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Bacteriological Concentrations Of Groundwater From Shallow Wells In Seme Area, Kisumu County, Kenya.

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Abstract
Globally water sources for domestic, irrigation and industrial uses are deteriorating as a result of intensive human activities. Surface pans, boreholes and shallow wells are some of the major sources of groundwater used for irrigation as well as domestic purposes. This study was aimed at assessing groundwater quality in Central Seme area, Kisumu County. Bacteriological parameters was the main focus and included total coliforms and E. coli. 15 shallow wells were purposively selected and their geographical positions shown using GIS. Collection of water samples was done in the month of September and transported to Lake Victoria South Water Works Agency (LVSWWA) laboratory in Kisumu for analysis within 24 hours. Results from laboratory analysis was compared to WHO and KEBs guidelines for drinking water purposes. The mean value recorded for total coliforms was 153.47 CFU/100ml where W_1 202, W_2 undectectable levels, W_3 182, W_4 328, W_5 160, W_6 188, W_7 220, W_8 314, W_9 96, W_{10} 106, W_{11} 144, W_{12} 134, W_{13} 120, W_{14} 18 and W_{15} 89. E. coli had a mean of 49.87 CFU/100ml where W_1 96, W_2 undetectable levels, W_3 250, W_4 88, W_5 & W_6 undetectable levels, W_7 150, W_8 128, W_9 , W_{10} & W_{11} undetectable levels, W_{12} 36, $W_{13,}$ W_{14} and W_{15} undetectable levels. Both total coliforms and E. coli were measured in CFU/100ml of water samples. Significant differences was accepted at $p \leq 0.05$, total coliforms ($p=0.000$) and E. coli ($p=0.025$). This was in comparison with WHO/KEBS standards for drinking purposes. $p=0.000$ total coliforms and $p=0.000$ E. coli, showed significant differences among the wells. Well water from Seme Sub County was found to be contaminated by microbial bacteria and therefore the study recommended thorough treatment of the well water to remove contaminants before use, proper storage of well water since contamination also occur during storage processes and adequate sanitation solutions since groundwater is widely used as the main source of water in the area.

Keywords: - *Shallow wells, Water quality, Water quality parameter.*

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I. Introduction

Water is vitally necessary for human life. Support of human health as well as economic and social development is entirely dependent on ready access to enough water supplies (Mohammad 2015). Although water is usually regarded as abundant resource that covers 70% of the planet Earth, its availability to human is affected by many factors such as poor quality due to intense pollution, shortages as a result of high demand by rising population, climate change among others (Mohammad, 2015). For instance, climate change increases precipitation in some areas leading to floods and hence 21 million individuals globally are in danger of river flooding each year (UNIDA, 2015). To add onto, approximately over 5 million families worldwide utilize unsanitary water (Khalifa & Bidaisse 2018). Shortage of water supply in Kenya and the entire developing countries has been and still a major challenge. Furthermore, about 50% of the entire global population will be staying in regions of increased water scarcity by 2025 as a result of the existing climate change problem (UNIDA, 2015).

India experiences high annual rainfall though not evenly distributed in time and space resulting in much of the rainfall escaping as runoff hence incomplete utilization of surface water (Gupta *et. al.,* 2017). South Africa Council for S.I.R reported that approximately over a million South Africans do not have enough infrastructure for clean water distribution (Edokpayi *et al.,* 2017). Water shortage in Kenya is caused by draught, floods, increased population and degradation of forests as well as water pollution (Olago 2019). In addition to, Northern Water Services Board (NWSB) 2019 reported that acute water shortage had hit Northern Kenyan and over 2 million people and hundreds of livestock were in need of urgent water supply. Water quantity as well as poor water quality in Kenya has led to loss of lives due to diseases such as cholera, typhoid, dysentery and diarrhea (WHO 2018, Kumar *et al*., 2016). It has also led to low standard of living and affected education in some areas where children miss crucial hours of school in search of water (WASREB, 2016). WHO reports that 41% Kenyans are dependent on groundwater sources from dug shallow wells and boreholes while 59% uses improper sanitation solutions (WHO, 2018). Most of these problems are common in rural areas and slums (UNICEF, 2020).

