Coliform status of water bodies from two districts in Ghana, west Africa: implications for rural water resources management

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Abstract

Investigations were conducted on the total and faecal coliform status of streams, hand-dug wells and boreholes highly patronised by communities in the West Akim and Kwaebibirem Districts, Eastern Ghana. Total coliform values obtained range from 60–2,672 cfu, 0–680 cfu and 0–128 cfu for streams, hand-dug wells and boreholes, respectively. Faecal coliform values similarly range from 31–1,988 cfu, 0–136 cfu and 0–36 cfu for streams, hand-dugs and boreholes, respectively. The data indicates that samples from streams and hand-dug wells returned high coliform counts beyond the Maximum Permissible Levels (MPL) recommended by the World Health Organization (WHO). Some borehole water contained coliform counts above MPL. Because many rural people in the areas studied, and indeed in most areas in Ghana, depend heavily on these principal sources of water for drinking and other domestic purposes, a policy response that incorporates periodic assessment of water quality in rural communities may be appropriate. In addition, it would seem that current government and development partner programmes in the water resources sector that emphasise provision of borehole water must be integrated with land use considerations, water quality monitoring and education on environmental awareness in local communities.

Keywords: Coliform; Ghana; Kwaebibirem; Water resources; West Akim

Introduction

Rivers, streams and shallow hand-dug wells are traditionally the main sources of water available for use in many rural communities in Ghana. In areas where water from these sources is unreliable, especially during the seasonally dry weather conditions, access to vital water for drinking and other domestic purposes becomes critical. In recent years, the government of Ghana, in collaboration with development partners and Non Governmental Organisations (NGOs), have provided boreholes to augment and improve the quality of water for some rural people (Gyau-Boakye \& Dapaa-Siakwan, 1999). The reason for the provision of boreholes as an alternative to existing sources of water for rural communities lies in the fact


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that borehole water is presumed to be pathogenically safe, suggesting a zero coliform count per 100 ml of water (Hodges, 1973; Cruickshank et al., 1975; Cheesbrough, 1994; Price, 1996; Bartram & Balance, 2001; WHO, 2004). In spite of government’s continuing efforts, factors such as increasing costs for borehole development, increasing population growth, the sparse nature of rural settlements, and the competing demands for scarce national resources have hindered efforts to effectively provide safe water to many people in rural areas. For example, even though investigations conducted on some isolated boreholes in Ghana suggested some levels of bacteriological pollution (Centre for Scientific & Industrial Research, 1983; Kortatsi, 1994), rural people still continue to use water from rivers, wells and some boreholes which might not be wholesome. This situation has often led to serious but otherwise preventable waterborne diseases, especially predominant during annual dry periods when access to water becomes very scarce for many rural communities. This study was therefore undertaken to investigate the coliform status in water available to typical rural communities in Ghana, with a view to providing useful information that could help inform policy towards effective management of rural water resources.

**Study area**

The West Akim and Kwaebibirem Districts have a total surface area of about 2,248 km² and are located in eastern Ghana (Figure 1). The two districts lie approximately between longitudes 0°25' and 1°00', and latitudes 5°40' and 6°75'. The land is generally undulating with topographic elevations ranging between 60 and 460 m above mean sea level (Dickson & Benneh, 1990). The Atiwa Range forms the major topographic feature in the area but, apart from this, the land is generally low-lying with extensive marshlands. Prominent streams that drain the area include the Ayensu, Abukyen, Birim and their tributaries: the Kadepon, Piram, Subinsa and Apaem.

According to the Ghana Statistical Service (2000), the population of the two districts is around 324,140 out of which about 66% are located in the rural areas. The District is heterogeneous in terms of ethnicity with broad cultural diversity. The majority of the people are, however, Akans with other settlers like Nigos, Krobos, Ga-Adangbes, Ewes and people who originate from Northern Ghana either as farmers or miners (Kesse-Tagoe & Associates, 2000). The major occupation of the inhabitants is subsistence agriculture of food and cash crops. Some people engage in artisanal and small-scale mining (gold and diamonds) as well as petty trading, livestock and hunting. The population density is approximately 128 persons per km² as against an average of about 109 persons per km² for the eastern region. The fairly high population density, the subsistence (mainly slash and burn) farming techniques and, for several decades, increased illegal mining activities in the two districts have tended to exert enormous pressure on the natural environment, especially on water resources. People in the area largely depend for their domestic water supply on rivers and streams, hand-dug wells and boreholes. There have been reports of pollution and drying of some water bodies during part of the year (Kesse-Tagoe & Associates, 2000).

