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Prevalence and antimicrobial resistance pattern of *Escherichia coli* in drinking waters in Jalingo Metropolis, Taraba State, North-Eastern Nigeria

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ABSTRACT

Fecal coliforms and *Escherichia coli* are bacteria that inhabit the human or animal intestinal tracts, therefore associated with human or animal wastes. Their presence in drinking water is a strong indication of sewage or human/animal wastes contamination and determines the safety/quality of the water. When these waters are used as sources of drinking waters without treatment or inadequate treatment, these bacteria may end up in drinking waters and causes diarrheal related infections. In an attempt to determine the occurrence of *E. coli* in drinking waters in Jalingo Metropolis, Taraba State, North-eastern Nigeria, 300 water samples comprised of well, bottled, sachet and waters from commercial water vendors (popularly called "Yan-Garuwa) were analyzed. The results show that 28 (9.3%) *E. coli* were isolated with well waters having the highest isolation rate of 15/80 (18.5%) followed by Yan-Garuwa, 8/80 (10.0%) and sachet waters, 5/60 (8.3) ($P < 0.05$). No *E. coli* was isolated from both borehole and bottled waters analyzed. The antimicrobial resistance and susceptibility patterns of the 28 *E. coli* show high resistance to ampicillin (100%), penicillin (100%) tetracycline (78.6%), and erythromycin (71.4%). However, low resistance was recorded against streptomycin (28.6%) and ciprofloxacin (17.9%), respectively. On the other hand, the highest susceptibility was observed with gentamicin, chloramphenicol and Nalidixic acid with 28 (100.0%), 23 (82.1) and 25 (89.7), respectively. The study recommends disinfection and proper hygienic measures during preparation and handling of water and also proper construction of wells to avoid run-off of sewage during rain.

Keywords: Prevalence, antimicrobial resistance, *Escherichia coli,* drinking waters, sewage.

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INTRODUCTION

Waterborne diseases are caused by pathogens that are mostly transmitted through contaminated water during bathing, washing, drinking, food preparation and the consumption of food prepared by contaminated waters (NPC/UNICEF, 2001). Examples are waterborne diarrheal diseases which affect mainly children in developing countries. According to the World Health Organization, such disease account for an estimated 4.1% of the total daily global burden of disease, and cause about 1.8 million human deaths annually. The World Health Organization estimates that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene (WHO, 1996). In Nigeria, there is inadequate supply of potable and safe water and also sanitation procedures that resulted in the preponderance of water borne and sanitation related diseases (Adewusi, 2012). These diseases attributed to poor sanitary and hygienic conditions and also consumption of unsafe water is the second cause of infant mortality after malaria and the third main cause of under-five mortality (Adewusi, 2012).

Waterborne diseases can have a significant impact on the economy, locally as well as internationally. People

who are infected by a waterborne disease are usually confronted with related costs and seldom with a huge financial burden. This is especially the case in less developed countries. The financial losses are mostly caused by costs for medical treatment and medication, costs for transport, special food, and by the loss of manpower. Many families must even sell their land to pay for treatment in a proper hospital. On average, a family spends about 10% of the monthly household's income per person infected (Nwachuku et al., 2005).

The safety of potable water requires that the level of disease causing micro-organisms should be reduced below levels that can cause human infections. It must also be free from chemical substances, which are dangerous to health (Pelczar et al., 1986; Eaton et al., 2005).

Microorganisms causing diseases that are characteristically water borne prominently include protozoa, bacteria, viruses and intestinal parasites, which invade tissues or circulatory system through walls of the digestive tract (Janovy et al., 1996; Nwachuku and Gerba, 2004; Dziuban et al., 2006; Petrini, 2006). The most common agents associated with water borne gastrointestinal illness are *Shigella, Salmonella, Toxoplasma, Campylobacter, Cryptosporidium, Giardia, Pathogenic E. coli* and *Klebsiella pneumonia* (Horan et al., 1988; Nwachuku et al., 2005; Dziuban et al., 2006; Petrini, 2006). Most of the ground water suppliers are often pump water which are distributed into the system without proper treatment or disinfection (Bagley, 1985), and also proper hygienic measures are not taken during handing of drinking water (Kokkinakis et al., 2008). This may result in contamination with the coliforms and other enteric bacteria. Many studies have documented the presence of these organisms in water with counts exceeding national and international standards recommended for potable water for human consumption (WHO, 1996; Bharath et al., 2009; Kokkinakis et al., 2008). This study is aimed at providing preliminary information on the occurrence of *E. coli* and their antimicrobial resistance pattern in drinking waters in Jalingo Metropolis, Taraba State, North-eastern Nigeria.

