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ACCESS TO SANITATION AND SAFE WATER:
GLOBAL PARTNERSHIPS AND LOCAL ACTIONS

Groundwater quality, sanitation & vulnerable groups: Case study of Bawku East District

B. M. Tiimub, A. M. Forson & K. Obiri-Danso, Ghana

The effect of human hygienic behaviour on the quality of groundwater was investigated using standard methods for trace elements and bacteria pollution indicators in Bawku East District of Ghana in 2006. No iron was detected in water; manganese levels were higher in wells than boreholes and fluoride levels exceeded the WHO standard (1.5mg/l) by 0.5-1.0mg/l in one well and a borehole at Bawku. Typical bacteria numbers deviated from normal trends (i.e.10^{14}, 10^{11}, 10^{8}, and 10^{4} for total coliforms, faecal coliforms, E. coli and enterococci in the well water compared to 10^{6}, 10^{5}, 10^{3} and 10^{2} in the boreholes respectively). The six UNICEF boreholes were within the WHO guideline of zero helminthes (100-1 ml) but the wells were not. Hence, quality of the boreholes was higher than the wells for drinking purposes.

Introduction of research background and purpose of the paper

The increasing popularity and use of groundwater as the main source of potable water supply world wide is probably due to - its ready availability, cool temperatures, ability to under go natural purification, etc. which make it attractive (USGS, 1999; Asbolt *et al*.,1994). In Ghana, 62-71% of rural and periurban communities rely on groundwater (WRRI 1994). Following recommendations of the Water Resources Sub-sector of Government of Ghana, 1969-70 - communities below 500 inhabitants were supposed to benefit from hand dug wells; between 500 to 2000 - hand dug wells and hand pump boreholes and 2000 to 5000 - pipe borne system based on both surface and groundwater sources (Gyau-Boakye *et al*., 1999). This paper summarizes findings on the dangers of poor human hygienic behaviors on drinking water contamination in Bawku East District (BED) and suggests recommendations for partnership actions and development policy making.

Challenges of water development in Upper East Region and the Bawku East District of Ghana

Iron, fluoride and arsenic levels in boreholes, reported to be high, sometimes above the WHO limits (Pelig-Ba et al., 1991). And population growth, unhygienic practices such as opens defecation, burial of corpses closer to wells and boreholes etc, make water quality questionable (BMA 2006).

The main objective was to understand the effect of human hygiene behavior on the quality of groundwater. The specific objectives were to assess: borehole and well water quality by measuring levels of total coliforms, faecal coliforms, entertococci, E. coli and helminthes; fluoride (F), iron (Fe), and manganese (Mn).

Methods of sampling and data analyses

Personal observations were made on the hygienic habits of inhabitants vis-à-vis the use of water and sanitation facilities. Groundwater samples (360) were analyzed monthly from February to July, 2006 in six communities of the Bawku East District (Figure 1). F, Mn and Fe were analyzed using the Atomic Absorption Spectrophotometry (AAS) method with AAS machine. Total coliform, faecal coliform, *E. coli* were analyzed using the three Most Probable Number (MPN) methods (Collins *et al*., 1989). Pour plate technique was used in enumerating enterococci. Using the same serial dilutions prepared for thermotolerant coliform enumeration, 1 ml aliquots of each of the dilutions were placed on already set Petri dishescontaining Slanetz and Bartley agar. The Petri-dishes were allowed to dry. It was incubated for 4 hours at 37°C and then transferred to 44°C for 44-48 hours. Petri-dishes showing red, maroon or pink colonies were counted using a colony counter. The bacterial count of the original sample was then determined by multiplying the number of colonies that developed by the degree of dilution (dilution factor) and expressed as colony forming units (cfu) **$100ml^{-1}$**.Quantification and identification of helminthes eggs was done by centrifuging based on (Schwartzbrod *et al.*, 1998 Modified Environmental Protection Agency (EPA France, 1993) Method and World Health Organization (WHO, 1997 Protocols).

