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SENSITIVITY OF *ESCHERICHIA COLI, KLEBSIELLA PNEUMONIAE* AND NINE OTHER BACTERIAL SPECIES ISOLATED FROM DRINKING WATER IN THE LOWER VOLTA BASIN TO SOME COMMONLY USED ANTIBIOTICS

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Abstract

In monitoring water in rural and poor urban communities for potentially harmful bacteria, the conventional methods for detecting total and faecal coliforms on MacConkey Broth were used. Streaks on Plate Count Agar were used for identification, bacteriological and biochemical characterisation using the API 20E kit. Stored drinking water from villages in the South Tongu and East Dangbe Districts kept in earthenware pots (17-78 l capacity) for up to 1 week contained several species of bacteria including *Acinetobacter* sp., *Aeromonas sobria, Chryseomonas luteola, Citrobacter amalonaticus, C. diversus, C. freundii, Edwardsiella* sp., *Enterobacter aerogenes, E. cloacae, E. sakazakii, Escherichia coli, E. hermanii, Hafnia alvei, Klebsiella pneumoniae, Kluyvera* sp., *Pseudomonas fluorescens, Serratia fonticola, S. odorifera, S. plymutica, Salmonella arizonae, Shigella* sp., and *Yersinia intermedia*. The sensitivity of *E. coli, K. pneumoniae* and nine other bacterial species isolated was tested using the disc diffusion method containing sensitivity disc rings incorporated with antibiotics including ampicillin 10 g, cefotaxime 30 g, tetracycline 30 g, amikacin 30 g, cotrimoxazole 25 g, and chloramphenicol 30 g. About 87.5 per cent (14/16) strains of *E. coli* and 88.2 per cent (15/17) strains of *K. pneumoniae* were resistant to ampicillin; 31.3 per cent (5/16) strains of *E. coli* were resistant to tetracycline and sensitive to the remaining antibiotics. The resistance of the remaining microbes to the antimicrobials was considerable. It is suggested that close monitoring of quality of water

Résumé

AMOAH, C., ODAMTTEN, G. T. & LONGMATEY, H.: *Sensibilité d'*Escherichia coli, Klebsiella pneumoniae *et neuf autres espèces bactériennes isolées d'eau potable du bassin de la basse-volta aux quelques antibiotiques fréquemment utilisés.* Nous avons employé les méthodes conventionnelles pour le dépistage de coliformes fécales et totales sur MacConkey Broth. Des filets sur la plaque de Comte d'Agar étaient utilisés pour l'identification, la caractérisation bactériologique et biochimique en employant le kit d'API 20E. L'eau potable entreposée des villages des Districts de South Tongu et East Dangbe mise dans les potéries (17-78 capacité des litres) pour jusqu' à 1 semaine contenait plusieurs espèces de bactéries, à savoir *Acinetobacter* sp., *Aeromonas sobria, Chryseomonas luteola, Citrobacter amalonaticus, C. diversus, C. freundii, Edwardsiella* sp., *Enterobacter aerogenes, E. cloacae, E. sakazakii, Escherichia coli, E. hermanii, Hafni alvei, Klebsiella pneumoniae, Kluyvera* sp., *Pseudomonas fluorescens, Serratia fonticola, S. odorifera, S. plymutica, Salmonella arizonae, Shigella* sp., *et Yersinia intermedia.* La sensibilité de *E. coli, K. pneumoniae* et neuf autres espèces de bactéries isolées se déroulait utilisant la méthode de diffusion à disque contenant les disques ronds de sensibilité incorporées à ampicillin 10 g, cefotaxime 30 g, tetracycline 30 g, amikacin 30 g, cotrimoxazole 25 g, chloramphenicol 30 g, etc. Approximativement 87.5 % (14/16) souches de *E. coli* et 88.2 % (15/17) souches de *K. pneumoniae* étaient ampicillorésistant; 31.3 % (5/16) de *E. coli* étaient tetracyclorésistant

coupled with education in cleaning storage containers, using the traditional heat sterilisation method, can effectively reduce contamination and, thus, curtail the health risk associated with drinking unsafe water.

