# Gully Initiation on the Quartzite Ridges of Ibadan, South West, Nigeria

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# INTRODUCTION

- Patton and Schumm, 1975; Imeson and Kwaad, 1980; Poesen et al. 2003- Gullies occur when a geomorphologic threshold is exceeded.
- Schumm *et al*. (1974) ,Poesen et al. (2002), Zhu, 2012, Vendrusculo, 2014, Menendez-Duartz *et al*., Kumar et al. (2020), Poesen (1993) – reveals it occurs in several climes, caused by several factors with varying characteristics.
- And so many other definitions……..
- But all definitions point to the fact that Gullies are characterized by:

1. Depressions greater than rills .
2. Their development is initiated by the action of concentrated overland flow on soil materials.

# GULLY EROSION STUDIES FROM NIGERIA

- Okagbue and Uma, 1987)- Examined the different dimensions/forms of Gullies on the Southeastern sedimentary basin.

- Several other studies (Ofomata, 1965; Nwajide and Hoque, 1979; Henry *et al*. 2016) – Affirmed the role of soil and geology on the process of gully evolution, still in the SE sedimentary basin.

- Adediji, et al. (2013), Faniran and Areola, 1974; Conforti, et al. 2011- concluded that human activities are responsible for gully initiation and acceleration on the basement complex terrains of southwestern regions.

# Why study Gully erosion on the Basement complex of Nigeria

- Gullying processes on the sedimentary terrain have received significant attention from researchers while such processes are often overlooked in the Basement Complex areas because of their perceived resistance to denudation.

# Aim and Objectives

Aim –

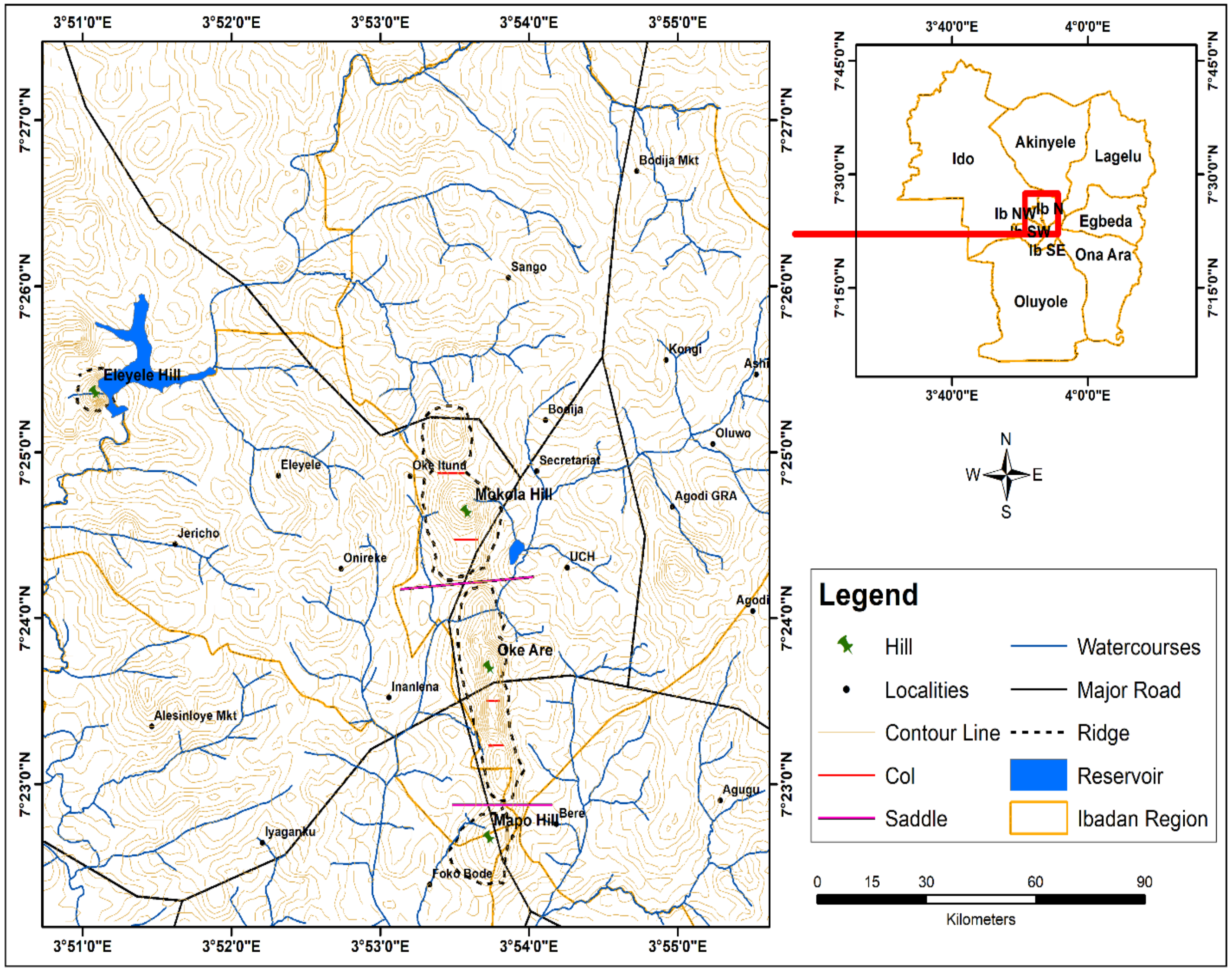
Assess the development and the initiation of gully erosion on the quartzite ridges of Ibadan, Nigeria.

