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Temporal variation in coliform densities in groundwater supplies in a County Residential Estate

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ABSTRACT

A study was carried out to investigate the extend of microbiological contaminants associated with sanitary waste in groundwater supplies in a densely populated residential estate. Samples were drawn from sixteen underground wells during wet and dry seasons and assayed for coliform densities in relation to proximity to pit latrines. The wells recorded presence of both total and fecal coliform bacteria, with peak contamination occurring during the wet season (mean total coliform count, cells/100ml – 1268.63) compared to dry season (mean total coliform count, cells/100ml- 520.07). The total coliform count varied significantly between the seasons (t=2.13, p=0.00002, P < 0.05). Similarly there was a significant difference in the fecal coliform count during the seasons (t=2.131, P=0.0064, p< 0.05) with a higher mean count (228.125) occurring during the wet season compared to 14.75 - dry season. A decrease in well depth marked an increase in coliform count during the wet season. Bacterial count was not significantly related to well- pit latrine isolation distance. Presence of E. coli in the groundwater is an indicator of possible presence of harmful pathogenic microorganisms associated with fecal pollution such as Salmonella, campylobacter, Shigella and enteric viruses which cause gastro-intestinal distress. Poorly constructed wells in proximity to pit latrines and open sewers occasioned by small sized landholdings poses a significant health threat to the inhabitants. Hence there is need to create awareness on construction regulatory standards of groundwater wells in order to curb the risk of contracting water-borne infections.

Key words*: coliform density, groundwater, pit latrines, contamination*

INTRODUCTION

Approximately 80% of the world's population lives in places where the available water is unportable. In many countries, polluted water has been established to account for more illnesses than all other causes of diseases combined [1]. Approximately 2.5 billion children die each year due to unsafe water and poor sanitation facilities [2]. Globally, there has been an overall increase in investment in water and sanitation to cope with the increasing demand; however, many regions of the world are in dire need of safe water and adequate sanitation services [1]. Water and sanitation are closely related to human health. Provision of safe water and improvement in sanitation lead to significant improvement in health through a reduction in the occurrence of diseases [3]. Availing safe drinking water to households and communities is identified as an effective strategy in tackling health problems and is an important intervention in reducing the burden of diseases [2]. Kenya is rated as a water scarce country with a current renewable freshwater supply at 647,000 liters per capita per year. This is far below the global benchmark of one million liters per person/year. Access to safe water in Kenya is estimated at 68% in urban areas and 49% in rural areas [4].

Kenya's water availability projection by 2025 will be in the "danger zone" of 235,000 liters per capita per year [5]. The Kenya vision 2030 flagship project in the health sector is to improve water and sanitation and to make these both accessible and available to the rural and urban populace by 2030 [6]. The local county authorities have largely been responsible for water and sewerage service provision and development within their areas of jurisdiction in the country. Inefficiency that characterizes most local county authorities, coupled with inadequate laws and laxity in their enforcement contributes to insufficient safe water supply and collapse of sewerage infrastructure. Kithaayoni estate in Machakos County lies outside the town's main water supply and sewerage system. The residents entirely depend on ground water supplies, mainly well water in proximity to pit latrines and septic tanks occasioned by small sized landholdings due to the increasing population demand. The groundwater is subject to fecal contamination during storms as surface runoff washes poorly disposed human waste to the sub-standard wells which act as sinks posing a great public health threat. Consumption of fecally contaminated water can lead to diseases such as cholera, dysentery, typhoid fever, poliomyelitis, among other water borne ailments. Many of the pathogens that cause illness and death to mankind are water related in one way or another [7]. The establishment of the microbiological groundwater quality within the densely populated estate with no proper sanitary infrastructure is therefore paramount for ideal policy decisions regarding dissemination of public health information.

MATERIALS AND METHODS

Physico- chemical parameters.

