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Impact of Biotic Stresses on the Alpine Scrub, Pasture Land and Forest Area of Branwar Forest Division, Kashmir Himalaya

By Idrees Yousuf Dar & G. A. Bhat
University of Kashmir, India

Abstract - The present study was carried out for assessing different type of biotic stresses in Branwar Forests of Kashmir Himalaya. The Present Study area i.e., Branwar Forest Range lies over and above famous tourist area of Yus Marg on one side and Neel Nag Forest Lake on the other side. The present investigation was carries out from April, 2010 to April, 2011. The cumulative effect of the biotic interferences was significantly seen in the reduction of vegetation cover. The present study revealed that the prominent factor for the exploitation of the vegetation cover of Branwar forest study area at herbaceous level is simply the overgrazing. The increasing disturbances not only disturb the plant species diversity, richness and evenness significantly but various plant species have got completely eliminated by different kinds of interferences like overgrazing, deforestation, hydal power production, forest fire, Stone extraction, road construction etc. The forests in the region are suffering from severe biotic stress. The forests are intimately linked with the agro-ecosystems in the mountainous areas of the Himalaya and the depletion has definite and obvious impacts on the overall socioeconomic and agricultural scenario of the entire region.

Keywords : Forest, Importance Value Index, Grazing, Deforestation, Scrub, Biomass, Primary Productivity, Biotic Impact.

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Keywords : Forest, Importance Value Index, Grazing, Deforestation, Scrub, Biomass, Primary Productivity, Biotic Impact.

I. Introduction

From the past centuries human beings have influenced the forests, however, the impact has enormous in recent times. A comprehension assessment of the state of world's forests, recently released by the Food and Agricultural Organization of the United Nations (FAO, 2006), indicates that total forested area continues to decline significantly. Forests are defined as terrestrial ecosystems dominated by trees where the tree canopy covers at least 10 percent of the ground area (World Resource Institute, 2000). Forests, constituting a dominant and important ecosystem on Earth, provide a wealth of goods such as food, timber, fuel-wood, drinking and irrigation water, fodder, non-timber products, genetic resources and services, like remove air pollutants and release oxygen, cycle nutrients, provide human and wildlife habitat, maintain watershed functions and biodiversity, sequester atmospheric carbon, provide employment, moderate weather extremes and impacts, generate soil, provide recreation, and contribute to aesthetic beauty (Matthews *et al*., 2000). Once distributed over half the planet, forests today cover only about 25 % of the world's total area, excluding Polar Regions. The World Resource Institute (WRI, 2000) has estimated that only about 22% of the world's original (old growth) forest cover is intact. Agenda 21 of the Earth Summit held in 1992 clearly stated that world over the forests are threatened by uncontrolled degradation and conservation to other types of land uses, under the influence of increasing human needs, agricultural expansion, and environmentally harmful mismanagement, including unsustainable commercial logging, overgrazing and unregulated browsing, etc. The degradation of forests is chiefly due to various anthropogenic pressures (Lone and Pandit, 2005). Overgrazing reduces plant leaf areas, which reduces interception of sunlight and plant growth. Plants become weakened and have reduced root length, and the pasture sod weakens. The reduced root length makes the plants more susceptible to death during dry weather. The weakened sod allows weed seeds to germinate and grow. If the weeds are unpalatable or poisonous, major problems can result.

II. Material and Methods

The plant community organization studies were conducted by stratified sampling technique using quadrats of different convinces as sampling units of different vegetational strata (trees, shrubs and herb strata). For tree canopy it was 10m×10m; for shrubs it was 5m×5m while for herb stratum it was 1m×1m. In

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the present study, trees in seedling or sapling stages at each quadrat were also counted as trees. The vegetation data were further computed for frequency, density and abundance following Curtis and McIntosh (1950). The relative values of frequency, density and dominance were determined as per Phillips (1959). These values were summed to represent IVI (Importance Value Index) of individual species in order to express the dominance and ecological success of the species (Curtis, 1959).The impact of deforestation was studied in terms of Importance Value Index (IVI) of trees at all the study sites. The relative values were summed up to determine the IVI of each tree species and thus the deforestation estimation. The estimation of primary productivity and intensity of grazing were estimated by biomass analyses using harvest method. For this purpose, the quadrats of definite size (40×40 cm2) were laid randomly at all the study sites during different seasons of the year. From each quadrat, the above ground parts (live as well as dead) of all the plants were clipped by using scissors and the material was dried to constant weight at 1050C. The difference in productivity values are explained on the grounds of effect of grazing (biotic factor) in the area under study.

$$Roduction\ Rate\ = W_2 - W_1$$

Where, W_2 = is the dry weight at time t_2 W_1 = is the dry weight at time t_1

III. Study Area and Study Sites

The present study is being carried out for assessing Edaphic Factors and Plant Community Organization in Branwar Forests of Kashmir Himalaya. The Present Study area i.e., Branwar Forest Range lies over and above famous tourist area of Yus Marg on one side and Neel Nag Forest Lake on the other side. It forms the main hydrologic catchment for the famous fresh water stream of Dudhganga in the Pir Panjal Forest Division. The stream is important for Trout fish. The Branwar Forest Area is an important area of Dudhganga Forest Division and is about 40 km away from Srinagar city encompassing an area of about 5148.50 ha which include a sizeable portion of alpine scrub and pasture land. Branwar forest region form a compact and linear strip like area, running from south east to north-west in length and from north-east to south-west in breadth. The main topographical feature of the tract is the Pirpanjal Mountain Range. Towards the foot of the mountains fan like projections with flat tops run at a very gentle angle towards the valley (karewas). The area is drained by a number of streams and nallas, e.g., Dudhganga, Shaliganga, etc. ultimately tributing to river Jhelum. All the area is open to grazing and grass cutting except those which are closed for the purpose by notification. There is no restriction as regarding to cattle grazing in these forests or the distance they come from, however browsing by goats in Deodar Forests is prohibited (Forest Plan, 1988-89). For the last two decades human activities have been on an increase in this part of the Dudhganga catchment. Besides being used as a heavily grazed range and pasture area it is being utilized for a dam construction and power generation. As such environmental monitoring of the area becomes imperative. For studying both plant community attributes and Edaphic factors of the study area the soil and plant samples are being gathered from four different sites Four sites were selected in the Branwar forest area in order to study the various edaphic factors (physico-chemical properties) and plant community organization. The study sites were selected in the forest area having same aspect, climate, topography, parent material, vegetation and were adjacent to each other so that the sites were comparable. General characteristics of the study sites are shown in Table1. Other main features for comparison of the study sites are as under:

Site I (Near Village Site) (NS): This site is located near the main entrance to the forest area and is the nearest to the village Branwar.

Site II (Riparian Site) (RS): This is located on the right side of Nalla Dudhganga deep in the forest. This site adjoins newly constructed and operative small scale hydal power project.

Site III (Dense forest Site and/or Dam forest site) (DS): This site is located in the Protected Dense forest near the newly constructed water storage dam for the operation of small scale mini power project.

Site IV (Protected Forest Site) (PS): This site is located in the protected forest area.

IV. Results

The floristic survey of the vegetation of Branwar forest showed that the natural growth was normal baring certain unprotected areas which were subjected to overgrazing, trampling, deforestation, stone quarrying, constructional activities and other anthropogenic activities

V. Deforestation

Overall the deforestation activities in the study area were quite apparent. As per the official records of the Forest Department (Divisional Forest Department Chadoora, J&K Govt.), the timber extraction was estimated to be 13869 cft for 2009-10 and 16135 cft for 2010-11 (Table 3). These estimates are certainly very low as compared to the actual ones as smuggling of timber is the routine practice in the area, being manifold. Similarly, firewood collection is again many times higher than the official quoted data (Table 3 and 4). The data on the impact of deforestation on tree species at the study sites based on Importance Value Index (IVI) of the tree species is presented in Table 2 and fig. 1. The forest vegetation community appeared to be in varied stages of development in the area. Site-wise variation revealed that at near village (NS) site, the Importance Value Index (IVI) was maximum for *Pinus wallichiana* (126.7), followed by *Abies pindrow* (80.3), *Salix sp.* (43.0), *Robinia psedoacacia* (27.9) and *Ulmus villosa* (23.0) and at riparian forest (RS) site, the IVI was maximum for *Abies pindrow* (156.6), followed by *Pinus wallichiana* (118.6) and *Salix sp*. (24.7). The IVI for dam forest (DS) site and protected forest (PS) site was maximum 203.4 and 256.0 for *Pinus wallichiana* and least 94.54 and 43.94 was for *Abies pindrow* respectively. It is evident that the sites (I & II) are not protected and are subjected to more anthropogenic stress than dam forest (DS) site and protected forest (PS) site as is indicated from the IVI of tree vegetation being maximum at protected sites (III & IV).

a) Impact of grazing intensity on herbaceous vegetation

The area encompassing Branwar forest is sparsely populated by humans but is in close proximity with few villages having a fairly rich livestock population of 7110 animals comprising 3727 sheep, 610 goats and 2773 cattle (Table 37 and fig. 30), but the number may be much higher because the number of livestock owned by Gujars and Bakerwals living within the forest was not available. The data on productivity estimates at the study sites are depicted in Table 38 and fig. 31 & 32. An insight of the data showed that for near village (NS) site the aboveground biomass varied between a maximum of 270.00 g m-2 in autumn and a minimum of 162.20 g m-2 in spring. At riparian forest (RS) site the aboveground biomass varied between 280.00 g m-2 and 166.40 g m-2 similarly for dam forest (DS) site and protected forest (PS) site the above ground biomass varied between a maximum of 370.00 g m-2 and 398.00 g m-2 and a minimum of 245.00 g m-2 and 266 g m-2 respectively. The highest values of productivity of 159.60 g/m2/year was recorded for protected forest (PS) site, followed by 143.40 g/m2/year for dam forest (DS) site , 112.00 g/m2/year for near village (NS) site and 108.00 g/m2/year for riparian forest (RS) site.

b) Resource utilization

The people of the region, being dependent on biomass, have been living in close association with the flora of the forest from times immemorial. They use the plant resources not only for house building, timber, agriculture implements, food, fodder and other uses.

c) Other anthropogenic pressures

Other human pressures which are also destabilizing and degrading the forest soil and vegetation include stone extraction, construction of small water storing dam and power generating house for small scale hydro power generation operating within the forest area. The forest area of 143.18 hectares stands sanctioned to the power project and to other constructional activities by the Forest Department, J&K Govt. (Forest division, Chadoora). Besides a network of roads is also being constructed near and within the forest which will also brings habitat fragmentation.

VI. DISCUSSION

The results of the present study indicate that a multitude of ecological stresses have disturbed the forest ecosystem as reflected by variability in soil characteristics and plant community organizational features. The mild disturbances increase the species diversity, richness and evenness while severe disturbance lead to a decrease in these variables for all types of vegetal zones. On the other hand, the reduction in vegetation cover due to various factors not only makes the soils prone to erosion but also lead to loss of major plant nutrients due to leaching. Thus, the growing biotic stresses are responsible for modifying the natural ecosystem in terms of its structural and functional attributes which not only modify that nature of soil both in terms of its composition and texture but also reduce the rich biodiversity of plants and their productivity. The Importance Value Index (IVI) of the tree species at the protected sites depicted higher values against the unprotected sites. The plant biomass varied considerably through different seasons in both the protected and unprotected sites. The highest values of biomass during summer and autumn are due to the presence of more number of species which could further be attributed to the fact that more hospitable situations were created facilitating their phenotypic development and thus increasing their population. The adverse effects of grazing were compounded by the fact that grazers were found to consume not only the leaves and stems but also the inflorescence of the plant species. The removal of organic matter in the form of herbage biomass and trampling by grazers has caused edaphic changes and consequently the vegetal changes at the grazed sites. The above findings are further corroborated by the work of other investigators while studying the effect of grazing on structure and productivity of vegetation (Lone and Pandit, 2007). Contrary to the present study, Chakravarti and Bhati (1971) observed no significant decrease in plant cover due to grazing in afforested dunes of Rajasthan although the author noted that some of the species decrease in their coverage against an increase in others.

VII. CONCLUSION

Low vegetation cover caused decrease in the species diversity of trees and increased that of shrubs, while intermediate values were observed for herbs. Lower values of richness and evenness at unprotected sites of near village (NS) sites and riparian forest (RS) site indicates that natural forests are degraded because of lower vegetation cover that may be due to cutting of trees, firewood collection, cattle grazing, road construction and other anthropogenic stresses that can be restored by providing protection which ultimately help in regeneration process. The different vegetation types have been found to influence the soil to different extents. Trees and other plant species influence the physical and chemical properties of the soil by several mechanisms. Differences in litter quantity and nutrient status, root nutrient uptake and activity, interception of atmospheric deposition, canopy interaction, rock weathering and leaching can cause difference in the physical and chemical characteristics of top soils under various canopy cover. The results of the present study indicate that a multitude of ecological stresses have disturbed the forest ecosystem as reflected by variability in soil characteristics and plant community organizational features. On the other hand, the reduction in vegetation cover due to various factors not only makes the soils prone to erosion but also lead to loss of major plant nutrients due to leaching.

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Table 1 : Characteristics of selected study sites.

S.No.	Sites	Latitude	Longitude	Altitude (masl)	Tree density (10m^2)	Soil type	Dominant tree species
01.	NS (I)	33^{0}52′ 11.3″N	74^{0}39′ 22.2″E	2146	2.2	SiL	*Pinus wallichiana*
02.	RS (II)	33^{0}51′ 45.0″N	74^{0}39′ 20.6″E	2181	14.0	ScL	*Abies pindrow*
03.	DS (III)	33^{0}50′ 36.0″N	74^{0}38′ 52.3″E	2383	21.8	CL	*Pinus wallichiana*
04.	PS (IV)	33^{0}51′ 28.2″N	74^{0}38′ 54.6″E	2318	86.9	CL	*Pinus wallichiana*

Table 2 : Impact of deforestation on tree species at the study sites based on Importance Value Index (IVI) of the tree species.

S. No.	Name of the tree species	IVI		IVI	
		Protected areas		Unprotected areas	
		NS	RS	DS	PS
01.	*Abies pindrow*	80.3	156.6	96.54	43.94
02.	*Pinus wallichiana*	126.7	118.6	203.4	256.0

03.	*Robinia psedoacacia*	27.9			
04.	*Salix sp.*	43.0	24.7		
05.	*Ulmus villosa*	23.6			

Table 3 : Out-turn of timber in cubic feet during 2009-10 and 2010-11 at different study site of Branwar forest.

S.No.	Sites	2009-10	2010-11
01.	Site I & II	12509	15306
02.	Site III & IV	1360	829
03.	Total	13869	16135

Source : Divisional Forest Office, Chadoora

Table 4 : Out-turn of firewood (fuel) in quintals during 2009-10 and 2010-11 at different study sites of Branwar forest.

S.No.	Sites	2009-10	2010-11
01.	Site I & II	1018	1185
02.	Site III & IV	475	329
03.	Total	1493	1514

Source: Divisional Forest Office, Chadoora

Table 5 : Population estimates of livestock of different villages near Branwar forest during 2010-11. Source: Sheep and Animal Husbandry Department, J&K Govt.

S. No.	Village	Sheep	Goat	Cattle	Total
01.	Branwar	968	346	936	2250
02.	Bonen	493	107	380	980
03.	Surasyar	842	98	560	1500
04.	Dadampora	1424	59	897	2380
06.	Total	3727	610	2773	7110

Source : Sheep and Animal Husbandry Department, J&K Govt.

Table 6 : Variation in the biomass production (g/m^2) of herbaceous vegetation at different study sites during different seasons of 2010.

S.No.	Seasons	Site I (NS)		Site II (RS)		Site III (DS)		Site IV (PS)	
		AGB (g/m^2)	ANP	AGB (g/m^2)	ANP	AGB (g/m^2)	ANP	AGB (g/m^2)	ANP
		108.00		112.00		186.60		196.80	
01.	Spring	162.20	54.20	166.40	54.40	245.00	58.40	266.00	69.20
02.	Summer	226.60	64.40	210.20	43.80	296.50	51.50	330.30	64.3
03.	Autumn	270.00	43.40	280.00	69.80	370.00	73.50	398.00	67.7
04.	Winter	210.00	-50.00	220.00	-60.00	330.00	-40.00	356.40	-41.6
05.	Total		112.00 g/m^2/y		108.00 g/m^2/y		143.4 g/m^2/y		159.6 g/m^2/y

AGB = Above ground Biomass & ANP = Above-ground Net Productivity.

Figure 1 : Importance Value Index of various tree species at the study sites.

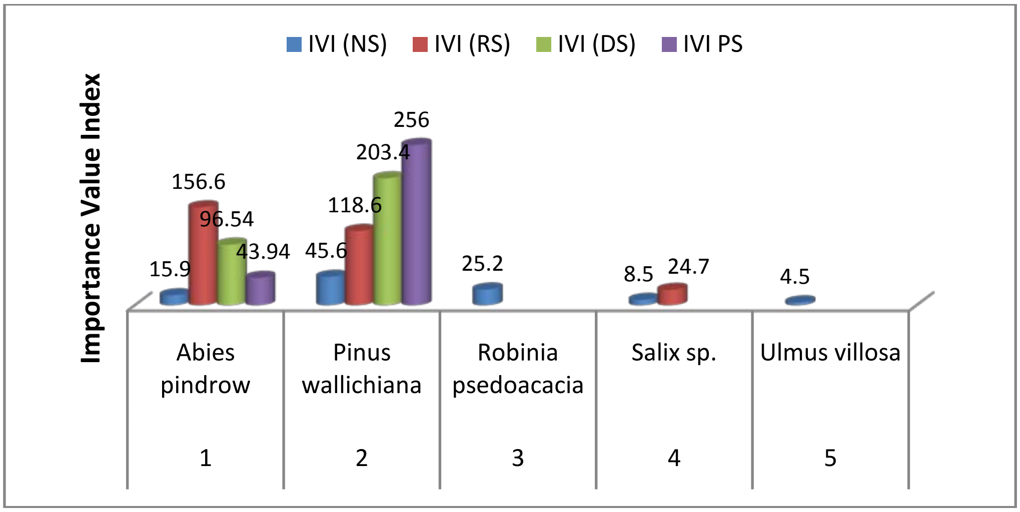


Figure 2 : Population estimates of livestock of different villages of Branwar forest during 2010-11.

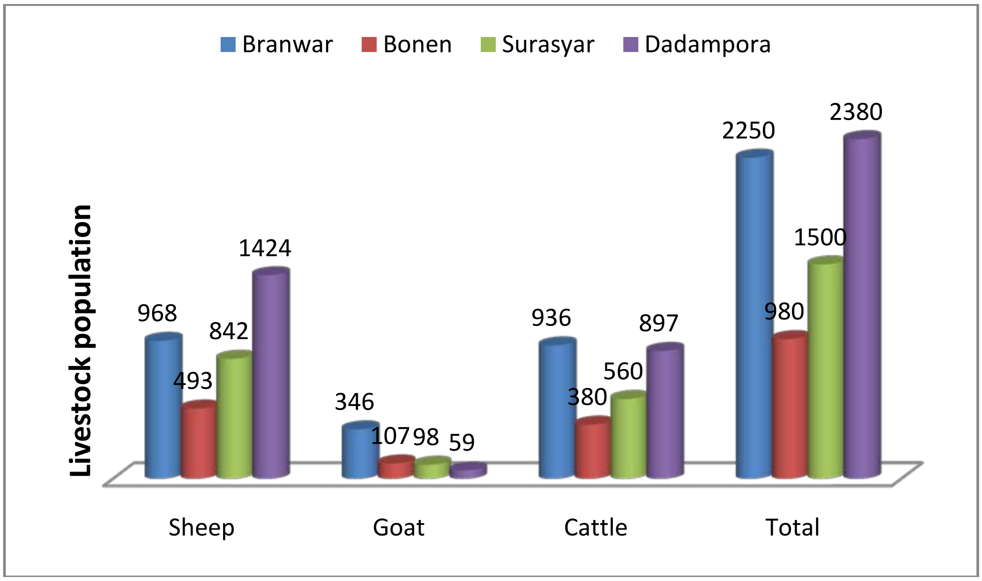


Figure 3 : Seasonal variation in the above ground biomass of herbaceous vegetation at various sites of Branwar forest during 2010-11.

