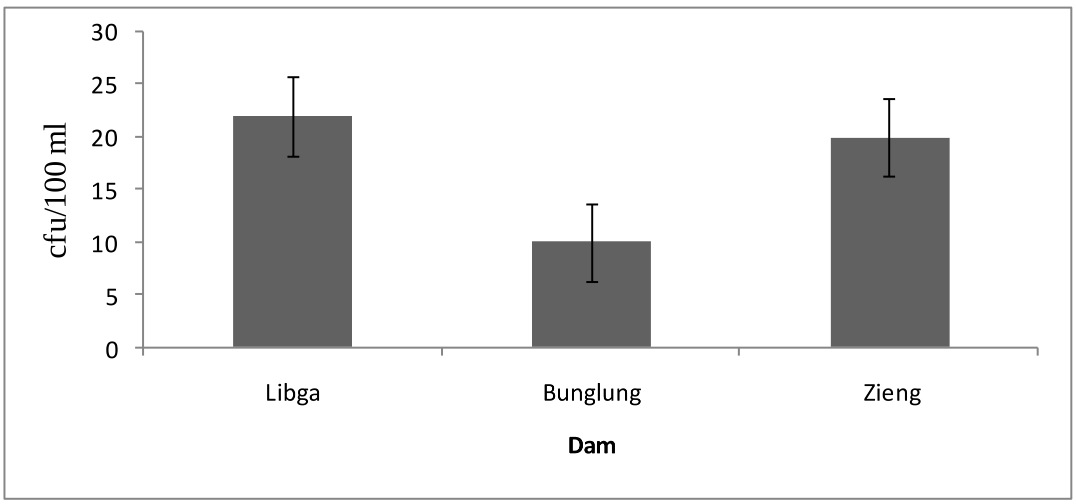

Figure 3: Mean faecal coliform count from the dams

Total hardness is a parameter of water quality used to describe the effect of dissolved mineral (Ca^{2+} and Mg^{2+}), determining solubility of water for domestic, industrial and drinking purpose attributed to presence of bicarbonates, sulphate, chloride and nitrates of calcium and magnesium (Arya and Gupter, 2013). There is evidence that hard water plays a role in heart diseases. Higher concentration of Mg makes the water unpalatable and act as laxative to human beings (Preeti et al., 2009). The water containing excess hardness is not desirable for potable water as it forms scales on water heater and utensils when used for cooking and consume more soap during washing of clothes (Gupta et al., 2009).

The total hardness concentration in this current study ranged from 8,000 to 50,000 µg/l with a general mean value of 22,900±12,530 µg/l. Calcium levels recorded ranged from 1,600 to 12,800 µg/l with a general mean of 5,100±3,490 µg/l whilst magnesium concentrations ranged from 1,000 to 4,360 µg/l with a general mean of 250,000±1,010 µg/l. Total hardness, calcium and magnesium concentrations were below the WHO (2008) and GSB stipulated limit for drinking purpose. The total hardness shows strong positive correlation with total dissolved solids, electrical conductivity, calcium, magnesium and potassium at 1% significance level and 5% significance level with total alkalinity and sulphates. These imply that each pair have common source of pollution or interact effectively in the dam water.

Total coliform, faecal coliform and *Escherichia coli* are all indicators of drinking water quality. Total coliform refer to the large collection of different bacteria whilst faecal coliforms are types of total coliform, mostly used as faecal indicators (WHO, 2006). The present study recorded total and faecal coliform count in the dam water samples that exceeded WHO (2008) and GSB stipulated limits for drinking water (Figure 2 and 3). This could be attributed to the open defecation and livestock faecal waste which are common practice in the study area. This study recorded total and faecal coliform count, higher than that of Kpieta and Laari (2014) who studied small-scale dams water quality andthe possible health risk to users of the water in the upper west region of Ghana. The presence of coliform bacteria is an indication of microbial contamination that can lead to water-borne disease burden in the communities. This renders the dam water unwholesome for drinking purpose and other household chores without some form of treatment. These pose serious challenges to both consumers and resources managers in the study areas in their quest to meet millennium development goal 7. The direct public health impact, and possible socio-economic effects that may result from ingesting coliform-infested water, may be far more disastrous on an already vulnerable and predominantly poor population (Cobbina et al., 2009).