**Methodology**

After a preliminary visit to various communities in the two districts, 18 sampling sites comprising 8 boreholes, 7 stream sources and 3 hand-dug wells in 6 communities were selected (see Figure 1), based primarily on factors such as population and extent of usage or level of patronage of water from these...
sources. Most of the communities, dominated by farmers and artisanal miners, had populations below 5,000. Each community selected had at least a borehole and a stream as the principal sources of water for the inhabitants.

Prior to water sampling, important observations were made of sanitary conditions and possible sources of contamination, both anthropogenic and natural, that occur in the proximity of water bodies and/or are likely to influence water quality from all the sources sampled. For example, it was observed that in some places, refuse dumps and places of convenience (toilets) were sited close to water bodies. In other cases, organic and inorganic waste as well as waste water from various human activities had been disposed of near or into water bodies which also served as sources of water for some communities.

Water samples were taken from boreholes fitted with hand pumps. Before samples were taken, the pumps were continuously operated for about 5 minutes, after which the mouth of the borehole was cleaned with cotton wool soaked in 70% concentrated alcohol and then flamed for about 5 minutes. Water was again pumped out for a further 3 minutes to allow the metal to cool. Water samples were then collected by direct flow into sterilised bottles and carefully sealed. For hand-dug wells, sterilised bottle was tied to a rope using a 0.500 g stone as the weight. To reduce contamination, the stone was cleaned with 70% concentrated alcohol. The lid was removed and the bottle lowered into the well to a depth of about 1 m below the water surface. The bottle was removed and quickly covered. Immediately after
collection, samples were placed in an insulated box (an ice chest) filled with ice cubes to keep the temperature below 4°C. Water samples from streams were also collected from depths of about 1 m from the active part of the river where people normally collected water for domestic purposes. Steps were taken at all times to avoid contamination using standard procedures. The membrane filter technique (MFT) was used. All other equipment used for the exercise were sterilised by autoclaving on the eve of each sampling day.

In order to culture bacteria that may have been present in the water samples, 2.5 ml-lauryl sulphate broth was poured onto an absorptive pad placed in a small petri dish. To prevent individual colonies from clustering, 50 ml of water samples taken from boreholes and 10 ml from hand-dug wells and streams were each diluted to 100 ml and filtered through a membrane filter system. The filter paper was removed with sterilised forceps and carefully placed on the soaked pad. Two membrane preparations were made for each water sample and incubated for a period of 18 hours at 37°C and 44°C for total and faecal coliforms, respectively. After the incubation period, yellow lactose fermenting colonies were identified, counted, and results expressed in colony forming units (CFU/100 ml) (Cruickshank et al., 1975; Cheesbrough, 1994; American Public Health Association, 1995; Price, 1996; Bartram & Balance, 2001). Coliform count analyses were carried out at the Bacteriological laboratory at the Noguchi Memorial Institute for Medical Research (NMIMR) at the University of Ghana, Legon.

Results

Total and faecal coliform data from the three main sources of water available to the respective communities in 2006, in January, February, March (corresponding to the dry season) and in June (rainy season) are presented in Table 1. Because there was no hand-dug well in some of the communities (i.e. in Asuokaw, Abodom and Adankrono), water samples from two different sites along the stream were collected at Asuokaw, whilst water from two different boreholes were also sampled at Abodom and Adankrono. It is seen that, in general, both total and faecal coliform counts in water sampled exhibit variability in terms of location (community), water source (borehole, hand-dug well and stream) and period of sampling (see Table 1, and also Figures 2–5). Borehole water at Asuokaw (ASW), Asamankese (ASK), Nyanoa (NYN) as well as one at Abodom (ABD) had detectable (up to 6 cfu/100 ml) to no coliform bacteria present (Figure 3). However, water from the borehole at Abaam (2–128 cfu/100 ml), one of the boreholes (BHE2) at Abodom (0–56 cfu/100 ml) and two at Adankrono (0–16 cfu/100 ml and 0–15 cfu/100 ml) registered quite significant coliforms throughout the sampling period.

