Application of Recharge, Aquifer Media, Vadose Zone and Hydraulic Conductivity on Modeling Vulnerability of Groundwater To Pollution In Central Rift Basins, Kenya.

Kemboi, E.[1], Barongo, J.O.[2] and, Olago, D. O [3].

[1,2,3.] Department of Geology,
University of Nairobi,
P.O. Box 30197 Nairobi 00100

Tel: 254 – 20 - 4442014/5,

Fax: 254 – 20 – 4449535,

•The Central rift basins comprise the three lakes of Nakuru, Elmentaita, and Naivasha. It is in the step faulted portion of the Rift valley confined by latitudes 0º 15 S´ and 0 º 55´ S and Longitudes 35 º 50´ E and 36 º 40´ E in Kenya (Figure1.1) occupied by Kenya dome that lies within the Aberdares detachment (Bosworth, 1986).

•The three lakes of Nakuru, Elmentaita, and Naivasha are remnants of large Gamblian Lake; composed of rare sedimentary deposits uplifted or down faulted along inner trough margins that have been formed mostly since Pleistocene. Volcanism was intense between 7 and 2 Ma that no long lived lake environment developed.

•The geology is characterized by tephrites, basalts, trachytes, phonolites, ashes tuffs, agglomerates and acid lavas rhyolite, and obsidian, (Thompson and Dodson, 1963) and quaternary lacustrine deposits from large ancient lakes. The oldest rocks found *in situ* are of Tertiary.

Objective

The aim of this study is to provide a hydrogeological assessment of vulnerability to groundwater pollution based on DRASTIC model, which can be used for protection and management of groundwater.

•Four parameters involving Recharge, Aquifer media, Impact of the vadose zone,
and hydraulic Conductivity have been considered.
•Results show that recharge variation is contributed by the annual rainfall and faults patterns, with the highest recharge in the Aberdares due to the high rainfall compared to the rift, which is arid to semi arid. Susceptibility of the aquifers to pollution is generally high in the eastern and northern parts.
• The strata of the vadose zone are similar to except for an additional layer of clays in aquifer media.
•The hydrogeological zones vulnerable to pollution are few and widespread are restricted to the western, eastern and the northwestern Naivasha region, Aberdares near Kipipiri and Ol Kalou.

•Vulnerability study of groundwater pollution in the basins has been made

•by employing Arcview 3.2 and Spatial analyst 2.0 Geographic Information System (GIS), overlay arithmetic of DRASTIC, an acronym that stands for Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone, and hydraulic conductivity (Aller *et.al.,*1987; Deichert and Hamlet, 1992).

•DRASTIC designates a standardized system for evaluating groundwater pollution potential.

•Determination of the pollution potential for a given area involves multiplying each factor rating by its weight and adding together the resulting values.

•Higher sums represent a greater pollution potential or a greater vulnerability of aquifer to contamination.