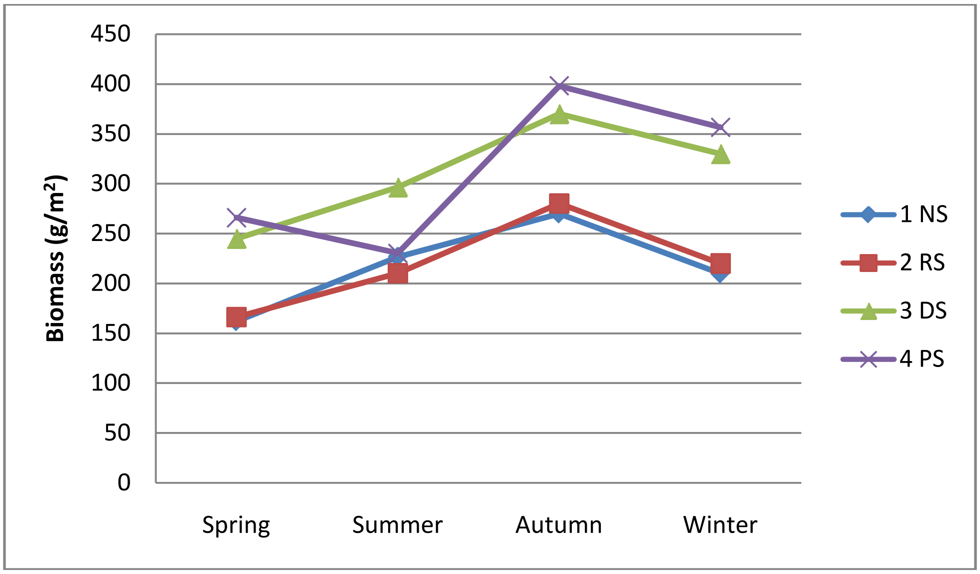
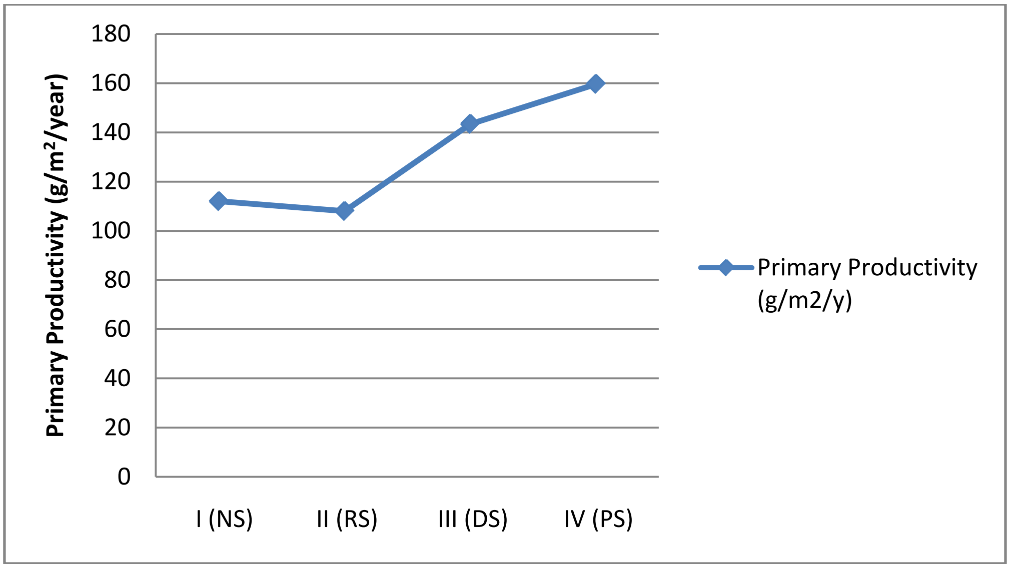


Figure 4 : Primary Productivity (g/m^2/year) of herbaceous vegetation at various sites of Branwar forest during 2010-11.



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Geomicrobiology and Geochemistry of Cave Spring Water from Jaintia and East Khasi Hills of Meghalaya, India

By Gulzar Ahmad Sheikh, Idrees Yousuf Dar, R. Bhaskar, A. K. Pandit & Theophilus

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Abstract - The present study was undertaken to know the concentration of various trace elements and the condition of water quality parameters in the cave water samples besides studying the role the microbes play in the precipitation of minerals in caves. The results revealed that the concentration of various trace elements such as copper, zinc, nickel and cadmium were low and below the water quality standard limits given by WHO, 2006. While that of manganese it was exceptionally high, may be due to erosion of the manganese minerals deposits by the spring cave water. The results also revealed that phosphate is present in very low concentration while sulphate is present in high concentration which again may be due to erosion of secondary sulphate minerals. The co-relation matrices and one tailed analysis of variance of physic-chemical factors have been computed and analyzed .The positive correlation coefficient was observed between pH and alkalinity, hardness and conductivity, sulphate and turbidity. The one tailed ANOVA confirms that site spatial variations have less significant effect on concentration of trace elements. Microbial analysis showed that various types of microbes are present in cave sample which may play an important role in mineral precipitations.

Keywords : Geomicrobiology, Water quality, Speleothem genesis , Mineral precipitation.

GJSFR-H Classification : FOR Code: 060504, 040699

GEOMICROBIOLOGY AND GEOCHEMISTRY OF CAVE SPRING WATER FROM JAINTIA AND EAST KHASI HILLS OF MEGHALAYA, INDIA

Geomicrobiology and Geochemistry of Cave Spring Water from Jaintia and East Khasi Hills of Meghalaya, India

Gulzar Ahmad Sheikh [α], Idrees Yousuf Dar [σ], R. Bhaskar [ρ], A. K. Pandit [ω] & Theophilus [¥]

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I. INTRODUCTION

Caves are formed in limestone areas and other rocks of similar composition by the process of weathering and erosion by water. The rainwater reacts with carbon dioxide from the atmosphere to form a weak carbonic acid solution. This solution slowly dissolves carbonate rocks and forms cavities and passages. The cavities and passageways are formed where the maximum amount of continuous water flow occurs, right below the water table. Once the water table has lowered, leaving the caves in the aerated zone, the deposition of calcite occurs, creating different beautiful "cave decorations" called speleothems. Sulphuric acid, often found in water from bogs in very low concentration produces a significant amount of limestone solution by the oxidation of sulphide ore, thereby causing localized cavern formation (Caro, 1965). Organic acids such as formic, acetic and butyric formed in plants both during life and by decay after death are available in the soil and can be leached by water to dissolve limestone. The study of cave microbiology deals with the microscopic life that resides in cave. Without photosynthesis, caves are cut off from most energy that supports life on the surface. As a result, cave microorganisms must look for alternative sources of energy for their survival, such as those found in the atmosphere, or present in the very rock itself (Barton *et al.*, 2004; Chelius and Moore, 2004; Spilde *et al.*, 2005). In adapting to these extremely starved environments, microorganisms produce elaborate scavenging mechanisms to pull scarce nutrients into the cell (Koch, 1997). When these organisms are then exposed to the rich nutrients of a Petri plate, they cannot turn down these scavenging mechanisms and quickly gorge themselves to death (Koch, 1997, 2001). As a result, microorganisms from starved cave environments may have a hard time adapting to rapidly changing nutrient status *in vitro,* and simply die from osmotic stresses (Koch, 1997).The present study was undertaken to analyze the geochemistry of cave water samples and to analyze the geomicrobiology of speleothems.

II. MATERIAL AND METHODS

The samples of caves spring water & rock samples were collected from Meghalaya by the Depatment of Environmental science and Engineering, Guru Jambheshwar University of Science and Technology, Hisar (Haryana).The Physico-chemical parameters of water were carried out as per the standard methods.

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E-mail : wilderness4@gmail.com

S.No.	Parameters	Methods
1.	pH	pH meter(APHA 1998)
2.	Dissolved Oxygen	Winkler's titration method (APHA, 1998; Wetzel and Likens, 2000)
3.	Conductivity	Conductivity meter(APHA 1998)
4	Water Temperature	Thermometer(APHA 1998)
5	Total Alkalinity	Titrimetric method(APHA 1998)
6	Total dissolved solids	(APHA 1998)
7	Calcium Hardness	EDTA titrimetrc method (APHA 1998)
8	Magnesium Hardness	EDTA Titrimetric method(APHA 1998)
9	Total Hardness	Complexometric method(APHA 1998)
10	Chloride	Argentimeteric method(APHA 1998)
11	Nitrite	Spectrophotometric method (APHA,1998;Wetzel and likens, 2000)
12	Nitrate	Sodium salicylate APHA, 1998; Wetzel and Likens, 2000)
13	Ammonical nitrogen	Phenate method (APHA, 1998; Wetzel and Likens, 2000)
14	Ortho-phosphate	Ascorbic Acid method (APHA, 1998; Wetzel and Likens, 2000)
16	ace Metals(Cu, Zn, Ni, Cd, & Mg)	Atomic Absorption Spectrophotometer (AAS) (APHA, 1998)

The data collected were subjected to pearsons correlation matrix to study the significant level at $p< 0.05$ and $p< 0.01$(two tailed) to note the positive and negative correlation among physic- chemical factors. Similarly one way ANOVA was applied to know variation among trace elements. The spss version.16.0 statistical programme was used for all statistical analysis throughout this research.

a) Geo-microbiology of caves

Rock samples were crushed to make powder. One gram of powdered rock sample was dissolved into 100ml distilled water and agitated in a shaker for 15 minutes. Nutrient agar medium was prepared by dissolving 31gm of nutrient agar in one liter distilled water. The media, glassware like micro tips, 40 test tubes having 9ml distilled water were autoclaved at 121^0C and 15 psi pressure for 15 minutes. Then, the media was poured in the sterilized Petri plates in laminar flow and allowed to keep undisturbed until the media was solidified. After that dilutions of the order of 10^{-2} of the rock sample were prepared and then inoculation was done. Then the Petri Best wishes, plates were wrapped with paraffin wax and were kept in the incubator at 28^0C for five days. Then the colonies were identified using Gram Staining technique and Most Probable Number method (MPN).

III. RESULTS AND DISCUSSION

The present study was undertaken to know the concentration of various trace element in the cave water samples and to know the condition of water quality parameters. Geochemical analysis of cave waters revealed that there is a significant difference in the concentration of various trace metals from different sampling sites as shown in figure 1. The concentration of copper ranged from 0.2466 ppm in sample No. SI-3 to 0 ppm in most of the samples (Table 1) In case of zinc maximum concentration is found in sample No. S1-3 i.e. 3.9417 ppm followed by MC1W – 01 (3.1612 ppm.) while minimum concentration is detected in sample no. S2-6 i.e.0.0787 ppm. Nickel showed overall low concentration being maximum in sample no. MC2W-11 i.e. 1.8784 ppm, and minimum in sample no. S3-9 i.e. 0.0247 ppm. In case of cadmium concentration ranges from 0.02423 ppm (in sample no.MC2W-03) to 0.001287ppm.(in sample no. MC2W – 02).However, manganese showed highest concentration ranging from 5.7353 ppm. in sample no.MC2W-03, while minimum i.e. 0.114 ppm. in MC2W-07. It has been found manganese-oxidizing bacteria such as *Leptothrix* in a stream in Matts Black Cave, West Virginia, and attributed the formation of birnessite in this cave to the precipitation of manganese around sheaths of bacteria Broughton (1971) and Moore (1981).The pH ranged between 7.6 to 8.2 indicating slightly alkaline nature. Acidity ranged between 10 to 40 ppm. which may be due to free carbon dioxide, trace amount of sulphuric acid and nitric acid (Table2).However alkalinity ranged between 40 ppm (in sample no.MC2W-02, S1 and S3) to 100 ppm. (in sample MC2W-01 and MC2W-11) which may be due to presence of free ions of hydroxide, carbonate and bicarbonates. In case of conductivity it ranged from74.16 μs in sample S3 to253 μs in the sample no. S1 which may be due various free ions present in the sample. Hardness of caves water samples ranged from 240 ppm. to 100 ppm. which may be due ions such as, carbonate and bicarbonates of calcium and magnesium. However the turbidity ranged from 0.1 to 2.2 which may be due to suspended matter ranging from pure inorganic substance to those that are organic in nature. In case of phosphate ions the concentration is extremely very low ranging between 0.02 ppm. in sample no. MC1W-01 to 0.26 ppm. in sample no. MC2W-03. However in case of sample no. S2 phosphate ions are absent. In case of sulphate the concentration varied from 0.3 ppm. in the sample no. S2 to 16.2 ppm. in the sample no. MC2W-02 thus being maximum in MC2W-02 cave sample. The results revealed that the concentration of various trace elements such as copper, zinc, nickel and cadmium were low and below the standard water parameter limits. While that of manganese it was exceptionally high, may be due to erosion of the manganese minerals deposits by the spring cave water. The results also revealed that phosphate is present in very low concentration while sulphate is present in high concentration which again may be due to erosion of secondary sulphate minerals.

Morphological characteristic of microbial colonies (Plate1 & Plate 2, Table 3) revealed that both gram positive and gram negative microbes were existing in different forms. They play an important role in mineral precipitation (Frankel and Bazylinski, 2003). Studies revealed that calcite was the dominant mineral and an abundant microbial community was detected by direct microscopic observation after DAPI staining which were indicative of microbial involvement in the speleothem genesis (Baskar *et al.* 2005, 2006, 2007). The iron-oxidizing species *Gallionella ferruginea* and *Leptothrix sp.* has been recovered from cave samples (Peck, 1986). Further detailed investigations are required involving *in vitro* culture experiments and molecular techniques to quantify the extent of microbial participation in speleothem genesis. Progress in the field will depend on cross-disciplinary studies involving the abilities of biologists to recognize assuredly biological structures and measure these processes within the cave environment; and geologists, who can apply the complex tools of chemistry and geology to the problem.

The study of cave microbes has significant implications in the preservation of ancient marble monuments and statues, where microorganisms could be used to deposit a veneer of calcite to protect ancient structures from continued erosion (Laiz *et al.* 2003) and can be inoculated into contaminated environments to rapidly degrade pollutants and allow restoration of natural habitats in a process called bioremediation. Cave microorganisms also have the potential to harbor unique antibiotics & with properties that allow efficient ethanol production for fuel, enzymes for environmentally friendly paper processing and even the improved stonewashing of jeans(Onaga, 2001).

IV. Statistical Analysis

The data collected were subjected to pearsons's correlation matrix to study the significant level at $p< 0.05$ and $p< 0.01$(2 tailed) to note the positive and negative correlation among the physico-chemical factors. The statistical analysis of pearson's correlation coefficient is presented in table-4.The study of correlation coefficient between various physico-chemical factors indicated that PH values varied with the variation of alkalinity. The rise of carbonate and bicarbonate concentrations increased the level of PH and hence alkalinity. Alkalnity enhanced the decomposition of organic matter which in turn increase concentration of nitrite, phosphate and sulphate ions. The abundant of ca and Mg in addition to nitrite, sulphate and phosphate are responsible for an increase of hardness and a perfect positive correlation with conductivity. The high concentration of sulphate makes water turbid and hence increases turbidity of water.

V. Acknowleedgement

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Table 1 : Geochemistry of trace elements.

Sample No.	Copper (ppm)	Zinc (ppm)	Nickel (ppm)	Cadmium (ppm)	Manganese (ppm)
MC1W – 01	0.1695	3.1612	0.4827	0.01210	2.9899
MC2W – 07	0.0	0.4263	0.3543	0.01923	O.114
MC2w – 02	0.0	1.9085	0.5849	0.00128	3.8015
MC2W – 03	0.0	1.5806	0.1071	0.02423	5.7353
MC2W – 01	0.0154	1.6593	0.6898	0.1099	4.4588
MC2W – 11	0.0	1.3052	1.8784	0.0212	0.6384
S1 – 3	0.2466	3.9417	1.6065	0.01847	5.0080
S2 – 6	0.0	0.0787	0.5849	0.02377	2.1683
S3 – 9	0.0	0.8723	0.0247	0.01741	1.0280
Mean	0.0479	1.6593	0.7014	0.0275	3.2285
S.E(±)	0.0876	1.2397	0.0929	0.0316	1.8525
C.D	0.1716	2.4298	0.1820	0.0619	3.6309

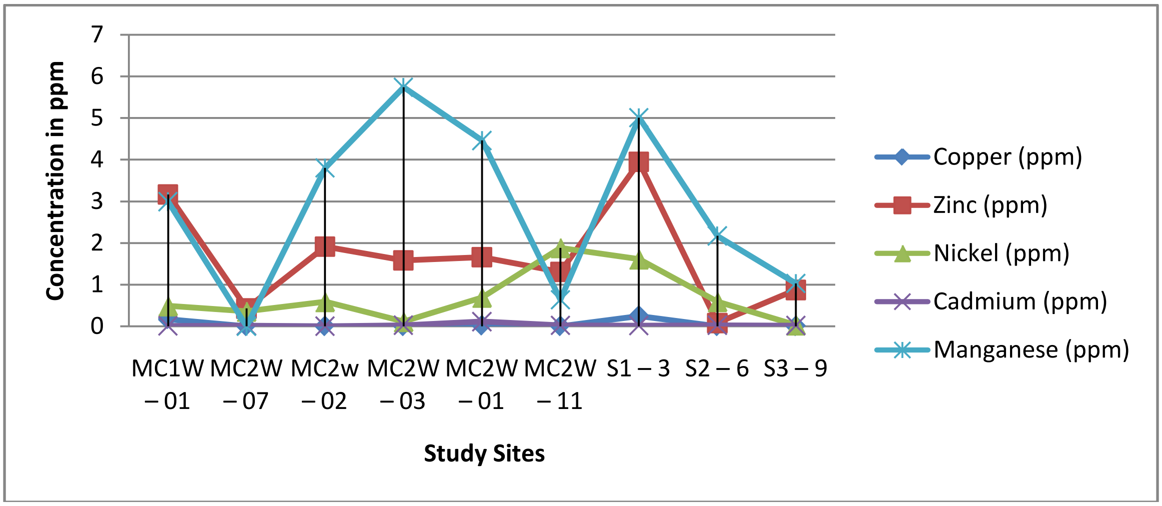
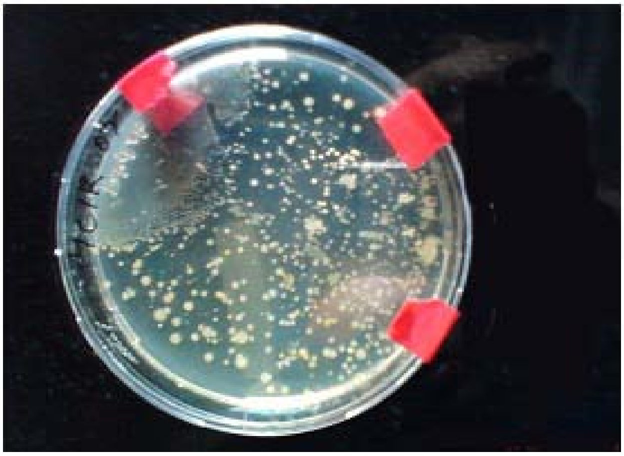


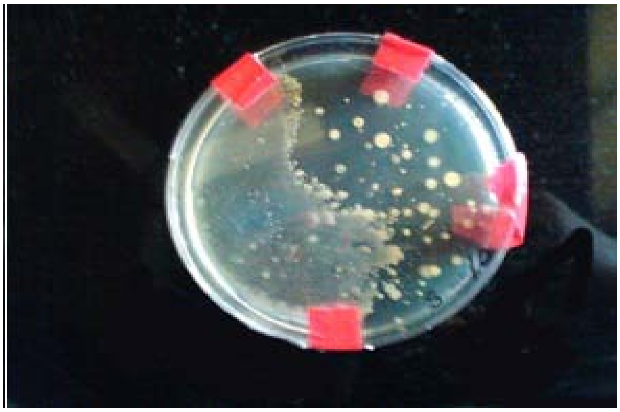
Figure 1 : Showing variation in concentration of heavy metals at different sites.

