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An Investigation on the Radiation Hazards Associated with the Use of Abakaliki Pyroclastic from Southeastern Nigeria as Construction Materials

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Abstract - This paper presents an investigation on the health risks that may be associated with pyroclastic rocks when used as construction materials. Radionuclides in the pyroclastic rocks from the Abakaliki and Ezillo areas (both in Ebonyi State, Southeastern Nigeria) were assessed. Data show that the uranium concentration in the pyroclastic rocks vary from 1 – 3 ppm (or 0.01 – 0.03 Bq.g-1) for the Abakaliki area, and 2 – 5 ppm (or 0.02 – 0.05 Bq.g-1) for the Ezillo area. The Radium equivalent activity of the Abakaliki pyroclastics varied from 20.0 – 62.90 mBq.g-1 while that of Ezillo varied from 62.9 – 145.8 mBq.g-1. A comparison with the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) recommended standard (that Radium equivalent activity in building materials must be below 370 Bq.kg-1 or 0.37 Bq.g-1) suggests that the radium equivalent activity for the pyroclastics from both areas in the southeastern Nigeria were all well below the maximum permissible level for dwelling homes. This therefore implies that they are safe, health wise, as construction materials for residential buildings.

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Chijioke M. Amakom [α] & Okechukwu P. Aghamelu [σ]

Abstract - This paper presents an investigation on the health risks that may be associated with pyroclastic rocks when used as construction materials. Radionuclides in the pyroclastic rocks from the Abakaliki and Ezillo areas (both in Ebonyi State, Southeastern Nigeria) were assessed. Data show that the uranium concentration in the pyroclastic rocks vary from 1 – 3 ppm (or 0.01 – 0.03 $Bq.g^{-1}$) for the Abakaliki area, and 2 – 5 ppm (or 0.02 – 0.05 $Bq.g^{-1}$) for the Ezillo area. The Radium equivalent activity of the Abakaliki pyroclastics varied from 20.0 – 62.90 $mBq.g^{-1}$ while that of Ezillo varied from 62.9 – 145.8 $mBq.g^{-1}$. A comparison with the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) recommended standard (that Radium equivalent activity in building materials must be below 370 $Bq.kg^{-1}$ or 0.37 $Bq.g^{-1}$) suggests that the radium equivalent activity for the pyroclastics from both areas in the southeastern Nigeria were all well below the maximum permissible level for dwelling homes. This therefore implies that they are safe, health wise, as construction materials for residential buildings.

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I. Introduction

External exposures to radiation arise from terrestrial radionuclides present at trace levels in soil, rocks and other materials that could be used in building construction projects. Irradiation from these materials is mainly by gamma emissions from radionuclides; ^{238}U and ^{232}Th series and from ^{40}K.

Building raw materials and processed products can vary greatly in radionuclide content depending on the character and the geology of the origin (Schuler et al, 1991). Radioactivity in building materials can lead to health risks in homes, offices and other working places. In the dwelling homes, the exposure rate depends on the concentrations of the radionuclides in the materials with which it was constructed, the quantity of these construction materials and the form of the dwelling home (Farai and Ademola 2004). In an airy room, the radon concentration depends mainly on the rate of radon exhalation from building materials, and the ventilation rate (Mustonen, 1984).

Hamilton (1971) reports that clay bricks contain typically 1.4 ppm of radium whereas, granite bricks have an elevated concentration of 2.4 ppm. All these natural sources of radiation in building materials result in internal and external dose to the public. About 54% of the total external dose received by the public in normal background areas originates from ^{40}K, ^{226}Ra and ^{228}Ra (UNSCEAR, 1980).

In the southeastern Nigeria (Figure 1), there are massive occurrences of pyroclastic rock bodies at Abakaliki and Ezillo (Ofoegbu and Amajor 1987), and at Uturu and Lokps-Ukwu areas (Onwughalu and Ukaegbu 2009). These rocks are used in virtually all forms of building construction in the area. However, the analyses on the samples of pyroclastics from the Abakaliki and Ezillo by Ofoegbu and Amajor (1987) have shown that they contain detectable amounts of radionuclides. Information is sparse on the environmental and health impacts of radiation from these rocks in the Abakaliki and Ezillo areas.

In this work, an attempt has been made to asses the radiation risks associated with the radionuclide in the Abakaliki and Ezillo pyroclastic rocks, when used as construction materials especially for residential buildings.