Pollution potential index = RrRw + ArAw + + IrIw + CrCw

Where,

R = Recharge

A = Aquifer media

I = Impact of vadose zone

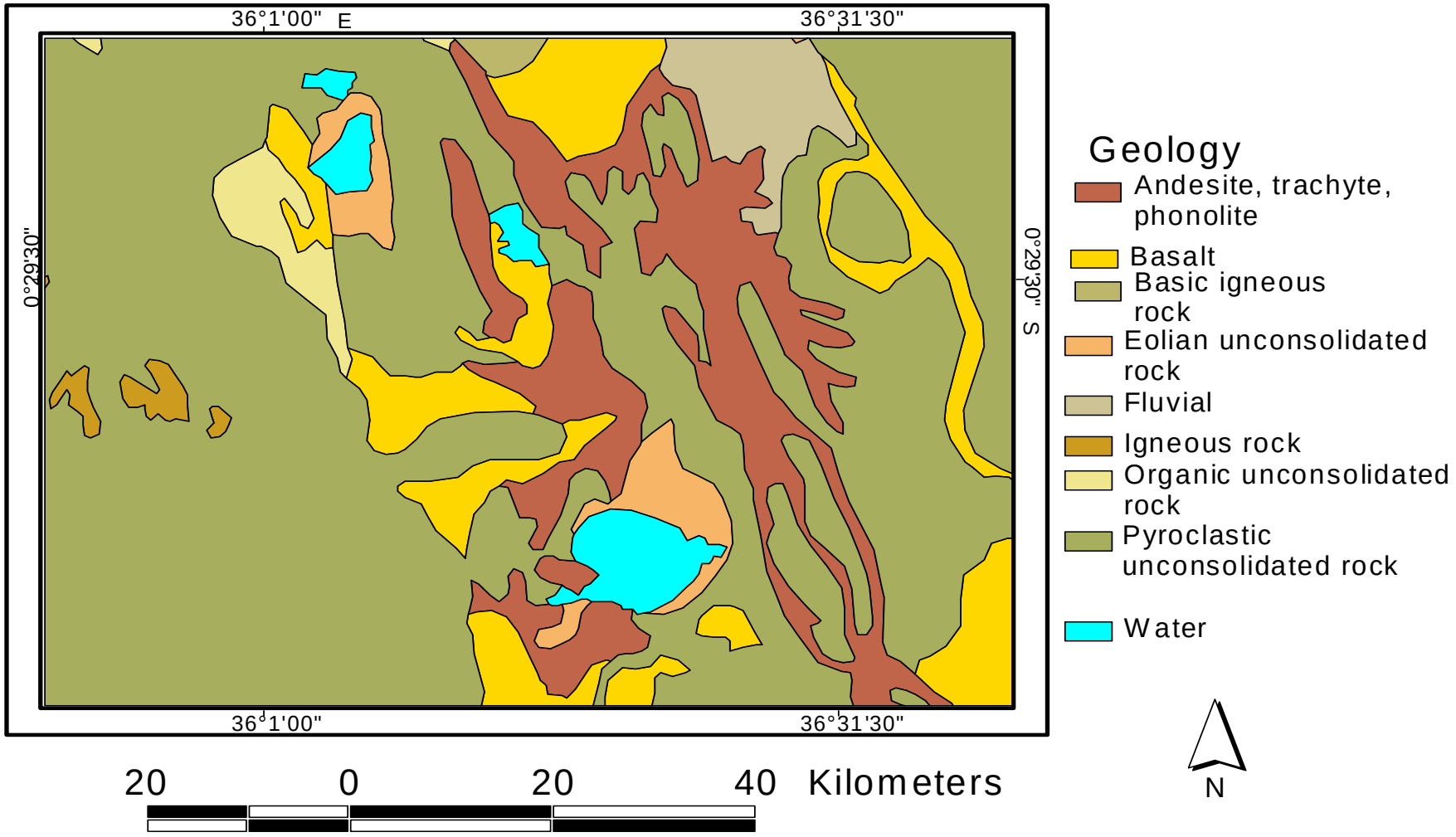
C = Hydraulic conductivity of the aquifer.

The subscripts r and w denote the rating and weight, respectively (Ckakrabotry *et.al.,* 2007).

Groundwater remediation on contamination is harder than surface water making it a greater concern because pesticides that have short life span may degrade slowly in groundwater (Noah, 2002).

The vadose zone provides protection to unconfined aquifers from pollution by retardation of recharge flow giving room for microbial die off.

Aquifer media, grain and pore sizes of rock material, determines the attenuation of contaminant, largely by dilution and microbial die-off in case of microbial contamination.


36°1'00" E
36°31'30"
0°29'30" S
0°29'30"
36°1'00"
36°31'30"
Geology
Andesite, trachyte, phonolite
Basalt
Basic igneous rock
Eolian unconsolidated rock
Fluvial
Igneous rock
Organic unconsolidated rock
Pyroclastic unconsolidated rock
Water
20 0 20 40 Kilometers
N

•Most of the drainage from the escarpments tapers off and disappear into the pyroclastics, ashes and lacustrine sediments covered plains leading to extensive water tables due to high porosity of the rocks.

•Perched aquifers are also found along intermittent streams and rivers on flood plains made of alluvial deposits. Flood plain deposits are of reworked pyroclastics, volcanic sands, pebbles and even boulders.