Water samples collected from the two streams at Asuokaw (ASW1 and ASW2, Figure 4) had total and faecal coliform values that range from 300–2,672 cfu/100 ml and 54–1,988 cfu/100 ml, respectively. Total coliforms in one stream (i.e. AWS1) increased from 1,500 cfu/100 ml in January to 1,600 cfu/100 ml in February but thereafter consistently decreased in March and June (560 cfu/100 ml and 300 cfu/100 ml, respectively) (Figure 4). Faecal coliform counts, however, decreased consistently from January through February and March to June (1,350 cfu/100 ml, 1,200 cfu/100 ml, 160 cfu/100 ml and 54 cfu/100 ml, respectively). Water from the other stream (i.e. AWS2) recorded the same total coliform counts in January and February (1,800 cfu/100 ml) but this decreased to 1,000 cfu/100 ml in March only to show an appreciable spike in June (2,672 cfu/100 ml). Faecal coliforms consistently decreased from January to March (1,800, 1,600 cfu/100 ml and 760 cfu/100 ml) but again increased to 1,988 cfu/100 ml in June (Table 1). Both total and faecal coliform counts in stream water at Asamankese (ASK, Figure 4)
Table 1. Sample site description and coliform counts (cfu) obtained from water at various sampling sites in eastern Ghana. (“Total” and “Faecal” = Total and Faecal coliforms, respectively; January, February and March = dry season; June = rainy season).

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<tr>
<td>Asuokaw (ASW)</td>
<td>Borehole</td>
<td>BHA1</td>
<td>About 70 m from a toilet facility (an improved pit latrine—KVIP)</td>
<td>0.00 0.00 0.00 0.00</td>
<td>0.00 0.00 0.00 0.00</td>
<td>1500.00 1350.00 1600.00 1200.00</td>
<td>560.00 160.00 760.00 760.00</td>
<td>2672.00 1988.00</td>
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<tr>
<td>Stream</td>
<td>RVA2</td>
<td>Refuse dump located upstream of sampling point</td>
<td>1800.00 1800.00 1800.00 1800.00</td>
<td>300.00 300.00 300.00 300.00</td>
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<tr>
<td>Stream</td>
<td>RVA3</td>
<td>Refuse dump downstream of sampling point</td>
<td>1800.00 1800.00 1800.00 1800.00</td>
<td>560.00 160.00 760.00 760.00</td>
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<td>Asamankese (ASK)</td>
<td>Borehole</td>
<td>BHB1</td>
<td>Close to local market, fuel station and lorry park</td>
<td>0.00 0.00 0.00 0.00</td>
<td>0.00 0.00 0.00 0.00</td>
<td>1500.00 1350.00 1600.00 1200.00</td>
<td>560.00 160.00 760.00 760.00</td>
<td>2672.00 1988.00</td>
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<td>Hand-dug well</td>
<td>HDB2</td>
<td>Surrounded by a lot of houses</td>
<td>1952.00 1800.00 1760.00 1600.00</td>
<td>420.00 300.00 680.00 680.00</td>
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<tr>
<td>Stream</td>
<td>RVA3</td>
<td>Recipient of hospital effluent</td>
<td>321.00 25.00 310.00 20.00</td>
<td>250.00 20.00 250.00 20.00</td>
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<td>Nyan (NYN)</td>
<td>Borehole</td>
<td>BHC1</td>
<td>Close to a huge refuse dump</td>
<td>6.00 0.00 5.00 0.00</td>
<td>0.00 0.00 0.00 0.00</td>
<td>1800.00 1602.00 1800.00 1800.00</td>
<td>424.00 712.00 200.00 200.00</td>
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<td>Hand-dug well</td>
<td>HDC2</td>
<td>Close to a huge refuse dump</td>
<td>1800.00 1602.00 1800.00 1800.00</td>
<td>568.00 200.00 200.00 200.00</td>
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<tr>
<td>Stream</td>
<td>RVB3</td>
<td>Recipient of human excreta</td>
<td>1800.00 1602.00 1800.00 1800.00</td>
<td>568.00 200.00 200.00 200.00</td>
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<td>Abaam (ABM)</td>
<td>Borehole</td>
<td>BHD1</td>
<td>Close to a (polluted) stream and refuse dump</td>
<td>8.00 2.00 10.00 4.00</td>
<td>56.00 4.00 56.00 4.00</td>
<td>1800.00 1600.00 1800.00 1800.00</td>
<td>106.00 36.00 106.00 36.00</td>
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<td>Hand-dug well</td>
<td>HDD2</td>
<td>Located within a house</td>
<td>140.00 25.00 680.00 136.00</td>
<td>130.00 10.00 130.00 10.00</td>
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<tr>
<td>Stream</td>
<td>RVD3</td>
<td>Immediately outskirts of town</td>
<td>1800.00 1600.00 1800.00 1800.00</td>
<td>568.00 200.00 568.00 200.00</td>
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<td>Abodom (ABD)</td>
<td>Borehole</td>
<td>BHE1</td>
<td>Located at the outskirts of town</td>
<td>2.00 0.00 0.00 0.00</td>
<td>6.00 0.00 6.00 0.00</td>
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<tr>
<td>Borehole</td>
<td>BHE2</td>
<td>Close to cattle pen and refuse dump</td>
<td>2.00 0.00 15.00 9.00</td>
<td>30.00 5.00 30.00 5.00</td>
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<tr>
<td>Stream</td>
<td>RVE3</td>
<td>Stream receives household waste</td>
<td>1800.00 1700.00 2000.00 1860.00</td>
<td>800.00 306.00 800.00 256.00</td>
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<td>Adankrono (ADK)</td>
<td>Borehole</td>
<td>BHF1</td>
<td>Located close to a school</td>
<td>4.00 0.00 2.00 1.00</td>
<td>16.00 0.00 16.00 0.00</td>
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<tr>
<td>Borehole</td>
<td>BHF2</td>
<td>Close to cattle pen and refuse dump</td>
<td>4.00 2.00 0.00 0.00</td>
<td>15.00 0.00 15.00 0.00</td>
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<tr>
<td>Stream</td>
<td>RVF3</td>
<td>Close to palm oil extraction site and illegal mining (galamsey) operations</td>
<td>1800.00 550.00 150.00 120.00</td>
<td>60.00 31.00 60.00 31.00</td>
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decreased from January to June (total coliforms from 1952 to 368 cfu/100 ml and faecal from 1,800 to 168 cfu/100 ml).

