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Characterization of Municipal Solid Waste in the Federal Capital Abuja, Nigeria

By Benjamin Ternenge Abur, Emmanuel Enomena Oguche & Gideon Ayuba Duvuna
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Abstract- Municipal solid waste management has emerged as one of the greatest challenges facing environmental protection agencies in developing countries. This paper presents a characterization study of the municipal solid waste generated in the Federal Capital Territory, Abuja, Nigeria. The characteristics of the municipal solid waste were determined in terms of the components, average mass (kg) and percentage generated per district. It was found that 56.20%/52.0% of the solid waste generated in the area is made up of food/ petrucsible; rubber 10.20%/3.56%; paper 10.00%/ 12.46%; glass/ceramics 7.60%/1.42%; plastics 7.4%/2.85%; metals 2.60%/0.71% and other forms of waste 5.60%/25.62% (dust particle, Ash, stones) for wet and dry seasons respectively and the waste generation rates ranged from 0.59 to 0.79 kg/capita/day. The AEPB is faced with constraints like lack of institutional framework, inadequate budgetary provision, lack of institutional framework, inadequate bylaws and regulations and insufficient information on the quantity and composition of the solid waste. It is suggested that adequate financial provision, proper waste legislation, training and re-training of staffs and community full participation in waste management be encourage while formal composting and recycling facilities should be setup.

Keywords: *characterisation, municipal solid waste, abuja, composting, recycling.*

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Characterization of Municipal Solid Waste in the Federal Capital Abuja, Nigeria

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I. Introduction

Solid waste can be defined as garbage, refuse and other discarded materials including waste resulting from industrial, commercial and agriculture operations and from community activities or waste that are normally solid and that are discarded as useless or unwanted (Tchobangolus, 1983). The solid content is technically known as refuse while the liquid substances are called effluent (Ahmed, 2002). According to Environmental Protection Department Air Management Group, EPDA (2001), waste involves categories of household, municipal, commercial and industrial wastes, some hazardous and toxic.

Municipal solid waste includes wastes generated from residential, commercial, industrial, institutional, construction, demolition, process, and Residential Single and multifamily dwellings generate food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes. Commercial Stores, hotels, restaurants, markets generate paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, etc (Tchobanoglous et al., 1993).

Waste characterization is a fundamental component in any municipal waste management scheme (MWMS) of urban solid waste in a city but such data are not commonly compiled in cities across Africa (Guadalupe et al, 2009).

Waste characterization data consists of information on the types and amounts of materials (paper, food waste, glass, yard waste, etc.) in the waste stream. It depends on a number of factors such as food habits, cultural tradition, socioeconomic and climatic conditions. It varies not only from city to city but even within the same city itself (Gawaika, 2004).

The composition and characteristics of municipal solid waste is influenced by certain factors, which include the area (residential, commercial, etc), the economic level (differences between high and low-income areas), the season and weather (differences in the amount of population during the year, tourist places) and culture of people living or doing business in the area. High-income areas usually produce more inorganic materials such as plastics and paper, while low-income areas produce relatively more of organic waste. Uncontrolled or improperly sited open solid waste dumpsites constitute health hazards and damage the aesthetic beauty of many cities in Nigeria (Napoleon et al 2011). Characterization of municipal solid wastes is simply a descriptive means of identifying the various constituent of the waste stream in times of quantity and quality generation taking into account location as well as seasons in which these wastes are generated. It is a means of finding out how much paper, glass, food waste, etc. is discarded in the municipal waste stream.

According to Gawaikar (2004), characterization of municipal solid waste helps in determining the quantity of waste generated in a particular location at a particular time of the year. This help in identifying the trend of generation as well as the influencing factors. It makes proper planning of solid waste management, determining the size and number of functional units and

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equipments required for managing the waste, the needed resources for the protection of environment and public health. Characterization is also important to determine its possible environmental impacts on nature as well as on society (Alamgir et al, 2005).

Treatment methods differ in dealing with different waste streams (Jarusombat, 2002). Options include recycling, land filling, biological treatment (i.e composting and gasification), and thermal treatment such as mass burn incineration (with or without energy recovery) and fuel burning (Refuse Derived Fuels-RDF) (Babcock and Wilcox, 2003, Yongziang et al.2003, Glusszynski 1995, Harvey 1987).

Municipal Solid Waste (MSW) data are sometimes measured both in volume (m3/capita/day) and in weight (kg/capita/day).

II. Materials and Methods

For the purpose of this study the the Gosa dumpsite located in the Federal Capital Territory was used for the waste collection and characterisation. Gosa dumpsite was chosen as it serves as the current solid waste management dumpsite in Abuja and also due to its problems, size, and challenges. The site has an approximate 90 hectare (222acres). The study was undertaken in the wet and dry seasons of 2010 and carried out in three steps.

Step 1: Documents, records and academic literature relating to municipal solid waste management.

Step 2: The Abuja environmental and protection board (AEPB) the environmental agency workers, private contractors, residents and scavengers involved in municipal solid waste management were interviewed to update information in the document and records collected.

Step 3: Gosa dumpsite was visited for the collection, sampling, separation and characterization.

Samples of freshly disposed municipal solid wastes from the waste stream at Gosa dumpsite were manually and randomly collected, identified, sorted out, characterized and weighed.

For the classification of waste, seven waste components were considered. These were food, paper, iron, glass, rubber, plastic and others. Others in this category represent solid waste that are not identifiable or do not fall into the first six categories. Sorting and weighing of collected waste were done at the dump site. The materials and resources used at the dumpsite for data generation were sorting platform, an electronic scale for weighing the waste, bins for all the sorting categories, gloves, a calculator and trained assistants.

The study also involved the use of questionnaires for the public as well as for the relevant government agency saddled with the responsibility (The Abuja environmental and protection board, AEPB). The questionnaire was designed and structured such as to allow the respondents to freely express their feelings as expressed or stated by variables and were administered to the general public in the study area in the months of March and August, 2010.

Descriptive statistics was used in obtaining frequency, counts and expressing such in percentages.

III. Estimation of Municipal Solid Waste Generated in the Federal Capital, Abuja

A total of 727 trips was estimated to be made weekly by the privately owned waste trucks evacuating waste from different locations in the Federal Capital to Gosa dump site. Each waste truck is estimated to have a carriage capacity between 8 – 10 tonnes.

In view of the above, the total estimate of tonnes of solid waste evacuated for year 2010 in the Federal capital, Abuja lie between 302,372 to 378,040 tonnes (302472000kg to 378090000kg) and the average solid waste generation rate is also estimated to lie between 0.59 – 0.74 kg/person/day.

Table 1: Annual Estimation of Municipal Solid Waste in the Federal Capital, Abuja for Year 2010.

Name of District	Waste per Annum (kg)	Percentage (%)
Phase I (Abuja Districts)	144,040,000	38.10
Phase II & III	76,440,000	20.22
Satellite Towns/Suburban Districts	157,560,000	41.68
Total	**378,040,000**	**100%**

Table 2 : Breakdown of Municipal Solid Waste Generation Rate in Abuja District Year 2010.

Name of District	Mass (Kg)	Percentage (%)
Asokoro	14, 560, 000	10.11
Central Area	8, 320, 000	5.78
Garki	50, 960, 000	35.38
Maitama	19, 240, 000	13.36
Wuse	50, 960, 000	35.38
Total	**144, 040, 000**	Total=100

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Table 3 : Physical Characterisation Household Wastes at Gosa Dumpsite During the Wet Season of 2010.

Wastes type	Mass (kg)	Percentage (%)
Fabrics	-	-
Food/petruscible	19.1	56.2
Glass/ceramics	2.6	7.6
Metals	0.9	2.6
Paper	3.4	10.0
Plastics	2.5	7.4
Rubber	3.6	10.2
Others	1.9	5.6
Total	34.0	100.0

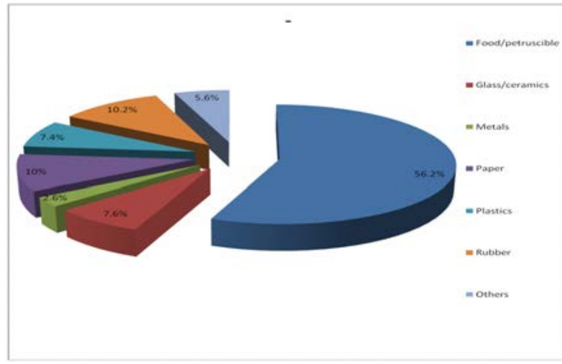

Fig. 1: Percentage of the Physical Characterisation of Household Wastes at Gosa Dumpsite during the Wet Season of 2010.

Table 4 : Physical Characterisation of Household Wastes at Gosa Dumpsite during the Dry Season of 2010.

Wastes type	Mass (kg)	Percentage (%)
Fabrics	0.4	1.42
Food/Petruscible	14.6	52.00
Glass/ceramics	0.4	1.42
Metals	0.2	0.71
Papers	3.5	12.46
Plastics	0.8	2.85
Rubber	1.0	3.56
Others	7.2	25.62
Total	28.1	100.0

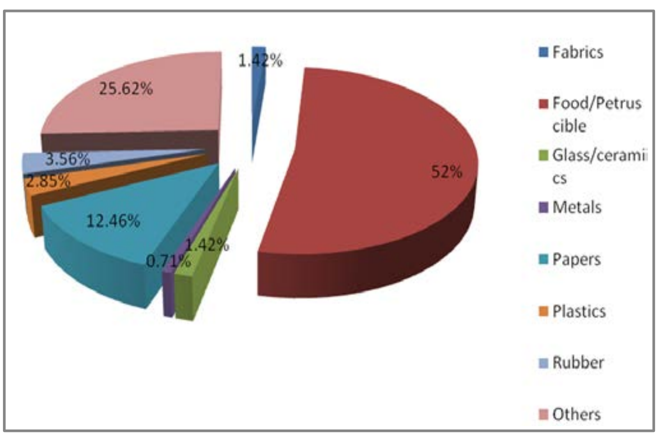

Fig. 2 : Percentage of the Physical Characterisation of Samples of Household Wastes at Gosa Dumpsite during the Wet Season of 2010.

IV. Discussion of Results

a) Waste Collection and its Transportation in Abuja

It is both the function of the state and local government environmental protection agencies to collect and properly dispose municipal solid waste. Due to the increasing rate of waste generation, private contractors are also involved in the waste collection for a fee. Hence, private solid waste collection operators exist in parallel with the official agency charge with the collection of waste just like in other cities in Nigeria. The private contractors are designated to specific areas of the town. These private companies were found to have higher efficiencies than the government agency but better still are not properly monitored or regulated by the government agency including dishonesty on the part of some of the contractors and late payment of contractors by the government worsen the situation. Stationary containers system is adopted for waste collection; the waste containers remain at the points of waste generation and collected few days for disposal by the Abuja Environmental Protection Board, AEPB and the private contractors designated to specific locations. The residents of are requires to deliver the waste to the storage container which are generally kept at open spaces along street ends or junctions. The positioning of fixed containers were mostly in the suburban unlike in the major town movable bins mostly of plastic nature were place house-to-house for the collection of the waste. This method of waste collection is less convenient for the sanitation staffs. Some of the containers are movable while some are fixed on the ground.

