THE PHYSICO-CHEMICAL AND MICROBIOLOGICAL ASSESSMENT OF GURARA RIVER AROUND IZOM IN NIGER STATE, NIGERIA.

BY

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DEDICATION

This thesis is dedicated to my beloved wife, Janet Abu Adama and Blessed memory of Late Baba Gideon Salawu Adama.

DECLARATION

I hereby declare that this thesis is my own work and has not been presented in any form for another qualification at any other University or institution. The information derived from the published or unpublished works of others have been duly acknowledged in this work.

Adama Solomon Bake

10/10/08
Date

CERTIFICATION

This thesis titled The Physico-Chemical and Microbiological Assessment of Gurara River around Izom in Niger State, Nigeria by Adama Solomon Bake (M.Tech/SAAT/03/939) meets the regulation governing the award of the degree of M.Tech of Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

Water samples were collected from River Gurara, once monthly for a period of twelve months(June 2004 - May 2005). Physico-chemical and microbial studies were carried out on the water samples. The parameters and microbial load determined were statistically analysed to reveal the presence or absence of any relationship among this parameters. The parameters monitored showed marked variations between different samples, stations, seasons and sub seasons. The mean value of temperature, (29.09 ^{o}c), biochemical oxygen demand (0.58 mg/L), pH, (6.72), chemical oxygen demand (1.96mg/L) total suspended particles (0.01cm^2), alkalinity (1.22mg/L) show no significant ($P>0.05$) variations between the stations season and sub-seasons. However significant differences ($P<0.05$) were observed in dissolve oxygen, electrical conductivity (19.04 μ hos/cm), and hardness (0.60mg/L) values of the stations. The microbial analysis showed the presence of enteric gram-negative, gram positive and pyogeric groups of bacteria which include *Klesbiella*, *proteus*, *E.coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Staphylococci feacalis*, *Streploccoci*, *Baccilus* and *aeromons*, while fungi examination showed presence of *Rhizopus*, *Fusarium*, *Aspergillus* (*Parasitus*, *Versilder*, *nidulans*, *Versicolour*, *glaucus* and *fumigatus*) *mucor*, *penicillium*.

The low dissolved oxygen range (0.21-1.91mg/L) and presence of coliforms in all the stations show that the river is organically polluted. The electrical conductivity range (4.4-80.98umhos/cm) and total hardness range (0.8-0.82 mg/l) fall below recommended values while coliform count unit range (cf/1lm96-152) is above recommended value for other tropical rivers by other researchers. However, low DO and high BOD, COD and low hardness recorded in stations 3, 4 and 5 where human activities are highly concentrated indicated that Izom environ populace have some impact on the water quality and public health status of River Gurara. It is recommended that Gurara River has potential for fish production however this river is non portable for human consumption.

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ABBREVIATION PAGE

DO	Dissolved Oxygen
BOD	Biochemical Dissolved Oxygen
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
pH	Hydrogen Ion
TSP	Total Suspended Particles
Hard	hardness
ALK	Alkalinity
CFU	Coliform Unit
Mg/l	milligram per Litre
N.N.P.C.	
μmhos/cm	micro ounce per centimeters
ml	millilitre
Mg/m^2	milligram per meter square
Km	kilometers
Temp	temperature
WHO	World Health Organization
APHA	American Public Health Association
WRS	Warm Rainy Season
CRS	Cold Rainy Season
CDS	Cold Dry Season
WDS	Warm Dry Season
ST.1	Station 1
ST.2	Station 2
ST.3	Station 3
ST.4	Station 4
ST.5	Station 5

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

The study of limnology is becoming more established in Nigeria due to the increasing awareness of the usefulness of water resources as a gift of nature to man and aquatic lives. The great drive toward water resources for fisheries, irrigation, livestock watering, recreation, domestic and industrial water supply, tourism attraction and public health hazard and conservation of fresh water ecosystem undermined the need for scientific investigations on the inland water bodies.

Such study involves assessing the physico-chemical parameters and microbial load of water to determine its potential productivity for future uses, and hazards to aquatic and human lives.

The quantity and quality of water are important; it is quality that determines and supports its biological composition. (Kolo, 1996).

The quality and biological conditions of water bodies determined by it characteristic features. The physical, chemical, bacterial and fungi loads are necessary parameters assessed to ascertain a healthy ecosystem and sustenance of human race.

In Nigeria, limnological studies began in twentieth century with the works of pioneers like Onabamiro, Holden and Green who worked on some Nigeria rivers.

The term limnology can be defined as "The study of inland waters". This includes rivers, creeks, ponds, pools, swamps, lakes and salt lakes and other wet lands (ASL, 2005). It is also defined as the study of all events physical, chemical or biological occurring in fresh water bodies. It could also be defined as the "Study of functional relationship and productivity of fresh water ecosystems as they are regulated by the dynamics of their physical, chemical and biotic environment". Limnology is therefore the

study of water bodies, its properties and biodiversity, status. The biodiversity, usefulness (portability) and characteristics of a river depend on its physico-chemical prospective which in turn gives clear reasons why some water bodies produce much more fish than others (Adebisi, 1981; Stirling and Philips, 1990). Thus, these parameters influence horizontally their composition and feeding regime (Adeniyi, 1978). These parameters which have an effect on the fish's behavior are those which characterized it habitat, which provide optimal conditions for eating and for reproduction (Jean-Luc Blance 1997).

These information is vital to fisheries management, by identifying damage done to the fish population and public health.

The limnological information help in solving some problems related to the development and management of inland fisheries and public health, hence the place of fisheries and limnological data in the studies of water bodies is of great paramount.

Water bodies are home for micro-organisms, some are resident flora which are useful or harmful component of the aquatic ecosystem, while some are pathogenic in nature and their presence as indicator organisms and posed a great threat to public health and fisheries.

1.1.1 Water Resources of Nigeria and their Importance

Water as free gift of nature to mankind, has been harnessed in many aspects, such as Agricultural activities like fishing, arable farming, irrigation, aquaculture, nomadism husbandry, tertiary industries like building & constructions, domestic uses, sports and recreation and transportation.

Water is every thing to life, without water human race and aquatic biodiversity are at the risk of being endanger and extinction.

inland water resources include the vast flood plain around the river channels which dissected the state.

These flood plains have been harnessed into fish ponds, around Bida and Wuya area of the state. There we have both Federal, State and private fish farms. In some areas like Doko and its suburbs the flood plain are harnessed for rice production and also irrigation of sugar cane plantations.

In other to manage and monitor these abundant fresh water resources, Federal Government has established two research institutes in this state. These are National Institute for Fresh Water Fisheries Research (NIFFR) in New-Bussa and National Cereals Research Institute (NCRI) in Baddegi near Bida to monitor water quality and conduct research in rice and cereals crops.

1.2 Significance of Limnological Work

Limnological research provides necessary back ground for the effective harnessing of potentialities of our nation's fresh water resources.

Nigeria inland water resources are numerous; covering about 15 million hectares (Ita, 1993). Liminological information is needed in the study and management of fresh water resources, to determine pollution or contamination which may pose a serious threat to both man and life in fresh water.

Anyawale (2003) reported that the productivity of inland water resources of Nigeria has been on the down ward trend severally due to the effects of drought, dam construction, environmental degradation and over exploitations. It had therefore become very urgent and important to seriously study both the short and long term impacts of our fresh water ecosystem so that regular management polices could be formulated for the conservation of our fresh water resources.

Modern industrial and urbanization depend on rivers, streams for dam construction for water supply. Some Nigeria rivers are medium of transportation for the localities even though some are seasonal.

The fresh water ecosystem in Nigeria is vast and spread all over the country from the coastal region to the arid zone of the lake Chad Basin, it consist of lotic and lentic water bodies.

The approximate extent of the major inland water system is estimated at about 10, 812, 400 hectares, making up about 11.5% of the total surface area of Nigeria, which is estimated to be approximately 94, 185, 000 hectares (Azionu, 2001).

Figure 3.1. map of Nigeria showing the catalogue of water resources which empties into the ocean. The major Nigeria rivers are Niger and Benue, others are Osun, Ogun, Imo, Cross River, Anambra, Kwa Iboe, Tiga lake, River Yobe, Lake Chad, these rivers are a great resource to the nation. They are harnessed for hydroelectric power generation, domestic and industrial water supply, irrigation and fisheries (Anyawale, 2003).

1.1.2 Niger State Water Resources and Their Development.

Niger state is drain with many rivers (Figure. 3.2). The state is dissected with rivers that form tributaries to the big rivers.

The main rivers are, Niger and Kaduna which have prominent features as rapid fall and gorge which gave birth to generation of Hydroelectric power generation, at Kainji, Jebba, Shiroro and propose one at Zungeru, other river include Lavun, Gbako, Shiroro, Chanchaga Gurara, Mariga, Muye.

Many of the streams and smaller rivers, lakes, and reservoirs include, Tagwai, Bosso and Chanchaga dams that supplies municipal water to Minna town and its environs. Suleja dam built on Kupe River, supplies Suleja township with water. The Gbako Reservoir built on Gbako River supplies Bida Township with water. The state's

This field of aquatic resource management provides information to develop new management strategies for the preservation of biodiversity in tropical aquatic ecosystem (Donald, 1995).

1.3 Justification

In view of the great importance of water to life, aquatic productivity and the river Gurara as the main source of water to Bonu, Lambata/Gawu and Izom communities, tourism attraction to Gurara water falls, dry season irrigation along the bank and periodic out break of water borne disease (epidemics) in these communities such as vomiting and diarrhea, typhoid fever, cholera, dysentery, guinea worm infestation, malaria have been reported in the Routine monthly disease notification of the primary health care department of Gurara local government especially during the dry seasons when the people depend more on the river.

These water borne diseases claim many lives annually. With all the above uses and potential uses and productivity of River Gurara around the Izom environment. Which have no limnological and potential health hazard research record to serve as baseline information on this river around this study area. Hence the justification of this research work.

1.4 The General Objective of this Study:

Is to determine Water Quality status of Gurara River around the Gurara water falls and Izom environment for the purpose of fish production and public consumption The Specific Objective are as Follows:-

i. To analyze the physico-chemical parameters of the River Gurara around the water fall area and Izom environs.

ii. To determine the seasonal and sub-seasonal variations in the water quality parameters.

iii. To ascertain the public health implication of the Gurara River.

iv. To verify the impact of human factors on River Gurara from the upstream of the Gurara falls to the out skirt of Izom settlement.

1.5 Scope and Limitation of the Study

The study area covers 3km up stream of Gurara water falls and about 17km away from water falls, with sampling stations which are 3km up stream water falls, foot of the falls, confluence of Tafa and Gurara rivers, Izom township bridge and outskirt of the settlement 9 physico-chemical water quality parameters were (temperature, DO, BOD, COD, pH, EC, TSP, Hardness, alkalinity, and also bacterial and fungi load for a period of 12 months (June 2004-May 2005.

The samples were taken to laboratory for analysis. The research did not cover the entire distance of the river; it is limited to the up and down stream of Gurara water falls and Izom settlement area. Some information in the field were acquired through observation and interview of users of the water. Despite these stated limitations, the best use was made of the available materials for the accomplishment of the aim and objectives of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The physico-chemical and biological properties of water affect the survival, growth and reproduction of aquatic life. These water quality variables could be grouped into three main heading: Physical water quality parameters, Chemical water quality and Biological water quality.

The quality of water is the basis of value of water as a resource. The hydrological regime, of the lake, which affects water depths and inundation of areas and also nutrient from the tributary rivers, affects the water quality and consequent community of the lake (Adeniji, 1973).

Kolo (1989) reported that industrial effluent discharges into inland waters have their own tolls of effects which affect the quality of the receiving water bodies. Stirling (1985), said variations in river water quality have been explained in terms of dominance of either precipitation chemistry, bedrock chemistry or evaporation crystallization process within the lake and its entire basin, the hydrological regime of river affect inundation of areas and nutrient from tributary streams affects water quality.

Some of the water quality parameters used in assessing a water body include physico-chemical and microbial load.

2.2 Temperature

Temperature affects water chemistry and physiological functions of aquatic organisms. It influences the amount of oxygen that can be dissolved in water, (as temperature increases, dissolved oxygen levels decrease; photosynthesis by phytoplankton increase with increase in temperature, metabolic rates increase with increase in temperature and as temperature increase, the sensitivity of organisms to

toxic wastes, parasites and diseases increases. Aquatic organisms has temperature tolerant range, outside which they can not function. Water temperature therefore affects the activity, behaviour, feeding, growth and reproduction of fishes and aquatic life, Dupress and Huner (1984), (1986), and Larry (1995). Reported that in tropical zones where seasonal changes are less, temperature changes are of greater significance.

The dynamic weather conditions account for the temperature changes in large water bodies, that is wind action, turbidity affects, light penetration result into changes in temperature and dissolved oxygen, low sunshine duration and incident radiation due to cloudy day reduces water temperature, (Ovie and Adeniji 1993). The biological processes are said to be influenced by the changes in the environmental temperature and increase in temperature catalyses most of chemical substances reactions, unlike most gases which become less soluble at high temperature (Boyd, 1990) Temperature determine the amount of gases water will hold at a certain time (e.g. oxygen). Therefore increase in water temperature, gives low amount of dissolved oxygen.

Temperature affect the rate of chemical reactions reducing the solubility of gases and amplification of taste and odours, for example, fishes have been shown to vary in their ability to withstand heat and that spawning activity would cease if temperature drops near below the tolerance range (Alabster *et al* 1982). Specific temperature ranges, seasons and location affect distribution and composition of various species of phytoplankton. Sadiku (1993) and Kolo (2003,) reported that photosynthesis is temperature dependent, temperature has been said to be the greatest influential water quality characteristic to aquatic lives, [Kolo, R.J; Yisa Moses, 2000]. The optimum temperature range of 25 – 32^{o}C is good for warm water fishes (Dupree, and Humer, 1984).

2.3 Dissolved Oxygen

This refers to the amount of oxygen in the water column. Dissolved oxygen is important because aquatic organisms need oxygen to survive and grow if there is no enough oxygen in the water. Fish population will be affected by increase in mortality of adults and juveniles, reduction in growth, lower survival rates of eggs and larvae and changes in species composition.

Increase water temperature, suspended sediment, algal blooms and organic pollutants, through oxidation alter dissolved oxygen level and water biodiversity (Jean-luc le Blance, 1997).

Dissolved oxygen is important for the evaluation of surface water quality and waste treatment control. Dissolved oxygen content of water body is commonly taken as an indicator of potential production rate of primary and secondary production (Wade, 1980).

Different organisms have different oxygen range requirements and outside such ranges disease outbreak and abnormal behavior which may culminate in mortality may result (Kolo and Yisa, 1999).

Low oxygen level in water bodies is associated with increasing levels of toxic gases such as ammonia, carbondioxide, nitrous oxide, hydrogen sulphide and methane with noxious smell characteristic (Adebisi, 1981). In rivers, wind current and conventional current created by local heating plays an important role in dissolving and transporting oxygen to the bottom (Ovie and Adeniji, 1993). Photosytynthesis by primary producers (aquatic plants) is the primary source of dissolved oxygen in the photic zone of the water mass, while respiration may lower the oxygen concentration in the night to critical level and photosynthesis lead to super saturation during the day which may lead to embolism. Respiration, decomposition of organic matter, gasses, the presence of iron to form soluble ferric hydrate consumes oxygen. The oxygen concentration in water

depends on a number of factors such as organic load (Ebere and Alex, 1991;). Altitude, ambient atmospheric pressure and season, Ovie and Adeniji, 1993, Ekom and John, 1993). water depth. The uptimum range of not less than 5mg/L is required.

Oxygen has a moderate solubility in water and this decrease with increase in temperature (Kolo and Yisa, 1999) . Henry's law states that warm water dissolved less oxygen than cold water. Okhawere (2003) said water without oxygen is flat in taste as is found in some types of ground water.

2.4 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) shows total degradable organic pollutants accessible to biochemical degradation in any water body.

Polluted water has greater dissolve oxygen demand (Dickson, 2001). When BOD is high the oxygen level may be low. Boyd (1973) Reported that BOD of water increases with increasing chemical oxygen demand and that COD may be used to estimate BOD. Higher BOD value observed in the wet season than dry season was due to input of decomposing organic matters through surface run-off water (Ekom *and John,* 1993). They also observed seasonal and spatial variation in BOD values.

2.5 Chemical Oxygen Demand (COD)

This is a total amount of oxygen which is required to completely oxidize all the organic matter in a water sample to carbondioxide.

The chemical oxygen demand of water sample increases with increase of organic matter concentration.

The measurement of COD is based on the principle that almost all the organic compounds in water can be oxidized to carbondioxide and water by the action of strong agent under acid condition (kubela method).

2.6 Hydrogen ions Concentration (pH)

The term pH means negative logarithm of hydrogen ion concentration within a range of values from 0-14 which indicates whether the water is acidic or basic. The pH of natural water is usually determined by the carbondioxide, bicarbonate/carbonate equilibrium which lies in the range between 6.5 and 8.5 (Stirling, 1985; Ovie and Adeniji, 1993). pH is a factor that determines aquatic ecosystem productivity. The acidic range (4.5-6.5) and highly alkaline (8.5), water bodies are generally considered unproductive, but 6.5-8.0 range is most favourable for productivity. Seasonal variation of pH though small in magnitude has been found to be positively correlated with the seasonal or diurnal variation of phytoplankton populations in some water bodies. (Khan *et al,* 1983). Significant difference between dry and wet season pH has been observed (Silva and Ronald, 1987 in Kolo 1996). Brown, (1971). Observed that hard water with high calcium content had a high pH value and soft water with a low calcium content showed a lower pH value. pH influences the toxicity of ammonia, metals and pollutant to aquatic organisms(Okhawere, 2003).

Naturally acidic waters may result from water draining, peat swamps, acidic rock or acid sulphide soil, humic substances resulting from decomposition of organic matters, sediments phytoplankton especially during flood effluent from mining and various industries may be acidic and high acidic water are toxic to fish in that they cause gradual break down of gills epidermis, loss of body salt and difficulties in taking up oxygen (Kolo and Yisa, 2000).

Alkaline waters may result from algal bloom, calcium and silica rich area and pollution from soft-drink and brewing industries.

Kolo and Olademiji, (2003). Recorded higher pH value at the high water level period than at the low level period in lake Shiroro, Nigeria.

2.7 Electrical Conductivity

Conductivity is the estimate total amount of dissolved solutes or solids in water (Oni, 1997). It is always been used by limnologist as a valuable method to estimate the degree of mineralization of waters.

Hadrian (1985). Reported that the amount of dissolved ionisable salts in freshwater is generally considered to be related to their potential biological productivity. Electrolyte conductivity is the quantitative measurement of the ability of a water sample to allow electric current to pass through it (Yahaya, 1998).

Electrical conductivity of any water is dependant on the composition of the sediments, nature of various dissolved substances and salt and also the temperature at which it is measured (Adeniji, 1975).

The conductivity of most fresh water is said to be in the range of 5-50 µmhos/cm, increase in temperature unit has been found to cause a consequent increase in conductivity the same is true for carbondioxide. Flooding, inundation and the composition of drawned organic materials have decreasing effect on conductivity (Imevbore, 1965). Lower and less variable conductivity values in the wet season than dry season in some river in the South-Western part of Nigeria (Ogunkoya and Adejuwon, 1990 in Kolo, 1996). Conductivity of 63-258 µmhos/cm and similar range was reported on some inland Nigeria rivers.

Higher conductivity was observed during high water level period in some water bodies, this was attributed to run-off into such water bodies.

2.8 Turbidity/total Suspended Particles.

A turbid water is one that is not clear, but contains suspended matter, such as clay, silt, plankton and other microscopic organisms. High turbidity of water is common with surface water during the raining season.

The presence of turbid materials tends to reduce light penetration. The planktonic organisms is desirable, but clay particles is not desirable, because high content of it will settle down to the bottom of the water and smoothers plankton and fish eggs (Hadrian, 1985). The clay and silt apart from impacting undesirable colour to water, are generally harmful to the aquatic plants (Stirling, 1985). Turbidity has direct effect on physiology of organisms, such as on the efficiency of gas exchange system in fish. A damage gill of fish has been observed in shallow areas of lakes Chilwa and Chad as a result of turbid water with suspension. The sight of turbid water is aesthetically offensive to man and are not used for drinking. Persistent-high turbidity affects zooplankton composition (Kolo, 1996). Turbidity was observed to play a role in nutrient-dynamics (mainly Nitrogen and phosphorus) thus influence aquatic productivity (Dickson, 2001). Various methods can be used to measure turbidity which include bottle procedure, Jackson candle, turbidometre and photo-electric (Nephelometric procedure (Oni, 1997).

2.9 Hardness

Hardness is the measurement of total concentration of calcium and magnesium ions in the water. It is expressed as calcium carbonate. Water hardness could be used as an index of buffering capacity and productivity of the water body in question (Hadrian 1985). Its value could be influenced by a number of factors such as source of the water and the treatment it received

The degrees of water hardness determine the solubility of some metals into water body (Stirling, 1985). Metals are generally known to be less soluble in hard water than in soft water. Inorganic salts present in industrial waste causes water to be hard. Hard water increases the rapid poisonous affect of metals on the affected organism (Stirling, 1985).

Soft water which tends from neutral to acidic are know to be less productive than hard water which is alkaline (Boyd, 1979). Water hardness has been classified as stated below optimum level or 20 – 300mg/L is desired. (Boyd et al, 1979).

Concentration mg/l $CaCO_3$		Description
0 – 75	-	Soft
75 – 150	-	Moderately hard
150 – 300	-	Hard
300 and up	-	Very hard

2.10 Alkalinity

This is the total carbonate of calcium and magnesium in solvent. It is usually divided into caustic alkalinity above pH of 8.2 and total alkalinity above pH of 4.5. Total alkalinity is known to affect the toxicity of pollutant, especially metals to aquatic organisms (Hadrian, 1985). Alkalinity affects fish production positively directly or indirectly by affecting phytoplankton growth (Hadrian, 1985). High ionic concentration and alkalinity were observed to cause mass mortality in Tilapia in lake Chilwa in Malawi. Morgan (1972) Attributed the mortality of fish to opaqueness of the cornea. Alkalinity is important because it buffers changes in pH occurring naturally in water bodies as a result of photosynthetic activity of the chlorophyll bearing plants. The optimum values of alkalinity has been given at 20mg/l to 300mg/l or more as calcium carbonate (Stirling, 1985;). Carbonates, bicarbonates, phosphates and hydroxides increases alkalinity in natural waters Lower and less variable alkalinity in the wet season than dry season was observed in Nigeria rivers (Wright, 1985;). Higher alkalinity values were recorded during the high water level in some lakes (Sidinei, 1992 in Kolo, 1996). This was attributed to surface run-off in to the lakes and other hand, Ovie and Adeniji, (1993). Observed higher alkalinity during low water level in Shiroro lake Nigeria.

2.11 Microbial load

Man make use of water for daily activities and on the process altered the natural hydrology, this act lead to the pollution of water. Okhawere, (2003), reported that as water passed through its hydrologic cycle, it gather numerous impurities such as dust, smoke and gases which fill the air and tend to contaminate rain water. The surface runoff-picks up human waste and fertilizer, detergent chemicals such as (Pesticide, herbicides, fertilizer, detergent) and disease causing organisms. (Wagner and Laniox, 1969 in Okhawere, 2003). As the surface run off enters the earth through see-page and infiltration some of the suspended impurities may be filtered out, but at the same time, other chemical and minerals are dissolved and carried along. Rivers, streams and other sources can receive domestic and industrial effluent from various sources. Contamination of water by sewage or excrement from human or animal is the greatest danger associated with water. (Ogbulie *et al*, 1998 in Okhawere, 2003.

Water has its normal flora or a harmless group of bacteria, when normal flora, get access to the tissue of organism, it becomes pathological. Water that contains a large number of bacteria may be very safe for drinking. The purpose for examining water microbiologically is to help to determine the sanitary quality and it suitability for general use Okafor, (1985), reported that "relative extent of the absence of suspended matter, colour, taste unwanted dissolved chemicals, bacterial indicative of faucal presence and other offensive objects or properties". Water that is considered safe for human consumption should, among others be free from microbiological contamination, it should meet the standard for taste, odour and appearances, its should be greater than the prescribe limit, (Okafor, 1985). Ironically, most Africans as confirmed by Kirkwood (1998) do not have access to such water and the need for safe water is generally at it peak in the developing countries with the various deadly water-born diseases by testing for indicator organisms.

Some bacteria are known to be specific inhabitants of intestinal tract even though they may themselves not be agent or diseases harmful chemicals. Hence, a deadly threat to life since the source is drinkable (Okhawere, 2003).

Fecal pollution of water resources is a problem of world wide concern, (Okafor, 1985). Have reported that the organisms used as indicators of faecal contamination are:-

Coliform, streptococcus faecalis, clostridum, perfringens Bifido Bacteria, Salmonella, *Vibrio cholerae*, shigella and versinia.

2.12 Coliforms

They are bacteria that inhabit intestinal tract, and include members of the genera Escherichia, Klebsiella, enterobacter and citrobacter. These bacteria are classified in the enterobacteriacae family (Sloat and Ziel, 1991). They are gram-negative non-sporing rod. They are facultative anaerobes and grow in the presence of bile salt:- Some are thermotolerant and are mostly faecal in origin (Edwards and Ewings, 1972).

Coliform bacteria are pathogens and as reported by Wright, *et al* (1976), they are responsible for such intestinal infections as bacterial dysentery, typhoid fever and some bacteria food poisonings such as staphylococcus *aureus, E.coli, Bacillus sp.* These diseases are exclusively transmitted by feacal contamination of water and food materials. Stainer, *et al* 1989 in Okhawere, 2003, reported that transmission through contaminated water supply, is by far the most serious source of infection and is responsible for the massive epidemic outbreak of the more serious enteric disease (Particularly typhoid fever and cholera) that periodically sourged all countries until the beginning of the last century. The ratio of indicator to actual pathogens hazard is not fixed. The feaces from human with higher infection rates are of greater concern. The more pathogens an individual carries, the more hazardous their feaces. The infestation

are around 5% in the U.S. and approaches 100% in area with poor hygience and contaminated water supplies. The typical first world standard for drinking water coliform is to be less than 1 per 100ml. (0.5mg/m^2) and Third world, untreated drinking water is 50 per 100ml. (Oasis design internet, 2003).

The presence of general coliforms indicate that the water has come in contact with plant and animal life, they are universally present in water and they are of little concern at low levels. Fecal coliforms particularly E. coli indicate presence of mammals or birds feaces in the water. Pigeons and dogs were reported to harbour *Staphyloccocus intermidius* therefore they serves as important vehicle for the spread of opportunistic or zoonotic pathogens. (Futagawa-saito k. et al, 2004).

Ernest, *et al* (1970), discussed many diseases cause by bacteria groups which include enteritis sepsis, pneumonia skin infection, abscess urinary track infections, eye infection, enteric fever, lesions and inflammation of major organs. It is reported that naturally many animals are infected with pathogens and have them on their tissue, excreta or eggs. These animals include shell fish, cattles, rodents, and fowls.