The known causes of groundwater contamination are industrial wastes, hospital wastes, agricultural runoffs and domestic discharge among others (Algoul *et al.,* 2019). All these introduces microbes into water bodies. Activities of these microbes affect groundwater quality (Haseena *et al.,* 2017). This occurs due to leachates from both animal and human effluents (Karunanidhi *et al.,* 2021). Consequently occurrence of bacteria such as total coliforms and E. coli in water bodies increases prevalence of infectious diseases such as cholera, diarrhoea, dysentery and typhoid to human beings when consumed (Haseena *et al.,* 2017). According to WHO 2018, 14.75% of total deaths in Kenya occur as a result of diarrhoeal diseases. Specifically *Escherichia coli* (*E.coli*) bacteria in groundwater indicate contamination by fecal matter of human beings and other animals (Al-Tameemi *et al.,* 2020). As soon as groundwater is polluted, it is difficult renewing its quality with respect to long duration of storage recovery cycle, therefore supervision and valuation of its quality regularly is vital (Wu *et. al.*, 2015, Patil *et al.,* 2012). Such kind of water is unsuitable for drinking purposes unless properly treated to eradicate bacterial growth which can be achieved through chlorination and even boiling (Al-Tameemi *et al.,* 2020). Therefore, regular evaluation of quality of water from the shallow wells for human consumption is necessary to prevent or reduce their contamination.

II. Materials And Methods

Study area

The study area was Central Seme in Seme Sub-County located in Kisumu County. The Sub County boarders Kisumu West Sub County with a population of approximately 121,667 where male 57,658 and female 64,007 (Kenya Census Data 2019). It lies between the latitude of 0.0833^0 S and longitude 34.5167^0 E with an elevation of 1278 meters above sea level. It's about 72 kilometers from Kisumu town. It occupies an area of approximately 190.20 in Sq.Km (IEBC, 2017).

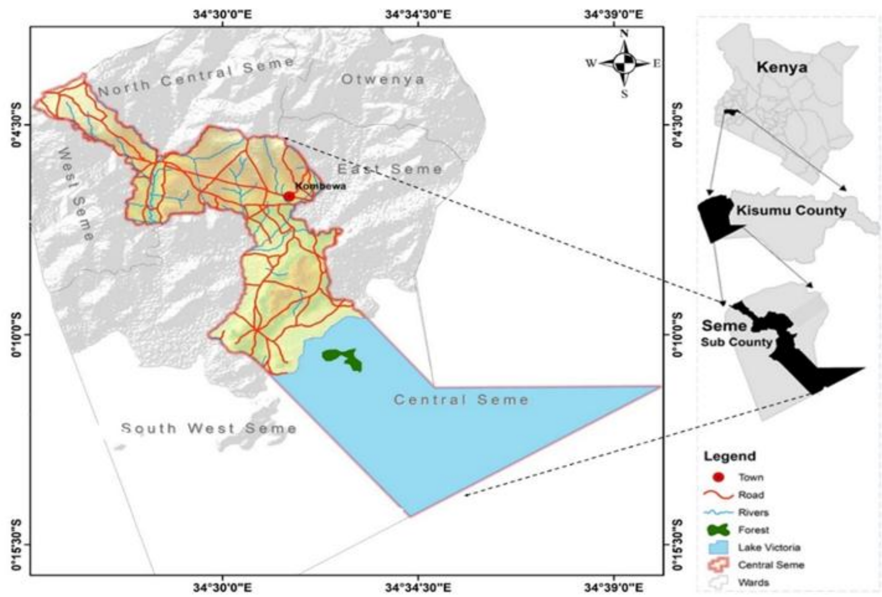

Figure. 2.1: Map of Kisumu County showing Seme Sub- county and Central Seme the study area. Source: (World Resourses Institute WRI 2020).

