The Effect of Septic Tanks Sewage Disposal System Distances on Borehole Water Quality in Ongata Rongai, Kajiado County, Kenya

DEBORA H A. ABONG’O
DEPARTMENT OF CHEMISTRY, UNIVERSITY OF NAIROBI
EMAIL: dabongo@uonbi.ac.ke

JOHN O. ONYATTA
DEPARTMENT OF CHEMISTRY, UNIVERSITY OF NAIROBI
EMAIL: john.onyatta@uonbi.ac.ke

HINGA MBUGUA
DEPARTMENT OF CHEMISTRY, UNIVERSITY OF NAIROBI
EMAIL: hingambugua@gmail.com

Corresponding Author:
DEBORA H A. ABONG’O
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF NAIROBI, KENYA
EMAIL: dabongo@uonbi.ac.ke
Abstract
Septic systems are designed to treat human wastes, hence properly functioning systems should be able to attenuate organic matter, microbes and most cations. The borehole water quality in Ongata Rongai in Kajiado County, Kenya is of concern due to construction of septic tanks near the boreholes. A study was conducted to determine the effect of septic tank disposal system distances on borehole water quality. Water samples were collected from ten different boreholes at mean distances ranging from 16 -146 m from five septic tanks in the high to medium density settlement areas that use borehole water for domestic purposes. The study showed that nitrates (16.8±1.0 mg/l), chlorides (144.4±4.6 mg/l), sodium (217±4.24 mg/l), chemical oxygen demand (COD) (75±8.0 mg/l) and total dissolve solids (TDS) (896±1.9 mg/l) were the common contaminants in the analyzed borehole waters during the wet season (May) based on World Health Organization (WHO) standards. This study is of significance in providing policy guidelines for sighting of septic tanks in area.

Key words: Boreholes, Ongata Rongai, Septic tank distance, Water quality.

I. Introduction
The increased demand for clean and adequate water for domestic use is one of the necessities that require urgent attention (Mumma et al., 2011). Groundwater makes up 97% of global freshwater, excluding ice and is the most intensively exploited natural resource in the world (Mumma et al., 2011). The current policy of Nairobi Water and Sewerage Company (NWSC) is concerned with surface water however there is little concern over the groundwater (Focht and Verstreete, 1977). In the non-planned peri-urban settlements like Ongata Rongai in Kajiado County, the residents rely on water boreholes that have been constructed within the vicinity of septic tank disposal systems.

The groundwater contamination by septic disposal systems is likely to occur in areas where the septic tanks are placed closely to the boreholes. The concern on the effect of septic tanks on the water quality prompted this study to be initiated. Furthermore, the water supply from Oloolaiser Water and Sewerage Company that is mandated to serve Ongata Rongai and Ngong areas of Kajiado County has proved to be unreliable over the years (Kazungu, et al, 2011). According to De (2010), contamination sources to groundwater include pathogenic microbes, heavy metals, organic substances and inorganic chemicals. Omwenga et al., (2009) reported that there is a direct link between access to portable water to reduction in epidemic diseases as well as infant survival rates. Studies have shown that 50% of all preventable illnesses in Kenya are water, sanitation and hygiene related (WHO, 2003). Nairobi and its environs are faced with a population influx that has resulted into rapid, unplanned urbanization, and lack of a proper sewerage system (Omwenga, et al., 2009). At household level, access to water supply and waste disposal are low and only 66 % of households have sewer connections (Omwenga, et al., 2009). The quality of ground water is threatened by overwhelming numbers of septic tanks, improper disposal of household wastes and wastewaters (WHO, 2003).

According to Kenya Vision 2030 which is the country’s development blue print for the period 2008 to 2030, Kenya, is to ensure that improved water and sanitation are available and accessible to all. Adelekan (2010) reported that groundwater in urban areas is under threat of contamination from solid waste leaches, raw sewage and industrial effluent discharges that seep into groundwater bearing rocks. Therefore, the sighting of septic tanks in the vicinity of water boreholes has raised health concerns on the water quality among the residents of Ongata Rongai in Kajiado County Kenya. Hence this study was undertaken to determine the level of borehole water contamination in Ongata Rongai,
Kajiado County Kenya arising from septic tank disposal systems as a result of their distances to the boreholes.