Some of the available vehicles used for the solid waste collection and disposal were the compactor trucks, side loaders, rear loaders, mini trucks, tippers, skip trucks and open back trucks are the commonly used collection trucks and were in-short supply and mostly out of service due to frequent breakdown as a result of overuse.

Research finding revealed challenges faced by the agency saddled with the responsibility of waste management in Abuja, which include inadequate budgetary provision, poor trained staff, lack of institutional framework, insufficient information on the quantity and composition of the solid waste and inadequate bylaws and regulations.

b) Waste Generation, Characterisation and Recycling

The result in table 3 reveals that population density influences greatly on waste generation rate as this is seen by the estimated fractions of household waste evacuated from the Satellite towns/Suburban districts as most workers in the territory resides in the satellite towns hence the major reason for such volume of waste generated. The closeness of industrial area to the dumpsite could also attribute to it. Phase I is home exclusively to the elite society and it is next to the Satellite towns in percentage of tonnes of municipal solid waste generated annually. Phase II and Phase III are estimated to have the lowest annual percentage of tonnes of waste generation. Table 5 puts Garki and Wuse as the highest generators of municipal solid waste ahead of Maitama followed by Asokoro and lastly Central Area under Phase I (Abuja District). This trend is undoubtedly influenced by income and the socio-economic activity and population density.

The analysis of solid waste composition in the study for both wet and dry seasons shown in tables 3 and 4 indicates that 56.2% and 52.0% of the solid waste is made up of food/petruscible materials for the wet and dry seasons respectively. The other composition are; plastics (7.4% and 2.85%; glass/ceramics (7.6% and 1.42%); metals (2.6% and 0.71%); paper (10.0% and 12.46%) and rubber (10.2% and 3.56%).

This indicates that composting/biodegradation can be used for the disposal of this 56.2% and 52.0% of the waste and the fertiliser can be derived as the end-product. This is in-line with previous research work by Hoornweg et al, (1999) where they found out that waste stream are over 50% organic materials in developing countries. In separate works in Bandung and Indonsia have shown that residential waste composed of 78% and 81% composable materials (Cointreau, 1982). High-income earners consume more of packaged products that give rise to a higher percentage of non-biodegradables (inorganic materials) like metals, plastics, glass/ceramics (Ogwueleka, 2009). This was found to be true as higher percentage of the inorganic materials were influence by the income rate.

The average per capita waste being generated in the study area is estimated to lie between 0.59 – 0.74 kg/capita/day depending on the location. Dauda and Osita (2003) obtained 0.25kg/capita/day for Maiduguri, Igbinomwanhia and Olanikpekun (2007) research study review 0.56kg/capita/day for Mushin, Lagos and Solomon (2009) quoted 0.49kg/capita/day for average Nigeria communities with household and commercial centres. The range of 0.59kg/capita/day to 0.74kg/capital/day depends on the socioeconomic status of the people and thus the location.

Presently at the Gosa dumpsite, there are no formal recycling and composting. Scavengers were in their number scavenging useful materials for recycling to earn a living. These scavengers were mostly young men who drop out of school due to one reason or the other whereas in some few cases are men who earn their living through it. The work is hazardous to their health as they operate without protective wares. Recycling which is a solid waste management technique is more desirable and environmental friendly. The practice of recycling and composting would save cost in waste management (Agunwamba, 1998).

V. Conclusion

The first step in waste management is to gain an understanding of the waste types being generated in order to design appropriate collection and disposal strategies and this can be achieve through characterisation of waste. The largest proportion of waste in Abuja metropolis can be composted rather than disposed of. The solid waste being generated is made of seven major components (fabrics, food/petruscible, glass/ceramics, metals, paper, plastics, rubber and others). The study shown that 56.2% and 52.0% of the total solid waste generated in the FCT was made of biodegradable matter. The per capita waste generated in the FCT lie between 0.59 – 0.74 kg/capita/day. The result clearly suggest the need to establish a formal composting (for 56.2% and 52.0% of the waste) and recycling facilities (for 37.8% and 21% of the waste) within the FCT using the result of this characterisation study as a guide.

Efforts should be made by stakeholders to evolve policies for disposal, waste reduction and recycling project. There is need for adequate budgetary provision for Abuja Environmental Protection Board, AEPB for proper training and replacement of the existing vehicles with modern equipment to reduce operating costs. The agency should also encourage community participation and involvement in waste management. Also formal composting and recycling facilities should be setup at Gosa dumpsite.

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Environmental Effects of Sand and Gravel Mining on Land and Soil in Luku, North Central Nigeria

By Ako T. A., Onoduku U. S., Oke S. A., Idris F. N., Umar A. N., Ahmed A. A. & Abba F. M.

Federal University of Technology, Nigeria

Abstract- The increase in the demand for sand and gravel for construction and other purposes such as flood control has placed immense pressure on the environment where sand and gravel resources occur. This study was carried out to determine the environmental effects of sand and gravel mining in Luku, North central Nigeria, using field observations and laboratory analysis of soil samples. Field work was carried out in the area to determine the physical environmental effects of mining while soil samples were analysed at the National Geo-science Research Laboratory (NGRL), of Nigerian Geological Survey Agency (NGSA), Kaduna for trace elements using X-Ray Fluorescence (XRF) method. Result of the field observations shows that destruction of landscape, reduction of farm and grazing land, collapsing river banks, deforestation and water pollution are the environmental effects that result due to sand and gravel mining in the area. Result of the chemical analysis shows that average concentrations of Pb, As, Cu, Ni, Cd, Hg, Ag and Zr are 47.8, 4.17, 50.9, 32.7, 2.48, 0.1, 0.8 and 496.1ppm respectively. These concentrations are higher than the average standard concentrations of these elements found in the upper continental crust. These higher concentrations may have very negative effects on plants and animals in the area and cause diseases such as brain and kidney damage, lung irritation, cadiac abnormality and event death to plants and animals.

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Abstract- The increase in the demand for sand and gravel for construction and other purposes such as flood control has placed immense pressure on the environment where sand and gravel resources occur. This study was carried out to determine the environmental effects of sand and gravel mining in Luku, North central Nigeria, using field observations and laboratory analysis of soil samples. Field work was carried out in the area to determine the physical environmental effects of mining while soil samples were analysed at the National Geo-science Research Laboratory (NGRL), of Nigerian Geological Survey Agency (NGSA), Kaduna for trace elements using X-Ray Fluorescence (XRF) method. Result of the field observations shows that destruction of landscape, reduction of farm and grazing land, collapsing river banks, deforestation and water pollution are the environmental effects that result due to sand and gravel mining in the area. Result of the chemical analysis shows that average concentrations of Pb, As, Cu, Ni, Cd, Hg, Ag and Zr are 47.8, 4.17, 50.9, 32.7, 2.48, 0.1, 0.8 and 496.1ppm respectively. These concentrations are higher than the average standard concentrations of these elements found in the upper continental crust. These higher concentrations may have very negative effects on plants and animals in the area and cause diseases such as brain and kidney damage, lung irritation, cadiac abnormality and event death to plants and animals.

I. Introduction

Sand and gravel mining refers to the process of removing sand or gravel from a place of its occurrence (Langer, 2003). These materials occur in a variety of natural settings and are commonly used in the construction industries worldwide. Sand and gravel occur on land, oceans, rivers, streams, flood plains or hills (Kondolf et al., 2008). An increase in demand for sand and gravel for construction purposes has placed immense pressure on sand and gravel resources. Therefore, the extraction of these two important construction aggregates is bound to have considerable negative effect on the place where they occur. These aggregates are also mined for other purposes such as navigation purposes, agricultural drainage, flood control and channel stability but still remains the major material in the construction industries.

Rivers and their floodplains are an economical source of sand and gravel. Although these aggregates are of paramount importance, previous studies (Kondolf, 1998a; Langer, 2003; Kondolf et al., 2008) have show that in-stream mining of these aggregates can reduce water quality as well as degrade the channel bed and banks. The mining of these aggregates on the floodplain can affect the water table and alter the land-use for agricultural purposes (Langer, 2003). Rivers flood and shift their courses from time to time, resulting in natural cycles of erosion and deposition of sand and gravel. The extraction of sand and gravel from rivers, streams, floodplains and channels conflict with the functionality of river ecosystems. Some of the disturbance is from the mining methods and machineries used. The most common environmental impact is the alteration of land use, most likely from underdeveloped or natural land to excavations in the ground (Langer, 2003). Social pressures like population growth can also cause the environmental impacts of these aggregate mining.

Sand and gravel mining has been one of the serious environmental problems around the globe in recent years. Much work has been carried out to access the environmental impacts of sand and gravel in Nzhelele Valley, Limpopo Province, South Africa (Mathada and Kori, 2012), where there is an increase in demand for sand and gravel for construction purposes. The extraction of sand and gravel from river, stream terraces, floodplain and channels, conflicted with other resources such as fisheries, recreational functions and with the stability of the river channels. Using field observation and environmental impact assessment guidelines, they identified a host of environmental impacts along Nzhelele valley. These impacts ranged from collapsing river banks, habitat destruction, floodplain ponding, landscape destruction, dust, noise, to sedimentation. Their work has shown that there is significant environmental degradation in Nzhelele valley as a result of unregulated sand and gravel mining. These negative effects had disturbed the balance in nature and this had multiplier effects on the ecosystem. They therefore recommended that the government develops and implements policies and regulations designed to protect the environment around sand and gravel mining areas.

Musah (2009), assessed the sociological and ecological impacts of sand and gravel mining when he noticed that commercial gravel extraction to supply

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aggregate to the construction industry in the Northern Region of Ghana particularly the East Gonja District and the Gunnarsholt area of Iceland, had been on the increase in recent years. Perceived sociological and ecological impacts in the two study areas varied but some appeared common to both. The common impacts shown in the results obtained from his work were loss of farm or grazing lands, formation of pits with water stored in them, enhancement of erosion and loss of vegetation, destruction of landscape, generation of conflicts, loss of biodiversity and dust pollution. Other impacts of mining peculiar to EGD were abandoned mine pits serving as sources of breeding grounds for the spread of diseases, loss of economically important trees which causes unemployment among women folk, and the pollution of underground water.

