LEAD (Pb) CONCENTRATION IN THE WATER OF KUBANN1 RIVER DAM, ZARIA

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DEPARTMENT OF GEOLOGY,
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AHMADU BELLO UNIVERSITY, ZARIA

SEPTEMBER, 2000

CERTIFICATION

This work entitled "Lead (Pb) Concentration in the water of Kubanni Dam, Zaria by Muhammad Lawal GARBA meets the regulation governing the award of degree of Master of Science in Geology (Hydrogeology), Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DECLARATION

I Muhammad Lawal GARBA, with registration number M.Sc/Sci/15492/97-98, hereby declare that this thesis is the product of my own research and has not been presented for higher degree in any other University. All quotations have been acknowledged and distinguished.

Muhammad Lawal GARBA,

15 JANUARY 2001

Date

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ABSTRACT

Past studies in Kubanni Dam indicated such a high concentration of Pb, that if substantiated pose a danger to the health of the residents of ABU Main Campus, who consume water from Kubanni Dam. But the values obtained from the past studies often contradict each other, that is from 0.5ppm, (Udoh, et. al., 1986)005ppm, (Obamuwe, 1998), and 0.003ppm (Jeb, 1996). This study aims at reassessing the level of Pb concentration in the Kubanni Dam.

To ensure the highest possible reliability of results, inter-laboratory and inter-technique comparisons were employed. Whereby same sample was divided into two and given at the same time to two different laboratories that either operate the same technique or different techniques. Laboratories used for this purpose includes; the Department of Geology Ahmadu Bello University Laboratory Zaria, Institute of Chemical Technology Laboratory Basawa, National Animal Production Research Laboratory Shika, Geological Survey Laboratory Kaduna, Nigerian Defence Academy Laboratory Kaduna and Onarem Research Laboratory, Niger Republic. All these laboratories operate AAS of different models. And lastly, the Centre for Energy Research Laboratory A.B.U. Zaria which operates X-ray Fluorescence Technique. The variety of techniques and laboratories employed allow tor the elimination of non credible laboratories. That is, laboratories that gave for the same sample two different results were eliminated, and those that gave results that do not differ, much were accepted as more credible.

Findings from both Kubanni Dam and from areas considered as non polluted indicated a Pb concentration in the range of <0.024 to <0.011 ppm for the Kubanni

Dam and from <0.014 to <0.()08ppm for non polluted areas, that is at the level of its usual concentration in non polluted water. The first two figures indicate that, there is either no Pb pollution in Kubanni Dam, or in the worst case, there is insignificant Pb pollution, and therefore high values obtained by some of the previous workers cannot stay.

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1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Studies have been made of the concentrations of heavy metals in Kubanni Dam, with most of them showing abnormally high concentration of trace elements especially of Pb (e.g. Udoh et. al., 1986; and Obamuwe, 1998). The results obtained, however, do not agree with each other, which cast some doubts about their reliability. Therefore, this study was conceived in order to confirm, or otherwise, the findings of the previous studies because of the consequences of anomalous heavy metal concentration in drinking water and the environment.

Of the heavy metals, Pb has been singled out as the main focus of this study. This is due to its highly toxic nature, and also because of its easy mobility in human environment.

Results obtained from the previous studies with respect to Pb show both abnormally high concentrations hazardous to the health of water consumers, and normal concentration acceptable for drinking water. Which of these results is acceptable becomes the task of the present work.

1.2 OBJECTIVE OF THE STUDY

The objective of this study is to determine concentration of Pb in water of Kubanni Dam. In order to achieve the said objective, the following will be undertaken:

a) Determination of the Pb concentration in water of Kubanni Dam, and as well in groundwater in Kubanni Dam drainage basin.

b) Determination of directions of groundwater and surface water flow in the drainage basin of Kubanni Dam, in order to demarcate source of any possible pollution.

1.3 JUSTIFICATION OF THE PROPOSED STUDY

As shown by Cannon (1976), and WHO (1996), the concentration of Pb in natural fresh water is very low. This is due to the fact that, although small amounts of Pb are widely distributed as a minor constituent in rocks, soils, and minerals, it is only slowly released by weathering process. But surprisingly this is the reverse with Kubanni Dam, where previous workers have indicated the existence of excessive Pb concentration in the reservoir, which has to be proved in order to justify the fear of possible Pb poisoning by the consumers of such water. This would be achieved first by establishing the background concentration of Pb in the groundwater of the catchment area (in supposedly non polluted areas). Results obtained will be compared with those obtained from the dam. If excessive concentration of Pb in Kubanni dam is proved, the source of pollution will be constrained and proposal made on eliminating the pollution. Should there be no Pb pollution in Kubanni dam, then;

a) the work will contribute to the understanding of the level of concentration of Pb in non polluted groundwater of the predominantly Older Granite terrain of Zaria; and

b) Fears, that residents of A.B.U campus are slowly poisoning themselves by drinking water polluted by toxic Pb, will be alleviated.

1 · 4. DESCRIPTION OF THE STUDY AREA

1 · 4.1 Kubanni Dam - Its Purpose and History

The Kubanni Dam (Plate 1) is an impounding reservoir located within the Ahmadu Bello University Main Campus, Zaria. The Kubanni Dam project was first mooted by the Estate Department of Ahmadu Bello University, Zaria, in 1970, in an attempt to satisfy the rapidly increasing water demand of the Main Campus. The feasibility studies started in 1970, with the actual construction starting in 1972 and completed by 1980. The plant became fully operational in 1982. According to Baker et el., (1979), before the construction of the Dam, the river Kubanni for most of its length was a seasonal river, fully flowing immediately after heavy rainfall, but with no surface flow at all during the dry season.

The Dam (Plate 1) according to Ologe (1973) is about 800m long, with a catchment area of about 57km^2. It covers an area of 80.94ha (0.8km^2) and have a storage capacity of 2.4 million cubic meter. This represents the amount of water that will be available at the end of the rainy season.

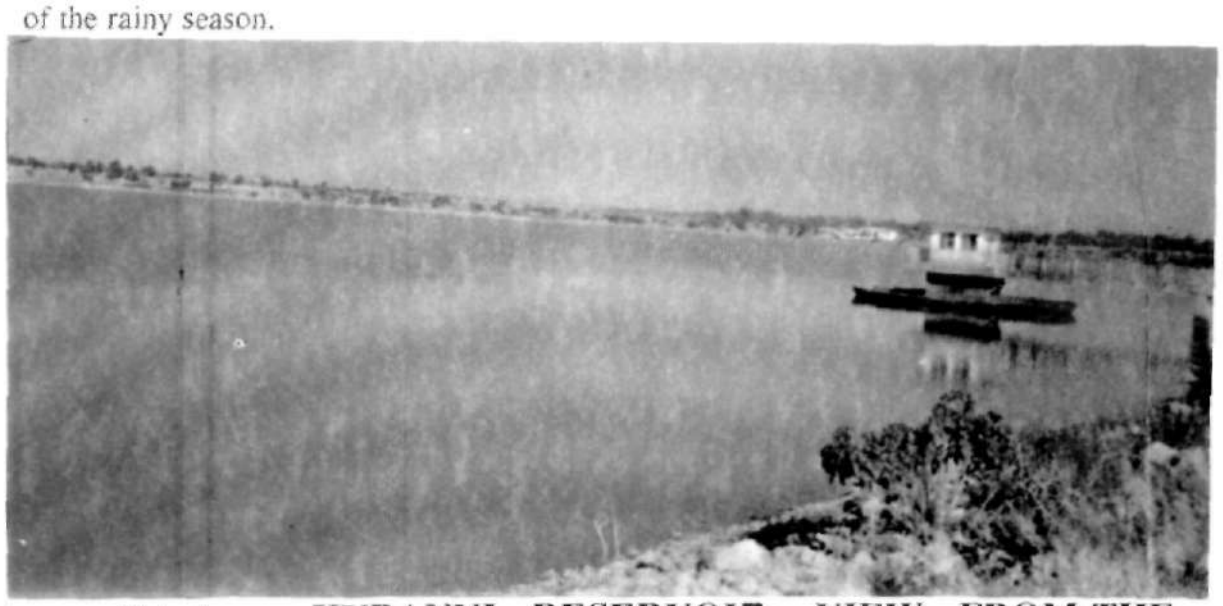


Plate 1: KUBANNI RESERVOIR. VIEW FROM THE CREST OF THE DAM TOWARDS WEST

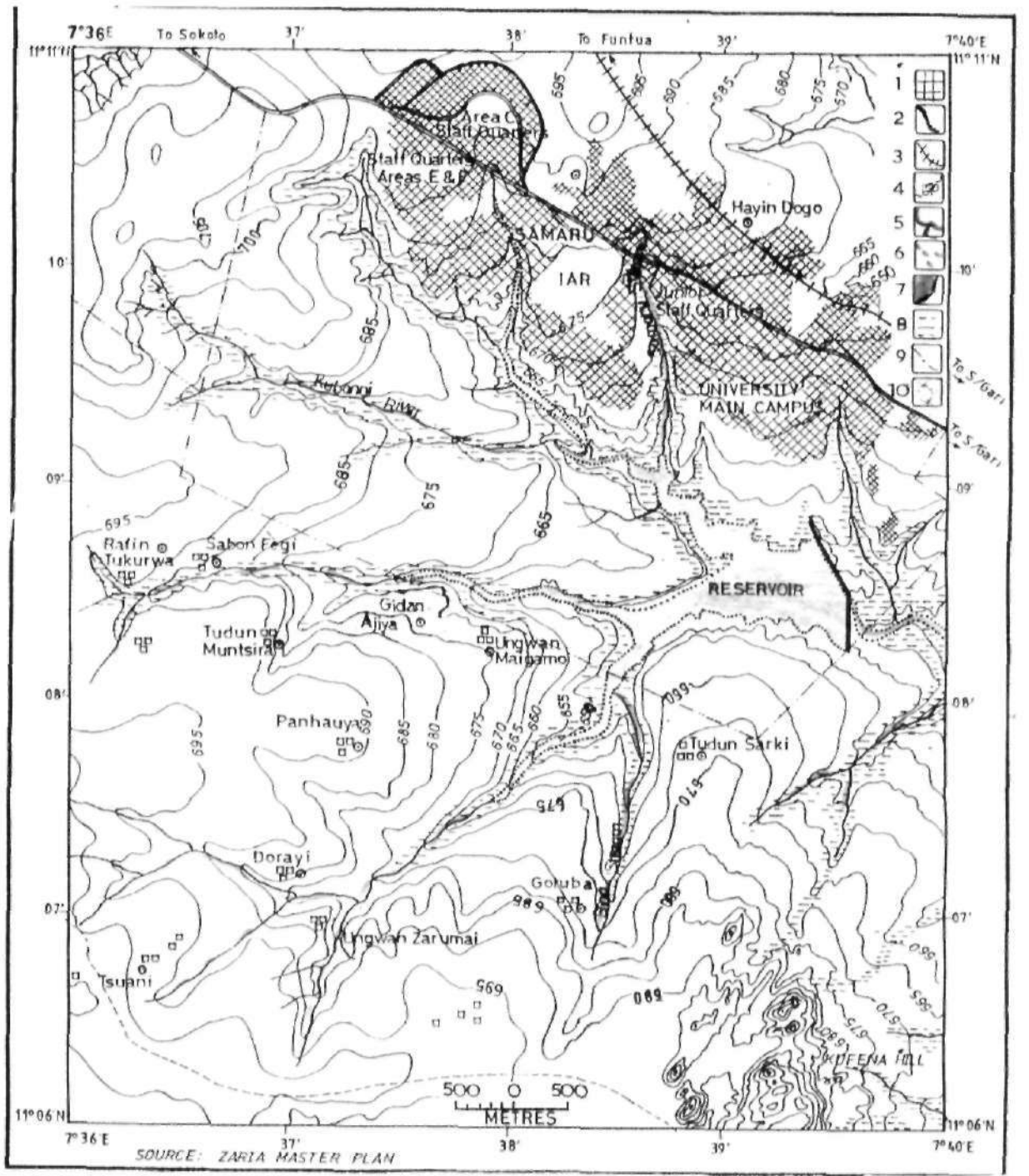


Fig. 1: **LOCATION MAP OF THE STUDY AREA;** *Legend: (1) Built up Areas, (2) Major Roads, (3) Rail Line, (4) Contours in Metres, Above Mean Sea Level, (5) Perennial Stream, (6) Ephemeral and Intermittent Streams, (7) Kubanni Impounding Reservoir, (Plate 1), (8) FloodPlain, (9) ABU Property Boundary.*

1.4.2 Location, Extent and Accessibility

The study area is located on the Basement Complex area of Nigeria, on sheet 102 Zaria SW. It covers an area of about 76km^2. The area falls between latitudes 11°06'00"N to 11°11'00"N and longitudes 7°36'00"E to 7°40'00"E. It is well accessible, with good road network and footpaths, especially from the Zaria - Gusau Road. Except during the peak of the rainy season, most of the stream courses are passable.

1.4.3 Relief and Geomorphology

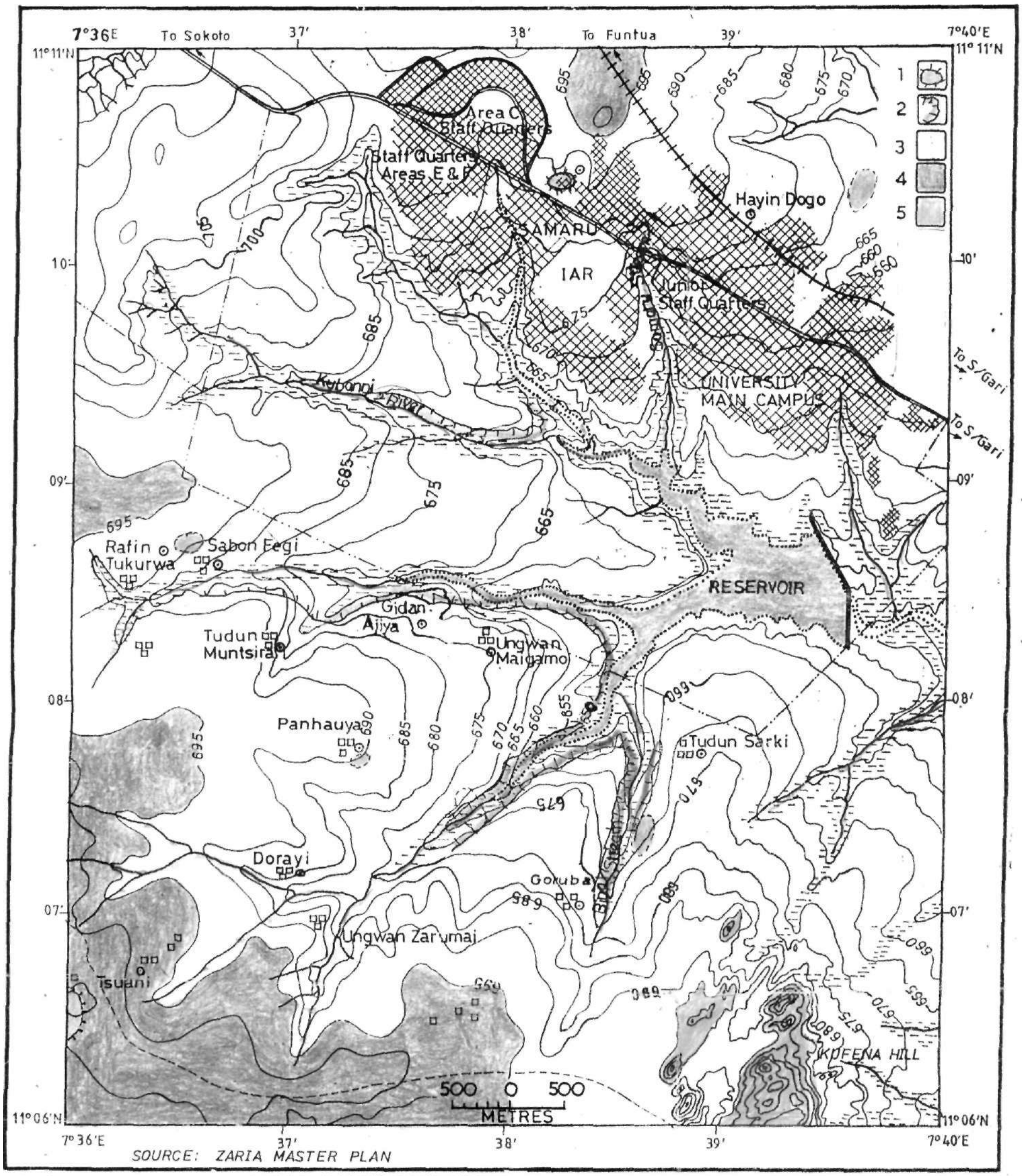
The Kubanni drainage basin is part of a vast, gently dissected plain. This plain is for most part covered by a thick alluvium. The landforms comprise of inselbergs, escarpments with duricrust capping, plains, and valleys (Fig. 2).

Blocky inselbergs and whalebacks are the most conspicuous features of the area, with the Kufena hill rising to about 720m metres above mean sea level or 40 metres above the surrounding plains. The inselbergs are mostly blocky and sometimes convex shaped as typified by the Kufena hill.

The plains are of two types, the Recent denudational plain and probably the Tertiary depositional surface. The plain was largely dissected by gullies generally attributed to the indiscriminate deforestation, improper land clearing and farming practices. These lead to the stripping the area of its natural cover making it easier for erosion to take place e.g. Plate 2, where a scarp is shown in one of the developed gullies.