Water sampled from hand-dug wells at Asamankese, Nyanoa and Abaam also showed distinct differences in total and faecal coliform contents (Figure 5). Total coliforms in water from Asamankese and Nyanoa showed a general decrease from January to June. Water from Abaam, however, recorded an unusual increase in coliform contents in February. During sampling, desilting of the well was being done, suggesting that the high coliforms registered could have resulted from contamination from human activity.

A few general trends could be observed in the data obtained. For example, samples collected from boreholes in the wet season had comparatively more coliforms than similar water samples from the same boreholes in the dry season (Figure 3(a) and (b)). This likely resulted from infiltration of coliform-rich surface water through porous soil profiles into the shallow aquifers of the boreholes. Such point sources of coliform-rich water could have been enhanced by the unsanitary conditions that generally prevailed.

Fig. 2. Temporal variations in coliform counts in: (a) boreholes; (b) hand-dug wells, and; (c) streams. (TC: Total coliforms; FC: Faecal coliforms).
around or close to boreholes. An alternative explanation could be that less patronage of boreholes in the wet season due to the abundance of rain water possibly leads to increased coliforms per unit volume of water in the boreholes.

Water from hand-dug wells and streams also generally decreased in coliform counts from the dry to the wet season (Figures 4 and 5). Of the 7 locations where stream water was sampled, 5 showed appreciable decreases in coliforms from the dry season (i.e. January, February and March) to the wet season (June) (Figure 4). Again, unlike boreholes, streams and hand-dug wells are more or less open to contamination from various point and diffuse sources in the surrounding environment. Apart from infiltration of coliform-bearing surficial water, desilting of the well at Abaam (ABM) at the time of sampling likely contributed to the high coliform counts observed in February (Figure 5). The desilting was undertaken by people without protective gear and under conditions that could not be described as safely hygienic. Similarly, the exceptionally high levels of coliforms recorded in stream water at Asuokaw (ASW2) in the rainy season (Figure 4) were possibly due to infiltration of leachate from a refuse dump located in the proximity of the sampling site (Figure 6).

