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WATER SCARCITY AND THE LINKAGE EFFECTS OF HYDROPROJECTS IN AYA RIVER BASIN AT OGOJA, SOUTH EAST NIGERIA

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ABSTRACT

A study of the water resources potential in relation to the perennial water scarcity in Aya River Basin at Ogoja was carried out. It was observed that the groundwater potential of Aya River Basin is considerably low, and that groundwater aquifers may be difficult to locate. This was attributed to the fact that Ogoja area is underlain by a Cretaceous sedimentary sequence of predominantly impervious shales, with minor deltaic sediments, which have shallow aquifers existing in fractured areas. Projected total water abstraction from Aya River of 14,280m3 per day for water supply, and 12,500m3 per day for irrigation of 250 hectares by 2015, represents very high limits for Aya River whose dry season flow is about 200 litres per second, thus resulting in a "linkage effect" on Aya River yield. Calculated water use of 38.45m3/person year for water supply and irrigation in 1992 is far below the world's current average of 800m3/person year, thus placing the basin below the bottomline of water-scarce countries.

KEY WORDS: River basin, perennial water scarcity.

INTRODUCTION

Aya River Basin is that unit of land at Ogoja, the central area of the basin which lies within latitudes 6° 40′ N and 6° 45′ N, and longitudes 8° 48′E and 8° 50′E, and drains into the only perennial river, Aya River, in the basin (Figure 1). Aya River basin has a surface area of about 1600km^2, and consists of eight communities with a 1992 total population of about 70,510 (Fig. 1). The eastern boundary of the catchment area is Obanliku (in Obudu Hills) some 10 km east of Obudu and about 50km east of Ogoja. The northern boundary is about 25km north of Obudu near Gakem in Cross River State/Adikpo in Benue State of Nigeria. The catchment extends down south to the fringe of the rain forest area between Ubong and Okubusho. The highest point of the catchment area is about 1100m above sea level. The tributary rivers are Nyari, Monaya, Echin, Betsun and Debekim.

The basin has a tropical climate with a distinct wet season (May to October) which alternates with the dry season (November to April), while temperatures are characterised by diurnal annual variations. The vegetation consists of a few scattered trees and thick grasses, which quickly wither during the dry season. The basin is the only source of economic survival and reduction or elimination of poverty in the area if integrated management strategy is applied to ensure sustainability.

The problem of water scarcity in the basin has been quite noticeable for several decades, sometimes resulting in long periods of drought. Unfortunately, some hydroprojects on irrigation and water supply within the basin appear to have resulted in a "linkage effect" on the water yield of Aya River, which is the main river of the basin.

This study examines the water resources potential and the prevailing meteorological and hydrological features of the basin, besides the impacts of hydroprojects on the discharge potential of Aya River, the main source of water in the basin. The study also focuses on how best the basin could be managed to check the consequences of water scarcity or drought in the area.

DATA

Data for this study were obtained from the Cross River Government commissioned feasibility studies by GKW Consult in association with GKW Nigeria Limited, on "Rehabilitation/Expansion of Ikom and Ogoja Water Schemes."

These included the meteorological data (Cross River Basin Development Authority, 1993), water level readings at the low water staff gauge at Ogoja from 11th January to 22nd April, 1993, discharge measurements made in January and March, 1993, at Aya River at Ogoja and its tributaries (the locations are marked in Figure 1), hydroprojects in Aya River catchment area, total water demand calculated for Aya River catchment basin in 1993 and results of water quality analyses - Aya River, Ogoja, March, 1993.

DATA ANALYSIS

Table 1 shows computations from the meteorological data of Aya River basin (Cross River Basin Development Authority, 1993). This shows very high evapotranspiration relative to direct run-off. Mean annual temperature is 28°C, while humidity varies from 26% at the peak of dry season (January) to 60% in the wettest months (Ushie, 1995, Cross River Basin Development Authority, 1993).