CONCLUSION

The physico-chemical characteristics of the dam water samples were within WHO and GSB stipulated limits for drinking water except turbidity. Coliform count of the dam water was high compared to the permissible WHO and GSB standards for drinking water. The presence of coliform bacteria indicates presence of pathogens that can cause water-borne diseases hence there is need for concern. It is recommended that dam water should be treated against the coliform bacteria before used for drinking and other domestic chores.

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Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

REFERENCES

American Public Health Association (1998). Standard methods for the examination of water and waste water, 20th Ed. Washington.

Arya S, Gupta R (2013). Water quality evaluation of Ganga River from up to downstream area at Kanpur City, J. Chem. and Cheml. Sci., 3(2): 54- 63.

Bacho ZLF (2011). 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.

Bhatt LR, Lacoul P, Lekhak HD, Jha PK (1999).Physicochemical characteristics and phytoplankton of Taudha Lake Kathmandu, Poll. Res., 18(14): 353-358.

Diersing N (2009). Water quality; frequently asked questions. PDA.NOAA. Retrieved from http://www.floridakey.noaa.gov/pdfs/wqfaq.pdf. Accessed on 25th April, 2015.

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.

Gupta P, Vishwakarma M, Rawtani PM (2009). Assessment of water quality parameters of Karwa Dam for drinking suitability. Int. J. theoretical and appl. Sci., 1(2): 53-55.

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: 219-234.

Ireland Environmental Protection Agency (2001). Parameters of water quality: interpretation and standards, environmental protection agency, Johnstown, pp. 133.

Kpieta BA, Laari BP (2014). Small-scale dams water quality and the possible health risk to users of the water in the Upper West Region of Ghana. European Sci. J., 10(14): 249-270.

MOPE (2001). Ministry of Population and Environment of Nepal, Nepal: State of Environment Report 2001. UNEP, ICIMOD, MOPE, SACEP and NORAD.

Organisation for Economic Co-operation and Development (OECD). (2007). African Economic Outlook 2007 - Ghana Country Note. Retrieved 2014-12-25, pp. 294.

Paul and Walton. (2004). Core concepts in Health, 9thed. Published byMcGraw Companies, Inc 1221 Avenue of Americas, New York, and NY100020.

Pradhan B (2000). Drinking Water Quality in Kathmandu Valley, Nepal. Health Prospect New Vision for New Century. Kathmandu.

Preeti G, Monica V, Puspa MR (2009). Assessment of water quality parameters of Kerwa dam for drinking suitability. International journal of theoretical and applied science, 1(2): 52-55.

Rajkumar S, Velmurugan P, Shanti K, Ayyasamy PM, Lakshman AP (2004).Water quality of Kodaikanal Lake, Tamilnadu in relation to physicochemical and bacteriological characteristics. Capital Publishing Company. pp. 339-246.

Schilling KE, Wolter CF (2001). Contribution of base flow to nonpoint source pollution loads in an agricultural watershed. Ground Water, 39(1): 49–58.

Tiwari P (2000). An analysis of sectoral energy intensity in India. Energy policy, 28 (11): 771-778.

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 9 JN, UK.
United Nations (2006). Water a shared responsibility. UN World Water Development Report 2. 2006. Retrieved from www.unesco.org/water/wwap. Accessed on 25th April, 2015.
Usha NM, Jayaram KC, Lakhmi-Kantha H (2007). Assessment of surface and Ground water quality of Hebbal Lake, Banglore Case study. Proceedings of Tall: The 12th world lake Conference, pp. 1737-1741.
Weyer PJ, Cerhan JR, Kross BC, Hallberg GR, Kantamneni J, Breuer G, Jones MP, Zheng W, Lynch CF (2001). Municipal drinking water nitrate level and cancer risk in older women: The Iowa women's health study. Epidemiology, 11: 327–338.
World Health Organisation (2008). Guidelines for drinking-water quality, 3rd Edition, World Health Organisation, Geneva.
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.