Aromolaran (2012) studied the effects of sand mining activities of rural people on agricultural land in Agraian communities of Ogun state in Nigeria. His work revealed that mining of sand and gravel on agricultural land is one of the alternative livelihood activities of the rural people in Nigeria and is now becoming an environmental issue. He equally noticed that there is increase in demand for sand for construction and other purpose as communities grow because the construction at present requires less wood and more concrete, which sprout a demand for low-cost sand. Mining of sand on farms and fallow agricultural land is becoming common and this is having noticeable impacts on the soil structure, vegetation and local wildlife in the rural areas. He noticed that sand mining is widespread, highly unregulated, uncontrolled and is being carried out at an alarming rate. The gravity of the situation beyond the affected communities and the region at large is enormous and poses a threat not only to the environment but also to food security. Although sand mining contributes to the construction of buildings and development, its negative effects include the permanent loss of sand in areas, as well as major habitat destruction. Sand mining is regulated by law in many places, but is still often done illegally.

Steve Blodgett (2012) carried out the Environmental Impacts of Aggregate and Stone Mining in New Mexico. The results of his study showed that the primary environmental impacts from aggregate and stone mining in New Mexico are degraded air quality and associated health effects, resulting from airborne emissions from both the stack and the disturbed areas at these mines. Because the economics of construction materials depend heavily on the proximity of the mine to the point of use, aggregate and stone mines are found in the highest concentrations in urban areas where most home and office construction and general highway construction occurs. However, these mines are located in every states of the county and many of the largest of the mines producing road construction materials are situated immediately adjacent to highways in order to reduce haul costs. Consequently, the majority of both active and inactive sand and gravel mines are located along interstate highways or major state and county roads.

Luku is located in North Central Nigeria and sand and gravel mining is currently taking place there because the place is a very attractive source for these materials. The area is easily accessible and the materials are easy and cheap to extract by the miners. Mining of these materials in the area is being carried out without any attention given to the negative environmental impacts associated with the activities. This work therefore aims at studying the environmental effects of sand and gravel mining on land and soils in Luku using field observations and laboratory analyses of soil samples. The work also looks at the possible health issues that may result due to high concentration of trace elements in the soils of the area.

II. Materials and Methods

a) *Field Work*

This work follows a qualitative approach in assessing the environmental impact of sand and gravel mining in Luku, North central Nigeria. Investigations were carried out via field mapping and collection of samples. Outcrops were observed and described based on their colour, texture, structural element, mineralogy, mode of occurrence and field relationship. On the field, data were obtained using a global positioning system (GPS) which was used to capture coordinates for the location of mining activities in the area. A camera was used to obtain photographic impressions because of their significant importance in this project. Field observations were made in other to note the existing physical impacts of sand and gravel mining in the area. A shovel was used to collect soil samples from different locations using the random sampling method, from both mined and unmined locations. The soil samples were used to analysed for trace elements concentrations in the area.

b) *Laboratory Work*

i. *Sample Preparation*

A total of ten (10) samples were collected from the field for chemical analysis. Samples were taken to the laboratory and air dried for about 72 hours in order to remove the moisture content in them. Each dried sample was crushed or pulverized using a Retch PM 200 or 400 grinding ball mill to a fine powder of 75μm size in other to obtain homogeneity of samples. 75g each of the crushed samples was weighed using an electric weighing balance and put into a polyethene bag and properly labeled for easy identification. The samples were then ready for analysis to determine the trace elements and their concentrations. The sample preparation was done in the laboratory of Geology

Department, Federal University of Technology, Minna, Nigeria.

ii. *Laboratory Analysis*

The powdered samples were analysed for Trace elements using X-ray Fluorescence (XRF) machine, model: PANalytical, at the National Geo-science Research Laboratory (NGRL), of Nigerian Geological Survey Agency (NGSA), Kaduna. The software used for the analysis was Millipal 4. In this method, about 10g of each the eleven prepared samples was weighed into the sample cup of the X-ray Fluorescence machine and analysed according to the method described by Ezeaku, 2011. The mean concentration of each element in the samples was compared with Wedepohl, (1995) and Taylor and McLennan, (1985) average concentration of elements in upper continental crust. Values that correspond or fall below the expected limit were accepted as safe while values above the limits indicate very high concentrations of such elements in the soil which can cause serious environmental problems to plants and animals including man.

III. Results and Disscussion

a) Geology of the Area

The project area is a part of the Minna – Kusheriki schist belt. Geological mapping reveals that the area is composed of Schists intruded by granitic rocks (Fig 1). The Schists are generally dipping in a North-West direction. Granitic rocks outcrop mostly at the Southern part of the area covering about 15% of the total area while schists cover the remaining part of the area. The schists in the area range from medium to coarse grained and consist of quartz, mica and feldspar. Structural features on the schist include joint and foliation which result into schistocity. The granite in the area are intrusive to the schists and are highly jointed. These rocks have been highly weathered resulting in a lot of sand and gravel in river channels, banks and on land.

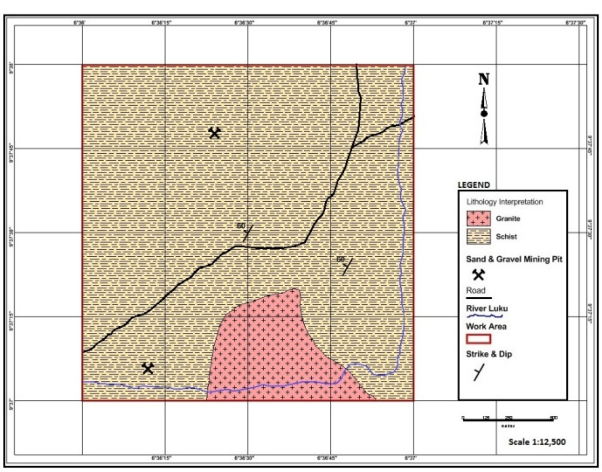

Figure 1 : Geological Map of the Study Area.

b) Field Observations

The study area is currently experiencing sand and gravel mining in considerable quantities and this has resulted in various physical environmental impacts which were observed during field studies. These impacts include

i. *Reduction of Farm and Grazing Lands*

Results from field observation showed that one of the physical effects of sand and gravel mining in Luku is the reduction of farmlands and grazing lands. Farming and animal rearing is one of the activities taking place in the area but sand and gravel mining has taken up most of the productive land meant for these activities. This is because for sand and gravel to be extracted, vegetation is destroyed and this vegetation serves as food for their cattle. This then denies both animals and inhabitants in the area their means of livelihood (Fig. 2). In East Gonja District in Ghana where agriculture is the predominant economic activity in the area, Musah, 2012, reported that gravel mining has not only denied the people in the area their means of livelihood but also to those who practiced agriculture as a way of life, infringed on their cultural heritage.

Figure 2 : Loss of Vegetation Due to Sand and Gravel Mining. This Leads to Reduction in Farming and Grazing Grounds in the Study Area.

ii. *Destruction of Landscape*

Landscape destruction, is one of the significant effects of mining in the area. The original landscape has been destroyed and altered as a result of excavated pits and trenches, leaving behind unpleasant sights which as well render the land unsuitable for any productive purpose (Fig. 3). During the raining season these pits collect and store stagnant water and as such, serve as breeding ground for pests such as mosquitoes and other water borne insects which in turn can affect the health of the people living in and around the area.

Figure 3 : Pits Formed from Sand and Gravel Mining Resulting in the Destruction of the Original Landscape of the Area.

iii. *Collapse of River Bank*

There is collapse of river banks in the area due to sand and gravel mining (Fig.4a and b). The extraction of sand and gravel around and within the river makes the banks of the river weaker and gradually collapses. This does not only leads to filling of the river channel with sediments but gives room for the water in the river to flow out resulting in erosion which washes away the soil.

Figure 4 : Collapse of River Bank Due to Sand and Gravel Mining in Luku.

iv. *Deforestation*

Mining of sand and gravel in the study area resulted in destruction of vegetation thereby destroying the natural habitats of some animals (Fig.5). Some very important plant species are also destroyed and the soil is exposed to erosion.

Figure 5 : Destruction of Vegetation Due to Sand and Gravel Mining Leading to Lost of Natural Habitats of Some Animals and Some Plants Species.

v. *Water Pollution*

Sediments from mines running off into river and wetlands are significant source of water pollution. Both surface and ground water quality are been affected through contamination with suspended and dissolved materials. In-stream mining of sand, gravel and gold in the area has led to the re-suspension of sediments in the water causing the brownish colouration of the water and this water is been consumed by the miners in the area due to lack of alternative source for drinking water (Fig. 6).

Figure 6 : Polluted River Water Due to Sand, Gravel and Gold Mining in Luku Village.

vi. *Air Pollution*

Air pollution is also one of the environmental impacts observed in the area. This air pollution resulted from the use of a jack hammer (Fig. 7) to facilitate drilling which aroused dust particles in the air. Industrial minerals such as silica flux and very fine gypsum can result to such pollution which can cause irritation of the lungs and mucus membrane.

Figure 7 : Dust Generation Due to Drilling Activity Resulting in Air Pollution in Luku.

c) *Geochemistry of Soil Samples*

The result of the laboratory analysis of the soil samples is presented in Table 1 while the average concentration of these elements with average permissible standard concentration of elements in the upper continental crust by Wedepohl (1995) and Taylor and McLennan (1985) is presented in Table 2.

Table 1 : Concentration of Trace Element in the Soil Samples.

Element (ppm)	LGS1	LGS2	LGS3	LGS4	LGS5	LGS6	LGS7	LGS8	LGS9	LGS10	Average value
Pb	43	82	91	4	13	6	6	14	26	143	42.8
As	2	7	1	0.2	10	3	4.5	4	1	9	4.17
Cu	48	82	39	41	56	67	42	46	43	45	50.9
Zn	51	11	9.6	9	56	67	42	46	43	45	37.96
Ni	15	10	23	31	90	39	20	36	45	18	32.7
V	53	79	47	86	100	30	40	70	60	12	57.7
Cr	1	15	3	3.6	4.1	1	2.2	2	1.7	1200	123.36
Ba	740	1060	1000	320	1000	370	660	510	690	480	683
Sr	22	350	713	48	371	52	53	51	77	658	239.5
Mn	514	700	1120	290	343	142	555	556	400	67	468.7
Cd	-	1	2	-	1	4	5.5	6.3	3	2	2.48
Sb	1	3	-	-	5	-	-	1	2	-	1.2
Co	12	-	6	11	-	12	4	11	-	3	5.9
Th	-	2	-	5	3	2	-	11	-	7	3
Mo	-	-	2	-	1	1	-	-	-	-	0.4
Hg	-	-	-	1	-	-	-	-	-	-	0.1
Ag	-	1	2	-	1	2	1	-	1	-	0.8
Sn	-	-	1	2	-	-	-	-	-	-	0.3
Au	-	0.1	0.2	-	-	1	0.6	0.3	-	0.8	0.3
Yb	-	-	4	-	-	-	-	1	-	-	0.5
Re	11	-	-	3	10	4	-	-	2	-	0.3
Ta	-	-	2	1	-	-	-	-	-	-	0.3
Eu	11	-	21	9	7	2	25	26	19	27	14.7
Y	14	-	12	12	10	15	25	24	31	21	16.4
Rb	27	5	-	2	37	6	-	29	4	43	15.3
Zr	551	710	920	170	893	223	241	226	101	926	496.1
Nb	8	42	4	32	11	6	2	8	-	7	12
Ga	-	-	40	20	-	-	10	15	21	9	11.5

Table 2 : Average Concentration of Selected Element and their Standard Concentration in the Upper Continental Crust.