General coliforms indicate that the water has come in contact with plant and animal life, they are universally present in water, and they are of little concern at levels.

The Microbes that causes diseases are complex, dynamic and constantly evolving. The impact of social and environmental factors on infectious diseases outbreaks has been greatly amplified by doubling of the world's population, accelerating most rapidly in the development countries of the tropics and subtropics where diseases continued to have hold resulted in inadequacy of sanitation, crowded living conditions and other basic infrastructures issues associated with population growth. (David, 2005)

Fungi-These are Saprophytic organisms, good number are pathogenic in nature which follow a primary bacterial or parasitic infections, physical injury or traumatic

conditions. They cause disease of fish and man these include S. Prolegnis Sp, Branechiomyces Sanguinu, phoma herbarium.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Study Area

The river is located in South-Eastern part of Niger state, Longitude 9^{o}.30N and Latitude 7^{o}.00E under Gurara local government area in Suleja emirate.

River Gurara is one of the tributaries of river Niger, which form confluence at Abugi, in Kogi state. (3.2). The premier Gurara water falls, discovered in 1928, has international tourism potential status. The role of river Gurara as a major source of water for Bọnu, Gawu/Lambatta, and Izom communities, a semi-rural urban towns, with high population density of about 23,000 (Census, 1991). The communities which experienced periodic out break of diseases (epidemics) which claimed many lives might be attributed to the water-borne diseases.

The river took it sources from North-central of Nigeria high land with catchments around Jere (Southern Kaduna), it flows down South-ward, it flows within its course around the study area, characterized by U-shaped valley, being in it middle course, the bed are underlayed with rough-rocky boulders and pebbles, this makes the flowing river swift, having high velocity and produce audible drumming sound especially during the rainy season.

These features make the river difficult medium of transportation, fishermen use gourds to swim cross the river and occasionally dug-out canoe, when the river is at it full regime.

The study area is sited in Gurara local government area of Niger state at Bonu village few kilometers upstream before the water falls. Station 1 is about 3km upstream of the water fall around Bonu settlement. Station 2 is at the foot of water falls, which is 3.5 km away from station1.

Station 3 is at the confluence of river Tafa and Gurara around Wagu village and Zhigbodo hamlet, which is 10km down stream of the Gurara water fall.

Station 4 is at Izom Township Bridge which is about 3 km from the confluence.

Station 5, is at the outskirt of Izom settlement which is about 4km from the Izom township bridge. (Fig 3.3).

The study site covers about 20km (twenty kilometers), the area is sparsely populated, with Gbagyi, Gbari and Koro tribe's, settlements which include villages like Bonu, Tunchi, Padawa, Gwachife, Wagu, Zhigobo, Buchi, Tayele and major densely populated rural settlements which include Lambata, Gawu, Kpau and Izom town.

The human activities are basically peasant agricultural practices (farming, cattle rearing, fishing and mining). Major settlements have large population of business men, traders, civil servant and farmers who depends on Gurara river as a source of water.

Between station 3 (confluence of Tafa and Gurara) and Izom settlement are many human activities seen around the bank of the river and it tributaries such includes rice farming, sugar cane, Banana, vegetable farming and dry season farming through irrigation. The Fulani cattle herdsmen settle around to get drinking water and green grasses for their animals. Tertiary industries inform of block molding, burnt clay block, car washing, domestic washing/laundry, bathing in the river are evident around Izom settlement. N.N.P.C sub-pump station Izom also channeled their treated effluent into Gurara River in the study area through Koko stream.

The Gurara water fall attracts visitor's from international, national and local communities especially during national festivals, i.e. Christmas, Sallah, New Year, public holidays, and students on excursion.

Fig 3.1:

TITLE:

DISTRIBUTION OF RESERVOIRS & FADAMAS IN NIGERIA

SOURCE:

PETROLEUM (SPECIAL) TRUST FUND

MASTER PLAN STUDY
for the development of the
FISHERIES SUB-SECTOR IN NIGERIA

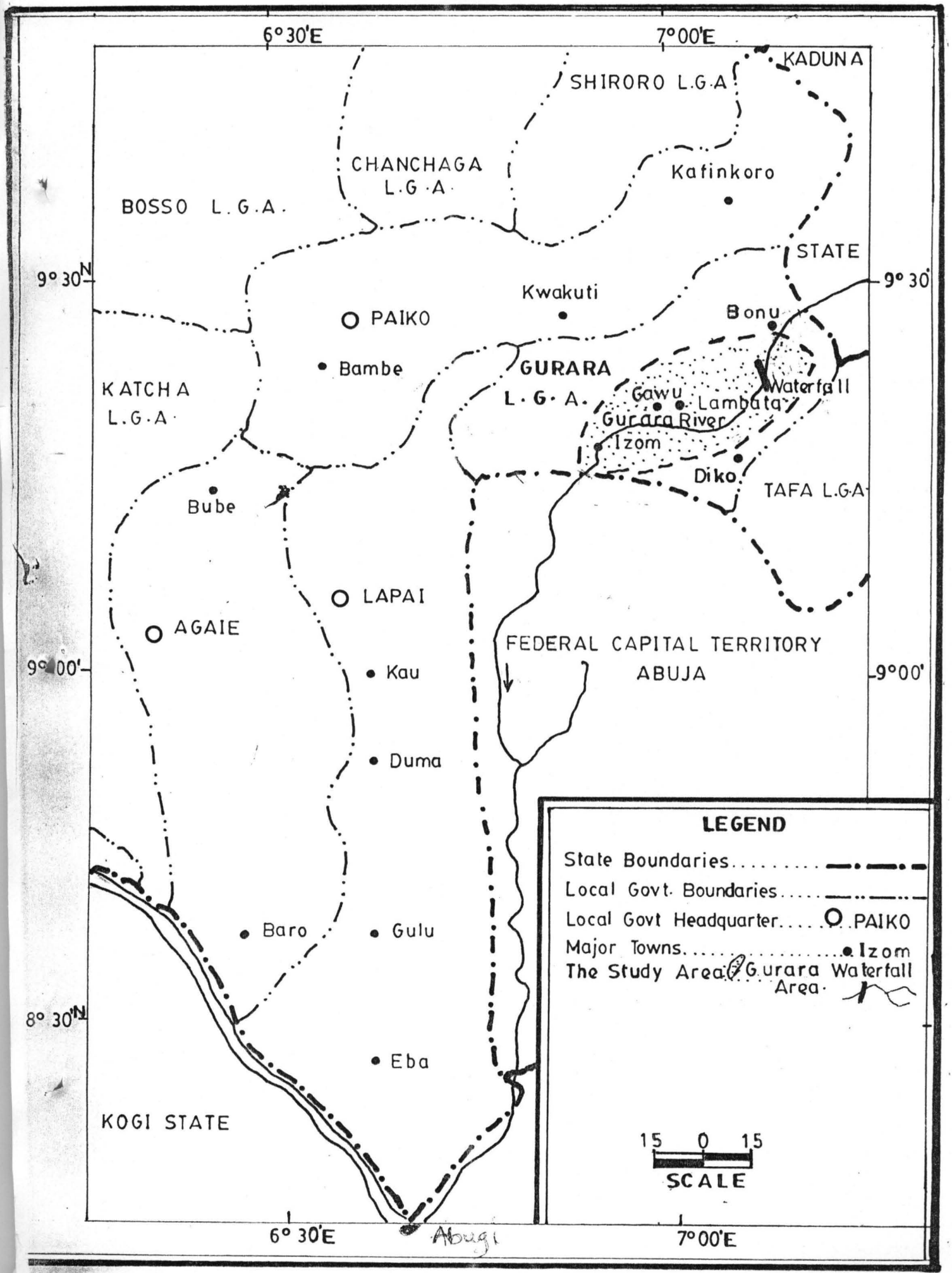

Fig 3.2: MAP OF THE STUDY AREA

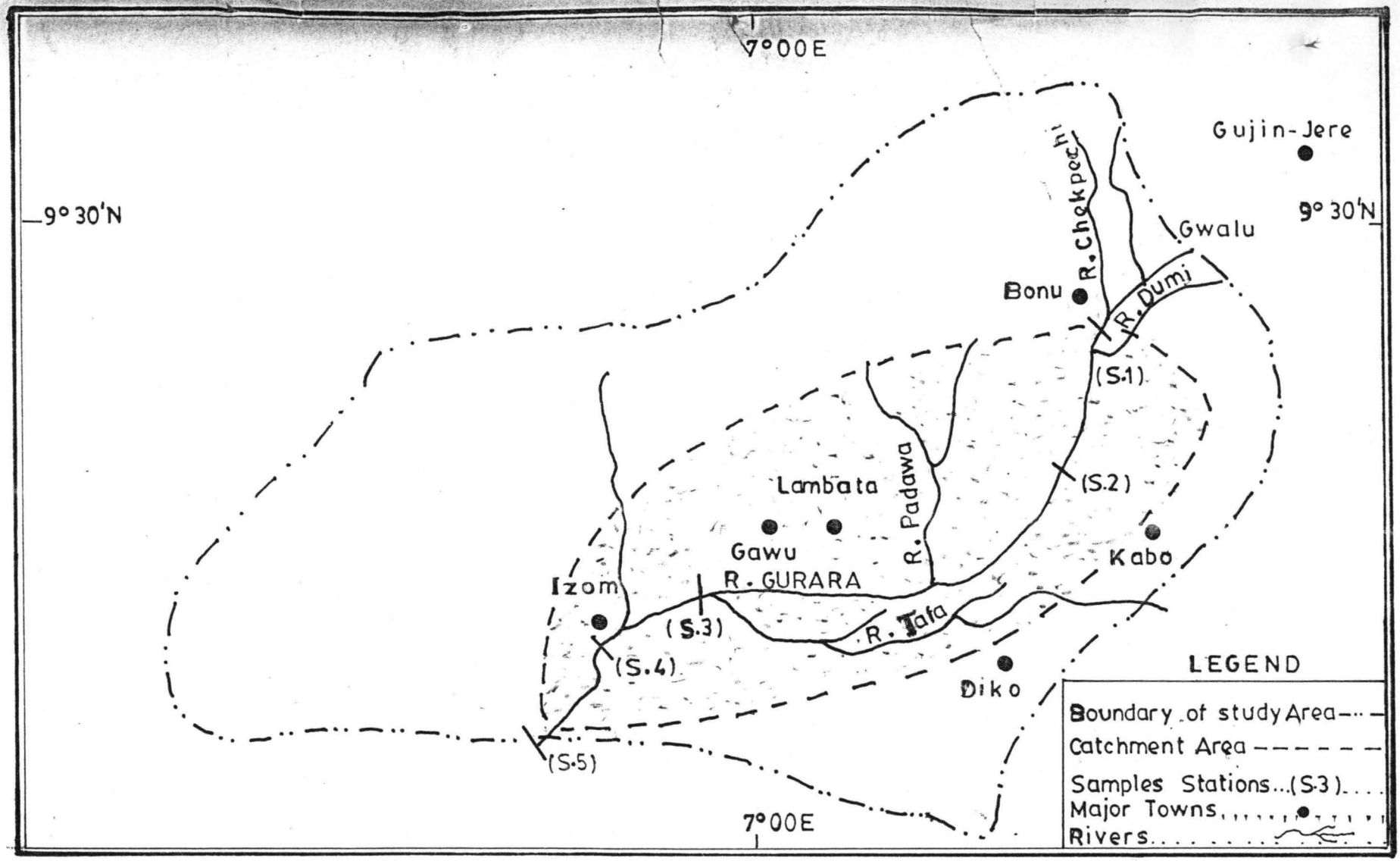

Fig 3.3: MAP OF THE STUDY AREA SHOWING SAMPLE STATIONS.

3.2 Climate and Vegetation

The study area falls within Guinea Savannah belt with monthly rainfall from about 2 inches to 12 inches, while annual rain fall reaches up to 58 inches. About 90% of rainfall is in the month of April – September (Six month rainfall). The rain usually comes with heavy lighting and thunder storm, particularly at the beginning and towards the end of the rainy season.

Temperature is high, with annual mean of 27°c and maximum of 34°c.

The vegetation consists of grasses and scattered trees with thick semi-forest vegetative cover along the river course.

3.3 Socio-Economic

Gurara River is a free gift of nature to the communities and it is the primary source of water to villagers and densely populated semi-urban-rural settlements of Izom, (Linear settlement) and Gawu/Lambata Conurbation.

The river is use for fishing, irrigation, swimming, tourism centre and potential for hydro-electricity generation. Few indigene are engaged in seasonal fishing, more of Hausa settlers are fishermen and some engaged in dry season farming producing vegetables, Lambata, Izom, Abuja and Minna serves as markets centres for the sell of fish and farm produce.

3.4. Hydrology

River Gurara, has its sources from the foot of North-central highland of Nigeria around Gere (Southern Kaduna). It is a major tributary of river Niger. The river flows in a South-ward direction and empties into river Niger at Abugi (Fig 3.2). The tributaries of river Gurara are Tafa, Koko and Danko.

The river is characterized by clear low-volume in dry season (December-April) and high-volume during rainy season (May-November). It is usually turbid and at it highest volume in August-September.

The river is at it middle course in this section, so it assume characteristic U-shape with flowing water body confined to the deep course. Gurara flows swiftly on a high speed (velocity) over the rocky-rough bed with rapids and falls out-look, producing humming sound as it flows especially during the high water volume periods. Station I have the widest width and shallow.

The low water level is characterized by clear water and reduced to pools, Islands within the river course between (February-March). The high volume is seen between (July-October) with turbid water filling the entire river course and flooding of the adjacent low lands. The bed is underlayed with alluvial sand deposit from Izom Township Bridge downward.

3.5 Land Use Pattern

The topography of the area consists of irregular terraces with both steep and low gradient land sloping toward the river course.

The course of river Gurara is characterized by rocky bed, banks sloping toward the river course. The topography gives room for seasonal streams and pools. The soils of the area developed from the basement complex rocks. The soils are dark-brown, dark grayish. The texture is generally course to medium and are poorly drained. The soil is liable to water logging for short periods.

The area is under guinea savannah, consisting of coarse grasses, shrubs, and wood land. The wood lands consist of *Kayas sp.* Shea butter tree, locust beans trees and a thick canopy of evergreen broad, leafed trees vegetation around the river bank. Agriculturally, yam, cassava, guinea corn, maize, beans, groundnut, melon, soyabeans

are the predominant crops in the area. Beni-seed, sugar cane, onions, vegetable are also cultivated. Palm trees, banana, mangoes, garden eggs, paw-paw and cashew are the most important local fruits. Herbicides and fertilizers are used by the farmers and end up as surface run-off into the river

3.6 Collection of Samples

River Gurara was used for my studies with 5 sampling station between Gurara Water falls and Izom settlement. The sampling of surface water was carried out once in every month for twelve (12) months usually in the third week of the month from June 2004 - May 2005. Samples were collected in one (1) litre plastic bottles and oxygen bottles which aseptically washed with chorex detergent and small disinfected bottles for microbiology examination. The samples were immediately transported with ice block to fisheries laboratory for water quality analysis and microbiology laboratory of the Federal University of Technology, Minna for analysis. Sample water was collected between the hours of 7.30-11.00 am with assistance of fishery department field assistant.

3.7 Experimental Design

The sampling was carried out randomly once every month in each station for the determination of physico-chemical parameter and microbial load of Gurara River. The experimental design was randomized block design with two treatment and two factors.

3.8 Determination of Water Quality Parameters

3.8.1 Temperature

The air and water temperature were measured at each station using the centigrade mercury in glass bulb thermometer (0-110°c) reading was taken at level of the eye minicus point. Air temperature was taken by holding thermometer above water

for about 5 minutes until it stabilized before reading was taken. The water temperature was determined by lowering the thermometer into the water sample in plastic can and reading taken when it established.

3.8.2 Dissolved Oxygen

At each station water samples were collected in 250ml sampling bottles. These were fixed for oxygen using 1ml each of mangnous sulphate (reagent 1) and sodium potassium-iodine solution (reagent 11) sample were later titrated for dissolved oxygen by Winkles method. The calculation is based on the formula given by Boyd, (1979).

Do mg/l = $\frac{\text{(ml titrate) (N) (8) (1000).}}{\text{Sample volume used in ml}}$

Where N = Normality of sodium thiosulphate solution 0.02N ($Na_2S_2O_3$)

3.8.3 Biochemical Oxygen Demand (BOD)

Water sample were collected at each station with 250ml stopered sampling bottles. The oxygen was fixed at the field using reagent 1 (KI) and II. ($MnSO_4$). The bottles were rapped with black polythene bag. The samples were kept or incubated in the dark cupboard to prevent photosynthesis by the plankton at room temperature for five days. The samples were then analyzed for oxygen by wrinkles method (APHA, 1990 and Lind, 1979). Before incubation, part of the sample was titrated to get the initial dissolved oxygen.

BOD, = Do on day 1 – Do on day five (5).

3.8.4 Chemical Oxygen Demand (COD)

50ml of sample water was measured in a beaker + contral water (distilled water). About 2ml of 0.01225 $Nkmno_4$ was added to the water sample using pipette, it gives purple colours and 2 drops of H_2SO_4 was added.

The sample was boil on a cooker for 30 minutes. It was then removed and allowed to cool at the room temperature.

After cooling 0.5ml of 50g/kl was added and shaken to give orange colour solution, few drops of starch solution was added to give brown colour solution which titrated with 104 $Na_2S_2O_3$. it changes colour from brown to blue which marked the end point and the reading was taken.

3.8.5 Hydrogen Ion Concentration (pH)

The pH of water samples at each station determine using Kent Eil 7045/46 pH meter in the laboratory room temperature. pH meter was connected to electricity and switch, the reading was stablised at zero before inserting electrode into each sample for reading electric, is clean up before it was being re-used for the next sample reading.

3.8.6 Electrical Conductivity (Ec)

The conductivity of water at each station was determined by using model W.PA CMD 400 conductivity meter. The readings were expressed in micro μhomscm per centimeter.

The model W.P.A CMD 400 was connected to electricity and switch on. It was allowed to stabilize at zero. The electrode was calibrated using standard. It was then rinsed and inserted into each water sample bottle, and allowed to stabilize before taking the reading. After reading the electrode was cleaned up before inserting it into another sample.

3.8.7 Total Suspended Particles (Tsp)

Total suspended particles at each station were determined by evaporation of water samples. The empty Petri dish was weighed, then 10ml of water sample was put

to Petri dish using pipette and re-weighed, it was then kept on the oven for about four hours at temperature of 100% until water dried up. The dry Petri dish was allowed to cool and weight and initial weighing was subtracted from the final weight to get the total suspended particles.

3.8.8 Total Hardness

10ml of water sample was taken and 1ml of ammonium chloride (NH_4Cl) was added to it as a buffer. A drop of Eriochrome-Bleak-T indicator was also added to it to give a wine-red colour solution.The solution was titrated against 0.01N ethylene Diameine teltra. Acetic acid (EDTA) solution until blue colouration appeared which indicated

The formula for calculating hardness is based on the one given by Lind, (1979) and APHA, (1990).

Total hardness mg/l $CaCO_3$=

$$\frac{\text{Ml of EDTA x Normality EDTA x 50 x 100}}{\text{Over volume of sample used in ml}}$$

3.8.9 Total Alkalinity

100ml of the water sample was measured into 250ml, Eziemever flask, and a drop of methyl orange was added to it as indicator to give a yellow colouration it was then titrated with 0.02N. H_2SO_4 until a pink range colour appeared which marked the end point of the titration.

the calculation was based on the formular

$$\text{Total Alkalinity mg/l} = \frac{(Va)\,(N)\,(50{,}000)}{\text{Volume of water sample}}$$

Va = mL of acid

N = normality of acid

(Lind, 1979).

3.9 Microbiological Examination Method

3.9.1 Bacteriological Analysis

The common methods used by public health microbiologist are two

i. The multiple tube fermentation method

ii. The membrane filtration methods (Okafor, 1985). Used multiple-tube method.

iii. The Multiple-Tube Method

The multiple-tube test is also called the dilution method or the most probable number (MPN) method. It involves a three- stage determination employ the presumptive, confirmed and complete tests. Each of these parts is concerned with the characteristic of coliform. It involves making of eplicated of each dilution factor, as this would give a more sensitive and accurate result. The presence of E.coli in any of the inoculated test tubes gives a positive result of acid and gas production within 48 hours.

3.9.2 Procedure for Bacterial Identification

A. **Presumptive Test:** This is to determine the presence of Coliform bacteria in a water sample.

i. A test tube rack was set consisting of three group of separate series making a total of nine tubes.

ii. The test tubes were labeled accordingly, (volume and stations respectively) and sample inoculated.

iii. The samples where shaken thoroughly and using a 10ml pipette 10ml aliquots was inoculated into three tubes labeled LB 2 x – 10ml. Using a 1-ml pipette 1-ml of water was inoculated into three tubes. Label LB1 x – 1ml. with subsequent of

fleming of container Using a 0.1ml pipette 0.1ml of water was transferred to three tubes labeled LB1 x – 0.1ml.

iv. The procedure were repeated for the 5 samples analysed. The tubes were incubated for 24-48 hours at 38°c

B. **Confirmed Test:** This is to confirm the presence of coliform bacteria in sample water show a positive presumptive test.

i. The Eosin methlene blue Agar (EMBA) plates and macconley agar plates were labeled, from presumptive test, one EMB plate, one macconk e.g. Agar plates were straked to obtain discrete colonies

ii. The procedure were repeated for the remaining samples.

iii. All plates were incubated at on inverted position for 24 hours at 37°c. Finally Gram staining is done. This is for the observation of Gram-negative non-spore forming rods (E.coli)

C. **Complete test**. This is final analysis of water sample to confirm the presence of coliform bacteria in water sample to confirm suspicious doubtful result of the previous test.

i. The test tubes were labeled as before. One lactose both and one nutrient agar Slent from the isolated colonies were obtained from an EMB or Macconkey agar plate from confirmed test".

ii. All these tubes were incubated for 24 hours at 37°c

iii. Observation and Result

iv. All the test tubes were examined after 24 and 48 hours of incubation and result recorded in the char below:

a. Positive (+): 10% or more gas appears in a tube in 24 hours.

b. Negative (-): there is no gas in the tube in the series in 48 hours.

Key Note

LB2 x – 10ml = Double strength lactose broth.

LB1 x 1ml = Single strength lactose broth.

MPN = Most probable number.

D. Interpretation

i. Gas appeared in all three tubes labeled (LB2 x 10, LB1 x – 1 and LB1 x – 0.1, the series were read as 3-3-3 from MPN tables, such a reading indicated that there is approximately 1, 000 micro-organisms per 100ml of water with a 95% probability that there are between 150-4, 800 organisms present. The most probable number (MPN) of colifrom present in 100ml of water tested can be estimated by the number of positive tubes that shown up after incubation.

B1. Confirmed Test

All plates were examined as to the presence of E.coli colonies

C1 Completed Test

The samples incubated were examined as to the presence or absence of acid and gas.

Gram staining was performed using the nutrient agar culture of the organisms that showed a positive result in the lactose fermentation broth. The slides were examined under the microscope for the presence of gram-negative, short bacilli which are indication of *E. coli* and therefore non-portable water. Gram staining reactions and morphology of the cells were recorded.

Key Note

A - Acid production

G - Gas production

\+ - positive

\- - negative

Organisms

Cocci in cluster - *staphyloccus aureus*

Short rods - *E. coli*

Rods - *Salmonellae* typhi

Rods - *Aeromonas spp*

Minute cocci - *Streptococcus feacalis*

D1. Standard Total Viable Plate Count

Total number of viable bacteria in sample water is of limited value by itself, although is a useful supplementary test. It gives an indication of the amount and type of organic matter present in the water supply.

1ml of each samples in pipette with a sterile pipette into sterile Petri-dishes. A sterile molten medium was poured into the Petri-dish and mixed properly. Incubation was developed were enumerated.

3.10 Fungi Identification

The isolate was picked from sabourad dextrose Agar, you now place it is now placed on clean slide, and a drop of lactophenol cotton blue was added then cover with coverslip. It was now examined under microcope using x 10 and 40 objective lens of the fungi, the structure of the fungi observed was then compared with standard.

3.11 Statistical Analysis

Data collected were processed for statistical analysis-one way analysis of variance were employed to verify difference between means in a multiple range test. Statgraphics statistical package was used to analyse the data and cricket graph was used in the drawing of the graph.

CHAPTER FOUR

4.0 RESULTS

4.1. PHYSICO-CHEMICAL PARAMETERS

4.1.1. Air Temperature

Temperature fluctuate from one station to another, it increases decreases in January to February (27°C) before it increases sharply in March to May (40°C). Station 2 had highest mean value, followed by stations 3, 5 and 4 respectively. Station 4 had the least mean value fig: 4.1.

Analysis of variance shows no significant difference between stations ($p>0.05$) Table: 4.2 and 4.3. The result of t-test show no significant difference between dry and wet seasons ($p>0.05$) Appendix 21.

Seasonal variation in stations show higher mean value in dry season than the wet seasons figure 4.21.