According to Kisumu County Weather Statistics 2016, the mean annual rainfall ranges between 1200mm and 1300mm. The rainfall is bimodal, where short rains occur in the months of September to December while long rains are in the months of March to June. It is warm throughout the year with annual temperature ranging between $20^{o}C$ and $35^{o}C$. Coolest months are July and August (24^0C) while Feb and March (30^0C) are the hottest (Kisumu County Weather Statistic 2016). Seme area is compost of tertiary volcanic rocks including phenolics, basalts and granitic rocks. Sedimentary rocks are found near the lake, formed as a result of pre-existed ores due to erosion, transportation and deposition. These are overlain by alluvial deposits and soil compost of sands, clay (little) and gravel. The vegetation is mainly shrubs with few trees (Belcher 2015, Sifuna *et al.,* 2014). The main ecomonic activity is subsistence farming where the farmers use fertilizers, herbicides and pesticides to increase crop production. The crops grown are sugarcane, groundnuts, sorgum, beans, maize and millet as a cah crop. Livestock keeping is on small scale while fishing is practised by the communities living along the shores of Lake Victoria (Sifuna *et al.,* 2014).

Sampling methods

The research design used in this study was quantitative. Seme Sub-County was selected since most people in the area uses groundwater for human consumption as well as watering livestock. The groundwater sources includes dug wells and drilled boreholes. To get a representative samples of shallow wells in the study area, it was divided into three zones: Kanyadwera, Kombewa and Othany. From each zone, 5 shallow wells were purposively selected. This sampling method was used because of the difficulty in identification of residential homes with shallow dug wells in the area. A total of 15 wells were marked using GIS machine and the mapping was done with the help of Arc GIS system. Information on the depth of the wells was gotten from the well owners.

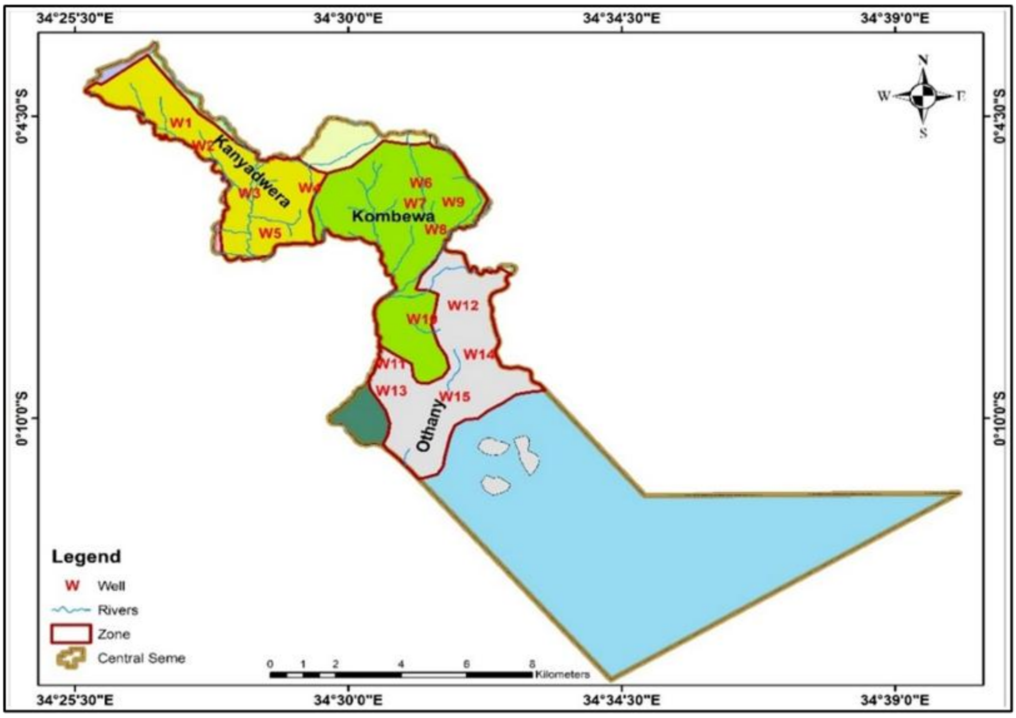

Figure 2.2: Map showing distribution of sampled shallow wells.
Source: WRI (2020).