Elements	Average concentration from study area	Standard concentration by Wendepohl (ppm)	Standard concentration (ppm) by Taylor and McLennan
Pb	42.8	17	20
As	4.17	2.0	1.5
Cu	50.9	14.3	25
Zn	37.96	52	71
Ni	32.7	18.6	20
Mn	468.7	527	600
Cd	2.48	0.102	0.098
Co	5.9	11.6	10
Mo	0.4	1.4	1.5
Hg	0.1	0.056	-
Ag	0.8	0.055	0.05
Zr	496.1	237	190

d) *Geochemistry*

i. *Lead*

From the result above, the concentration of lead (Pb) range from 4ppm to143ppm with an average concentration of42.8ppm (Table 1), while the standard concentration by Wendepohl, Taylor and McLennan are 17ppm and 20ppm respectively (Table 2). Hence this shows that there is a high concentration of lead in the area and this has a negative impact on the environment and man. The inhabitants in this area partake in agricultural activities. Plants on the land may tend to absorb the lead through their roots and this plants if consumed by man and animals can result to lead poisoning. Lead poisoning is a medical condition in humans and other vertebrates caused by increased levels of the heavy metal in the body which can cause disorders to the heart, kidneys, reproductive and nervous system (Lenntech, 2012).

ii. *Arsenic*

From the result obtained from the study, the concentration of arsenic (As) in the study area range from 0.2ppm to 10ppm with an average concentration of 4.17ppm (Table 1), when compared to the standard concentration of 2.0ppm and 1.5ppm by Wendepohl, Taylor and McLennan (Table 2), it shows that the concentration of arsenic in the area is higher than the required standards. The study area has rivers flowing through and arsenic can contaminate the water. Inhabitants and miners within the area depend on the water in the river for drinking and other uses due to lack of alternative source for water supply. Arsenic in drinking water, poses the greatest threat to public health (lenntech, 2012). Long term exposure to arsenic via drinking water causes cancer of the skin, lungs, urinary bladder and kidney.

iii. *Copper*

The concentration of copper (Cu) in the soil samples ranges from 39ppm to 82ppm with an average concentration of 50.9ppm(Table 1) compared to the standard of 14.5ppm and 25ppm by Wendepohl, Taylor and McLennan respectively (Table 2). This shows that copper is in excess in the area. Environmental and health impacts associated to copper includes, on copper rich soils, only a limited number of plants has the chance to survive. Due to the effects upon plants copper is a serious threat to the production of farmlands, depending upon the acidity of the soil and presence of organic matter (Lenntech, 2012). When soils and farmlands are polluted with copper, inhabitants and animals that depend on such plants will absorb concentrations that are damaging to their health, such as damages to the liver and kidney when ingested or breathed in excess.

iv. *Nickel*

The results above show that, the concentration of nickel (Ni) ranges from 15ppm-90ppm and an average concentration of 32.7ppm (Table 1) with standard averages of 18.6ppm and 20ppm, by Wendepohl, Taylor and McLennan respectively (Table 2). This shows that the concentration of nickel in the area is high compared to the standards. High concentration of nickel in soils can damage plants and can cause various kinds of cancer on different sites within the bodies of animals.

v. *Cadmium*

From the result, it is shown that cadmium (Cd) ranges from1ppm to 6.3ppm, with an average concentration of 2.48ppm (Table 1) when compared to the standard concentration of 0.102ppm and 0.098ppm by Wendepohl, Taylor and McLennan respectively (Table 2). The comparism shows that the concentration of cadmium in the soils of the area is higher than the standard concentration in the upper continental crust. This can pose a threat to human because candium accumilated in the body takes a very long period of time to be excreted and may result in severe damage to the lungs via inhalation (Lenntech, 2012). Cadmium strongly adsorbs to organic matter in soils and when present in large concentration in the soil, it can be extremely dangerous, as the uptake through food will iincrease. Soils that are acidified, enhance the cadmium uptake by plants. This is a potential danger to the animals that are dependantn upon the plants for survival. Earthworms and other essential soil organisms are extremely supsseptible to cadmium poisoning.

vi. *Mercury*

The results from the study show that the concentration of mercury (Hg) in the area is 1ppm with an average concentration of 0.1ppm (Table 1). When compared to the standard concentration of 0.056ppm by Wendepohl shows that mercury is of a higher concentration than the standard in the upper continental crust (Table 2). The high concentration of mercury in the soil can be absorbed by the plants, since the inhabitants in the area caryout agricultural poractices. Such plants, if consumed by man or animals can cause damage to the brain and kidney, lung irritation and also DNA alteration (Lenntech, 2012).

vii. *Silver*

The concentration of silver (Ag) ranges from 1ppm to 2ppm with an average concentration of 0.8ppm (Table 1). Comparing the concentration of silver to the standard concentration of 0.055ppm and 0.05ppm by Wendepohl, Taylor and McLennan respectively shows that the concentration of silver in the area is higher (Table 2). Plants can absorb silver from the soil, and this plants are consumed by man and animals who depends on it for survival resulting to several health problems such as cardiac abnormalities to human, lung and liver damage to animals and even death (Lenntech, 2012).

viii. *Zircon*

The concentration of zircon in the area ranges from 101ppm to 926ppm, with an average concentration of 496.1ppm. When compared to the standard concentration of 237ppm and 190ppm by Wendepohl, Taylor and McLennan respectively, shows that the concentration of zircon in the area is higher than the standard concentration and this may contaminate the soil and water in the area.

However, the result of the analyses shows that the concentration of zinc (Zn) ranges from 9ppm-67ppm, with an average concentration of 37.96ppm, manganese (Mn) 67- 1120ppm and an average concentration of 468.7ppm, cobalt (Co) 3-12ppm with an average of 5.9ppm, molybdenum (Mo) 1-2ppm with an average of 0.4ppm (Table 1). The average concentrations of these elements in the soils of the study area is however lower than the average standard concentration by Wendepohl and Taylor and McLennan (Table 2). This therefore means that that the concentrations of these elements are low and this may have no negative effects on the environment.

IV. Conclusions

The demand for sand and gravel for construction and other purposes is growing every day, and the process of mining these aggregates has resulted to serious environmental impacts. In Luku area of North Central Nigeria, sand and gravel mining has been going on at a large scale. Results of field work shows that destruction of landscape, deforestation, water pollution, loss of farm and grazing lands and the collapse of river banks are the physical environmental impacts associated with mining of these materials in the area. Result of analysis of soil samples indicates that lead, arsenic, copper, nickel, silver, mercury, zircon and cadmium have average values which are higher when compared to the standard approved concentration in the upper continental crust. The occurrence of these trace elements in excess in the soil and water, can have negative effects or lead to the death of man, animals and the destruction or extinction of some plants in the area. However, zinc, molybdenum, cobalt and manganese have average concentrations below the standard approved concentration in the upper continental crust and this may have no negative effects on the environment.

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A Comparative Hydrogeochemical Study of Granitic Fractured and Alluvial Channel Aquifer Systems

By Jacob Nyende, Modreck G & Van Tonder G
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Keywords: hydrogeochemistry, granitic fractured, alluvial channel aquifer, wish, phreeqc model, pallisa district, modder river catchment.

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I. Introduction

Hydrogeochemical processes in groundwater are largely controlled by the physical and chemical interactions that occur between the groundwater water and the aquifer materials. Hydrogeochemical processes are responsible for the seasonal, temporal and spatial variations of groundwater chemistry and consequently the quality (Rajmohan and Elango 2004). In alluvial channel aquifers that typically consist of unconsolidated sediments, groundwater hydrogeochemical processes are mainly influenced by the mineralogy of sediments that interacts with the infiltrating water. Alluvial aquifers located along the major rivers of the Southern Africa Karoo basin typically comprises of unconsolidated calcrete, clay, silts and sand deposits. According to Woodford and Chevallier (2002), Quaternary deposits are a major characteristic along main rivers of the Karoo basin. Calcrete sediments at shallow depth are a common phenomenon close to river channels in semi-arid to arid climates. The case study site 1 is characterised by arid to semi-arid conditions. The formation of calcretes close to river channels can also be related to shallow water tables and high infiltration rates that contribute to the precipitation of leached carbonates and dolomite minerals in the groundwater (Parsons and Abrahams 1994). In the riparian zones, evapotranspiration can also contribute to mineral precipitation in the vadose when the aquifer has a shallow water table. Dissolution of calcite and dolomite minerals can influence the groundwater chemistry and may also create preferential flow paths for groundwater recharge at the surface and within the deposits. Ion exchange reactions involving Na^{+} and Ca^{2+} often dominate geochemical processes in detrital sedimentary aquifers (Cardona *et* al. 2004). Agricultural chemicals such as fertilizers and pesticides have also been noted as significant contaminant sources for alluvial aquifers (Kelly 1997). It is upon such a background that this chapter was aimed at investigating the hydrogeochemical processes and their contribution to the overall water quality. The study utilizes the conventional Piper diagram, bivariate plots and PHREEQC model (Parkhurst and Appelo 1999) to analyze groundwater chemistry data obtained during sampling runs conducted in February, May and August of 2011.