Water sampling was done during the months of march/April (wet season) and August/September (dry season). Field measurements included water PH, temperature, total dissolved solids and electrical conductivity. These were measured by their respective electrodes using a universal multiline P4 WTW (Weilheim Germany) meter and their range and mean values recorded. Well depth and the distances of wells from the nearest pit latrines were recorded.

Microbiological assays

Water samples were drawn into sterile 250 ml Teflon bottles using aseptic techniques and transported to the laboratory in ice cooler boxes within 6 hours for microbiological assays. Total and fecal coliform bacteria were assayed using the membrane filter technique.

Total coliform test

Sterile absorbent pads were placed in petri plates using sterilized forceps. 2.0 ml of M-Endo broth MF was added to the surface of each pad. 100ml water sample was filtered and the membranes (0.45 µm pore size) transferred respectively to each plate. The plates were incubated at 35^{o}C for 24 hours. Pink to dark red with a metallic sheen colonies were counted and recorded as total coliforms [8].

Fecal coliform test

Using the sterile forceps, sterile pads were aseptically inserted into snap- lid petri plates. 2.0 ml of M-FC broth was added to the surface of each pad. 100ml of the water sample was filtered and the membranes added to the plates respectively. The lids of the petri plates were snapped, sealed with waterproof tape and placed in a whirlpak bag. The plates were incubated in a 44.5 ± 2^{o}C water bath for 24 hours with the bags beneath the surface. Blue colored colonies were counted as fecal coliform colonies [8].

RESULTS AND DISCUSSION

Physico- chemical analysis

Physico-chemical characteristics especially temperature and PH influence the growth and diversity of microbial populations. The water temperature ranged from 22.00-25.00 ^{o}C and 21.50 – 24.00 ^{o}C in dry and wet seasons (Table- 1). This moderate temperature was suitable for the bacterial growth since most heterotrophs and coliform bacteria are mesophilic. During the dry season, bacterial numbers were observed to increase with decline in temperature recording a significant correlation (P= 0.02) (figure -1). The survival and growth of microorganisms has been established to increase in cooler conditions [9].