E. coli is the head of the large bacterial family, *Enterobacteriaceae*, the enteric bacteria, which are facultative anaerobes and Gram-negative rods that live in the intestinal tracts of humans and animals in health and disease. It is an emerging cause of foodborne and waterborne illness and its presence in water is a strong indication of recent sewage or animal waste contamination. Although most strains of *E. coli* are harmless and live in the intestines of healthy humans and animals, this strain produces a powerful toxin that can cause severe illness (Kaper et al., 2004). Infection often causes severe bloody diarrhea and abdominal cramps; but sometimes non-bloody diarrhea with no fever. In 2 to 7% of infections, particularly children under 5 years of age and the elderly, the infection can also cause a complication called hemolytic uremic syndrome, in which the red blood cells are destroyed and the kidneys fail. *E. coli* have being implicated in several outbreaks of diseases in the USA, UK and other parts of the world which was traced to contaminated hamburgers, undercooked ground beef, milk etc (Scotter et al., 2000; Daly et al., 2002).

MATERIALS AND METHODS

Study area

The study was carried out in Jalingo Metropolis, Taraba State. Jalingo is the capital of Taraba State which was created in 1991 by Federal Military Government of Nigeria. It is located between latitude 6° 30′ and 9° 36′ North and longitude 9° 10′ and 11° 50′ East. It is located on the Guinea Savannah region and has two seasons; the dry season, which start from October to March and the rainy season which start from April to ends of September (TSMISD, 2004).

Sample collection

Waters used for the study comprised of the ones used directly in various households and the ones sold in shops and vendor for human use. Well waters were obtained directly from the wells in different locations within the metropolis, while bottled, sachet and waters from commercial water vendors (popularly called "Yan-Garuwa) were purchased without any information on the purpose. The well waters and those obtained from water vendors were placed in sterile sample bottles, while bottle and sachet ones were obtained already in their bottles and sachets. All the water samples were placed on ice and transported to the laboratory for bacteriological examinations.

Laboratory procedures

Escherichia coli isolation involved pre-enrichment by adding 20 ml each of the water sample to equal amount of Trypton Soya Broth followed by incubation at 37°C for 2 h (Garba et al., 2009). The incubated broth was then streaked onto the surface of Eosin Methylene Blue (EMB) agar which was prepared according to the manufacturer's instructions (Ogunleye et al., 2013). All plates were then incubated at 37°C overnight (Scotter et al., 2000). Colonies which appeared as greenish metallic sheen were considered as *E. coli* (Ogunleye et al., 2013), and were further identified by gram staining technique, indole, motility, methyl-Red-Voges-Proskauer (MR-VP) and simmon citrate tests (Ewing, 1986; Ahmad et al., 2009).

Antibiotic resistance and susceptibility tests

Antibiotic resistance profile of the *E. coli* isolates was performed by disk diffusion methods as described by British Society for Antimicrobial Chemotherapy (BSAC) (2009). The following panel of the antimicrobials and their concentrations were used for the resistance and susceptibility: Ampicillin (10 µg), Chloramphenicol (30 µg), Ciprofloxacin (10 µg), Erythromycin (15 µg), Gentamicin (10 µg), Nalidixic acid (30 µg), Penicillin (10 IU), Streptomycin (30 µg) and Tetracycline (30 µg) (Oxoid, England). Zones of inhibitions were measured and interpreted according to BSAC guidelines as resistance, intermediate resistance and susceptible.