et sensible aux autres antibiotiques qui restent. Il y avait une résistance considérable des autres microbes aux antimicrobiens. Il est suggéré qu'une surveillance de près de qualité d'eau ajouté à l'éducation sur le nettoyage de récipients d'entreposage employant la méthode traditionnelle de stérilisation par la chaleur pourrait réduire efficacement la contamination et réduire par conséquent le risque pour la santé lié au boire d'eau non potable.

Introduction

Supplying clean potable water has become a formidable problem in the rapidly expanding population in the developing world. Most rural and poor urban communities in developing countries do not have household pipe connections which supply potable water directly on sustained basis. Consequently, many fetch water from rivers, streams, ponds, dugout wells and other sources for household use and for drinking (LVEIS, 1996, 2000). In developed countries, industrialization and development in agriculture were due to availability of water for irrigation, industries and domestic use (Bartram & Balance, 2001).

Water is one of the vehicles of gastro-intestinal diseases because it frequently washes soil bacteria and sewage microorganisms during heavy rains into large bodies of water. Amoah, Odamtten & Agbodaze (1990) isolated enteric non-spore-forming bacterial species from riverine water and prawns from the Volta river including *Aeromonas sobria, Enterobacter agglomerans, E. aerogenes, E. cloacae, Citrobacter freundii, Klebsiella pneumoniae, Plesiomonas shigelloides, Serratia liquefaciens, S. fonticola,* and *Morganella morgani*. The extent of contamination by the different bacteria species varied. For example, *P. shigelloides* was isolated more frequently (3/20) from prawns (*Macrobrachium* spp.) than from the riverine water (1/265) (Amoah, Odamtten & Agbodaze, 1996).

The main diseases carried by water are enteric fever, dysentery, cholera, infectious hepatitis and gastro-enteritis (Talaro & Talaro, 1993; Atlas, 1995; Nester, Roberts & Nester, 1998). When water is stored for drinking purposes, it is always advisable to remove suspended materials and to keep it, as far as possible, free from microorganisms. However, the local method of storing water in earthenware pots and other containers makes it a difficult proposition because there can be cross contamination between human beings handling the cup and pots after successive scooping with the same cup. Any individual who is a carrier of a potential pathogen can pass on infective organism when handling the scooping cups and containers. Most incidence of microbial resistance to drugs is now making it difficult to treat infectious diseases due to the extensive misuse of antimicrobial drugs which has favoured the emergence of resistant bacterial strains. For example, *Staphylococci* in skin scales and *Acinetobacter* spp. may survive for long periods and, hence, contribute to outbreaks of infections (Clarke & Humphreys, 2001). Records in Kenya, Thailand, Mexico and Peru indicate that tetracycline, ampicillin and trimethoprim recommended for the empirical treatment for diarrhoea are largely ineffective against *Shigella* spp. and entero-aggregative *Escherichia coli* (Sang *et al.*, 1997; Yamamoto, Escherurria & Yokota, 1992).

Some bacteria isolated from the drinking water were tested for susceptibility or resistance to eight commonly used antibiotics in Ghana.

Experimental

The samples were collected from village communities in the North Tongu and East Dangbe Districts of Ghana and from the Volta river at Dodoekope (Fig. 1). The villages were Mepe, Adidome and Dodoekope. The study area is about 60 km from Accra, the capital of Ghana. The three communities have a total population of 12,000.