1.4.4 Climate

Zaria area has a tropical continental climate with a very distinct wet and dry season. The wet season begins in April and ends in October, during the high sun period. The dry season, in which there is no rainfall, occurs from October to March. The total



SOURCE: ZARIA MASTER PLAN

Fig. 2: GEOMORPHOLOGICAL (MORPHOGENETICAL) MAP: *Legend: (1) Mesa Hill (Lateritic Depositional Surface), (2) Scarps (Escarpments), (3) Younger Accelerated Erosion Surface, (4) Older Erosional Surface (5) Inselbergs (Ruwares and the blocky type).*

mean annual rainfall in the area is 1047.7mm mean of 1928 - 1997 (Meteorological Data Station, I.A.R. Samaru).

The mean daily maximum temperature rises gradually from January and show a major peak in April and a minor one in August. The minimum temperature rises from its lowest value in December-January to its highest in July -August,(Meteorological Data Station I.A.R. Samaru).

1.4.5 Vegetation

The area lies within the Northern Guinea Savannah Zone. It is characterized by an open sub-humid broad-leaved savannah woodland vegetation with short to medium grasses. The vegetation on the whole have been greatly disturbed either by overgrazing, bush burning, deforestation for firewood, or cultivation. Few of the common woody tree species in the area include Isoberlina doka, locus bean (Parkia biglobosa), baobab (Adansonia digitata) and shear butter trees (Vitallaria paradoxin).

Jackson (1970), stated that, along the river valleys, there are often fringes of forest, in some places with tall trees and well developed undergrowth. These are however susceptible to fire damage resulting from bush burning, but may be represented in some cases by only a few scattered trees.

1.4.6 Landuse

Most of the land area in the Kubanni basin, with the exception of built up areas, the floodplains, and the stream courses that fall within the University land area, all were

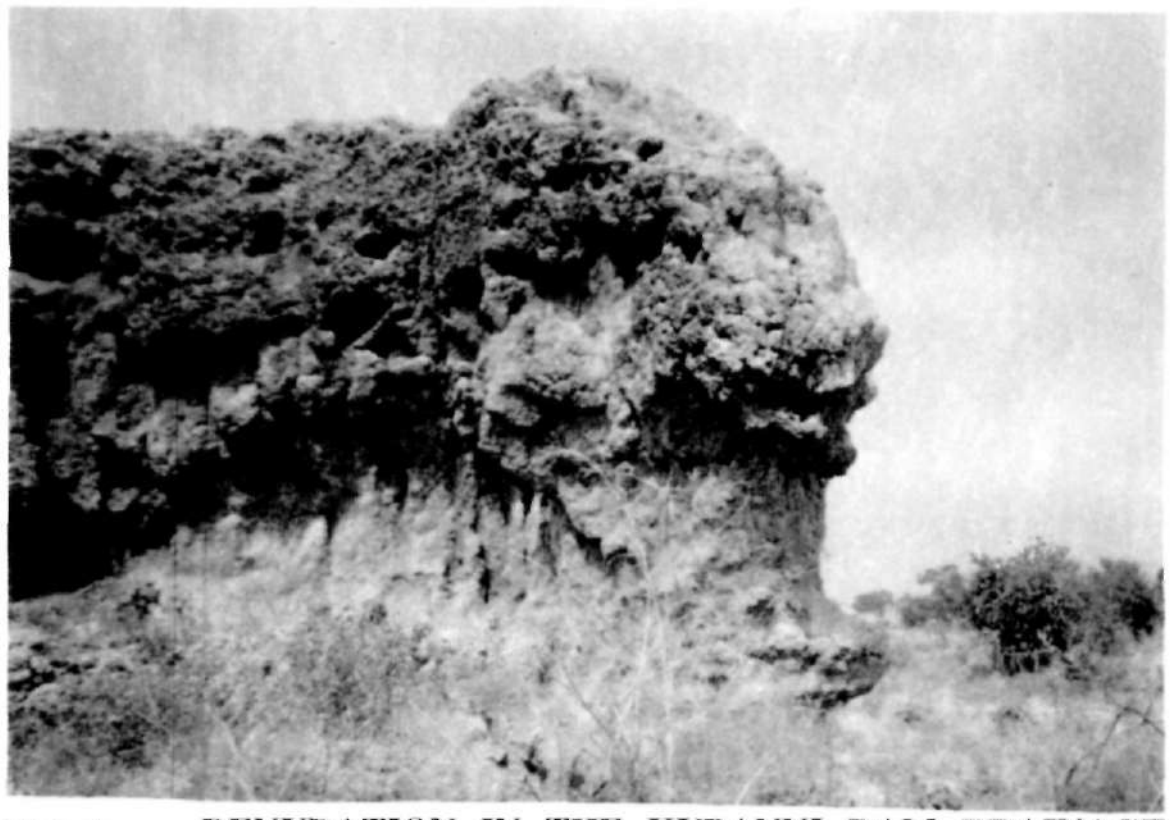


Plate 2: DENUDATION IN THE KUBANNI DAM DRAINAGE BASIN

Used for subsistence farming, until recently, when the University prohibited any cultivation within the valley.

1.4.7 Geology

1.4.7.1 Overview of Geology of the Basement Complex

The Basement Complex of Nigeria forms part of the Pan-African Mobile Belt, and lies between the West African Craton and the Congon Craton, and South of the Tuareg Shield (Black, 1980).

Three main rock types found on the complex are:

a) The Migmatite-Gneiss complex which is Precambrian to Palaeozoic in age.

b) Narrow Schist belts trending North-South, which are restricted to the western half of the country and are Proterozoic in age.

c) The Older Granite that intruded the Migmatite-Gneiss complex and the Schist belt between 700M.Y and 400 M.Y ago during the closing stage of the Pan-African cycle.

Ajibade (1988), also stated that the Nigerian Basement Complex additionally includes three other units, and these are:

i) Charnokitic, gabbroic and dioritic rocks.

ii) Metamorphosed to unmetamorphosed calc-alkaline, volcanics and hypabyssal rocks.

iii) Unmetamorphosed basic and intermediate dykes including dolerites.

1.4.7.2 Geology of the Study Area

1.4.7.2.1 Rocks

The study area which lies to the NW of Zaria city, is composed of Precambrian rocks of the Gneiss-Migmatite Complex intruded by the Pan-African Older Granites. The distribution of the various rock types is as shown on the geological map of the area (Fig. 4). Rock units observed in this area include from the oldest, to the youngest

i) Biotite gneiss

ii) Older Granite (comprising of the coarse porphyritic variety and the medium grained granite).

iii) Microgranite and Pegmatites.

Biotite Gneiss: This was observed only along stream channels, more especially the upper part of Samaru stream where it mostly outcrops (see Fig. 3). They are deeply weathered with a light brown to grey colour. Texturally, they are mostly medium grained, with one of the outcrops showing a textural variation, that is, it has porphyroblast of feldspars embedded in fine to medium grained groundmass. Whereas the rest were granular.

Older Granite: This rock type is the most common in the study area occupying almost two thirds of the area. It outcrops as dome inselbergs, low whalebacks inselbergs, and also as low lying outcrops called ruwares. It occurs in two varieties.

i) The porphyritic variety which is mostly confined to deeply eroded valleys and stream channels. It is deeply weathered with the phenocrysts possessing equant shape without any preferred orientation. In one exposure a clearly depicted gneissose foliation was observed. This makes it difficult to be distinguished from the porphyroblastic Gneiss observed in location 12 (Fig. 3), if not for the laters clearly exposed foliation. This rock type was also observed at location 11 where it occurs as a large xenolith contained within a medium grained granite.

ii) The medium grained granite predominates over the porphyritic variety and is fresher than the porphyritic type. It occurs mostly as dome inselbergs

and low whaleback. In hand specimen, orthoclase, biotite and quartz are observed.

Pegmatites: These consist principally of coarse feldspar (orthoclase), quartz, biotite and sometimes muscovite. Their composition is almost equal to that of the earlier described granites if not for their muscovite content. The pegmatites vary in width from less than one metre to a few centimetres.

Microgranites: These usually occur within the main granitic exposure as late intrusions possibly infilling tensional cracks. They are fine grained with composition similar to that of the earlier described granite.

The quartz veins occur as small veins and veinlets and are almost exclusively composed of quartz. They range in thickness from less than a centimetre to about ten centimetres and occasionally cross cutting the pegmatites.

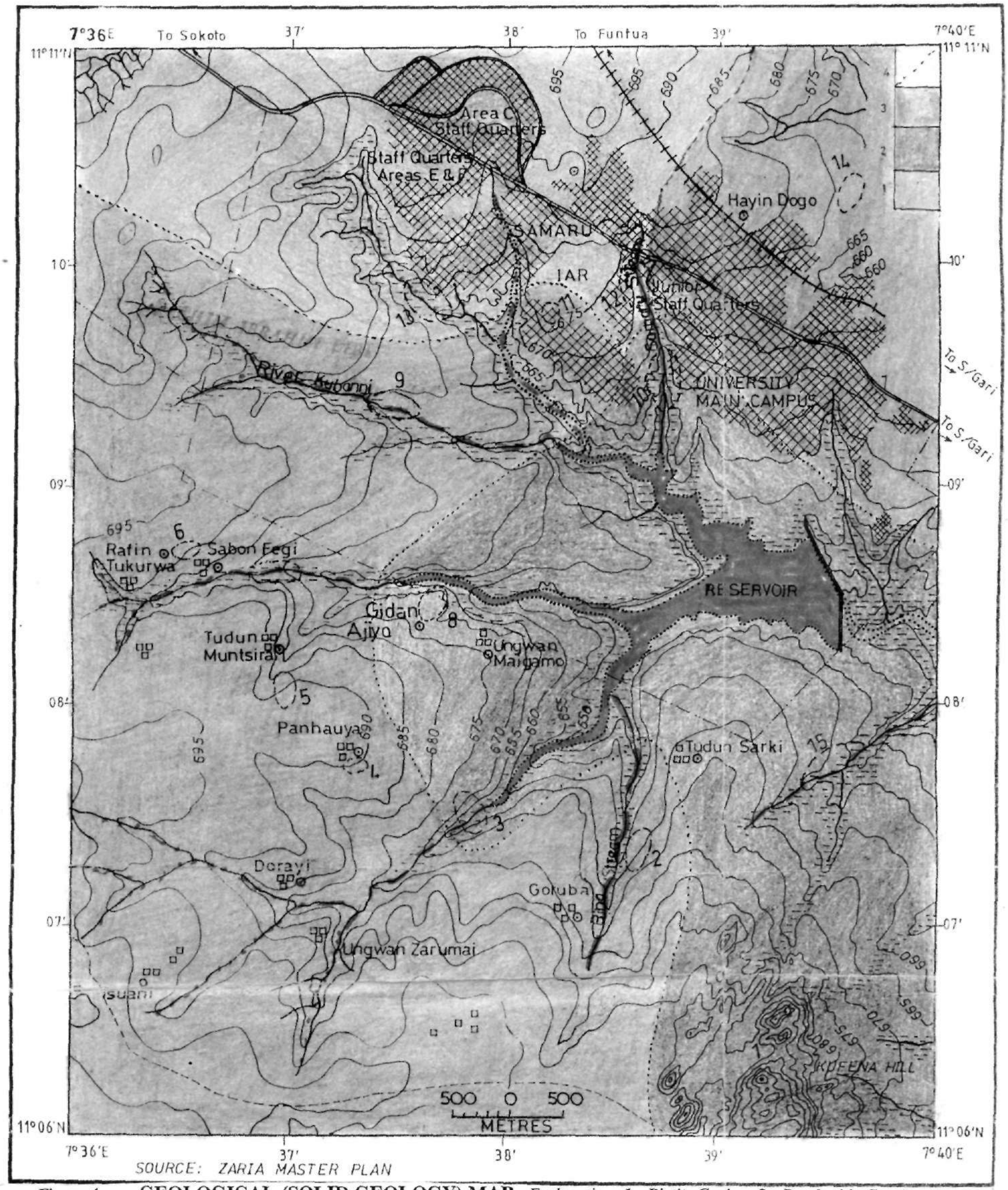


Figure 4: **GEOLOGICAL (SOLID GEOLOGY) MAP**. *Explanation: 1. Biotite Gneiss. 2. Porphyritic Granite. 3. Medium Grained Granite. 4. Solid Rock Boundary. For other explanations see figures 1.*

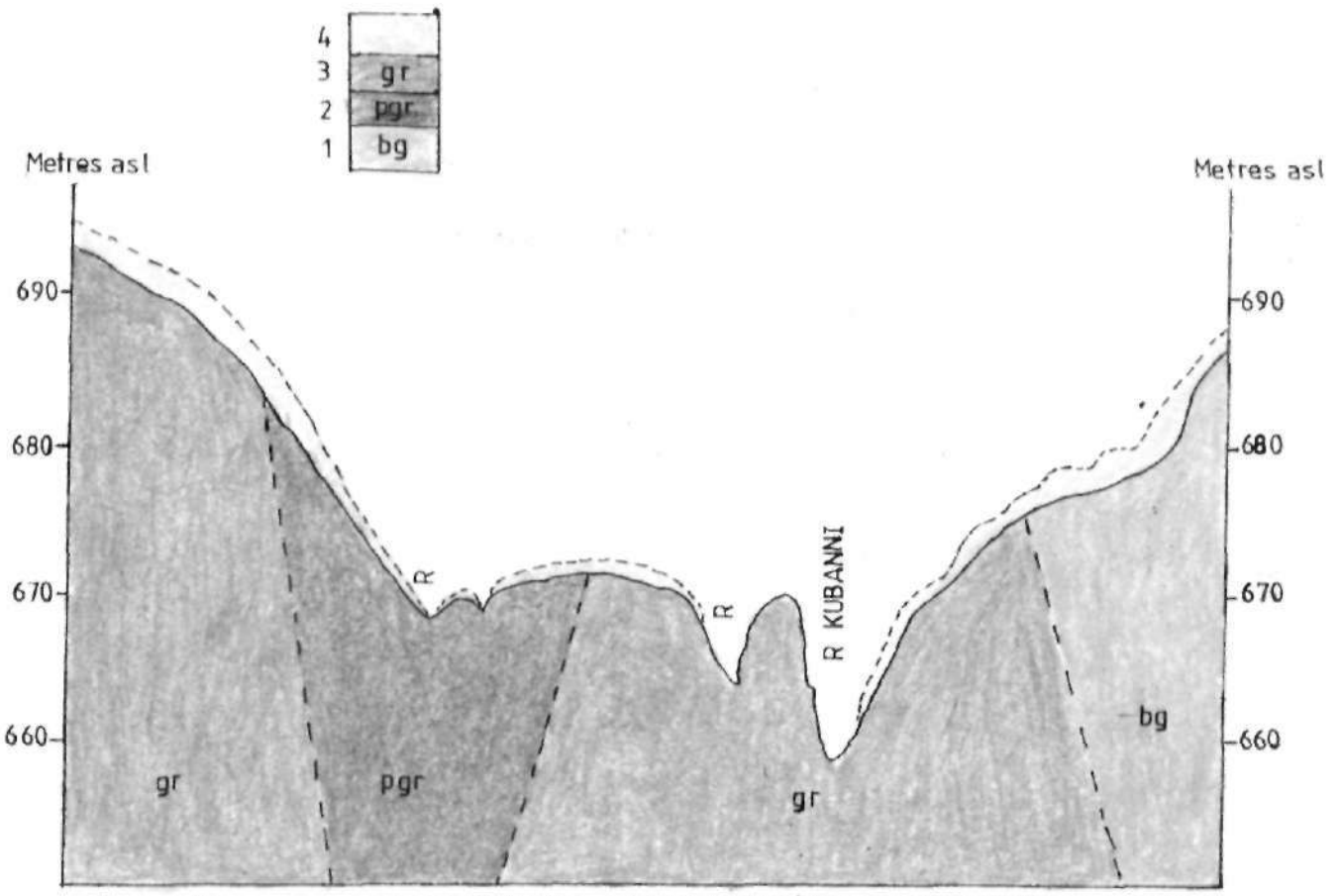


Figure 4b: **GEOLOGICAL CROSS-SECTION THROUGH FIGURE 4.**
Horizontal Scale 1:61, 500, Vertical Scale, 1:5000. Explanation: 1)Gneiss. 2) Porphyritic Granite. 3) Medium Grained Granite. 4) Soft Overburden.