Objectives :

- assess the morphological characteristics of gullies on the quartzite ridges, and
- examine the factors of gully development on the ridges and their relationship with gully morphology.

# Study area

- The study sites are Mokola ridge, Mapo ridge and Eleyele Hill – All in Ibadan.
- The geomorphology of Ibadan – consists of HILLS, PLAINS & VALLEYS.
- Rainfall-
- Elevation -174 m and 365 m above sea level
- Ibadan is underlained by Basement Complex rocks which mainly consist of the metamorphic rock types of Pre-Cambrian age, but with some intrusions of granites and porphyrite of Jurassic age.
- The Hills / Ridges are Quartzitic with intrusions of some schist.



# Field Measurement

- Gully length, width & depth were  measured at an interval of 5 metres with a measuring tape
- Gully slope was measured using abney level and ranging poles.
- Soil samples at depth 0 – 15 cm was collected from each gully section using soil auger and core sampler.
- Soil samples were kept in  opaque cellophane bags to preserve their original properties while they are being transported to the laboratory for analyses.
- Photographic shots and coordinates of the gullies would be obtained using digital camera and Global Positioning System (GPS).

# Morphological characterization

| Derived variables | Formulae |
|---|---|
| **Cross-sectional area** | $A = h(b + s.h)$ (Ehiorobo and Audu, 2012)<br>Where, A = gully cross-sectional area, h = depth of gully, b = gully breadth, and s = side slope |
| **Gully Volume/Soil loss ($V_L$)** | $V_L = \frac{L}{6}[A_1 + 4A_m + A_2]$ (Schoffield, 1993)<br>Where, Where, $V_L$ = volume of soil loss between the sections; $A_1$ = cross-sectional area of the first section; $A_2$ = cross-sectional area of the second section; and $A_m$ = cross-sectional area of section mid-way between first and second sections. |
| **Gully density (D)** | $D = \frac{Gully\ length}{Area}$ (Gawrysiak L, Harasimiuk, 2012) |
| **Gully frequency (F)** | $F = \frac{No.of\ gullies}{Area}$ (Gawrysiak and Harasimiuk, 2012) |
| **Gully shape** | $Gully\ shape = \frac{2\pi \times Area}{(Perimeter)^2}$ (Xu et al. 2012) |

# Laboratory and Statistical Analyses

- The soil samples were analyzed in the laboratory for pH, Electrical conductivity (EC), organic matter (OM), sodium absorption ratio (SAR), and exchangeable sodium percentage (ESP) using standard laboratory procedures.
- Spearman Rank Correlation was used to infer the relationship between variables.