Table 2 : Geochemistry of Caves water

S. No.	Sample	Ph	Temp. (^{0}C)	Acidity (ppm)	Alkanity (ppm)	Conductivity (μS)	Hardness (ppm)	Turbidity (ppm)	Phosphate (ppm)	Sulphate (ppm)
01.	MC1W-01	7.7	11.5	40	80	209.3	220	0.7	0.02	9.4
02.	MC2W 01	8.2	11.6	20	100	187.9	100	1.5	0.08	12.3
03.	MC2W 02	7.6	13	40	40	227.2	200	2.2	0.04	16.2
04.	MC2W 03	7.7	12.5	20	60	158.5	220	0.1	0.26	5.1
05.	MC2W 07	7.6	13	40	60	162.3	200	0.1	0.12	6.4
06.	MC2W 11	7.9	11	10	100	152	200	0.2	0.06	4.3
07.	S_1	7.6	8	20	40	253	220	0.1	0.07	1.2
08.	S_2	7.8	11.5	40	80	243.1	240	0.4	0.00	0.3
09.	S_3	7.7	12	40	40	74.16	100	0.2	0.05	9.8
10.	Mean	7.7	11.5	30	66.66	185.27	188.88	0.61	0.07	7.22
11.	S.E(±)	2.5	1.5	12.24	24.49	55.86	52.06	0.74	0.076	5.19
12.	CD (5%)	4.9	2.94	23.99	48.98	109.48	102.03	1.45	0.14	10.17



MC2R-14
PLATE-1



S-10
PLATE-2

Table 3 : MICROBIAL COLONY CHARACTERISTIC.

Sample No.	Viable Count	CFU/g	Colour	Forrm	Elevation	Margin	Texture	Gram stain	Type
MCIR-01	15	15×10^2	Pale yellow, Creamy white.	Circular, Irregular,	Flat, Convex.	Entire, undulate, erose.	Smooth, Slimy	+ve +ve	*Cocci,* *Cocci,*
MCIR-02	34	34×10^2	Creamywhite, Slightly pink, Pale yellow	Circular, Irregular, Puntiform	Convex, Pulvinate, Raised.	Entire, Undulate, curled.	Powdry, Glutinous , Slight Slimy	+ve -ve -ve	*Cocci,* *ccoci* *cocci*
S-10	32	32×10^2	Creamy white, Pale yellow.	Circular, Punctiform	Convex, Raised.	Entire, Undulate,	Smooth, Slimy.	-ve -ve	*Cocci.* *Cocci*
S-15	19	32×10^2	White, Yellow, Creamy white.	Circular, Irregular Filamentous	Convex, Pulvinate Flat	Lobate, Erose, Curved.	Glutinous, Powdry, smooth.	+ve +ve -ve	*Cocci* *Cocoi* *Cocci,*
MC2R-14	45	45×10^2	Orange, Slightly Brown, Creamy white.	Irregular Filamentous. Punctiform.	Convex, Flat, Pulvinate.	Undulate, Lobate, Curved.	Glutinous, Smooth, Powdery.	-ve -ve +ve	*Cocci* *Cocci* *cocci*
S-17	14	14×10^2	Orange, Translucent.	Circular, Irregular	Convex, Pulvinate.	Entire, Undulate,	Smooth, Powdery,	-ve +ve	*Cocci* *cocci*
S-7	17	17×10^2	Creamywhite, Greyish black, Pale yellow.	Punctiform, Circular, Irregular.	Convex, Raised. Flat	Entire, Undulate, lobate.	Slimy , Glutinous, Powdy	+ve +ve +ve	*Cocci* *Cocci* *Cocci*
S-9	14	14×10^2	Red, Pale yellow,	Circular, Irregular.	Raised, Convex.	Undulate, Filamentous.	Rough, Slimy.	-ve -ve	*Cocci* *Cocci*
MCIR-13	17	17×10^2	Pale yellow, grayish white,	Circular, Irregular.	Raised, Convex,	Entire, Undulate,	Powdery, Smooth.	+ve +ve	*Cocci* *Cocci*
MCIR-24	Uncountable	Uncountable	White, Creamy white.	Punctiform, Circular.	Convex, Pulvinate.	Entire , Erose.	Smooth, Slimy ,	-ve +ve	*Cocci,* *Cocci*

Table 4 : Geochemistry of Caves water.

	A	B	C	D	E	F	G	H	I
A	+1								
B	-.014	+1							
C	-.300	+.431	+1						
D	+.866**	-.115	+.000	+1					
E	-.134	+.057	+.247	-.312	+1				
F	+.257	-.106	-.345	+.332	+925**	+1			
G	+.244	+.330	+.044	+.161	-.178	+.149	+1		
H	-.083	+.228	-.576	-.314	-.197	+.126	-.302	+1	
I	+.130	+.550	+.148	-.012	+.175	-.249	+.809**	-.097	+1

*** = Correlation is high significant at $p < 0.01$ level, '-' indicate negative correlation, '+' indicate positive correlation, Where A= PH, B= Temp., C= Acidity, D= Alkanity, E= Conductivity, F= Hardness, G= Turbidity, H= Phosphate, I= Sulphate*

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Groundwater Quality Appraisal of Some Hand-Dug Wells and Boreholes around Okemesi and Ikoro Area, Southwestern Nigeria

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Abstract - The study area falls within the basement complex of southwestern Nigeria. The dominant lihologic units are quartzites of Effon Psammite Formation which occur mostly as massive quartzites, schistose quartzites and quartzite schists. Fifteen (15) water samples were collected from the study area at regular intervals which includes nine (9) samples from Okemesi Ekiti and six (6) samples from Ikoro Ekiti respectively. These samples were analysed in order to determine their physical, chemical and bacteriological characteristics. The physiochemical results showed that temperature ranges between 26.7ºC-27.7ºC, conductivity (80-1680)µs/cm, appearance is clear, colour in hazen scale is <10 for all samples, turbidity (0-9.35)NTU which showed that the water are less turbid, tasteless and odourless, pH (5.96-7.74) which is slightly acidic to alkaline, total dissolved solids (53.6-1126)mg/l and total hardness (28-414)mg/l. The cations and anions range as follows in the samples; Ca^{2+} (16-254)mg/l, Mg_2+ (12-226)mg/l, Cl- (5.99-210)mg/l, NO_3 - (0.98-30.8)mg/l though not detected in all the samples, Fe (0.27-0.67)mg/l, Na^+(3.89-137)mg/l, Mn(0.008-0.018)mg/l, HCO_3 - (6.0-126)mg/l. All the cations and anions analyzed conform to WHO (1993) standard for drinking water as all their values fell within the maximum permissible limits. The bacteriological analysis for total coliform/100ml as in total bacteria counts range between (7-16) Cfu/100ml, these shows a relatively high load of bacteria in the tested samples.

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GROUNDWATER QUALITY APPRAISAL OF SOME HAND-DUG WELLS AND BOREHOLES AROUND OKEMESI AND IKORO AREA, SOUTHWESTERN NIGERIA

Strictly as per the compliance and regulations of :

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I. INTRODUCTION

Water is essential for survival of all living things. With world's population growing rapidly, water resources of the world is one of its most important assets. A large percentage of the mass of living organisms is made up of water. The quality of water is of vital importance whether for industrial or domestic purposes. For water to be of consumable quality, it must attain a certain degree of purity. According to Davis and De Wiest (1966), drinking water standard are based on two main criteria namely; the presence of objectionable taste, odour and colour; and the presence of substances with adverse physiological effects. However, mineral enrichment from underlying rocks can change the chemistry of water, making it unsuitable for consumption (Ako et al. 1990).

Water can also be a source of serious environmental and health problems if the design and development of such water supply system is not coupled and tied with appropriate sanitation measures. According to Oloke (1997), drinking water can act as a passive means of transporting nutrients into the body system. However, the objectives or primary concern in providing potable water are freedom from harmful micro-organisms and freedom from undesirable or harmful chemicals. Therefore, both the physiochemical and bacteriological assessment of potable water is of paramount importance and monitoring must be given the highest priority. A lot of literatures abound on groundwater prospecting and development in the basement complex such as Jones and Hockey (1965), which worked on groundwater prospect in the basement complex rocks of south western Nigeria and concluded that beneath the veneer of regoliths, the fresh basement rocks are highly fractured at shallow and greater depth. The crystalline basement complex rocks and their weathered derivatives constitute large reservoirs of groundwater which can yield considerable amount of water for human consumption especially in the areas where the overburden (soil) are sufficiently thick, porous and permeable enough to allow migration and accumulation of groundwater. Davis and De-Wiest (1966) revealed that crystalline rocks are poor water bearing aquifers because of their low porosity and low permeability except when secondary structures developed as a result of tectonic activities, selective dissolution of mineral grains and weathering. Azeez (1972), divided SW Nigeria into eight hydrogeological provinces and Odeyemi et al (1985), examined the remote sensing of rock fractures and groundwater development in parts of south-western Nigeria. However, this study focuses on water quality assessment by determining the physical, chemical and bacteriological properties of water from hand dug wells and boreholes around Ikoro and Okemesi area, Southwestern Nigeria with the objective of assessing its quality for human consumption and domestic usage.

The study area falls within the basement complex of southwestern Nigeria. Ikoro Ekiti in Ijero local government area of Ekiti State lies within latitudes 7°65' N and 8°00' N of the equator and longitudes 4°75' E and 4°95' E of the Greenwich meridian while Okemesi Ekiti in

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Ekiti west local government area of Ekiti State lies within latitudes 7°55' N and 7°80' N of the equator and longitudes 4°55' E and 4°59' E of the Greenwich meridian. The study area also lies north east of Ilesha in Osun State (Fig.1).The type of human settlement in the study area is the linear type in which houses and buildings are constructed along major roads following a regular pattern.

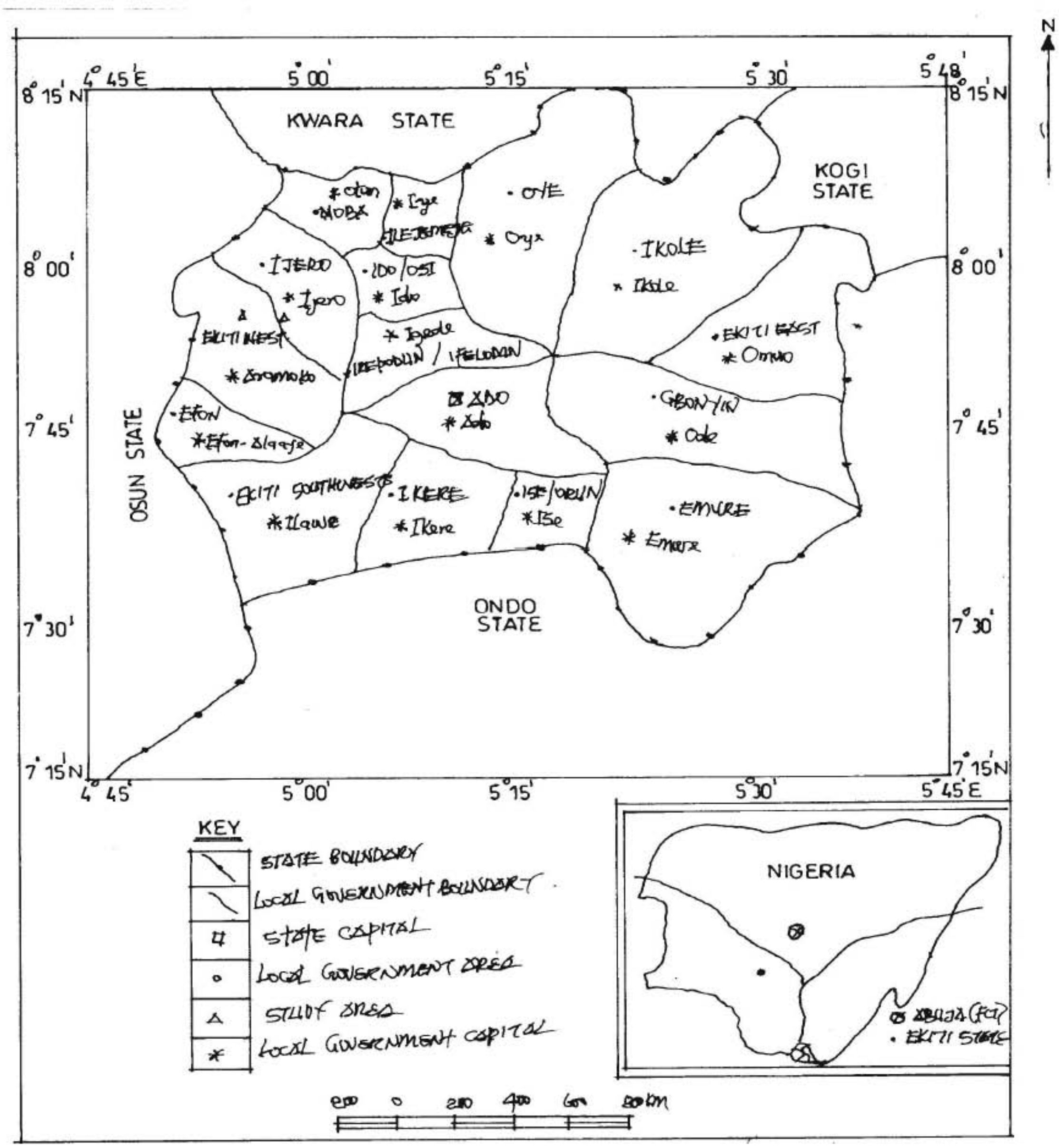

Fig.1 : Map of Ekiti State showing the study areas (Inset: map of Nigeria showing the study area.

II. Topography and Drainage

The topography of the study area is rugged with series of highlands, lowlands and massive rocks. The major topographic landform within the area is the ridge system formed by quartzite exposures that have undergone varying degrees of weathering and are characterised by undulating landforms. Trellis drainage pattern is in existence in the study area and majority of the rivers flow north-southwards and are structurally controlled. They get dried up during the dry season because their tributaries are seasonal but the major river is perennial. The major river that runs through this area is river oshun, which flows from highlands to relatively lowlands. (Fig.2)

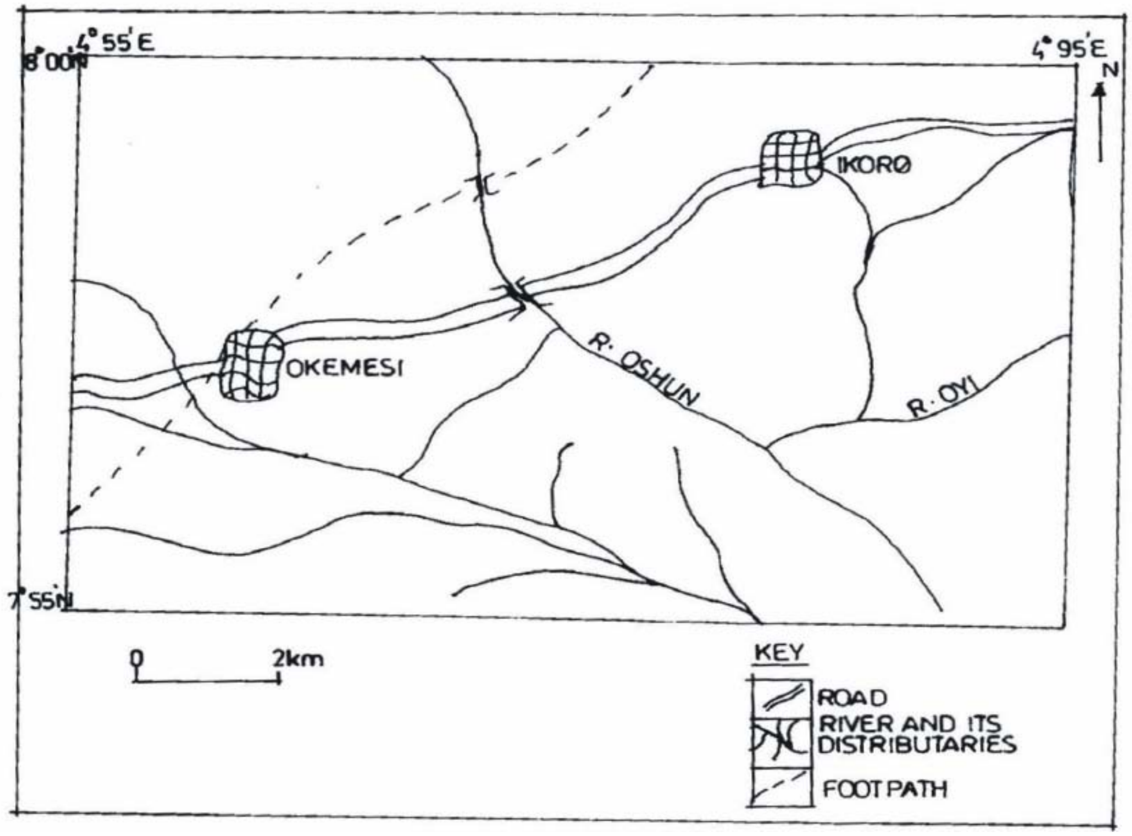

Fig.2 : Trellis drainage pattern of the study area

III. Geologic Setting of the Study Area

The study area belongs to the basement complex terrain of southwestern Nigeria (Fig.3) and lies within the Ilesha schist belt. The basement complex rocks are Precambrian in age although the rocks are also found in the early Paleozoic. The basement complex of southwestern Nigeria lies to the rest of the West African craton in the region of late Precambrian to early Paleozoic orogenesis. Structurally, the Precambrian geology of Nigeria lies within the structural framework of Africa and this can be divided into cratons and Pan-African mobile belts. The Nigeria basement complex extends westwards and is continuous with the Dahomeyan of the Dahomey-Togo-Ghana region. To the east and south, the basement complex is covered by the Mesozoic-Recent sediments of the Dahomey and Niger coastal basins. The West African craton and the Pan-African events which present the framework of West Africa in the igneous/ metamorphic structural framework of Africa consist of Precambrian rocks that have been subjected to major supra-crustal plutonic events. These events are;

i. Leonian 3000Ma
ii. Liberian 2500-2700Ma
iii. Eburnean 1850±250Ma
iv. Kiberian 1150±100Ma
v. Pan African 600±150Ma
vi. Harcynian 300Ma
vii. Alpine orogeny of the Atlas Mountain

The rocks of the Precambrian basement complex of Nigeria have been grouped into four lithologic units by Dada (2006) as follows:

(i) Migmatite-Gneiss-Quartzite Complex;
(ii) The schist belts
(iii) Pan African Granitoids and;
(iv) Unmetamorphosed minor acid and basic rocks

IV. Local Geology of the Study Area

Ikoro and Okemesi Ekiti lie within the south-western part of Nigeria basement complex (Figs 4 and 5). The dominant rock type in the study area is the quartzites of the Effon Psammite formation which occurs mostly as massive quartzites, schistose quartzites and quartz schists. The Effon Psammite formation (Hubbard, 1966; De Swardt, 1953; Dempster, 1967) is a belt of quartzites, quartz schists and granulites which occur largely east of Ilesha and runs for nearly 180km in a general NNE-SSW direction. This environment like other areas within the Nigeria basement complex was subjected to the Pan African orogenic event about 600±150Ma (Ajibade et al, 1980). The abundance of quartzite exposure in the study areas could by no means be a strange occurrence because of the proximity of this locality to Efon-Alaaye Ekiti popularly known for the Effon Psammite formation. Rahaman (1976) gives a general description of the mineralogy of the quartzites found in the southwest as being dominated by eight minerals where three or four are usually present such as quartz, muscovite, hematite etc. The colour of the quartzites found within the study area varies for instance, the schistose types are pure and white in colour, and the ferruginous ones exhibit a grey colouration when the samples are fresh but display brownish colouration when weathered. The different lithologies in the study area have been subjected to deformation which led to the development of synformal structures on the metamorphic rocks. The well pronounced structures include fractures, foliations, veins e.t.c. The general trend of the folds and foliations in the area is NNE-SSW direction (G.S.N. sheet 61 Akure). Rocks found in Ikoro Ekiti include charnockites, quartzites, schists, schistose quartzites and biotite gneisses while those of Okemesi include quartzites, schistose quartzites, migmatites and paraschists. These rocks with their associated meta- igneous rocks have been migmatized to various degrees. Also, the granites exhibit both intrusive and replacement characteristics in the area under investigation. The charnockites form an elongated N-S trending and they range from fine grained to coarse grained rocks of charnockitic affinities and from fine grained to coarse grained porphyritic granites.