TABLE 1.1 DESCRIPTION OF ROCK OUTCROPS WITH PROBABLE NAMES AND AGES

LOCATION	COORDINATES	DESCRIPTION OF OUTCROPS	PROBABLE NAME	PROBABLE AGE
1.	11°06'09"N 7°39'17"E	An inselberg of porphyritic structure. It occurs as the most prominent feature of the study area. Colour varies from dark grey to light grey. At the southern part, the rock outcrop is being quarried for construction work	Coarse Grained Porphyritic Granite	Early Pan-African
2.	11°07'22"N 7°38'39"E	A deeply weathered discrete boulders exposed along the Bina stream. Colour is greyish to dark brown. This probably is due to the effect of weathering.	Coarse Grained Granite	Pan-African
3.	11°07'30"N 7°37'53"E	Coarse to porphyritic granite, colour is greyish in fresh varieties, but it changes to light brown where affected by weathering. Phenocrysts are closely packed together, they are equant in shape, with the rock displaying faint foliation giving it a gneissose appearance	Porphyritic Granite	Early Pan-African
4.	11°07'46"N 7°37'22"E	A combination of low whaleback and blocky inselberg. Texturally they are medium to coarse grained with the blocks deeply weathered probably due to their fractured nature which facilitates the downward movement of water deep into the rock and thereby resulting to their chemical decay. This mostly is restricted to the western side of the exposure. To the north east, the rock displays a weak foliation, and also not too deeply weathered probably due to its domical nature	Medium to Coarse Grained Granite	Late Pan-African
5.	11°08'05"N 7°36'58"E	Granitic pavement of same composition as in four above	Medium Grained Granite	Late Pan-African
6.	11°08'42"N 7°36'30"E	Coarse to medium grained granite, occurring as a low whaleback and is dark grey in colour	Medium grained granite	Late-Pan African
7.	11°08'38"N 7°36'50"E	Medium grained granite that is oriented towards NW-SE. It is dark grey in colour and this may be due to its prominence of biotite	Medium Grained Granite	Late Pan-African
8.	11°08'30"N 7°37'33"E	Same as in 3 above	Porphyritic Granite	Early Pan-African

9.	11°09'18"N 7°37'27"E	Coarse grained granite, occurs along the main Kubanni river and is deeply weathered	Coarse Grain Granite	Pan- African
10.	11°09'22"N 7°38'42"E	Same as in 3 and 8 above	Porphyritic Granite	Early Pan African
11.	11°09'42"N 7°38'09"E	Medium grained granite. Colour is pink due to the prominence of orthoclase feldspar. It occurs as the main outcrop, within which a large xenolith of porphyritic granite is contained.	Medium Grain Granite	Late Pan-African
12.	11°09'52"N 7°38'38"E	A mixture of freshly exposed and deeply weathered gneisses. Foliation is well exhibited with the outcrops trending north-southerly direction. On one of the exposures phenoblasts of feldspars were clearly observed thereby making the exposure a porphyroblastic variety.	Biotite Gneiss	Dahomeyan
13.	11°10'10"N 7°38'33"E	Same as in twelve above	Gneiss	Dahomeyan
14.	11°10'16"N 7°39'33"E	Deeply weathered coarse grained granite, it occurs as large exposed boulders.	Coarse Grained Granite	Pan-African
15.	11°07'43"N 7°39'30"E	Coarse porphyritic granite. freshly exposed and occurs along stream channel as a granitic pavement.	Porphyritic Granite	Early Pan-African

1.4.7.2.2 Water

Surface Water

The main Kubanni river and streams that flows into it, all are seasonal with the exception of Samaru stream. They are mostly ephemeral (i.e. those that flows during and immediately after the rainfall), and seasonal (that is, those that flow during the rainy season, but dry up during the dry season). These streams mostly drain runoff from the plains most of which are farmlands. Streams that flow for some duration into the dry season are mostly being fed by groundwater discharge (that is, they are effluent streams). On the other hand, flow in Samaru stream, apart from the groundwater discharge is mostly sustained by discharged domestic effluents and runoff from Samaru village.

Groundwater

In the study area, two types of aquifers exist, and these are the Regolith Aquifer and the Fractured Crystalline Aquifer. Both the two are important groundwater sources.

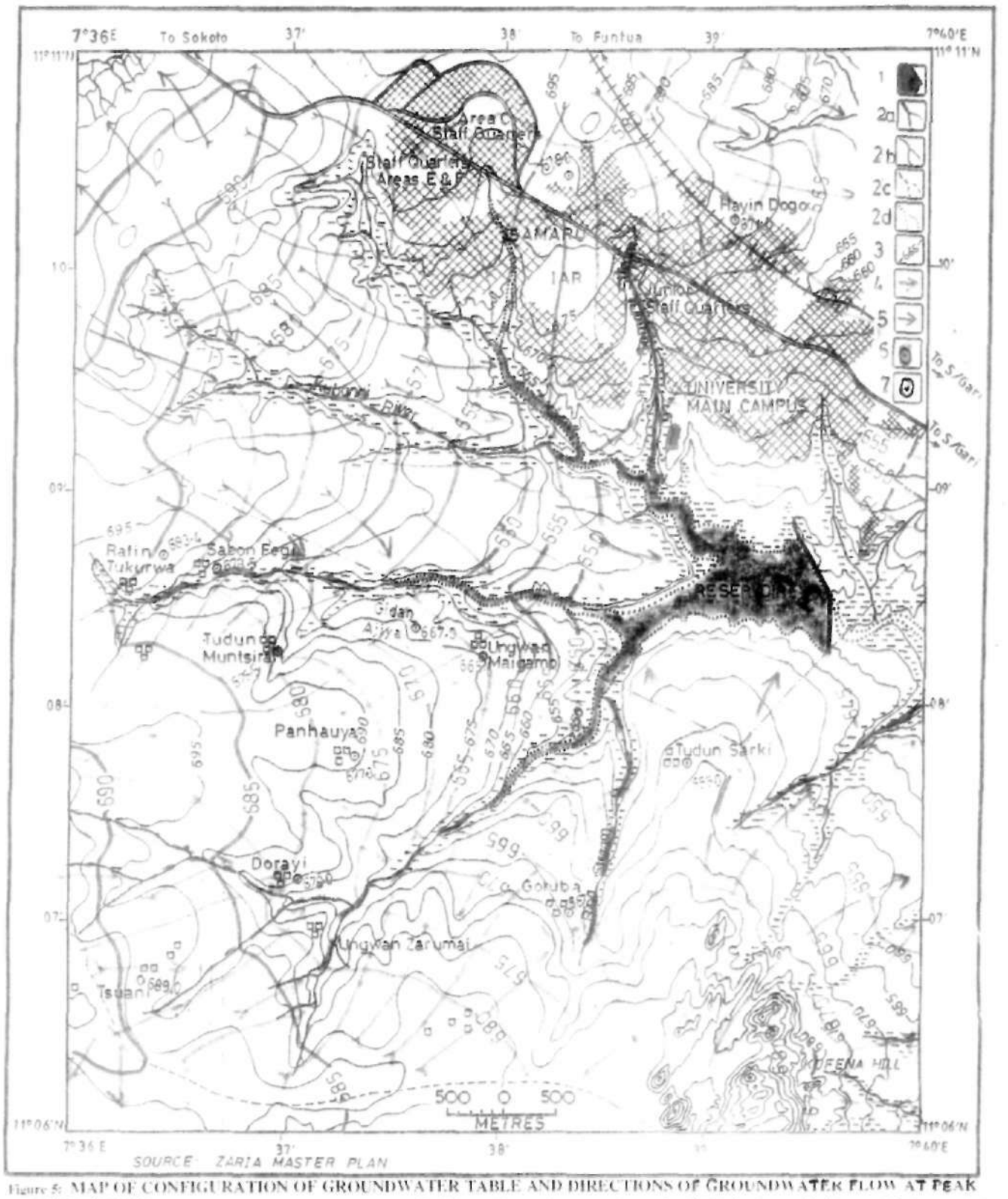
The Regolith Aquifer in Northern Nigeria varies in thickness from less than 10m to more than 50m (Adanu, 1987, also figure 7 and 8 of this work). It is stratigraphically made up of collapsed zone (sandy at the top and clayey at bottom), the saprolite (clay derived from in situ weathering) and saprock (weathered bedrock). Water table typically occurs at shallow levels of less than 10m to 15m with the wells being mostly phreatic in character. The Regolith Aquifer provides the main storage for deep boreholes. According to Adanu (1987), boreholes yield are generally low, mostly in the range of 0.3 l/s to 0.5 l/s which depicts the low permeability of the aquifer due to its clayey nature, but well yield is generally sufficient to sustain handpumps for rural domestic needs. The most common abstraction method is by hand dug wells mostly unlined which are found in each of the compounds in the area of study. But generally, in all the villages visited there is a centrally located concrete lined well which probably have been constructed by their Local Government Council.

The Fractured Crystalline Aquifer, unlike the Regolith Aquifer is highly permeable, with the water being contained within the fractured zone, but this water is beyond the means of the villagers.

The groundwater flow systems are restricted between recharge on the watershade by infiltration of precipitation, and discharge at the valley bottom, and this mostly supplement surface flow during the dry season (Fig. 5 and 6). This as can be seen on the

Figures 5 and 6 is occurring mostly along Samaru stream, and probably that is part of what is sustaining the flow of that stream throughout the year.

The water table contour line configuration for both the dry and wet seasons with their corresponding flow directions indicated by arrows which have been drawn perpendicular to the contour lines (equipotential lines) are diverging from the watersheds (that is topographically high areas), which are recharge areas and are converging towards the stream channels which are discharge areas.



SOURCE: ZARIA MASTER PLAN

Figure 5: MAP OF CONFIGURATION OF GROUNDWATER TABLE AND DIRECTIONS OF GROUNDWATER FLOW AT PEAK OF DRY SEASON *Legend: 1 - Impounded area, open water table of Kubanni impounding reservoir as at April 1999. 2 - Streams: 2a Perennial, flowing at end of dry season 2000; 2b Perennial not flowing, with lushes of water in the river channel; 2c - Seasonal, dry with waterholes in the alluvium; 2d - Seasonal, dry channel no waterholes in the channel. 3 - Contours of the groundwater table, at the peak of dry season (end of April, 2000) in metres above sea level. 4. Directions of the groundwater flow presumably non polluted water; 5 - Directions of groundwater flow, presumably water polluted by residential effluents. 6 - ABU Solid Refuse Dump. 7. Hand-dug wells and elevation of water in metres above sea level at the end of dry season (end of April, 2000).*

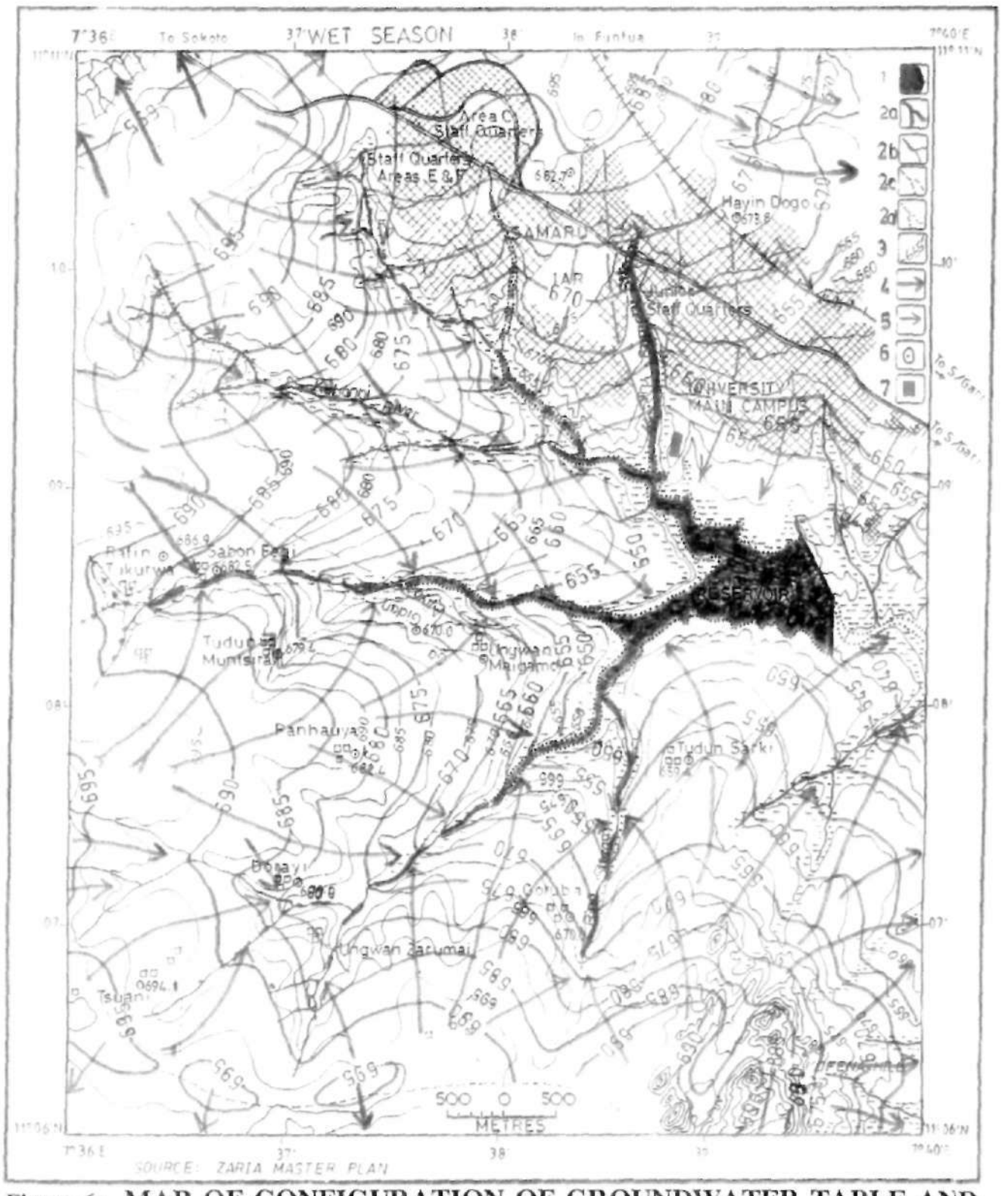


Figure 6: MAP OF CONFIGURATION OF GROUNDWATER TABLE AND DIRECTION OF GROUNDWATER FLOW AT PEAK OF RAINY SEASON.

For explanations see figure 5.

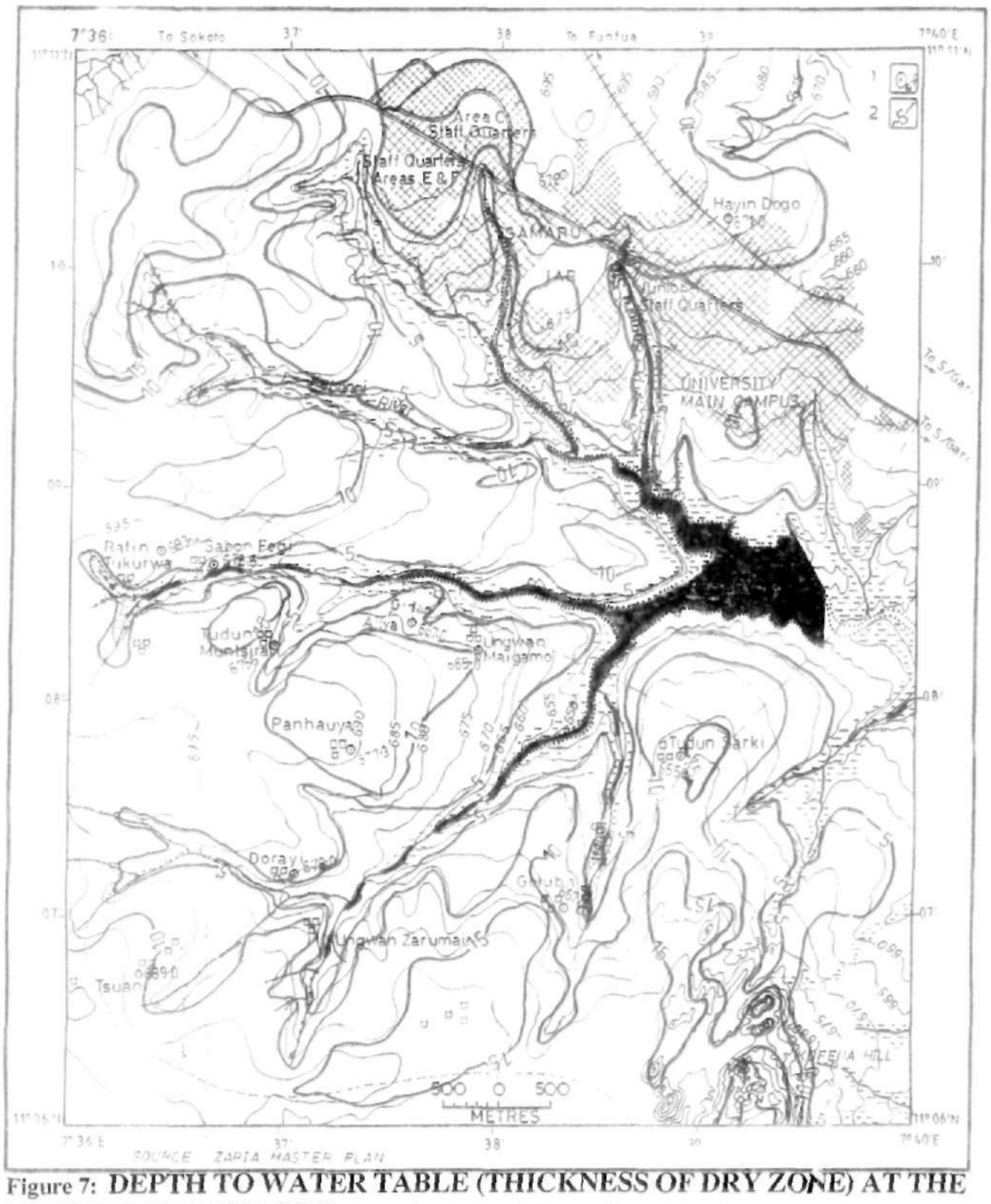


Figure 7: DEPTH TO WATER TABLE (THICKNESS OF DRY ZONE) AT THE PEAK OF DRY SEASON, *Legend: 1. Hand-dug wells and depth to water table in metres below ground surface as measured at end of April 2000. 2) Contours of depth to water table in metres below ground surface, at the peak of dry season. For other explanations see figures 1 and 4b.*