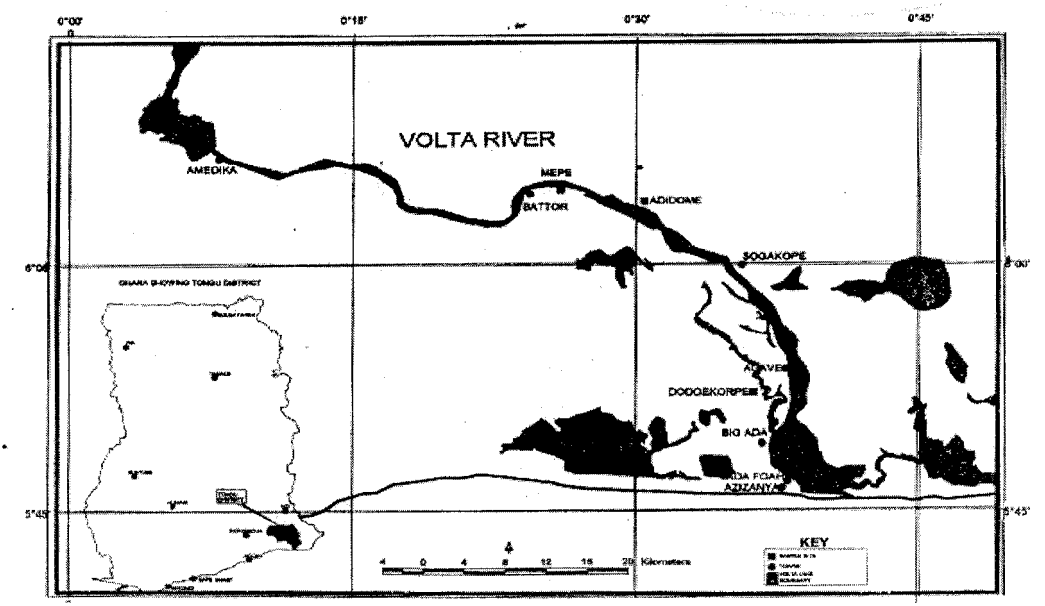

Fig. 1. Map of the Lower Volta showing sampling sites beyond the Kpong Dam.

The major occupations are farming and fishing. The main diseases reported in the study area are bilharzia, malaria and gastro-intestinal diseases. Fig. 2 shows that the inhabitants use water from the Volta river as compared to other sources like ponds, wells and streams.

Sample collection

Samples of drinking water from the Volta river and households were collected from March 1998 to April 2002. The water from the Volta river at Dodoekope was collected at a depth of 0.5 m, using 250-ml wide-mouth glass sampling bottles. The sterilized sampling bottles were inverted in the water and their lids opened to collect the sample, making sure some air space was left, (which was necessary for homogenizing the sample at the laboratory), and then covered immediately (APHA, 1998).

From households, sterilized aluminium cups with handles were used to scoop water from the storage containers, poured into 250-ml wide-mouth glass bottles to about three-quarters full and covered immediately. The bottles were all stored on ice and taken to the laboratory within 4 h for bacteriological analysis and then plated for microbial isolation and identification.

Total coliform (TC) and faecal coliform (FC) counts were determined using MacConkey Broth incubated at 37 and 44 °C and recorded as MPN/ 100 ml (APHA, 1998).

The colonies were streaked on Plate Count Agar (PCA, Oxoid CM325) for subsequent identification and biological characterisation using API 20E Kit (Bio Merieux, SA France).