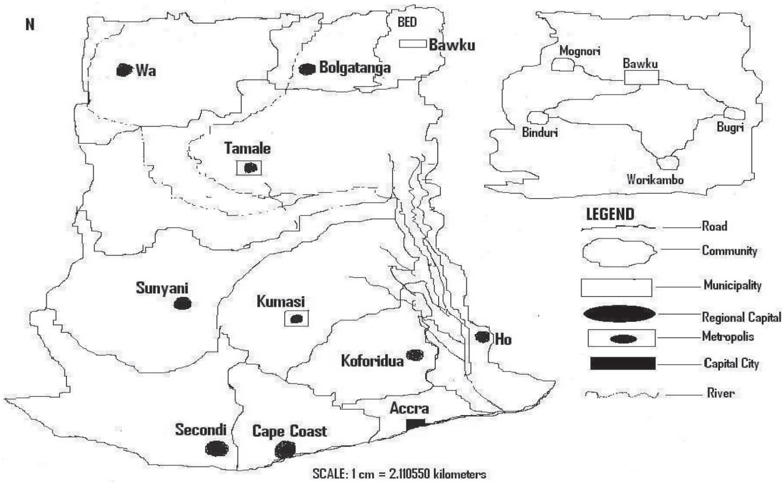


Figure 1. Map of Ghana and the Bawku East District showing the communities from where the water samples were collected

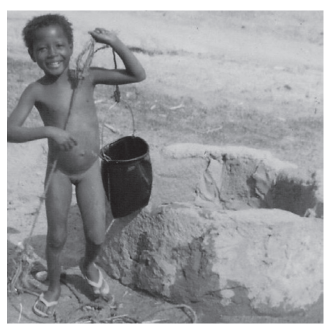
Source: KNUST/UNICEF-Field Survey, 2006

Results and discussion

The sanitation of wells, boreholes and toilet facilities were observed to be poor. Most wells were sited very close to gutters often choked with piles of garbage and liquid wastes in Bawku (Photograph 1). Most water carrying receptacles were old rusty iron buckets and local containers ("gogga") constructed with vehicle inner tyre tubes and tied to nylon or jute ropes, often left in the muddy surroundings of the well or coiled into containers when unused. It sometimes became playing tools for children (Photograph 2). High rate (41.7%) of open space defecation in the district coupled with location of some wells closer (<500m) to major drainage systems could contaminate groundwater with faecal coliforms.

Photograph 1. A well sited close to drainage system at Bawku

Source: KNUST/UNICEF-Field Survey, 2006



Photograph 2. Young girl drawing water with "gogga" at Azanga well in Bawku

Source: KNUST/UNICEF-Field Survey, 2006

Trace elements in well and borehole waters

No *Fe* was detected in all the water samples analyzed. The mean *F* levels in wells ranged between 0.03mg/l and 1.8mg/l. Low (0.03mg/l) concentration was recorded in the Azanga well but it was high (1.8mg/l) in the Mognori well. And there were significant ($p<0.001$) differences between the wells for *F*.

Mean *F* levels in the boreholes were higher compared to the wells, ranging between 0.25mg/l and 2.22mg/l. The *F* levels of (1.65, 1.70 and 2.22)mg/l in Binduri Clinic, Bawku New Transport Yard and Police Station wells, respectively exceeded the WHO limit of 1.5mg/l. There were significant ($p<0.01$) difference between the boreholes and wells for *F*. High patronage of these wells by residents and the traveling public may be a source of worry to health personnel. High levels of *F* in drinking water have been shown to contribute to florosis incidents in the tooth of consumers (Samuel *et al*., 1981). Pelig-Ba *et al*., (1991) however, reported that exceeding the WHO limit for *F* by 0.50 mg/l was low and could be tolerated.

Mn levels ranged from 0.001mg/l - 0.012mg/l with no defined pattern or significant ($p<0.05$) differences between the wells and boreholes from any of the sites or date of sampling. Generally, *Fe* and *Mn* concentrations in H_2O were within the WHO Guidelines of ≤ 0.5 mg/l and ≤ 2mg/l, respectively.