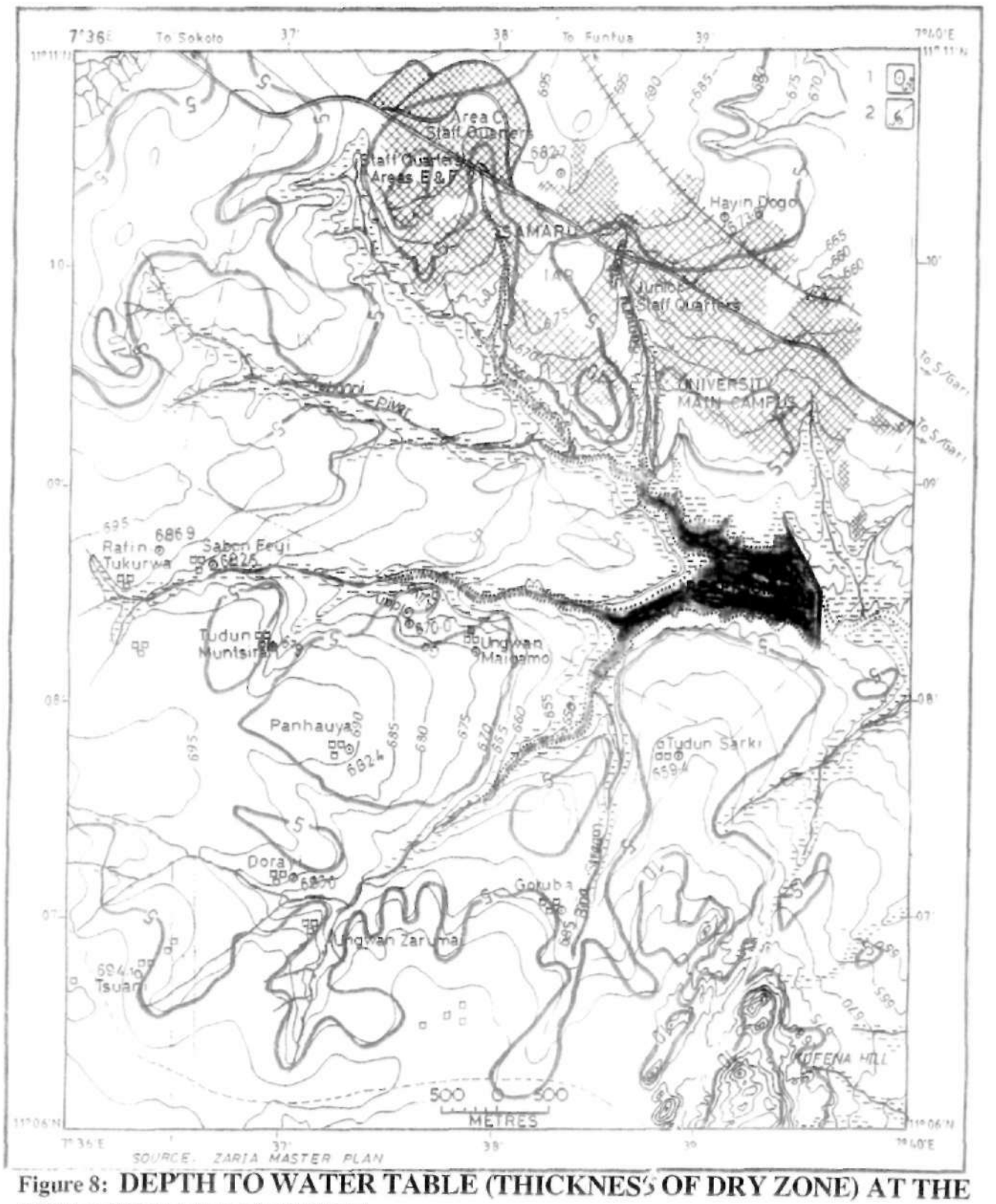


Figure 8: DEPTH TO WATER TABLE (THICKNESS OF DRY ZONE) AT THE PEAK OF RAINY SEASON,

Legend: 1. Hand-dug wells and depth to water table in metres below ground surface as measured at end of August, 2000. 2) Contours of depth to water table in metres below ground surface, at the peak of Rainy season. For other explanations see figures 1 and 4b.

2. REVIEW OF HEAVY METALS

2.1 Heavy Metals - What is it?

According to environmental impact statement glossary, heavy metals are metallic elements generally occurring in trace amounts in water, including, Fe, Mn, Cu, Al, Cd, Pb, As, Hg and V etc, usually considered to have an atomic number above 21. They can damage living things at low concentration and some of them tend to accumulate in the food chain. All of them belong to the trace elements, but some of them like manganese and iron, do not belong to trace elements (that is, elements in concentration less than 1ug/g, Ward (1995).

2.2 Sources of Metals in Natural Water

2.2.1 Natural Source

The sources of trace elements in natural water are either natural, that is due to mobilization from soil, vegetation, alluvium or bedrock. Taking for example Pb which is the subject matter of this work, its average abundance in the earth crust is approximately 15ppm, Wedepohl (1964). The Pb content of the common rock types that make up the crust of the earth ranged from about 30ppm for granitic rocks, rhyolite, and black shale to about 1ppm for evaporite sediment, basalt, and the ultramafic igneous rocks such as dunite which is rich in iron and magnesium and poor in silica,according to Lovering (1976).

Pb is also present in trace amounts in many of the common rock-forming minerals. According to Wedepohl 1964, the common silicate minerals found in igneous rocks in order of decreasing Pb content are;

1. Potash feldspar,
2. Plagioclase feldspar and muscovite mica,

3. Pyroxenes, amphiboles and biotite mica; and

4. Quartz.

But despite the abundance of Pb in rocks and minerals (more especially acidic igneous rocks), chemical weathering of common rocks can only contribute minor quantities of Pb to surface water, according to Wedepohl (1964). This low Pb concentration of streams and lakes is probably controlled by Pb adsorption on clay minerals and organic residues, and is thus enriched in the B horizon (of soil profile, for some soils) and this according to Presant (1971) is attributable to the presence of excess clay.

Also, some heavy metals from Basement Complex of Kano area were studied by Magdi (1999). He took 61 samples from fresh bedrock (Older Granite and Schist), saprolite, and indurated laterite. Samples were oven dried and pulverized at the Department of Geology, A.B.U., Zaria. Analyses were done at the Centre for Energy Research and Training, Zaria using X-ray fluorescence technique. He found that from lateritic profiles developed over Granite Pb was 50, 34, 38 and 53ppm in fresh granite, saprolite, mottled zone and the duricrust respectively and this the Author thinks do correlates with the values given by Wedepohl (1964). Table 2.1 is showing the average and ranges of some of the elements he analysed.

As for Tije (1995), he collected his samples from the Younger Granite of Jos at Tenti, where he took 23 samples from parent rock (cassiterite granite) to saprolite layer. He wet sieved his samples, air dried the collected clay fraction, pulverized and digested with aqua regia in

Table 2.1: CONCENTRATION OF HEAVY METALS IN OLDER GRANITE OF KANO AREA. *According to Magdi (1999) All Results are in ppm.*

Method	XRF CERT ABU	XRF CERT ABU	XRF CERT ABU	XRF CERT ABU	XRF CERT ABU	XRF CERT ABU	XRF CERT ABU
Element	V	Ti	Ni	Cr	Pb	Zn	Cu
Range	190-536	1480-3200	30-136	109-251	20-64	28-99	23-91
Mean	326	2356.7	53	180	41	47	41

a ratio of 1:3. His results are as shown on Table 2.2. Analyses were done using an atomic absorption spectrophotometric method model GBC 903, at Kaduna Polytechnic. Detection limits of the determined elements were not stated by the author.

Both Table 2.1 and 2.2 disagree with each other and the difference is too big to relate it to different method of analysis or location of sample, but the author is of the opinion that the difference is much to do with the different method employed by each of the author, in preparing his sample for analysis. While Magdi (1999) analysed his whole sample, Tije (1995) analysed the sieved silt clay fraction he collected after wet sieving his samples. But generally, Magdi's (1999) results are more close to the averages given by Wedepohl (1964).

Also soil and clay mineral contain significant quantities of these metals. Iron is a major component of illitic and montmorillonitic clays and it makes up 0.09% of kaolinitic clays according to Sherman et. al. (1974). Titanium is present in smaller amounts in the three clays. Also soils with large organic fraction are capable of binding significant quantities of metals through organic metal complexing (e.g. lead) Tables 2.3 and 2.4 are showing some trace elements content of uncultivated soil after Ali (1984) and that of an irrigated soil after Dahiru (1989).

Table 2.2: SOME HEAVY METALS IN FRESH GRANITE AND GRANITE WEATHERING PROFILE FROM YOUNGER GRANITE AT TENTI, JOS PLATEAU, BARIKIN LADI LGA. *All results in ppm. According to Tije, 1995. Note, that these concentrations are not comparable with these obtained by Magdi, 1999, from Older Granites of Kano area, presented in Table 5.1 .(After Schoencich,2000).*

GEOLOGICAL PROFILE	Sample	Cr	Co	Ni	Zn	Pb
? Top soil	R	6.0	1.0	5.0	8.0	-
Rd lateritic soil	E1	-	1.0	-	15.0	-
	E2	5.0	1.0	-	12.0	3.0
1.3m						
Purplish saprolite	D1	12.0	2.0	2.0	18.0	-
	D2	-	1.0	-	12.0	1.0
	D3	3.0	0.45	-	5.3	2.0
	D4	5.0	1.2	-	18.3	1.0
	D5	2.0	5.0	-	3.0	2.0
1.9m						
Reddish-brown Saprolite	C1	3.0	1.0	5.0	5.0	1.0
	C2	6.0	0.45	12.0	5.0	-
	C3	-	0.45	-	5.0	1.0
	C4	10.0	1.0	-	18.0	-
	C5	12.0	7.0	2.1	18.0	-
2.2m						
Greenish-greyish weathering rinds	B1	15.0	1.0	1.8	5.0	-
	B2	6.0	7.0	-	11.0	-
	B3	11.0	1.2	1.8	18.0	-
	B4	10.0	1.0	2.0	18.0	2.0
	B5	12.0	4.0	6.0	5.2	1.0
3.0m						
Greenish-greyish weathering rinds	A1	10.0	1.0	2.0	11.0	6.0
	A2	5.0	1.0	2.0	3.0	2.0
	A3	7.0	0.2	2.0	5.0	5.0
	A4	10.0	1.0	2.0	18.0	4.0
	A5	8.0	0.2	-	5.2	-
?m						
AVERAGE	E	5.0	1.0	-	13.5	5.0
	D	5.50	1.93	2.0	**11.32**	**1.5**
	C	7.75	1.98	6.36	10.20	1.0
	B	10.80	2.88	2.90	11.44	1.5
	A	8.0	0.68	2.00	8.44	4.25
TOTAL ABCDE, AVERAGE		7.9	1.75	3.52	10.52	2.38

Table 2.3: MINERAL COMPOSITION OF UNCULTIVATED SOIL *after Ali, 1984*

Method of Analyses	AAS Perkin Elemer	AAS Perkin Elemer	AAS Perkin Elemer	AAS Perkin Elemer	AAS Perkin Elemer
Element	Mg	Zn	Pb	Cu	Co
Range (ppm)	1.35-24.6	0.45-1.28	0.0-1.47	0.02-0.44	0.6-4.5

Table 2.4: CONCENTRATION OF METALS IN SOIL OF KUBANNI VALLEY. Prior to its irrigation. After Dahiru (1989). All results are in ppm. Analysis was done at Kaduna Refinery using AAS, detection limit of elements analysed not stated by the author.

Metal	Range	Mean
Zn	2.26 - 3.87	2.79
Mn	30.40 - 42.20	36.29
Pb	0.35 - 0.48	0.43
Cd	0.01 - 0.06	0.03

Precipitation and atmospheric fallout:. This is another important source of heavy metals in soil and surface water through their introduction by precipitation and dry fallout on the water surfaces of drainage basins. The air that moves over the earth surface carries a large quantity of particulate matter or aerosols. This particular material is constantly being removed from the atmosphere by gravitational settling and impingement on surfaces, as well by rain almost as fast as they are added. The materials added to the atmosphere comes from natural sources and as well through man`s activities and it usually contains appreciable amount of trace elements. Among the natural sources is harmattan dust. Table 2.5 is showing the elemental concentration in harmattan haze in Samaru Zaria as analysed by Adetunji et. al. (1989).

Table 2.5: **AVERAGE CONCENTRATION OF ELEMENTS IN HARMATTAN HAZE**, *ng/kg dry weight, After Adetunji et. al., (1989). Values in column three and the last column have been converted into Φg/g by the Author*

Element	November, 1980		Dec. 1980	Jan. 1981	Uncultivated soil, Samaru	
	ng/kg	μg/g	ng/kg	ng/kg	ng/kg	μg/g
Li	12.500	0.0125	12.500	11960.0	-	-
Mg	8716.3	0.0087	6588.7	8,600.0	152.0	0.000152
Fe	50,000	0.05	29411.7	62,500	-	-
Cu	93.3	0.000093	36.5	140.0	0.8	0.0000008
Cr	0.0	0.0	0.0	0.0	-	-
Co	0.0	0.0	0.0	0.0	-	-
Zn	333.3	0.00083	184.7	660.0	4.2	0.0000042

For the above table, the authors continuously collected in the months of November, December, and January of the 1980 - 81 harmattan dust at a height of 3.5m above the ground. Samples were collected with a high volume centrifugal cylonair Blower (CHE4) which is sited in a rural area completely devoid of industrial atmospheric pollution. After sampling, the sample filters were weighted and then wet-digested in a mixture of sulphuric acid, nitric acid and perchloric acids in the ratio 1:6:2. Analyses was done using AAS Perkin-Elmer model 290B. The detection limits of the determined elements were not stated by the authors. Their results of the harmattan dust are slightly higher than those obtained for similar element from the analysed uncultivated soil and this makes the results inconclusive, seen that sampling was conducted in a remote site devoid of atmospheric pollution (according to the authors) which of course disqualified the possibility of that occurring.

5.2.2 Pollution

This is the principal source of trace metals in natural waters by direct discharge of various treated and untreated industrial, agricultural or domestic effluents. The contamination of the water body or drainage basin through the additional wet and dry fallout of metals attributable to man's activities have been discussed.

Agriculture: Trace metals play an important role in the nutritional requirements of food and food products. The normal source of these metals to plants is the soil in which they are grown. The distribution of these metals in rock and soils have been discussed earlier. In general, the concentration available are usually very small, and in some cases may not be sufficient to provide the needed requirements of the plants, and therefore an artificial addition is required by the use of chemical fertilizer, which also is another source of trace elements into surface and groundwater bodies. Lastly the irrigation water used for irrigating crops is also sometimes loaded with trace elements especially if domestic effluents are being discharged into those waters. Table 2.6 is showing the mean concentration of trace elements in irrigation water used by dry season farmers in the Kubanni valley according to Dahiru (1989).

Domestic Effluents: Food containing the nutrients and trace metals taken up from the soil is consumed by humans and other animals. Not all nutrients and trace elements are retained in the body, the excess is being passed out in their excrements. Also household laundry detergents and cosmetics contain some of these metals. Discharged effluents containing these substance, runs into our water systems daily.

Table 2.6: **MEAN METAL CONCENTRATION OF SOME HEAVY METAL IN THE TREATED WATERS OF A.B.U. STABILIZATION POND AND TAPWATER**. *After Dahiru (1989). Analysis was done with AAS at NNPC Refinery.*

Metal ppm	Sewage Effluent	Tapwater	FAO Irrigation Water Standards
Zn	0.31	0.20	2.0
Mn	0.21	0.10	0.2
Pb	0.11	0.07	5.00
Cd	0.02	0.01	0.01

The actual amounts of trace metals in domestic sewage may vary according to the water usage, quantity and type of food eaten, time of the year, economic status and the prevalence of garbage. Sridhar and Bammake, (1986) measured the heavy metal contents of some solid waste produced in residential areas, a market, a cafeteria and the compost in Ibadan. Their results indicated that the solid waste produced in low density areas with higher per capita income and cafeteria wastes were having a higher and low levels of heavy metals respectively.

Industrial Discharges: Representative concentrations of the various metals in the effluent from industries are difficult to provide, since they vary with the type of industry and with specific operation within the industries.

2.3: Heavy Metals and Drinking Water Quality

The presence of trace metals in water supplies has a variety of implication concerning the potability and the ultimate other uses of drinking water. Table 3.5 briefly summarizes

the various types of water quality implication with examples of metals involved as well as other trace elements.

Table 2.7: CLASSIFICATION OF TRACE ELEMENTS IN WATER SUPPLIES ACCORDING TO WATER QUALITY SIGNIFICANCE, *According to Brezonik (1974).*

Significance	Trace Element
Esthetic Significance (taste and discolouration problem)	Cu, Fe, Mn, Zn
Toxic at levels found in some waters	As, B (to certain plants only) Ba, Cd, Cr, Hg, Pb, Se.
Toxic, but present levels in water supplies are probably unimportant	Ag, Be, Bi, Ni and Sb
Probably not toxic up to ppm level (present levels ppb or less)	Ga, Ge, Sn, Sr, Ti, V, and Zr.
Nutrient metals (at ppb-ppm levels), some toxic at higher levels	B, Co, Cu, Fe, Mn, Mo and Zn

Most of concern over trace metals in drinking water stems largely from human health consideration, that is the effects soft chronic low level exposure to such elements as cadmium, lead, selenium,beryllium, antimony and cobalt.