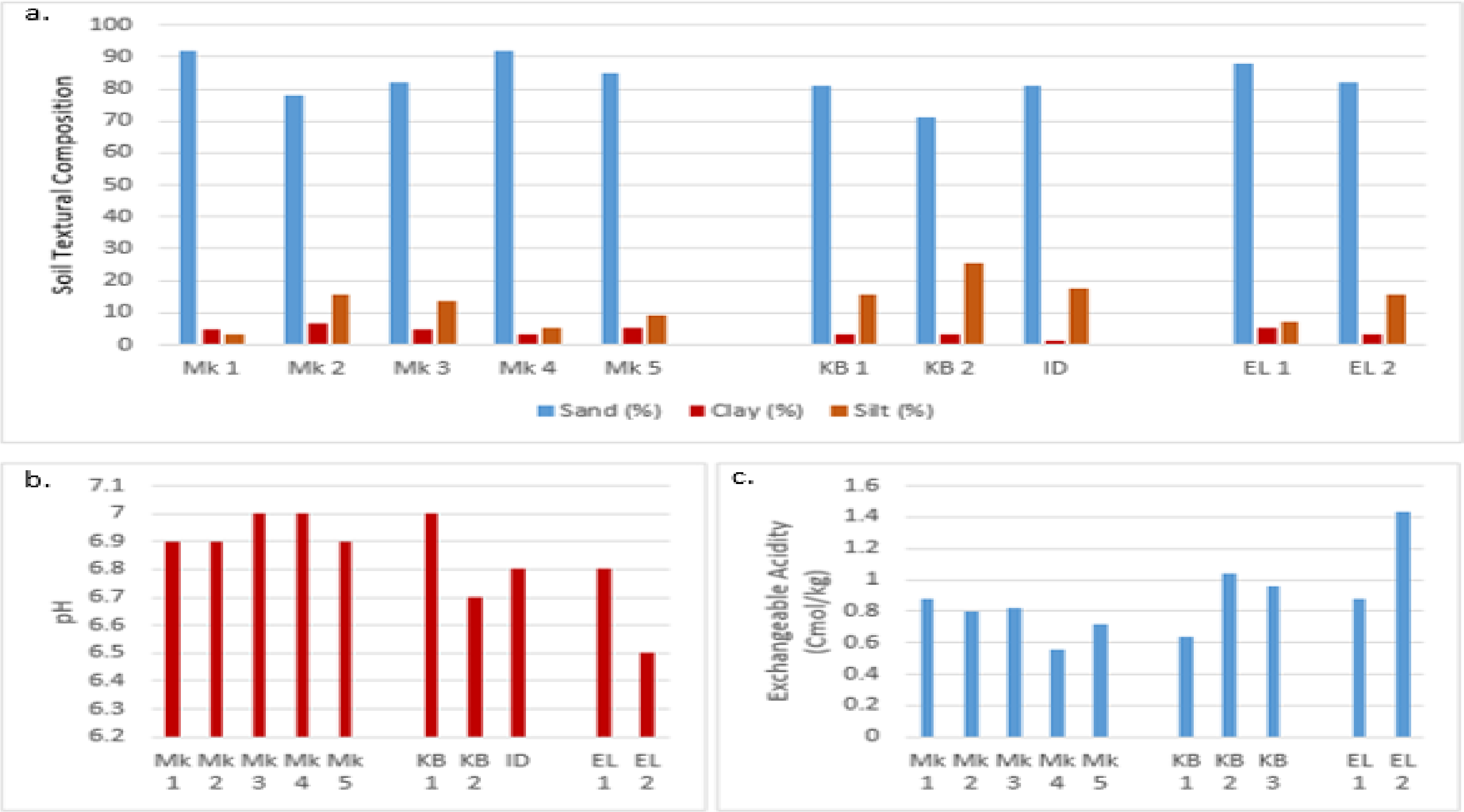
# Table 1. Characterization of Gully Systems on Quartzite Ridges in Ibadan