•Confined aquifers are found in fractured volcanics or along weathered contacts between different lithological units. Unconfined aquifers in sediments covering parts of the rift floor.

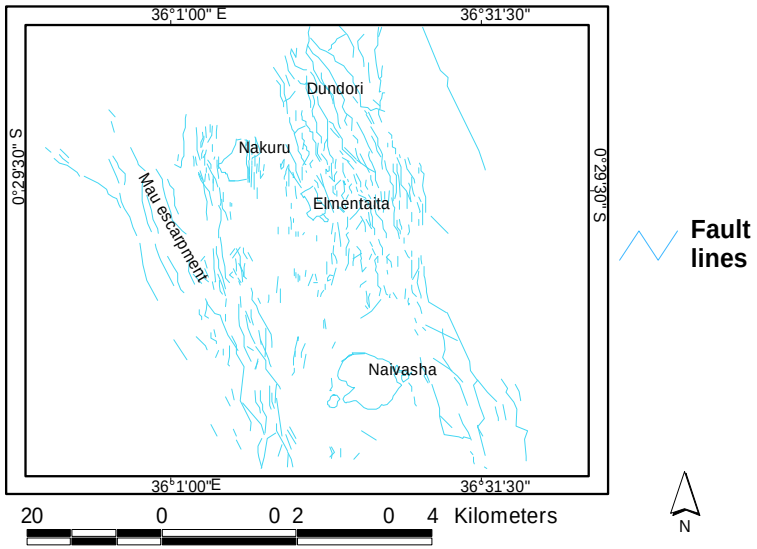


Figure Structural map of Nakuru- Elmentaiata –Naivasha basin generated from fault lines in geological maps and linearments on Landsat imagery.