It should also be noted that a few toxic metals do occur relatively often in drinking water supplies at levels approaching or exceeding the WHO drinking water standards as examplified by Obamuwe's (1988) results of cadmium, lead and antimony who's concentration are in excess of the stipulated drinking water guideline values. A similar report was given by Dahiru (1989) both of which the author cannot ascertain their credibility due to their wide variations.

According to the above table, there are eight elements of principal concern in terms of their toxicity and another five which while toxic, probably occurs at insignificant levels. The physiological effects of these metals are quite varied, for example, low level cadmium exposure have been implicated with cardiovascular problems, whereas at higher level it causes kidney and liver damage, lead affects the kidney and nervous system.

2.4. Effects of Metals on Human's

Metals being elements, can neither be degraded nor metabolized; that is, they are an example of ultimate persistence. Most elemental metals do not easily enter living organisms, but metals can form both inorganic and organic compounds, which may differ markedly in their access to and effects on living organisms, Magnus (1994).

All metals are toxic if present in an organism in excess, but some heavy metals, such as Zn, Cu, Mn and Fe, at a lower concentration are essential for the growth and well-being of living organisms including man, however, they are likely to show some toxic effects when organisms are exposed to levels higher than normally required. Other elements such as Hg, Cd and Pb are not essential for metabolic activities and they exhibit only toxic properties.

Metals may be taken up in inorganic or organic forms, for some elements such as arsenic and copper, the inorganic form is the most toxic, for others, such as mercury, lead, and tin the organic forms are the most toxic, Biney, et. al. (1994).

Toxicity means the degree of danger posed by a substance to animal or plant life. Toxic substances include, heavy metals, pesticides, and cyanides. The source and toxicity effect of some of these trace elements are as follows:

2.4.1 Cadmium:

Cadmium has no known role in living systems, cadmium is released into the environment from pigments, and as rubber tyres worn out against pavement, also from electroplating work. Cadmium is a known impurity in zinc ores and is also released into the environment from cigarette smoke which is being considered by some toxicologist as the heaviest exposure that American smokers have (Magnus, 1994).

Its biological effects includes kidney ailment, whereby if saturated, it is released into the blood streams and may trigger malignant hypertension. Cadmium also leads to bone fragility.

2.3.2 Lead (Pb):

Lead is released into the environment primarily through its combustion from tetraalkyllead in automotive engines, and also through paints and pigments. Pb accumulates in the bones and is said to cause mental retardation in children. Typical symptoms of acute Pb poisoning or plumbism are intestinal cramps or painters colic (in which severe abdominal pain is the cardinal symptom). It also results in renal failure and sterility, according to Magnus (1994).

2.4.3 Chromium (hexavalent):

Chromium is widely distributed in the earth crust, and it exists in the oxidation states $^{+}6$, $^{+}3$ and $^{+}2$,(WHO 1996). Chromium is also an essential element that is released into the environment through pigments, paints, ceramic and industrial discharges etc. Chromates are

water soluble, with the hexavalent ion being the most toxic. Haxavalent chromium has been implicated with lung cancer, liver and kidney damage.

The effects of two or more of these toxicants can be antagonistic or may be additive or synergistic, example is that copper behaves synergistically with zinc, cadmium and mercury but antagonistically with cyanide, Mason (1981). Also the toxicity of various compounds in water will be strongly affected by the quality of the water, especially by such factors as dissolved oxygen concentration, water hardness, the temperature and the pH. That is, toxicity increases with decreasing dissolved oxygen and with pH and it declines with increasing water hardness. The toxicity of Cd, Cu, and Zn are all increased by decreasing water hardness and by reduced level of dissolved oxygen(Ellis, 1989).

2.5 PREVIOUS INVESTIGATION IN THE STUDY AREA

Of recent, various attempts have been made to determine the quality of the impounded water, (both raw and treated), but the main emphasis of the pioneer workers is mostly to do with water supply investigation, and the general geology of the area, most of which have been undertaken before the final construction of the dam in 1980.

Among the many previous workers in the basin are: Du Preez (1961),who worked on the water supply for the Ahmadu Bello University site. Oluwa (1967) of the Geological Survey of Nigeria worked on the groundwater conditions in the Zaria area. Ososami (1968), also attempted a groundwater assessment in the Kubanni valley for the purpose of water supply to the A.B.U. Main Campus, where he made a very little mention of the geological formation of the entire area he worked on. Omolokun, (1970) worked on the irrigation water

From a small scale excavation in a dry river bed, where he limits his study to only a small portion of the Kubanni drainage basin, his main focus are, the yield of shallow wells situated in a dry bed, the effective method of retaining banks in such wells, and the suitability of the water and land for irrigation practices.

The first detailed accounts of the Basement Geology of the area of study are that of McCurry (1970), and Wright and McCurry (1970). These authors worked on the geological mapping of the various rock types in and around Zaria, with little emphasis on the Quaternary deposit of the area.

Egbeifor's (1978) work dwelled on the evaluation of the hydrogeological properties of the Kubanni basin. He also undertook some chemical analysis of wells in Samaru in order to determine their suitability for domestic, agricultural and future industrial usages, where he plotted a trilinear diagram and which reveals the potability of the water. But his conclusion did not satisfy the author, because he based his chemical quality studies mainly on major ions disregarding the trace elements. Therefore the Author's view is that he should not have generalized his conclusions, but rather he supposed to have restrict it based on what he has analysed.

Ogunrombi (1979) also did some studies on the quality of the impounded water and he came out with the conclusion that the water is potable, but his conclusion cannot be without some reservation, that is, his iron content which reads 7.67mg/l is doubtful seeing that the WHO guideline value for iron is 0.3mg/l and that also in the presence of oxygen, iron is precipitated which settles at the bottom, therefore such a high concentration is suspicious.

Hilary (1984), worked on the quality of some wells water in Samaru. His conclusion is that the water is suitable for domestic use, for his result showed Cd, Pb, As, Ni and Cu,to be below the detection limit of the technique he used, with Fe and Zn present in smaller concentration. The only reservation on his result is the high Mg content of the water in the range of 3 - 22mg/l which is very high, though it is still within the permissible range.

In their own work, Udoh et. al. (1986), tested the raw and the treated waters of Kubanni dam, and in which they found Hg, As, and Cu to be below the detection limit of the analytical method they used (that is, AAS, Pye Unicam model), but their Pb content is high for the raw water reading 0.5ppm which is too high if we are to consider the current World Health Organization 1996 drinking water guideline value of 0.01mg/l (10 ppb), therefore their declaring the water potable is questionable.

Dahiru (1989) investigated the concentration of some heavy metals absorbed by irrigation crops using treated effluent water, with tap water as a control. He came out with the conclusion that the sewage effluents contains slightly more of Cd, Pb, Zn and Mn than the tap water. And that the concentration of Mn absorbed by the various parts of the test crops were significantly higher in the tapwater than in the sewage effluent irrigated crops. His final conclusion is that the concentration of the metals in both the sewage effluent and the tapwater are well below their permissible limit and may not be toxic to the irrigated crops, animals and man that consume the crops. But he later recommended for further studies which the Author thinks to be more proper than his declaration, that the crops may not pose danger to their consumers or that the tap water is potable. Because a water with a Pb

concentration of 70ppb and 10ppb of Cd cannot be potable considering their guideline values of 10ppb Pb and 2ppb Cd (WHO, 1996).

Jeb (1996) collected samples from three sub-basins he demarcated within the Upper Kubanni catchment area. After filtering the samples at the field, he acidified them to pH <2. At the laboratory, samples were further digested using concentrated HNO_3 acid combined with heating until when a clear liquid solution is formed. This he analysed for six elements using AAS in an unspecified laboratory. His conclusion shows that out of the six elements he analyzed, Pb occurs between 0.005ppm to 0.001ppm and that Ca, Mg, Cu and Zn are occurring above the WHO permissible limit. To the Author his method of sample pre-concentration is new to him, because since the samples were initially filtered, it make no sense to use much of HNO_3 to digest suspended solids, since the essence of filtration is to remove suspended sediments. Pre-concentration can easily be achieved by simple heating of the samples in an oven at a low to moderate temperature. This is the crudest form, an alternative is the use of chelating agents example is ammonium pyroldine dithio-carbamate (APDC).

In his own work Obamuwe, (1998), studied the trace elements content of the impounded water where he analyzed almost all of the transition elements, using an X-ray fluoresences technique. His result show that, with the exception of Cd, Pb and Sb, all other elements are below their WHO permissible limit, but he finally made a wrongful conclusion by declaring the water as being suitable for drinking and domestic use. Wrongful in the sense that a water with Cd content in the range 0.994 - 0.433 mg/l, Pb in the range 0.0969 - 0.0123 mg/l and Sb in the range of

0.656 - 0.307mg/l is not at all safe for drinking considering the toxic effects of these elements.

Last but not the least, Udoh (1999) also tested the water of Kubanni dam in both its raw and treated forms and concluded that the water is suitable for domestic use. But on looking at his recalculated lead value (recalculated by the Author) it shows a concentration range of 0.037 to below detection limit of the technique. Taking the 0.037mg/l value one cannot say that the water is potable.

3. METHODOLOGY OF RESEARCH

3.1 Sampling, Pretreatment and Preservation

This being a crucial aspect of water analysis was given the adequate consideration it deserves in order to avoid the contamination of the collected samples and also to preserve their integrity prior to their analysis. Some analytical results are in fact in error because of wrongful sampling procedure, rather than because of faulty laboratory techniques. Therefore, in this work all the necessary precautionary measures were applied to prevent any slightest change in the collected samples. These problems were taken care of by:

a) Selecting the appropriate container to suit this type of work, because leaching of the contaminants from the vessel walls into the solution usually occur. But this can not be generally prevented, but can be minimized by the selection of the appropriate container material e.g. polyethylene as used in this work.

b) Acidification of the collected samples to prevent the adsorption and precipitation of the trace component in solution.

c) Also for samples taken from the dam and flowing streams, the samplers were filled and closed under the water in order to have a uniform sample, because sometimes at the surface of such waters there may exist a surface micro-layer which can be enriched in some traces.

d) At each sampling point the sampler was rinsed twice before being used for sample collection. After being pre-washed before the exercise was embarked upon using distilled water.

Acidification of samples was done to a pH <2 with an ultra-pure nitric acid and thereafter transported to the base for deep refrigeration.

Each of the sample collected was identified by a label on its container showing:

i) The nature of the sample,

ii) Time and date of sample collection,

iii) Name of collector,

iv) Location of sampling and the pretreatment given,

v) The pH, and temperature as at the time of collection.

3.2 Field Analysis

For reasons of inevitable changes of certain physical parameters with time, they had to be measured outright at the spot of sample collection. The following determinations were always made at the source of each of the collected sample.

i) pH and

ii) Temperature

3.3 Laboratory Techniques

In view of the fact that past analyses were done either using atomic absorption spectrophotometry, or by X-ray fluorescence technique, it was decided that in this work the two techniques will be used and results obtained will be compared with the past analyses. This was achieved by collecting two samples at each of the sampling points at the same time. These samples were given the same

kind of treatment and were taken to the two laboratories selected at the same time. Even though there at the laboratories analyses were not done on the same day, the difference is not much and therefore the results were considered to be not affected by aiging.

For the first sampling, eleven samples were collected in duplicate, three out of which are from the reservoir. One set of the duplicates made up of eleven samples were taken to the first laboratory and were analysed using an atomic absorption spectrophotometer (Bulk model) at the Department of Geology A.B.U., Zaria. Four samples out of the remaining duplicate samples were taken for analysis using an X-ray fluorescence technique at the Centre for Energy Research, A.B.U, Zaria. These are samples 1, 2, 10, and 11. This was done in order to check and compare with:

i) The AAS results of the same samples,

ii) To make a comparison with Obamuwe, 1998, results whose overall analyses were done with the same technique.

In all, at the first stage of analysis nine elements were analysed using the AAS method of analysis,these are Pb, Co, Ni, Ag, Cr, Fe, Zn, and Cu. For the XRF analysis which has a lower detection limit compared to the AAS, most of these elements were below the detection limit of the technique with only Pb, Ti, Cu, and Fe showing a reasonable concentration which are either less than or slightly higher than their respective detection limit of the technique.

Therefore, the work was narrowed down to the investigation of Pb, and for this twenty four samples were collected from three water bodies (Fig. 9). These are:

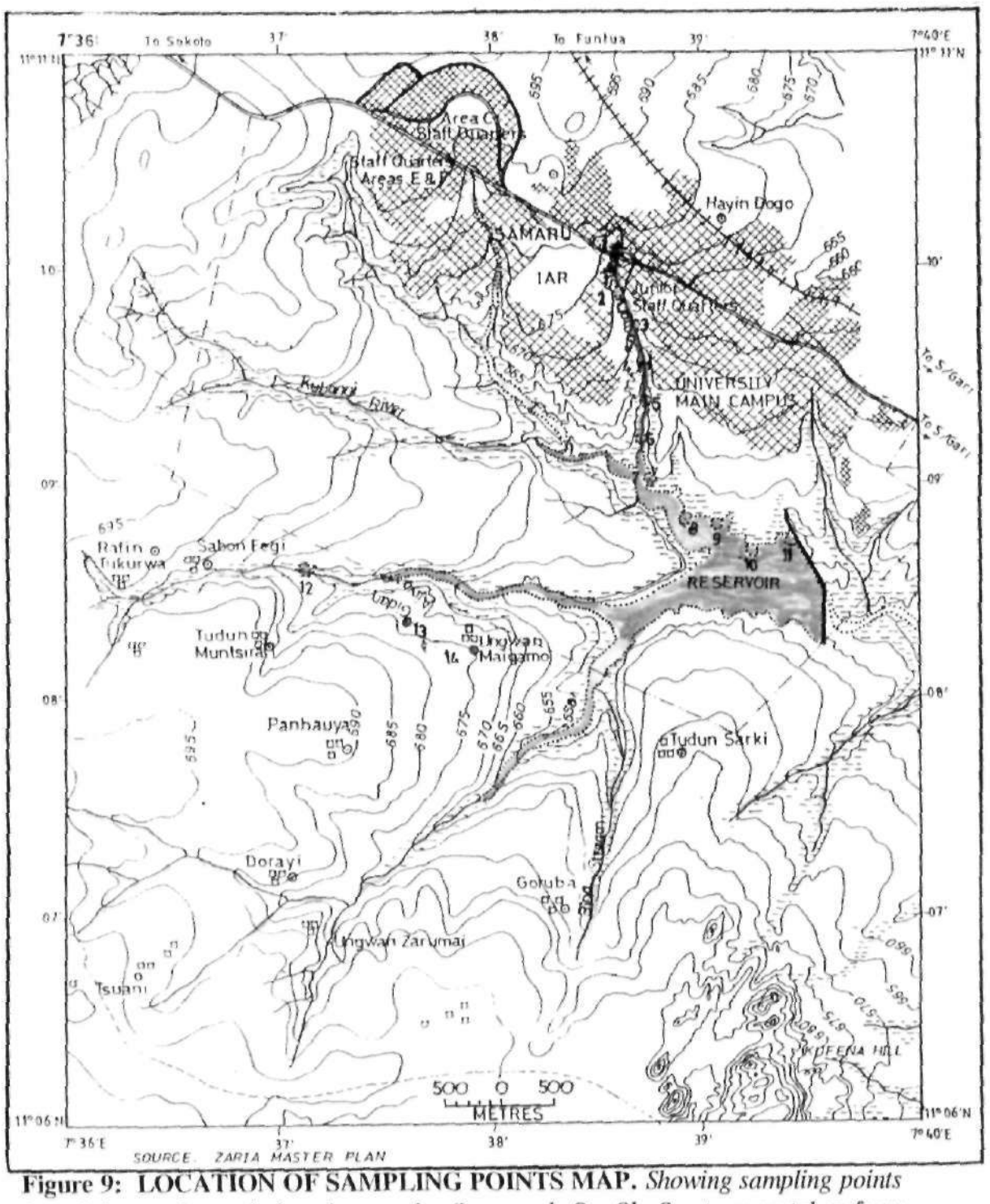


Figure 9: LOCATION OF SAMPLING POINTS MAP. *Showing sampling points in red dots and sample location number(i.e sample 9a, 9b, 9c etc were taken from sample location 9). For other explanation see figure one.*

i) The Reservoir,

ii) A seasonal stream that flows into the dam,

iii) Samaru stream.

At each of the sampling points a set of eight samples were collected and treated instanteneously. Four out of each set were filtered, and the remaining four not filtered. This was done in order to determine the concentration of Pb in both dissolved and total forms. Therefore, two sets of six samples each comprising of three filtered and three unfiltered samples were submitted to two different laboratories at the same time. A day after, the result from one of the laboratories was received and in which the recording was unprofessionally done, that is all values were recorded as non detected simply because the instrument gave negative values for all the six samples. Because of this, the samples were taken to another laboratory that operates the same technique for re-analysis.

