University of Nairobi
Department of Geology
Presentation on,
POLLUTION OF GROUNDWATER IN URBAN AREAS OF KENYA; FOCUSING NAIROBI CITY

presented by,
NAME: NKONGE MURUNGI ELIUD
REG NO: I13/3167/2008
COURSE: SGL 413 Project In Geology

MAY 2012
objectives

1. To find out the concentration of the organic, inorganic and microbiological constituents in the borehole water and the causes of high levels and low levels of the constituents and their effect to the quality of groundwater.

2. To find out how the quality of water determines its use for domestic purposes, industry or agriculture.

3. To find out whether the deterioration of the groundwater quality is contributed by urbanization in Kenya.

4. To enhance proper water conservation measures in protection of the groundwater from pollution.
Topics

• Introduction
• Literature review
• Research methodology
• Data analysis
• Conclusion and recommendation
Introduction

• Location of the study area
• Population
• Climate and vegetation
• Significance of the Study.
• Research Assumptions.
• Limitations of the Study.
Population

- Population (2009) is 3,138,295
- Density: 4,509/Km²
- Home to thousands of Kenyan businesses and many international companies and organizations
Climate

- Elevation: 1,795m (5,889 ft) above sea level
- Moderate climate.
- According to Koppen climate classification, Nairobi enjoys a subtropical highland climate
- Cool evenings June/July. Temps drop up to 10 degrees Celsius
- Sunniest and warmest months are December to March with mean max. temps. of 24 degrees Celsius
- Two rainy seasons
Significance of the Study.

• This study is significant in that by the end of it, the researcher will be able to find out to what extent the concentrations of various physio-chemical and chemical parameters have led to deterioration of the water quality and the possible sources of the pollution.

• The study will also help the researcher and the other people to extend their existing knowledge about the effects/impacts of pollution of the groundwater in the society and the need to have a polluted free environment.

• The research will also enable the government and local authorities to come up and implement regulations and laws governing groundwater conservation.
Research Assumptions.

The study is based on the following assumptions:

• That the selected sample of boreholes is a true reflection of the characteristics of the groundwater in the aquifers where these boreholes have been drilled.

• That the borehole depths are different and may pass trough rocks of different formations.

• That the borehole water samples are collected at different seasons and periods of the year.
Limitations of the Study.

The following are some of the limitations of this study;
• Much of the data and reports on the industrial effluent constituents were not available. This limited the acquisition of this data.
• The respondents’ authorities limited knowledge on the contribution of industrial pollution to the groundwater as results on the industrial effluents physical/chemical analysis were not obtained.
• Financial constraints. This could not allow extensive research on this particular topic. e.g. obtaining data from other towns in the country.
Literature review

• Hydrogeology
• Water quality and Determination
• Factors contributing to deterioration of groundwater quality in Nairobi
Hydrogeology

• Groundwater in volcanic rocks is limited to fractures and erosion levels. Within the volcanic succession fresh lavas are not water bearing because of their massive and impervious nature.

• The most significant aquifer system is the Upper Athi Series aquifer system. It is the main aquifer for boreholes in Nairobi and Kiambu area composed of tuffs, lake beds and sediments (Wamwangi, 1981).

• The volcanic rocks show a wide range of porosity and permeability and have developed aquifer units separated by lower permeability strata. The aquifer mainly comprise of the Kerisha Valley Series and Upper Athi Series. The extension of this multi-layered aquifer system is fairly well known for the many boreholes that have been drilled to depths of 100-350 m (Stephen et al., 2005, Tuinhof, 2005).
Hydrogeology

• Other aquifers are found in weathered inter-lava layers and in fractured zones and superficial deposits at the top of the geologic sequence (Masibo, 1990).

• In the eastern part the volcanic rocks thin out exposing the metamorphic Basement System rocks where aquifers are predominantly found in fractured and deeply weathered zones.
Water quality and Determination

- Water quality for domestic use
- Water quality for agriculture
- Industrial use
# Water quality for domestic use

- **Table 2.1 Drinking water standards for inorganic substances (after, WHO, 1993)**

<table>
<thead>
<tr>
<th>Inorganic chemicals</th>
<th>Tolerance limit</th>
<th>Inorganic chemicals</th>
<th>Tolerance limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>0.01</td>
<td>Copper</td>
<td>2</td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>0.7</td>
<td>Cyanide</td>
<td>0.07</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>0.003</td>
<td>Manganese</td>
<td>0.5</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>0.05</td>
<td>Molybdenum</td>
<td>0.07</td>
</tr>
<tr>
<td>Fluoride (F)</td>
<td>1.5</td>
<td>Nickel</td>
<td>0.02</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.01</td>
<td>Nitrite</td>
<td>3</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>0.001</td>
<td>Uranium</td>
<td>0.009</td>
</tr>
<tr>
<td>Nitrate (N)</td>
<td>50</td>
<td>Antimony</td>
<td>0.018</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water quality for agriculture

• Irrigation water should contain Ca and Mg ions sufficient to equal or exceed the Na ions. The sodium effect can be calculated by the sodium adsorption ratio (SAR Method) (Ali, Sayed, Yaser, 2012)

• \[
\text{SAR} = \frac{\text{Na}}{\sqrt{\left(\text{Ca} + \frac{\text{Mg}}{2}\right)}}
\]

• Where, Na, Ca and Mg are in milliequivalents per litre from water analysis.

