SUITABILITY OF GROUND WATER RESOURCES FOR IRRIGATION IN NIGER STATE: CASE STUDY OF (MUNYA, WUSE, SULEJA, SHIRORO AND GURARA LGA.)

BY

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CERTIFICATION

This project have been fully read and duely approved by the undersigned as having met the requirements for presentation of project by the department of Agricultural Engineering, Federal University of Technology, Minna.

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DEDICATION

This project work is dedicated to my late father.

LATE ALH. HASSAN SULEIMAN GEGU

ACKNOWLEDGEMENT

In the name of Allah, the Beneficent, the Merciful. All praises be unto Him, the Lord of the world for guiding me throughout the course of this programme.

My profound gratitude goes to the following people, they have been of immeasurable help to me;

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The school environment and its academic curriculum combined up to make it a citadel of academic excellence. I hope the school could keep it up.

ABSTRACT

Suitability of ground water Resources in five local government area of Niger State were evaluated with respect to their quality and availability for dry season irrigation farming.

Samples of the water were taken from five boreholes from each of the local government areas. The physical chemical properties were tested i.e Quality and quality were estimated. The quantity as a parameter also, in this project work was estimated by the use of bore hole depth and state water level with the estimation of yield per second of each bore hole.

The TDS were generally less than 250mlL this results shows that irrigation activities can be carried out on all the soils. (TDS = Total Dissolve Solids). The waters generally have low electrical conductivity, which shows that irrigation can be carried out on, with most crops with little likelihood of soil salinity developing.

CHAPTER ONE

1.0 INTRODUCTION

1.1 INTRODUCTORY NOTES:

Rain-fed agriculture account for most of the food and fibre grown in Niger State. The natural result of seasonal variation of climate on farming activities gives no room for continuous food production. Under this natural conditions, the result is dry season irrigation farming becomes a necessity in view of the ever increasing population (Muhammed and Dr. N. A. Egharevba 1999).

Agricultural activities is ever increasing thereby making it the world's largest water user in terms of volumes. Agriculture is also a relatively low value low efficiency and highly subsidized water user. Irrigated agriculture is expected to produce much more in the future. A recent estimates, tells us that agriculture will use 17% more water to meet the food demand of the ever increasing population.

The quantity and quality of the state usable surface water supply, still faces some shortage from an ever expanding population and increased other sectors usage, in spite of all the progress made by the state government in the provision of sufficient water for all crops demand and human use.

The use of unexplored ground water resources has evolved as an alternative to augment the surface water supplies. A good knowledge of the availability and quality of the ground water in the state and its suitability for the crops grown and the soil becomes very important.

1.2 DESCRIPTION OF STUDY AREA

1.2.1 LOCATION

The study area of the project work comprise of five local government areas in the South Western part of Niger State of Nigeria, Viz; MUNYA, WUSE SULEJA, SHIRORO AND GURARA – L.G.A'S They are located on longitude $6^0 28^w$ and latitude 11^0N

1.2.2 CLIMATE

These area have the same or similar climate condition as that of the middle belt of Nigeria. Wind direction is normally along South West and North East axis. The season of rainfall lasts for 190 – 200days, if has annual rainfall of about 1200mm with August recording the highest rainfall of 300mm. Mean monthly temperature is March at 37^0C and lowest in August at 25^0C.

1.2.3 GEOLOGY

The geology of the areas is characterized by sand store in Suleja and some part of Wuse local government area and sandy soil and water in the other three local government area of MUNYA, SHIRORO.

1.2.4 ECONOMIC ACTIVITIES

The people of these local government area are predominantly farmers, except in Suleja town ~~were~~ Where other commercial activities is taking place. The land is aralable for the cultivation of food like: Rice, Guinea Corn, Maize, Cassava, Vegetable and Fruits. During the dry season, people engage themselves in auxiliary works except in the inland valleys were irrigation's takes place or along the rivers Banks.

1.3 GENERAL OBJECTIVE

The general objectives is to determine the suitability of ground water in Niger State in terms of its quality and availability to dry season irrigation farming.

1.4 SPECIFIC OBJECTIVE

The specific objectives are to:

- Assess the physico-chemical properties of the ground-water resources in the five local governments in focus.
- Estimate the probable yield potential of the bore holes examine and use this to evaluate the availability of the ground water for irrigation purpose.
- Determine the suitability of the ground water resources in MUNYA, SULEJA, Wuse Shiroro and Gurara for irrigation farming.

1.5 JUSTIFICATION

As seasonal variations of climate provides no room for continuous production of Food to the people of Niger State. The need to have sound knowledge of the quality and availability of the water to be used during dry season becomes imperative. Day season farming account for a larger volume of water in agriculture. In view of this, the people has practiced irrigation on subsistence scale for a long time. Improvement can be made to increase output through the knowledge this project work is posed to address.

Irrigation water must be suitable and sufficient to meet the scope water requirement and most not contain Toxic compound to the crops or harmful to the soil been cultivated.

1.6 SCOPE OF STUDY

The scope of study is limited to five local government areaS in Niger State: Suleja, MUNYA, WUSE, SHIRORO and GURARA, using only give representatives samples from each local government area.

Bore hole yield was estimated, due to lack of yield data during constructions and development of the bore holes.

CHAPTER TWO

2.0 LITERATURE REVIEW

TODD (1980) referred to ground water as water occupying all the voids within A geologic stratum. This saturated zone is to be distinguished from an Unsaturated aeration zone where voids are filled with water and air, water contained in saturated zones is important for engineering works and supply developments. Unsaturated zones are usually found above saturated zones and extend upward to the ground surface.

Hydrologic circle has shown that a part of the rainfall infiltrate into the ground to joint the water table constitute the ground water. Water seeping in from the canals, reservoirs and lakes at higher attitude also forms the ground water. At the unsaturated zone, water includes soil moisture within the roof zone, if is a major concern for agriculture.

2.1 ADVANTAGE OF GROUND WATER

It have been observed that the qualify of ground water is generally superior to surface water as it is naturally filtered. Cases where the salt content is very high it becomes not suitable to irrigation and other domestic use (Mazundu 1983). Being underground, it is highly preserved and does not require the construction of costly storage structures, such as Dams, barrages, etc. there is also a very little evaporation loss. The cost of the distribution network, e.g. Main and branch canals etc. can be saved. In the case of surface storage the storage and distribution systems occupy considerable low surface and make the land so acquired unproductive.

The underground reservoirs are made by nature and some to these have capacities to store much more water that what artificial man-made reservoirs can hold. The problem associated with underground storage is that the water has to be lifted artificially through pumps or other surface services.

However, recent developments in countries such as Israel where artificial underground cut-offs have been constructed to raise the water table has helped considerably in reducing the cost because of the reduction in the pumping head. In many places the underground water lies under artesian conditions and once the water bearing strata is period through, water flow out of the well under natural hydro static Pressure head.

Another advantage of groundwater is the flexibility of use. In the case of surface irrigation, a farmer has to draw his share irrespective of his actual need at the given point of him. But in the case of ground water, there is no such compulsion. A farmer can operate his pump any time and for any duration which suits him best. Most of the surface irrigation schemes operate at a very low efficiency (about 15 to 20%) due to colloses loose in convergence, application and improper management. The efficiency of ground water irrigation is high at about (80 to 90%) because of little losses and better control (MANZUNDU, 1983).