The last sampling conducted were mainly restricted to the reservoir and wells located in non polluted background. This was done in order to know the level of this element in areas considered non polluted and then to compare their results with what is to be obtained from the reservoir. This is intended to be achieved by collecting a sample, dividing it into two and giving the two to the same laboratory at the same time, and also by collecting a sample, dividing it into two and giving them out to two different laboratories at the same time. Results obtained will be placed side by side with each other in order to see how they will correlate with each other. This the Author thinks is a prerequisite in analysis for achieving good compatibility of data and hence permitting valid conclusions to be drawn about the

quality of the water and the related risk to human consumption. Also it was intended to investigate whether there is a contribution of this element from the rocks and soil of the study area. To achieve this, nine samples of rock and soil were collected. These samples were dried in a low temperature oven (105°C) and pulverized with a tungsten carbide spex mill to fine powdered form at the laboratory of the Department of Geology, A.B.U., Zaria. Each powdered sample was prepared as a pellet by homogenous mixing with 2 - 3 drops of an organic liquid binder. A specac hydraulic press was used in making the pellets with a 19mm diameter disc using a pressure of 204081.6Nm^{-2}.

3.4 Suitability of the Various Techniques Used

Different methods abound for the determination of trace elements in water samples, but the selection of an appropriate method is dictated by many factors, simply because the different methods differ in their sensitivity ,specificity, precision, accuracy, ease of operation, speed, and cost(Reeves and Brooks, 1978). Compromise among these factors is largely determined by the purpose for which the data are to be used, and to some extent the nature of the sample, and the availability of analytical method of choice. For a given method, sensitivity is a function of the metal being analysed, the matrix in which it occurs, and the sophistication of instrumentation, according to Brezonik, 1974. Sensitivity is also dependent on the method of sample preparation. Some analytical procedures involve pre-concentration of the metals from solution, the most simple of these methods being ion exchange using chelating resins, which after being the simplest is also the most

desirable method for metals. This was done for the samples analysed with the X-ray fluorescence technique.

In this work analyses were restricted to two of the existing techniques due to the non availability of the other methods to the Author, and also due to cost of analysis, that is, AAS and XRF.

For the atomic absorption spectrophotometric method, it has the advantage of speed, sensitivity, simplicity, suitability for liquid samples and the ease of operation. Also it has the advantage of analysing complex mixture without prior separation, that is, by direct aspiration (without filtration). This was the method that was solely used in the second round of analyses.

On the other hand, the X-ray fluorescence, method is also known for its sensitivity and its suitability for liquid samples. Further important advantage it has, are its multi-element capability and its minute sample mass requirement for easy quantification of the detected elements, which allows fast and direct analysis of water, according to Barreiros et. al., (1996).

Even though the X-ray fluorescence technique was used just on some few samples, it was observed that the two methods are both suitable for the analyses of trace elements in water with the X-ray fluorescence method apart from being used for quantitative determination, is also most suitable for qualitative analysis.

But generally speaking, results obtained in the second round of analysis using the AAS were highly variable with wide discrepancies.

3.5 RESULTS AND DISCUSSION

The results of the analyses done in this work are as tabulated below in Tables 3.1 to 3.5.

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Table 3.1 CONCENTRATION OF ELEMENTS IN AN UNFILTERED WATER SAMPLES, ACCORDING TO THE LABORATORIES AND TECHNIQUES USED. *All results are in mg/l and sample location are as shown on figure 9.*

Sample Number and its Method of analysis	1a	1b	1c	2b	3	4	5	6	7	8	9	10a	10b	11a	11b
	AAS	XRF	AAS	XRF	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	XRF	AAS	XRF
Sample Identification	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Dam Water	Dam Water	Dam Water	Dam Water	Dam Water
Co-ordinates	11°09'50"N 7°38'38"E	11°09'50"N 7°38'38"E	11°09'35"N 7°38'41"E	11°09'35"N 7°38'41"E	11°09'11"N 7°38'47"E	11°08'57"N 7°38'49"E	11°08'41"N 7°38'49"E	11°08'26"N 7°38'49"E	11°08'12"N 7°39'00"E	11°08'7"N 7°39'04"E	11°08'11"N 7°39'17"E	11°08'27"N 7°39'22"E	11°08'27"N 7°39'22"E	11°07'55"N 7°39'32"E	11°07'55"N 7°39'32"E
Date of Sampling	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99
Date of Analysis	3/6/99	8/6/99	3/6/99	8/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	8/6/99	3/6/99	8/6/99
Sampled by	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba
Temp. at Sampling Time	27°C	27°C	28°C	28°C	30°C	30°C	30°C	29°C	29°C	29°C	29°C	29°C	29°C	30°C	30°C
pH at Sampling Time	6.5	6.5	6.5	6.5	7.0	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0
Container Used	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene
Pretreatment If any	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified
Laboratory	Dept. of Geol. A.B.U	C.E.R.T A.B.U	Dept. of Geol. A.B.U	C.E.R.T A.B.U	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	C.E.R.T A.B.U	Dept. of Geol.	C.E.R.T A.B.U
Analyzed by	Mr. Edegbo	Dr. Funtua	Mr. Edegbo	Dr. Funtua	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Dr. Funtua	Mr. Edegbo	Dr. Funtua
Pb	0.110	0.024	0.140	0.026	0.085	0.067	0.056	0.067	0.101	0.059	0.045	0.067	<0.024	0.544	<0.024
Cr	0.112	-	0.109	-	0.075	0.112	0.087	0.095	0.095	0.087	0.080	0.102	-	0.188	-
Ni	0.044	-	0.054	-	0.044	0.041	0.078	0.051	0.081	0.041	0.046	0.048	-	0.044	-
Co	0.021	-	0.014	-	0.034	0.023	0.024	0.023	0.025	0.025	0.021	0.011	-	0.031	-
Ag	0.038	-	0.054	-	0.030	0.043	0.038	0.034	0.027	0.041	0.028	0.029	-	0.050	-
Cu	0.040	<0.037	0.022	0.030	0.019	0.011	0.017	0.012	0.030	0.017	0.013	0.010	0.030	0.015	0.063
Zn	0.016	0.043	0.034	0.030	0.025	0.100	0.097	0.131	0.154	0.154	0.046	0.013	0.053	0.067	0.231
Fe	1.186	2.670	1.830	4.480	2.255	1.346	2.556	1.513	10.248	3.010	1.310	0.513	2.470	3.880	10.100
Mn	0.251	-	0.363	-	0.427	0.242	0.201	0.071	1.377	1.617	0.133	0.059	-	0.260	-
Ti	-	-	-	-									0.171	-	0.550
Zr		0.017		0.009									0.011	-	0.025

Table 3.2:CONCENTRATION OF Pb IN WATER SAMPLES FILTERED AND UNFILTERED, ACCORDING TO VARIOUS LABORATORIES USED. *Location of Samples are as shown on Figure 9 All Results are in mg/l.*

Sample Number			9b	9b	12a	12a	4b	4b
Material Sampled			Dam Water Filtered	Dam Water Unfiltered	Stream Water Filtered	Stream Water Unfiltered	Stream Water Filtered	Stream Water Unfiltered
Co-ordinates			11°08'16"N 7°39'30"E	11°08'16"N 7°39'30"E	11°08'12"N 7°37'35"E	11°08'12"N 7°37'35"E	11°09'10"N 7°38'39"E	11°0910"N 7°38 39E
Sampling Date			14/10/99	14/10/99	14/10/99	14/10/99	14/10/99	14/10/99
Sampled By			M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,
Tempt. of water at sampling site			29°C	29°C	30°C	30°C	30°C	30°C
pH of water at sampling site			6.0	6.0	6.0	6.0	6.0	6.o
Sampling container used.			Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene
Pretreatment given			Acidified to pH <2	Acidified to pH <2	Acidified to pH <2	Acidified to pH <2	Acidified to pH <2	Acidified to pH <2
LABORATORIES	SHIKA	28/10/99	5.30	4.40	7.10	6.30	9.00	3.20
	NAPRI	8/11/99	0.029	0.27	1.51	2.057	1.49	2.26
		23/11/99	0.62	0.11	0.01	0.02	2.00	2.70
	CHELTEC	25/10/99	-0.02	0.14	-0.05	0.00	-0.10	-0.10
		5/11/99	0.00	1.125	0.00	0.125	1.75	0.38
	GSN	16/10/99	n.d	n.d	n.d	n.d	n.d	n.d

Table 3.3: LEAD CONCENTRATION IN AN UNFILTERED DAM AND WELL WATERS ACCORDING TO NDA LABORATORY. *All Results in mgl.*

Sample Number	9c	9c	13a	13a
Nature of Sample	Dam Water	Dam Water	Well Water	Well Water
by Whom Collected	M.L. Garba	M.L. Garba	M. L. Garba	M. L. Garba
Time Collected	28/12/99	28/12/99	28/12/99	28/12/99
pH of water at Sampling site	6.0	6.0	6.0	6.0
Temperature of water at Sampling site	29°C	29°C	29°C	29°C
Co-ordinates	11°18'16"N 7°39'30"E	11°08'16"N 7°39'30"E	11°08'22"N 7°37'41"E	11°08'22"N 7°37'41"E
Analyzed by	Mr. Goddy	Mr. Goddy	Mr. Goddy	Mr. Goddy
Results (ppm)	0.461	0.071	0.248	0.245

Table 3.4 CONCENTRATION OF ELEMENTS IN AN UNFILTERED WATER, SOIL, AND ROCK SAMPLE ACCORDING TO C.E.R.T. LABORATORY. *The results for Water samples are in mg/l, an those for Rock and Soil samples are in ug/g. Location of samples are as shown on figure 9.*

Sample Number	9d	10b	14c	15	16	17	18	19	20	21
Sample Identification	Dam Water	Well Water	Well Water	Orthoclase	Muscovite	Medium Granite	Porphyritic Granite	Gneiss	Soil (mottled zone)	Soil (pallid zone)
Co-ordinates	11°08'16"N 7°39'30"E	11°08'19"N 7°37'41"E	11°08'22"N 7°37'14"E	11°09'48"N 7°36'15"E	11°09'48"N 7°36'15"E	11°09'42" N 7°38'09"E	11°07'30"N 7°37'53"E	11°09'52"N 7°38'38"E	11°07'22"N 7°35'39"E	11°07'22"N 7°35'39"E
Date of Sampling	7/3/2000	7/3/2000	7/3/2000	14/2/2000	14/2/2000	14/2/2000	14/2/2000	14/2/2000	14/2/2000	14/2/2000
Date of Analysis	20/3/2000	20/3/2000	20/3/2000	20/3/2000	20/3/2000	20/3/2000	20/3/2000	20/3/2000	20/3/2000	20/3/2000
Sampled by	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,	M.L.Garba,
Temparature of Water at Sampling Time	28°C	29°C	29°C	-	-	-	-	-	-	-
pH of Water at Sampling Time	6.0	6.0	6.0	-	-	-	-	-	-	-
Container Used	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene
Pretreatment if any	Acidified to pH <2.0	Acidified to pH <2.0	Acidified to pH <2.0	Pulverized to fine powder	Pulverized to fine powder	Pulverized to fine powder	Pulverized to fine powder	Pulverized to fine powder	Pulverized to fine powder	Pulverized to fine powder
Laboratory	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T	C.E.R.T
Analysed by	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua	Dr.Funtua
Cd	<0.416	<0.260	0.304	-	-	-	-	-	-	-
Pb	<0.011	<0.014	<0.009	60.000	<12.400	25.100	23.700	<7.600	14.800	17.300
Sb	<0.304	<0.210	<0.268	-	-	-	-	-	-	-
Ni	<0.012	<0.011	<0.008	-	<13.100	-	-	-	-	-
Co	<0.022	<0.014	<0.014	-	<34.100	-	-	-	-	-
Cr	<0.023	<0.024	<0.021	-	<48.700	-	-	-	-	-
Ti	0.054	<0.048	0.115	<275.000	572.000	665.000	591.000	1680.000	2560.000	3020.000
V	<0.032	<0.036	<0.026	-	<77.400	-	-	-	-	-
As	<0.008	<0.011	<0.006	<6.040	<8.610	<5.730	<5.920	<5.140	<5.090	<5.310
Se	<0.005	<0.045	<0.003	-	-	-	-	-	-	-
Zr	<0.003	0.003	0.006	<1.080	<3.050	57.200	55.000	130.000	477.000	255.000
Sn	<0.263	<0.276	0.327	-	-	-	-	-	-	-
Cu	<0.008	<0.010	<0.007	-	<11.000	-	-	-	-	-
Zn	0.415	<0.009	<0.005	<9.360	17.900	127.000	13.000	33.600	10.300	18.500
I	<0.149	<0.140	<0.132	-	-	-	-	-	-	-
Br	<0.004	<0.004	<0.004	80.400	<38.700	83.000	65.400	73.400	88.900	66.900
Fe	1.590	0.492	1.250	566.000	9630.000	4520.000	4580.000	14700.000	9000.000	14400.000
Mn	-	-	-	<48.000	182.000	71.000	113.000	356.000	244.000	200.000

Table 3.5: CADMIUM, LEAD, AND ANTIMONY CONCENTRATIONS FROM AN *UNFILTERED* DAM AND WELL WATERS ACCORDING TO THE OFFICE NATIONAL DES RECHERCHES MINIERES ONAREM, NIGER REPUBLIC. *Sample location is same as those of table 4.4. All results are in mg/l.*

Sample Number	9e	13c	14b
Nature of Sample	Dam Water	Well Water	Well Water
By Whom Collected	M. L. Garba	M. L. Garba	M. L. Garba
Co-ordinates	11°08'16"N 7°39'30"E	11°08'19"N 7°37'41"E	11°08'22"N 7°37'14"E
Date Collected	07/03/2000	07/03/2000	07/03/2000
Date of Analyses	09/03/2000	09/03/2000	09/03/2000
pH of Water at Time of Collection	6.0	6.0	6.0
Temperature of Water Sampling Site	29°C	30°C	30°C
Cd	0.00	0.01	0.00
Pb	0.00	0.00	0.00
Sb	0.00	0.00	0.02

Comparing the XRF result of tables 3.1 and 3.4 (for the water samples),the results of Pb, Zn, Cu, Fe, and Zr do correlate with each other.And for table 3.4 alone, the results of As, and Se were at their natural level of concentration in fresh water .But for the rest of the elements, more especially Cd, Sn, and Sb their values are very high. Infact for Sn, the value obtained is higher than what Schoeneich (2000) obtained from the Jos Plateau,and *therefore this cannot stand except if the technique used is not* suitable for the determination of these elements from water sample.

4. LEAD IN THE ENVIRONMENT

Lead (Pb) is a soft grey metal that readily combines with anions to form divalent salts. It exists in compounds in the divalent and tetravalent forms, but the divalent specie is the most common and the most stable form, according to Wedepohl (1964). Magnus in 1994 described it as the most important hazard in the development of civilization, and for that it have received a great deal of attention worldwide. This is due to its ubiquitous nature consequent upon its heavy use as a gasoline additive which makes it versatile, and thus common to all environmental compartments of urban areas (i.e. soil, dust, vegetation and open water bodies).

4.1 Crustal Abundance

As stated in Section 5.2 of this work, the average concentration of Pb in the Earth crust is about 15ppm, Wedepohl (1964). Thus a certain amount of this highly toxic element has been present in man and his environment, with orthoclase feldspar been recognized to be the most important Pb carrier of magmatic rocks. Common magmatic rocks of the upper continental crust contains about 20% K-feldspar (and 40% plagioclase feldspars), and the two feldspars contribute 11 and 2ppm of Pb to the total Pb content of the common continental rocks, according to Wedepohl (1964).

4.2 Behaviour During Weathering

When granitic rocks are chemically weathered, the leached Pb is not easily mobilized, but it is adsorbed on the newly formed clay minerals (e.g. kaolinite).

This low rate of mobilization of Pb during chemical weathering is observable from its low concentration in surface runoff, according to Wedepohl (1964). This also can be observed from Magdi's (1999) work, where his analysis of a chemically decomposed granite gave a Pb value of 28.77ppm, with the fresh granite containing 50.00ppm Pb. This indicates a Pb loss of about 44% if the weathered sample is identical with the fresh rock analysed in this investigation. Also according to the same author, more advanced decomposition of the same granite during lateritization resulted in a pronounced accumulation of the mobilized Pb in the indurated layer of the same profile. Even though the Author did not analyse any ferruginous concretion, his values obtained by analyzing rock and soil samples confirms part of the above observations. That is, the present Author obtained 24ppm Pb in the fresh exposed outcrop, with 17 and 15ppm in the completely decomposed outcrops, that is, on average a loss of 34% Pb. This therefore implies that Pb is slightly leached from its source, and therefore its mobility is low except if pH conditions revert to acidic, then its solubility increase, but not in high concentration because of the low solubility of lead sulfate (Pb S04). But in neutral or somewhat alkaline condition the Pb is hydrolyzed and is readily co-precipitated with hydroxides of more abundant elements or is adsorbed by clay minerals, according to Wedepohl (1964).