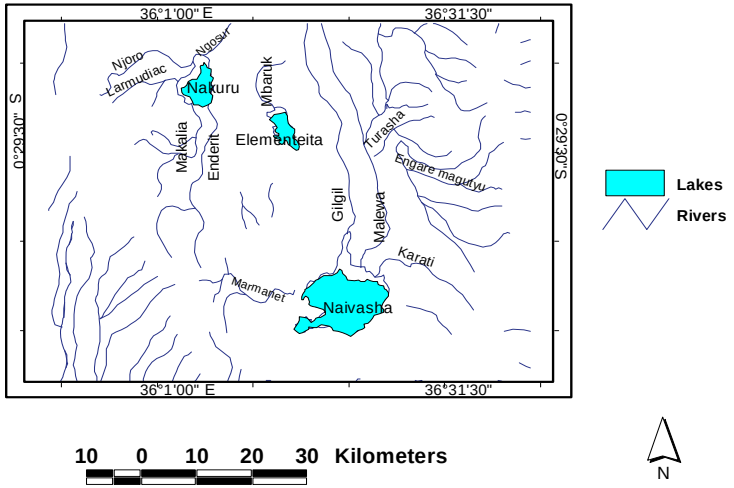
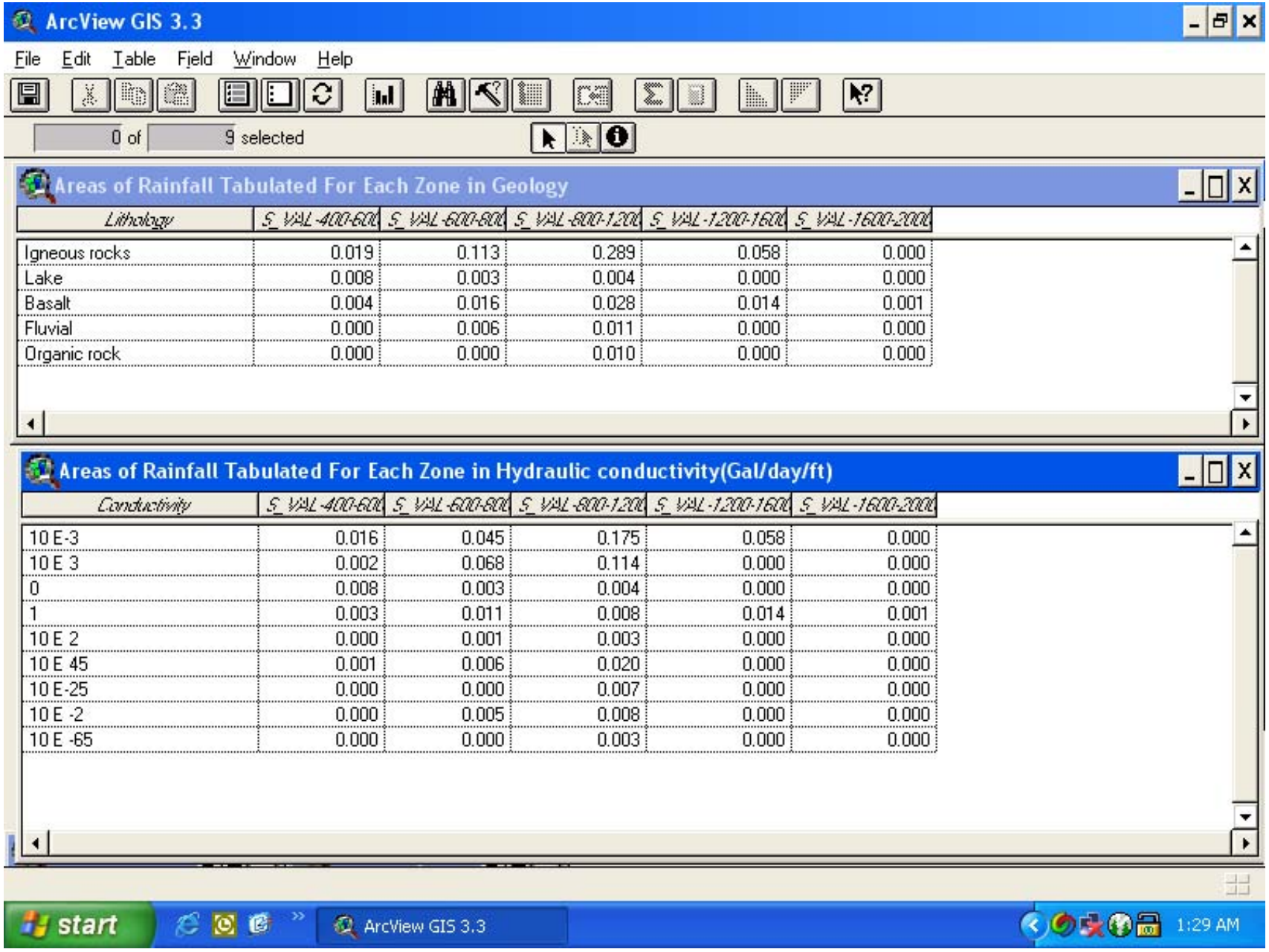


Figure Drainage of Lakes Nakuru-Elmentaita-Naivasha basins, adapted from ILRI (2002).

•Subsidence due to Collapse of sinkholes after rainfall (Ngecu and Nyambok 2000) permit litter and waste water discharged through intermittent rivers, valley depression to contaminate groundwater are potential health hazards (IPCC, 1997; Government of Kenya, 2002).

•Three major episodes of faulting are recognized. The first episode of Late Miocene is referred to as boundary faults. The second episode of late Pliocene is concomitant to rifting within the rift valley formed fault steps, horst and graben structures. The third episode of Quaternary represents the development of major almost parallel faults (Ngecu and Nyambok, 2000).

•The major faults display large scale structural domains associated with large accumulations of pyroclastics and trachyte lavas intercalated with tuffs and welded tuffs (Morley *et.al.,* 1990). Buried faults and other tectonic structures often indicate the path of drainage lines, linear fractures or permeable lithology alternating with impermeable lithology, marking the edge of lava (Onywere, 1997).