Air temperature show positive correction with water temperature, pH and electrical conductivity ($p<0.05$) Table 4.1

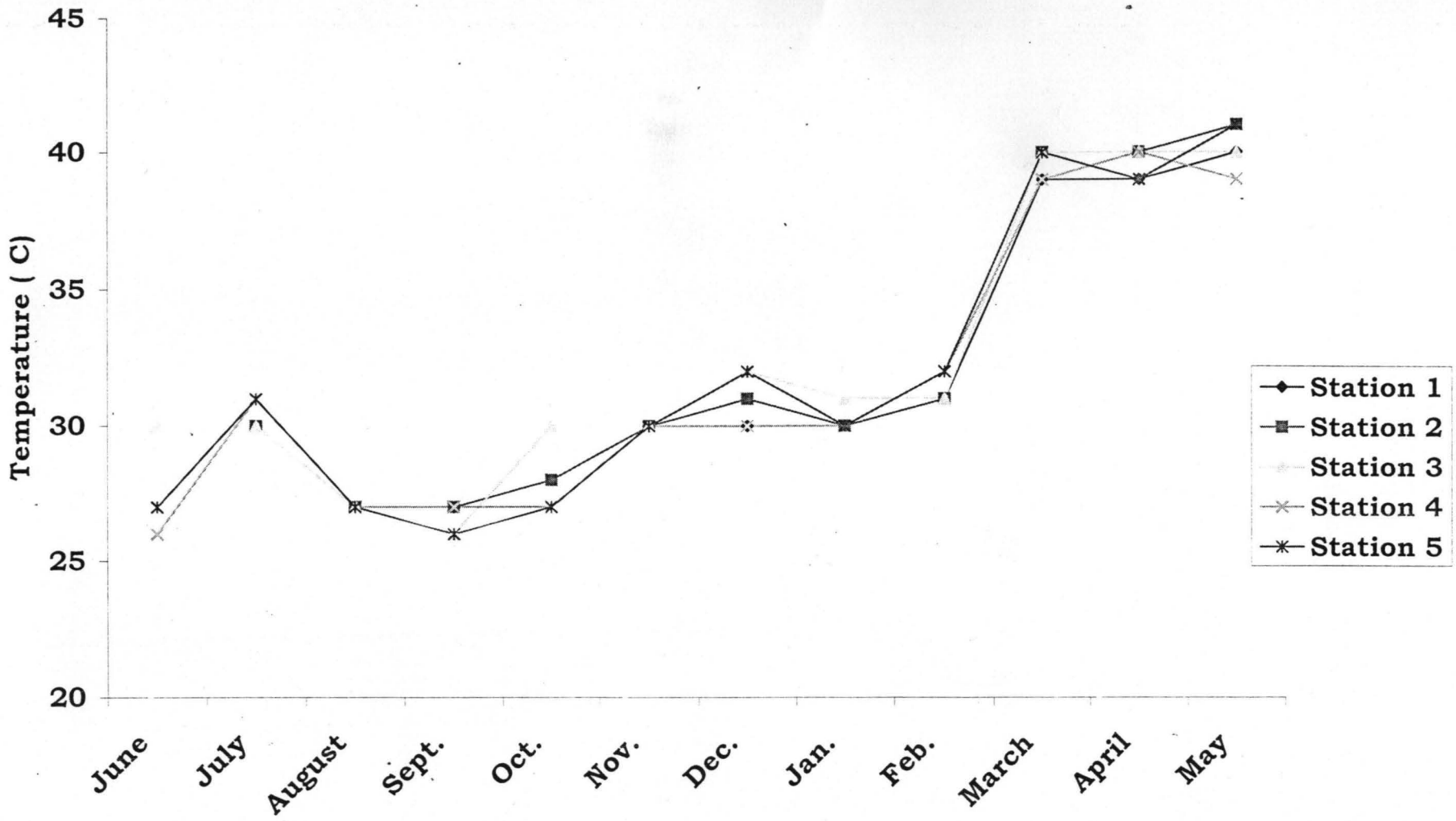

Figure 4.1: Mean Monthly Air Temperature Variation at Different Stations along River Gurara

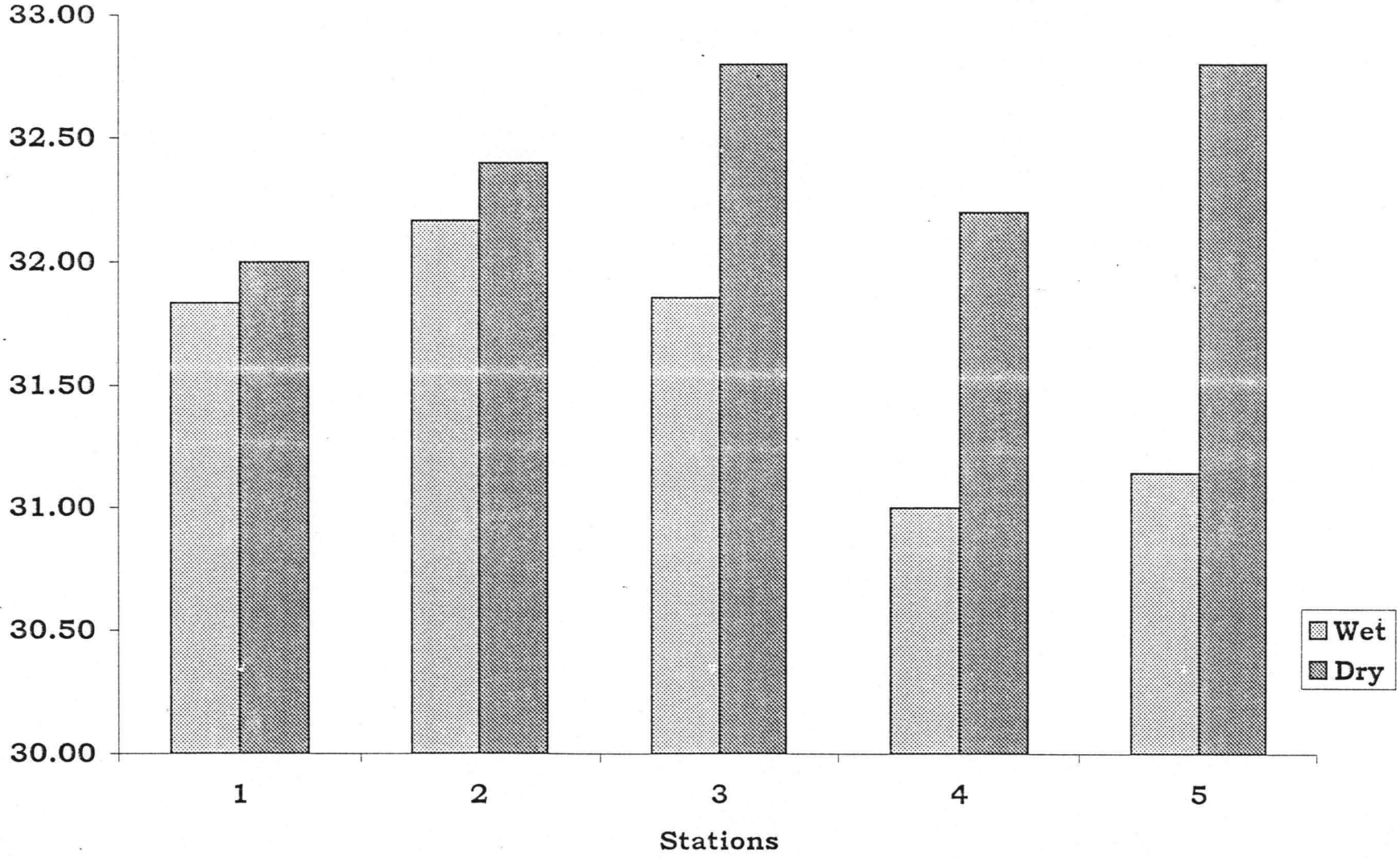

Figure 4.2 : Seasonal Variations in Air Temperature of Gurara

4.1.2. Water Temperature

Water temperature shows sharp contrast between stations and months. Station 3 and 5 had the highest mean value respectively (36.6°C) while station 4 had the least mean value (23 °C) figure 4.3. Analysis of variance show that stations do not differs from each other ($p>0.05$) but sub-season differs respectively ($p<0.05$) a, b and c tables 4.2 and 4.3.

Stations seasonal variation show higher wet season water temperature in all the stations than dry season figure: 4.21. The t-test result show significant difference between dry and wet seasons ($p<0.05$) Appendix 21. Seasonal variation show slightly higher mean value in wet season than dry seasons (29.09°C and 28.8°C) respectively.

Water temperature shows positive correlation with air temperature, pH, total suspended particle, electrical conductivity Table 4.1

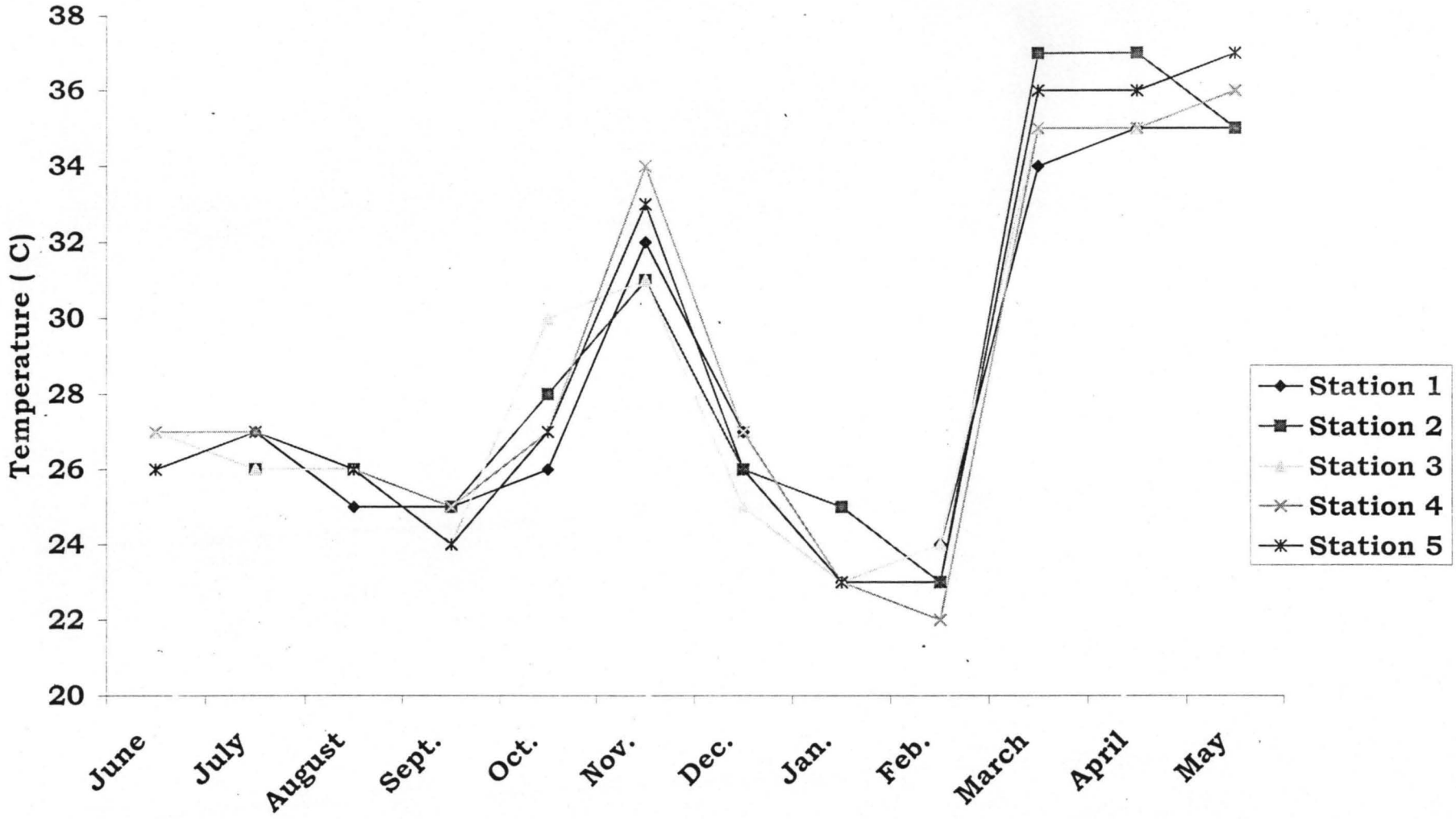

Figure 4.3 : Mean Monthly Water Temperature Variation at Different Stations along River Gurara

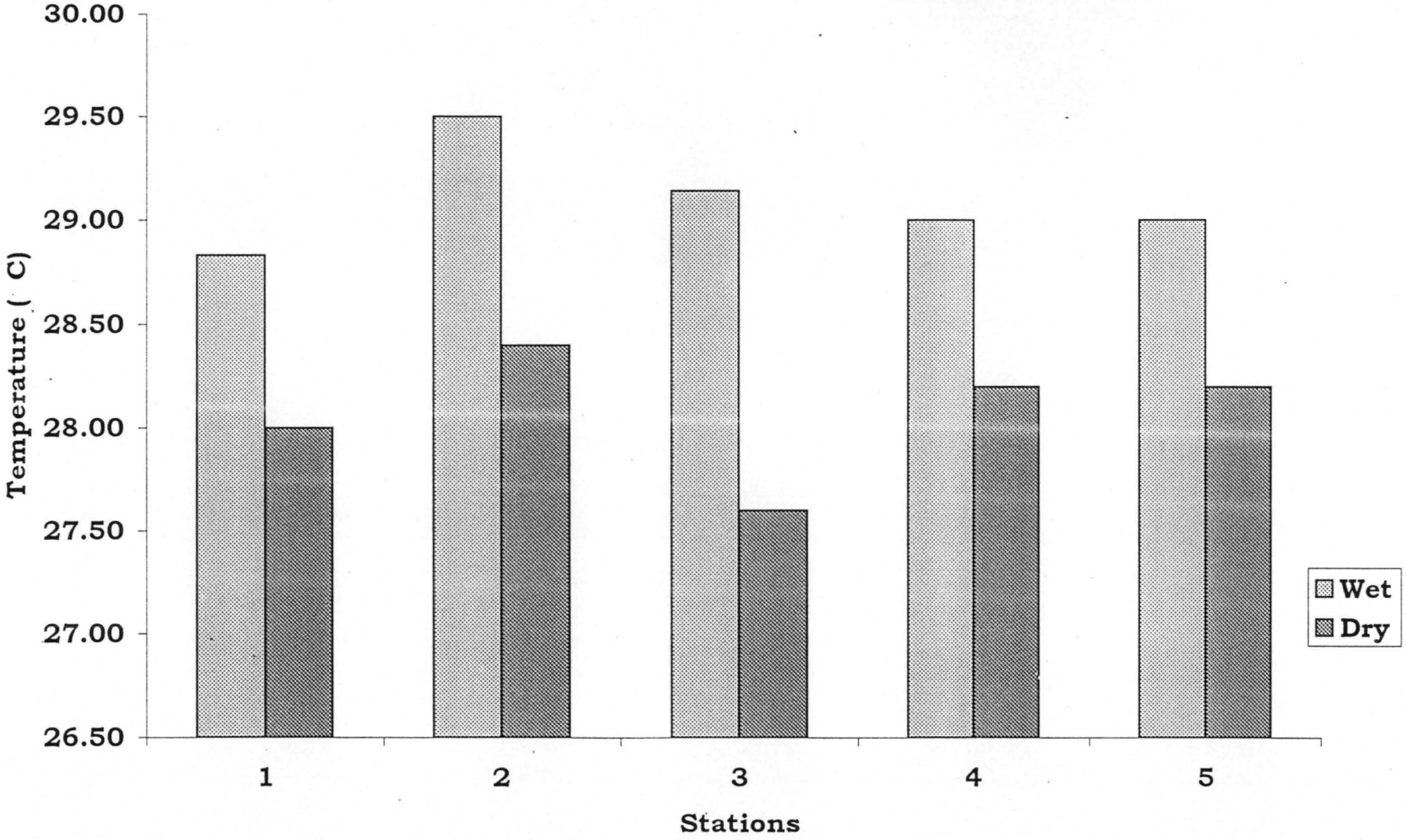

Figure 4.4 : Seasonal Variations in water Temperature (C) of Gurara River

Table : 4.1 The correlation matrix values for the physico-chemical parameters measured at different-stations of River Gurara

	Air Temp.	Water Temp	DO.	BOD.	COD.	pH	EC	T.S.P	Hardness	Alk.
Air Temp.										
Water Temp.	0.76*									
DO.	0.05	-0.17								
BOD.	0.05	0.10	0.11							
COD.	-0.15	-0.30	0.16	-0.14						
pH	0.39*	0.27*	0.19	0.10	-0.30					
EC.	0.16*	0.36*	0.49*	-0.03	-0.03	-0.52*				
T.S.P.	0.10	0.28*	-0.25	0.03	-0.32*	0.25	-0.20			
Hardness	0.04	0.13	1.14	0.53	-0.14	-0.20	-0.04	-0.25		
Alk.	-0.18	-0.22	0.005	0.16	-0.15	-0.33*	-0.03	-0.25	1.00	

* Significant ($P<0.05$)

Table: 4.2 The mean values of the Parameters measured at different sub-seasons of River Gurara. (June 2004- May 2005)

Parameters	Sub-season 1	Sub-season 2	Sub-season 3	Sub-season 4
Air Temp.	28.56 ± 0.51[a]	28.20 ± 0.42[a]	29.87 ± 1.08[a]	39.80 ± 0.17[b]
Water Temp.	26.30 ± 0.17[ab]	28.13 ± 0.88[b]	24.27 ± 0.42[a]	35.60 ± 0.23[c]
DO	0.66 ± 0.09[a]	0.40 ± 0.08[a]	0.86 ± 0.18[a]	0.59 ± 0.16[a]
BOD.	0.36 ± 0.04[a]	0.17 ± 0.06[a]	0.52 ± 0.09[a]	0.56 ± 0.14[a]
COD	3.96 ± 1.56[b]	0.91 ± 0.19[a]	2.28 ± 0.25[ab]	0.60 ± 0.41[a]
pH	6.46 ± 0.05[a]	6.86 ± 0.10b	7.02 ± 0.11[b]	7.03 ± 0.02[b]
EC.	4.93 ± 0.24[a]	10.34 ± 0.10[ab]	36.79 ± 8.52[bc]	57.49 ± 7.96[c]
T.S.P.	0.01 ± 0.00[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]
Hardness	0.53 ± 0.06[a]	0.57 ± 0.80[a]	0.29 ± 0.05[a]	0.55 ± 0.11[a]
Alkal.	0.59 ± 0.05[a]	1.87 ± 0.53[a]	0.89 ± 0.16[a]	0.8 ± 0.07[a]

Mean values with same letter in rows are not significantly different (P> 0.05).

Sub season 1. warm rainy season 2. cold Rainy season 3. dry cold season 4. hot dry season

Table: 4.3. The mean value of the parameters measured at different station of river Gurara and their

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5
Air Temp.	30.54 ± 2.15[a]	32.27 ± 1.62[a]	32.25 ± 1.62[a]	31.50 ± 1.46[a]	31.83 ± 1.54[a]
Water Temp.	28.45 ± 1.39[a]	29.00 ± 1.55[a]	28.50 ± 1.35[a]	28.67 ± 1.43[a]	28.67 ± 1.53[a]
DO.	0.71 ± 0.16[a]	0.53 ± 0.19[a]	0.79 ± 0.13[a]	0.52 ± 0.18[a]	0.58a ± 0.15[a]
BOD.	0.48 ± 0.07[a]	0.72 ± 0.12[a]	0.57 ± 0.13[a]	0.52 ± 0.11[a]	0.44 ± 0.10[a]
COD.	1.61 ± 0.45[a]	1.76 ± 0.49[a]	2.00 ± 0.55[a]	1.92 ± 0.50[a]	1.94 ± 0.54[a]
pH	6.82 ± 0.07[a]	6.91 ± 0.08[a]	6.91 ± 0.11[a]	6.88 ± 0.11[a]	6.81 ± 0.17[a]
EC	26.46 ± 8.53[a]	27.17 ± 8.35[a]	29.46 ± 9.77[a]	28.11 ± 9.99[a]	29.37 ± 9.90[a]
TSP	0.02 ± 0.01[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]
Hardness	0.50 ± 0.07[a]	0.39 ± 0.06[a]	0.54 ± 0.09[a]	0.45 ± 0.10[a]	0.54 ± 0.12[a]
Alkal.	1.26 ± 0.14[a]	0.93 ± 0.20[a]	1.10 ± 0.32[a]	1.18 ± 0.49[a]	0.90 ± 0.29[a]

Mean values with same letter in rows are not different significantly (P> 0.05).

4.1.3 Dissolved Oxygen

Station 2 had the widest range and highest mean value. Station 1 had the least mean value. The highest mean value was recorded between January-March in all the stations. Low value was recorded in all the stations between June and January, fluctuating within the same range (0-1 mg/l) as could be seen in fig. 4.9

Seasonal variation shows higher value in dry season than wet season in all the stations except in station 5 with higher wet season value (Fig. 4.21)

Analysis of variance mean of stations and sub-season do not differ significantly ($p>0.05$) table 4.2 and 4.3.

Result of t-tests show significant difference between wet and dry season (Appendix 21)

Dissolved oxygen show positive correlation with electrical conductivity (Table 4.1).

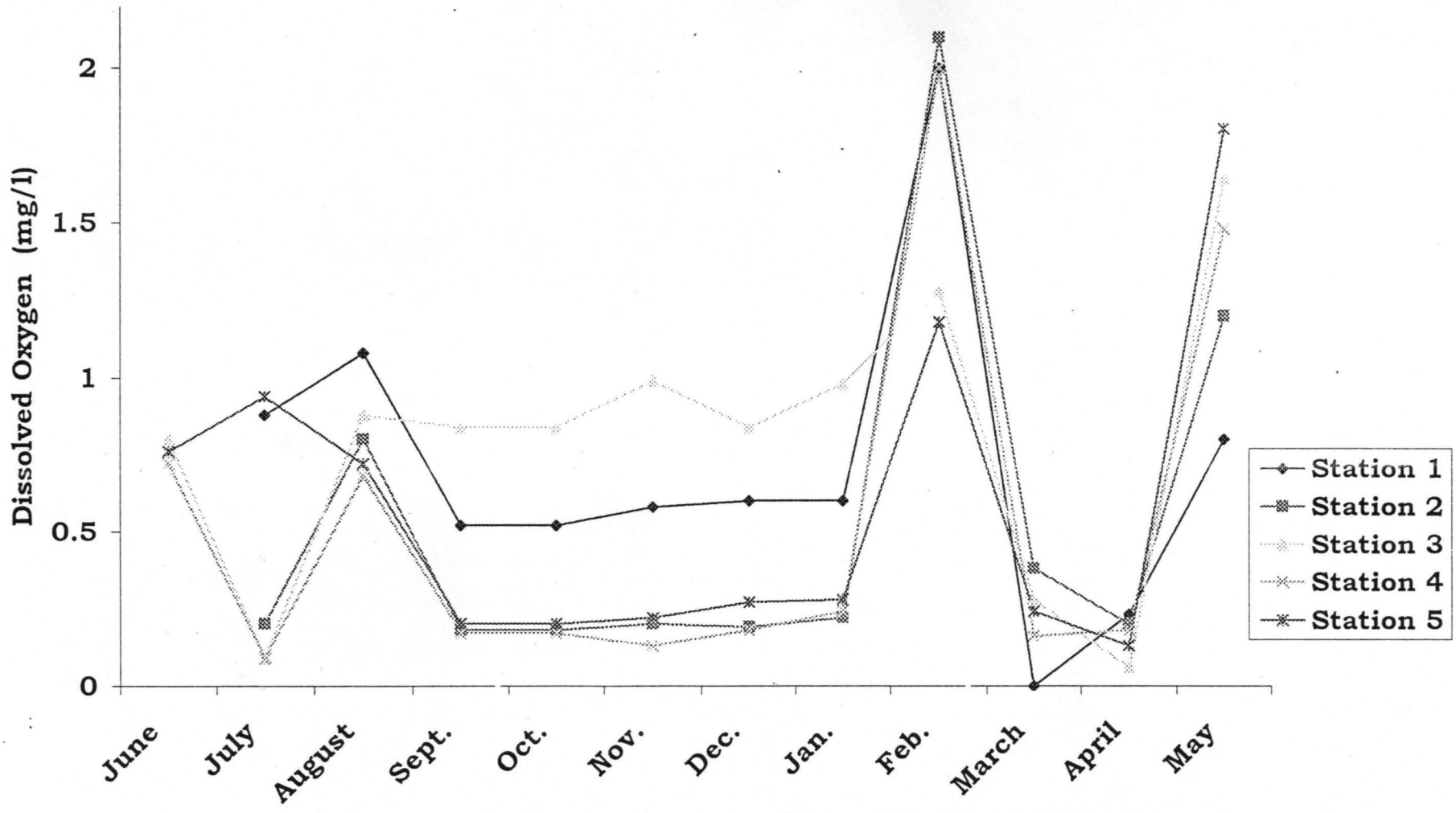

Figure 4.5 : Mean Monthly Dissolved Oxygen Variation at Different Stations along River Gurara

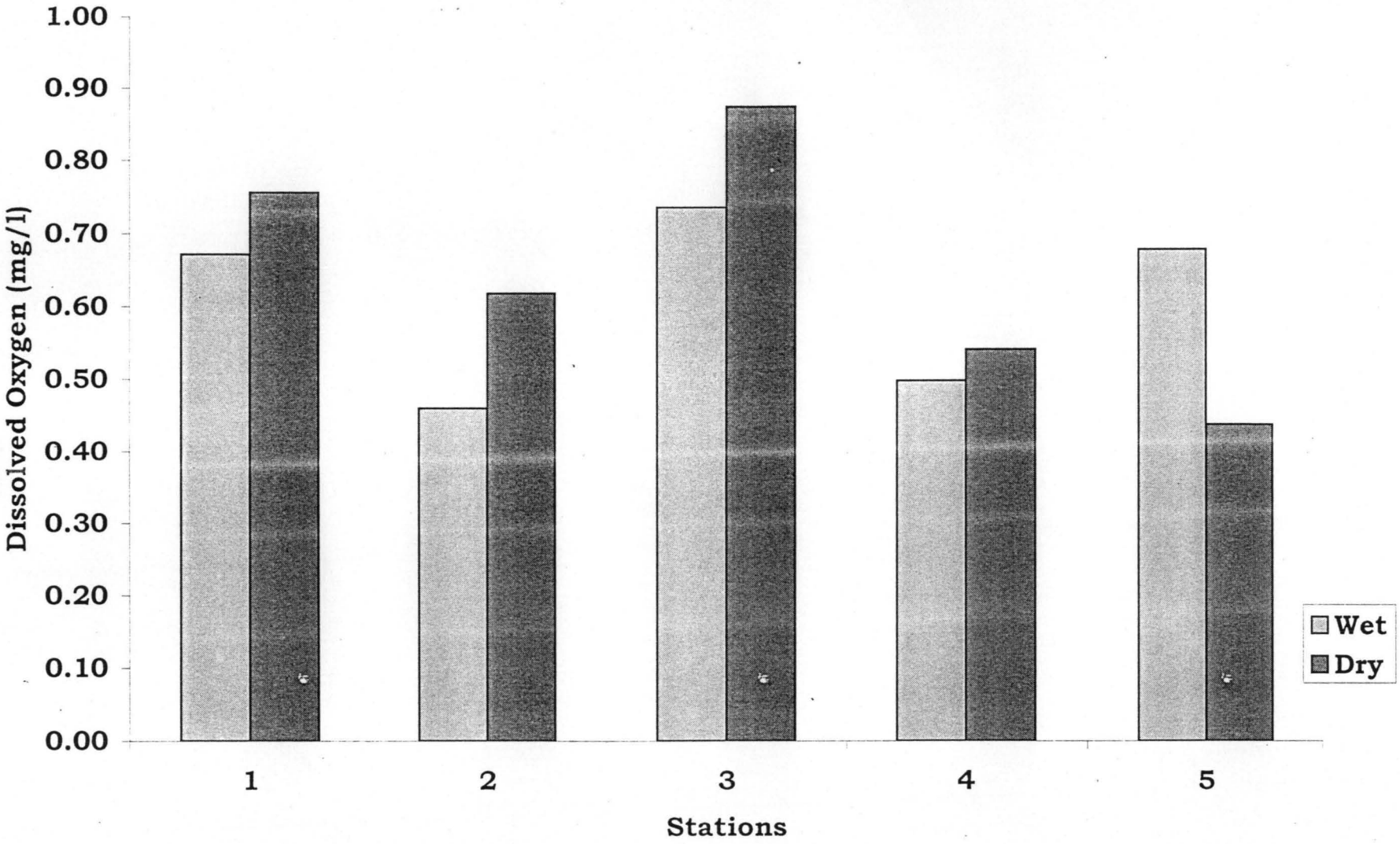

Figure 4.6 : Seasonal Variations in Dissolved Oxygen of Gurara River

4:1.4 Biochemical Oxygen Demand

Station 2 recorded highest mean value in the month of April, while station 3, 4 and 5 had least mean value figure 4.7

Biochemical oxygen demand (BOD) shows fluctuating ranges in mean value within sub-seasons. Low value was recorded in warm rainy sub-season (June-August) it increases a bit in cold rainy sub-season (September-November), a further decrease was recorded in cold dry season (December-February) and decreases in late cold dry season (February-March) and a sudden sharp increase in mid-hot dry sub-season (April-May) wet season mean value was higher than dry season in all the stations figure 4.21

Analysis of variance showed no mean significant difference in all the stations and sub-seasons ($p>0.05$) table 4.2 and 4.3 wet season show slight higher mean value than dry seasons ($p>0.05$). BOD only shows positive correlation with hardness table 4.1.