II. Previous Researches on Rocks as Construction Materials

The use of rocks in construction dates back to the days of the primitive man. However, the demand and utilization in various construction projects continue to increase proportionally to the sophistication in building technology and civil engineering.

Today, almost all types of rocks, as well as other naturally occurring and artificial materials, are employed in construction projects. Presently, rocks such as charnockite (Eze 1997), granite, dolerite and basalt (Krynine and Judd 1957), marble and slate (Bell 1993) are being utilized as building stones, highway-runway

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surfacing materials, foundation filling, concrete aggregates, surface finishings, as well as in dams and tunnels constructions. However, these rocks, in addition to being economically available, are supposed to pass some building, engineering and health safety standards.

In the Abakaliki and Ezillo areas, southeastern Nigeria (see Figure 1), pyroclastic rocks, found associated with the thick Albian Asu River Group and Turonian Eze Aku Group respectively (Reyment 1965) sediments, are being quarried and utilized in most projects that require rocks as construction materials. The occurrence and petrology of these rocks commonly to as the 'Abakaliki Pyroclastics' (Okezie 1965; Uzuakpunwa 1974; Ofoegbu and Amajor 1987) have been extensively studied (Farrington 1952; Olade 1979; Uzuakpunwa 1974). Figure 2 presents the geology of the southeastern Nigeria (i.e. the southern Benue Trough).

III. Materials and Methods

This research adopts data generated by Ofoegbu and Amajor (1987). They collected forty samples (twenty samples from each area) from some pyroclastic rock bodies in the Abakaliki and Ezillo areas. Details on the sampling and testing procedures are presented in their work, while the accessibility of the sampled localities is shown in Figure 3.

IV. Radium Equivalent Activity

Radium equivalent activity (Ra_{eq}) is a common index used to compare the total activity concentration of U, Th and K in a building material. Hamilton (1971) defines it as a weighted sum of the activity concentrations of the radionuclides. The Radium equivalent activity was calculated in this study using the equation below;

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \qquad (1)$$

Where, A_{Ra}, A_{Th} and A_K are the activity concentrations of ^{226}Ra (^{238}U), ^{232}Th and ^{40}K respectively.

The third term in equation (1), ($0.077A_k$) was dropped since ^{40}K was not measured in the samples. Equation (1) was based on the estimation that 370 $Bq.kg^{-1}$ of Ra, 259 $Bq.kg^{-1}$ of Th and 4810 $Bq.kg^{-1}$ of K produce the same gamma ray dosage.

The following conversions were made:

Uranium, 1ppm = 0.33 $pCi.g^{-1}$, 1 $pCi.g^{-1}$ = 3 ppm

Thorium, 1ppm = 0.11 pCi.g-^{1}, 1 pCi.g-^{1} = 9.1 ppm

One Becquerel (Bq) = 27 picocuries (pCi)

One picocurie (pCi) = 0.037 becquerels (Bq)

V. Results and Discussion

The data for the uranium and thorium concentrations of the Abakaliki and Ezillo pyroclastic rocks are shown in Tables 1 and 2 respectively. The uranium concentration in the pyroclastic rocks were found to vary from 1 – 3 ppm or 0.01 – 0.03 $Bq.g^{-1}$ for the Abakaliki area and 2 – 5 ppm or 0.02 – 0.05 $Bq.g^{-1}$ for the Ezillo area. The thorium concentration ranges from 2 – 7 ppm or 0.002 – 0.07 $Bq.g^{-1}$ for the Abakaliki samples and, 8 – 15 ppm or 0.08 – 0.15 $Bq.g^{-1}$ for the Ezillo samples. These ranges thus, suggest that the Ezillo pyroclastics record slightly higher concentration of uranium and thorium.

The observed variations in concentrations of the radionuclides may be a reflection of the differences in the geochemistry of the samples. Ofoegbu and Amajor (1987) had classed the Abakaliki pyroclastics as alkaline basalts and Ezillo pyroclastics as sub-alkaline. They conclude that the geochemical difference in composition of the Abakaliki and Ezillo pyroclastics may be either primarily due to fractional differentiation of a single magma in which case both units are of the same age, or that they belong to different volcanic sources in time and/or space.