Bacteria contamination levels of water

Drinking water is adequate safe without coliforms (WHO 1997). However, this study recorded higher bacterial numbers; 10^{14}, 10^{11}, 10^{8}, and 10^{4} for total coliforms, faecal coliforms, E. coli and enterococci in the well water compared to 10^{6}, 10^{5}, 10^{3} and 10^{2} respectively in the boreholes. Total coliform numbers (100-1ml) in all the six wells ranged between 5.79×10^{12} and 1.29×10^{14} with no significant ($p<0.93$) differences between them. However, faecal coliforms numbers were lower, ranging between 4.90×10^{9} and 2.04×10^{11} with no significant ($p<0.85$) differences between them. Escherichia coli numbers were much lower varying between 1.37×10^{7} and 2.15×10^{8} with no significant ($p<0.73$) differences between them. Enterococci numbers were very low ranging between 6.49×102 and 3.95×104 with significant ($p< 0.02$) differences between them.

Similarly, bacterial numbers (100-1 ml) in the six boreholes were generally lower compared to that in the wells. It ranged between 3.24×10^{5} and 2.25×10^{6} for total coliforms, 1.23×10^{4} and 1.01×10^{5} for faecal coliforms, 6.63×10^{2} and 3.59×10^{3} for Escherichia coli and 0.01 and 8.50×10^{2} for enterococci. There were no significant differences in the numbers of total coliform ($p<0.84$), faecal coliforms ($p<0.52$) and Escherichia coli ($p<0.98$). However, there were significant ($p<0.001$) differences in enterococci numbers.

Strongyloides stercoralis (in range of 1-3 per litre) was the main helminthes eggs found in all water wells. No eggs were detected from all the six boreholes. These boreholes were fitted with hand pumps to prevent direct water contact by animals or humans – but two of it developed serious cracks for poor maintenance reasons, probably leading to a higher rate of bacteria infiltration to groundwater sources often aided by rains in the wet season (Morgan, 1990). Surprisingly, all the six wells lacked cover slabs.

Generally, the use of rusted and unhygienic receptacles to draw water due to lack of windlass on the wells, development of fissures etc., sitting of pit latrines and drainage systems closer to wells, constitute points of direct microbial contamination of groundwater under heavy rainfall which had been observed in France and Uganda (Barrett and Howard, 2002). A vertical safety distance between wells, latrines or drainage systems depends on the prevailing soil permeability as well as the water table (ARGROSS, 2001). This highlights the necessity of formulating alternative measures to check faecal coliform pollution.

Conclusion and recommendations

The efforts to improve global water and sanitation supplies under the Millennium Development Goals MDGs) to prevent water related diseases, heralded by UNICEF in Ghana, has lead to provision of water and Sanitation facilities. However, poor sitting of some of the facilities vis-à-vis unsightly open defecation was observed in the BED despite the fact that the borehole water quality was higher than wells for drinking.

Households to therefore, include toilet facilities in their building plans to reduce open space defecation. Stake holders should aim at mechanizing the high yielding boreholes and provide all open wells with aprons and sanitary covers to facilitate a balanced distribution of potable water and avoid pollution. Stakeholders should integrate Participatory Hygiene and Sanitation Transformation (PHAST) in water quality monitoring to enhance community involvement in identifying their own beliefs and practices in order to decide on what needs to be changed through effective information sharing processes to improve upon sanitation habits. More funds should be allocated to provide adequate water and sanitation facilities in sustaining humanity in areas of Bawku East District where there is also land limitation, and flood disasters.

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Note/s

Enterococci - facultative anaerobic organisms, ie they prefer the use of oxygen and some are intrinsically resistant to antibiotics such as β-lactam.

*Escherichia coli***-** bacteria species that, its detection and identification as faecal organisms (or presumptive *E. coli)* is considered to provide sufficient information to assess the faecal nature of water pollution.

Faecal coliforms - bacteria from faecal matter which ferment lactose at a temperature of 44 ^{o}C in 24 hours.

Helminths- parasitic worms normally found in the intestinal tracts of warm blooded animals.

KNUST-Kwame Nkrumah University of Science and Technology

WEDC- Water, Engineering and Development Centre

Total coliforms- lactose fermenting bacteria at a temperature of 37 ^{o}C within 24 hours.

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Contact details

Tiimub Benjamin Makimilua
C/o Melcom Ltd Box 5019, Kumasi - Ghana
Tel: + 233- 0244 501055
Email: benmakimit@yahoo.com

Michael A. Forson
UNICEF, 4-8th Rangoon Close Box 5051,
Accra-North -Ghana
Tel: +233-21-772524/777972/773583-4
Fax:+233-21-773147
Email: mforson@unicef.org