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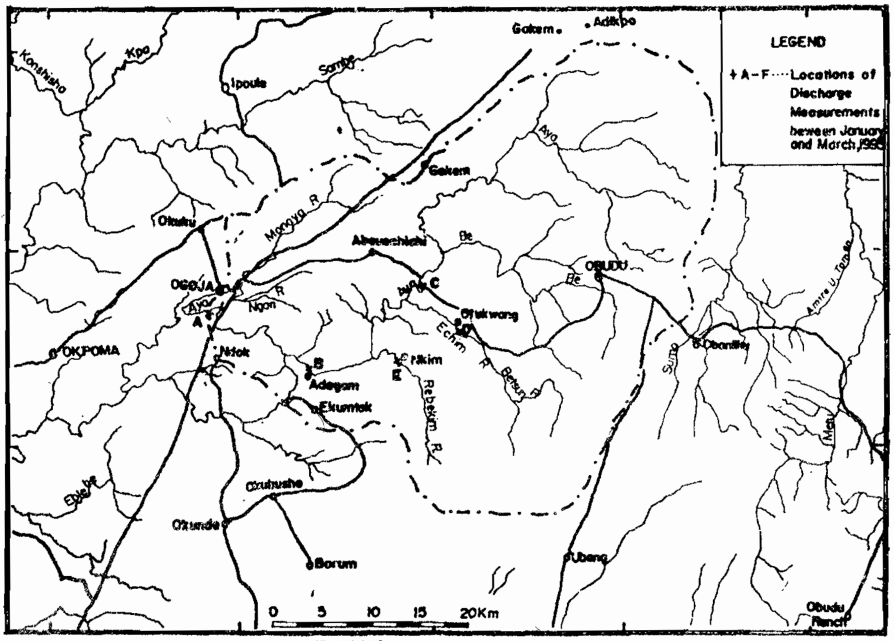

FIG. I CATCHMENT AREA AYA RIVER AT OGOJA

TABLE 1: Meteorological Data (Cross River Basin Development Authority, 1993)

Mean Annual Precipitation (mm)	Mean Annual Evapotrans-piration (mm)	Direct Run-off (mm)	Mean Annual Temperature (°C)	Humidity (%)
1941	1122	819	28	26-60

TABLE 2: Water Level Reading at the Low Water staff Gauge at Ogoja (GKW Consult, 1993).

Jan 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18 19 20 21
Water level (cm) 55/53/52/50/50/50/49/49/48.5/48/47.5/46/43/41/42/40/40/40/39.5/39.5

Feb. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18
Water level (cm) 39/39/38.5/39/37.5/37/36.5/34/32/30/30/29.5/29/29/29.5/30/30/
Feb. 19 20 21 22 23 24 25 26 27 28 29

Water Level (cm) 30/29/28.5/28.5/30/30/30/29.5/29/29/29

Mar. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 1618 19

Water level (cm) 27.5/27/26/26/25.5/25.5/25/23/22.5/22/22/27/26/25/25/24/30/30

Mar. 20 21 22 23 24 25 26 27 28 29 30 31
Water level 29/29/27.5/25.5/22/20/19.5/19/19/18/18/18

Apr. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18 19 20 21 22
Water Level (cm) 27/27/25/23/20/20/20/19/19/19/19/18/18/18/18/18/17/20/20/20/19

TABLE 3: Results of the Discharge Measurements in January and March, 1993 (GKW Consult, 1993)

Site	Date	Discharge (l/s)	Water Stage (cm)
A: Aya R., Ogoja	11/1/93	3000	
	21/1/93	1950	55
	8/3/93	360	45
	9/3/93	310	23
B: Aya R.,	8/3/93	250	21.5
Adagum	13/1/93	500	
C: Aya R., Bridge	20/1/93	400	
Obudu Road	9/3/93	30	
D: Echin R.	8/3/93	110	
E: Debekim R.	8/3/93	120	
F: Monaya R.	13/1/93	220	
	9/3/93	25	

Table 2 shows water level readings at the low water staff gauge at Ogoja from 11th January to 22nd April, 1993 (in cm). This shows variations in the monthly water levels as expressed in Figure 2, while Figure 3 which was provided by the Cross River Basin Development Authority, shows highest rainfall events during May to October.

Figure 4 shows the flow discharge at Ogoja, which indicates the lowest flow recorded within the measurement period in 1993, to be 200 litres per second, and indicates low level of discharge during the dry season, between January and April. Figure 5 shows the water stage diagram, while figure 6 shows the baseflow recession curve of Aya River in which an increase of the recession constant K with a decrease of the flow discharge was not evident.