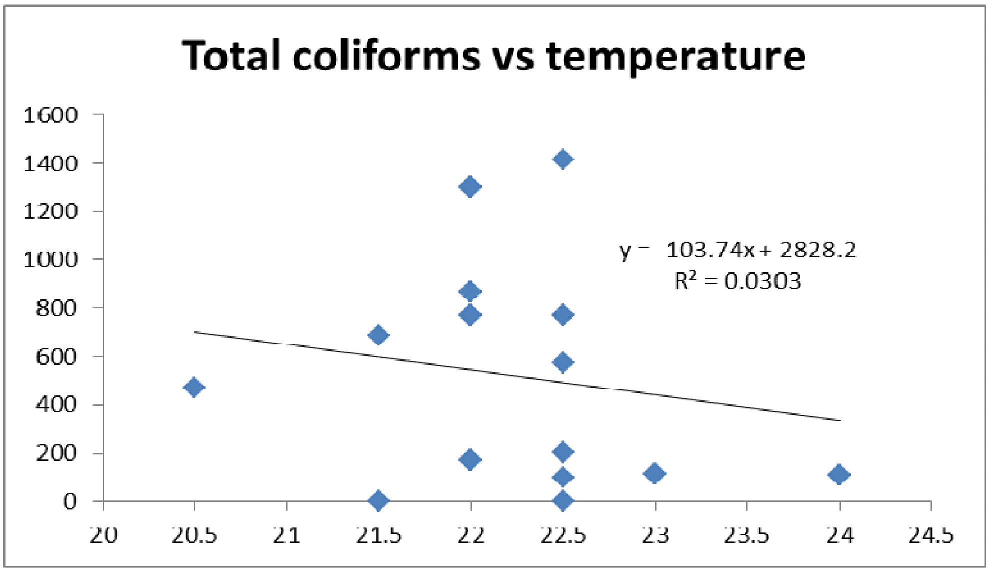

Figure 1. Relationship between total coliforms and water temperature

The pH range of the water in the wells (6.10 – 6.86 and 6.60 – 7.70 in dry and wet seasons) was generally neutral or slightly alkaline which was favorable for bacterial multiplication. The total dissolved solids ranged from 00 – 510 mg/l, and 00 - 801 mg/l in dry and wet seasons and electrical conductivity, 00 – 1020 µs and 00 – 1203 µs in dry and wet seasons. Most of the physico- chemical parameters recorded high mean values during the wet season attributable to runoff deposition of sanitary waste from households containing organic matter, detergents and residues of chemical pesticides and fertilizers from the adjacent agricultural farms which contributed to high total dissolved solids also influencing the electrical conductivity. Generally most of these physico-chemical parameters did not significantly influence the bacterial count.

Table- 1. Physico-chemical parameters during the seasons

Wells	Temp °C		PH		TDS mg/l		Conductivity (µs)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
K1	25.00	21.50	6.50	6.90	97.00	110.00	130.00	740.00
K2	22.50	22.50	6.60	7.60	215.00	720.00	330.00	440.00
K3	23.00	22.00	6.80	7.40	.00	660.00	390.00	1203.00
K4	22.00	21.50	6.10	6.60	110.00	780.00	78.00	506.00
K5	22.50	22.50	6.60	6.90	140.00	801.00	300.00	912.00
K6	22.00	22.00	6.20	7.40	120.00	202.00	.00	282.00
K7	22.00	22.50	6.70	6.90	510.00	499.00	.00	00
K8	25.50	20.50	6.60	7.40	200.00	219.00	220.00	210.00
K9	23.00	23.00	6.43	7.20	.00	.00	760.00	474.00
K10	23.50	22.50	6.10	6.60	.00	.00	.00	160.00
K11	22.00	22.00	6.64	7.70	271.00	350.00	490.00	1160.00
K12	22.00	22.50	6.86	7.30	.00	312.00	.00	315.00
K13	22.50	24.00	6.90	6.94	480.00	269.00	1020.00	371.00
K14	22.50	22.50	6.64	7.30	230.00	519.00	.00	370.00
K15	23.00	22.00	6.77	7.10	170.00	47.00	360.00	320.00
K16	23.00	22.50	6.64	7.40	260.00	530.00	170.00	810.00
Mean	**22.84**	**22.25**	**6.57**	**7.17**	**175.19**	**376.13**	**265.50**	**517.06**

Bacterial counts

Coliform bacteria were detected in all (100%) the water wells sampled in wet season and in 87.5% of the wells during dry season. However, total and fecal coliforms varied significantly with the seasons. The wet season recorded high total coliforms with a mean of 1268.61 compared to the dry season (mean 520.06). This marked a significant difference, t=2.13, P=0.00002, P< 0.05. Similarly there was a significant difference in the fecal coliform count between the seasons (t=2,131, P=0.0064, p<0.05) with the wet season recording higher fecal coliform counts (mean 228.13) compared to dry season (mean 14.75). This seasonal variation in bacterial contamination is attributable to wet weather (rainfall). Water and soil characteristics facilitate bacterial movement hence more contamination was evident in wet weather compared to dry conditions. Coliform bacteria can multiply rapidly or die off quickly depending upon water temperature and other variables [11]. Persistence of the bacteria through the dry season indicated suitability of the physico –chemical characteristics for bacterial growth. All the wells sampled yielded coliform colonies exceeding the limits stipulated by WHO maximum limits for drinking water –0 colonies/100ml water sample [11] except well K4 and K12 (dry season) (table-2). Groundwater in a properly constructed well should be free of coliform bacteria. Presence of coliforms in well water implies surface water has leaked into the well. This could be due to poor construction or cracks in the well since during the rainy season the sub-standard pit latrines and open sewers have their contents overflow and microorganisms may enter the water supply around a defective well casing or if the well over is not watertight. Soil wetness also facilitates contaminants travel through seepage hence more microbes in wastes from poorly constructed pit-latrines find their way into wells. This is evidenced by the high coliform counts during the wet season. The presence of a fecal coliform (*E. coli*) in drinking water is of immediate concern as many diseases can be spread through fecal transmission. Since these organisms are present, other disease causing enteric pathogens such as *salmonella, shigella, vibrio* and *campylobacter* may also be present [12]. The enteropathogens are likely to be present in much lower numbers than fecal coliforms, and a few infective bacteria are usually unable to overcome body defenses [13]. However, the risk of water borne illness dictates that the water must be boiled to kill the organisms before it is safe to drink.