Discussion

The presence of coliform bacteria in water from the streams and hand-dug wells in the present study, though not unusual, present formidable challenges for water resources management in rural Ghana and,
indeed, in most parts of sub-Saharan Africa. In spite of the fact that various studies have reported unacceptably high levels of pollution in many streams and rivers, many rural people continue to not only depend but at times even show preference for water from these sources for domestic use including drinking (Canadian International Development Agency/Ghana Water Resources Commission, 2006; Gyampoh et al., 2008). This could be attributed to certain prevalent socio-cultural preferences and beliefs, proximity (i.e. ready access or availability) and absence or lack of suitable alternative sources of potable water (Ormston, 2005). In many communities, such water bodies or areas around them serve as recipients of various forms of domestic and agricultural waste which easily infiltrate the soil and eventually leach out into the streams and rivers (Freeman, 1989). Many hand-dug wells constructed also tap water from shallow aquifers which are highly prone to surficial pollution. As observed in this study, the dumping of refuse and human excreta in and around water bodies is still prevalent (see Figure 6), suggesting the possibility of contamination from pathogenic bacteria and other sources. Detection of coliforms in borehole water, no matter how low the counts (in cfu/100 ml), without doubt introduces much concern regarding the bacteriological safety of the water. In some communities, significantly high coliform bacteria in borehole water appear to qualitatively correlate with levels of possible pollution in the immediate surroundings (see Table 1). In addition, the levels of investment involved and the importance attached to borehole development as a preferable alternative to stream and well water for rural communities make any such observation highly significant.

In an attempt to reduce the socio-economic and health risks associated with unsafe water use, various efforts have been made in the past few decades by the Government of Ghana, supported by development partners, towards provision of borehole water in many rural communities as an essential
component of the Ghana Poverty Reduction Strategy (GPRS) (Ghana National Development Planning Commission, 2005). Huge investments in the rural water sector have therefore been made, from structural reforms to the availability of credit to support the sector (CWSA, 2004). A major restructuring of the water sector was undertaken in 1993 within the framework of a decentralised policy that eventually resulted in the creation of the Community Water and Sanitation Agency (CWSA) in 1994 (CWSA/Bongo District Assembly, 2007; WSP, 2004). As part of the policy, District Assemblies (DAs), as trustees of water facilities at the local level, were required to assist community

![Fig. 5. (a) Total coliform counts and (b) faecal coliform counts in hand-dug well water. (ASK: Asamankese; NYN: Nyanoa; ABM: Abaam).](image)

![Fig. 6. Refuse dump (a) created along the banks of stream (b) patronised by rural people.](image)
based organisations such as Water and Sanitation Committees (WATSAN) and Water and Sanitation Development Boards (WSDBs) who were mandated with management of water facilities in various communities. These major structural changes, though laudable, have not as yet been effectively integrated into water resources management programmes in communities to the extent that there still appears to be a huge gulf between the policy framework and what occurs at the local level.

For example, under the first Community Water and Sanitation Programme (CWSP1) from 1994–1999, US$25 million was spent on 26 out of the 110 districts in Ghana. From 1999–2004, under CWSP2, US$32.2 million, including International Development Agency (IDA) credit (US$28 million) and Government financing (US$4.2 million) was again made available. In 2004, about US$25 million was sourced from the African Development Bank (ADB) and earmarked for water and sanitation for the western and central regions of Ghana. Currently, under the Millennium Development Authority (MiDA) facility, Ghana is to benefit from US$547 million, of which US$74 million is to be used for educational buildings, electrification and water and sanitation (ADB/AWF, 2006; MiDA, 2008); in the water and sanitation sector of this package, 23 districts in 5 regions, including the Eastern Region, are to benefit from construction of boreholes with hand pumps, boreholes with piped systems, surface water supply systems with piped distribution, repair or rehabilitation of existing borehole systems, and expansion of the existing piped system. In most of these programmes, however, comparatively little (if any) emphasis is given to safety of untreated surface water even though, as indicated above, available evidence suggests extensive use of water from such sources by many people in rural Ghana, and possibly by the urban poor (Ormston, 2005; Gyampoh et al., 2008).