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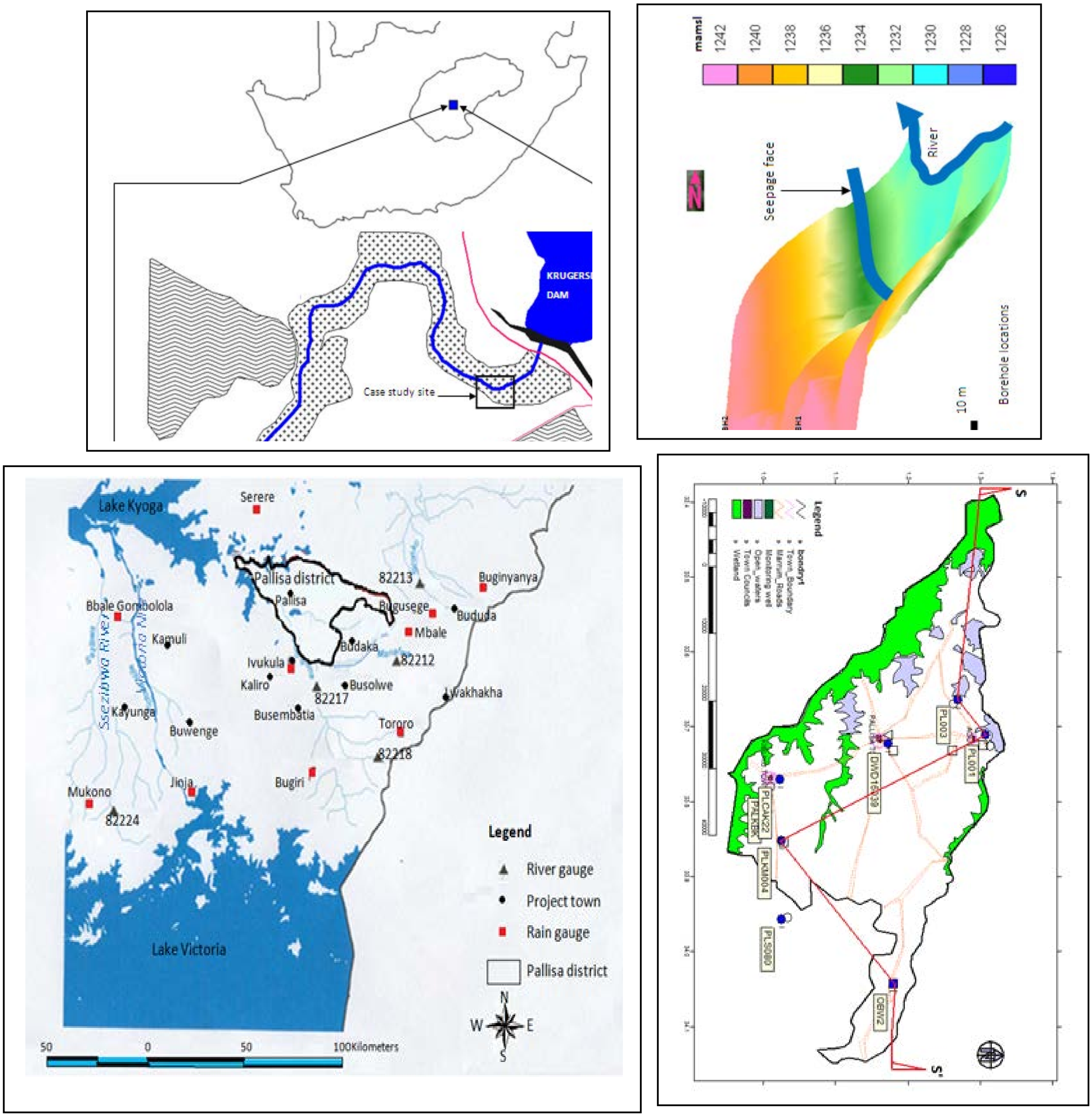

Figure 1 : Location of the Two (2) Case Study Sites – The Modder River Catchment in Bloemfontein and Pallisa District within The Kyoga Basin.

II. Description of the Two Case Study Areas

a) *The Case Study Site 1*

It is located in the Modder River catchment, downstream of the Krugersdrift Dam which is situated about 30 km from the city of Bloemfontein, in the Free State Province of South Africa (Figure 1). Modder River is a seasonal river in which the majority of the flow occurs during the rainy season. The study area is surrounded by farms that are mainly characterised by summer and winter crop production. In general, the study area is characterised by arid to semi-arid climate with long periods of low rainfall events. The area is generally dry and on average receives about 600 mm of rainfall per annum. The rainfall is often associated with heavy thunderstorm activities. During the 2010/2011 rain season the study area received about 680 mm of rainfall (Figure 2). February and June 2011 were characterised by extremely high rainfall amounts in excess of 150 mm which resulted in flooding events. The riparian vegetation alongside the Modder River banks comprises of tall thorn trees, small Bushveld shrubs and thick grasses.

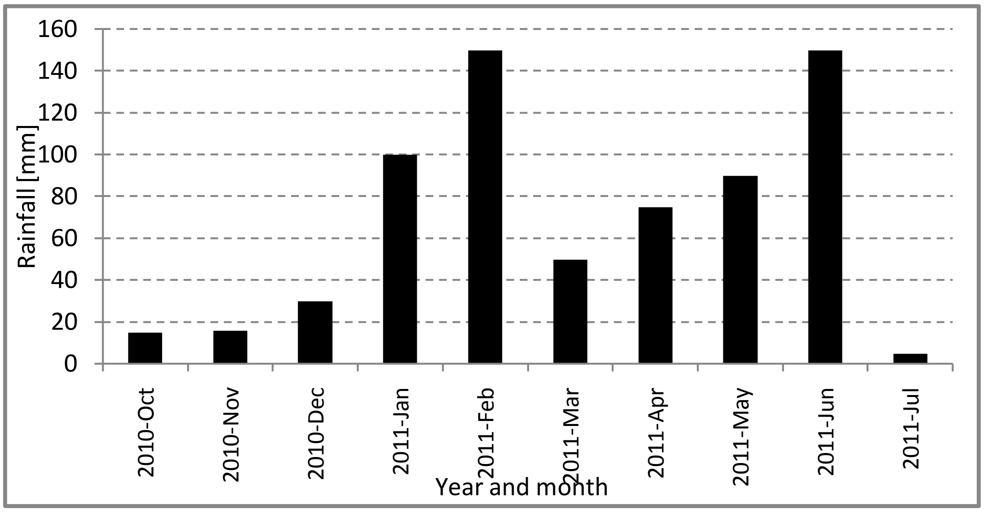

Figure 2 : Monthly Rainfall for the Study Area Recorded during the 2010/2011 Rain Season.

b) The Case Study Site 2

Pallisa District lies within the Kyoga Basin and is located in the eastern part of Uganda. It is approximately 1 585 km^2 in area and is bordered by Kumi District to the north, Budaka District to the east, Butaleja District to the south - east, Namutumba District to the south, Kaliro District to the west, to the north - west lies both Kamuli District and Soroti District. The chief town is Pallisa and its coordinates are 01° 1''N, 33° 43''E (Figure 1). Pallisa District is located between latitude 33° 25''E and 34° 09''E and Longitude 0° 50''N and 01° 25''N. There are small towns of Kabwangasi, Kamuge, Kibuku and Butebo within Pallisa district. The topography slopes gently from east to west with land surface elevations from 1 200 mamsl in the eastern part to near 1 000 mamsl in the south - western part (Figure 2). Most of the land is used for small scale agricultural farming while wetlands, woodland, bush land, grassland, deciduous plantations and urban areas represent about 30% of the land surface. The average temperatures range between 20 - 30° C, with minor daily temperature variations. Mean annual minimum temperature is 18° C and the mean annual maximum temperature is 32° C. The weather conditions are characterised with bi - modal rainfall system controlled by the Inter - Tropical Convergence Zones (ITCZ) (Nyende 2007). The mean annual precipitation is about 1 250 mm/year.

III. Geohydrological Properties

For Study site 1, groundwater mainly flows in the gravel-sand channel deposits which are typically characterised by high hydraulic conductivity properties. The hydraulic conductivity of the aquifers spatially varies depending on the sorting of the channel deposit aquifer materials and the amount of silt and clay present in the deposits. In other words, the sorting of gravel-sand aquifer materials and the silt-clay content has great influence on the aquifer hydraulic properties. Although high hydraulic conductivities of the gravel-sand deposits are good for groundwater yields, it can also accelerate contaminant migration. Groundwater water recharge of the shallow alluvial cover aquifers occurs locally through normal and preferential infiltration as enhanced by the dense vegetation that often characterises riparian zones. Surface runoff and drainage from the terrestrial land also assist in the accumulation of water on the lower riparian zone thus enhancing the infiltration of water into the shallow alluvial cover aquifer system. Because of shallow water table conditions, the recharge process is often quick. The locally recharged groundwater of the alluvial cover aquifer typically has short residence time. High hydraulic properties of the channel deposits facilitate quick groundwater movement which consequently discharges into the river system. Geochemically, the shallow local groundwater system would be characterised by low Total Dissolved Solids (TDS) because of limited time in contact with the non-saline aquifer materials. Coarse-grained alluvial channel aquifers can be approximated by a homogeneous porous media when estimating hydraulic and transport parameters. However groundwater and transport flow in the sediments is greatly controlled by aquifer material architecture (Zappa et al. 2006). It is therefore important to understand the effects that the physical properties of channel deposits has on the spatial variation of measured aquifer parameters. The influence that physical and chemical properties of geological material have on the spatial variation of geohydrological properties is collectively referred to as "heterogeneity".

In study area 2, water is abstracted from both the fractured bedrocks and from the overlying weathered regolith (BH PL003; BH OBW2). The regolith aquifer is seen increasingly as a usable resource which aid agencies are seeking to develop on grounds of favourable yields and lower cost than the deeper groundwaters from the basement (BH PL004) (Figure 3).

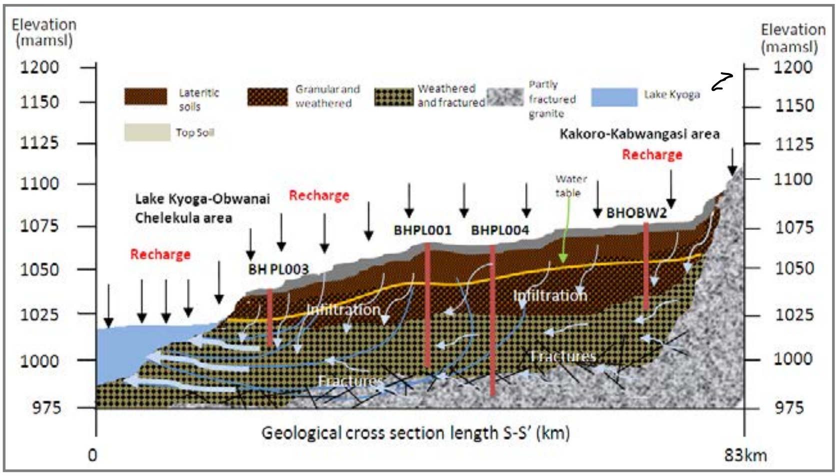

Figure 3 : Schematic Hydrostratigraphic Units of the Kabwangasi - Kakoro - Lake Kyoga Exaggerated Cross-Sectional Conceptual Geological Model of Groundwater Flow in Pallisa District, Eastern Uganda (Not to Scale). Arrows Show Concentration of Recharge.