2. Materials and Methods

2.1 Study area

The study area, Ongat Rongai, (Figure 1) covers an area of 16.5 km$^2$ with a population of 41,000 people that is projected to reach 52,513 in 2015 (GoK, 2008). It is a fast developing residential urban area within Kajiado County; at latitude (0° 53’ 60’’ S), and longitude (36° 25’ 60’’ E). It is located 50 Km from Kajiado County head offices and 20 Km from Nairobi County central business district (CBD) along the Langata-Magadi Road, Figure 1.

![Figure 1. The location of the sampling sites](image-url)
2.2 Sampling of the borehole waters

A total of 10 boreholes in the whole catchment area (Table 1) that were located adjacent to the septic tanks sewage disposal systems (≤ 200 m) were selected for sampling. A baseline data on depth, water rest level and yield at the time of drilling the boreholes were obtained from the Ministry of Water, Environment and Natural Resources before water sampling (Table 1). The distance between each borehole and the septic tanks were measured and recorded (Table 1).

Table 1: Baseline data and distance between the selected boreholes and Septic tanks

<table>
<thead>
<tr>
<th>Borehole No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole depth (M)</td>
<td>210</td>
<td>80</td>
<td>178</td>
<td>234</td>
<td>94</td>
<td>296</td>
<td>162</td>
<td>286</td>
<td>130</td>
<td>160</td>
</tr>
<tr>
<td>Water rest level (M)</td>
<td>30</td>
<td>20</td>
<td>48</td>
<td>51</td>
<td>27</td>
<td>67</td>
<td>43</td>
<td>116</td>
<td>23</td>
<td>50</td>
</tr>
<tr>
<td>Yield (M³/hr⁻¹)</td>
<td>6</td>
<td>12</td>
<td>13</td>
<td>11</td>
<td>13</td>
<td>10</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Distance from septic tank</td>
<td>63</td>
<td>33</td>
<td>61</td>
<td>31</td>
<td>16</td>
<td>120</td>
<td>16</td>
<td>33</td>
<td>32</td>
<td>146</td>
</tr>
</tbody>
</table>

The water samples were collected in triplicates in two-litre plastic containers, that were thoroughly cleaned by rinsing with about 50 ml of 8M HNO₃, followed by repeated washing with de-ionized water. Water sampling was done in March (dry) and May (wet) seasons in 2014 in order to determine the effects of the long rain and dry seasons on water quality parameters.

The sample containers were labeled and the samples were temporarily stored in polyurethane cool boxes containing dry ice in the field vehicle for transportation to the laboratory for subsequent analyses. A total of thirty samples were collected from each location, during the dry and wet season. Temperature, pH, and conductivity were measured on the site at the time of water sampling using HANNA pH meter, (Model HI 28129); Jenway conductivity meter, (4510 model).

Water samples for bacteriological analysis were collected in triplicate in a 1 litre glass bottles that were thoroughly cleaned and initially sterilized in an autoclave. The hands were cleaned using the cotton swab soaked in methylated spirit and the mouth of the water faucet were also cleaned in the same manner (APHA, 1994). The samples were taken to the laboratory and were stored in the refrigerator at ≥ 4°C and analyzed within 6 hours after collection.

2.3 Analysis of water samples

Water samples were analyzed according to APHA (1994) Standard Methods for the Examination of Waters and Wastewaters and the Water Quality Sampling Manual. Total dissolved solids were determined according to common procedures gravimetric analysis. Turbidity was determined by Nephelometric method using Hanna H198703 turbidimeter (APHA, 1994). Alkalinity was also analyzed according to APHA (1994) and the total alkalinity was calculated according to equation (1).

\[ \text{Total alkalinity (mg/l)} = \left( \frac{V \times M \times 100,000}{\text{ml of sample used}} \right) \]  

where \( V \) = volume of acid used and \( M \) = Molarity of acid used.

2.4 Analysis of the inorganic constituents E. Coli

2.4.1 Analysis of ammonia

To determine ammonia concentration, 2ml 10% NaOH was added to 100 ml of the water sample followed by 1ml of 10% ZnSO₄.7H₂O and 1ml of NaOH. The mixture was filtered (Ca, Fe, Mg, S²⁻, were precipitated) and the colourless middle fraction was drawn. 1 drop of 50% EDTA [disodium salt]
was added and mixed well followed by 2ml of Nesler’s reagent (70g KI + 160g NaOH, ice cooled, diluted to one litre and mixed well by shaking). The resulting yellow colour was determined using UV spectrophotometer (Model: UV-1601) at 420nm and the level of ammonia (ppm) recorded.