2.2 HISTORICAL BACKGROUND

Groundwater development dates from ancient times. The old testament made references to ground water springs, and well other than dug wells, groundwater in ancient times was supplied from horizontal wells known as Qanats. These existed to the present day and can be found in the arid regions of South Western Asia and North Africa extending from Afghanistan to Morocco. Qanets are laboriously hand constructed by skilled workers employing techniques that date back 3000 years.

2.3 UTILIZATION OF GROUND WATER

Groundwater is an important source of water supply through out the would. Its uses in irrigation, industries, municipalities and rural homes continue to increase. Cooling and air conditioning have made heavy demands on groundwater because of its characteristic uniformity in temperature. Shortage of groundwater in areas where excessive withdrawals have occurred emphasize the need for accurate estimates of the available subsurface resources and the importance of proper planning to ensure the continued availability of water supplies. There is a tendency to think of groundwater as being the primary water source in arid regions and of surface water in human regions. But a study of groundwater use in the United States of America, for example reveals that groundwater serves as an important resource in all ~~climates~~ climatic zones (Murray et al, 1975). Reasons for this, include the its excellent quality (which typically requires little treatment) and its relatively low cost of development. (Further more in humid location such as Akure and Afikpo (Nigeria). Groundwater predominates as the water source because the high infiltration capacity of the soils sharply reduces surface runoff.

During drought crops perish in Northern Nigeria. Surface water resources all but disappears in many areas. Emergency measures of many types are usually instituted to sustain public water supply and irrigation but the drilling of thousands of tube wells in the Fadama areas became a key factor in meeting restricted water demands during the critical periods.

Practically all groundwater originates as surface water. Principal sources of natural recharge include precipitation, stream flow, lakes and reservoirs. Other contributions, known as artificial recharge, occur from excess irrigation, seepage from canals and water purposely applied to argument groundwater supplies. Even sea water can enter underground along coasts where hydraulic gradients stop downward in an inland directions. Water with the ground moves downward it sough the unsaturated zone under the action of gravity, where as in the saturated zone its moves in a direction determine by the suborning hydraulic situation. Discharge of groundwater occurs when water emerges from underground. Most natural discharge occurs as flow into surface water bodies, such as streams, lakes and oceans, flow to the surface appears as a spring.

Groundwater near the surface may return directly to the atmosphere by exploration from within the soil and by transpiration from vegetation.

2.4 QUALITY OF GROUND WATER

It is now generally recognized that the quality of groundwater is just as important as its quality. All groundwater contain salts in solution that are derived from location and past movement of the water. The quality required of a groundwater supply depends on its purpose; thus needs for sinking water, industrial water, and irrigation water very widely. To establish quality criteria, measures of chemical, physical, biological, and radiological constituents must be specified, as well as standard methods for reporting and comparing results can pose hazard if their presence goes unrecognized. The uniformity of groundwater temperature is advantageous of water supply and underlying saline groundwater are important because of the often potential benefits or demerits depending on their concentrations.

2.4.1 SOURCES OF SALINITY

All groundwater contain salts in solution reported salt contents range from 25mlL in quartzite spring to, more than 300,000mgll in 6 sins (white et al 1963). The type and concentration of salts depend on the environment, movement and source of the groundwater ordinarily, higher concentration of dissolved constituents are found in groundwater than in surface water because of the greater exposure to solute materials in geologic strata solute salts in groundwater originate primarily from solution of rock materials. Bicarbonate, usually the primary anion in groundwater, is derived from carbon dioxide released from organic decompositions in the soil salinity varies with specific surface area of acquifer materials, solubility of minerals and contact time, values had to be lightest where movement of groundwater is least; hence, salinity generally increases with depth. A common geochemical reference in groundwater include bicarbonate water near ground surface varying to chloride waters in the deepest portions of formations.

Salts are added to groundwater passing through soil by soluble products of soil weathering and of erosion by rainfall and flowing water. Excess irrigation water percolating to the water table may contribute to substantial quantities of salt. Water passing through the root zone of cultivated areas usually contain salt concentrations several times that of the applied irrigation water. Increases result primarily from the evatranspiration process which tends to concentrate salt in drainage waters. In addition soluble soils materials fertilizers and selective absorption of salts by plants will modify salt concentrate of percolating waters. Factors governing the increase include soil permeability, drainage facilities, amount of water applied, crops and climate. Thus, high salinity may be found in soils and groundwater of arid climates.

2.5 MEASURES OF WATER QUALITY

In specifying the quality characteristics of ground water, chemical, physical, and biological analysis are normally required. A complete chemical analysis of a groundwater sample include the determination of the concentrations of the inorganic constituents present; organic and radiological parameters are normally of concern only where human-induced position affect quality. Dissolved salts in groundwater of normal salinity occurs as dissociated ions, in addition, other minor constituents are present and reported in electrical form. The analysis also includes measurement of pit and specific electrical conductance. Depending on the propose of a water quality investigation, partial analysis of only particular constituents will sometimes suffice. Illustrative chemical analysis of groundwater from a rarity of geologic formation are shown in table 1 (According to white).

Properties of groundwater eradicated in a physical analysis include temperature, colour, turbidity, odour and tast. Biological analysis include test and defects the presence of coliform bacteria, which indicate the sanitary quality of water for human consumption.

Because certain coliform organisms are normally found in intestines of human and animals, the presence of these in groundwater is tantamount to its contact with sewage sources. The American public Health association and other specify standard methods of water analysis, most laboratories conducting water analysis follows these procedure.

TABLE 1

Table 1 rock type geologic are formation	Granite carboniferous mc cormick country south carolina	Basait Tertiary Moses lake Washighnton	Andesite Paleozoic Lndolph Corntry, North Carolina	Sandstone m Sipi Cawford country Pennsylvania	Shade Mississipi Cu yahopga country Ohil
Well depth, m	77	64	49	37	22
Chemical concentrating mglL					
Si02	35	55	31	14	19
AL	1.0	-	0.2	0	-
Fe	0.18	0.03	0.16	1.3	1.3
Mn	0.13	-	0.03	0	-
Cu	0	-	0.01	0	-
Zn	0.09	-	-	0	-
Ca	13	29	14	44	123
Mg	4.3	19	5.6	11	70
Na	8.4	12	9.6	60	61
K	3.5	3.5	0.4	4.1	2.2
$HC0_3$	72	177	74	327	539
$C0_3$	0	0	0	0	0
CL	3.8	6.9	8.8	4.4	3.5
F	0.2	0.4	0	0.2	0.4

N03	0.4	9.7	6.8	4.4	3.5
P04	0.1	-	0	0	-
Specific					
Conductance	150	340	163	533	1180
PH	7.0	7.9	7.2	7.4	7.3

CHEMICAL ANALYSIS OF GROUNDWATER FROM VARIOUS GEOLOGIC FORMATIONS (AFTER WHITE, ET AL)