The regolith layer typically has an upper horizon of clayey sediment which is effective at filtering out some surface-derived pollutants (e.g. bacteria) and in restricting entry of air to the underlying aquifers. This has some implications for the degree of aeration of the aquifers and of the resulting groundwater chemistry. The basement aquifer has poor permeability but is variably fractured. The development of fractures is crucial for the availability and yield of groundwater; hence the productivity of the aquifer is highest at the shallowest levels. According to Briggs et al. (1989), the high rainfall and temperature of tropical climates serve to increase the rate at which chemical weathering processes occur as a result of hydrolysis, oxidation and dissolution. The geopetal imprint of long-term deep weathering and erosional unloading was identified in the vertical heterogeneity of the fractured-bedrock and weathered-mantle aquifers; the horizontal heterogeneity is lithologically controlled. The two units form an integrated aquifer system in which the more transmissive (5-20 m^2/d) (Nyende, 2013) and porous weathered mantle provides storage to underlying bedrock fractures ($T = 1$ m^2/d). The thickness and extent of the more productive weathered-mantle aquifer are functions of contemporary geomorphic processes.

IV. Methods

a) Groundwater Sampling for Site 1

For study site 1, a total of 16 groundwater and two river samples were collected during three sampling events in February, May and August and December 2011. Six of the groundwater samples were obtained from background boreholes (terrestrial aquifer) while one of the samples was obtained from the seepage water flowing out at the contact plane between the overlying unconsolidated sediments and the shale bedrock at the river bank. Samples from the boreholes were collected in clean polyethylene bottles using a low flow pump at an abstraction rate of 0.30 l/s. Temperature and electrical conductivity (EC) were continuously monitored in the purged water. Samples were only obtained after the stabilisation of temperature and EC. Figure 1 shows the location of boreholes from which the groundwater samples were collected. River samples were collected downstream and up stream of the alluvial channel aquifer.

Inorganic groundwater chemistry analyses were conducted by the Institute for Groundwater Studies (IGS) laboratory of the Free University in South Africa. The samples were analysed for major and minor ions; and silicon. The validity of the analytical measurements of the ions was determined by calculating the ionic balance error and is within the ± 5% range. Saturation indices of quartz, calcite and dolomite as the most dominant and major minerals respectively were calculated using PHREEQC model (Parkhurst and Appelo 1999).

b) XRD and X-Ray Analysis for Site 1

The X-ray fluorescent spectrometry (XRF) and X-ray diffractometry (XRD) analysis was performed on randomly selected geological logs to determine the presence and absolute quantities of mineral species and major oxide elements in the geological samples. Six samples representative of the soil, calcrete, clay-silt, gravel-sand and shale formation were selected for the analysis. Hundred grams of disturbed samples were randomly collected from calcrete, alluvium-silt, clay and gravel-sand formations of the boreholes drilled into the alluvial channel aquifer. The logs from different boreholes were then mixed to obtain a representative sample of the lithology. The XRF and XRD analysis was conducted by the Geology laboratory of the Free State University in South Africa.

c) Groundwater Sampling for Site 2

For the study site 2, groundwater sampling was carried out in 2010 - 2011. In order to study the variation of groundwater quality in the study area, groundwater and soil samples were collected with the help of the Directorate of Water Resources Department, Entebbe and Kyambogo University twice a year during wet and dry periods, from July - October 2010 and December 2010 - March 2011. Samples were collected during the driest part of the year to avoid dilution by infiltration and the wettest part when dilution had taken place under the recharge activity. Water and soil samples were collected in such a way that they represented different types of lithological units, (i.e. from different topographic levels), human impact and different climatic conditions. A total of 176 groundwater samples were collected from existing 56 sampling stations that included two newly drilled deep and four shallow wells. The boreholes are used for domestic water supply. Plastic sampling bottles were rinsed with distilled water before being used to sample. The bottles were tightly sealed, stored in ice box in the field (at 4° C) and taken to the Government laboratory at Wandegeya in Kampala for analysis. The sample preservation and analysing techniques were in accordance with the standard test procedures. The collected groundwater samples were analysed for major ions such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^-, Cl^- and SO_4^{2-}. Sensors were used for on-the-spot field water quality measurement of TDS, electrical conductivity (EC), pH and temperature. Alkalinity was measured (by Gran-titration) within 12 hours at a field laboratory. Trace elements such as lead and arsenic were not analysed, due to limitations of standards and reagents. Field measurement of pH is essential for meaningful interpretation of the results, especially for groundwater modelling, since loss of CO_2 could take place between the well head and the laboratory, thus leading to a pH rise. EC is a key parameter in both surveys and monitoring, since it enables the quick detection of spatial or temporal changes in the groundwater. Total hardness was calculated using the WISH computer software. In order to study the quality of groundwater, the chemical data were evaluated in terms of its suitability for domestic, agriculture and drinking purposes. The analysed data not only could be used for the classification of water for utilitarian purposes but also for ascertaining the various factors on which the chemical characteristics of water depend. Boreholes were pumped until stable readings for the parameters were obtained. Water samples were also collected in yellow high density polyethylene bottles except for samples for the analyses of hydrogen and oxygen isotope ratios. In the field, two filtered (0.45 μm cellulose nitrate membrane filter) samples (one part was acidified to pH = 1 with ultra-pure HNO3 in new pre - flushed PE bottles and the other not acidified) were then taken for laboratory analysis for the determination of cations as described by Edmunds (1996b). Concentrations of cations in water and the rock samples were determined by Atomic Absorption Spectroscopy (AAS); following dissolution of the rock sample powders in 2NHCl. Analyses of anions were carried out on a Dionex DX120 ion chromatograph. The detailed hydrochemical characteristics of potable groundwater, including variations in concentrations of major cations and anions, are described in US 201:1994 and US 43:1999 for drinking water quality.

V. Results

The groundwater chemistry analysis results have been used to identify and describe the hydrogeochemical processes governing the groundwater evolution and their contribution on the overall groundwater quality.

Table 1 shows the maximum and minimum concentrations of major and other important ions in groundwater samples collected from the aquifer.

Table 1 : Maximum and Minimum Concentrations of Major Ions and Other Important Ions Measured in the Groundwater during the Monitoring Period, also Shown in the Table is the South African National Standards (SANS 1996) of Drinking Water Quality Target Concentrations.

Ions	Minimum [mg/l]	Maximum [mg/l]	SANS 1996 [mg/l]
Na^+	82.90	209.60	≤ 100
K^+	4.75	8.23	≤ 50
Ca^{+2}	32.50	56.40	≤ 32
Mg^{+2}	40.09	82.80	≤ 30
Cl^-	48.84	107.00	≤ 100
SO_4^{-2}	20.02	74.83	≤ 200
F^-	0.25	0.73	≤ 1
NO_3^- (N)	0.00	0.82	≤ 6
HCO_3^-	365.00	613.00	-[a]
Si^{+4}	19.05	23.93	-

[a]*- no standard available*

The Ca^{+2} and Mg^{+2} concentrations in the all the groundwater samples exceed the SANS (1996) drinking water quality target values of 32 and 30 mg/l respectively. Abundance of the major ions is in the following order: $HCO^{3-} > Na^+ > Cl^- > Mg^{+2} > Ca^{+2} > SO^{4-2} > K^+$. Sodium and HCO3- are the most dominant cation and anion with an average contribution to total cations and anions of at least 60 % and 80 % respectively. Based on the Piper diagram (Figure 4); the groundwater is classified as a Na^{+}-HCO_3^{-} water type.

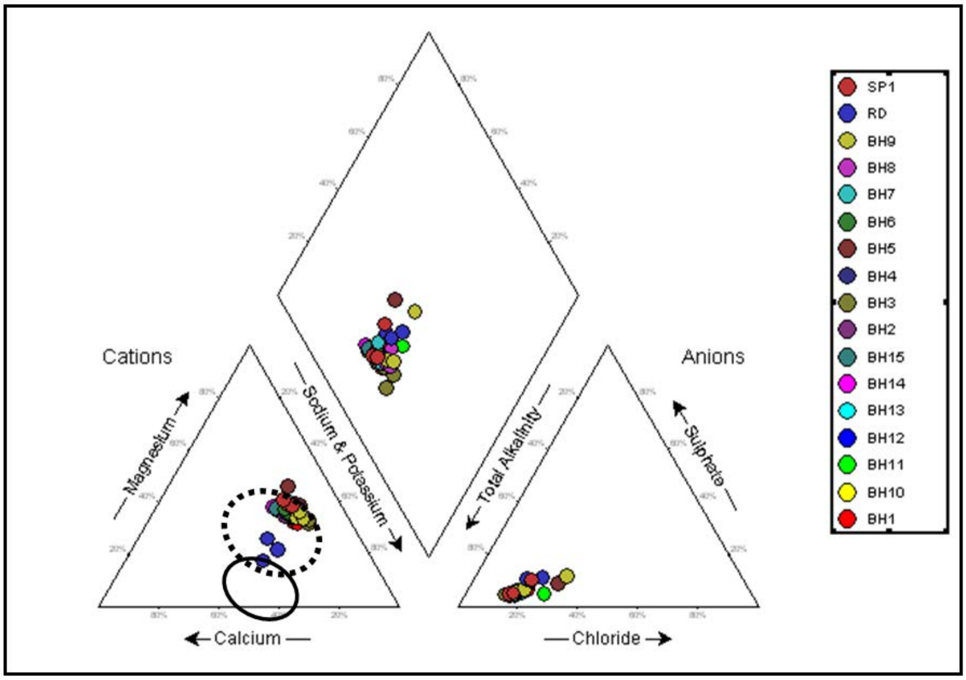

Figure 4 : Groundwater and River Samples Plot on a Piper Diagram; Groundwater Samples are Encircled by the Dashed Oval while the Bold Oval Encircles the River Water Samples.

Table 2 shows the major elements oxides and minerals detected by XRF and XRD analysis. The XRF analysis (Table 2) shows that the alluvial channel deposits are dominated by silicates, aluminum and iron oxides. Magnesium, calcium and potassium oxides in the unconsolidated channel deposits occur in relatively small contents of above 1 %. The clay-silt formation has the greatest abundance of the calcium major oxide in excess of 11 %. Anhydrite constitutes about 43 % of the fines.

Table 2 : Major Minerals Detected in the Alluvial Channel Aquifer Materials; XX - Dominant (> 40 % Per Volume), X - Major (10-40 % Per Volume), Xx - Minor (2-10 % Per Volume) and X - Accessory (1-2 % Per Volume).