Tables 1 and 2 also contain the Radium equivalent activity obtained from the Abakaliki and Ezillo pyroclastic rocks. The Radium equivalent activity of the Abakaliki pyroclastics varied from 20.0 – 62.90 $mBq.g^{-1}$ while that of Ezillo varied from 62.9 - 145.8 $mBq.g^{-1}$. According to UNSCEAR (1982) recommendation, Radium equivalent activity in building materials must be below 370 $Bq.kg^{-1}$ or 0.37 $Bq.g^{-1}$. Comparing the results obtained and the standard given by UNSCEAR (1982), the Radium equivalent activity were all well below the maximum permissible level for dwelling homes.

VI. Conclusions

This study has shown that although the Ezillo pyroclastics have slightly higher concentrations of uranium and thorium than the Abakaliki pyroclastics, both have their Radium concentration equivalents well below the UNSCEAR recommended level for construction materials. This may imply that, on the basis of radium concentration equivalents, they are safe for use as building materials. In other words, evidences of significant irradiation in residential buildings constructed with the pyroclastics may be originating from other source(s) apart from the pyroclastics.

VII. Acknowledgements

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References Références Referencias

1. Aghamelu, O. P. 2007. A comparative study of the geotechnical properties of crushed shales from the Abakaliki, Awgu and Enugu Shale Formations, southeastern Nigeria. M.Sc Thesis, Univ Nigeria, Nsukka, 50pp.
2. Farai I.P and Ademola J.A 2004. Radium equivalent activity concentrations in concrete building blocks in eight cities in Southwestern Nigeria, jol of env. Rad. Pp 119-125.
3. Bell, F. G. 1993. Engineering geology. Blackwell Science, Oxford, 352pp.
4. Cothern C.R and Lapponbuoh W.L. 1983. Occurrence of uranium in drinking water in U.S.A.Health physics, vol. 45, pp 89-99.
5. Eze, E. O. 1997. Geotechnical assessment of some charnockites from Nigeria as construction materials. Quarterly Journal of Engineering Geology, Vol. 30, 231-236.
6. Farrington, J. L. 1952. A preliminary description of the Nigerian lead-zinc field. Economic Geology. Vol. 47, 583-608.
7. Hamilton E.I. 1971. The relative radioactivity of building materials; Am Ind. Hyg. Ass. Journal vol. 32, pp398.
8. Krynine, D. P. and Judd, W. R. 1957. Principles of engineering geology and geotechnics. McGraw-Hill, New York, 699pp.
9. Mustonen R. 1984. Methods for evaluation of radiation from building materials; Radiation protection dosimetry, vol. 7, pp 235-238
10. Ofoegbu, C. O. and Amajor, L. C. 1987. A geochemical comparison of the pyroclastic rocks from Abakaliki and Ezillo, southeastern Benue Trough, Nigeria. J Min Geol. Vol. 23 Nos. 1&2, 45-52.
11. Okezie, C. N. 1965. A preliminary report on the igneous rocks of Abakaliki town and environs and their relations to lead-zinc mineralization. Unpubl Geol Surv Nigeria Rept. 1349, 30pp.
12. Olade, M. A. 1979. The Abakaliki pyroclastics of the southern Benue Trough, Nigeria; their petrology and tectonic significance. J Min Geol, Vol 16, 17-24.
13. Onwualu-John, J. N. and Ukaegbu, V. U. 2009. Petrogenetic and geotectonic implications of the Lokpa-Ukwu pyroclastics in southeastern Benue Trough, Nigeria. 45th Nigerian Mining and Geosciences Society, Intl Conference, Owerri 2009, Abstract vol. pp20-21.
14. Reyment, R. A. 1965. Aspects of the geology of Nigeria. Ibadan Univ Press.
15. Schuler Ch., Crameri R. and Burkart W. 1991. Assessment of the indoor Rn concentration of Swiss building materials; Health physics, vol.60, pp 447-451
16. United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR 2000 Report to the General Assembly, New York: United Nations.
17. United Nations Scientific Committee on the Effects of Atomic Radiation, (UNSCEAR) 1980. Sources, effects and risks of ionizing radiation. New York: Report to the General Assembly.
18. United Nations Scientific Committee on the Effects of Atomic Radiation, (UNSCEAR) 1982. Ionizing radiation sources and biological effects. New York: UNSCEAR (A/37/45).
19. Uzuakpunwa A. B. 1974. The Abakaliki pyroclastics, eastern Nigeria: new age and tectonic implications. Geological Magazine, Vol. 111, 761-769.