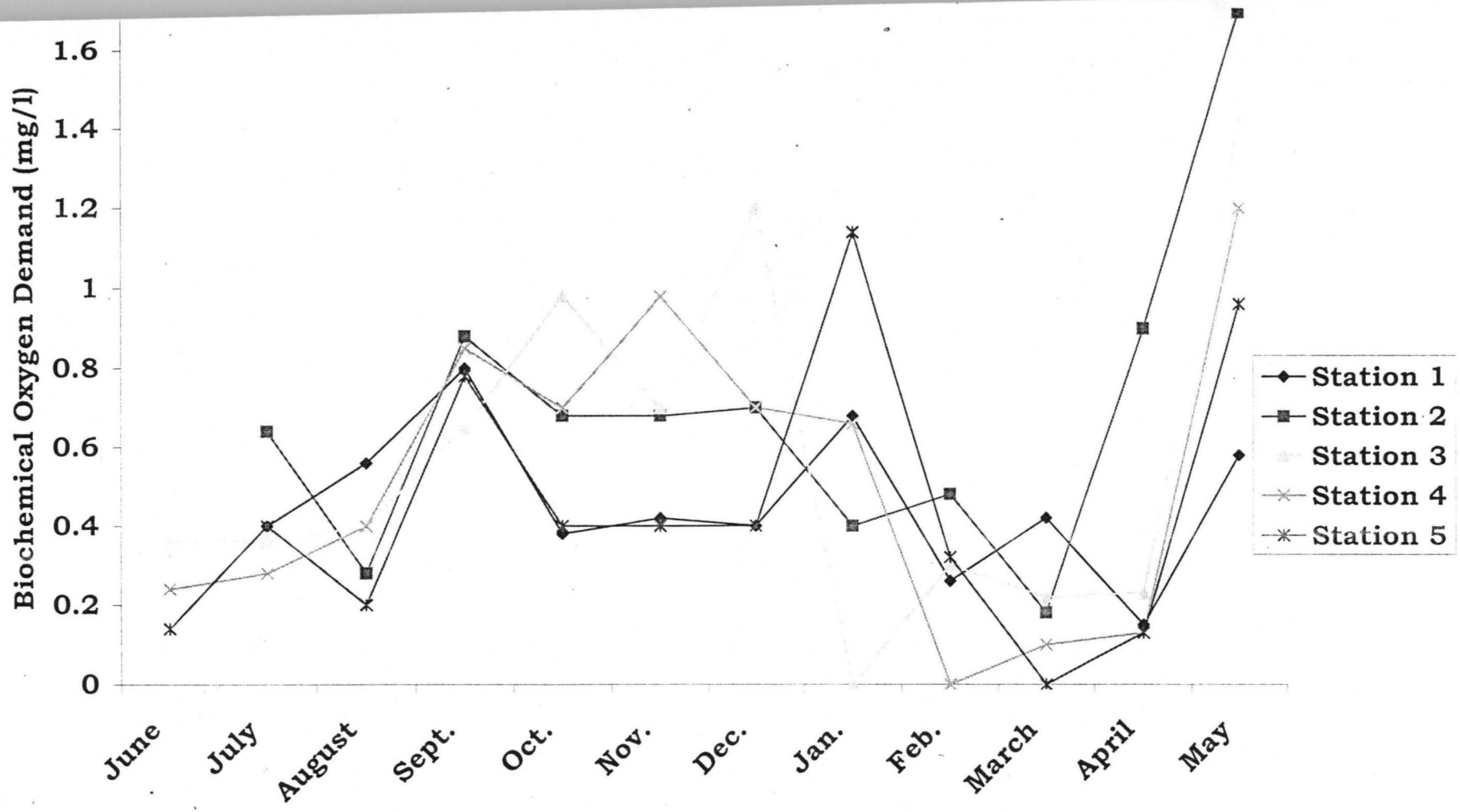

Figure 4.7 : Mean Monthly Biochemical Oxygen Demands Variation at Different Stations along River Gurara

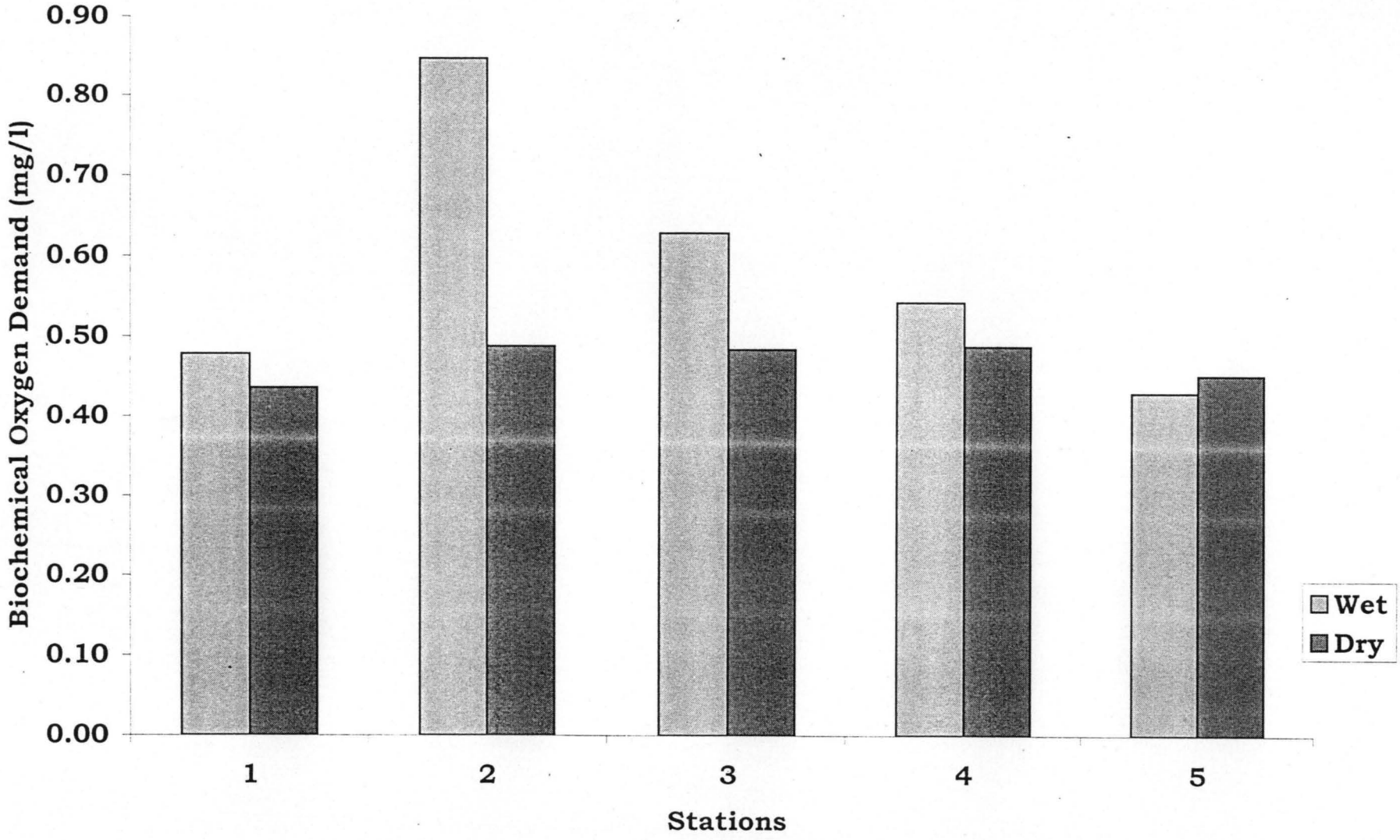

Figure 4.8: Seasonal Variations in Biochemical Oxygen Demand of Gurara River

4.1.5 Chemical Oxygen Demand (COD)

Station 5 had the widest range and highest mean value and station 3 had least mean value.

Highest mean value was recorded in warm rainy sub-season (June-August) followed by a very sharp decrease, which rises in cold rainy sub-season (September-November) it increases further in cold dry season (December-February) and decreases down in hot dry season (March-May) Fig. 4.9. Higher seasonal variation occurred in wet season in all the stations exception of station 1 Fig. 4.21.

Analysis of variance shows no significant difference in all the stations ($p>0.05$) while significant difference was recorded in stations 3 and 4 sub-seasons respectively ($p>0.05$) table: 4.2 and 4.3. Result of t-tests shows significant differences between wet and rainy seasons ($p<0.05$) (Appendix 21)

There was slight higher wet season mean value than dry season fig: 4.20.

COD correlate negatively with water temperature pH and total suspended particle table 4.1

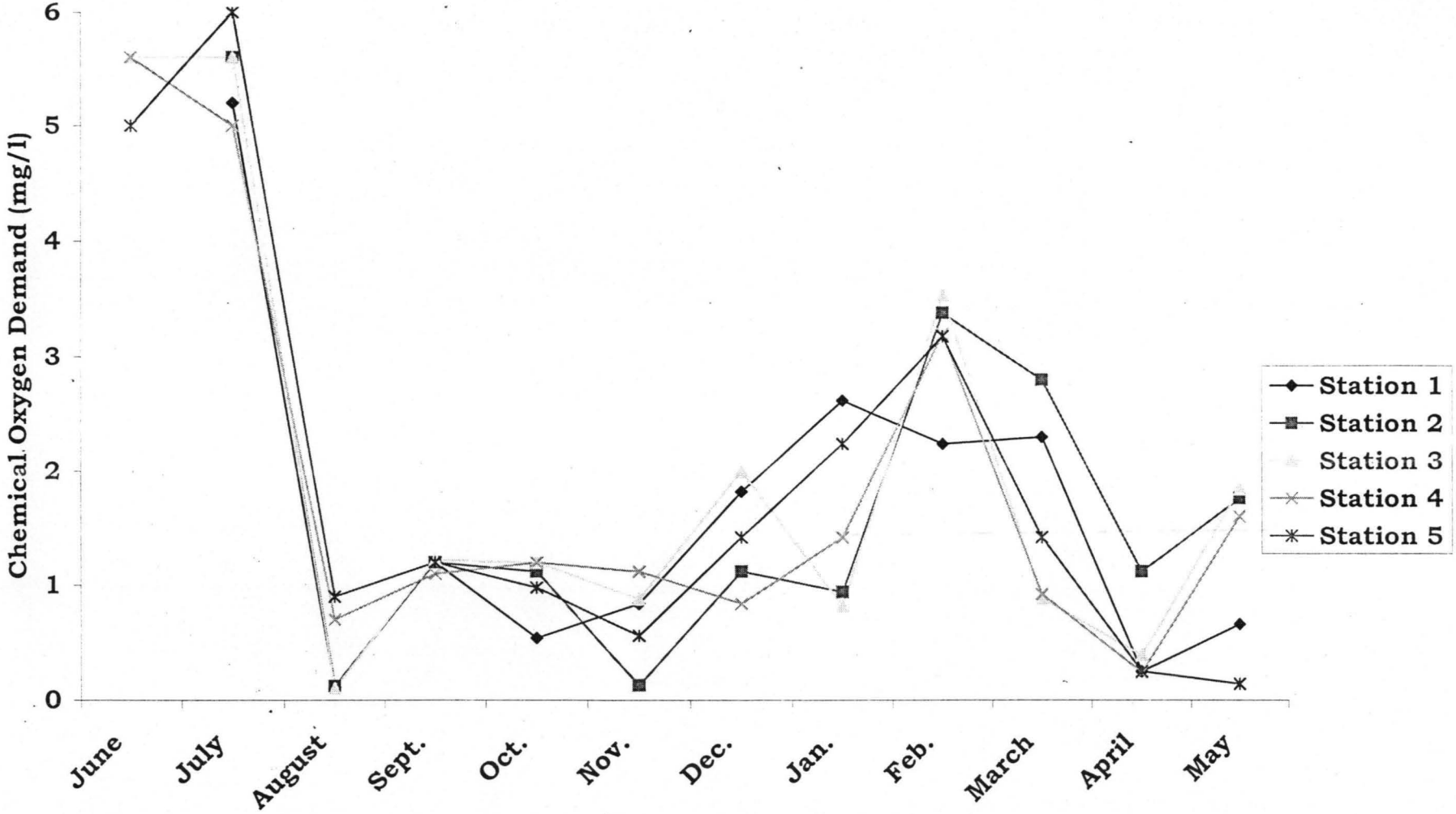

Figure 4.9 : Mean Monthly Chemical Oxygen Demands Variation at Different Stations along River Gurara

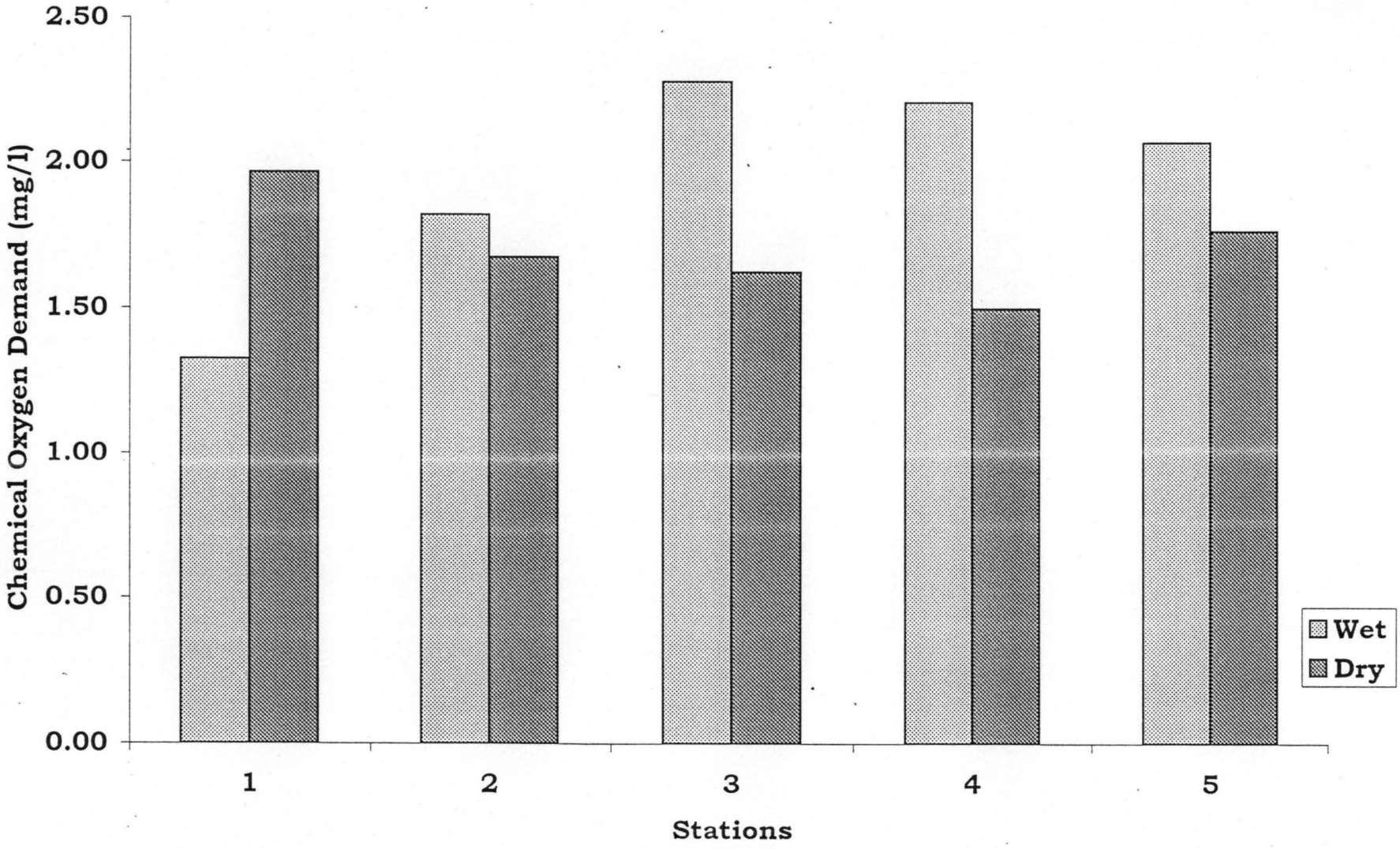

Figure 4.10 : Seasonal Variations in Chemical Oxygen Demand of Gurara River

4.1.6 Hydrogen ion (pH)

pH range was between 6.4 – 7.3 station 5 had the widest range and the least was station 2 figure: 4.11. Seasonal variation shows high mean value in dry season than wet seasons (Figure 4.21).

Result of t-test show no significant difference between dry and wet season ($p<0.05$) (Appendix 21) Seasonal variation show slight higher value in dry season than wet season within the range of 6:7-7.0 station seasonal variation was also higher in dry season than in wet season. Figure: 4.12

Analysis of variance show no significant difference along the stations ($p>0.05$) but significant difference was recorded in the sub-season, 2, 3 and 4 (cold rainy, cold dry and hot dry sub-season) respectively ($p<0.05$) table 4.2 and 4.3. pH show significant positive correlation with air temperature and negative correlation with water temperature, electrical conductivity, chemical oxygen demand and alkalinity table 4.1

pH was low in warm rainy sub-season and increased in cold rainy sub-season, which maintain a relatively fluctuating range in the remaining sub-seasons.

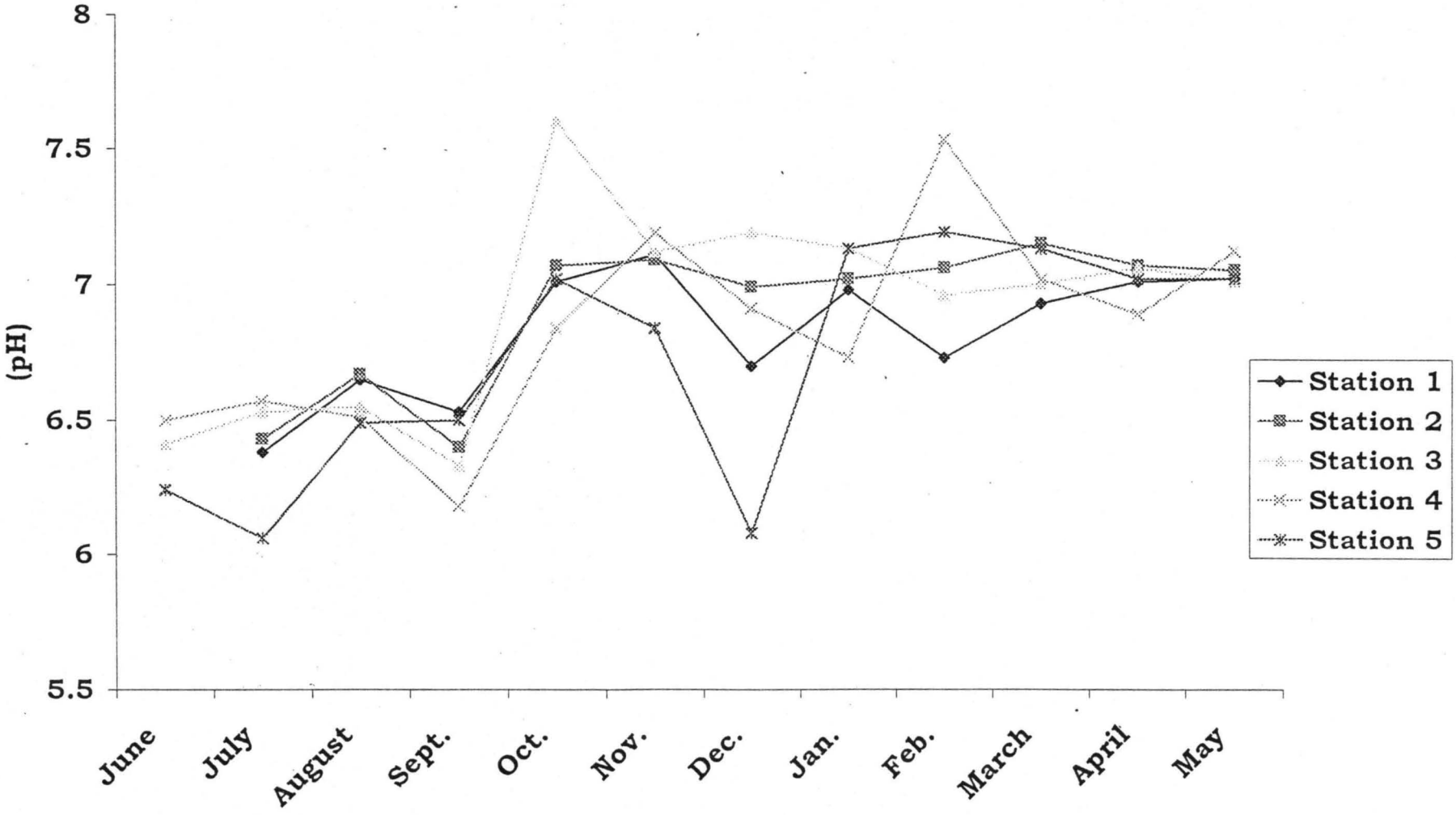

Figure 4.11 : Mean Monthly pH Variation at Different Stations along River Gurara

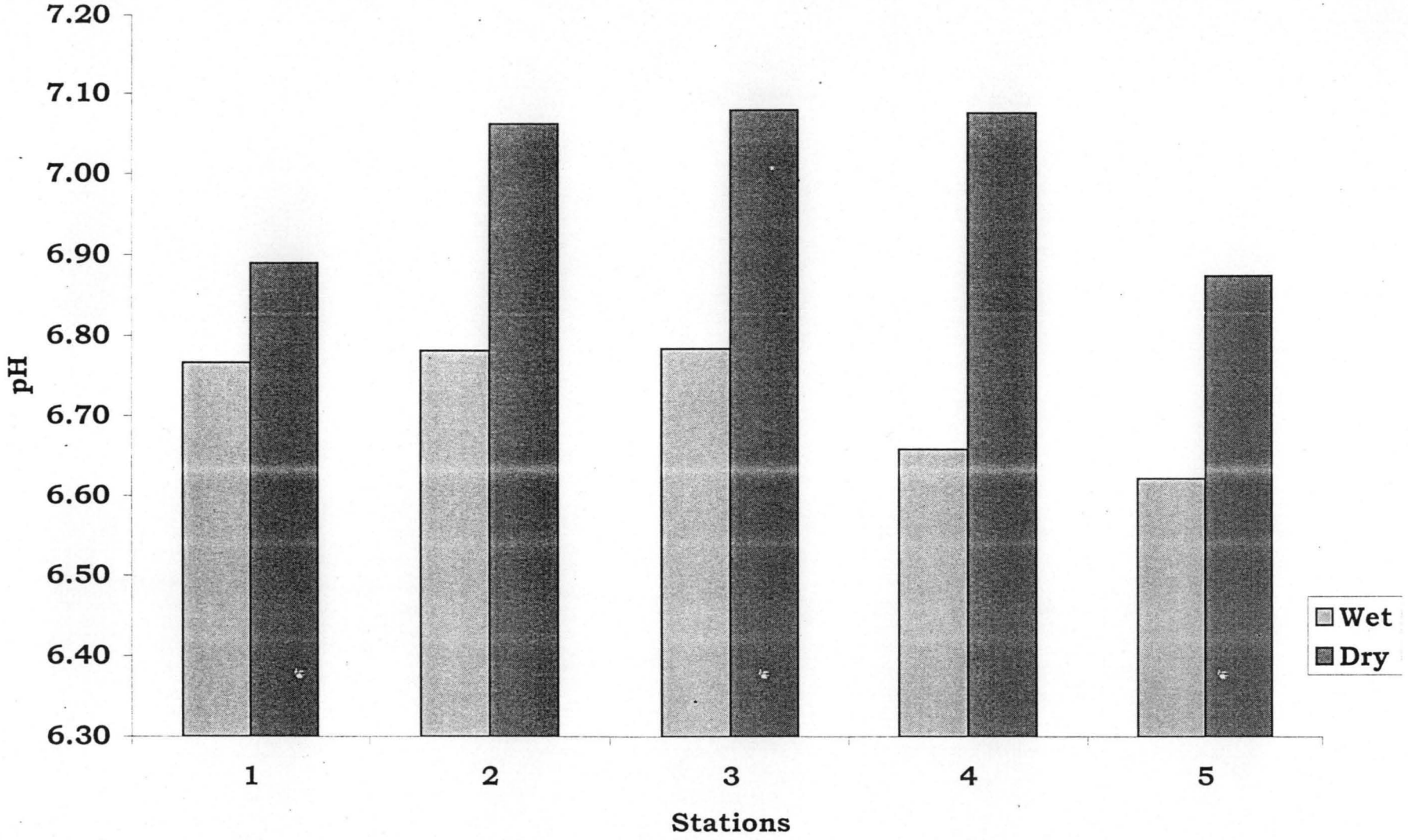

Figure 4.12 : Seasonal Variations in pH of Gurara River

4.1.7 Electrical Conductivity (Ec)

Station 4, had the highest mean value and station 3 had least mean value. Electrical conductivity had his highest mean value recorded in cold dry season (December-February) and early hot dry sub-season (March) followed by very sharp drop in April and high increased in late hot dry season (May) and relatively uniform low mean between (June-November)

Higher seasonal variation was recorded in all the stations in dry season than wet season in the entire stations figure 4.13.

Analysis of variance show no significant difference along the stations ($p>0.05$) but show a significant difference in the sub-seasons except (1) warm rainy sub-season mean value in all the stations Table 4.2 and 4.3

Result of t-tests show no significant difference between wet and dry seasons ($p<0.05$) (Appendix 21).