Table-2. Total and fecal coliform count during the seasons

Wells	Wet season		Dry season	
	Total coliforms	Fecal coliforms	Total coliforms	Fecal coliforms
K1	1203.00	435.00	689.00	79.00
K2	789.00	6.00	102.00	.00
K3	1120	208.00	172.00	.00
K4	461.00	43.00	.00	.00
K5	579.00	22.00	770.00	2.00
K6	2419.00	22.00	770.00	2.00
K7	1957.00	988.00	576.00	52.00
K8	1413.00	579.00	469.00	1.00
K9	1120.00	126.00	114.00	.00
K10	980.00	82.00	201.00	5.00
K11	986.00	211.00	866.00	13.00
K12	62.00	3.00	.00	.00
K13	1610.00	48.00	108.00	.00
K14	1451.00	170.00	770.00	2.00
K15	1733.00	93.00	1300.00	6.00
K16	2016.00	654.00	1414.00	74.00

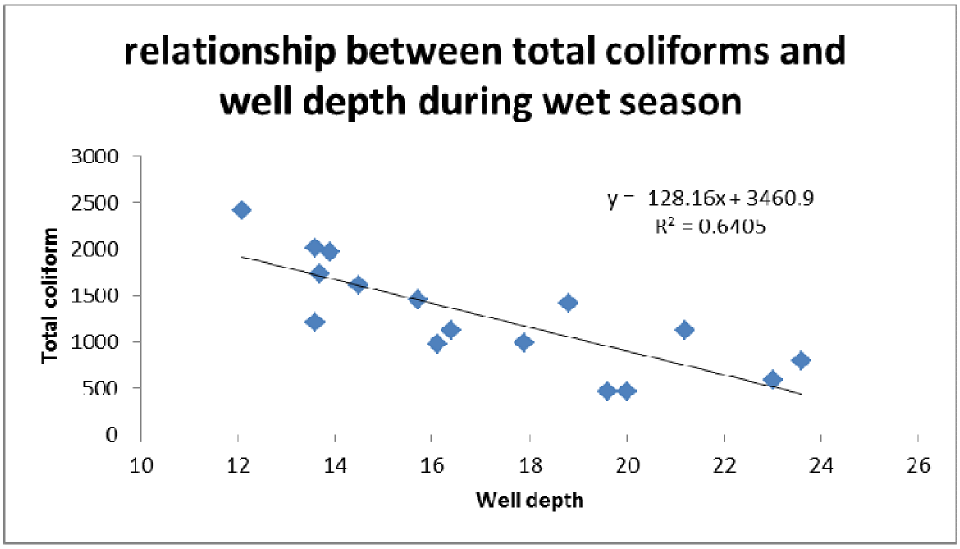

Figure1. Total coliforms and well depth during wet season

Well depth and well - pit latrine distance relative to coliform counts
The well depth ranged from 12.10 to 23.60 meters with a mean depth of 17.11 meters. Similarly, the distance between the wells and the nearest pit latrines ranged from 8.50 to 28.80 meters. The findings indicated a positive relationship between coliform count and well depth during the wet season ($F=0.00197$, $P<0.05$) (figure- 2) with shallow wells recording higher counts. However, the relationship during the dry season was not significant ($F= 0.056$, $P>0.05$) possibly due to die off rates. The survival of coliform bacteria in drinking water can range from one to several weeks depending on temperature and other conditions [14]. The decrease in coliform count with increase in depth is due to the ability of soil to filter bacteria as water infiltrates by gravity.