		Major minerals detected in the channel deposits and their relative % content					
Sample description	Depth [mbgl]	Quartz	Calcite	Dolomite	Magnetite	Pyrite	Gypsum
Soil	0-1	XX	<x		x	<x	
Calcrete	1-3	XX		xx	xx		<x
Clay-silt	3-5	XX	X		x		
Gravel-sand	5-8	XX	xx				
Shale	8-12	XX	xx		<x		

The XRD analysis (Table 2) shows that quartz is the super dominant mineral in all samples of the channel deposits sediments that were analysed. Calcite was detected as a minor mineral in the gravel-sand and shale but is the dominant mineral constituent of the clay-silt formation. Dolomite and magnetite occurs in the calcrete deposits as major minerals.

The distribution of the major ion composition in Pallisa District is shown in Figures 5 and 6 by Piper Tri - linear diagrams. From Figures 5 and 6, it can be seen that most wells in saprolite, fractured and granite layers are mainly dominated by Ca+Mg, Na+K, CO_3+HCO_3, Ca-HCO_3^{-}-SO_4 or HCO_3^{-}Cl+SO_4 - waters.

Water samples from the basement rocks are typically low in Mg, Cl, SO_4, and high in Ca. Hence, they are of Ca-HCO_3, or Ca-HCO_3 - type, with a few of Mg-Ca-HCO_3 type. Water samples from sandstone are Na¬Ca-Mg-HCO_3, Mg-Ca-HCO_3 and Na-HCO_3 - types. Others have Ca-Mg-Na+K and are not dominant in any type. The Piper diagrams also show overlapping hydrochemical characteristics of borehole water for the dry and wet seasons. Groundwater in Pallisa is generally of Ca-[Mg]-HCO_3 - type. This type of water is typical of shallow groundwater systems in crystalline areas. With increasing depth an increase in magnesium is observed.

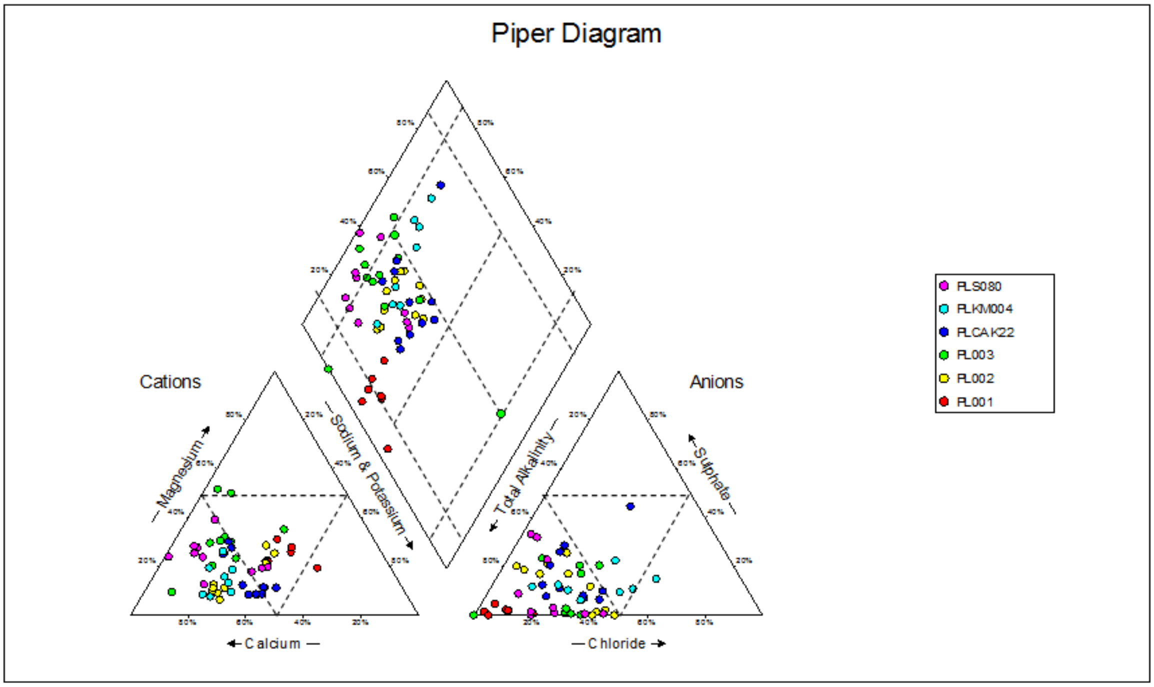

Figure 5 : Piper Tri - Linear Diagrams Showing Hydrochemical Facies of Groundwater during the Wet Season in the Different Boreholes of Pallisa District in Eastern Uganda

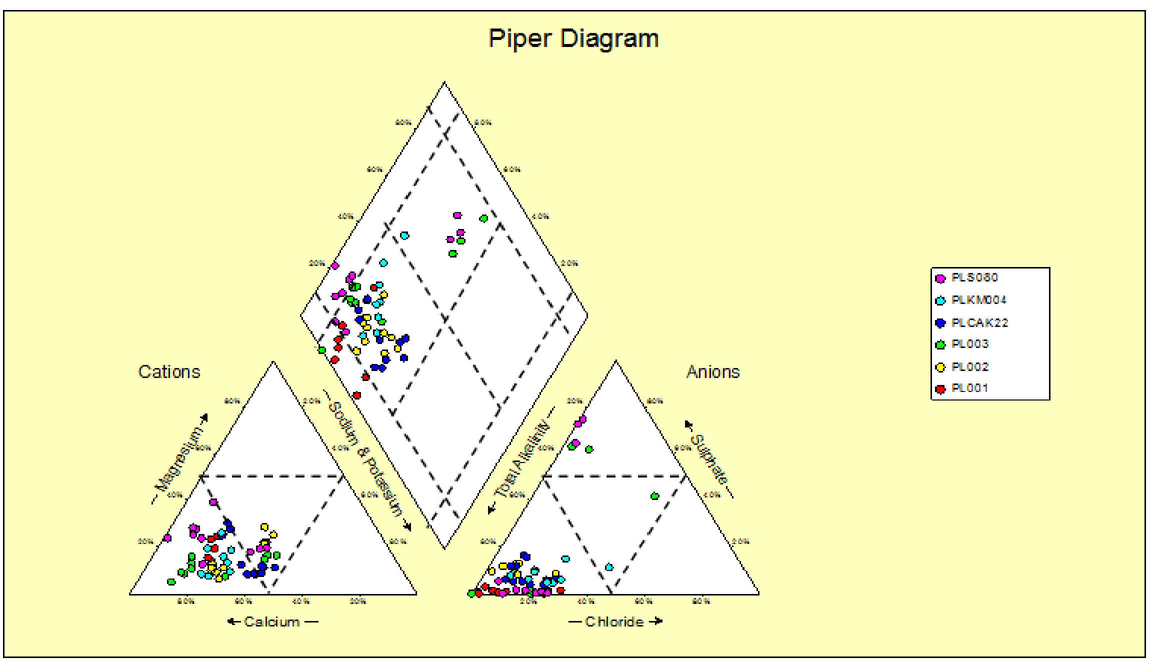

Figure 6 : Piper Tri - Linear Diagrams Showing Hydrochemical Facies of Groundwater during the Dry Season in the Different Boreholes of Pallisa District in Eastern Uganda.

VI. Discussion

The discussion seeks to identify and describe the possible hydrogeochemical processes contributing to the formation of a Na^+-HCO_3^- groundwater type (Figure 7). Attention has also been placed on levels of nitrates as nitrogen NO_3^-(N) in the groundwater given the proximity of the alluvial channel aquifer to agricultural farming activities. Identification of the important hydrogeochemical process in a groundwater system is not a unique exercise mainly because different reactions and weathering process can result in similar type of ions being present in the groundwater. The task of identifying the major hydrogeochemical processes is more of a diagnostic in nature. Two optional approaches can be used, firstly one can use the concentrations of the ions

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detected in groundwater to work backwards and try to identify their origins. On the other hand, it is also possible to start by identifying the minerals and major element oxides of the aquifer materials and then comparing their predicted potential influence on the groundwater quality to the measured ions. The relative nature of the exercise calls for the use of complimentary lines of evidence to identify and understand hydrogeochemical processes as demonstrated in this paper.

VII. Hydrogeochemical Processes

a) Carbonate System

The carbonate systems of the site only consist of bicarbonate (HCO_3^-) ion that constitutes more than 80 % of the total anion in the groundwater system (Fig. 5). The weathering and dissolution of calcite and dolomite minerals that were detected in the unconsolidated deposits is the main sources of HCO_3^-, calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions in the groundwater system. The carbonate mineralogy of calcretes is mainly dominated by calcite and dolomitic minerals (Parsons and Abrahams 1994). Although calcium (Ca^{2+}) often dominates in calcrete minerals, calcite rich in magnesium (Mg^{+2}) has also been reported in the Kalahari region of Southern Africa (Watts 1980). The presence of HCO_3^-, Ca^{+2} and Mg^{+2} in the groundwater system can therefore be explained using the processes of the carbonate system. A flow diagram in Figure 7 provides the following stages below:

i. *Stage 1*

Carbon dioxide (CO_2) in the soil medium reacts with the infiltrating rain water to form carbonic acid ($H_2CO_3^-$). Elevated levels of CO_2 are generally expected in the soil at the site from the respiration of organic matter.

ii. *Stage 2*

Infiltrating recharging waters rich in $H_2CO_3^-$ interacts with calcrete reacting with calcite ($CaCO_3$) and dolomite $CaMg(CO_3)_2$ minerals within the deposits. The reaction leads to the dissolution of calcite and dolomite minerals, thus providing Ca^{+2}, Mg^{+2} and HCO_3^- ions in the groundwater.

iii. *Stage 3*

Stage 3 is controlled by cation exchange reactions where Ca^{+2} and Mg^{+2} exchanges for Na^+ on alluvium silt-clay sediments. The silt-clay sediment absorbs Ca^{+2} and Mg^{+2} while Na^+ is released into the groundwater solution. Although no practical tests were conducted to test the occupation of the exchanger sites, the study seeks to assess the possible contribution of ion exchange process to the elevated Na^+ based on theoretical understanding and field results.

iv. *Stage 4*

Stage 4 defines the existing groundwater type from the preceding reactions in stages 1 to 3. The process typically takes place during groundwater recharge where Ca^{+2}, Mg^{+2} and HCO_3^- ions often flushes salt water out of the aquifer. The resulting groundwater in the gravel-sand main aquifer layer is Na^+-HCO_3^- type.