TAB

Rock type geologic location age	Limestone cretaceous uvaide country Taxas	Dolomite silution milwaukec wisconsis	Quartzite cambrian bucks country pennsylvania	Schist cambrian girinnett country Georgia	Allluvium Plesistocene franklin 20 country Ohio
Well depth, m	107	152	154	183	36
Chemical concentrating mglL					
510_2	11	18	17	21	20
Al	-	0.2	-	0	-
Fe	0.18	0.039	1.6	0.11	2.3
Mn	-	0.03	-	0.02	0
Cu	-	0	-	0	-
Zn	-	0	25	0.02	126
Ca	74	35	5.1	2.7	43
Mg	9.5	33	-	5.7	43
Na	24	28	4.5	16	13
K	7.0	1.3	3.8	0.7	2.1
$HC0_3$	277	241	80	138	440
$C0_3$	0	0	0	0	0
50_4	1.9	88	13	9.6	319
Cl	24	1.0	8.0	2.5	8.0

F	0.4	0.9	0.4	0.5	0.7
$N0_3$	4.1	1.2	0.3	0	0.2
$P0_4$	-	0	-	0	-
Specfic Conductance	570	511	206	237	885
PH	7.0	8.2	7.1	8.0	7.6

Sources:- white et al, 1973

WATER QUALITY ~~CRITRIA~~ CRITERIA FOR IRRIGATION

The suitability of groundwater for irrigation is contingents on the effects of the mineral constituents of he water on both the plant and the soil (Richards 1954). Salts may have plant growth physically by inviting the up take of water through modification of Osmotic processes, or chemically by metabolic reactions such as those caused by Toxic constituents. Effects of salts on soils, causing changes in soil structure, permeability, and aeration, indirectly affect plant growth. Specific limits of permissible salt concentration for irrigation water cannot be stated because of the wide variations in salinity Florence among different plants; however, field plots studies of crops grown on soils that are artificially adjusted to various salinity levels provide valuable information relating to salt tolerance.

In table (2) relative tolerance of crops to soil water salt concentrations are listed for major crop divisions. The criteria applied was the relative yield of the crop on a saline soil as compared to its yield on a non-saline soil under similar growth conditions. Within each group, the crops are listed in order or increasing salt tolerance; electrical conductance values at the top and bottom of each column represent the range of salinity level at which a 50% decrease in yield may be expected. It should be noted that these concentrations refers to soil water, which may be expected. It should be noted that these concentrations refer to soil water, which may contain concentrations from 5 to 10 times that of applied irrigation water. Soil type, climate conditions, and irrigation practices may influence the reactions of a given crop in table (2) reflects its relative salts tolerance under customary irrigation condition:-

TABLE(2) RELATIVE TOLERANCES OF CROPS TO SALTS CONCENTRATION (AFTER RICHARDS)

CROP DIVISION	LOW SALT TOLERANCE	MEDIUM SALT TOLERANCE	HIGH SALT TOLERANCE
Fruit Crops	Lemon	Date	Date Palm
	Strawberry	Olive	
	Peach	Fig	
	Almond		
	Plum		
	Prone		
	Grapefruit		
	Orange		
	Apple		
	Pear		
VEGETABLE CROPS	3000 0Slcm	4000 Oslcm	10,000 Oslcm
	Green Bean	Cucumber	Spinach
	Celesy	Squash	Asparagus
	4000 O Slcm	Onion	Garden Beet
		Carrot	12,000 O Slcm
		Potato	
		Sweet Corn	
		Lettuce	
		Cauliflower	
		Bell Pepper	

		Cabbage	
		Broccoli	
		Tomato	
		100,000 O Slcm	
Forage Crops	2000 Oslcm	4000 Oslcm	12,000 O Slcm
	Burnet	Grass	Barley (Hay)
	Ladino clover	Oats (hay)	Western Wheat
	Red Clover	Wheat (hay)	Grass
	Meadows Foxtail	Rye (hay)	Bermuda grass
	White Dutch clover	Alfalfa	Nattall alcali grass
	4000 Os/cm	Sudan Grass	Salt grass
Field Crop	4000 O S/cm	6000 O S/cm	10,000 O Slcm
	Filed Bean	Castor bean	Cotton
		Sun flower	Rape
		Flax	Sugar beat
		Corn (Field)	Besley (Grain)
		Sorghum (grain)	16,000 O S/cm
		Rice	
		Oat (grain)	
		Wheat (Grain)	
		Rye (grain)	
		10,000 O S/cm	

NOTE: Electrical conductance values represent salinity levels of the saturation extract at which a 50% decrease in yield may be expected as compared to yields on non saline soil under comparable growing conditions. The saturation extract is the solution extracted from a soil at its saturation percentage. Sodium concentration is important in classifying an irrigation water because sodium reads with soil to reduce its permeability.

Soils containing a large proportion of sodium with carbonate as the predominant anion are termed alkali soils, those with chloride or sulphate as the predominant anions are termed saline soils. Sodium content is usually expressed in terms of percent sodium to sodium absorption rate (SAR).

Boron is necessary in very small quantity for normal growth of all plant but in larger concentration it becomes toxic. Quantities needed varies with the crop type: Sensitive crops require minimum amount on several times, these concentration relative boron tolerances of a number of crops are summarised in table (3).

Sodium concentration is very important in grouping an irrigation water because sodium reduce the permeability of soil. Soils contain a larger proportion of sodium with carbonate as the predominant anion are termed alkali soils.

Soils with chloride or sulphate as the predominant anions are termed saline soils. Sodium content is usually expressed in terms of percent sodium or sodium adsorption rate (SAR).

Boron is good in very small quantity for normal growth of all plants. In larger concentration it because toxic. The quantity or amount of Boron needed varies with the crop type: Sensitive crops require minimum amounts whereas tolerance crops will make maximum growth on several time. These concentration relative boron tolerance of number of crops are summarised in table (3).

TABle- **3 RELATIVE TOLERANCE OF PLANTS TO BORON (AFFAIR RICHARDS) LISTED IN ORDER OF INCREASING TOLERANCE.**

SENSITIVE	SEMI TOLERANCE	TOLERANCE
Lemon	Lima-bean	Carrot
Grape Fruit	Sweet Potato	Lettuce
Avocado	Bell Pepper	Cabbage
Orange	Pumpkin	Turnip
Thornless Black berry	Zinnia	Onion
Apricot	Oat	Brand Bean
Peach	Milo	Gladiolus
Cherry	Corn	Alfalfa
Persimmon	Wheat	Garden beef
Kadota fig	Barley	Mangel
Grape	Olive	Sugar beef
Apple	Ragged Robin Rose	Date Palm
Rear	Field Pea	Palm
Plum	Radish	Asparagus
American elm	Sweet Pea	Athel

Irrigation water has been classified as excellent, Good, Permissible, Doubtful, or unsuitable depending on their percentage sodium, the electrical conductance, and Boron concentrations. The classification is shown below. (WILCOX 1955)

TABLE (4) QUALITY CLASSIFICATION OF WATER FOR IRRIGATION

			BORON MglL		
Water Class	Percentage Sodium	Specific Conductance O S/cm	Sensitive Crops	Semi Tolerance crops	Tolerance Crops