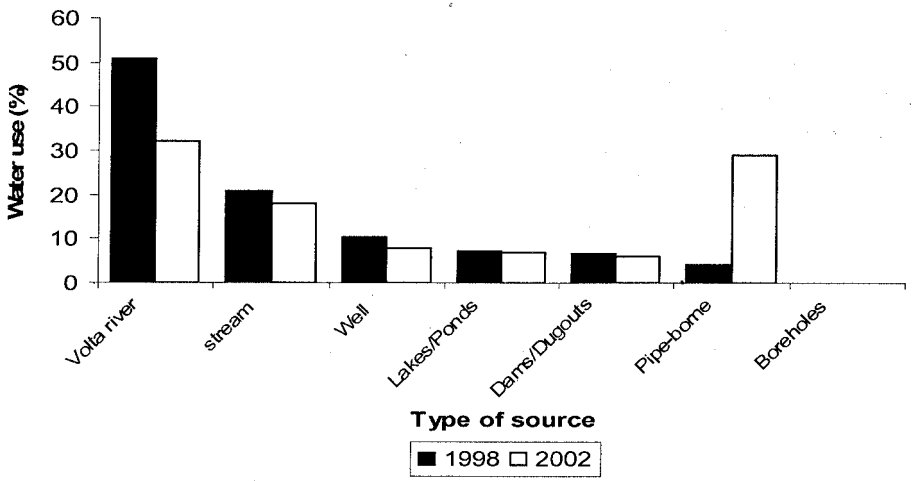

Fig. 2. Percentage use of primary water sources in the study area in 1998 and 2002.

Antibiotic susceptibility test of E. coli, K. pneumoniae *and other microorganisms*

The *in vitro* antibiotic susceptibility test was applied using the disc diffusion Kirby-Bauer method (WHO, 1997) on the same plate with antibiotic sensitivity disc rings (Britania Discograma, Tm Argentina). The plates were incubated microaerographically for 48 h. Concentrations of the antibiotics in the discs were ampicillin (10 ìg), cefotaxime (30 ìg), cefuroxime (30 ìg), tetracycline (30 ìg), amikacin (30 ìg), cotrimoxazole (25 ìg), gentamicin (10 ìg), and chloramphenicol (30 ìg).

Influence of traditional scrubbing and smoke sterilization process on total coliform and faecal coliform counts in stored drinking water

The earthenware pots for storing drinking water varied in capacity (17-78 l). Included in this study was a 66-year-old earthenware pot (78 l) from one household at Dodoekope (East Dangbe District).

The inhabitants in the study area have a traditional method of cleaning the earthenware pot storage containers from time to time. Unfortunately, this is seldom practised these days. In this experiment, the pots were washed, inside and outside, first with soap and rinsed with water before smoking with dry inflorescence of oil palm (*Elaeis guineense*). Thereafter, freshly fetched river water was mixed with sterile distilled water in the ratio 1:5 and 1:10 v/v before pouring into the storage container. The control was a mixture of stand pipe water mixed in the same ratio with sterile distilled water. The water was left for 2 days before microbiological test for TC and FC counts.

Results

Varied bacterial species were isolated from the riverine water, dugout well and stored drinking water (Table 1). Some species not isolated from the river water and well water were encountered in the stored water. These were *Acinetobacter* sp., *Citrobacter amalonaticus, C. diversus, C. freundii, Edwardsiella* sp., *Enterobacter sakazakii, E. hermanii, Hafnia alvei, Klebsiella oxytoca, Kluyvera* sp., *Pseudomonas fluorescens, Yersinia intermedium, Salmonella arizonae,* and *Shigella* sp. Stored water was contaminated with the highest number of bacterial species (23), and was statistically ($P < 0.05$, Student's t-test) significantly different from the number encountered in the river (7) and the well (9).

Table 2 presents results of the antibiotic sensitivity test. Clearly, 87.5 per cent (14/16) of

TABLE 1
List of bacteria species isolated from river (1), well (2), and stored water (3) in the study area

Total number of species	*Total number of genera*
River (7)	River (7)
Well (9)	Well (8)
Stored water (23)	Stored water (23)

Aeromonas sobria[1,3]	*E. sakazakii 3*	*Kluyvera* sp.
Acinetobacter sp.	*Edwardsiella* sp.[3]	*P. alcalifaciens*[1]
C. diversus[3]	*Enterobacter aerogenes*[1,2,3]	*Pseudomonas fluorescens*[3]
C. freundii[3]	*Escherichia coli*[2,3]	*S. boydii*[2]
Cedecea sp.[1]	*Hafnia alvei*[3]	*S. odorifera*[1,3]
Citrobacter amalonaticus[3]	*K. cryocrescens*[3]	*S. plymutica*[3]
Cryseomonas luteola[2,3]	*K. oxytoca*[3]	*Salmonella arizonae*[3]
E. cloacae[3]	*K. pneumoniae*[1,2,3]	*Serratia fonticola*[2,3]
E. hermanii[3]	*K. ornithinolytica*[1]	*Shigella flexneri*[2]
E. intermedium[2]		*Yersinia intermedia*[3]