FID	Name	Elevation	Longitude	Latitude	Depth
Kanyadwera					
0	W1	1162.149	34° 31' 11.964"	- 0° 8' 11.436"	24.50m
1	W2	1149.594	34° 30' 42.012"	- 0° 8' 59.496"	11.88m
2	W3	1165.322	34° 30' 36.792"	- 0° 9' 22.716"	12.80m
3	W4	1206.208	34° 32' 11.04"	- 0° 8' 50.316"	14.32m
4	W5	1204.878	34° 28' 40.98"	- 0° 5' 29.292"	8.83m
Kombewa					
5	W6	1225.636	34° 31' 11.748"	- 0° 5' 51.648"	10.00m
6	W7	1215.869	34° 31' 45.624"	- 0° 9' 37.008"	30.50m
7	W8	1212.972	34° 31' 12.864"	- 0° 6' 13.572"	28.70m
8	W9	1213.173	34° 31' 12.504"	- 0° 6' 13.536"	15.85m
9	W10	1212.247	34° 28' 43.896"	- 0° 6' 38.052"	17.00m
Othany					
10	W11	1229.876	34° 29' 21.264"	- 0° 5' 50.172"	19.35m
11	W12	1242.72	34° 27' 35.604"	- 0° 5' 5.676"	14.90m
12	W13	1253.202	34° 27' 15.516"	- 0° 4' 47.136"	20.25m
13	W14	1222.507	34° 31' 55.128"	- 0° 7' 57.72"	15.24m
14	W15	1220.079	34° 31' 46.992"	- 0° 6' 4.212"	14.02m

Table 2.1: Well-coordinate positions Source- GIS system, depth - from residents

Sample collections and storage.

Water samples was collected in the month of September 2021 in accordance to Environmental Protection Agency. Samples for bacteriological parameters was collected in standard glass bottles neatly corked and covered using alluminium foil and transported to Lake Victoria South Water Works Agency (LVSWWA) laboratory in Kisumu within 24 hours. Analysis was done in accordance with WHO guidelines for drinking water quality standards (APHA 1998, WHO 2017). Analytical method used was multi-tube method.

Data analysis and presentation.

Data was analyzed using one way anova and chi-square (Edokpoyi *et. al.*, 2018) to find out the significant differences in bacteriological concentration of the well waters compared to KEBs and WHO standard limits for drinking purposes and among the wells. Tables and graphs were used to present the data obtained.

III. Results And Discussion

Table 3.1: shows the comparison of mean values of bacteriological parameters among the wells within the study area. Table 3.2 shows analysis of the results in comparison with WHO/KEBS for drinking water.

Total coliforms

The level of total coliforms population within the wells showed variation, it ranged from undetectable levels in W2 to 328 CFU/100ml in W4 (Figure 3.1). The mean coliform population recorded was 153.4 CFU/100ml (Table 3.2). Well 2 recorded undetectable levels which was below WHO/KEBS limit for drinking purposes and therefore considered safe for human comsumption. The mean coliform population in groundwater was significantly different compared to the standards of WHO and KEBS *p=0.000* (Table 3.2) as well as among the 15 wells in the area *p=0.000* (Table 3.1)

