27th WEDC Conference Lusaka, Zambia, 2001

PEOPLE AND SYSTEMS FOR WATER, SANITATION AND HEALTH

Borehole water quality in Volta Region of Ghana

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THE DANISH INTERNATIONAL Development Agency (DANIDA) in 1991 began to assist the Ghana Water Company Limited (GWCL) to implement a rural water supply and sanitation project to improve health and the standard of living of the people in the Volta Region of Ghana. The Water Research Institute (WRI) has since the formulation of the Volta Rural Water Supply and Sanitation Project (VRWSSP) carried out data collection and monitoring assignments covering water resources in the Volta Region. In addition to the initial data collection, WRI was also contracted to initiate a research project to increase the understanding of the effects of land use changes on surface water resources. This very issue is important for the long-term use of small streams and springs for piped water systems and to develop appropriate methods for protection of their catchment areas.

Essence of study

The data collection was necessary to establish the background for feasibility study and design of water supply systems in individual communities. The data will also serve as a starting point for the establishment of the water resource database. This study will therefore not only be of benefit to the Volta Region, but will also contribute to a better understanding of environmental changes and impacts on water resources in Ghana. The socio-economic implications of the study identified from Volta Region can be extended to other parts of the country.

Hand dug wells

It was projected in 1991 that, a rural population of 970,000 people lived in the 12 districts constituting the study area. A target rural population of 735,000 people who are without a safe and adequate water supply was identified in the region by DANIDA. The survey showed that there were hand dug wells in 60 towns with population more than 4,000 people and 280 villages with population less than or equal to 4,000 people. Considering that there were 6,300 villages with population less than or equal to 4,000, the number of villages with wells was quite minimal.

Field data in the form of measurements in wells and well use information was compiled for a total of about 1500 wells made up of 1,070 private wells and 430 community wells. The survey also showed that there are wide variations in the ratio of community to private wells from one district to another (DANIDA, 1993).

Dug well site conditions

Slightly more than 80% of the dug wells are located in low elevation areas such as valleys, flat lands and coastal plain, and the rest on top of hills or upper slope areas. A large majority of the community wells are located within 200m of the centre of the user community. In contrast, just a handful of wells are located at distances greater than 200m from the centre of the user community.

In all, about 90% of wells could be described as having a clean or fairly clean nearby surroundings. In the case of a few wells scattered over the study area, the surroundings were untidy and some of the wells were sited unacceptably close to refuse dumps, unlined private pit latrines or cemeteries.

A large proportion of the wells also had no cover whatsoever. Among those wells that had covers, wooden covers and roofing sheets constitute the commonest material for covering wells. With regards to the lining of wells, about 50% of the wells had no lining block masonry and concrete provided the commonest lining material. Lifting devices in use include rope and bucket and electric submersible pump. Many of the shallow wells got dry during the dry season and regular deepening was required during the dry season to enhance well recovery, especially when there is drought.

Although hand dug wells and boreholes are similar in the sense that the source of water is groundwater, they are characteristically different in that hand dug wells are constructed locally with hands and have bigger diameter. They are mostly shallow and mainly fetched with bucket and rope. The boreholes are constructed with a drilling rig and lined with PVC full pipes that are installed in water bearing sections of the holes. After installation, the wells are cleaned and developed using air flushing.

From the survey, the diameter of the wells ranged from about 1.0m to 3.0m. The larger diameter of the wells was mostly shallow community wells.

The range of well depths obtained for the study area was 1.0 to 30.0m, although over 60% of wells were between 1.0m and 5.0m deep and about 15% of the wells were between 15.0m and 30.0m deep. In Ghana, the deepest borehole drilled is 70m whilst the largest borehole drilled is 8 inches in diameter. On average, the diameter of the boreholes varies between 4 and 6 inches.

User community

The user population of each well was determined by counting the number of people in each household that depends on the well and adding up the number of people in all the various households that use the well. Although wells play a major role in the traditional water supply scenario, several alternative sources (e.g. rivers, streams and dams) of water could be found but may be unsafe. Currently, boreholes fitted with hand pumps are also available in several districts. However, a large majority of the rural population in the study area are yet to be provided with boreholes. In this paper, the physico-chemical and bacteriological quality as well as the socio-economic impacts are assessed for the constructed boreholes in selected communities of the study area.