Table 1. Prevalence of *E. coli* in drinking waters in Jalingo Metropolis, Taraba State, North-eastern Nigeria

Type of water	No. of water examined	No. of water positive	% of water positive
Borehole water	65	0	0.0
Bottled water	15	0	0.0
Sachet water	60	5	8.3
Well water	80	15	18.8
*Yan-Garuwa water	80	8	10.0
Total	300	28	9.3

*Local water vendors.

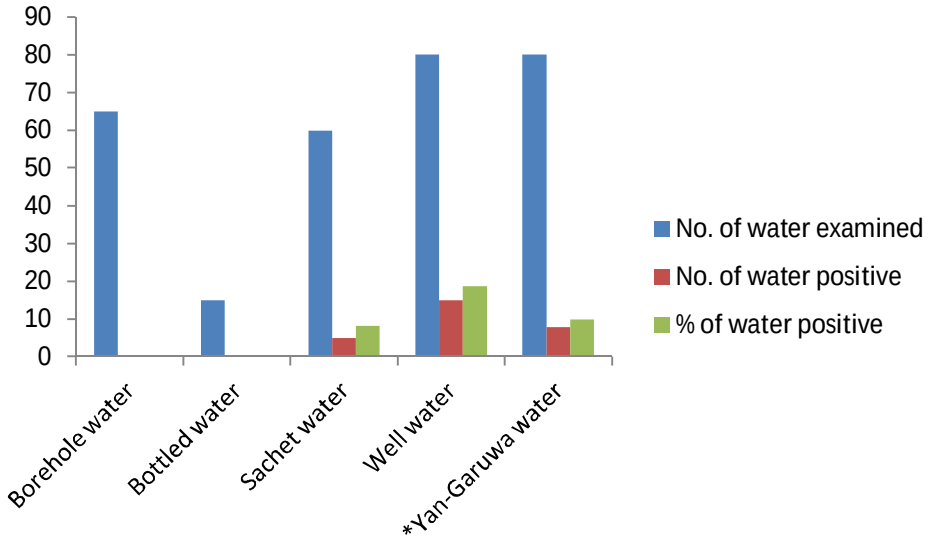

Figure 1. Percentage of *E. coli* in each of the water sample analyzed.

Data analysis

Data obtained were presented in tables and charts with frequencies and percentages calculated for the study variables. They were further analyzed statistically using Statistical Package for Social Sciences (SPSS) Version 13 software. Chi-square test at 5% level of confidence was used to compare the occurrence of *E. coli.* A P value < 0.05 was considered significant for all comparisons.

RESULTS

The results obtained from the study show that 28 (9.3%) *E. coli* were isolated out of the 300 hundred water samples analyzed (Table 1 and Figure 1). The isolation rate of the *E. coli* in well waters, 15/80 (18.5%) was significantly higher (P<0.05) than in Yan-Garuwa, 8/80 (10.0%) and sachet waters, 5/60 (8.3) respectively. No *E. coli* was isolated from both borehole and bottle waters analyzed.

Table 2 and Figure 2 show the resistance and susceptibility patterns of the 28 *E. coli* to the commonly used antimicrobials. Ampicillin and penicillin recorded 100% resistance while tetracycline, erythromycin and streptomycin recorded 78.6, 71.4 and 28.6% resistance respectively. On the other hand, the highest susceptibility was observed with gentamicin, chloramphenicol and Nalidixic acid with 28 (100.0%), 23 (82.1%) and 25 (89.7%), respectively.

DISCUSSION

Fecal coliforms and *E. coli* are bacteria that are associated with human or animal wastes. They usually live in human or animal intestinal tracts, and thus spread from human and animal wastes. Their presence in drinking water is a strong indication of recent sewage or human/animal waste contamination (Odonkor and Ampofo, 2013). During rainfalls, snow melts, or other types of precipitation, *E. coli* may be washed into creeks, rivers, streams, lakes, or ground water (Garba et al., 2009). When these waters are used as sources of drinking waters without treatment or inadequate treatment, *E. coli* may end up in drinking water (Garba et al., 2009). These pathogens may pose a special health risk for infants, young children, and people with severely

Table 2. Antimicrobial resistance and susceptibility pattern of the *E. coli* (N = 28) from drinking waters in Jalingo Metropolis, Taraba State, North-eastern Nigeria.