E. coli strains and 88.2 per cent (15/17) strains of *K. pneumoniae* and the single strain of *Salmonella arizonae* were resistant to ampicillin; 31.3 per cent (5/16) of *E. coli* strains were resistant to tetracycline but susceptible to the rest of the antibiotics tested. About 25 per cent (1/4) of *Shigella flexboydii* strains were resistant to ampicillin, cefuroxine, cefotaxime, cotrimoxazole, chloramphenicol; and 50 per cent (2/4) to tetracycline (Table 2). Fifty per cent (1/2) of *Serratia fonticola* strains were resistant to cefotaxime. About 50 per cent (2/4) strains of *Acinetobacter* sp. and *Enterobacter* sp. were resistant to ampicillin. Fifty per cent (2/4) strains of *Acinetobacter* sp. were resistant to cefuroxime, cefotaxime, tetracycline, cotrimoxazole, and chloramphenicol (25 %). Therefore, resistance of the microbes to the test antimicrobials was considerable.

The stored drinking water in the selected homes in the study area was laden with high TC and FC well above the acceptable WHO standards for unpiped drinking water (Table 3). Neither the supply of special scooping cup nor prior training in its use assisted in mitigating the contamination of stored drinking water by the inhabitants of the households.

The traditional method of cleaning and sterilizing the earthenware pots with palm tree inflorescence and strict adherence to proper personal hygiene, however, reduced TC count drastically (< 90 %) and eliminated faecal coliform bacteria (Table 4). The differences observed after treatment were statistically significant ($P < 0.05$), using Duncan's Multiple Range Test of Significance.

Discussion

Good quality water is crucial for sustainable socio-economic development (Bartram & Balance, 2001). The World Health Organisation quality standards (WHO, 1984, 1985, 2002) prescribe specific drinking water guidelines for physical, chemical and microbiological purity. Good hygiene practices are as important as providing clean and safe drinking water. Sometimes clean

TABLE 2

Antibiotic susceptibility test on listed bacterial isolates from drinking water in the Lower Volta Basin*

Bacterial species	*Ampicillin (30 ìg)*		*Cefuroxime (30 ìg)*			*Cefotaxime (30 ìg)*			*Tetracycline (30 ìg)*			*Amikacin (30 ìg)*			*Cotrimoxazole (30 ìg)*			*Gentamycin (30 ìg)*			*Chloramphenicol (30 ìg)*			
	%		%			%			%			%			%			%			%			
	N	*R*	*I*	*S*	*R*	*I*	*S*	*R*	*I*	*S*	*R*	*I*	*S*	*R*	*I*	*S*	*R*	*I*	*S*	*R*	*I*	*S*	*R*	*I*	*S*
Escherichia coli	16	88	0	12	0	0	100	0	0	100	31	6	63	0	0	100	18	0	82	6	0	94	13	0	87
Klebsiella pneumoniae	17	88	12	0	0	0	100	0	6	94	12	0	88	0	0	100	0	0	100	6	0	94	18	0	82
Shigella flexneri-boydii	4	25	0	75	25	75	50	25	75	0	50	25	25	0	0	100	25	0	75	0	0	100	25	0	25
Serratia fonticola	1	100	0	0	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0		100	00	100
Citrobacter freundii	4	25	0	75	25	75	50	25	75	0	50	25	25	0	0	100	25	0	75	0	0	100	25	0	25
Serratia plymutica	1	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100
Serratia fonticola	2	0	0	100	0	0	100	50	0	50	0	50	50	0	0	100	0	0	100	50	0	100	100	0	100
Acinetobacter sp.	4	50	0	50	50	0	50	50	0	50	50	0	50	0	0	100	0	0	100	0	0	100	0	0	100
Enterobacter sp.	4	50	0	50	25	25	50	0	25	75	0	75	25	0	0	100	0	0	100	0	0	100	0	0	100
Kluyvera sp.	2	0	0	100	0	0	100	0	0	100	50	0	50	0	50	50	0	50	50	0	0	100	0	0	100
Salmonella arizonae	1	100	0	0	0	100	0	100	0	0	0	0	100	0	0	100	0	0	100	0	0	100	0	100	0