| Gully System | Gully Site | Altitude (m) | Wmax (m) | Wav (m) | Dmax (m) | Dav (m) | L (m) | Straight Length (m) | Wb (m) | Order |
|---|---|---|---|---|---|---|---|---|---|---|
| **Mokola Hill** | Mk 1 | 235.60 | 2.76 | 2.03 | 1.74 | 1.18 | 39.40 | 31.50 | 0.60 | 1 |
| | Mk 2 | 241.20 | 1.21 | 0.82 | 0.96 | 0.85 | 5.98 | 5.71 | 0.71 | 1 |
| | | 244.10 | 0.91 | 0.51 | 0.91 | 0.75 | 5.20 | 4.20 | 0.42 | 1 |
| | | 246.70 | 8.30 | 5.70 | 1.60 | 1.56 | 10.10 | 9.60 | 5.20 | 2 |
| | Mk 3 | 221.70 | 5.12 | 4.52 | 2.40 | 2.2 | 13.90 | 12.80 | 2.47 | 1 |
| | | 237.60 | 1.71 | 1.64 | 1.66 | 1.62 | 24.80 | 22.70 | 1.60 | 1 |
| | | 213.70 | 5.70 | 5.50 | 3.12 | 2.95 | 48.30 | 38.70 | 4.90 | 2 |
| | Mk 4 | 234.40 | 4.90 | 4.85 | 1.21 | 1.1 | 40.50 | 37.90 | 5.40 | 2 |
| | Mk 5 | 241.10 | 6.23 | 5.70 | 2.24 | 1.93 | 50.20 | 39.40 | 3.30 | 1 |
| | | 192.20 | 26.40 | 25.3 | 8.16 | 7.15 | 29.20 | 26.10 | 23.40 | 2 |
| | | 224.80 | 3.88 | 3.62 | 5.52 | 4.8 | 50.20 | 49.40 | 0.98 | 3 |
| **Mapo Ridge** | KB 1 | 197.30 | 2.80 | 2.57 | 1.40 | 1.2 | 39.59 | 27.30 | 2.23 | 1 |
| | | | 2.20 | 2.10 | 1.34 | 1.26 | 2.10 | 1.90 | 1.80 | 2 |
| | | | 5.41 | 5.87 | 1.85 | 1.6 | 80.23 | 72.62 | 1.62 | 1 |
| | KB 2 | 187.50 | 4.27 | 4.11 | 1.30 | 1.1 | 10.36 | 9.54 | 4.01 | 1 |
| | | | 3.45 | 3.21 | 3.48 | 3.32 | 18.10 | 13.20 | 2.90 | 2 |
| | | | 7.25 | 6.42 | 3.75 | 3.42 | 65.69 | 58.21 | 6.20 | 1 |
| | | | 30.10 | 29.00 | 2.10 | 2 | 8.87 | 6.12 | 28.10 | 1 |
| | ID 1 | 133.70 | 2.41 | 2.31 | 1.30 | 0.9 | 26.80 | 18.60 | 2.11 | 1 |
| | | | 2.49 | 2.32 | 0.91 | 0.9 | 58.10 | 32.60 | 2.20 | 2 |
| | | | 6.09 | 5.88 | 3.30 | 3 | 19.80 | 14.20 | 5.70 | 2 |
| **Eleyele Hill** | EL 1 | 190.30 | 1.86 | 1.73 | 1.56 | 1.4 | 37.91 | 41.70 | 0.84 | 1 |
| | EL 2 | 191.60 | 2.04 | 1.40 | 1.65 | 1.43 | 82.00 | 83.40 | 0.65 | 1 |