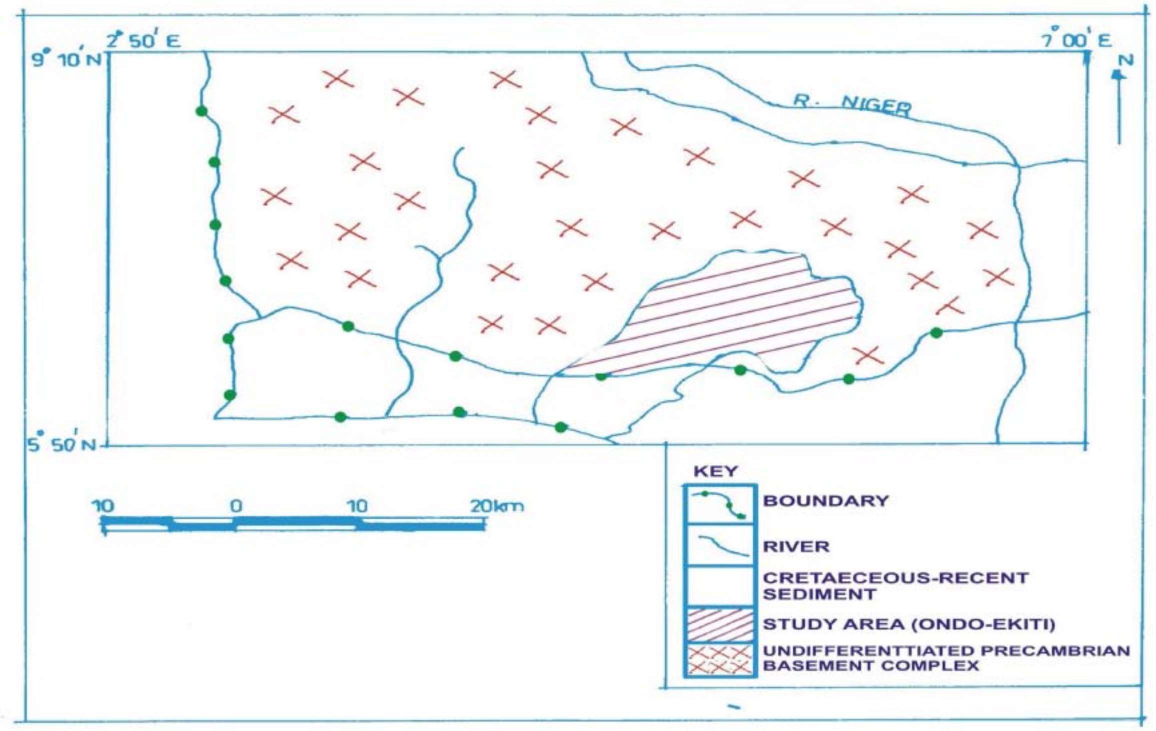

Fig.3 : Geological map of southwestern Nigeria (Adapted from Kogbe, 1976)

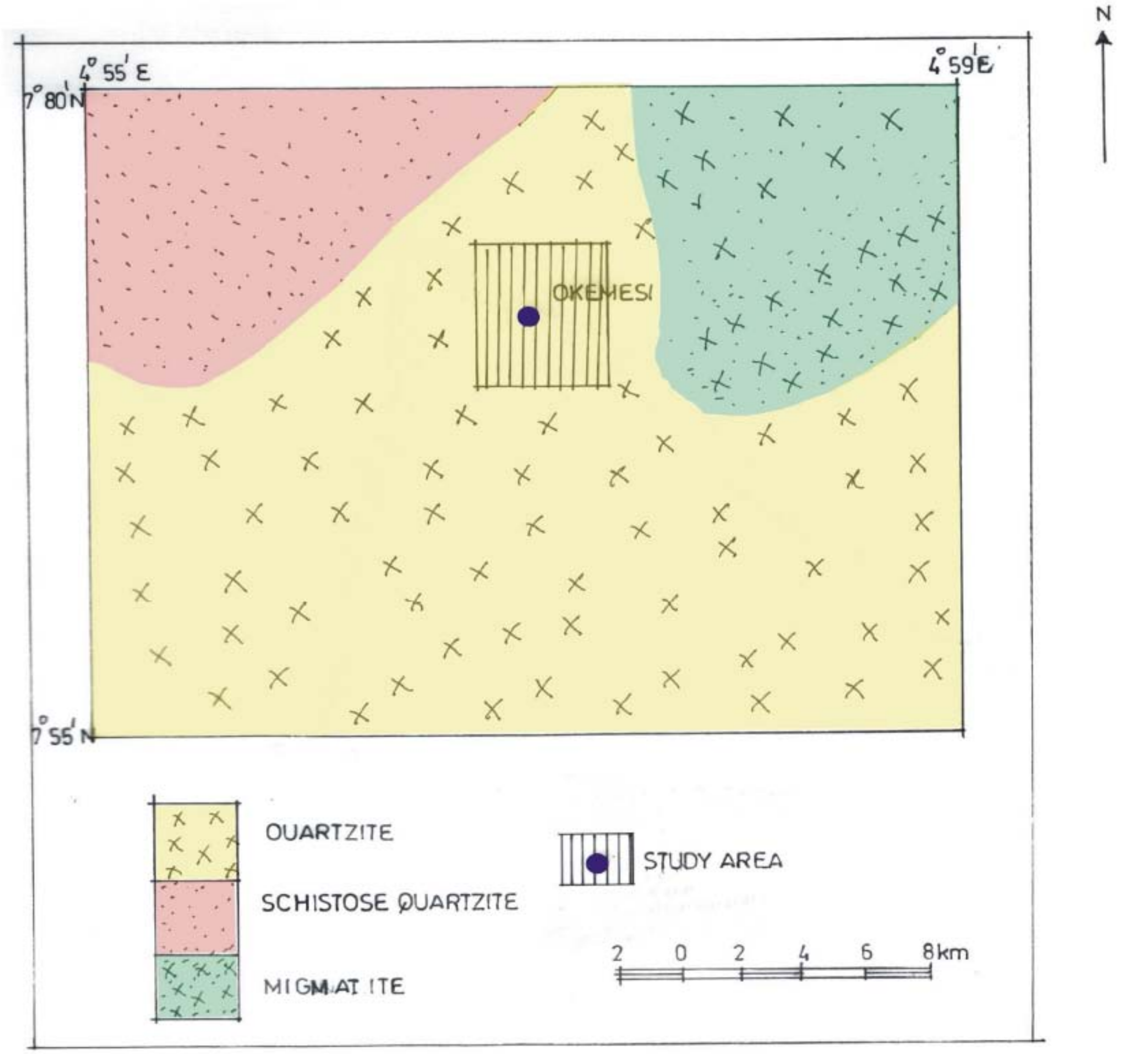

Fig. 4 : Geologic map of Okemesi Ekiti

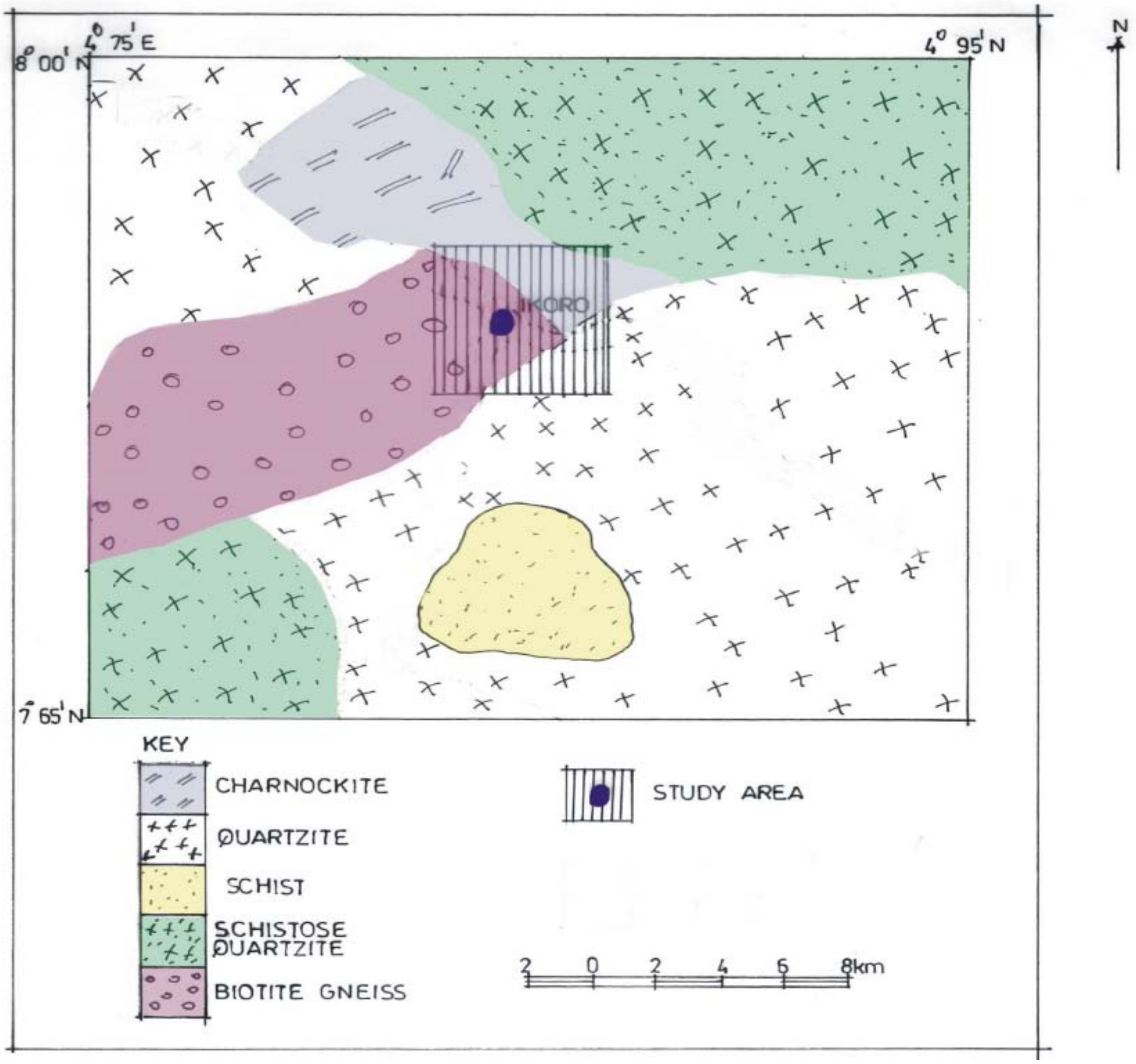

Fig. 5 : Geologic map of Ikoro Ekiti

V. Hydrogeological Setting of the Area

The availability of groundwater in the study area depends on the presence of decomposed material usually called overburden, which possesses a significant thickness and lateral extent to serve as reservoir. However, the quantity of water that can be accommodated under the subsurface depends also on the degree of porosity and permeability of the subsurface strata, it is a measure of the openings in which groundwater can exist. Although, basement rocks look solid to the naked eye but a microscopic examination reveals the existence of openings in the rocks. Following the instituted weathered profiles developed in the study area, the major soil types found there include alluvial soil, lateritic soil, sandy soil and clayey soil (Fig.6). The lateritic soils are highly weathered sub-soil that contains iron and aluminium. It ranges from soft, earthy, porous soil to hard dense rocks. The alluvial soil gives a record of high water level, the sandy soil in the area also forms a good and prolific aquifer, and the occurrence of clayey soil is not very prominent in the area under investigation.

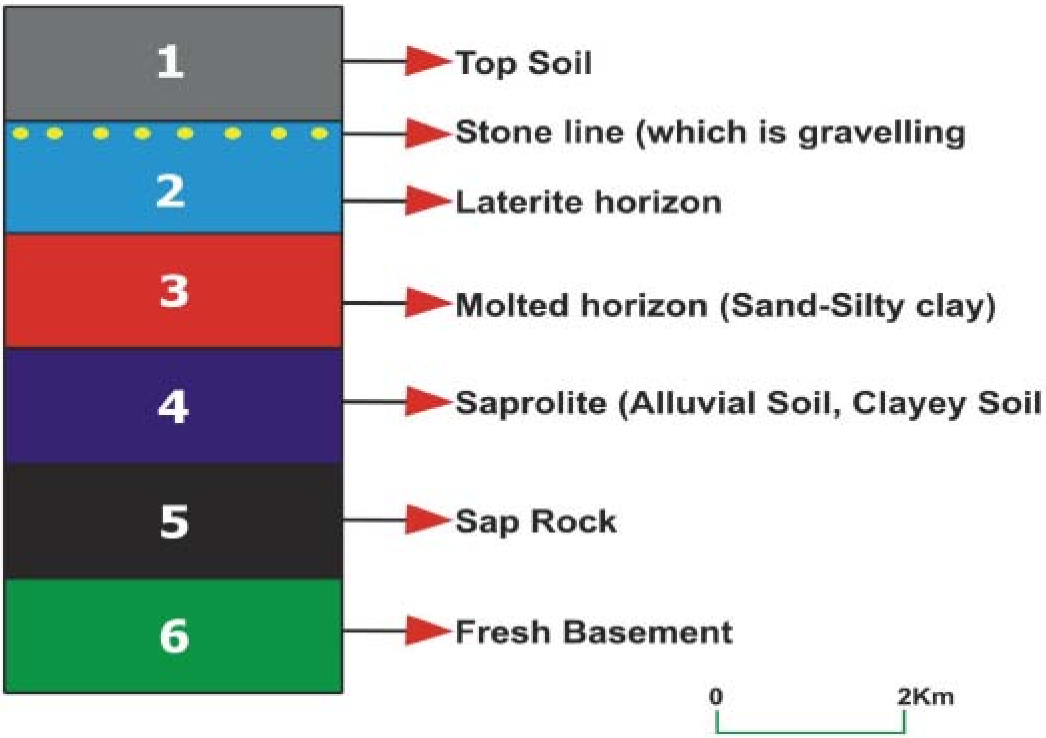

Fig. 6 : Weathering profile in the study area

The hydrogeological characteristic of the area under study is that the weathered products of the basement rocks often form a significant water-bearing layer directly overlying the fresh basement rocks as regoliths. Therefore, the process of rock weathering enhances the development and accumulation of groundwater in that the regoliths facilitates the ingress of water into the overburden and so transforms the ordinarily impermeable and impervious granites and gneisses into sources of abundant groundwater reserves and as such, water supply are exploited in this weathering profile through shallow hand-dug wells and boreholes by inhabitants. Metamorphic deformation and tectonism that occurred in these areas as well as the developed structural features are favourable to groundwater development and accumulation as confirmed by field observations.

VI. Method of Study

Fifteen (15) water samples were collected randomly from hand dug wells and boreholes within Ikoro and Okemesi Ekiti. The GPS was used to determine the geographic positions of these wells. Five (5) borehole water samples and four (4) hand dug well water samples from Okemesi and One (1) borehole water sample, five (5) hand dug well water from Ikoro were collected into clean and well drained sample bottles and were carefully labelled for each location. The water samples were collected early in the morning in order to allow suspended mineral matter to have settled down. The fifteen (15) samples were taken to the Federal Ministry of water resources, Regional Water Laboratory, Alagbaka, Akure, Ondo State for physio-chemical and bacteriological analysis.

VII. Results

The results of the physical characteristics of the wells and boreholes in the study area are presented in tables 1 and 2, while those of the chemical characteristics are presented in tables 3, 4, 5, 6, 7 and 8 respectively.

Table 1 : Physical Characteristics of The Wells And Boreholes In Okemesi Ekiti

S/N	Location	Type of Well	Depth (M)	Lithology	Temp (°C)	Appearance	Colour (Hazen Unit)
2	Chief Odofin's house	BH	16.15	Quartzite	26.7	Clear	<10
3	St. Michael Anglican Church	BH	15.24	Quartzite	27.7	Clear	<10
4	Aafin Owa Ooye Okemesi	BH	17.68	Schistose quartzite	27.6	Clear	<10
5	Iro quarters	BH	18.29	Quartzite	27.3	Clear	<10
6	Oke Onire St (Ile Richard)	BH	21.34	Massive quartzite	27.0	Clear	<10
7	Oke Onire st	HDW	14.51	Quartzite	26.7	Clear	<10
8	Oke Onire st	HDW	12.62	Quartzite	27.1	Clear	<10
9	Oke Onire st	HDW	11.36	Quartzite	27.7	Clear	<10
10	Ile Obanla	HDW	12.62	Schistose quartzite	27.4	Clear	<10

Table 2 : Physical Characteristics Of Boreholes And Wells In Ikoro Ekiti.

S/N	LOCATION	TYPE OF WELL	DEPTH (M)	LITHOLOGY	TEMP (°C)	APPEARANCE	COLOUR
1	Opposite Magistrate Court	BH	17.07	Biotite Gneiss	27.3	Clear	<10
2	Odo Ojobe St	HDW	7.57	Biotite Gneiss	27.2	Clear	<10
3	Omoleye St	HDW	8.20	Quartzite	27.3	Clear	<10
4	Oke Iwaro St	HDW	11.36	Schistose Quartzite	27.0	Clear	<10
5	Idiolowo St (Palace Junction)	HDW	10. 72	Schistose Quartzite	27.0	Clear	<10
6	Oke Mesi	HDW	8.83	Quartzite	27.1	Clear	<10

Note : Bh- Boreholes
Hdw- Hand Dug Wells

Table 3 : Result Of Chemical Characteristics of Water In Okemesi Ekiti

Parameters	Sample 2	3	4	5	6	7	8	9	10
PH	5.97	6.87	6.82	6.66	6.23	6.52	5.96	6.43	6.64
Turbidity(NTU)	0.35	0.00	0.42	0.00	0.17	0.27	0.75	3.99	9.35
Conductivity(µs/cm)	1000	250	600	860	80.0	270	150	210	530
T.D.S (mg/l)	670	168	402	576	53.6	181	101	141	355
Total hardness	188	90.0	150	328	28.0	70.0	52.0	80.0	130
Calcium hardness	122	54.0	104	102	16.0	32.0	26.0	60.0	96.0
Magnesium hardness	66.0	36.0	46.0	226	12.0	38.0	26.0	20.0	34.0
Nitrate (NO_3) mg/L	0.98	1.32	ND	ND	ND	ND	ND	ND	11.3
Iron (mg/L)	0.35	ND	0.65	0.43	0.52	ND	0.49	0.27	0.38
Alkalinity	22.0	14.0	8.00	42.0	6.0	10.0	6.0	14.0	26.0
Manganese (Mn)	0.018	ND	ND	0.009	ND	ND	0.008	0.023	0.014
Calcium (Ca^{2+})	48.9	21.6	41.7	40.9	6.41	12.8	10.4	24.0	38.5
(Mg^{2+})	16.1	8.78	11.2	55.1	2.92	9.27	6.34	4.88	8.29
(Cl^-)	124	28.9	81.9	79.9	5.99	26.9	10.9	10.9	35.9
Sodium (Na)	80.6	18.8	53.2	51.9	3.89	17.5	7.08	7.08	23.3
Bicarbonate (HCO_3)	22.0	14.0	8.00	42.0	6.0	10.0	6.0	14.0	26.0

Table 4 : Result of Chemical Characteristics Of Water In Ikoro Ekiti

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Ph	7.74	7.00	6.70	6.97	7.50	6.82
Turbidity (NTU)	0.00	0.47	0.70	0.00	0.34	0.03
Conductivity (µs/cm)	760	930	1210	1070	1680	1350
TDS (mg/l)	509	623	811	717	1126	905
Total hardness (mg/l)	152	236	300	318	414	346
Calcium hardness	108	172	154	190	232	254
Mg hardness (mg/l)	44.0	64.0	146	128	182	92.0
NO_3 (mg/l)	30.8	18.3	11.2	9.7	5.4	ND
Fe (mg/l)	0.57	0.48	ND	0.67	0.33	0.45
Alkalinity (mg/l)	96.0	104	68.0	180	126	78.0
Manganese (mg/l)	0.018	0.010	ND	0.015	0.011	0.015
Magnesium (mg/l)	10.7	15.6	35.6	46.4	56.6	22.4
Chloride (mg/l)	38.9	86.0	131	86.0	210	152
Sodium (mg/l)	52.3	55.9	85.2	55.9	137	98.8
Bicarbonate (mg/l)	96.0	104	68.0	180	126	78.0
Suspended solids (mg/l)	251	307	399	353	554	445
Calcium (mg/l)	43.3	68.9	61.7	76.2	93.0	102