2.4.2 Analysis of nitrate

To analyze nitrate, 500ml of water sample was taken in NH₃ distillation apparatus; 50ml of 10% (w/v) NaOH was added and evaporated to about 200 ml then cooled. 3g of Devarda’s alloy, then 30ml of 10% NaOH was added and immediately connected to the flask with a vertical condenser with an outlet dripping into a receiver containing 200ml of 0.1M H₂SO₄. The mixture was distilled for 1 hour and the distillate was made up to 250ml. 10 ml aliquot was drawn into a 50 ml volumetric flask and neutralized to pH 4.5 using 0.1 M H₂SO₄. 2ml of Nestler’s reagent was then added and the distillate directly back titrated with standard alkali (0.2 M NaOH) using Methyl red as indicator and the results calculated.

2.4.3 Analysis of nitrite

Nitrite was determined by taking 40 ml of water sample in a 250ml conical flask and pH was adjusted to 7.0 using H₂SO₄ or NaOH, 2ml of sulphanilamide solution (50g in 500ml of 1.2N HCl) was added, shaken then allowed to stand for 10 minutes, 2ml of N-(1-naphthyl) ethylenediamine dihydrochloride (0.83 g in 200ml cold water, cooled, filtered, and diluted to 250ml with glacial acetic acid) was added, and diluted to 50 ml and mixed thoroughly. The mixture was left to stand for 1 hour and the resulting purple azo dye measured spectrometrically at 543nm, against standards covering the range of NO₂.

2.4.4 Analysis of chloride

To analyze chloride, 100ml of water sample was measured in a 250ml conical flask and the pH adjusted to 7-10 using 1 M H₂SO₄ or NaOH. 0.5 g of Na₂B₄O₇ was then added as a buffer to keep the pH at 9.0 then 1ml of 5% K₂CrO₄ solution added as an indicator and stirred well. The solution was titrated with 0.0282 N AgNO₃ (282ml of 0.1N AgNO₃ diluted to one litre) to a permanent reddish tinge. The reaction occurred according to equation (2).

\[ \text{Cl}^- + \text{Ag}^+ \leftrightarrow \text{AgCl} \] (white) \[ \rightarrow 2\text{Ag}^+ \text{(excess)} + \text{CrO}_4^{2-} \rightarrow \text{Ag}_2\text{CrO}_4 \text{(red)} \] (2)

The amount of chloride in the sample is related to the amount of AgNO₃ using the relation in equation (2).

2.4.4 Analysis of sulphate

Sulphate was analyzed by drawing 250ml of water sample into a conical flask and adding 5 ml of 3M HCl and shaking to mix followed by addition of 1g of BaCl₂ solution. The mixture was heated to near boiling point, and then left to stand for 5 minutes. The sulphate was precipitated in HCl medium as BaSO₄, which was then left to stand a few minutes, filtered and washed until free from Cl⁻, then ignited and weighed as BaSO₄.

2.4.5 Analysis of sodium

To analyze sodium a standard Sodium Stock Solution, 100.0 ppm was prepared by accurately (to 0.1 mg) weighing out by difference 0.1271 g of reagent grade NaCl using an analytical balance. The salt was quantitatively transferred into a 500ml volumetric flask (0.100 g Na/l = 100 mg/l = 100 μg/ml = 100 ppm Na). 100 ml of deminized water was added to the flask then swirled to dissolve all of the salt before diluting to volume with deminized water. The sample was analyzed using a single-channel flame photometer (Model PFP7).
2.5 *Escherichia coli* form analysis

The culture medium for incubating *Escherichia coli* was made from a mixture of 10g peptone, 10g lactose, 2g KH$_2$PO$_4$, 15g agar, 4g eosin-Y and 0.065g methylene blue in one litre of distilled water (pH 7.1 after sterilization). 0.1 ml of water sample was incubated in the culture media on a membrane at 37±1ºC for 48 hours in mammert incubator and the number of coliform colonies were counted and expressed as colony counts per 100ml of water sample.