Antimicrobial	No. (%) resistant	No. (%) intermediate	No. (%) susceptible
Ampicillin	28 (100.0)	0 (0.0)	0 (0.0)
Chloramphenicol	3 (10.7)	2 (7.1)	23 (82.1)
Ciprofloxacin	5 (17.9)	2 (7.1)	21 (75.0)
Erythromycin	20 (71.4)	0 (0.0)	8 (28.6)
Gentamicin	0 (0.0)	0 (0.0)	28 (100.0)
Nalidixic acid	3 (10.3)	0 (0.0)	25 (89.7)
Penicillin	28 (100.0)	0 (0.0)	0 (0.0)
Streptomycin	8 (28.6)	0n (0.0)	20 (71.4)
Tetracycline	22 (78.6)	0 (0.0)	6 (21.4))

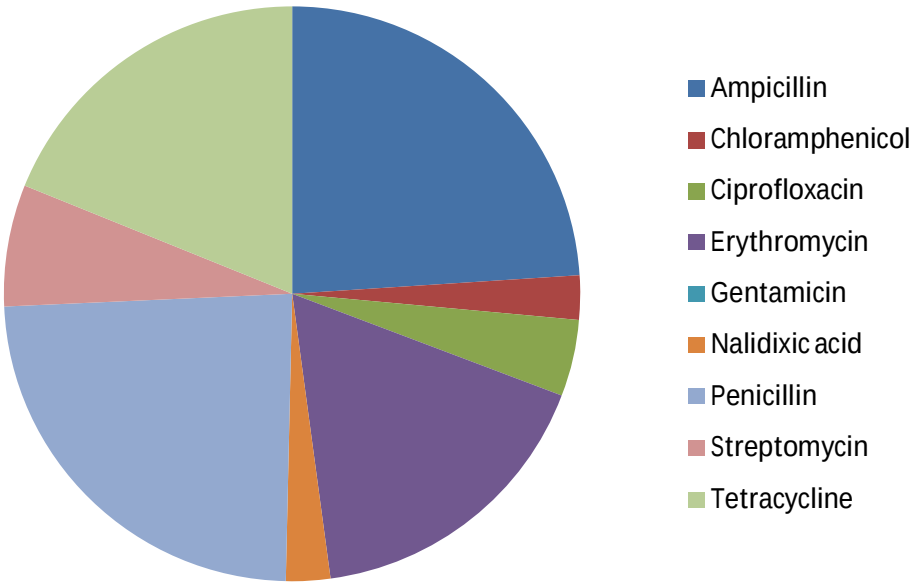

Figure 2. Proportions of percentage resistance of the 28 *E. coli* against each antimicrobial analyzed.

compromised immune systems causing diarrhea, cramps, nausea, headaches, or other symptoms (Moe et al., 1991). The World Health Organization (WHO) recommends that water that is satisfactory for human and animal consumption should not contained any coliform or *E. coli* (WHO, 1996). However, several studies around the globe including Nigeria have documented the presence of these pathogens in an amount exceeding the WHO recommendations (Moe et al., 1991; Abong'o and Momba, 2008; Garba el al., 2009; Odonkor and Ampofo, 2013; Ogunleye et al., 2013).

The isolation rate of *E. coli* in the drinking water from this current study is 9.3% (Table 1 and Figure 1). This result differ from and lower than the 25.5, 32.2 and 21.0% reported by Abong'o and Momba (2008), Ahmad et al. (2009) and Garba et al. (2009) in Amathole-District, South Africa, Muzaffarabad, Pakistan and Gusau, North-Western Nigeria respectively. The reason for the difference could be that all the three studies used the filtration techniques to enumerate both the total coliforms and *E. coli*. This procedure might have concentrated these organisms for easy detection in the medium. All the same the presence of this pathogen is of public health importance and did not meet the World Health Organization standard of zero *E. coli* per 100 ml of water. It was evident that well water had the highest occurrence of 18.8%, followed by the commercial water vendors (popularly called Yan-Garuwa) with 10.0% and sachet water with 8.3%. However, no *E. coli* was isolated from both the borehole and bottled waters examined. This result is comparable to that observed by Garba et al. (2009) in Gusau, North-Western Nigeria, who also reported high prevalence of *E. coli* in well water (45.5%) than packaged water (13.3%). However, the current