Table 5 : Summary Of Physico- Chemical Characteristics And Who's Standard For Drinking Water

S/N	Parameters	Range		Mean values		WHO, 1993 standards	
		Okemesi	Ikoro	Okemesi	Ikoro	Highest desirable	Maximum permissible
1	PH	5.96-6.87	6.7-7.74	6.46	7.12	7.0-8.9	6.5-9.5
2	Temperature °C	26.7-27.7	27.0-27.3	27.24	27.16	-	-
3	Conductivity(µs/cm)	80-1000	760-1680	438.9	1166.7	900	1200
4	Appearance	C	C	C	C	C	C
5	Turbidity	0-9.35	0-0.70	1.7	0.37	5.0NTU	5.0NTU
6	TDS (mg/l)	53.6-670	509-1126	294.18	781.83	500mg/l	1500 mg/l
7	Total hardness	28-328	152-414	124	29.33	100 mg/l	500 mg/l
8	Alkalinity	6-42.0	68.0-126	16.44	96.67	100 mg/l	100 mg/l
9	Calcium	16-122	108-254	680	185.0	NS	NS
10	Magnesium	12.0-226	44-182	56.0	109.33	20 mg/l	20 mg/l
11	Chloride	5.99-124	38.9-210	45.03	117.32	200 mg/l	250 mg/l
12	Nitrate	0.98-11.3	5.4-30.8	1.51	12.57	0.2 mg/l	3 mg/l
13	Iron	0.27-0.65	0.33-0.67	0.34	0.42	1 mg/l	3 mg/l

14	Sodium	3.89-80.6	52.3-137	29.26	80.85	200 mg/l	200 mg/l
15	Manganese	0.008-0.023	0.010-0.018	0.008	0.012	0.1 mg/l	0.4 mg/l
16	Bicarbonate	6-42.0	68.0-126	16.44	96.67	-	-

Table. 6 : Correlation Coefficients Of The Physio-Chemical Parameters

Localities	Parameters	Correlation Coeeficient (R)	Remarks
Okemesi Ekiti	Between Total Hardness & Alkalinity	0.89	Positive correlation
	Between PH & Alkalinity	0.23	Positive correlation
	Between TDS & PH	0.03	Positive correlation
	Between TDS & Alkalinity	0.72	Positive correlation
Ikoro Ekiti	Between Total Hardness & Alkalinity	1.0	Positive correlation
	Between PH & Alkalinity	0.0023	Positive correlation
	Between TDS & PH	-0.13	Negative correlation
	Between TDS & Alkalinity	0.0023	Positive correlation

Table 7 : Result of Bacteriological Characteristics Of Water In Ikoro Ekiti

Parameters (Cfu/100ml)	Sample 2	3	4	5	6	7
Total Bacteria Count	10	12	11	8	10	9
E-Coli	0	0	0	0	0	0

Table 8 : Result of Bacteriological Characteristics of Water in Okemesi Ekiti

Parameters (Cfu/100ml)	Sample 2	3	4	5	6	7	8	9	10
Total Bacteria Count	9	7	10	8	12	11	10	14	16
E-Coli	0	0	0	0	0	0	0	0	0

VIII. DISCUSSION OF RESULTS

The results of the physical, chemical and bacteriological analyses has been presented in tables 1, 2, 4, 5, 6, 7 and 8 respectively and were compared with WHO (1993) standards (Table.5). The physical analysis of the water samples revealed that all the water samples are clear with its Hazen's unit less than 10, they have no taste and odour with respect to human senses. The lowest temperature which is 26.7°C was obtained from sample 2(BH) and 7(HDW) in Okemesi Ekiti while the highest temperature 27.7°C was obtained from sample 3(BH) and 9(HDW) in Okemesi. The temperature ranges from 26.7-27.7°C in Okemesi Ekiti and 27.0-27.3°C in Ikoro Ekiti. However, the World Health Organisation sets no guideline for temperature. The conductivity of the water samples vary from 80.0-1680μs/cm (Table 6). The highest value for conductivity is found in Ikoro sample 5 while the lowest is found in Okemesi sample 6. All the samples tested has a conductivity value which range between the highest desirable and maximum permissible limit of WHO except Ikoro samples 5 and 6 whose values are higher having 1,680 and 1,350μs/cm respectively . The total dissolved solids concentration for the tested water samples vary from 53.6-1126mg/l which fell under the fresh water classification except Ikoro sample 5 which has a greater value of 1126mg/l and are classified under moderately saline water (Hem, 1970). With respect to the World Health Organisation for drinking water, all the tested samples fell within the highest desirable and maximum permissible limit which is (500-1500)mg/l respectively (Table.5). The average results of turbidity carried out on the water samples showed that all the samples fell within the highest desirable limit of World Health Organisation (WHO) standard for drinking water except Okemesi sample 10 whose value 9.35NTU is higher than the maximum permissible limit of WHO's standard (Table.5). The results of the chemical tests also showed that the pH value of water sampled ranges from 5.96-7.74 which indicated that the samples are slightly acidic to slightly alkaline, and the values conformed with WHO recommended standards for drinking water which is 6.5-9.5. The alkalinity of water sampled ranges between 6.0-126.0mg/l which also fell below the highest desirable limit of WHO except samples 2,4and 5 (Ikoro) which has a greater value of 104mg/l, 108mg/l and 126mg/l respectively. Hem (1970) classified water based on its hardness as follows;

Hardness (mg/l $CaCO_3$)	Range
Soft	0-60
Moderate	61-120
Hard	121-180
Very hard	>180

The total hardness of water samples ranged between 28-414mg/l which indicates great variation in hardness of tested water samples. Samples 6&8 (Okemesi) having a value of 28.0mg/l and 52.0mg/l respectively are soft; samples 3, 7, 9 (Okemesi) are moderate; samples 4 & 10 (Okemesi) and sample

1(Ikoro) are hard; samples 2 & 5(Okemesi) and samples 2, 3, 4, 5 & 6 (Ikoro) are very hard. All the water samples tested has a value of total hardness that fell within acceptable limits of WHO (100-500)mg/l. Also, the value of nitrate in some of the water samples range between 0.98-30.8mg/l which exceeded the highest desirable limits of WHO. The chloride concentration in the water samples range between 5.99-210mg/l which is below the maximum permissible limit of WHO which is 250mg/l. The range of Fe concentration in tested samples is (0.27-0.67)mg/l which is also below the desirable limits of WHO (1)mg/l. The concentration of sodium in tested water samples range between (3.89-137) mg/l which is below the highest desirable limits of WHO (200)mg/l .

The summary of the various physical and chemical parameters, their mean values compared with WHO standards for drinking water is shown in Table 5. Virtually, all the mean values of parameters tested for in the water samples from Ikoro Ekiti are higher than that of Okemesi Ekiti except in the case of temperature, turbidity and total bacteria count (Table .5). The variation in progression as one parameter relates to the other is shown in figs 7, 8, 9, 10, 11 and 12. There is a great variation as PH, TDS and Alkalinity relates one with another as shown on the graphs. The overall mean of the turbidity value for Ikoro samples is 0.37NTU while that of Okemesi is 1.7NTU (Table.5) and the recommended value for turbidity by World Health Organisation is 5.0NTU both at highest desirable limit and maximum permissible level. Thus, from this comparison, it can be conveniently said that the water samples from Ikoro and Okemesi Ekiti are less turbid. All the parameters (PH, Alkalinity, TDS, Total Hardness) are positively correlated except TDS and PH for Ikoro samples which is negatively correlated (Table.6).

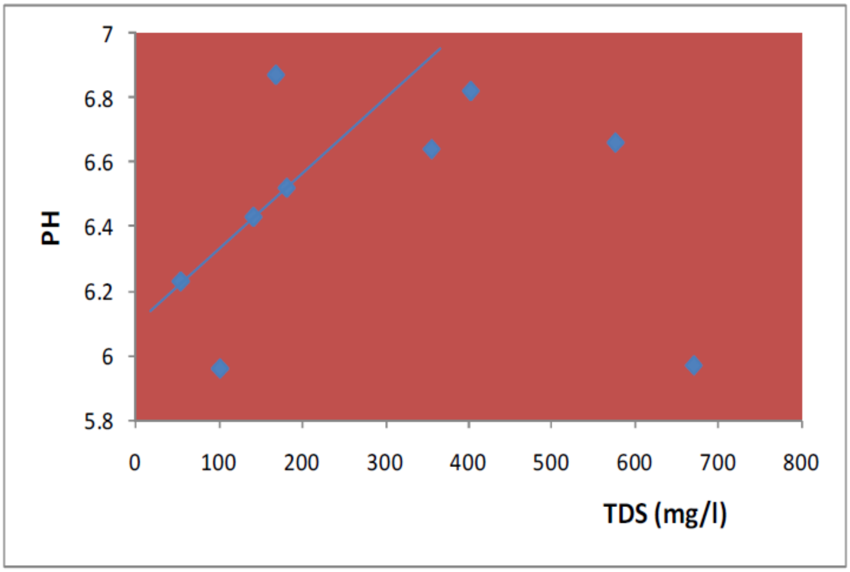

Fig 7 : Graph of PH against TDS for Okemesi samples.