TABLE 4: Hydroprojects in Aya River Catchment Basin

Name of Hydroproject	Location of water Abstraction at Aya River	Purpose	Maximum Water Required (m3/day)
1. Ogoja water supply scheme	Raw water intake 30m east of Abakpa/Ogoja Bridge head	Raw water pumped from the low lift to the treatment plant	6,360 at present, 6,495 in the year 2005 and 10,665 in 2015, and 14,280 (+)
2. Ogoja Irrigation Project (under CRBDA)	3km upstream of the intake of Ogoja water Board on the left bank of Aya River just downstream of Katsina Ala-High way bridge	Water is abstracted to irrigate the farm during period of low rainfall	3,360 required for present project of 125ha, and 12,500 for future expansion scheme of 250ha
3. Irrigation at Nyari catchment	A few km east of Ogoja (*)	Surface flooding of rice field	Water demand not known
4. Planned Ibil Irrigation scheme	25km Southwest of Ogoja (downstream) at Aya River	Involves the construction of a dam	Water demand not known
5. Obudu dam	At River Be at the northern border of the catchment area		

Key: (*) Distance not investigated
(+) Total required water projection for 2015.

Table 3 represents the results of the discharge measurments in January and March, 1993, which show discharges of 360 l/s and 310 l/s on the 8th and 9th March respectively.

Table 4 shows hydroprojects in Aya River Catchment basin. The daily raw water needed to be abstracted from Aya River for water supply and irrigation is about 26780m³, which is by far higher than the water yield of Aya River in the dry season.

Table 5 shows calculated and projected water demand for the years 1992, 2005 and 2015 whose total per capita values appear rather low. Table 6 shows the water quality (chemical) of Aya River at Ogoja in March, 1993, although bacteriological results were not obtained for lack of reagents and media. It shows varying values for turbidity between dry season and rainy season.

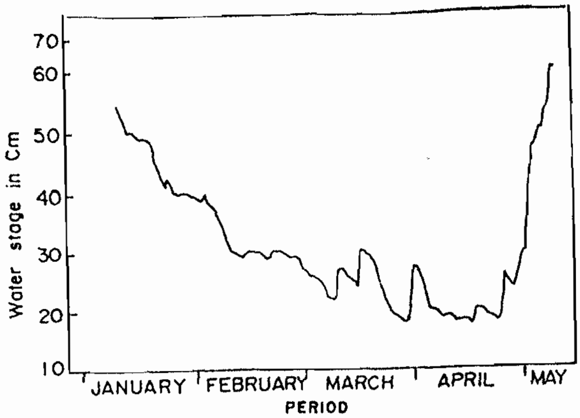

FIG.2 AYA RIVER-OGOJA Water stage Readings -Dry season 1993

DISCUSSION

Natural conditions for water scarcity and occurrence of drought are evident in Aya River Basin. The potential for desert encroachment is exacerbated by primitive farming methods, bush burning, socio-economic situations and cultural activities of the basin communities.

Although meteorological conditions in the basin are typical of rainforest areas of Africa (Hekstra, 1985), rainfall variability in the basin is associated with occasional incidence of drought in the catchment area. The basin is characterised by a distinct wet season (May to October) which alternates with dry season (November to April). Total annual rainfall is about 1941mm of which 87 to 92% is received during May to October (Ushie, 1995). With a mean annual temperature of 28°C,

TABLE 5: Total Water Demand Calculated for Aya River Basin (GKW Consult, 1993)

Year	Domestic Industrial Demand (m³/d)	Institutional /Industrial Demand (m³/d)	Agricultural/ Irrigational Demand (m³/d)	Total (m³/d)
1992	3,199.64	868.90	3,360.00	7,428.54
2005	4,956.46	1,537.25	15,000.00	21,493.71
2015	8,239.92	2,428.66	(*)	10,668.58(+)

Key: (*) Uncalculated projected agricultural/irrigation water demand for year 2015
(+) Total required water projection for 2015