2.3.7 Chemical oxygen demand

Estimation of Chemical Oxygen Demand (COD) was done by reflux titrimetry (APHA 1994). 250ml of borehole water was at 27°C was transferred to a cleaned flask. 10ml of KMnO$_4$ 0.0125M was added followed by 10ml of 20% v/v H$_2$SO$_4$. It was then mixed gently and incubated at 27°C for 4 hours. The mixture was examined at intervals, when the pink colour of permanganate tends to disappear, and 10ml of KMnO$_4$ was added. After 4 hours, 1ml KI solution was added and titrated with 0.0125M Na$_2$S$_2$O$_3$ using starch as an indicator, until the blue colour just disappeared. COD was calculated as follows:

$$\text{COD (mg/l)} = \frac{([\text{ml of Blank-ml required of sample}] \times 1000)}{A} \times \text{Volume of sample used.}$$

where $A =$ Total Volume of KMnO$_4$ 0.0125M added to samples.

3. Results

The values for the borehole water parameters that were analyzed against the borehole distance from the septic tank disposal system are indicated in Table 2 and Table 3 for the dry and wet seasons respectively.

**Table 2: Water borehole parameters versus the borehole distance from the septic tank disposal system during dry season**

<table>
<thead>
<tr>
<th>Borehole site No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (m)</td>
<td>63</td>
<td>33</td>
<td>61</td>
<td>31</td>
<td>16</td>
<td>120</td>
<td>16</td>
<td>33</td>
<td>32</td>
<td>146</td>
</tr>
<tr>
<td>pH</td>
<td>8.4</td>
<td>7.4</td>
<td>7.8</td>
<td>7.8</td>
<td>8.6</td>
<td>6.5</td>
<td>8.2</td>
<td>8.5</td>
<td>8.5</td>
<td>7.8</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>4.9</td>
<td>4.5</td>
<td>2.1</td>
<td>4.1</td>
<td>4.7</td>
<td>2.1</td>
<td>4.8</td>
<td>1.9</td>
<td>3.9</td>
<td>4.3</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>513</td>
<td>788</td>
<td>412</td>
<td>766</td>
<td>840</td>
<td>477</td>
<td>174</td>
<td>709</td>
<td>598</td>
<td>709</td>
</tr>
<tr>
<td>Conductivity($\mu\text{Scm}^{-1}$)</td>
<td>1265</td>
<td>1002</td>
<td>918</td>
<td>1222</td>
<td>812</td>
<td>830</td>
<td>318</td>
<td>1134</td>
<td>802</td>
<td>1134</td>
</tr>
<tr>
<td>Ammonia (mg/l)</td>
<td>0.6</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Nitrite (mg/l)</td>
<td>12</td>
<td>12</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>4</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>94</td>
<td>130</td>
<td>34</td>
<td>126</td>
<td>130</td>
<td>51</td>
<td>108</td>
<td>119</td>
<td>39</td>
<td>96</td>
</tr>
<tr>
<td>Sulphate (mg/l)</td>
<td>198</td>
<td>193</td>
<td>68</td>
<td>74</td>
<td>81</td>
<td>71</td>
<td>99</td>
<td>82</td>
<td>67</td>
<td>81</td>
</tr>
<tr>
<td>Sodium (mg/l)</td>
<td>215</td>
<td>159</td>
<td>102</td>
<td>212</td>
<td>192</td>
<td>8</td>
<td>142</td>
<td>130</td>
<td>203</td>
<td>102</td>
</tr>
<tr>
<td>E. Coli (cfu)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>75</td>
<td>20</td>
<td>5</td>
<td>10</td>
<td>19</td>
<td>9</td>
<td>16</td>
<td>6</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

0= Below detectable level
Table 3: Water borehole parameters versus the borehole distance from the septic tank disposal system during the wet season