KEY: N – no. of strains I – intermediate S – sensitive R – resistant

*Based on data collected from Britania Discograma™ Antibiotic Sensitivity Disc Rings

water is contaminated during handling before consumption. Work in Bangladesh (Aziz *et al.*, 1990) indicated that more than 30 per cent of water samples taken from stored drinking water in homes were contaminated (>1000 faecal cfu/100 ml), although the source was clean.

The stored drinking water sampled from households in the South Tongu and East Dangbe Districts of Ghana were laden with many bacteria like *Acinetobacter* sp., *Chryseomonas luteola, Citrobacter amalonaticus, C. diversus, C. freundii, Edwardsiella* sp., *Enterobacter aerogenes, E. cloacae, E. sakazakii, Escherichia coli, E. hemanii, Hafnia alvei, Kelbsiella oxytoca, Kluyvera* sp., *Pseudomonas fluorescens, Serratia fonticola, S. odorifera, S. plymutica Yersinia intermedium, Salmonella arizonae* and *Shigella* sp. (Table 1). Many of these were not found in the river and well water and, thus, indicate secondary contamination human skin microflora through handling scooping cups and pots.

Acinetobacter species are opportunistic pathogens responsible for outbreaks in clinical areas with critically ill patients such as the Intensive Care Unit (Webster, Towner & Humphreys, 2002; Jawad *et al.*, 1998; Jawetz, Melnick & Adelberg, 1984). *Acinetobacter species* can persist in the environment and, hence, contribute to outbreak of infections leading to diseases like urethritis, bacteraemia and pneumonia (Clarke & Humphrey, 2001). These potential pathogens are the most commonly isolated non-fermentors in clinical laboratory and common flora of skin and mucous membrane of humans.

Aeromonas spp. cause opportunistic nosocomial infections, septicaemia, meningitis, and pneumonia. Other reports have associated haemolysin production by *Aeromonas* with cytotoxicity (Daily *et al.*, 1981). *Serratia* spp. are sometimes associated with gastroenteritis and are also known to cause nosocomial infections (Ketchum, 1984). *Enterobacter aerogenes* may be found causing urinary tract infection and in sepsis. *Salmonella arizonae* has been isolated from cockroaches (*Periplaneta americana*) commonly found in households in the study area (Agbodaze *et al.*, 1988). Bacteria in the genus *Shigella* cause bacillary dysentery (shigellosis) and can be found in the intestine of humans and primates as well as in water contaminated with human faeces (Talaro & Talaro, 1993). Major causes of diarrhoea have most often been attributed to *E. coli, Salmonella* and *Shigella* species (Ani *et al.*, 1989).

The genera of bacteria in soil or water include *Citrobacter, Edwardsiella, Aerobacter, Aeromonas, Enterobacter, Erwinia, Escherichia, Hafnia, Klebsiella, Morganella, Proteus, Kluyvera, Pseudomonas, Serratia, Yersinia, Vibrio* and *Shigella* spp. (Nester *et al.*, 1998). Ten of these genera were isolated from the stored water from North Tongu and East Dangbe Districts of the Lower Volta Basin of Ghana (Table 1). This confirms the previous isolation of some species by Amoah *et al.* (1990,1996) from the same water source.