TABLE 6: Results of the Water Quality Analyses - Aya River, Ogoja, March 1993

Date of Analysis: 09/03/93						
Location of Water Sampling: Aya River, Ogoja -Intake Structure						
Type of Parameter	Parameter	Unit	Measured Value	Corresponding International Standard		
				WHO[1]	EEC[2]	TwVo[3]
General	Odour	(-)	Odourless		tr.lev.:3	tr.lev :3
	Colour	(-)	clear	15 TCU	20mg/lPt/Co	0.5 m⁻¹
Physical	Temperature					
	*air	(°C)	30	-	-	-
	* water	(°C)	25	-	25	25
	pH-value	(-)	7.6	6.5-8.5	6.5-8.5	6.5-9.5
	Conductivity	(µS/cm)	80	-	400	2000
Chemical	$Fe^{2+/3+}$	(mg/l)	0.8	0.3	0.2	0.2
	NH_4^+	(mg/l)	0.32	-	0.5	0.5
	NO_2	(mg/l)	<0.05	-	0.1	0.1
	NO_3	(mg/l)	<1.0	10	50	50
	SO_4^{2-}	(mg/l)	<10	400	250	240
	Mn^{2+}	(mg/l)	0.02	0.1	0.05	0.05
	Cl	(mg/l)	21	250		250
	P_2O_5	(mg/l)	<0.1	-	5	-

(1) World Health Organization: Guidelines for drinking water quality, Geneva, 1984
(2) EEC - Guidelines concerning the quality of water for human consumption, Brussels, 1980
(3) Trinkwasser - Verordnung der BRD, German Drinking Water Decree, Bonn, 1990

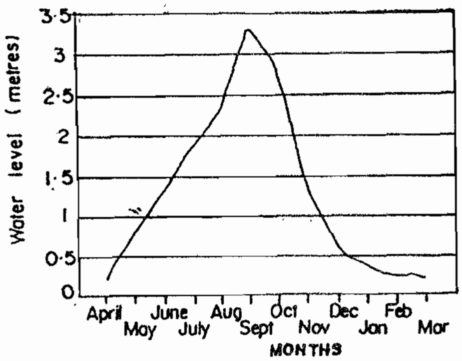

FIG.3 AVERAGE ANNUAL WATER LEVEL HYDROGRAPH AYA RIVER AT OGOJA (1979 1989)

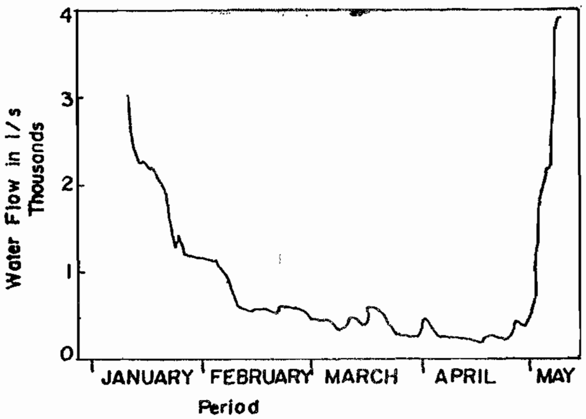

Fig. 4 : AYA RIVER - OGOJA : Flow Discharge-Dry season 1993.

Geologically, Ogoja area is underlain by a Cretaceous sedimentary sequence of predominantly impervious shales with minor deltaic sediments, which have shallow aquifers existing in fractured areas. Reyment (1965) and Peters (1978) ascribed the sedimentary sequence to the Asu River Groups, belonging to the lower Albian age, having been deposited in the earliest phase of sea transgression. In fact, middle Albian to middle Turonian sediments can be found (Peters and Ekweozor, 1982). Thus, availability of groundwater may be due to the development of secondary porosity in jointed areas resulting from fracturing (Ushie, 1995). This explains the failure of borehole exploitation in the area.

humidity varies from about 26% at the peak of dry season (January) to 60% in the wettest months. There is variation in rainfall pattern in the basin. Thus, there is complete absence of rainfall up to late July in some years. This was the case in the second half of 1970s and mid - 80s that resulted in severe drought in Ogoja. Thus, susceptibility to climatic conditions (Mattei, 1979) appears to be one of the major natural factors that result in drought (FAO World Food Day, 1994) in the area.

Although the basin extends to the rain forest area between Ubong and Okubusho (Figure 1), the vegetation consists of a few scattered trees and thick grasses which wither and dry up during the dry season. Some shrubs and secondary forests may be found, and generally there is land fallowing in the entire catchment area. Mixed farming system of semi-arid regions south of the Sahara (Hekstra, 1985) is practised in the basin, and crop cultivation is limited by excess rainfall, easy run-off (Table 1) and high seepage during peak rains between May and October. Thus, apart from the potential impact of drought in the area, primitive land use practice ,has resulted in the deterioration of agricultural land with consequent crop failure year after year.