Table 1 : Activity concentration and Radium equivalent activity of the Abakaliki Pyroclastics

Sample	*U (ppm)	U (Bq/g)	*Th (ppm)	Th (Bq/g)	Ra_{eq} (mBq/g)
A1	2	0.02	6	0.02	48.60
A2	1	0.01	4	0.01	24.30
A3	2	0.02	4	0.01	34.30
A4	2	0.02	7	0.03	62.90
A5	2	0.02	3	0.01	34.30
A6	2	0.02	3	0.01	34.30
A7	1	0.01	4	0.01	24.30
A8	2	0.02	7	0.03	62.90
A9	2	0.02	6	0.02	48.60
A10	2	0.02	4	0.01	34.30
A11	2	0.02	3	0.01	34.30
A12	2	0.02	2	0	20.00
A13	3	0.03	2	0	20.00
A14	2	0.02	3	0.01	24.30
A15	2	0.02	3	0.01	24.30

A16	2	0.02	4	0.01	24.30
A17	2	0.02	7	0.03	62.90
A18	2	0.02	5	0.02	48.60
A19	3	0.03	4	0.01	44.30
A20	2	0.02	5	0.02	48.60

*(*data from Ofoegbu and Amajor, 1987)*

Table 2 : Activity concentrations and Radium equivalent activity of the Ezillo Pyroclastics

Sample	U (ppm)	U (Bq/g)	Th (ppm)	Th(Bq/g)	Ra_{eq}(mBq/g)
E1	3	0.03	13	0.05	101.5
E2	3	0.03	9	0.03	72.90
E3	2	0.02	8	0.03	62.90
E4	2	0.02	10	0.04	77.20
E5	3	0.03	9	0.03	72.90
E6	3	0.03	9	0.03	72.90
E7	2	0.02	10	0.04	77.20
E8	3	0.03	12	0.05	101.5
E9	2	0.02	9	0.03	62.90
E10	2	0.02	10	0.04	77.20
E11	3	0.03	12	0.05	101.5
E12	2	0.02	10	0.04	77.20
E13	4	0.05	14	0.06	135.8
E14	5	0.06	15	0.06	145.8
E15	2	0.02	8	0.03	62.90
E16	4	0.05	12	0.05	121.5
E17	3	0.03	13	0.05	101.5
E18	2	0.02	8	0.03	62.90
E19	3	0.03	9	0.03	72.90
E20	5	0.06	15	0.06	145.8