Materials and methods

Field visits were made to the Volta Region of Ghana between 1999 and 2000 where water samples from newly constructed and rehabilitated boreholes in some communities were taken into 1 litre plastic bottles and sterilised glass bottles, kept in cold boxes and transported to the laboratory for the physico-chemical and bacteriological analyses. pH, turbidity and conductivity were measured on the field using a portable pH meter, a turbidimeter and a conductivity meter respectively. Nutrients were analysed using colourimetric methods (APHA, 1995), Iron was determined using a SOLAAR 969 Atomic Absorption Spectrophotometer. The Membrane Filtration (MF) method was used for the determination of the coliforms as follows:

- Total Coliform Counts - determination was in Lauryl Sulphate broth incubated at 37°C ± 0.5 for 16 hours; and
- Faecal Coliform Counts - determination was in Lauryl Sulphate broth incubated at 44°C ± 0.2 for 16 hours.

All the other parameters stated in table 1, were analysed using standardised methods (APHA, 1995).

Results and discussion

The pH values of the borehole (B/H) waters were within the World Health Organisation (WHO) guideline value of 6.5 –8.5 (WHO, 1993) except at Ave Hevi and Ahlepedo Glima where the waters were alkaline (Table 1). However, the dug well waters had a wider pH range and were slightly acidic in nature. Values ranging from 4.6 to 7.3; 4.6 to 7.9; 5.1 to 7.2; 5.8 to 8.2 and 5.3 to 6.9 were recorded at Keta, Ketu, Akatsi, Kpandu and Jasikan districts respectively. Dug wells with low pH have a potential to enhance corrosion but may not affect its use for domestic purposes. Conductivity (Cond.) measurements of the boreholes were generally high. That of the dug wells varied from one district to another. Range of measurements was 86 to 15,150uS/cm (Ketu); 200 to 2,700uS/cm (Keta); 100 to 540uS/cm (Kpandu); 120 to 1,100uS/cm (Jasikan) and 80 to 940uS/cm (Hohoe).

Except at Ahlepedo Glima, turbidity (Turb.) readings of the boreholes were very low. Chloride (Cl^{-1}) levels of the boreholes were moderate, but communities with high levels may be due to seawater intrusion, as some districts were close to the coast. The dug well waters had chloride ranges of 46 to 2,554mg/l (Akatsi); 25.3 to 4,926mg/l (Ketu); 57 to 1,239mg/l (Keta); 6 to 35.9mg/l (Ho); 30 to 2,154mg/l (Sogakope) and 85 to 313mg/l (Kpandu), mainly due to domestic activities. For the borehole waters, total hardness (T/H) and calcium (Ca) were moderate making the water soft. Nitrate ($N0_3$ –N), ammonia (NH_3 –N) and Fluoride (F^{-1}) were also, generally low and satisfactory (Table 1). Suspended solids (SS) measured were appreciably low although Ahlepedo Glima and Torve (B204/B01) recorded high SS values of 142mg/l and 338mg/l respectively.

The dug wells had a wide range of hardness varying from very soft to very hard water types. T/H measured ranged from 21.2 to 1,926mg/l (Akatsi); 34.4 to 2,040mg/l (Ketu); 40 to 663 mg/l (Keta); 40 to 1,910mg/l (Sogakope) and 99 to 428mg/l (Kpandu). The exceedingly high T/H observed for some of the dug wells meant that these well supplies might not lather easily with soap and therefore limit its use for domestic laundering.

The nitrate and ammonia concentrations of some of the dug well supplies were high, exceeding the WHO upper limit of 50 mg/l NO_3^- and 0.5mg/l respectively. Such high concentrations may reflect the unsanitary conditions prevailing at these wells, since the major source of nitrate and ammonia is likely to be human and animal wastes, resulting from runoffs. The high nitrate may reduce the potability of the dug well supplies and in some cases may cause methaemoglobinaemia in bottle-fed infants (DANIDA, 1993).

Iron levels in some boreholes and dug wells exceeded the WHO guideline value of 0.3mg/l. Although high iron concentrations may not pose any heath hazards to users, the occurrence of the yellowish-brown colouration especially, in some dug well waters resulted in the rejection of these dug wells by the communities.

Bacteriologically, only a few of the boreholes recorded zero faecal coliform (F/C) and total coliform (T/C) counts, and this suggests that the systems be properly disinfected before commissioning in order not to aggravate the coliform situation.

Comparing the results of the bacteriological analyses with the WHO Guidelines for potable water revealed that, most of the dug wells were bacteriologically unsafe for drinking. This bacteriological contamination is expected since most of the dug well heads were cracked and even some had no wellhead. Also, some of the dug wells did not have a clean environment, which meant that surface runoffs could easily infiltrate into the wells.