• The Values of SAR above 10 indicates a danger of sodium problem.
Industrial use

• Quality requirements vary greatly according to the potential use in application to industrial use.

• Low quality water as sea can be satisfactorily employed for cooling of condensers
Factors contributing to deterioration of groundwater quality in Nairobi

- Solid waste landfills and dumpsites
- Infiltration from polluted streams and dams
- The soils and underlying rocks
- Seepage of industrial effluents
- Seepage from latrines, septic tanks, sewers and drains
- Leakage from underground storage of petroleum and chemicals
Research methodology

• The sample size of this study was thirty two boreholes water analysis selected randomly from Kibera, Makadara, Dagoretti, Embakasi, Kasarani, Westlands and Central divisions in Nairobi.

Data Analysis Design

• **Classification**: Involved arranging data in groups on the basis of common characteristics. This study used classification according to concentrations of various physical and chemical parameters using tables.

• **Correlation analysis**: Involved studying the joint variation of the variables to determine the amount of correlation between them. The reason for using this type was because it was appropriate in understanding the relationships between variables and determining the levels of fluoride between various divisions.

• **Descriptive analysis**: Involved the study of distribution of variables. In this study, there was a descriptive analysis of the concentrations using graphs and histograms.
Data Analysis

pH

Dagoretti
Westlands
Embakasi
Kibera
Makadara
Kasarani
Central
Data analysis cont’

Conductivity

- Dagoretti
- Westlands
- Embakasi
- Kibera
- Makadara
- Kasarani
- Central
Data analysis cont’

Turbidity (N.T.U)
Data analysis cont’

Fluoride (mg/l)

- Dagoretti
- Westlands
- Embakasi
- Kibera
- Makadara
- Kasarani
- Central
Data analysis cont’

Iron

Dagoretti 2.6
Westlands 1.3
Embakasi 0.3
Kibera 1.9
Makadara 0.2
Kasarani 0.1
Central 0.1
Data analysis cont’
Data analysis cont’

Total Dissolved Solids (TDS)
Data analysis cont’

Colour

• Borehole water analysis in Westlands division reported colour concentration of upto 85 mgPt/l (Hazen units).

• Coloured water was reported in Dagoretti and Kibera division with concentrations of upto 50 mgPt/
Summary of the findings

• The study found out that the pollution of the groundwater in Nairobi region is not by anthropogenic sources from urbanization but, from the underlying minerals in soils and rocks. This is true in that, the most dominant cations in the borehole waters were Na ions. The F ions were found in all the borehole waters analysis. The groundwater enrichment of Na and F is through leaching of sodic-rich volcanic rocks and pyroclastics.

• Nevertheless, there is potential pollution from the industrial effluents, leachate from dumpsites, liquid and solid waste disposal in streams/rivers and other anthropogenic sources. Therefore, they should be closely managed to avoid pollution of aquifers in Nairobi.
Findings cont’

• It was also found that the groundwater in Nairobi area contains high Fluoride concentrations of more than 1.5 mg/l in most parts and this water is not safe for drinking purposes. Considerable amounts of iron were also present in some areas in concentrations exceeding 0.25 mg/l.

• It is also clear that the groundwater in the area is unsuitable for irrigation purposes due to high concentration of sodium in relation to Ca and Mg ions. Highly sodic water will lead to soils with high Sodium Adsorption Ratio (SAR), alkaline soils in which little or no vegetation can grow.

• Finally, in terms of industrial use the water vary in terms of the intended potential use. Therefore, the chemical and physical constituents should be determined before any potential use for proper selection and use.
Conclusion

• From the above findings, it was concluded that the pollution of the groundwater in Nairobi region is not by anthropogenic sources from urbanization but, from the underlying minerals in soils and rocks.

• However, it was noted there is potential pollution from the industrial effluents, leachate from dumpsites, liquid and solid waste disposal in streams/rivers and other anthropogenic sources and thus they should be closely monitored to avoid pollution of aquifers in Nairobi.

• It was also found that the groundwater in Nairobi area contains high Fluoride concentrations in most parts and this water is not safe for drinking purposes. Considerable amounts of iron were also present in some areas in large concentrations.
Conclusion cont’

• Moreover, the groundwater in the area is unsuitable for irrigation purposes due to high concentration of sodium in relation to Ca and Mg ions. Highly sodic water will lead to soils with high Sodium Adsorption Ratio (SAR), alkaline soils in which little or no vegetation can grow.

• Finally, in terms of industrial use the water vary in terms of the intended potential use. Therefore, the chemical and physical constituents should be determined before any potential use for proper selection and use.
Recommendations.

• Detailed research of the area should be carried out to determine the levels at which the groundwater is polluted through infiltration of toxic substances arising from human activities and industrialization in Nairobi area.

• Proper management of any waste placed on or in the ground. This involves proper selection of waste disposal sites, management of industrial effluents and other human sources of pollution.

• Rules and laws governing building of residential settlements and industries to be put up and strictly implemented in urban areas in Kenya.
Recommendations cont’

• Development of technologies that will enhance proper purification methods. Proper defluoridation and inspection of water should be carried out for drinking purposes. For turbidity, treatment that includes coagulation and flocculation with lime, sedimentation, filtration, chlorination and pH adjustment should be employed.

• The government should also give out strict rules that govern groundwater quality protection.

• Creating awareness on the importance of conserving groundwater and impacts of pollution to the people through symposiums, music and workshops.
Recommendations cont’

• Finally, the use of commonsense in protecting this fundamental resource.