From the antibiotic susceptibility patterns recorded (Table 2), no single antibiotic could be deemed to be universally effective against all the bacterial strains isolated. The fact that *K. pneumoniae* was resistant to ampicillin is not surprising. However, the resistance of 87.5 per cent of *E. coli* strains to ampicillin is alarming and deserves further investigation.

The low activity of ampicillin to *E. coli, K. pneumoniae, Acinetobacter* sp., and *Enterobacter* sp. may reflect a high capacity of the â-lactamase against ampicillin (Verschraugen, 1998). This is supported by the fact that cefotaxime, a â-lactamase-stable cephalosporin, was invariably active against *E. coli* and *K. pneumoniae,* but not *Salmonella arizonae* (Table 2). Cefpirome, a fourth-generation cephalosporin, was found to be more active than other cephalosporins against *E. coli* (87% vs 61%), *Klebsiella* spp. (84% vs 56%), *Enterobacter* spp. (88% vs 59%), *Proteus* (97% vs 92%), *Salmonella typhi* (98% vs 96%), methicillin-

TABLE 3

Influence of the use of a scooping cup on the microbiological quality of drinking water from indicated sources and stored in container for 7 days

Settlement area district	*Source of drinking water*	*Type of storage container (Capacity in litres)*	*Type of scooping container*	*Bacteriological quality of (MPN/100 ml) Raw water*		*Stored water*	
				TC	*FC*	*TC*	*FC*
North Tongu	Volta river Untreated water Well	Earthenware pot either covered or uncovered (Range 18-40 litres)	Plastic cup Calabash Enamel Tomato tin	10-640+ 0-1200* 0-1000** 100-520***	20-1000** 0-600* 0-240** 20-220***	60-480+ 0-1000* 0-840** 520-620***	0-300+ 0-100* 0-40** 0-140***
Dangbe East	Volta river Well	Earthenware pot either covered or uncovered plastic buckets (Range 13-78 litres)	Plastic cups Enamel cups	10-640+ 0-1000***	20-220+ 0-100*	80-800+ 0-980**	10-220+ 0-540**

WHO Standards: Unpiped; FC = 0 MPN/100 ml TC = <3 MPN/100 ml

- *Instruction on the use of scooping cup followed
- ** Instruction on the use of scooping cup not ignored
- *** No scooping cup provided
- \+ Initial data before supply on new scooping cup

sensitive *Staphylococci* (86% vs 59%), and *Enterococci* (82% vs 72 %) (Hafeez *et al.*, 2000).

Antimicrobial resistance is not an infectious disease, like small pox or poliomyelitis that one can eradicate (WHO, 1998a). It is a natural response of microbes exposed to antimicrobial agents. Therefore, resistance control measures have to be one of containment, aiming at reducing the rate of emergence and spread of resistance strains. To contain the threat of antimicrobial resistance, it is important to determine the magnitude and trends of resistance and to define the relative importance of different contributing factors such as therapeutic, behavioural, economic, social, and health system factors including other issues in veterinary and agriculture (WHO, 1997; 1998a; 1998b; 1998c).

The unjustifiable faith in the use of antibiotics as a panacea has led to their being overused. Patients are coerced by drug peddlers to purchase antibiotics even without appropriate prescriptions and without knowing the exact cause of infections; culprits invariably partially comply with prescriptions. They interrupt treatment prematurely or may often be unable to afford a full course, thereby creating an ideal environment for microbes to adapt rather than be killed. The problem is accentuated by the low quality antibiotics (poorly formulated or manufactured, counterfeited or expired) still being sold and used for self-medication or prophylaxis (WHO, 1998b).