Excellent	<20	<250	<0.33	<067	<1.00
Good	20 – 40	250 – 750	0.33-067	067 – 1.33	1.00-2.00
Permissible	40-60	750-2000	067-1.00	1.33-2.00	2.00 – 3.00
Doubtful	60 – 80	2000-3000	1.00-1.25	2.00 – 2.50	3.00 – 3.75
Unsuitable	780	73000	71.25	72.50	73.75

TABLE 4 GUIDELINES FOR INTERPORATION OF WATER QUALITY OF IRRIGATION (SOURCE: WECCOLT, 1970)

Irrigation Problem		Degree of Problem	
1.	No Problem	Increasing Problem	Severe Problem
1.Salinity Affect water available to crop Ec (mm hos/cm	< 0.75	0.75 – 3.0	73.0
2. Permeability affects rates of infiltration of the water into and through soil	70.5	0.5 – 0.2	< 0. 2
3. Specific 1 on toxicity crops (a) Sodium (mglL (b) Chloride (mglL (c) Boron (mglL	<3 <4 <0.75	3-9 4-10 0.75-2.0	>9 >10 >2.0
4. Miscellenceous effects affect sensitive crops (a) No3 - N (b) $HC0_3$ (Mglc) Overhead sprinkling	<5 <1.5	5-50 1.5 – 8.5	>3.0 >8.5

2.8 GROUND WATER QUALITY AND AVAILABILITY FOR IRRIGATION

The quality of groundwater has to go side by side with the availability, the quantity of water that can be found or available in an area will largely depend on the geologic formation. A geologic formation that has considerable quantities of water is termed Acquifer. Many types of formations serves as an acquifer (Black and Sehroeder, 1973).

A key requirement in their ability to store water in the rock pores. The role of various geologic formations as acquifer are briefly described in the following subsection.

- CLAY- the pores are so small that they are regarded as relatively impermeable.
- INGNEOUS and metamorphic rocks: - they are poor acquifer, they are relatively impermeable.
- SANDSTONE This is cemented forms of sand and gravel. As much the cement has reduced their porosity and yield.

- STORAGE CONFFICIENT: Water recharged to, or discharged from an acquifer. represents a change in the storage volume within the acquifer. For unconfined acquifer this is simply expressed by the product of the volume of acquifer lying between the water table at the beginning and at the end of period of time and the average specific yield of the formation. In confined acquifer however, assuring the acquifer remains saturated, changes in pressure produces only small changes in storage volume. Thus, the hydrostatic pressure within an acquifer partially supports the weights the over.

CHAPTE THREE

3.0 MATERIALS AND METHODS.

3.1 INTRODUCTORY NOTES:

In irrigation water evaluation and quality control programme, water sample analysis are conducted to know whether the existing irrigation water(s) would or have any detrimental on harmful effects on the soil or corp.

This chapter looks into the sampling locations laboratory analysis of the water samples estimation of bore hole yields not only that, but the method adopted to the course of this project work procedure, precaution and problems encounter and how it was over come.

3.2 SAMPING LOCATIONS

The sampling location covers five bore holes each, in each of the 5 local government areas. These are, SHIRORO, GURARA, MUNYA, WUSE and SULEJA Local Govt. Areas.

The bore holes are not equally spaced as they were constructed bearing in mind the settlement locations that were chosen were spread around each of the local government areas, not necessarily considering density of the bore hole in a particular place.

Irrigation water samples are collected from each sampling bore hole with detailed labeling to identify each sample.

1. LGA Local Government Area.
2. Date of Collection
3. ID Identification
4. Date of Analysis
5. Village – Village at which the samples have collected.

TABLE 6 THE LOCATION OF SAMPLING PLANTS AND DATE ANALYSES

L.G.A SHIRORO	VILLAGES	ID	DATE COLLECTED	DATE ANALYSED	ZONE
1.	FGC Kuta	SI	8/2/2002	07/2/2002	Southwest
2	Alawa	S2	8/2/2002	07/2/2002	Southwest
3	Gwada	S3	8/2/2002	07/2/2002	Southwest
4	Mutundaya	S4	8/2/2002	07/2/2002	Southwest
5	Gwada Cm)	S5	8/2/2002	07/2/2002	Southwest
GURARA					
1	Tuma	G1	12/2/2002	13/2/2002	Southwest
2	G.S.C.Izom	G2	12/2/2002	13/2/2002	Southwest
3	Numba Gwari	G3	12/2/2002	13/2/2002	Southwest
4	Lambata (m)	G4	12/2/2002	13/2/2002	Southwest
5	Pari Abata	G5	12/2/2002	13/2/2002	Southwest
MUNYA					
1	Jarfulu	M_1	16/2/2002	17/2/2002	Southwest
2	Guni	M_2	16/2/2002	17/2/2002	Southwest
3	Beni	M_3	16/2/2002	17/2/2002	Southwest
4	Sarkin Pawa	M_4	16/2/2002	17/2/2002	Southwest
5	Birnin Koro	M_5	16/2/2002	17/2/2002	Southwest
TAFA					
1	Sabon Wuse	T_1	20/2/2002	21/2/2002	South West
2	Ijakoro	T_2	20/2/2002	21/2/2002	South West

3	Kabo	T_3	20/2/2002	21/2/2002	South West
4	New Bwari	T_4	20/2/2002	21/2/2002	South West
5	Ija Gwari	T_5	20/2/2002	21/2/2002	South West
SULEJA					
1	Kwankwashe	S1	24/2/2002	25/2/2002	South West
2	Madalla	S2	24/2/2002	25/2/2002	South West
3	Maje	S3	24/2/2002	25/2/2002	South West
4	Kabula	S4	24/2/2002	25/2/2002	South West
5	GSS Suleja	S5	24/2/2002	25/2/2002	South West

3.3 PRE-TREATMENT OF WATER SAMPLES

Before treatment of your samples, the samples are kept in an air-conditioned room as to maintain room temperature, not exceeding 25^{0C}. The propose of doing this was to reduce microbial activities, as much as possible to the bearer minimum. Immediately sampling exercise was over and pretreatment accomplished water samples were conveyed to the laboratory for series of physico-chemical analysis.

3.4. LABORATORY ANALYSIS OF WATER SAMPLES

As soon as sampling was accomplished, water sample ware taken to the laboratory for the chemical analysis. Those parameter that can affect the quality of irrigation water were noted. The parameters being analysed in the water samples include

- Ph value (acidity / alkalinity determination at temp. of 250^{C})
- Total dissolve solids (TDS)
- Proportions of sodium (Na^+) Irons to other cations such as Ca^{2+} (Calcium) and mg^2+ (Magresion)
- Hardness; Bicarbonate ($HC0_3$) concentration.

The analysis do include both macro and micro nutrient elements which includes

Nitrate $N0_3$	-	Nitrogen
Phosphate $P0_4$	-	Phosphorus
Potassium	-	K^+
Calcium	-	Ca^{2+}
Magnesium	-	Mg^{2+}

The samples were also made to go through further analysis to determine salt contain compounds.

Sulphate $S0_4$

Chloride K-CL

Bicarbonete $HC0_3$.