ArcView GIS 3.3
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0 of 9 selected
Areas of Rainfall Tabulated For Each Zone in Geology
Lithology | S_VAL-400-600 | S_VAL-600-800 | S_VAL-800-1200 | S_VAL-1200-1600 | S_VAL-1600-2000
Igneous rocks | 0.019 | 0.113 | 0.289 | 0.058 | 0.000
Lake | 0.008 | 0.003 | 0.004 | 0.000 | 0.000
Basalt | 0.004 | 0.016 | 0.028 | 0.014 | 0.001
Fluvial | 0.000 | 0.006 | 0.011 | 0.000 | 0.000
Organic rock | 0.000 | 0.000 | 0.010 | 0.000 | 0.000
Areas of Rainfall Tabulated For Each Zone in Hydraulic conductivity(Gal/day/ft)
Conductivity | S_VAL-400-600 | S_VAL-600-800 | S_VAL-800-1200 | S_VAL-1200-1600 | S_VAL-1600-2000
10 E-3 | 0.016 | 0.045 | 0.175 | 0.058 | 0.000
10 E 3 | 0.002 | 0.068 | 0.114 | 0.000 | 0.000
0 | 0.008 | 0.003 | 0.004 | 0.000 | 0.000
1 | 0.003 | 0.011 | 0.008 | 0.014 | 0.001
10 E 2 | 0.000 | 0.001 | 0.003 | 0.000 | 0.000
10 E 45 | 0.001 | 0.006 | 0.020 | 0.000 | 0.000
10 E-25 | 0.000 | 0.000 | 0.007 | 0.000 | 0.000
10 E -2 | 0.000 | 0.005 | 0.008 | 0.000 | 0.000
10 E -65 | 0.000 | 0.000 | 0.003 | 0.000 | 0.000
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ArcView GIS 3.3
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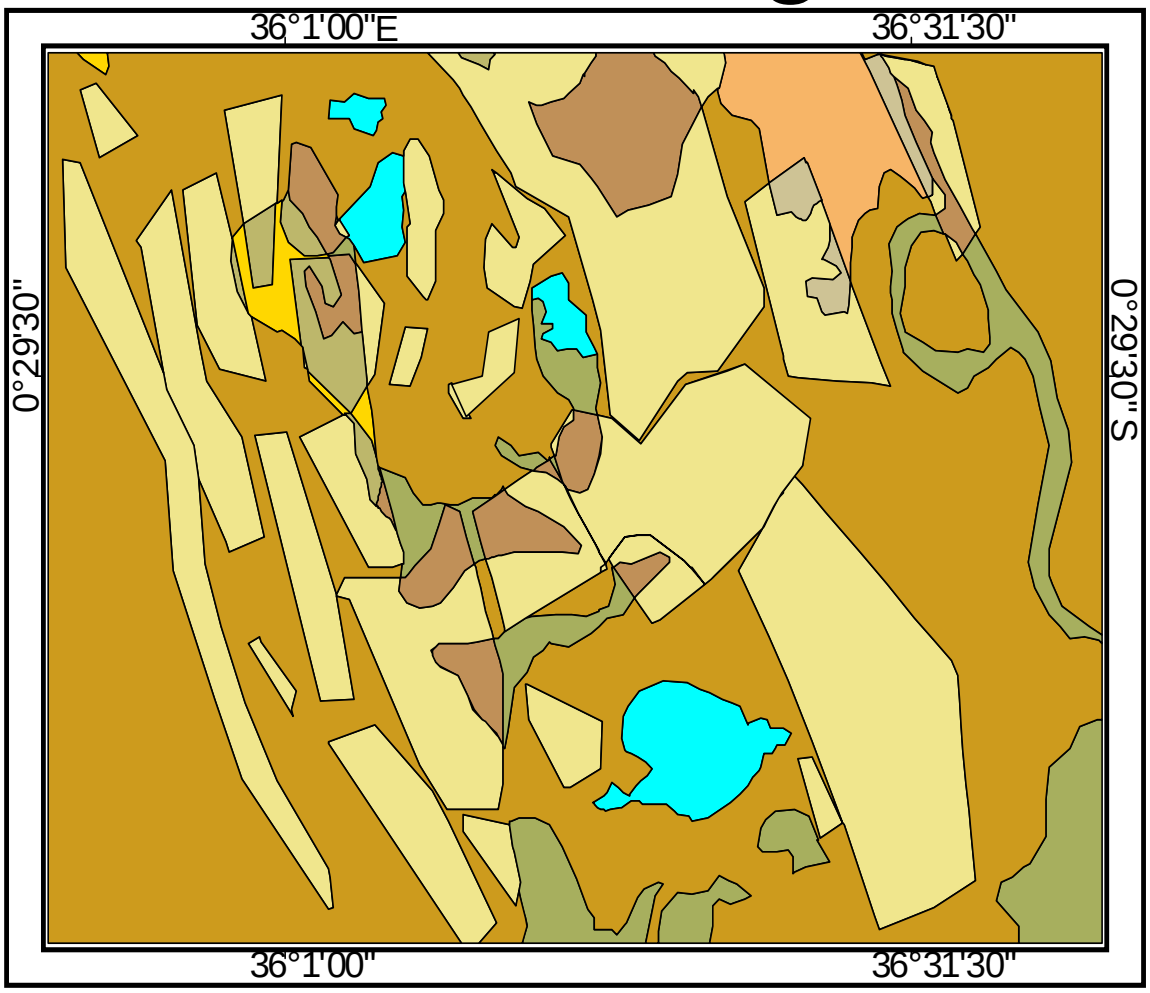
Recharge