The groundwater potential of Aya River Basin is considerably low, and sizeable groundwater aquifers in acceptable depths may therefore be difficult to locate.

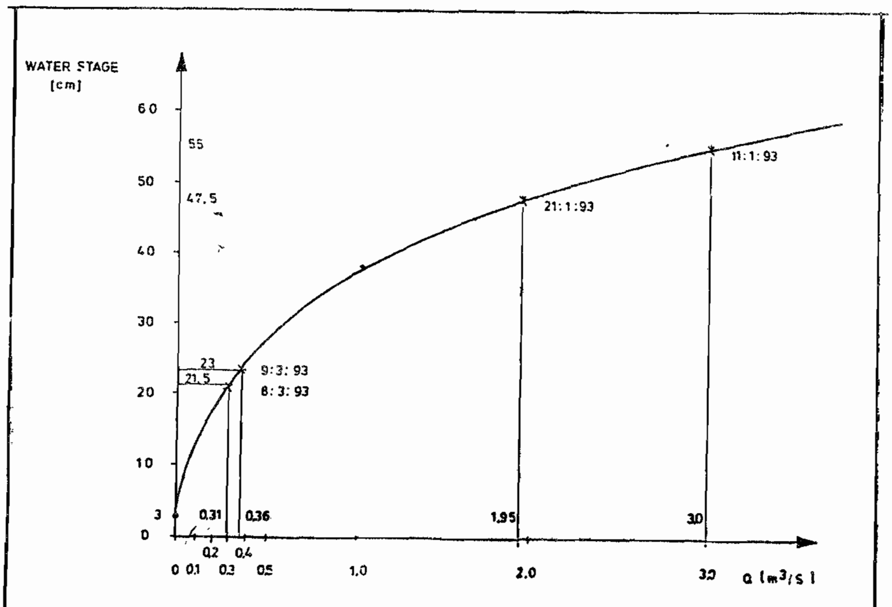

FIGURE 5: STAGE-DISCHARGE DIAGRAMME OGOJA, AYA RIVER

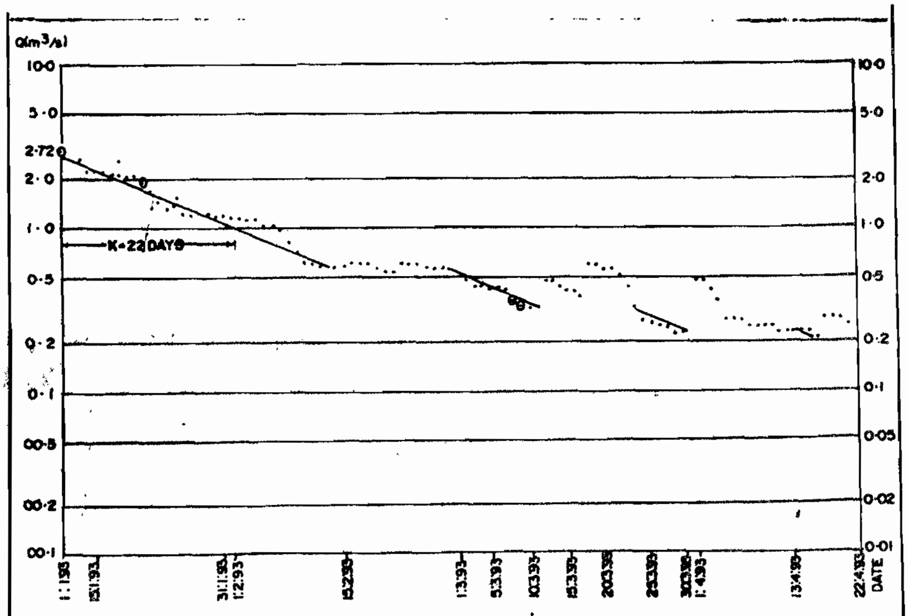

FIG. 6 BASEFLOW RECESSION CURVE AYA RIVER OGOJA

Aya River is the only perennial surface water in the catchment area, although characterized by low flow. There is vaiation in the monthly water levels (Table 2, Figures 2 and 3). In the course of dry season, and probably due to high evapotranspiration and some infrequent rainfall in the area, the gradient of the water stage hydrograph decreases over time. Of course, small rain events result in an increase of discharge, just for a few days, until the emptying of the underground reservoir continues. From the parallel lines shown in Figure 6, it is evident that an increase of the recession constant, K, with a decrease of the flow discharge could not be found. This indicates that the main contribution to the low flow of Aya River in Ogoja originates from a small portion of the catchment area at the hilly forest region southwest of Obudu where the tributaries, Debekim and Echin Rivers have their sources. The Aya River flow measurements at Ogoja for 8th and 9th March, 1993 (Table 3) showed 360l/s and 310l/s respectively, out of which Debekim River contributed 120l/s and Echin River 110l/s. Only flows of 30l/s each were shown by the measurement in Aya River at Abouochichi – Obudu bridge and Monaya River.