Water samples went tested for micro elements levels considering the toxic effect that might hinder the performance of crops if found is be in large amount in irrigation water.

Iron Fe^{2+}

Manganese Mn^{2+}

Boron.

Analysis for hardness and electrical conductivity were also performed on the water samples.

3.4.1 METHOD OF ANALYSIS

In the water samples analysis, we bore in mind the FAO and WHO guidelines and procedure as specified by water and waste water analysis Association 8th Edition.

Electrical conductivity meter was used to determine the following physical parameters on site.

Temperature 0^C.

Total Dissolved solids TDS (mglL)

Electrical conductivity in Mhos/cm

A multi parameter (Spectrophotometer) was use analyse and determination of water concentration and all other parameters.

3.4.2 WATER MEASUREMENT PROCEDURE

Power connection.

The 12V DC adopter was Plugged into the DC socket. And the adopted was plugged into the outlet.

MEASUREMENT PROCEDURE

The meter is on by pressing the on/off botton

* The meter perform an LCD self diagnostic test by displaying a full set of figures.
* It shows a scrolling cloomessage
* Pl then appears on the secondary LCD to inform that the parameter measurement can be performed.
* The programes number is then selected by using the programme button
* The produre for each parameter was then adopted.

Total chlorine: the EPA recommended DPD method 3.3.0.5 was used the reaction between the chlorine and the DPD reagent causes a pink tint in the sample. The result is presented in mglL.

Colour of water: Adaptation of the Colorimeter platinum cobalt method was used. The result is presented in PCU (Platinum Cobalt unit).

Cupper: Adaptation of the EPA approved method. The reaction between cooper and its bincin chorinate reagent causes purpel tint in the sample.

Fluoride: Adaptation of SPADS methods. Reaction between fluoride and the liquid reagent causes a red tint in the sample.

Calcium: Adaptation of the standard method for water and waste water 18^{th} edition. Calmagite method. The reaction between Ca and reagents causes a red tint in the sample.

MAGNESIUM: Adaptation of the standard methods for the examination of water and waster water, 18th edition. EDTA Calorimetric method. The reaction between Mg. And a reagent causes a violet tint in the sample.

Iron: Adaptation of the phenatroline EPA method 315B for natural and treated waters. The reaction between iron and reagent cause an orange tint in the sample.

MANGANESE: Adaptation of the standard methods of the examination of water and waster water 18th Edition per sulfate method. The reaction of Manganese and reagent causes a violet tint in the sample.

NITRATE: Adaptation of the cadmium reduction method the reaction between nitrate nitrogen and the reagent causes an amber tint with the sample.

DISSOLVED OXYGEN: Adaptation of the standard methods for the examination of water and waste water 18th Edition, azide modified winkler method. The reaction between dissolve oxygen and the reagent causes a yellow tint in the sample.

PH: Adaptation of the phenol red method the reaction with the reagent causes a red tint in the sample

PHOSPHATE: Adaptation of the standard methods for the examination of water and waste water (18th Edition). Amino acid method. The reaction between phosphate and reagents causes a blue tint in the sample.

TURBIDITY, TEMPERATURE: and conduction –were determine with the conductivity meter that displays their readings automatically

POTASSIUM, SODIUM, HARDNESS, SULPHATE

We use lovibond mini kit test, tablets corresponding to the parameters are chosen and the readings taken to have the values in mglL.

3.5 ESNMATION OF BORE HOLE YIELD

Yield information is unavailable any where. The estimation of borehole yield was made or gotten using the direct field method. If involves pumping water at a constant rate since all the bore hole are fitted with hand driven pumps, the pumping was done by one person at the same rate for five minutes period, and two plastic bucket of 10 litres each were used to collect the discharge water. The number of buckets collected are recorded. The rate of Discharge of water was estimated.

Yield test is completed by measuring the static water level after which the well is pumped at a maximum rate until the water level in the well stabilizes. The depth of water is then noted. The discharge is then determined by any of the several measuring devices connected to the discharge pipe.

This method adopted gaves us a sound estimate of the yields of these bore hole and each can be a basis for fully understanding of the availability of water within the acquifers.

3.6 DEPTH OF STATIC WATER LEVEL

An estimate of the depth of static water level is used to determine the safe yield of a well and in quantifying the amount of water the borehole can deliver over a range of time.

The static water levels was evaluated by first removing the hand pump using set of 16mm spanners with permission from the village heads or user of the bore hole. Then a still tape is put or immersed into the borehole util it reaches the bottomless pit of the borehole. That is the area where gravel packs are constructed. The depth of water from below the tape to last water level in the tap is recorded.

Depth of bore hole information was soured from RUWATSAN and Niger State Ministry of water resources and Rural development Minna

The static water level depth was subtracted from the depth of the borehole to give us the dynamic water level.

3.7 CHEMICAL EQUIVALENLE

The weight per volume units is expressed in milligram per litre (mglL). Total ironic concentrations is also expressed in this manner. One equivalent weights of a cation combines with one equivalent weight of an anion. The combining weight of iron is equal to the formula weight divided by its charge When the concentration in milligram per litre is divided by the combining weight, an equivalent per litre (MglL) results.

TABLE 5 CONVERSION FACTORS FOR CHEMICAL EQUIVALENT

(Concentration in MglL times the conversion factor yields concentration in medl).

CHEMICAL CONSTITUENTS	CONVERSION FACTOR
Bicarbonate ($NC0_3$)	0.01639
Calcium (Ca^{2+})	0.64990
Carbonate ($C0_3^{2}$)	0.03333
Chloride (Ct)	0.02821
Magnesium (Mg^{2+})	0.08226
Manganese (Mn^{2+})	0.03640
Nitrate ($N0_3$)	0.01613
Phosphate (P04)	0.03159
Potassium (K+)	0.02557
Sodium (Nat)	0.04350
Sulphate ($S04^{2}$)	0.02082
Source: Hem, (1970)	

3.2 THE COMPUTATION (CALCULATION) OF PERCENTAGE SAODIUM AND SODIUM ADSORPTION RATIO (SAR)

The concentration of sodium in irrigation water is important to be noted because sodium reacts with soil to reduce its permeability. Sodium content is usually expressed in forms of percent sodium (also known as sodium percentage and soluble – sodium percentage.

$$\% Na = \frac{(Nat + K)\ 100}{Ca + Mg + Na + K}$$ Expressed in Milli equivalent per litre

$$SAR = \frac{Na}{Ca + Mg) / 2}$$ Expressed in mili equivalents per litre

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter deals with result gotten from analyzing the water sample. The depth and field of the borehole are presented. The implication of these findings is discussed as well.

4.2 INTERPRETATION DISCUSSED

Water analysis results are presented in this chapter in table form to be seen.

4.2.1. PH VALVE

A PH value below (7) indicates acidic concentration, while PH value above indicates alkaline character of the water.

However, the PH value represents the Hydrogen ion (H+) concentration in water. It is also the logarithm of the reciprocal of the hydrogen ion concentration.