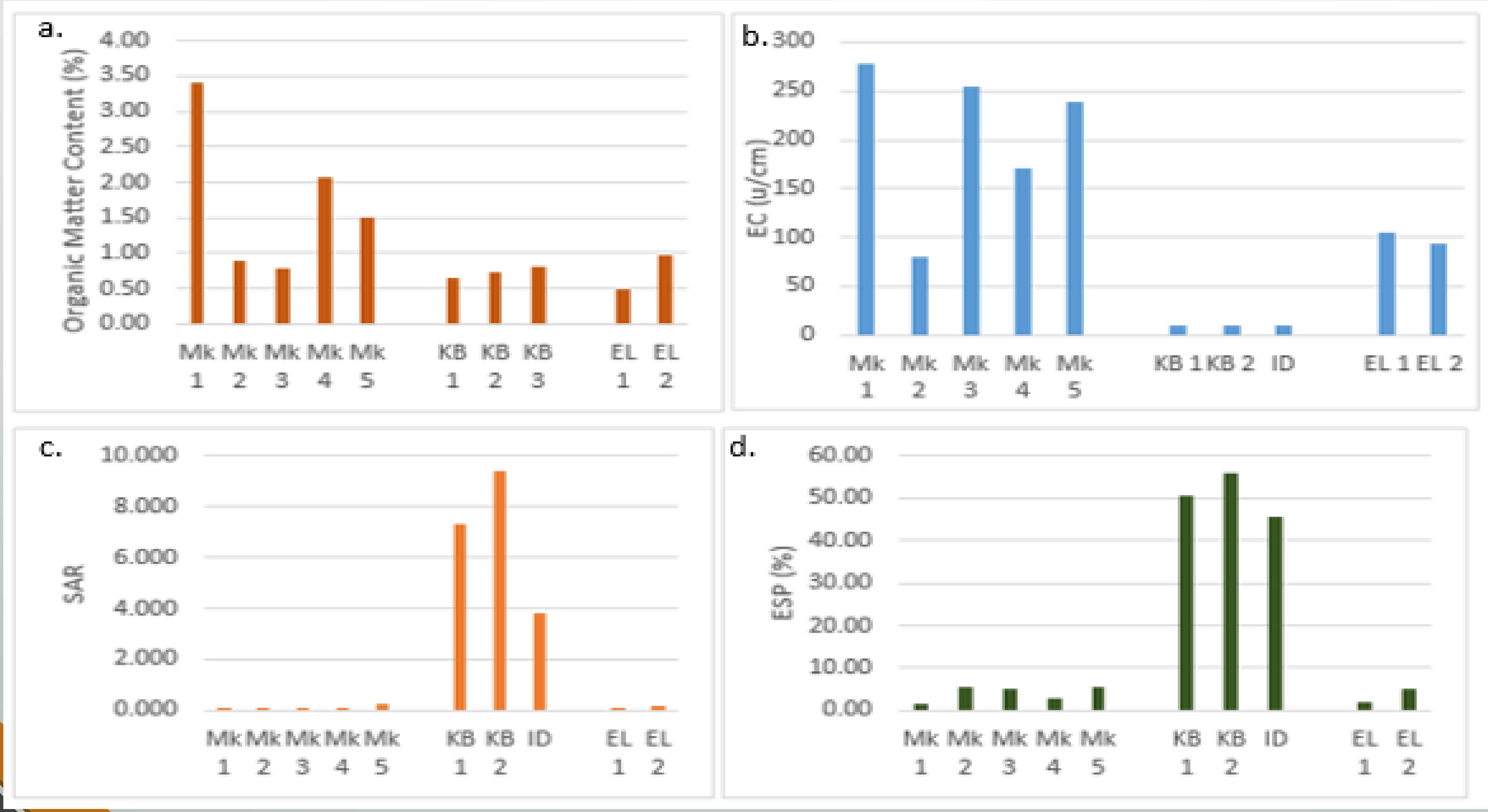
Figure 1. Mokola hill gully system

## Figure 2. Gully morphology at Eleyele Hill

# Figure 3. Soil textural composition, pH & Exchangeable acidity of the gully systems



# Figure 4. Organic matter, electrical conductivity (EC), sodium absorption ratio (SAR) & exchangeable sodium percentage (ESP).



# Factors of Gully Development

- Topography – Gentle sloping concave valley side of the ridge.
- Lineament – lines of weakness
- Soil properties – Sodic composition (SAR & ESP) and high EC.
- Land use – Improper land use, footpaths, bush burning, farming, construction.

# Relationship between morphology and gully development

- The relationship between topography and gully development was asserted by identifying the degree of association between hill slope elevation and gully width/depth ratio.
- Correlation analysis returned a negative coefficient of $r = -0.462$ ($p < 0.05$). Therefore, there is an inverse relationship between the altitude and gully development.
- The occurrence of the gullies on gentle slopes of the ridges is supported by the findings of Le Roux and Sumner (2012); Tamene et al. (2006); Kakembo et al. (2009)
- SAR ($r = 0.794$) and ESP ($r = 0.867$) are positively correlated with gully cross-sectional area ($p < 0.05$).
- Organic matter content and electrical conductivity are not statistically significant ($p > 0.05$).
- Similarly, strong positive relationship was observed between SAR ($r = 0.758$, $p < 0.05$), ESP ($r = 0.661$, $p < 0.05$) and gully volume at 0.05 level of significance.
- This suggests that sodic rich mineral content of the parent material of the gully systems exact strong influence on the process of gully development.
- This inference is in line with previous researches conducted by Poesen *et al*. (2002), Romero Diaz *et al*. (2007) and Samani *et al*. (2008).

# Relationship between morphology and gully development cont'd

- From the results, we posit that gullies formed on gentle slopes are usually characterised by wide and U-shaped channels. These gullies are largely discontinuous, not too deep, and their slope ranges between 3° - 7°.
- Whereas, the gullies on the steep slope (15° - 30°) are crusted with bedrocks that are characterised by deep and narrow channels.
- The relationship between SAR and ESP suggests that sodic soils encourage gully initiation. This implies that gully initiation processes are dominant on gently sloping terrain due to the availability of large surface area and weathered regolith that will enhance fluvial processes of material detachment on the one hand and subsurface processes like piping on the other hand.

# CONCLUSION

- As observed from the study, topography, lineament, soil properties and human activities encourage the initiation and development of the gullies.
- Also, the study concluded that the presence of excessive amounts of exchangeable sodium reverses the process of compaction and causes soil aggregates to disperse into their constituent individual soil particles.
- And finally, further geomorphological assessment of landform units in Ibadan is necessary with a view of identifying potential geomorphic risk prone areas, an essential component of risk management of the dense urban areas of the humid tropics.

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