<table>
<thead>
<tr>
<th>Borehole site No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole distance (M)</td>
<td>63</td>
<td>33</td>
<td>61</td>
<td>31</td>
<td>16</td>
<td>120</td>
<td>33</td>
<td>32</td>
<td>146</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.9</td>
<td>7.5</td>
<td>7.6</td>
<td>7.8</td>
<td>8.4</td>
<td>8.0</td>
<td>6.5</td>
<td>8.0</td>
<td>7.6</td>
<td>7.7</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>4.9</td>
<td>4.5</td>
<td>2.1</td>
<td>4.7</td>
<td>4.1</td>
<td>4.7</td>
<td>2.1</td>
<td>4.8</td>
<td>1.9</td>
<td>3.9</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>611</td>
<td>890</td>
<td>422</td>
<td>770</td>
<td>896</td>
<td>480</td>
<td>180</td>
<td>702</td>
<td>592</td>
<td>702</td>
</tr>
<tr>
<td>Conductivity(µScm⁻¹)</td>
<td>1215</td>
<td>994</td>
<td>912</td>
<td>1218</td>
<td>808</td>
<td>840</td>
<td>315</td>
<td>1030</td>
<td>811</td>
<td>1030</td>
</tr>
<tr>
<td>Ammonia (mg/l)</td>
<td>0.8</td>
<td>0</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>6.7</td>
<td>7.1</td>
<td>3.7</td>
<td>4.8</td>
<td>5.8</td>
<td>5.1</td>
<td>6.6</td>
<td>2.2</td>
<td>3.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Nitrite (mg/l)</td>
<td>15</td>
<td>17</td>
<td>4.4</td>
<td>9.7</td>
<td>13.4</td>
<td>4.1</td>
<td>13.9</td>
<td>11</td>
<td>6.7</td>
<td>5.7</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>113</td>
<td>144</td>
<td>35</td>
<td>126</td>
<td>156</td>
<td>51</td>
<td>128</td>
<td>119</td>
<td>39</td>
<td>96</td>
</tr>
<tr>
<td>Sulphate (mg/l)</td>
<td>184</td>
<td>182</td>
<td>68</td>
<td>74</td>
<td>93</td>
<td>70</td>
<td>98</td>
<td>82</td>
<td>77</td>
<td>81</td>
</tr>
<tr>
<td>Sodium (mg/l)</td>
<td>217</td>
<td>160</td>
<td>102</td>
<td>146</td>
<td>219</td>
<td>192</td>
<td>143</td>
<td>131</td>
<td>203</td>
<td>103</td>
</tr>
<tr>
<td>E. Coli (cfu)</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>7</td>
<td>18</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>8</td>
<td>14</td>
<td>5</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

0= Below detectable level

Borehole at site 10 was farthest away from the septic tanks while site 5 and 7 were the closest.

4. Discussion

The analyzed parameters are discussed starting with the borehole farthest from the septic tank up to the one closest to the septic tank.

**pH**

At borehole site 10 which was 146M from the septic tank, the pH was 7.7 and 7.8 for dry and wet seasons respectively while borehole sites 5 and 7 which were 16 M away from the septic tanks pH was 6.5 and 8.0 for the dry season and 7.8 and 8.2 for the wet seasons. The distance or the season showed no significant influence on the pH.

**Total dissolved solids (TDS)**

The TDS for the borehole at site 10 (146 m from septic tank) was 702 and 709 mg/l for dry and wet seasons respectively. For borehole at site 5 and 7 which were 16 m from the septic tanks, the TDS were 896 and 180 (mg/l site 5) for dry and wet season respectively and 840 and 174 mg/l (site 7) for dry and wet season respectively. For the boreholes at site 10 (146 m away) and site 5 (16 m away) the TDS values were greater than 500mg/l according to WHO (2008). The borehole at site 7 which was 16 m away the TDS values were less than the WHO standard. The study showed that TDS was not influenced by the distance but could be influenced by other factors such as borehole depth.

**Turbidity**

Turbidity is caused by the scattering of light in all directions by un-dissolved substances. The study did not show any variations in turbidity when the borehole 10 (146 M) was compared to boreholes 5 and 7 (16m away from septic tank). The values were within the WHO limit (WHO 2008) of 5 Nephelometric Turbidity Unit (NTU).
Electrical conductivity
Electrical conductivity variation was observed in the sampled waters especially when borehole at 146 m was compared to the ones closest to the septic tank (16 m). There were other borehole sites that had higher values yet they were neither the farthest nor the closest. This shows that the distance did not influence the electrical conductivity. However in polluted water, a higher conductivity greater than 1000 μS/cm can be observed. The WHO (2008) provides a guideline of a maximum of 2500 μS/cm. The study revealed that the conductivity of the groundwater samples was not consistent in both wet and dry seasons. However there is a decrease in electrical conductivity during the wet season (Tables 2 and 3).