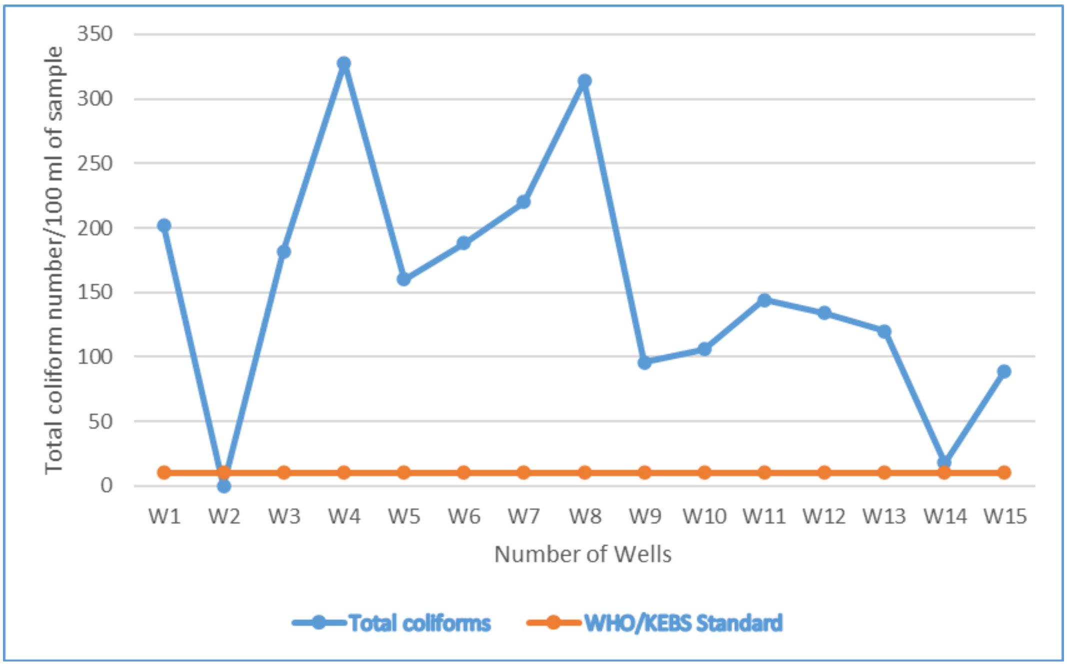

Figure 3.1: Measured values for Total coliforms during the study period (2020).

Bacterial contamination of shallow wells is influenced by seasons (Adimalla & Wu 2019). During wet seasons there's a lot of run offs which gets into uncovered well waters. Infiltration of wastewater from surrounding environment (Lutterodt *et al.*, 2021) is another leading factor. Location of the wells is also a contributing factor since some are dug in close vicinity to pit latrines which are sited at high altitude than the wells, there could be a possiblity of leaking human waste effluents into well water (Mbaka, Mwangi & Kiptum 2017).

The high number of bacteria in more than 80% of the sampled wells in the study area could be as a result of high contamination due to runoffs and seepage especially the wells which had no protective fencing around them or even cover. Dried human or cattle wastes may have also been blown away by the wind into the wells.

The mean value of total coliforms of 153.4CFU/100ml recorded in groundwater of Seme is lower than 198.6 MPN/100ml in groundwater of Veracruz, Mexico (Megchun *et al.,* 2015) but higher than 6.3CFU/100ml recorded from groundwater in Nigeria (Adenkule *et al.,* 2012). Lutterodt et al 2021, also recorded countless coliforms population in shallow wells of Coastal Ghana.

E. coli

Population of *E.coli* in the study area showed variation. It ranged from undetectable levels in W2, W5, W6, W9, W10, W11, W13, W14 and W15 to 250 CFU/100ml in W3 (Figure 3.2). The mean *E. coli* concentration was 49.87CFU/100ml (Table 3.2). This value was above WHO/KEBS standards for drinking purposes. There was significant difference in mean population of *E. coli* in groundwater compared to WHO and KEBS limits for drinking water (*p=0.025*, Table 3.2) as well as among the wells *p=0.000* (Table 3.1).