Seasonal variation in all the stations shows higher mean value in dry season than wet season. Fig. 4.14

Electrical conductivity show positive correlation with air temperature, water temperature p^H and dissolved oxygen table 4.1

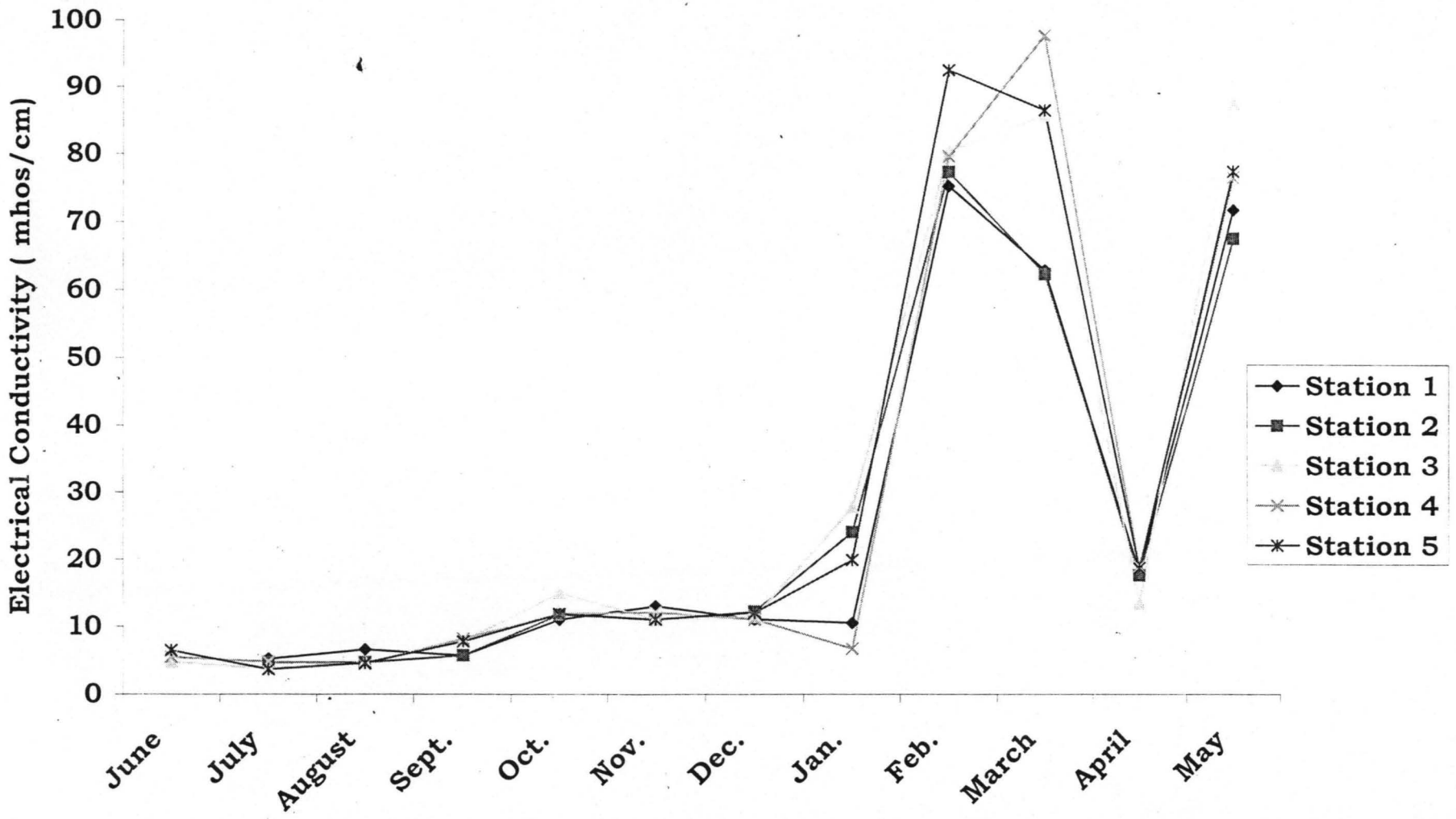

Figure 4.13 : Mean Monthly Electrical Conductivity Variation at Different Stations along River Gurara

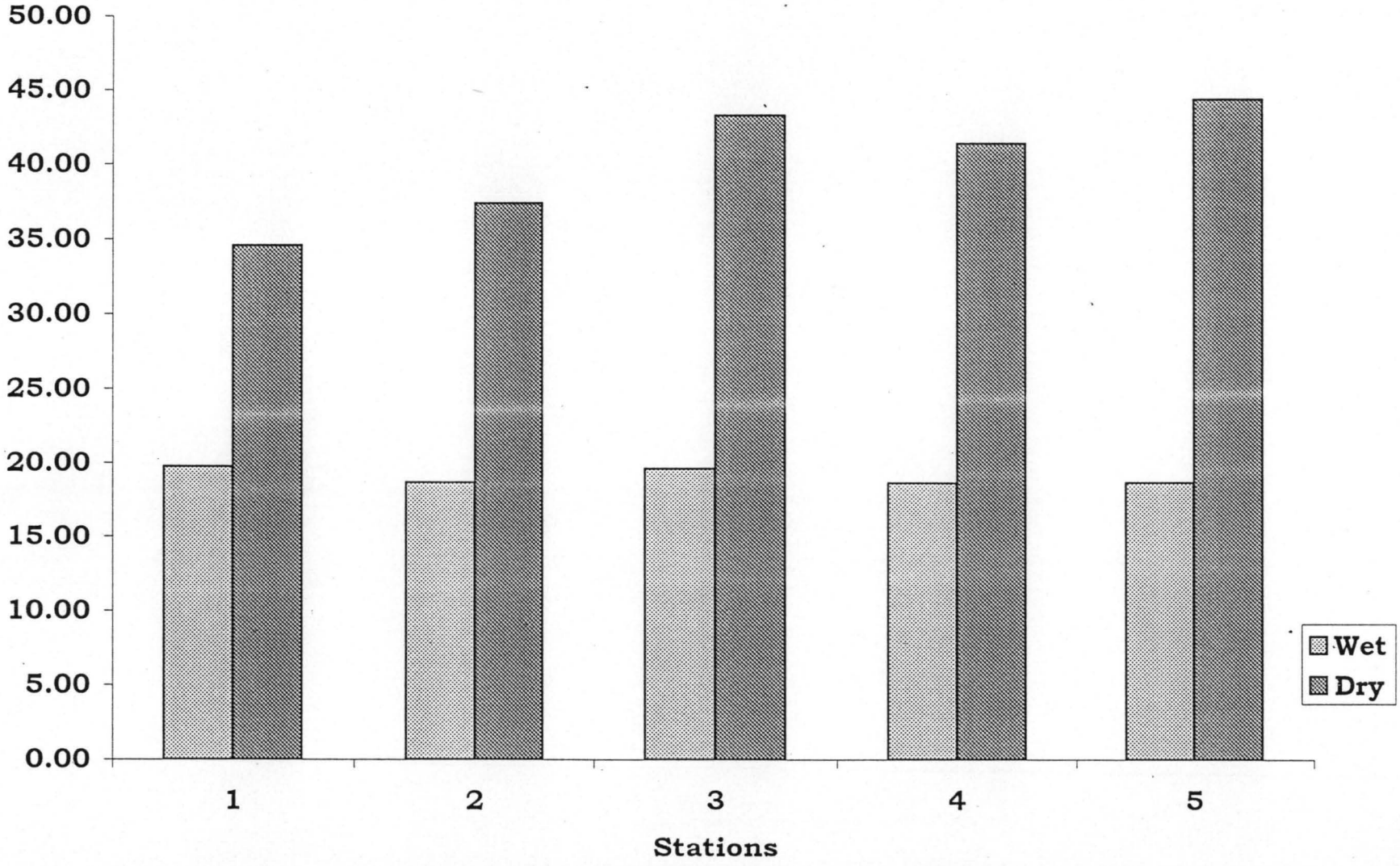

Figure 4.14 : Seasonal Variations in Electrical Conductivity of Gurara River

4.1.8 Total Suspended Particles (TSP)

Stations 1 and 3 had highest mean value while station 4 and 5 had least mean value (0.06 and 0.00). Mean value was low generally with two peak mean value recorded in (September – January) and (march-may) figure 4.15

Stations seasonal variation show higher wet season mean value than dry season in station one and contrasting higher dry season mean value in dry seasons (2,3,4 and 5) figure 4.16.

Analysis of variance does not show significant difference from stations and sub-seasons ($p<0.05$) table: 4.1 and 4.3.

Seasonal variation between wet season and dry season was very low and do not differs. Figure 4.21

The result of t-test show significant difference between wet and dry seasons ($p<0.05$) (Appendix 21)

Total suspended particles show positive correlation with water temperature and negative correlation with chemical oxygen demand table: 6.

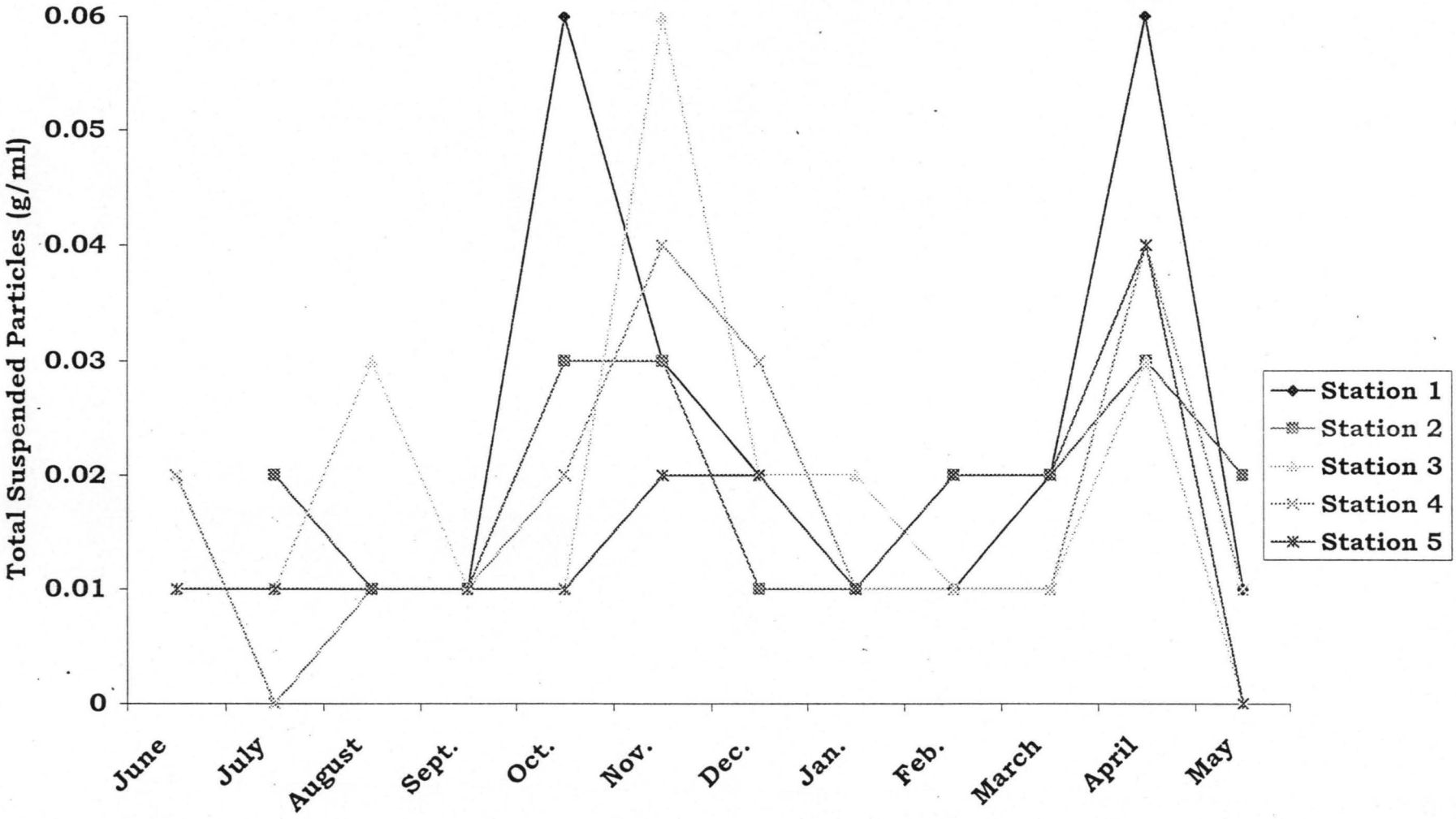

Figure 4. 15: Mean Monthly Total Suspended Particles Variation at Different Stations along River Gurara

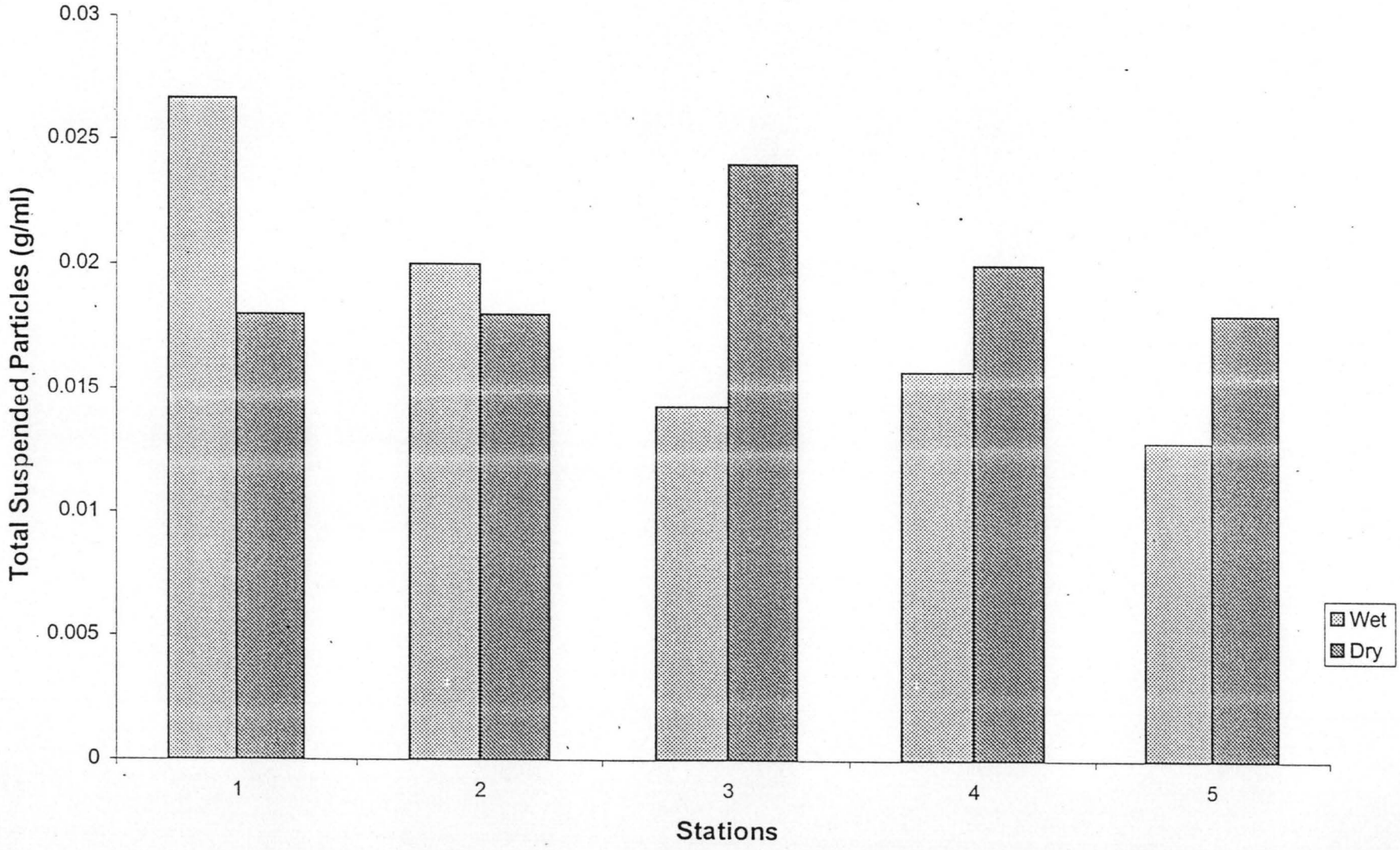

Figure 4.16 : Seasonal Variations of Total Suspended Particles of River Gurara

4.1.9 Hardness

Station 5 had the widest range and recorded highest and least means value. Mean value increases from warm rainy sub-season (June-August) which fluctuate and decreases sharply in hot dry sub-season (March-May) in all the stations than wet season(Figure: 4.17).

Analysis of variance does not differ significantly from each other in all the stations and sub-stations.

($p<0.05$) table 4.2 and 4.3

Result of t-test show no significant difference between the seasons ($p>0.05$) Appendix 21.

Higher mean value was recorded in wet season than dry season figure 4.21 hardness show significant correlation with biological oxygen demand table: 4.1.

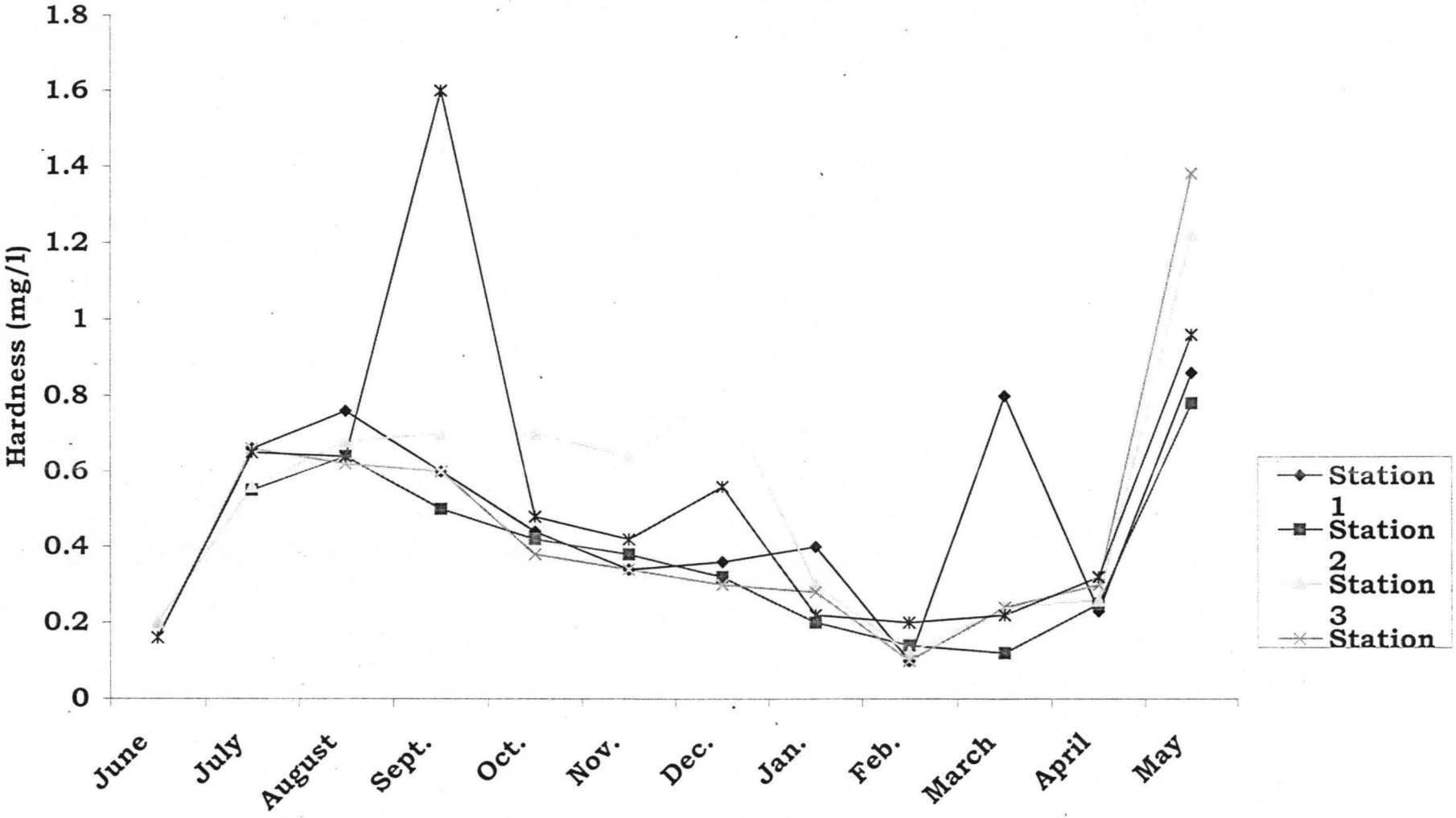

Figure 4.17 : Mean Monthly Water Hardness Variation at Different Stations along River Gurara

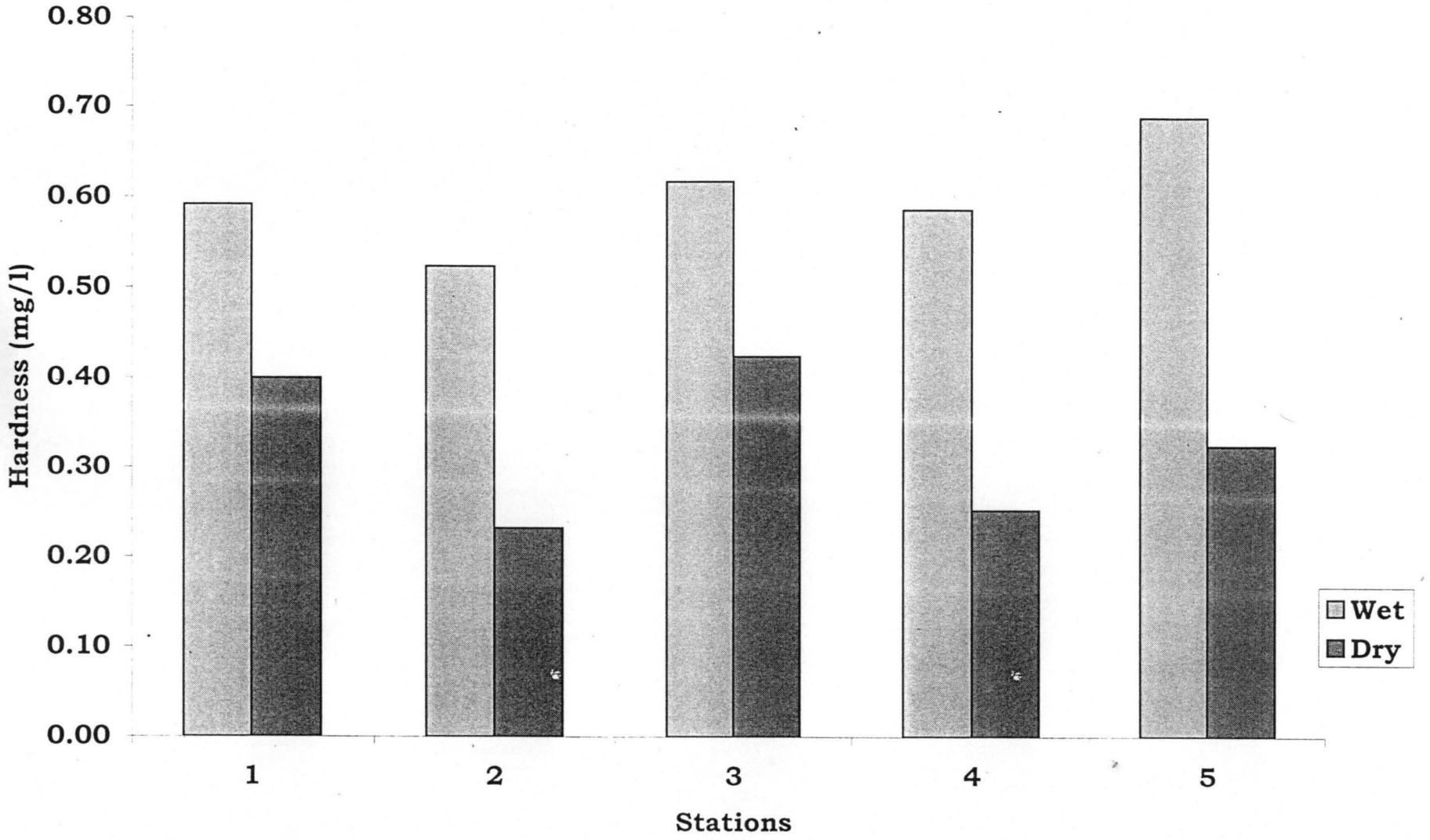

Figure 4.18 : Seasonal Variations in Hardness of Gurara River

e least mean value in the month of April.

Alkalinity was at it peak in cold rainy sub-season (September- October), it dropped sharply in ɔvember and fluctuate within the same range to the month of May (warm rainy sub-season) corded low mean value fig. 4.19.

easonal variation show higher mean value in all the station in wet season than dry season with e highest value recorded at 44. Figure 4.20

nalysis of variance do not differ significantly in station and sub-seasons ($p>0.05$) Table 4.2 nd 4.3

lkalinity mean value was higher in wet season compare to dry season (Figure 4.21)

esult of t-test shows significant difference between wet and dry season ($p<0.05$) Appendix 21

lkalinity show significant correlation with Hydrogen ion only table 4.1.