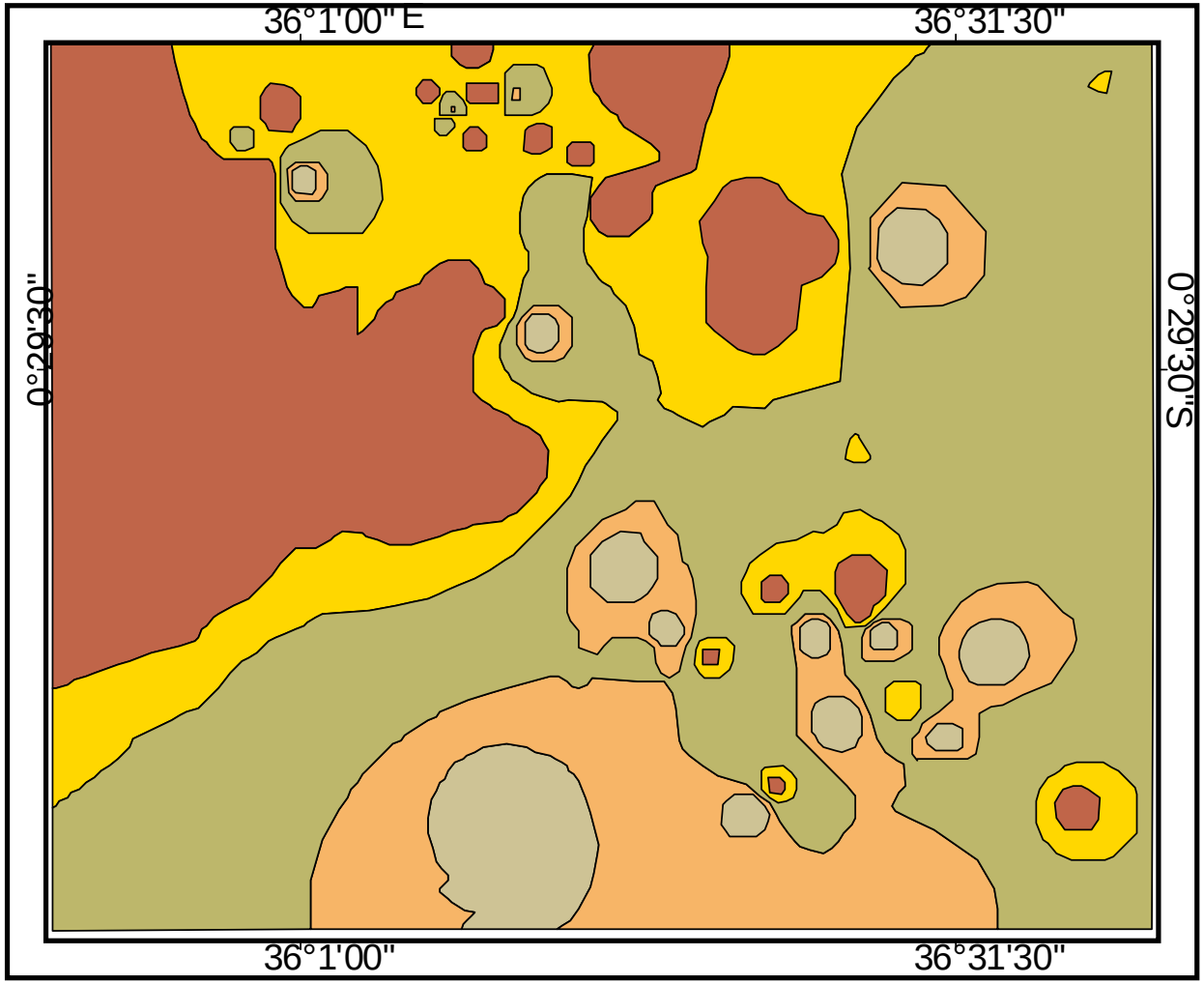


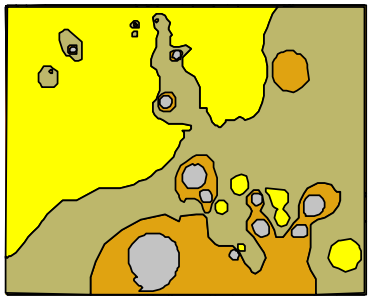
Recharge

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- Lakes

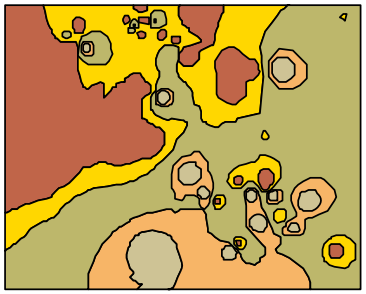
N

30 0 30 Kilometers





Vadose zone



Hydraulic conductivity

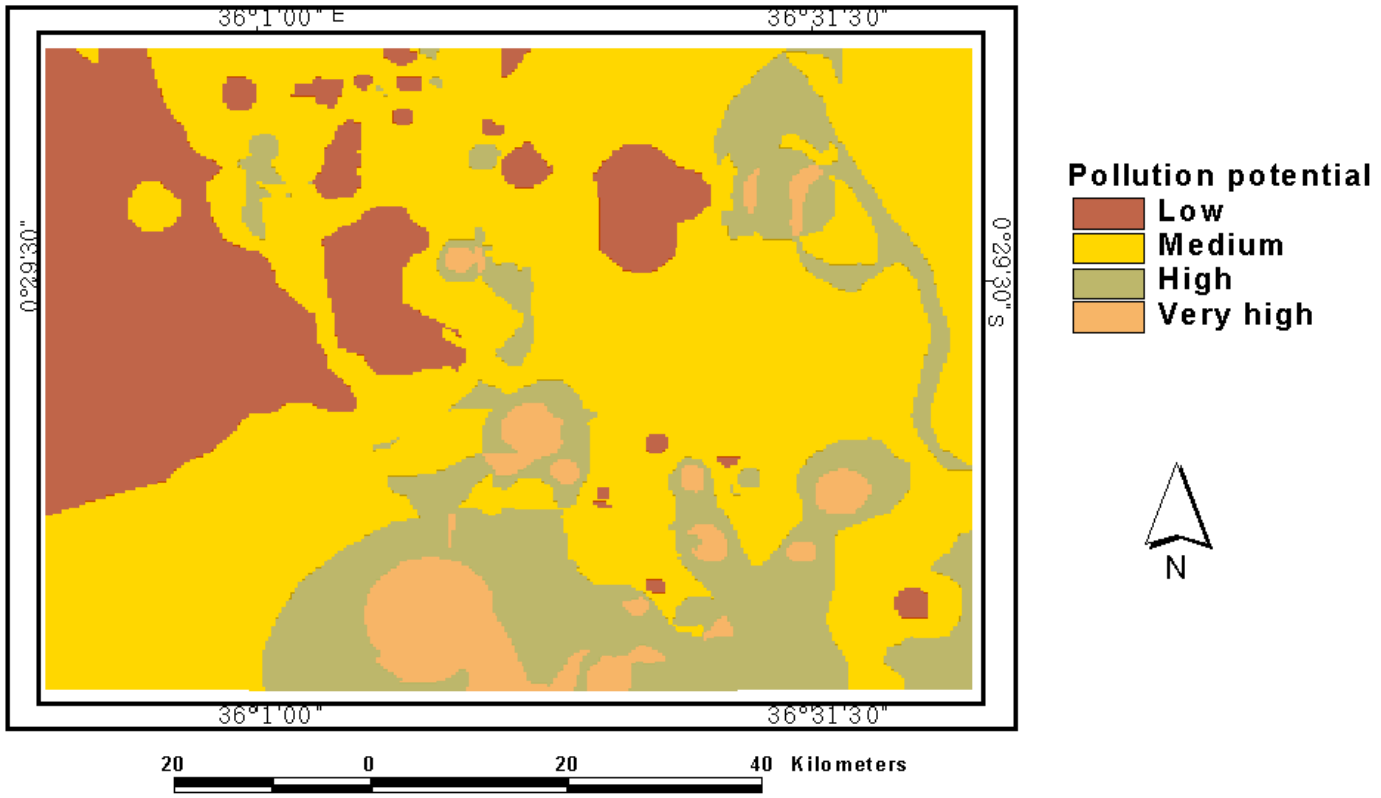
Key

- 2
- 4
- 6
- 8
- 10

Aquifer media

10 0 10 20 30 **Kilometers**

N


36°1'00" E
36°31'30"
0°9'30"
0°29'30"S
36°1'00"
36°31'30"
20
0
20
40 Kilometers
Pollution potential
Low
Medium
High
Very high
N

•Contaminant could reach a susceptible groundwater supply. Vulnerability of groundwater to contamination entails susceptibility and the presence of a contaminant.

•Vulnerability is a relative, qualitative, non- measurable, dimensionless property, of two types: specific vulnerability and intrinsic.
•The intrinsic vulnerability takes into account hydrogeological characteristics but is independent of the nature of contaminants. Specific contaminant takes into account the properties of the contaminant.