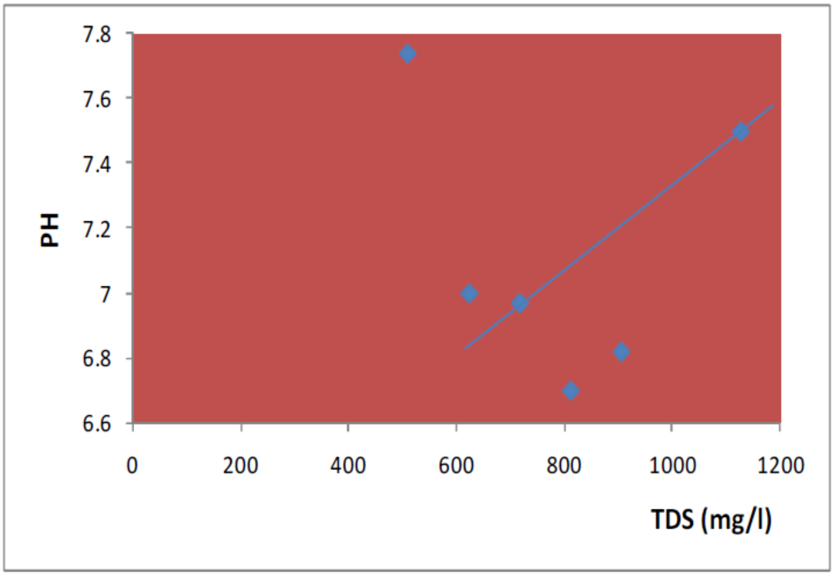

Fig .8 : Graph of PH against TDS for Ikoro samples

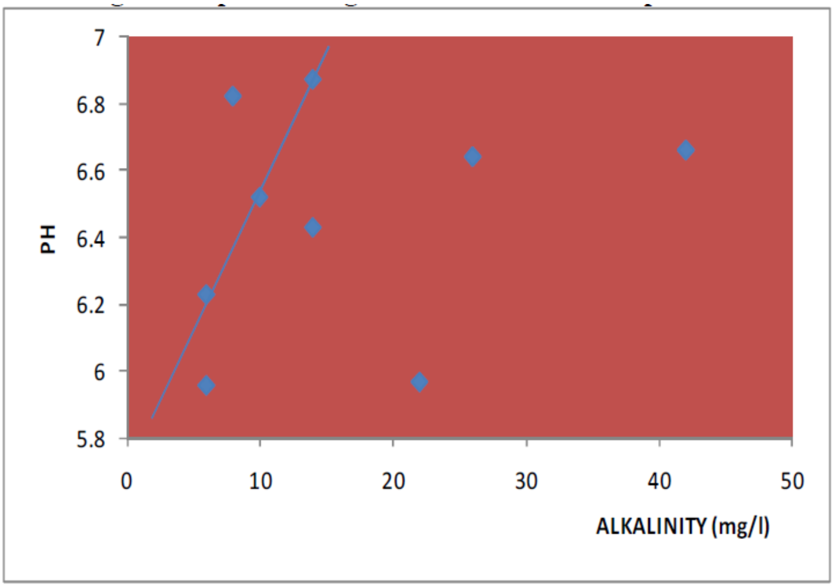

Fig. 9 : Graph of PH against Alkalinity for Okemesi samples

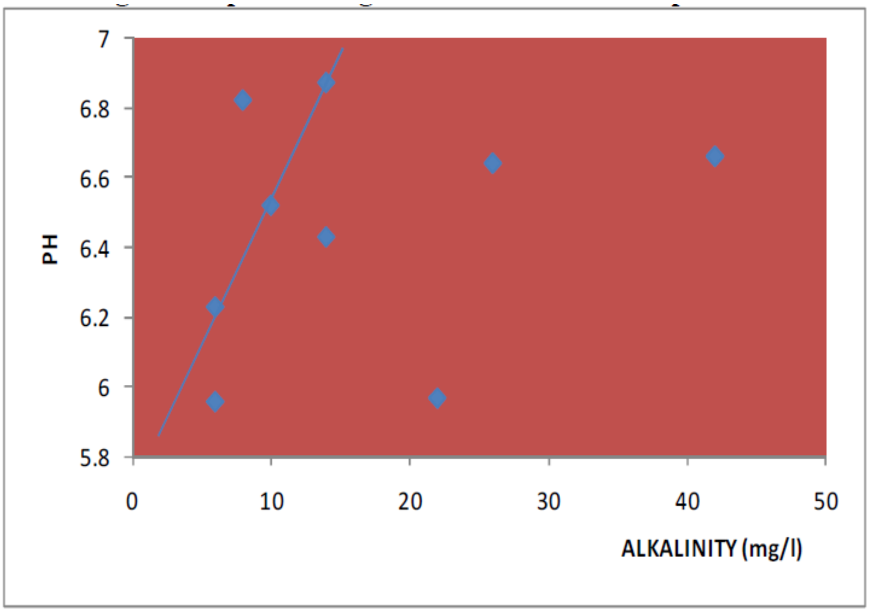

Fig. 10 : Graph of PH against Alkalinity for Ikoro samples

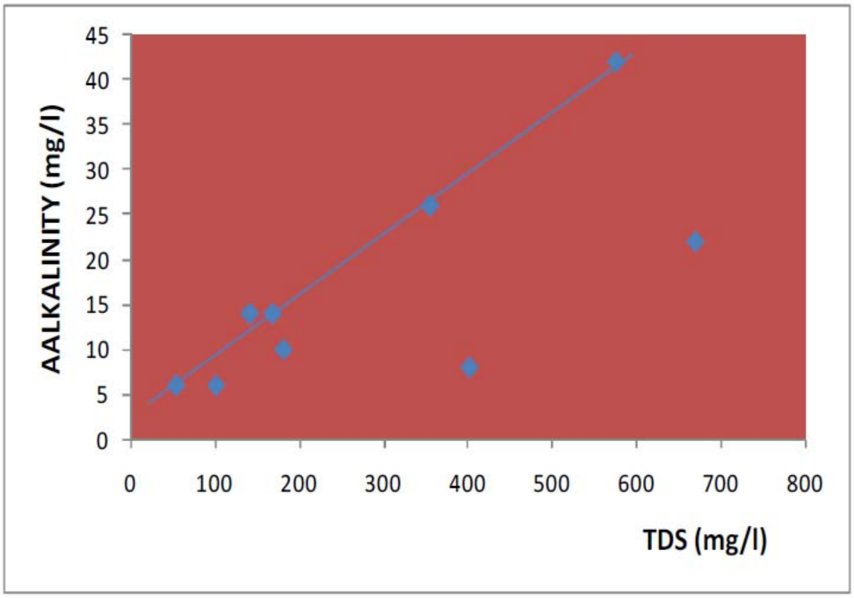

Fig. 11 : Graph of Alkalinity against TDS for Okemesi samples

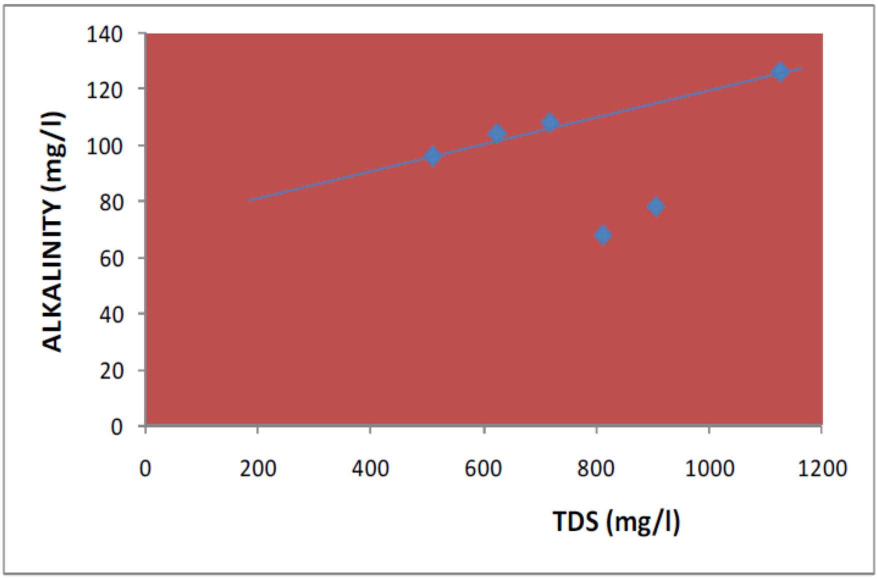

Fig. 12 : Graph of Alkalinity against TDS for Ikoro samples

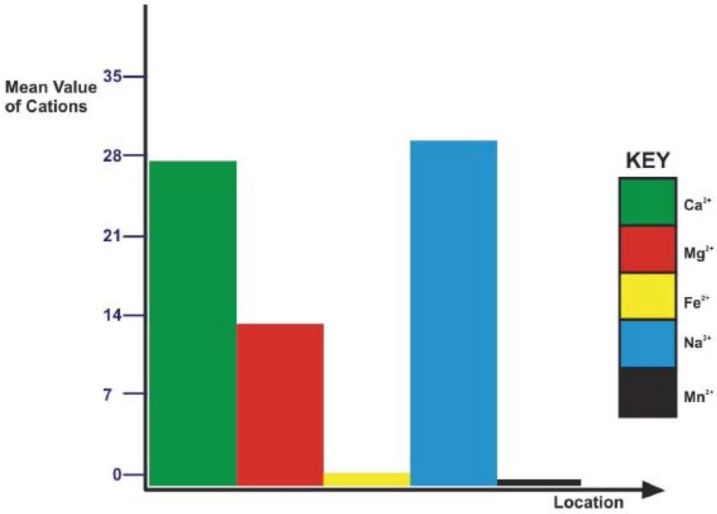

Fig. 13 : Histogram of mean concentration of cations for Okemesi

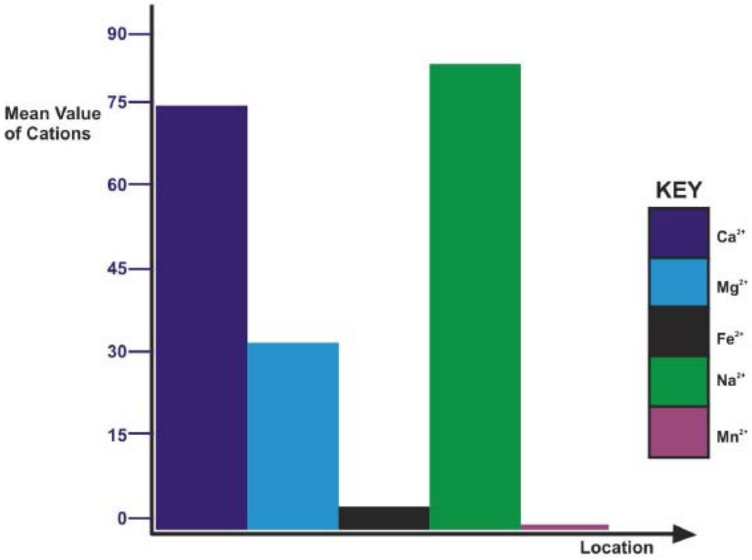

Fig. 14 : Histogram of mean concentration of cations for Ikoro samples

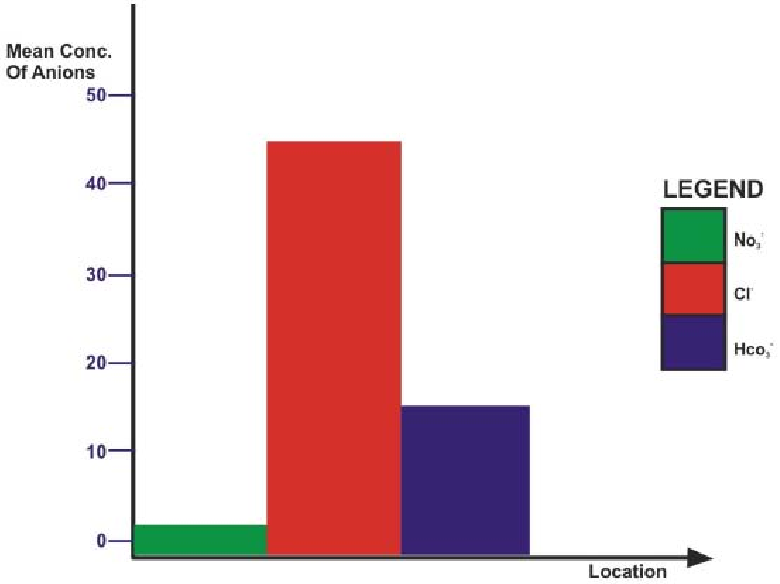

Fig.15 : Histogram of mean concentration of anions in Okemesi

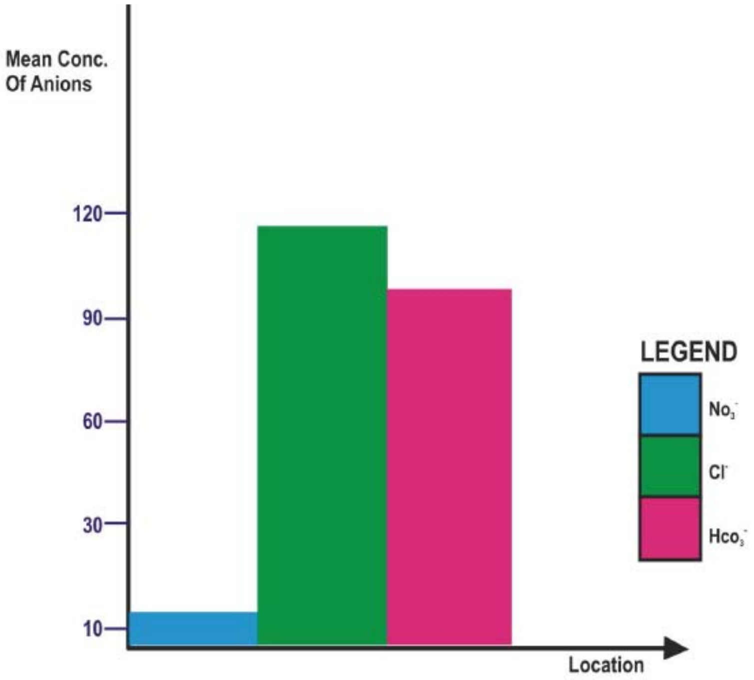

Fig.16 : Histogram of mean concentration of anions in Ikoro

The total bacterial counts for the analysed water samples from the study area range between 7Cfu/100ml-16Cfu/100ml (Tables 7&8), this shows a relatively high load of bacteria in the water as no sample should contain more than 3 coliform per 100ml as stipulated by World Health Organisation. The results of analysis shows that the total bacteria counts in Okemesi water samples range from 8Cfu/100ml-12Cfu/100ml and that of Ikoro Ekiti ranges from 7Cfu/100ml-16Cfu/100ml with the overall mean of 10.78Cfu/100ml respectively. All the water samples analysed from both Ikoro and Okemesi has zero value for E-Coli which is acceptable as World Health Organisation states that no sample should contain E-Coli in 100ml. Coliform organisms should not be detectable in 100ml water sample. However, the quality of water is strictly based on some physical, chemical and bacteriological parameters. Some of these parameters are inherent in surface water and their sources are mainly from precipitation, leaching of soil particles during infiltration, decay of organic matter, salt water intrusion, exchange of ions with surrounding rocks and human activities etc. Continuous occurrence of these processes lead to the increase in concentration and values of the parameters which in turn influence water quality. According to WHO (1993) standard for drinking water, the maximum allowable range for pH of water is 6.5-9.2 and the result obtained from analysis showed that the pH of all the water sampled at Ikoro-Ekiti are within acceptable limit, but in the case of water sampled at Okemesi, Sample 2, 6,8,9 has pH less than the WHO's limit. This low pH may be due to the presence of some contaminants such as ammonia that can furnish hydrogen ion in water (e.g. ions of iron). It might be due to dissolved carbon dioxide absorbed from air or released into the water as a result of bacteria activities. According to the result obtained, the wells and borehole investigated appeared to have uniform temperature which range between 26.7°C - 27.7°C and this is a typical characteristic of groundwater temperature, the uniformity in groundwater temperature is advantageous for water supply. The physical parameters such as colour, temperature, conductivity, pH, TDS and total hardness of water in the study area are satisfactory for drinking water. Except for the turbidity of Okemesi sample 10 whose value 9.35NTU exceeds that of WHO standard of 5.0NTU.Water become turbid when substances like silt, clay, colloidal and organic matter are present. This especially happens to surface water during rainy season. The chemical parameters of water are its anion and cation concentrations (table 5 and figs 13, 14, 15 and 16). The concentration of magnesium in most of the water sampled exceeded the highest desirable value as stipulated by WHO. Chloride concentration is very low compared with that of the WHO standard for drinking water (250)mg/l. Although, the chloride concentration in sample 5 (Ikoro) has a high value compared with other samples, the highest value for water hardness is found in sample 5 and 6 (Ikoro) and this is as a result of the high concentration of calcium and magnesium ions that dissolves in the water samples. The water hardness results obtained are permissible because the values are below the maximum permissible concentration for water hardness which is 500mg/l. The nitrate concentration is relatively high when compared with WHO standard for drinking water. High concentration of nitrate results in the death of young infants as a result of metahaemoglobinaemia or blue baby disease. Since the gastric juice of young infants lack acidity, nitrate-reducing bacteria can grow in their upper intestinal tracts. When nitrate is ingested, it can be reduced to nitrite before the nitrate is completely absorbed in the bloodstream and combine with haemoglobin to form metaheamoglobinaemia, which is ineffective as oxygen carrier. This produces anoxenia which can lead to the death of infants by asphyxia. Older infants and adults can tolerate higher level because their stomach's PH is too low for nitrate reducing bacteria. However, nitrate reducing bacteria leads to the production of nitrosamines in the stomach. The sodium concentration in sampled water varies uniformly and its concentration is below the highest desirable limit recommended for drinking water by World Health Organisation.

There are variations in the results obtained for total dissolved solids of the water samples and this may be due to high concentration of calcium and magnesium ions and probably the aquifer of these samples contain clay minerals which consequently dissolve solids. The World Health Organisation recommended that the number of bacteria and coliform count should be zero per colony. The result obtained from the microbial test (Tables 7&8) showed that the total number of bacterial count found in all the water samples are numerous and are above the WHO standard whereas the E-Coli have a zero value for all tested samples. The bacteria might have originated as a result of faecal contamination in the water by human beings and animals or they could have been deposited in sediments and now migrated into the water. Therefore, it will be advised that the water in the areas be boiled properly before consumption or use other methods of purification to make it potable so as to prevent the outbreak of diseases. The presence of these bacteria in water results in disease like diarrhoea, cholera, typhoid, infections, hepatitis, giardiasis, amoebiasis and dracunuliasis; if there is continuous consumption of the water from the study areas. (Adapted from Bradley, D.J London school of Hygiene and Tropical Medicine).

IX. Conclusion

A comparison of results of the physiochemical and bacteriological analysis of the water samples collected from the study areas and the WHO international standard on potable water revealed that the water in the study area has no permanent chemically induced colour, they are tasteless, odourless and are slightly acidic to slightly alkaline. The low total dissolved solids (TDS) revealed the water to be from a fresh water source. The chloride and nitrate gives an indication of faecal pollution in the water, this is reflected in the bacteriological analysis employed which showed that the water in the study area is contaminated with faecal coliform. It is suggested that the high load of bacteria in the water might have originated from plant debris, animal and human excretal, legumes and the atmosphere. The high bacteria count indicates very heavy pollution which is beyond the limit of the World Health Organisation bacteriological standard for drinking water. This is unacceptable and not recommended as potable water unless special treatments and designs are adopted. It can be concluded that the water chemistry has been found to be dependent on the chemistry of the basement rock, leaching during infiltration, exchange of ion with the reservoir rock, human activities and effluent, discharge from rivers. Also, it was observed that not only the geology, topography, weather (climate) and rock influence water chemistry but man himself has a very strong influence. Therefore, it can be concluded that the entire water sample analysed met the requirements for good water supply with minimum scientific treatment.

X. RECOMMENDATION

It has been observed from this study that hand dug wells and boreholes based on chemical and bacteriological analysis result is potable for public water use such as drinking, cooking and other domestic purposes. Also, majority of these wells can serve as a means of transporting diseases into human body. Therefore, the following recommendations are hereby made from the outcome of the research:

1. Wells constructed should be properly ringed and covered to avoid the washing of surface particles into the wells during rainy seasons.
2. The wells should be treated with chlorine and alum from time to time to keep the water fit for human consumption. Water from the wells and boreholes should be boiled before drinking.
3. Government should set up a board to enforce the cleanliness of well environment to ensure the portability of the water supply.
4. The hydrogeological mapping and groundwater quality of the area should be reinvestigated thoroughly, at least for a minimum period of two years so as to improve on this work.
5. Stream passing through a well location should be prevented from polluting or contaminating such well.
6. There should be proper disposal of industrial and household waste.

Since men cannot survive without water, it is very necessary that water wells and boreholes in our communities be purified to meet the agreement with the World Health Organisation requirement.

XI. AKNOWLEDGEMENT

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Detection of Liquefied and Gaseous form of CO_2 Implementing New Method in Non-Dispersive Infrared Spectroscopy Sensor System

By Himansu Mohan Padhy & Pranati Mishra

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Keywords : optics, carbon dioxide (CO_2), Measurement System, NDIR Sensor, DMA Controller.

GJSFR-H Classification : FOR Code: 250104

DETECTION OF LIQUEFIED AND GASEOUS FORM OF CO2 IMPLEMENTING NEW METHOD IN NON-DISPERSIVE INFRARED SPECTROSCOPY SENSOR SYSTEM

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Himansu Mohan Padhy [α] & Pranati Mishra [σ]

Abstract - The global warming increasing daily and showing serious impact on earth environment due to Carbon dioxide (CO_2) content in the atmosphere, and many other human activities. And it is very important to measure and analyse the concentration of Carbon dioxide before it became dangerous to humankind. In the present paper an optical signal is used to measure the level of Carbon dioxide in open space and in food Industry. So that, the engineers can take appropriate verdicts in advance before it become too late. CO_2 also plays vital role as output of industrial gas, helps in production of chemicals and also in preparation of food and food packaging. The ability to quantify gas concentrations with high sensitivity, excellent selectivity and rapid response by means of direct laser absorption spectroscopy is important.

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I. INTRODUCTION

Measurements of atmospheric concentrations of CO_2 will provide valuable information of the environmental conditions and intensities of carbon. Such studies will help the human being to analyse and control the global greenhouse warming. Now a days global warming becoming a serious issue which to control and reduce greenhouse gases. Atmospheric CO_2, one of the major components in greenhouse gases which is a cause of large global warming on earth. The CO_2 absorbs the earths heat and warm up the atmosphere. The CO_2 largely induced due to chemical processes in oceans, earth and the usage of land and natural resources by human.

While practicing experiments with CO_2 some precautions need to be taken due to some hazards. Carbon Dioxide gas exists as colourless, cryogenic liquid. At low concentrations, both the gas and the liquid forms are odourless. At higher concentrations Carbon Dioxide will have a sharp, acidic odour. At concentrations between 2 and 10%, Carbon Dioxide can cause nausea, dizziness, headache, mental confusion, increased blood pressure and respiratory rate. If the gas concentration reaches 10% or more, suffocation and death can occur within minutes. Contact with the cold gas can cause freezing of exposed tissue. Moisture in the air could lead to the development of carbonic acid which can be irritating to the eyes. All forms of Carbon Dioxide are non-combustible. Carbon Dioxide is heavier than air and should not be allowed to accumulate in low lying areas [4].So the Carbon dioxide analysis is more important in all aspects of the life to protect ourselves, to protect the environment and to protect the earth from global warming.

CO_2 is an important industrial gas for many different uses that include production of chemicals for instance urea which is mostly used at farms, inert agent for food packaging which will help in increasing the expiry data of the content in the package, beverages, fire extinguishers, refrigeration systems, welding systems, water treatment processes, and many other smaller scale applications. And it is also revealing the importance of the Carbon dioxide gas in food processing industry to make the food in hygienic form.

There are already some existing methods actively involved in present scenario. A Surface Plasmon Resonance method is presented in [5], which is following a dispersive optical based sensor technique to measure the carbon dioxide concentration. This system produces high sensitive and accurate measurements when compared with traditional methods and chemical process methods. In dispersive measurement system, prisms are used and need to set a predefined wavelength from broad category of prism output wavelength. The selected light beam will pass through the sample chamber. It is all a complex process to select a particular wavelength of a prism. However, the dispersive systems are tending to be larger, complicated and more costly and hence they are less suitable for portable instrument measurement system [6]. In another method the carbon dioxide concentrations are analysed by fundamental chemical process [7]. Although this system produce accurate measurement readings the control process is little tedious job and achieving sensitivity is difficult when compared with optical system.

In the present paper working principles of NDIR sensors and operations are discussed to find the concentration of Gaseous Carbon dioxide. And

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Liquefied Carbon dioxide measurement techniques also discussed in the present paper to measure the concentration of required Carbon dioxide in food processing Industry.

II. MOTIVATION

The active gases aretransparent to incoming short-wave solar radiation, but they absorb and re-radiateoutgoing long-wave terrestrial radiation, thus heating the atmosphere. This energyabsorption is measured in Watts/m^2 and is called "radiative forcing". Gases which exhibitthis property are called "greenhouse gases"[1]. The main greenhouse gas is CO_2. The CO_2 emissions are seriously affecting the environment. The CO_2 emissions cause the increase in the global warming and indirectly involved in the change of climate conditions. The CO_2 also have some advantages beside its disadvantages. The CO_2 is used in some food preparations, food packaging and in preparation beverages. But few percentage of CO_2 is allowed in food processing industry. Beyond the allowed percentage it may contaminate the food which is not allowed to have by corporeal. So it is highly essential to measure the CO_2 concentration in food processing industry and also to analyse the percentage of CO_2 in the environment. On the earth atmosphere the sun radiates infrared waves with high intensity. The same waves again reflected from earth surface back to space. But while reflecting, the intensity of these waves will be reduced due to the earth atmospheric weather. Based on this principle a light source can be used to analyse the concentration of the gases. In the present paper IR waves are used to analyse the CO_2 gas in open air and also discussed to analyse the CO_2 concentration in food processing industries.

III. EXISTING METHODS

In the present section some existing and actively involved methods are discussed to understand the Gas sensor measurement system.

3.1 Refractometric fiber optic sensors Measurement : The Refractometric fiber probe was immersed in thesolution and fixed in rigid. In each case, refractive indexwas measured after some minutes of bubbling withthe corresponding gas.The results showed a consistent visibility differenceof 1% between the two states, meaning that therewas a refractive index decrease of approximately 0.005 refractive index unit induced by the increase in CO_2 concentration [8].

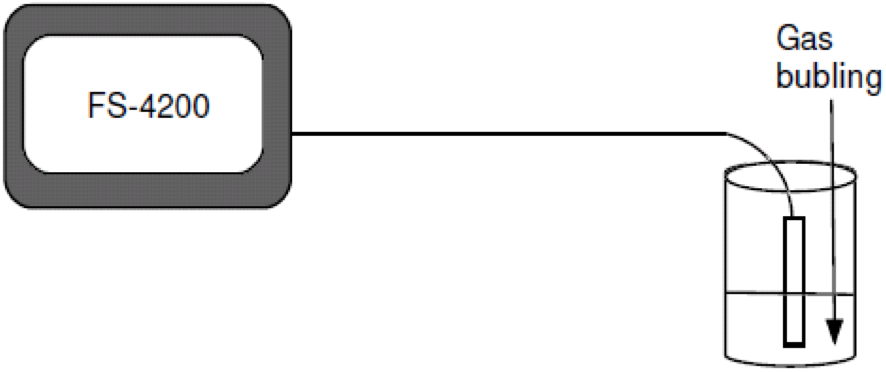

Figure 1 : Setup used to evaluate refractive index changes of the polymer precursor solution.

1.2 ***LED-LED Portable co_2 gas sensor :*** In this system a test rig was constructed to ensure the accurate alignment of the two LED pair channels, the secure placement of the chemical sensing membrane and to investigate the effect of the distance between the emitter and detector LEDs. The membrane housing contained two sensing chambers wherein each was fitted with one LED emitter/detector pair. Furthermore, the chambers were designed with hollow through-hole sections to allow for a flow of gas to react with the sensing membrane. The LEDs were polished and flattened down, and placed within threaded housings, so that the rotation of the housing inside the tapped holder varied the distance between the emitter and the detector. The distance was adjusted by inserting different sized washers, each of a pre-set designed thickness. Finally, the membrane holder allows the sensing surface to be directly aligned with both the emitter and detector LEDs.

1.3 ***NDIR Sensor Design :*** The figure 2is showing a top view of the overall NDIR sensor design. The gas sample diffuses through a metal which on the top. Polychromatic light from the incandescent bulb passes through the gas sample and is absorbed in proportion to the amount of CO_2 present. Reflection of light off the internal walls increases the path length and hence it increases the sensitivity. The filter in front of the detector removes all the light except that at 4.26μm, corresponding to CO_2[6].

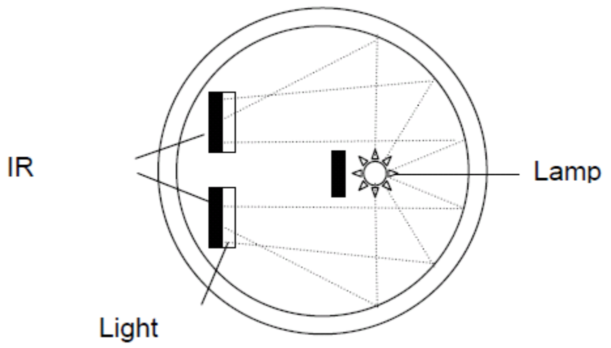

Figure 2 : Top View of NDIR sensor

1.4 ***Chemical Gas Sensor :*** Chemical CO_2 gas sensors with sensitive layers depend on polymer or heteropolysiloxane have the principal advantage of very low energy consumption and can be condensed in size to fit into microelectronic-based schemes. The short- and long term drift effects and low lifetime are major drawbacks when compared with the NDIR measurement principle [3].