result is not in agreement with those reported by Bharath et al. (2009) and Kokkinakis et al. (2008) who discovered *E. coli* in bottled water with an incidence of 1.5 and 13% respectively in Trinidad and Crete, Greece. Most of the wells sampled are shallow and opened; therefore contamination might be through surface run-off during rains, leaching and directly by animals and poultry reared in various households (Garba et al., 2009). This may be the reason of the total absence of the pathogen in borehole waters which are normally dug very dip and required the use of machines to even draw the water out. The water sales by the commercial water vendors are also significantly contaminated by the pathogens with a prevalence of 10.0%. The contamination might have resulted either from the sources (wells, streams or rivers) or directly through unhygienic practices of the handlers (this needs to be verified).

The antibiotic resistance pattern of the *E. coli* isolates show that all (100%) of the isolates were resistance to penicillin and ampicillin, while 78.6 and 71.4% were resistance to tetracycline and erythromycin respectively (Table 2 and Figure 2). This is in agreement with the findings of Ogunleye et al. (2013) in which 96.7 and 73.8% resistance was recorded against ampicillin and tetracycline. However, unlike the study of Ogunleye et al. (2013), where high resistance was recorded against chloramphenicol (95.6%), ciprofloxacin (51.3%) and Nalidixic aid (61.7%), a low resistance of 17.9, 25.0 and 10.3% was obtained against these antibiotics. The findings from this study are favorably comparable to that of Garba et al. (2009) for recording zero resistance to gentamicin, and low resistance to ciprofloxacin and streptomycin in both studies (Table 2 and Figure 2). The fact that low resistance was recorded against these antibiotics may suggest that these antibiotics may be the drug of choice in the treatment of *E. coli* infection in the study area.

The total coliforms and *E. coli* as indicators of water quality is of concern to public health due largely to transmission to humans resulting to diarrheal related diseases that are mostly not detected. It was estimated that one-third of diarrheal related diseases and intestinal infections are waterborne, and that 40% of all deaths and 5.7% of the total disease burden are due to water, sanitation and hygienic associated problems (Odonkor and Ampofo, 2013).

Conclusion

It was concluded from this study that well and some sachet waters sold within Jalingo Metropolis do not meet the WHO standard for drinking water due to the presence of *E. coli.* The presence is an indication of sewage or human/animal wastes contamination and may also suggest that other coliforms and bacteria may be present. However, borehole and bottled waters are safe since they do not contain any *E. coli* in them.

RECOMMENDATIONS

1. The study recommends that regulatory agencies such as NAFDAC should ensure that all sachet waters for human consumption should be properly treated and also hygienic measures during processing and handling.
2. Wells should be constructed deep and away from any sewage or drainage system to avoid leaching or run-off of materials into the wells.

REFERENCES

Abong'o BO, **Momba** MN, **2008**. Prevalence and potential link between *E. coli* 015:H7 isolated from drinking water, meat and vegetables and stools of diarrhoeic confirmed and non-confirmed HIV/AIDS patients in the Amathole District-South Africa. J Appl Micribiol, 105(2):424-431.

Adewusi OA, **2012**. A study of the National Rural Water Supply and Sanitation Programme aimed at achieving Millennium Development Goals in eradicating water borne diseases in Nigeria. J Emerg Trends Econ Manag Sci, 3(3):272-276.

Ahmad MD, Hashmi RA, Anjum AA, Hamif A, Ratyal RH, **2009**. Drinking water quality by the use of Congo Red Medium to differentiate between pathogenic and non pathogenic *E. coli* at poultry farms. J Anim Plant Sci, 19(2):108-110.

Bagley ST, **1985**. Habitat association of *Klebsiella* species. Infect Control, 6(2):52-58.

Bharath J, Mosodeen M, Motilal S, Sandy S, Sharma S, Tessaro T, Thomas K, Umamaheswaran M, Simeon D, Adesiyun AA, **2003**. Microbial quality of domestic and imported brands of bottled water in Trinidad. Int J Food Microbiol, 81(1): 53-62.