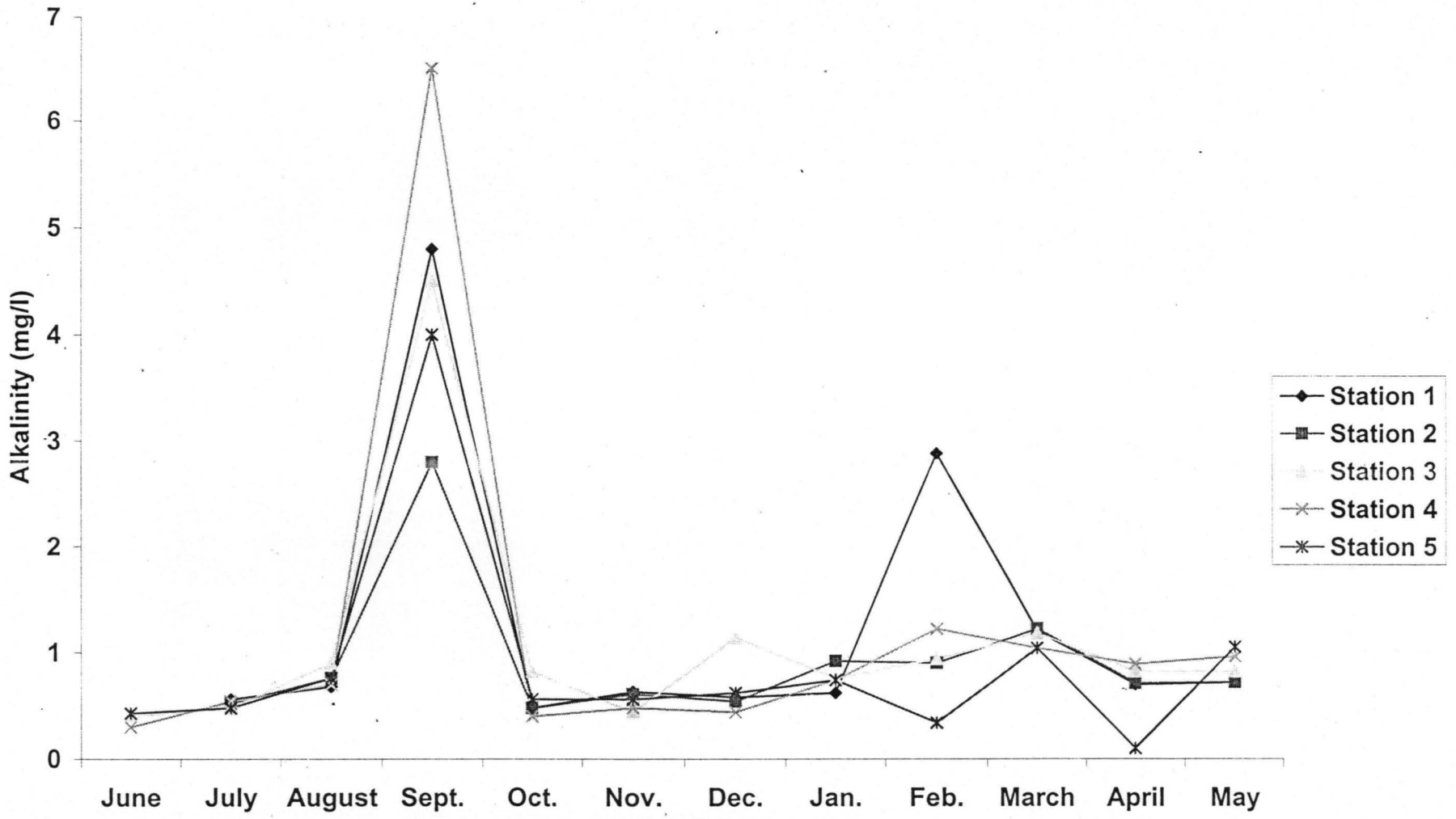

Figure 4.19 : Mean Monthly Alkalinity Variation at Different Stations along River Gurara

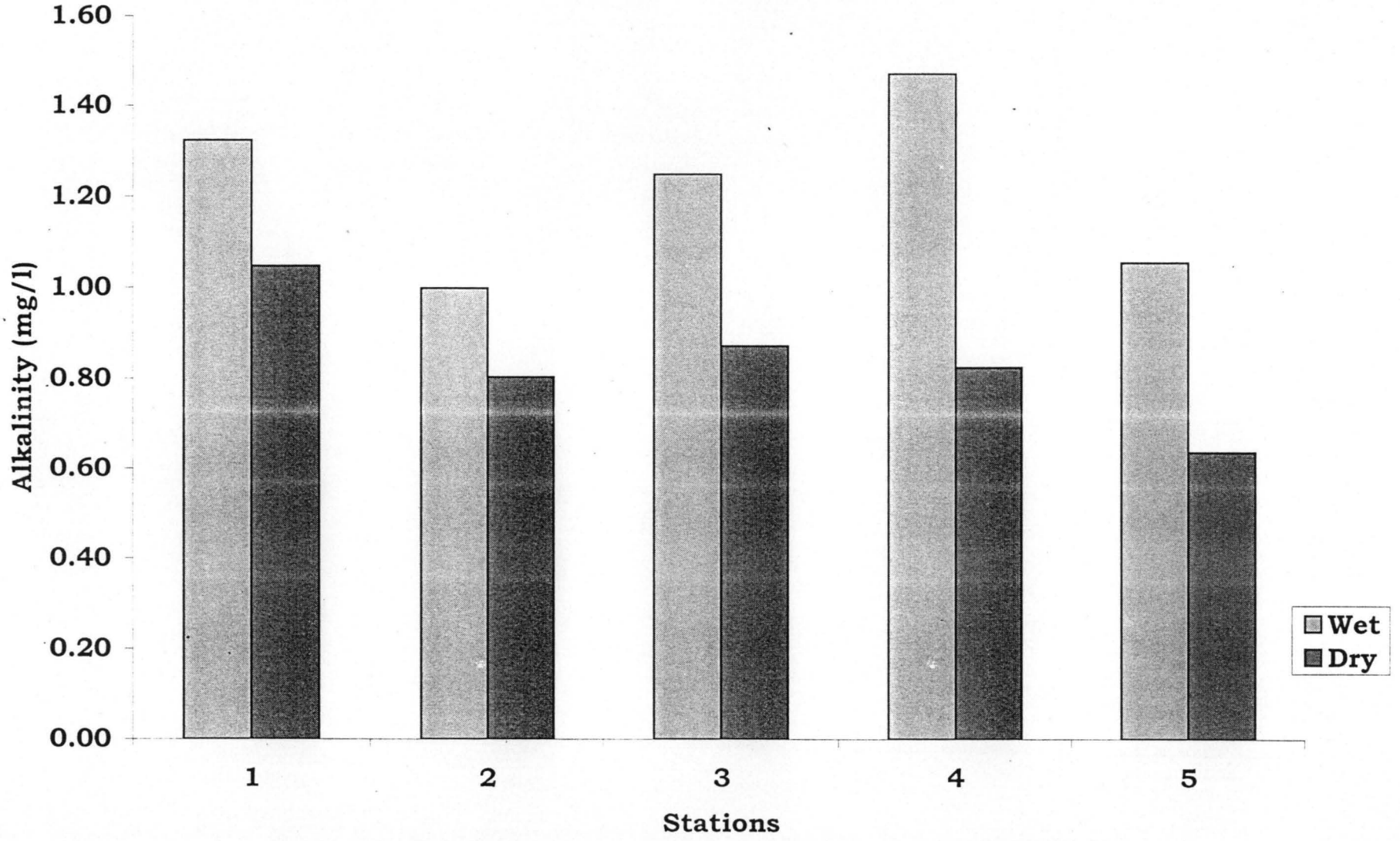

Figure 4.20 : Seasonal Variation of Alkalinity of Gurara River

4:2 Microbial Load Examination

4:2:1 Bacteriology Examination

Bacteria isolate from the sample water are of wide range groups. These include enteric Gram-negative and *Pyogenic cocci* group. The enteric gram-negative ie coliform bacteria, include, *Klesbiellae*, *Proteus* group, *Pseudomonas aeruginosa*, *Salmonellae, Pyogenic cocci* and gram positive which are *Staphylococci and Streptococci.*

Their occurrence and distribution varies fluctuating from station to station Table 4.4, 4.5 and Appendix 20. *Escherichia coli* and *Staphylococcus aureus* and *Pseudomonas aeruginosa,* occurred in all the months in different stations, some repeatedly.

Klebsiella sp salmonellae typhi Baccillus Aeromonas sp and *streptococcus feacalis* were absent in some stations.

Streptococcus pyogeues, *Proteus vulgaris* had the least occurrence in only two months and two stations (June to November) in station 5 and 4, and November to May, station 5 and 3 respectively.

The Escherichia coli had the highest frequency of distribution in all the stations followed by *staphylococcus aureus* and *pseudomonas aeruginosals* respectively. They occurred in all the months. Stations 5, 3 and 4 had the higher number of species isolate from the sample water. There was higher occurrence of species during the rainy season than dry season.

Fig 4: **Bacteria Organisms Isolated from water samples of Gurara River (JUNE 2004 – MAY 2005)**

	Bacteria species	STATIONS WHERE THE ORGANISMS WERE ISOLATED DURING THE SAMPLING PERIOD.											
		JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY
1	*Stretococcus faecalis* *	2, 3	___	4, 5	4	___	5	5	2	4	2, 4	5	1, 4
2	*Pseudomonas aeruginosals*	5, 4	5	3	5	2	3	3	2, 4	1	1	1	1
3	*Escherichia coli* *	2, 1, 3,	2	1, 2, 3, 5	1, 3, 5	1	4	1	1, 3	3	5	3	2, 5
4	*Salmonellae typhi* *	2	3	___	2	5	___	5	___	___	___	___	2
5	*Staphylococcus aureus*	1, 4	1	1, 3, 4	1, 4	3	2	2	1, 5	2	1	2	2, 5
6	*Klebsiella aerogenes* *	___	___	___	2	5	1	___	4	___	___	4	3
7	*Proteus vulgaris* *	___	___	___	___	___	5	___	___	___	___	___	3
8	*Bacillus subtilis*	2	___	2	___	___	___	___	5	3	___	___	4
9	*Aeromanas formicans* *	4	___	3	3	4	5	5	3	5	___	___	5
10	*Streptococcus pyogeues*	3	___	___	___	___	4	___	___	___	___	___	___

Keys

* Indicator Organisms

___ Absent

Station1. Upstream Gurara water falls

Station 2 Foot pool of water falls

Station 3 Confluence of Tafa and Gurara rivers

Station 4 Izom township bridge

Station 5 Out skirth of Izom town.

Stations where these organisms where found respectively in the samples water

INDICATOR ORGANISMS (BACTERIA) Isolated From SAMPLE WATER OF GURARA RIVER IN 5 STATIONS BETWEEN (JUNE-MAY 2004 – 2005)

1 *Streptococcus faecalis*

2 *Escherichia coli*

3 *Salmonella typhi*

4 *Klebsiella aerogenes*

5 *Aeromonas formicans*

6 *Proteus vulgaris*

2 Fungi Species Isolate.

Fungi species isolated from sampled water are of different groups. They varies between months and stations table: 4.5.

ergillus niger, Aspergillus Flavus had the widest range and highest occurrence in all the ions, followed by *Rhizopus species* and *fusarium sp.*

ergillus Fumigatus, A. Parasitus, mucor sp and pencillium sp where absent in some months. ere was low occurrence of *Aspergillus versildor and A. nidulans* in few months and stations, ly this species are not well adopted to aquatic environment. *Aspergillus Versicolour* and *A. ucus* are the least recorded species. The month of May had the highest occurrence. Wet ason had high number and frequency than dry season.

Fig 4.5: **Fungi Isolated from water samples of Gurara River (2004-2005)**

	Fungal Species	STATIONS WHERE THE ORGANISMS WERE ISOLATED DURING THE SAMPLING PERIOD.											
		JUNE	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
1	*Aspergillus fumigatus*	___	3,	2, 5	3	1, 4	4	2	5	1	2	1	1, 5
2	*Aspergillus parasitus*	2	1	4	1		2	2	3	3, 4	2, 4	3	1, 5
3	*Aspergillus niger*	3, 4, 5	2, 4, 5	1, 3, 4 5	1, 2	1, 2, 4, 5	1, 4	3, 5	1, 4	1, 5	3	2, 4	1, 3
4	*Penicillus notatum*	___	___	___	5	___	5	1	2, 5	2	3, 5	2	2, 4
5	*Fusgrium* nivale	4	3	1	3		3, 4	3	2, 5	2	4	1, 5	2
6	*Rhizopus* nigrica	3, 4	4	2, 4	4	2	1, 5	4	3	3	5	5	2
7	*Aspergillus glaucus*	___	___	___	___	___	___	___	___	___	___	___	3
8	*Asperaillus flavus*	3, 4, 3, 5	5, 4	3	2	1, 3, 5	2, 5	3	4	5	1	3, 4	3, 5
9	*Mucor spp*	3, 4, 5	4	4	___	3, 4, 5	___	5	2	3, 4	1	4	3
10	*Aspergillus nidulans*	___	___	___	___	___	___	___	4	___	___	___	4
11	*Aspergillus versildor*	___	___	1	___	___	3	1	___	___	___	___	4
12	*Aspergillus glaucus*	___	___	___	___	___	___	4	1	___	___	___	___
13	*Aspergillus versicolour*	___	___	___	___	___	___	___	1	___	___	___	___

Keys

___ Absent

Station1. Upstream Gurara water falls
Station 2 Foot pool of water falls
Station 3 Confluence of Tafa and Gurara rivers
Station 4 Izom township bridge
Station 5 Out skirth of Izom town.

Stations where these organisms where found respectively in the samples

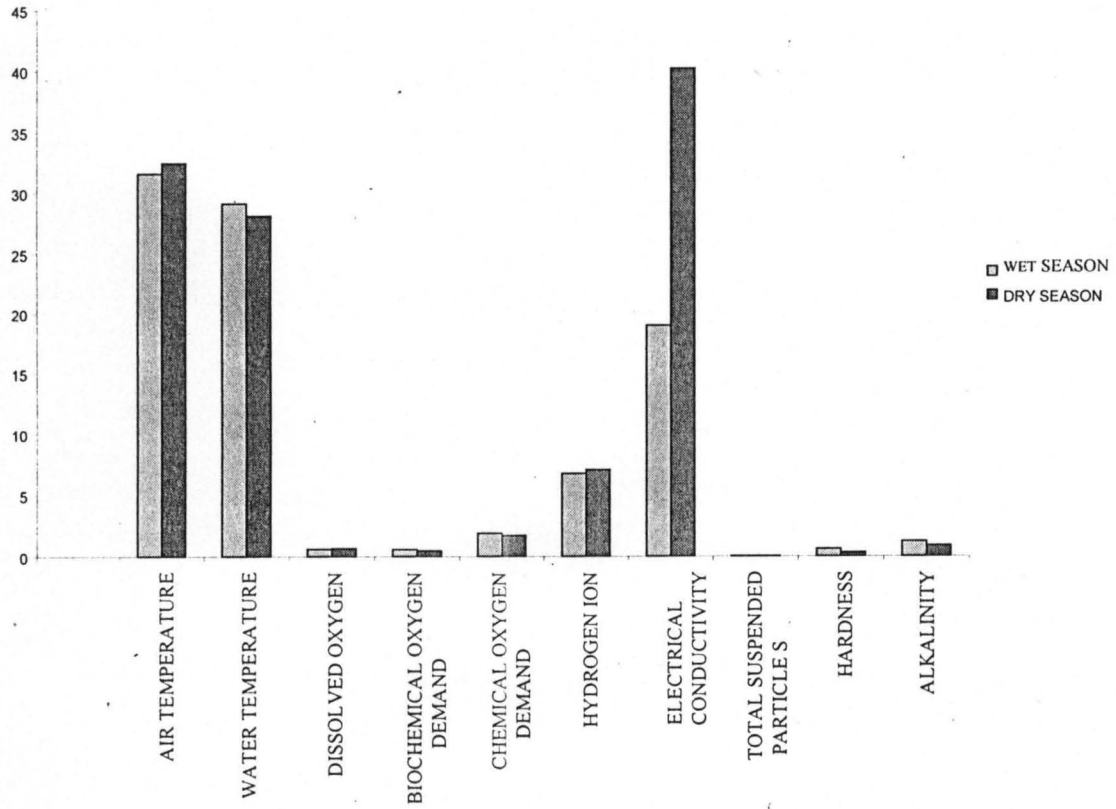

Fig: 4.21 Bar Graph Comparing the Physico-Chemical Parameters between Wet and Dry Season in River Gurara Around Water Falls and Izom Environs.

Table 4.6: Doubtful, Gas develops in a tube after 48 hours (A Presumptive Test).

Water sample code	LB2 x-10ml			LB1 x – 1			LB1 x – 0.1					
TUBE	1	2	3	4	5	6	7	8	9	Ready	MPN	Range probability
ST1	+ve	+ve	+ve	+	+	+	+	+	+	3-3-3	1, 100	150-4, 800
ST2	+	+	+	+	+	+	+	+	+	3-3-3	1, 000	150-4,800
ST3	+	+	+	+	+	+	+	+	+	3-3-3	1, 000	150-4, 800
ST4	+	+	+	+	+	+	+	+	+	3-3-3	1, 000	150-4, 800
ST5	+	+	+	+	+	+	+	+	+	3-3-3	1, 100	150-4,800

Key Note
LB2 x – 10ml = Double strength lactose broth.
LB1 x 1ml = Single strength lactose broth.
MPN = Most probable number.

Table 4.7: Confirm Test of Microbial Examination

Water sample	Coliforms		Portable
Code	EMB plate	Macconkey plate	Not conclusive
ST1	Metallic sheen green pale mucoid colonies	Pale mucoid pink, pink	
ST2	Pale pink, brown colonies	Pink colonies pale pink colonies	
ST3	Methllic dark shean green colonies, pink	Pink colonies pale pink colonies macoid, pink	
ST4	Dark brown colonies pale pink, metallic sheen	Pink colonies pale mucoid colonies	

Table 4.8: Complete Test for Microbial Examination

Water sample code	Lactose broth A/G/(+) or (-)	Gram stain reaction morphology	Portability	
			Portable	Non-portable
ST1	A/G	+ve Cocci clusters, veshort rods		✓
ST2	A/G	-ve rods, +ve cocci		✓
ST3	A/G	-ve rods –ve short rod, +ve cocci long chain		✓
ST4	A/G	-ve rods, +ve cocci in cluster		✓
ST5	A/G			✓

Table 4.9: Standard Total Viable Plate Count for Microbial Examination

Samples code water	**Coliforms cfu/1ml**	**Indicator organisms**
ST1	120	34
ST2	96	25
ST3	130	86
ST4	113	95
ST5	152	96

CHAPTER FIVE

5.0 DISCUSSION

5.1 Physico-chemical Characteristic

This study has been carried out to assess the limnological and microbal properties of River Gurara and the effect of human activities in the environment. The water quality parameters variation between the samples, stations, months and season was revealed.

The result on both air and water temperature for all the stations followed the same pattern in variation figure 4.21 this agreed with the finding of Dickson, (2001). Who indicated that a standard air data can be adopted to predict water temperature as there is a linear relationship between the two parameters. This assertion was confirmed by the observed correlation between air and water temperature.

High temperature value recorded in the month of March (hot dry sub-season) in all the stations is due to intensive sun ray that sub-season, which decrease with the coming of rains. The low temperature value recorded in (December-February) may be due to the effect of dry cool harmattan weather brought about by North East trade wind. Late summer sun rays account for high peak temperature in September - November.

Wade, (1985) observed that the temperature is an important physical factor influencing water quality as well as the distribution and abundance of organisms. The rate of biological and chemical processes depends on temperature ranges for their optimal health. Optimal temperatures for fish depend on the species (Brungs and Jones, 1977). The high temperature value of $37^{O}C$ recorded agreed with the report of Gesamp (1984) who said many organisms within the tropical region live very close to their upper thermal limits. The temperature range for fish is $25^{o}C$-$30^{o}C$ (Dupree and Humer, 1984). Air temperature was the major factor influencing water temperature. Effluents discharged into the body of water also greatly modified Water temperature (Dickson, 2001). Hence the slight high temperature value recorded in sampling

stations 4 and 5 where a lot of human activities are concentrated using the river and discharging waste materials into the water this agreed with what Akpan, 1984 (in Dickson, 2001), observed in the Delimi river in Jos, Plateau, low value of temperature due to harmattan was also observed by some researchers in some African inland water bodies. (Kolo and Olademiji, 2004).

The positive and significant ($P<0.05$) correlation of temperature with total suspended particles agrees with work of Boyd and Frobish (1990). Findings in which they observed that temperature of surface waters in turbid (pond) are greater than those of clear water Table 4.21. Dickson, (2001), observed dissolved oxygen concentration was highest in the period of high abundance of aquatic organisms.

The low dissolved oxygen recorded in all the station was list expected due to the nature of river course that is full of rapids and falls causing the river to flow- fast and swift that is expected to have been highly aerated because of turbulence and revised is the findings. The low dissolved oxygen may likely be due to high discharge of organic and inorganic waste into the river, through surface-run-off and human activities around the river bank, this agrees with findings of other researchers. Who reported that water with high organic or inorganic pollution have very little oxygen dissolved in them. The reason for low dissolved oxygen in this finding is open for further research.

High value of dissolved oxygen recorded in all the stations between December – February may be due to cool weather, cool water contains more dissolved oxygen than warm water (APHA, 1990).

The low dissolved oxygen mean value recorded in station 1 in dry season could be as a result of shallow, clear water that might easily be heated up due to high sun ray radiation which occurred at that sub-season, might resulted to high temperature of about 42°C.

Biochemical oxygen demand measures the amount of oxygen consumed by micro organisms in organic matters in stream water and also measures the chemical oxidation of organic matters (APHA, 1990).

The higher biochemical oxygen demand mean value recorded at station 2 could be as a result of pool at the foot of the water falls, which might have accumulated organic sediments and high temperature causing the decay of organic matters using up the dissolved oxygen leading to lower dissolved oxygen content and high Biochemical oxygen demand value. Similar effect was observed in Eleiyele reservoir in Ibadan by Obioha, 1984 (in Kolo, 1996).

The least means value recorded in stations 3, 4, and 5 in the month of (January-February) might be due to cool weather (harmattan) which might inhibited the decomposition of organic matters by microbes at that period. Biochemical oxygen demand levels at a sampling site with slower, deeper water might be higher for a given volume of organic and inorganic materials than the levels for a similar site in highly aerated waters (APHA, 1990).

Flood effluent resulting into inundation of wood lands could had been responsible for higher wet season mean value in stations 2, 3 and 4 respectively. Biochemical oxygen demand correlation with hardness agreed with report of (APHA, 1990).

The rate of oxygen consumption in a stream is affected by a number of variables such as temperature, pH, presence of certain kinds of microorganisms and the type of organic and inorganic materials in the water.

High chemical oxygen demand recorded in station 1 during dry season could be due to shallowness of water that easily get heated up resulting into high water temperature which in turn encourage chemical weathering of the bed rock. The higher mean value in warm rainy sub-season (June -August) may be due to decomposition of organic load, and February-March (hot dry sub-season is due to high discharge of organic matters due to high human activities who depend greatly on the river at this period for water might be responsible for the higher chemical oxygen demand at this sub-season.

The pH range (6.3-7.1) recorded in this study agreed with recommended range of (6.5-7.5) that will support aquatic life including fish (Boyd, 1979). Largest variety of aquatic animals prefers a range of 6.5-8.0 p^H outside this range there is reduction in the biodiversity in the stream, because it stresses the physiological system of most organisms and reduce their reproduction (APHA, 1990). The hydrogen ions of Gurara River varied in all the stations with slight increase in wet season. This could be due dilution effect of rain fall on the river. (Nwokedi, 1995). The slight low p^H value recorded from station 5 and 4 could be due to the effluent inflow from N.N.P.C sub-pump station and other human activities such as car washing and domestic sewage disposal into the river at that point.

Electrical conductivity is a measure of the ability of water to conduct an electrical current. It is affected by the presence of inorganic dissolved solids such as chloride, nitrate sulfate and phosphate (anions) and cations , sodium, magnesium, calcium, iron, and aluminum. Organic compounds like oil phenol, alcohol presence in water reduces conductivity.

The value recorded was low in wet season due to dilution factor and increases in dry season due concentration effect of solute and high temperature, the warmer the water, the higher the conductivity, for this reason, conductivity is reported as conductivity at (25 ^{o} C) and explain highest conductivity mean value recorded between (February-May)when higher temperatures where recorded.

The low value recorded in the month of (June – July) could be due to nature of River bed rock of the river course .APHA, (1990). Said conductivity in streams and rivers is affected primary by the geology of the area through which the water flows. Streams that run through areas with granite bed rock tend to have lower conductivity because granite is composed of more inert materials that do not ionize when washed into the water.

The higher dry season mean value was also observed by Ovie (1993) and Kolo (1996) in Shiroro Dam reservoir. Studies of Inland fresh waters indicated that streams supporting good mixed fisheries have a range between 150 and 500 μhoskm. Conductivity outside this range

could indicate that it is not suitable for certain species of fish or macroinvertebrate (APHA,1990).

The conductivity value recorded failed below this range and this might accounted for few fish species composition and low catch per effort from this river.

Turbidity is a measure of water clearity how ever the material suspended in water decrease the passage of light through the water. Higher turbidity increases water temperature because suspended particles absorb more heat. This in turn reduces the concentration of dissolved oxygen (O_2) because warm water holds less dissolve oxygen than cold water (APHA,1990). The total suspended particles value recorded was generally low in all the stations. This may be due to nature of this River at this section being confirmed to it deep course, it characteristic swift flow and rocky bed nature that reduces erosion and removal of sand particles etc.

High mean value recorded in the month of April-May could be due to suspended dust particles in the air which are washed down rain, in September-November could be due to high flood regime. The very low (zero) value recorded in station 4 and 5 in the month of July and May respectively could be to due low precipitation recorded in July and breakage of river bed gradient slope around Izom township bridge, which might had result into sedimentation of the particles (load).

The highest value recorded in station 1 and 3,could be due to large surface area as a result of widest width of River course at station 1and effluent from river Tafa tributary that brings additional suspended particles from surface run-off and the flood which brings in allochthanous materials.

The water hardness higher mean value recorded at station 5 and 4 may be due to decay process as a result of less water movement and moderate temperature, while high value in station 1 may be due to swifter water movement which aerates the water and encourage decay processes which in turn enhance acidic condition.

Higher wet season mean value in all the stations could be due to chemical weathering processes as a result of swift water movement. The low water hardness in all the stations suggest that the water is soft and have low level of calcium and magnesium, carbonate minerals in the river course since carbonate mineral have been implicated in influence the degree of water hardness (Boyd,1979). The record of this research agreed with finding of others on some Nigeria Inland water bodies (Adebisi,1981, and Kolo,1996).

Higher mean value in April-may could be due to mineralization as a result of higher temperature which believes to be high in dry season. Soft water (0-75mgh) $caco_3$ harness, which is within range of this research finding, soft water are known to be less productive water for fish production (Thurston et al,1979).

Alkalinity higher mean value recorded in all the stations in the month of (August-October) may be due to the dilution effect, less water movement, lower temperature, less weathering and decomposition process, while lowest mean value recorded at station 5 in the month of April-May, might result from acidic nature resulting from concentration effect during this period as a result of decay of organic matters, higher temperature and lower dissolved oxygen.

Low water alkalinity is associated to a consequent low productivity in aquatic ecosystem (Khan and Ejike, 1998).However a trend of lower wet season mean value was observed in some Nigeria water bodies (wright,1985 and Kolo,1996) which is not agreeing with the finding of this study.

5.2 Microbial Composition

Microbial analysis shows the presence of indicator organisms of bacteria and fungi Isolates Table 4.4 and 4.5.

High number of species isolate from stations 5, 3 and 4 from sample water might be due to eutrophication of water with organic and inorganic materials which provide nutrient for the bacteria to grow, as a result of several human activities carried out around this station. The

prevalence of few species, like *streptococcus faccalis*, *pseudomonas aeruginosals, Esherichia coli* and *staphylococus aureus* were more in hot dry season which indicated that they are thermophilic and shows contamination of human and animals feces on the water.

The highest occurrence of species during wet season than dry season could be due to favourable condition and unfavourable weather condition of dry cool harmattan and hot season high temperature might have inhibited the microbial growth Figure 4.2 and 4.3.