3.5 ***Surface Plasmon Resonance sensor :*** Surface Plasmon Resonance (SPR) is a charge density wave which takes place at the interface of two media with dielectric constants of opposite signs. This charge density wave is associated with a TM electromagnetic wave and whose field vector is at maximum[9].This wave can be optically excited by using a coupling prism coated with a thin metal layer, where a TM-polarized light beam is imposing on the metallizedface of the prism through the prism itself under total internal reflection conditions which is shown in figure 3 [5]. The resonance linewidth strongly depends on the excitation wavelength, the metallayer structureand the refractive index of the dielectric medium. This refractive indexvariations modify significantly the SPR conditions, varying the resonance angle value andhence the resonance angular position. Therefore the refractive index variations are incidentalby the spatial displacement of the resonance peak. These features allow SPR-based devices tobe used as high sensitivity optical sensors [5].

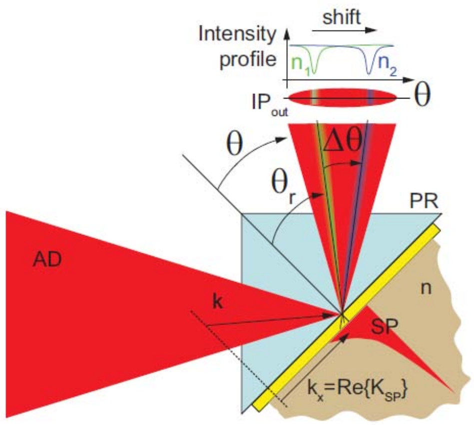

Figure 3 : Surface Plasmon Resonance Sensor

IV. Experimental Setup

4.1 Detection of Gaseous Carbon Dioxide : NDIR sensors are most often used for measuring carbon dioxide in gaseous environment [1] and have sensitivities of 20–50 PPM [2]. The main components in the present Non-Dispersive Infrared sensor device are an infrared source (lamp), a sample chamber,Reference chamber, a Light detector chamber. Before starting the process the sample chamber is fed with carbon dioxide to measure the actual concentration, and the reference chamber fed with Nitrogen as referenced gas to compare with the sample chamber. Then the Infrared light is directed from source lamp with high intensity through the sample chamber. Then some of the infrared rays absorbed by gas and partially the IR waves transmittowards the detector. In parallel,the reference chamber which is enclosed with the nitrogen gas is incident with the Infrared light. The infrared light is transmitted with same intensity levels through the reference chamber. In the reference chamber the infrared rays scattered in to nitrogen gas. The nitrogen gas absorbs some of the infrared radiation and partial radiations will be transmitted towards the detector. The detector has an optical filter in front of it that eliminates all light except the wavelength that the selected gas molecules can absorb. Ideally other gas molecules do not absorb light at this wavelength, and do not affect the amount of light reaching the detector[1] to compensate for interfering components.If the concentration of the carbon dioxide is high the absorption ratio in chambers increases. Similarly the radiations in detector chamber also increases.When a detector chamber absorbs some of the infrared radiation, it heats up and expands. This causes a rise in pressure within the sealed vessel that can be detected either with a pressure transducer. This pressure can be measured with low pressure diaphragms. These diaphragms will convert pressure in the detector chamber into displacement. Finally the displacement can be converted into analog signal with the help of Linear Variable Differential Transformer as shown in figure 4. The combination of these output voltages from the detector chambers from the sample gas can then be compared to the output voltages from the reference chamber. The analog signals are further need to convert into digital signals to process and analysis the signals through microcontroller. The analog signals generated from NDIR sensors are amplified and further converted into digital signals by passing them through Analog to Digital Converter as shown in figure5. The digital signals are fed to microcontroller through input ports for consideration to analysis and display the output on LCD screen

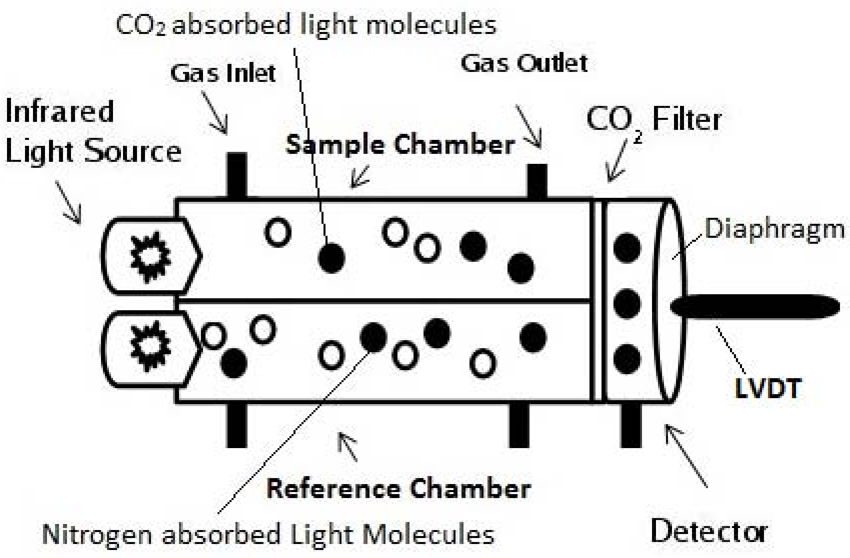

Figure 4 : NDIR Spectroscopic Sensor

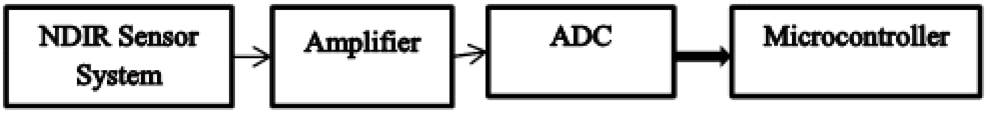

Figure 5 : Block diagram of CO$_2$ Measurement System

1.5 **Detection of Liquid Carbon Dioxide** : The first step in measuring Liquefied carbon dioxide, compress the carbon dioxide gas until it liquefies, at the same time removing the excess heat. The $C0_2$ gas will liquefy at a pressure of approximately 870 pounds per square inch at room temperature. Next, the pressure is reduced over the liquid carbon dioxide by sending it through an expansion valve into an empty chamber. The liquid will blaze, with some turning into gas causing the remainder to cool. As the temperature drops to -109.3°F, the temperature of frozen CO$_2$, some of it will freeze into snow. Connect liquid carbon dioxide to the inlet of the chamber, which is fixed with LIGHT on one side and Light detector on other side. When the liquid CO$_2$ flushes in to the chamber some of the cold CO$_2$ freeze in to snow. Firstly note the time to propagate the Light to the detector. Then note the time at the detector by emitting the liquefied CO$_2$ in to the chamber. The timing of detector excitement pulses are counted by external timer. If the sensing device is connected with 3rd generation microcontroller, it is not required to interface any external timer. The internal Direct Memory Access (DMA) control can be used to measure the time at detector. The DMA can also be used as counter [10][11]. The number of pulses at DMA represents the propagation delay between LED emitter and detector. Indirectly it is representing the concentration of CO$_2$ in the chamber. As the concentration of CO$_2$ goes on increasing the travelling period of the light waves also increases and further it increases the count at DMA terminal count register.

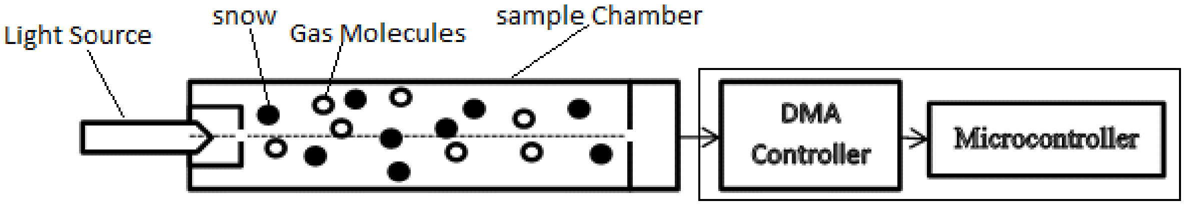

Figure 6 : Interfacing Diagram of Liquid gas sensor with DMA Controller

V. CONCLUSION

High sensitivity is achieved with Diaphragm attached in detector chamber of gas analyser. In liquid gas analyser DMA controller is used to measure the time taken to change the status of detector. The DMA controller is used to read pulses from the detector while microcontroller is busy with some other task. That is for instance, while microcontroller accessing the memory device, the DMA controller can fetch pulses from the light detector. The instrument is very capable of measuring low concentrations of CO_2 and it can also measure wide range of CO_2 with high sensitivity. In liquefied gas sensor system, power consumption is minimized since, without the intervention of the microcontroller the DMA controller is able to read the data waves from detector chamber. At the same time microcontroller can concentrate other tasks.

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Global Warming and Climate Change: A Review

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Abstract - Global warming, the gradual increase in Earth's temperatures and associated changes in global weather pattern, has had serious consequences in recent decades, constituting one of the major global issues of our time. This review highlights the sources of global warming, the country origins of Green House Gases (GHGs) emissions, the nexus between global warming and human activity, the costs of climate change drawing on findings on agricultural activity and, finally, policies to tackle global warming. The consequences of global warming still remain a subject of debate and speculation, but climate change studies hypothesize dire consequences for agricultural productivity and disease incidence globally, but especially for countries located nearer the tropics where temperatures are bound to rise higher.

GJSFR-H Classification : *FOR Code: 050101*

GLOBAL WARMING AND CLIMATE CHANGEA REVIEW

Strictly as per the compliance and regulations of :

Global Warming and Climate Change: A Review

Enwere Dike[α] & Uche CC Nwogwugwu[σ]

Abstract - Global warming, the gradual increase in Earth's temperatures and associated changes in global weather pattern, has had serious consequences in recent decades, constituting one of the major global issues of our time. This review highlights the sources of global warming, the country origins of Green House Gases (GHGs) emissions, the nexus between global warming and human activity, the costs of climate change drawing on findings on agricultural activity and, finally, policies to tackle global warming. The consequences of global warming still remain a subject of debate and speculation, but climate change studies hypothesize dire consequences for agricultural productivity and disease incidence globally, but especially for countries located nearer the tropics where temperatures are bound to rise higher.

I. INTRODUCTION

Global warming refers to the gradual increase in the Earth's temperatures and the associated changes in global weather pattern. Records show that the world's climate has barely changed since the Industrial Revolution in Western Europe which started in Great Britain in the late 1700s – that is, some two and quarter centuries ago. The world's temperature was reported stable throughout the 1800s, rose very slightly during the early 1900s, fell back in the 1950s through the 1970s, then started warming up again as from the 1980s. From the 1990s to the present (first decade of the 2000s), the world's temperature has risen by about 0.6 °C (= I . If) (**The Economist** 9th September 2006,; Noble and Watson 2006). It has been established that the earth has already warmed up by about 6 °C, since the first decades of the 1900s and is projected to warm up by as much as 5.8 °C by the first decades of 2100. Global warming has had serious consequences in recent decades, which have aroused international concern; some of these consequences include: a rise in sealevels; bleaching of coral reefs; thinning of sea ice; , retreating of glaciers; changes in precipitation patterns and growing seasons; changes in the frequency of pest and disease outbreaks; changes in the populations and geographical range of certain animal species; and changes in the cultivable ranges of certain animal species; and changes in the cultivable ranges of certain crops.

However, the current concern is not much the rise in the earth's temperatures as the cause of that rise. Available evidence shows that whereas previous changes in the earth's climate were caused by variations either in the angle of the earth's rotation or in its distance from the sun, the current change is man-made originating in greenhouse gases (GHGs). **The Economist** 9th September 2006,; Noble and Watson 2006; Cline 2088; Mclean and McMillan 2003 pp.225-6). Beside, the observed rise in the earth's temperature is occurring at a rate hitherto not experienced. Although the long-term consequences of climate change remain a subject of among scientists and economists, climate change models predict deforestation, desertification, a pole-ward shift of vegetation and animal populations, rising sea levels, and decreased precipitations.

In this review, we highlight the sources of global warming, the country-origins or sources of Green House Gases (GHGs) emissions, the nexus between global warming and human (economic) activity, the costs (economics) of climate change drawing on findings on agricultural productivity, and, finally, policies to tackle global warming.

II. CAUSES OF GLOBAL WARMING

A phenomenon also known as 'climate change' or 'the green house effect', global warming is the process whereby solar radiation that has reflected back off the earth's surface remains trapped at atmosphere levels, due to the build-up of carbon dioxide ($C0_2$) and 30 0ther GHGs – e.g., methane, nitrous oxide (N_20), etc- which helps create a layer that prevents the heat from the sun from escaping into space, thus warming the earth's temperature.

Another factor is burning of fossil fuels (oil, coal, gas), which contain the carbon dioxide that the original plants breathed in from the atmosphere. Fossil fuels are formed from plants which breath in carbon dioxide ($C0_2$) (during photosynthesis) and release oxygen (O_2) in that process. Levels of carbon dioxide have increased from around 289 parts per million (ppm) prior to the 1700s (the Industrial Revolution century, when industrial gas emissions became significant) to around 380 ppm presently; that of methane, the second most important of the GHGs, from 750 parts per billion (ppb) to nearly 1,750 ppb; and that of nitrous oxide from about 265 ppb to about 312 ppb (Noble and Watson, op. cit.). How to reduce the heavy accumulation and, also, stop further increase in GHGs are key concerns of current international environmental policies, to which we return.

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The second biggest source of GHGs is deforestation (18^{o}/$_{o}$), followed by industry (table1). Deforestation can be traced to poverty: poor rural households in developing countries depend on tropical forests for fuel-wood and new farmland. Around the global, 900 million people are known to live in absolute poverty in rural areas, dependent solely on the exploitation of natural products for food and income generation. The imperatives of short-term survival often force rural farmers in developing countries to resort to myopic agricultural practices of reduced fallow and increased acreage by encroaching on pasture and woodlands. This problem is worst in the high population density requires of Sub-Saharan Africa: Ethiopia, southern Malawi, southeastern Nigeria, Sierra Leone etc. Globally, African is reported to have suffered a net loss of forests exceeding 4 million hectares annually between 2000 and 2004, a result of conversion of forestland to agricultural use and dependence on fuel wood for energy. African foresland had declined from 656 million to 635 million hectares between 2000 and 2005.

Table 1 : World GHG Emissions by Sector (2000)

Sector	%
Energy generation (fossil fuels)	24.5
Deforestation	18.2
Industry (manufacturing)	13.8
Agriculture (livestock breeding etc.)	13.5
Transportation	13.5
Others	12.9
Waste	3.6

Source : The Economist, 2nd June, 2007, p. 4 (figure 1).

Table 1carries data on the ‘sectorial Origins of World GHGs’ sources of world GHG emissions. As already noted, energy generation is the major source (roughly 25%), followed by deforestation (18.2%) and m manufacturing (13.8%). The tendency to focus on fossil fuels explains why deforestation and even agriculture have not attracted deserved attention in discussions on sources of GHG emissions. For agriculture we should include especially livestock breeding: for instance, it has been found that every year the average sow and her piglets produce tonnes of carbon dioxide equivalent through the methane emissions from their effluent. In developing countries particularly the Pig-effluent collects in open lagoons which emit stench and gets infested with filies; sometimes it flows into nearby water systems.

Biofuels, produced from plants such as sugar cane, maize (corn), oilseed rape and wheat, are considered a promising way to reduce the amount of surplus carbon dioxide being pumped into the atmosphere by burning fossil fuels. The fact is that the plants from which biofuels are produced take up carbon dioxide during their growth, so that burning biofuels made from them should have no net effect on the amount of that gas in the atmosphere. Biofuels, it is claimed, should not contribute to global warning. There are however, studies disputing the practical application of this theory. The Paris-based International Council for Science (ICS) reports that the production of biofuels has aggravated rather than ameliorated global warming, reporting that most analyses had underestimated the importance to global warming of nitrous oxide, N$_2$0, by a factor of between 3 and 5. The amount of N$_2$0 released by farming biofuels crops such as maize and rape probably negates by itself any advantage offered by reduced emission of carbon dioxide.

Although nitrous oxide is not common in the earth’s atmosphere, it is reported to be more potent GHG than carbon dioxide and it hangs around longer. The upshot is that, over the course of a century, its ability to warm the planet earth is almost 300 times that of an equivalent mass of carbon dioxide (**The Economist 11th April 2009**).

Nitrous oxide is made by bacteria that live in soils and water and, these days, their raw material is often the nitrogen-rich fertilizer that modern farming consumes, which has increased six-fold since the 1960s. Maize is said to be a contributor of nitrous oxide, emission but maize is one of the main sources of biofuels.

Country Origins of GHG Emissions

When it comes to contribution by individual countries and regions, the United States ranks the principal source of GHGs (24% of global GHGs), but China is projected to overtake the United States by the year 2025 (table 2). At present rich countries (The United States plus the European Union) emit more carbon dioxide than developing countries as a whole do. But developing countries will overtake rich countries within the next decade or so; China, the most populous of the emerging economies, will become the global leader in GHG emissions by the year 2015.

Table 2 : Greenhouse-Gas Emissions (Billion tonnes of carbon equivalent) by country

Country	Year 2000	Year 2025 (projected)
China	1.4	2.9
United States	1.9	2.6
European Union (EU-15)	1.05	1.25
Former Soviet Union	0.8	1.20
India	0.5	0.8
Brazil	0.4	0.6

Source : The Economist 9th September 2006A, p.16

Every year China is reported to build 60 gigawatts of power-generation capacity, almost as much as Britain’s entire existing capacity. About 80% of China’s power is coal-based, the dirtiest energy source.

China has currently 40% of global stocks of coal-more than the United States, the EU and Japan put together. These analyses suggest that global policies to find solutions to GHG emissions should take the United States, China and the EU on board. As well, their sectoral targets should be energy, deforestation, agriculture and transportation.

III. Global Warming and Human Activity

It is clear that global warming is directly linked to human activity: emission from human activity provide the sources of GHGs. The first person to observe that link was the 19th –century Swedish Scientist Svante Arrhenius, who speculated that emissions from industry could double carbon dioxide levels in 3000 years, thus warming the earth. In 1938 Guy Calendar, a British engineer, in a talk to the Royal Meteorological Society, posited that the earth was warming, but his claims was dismissed as that of an eccentric.

As suggested earlier scientists speculated about global warming till the last decades of the 1900s, when 'the idea of global warming was retrieved from the bin and turned into one of the biggest arguments of our time'. (**The Economist**, September 9th 2006A pp 3-4). Scientific research has produced data, though often contradictory and speculative, to the effect that the earth is hotting up-eg. Artic Sea ice is melting unexpectedly fast at 9% a decade; glaciers are melting surprisingly swiftly; and a range of phenomena, thought to be unconnected to climate damage, are now linked to it.

Not all changes connected to global warming will be bad for all countries of the world. For instance, a rise in temperatures (warming) would benefit countries located in the cold regions e.g. Russia, Finland, Iceland, Canada, etc- by making parts of these countries that ate currently uninhabitable comfortable to live in. Let us note that some 25% of the world's undiscovered oil and gas reserves are located in Russia's cold, ice-covered regions, which could with global warming become easier to get at[1].

Among the most certain effects of climate change is rising sea levels caused both by thermal expansion of sea water and by partial melting of the vast sheets of ice in the polar region. Noble and Watson (2006 op. cit.). report that already the mean global see level has risen by between 10 and 25 centimeters. The Intergovernmental Panel on Climate Change (IPCC 2001), set up by the United Nations, forecasts an additional rise of between 8 and 88 centimeters by 2100[2]. Small island states – e.g. Maldives- stand threatened in their very existence by a rising ocean; as well, low-lying alluvial regions, such as the heavily populated delta of the Ganges and Brahmaputra Rivers. It is important to note, also, that many of the world's largest cities, including many of the developing world's most important, are built on coastlines. Such cities can only avoid being submerged by building costly protective infrastructure. Finally, rising see levels threaten the existence of a variety of biologically rich and economically important ecosystems such as coral reefs, mangrove forests, and other wetlands.

IV. The Economics of Climate Change

As pointed out above, not every change in climate change will be considered bad: countries in the cold regions, for instance, could benefit immensely from rising temperature; in contrast, the later will make Africa and India for instance, yet hotter, which will hurt agricultural productivity. However, Cline (2008) disagrees with this proposition, arguing, instead, that global warming will lead to a toiling off of agricultural productivity across the global

Table 3 : If Carbon Emissions Continue Unabated, By 2080s, Land And Farm Area Temperatures Will Rise Sharply.