From the results of water analysis the PH value samples from

5.9 to 7	in Shiroro Local Govt.		
5.7 to 7.2	in Gurara Local Govt.		
5.7 to 6.7	in Munya	,,	,,
6.1 to 6.9	in Tafa	,,	,,
5.9 to 7.2	in Suleja	,,	,,

The PH values of 23 samples shows Acidic concentration, this is very disturbing, as the soil crops become acidic over a period of time. In view of these results, lime fertilizers will be required to seduce the acidic content.

4.2.2 NITRATE (NO^-_3)

This is the chemical form in which nitrogen is absorbed to taking in by plants in the soil. From the results Nitrates was found to be relatively low only in some of the local government areas like 2 samples from Shiroro (0.7 – 0.26).

Tafa (0.6 - 0.5).

While most samples shows a very high nitrate concentration from (2 mg/l to 21mg/l.) while nitrogen may be acceptable as nitrogen supplying compound in irrigation water with regard to (crop production. It is usually regarded as a deleterious substance in construction and municipal water supplies.

4. 2.3. PHOSPHATE (PO^-_4)

Phosphate is the chemical form of phosphorus when in solution. Phosphorus is one of the 3 Primary nutrient largely required by plant for growth. Water analysis shows a very high rate of phosphorous content except in a few areas where the content appears very low - the need to supplement phosphorous by the application of fertilizers to the crops.

4.2.4. POTASSIUM (K_+)

This is also one of the 3 primary nutrient element require by plaints for morphological performance in the field. From the result potassium were food to be high in most water samples as from 2 to 11mg/l except in Suleja local government area where potassium is low from 0 – 5 mg/l.

However the result of 2 to 11mg/l is very appreciable for irrigation purpose but not desirable for municipal water supply.

4. 2. 5 SODIUM (Na^+)

It has the ability to destroy soil structure and capable of building up salt in the soil. It is therefore undesirable elements or substances in irrigation.

The sodium content of the water sample lyes between 0.1 – 3.4 mg/l – this can be used safely for irrigation purpose as the contents low.

4.2.6 CALCIUM AND MAGNESIUM (Ca^{2+}, mg^{2+})

Precipitation of calcium carbonate ($CaCo_3$) and magnesium carbonate ($mg\ Co_3$) in lateral line and sprinkler nozzles will reduce sprinkler system flow rate over time. The formation of this precipitate depends upon the concentration of carbonate and Bicarbonate in the irrigation water supply.

The PH value of the water supply determines the formation of white precipitates. From the water samples analysis calcium and magnesium are found to be low throughout. This is permissible, but when found to be high exceeding 50mg/l. Acid treatment might be needed, professional advice mist be sought before embarking on acid treatment for PH control of the water.

Calcium and magnesium are some of the basic and secondary nutrient elements required for tissue formation and production of healthy fruit in the tree crops.

However when form to be inadequate they most to supplemented through the use of Ca and mg containing fertilizer materials.

4.2.7 CHLORIDE (Cl-)

From agricultural point of view, the highest desirable and appreciable level of chloride in any water is 200mg/l.

However from the water samples analysis, the chlorine content is found to be for below this figure (allowable 200mg/l) above. Therefore chloride toxicity could not be a problem to the crops and soils in the field.

4.2.8. SULPHATE (So_4^-)

The same limit of 200mg/l that is desirable for chloride is also desirable for sulphate. All water samples shows sulphate content far below 200mg/l, which indicates a good quality for irrigation, proposes.

4.2.9 CARBONATE (Co_3) AND BICARBONATE (Hco_3).

From the result of the water samples carbonate are found in all the water samples. There are locations where they are low and some are selectively high.

However, High concentration of Hco_3 ions may result in precipitation of calcium and magnesium bicarbonate from the soil solutions, thereby increasing proportion of Na^+ (sodium) ions and carrying sodium lazards.

4.2.10 IRON (Fe^{2+}).

Iron concentrations of 0.5mg/l can be severed and must be corrected. This can be overcome by applying appropriate measures. The highest desirable level of Iron is 0.1mg/l while the maximum permissible level is 1.0mg/l.

Iron has chemical effect that could become a problem at the concentration of 0.1 mg/l. It has the ability to rust in some sprinkler or overhead irrigation systems.

Iron was found in most of the water samples, especially in areas like Suleja that has a concentration of 0.11 mg/l which is very severe. which is very severe. At Ija Gwari (Tafa) the iron concentration was found to be 0.8 mg/l which is also severe. Other samples of different location shows relatively low quantity of iron.

4.2.11 MANGANESE (Mn2+).

Permissible limits of manganese sample from 0 – 1.3mg/l from the water sample anaysis, manganese is found to be low in almost all part of study area except in Maje (Suleja) where we have concentration of 5.8mg/l. This could be corrected because of future effect.

4. 2. 12 BORON

Boron is very important to plant growth, when found in excess if becomes harmful to plant i.e. amount required for growth is very small. Boron is found to be absent in most location. Like S5, G1, G3, M, M4 etc while it was found to be high in places like T4, T3. Permissible limit ranges between 0 – 0 – 0.15mg/l.

4.2.13 TOTAL HARDNESS

The highest desirable level of total hardness, which inmost cases comprises of Ca Co_3 or $MgCo_3$ and $HC0_3$, is 400 mg/l. The permissible level of total hardness in any water is 500mg/l.

From the water samples result, total hardness is found to be very low throughout the quality of water process is okay as regard to hardness.

4.2.13 TOTAL DISSOLVED SOLIDS (TDS)

The suitability of water resources for irrigation proposes is determinable by the amount of total dissolved solid. (TDS) present in the water. The osmotic pressure of the soil solution increases when (TDS) is present in larger quantities, causing high soil moisture stress in the root zone which in turn hinder plant growth and affect crops yield.

The acceptable limit of TDS and PH for suitability indicates that water contain TDS up or 400mgll or less and a PH value below 8.0 are generally quite suitable for irrigation purposes.

However the water samples result shows low quantify of TDS all through only in S5 where the TDS is high at 451mgll. Which makes most of the samples suitable for irrigation purposes.

4.2.14 ELECTRICAL CONDUCTIVITY ~~PURPOSE~~ (EC x 10^6 MHOS/CM)

The electrical conductivity is use to measure salt concentration in any water. It measures and is expressed in mhos/cm Ec and salt concentration are proportion to each other. The international values of electrical conductive of water quality are given thus:

CLASS ONE: 0 – 100mhos/cm

1. Water sample can be used for irrigation with most crops as the samples have electrical conductivity with low salinity hazard.
2. Little likelihood of soil salinity developing
3. Leaching due to irrigation can handle presence of salt (except soils with extremely how permeability)

CLASS TWO: 200 – 400m hos.cm

1. Water sample can be used with moderate amount of leading
2. Salinity control required.

CLASS THREE: 400 800mhos/cm

1. Water samples cannot be used on soils with restricted drainage.
2. Management of salinity control required.

CLASS FOUR: 800 – 1600 mhos/cm

1. Water samples for irrigation under ordinary conditions.
2. Not suitable for irrigation under ordinary conditions
3. Soils must be permeable, very good drainage available
4. Irrigation water must be applied to excess to provide considerable leaching.
5. Only tolerant crops yield satisfactorily.