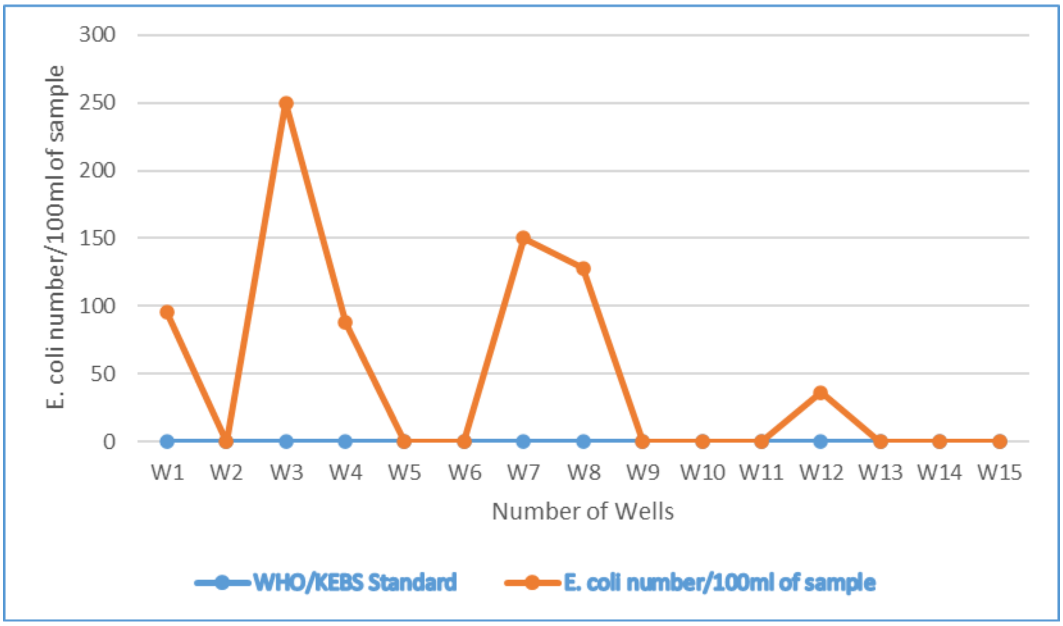

Figure 3.2: Measured values for E. coli during study period (2020)

Presence of E.coli in groundwater is influence by high human population and location to animal or human effluents (Indrastuti & Takizawa 2021). Dissolved oxygen is another factor that may contributes to high level of bacteria within well water. To add onto, absence of dissolved oxygen decreases growth of E. coli and vice versa (Aromolaran *et al.*, 2022).

The high concentration of *E. coli* population in W3 and W7 could be attributed to the location of the wells near pit latrines or sited at a higher ground than the wells. This facilitate seepage of human effluents into the well water. Lack of protective cover and cement lining surrounding the wall of the well is also a factor to consider.

The mean value of E. coli of 49.87 CFU/100ml recorded in wells of Seme is lower than 130 CFU /100ml recorded in groundwater of Jatimulyo, indonesia (Indrastuti & Takizawa 2021) but higher than 2.5 CFU/100ml recorded in Southwest, Nigeria (Aromolaran *et al.*, 2022).

Table 3.1: Statistical analysis of biological parameters of groundwater among the wells.

Parameters	Mean	n	SD	SE	P-value
E. coli	49.9	15	76.7	19.8	0.000
Total coliforms	153.4	15	91.9	23.7	0.000
Signif. codes:	0'***'	0.001'**'	0.01'*'	0.05'.'	

Source: Researcher.

Table 3.2: Statistical analysis of groundwater quality as compared to WHO/KEBS limits.

Variable	Obs.	Mean	Std. Dev.	WHO	KEBS	F Value	P Value
E. coli	15	49.87	76.69	0/100ml	0/100ml	2.518	0.025
Total coliforms	15	153.4	91.911	10/100ml	10/100ml	6.043	0.000
Signif. codes:	0'***'	0.001'**'	0.01'*'	0.05'.'			

Source: Researcher

IV. Conclusion And Recommendations

Conclusion

The level of bacteriological parameters of groundwater in Seme Sub-County was significantly different among the shallow wells.

There was also significant differences in shallow well waters within the study area compared to WHO/KEBS standard for drinking purposes. The water from the wells were contaminated by *E. coli* (49.87 CFU/100ml) and total coliforms (153.47 CFU/100ml) hence the quality of water from the wells was regarded as poor.

Recommendation

To meliorate the quality of shallow well water in the area, pot chlorination, proper boiling and rehabilitation of well covers as a better protection of the wells is recommended. Mass education on water quality should be availed frequently to Seme community. Lastly, regular treatment of water at household level before usage should be practised.

Recommendation for future studies.

Researchers are recommended of the following:-

1. Development of suitable and cost-effective technologies in groundwater treatment for rural communities is of great essence.
2. Heavy metals contamination of groundwater in the area.
3. Study on waterborne diseases caused by consumption of contaminated water.

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Almighty God Bless You All

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