Base Levels	Land Area	Farm Area
temperature[1]	13.15	16.20
precipitation[2]	2. 20	2.44
the 2080s		
temperature	18.10	20.63
precipitation	2.33	2.51
…and agricultural productivity will tail off across the global but most sharply in developing countries. (percentage change in agricultural output potential).		
World	**Withont CF[3]**	**With CF[4]**
Output weighted	-16	-3
Population weighted	-18	-6
Median by country	-24	-12
Industrial countries	-6	
Developing Countries[5]		
Median	-26	-15
Africa	-28	-17
Asia	-19	-7
Middle East & North Africa	-21	-9
Latin America	-24	-13

[1] Temperature is average daily in °C

[2] Precipitation is measured in millimeters per day

[3] Assumes no benefit to crop yields from increased carbon dioxide in atmosphere (carbon fertilization, CF).

[4] Assumes a positive impact in yields from carbon fertilization.

[5] Excludes Europe

Source: Cline (2008, table 1, p. 24).

Table 4 : How countries fare whether the impact of climate change is projected by economic or agronomic models, nearly all countries suffer

	Ricardian Model[a]	Crop model[a]	Weighted average withont CF	with CF
Argentina	-4	-18	-11	2
Brazil	-5	-29	-17	-4
United States (Southwest plains)	5 (-11)	-16 (-15)	-6 (-35)	8 (-25)
India	-49	-27	-38	-29
China (South Central)	4 (-19)	-13 (-13)	-7 (-15)	7 (-2)
Mexico	-36	-35	-35	-26
Nigeria	-12	-25	-19	-6
South Africa	-47	-20	-33	-23
Ethiopia	-31	-31	-31	-21
Canada	0	-4	-2	12
Spain	-4	-11	-9	5
Germany	14	-11	-3	12
Russia	0	-15	-9	6

Note : Ricardian models statistically infer the contribution of temperature and precipitation to agricultural productivity by examining the relationship of land price to climate, whereas crop models relate farm output to land quality, climate, fertilizer inputs, and so on.
Sources : Cline. (op. cit., table 2, p. 25).

Table 5 : Illustrative costs of Emissions-reducing technologies relative to a marker (= the technology that would be displaced by the new technology).

Technology	Marker	Cost unit	Cost of marker	Cost of substitute Short-term[b]	Long- term
Nuclear	Natural-gas-combined-cycle power plant	US cents/KWh	3.5-4	6	5
Electricity from fossil fuels and carbon capture and storage	Natural-gas combined-cycle power plant	US cents/KWh	3.5-4	5	6
Wind	Natural-gas combined-cycle power plant	US cents/KWh	3.5-4	5	6
Photo voltaic [a]	Grid electricity	US cents/KWh	10	15	8
Biofuels	Petrol	$/gigajoule	12	15	15

(a) Solar input = 2000KWh/m^2
(b)10 years
Source: ***The Economist*** *9th September 2006A* ***(table 3)*** *p. 14.*

Table 6 : Sources of Energy (% global energy supply)

Non- renewables (fossil- energy)	%
- Oil	34.3
- Coal	25.2
- Gas	20.9
Sub- Total	80.4

Renewables	
- hydo	2.20
- biomass	10.40
- tide	0.0004
- wind	0.064
- solar	0.039
- geothermal	0.410
	13.113

*Source : **The Economist** 2nd June, 2007, p. 20.*

Damage will be, generally, higher for countries located closer to the equator, where temperatures already tend to be close to crop tolerance level-and these countries are mostly located in Sub-Saharan Africa.

Economists have now accepted the view that geography, including temperature, has a profound development outcome (see, for instance, Gollup et al. 1969). The extremes of heat and humidity in the tropical regions contribute to deteriorating soil quality and the rapid depreciation of many natural assets. Such extreme tropical geographic conditions contribute, as well to the low productivity of certain crops, the weakened regenerative growth of forests, and poor health of both animals and human being leading to lower levels of productivity and efficiency.

Growth models now incorporated geographic factors, putting more weight on temperature, which raises estimates of the damage from climate change. Nordhaus (1994), for instance, estimates damage to the global economy of a 2.5 C temperature rise at 3% of global GDP. Table 5 displays data on estimates on the costs of climate change (loss in global GDP) and the costs of mitigating the effects of climate change. The problem here is that economists working on climate change face 'a cascade of uncertainties': how much carbon dioxide the world goes on emitting (which itself depends on whether governments pay attention to scientists' warnings); how past temperatures will increase in response to greater concentration of carbon dioxide (which depends on feedback loops'); what effect climate change will have on national economics (which depends on how people adapt to it); etc. (Bhargava 2006).

The cost of mitigating the costs of climate change depends principally on three factors. The first is how far energy demand can be reduced by relatively cheap energy-efficient technologies. Currently, global dependence on non-renewable fossil energy sources ranges up to 93% (table 6). The International Energy Agency (IEA) estimates that there are abundant cheap energy-efficient measures – e.g. new buildings, for instance, can be made 70% more efficient than average existing ones, reckoning that by the year 2050 energy-efficient technologies can reduce emissions back to 2000 levels at moderate cost.

The second factor is how fast the price of renewable energy technologies will fall. The gap between some of them and the fossil-fuel-based energy should shrink (table5), as technologies mature and manufacturing volumes rise: e.g. the cost of windpower, has come down from 8-10 cents to 3.5-4 cents per KWh since 1990 because of better-designed turbines and higher volumes.

The third factor is how fast emissions are reduced. Economists, in contrast to scientists, recommend a gradual approach; they point out that, as carbon dioxide hangs around in the air for up to 200 years, a tonne produced now is not much worse than a tonne produced in 20 years' time; that cutting emissions gradually is a great deal cheaper than doing it quickly, because machinery can be replaced with new, lower-emission varieties at the end of its life-cycle instead of being written off prematurely.

V. ENVIRONMENTAL POLICIES ON CLIMATE CHANGE

These policies can be categorized into two for purposes of the present analysis: national and global (international). The former refer to policies adopted by individual governments to attempt to address environmental problems peculiar to their countries; the latter, on the other hand, are socalled because they are targeted at environmental problems that transcend national boundaries – e.g. the threat to the ozone layer from chlorofluorocarbons (CFCs) and global warming leading to climate change. Global environmental policies are formulated and implemented collectively by national governments who accede to the multilateral treaties which usually form the basis for implementing global policies such as, for instance, the Kyoto Protocol on climate change drawn up in 2001.

a) National Policies

For this purpose, we draw solely on the experiences of the countries of the Organization for Economic Cooperation and Development (OECD) as well as those of East and Central Europe and former Soviet Union to illustrate the nature of, and problems relating to, national policies, given that systematic data on developing countries, especially Sub-Saharan African countries, are sparse, if not totally lacking (see also Sinn 2007; Stern 2009; Stern et al. 2007; Tol 2004; Weitzman 1974; World Bank 2006; Jones et al. 2008).

i. *Pollution Taxes*

In Europe as a whole policies have been targeted on energy, transport, agriculture, and economy. As energy is a major source of both pollution and tax revenue in the OECD economies particularly, attention has been focused on restructuring of energy pricing as a starting point in integrating environment and economy. (see, for instance, Portier 1996). Air pollution is a key environmental problem in the OECD; strategies here include pollution (emission) taxes, direct control or legislation, etc.

Pollution taxes are aimed to reduce damage to the environment by cutting emissions of products such as methane gases or carbon dioxide (CO_2). The rationale for a pollution tax, therefore, is to compel polluting producers to include in their prices the full social costs of production. In the OECD, pollution taxes, also known as eco-taxes, are an a affirmation of the 'polluter-pays principle' adopted way back in 1974 and ratified by the European Community (now European Union) in 1975.

The 'polluter-pays principle; which, essentially, allows pollution to occur but taxing it, derives from Arthur Cecil Pigon's 1932 classic **The Economics of Welfare**, which focused on problems of maximization of social welfare under neoclassical perfectly competitive equilibrium conditions Pigon argued that the neoclassical social welfare proposition was hampered by two factors: monopoly and externalities, both factors discounted in neoclassical general equilibrium economics. The notion of externalities came to be introduced in neoclassical economic theory to reflect-for the first time, indeed-the inherent contradiction between the interests of the private agent (firm or individual driven purely by private gain) and those of society as a whole. Let us recall that externalities, generally, refer to the effects of the activities of private agents which fail to be captured by market prices but which could impose costs on (in the case of negative externalities or diseconomies such as pollution) or yield benefits for (in the case of positive externalities) the society as a whole[3].

Pigou first formulated the socalled tax-subsidy solution to internalizing externalities, the idea that externalities should be corrected by government policy interventions in the form of imposing taxes on negative externalities and granting subsidies on positive externalities to adjust and supplement the operation of the private market mechanism. On this basis, Pigou evolved the concept of social cost to account for not only the direct private costs, but also the externalities. As noted already, Pigou's work did serve as the starting point for 'a new economic theory of welfare' whose main idea is the maximization of social welfare.

By the 1970s on wards, Pigou's theory began to attract attention in view of the new approach to economic growth based on the 'quality of life' concept. Contemporary concern with greenhouse gases (GHGs), polluted environment, etc.-i.e., with social costs not captured in private market prices-are the modern illustrations of Pigou's separation of divergences between marginal social and private benefits (and costs).

In several European countries direct coal subsidies began to be reduced as from the 1980s to 'force change to different fuels'. By reducing domestic coal subsidies (and importing coal from South Africa, Australia or Central Europe) West European countries had sought to reduce their volumes of methane and carbon dioxide (Co_2) emissions. Methane emission would be lower because imported coal primarily comes from open-cast mines and not, as in European mining regions, from deeper mines that generate large amounts of methane gases. Eco-taxes also began to be imposed, generally, meant to raise the prices of products which create pollution as they are manufactured, or disposed of e.g. lubricants, fertilizers, pesticides, non-returnable containers, mercury and cadmium batteries, 'feedstock' chemicals and packaging materials. By imposing the tax, the demand for the product will be reduced, which will induce the producers (firms) to take account of the external costs that their production activity imposes on society (see also Solsbery and Wiederkehr 1995).

ii. *Legislation*

Also known as the 'communal and control approach', legislation attempts to introduce direct controls, which may involve specifying minimum environmental standards on air and/or water quality, for example, or imposing complete ban on use of particular inputs. For example, the effluent form a refinery or chemical plant may be permitted (by legislation) to a 'specified' level of a particular pollution. In some cases, legislations may require the installation of specific types of anti-pollution equipment. At the consumer level, for instance, new automobiles in the European Union, as from the early 1990s, have to incorporate catalytic converters.

To be effective, legislations setting minimum environmental standards, apart from setting of inspectorates to monitor compliance, must make sure that the monitoring agencies possess knowledge of what the Pareto optimal level of pollution should be in the products being regulated. For the standard setting approach to be completely effective, the inspectorates must have knowledge of the marginal net private benefit (MNPB) curve and the external marginal cost, EMC, curve in order to determine the Pareto level of output and associated level of pollution. It is quite unlikely for such a situation to obtain in reality. Bedside, when standards are set across the board to all firms the process does not take account of the marginal cost of reducing pollution associated with individual firms.

iii. *Tradeable Emission Allowances*

In this approach, also known as tradable permits, the relevant government agency sets a global target for a reduction in a particular type of pollution. In the United States, for instance, under the 1990 **Clean Air Act**, the United States Environmental Protection Agency (USEPA) set a target for United States power states to cut annual emissions of sulphur dioxide from an average 19 million tons in 1980-1985 down to 9 million tow by the year 2000. it is important to note that the policies differ substantially in cost of implementation and effectiveness. Broadly, these approaches can be collapsed into two: regulatory and market-based.

The Regulatory Policies (comprising the legislation and tradeable emission allowances approaches) are used extensively in both industrial and developing countries. They are best suited to situation involving a few public enterprises and uncompetitive private firms. This is particularly true when the technologies for controlling pollution or resource use are relatively uniform and can easily be specifies by regulators- as in the case of Cubatao, Brazil, where (ETESB(the Brazilian State regulatory agency), to address serious pollution from particulates and sulphur dioxide, forced the larger polluters (public sector and multinational firms) to install precipitators and switch to low sulphur oil.

Market-based Approaches, if effectively implemented, will frequently be less costly in meeting environmental goals than regulatory alternatives. With market-based approaches, all polluters or resource users are faced with the same price and must choose their degree of control. In market-based approaches, each agent decides either to use fewer resources or pay for using more. Market-based policies that price environmental damage affect all polluters, which means that such approaches provide the right long-term signals to resource users. The polluter or resource user has the incentive to use whichever technologies most cost-effectively reduce environmental damage. However, price-based approaches will be effective only to the extent that polluters and resource users are sensitive to them, which depends on three factors: ownership, competition, and differences among users.

iv. *Environmental Financing*

How are revenues generated from eco-taxes used? Who finances environmental investment? In the OECD countries eco-taxes are ear-marked for specific environmental purposes- e.g. water and waste management? For one thing, ear-marking will help to bring political acceptability and support for otherwise politically unpopular taxes.

In Eastern Europe, as in developing countries, the public sector plays the role of key provider- sometimes the sole provider of finances for environmental investments. In the OECD countries, in contrast, the private sector and households shoulder a large part of the burden for spending on pollution control and environmental infrastructures (Gillespie 1996). In the East European countries, the institutional framework for environmental financing has been strengthened in a number of countries by the establishment of environmental funds capitalized by environmental taxes and charges which are then reallocated to support important environmental investments in air and enforcement mechanisms. Several other measures to strengthen environmental financing institutions have been put in place- e.g. 'green' equity schemes, to provide equity to projects and companies investing in environmental improvements- such as, for example, the Nordic Environmental Finance Corporation (NEFCO) provides a model of such schemes in the Baltic region.

b) International Policies

As noted above, this category of policies transcend national boundaries. Here we consider policies on global warming. Several international agreements have drawn attention to the need to manage the global environment. The **Montreal Protocol,** reached in 1987 to reduce the production and consumption of chlorofluorocarbon (CFCs) and halon substances which deplete the ozone layer in the upper atmosphere. The Montreal Protocol was amended in 1990 to target the phasing out of CFCs and halon by 2000. The agreement also provides for trade bans on CFCs and CFC-using products; the latter are inert and non-toxic substances, CFCs being widely used in refrigeration, foams, aerosols, and dry-cleaning processes, and halon in fire extinguishers. The Montreal Protocol has been relatively successful, having made it possible to replace those CFC-using and halon elements by less ozone-destroying and halon in fire extinguishers. The Montreal Protocol has been relatively successful, having made it possible to replace these CFC-using and halon elements by less ozone-destructive products.

As noted earlier, serious global efforts to address climate change began with the Earth Summit-formally known as the United Nations Conference on Environment and Development in Rio de Janeiro in 1992-which produced the United Nations Framework Convention on Climate Change (UNFCCC), a treaty aimed explicitly at limiting climate change by reducing emissions of GHGs. The UNFCCC, however, did not produce mandatory emission ceilings or enforcement provisions; instead, it provided for the signing of protocols under the treaty's auspices that would contain such mandates.

The Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) was negotiated at Kyoto, Japan, in 1997 and amended in 2001 and it is to expire in 2012[4]. However, it did not enter into force until 2005, after it had been ratified by the requisite number of countries. By 2006, 163 countries, including the European Union, had ratified the protocol, the major outstanding countries still obtaining being Australia, and the United States. The latter complained that, in its own view, the costs of compliance were excessive, the exclusion of developing countries will render the undertaking ineffective, and the scientific uncertainties surrounding climate change remain too significant to warrant the actions taken.

Under Kyoto, most of the developed countries agree to reduce their GHG emissions by an average of about 5% from 1990 levels between 2008 and 2012 when the treaty is due to expire. However, the negotiated emissions limits are differentiated according to countries and regions, ranging from a reduction of 8% to an increase not to exceed 10%. Developing countries are exempt from such firm commitments under Kyoto. Core elements of Kyoto includes rules for compliance; land-use, land-use change, and forestry (LULUCF) provisions; and mechanism which give countries some flexibility to achieve their GHGs emissions reductions commitments. Kyoto recognizes that LULUCF (whose essential role is development and preservation of carbon sinks) can play a vital role in achieving the ultimate goal of stabilizing Co_2 concentrations.

The second mechanism is the socalled Joint Implementation (J1), which permits legal entities in one country that has an emission commitment to earn credit towards that commitment by undertaking emissions reductions project in another such country. Countries facing relatively high costs for emissions reductions can reduce their costs of compliance by earning such credits in countries where the costs are lower.

The third mechanism is the Clean Development Mechanism (CDM), whose importance lies in bringing developing countries into the Kyoto protocol. Under CDM, as in J1, developed countries may accrue emissions credits towards their reduction commitment by sponsoring carbon emissions reduction projects in developing countries. CDM not only gives the developed country an opportunity to meet its commitments at lower costs than otherwise, it also promotes sustainable development in the developing country at the same time it encourages the transfer of technology (Noble and Watson op.cit).

Among the developed world, the European Union (EU) has taken Kyoto most seriously; in 2003, it established a trading system, the European Emission Trading Scheme (EETS), in which each country receives a fixed number of Co_2 emissions allowances for its companies in energy-intensive industries such as electric power generation, refining, paper, steel, glass, and cement-these are the socalled 'dirtiest heavy industries'. The EETS works as follows: national governments decide how much carbon the 'dirtiest industries' in their countries may spew forth; they then allocate 'permits to pollute' to each company in that line of industry. If a firm wants to exceed its limits, it must buy 'pollution permits' from cleaner firms or credits from developing countries that have set up special projects to lower emissions-e.g. protection of the Amazon rainforests in Brazil. Penalties for non compliance are set at € 100 in 2008-12 period (see Noble et al. 2005).

The IPCC has produced estimates of the costs to individual countries of complying with the Kyoto Protocol: these range from 0.2 to 2% of GDP in absence of international carbon permit trading, and from 0.1 to 1.0% of GDP if such trading takes place. These costs could be reduced further by expanding the stocks of carbon sinks: a forestation, reforestation, and avoiding deforestation; and improved forest, cropland, and grassland management; implementing project-based emissions swapping between industrial and developing countries through the clean Development Mechanism, and reducing emissions of other GHGs, including methane and halocarbons.

c) The Role of the World Bank

The World Bank is involved in global efforts to mitigate and adapt to climate change mainly through two initiatives: the Global Environment Facility (GEF) and the Carbon Finance Portfolio (CFP).

The World Bank is the implementing agency for the GEF, which was established in 1991 to provide funding for projects to support biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. Through the GEF, the World Bank disburses annually some $250 million for projects on energy efficiency, renewable energy, and sustainable transportation.

The World Bank was among pioneers facilitating carbon trading under the CDM and JI flexibility mechanisms of Kyoto. The Prototype Carbon Fund was lunched in 1999 with a target of $180 million, and by 2006 the World Bank was managing nine funds with available funds to then value of about $2billion.

VI. Conclusion

Global warning constitutes one of the major global issues of our time. Although a long-standing phenomenon, the current concern with global warning arises from two distinct facts: it is caused by human activity; and it is occurring at an unprecedented rate. The consequences of global warning still remain a subject of debate and speculation, but climate change studies hypothesize dire consequences for agricultural productivity and disease incidence globally, but especially for countries located nearer the tropics where temperatures are bound to rise higher. Global warning has received national and international policy attention over the past thirty years, having constituted one of the key themes in the rise of 'green economics' and 'green politics' over this same period.

Note

[1]According to Yale University Professor, Robert Mendelssohn, a 2.5^{0}c increase in temperature would increase GDP in former Soviet Union by 11% (and 0.3% in North America). A less optimistic forecast by William Nordhaus (dubbed the father of climate change), predicts a reduction in the United States GDP of 0.5% (Nordhaus 1994).

[2]See IPCC (2001); Mayer (2000); Noble et al. (2005), and Smith et al. (2003).

[3]For Pigou the essence of externalities that create a wedge between private and social interests in production: '… is that one person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices to other persons (not producers of like services), of such sort that a payment cannot be exacted from the benefited parties or compensation enforces on behalf of the injured parties' Pigou, op. cit, p. 183).

[4]This section relies on Noble and Watson 2006

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