•The highest recharge rates are in the basalts, followed by the pyroclastic unconsolidated sediments, fluvial sediments and tuffs. The escarpments have higher rainfall and low evapo-transpiration potential rates than the rift floor therefore contributes significant to the recharge of groundwater.
• Localized differences in infiltration and percolation of rainwater, affects the rate of upper aquifers contamination.

•An impermeable aquifer media can still conduct water in the presence of fractures (Fritch *et.al.,* 2000). An aquifer with high conductivity is vulnerable to substantial contamination as a plume of contamination can move easily through the aquifer.

•The degree of moisture potential in relation to gravity potential affects Seepage is the main transfer channel for contaminants to groundwater. Subsidence has been reported in Nakuru where fractures on the crust (Ngecu and Nyambok, 1999) lead to the formation of sinkholes parallel to the fault zones.

Over saturation reduces the shear strength of the sediments and introduces extra loading through saturation leading to subterranean erosion along faults. This leads to the formation of sinkholes which degrades the environment when sewage water, refuse and garbage enter into the groundwater systems.

- The effluents from agricultural fields, industrial and domestic wastes should be recycled or retreated before being released onto the environment to reduce environmental contamination.

- The places of high vulnerability where irrigation is carried out should be subjected to continuous monitoring through building of observation wells.

•The area is semi arid to arid with higher evapotranspiration rates than rainfall. The possibility of aquifer contamination occurring is low. The hydrogeological zones vulnerable to pollution are few.

Rocks and minerals can be used in improving soil fertility, correcting the pH of soil and conserving nutrients and water reduces dependence on chemical fertilizers. All plant nutrients are of geological provenance except nitrogen which can be introduced to the soil through various organic inputs.

•Rock mulches

•Potting mixes for tree and horticultural plant seedlings.

•Pesticides, fertilizers and feed additives carrier

Thank you