The ability of the soil to filter bacterial contaminants increases with the increase in depth from the surface. The longer the distance/depth, the better the soil filterability capacity and the lesser the bacterial load. More coliform bacteria are transported over shorter distances and at a much faster rate to enter the shallow wells compared to the deeper wells. This reduces their die off rate that usually occurs with time. Both seasons recorded no significant relationship between the bacterial count and the well pit latrine isolation distance, $r= 0.867$, $p>0.05$ (wet season) and $r=0.081$, $p>0.05$ (dry season).

It was observed that some wells both nearer and far away from the pit latrines (K15, K16) recorded increased numbers of coliform bacteria attributable to leakage of surface runoff due to poor construction/casing enhancing microbial contamination through cracks on the walls. Past experiments have confirmed presence of bacteria and viruses in percolating water. Fecal coliforms and fecal streptococci from percolation beds infiltrated sand and gravel and were detectable 200ft downstream from the percolation beds [15]. Quality water was found in a well (K12) quite close to a pit latrine implying the quality of well construction greatly reduces the chances of contamination. However, studies conducted in Central Ohio city of Delaware to determine a rough estimate of ‘safe distance’ between houses and wells from which water was microbiologically safe confirmed a hydrogeological connection between the latrines and the wells [16], where the distances separating a well and a pit latrine and the nature of geology within the locality determined the microbiological quality of the water.

CONCLUSION

Bacteriological quality of groundwater is influenced physical conditions such as standards of well construction, well depth and soil characteristics. Most groundwater supplies within Kithaayoni estate are fecally polluted and hence unfit for human consumption unless treated or boiled. The inhabitants and other users are therefore at risk of contracting water – borne infections such as typhoid fever, bacillary dysentery, cholera, infectious hepatitis, poliomyelitis and other ailments transmitted through consumption of fecally contaminated water. There is need to create awareness on the potential health threats of consuming untreated water and the importance of observing regulation standards of construction and maintenance of groundwater wells.

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REFERENCES

[1] W.H.O. Bulletin of the World Health Organization. Geneva, **2008,** 86 (1), 1-8
[2]World Bank, Better Health in Africa: Experiences and lessons learned, World Bank publications, **1995**, 3 & 31
[3]W.H.O. Community water supply and Excreta Disposal in Developing countries, Geneva, **1975,** 10
[4] Government of Kenya, MDGs status Report for Kenya, Govt printer, **2005**, 6
[5] Institute of Economic Affairs, the Daily nation, 6 April, **2008**, 21
[6] Government of Kenya, Kenya vision 2030: 1st Medium Term Plan, **2007**, 104
[7] W.H.O. guidelines for drinking water quality, 3rd Ed. Geneva, Switzerland, **2004**, 21
[8] J.P Harley and L.M Prescott. 3rdEd. Laboratory Exercises in Microbiology, Wm.C. Brown publishers, U.S.A, **1996**, 168
[9] NF Gray. Water Technology: An Introduction for Environmental Scientists and Engineers 2nd Ed. Butterworth-Heinemann, New Delhi, India **2005**, 26
[10] American Public Health Association. Standard methods for the examination of water and waste waters, 19th Ed. Washington DC, **1995**, 109

[11] W.H.O. guidelines for drinking water quality, Geneva, **1985**, 13, 121
[12] W.H.O. guidelines for drinking water quality, Geneva, **1984**, 13, 130
[13] E. Scott, *Journal of Hygiene* (camb) **1982**, 279-293
[14] American Public Health Association. Standard methods for the examination of water and waste waters, 18^{th} Ed. Washington DC, **1992**, 134
[15] SB Watts and WE Wood. Hand-dug wells and their construction. Intermediate Technology publications Ltd, London, UK, **1979**, 34, 36
[16] WA, Petty, Water quality in a stressed environment, Burgess publishing Co, Minnesota, USA, **1974**, 196-249