4.3 Soils

Soils in their clay fraction contain the residual Pb of weathered rocks on which they have been formed. This as earlier said, is due to the adsorption of this element on

the newly formed clay minerals such as kaolinite, according to Wedepohl (1964). What was obtained in this work, that is 15 and 17ppm, partially correlates to what Magdi (1999) obtained in his work, but disagrees with what Ali (1984), Dahiru (1989), and Adetunji et. al., (1989) reported. This probably is due to the variation in depth at which each of the analyst obtained their sample. That is to say that, the Author and Magdi (1999) obtained their samples from the mottled and pallid zones respectively, but the others did not specify in their reports. Also what the Author obtained generally agrees with what Shacklette et. al., (1971) have published in their survey of 863 soils sampled at about 20cm depth in a regular network over the United State in which their analysis gave a geometric mean of 16ppm Pb.

4.4 Abundance in Natural Waters and in the Atmosphere

The concentration of Pb in river waters under natural condition is low, wrote Wedepohl (1964). Although small amounts of Pb are widely distributed as minor constituents in rock and soils as revealed by the Author`s own analyses of rocks, soils, and minerals, Pb is only slowly released into such waters, as the chemical weathering of the rocks and soils can only contribute minor quantities of Pb due to its adsorption on clay minerals formed, and on other organic residue, and as well by precipitation of lead hydroxides, phosphate and/or carbonate. According to Ward (1995), Pb is present in freshwater and in rivers in concentration of 1 and 5Φg/l, and from the Author's own analyses, most of the values obtained were in the range <24 Φg/l to <10 Φg/l which confirms the values given by Ward (1995).

Anthropogenically, Pb is released to the environment through the combustion of tetraalkyllead compounds in automotive engines and which accounts for about 94.8% of all atmospheric Pb, according to Magnus (1994). In gasoline augmented with tetraethyllead, Pb is released as an aerosol with a medium diameter of 0.2Φm. Although, no data exist on the atmospheric concentration of Pb in the study area, it is believed that, just like in any other urban area where there is much activities leading to the release of exhaust gases from gasoline combustion, Pb is bound to be present in its atmospheric area, and which is being deposited on the soils, vegetation and open water surfaces through gravitational settling and impingement on surfaces of objects or ultimately through precipitation.

4.5 Health Effect of Environment Pb

Inorganic Pb (Pb^{2+}) is a broad-spectrum metabolic poison and there is no convincing evidence that it functions as an essential element in man; even at very low levels. All its known effects appears to be adverse, according to Magnus (1994), Pb reproductive and neurological effects are credited by some with assisting decline of the Roman empire.

According to Magnus (1994), the typical symptom of acute Pb poisoning or plumbism are: Intestinal cramps or painters colic, renal failure, sterility and irreversible brain damage. In children, Pb is suspected of contributing to hyperactivity, behavior disorders and learning disabilities.

Since Pb in drinking water from Kubanni dam is at the level <0.024 to <0.010ppm, which does not exceed reasonably levels permitted by WHO 1993 standards, therefore there is not Pb hazard for consumers of water from Kubanni dam.

4.6 Is There Pb Pollution in Kubanni Dam

From data presented and discussed, the Author can conclude that there is no Pb pollution in Kubanni dam as earlier proclaimed by some workers. This is so because from the results obtained from some of the laboratories used for analyses including the reference laboratory at Onarem, Niger Republic indicated a range of <0.024ppm to <0.010ppm,in the Kubanni dam, and from <0.014ppm to <0.008ppm for wells. Therefore, these results indicate that, either Pb is present in amount slightly above the WHO permissible limit for drinking water of 0.010ppm or that, it is present in concentration below the WHO permissible limit, since a value of <0.024ppm can also take the interpretation of <0.010ppm.

4.7 Suitability of the Water from the Study Area for Various Uses

From the afore-mentioned facts and findings, the Author can finally say that, the water of the study area is suitable for various uses in terms of its Pb content without any limitation (that is, for both domestic, agricultural and industrial uses). This is contrary to what some of the past workers have earlier reported (e.g. Obamuwe, 1998).

To the Authors belief, it is only accurate analytical results that can allow valid conclusions to be drawn about the quality of different types of water. The Author is not

saying that his results are more valid or more accurate than past analyses done in the study area, but at least there are various measures needed to be undertaken by each an every analyst to ensure good reproductivity and good accuracy of results. This the Author has achieved by embarking on inter-laboratory comparisons in which laboratories that gave different results for same sample were eliminated by discarding their results during conclusion. This has help the Author tremendously in establishing the non-existence of high Pb concentration as earlier documented by some of the past workers. That is, from <0.024 to <0.010ppm Pb for Kubanni dam. This range of concentration is of course suitable for drinking, for fish culture for irrigation and for domestic uses.

4.8 Protection of Kubanni Dam

It is important for us to understand that the availability of water alone is not sufficient, or that, it is not our ultimate desire, but "the quality of the water", that is the water must meet its quality criteria in terms of its intended domestic and industrial usage. When we have this in mind, it then becomes imperative on to us to know the source and the routes of the water we impound, this is also necessary because if we careless to monitor the source, we may end up impounding effluents and which if it contains trace metals will be difficult to remove. Because once any metal reaches a water body it will be difficult to remove, but will be partitioned among the various aquatic environmental compartments, that is water (in dissolved form), suspended sediments (by adsorption), sediments, and the biota by (bio-accumulation) and this will

be recycled from one medium to another with an ultimate final destination into human where the water is drunk or the fish eaten by them.

Therefore, to avoid pollution, or to minimize it in case where it has already occurred, and also to increase the life span of the reservoir, and also to conserve its water, the following measures needed to be taken according to the authors view:

i). Effluents, flowing into the Dam through Samaru stream should be monitored on timely basis to know the level of their chemical constituents. This is because to the Authors view if there is pollution in Kubanni dam, then Samaru stream is its major source which serve as a drain for all domestic effluents originating from Samaru village and also effluents discharged from the filling stations and mechanical workshops sited in there. Or alternatively, the course of that stream should be diverted from emptying into the dam to Kubanni stream below the dam. This if done, will solve if not all, then nearly all pollution problems ascribed to the dam.

ii) Afforestation should be intensified in the immediate area surrounding the dam, and also in areas being affected by gullying. This is also necessary in the sense that the rate at which silt, clay and sand are being washed into the Dam will be drastically reduced since this will reduce erosion and gullying and will also serve as wind breakers and therefore reduce evaporation rate. Overgrazing and bush burning should also be discouraged as this will also expose the soil to erosion which if on increase will accelerate the rate at which the Dam is silting up with the consequence of reducing the life span of the reservoir.

iii) The refuse dump sited at the back of ICSTA hall should be relocated to a more appropriate place(like the University Farm which has a vast land). This is because, even though that the refuse is continuously being incinerated, the residues are left behind and which are continuously being washed into the stream with their final destination being the Kubanni dam. This if done, the compost to be generated could be used to increase the farm soil fertility which is continuously being depleted.

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY AND CONCLUSION

Concentration of Pb in water of Kubanni dam, as well as water, soil, and rocks of Kubanni dam Drainage Basin was investigated. This investigation resulted in the following findings:

1. Concentration of Pb in Kubanni drainage basin, in groundwater considered by the Author as non polluted is at level of <0.014ppm and <0.008ppm which is comparable with expectations of Pb concentrations in non polluted water less than 0.010ppm according to Wedepohl (1964), and Schoeneich (2000).

2. Concentration of Pb in Kubanni dam which is the source of drinking water for ABU Campus was found to be less than 0.024 and less than 0.011ppm. These results are inconclusive. They indicate either that the water is non polluted or in the worst case negligibly polluted. But, in-light of these results high levels of Pb pollution in Kubanni dam reported by some previous researchers cannot stay.

3. In process of research, the Author found that, results of the chemical analyses of the same sample of water differ widely from laboratory to laboratory, and sometimes even the same laboratory gives widely different results of the same sample of water disguised as two different samples. This in the Author's opinion is one of the main reasons why results of the past investigation of Pb in Kubanni dam differ so much from each other. Yet the Author succeeded in identifying his non credible results by applying slightly modified (by the Author) inter-laboratory and inter-technique comparison approach and

ended with results which he believes, are more accurate than most of the previous results from Kubanni dam.

5.2 RECOMMENDATION

Findings, listed under 1, 2, and 3 above, added to the knowledge of regional hydrogeology, (finding 1 and 2) of Nigeria, and to the methodology of hydrochemical mapping (finding 3) but are not conclusive. Detection limits for the laboratory that provided results believed to be more accurate than the previous results from less than 0.024 to less than 0.008ppm of Pb are above non polluted concentrations which are expected to be around 0.007ppm. Therefore, the study should continue with the aim of monitoring pollution, which even if absent today may at any time enter Kubanni Dam through Samaru stream. However, any follow up study if it has to add to the knowledge instead of adding to the existing confusion should apply the procedures elaborated above, that is, namely;

1. Identify a laboratory capable of producing results down to 0.001 - 0.002 ppm levels (that is levels in non polluted water for most heavy metals).
2. Establish credibility of this laboratory by:

a) By the laboratory's past results,

b) By comparing results for the same sample of water disguised as different samples,

c) By giving for analysis sample of water of known concentration of heavy metals by the researcher.

These the Author thinks are necessary, because a lack of analytical quality renders useless many of the results obtained in monitoring campaigns. This creates economic losses because of the extra analyses and the cost in terms of quality of life can hardly be estimated, but may be very high.

3. And finally, the University Authority should consider re-directing the source of effluents to the dam, that is "Samaru stream" from flowing directly into the dam to below it's downstream.

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APPENDICES

APPENDIX 6.1.1; SAMPLE 1b.

Material: Stream Water.
Co-ordinates: 11°09'50"N; 7°36'38"E.
Analysed by: Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.1.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS1692 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.083	3.81E+02	1.0000	1.05E-05	1.82E-06
FE	6.400	0.959	1.77E+04	1.0000	2.63E-06	1.92E-07
CU	8.041	0.023	3.08E+04	1.0000	3.66E-08	-LOD-
ZN	8.631	0.032	3.63E+04	1.0000	4.33E-08	1.22E-08
PB	10.540	0.019	3.18E+04	1.0000	2.34E-08	1.06E-08
ZR	15.746	0.039	1.09E+05	1.0000	1.74E-08	4.45E-09

APPENDIX 6.1.2; SAMPLE 2b.

Material: Stream Water.
Co-ordinates: 11°09'35"N; 7°38'41"E.
Analysed by: Dr.I. Funtua in CERT, Zaria,by XRF technique.
Result is as presented on table 3.1.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS1693 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.114	3.81E+02	1.0000	1.45E-05	2.04E-06
FE	6.400	1.635	1.77E+04	1.0000	4.48E-06	3.21E-07
CU	8.041	0.019	3.08E+04	1.0000	3.01E-08	-LOD-
ZN	8.631	0.026	3.63E+04	1.0000	3.42E-08	1.18E-08
PB	10.540	0.017	3.18E+04	1.0000	2.60E-08	-LOD-
ZR	15.746	0.021	1.09E+05	1.0000	9.13E-09	-LOD-

APPENDIX 6.1.2.2; SAMPLE 16.

Material: Muscovite
Co-ordinates: 11°09'48"N;7°36'15"E.
Analysed by: Dr.I. Funtua in CERT,Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2480 MATRIX:[A0= 11000] WEIGHT [g/cm^2]: 0.018

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
K	3.312	1.510	1.38E+04	0.0032	3.39E-02	6.22E-04
CA	3.690	0.058	1.63E+04	0.0037	9.44E-04	-LOD-
TI	4.508	0.133	3.76E+04	0.0061	5.72E-04	6.74E-05
V	4.949	0.033	5.67E+04	0.0075	7.74E-05	-LOD-
CR	5.411	0.032	7.38E+04	0.0088	4.87E-05	-LOD-
MN	5.895	0.172	9.38E+04	0.0100	1.82E-04	1.70E-05
FE	6.400	12.385	1.15E+05	0.0111	9.63E-03	5.42E-05
CO	6.925	0.058	1.43E+05	0.0118	3.41E-05	-LOD-
NI	7.472	0.030	1.79E+05	0.0127	1.31E-05	-LOD-
CU	8.041	0.031	2.11E+05	0.0134	1.10E-05	-LOD-
ZN	8.631	0.064	2.53E+05	0.0141	1.79E-05	3.93E-06
W	8.340	0.034	1.05E+05	0.0138	2.35E-05	8.06E-06
GA	9.243	0.276	2.79E+05	0.0146	6.76E-05	4.16E-06
AS	10.532	0.048	3.61E+05	0.0155	8.61E-06	-LOD-
PB	10.540	0.040	2.10E+05	0.0155	1.24E-05	-LOD-
BR	11.907	0.031	4.99E+05	0.0161	3.87E-06	-LOD-
RB	13.375	3.381	5.49E+05	0.0165	3.73E-04	4.26E-06
SR	14.142	0.035	5.98E+05	0.0167	3.51E-06	-LOD-
Y	14.933	0.050	6.50E+05	0.0168	4.56E-06	-LOD-
ZR	15.746	0.043	8.34E+05	0.0169	3.05E-06	-LOD-
NB	16.584	1.658	9.12E+05	0.0170	1.07E-04	1.96E-06
MO	17.443	0.042	9.95E+05	0.0171	2.47E-06	-LOD-

APPENDIX 6.1.2.3; SAMPLE 17.

Material: Medium Grained Granite.
Co-ordinates: 11°09'42"N;7°38'09"E.
Analysed by:Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2473 MATRIX:[A0= 11000] WEIGHT [g/cm^2]: 0.120

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
K	3.312	0.732	1.33E+04	0.0029	1.87E-02	8.46E-04
CA	3.690	0.209	1.58E+04	0.0036	3.61E-03	4.91E-04
TI	4.508	0.153	3.63E+04	0.0063	6.65E-04	1.19E-04
MN	5.895	0.085	9.07E+04	0.0131	7.10E-05	2.18E-05
FE	6.400	8.265	1.11E+05	0.0164	4.52E-03	3.76E-05
ZN	8.631	0.105	2.44E+05	0.0340	1.27E-05	3.08E-06
W	8.340	0.583	1.01E+05	0.0314	1.83E-04	7.64E-06
AS	10.532	0.101	3.49E+05	0.0508	5.73E-06	-LOD-
PB	10.540	0.259	2.03E+05	0.0508	2.51E-05	3.62E-06
BR	11.907	2.456	4.82E+05	0.0612	8.31E-05	1.51E-06
RB	13.375	4.427	5.30E+05	0.0703	1.19E-04	1.58E-06
SR	14.142	1.223	5.78E+05	0.0743	2.85E-05	9.46E-07
Y	14.933	0.627	6.28E+05	0.0778	1.29E-05	8.49E-07
ZR	15.746	3.730	8.06E+05	0.0810	5.72E-05	8.76E-07
NB	16.584	0.539	8.81E+05	0.0838	7.31E-06	5.28E-07

APPENDIX 6.1.2.4; SAMPLE 18.
Material: Porphyritic Granite.
Co-ordinates: 11°07'30"N;7°37'53"E.
Analysed by: Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2474 MATRIX:[A0= 12000] WEIGHT [g/cm^2]: 0.100

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
K	3.312	0.958	1.33E+04	0.0027	2.61E-02	8.08E-04
CA	3.690	0.281	1.58E+04	0.0033	5.27E-03	4.57E-04
TI	4.508	0.124	3.63E+04	0.0057	5.91E-04	1.06E-04
MN	5.895	0.123	9.07E+04	0.0120	1.13E-04	2.08E-05
FE	6.400	7.658	1.11E+05	0.0150	4.58E-03	3.52E-05
ZN	8.631	0.097	2.44E+05	0.0308	1.30E-05	3.06E-06
W	8.340	0.402	1.01E+05	0.0285	1.39E-04	7.28E-06
AS	10.532	0.093	3.49E+05	0.0451	5.92E-06	-LOD-
PB	10.540	0.217	2.03E+05	0.0452	2.37E-05	3.78E-06
BR	11.907	1.698	4.82E+05	0.0538	6.54E-05	1.41E-06
RB	13.375	4.542	5.30E+05	0.0612	1.40E-04	1.63E-06
SR	14.142	7.797	5.78E+05	0.0644	2.09E-04	1.74E-06
Y	14.933	0.553	6.28E+05	0.0672	1.31E-05	8.93E-07
ZR	15.746	3.090	8.06E+05	0.0698	5.50E-05	9.28E-07
NB	16.584	0.346	8.81E+05	0.0720	5.46E-06	5.36E-07

APPENDIX 6.1.2.5; SAMPLE 20.
Material: Soil (mottled zone)
Co-ordinates: 11°07'22"N;7°35'39"E.
Analysed by: Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2476 MATRIX:[A0= 12000] WEIGHT [g/cm^2]: 0.120

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
K	3.312	0.311	1.33E+04	0.0026	8.68E-03	6.97E-04
CA	3.690	0.071	1.58E+04	0.0035	1.28E-03	-LOD-
TI	4.508	0.570	3.63E+04	0.0060	2.56E-03	1.21E-04
MN	5.895	0.275	9.07E+04	0.0124	2.44E-04	2.19E-05
FE	6.400	15.590	1.11E+05	0.0155	9.00E-03	4.70E-05
ZN	8.631	0.079	2.44E+05	0.0314	1.03E-05	2.82E-06
W	8.340	0.051	1.01E+05	0.0289	1.72E-05	-LOD-
AS	10.532	0.085	3.49E+05	0.0477	5.09E-06	-LOD-
PB	10.540	0.143	2.03E+05	0.0478	1.48E-05	3.24E-06
BR	11.907	2.495	4.82E+05	0.0581	8.89E-05	1.37E-06
RB	13.375	1.888	5.30E+05	0.0674	5.28E-05	1.10E-06
SR	14.142	0.953	5.78E+05	0.0714	2.31E-05	8.24E-07
Y	14.933	0.782	6.28E+05	0.0751	1.66E-05	7.50E-07
ZR	15.746	30.113	8.06E+05	0.0783	4.77E-04	1.84E-06
NB	16.584	0.653	8.81E+05	0.0813	9.12E-06	5.03E-07

APPENDIX 6.1.2.6; SAMPLE 21.
Material: Soil (pallid zone)
Co-ordinates: 11°07'22"N;7°35'39"E.
Analysed by: Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2475 MATRIX:[A0= 12000] WEIGHT [g/cm^2]: 0.110

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
K	3.312	0.378	1.33E+04	0.0028	9.84E-03	6.68E-04
CA	3.690	0.099	1.58E+04	0.0036	1.67E-03	3.94E-04
TI	4.508	0.714	3.63E+04	0.0063	3.02E-03	1.19E-04
MN	5.895	0.236	9.07E+04	0.0130	2.00E-04	2.09E-05
FE	6.400	26.081	1.11E+05	0.0162	1.44E-02	5.82E-05
ZN	8.631	0.141	2.44E+05	0.0311	1.85E-05	2.94E-06
W	8.340	0.043	1.01E+05	0.0287	1.47E-05	-LOD-
AS	10.532	0.086	3.49E+05	0.0465	5.31E-06	-LOD-
PB	10.540	0.163	2.03E+05	0.0466	1.73E-05	3.35E-06
BR	11.907	1.813	4.82E+05	0.0561	6.69E-05	1.31E-06
RB	13.375	2.868	5.30E+05	0.0645	8.39E-05	1.28E-06
SR	14.142	1.217	5.78E+05	0.0681	3.09E-05	9.07E-07
Y	14.933	1.378	6.28E+05	0.0713	3.08E-05	8.87E-07
ZR	15.746	15.270	8.06E+05	0.0742	2.55E-04	1.43E-06
NB	16.584	0.769	8.81E+05	0.0768	1.14E-05	5.37E-07

APPENDIX 6.1.3; SAMPLE 10b.