Conclusions and recommendations

- Generally, the physico-chemical quality of the boreholes was quite satisfactory and acceptable due to the deep nature of the aquifers;
- Bacteriologically, only a few of the boreholes recorded zero faecal coliform count and it was recommended that the system be properly disinfected before commissioning;
- The bacteriological quality of most wells was not within the acceptable standard, due to lack of well lining and inadequate protection of the wells from wastewaters as observed in the survey;
- Iron levels exceeding the WHO guideline value were recorded in some cases and iron removal system developed by Amuzu, 1987 should be incorporated prior to the commissioning of the boreholes. The high iron content was mainly due to the type of rocks found in the aquifers;
- The study revealed that due to seawater intrusion it was not prudent to site a borehole near the coast since the beneficiaries will find it difficult to drink the water and may again resort to the streams and rivers;
- District Water and Sanitation Teams (DWSTs) should be established by the District Assemblies where not in place, to oversee all water and sanitation activities within the districts and ensure the sustainability of the boreholes; and
- Water and Sanitation (WATSAN) committees (women inclusive) should be established to take responsibility of the operation and maintenance of the boreholes in communities where this was not being done. With WATSAN in place, the communities will be educated on the adverse effects of drinking unhygienic water.
- Hygiene education campaign should embrace water, sanitation and health. Causes, mode of transmission and prevention of water and sanitation related diseases should be critically addressed to enhance community ownership and management.

References

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Table 1. Results of Physico-Chemical and Bacteriological analyses of some communities in districts in the Volta region

	Community	B/H NO.	pH	Cond. uS/cm	Turb. (NTU)	Cl^- mg/lL	T/H mg/L	Ca mg/L	NO_3-N mg/L	NH_3-N mg/L	F^- mg/L	SS mg/L	Fe mg/L	T/C Counts/ 100ml	F/C Counts/ 100ml
1	Ave Hevi	B374/B03	12.3	3,940	2.7	457	580	248	20.9	<0.02	0.84	32	0.62	4	2
2	Ave Hevi	B420/B02	12.4	3,540	6.8	215	1,016	404	0.18	<0.02	0.36	31	0.24	0	0
3	Dodi Pepesu	KA/KOI/B02	6.5	399	4.3	5	168	53	0.23	0.24	0.18	4	0.96	2	0
4	Ampeyo	KA/FOI/B02	7.5	486	3.6	44	164	53	0.47	0.06	0.28	8	0.21	3	1
5	Agormor-wenu	A140/B04	6.6	993	<0.1	55	290	64	0.6	0.02	0.54	5	0.03	2	1
6	Gadzekpo Avokope	C250/B04	6.7	1,838	0.2	170	520	24	0.33	0.02	0.49	11	0.06	3	1
7	Dapaah Junction	KA/G02/BO1	6.8	285	0.1	14	120	31	0.43	0.08	0.36	3	0.1	3	2
8	Ave Hevi	D336/B04	6.4	2,160	5	504	460	102	0.7	<0.02	0.66	8	0.85	4	2
9	Ahlepedo Dramawu	A110/B03	7	571	0.9	34	194	35	0.52	0.14	0.48	6	0.23	3	1
10	Torve	C340/B03	7.2	5,190	4.5	630	1,510	312	0.18	0.09	0.81	12	3.52	2	1
11	Agbadzivorkope	E190/B02	6.8	619	0.2	62	194	39	0.39	0.13	1.09	3	<0.03	2	0
12	Ahlepedo Glima	B40/B02	11.3	2,990	29	57	870	232	18.9	<0.02	1.78	142	0.11	3	1
13	Atta Kofi	KA/003/B04	7.1	469	1.4	2	224	29	0.2	<0.02	0.3	2	0.39	3	2
14	Torve	B204/B01	7.1	6,280	5.2	909	1,410	281	1.68	<0.02	2.27	338	<0.03	3	1
15	Gadzekpo Ahovikope	B24/B03	7.1	1,687	8.1	249	660	112	0.94	<0.02	1.96	52	<0.03	2	1
16	Dodi Pepesu	KA/KOI/B03	6.3	232	9.3	6	100	16	0.1	0.33	0.36	3	0.49	3	1
17	Agormor Dodzikope	A120/B03	7.3	1,076	1.6	50	380	92	0.22	<0.02	0.38	6	0.06	3	2
18	Agormor Kpekume	A188/B05	6.5	3,260	0.2	315	1,080	140	1.82	0.04	0.41	10	0.08	5	2
19	Atta Kofi	KA/D03/B03	7.1	537	2.5	14	208	23	0.19	<0.02	0.46	3	0.71	3	1
20	Korve	A262/BO1	6.3	2,350	3.5	240	800	164	0.68	0.01	0.52	4	0.05	4	1
21	Agormor Katamamanikope	C65/BO1	6.3	1,810	0.6	180	690	124	0.41	<0.02	0.36	2	0.06	3	1