*(*data from Ofoegbu and Amajor, 1987)*

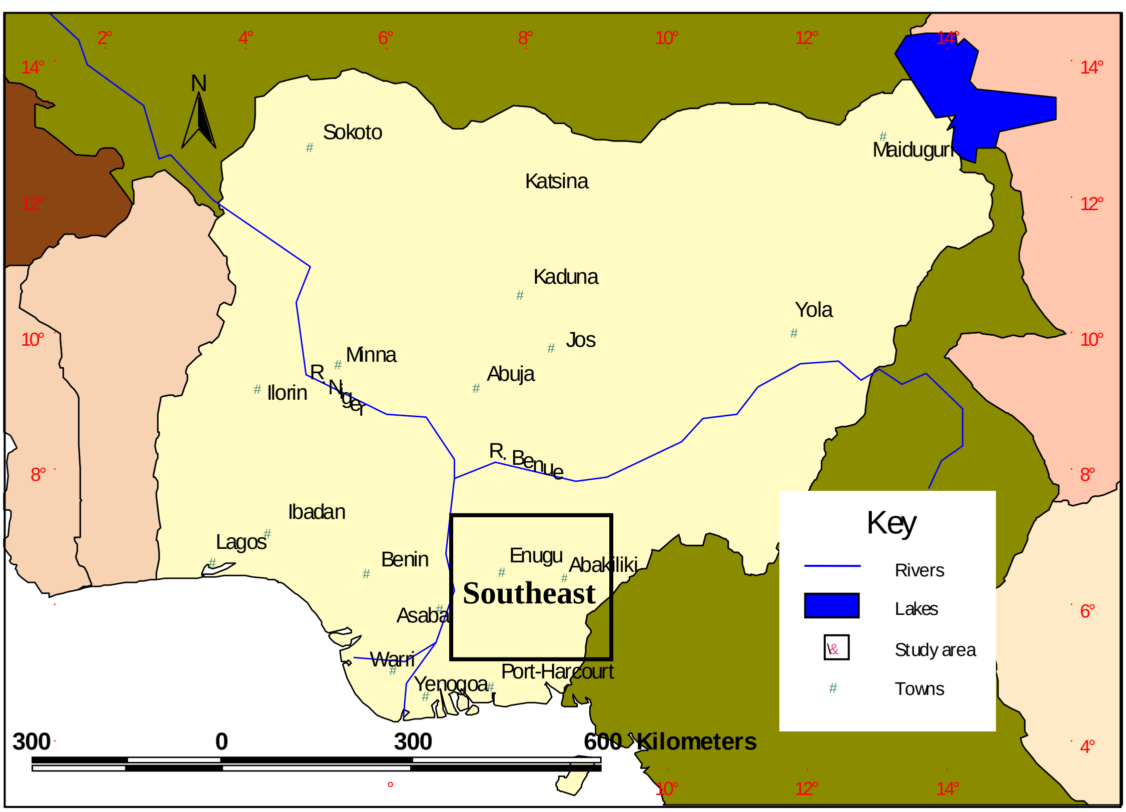

Figure 1 : Map of Nigeria showing the location of the southeast

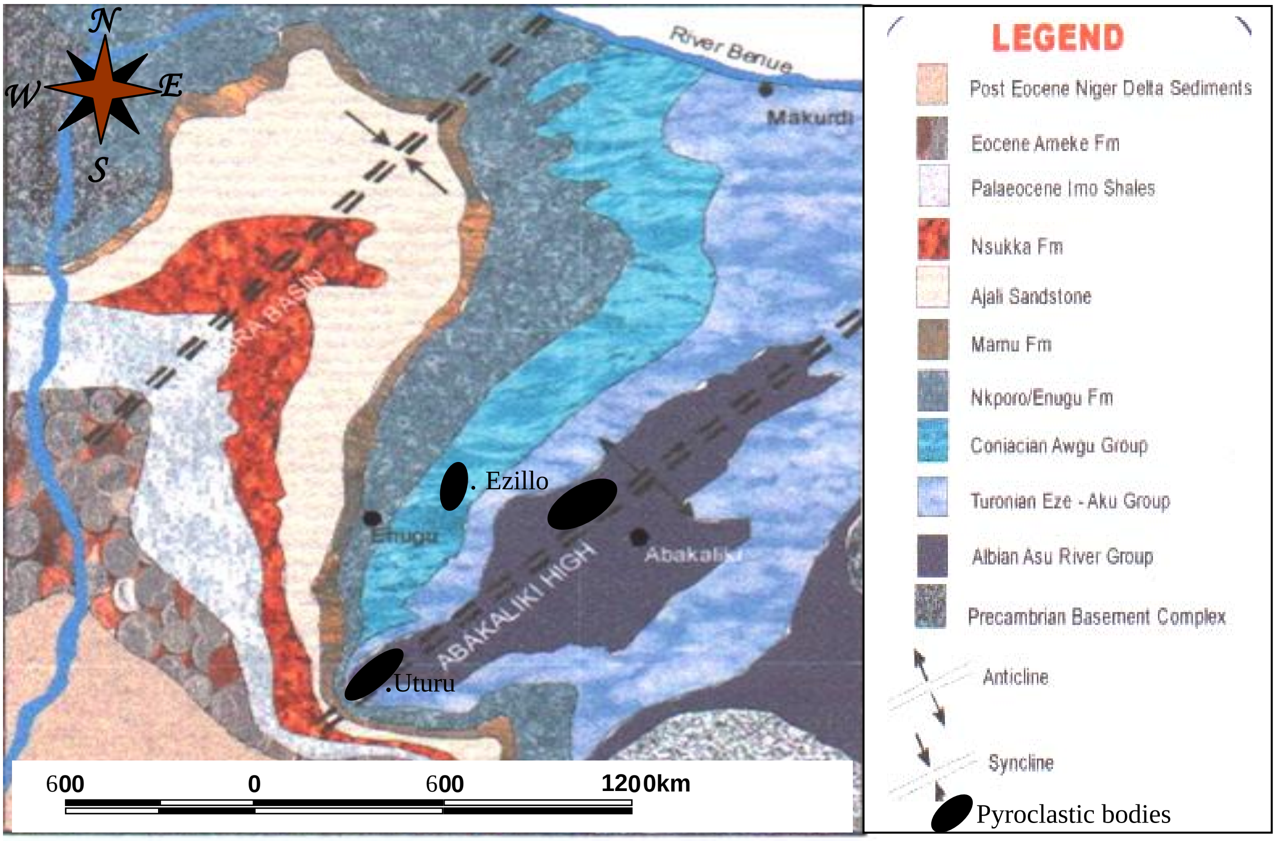