The lowest flow recorded within the measurement period in 1993 was 200l/s (Figures 4 and 5). This corresponds to a water level of 17cm on 17.4.93 (Table 2), and represents 117% of the maximum raw water quantity projected for the year 2015. Based on the hydrologic analysis of the low flow and same yield conditions of Aya River at Ogoja, it is apparent that, the water discharge in this river during dry years, drops to a level less than 100l/s which is lower than the raw water quantity required to supply the catchment area. By careful assessment, there is a probability in the range of 1 in 10 years, such period extending even up to 5 to 6 weeks in one year, for the occurrence of such low discharge.

Unfortunately however, besides 12,500m³/day (or 144.7l/s) required for irrigation, the maximum raw water supply quantity required for the basin is 14,280m³/day or 165l/s, representing 83% of the lowest flow of 200l/s. However, the present water supply (demands) of 6360m³/day or 73.5l/s , and 10,665m³/day or 123.2l/s for the year 2015 (Table 4), represents respectively 36.7% and 61.6% of the lowest flow of 200l/s. Thus, even the water abstraction of 14,280m³/day for water supply, represents an absolute upper limit for average dry reason conditions (between mid-January and end-April). The upper limit may be slightly lower for 12,500m³/day required for future Ogoja irrigation expansion scheme of 250ha.

The total water required for both water supply and irrigation for Aya River basin (Table 5) is comparatively low. For the year, 1992, requirment for water supply alone was about 7,428.54m³/day, equivalent to 27 x 10⁵m³ per year, or about 38.45m³ per person per year. Comparatively, this is by far lower than the current world's estimated average annual water use of 800 m³ per person per year (FAO World Food Day, 1994). Aya River Basin falls far below the bottomline of water-scarce countries categorized by hydrologists on the basis of availability of water supplies of less than 1000m³ per person per year (FAO World Food Day, 1994). The low water use of 38.45m³ per person per year could have resulted from little water being used for domestic waste disposal, and the fact that agriculture in the area is mostly rainfed. Furthermore, industrial activity is insignificant in the area. The water use picture is not likely to change much by the year 2005, and this is a reflection of the inadequate socio-economic situation in the area and most other areas in Africa south of the Sahara.

The cmparatively low water demand in the catchment area cannot still be met for now by Aya River which is already characterised by low flow. This is, in part, due to the "linkage effect" of water abstraction for the hydroprojects in the catchment area. Consequently the hydroprojects have little water to meet their respective demands and objectives. The minimum water flow of 200$^l/_s$ for Aya River is completely inadequate to meet the daily abstraction levels for Ogoja water supply scheme and the irrigation projects. Thus, effective management of the basin to limit water scarcity situation and the effects of drought in the long term, with resultant improvement in the socio-economic life of the communities, is desirable. In the long term, two approaches may be successful in checking water scarcity and the effects of drought. One is water conservation through rain harvesting (Maddocks, 1975), and sustainable exploitation of Aya River. The chemical quality of Aya River (Table 6) is acceptable by international standards (World Health Organizaion, 1984, European Economic Community, 1980, and German Drinking Water Decree, 1990); and although the biological/microbiological quality was not determined during the study, sanitation education and protection of the water resources from pollution is necessary to ensure that the available water is not indirectly scarce.

One other most effective way of sustainable management of the basin is the construction of a dam across the breadth of Aya River, because of its seasonal flow characteristic. This will provide water for multipurpose uses, in the long term. It will also improve the water quality, flora and fauna downstream (UNESCO, 1984, Edwards and Crips, 1980). However, the quality is likely to change when many industries spring up in the area. Although the consequences of a dam in Aya River are not here discussed, the long-term benefits in the drought-stricken basin will be enormous. However, full community participation and ownership of the programmes will ensure sustainability.

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