According to WHO (1997), resistant strains of *Salmonella, Campylobacter, Enterococci,* and *E. coli* that cause diseases in humans have been transmitted from animals to humans with detrimental consequences. The resistance of 87.5 per cent (14/16) strains of the *E. coli* to ampicillin warrants concern, not excepting the resistance of the single strain *Salmonella arizonae* to ampicillin and cefotaxime. The resistance of 25 to 50 per cent (1/4 to 2/4) strains of *Shigella*

flexbodyii to ampicillin, cefuroxime, cefotaxime, tetracycline, cotrimoxazole, and chloramphenicol may contain incipient drug resistance by phenotype microbes in this area of Ghana presumably as a result of abuse of antibiotics.

Williams & Heyman (1998) stated that low cost, first choice antibiotics have lost their power to clear infections of *E. coli, Neissera gonorrhoea, Pneumococcus, Shigella* and *Staphylococcus aureus* – increasing the cost and length of treatment of many common diseases including epidemic diarrhoea disease, gonorrhoea and pneumonia. *Escherichia coli* strain 044 has also been shown to be resistant to tetracycline, erythromycin, trimethoprim, sulphamethoxazole and amoxicillin/clavulane, but sensitive to chloramphenicol, nalidixic acid, azithromycin and cefuroxime (Sang *et al.*, 1997).

Surveillance and monitoring is essential for containing antimicrobial resistance (Sang *et al.*, 1997; Williams & Heyman, 1998). Information on resistance is needed at local, national and international levels to guide decision making and responses. However, surveillance of antimicrobial resistance requires laboratory facilities organised in a network within which date or patterns of resistance can be shared for analysis and interpretation (Williams & Ryans, 1998). In many developing countries like Ghana, and in countries with economies in transition, laboratory facilities and information networks will require considerable strengthening before reliable surveillance of resistance becomes a reality. The data on the antibiotic sensitivity of microbes from drinking water in rural Ghana in this paper show the urgent need for such an exercise in Ghana.

TABLE 4
Influence of cleaning of 66-year-old earthenware pot on total coliform (TC) and faecal coliform (FC) bacteria in the stored water

Dilution of ratio of water with sterile distilled water (v/v)	*Before sterilization of pot*		*After sterilization of pot*	
	TC	*FC*	*TC*	*FC*
Stored water*	280	60	20	0
1:5				
1:10	270	40	20	0
Stand pipe water				
1:5	0	0	-	-
1:10	0	0	-	-

*Water stored in a covered 66-year-old pot at *p*H 6.3 for 2 days
TC – total coliform FC–faecal coliform

Antimicrobial resistance cost money and human lives. Resistant infections are associated with increasing morbidity, prolonged hospital stay, and greater direct and indirect cost; prolonged periods during which individuals are infectious and greater opportunities abound for the spread of infection to other individuals (WHO, 1997). The inhabitants of the East Dangbe and North Tongu Districts in the Lower Volta Basin of Ghana lack good and potable water supply and adequate health facilities. The storage of good and bacteriologically acceptable drinking water could, therefore, assist in mitigating the incidence of water-related gastro-intestinal diseases and other health hazards.

The stored drinking water in households of the study area was laden with enterobacteria (Table 1), which was reflected in the high TC and FC

counts (Table 3) above the acceptable WHO standards for unpiped drinking water. The supply of special scooping cups and training on their use for collecting water from the storage containers did not significantly ($P \leq 0.05$) improve the quality of the water, because individuals whose skins were contaminated with opportunistic infectious microbes became vehicles of transmission to others through handling cups. Perhaps, provision of scooping cups with longer handles can prevent skin contact with water during the fetching process and, thus, curtail microbial contamination.

The traditional method of cleaning and heat-sterilizing earthenware pots using oil palm tree inflorescence has been a long-standing practice in Ghana. However, in recent years, the practice has not been adhered to by many rural dwellers. The results show that TC count was reduced by 90 per cent and FC by 100 per cent, using the washing and traditional heat-sterilization method (Table 4). If potable pipe-borne water reaches these areas in the near future, regular cleaning of storage containers could be an effective tool for sustaining good quality drinking water and, thus, reducing the health risks associated with drinking contaminated water.

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