Nitrate
When borehole 10 (16 m) was compared to 5 and 6 (16m) from the septic tanks, the nitrate levels were 2 mg/l and 3mg/l for borehole 10 for dry and wet season respectively while for site 5 it was 5.8 and 5mg/l for dry and wet seasons) and for site 7 the nitrate concentration was 6.6 and 7.0 mg/l (wet season and dry season). The borehole which was far away from the septic tank (146m) had a lower nitrate concentration while the one which was closer to the septic tanks (16m) had a higher nitrate concentration. The nitrate levels were with the WHO standards (WHO, 2008)

Nitrite
The nitrite concentrations ((5.7 mg/l and 6 mg/l) were lower in borehole 10 (146m) compared to boreholes 5 and 7 (16 m) while borehole 5 had 13.3 mg/l and 8 mg/l of nitrite for the wet and dry seasons respectively and borehole 7 had values 13.9 and 9 mg/l for the wet and dry seasons respectively.

Ammonia
Most of the sites did not show the presence of ammonia except sites 1, 2 and 5. Site 5 which was 16 m away from septic tank had 0.1 mg/l ammonia during dry season while site 10 (146 m) showed 0 mg/l ammonia. This could be due to the site’s close proximity to the septic systems effluent and /or other anthropogenic activities like heavy use of fertilizer.

Chloride
The chloride concentration at borehole 10 (146m from septic tanks) was 96 mg/l for both the dry and wet season (Tables 2 and 3) while at boreholes 5 and 7 (16m from the septic tanks) the values were 130 mg/l and 156mg/l (dry and wet season respectively) (Tables 2 and 3). These two comparisons indicate that chloride was high in the boreholes that were nearer to the septic tanks however this was not a general trend indicating that there are other factors that influence the chloride concentration in the borehole waters for example chlorine is usually added to septic tanks as disinfectant. Seasonal variation in the level of chloride in the water was observed mainly in the boreholes that were closer to the septic tanks however in all the boreholes the level of chloride was lower than the maximum value recommended by WHO standards of 300mg/l (WHO, 2008). Generally the level of chlorides increased with decrease in distance from septic tanks and was higher during the wet season than the dry season (Tables 2 and 3). This could be attributed to leaching of chloride ions into the borehole to recharge the ground water (Pilgrim et al, 1979).
**Sulphate**
The study showed that the distance from septic tanks had no influence on sulphate level, in the borehole water samples (Tables 2 and 3). The sulphate levels were within the WHO (2008) guideline limit of 250 mg/l.

**Sodium**
The pattern of pollution decreases with distance from the septic tanks for Sodium in a similar way that was observed for chloride levels. The level of sodium in borehole 10 (146 m from septic tank), was 102 mg/l and 103 mg/l for the dry and wet seasons respectively while for boreholes 5 and 7 (16m from septic tank ) the average sodium level was 167 and 181 mg/l for dry and wet seasons respectively. The frequent use of sodium chloride salt in food could have attributed to high levels of sodium in borehole waters closer to the septic tanks.

**Escherichia coli (E. Coli)**
Most of the sites (Tables 2 and 3) tested negative for faecal coliform indicating that the borehole waters sampled did not contain any E. coli and are safe for domestic purposes. According to the Kenya Bureau of Standards (KS, 2007) guidelines, coliforms should not be detected in water.

**Chemical oxygen demand (COD)**
The Chemical Oxygen Demand (COD) analysis showed high levels as distance from septic tanks reduced. Boreholes 5 and 7 which were 16 m from septic tanks had an average of 18 mg/l and 15mg/l for the dry and wet seasons respectively while borehole 10 (146m from the septic tanks) had a value of 10 mg/l and 9 mg/l for dry and wet seasons respectively. The COD values were slightly lower during the wet season indicating the possible dilution effect.

4. **Conclusion**
The study showed that the possible effect of septic tank distance on borehole water quality could only be realized when the boreholes are constructed at < 16 m from the septic tanks especially for the inorganic ions such as nitrates, nitrites, chlorides and sulphates. It is important to note that septic tank distance is not the only factor that would have impact on water quality, however the contamination which was observed to be higher in wet season could be attributed to increase in the amount of ground water recharge which results in soil saturation and consequently in reduced filtration. Septic tanks in Ongata Rongai could be considered as the source of inorganic constituents that enter the borehole waters.

**Acknowledgement**
The Department of Chemistry, University of Nairobi, Kajiado County, Ministry of Devolution and Planning and Kenya Water Institute (KEWI).

**References**