British Society for Antimicrobial Chemotherapy (**BSAC**), **2009**. BASC methods for antimicrobial susceptibility testing, version 8, January, 2009.

Daly P, Collier T, Doyle S, **2002**. PCR-ELISA detection of *Escherichia coli* in milk. Lett Appl Microbiol, 34(3):222–226

Dziuban EJ, Liang JL, Craun GF, Hill V, Yu PA, Painter J, Moore MR, Calderon RL, Roy SL, Beach MJ, **2006**. Surveillance for waterborne disease and outbreaks associated with recreational water-United States, 2003–2004. MMWR Surveillance Summaries, 55(SS 12):1–30.

Eaton AD, Clesceri LS, Rice EW, Greenberg AW, **2005**. Standard Methods for the Examination of Water and Waste water, 21st Edition, APHA, Washington, D.C.

Ewing WH, **1986**. Edwards and Ewing's identification of Enterobacteriaceae, fourth edition, Elsevier Science Publishing Co., Inc., New York, Pp. 132-134.

Garba I, Tijjani MB, Aliyu MS, Yakubu SE, Wada-Kura A, Olonitola OS, **2009**. Prevalence of *Escherichia coli* in some public water sources in Gusau Municipal, North-Western Nigeria. Bayero J Pure Appl Sci, 2(2): 134-137.

Horan TD, Culver W, Jaris G, Emori S, Bamerjee W, Martone E, Hornsbeny C, **1988**. Pathogen causing nosocomial infection. Antimicrob Newslett, 5:65-67.

Janovy J, Schmidt GD, Roberts LS, **1996**. Gerald D. Schmidt & Larry S. Roberts' Foundations of Parasitology. Dubuque, Iowa: Wm. C. Brown.

Kaper JB, Nataro JP, Mobley HL, **2004**. Pathogenic *Escherichia coli.* Nat Rev Microbiol, 2(2):123–140.

Kokkinakis EN, Fragkiadakis GA, Kokkinaki AN, **2008**. Monitoring microbial quality of bottled water as suggested by HACCP methodology. Food Contr, 19(10):957-961.

Moe CL, Sobsey MD, Samsa GP, Mesolo V, **1991**. Bacterial indicators of risk of diarrhoeal disease from drinking-water in the Philippines. Bull World Health Organ, 69(3):305-317.

NPC/UNICEF, **2001**. Situation Assessment and Analysis Children and Women's Right in Nigeria – a Wakeup call.

Nwachuku N, **Gerba** CP, **2004**. Emerging waterborne pathogen can kill them all? Curr Opin Biotechnol, 15(3):175–180.

Nwachuku N, Gerba CP, Oswald A, Mashadi FD, **2005**. Comparative inactivation of Adenovirus serotypes by UV light disinfection. Appl Environ Microbiol, 71(9):5633–5636.

Odonkor ST, **Ampofo** JK, **2013**. *Escherichia coli* as an indicator of bacteriological quality of water: an overview. Microbiol Res, 4(e2): 5-11.

Ogunleye AO, Okunlade AO, Jeminlehin FO, Ajuwape ATP, **2013**. Antibiotic resistance in *Escherichia coli* isolated from healthy cattle at a major cattle market in Ibadan, Oyo State, South Western, Nigeria. Afr J Microbiol Res, 7(37):4572-4575.

Pelczar MJ, Chan ECS, Krieg NR, **1986**. *Microbiology*. 5th edition, Pp. 2056-2120.

Petrini B, **2006**. *Mycobacterium marinum*: ubiquitous agent of waterborne granulomatous skin infections. Eur J Clin Microbiol Infect Dis, 25(10):609–613.

Scotter S, Aldridge M, Capps K, **2000**. Validation of the method for the detection of *E. coli* 0157:H7 in Foods. Food Contr, 11:85-95.

Taraba State Ministry of Information and Social Development (**TSMISD**), **2004**. Taraba State of Nigeria Dairy, Published by Johnson and Co. Ltd., Pp. 2-4.

World Health Organization (**WHO**), **1996**. Guidelines for drinking water quality, Vol. 2. WHO, Geneva.

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