However water samples analysis shows that the samples all fall within one headings. CLASS ONE: 0 – 100 mhos/cm. I.e water samples can be used for irrigation proposes, the electrical conductivity has a low salinity hazard.

4.2.15 <u>CHLORINE CONCENTRATION (Cl2)</u>

The under listed standard are used in classifying or rating chlorine content in irrigation water. Because high value of chlorine contents are unsuitable in irrigation waters.

CLASS ONE: 0 – 3 Meqll

1. Low chlorine hazard, irrigation water suitable for most crops.

CLASS TWO: 3.0 - .0 Megll

1. Slightly hazard on plants irrigation water can be used with care.

CLASS THREE: 6.0 10.0 Megll

Median hazard values

CLASS FOUR: 10-20 Megll

Values in this range can have harmful effects on plant use of samples not recommended for irrigation. Water sample analysed fall within class one i.e looking at the result it is therefore suitable for irrigation.

4.3 CHEMICAL ANALYSIS AND CLASSIFICATION OF THE ANALYSED WATER SAMPLES.

The results are classified into 5 tables, each of the table representing one of the local government areas as shown.

TABLE 4.3.1

RESULT OF CHEMICAL ANALYSIS AND CLASSIFICATION OF GROUND WATER IN CHIRORO LOCAL GOVT. AREA.

Sample	Ecmhos /cm	B Mg/c	Ca Mglc	Mg (*)	Na Megll	C03 + Hc03	CT (mgLL)	Sar	%Na	Water Class
S_1	1.67	1.3	0.13	0.0	0.00	2.3	0.01	0.00	26.75	Good
S_2	1.09	0.02	0.39	0.06	0.02	12.7	0.02	0.04	40.10	Permissible
S_3	3.4	3.4	0.31	0.15	0.04	57.67	0	0.08	26.73	Good
S_4	5	2.9	0.25	0.03	0.01	72.1	0.03	0.03	43.38	Permissible
S_5	2.2	0	0.09	0.02	0.00	4.68	0.01	0.00	41.09	Permissible

TABLE RESULTS OF CHEMICAL ANALYSIS AND CLASIFICATION OF GROUND WATET

4.3.2 IN GURARA LOCAL GOVERNMENT AREA.

Water Sample	Ec Mhos/ cm	B Mg/c	Ca Mglc	Mg (*)	Na	$C0_3$ $+Hc0_3$	Ct Mgll	Sar	%Na	Water Class
G_1	11.6	0	0.24	0.77	0.14	79	0.02	0.20	25.44	Good
G_2	34.7	0.2	0.09	0.08	0.01	36.2	0.9	0.03	68.08	Doubt.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS.

5.1 CONCLUSIONS

We understand that water samples were collected from 5 Bore hole from each of the local government areas (Niger state south west) Shiroro Tafa, Munya, Gurara and Suleja Local Govt. Area.

However, almost all the result show that the water sample are suitable for the purpose of irrigation, Except in Gurara Local Government where one of the location shows a doubtful water class of 68.08%.

The total dissolve solids fell far below 400mg/l in all samples i.e water can be use in all the soils.

The level of Nitrate and phosphate are low this shows a good drinking water and other Domestic uses. In the idea of irrigation a little Quantity of NPK fertilizer are refined for good yield of the crops.

The yield of the Bore holes are generally very okay. They gives so much potential for development. Generally, the ground water in south western part of Niger state are surface for irrigation farming purpose. Wherever There are modifications it has to be done to suit water Quality and availability for irrigation purposes.

Other sectoral usage of surface water is ever-increasing. Government has to as a matter urgency tap potential groundwater resources that abounds in these area to supplement rainfed agriculture and therefore make food available in our homes.

5.2 RECOMMENDATIONS

Where percentage sodium is very high the soil must be properly drained and sub soiled to make water usable and prevent the build up of sodium.

Although the ground water in south western part of this state is generally satisfactory for irrigation purposes.

Some problem were encountered in some places. For example where PH value of the water is found be below (7) i.e acidic lime fertilizers has to be used.

Where Irons (Fe^{2+}) are seen or observed to be severed, water here should be carefully maintained and be given necessary chemical treatment.

This project work should continue on other parts of the state to cover all the Local Govt areas of the state.

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TABLE 4.2(a)

RESULTS OF LABORATORY WATER ANALYSIS:

Sample	SHIRORO				
VILLAGE/LOCATION	*FGC,KUTA*	*ALAWA*	*GWADA*	*MUTUNDAYA*	*GWADA(M)*
PH	6.7	5.9	6.3	7	6.2
Temp 0C	28.9	29.7	26.2	27.9	30.1
Turbidity N/V	11	23	13.5	4	8
Cond. Ec micromhos/cm	1.67	1.09	3.4	5	2.2
Calcium (mg/l)	2.7	7.83	6.3	5	1.76
Magnesium (mg/l)	0.11	0.78	1.89	0.34	0.26
Sodium (mg/l)	0.1	0.35	0.98	0.23	0.15
Potassium (mg/l)	2	11	5	8	3
Sulphate (mg/l)	5	4.2	8	11	1.7
Chloride (mg/l)	0.11	0.56	1.76	9.2	3.78
Bicarbonate (mg/l)	2	9.8	56	72	0.9
Carbonate (mg/l)	0.3	2.9	1.67	0.1	0.22
Nitrate (mg/l)	7.9	0.7	6.3	3.6	0.26
Phosphate (mg/l)	1.8	9.7	5.7	2.7	4.8
Iron (mg/l)	0.4	1.2	0.8	0.1	0
Chlorine (mg/l)	0.2	0.7	0	1	0.2
Manganese (mg/l)	0.5	3	1.6	1.3	0.7
Copper (mg/l)	2.3	3.1	2.9	3.8	1.5
Boron (mg/l)	1.3	0.02	3.4	2.9	0
TDS (mg/l)	102	207	23	34	451
Dissolved Oxygen(mg/l)	2.3	3.2	1.4	1.9	2.7
Faecal Coliform(CFU/ml)	2	1	0	0	6

Sample	SHIRORO				
VILLAGE/LOCATION	*FGC,KUTA*	*ALAWA*	*GWADA*	*MUTUNDAYA*	*GWADA(M)*
BOREHOLE DEPTH(m)	34	45	25	49	350
STATIC WATER LEVEL(m)	12	23	8	6	103
YIELD(l/s)	0.8	1.7	0.5	0.4	708

TABLE 4.2(b)