Implications for sustainable management of rural water resources

The continued emphasis on borehole development by governments, development agencies and NGOs for supply of apparently safe drinking water in rural communities in many developing countries, laudable though it may seem, may have to be re-examined in so far as sustainable management of rural water resources is concerned. A first point to be considered is the selection of suitable sites for borehole construction. Many hydrogeologists and geophysicists involved in the selection of water points apparently give little or no consideration to environmental issues, their main objective for success being determined by the ability to “hit” water. As observed in the current study, water abstraction sources are often, for the purposes of convenience, located in or close to environmentally unhygienic areas which obviously make them highly susceptible to contamination with time. Sites earmarked or made readily available by communities for borehole construction are usually low lying, flood prone, near refuse or waste dumps and public toilets (abandoned or active) where there is not much land use competition, conflict or ownership. Additionally, not much consideration is usually given to the subsurface geology, suggesting that micro- and mega-structures in the underlying rocks that could potentially serve as conduits for surficial contamination of, for example borehole water, go essentially undetected.

Secondly, many borehole depths are fairly shallow (often less than about 30 m), making the water highly susceptible to contamination from infiltration and leaching through highly and deeply weathered surficial rocks.

Thirdly, population pressure, land degradation and encroachment on low-lying areas including wetlands for housing and other forms of development frequently render areas around previously existing
boreholes vulnerable to pollution from domestic and other forms of waste which contaminates water in aquifers.

A fourth issue is the lack of coordination and/or unclear regulatory regime amongst the various service providers in the rural water sector. For example, apart from boreholes constructed under the direct supervision of CWSA, a number of water facilities are also provided by stakeholders, such as religious bodies, NGOs and Community-Based Organisations (CBOs) without active participation of and/or prior knowledge or approval by CWSA. In addition, even though CWSA, the Ghana Water Resources Commission (WRC) and Environmental Protection Agency (EPA Ghana) have developed policy guidelines for construction of boreholes and abstraction of water, the “non-binding” nature and weak to non-existent enforcement place enormous constraints on effective service delivery at the community level.

Finally, the above problems are further exacerbated by the absence of periodic borehole water quality monitoring. In Ghana, for instance, there is as yet no department or separate section within the structure of the CWSA (the agency responsible for rural water supply) responsible for monitoring and evaluation. Hence, unlike urban water supply systems, very little, if any, attention is given to water quality monitoring once a water facility is made available in rural communities. Furthermore, inadequate capacity building and lack of remuneration for local or community-based bodies such as Water and Sanitation Committees (WATSAN), Water Boards, and District Water and Sanitation Teams (DWSTs) in the District Assemblies have also seriously hampered their ability to effectively manage borehole water systems at the local level (Camdessus, 2003).

In the case of streams and wells in rural areas, virtually nothing is done about the quality of water from these sources even though, as indicated above, available evidence suggests very high patronage, especially during periods of water scarcity. Because of increased pollution from various human activities, use of stream and well water could render many rural populations highly vulnerable to water-borne diseases resulting from the presence of pathogenic bacteria in the water. As observed in this study, many people still depend on such water sources in spite of the presence of significant coliform bacteria, to the possible detriment of their short- and long-term health and socio-economic well being.

Conclusion

This study demonstrates that periodic assessment of the quality of water available to rural communities may not only be appropriate but also necessary. Because many rural people depend heavily on these untreated sources of water, the presence of coliform bacteria in all the water bodies, including borehole water but especially in stream and well water, should be a cause for concern to all stakeholders involved in rural water delivery. Considering the socio-economic importance of access to safe water, it would seem a slight shift in focus from mere provision of apparently safe (borehole or hand-dug well) water to one that incorporates water quality assessment of both surface and ground water (but more especially surface water) may have to be considered as a matter of priority. In addition, continuous education on environmental awareness and capacity building could serve to enhance water resources management programmes in local communities. Though these have obvious cost implications, they nevertheless could help minimise risk from preventable water-borne diseases which could, in turn, reduce possible negative health and socio-economic impacts on already stressed and often poor rural people.
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References


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