The highest number of the species recorded on the month of May in all stations might be due to the early rain with high surface run-off. This agreed with the finding of (Cody *et al.*, 1961). Who reported the result of a mild rain is to greatly increase the bacteria contamination of a body of water.

Coliforms and fecal streptococci are indicator organisms commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic organisms. therefore, their presence in Rivers suggest that swimming in this river/streams, drinking water and eating fish from this source might be a risk, since it is difficult, time consuming and expensive to test directly for presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead). Sources of contamination include waste water treatment plant, on site septic system, domestic and wild animal manure and storm run-off. The same sources are also for river Gurara considering the nature of the environment; swift flow would have distributed the pathogens easily in the entire water column.

The source of effluent to river Gurara include irrigation, herbicide, pesticides application, human and animal feces, sewage, bathing, washing cloth (laundry) car washing and N.N.P.C pumping sub-station treated effluent might be responsible for the organisms isolated.

The pathogens isolated from the sample water i.e. bacteria species and fungi species are known to be associated with common health hazards and possible health risk are suffered by the water (river) users from time to time.

Coliforms e.g. *E.coli* and *Aeromons sp* isolated from sample water are of human origin and posed great health implication other species of bacteria could be from soil air and vegetation.

Fungi species isolated are opportunistic organisms hence people with immunosupression e.g. HIV/AIDS, diabetes etc. may be at a risk if they drink water from this River.

The monthly disease routine report (1994-2003) of Gurara local Government Primary Health Care unit, showed that Bonu, Gawu/Lambatta and Izom settlements had high and frequent records of disease like vomiting and diarrhea, thyphoid fever, cholera epidemic in 1996 and 2002, urinary track infections, skin diseases, conjuvititsis and wound infections. These diseases listed above are common to this communities and can be linked to bacteria and fungi as reported by (Ernest *et al*, 1970). The isolates recorded are pathogenic in nature and can be categorically said might be responsible for those diseases suffered by these communities. a similar disease are reported to be experienced among the Nupe's, who lives in riverine areas, claimed the use of herb, *Nymphea lotus* (aquatic plant) as remedy for such bacteria and fungi diseases. (Yisa *et al.*, 2004).

The highest record of fungi species in the month of May and wet season in stations could be as a result of high water regime and surface run-off leading to eutrophication which provide suitable medium for fungal growth.

CONCLUSION

The results of the physicochemical analysis shows that all the water quality parameters considered in this research fell within the tolerant level recommend by the World Health Organization (WHO, 1987). Except for dissolved oxygen, electrical conductivity and hardness which are below recommended range for fish production. Microbal analysis revealed the presence of coliform indicator organisms, station 3,4 and 5 revealed high level of total and faecal contamination which Coliform Unit (CFU) is above 50cfu per/100l for third world countries

recommended by WHO. This pollution may be due to over dependence on the river during the dry season. All the evidence of faecal pollution throughout the study period agrees with the Bacteriological and chemical analysis of source of portable water in Niger state reported by Okhawere, 2003. This result also agreed with the findings of Ampofo (1997) in a survey of microbial pollution of rural domestic water supply in Ghana. He further said that inadequate availability of water supply will hamper people's efforts to practice personal hygiene frequent fetching, washing, and bathing in the river will expose the river to pollution and user to infection. The use of river Gurara for drinking, bathing, irrigation, swimming and fish poses a great health risk for the river is non-portable and its potentials for fish production is average (low).

RECOMENDATIONS

A. Basic Health education for the communities on the danger of hazards associated with bacterially polluted water.

B. Organise effective monitoring team for water quality control by Ministries of Agriculture, Water resources and Health.

C. Provision of portable water supply to the communities (Bore hole, and tap water).

D. Boiling and filtering the water before drinking it, washing vegetables with saline water (salt) before eating and avoid swimming in the river.

E. Encourage good practice of personal hygiene, i.e. avoid bathing, defecating in the River, and proper use of latrine etc.

F. Discourage discriminate use of fertilizer, herbicide, pesticide and fish biocide in the river.

G. Nigerian National Petroleum Cooperation pump sub-station should treat their effluent before discharging it into the river.

H. The use of water purifier (tablet or sachet can be used to make the water safe for drinking at individual or family level.

I The digging of well for source of water should be encouraged.

K The low dissolved oxygen mean value recorded is subject to further investigation by other

researchers.

L Fish farm can be sited at the bank of River Gurara along its course.

M Ditches found on River bank around Izom settlement can be converted into earth pond.

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Appndix:I Monthly Water quality parameters measure at different Stations River Gurara

		tem air	tem water	pH	tsp	ec	bod	cod	alk	hard	do
ıne	1										
2004	2										
	3	30	27	6.41	0.01	4.8	0.36	5.6	0.4	0.2	0.8
	4	26	27	6.5	0.02	5.5	0.24	5.6	0.3	0.16	0.72
	5	27	26	6.24	0.01	6.5	0.14	5	0.43	0.16	0.76
ULY	1	30	27	6.38	0.01	5.2	0.4	5.2	0.56	0.66	0.88
	2	30	26	6.43	0.02	4.7	0.64	5.6	0.52	0.55	0.2
	3	30	26	6.53	0.01	3.9	0.36	5.6	0.48	0.56	0.09
	4	31	27	6.57	0	4.8	0.28	5	0.54	0.66	0.09
	5	31	27	6.06	0.01	3.7	0.4	6	0.48	0.65	0.94
UGUST	1	27	25	6.65	0.01	6.6	0.56	0.11	0.68	0.76	1.08
	2	27	26	6.67	0.01	4.7	0.28	0.12	0.76	0.64	0.8
	3	27	26	6.55	0.03	4.7	0.4	0.1	0.9	0.68	0.88
	4	27	26	6.51	0.01	4.5	0.4	0.7	0.7	0.62	0.68
	5	27	26	6.49	0.01	4.6	0.2	0.9	0.76	0.64	0.72
SEPT	1	27	25	6.53	0.01	5.7	0.8	1.2	4.8	0.6	0.52
	2	27	25	6.4	0.01	5.7	0.88	1.22	2.8	0.5	0.18
	3	26	24	6.33	0.01	7.8	0.65	1.1	4.5	0.7	0.84
	4	27	25	6.18	0.01	8.2	0.85	1.2	6.5	0.6	0.17
	5	26	24	6.5	0.01	7.8	0.78	1.2	4	1.6	0.2
OCT	1	28	26	7.01	0.06	11.02	0.38	0.54	0.48	0.44	0.52
	2	28	28	7.07	0.03	11.76	0.68	1.12	0.48	0.42	0.18
	3	30	30	7.6	0.01	15.01	0.98	1.2	0.82	0.7	0.84
	4	27	27	6.84	0.02	11.88	0.7	1.2	0.4	0.38	0.17
	5	27	27	7.02	0.01	11.87	0.4	0.98	0.56	0.48	0.2
NOV	1	30	32	7.11	0.03	13.06	0.42	0.84	0.63	0.34	0.58
	2	30	31	7.09	0.03	11.05	0.68	0.13	0.61	0.38	0.2
	3	30	31	7.12	0.06	11.04	0.7	0.88	0.44	0.64	0.99
	4	30	34	7.19	0.04	12.12	0.98	1.12	0.48	0.34	0.13
	5	30	33	6.84	0.02	11.08	0.4	0.56	0.56	0.42	0.22
DEC	1	30	27	6.7	0.02	11.08	0.4	1.82	0.58	0.36	0.6
	2	31	26	6.99	0.01	12.23	0.7	1.12	0.54	0.32	0.19
	3	32	25	7.19	0.02	11.47	1.2	2	1.14	0.82	0.84
	4	30	27	6.91	0.03	11.04	0.7	0.84	0.44	0.3	0.18
	5	32	26	6.08	0.02	12.07	0.4	1.42	0.62	0.56	0.27
AN.05	1	30	23	6.98	0.01	10.57	0.68	2.62	0.62	0.4	0.6
	2	30	25	7.02	0.01	24.07	0.4	0.94	0.92	0.2	0.22
	3	31	23	7.13	0.02	27.75	0	0.82	0.76	0.3	0.98
	4	30	23	6.73	0.01	6.7	0.56	1.42	0.74	0.28	0.24
	5	30	23	7.13	0.01	19.92	1.14	2.24	0.74	0.22	0.28
EB	1	31	24	6.73	0.01	75.2	0.26	2.24	2.88	0.1	2
	2	31	23	7.06	0.02	77.3	0.48	3.38	0.9	0.14	2.1
	3	31	24	6.96	0.01	80.4	0.3	3.54	0.94	0.12	1.28
	4	32	22	7.53	0.01	79.6	0	3.2	1.22	0.1	2
	5	32	23	8.13	0.02	92.4	0.32	3.18	0.34	0.2	1.18
AR	1	39	34	6.93	0.02	62.9	0.42	2.3	1.2	0.8	0
	2	40	37	7.15	0.02	62.3	0.18	2.8	1.22	0.12	0.38
	3	40	35	7	0.01	85.7	0.22	0.88	1.18	0.24	0.28
	4	39	35	7.02	0.01	97.6	0.1	0.92	1.04	0.24	0.16
	5	40	36	7.13	0.02	86.4	0	1.42	1.04	0.22	0.24
PRIL	1	39	35	7.01	0.06	18.2	0.15	0.25	0.7	0.23	0.23
	2	40	37	7.07	0.03	17.6	0.9	1.12	0.71	0.25	0.2
	3	40	35	7.06	0.03	13.5	0.23	0.39	0.82	0.26	0.06
	4	40	35	6.89	0.04	18.9	0.13	0.24	0.89	0.3	0.16
	5	39	36	7.02	0.04	18.7	0.13	0.25	0.1	0.32	0.13
AY	1	40	35	7.02	0.01	71.7	0.58	0.66	0.72	0.86	0.8
	2	41	35	7.05	0.02	67.5	1.7	1.76	0.72	0.78	1.2
	3	40	36	7.01	0	87.5	1.42	1.84	0.82	1.22	1.64
	4	39	36	7.12	0.01	76.5	1.2	1.6	0.96	1.38	1.48
	5	41	37	7.02	0	77.4	0.96	0.14	1.05	0.96	1.8

Appendix: 2

Appendix Mean monthly water quality parameter

Months	Air Temp	Water Tei	pH	TST	Elect. Cond.	BOD mg/L	CODmg/g	Alkalinity	Hardnes	Domg/L
June	27.70	26.67	6.38	0.01	5.60	0.25	5.40	0.88	0.17	0.76
July	30.4	26.6	6.39	0.01	4.44	0.42	5.48	0.52	0.62	0.44
Aug	27	25.8	6.57	0.01	5.02	0.37	0.39	0.76	0.67	1.91
Sep	26.6	24.6	6.39	0.01	7.04	0.79	2.19	4.52	0.8	0.38
Oct	28	27.6	7.11	0.03	12.31	0.63	0.59	0.55	0.48	0.38
Nov	30	32.2	7.07	0.04	11.67	0.64	0.51	0.54	0.42	0.42
Dec	31	26.2	6.77	0.02	11.58	0.52	1.22	0.66	0.47	0.42
Jan	30.2	23.4	7.01	0.01	12.8	0.58	1.61	0.76	0.28	0.46
Feb	31.4	23.2	7.28	0.01	80.98	0.67	3.14	1.26	0.13	1.75
Mar	39.6	35.4	7.05	0.02	78.98	0.18	1.02	1.14	0.32	0.21
April	66	59	11.68	0.05	28.97	0.56	0.22	1.07	0	0.27
May	40.2	35.6	7.04	0.01	76.12	1.21	0.49	0.85	0.82	1.58

Appendix:3 Correlation Analysis of Physico-chemical parameters of Aurora River

Sample Correlations

	airtemp	wattemp	pH	TSP	EC	BOD
airtemp	1.0000	.7613	.3871	.1024	.6145	.0503
	(58)	(58)	(58)	(58)	(58)	(58)
	.0000	.0000	.0027	.4441	.0000	.7079
wattemp	.7613	1.0000	.2726	.2826	.3600	.0982
	(58)	(58)	(58)	(58)	(58)	(58)
	.0000	.0000	.0384	.0316	.0055	.4634
pH	.3871	.2726	1.0000	.2519	.5216	.1021
	(58)	(58)	(58)	(58)	(58)	(58)
	.0027	.0384	.0000	.0564	.0000	.4456
TSP	.1024	.2826	.2519	1.0000	-.2041	-.1270
	(58)	(58)	(58)	(58)	(58)	(58)
	.4441	.0316	.0564	.0000	.1244	.3419
EC	.6145	.3600	.5216	-.2041	1.0000	-.0264
	(58)	(58)	(58)	(58)	(58)	(58)
	.0000	.0055	.0000	.1244	.0000	.8441
BOD	.0503	.0982	.1021	-.1270	-.0264	1.0000
	(58)	(58)	(58)	(58)	(58)	(58)
	.7079	.4634	.4456	.3419	.8441	.0000
COD	-.1492	-.3041	-.2969	-.3211	-.0259	-.1407
	(58)	(58)	(58)	(58)	(58)	(58)
	.2635	.0203	.0236	.0140	.8467	.2921
ALK	-.1799	-.2239	-.3300	-.2501	-.0297	.1642
	(58)	(58)	(58)	(58)	(58)	(58)
	.1766	.0910	.0114	.0583	.8247	.2182
HARD	.0376	.1272	-.1986	-.2506	-.0404	.5276
	(58)	(58)	(58)	(58)	(58)	(58)
	.7792	.3415	.1351	.0577	.7633	.0000
DO	.0459	-.1665	.1853	-.2514	.4944	.1130
	(58)	(58)	(58)	(58)	(58)	(58)
	.7322	.2116	.1638	.0570	.0001	.3983

Coefficient (sample size) significance level

Appendix 3 Continued

	COD	ALK	HARD	DO
airtemp	-.1492	-.1799	.0376	.0459
	(58)	(58)	(58)	(58)
	.2635	.1766	.7792	.7322
wattemp	-.3041	-.2239	.1272	-.1665
	(58)	(58)	(58)	(58)
	.0203	.0910	.3415	.2116
pH	-.2969	-.3300	-.1986	.1853
	(58)	(58)	(58)	(58)
	.0236	.0114	.1351	.1638
TSP	-.3211	-.2501	-.2506	-.2514
	(58)	(58)	(58)	(58)
	.0140	.0583	.0577	.0570
EC	-.0259	-.0297	-.0404	.4944
	(58)	(58)	(58)	(58)
	.8467	.8247	.7633	.0001
BOD	-.1407	.1642	.5276	.1130
	(58)	(58)	(58)	(58)
	.2921	.2182	.0000	.3983
COD	1.0000	-.1467	-.1394	.1618
	(58)	(58)	(58)	(58)
	.0000	.2718	.2967	.2250
ALK	-.1467	1.0000	.2489	.0046
	(58)	(58)	(58)	(58)
	.2718	.0000	.0595	.9729
HARD	-.1394	.2489	1.0000	.1380
	(58)	(58)	(58)	(58)
	.2967	.0595	.0000	.3017
DO	.1618	.0046	.1380	1.0000
	(58)	(58)	(58)	(58)
	.2250	.9729	.3017	.0000

Appendix:4

Table : Summary Statistics for the Physico-chemical Parameters at Different Stations of Gurara River

	Minimum	Maximum	Sum	Mean	Std. Deviation
Raining Season					
Air Temperature (^{O}C)	26.00	41.00	1042.00	31.58	5.76
Water Temperature (^{O}C)	24.00	37.00	960.00	29.09	4.58
pH	6.06	7.60	221.74	6.72	0.35
Total Suspended Particles (g/ml)	0.00	0.06	0.58	0.02	0.02
Electrical Conductivity (µmhos/cm)	3.70	87.50	628.34	19.04	25.07
Biochemical Oxygen Demand (mg/l)	0.13	1.70	19.16	0.58	0.38
Chemical Oxygen Demand (mg/l)	0.10	6.00	64.74	1.96	2.06
Alkalinity (mg/l)	0.10	6.50	40.34	1.22	1.51
Hardness (mg/l)	0.16	1.60	19.92	0.60	0.33
Dissolved Oxygen (mg/l)	0.06	1.80	20.18	0.61	0.47
Dry Season					
Air Temperature (^{O}C)	30.00	40.00	811.00	32.44	3.73
Water Temperature (^{O}C)	22.00	37.00	702.00	28.08	5.08
pH	6.08	8.13	175.85	7.03	0.34
Total Suspended Particles (g/ml)	0.01	0.06	0.49	0.02	0.01
Electrical Conductivity (µmhos/cm)	6.70	97.60	1005.05	40.20	34.15
Biochemical Oxygen Demand (mg/l)	0.00	1.20	11.74	0.47	0.33
Chemical Oxygen Demand (mg/l)	0.13	3.54	42.63	1.71	0.98
Alkalinity (mg/l)	0.34	2.88	21.78	0.87	0.50
Hardness (mg/l)	0.10	0.82	8.16	0.33	0.20
Dissolved Oxygen (mg/l)	0.00	2.10	16.14	0.65	0.63

Appendix:5

ppendix iv: Bacteria organisms sited in each stations in the isolated water sample

	Stations		Strep	Pseu	Esc	Salm	Stap	Kleb	Prot	Baci	Aero	Strep
		1	0	0	1	0	1	0	0	0	0	0
		2	1	0	1	1	0	0	0	1	0	0
Jun-04		3	1	0	1	0	0	0	0	0	0	1
		4	0	1	0	0	1	0	0	0	1	0
		5	0	1	0	0	0	0	0	0	0	0
	Total		**2**	**2**	**3**	**1**	**2**	**0**	**0**	**1**	**1**	**1**
		1	0	0	0	0	1	0	0	0	0	0
		2	0	0	1	1	0	0	0	0	0	0
Jul-04		3	0	0	0	0	0	0	0	0	0	0
		4	0	0	0	0	0	0	0	0	0	0
		5	0	1	0	0	0	0	0	0	0	0
	Total		**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
		1	0	0	1	0	1	0	0	0	0	0
		2	0	0	1	0	0	0	0	1	0	0
Aug-04		3	0	1	1	0	1	0	0	0	0	0
		4	1	0	0	0	1	0	0	0	0	0
		5	1	0	1	0	0	0	0	0	0	0
	Total		**2**	**1**	**4**	**0**	**3**	**0**	**0**	**1**	**0**	**0**
		1	0	0	1	0	1	0	0	0	0	0
		2	0	0	0	1	0	0	0	0	0	0
Sep-04		3	0	0	1	0	0	1	0	0	0	0
		4	1	0	0	0	1	0	0	0	1	0
		5	0	0	1	0	0	0	0	0	0	0
	Total		**1**	**0**	**3**	**1**	**2**	**1**	**0**	**0**	**1**	**0**
		1	0	0	0	0	0	1	0	0	0	0
		2	0	0	0	0	1	0	0	0	0	0
Oct-04		3	0	1	0	0	0	0	0	0	0	0
		4	0	0	1	0	0	0	0	0	0	0
		5	1	0	0	0	0	0	1	0	0	1
	Total		**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**1**
		1	0	0	0	0	0	1	0		1	0
		2	0	0	0	0	1	0	0	0	0	0
Nov-04		3	0	1	0	0	0	0	0	0	0	0
		4	0	0	1	0	0	0	0	0	0	1
		5	1	0	0	0	0	0	1	0	1	0
	Total		**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**2**	**1**
		1	0	0	1	0	0	0	0	0	0	0
		2	0	0	0	0	1	0	0	0	0	0
Dec-04		3	0	1	0	0	0	0	0	0	0	0
		4	0	0	0	0	0	0	0	0	0	0
		5	1	0	0	1	0	0	0	0	1	0
	Total		**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**
		1	0	0	1	0	0	0	0	0	0	0
		2	1	1	0	0	1	0	0	0	0	0
Jan-05		3	0	0	1	0	0	0	0	0	1	0
		4	0	1	0	0	0	1	0	0	0	0
		5	0	0	0	0	0	0	0	1	0	0
	Total		**1**	**2**	**2**	**0**	**1**	**1**	**0**	**1**	**1**	**0**

Appendix 5 Continued

	1	0	1	0	0	0	0	0	0	0	0
	2	0	0	0	0	1	0	0	0	0	0
Feb-05	3	0	0	1	0	0	0	0	1	0	0
	4	1	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	1	0
Total		**1**	**1**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**
	1	0	1	1	0	1	0	0	0	0	0
	2	1	0	0	0	0	0	0	0	0	0
Mar-05	3	0	0	0	0	0	0	0	0	0	0
	4	1	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0
Total		**2**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
	1	0	1	1	0	0	0	0	0	0	0
	2	0	0	0	0	1	0	0	0	0	0
Apr-05	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	1	0	0	0	0
	5	1	0	0	0	0	0	0	0	0	0
Total		**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**
	1	1	1	1	0	0	0	0	0	0	0
	2	0	0	0	1	1	0	0	0	0	0
May-05	3	0	0	0	0	0	1	1	0	0	0
	4	1	0	0	0	0	0	0	1	0	0
	5	0	0	0	0	1	0	0	0	1	0
Total		**2**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**0**

0 = Not present
1 = Present

Appendix: 6

Appendix v: Fungal species in each stations in the isolated water sample

	Station	Aspe	A.Para	A.niger	Renic	Fusa	Rhizo	A.glau	A.flau	Mucar	A. nid	A.Ver	A.gla	A.ver
	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	1	0	0	0	0	0	0	0	0	0	0	0
Jun-04	3	0	0	1	0	0	1	0	1	1	0	0	0	0
	4	0	0	1	0	1	1	0	1	1	0	0	0	0
	5	0	0	1	0	0	0	0	1	1	0	0	0	0
	Total	**0**	**1**	**3**	**0**	**1**	**2**	**0**	**3**	**3**	**0**	**0**	**0**	**0**
	1	0	1	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	1	0	0	0	0	0	0	0	0	0	0
Jul-04	3	1	0	0	0	1	0	0	1	1	0	0	0	0
	4	0	0	1	0	0	1	0	1	1	0	0	0	0
	5	0	1	1	0	0	0	0	0	1	0	0	0	0
	Total	**1**	**2**	**3**	**0**	**1**	**1**	**0**	**2**	**3**	**0**	**0**	**0**	**0**
	1	0	0	1	0	1	0	0	0	0	1	0	0	0
	2	1	0	0	0	0	1	0	0	0	0	0	0	0
Aug-04	3	0	0	1	0	0	0	0	1	0	0	0	0	0
	4	0	1	1	0	0	1	0	0	1	0	0	0	0
	5	1	0	1	0	0	0	0	0	0	0	0	0	0
	Total	**2**	**1**	**4**	**0**	**1**	**2**	**0**	**1**	**1**	**1**	**0**	**0**	**0**
	1	0	1	1	0	0	0	0	1	0	0	0	0	0
	2	0	0	1	0	0	0	0	0	0	0	0	0	0
Sep-04	3	1	0	0	0	1	0	0	0	0	0	0	0	0
	4	0	0	0	1	0	1	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	1	0	0	0	0	0
	Total	**1**	**1**	**2**	**1**	**1**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
	1	1	0	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	1	0	0	1	0	1	0	0	0	0	0
Oct-04	3	0	0	0	0	0	0	0	0	1	0	0	0	0
	4	1	0	1	0	0	0	0	1	1	0	0	0	0
	5	0	0	1	0	0	0	0	0	1	0	0	0	0
	Total	**2**	**0**	**4**	0	**0**	**1**	**0**	**2**	**3**	**0**	**0**	**0**	**0**
	1	0	0	1	1	0	1	0	1		0	0	0	0
	2	0	1	0	0	0	0	0	0	0	0	0	0	0
Nov-04	3	0	0	0	0	1	0	0	0	0	0	1	0	0
	4	1	0	1	0	1	0	0	0	0	0	0	0	0
	5	0	0	0	1	0	1	0	0	0	0	0	0	0
	Total	**1**	**1**	**2**	2	**2**	**2**	**0**	**1**	**0**	**0**	**1**	**0**	**0**
	1	0	0	0	1	0	0	0	0	0	0	1	0	0
	2	1	1	0	0	1	0	0	1	0	0	0	0	0
Dec-04	3	0	0	1	0	0	0	0	0	0	0	0	1	0
	4	0	0	0	0	0	1	0	0	0	0	0	0	0
	5	0	0	1	0	0	0	0	0	1	0	0	1	1
	Total	**1**	**1**	**2**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**1**	**2**	**1**
	1	0	0	1	0	1	0	0	0	0	0	0	0	0
	2	0	0	0	1	1	0	0	0	1	0	0	0	0
Jan-05	3	0	1	0	1	0	1	0	1	0	0	0	0	0
	4	0	0	1	0	1	0	0	0	0	1	0	0	0
	5	1	0	0	1	1	0	0	0	0	0	0	0	0
	Total	**1**	**1**	**2**	**3**	**4**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**

Appendix 6 Continued

	1	1	0	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	1	0	1	0	0	0	0	0	0	0
Feb-05	3	0	1	0	0	0	0	0	0	1	0	0	0	0
	4	0	1	0	0	0	0	0	0	1	0	0	0	0
	5	0	0	1	0	0	0	0	1	1	0	0	0	0
Total		**1**	**2**	**2**	**1**	**0**	**1**	**0**	**1**	**3**	**0**	**0**	**0**	**0**
	1	0	0	0	0	0	0	0	1	1	0	0	0	0
	2	1	1	0	0	0	0	0	0	0	0	0	0	0
Mar-05	3	0	0	1	1	0	0	0	0	0	0	0	0	0
	4	0	1	0	0	1	0	0	0	0	0	0	0	0
	5	0	0	0	1	0	1	0	0	0	0	0	0	0
Total		**1**	**2**	**1**	**2**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**
	1	1	0	0	0	1	0	0	0	0	0	0	0	0
	2	0	0	1	1	0	0	0	0	0	0	0	0	0
Apr-05	3	0	1	0	0	0	0	0	1	0	0	0	0	0
	4	0	0	1	0	0	0	0	1	1	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		**1**	**1**	**2**	**1**	**1**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**0**
	1	1	1	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	1	1	1	0	0	0	0	0	0	0
May-05	3	0	0	1	0	0	0	1	1	1	0	0	0	0
	4	0	0	0	1	0	0	0	0	0	1	1	0	0
	5	1	1	0	0	0	0	0	1	0	0	0	0	0
Total		**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**0**	**0**

0 = Not present

1 = Present

Appendix:7

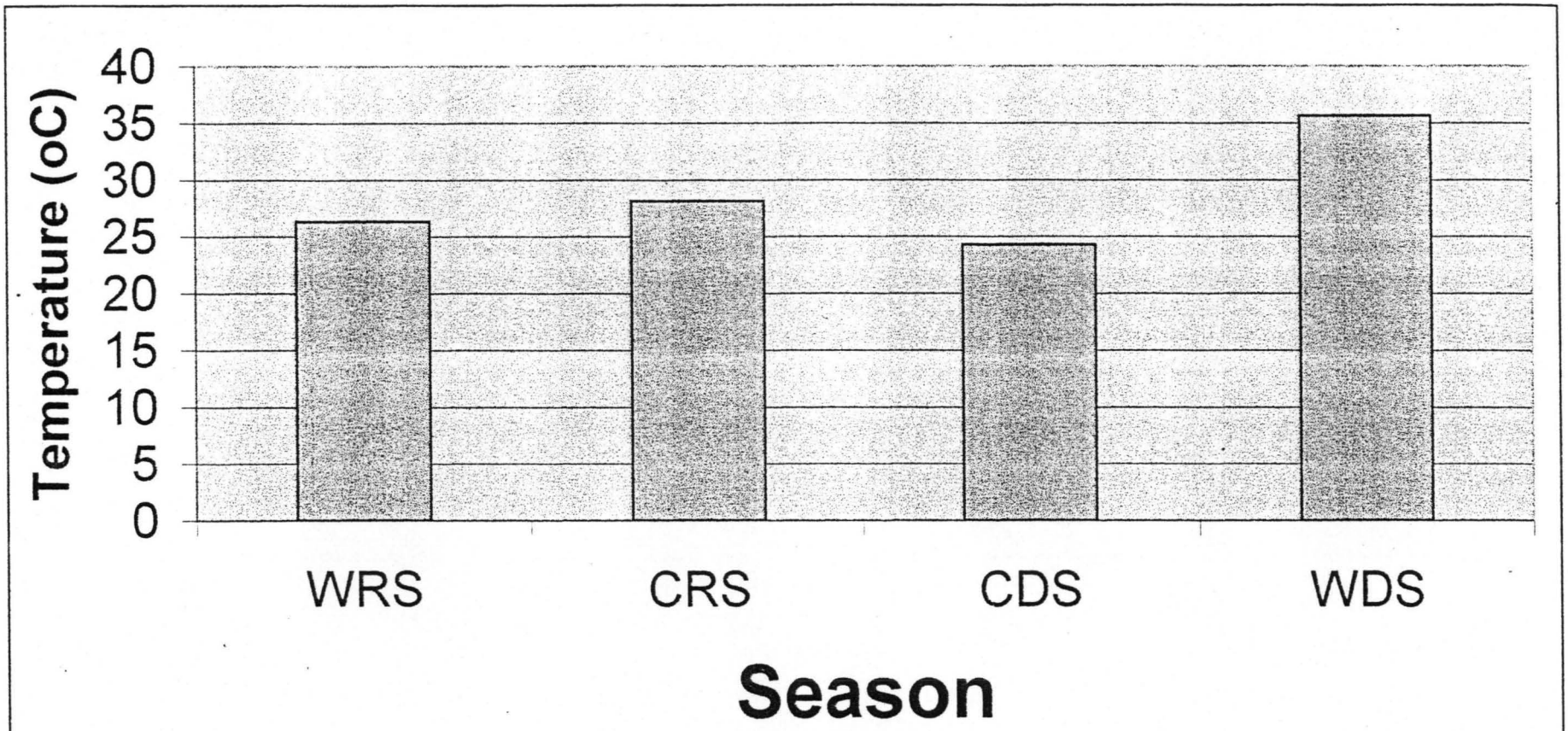

Fig. :Seasonal variation of temperature of water from Gurara waterfall.