Sample	GURARA				
VILLAGE/LOCATION	*TUMA*	*G.S.C IZOM*	*NUMBA GWARI*	*LAMBATA(M)*	*PARI ABATA*
PH	7.2	6.1	5.7	5.8	6.7
Temp 0C	26	28.7	29.5	27.3	30.3
Turbidity N/V	3	6	17	31	23
Cond. Ec micromhos/cm	11.6	34.7	23.5	13.7	3.9
Calcium (mg/l)	5	2	12	23	11
Magnesium (mg/l)	9.4	1.02	0.88	0.26	0.49
Sodium (mg/l)	3.4	0.34	0.28	0.1	0.15
Potassium (mg/l)	8	12	17	15	9.5
Sulphate (mg/l)	2.8	3	24.7	16.5	5
Chloride (mg/l)	0.8	32.9	8.9	2.6	0.7
Bicarbonate (mg/l)	78	34	0.9	32.9	8
Carbonate (mg/l)	1	2.2	2.56	2.11	1.98
Nitrate (mg/l)	21	2.1	3.8	4.1	0.8
Phosphate (mg/l)	8.9	1.2	0	4.8	2.9
Iron (mg/l)	0	0.1	0	0	0
Chlorine (mg/l)	0	0	0.6	0.3	0.22
Manganese (mg/l)	1	0.9	0.5	0.32	0
Copper (mg/l)	0.3	0	0.2	0	0
Boron (mg/l)	0	0.2	0	0.34	0.5
TDS (mg/l)	32	154	218	303	112
Dissolved Oxygen(mg/l)	3.7	2.6	2.8	3.1	1.7
Faecal Coliform(CFU/ml)	4	8	3	11	5

GURARA					
TUMA	*G.S.C IZO*	*NUMBA GWA*	*LAMBATA(M)*	*PARI ABATA*	
45	30	45	420	32	
20	12	25	201	10	
1.6	0.7	1.22	1131.8	0.65	

TABLE 4.2(c).

Sample	MUNYA				
VILLAGE/LOCATION	*JARFULU*	*GUNI*	*BENI*	*SARKIN PAWA*	*BIRNIN KORO*
PH	5.8	6.7	6.3	6.7	5.7
Temp 0C	31.5	30.2	29.7	31.3	30.4
Turbidity N/V	6	13	1	23	26
Cond. Ec micromhos/cm	11.2	21.8	5	7.3	1.9
Calcium (mg/l)	25	12.2	3	4.7	5.9
Magnesium (mg/l)	0.47	0.99	0.38	1.03	7.96
Sodium (mg/l)	0.21	0.31	0.12	0.41	2.67
Potassium (mg/l)	1.5	3	4	2	18
Sulphate (mg/l)	1.3	3.9	5.6	3	21.5
Chloride (mg/l)	1.8	9.5	0.7	9.1	2.44
Bicarbonate (mg/l)	6.9	61.8	9.8	1.67	1.56
Carbonate (mg/l)	3.7	2.9	1.87	5.99	6.9
Nitrate (mg/l)	2	1.4	1.9	3.6	2.4
Phosphate (mg/l)	3	2.3	1.8	7.9	2.1
Iron (mg/l)	0.1	1.01	0.3	0.2	0.1
Chlorine (mg/l)	0.1	0.4	0.78	0	0.2
Manganese (mg/l)	0.8	2.3	2.7	1.89	0.2
Copper (mg/l)	0	0	0	0	0
Boron (mg/l)	0	0.3	0.21	0	0
TDS (mg/l)	23	39	32	46	127
Dissolved Oxygen(mg/l)	1.4	2.8	3.1	2.3	2.2
Faecal Coliform(CFU/ml)	32	12	6	0	5

MUNYA					
JARFULU	*GUNI*	*BENI*	*SARKIN P*	*BIRNIN KORO*	
40	38	57	50	35	
8	23	18	15	20	
0.7	1.5	1.3	1.02	0.56	

TABLE 4.2(d).

Sample	TAFA				
VILLAGE/LOCATION	***SABON WUSE(M)***	***IJAKORO(M)***	***KABO***	***NEW BWARI***	***IJA GWARI***
PH	6.4	6.9	6.4	6.4	6.1
Temp 0C	27.8	29.8	25.9	28.4	29.3
Turbidity N/V	2	5	27	12	11
Cond. Ec micromhos/cm	2.7	2.96	1.9	4	15.4
Calcium (mg/l)	34.3	2.89	4.76	6	12.8
Magnesium (mg/l)	1.98	3.67	1.02	3.8	1.4
Sodium (mg/l)	0.52	1.35	0.47	1.3	0.28
Potassium (mg/l)	11	7	8	4	2
Sulphate (mg/l)	1	3.8	5.7	2	12.8
Chloride (mg/l)	0.66	0.98	3.8	9.8	7.6
Bicarbonate (mg/l)	7	4.8	45.1	30.5	2.3
Carbonate (mg/l)	0.7	0.56	0.11	2.44	2.6
Nitrate (mg/l)	1.02	2.4	0.6	0.5	4.9
Phosphate (mg/l)	3.6	1.9	1.03	0.7	3
Iron (mg/l)	0	0	0.2	0	0.8
Chlorine (mg/l)	0	0	0	0.8	0.67
Manganese (mg/l)	0	0.2	0.5	0	0.45
Copper (mg/l)	0	0	0	0	0
Boron (mg/l)	0.34	3	3.4	5.2	0.57
TDS (mg/l)	100	184	206	102	55
Dissolved Oxygen(mg/l)	3	2.8	2.7	2.1	2
Faecal Coliform(CFU/ml)	1	0	0	0	12

TAFA					
SABON WUSE(M)	***IJAKORO(M)***	***KABO***	***NEW BWA***	***IJA GWARI***	
350	200	40	32	35	
205	100	13	5	12	
1149.12	570.24	0.9	0.3	0.7	

TABLE 4.2(e).

Sample	SULEJA				
VILLAGE/LOCATION	*KWANKWASHE*	*MADALLA1*	*MAJE(M)*	*KABULA*	*GSS SULEJA*
PH	7.2	5.9	6.4	6.2	6.4
Temp 0C	27.4	28.1	29.3	30.4	27.5
Turbidity N/V	8	2	12	15	4
Cond. Ec micromhos/cm	3.6	5.9	2.9	1.8	1.07
Calcium (mg/l)	13.6	3.5	2.8	3.9	1.32
Magnesium (mg/l)	4.56	8.73	1.01	0.8	0.12
Sodium (mg/l)	2.01	3.1	0.32	0.23	0.1
Potassium (mg/l)	2	0	2	5	3
Sulphate (mg/l)	2	3.2	1.02	12.7	1.89
Chloride (mg/l)	0.98	6.8	0.87	5.87	1.98
Bicarbonate (mg/l)	29.8	5.9	97	35.9	23
Carbonate (mg/l)	3.7	1.9	0.3	0.45	0.67
Nitrate (mg/l)	2.5	11.8	0.2	12.4	1.89
Phosphate (mg/l)	2.5	5	1.02	34.8	2.13
Iron (mg/l)	0	0.3	0	0.11	0.1
Chlorine (mg/l)	0.7	0.3	0	0	0
Manganese (mg/l)	0.3	0.9	5.8	0.1	0
Copper (mg/l)	0.1	0	0.4	0.1	0
Boron (mg/l)	0	0	0	0.2	0
TDS (mg/l)	98	123	362	205	173
Dissolved Oxygen(mg/l)	4.1	2.7	3.4	2.7	2.9
Faecal Coliform(CFU/ml)	1	15	0	6	0

SULEJA					
KWANKWASHE	*MADALLA1*	*MAJE(M)*	*KABULA*	*GSS SULEJA*	
45	30	350	39	55	
8	12	150	8	24	
1.4	1.2	1128	0.5	1.5	