Figure 2 : Geological map of southeastern showing locations of pyroclastic rock bodies [Modified after Ofoegbu and Amajor (1987) and Aghamelu (2009)]

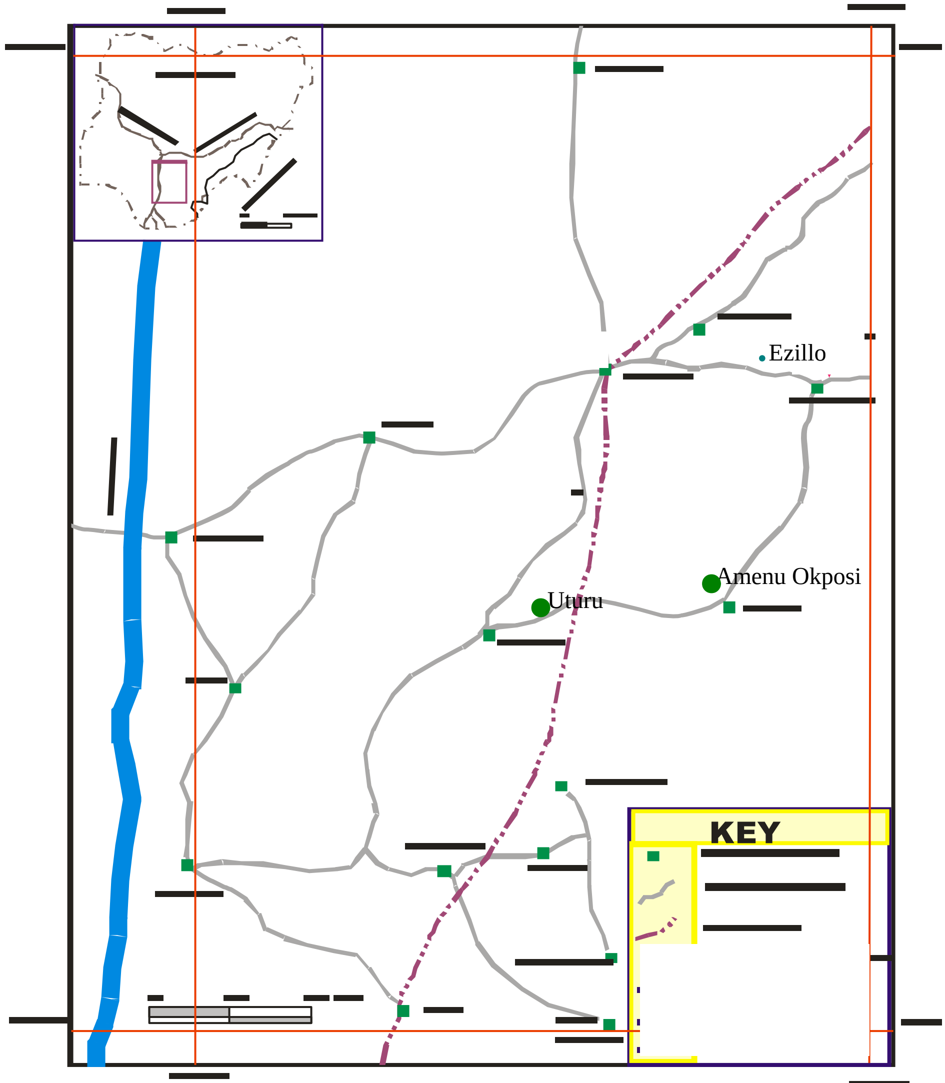

Figure 3 : Accessibility map of the southeastern Nigeria cities