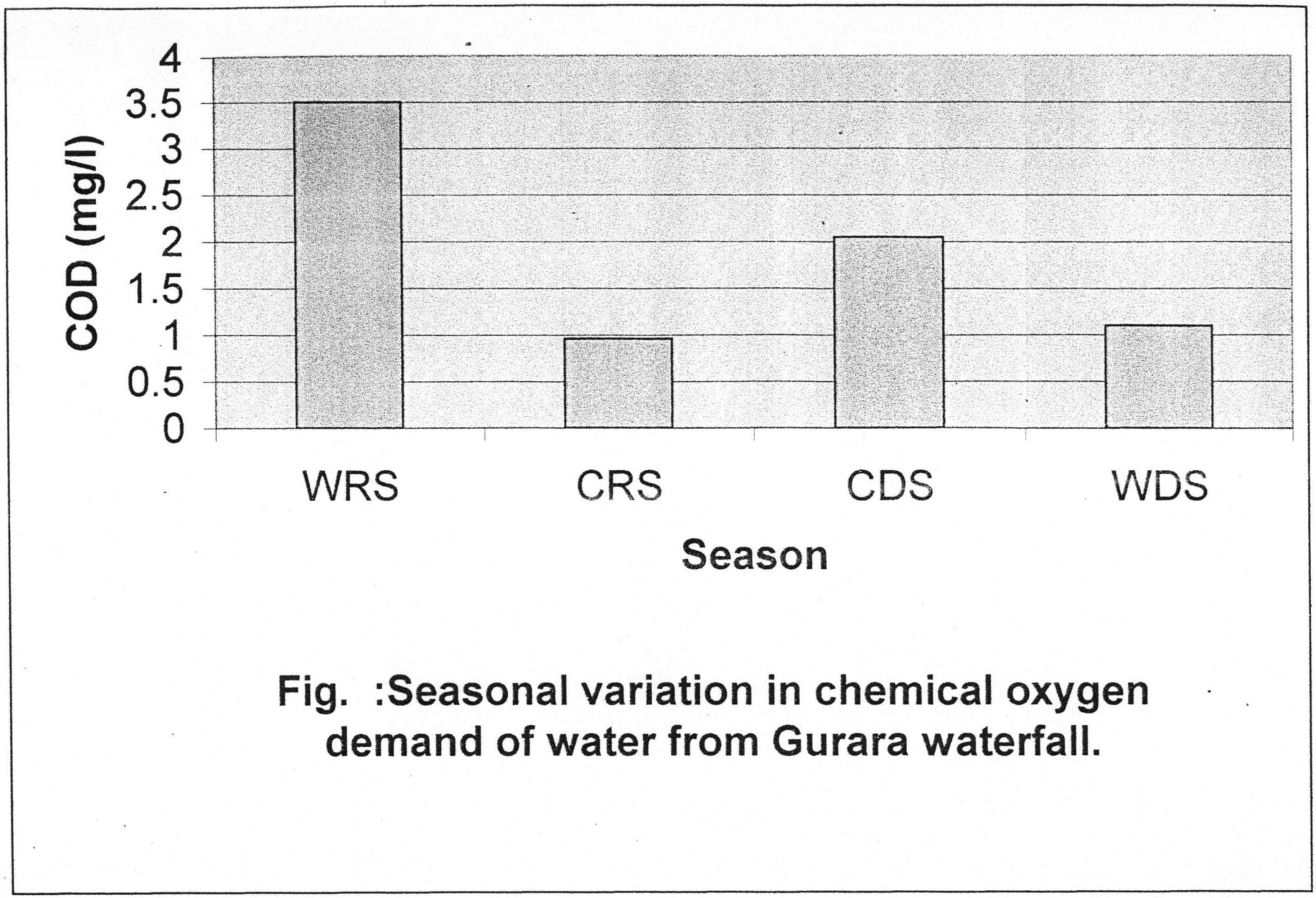

Fig. :Seasonal variation in chemical oxygen demand of water from Gurara waterfall.

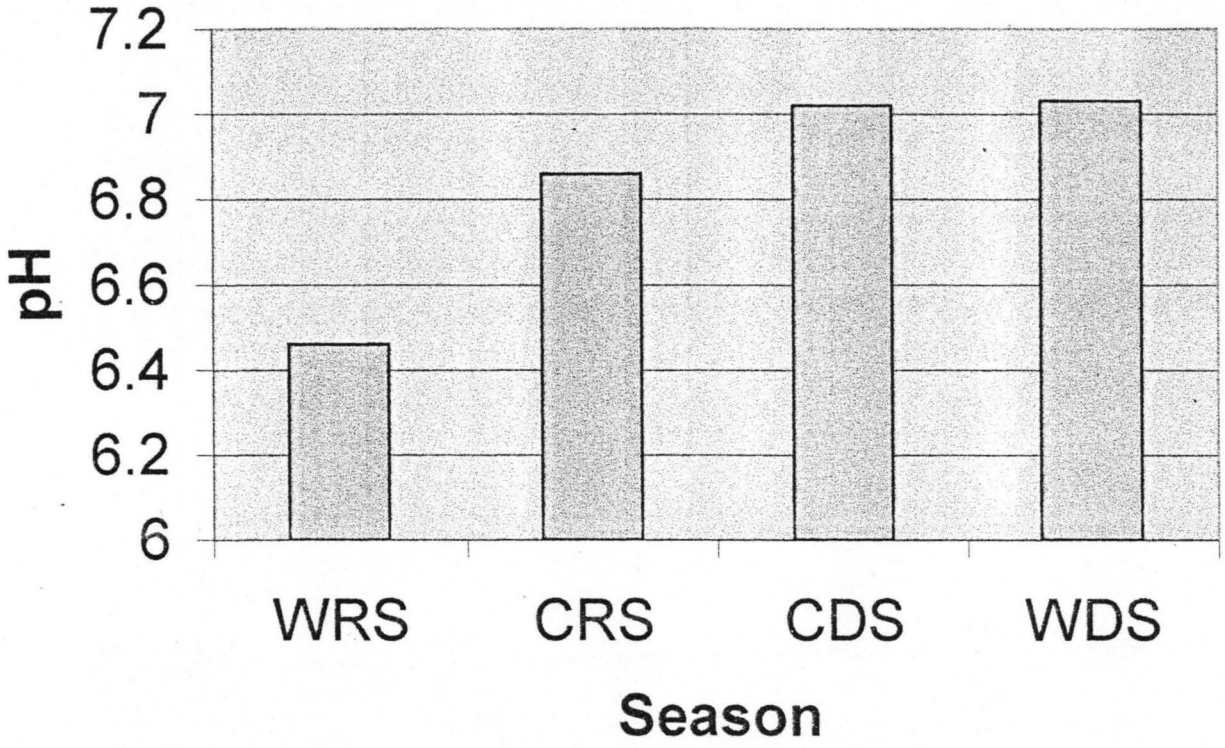

Fig. :Seasonal variation of pH of water from Gurara waterfall.

Appendix:10

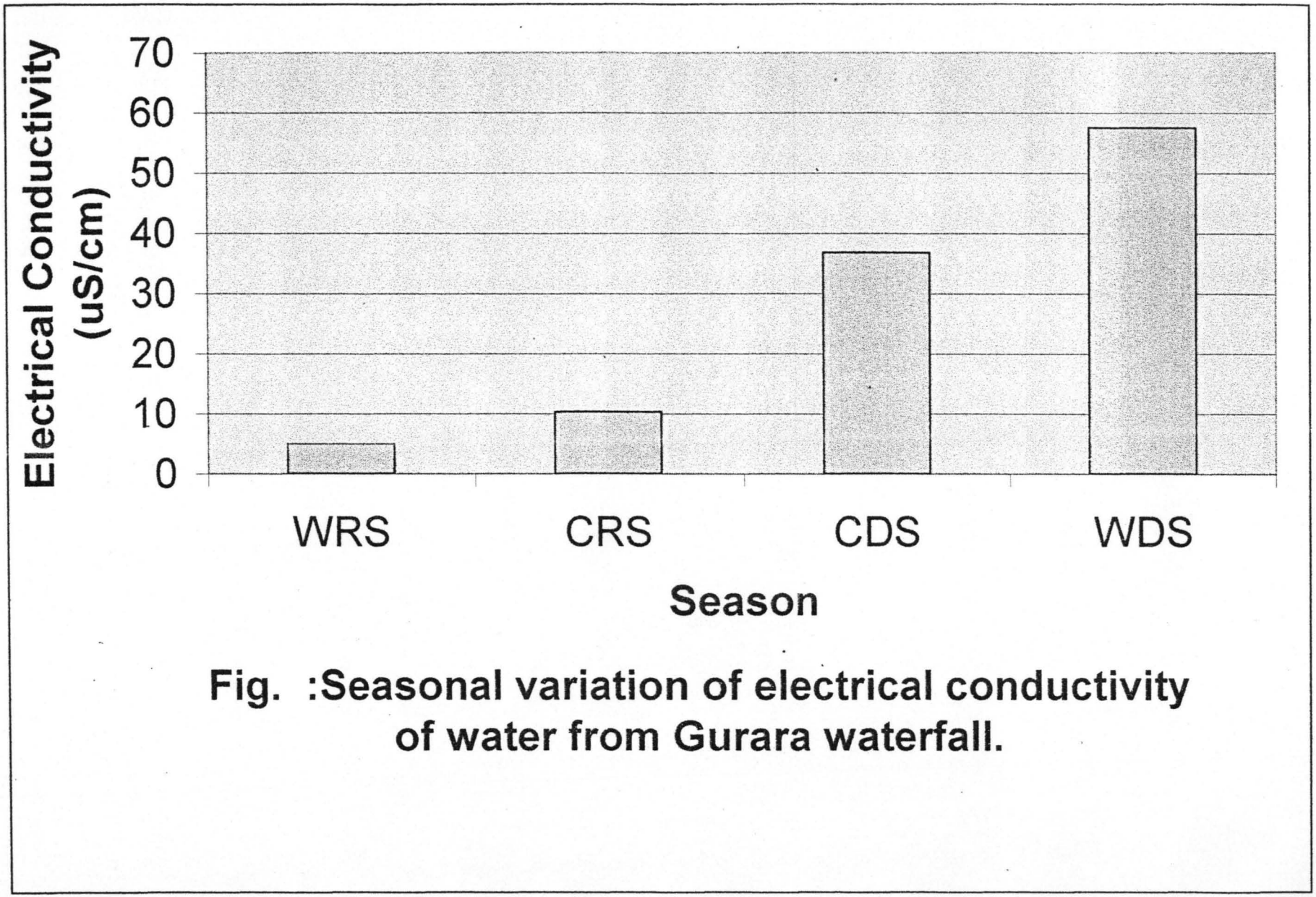

Fig. :Seasonal variation of electrical conductivity of water from Gurara waterfall.

Appendix:11

Analysis of Variance for ADAMA.airtemp

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1381.8855	7	197.41221	30.536	.0000
ADAMA.des	27.2358	4	6.80894	1.053	.3929
ADAMA.des2	1359.2974	3	453.09914	70.086	.0000
2-FACTOR INTERACTIONS	56.861657	12	4.7384714	.733	.7109
ADAMA.des ADAMA.des2	56.861657	12	4.7384714	.733	.7109
RESIDUAL	245.66667	38	6.4649123		
TOTAL (CORR.)	1684.4138	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.airtemp by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
1	11	30.545455	*
4	12	31.500000	*
5	12	31.833333	*
3	12	32.250000	*
2	11	32.272727	*

Multiple range analysis for ADAMA.airtemp by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
2	15	28.200000	*
1	13	28.461538	*
3	15	29.866667	*
4	15	39.800000	*

Appendix: 12

Analysis of Variance for ADAMA.wattemp

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1090.0378	7	155.71968	28.632	.0000
ADAMA.des	1.9702	4	.49256	.091	.9849
ADAMA.des2	1087.9949	3	362.66498	66.684	.0000
2-FACTOR INTERACTIONS	8.3990105	12	.6999175	.129	.9997
ADAMA.des ADAMA.des2	8.3990105	12	.6999175	.129	.9997
RESIDUAL	206.66667	38	5.4385965		
TOTAL (CORR.)	1305.1034	57			

2 missing values have been excluded.

Table of means for ADAMA.wattemp

Level	Count	Average	Stnd. Error (internal)	Stnd. Error (pooled s)	95 Percent Confidence for mean	
ADAMA.des						
1	11	28.454545	1.3906417	.7031485	27.030766	29.878324
2	11	29.000000	1.5491933	.7031485	27.576221	30.423779
3	12	28.500000	1.3679226	.6732135	27.136835	29.863165
4	12	28.666667	1.4319585	.6732135	27.303502	30.029831
5	12	28.666667	1.5291775	.6732135	27.303502	30.029831
ADAMA.des2						
1	13	26.307692	.1748485	.6468026	24.998006	27.617379
2	15	28.133333	.8829963	.6021404	26.914082	29.352585
3	15	24.266667	.4193722	.6021404	23.047415	25.485918
4	15	35.600000	.2350279	.6021404	34.380748	36.819252
ADAMA.des by ADAMA.des2						
1 1	2	26.000000	1.0000000	1.6490295	22.660942	29.339058
1 2	3	27.666667	2.1858128	1.3464269	24.940337	30.392996
1 3	3	24.666667	1.2018504	1.3464269	21.940337	27.392996
1 4	3	34.666667	.3333333	1.3464269	31.940337	37.392996
2 1	2	26.000000	.0000000	1.6490295	22.660942	29.339058
2 2	3	28.000000	1.7320508	1.3464269	25.273671	30.726329
2 3	3	24.666667	.8819171	1.3464269	21.940337	27.392996
2 4	3	36.333333	.6666667	1.3464269	33.607004	39.059663
3 1	3	26.333333	.3333333	1.3464269	23.607004	29.059663
3 2	3	28.333333	2.1858128	1.3464269	25.607004	31.059663
3 3	3	24.000000	.5773503	1.3464269	21.273671	26.726329
3 4	3	35.333333	.3333333	1.3464269	32.607004	38.059663
4 1	3	26.666667	.3333333	1.3464269	23.940337	29.392996
4 2	3	28.666667	2.7284509	1.3464269	25.940337	31.392996
4 3	3	24.000000	1.5275252	1.3464269	21.273671	26.726329
4 4	3	35.333333	.3333333	1.3464269	32.607004	38.059663
5 1	3	26.333333	.3333333	1.3464269	23.607004	29.059663
5 2	3	28.000000	2.6457513	1.3464269	25.273671	30.726329
5 3	3	24.000000	1.0000000	1.3464269	21.273671	26.726329
5 4	3	36.333333	.3333333	1.3464269	33.607004	39.059663
Total	58	28.655172	.3062171	.3062171	28.035125	29.275220

□

Appendix:13

Analysis of Variance for ADAMA.DO

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	2.3525184	7	.3360741	1.012	.4386
ADAMA.des	.6746613	4	.1686653	.508	.7303
ADAMA.des2	1.6772752	3	.5590917	1.683	.1869
2-FACTOR INTERACTIONS	1.6589552	12	.1382463	.416	.9477
ADAMA.des ADAMA.des2	1.6589552	12	.1382463	.416	.9477
RESIDUAL	12.623533	38	.3321982		
TOTAL (CORR.)	16.635007	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.DO by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
4	12	.5166667	*
2	11	.5318182	*
5	12	.5783333	*
1	11	.7100000	*
3	12	.7916667	*

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Multiple range analysis for ADAMA.DO by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
2	15	.3960000	*
4	15	.5853333	*
1	13	.6646154	*
3	15	.8626667	*

Appendix:14

Analysis of Variance for ADAMA.BOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1.3272859	7	.1896123	1.262	.2948
ADAMA.des	.4837296	4	.1209324	.805	.5297
ADAMA.des2	.8092265	3	.2697422	1.796	.1644
2-FACTOR INTERACTIONS	.6518727	12	.0543227	.362	.9692
ADAMA.des ADAMA.des2	.6518727	12	.0543227	.362	.9692
RESIDUAL	5.7084500	38	.1502224		
TOTAL (CORR.)	7.6876086	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.BOD by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
5	12	.4391667	*
1	11	.4772727	*
4	12	.5200000	*
3	12	.5683333	*
2	11	.7154545	*

Multiple range analysis for ADAMA.BOD by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
1	13	.3592308	*
3	15	.5226667	*
4	15	.5573333	*
2	15	.7053333	*

Appendix: 15

Analysis of Variance for ADAMA.COD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	56.627157	7	8.089594	3.156	.0099
ADAMA.des	.362543	4	.090636	.035	.9975
ADAMA.des2	55.487006	3	18.495669	7.215	.0006
2-FACTOR INTERACTIONS	6.5703580	12	.5475298	.214	.9968
ADAMA.des ADAMA.des2	6.5703580	12	.5475298	.214	.9968
RESIDUAL	97.409383	38	2.5634048		
TOTAL (CORR.)	160.60690	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.COD by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
1	11	1.6109091	*
2	11	1.7554545	*
4	12	1.9200000	*
5	12	1.9408333	*
3	12	1.9958333	*

Multiple range analysis for ADAMA.COD by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
2	15	.9620000	*
4	15	1.1046667	*
3	15	2.0520000	**
1	13	3.5023077	*

Appendix: 16

Analysis of Variance for ADAMA.EC

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	26059.592	7	3722.7988	5.076	.0004
ADAMA.des	258.229	4	64.5573	.088	.9856
ADAMA.des2	25979.928	3	8659.9760	11.808	.0000
2-FACTOR INTERACTIONS	545.30726	12	45.442272	.062	1.0000
ADAMA.des ADAMA.des2	545.30726	12	45.442272	.062	1.0000
RESIDUAL	27868.094	38	733.37089		
TOTAL (CORR.)	54472.993	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.EC by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
1	11	26.475455	*
2	11	27.173636	*
4	12	28.111667	*
5	12	29.370000	*
3	12	29.455833	*

Multiple range analysis for ADAMA.EC by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
1	13	4.930769	*
2	15	10.339333	**
3	15	36.786667	**
4	15	57.493333	*

Appendix: 17

Analysis of Variance for ADAMA.pH

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	3.0085873	7	.4297982	3.445	.0060
ADAMA.des	.1125763	4	.0281441	.226	.9224
ADAMA.des2	2.8957964	3	.9652655	7.737	.0004
2-FACTOR INTERACTIONS	.3867460	12	.0322288	.258	.9924
ADAMA.des ADAMA.des2	.3867460	12	.0322288	.258	.9924
RESIDUAL	4.7409167	38	.1247610		
TOTAL (CORR.)	8.1362500	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.pH by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
5	12	6.8050000	*
1	11	6.8227273	*
4	12	6.8325000	*
3	12	6.9075000	*
2	11	6.9090909	*

Multiple range analysis for ADAMA.pH by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
1	13	6.4607692	*
2	15	6.8553333	*
3	15	7.0180000	*
4	15	7.0333333	*

Appendix: 18

Analysis of Variance for ADAMA.HARD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	.9113947	7	.1301992	1.203	.3246
ADAMA.des	.1757355	4	.0439339	.406	.8031
ADAMA.des2	.7291764	3	.2430588	2.246	.0986
2-FACTOR INTERACTIONS	.5179622	12	.0431635	.399	.9553
ADAMA.des ADAMA.des2	.5179622	12	.0431635	.399	.9553
RESIDUAL	4.1116500	38	.1082013		
TOTAL (CORR.)	5.5410069	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.HARD by ADAMA.des

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
2	11	.3909091	*
4	12	.4466667	*
1	11	.5045455	*
5	12	.5358333	*
3	12	.5366667	*

Multiple range analysis for ADAMA.HARD by ADAMA.des2

Method: 95 Percent Tukey HSD Intervals

Level	Count	Average	Homogeneous Groups
3	15	.2946667	*
1	13	.5338462	*
4	15	.5453333	*
2	15	.5693333	*

Appendix:19

Analysis of Variance for ADAMA.ALK

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	14.790014	7	2.1128591	1.270	.2908
ADAMA.des	1.122340	4	.2805850	.169	.9530
ADAMA.des2	13.656883	3	4.5522943	2.737	.0568
2-FACTOR INTERACTIONS	2.1917973	12	.1826498	.110	.9999
ADAMA.des ADAMA.des2	2.1917973	12	.1826498	.110	.9999
RESIDUAL	63.204867	38	1.6632860		
TOTAL (CORR.)	80.186678	57			

2 missing values have been excluded.

Multiple range analysis for ADAMA.ALK by ADAMA.des

hod: 95 Percent Tukey HSD Intervals

el Count	Average	Homogeneous Groups
12	.9008333	*
11	.9254545	*
12	1.1000000	*
12	1.1841667	*
11	1.2590909	*

Multiple range analysis for ADAMA.ALK by ADAMA.des2

hod: 95 Percent Tukey HSD Intervals

el Count	Average	Homogeneous Groups
13	.5876923	*
15	.8780000	*
15	.8920000	*
15	1.8706667	*

Appendice:120

Identification of bacterial isolate from sample water code ST1/ST5 (June 2004 – May 2005)

Nature of sample			sta	mot	cat	coag	msa	sad	gram	Gel hyd	oxi	ure	meth red	indo pro	choferm					Isolate
Mean	cf/11m	nd/org													L	M	G	S	F	
St1	120	34	-	-	+	+	-	-	-	+	-	-	-	-	-	+	+	+	+	Staph.aureus
			-	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+	E.coli
St2	96	25	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	+	Strep.faeclis
			-	+	+	-	-	-	-	-	-	-	+	-	-	+	+	+	-	Salmonella
			+	+	-	-	-	-	-	+	-	+	-	-	-	+	+	+	+	Bacillus subtitus
St3	130	86	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	+	Strep.faecalis
			-	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+	E.coli
			-	-	+	+	-	-	-	-	-	+	+	-	-	-	+	+	+	Stre.pyogeues
St4	113	95	-	+	+	-	-		+	+	+	+	-	-	-	+	+	+	+	Pseu.aerug.
			-	-	+	+	-	-	-	+	-	-	-	-	-	+	+	+	+	Staph.aura
			-	+	+	-	-	-	+	+	+	-	-	+	+	+	+	+	+	Aeromonas formicans
St5	152	96																		

Keys:

Sta Starch hydrolisis
Mot motility test
Cat catalase test
Cog caogulase test
Gel gelatin hydrolysis
Oxi oxidase test
Ure urease test

Ind - indole production test
Meth - methyl. red test
L - lactose
MSA - manitol Salt Agar
SAD - sodium Azide Dextrose broth

CHO ferm-carbohydrate fermentation
Gram Gram Reduction Negative/positive
M Mannitol
G Glucose
S sucrose
F fructose
\+ Positive

Mean – coliforms . Ing org – Indicator Organisms. cfm – Coliform count per unit.

ppendix 21: Result of t-tests for comparison Between Wet and Dry Seasons for ysico-chemical parameters of River Gurara

	95% Confidence interval of the Difference				
	Lower	Upper	t	df	Sig. (2-tailed)
ir Temperature (°C)	-5.049	-2.071	-4.936	24.000	0.000
/ater Temperature (°C)	-2.761	0.601	-1.326	24.000	0.197
issolved Oxygen (mg/l)	-0.428	0.168	-0.900	24.000	0.377
iochemical Oxygen Demand (mg/l)	-0.129	0.214	0.515	24.000	0.283
hemical Oxygen Demand (mg/l)	-0.535	1.754	1.098	24.000	0.283
H	-0.593	-0.231	-4.701	24.000	0.000
lectrical Conductivity (µmhos/cm)	-44.999	-19.674	-5.271	24.000	0.000
otal Suspended Particles (g/ml)	-0.011	0.006	-0.575	24.000	0.571
Hardness (mg/l)	0.078	0.377	3.139	24.000	0.004
Alkalinity (mg/l)	-0.157	1.155	1.570	24.000	0.129

(P< 0.05) show significant difference.