Material: Dam Water.
Co-ordinates: 11°08'02"N;7°39'22"E.
Analysed by: Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.1.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS1702 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.052	3.78E+02	1.0000	6.62E-06	1.63E-06
TI	4.508	0.021	5.81E+03	1.0000	1.71E-07	-LOD-
FE	6.400	0.895	1.76E+04	1.0000	2.47E-06	1.80E-07
CU	8.041	0.019	3.06E+04	1.0000	3.03E-08	-LOD-
ZN	8.631	0.025	3.61E+04	1.0000	3.33E-08	-LOD-
PB	10.540	0.016	3.16E+04	1.0000	2.44E-08	-LOD-
ZR	15.746	0.024	1.08E+05	1.0000	1.07E-08	-LOD-

APPENDIX 6.1.4; SAMPLE 11b.

Material: Dam Water.
Co-ordinates: 11°07'55"N;7°39'33"E.
Analysed by: Dr. I. Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.1.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS1703 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.151	3.78E+02	1.0000	1.94E-05	2.86E-06
TI	4.508	0.066	5.81E+03	1.0000	5.55E-07	1.20E-07
FE	6.400	3.670	1.76E+04	1.0000	1.01E-05	7.19E-07
CU	8.041	0.040	3.06E+04	1.0000	6.34E-08	2.08E-08
ZN	8.631	0.156	3.61E+04	1.0000	2.11E-07	2.38E-08
PB	10.540	0.024	3.16E+04	1.0000	2.67E-08	-LOD-
ZR	15.746	0.048	1.08E+05	1.0000	2.15E-08	-LOD-

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APPENDIX 6.1.5; SAMPLE 9d.
Material: Dam Water.
Co-ordinates: 11°08'16"N;7°39'30"E.
Analysed by Dr. I.Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2481 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.189	2.45E+03	1.0000	3.75E-06	4.10E-07
CD	3.130	0.052	6.07E+03	1.0000	4.16E-07	-LOD-
SN	3.440	0.045	8.30E+03	1.0000	2.63E-07	8.78E-08
SB	3.610	0.053	8.47E+03	1.0000	3.04E-07	-LOD-
I	3.930	0.035	1.13E+04	1.0000	1.49E-07	-LOD-
TI	4.508	0.041	3.72E+04	1.0000	5.35E-08	1.96E-08
V	4.949	0.037	5.61E+04	1.0000	3.22E-08	-LOD-
CR	5.411	0.034	7.30E+04	1.0000	2.27E-08	-LOD-
FE	6.400	3.739	1.14E+05	1.0000	1.59E-06	1.74E-08
CO	6.925	0.064	1.42E+05	1.0000	2.20E-08	-LOD-
NI	7.472	0.043	1.77E+05	1.0000	1.17E-08	-LOD-
CU	8.041	0.035	2.08E+05	1.0000	8.14E-09	-LOD-
ZN	8.631	2.139	2.50E+05	1.0000	4.15E-07	6.37E-09
AS	10.532	0.055	3.57E+05	1.0000	7.49E-09	-LOD-
SE	11.210	0.040	4.02E+05	1.0000	4.89E-09	-LOD-
PB	10.540	0.045	2.08E+05	1.0000	1.05E-08	-LOD-
BR	11.907	0.036	4.94E+05	1.0000	3.51E-09	-LOD-
ZR	15.746	0.042	8.25E+05	1.0000	2.47E-09	-LOD-

APPENDIX 6.1.6; SAMPLE 13b.
Material: Well Water
Co-ordinates: 11°08'19"N;7°37'41"E.
Analysed by Dr. I.Funtua in CERT, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2482 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.191	2.45E+03	1.0000	3.79E-06	4.67E-07
CD	3.130	0.033	6.08E+03	1.0000	2.60E-07	-LOD-
SN	3.440	0.047	8.31E+03	1.0000	2.76E-07	-LOD-
SB	3.610	0.037	8.49E+03	1.0000	2.10E-07	-LOD-
I	3.930	0.033	1.13E+04	1.0000	1.40E-07	-LOD-
TI	4.508	0.037	3.72E+04	1.0000	4.78E-08	-LOD-
V	4.949	0.041	5.62E+04	1.0000	3.55E-08	-LOD-
CR	5.411	0.036	7.31E+04	1.0000	2.41E-08	-LOD-
FE	6.400	1.158	1.14E+05	1.0000	4.92E-07	1.28E-08
CO	6.925	0.041	1.42E+05	1.0000	1.39E-08	-LOD-
NI	7.472	0.038	1.77E+05	1.0000	1.05E-08	-LOD-
CU	8.041	0.042	2.09E+05	1.0000	9.77E-09	-LOD-
ZN	8.631	0.047	2.51E+05	1.0000	9.05E-09	-LOD-
AS	10.532	0.078	3.58E+05	1.0000	1.06E-08	-LOD-
SE	11.210	0.037	4.03E+05	1.0000	4.51E-09	-LOD-
PB	10.540	0.062	2.08E+05	1.0000	1.44E-08	-LOD-
BR	11.907	0.040	4.95E+05	1.0000	3.96E-09	-LOD-
ZR	15.746	0.055	8.27E+05	1.0000	3.21E-09	1.16E-09

APPENDIX 6.1.7; SAMPLE 14a.
Material: Well Water
Co-ordinates: 11°08'22"N;7°37'14"E.
Analysed by: Dr. I.Funtua in CERT,Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2483 MATRIX:PRECIPITATE [THIN] VOL.-WATER [ml]: 100.000

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
S	2.307	0.306	2.45E+03	1.0000	6.06E-06	4.68E-07
CD	3.130	0.038	6.08E+03	1.0000	3.04E-07	1.01E-07
SN	3.440	0.056	8.31E+03	1.0000	3.27E-07	8.57E-08
SB	3.610	0.047	8.49E+03	1.0000	2.68E-07	-LOD-
I	3.930	0.031	1.13E+04	1.0000	1.32E-07	-LOD-
TI	4.508	0.088	3.72E+04	1.0000	1.15E-07	1.87E-08
V	4.949	0.030	5.62E+04	1.0000	2.55E-08	-LOD-
CR	5.411	0.032	7.31E+04	1.0000	2.11E-08	-LOD-
FE	6.400	2.942	1.14E+05	1.0000	1.25E-06	1.52E-08
CO	6.925	0.041	1.42E+05	1.0000	1.39E-08	5.47E-09
NI	7.472	0.031	1.77E+05	1.0000	8.40E-09	-LOD-
CU	8.041	0.031	2.09E+05	1.0000	7.21E-09	2.95E-09
ZN	8.631	0.028	2.51E+05	1.0000	5.47E-09	-LOD-
AS	10.532	0.045	3.58E+05	1.0000	6.13E-09	-LOD-
SE	11.210	0.028	4.03E+05	1.0000	3.37E-09	-LOD-
PB	10.540	0.037	2.08E+05	1.0000	8.60E-09	-LOD-
BR	11.907	0.037	4.95E+05	1.0000	3.62E-09	-LOD-
ZR	15.746	0.099	8.27E+05	1.0000	5.80E-09	9.20E-10

APPENDIX 6.1.2.1; SAMPLE 15.
Material: Orthoclase feldsfer
Co-ordinates: 11°09'48"N;7°36'15"E.
Analysed by: Dr. I. Funtua in CRET, Zaria, by XRF technique.
Result is as presented on table 3.4.
Location of sample is as shown on figure 9.

ANALYSIS RESULTS

SAMPLE: IS2477 MATRIX:[A0= 12000] WEIGHT [g/cm^2]: 0.110

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
K	3.312	1.841	1.33E+04	0.0028	4.91E-02	9.97E-04
CA	3.690	0.077	1.58E+04	0.0032	1.54E-03	-LOD-
TI	4.508	0.055	3.63E+04	0.0055	2.75E-04	-LOD-
MN	5.895	0.050	9.07E+04	0.0116	4.80E-05	-LOD-
FE	6.400	0.914	1.11E+05	0.0145	5.66E-04	1.78E-05
ZN	8.631	0.071	2.44E+05	0.0311	9.36E-06	-LOD-
W	8.340	0.322	1.01E+05	0.0287	1.10E-04	6.63E-06
AS	10.532	0.098	3.49E+05	0.0465	6.04E-06	-LOD-
PB	10.540	0.568	2.03E+05	0.0466	6.01E-05	3.42E-06
BR	11.907	2.177	4.82E+05	0.0561	8.04E-05	1.35E-06
RB	13.375	11.345	5.30E+05	0.0645	3.32E-04	2.11E-06
SR	14.142	1.008	5.78E+05	0.0681	2.56E-05	8.22E-07
Y	14.933	0.334	6.28E+05	0.0713	7.47E-06	8.71E-07
ZR	15.746	0.065	8.06E+05	0.0742	1.08E-06	-LOD-
NB	16.584	0.064	8.81E+05	0.0768	9.53E-07	-LOD-

APPENDIX 6.2; SAMPLES 1a-11a.

Material:Stream/Dam Water.
Co-ordinates; As shown on table 3.1.
Analysed by: Samuel Edegbo in Geology, ABU Zaria, by AAS technique.
Results is as shown on table 3.1.
Location of samples is as shown on figure 9.

Sample Number and its Method of analysis	1a	2a	3	4	5	6	7	8	9	10a	11a
	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS
Sample Identification	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Stream Water	Dam Water	Dam Water	Dam Water
Co-ordinates	11°09' 50"N 7°38' 38"E	11°09' 35"N 7°38' 41"E	11°09' 17"N 7°38' 47"E	11°09' 57"N 7°38' 49"E	11°08' 41"N 7°38' 49"E	11°08' 26"N 7°38' 49"E	11°08' 12"N 7°39' 00"E	11°08' 7"N 7°39' 04"E	11°08' 11"N 7°39' 17"E	11°08' 2"N 7°39' 22"E	11°07' 55"N 7°39' 31"E
Date of Sampling	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99	26/5/99
Date of Analysis	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99	3/6/99
Sampled by	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba	M.L. Garba
Temp. at Sampling Time	27°C	28°C	30°C	30°C	30°C	29°C	29°C	28°C	29°C	29°C	30°C
pH at Sampling Time	6.5	6.5	7.0	6.5	6.5	6.5	6.5	6.5	6.0	6.5	6.0
Container Used	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene
Preservation if any	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified	Acidified
Laboratory	Dept. of Geol. A.B.U	Dept. of Geol. A.B.U	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.	Dept. of Geol.
Analysed by	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	Mr. Edegbo	# Mr. Edegbo	Mr. Edegbo
Pb	0.110	0.140	0.085	0.067	0.056	0.067	0.101	0.056	0.045	0.067	0.544
Cr	0.112	0.106	0.075	0.112	0.067	0.095	0.095	0.067	0.080	0.102	0.188
Ni	0.044	0.054	0.044	0.041	0.078	0.051	0.081	0.041	0.046	0.048	0.044
Co	0.023	0.054	0.034	0.023	0.024	0.023	0.025	0.025	0.021	0.011	0.031
Ag	0.038	0.054	0.030	0.043	0.038	0.034	0.027	0.041	0.028	0.029	0.030
Cu	0.040	0.022	0.019	0.041	0.017	0.012	0.030	0.007	0.013	0.010	0.015
Zn	0.016	0.034	0.025	0.100	0.097	0.171	0.154	0.154	0.046	0.013	0.067
Fe	1.186	1.810	2.295	1.346	2.558	1.313	10.248	3.005	1.710	0.513	2.880
Mn	0.251	0.363	0.427	0.242	0.301	0.031	1.375	1.637	0.153	0.059	0.269
Ti											
Zr											

APENDIX 6.5; SAMPLES 9c,and 13a
Material: Dam/Well Water.
Co-ordinates; As shown on table 3.3.
Analysed by : Mr. Goddy in NDA Kaduna.
Results are as shown on table 3.3.
Location of samples is as shown on figure 9.

Sample number	9c	9c	13a	13a
Date collected	28/12/99	28/12/99	28/12/99	28/12/99
Date analysed	7/01/2000	7/01/2000	7/01/2000	7/01/2000
Result(ppm)	0.461	0.071	0.248	0.245

APENDIX 6.3; SAMPLES 9a, 12a,and 4b.
Material: Dam/Sream Water.
Co-ordinates; As shown on table 3.2.
Analysed by : Mr. Rashidi Lawal in NAPRI Shika.
Results are as shown on table 3.2.
Location of samples is as shown on figure 9.

Date of Analysis	Sample Number/Results					
	9b	9b	12a	12a	4b	4b
28/10/99	5.3	4.40	7.10	6.30	9.00	3.20
8/11/99	0.029	0.27	1.51	2.06	1.49	2.26
23/11/99	0.62	0.11	0.01	0.02	2.00	2.70

APENDIX 6.4; SAMPLES 9b,12a,and 4b.
Material: Dam/Stream Water.
Co-ordinates; As shown on table 3.2.
Analysed by : Mr. Steve in CHELTEC Basawa,Zaria.
Results are as shown on table 3.2.
Location of samples is as shown on figure 9.

Date of Analysis	Sample Number/Results					
	9b	9b	12a	12a	4b	4b
28/10/99	-0.02	0.14	-0.05	0.00	-0.10	-0.10
8/11/99	0.00	1.13	0.00	0.013	1.75	0.38

APPENDIX 6.6; SAMPLES 9a,12a,and 4b.
Material:Stream/Dam Water.
Co-ordinates; As shown on table 3.2.
Analysed by:Mr. Collins in Geological Survey Kaduna by AAS technique.
Results is as shown on table 3.2.
Location of samples is as shown on figure 9.

LABORATORY REPORT

Name of Sender: M L Gimba

Nature of Samples: 6 water samples

Locality: Abu Zaria

Time: 11 am Saturday 16/10/99

Introduction: The Six water samples were received ~~treated~~ and analysed with Atomic Absorption Spectrometer for determination of lead. The Instrument was installed with Lead Cathode Lamp and it was Calibrated with lead standard Solutions 2, 4, 8, 12, 16 ppm. The Samples were aspirated into the atomiser ~~to~~ to read the various Concentrations. In all the Samples lead (Pb) was not detected. The Lowest detection Limit of lead is 2 ppm ~~in~~ but in all the Samples the result was negative: (eg. -0.232)

AAS model
UNICAM 929

1a	1b	2a	2b	3a	3b
nd ~~-0.232~~	nd	nd	nd	nd	nd ~~-0.232~~

nd = not detected

Remark: The result is expected this way because in most uncontaminated water Lead is not always detected, In wastewater especially waste water from Industries you find lead present.

APPENDIX 6.7; SAMPLES 9e,13c and 14b.
Material:Dam Water/Well Water.
Co-ordinates; As shown on table 3.5.
Analysed by: Mansour, A. in Office National Des Recherches Minieres Onarem, Niger Republic,by AAS technique.
Results is as shown on table 3.5.
Location of samples is as shown on figure 9.

OFFICE NATIONAL DES RECHERCHES MINIERES
ONAREM

Date : 09 03-2000
Heure : 10h 30
Opérateur : Mansour.A

ANALYSES CHIMIQUES :
A.A.S.

ELEMENTS DE TRACE

Standards :

Pb : 1-5-10

Cd : 0.5-1-2-4

Sb : 100-50-20-10

RESULTATS

ECHANTILLONS (Sample)	Pb	Cd	Sb
1	0.00	0.00	0.00
2	0.00	0.01	0.00
3	0.00	0.00	0.02