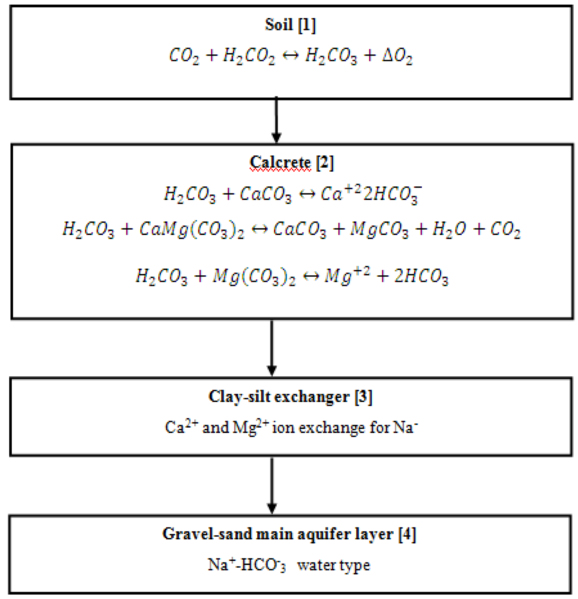

Figure 7 : A Flow Diagram Showing the Idealised Carbonate System Reactions that Occur during the Recharge Process as the Water Passes Through the Aquifer Media of Different Chemical and Physical Properties.

v. *Nitrates as Nitrogen NO_3^-(N)*

Studies have also established a correlation between strong exposure to nitrates in drinking water and the incidence of gastric and intestinal cancer (Cissé and Mao 2008). It is therefore imperative to assess the evolution of NO_3^-(N) in a typical alluvial channel aquifer.

However the low saturated hydraulic conductivities in the vadose zone gives infiltrating recharging waters sufficient time to go through denitrification thereby reducing the NO_3^-(N) levels in the water that reaches the alluvial channel aquifer.

vi. *Sodium*

Elevated Na^+ concentrations in the groundwater system can be attributed to a number of processes which include ion exchange and silicate weathering. Multiple evidences on bivariate plots to infer the contribution of the ion exchange geochemical process on the elevated Na^+ concentrations are presented.

vii. *Ion Exchange*

The Na^+ against Cl^- plot shows that all groundwater samples at the site are located above the 1:1 evaporation line (Figure 9) implying that the meteoric NaCl is not the source of Na^+ in the groundwater water. The shifting of the groundwater plots from the 1:1 line is due to increased Na^+ concentration and the ion exchange process can be used to explain the effect.

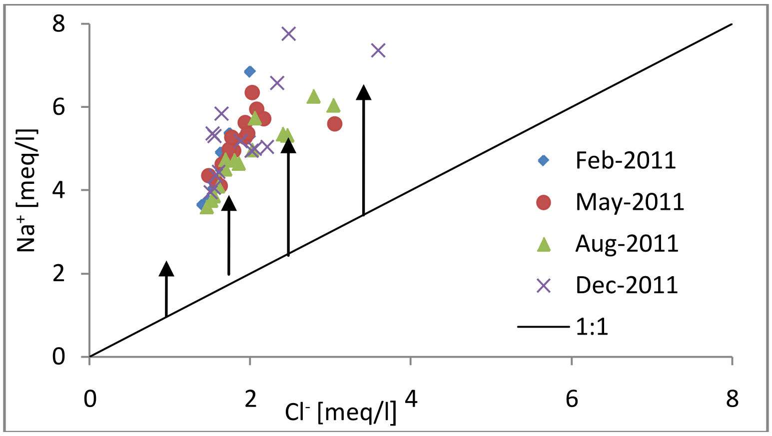

Figure 9 : Bivariate Plot of Na^+ Against Cl^- at the Study Site; Black Arrows Indicate the Contribution of the Ion-Exchange Process and Deviation from the 1:1 Evaporation Line; Meq/L – Milliequivalent Per Liter.

The plot of Ca^{2+} + Mg^{2+} versus SO_4^{2-} + HCO_3^- will be close to the 1:1 line if dissolutions of calcite and dolomite gypsum are the dominant reactions in a system (Guler 2002). The groundwater sample plots on the right side of the 1:1 line (Figure 10) and according to Fisher and Mulican (1997), ion exchange process tends to shift the sample plots to right. The shift to the right of the 1:1 line is due to the decrease of Ca^{2+} + Mg^{2+} cations as they leave the groundwater system to occupy the sediments exchange site left by Na^+.

A plot of (Ca^{2+}+Mg^{2+}-SO_4^{2-}-HCO_3^-) against (Na^+-Cl^-) was used to assess the existence of ion exchange reactions in the groundwater systems. By subtracting chloride from sodium chloride (considering that Cl^- is a conservative ion, and assuming that all Cl^- comes from precipitation), groundwater that are not influenced by ion exchange will plot close to zero on this axis.

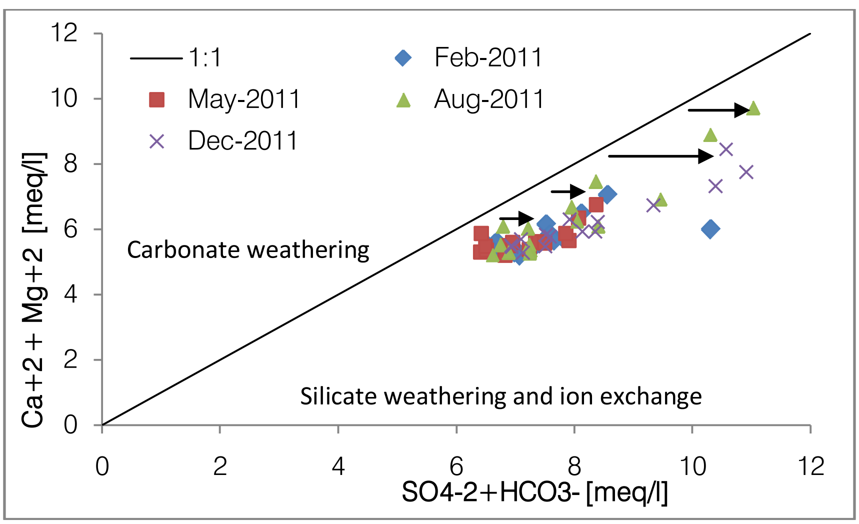

Figure 10 : Bivariate Plot Showing (Ca2++Mg2+) Against (SO42-+HCO-3) for the Groundwater Samples from the Alluvial Channel Aquifer and Terrestrial Aquifer.

Figure 11 a-d shows a plot of (Ca^{2+}+Mg^{2+}-SO_4^{2-}-HCO_3^-) against (Na^+-Cl^-) for the groundwater samples from boreholes drilled into the alluvial channel aquifer and terrestrial background aquifer.

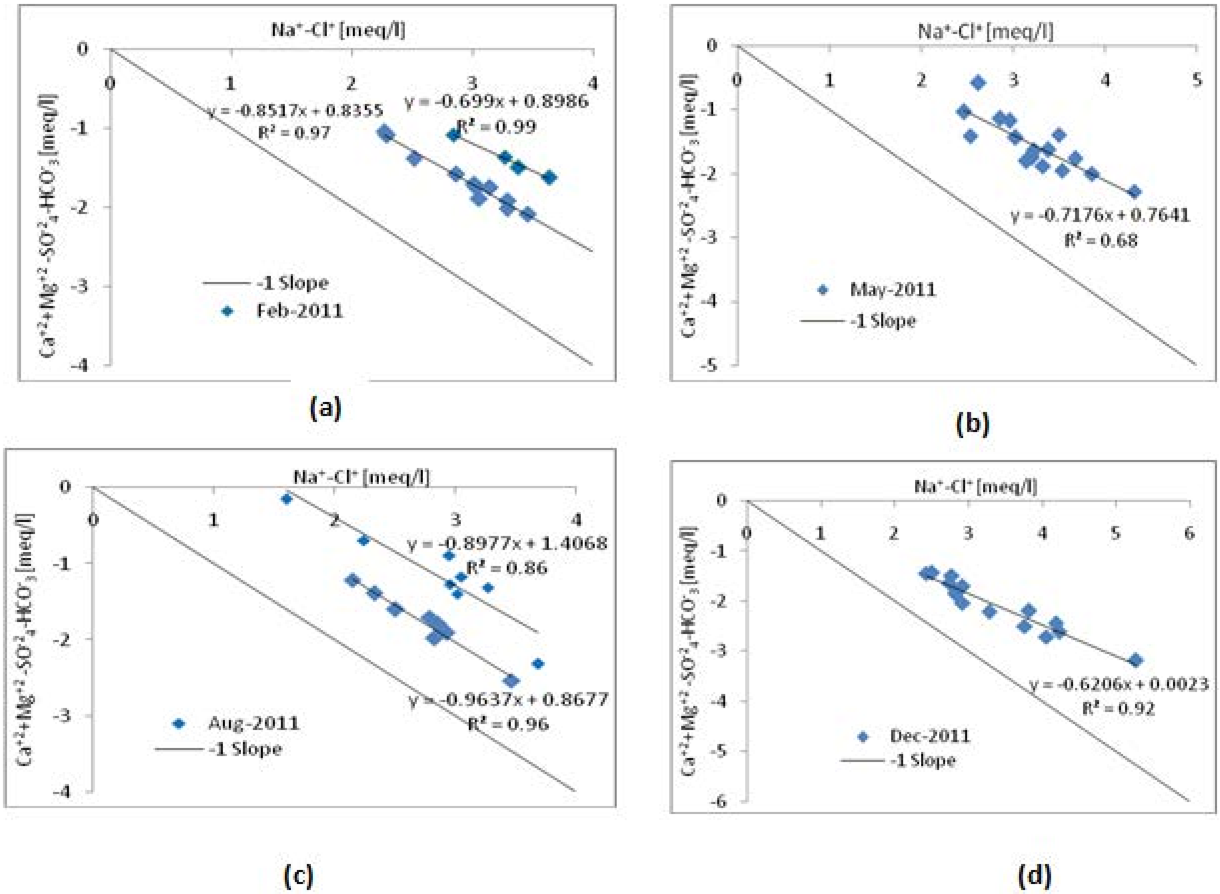

Figure 11 : Relationship between (Ca^{+2}+Mg^{+2}-$SO4^{-2}$-HCO_3^-) Against (Na^+-Cl^-) for Groundwater Sampled In February 2011 (A), May 2011 (B), August 2011(C) and December 2011 (D).

Linear regression plots on Figure 11(a-d) shows that groundwater samples fit into lines that have gradients between -0.69 and -0.96. The gradients of the lines are generally close to -1 and are characterised by a goodness fit of between (r^2 = 0.68 and 0.99), thus enhancing evidence about the occurrence of iron exchange in the alluvial aquifer. The two different slopes on the (Ca^{+2}+Mg^{+2}-$SO4^{-2}$-HCO_3^-) against (Na^+-Cl^-) plot of February 2011 (Figure 11, a) and August 2011 (Figure 11, c) implies that there might be two levels of ion exchange in the groundwater system. There is however no field evidence to ascertain the existence of different levels of ion exchange.

viii. *Silicate Weathering*

The unconsolidated channel deposits at the site are rich in silica as they make up at least 60 % of the total compositions major oxide elements. In general, silica is one of the most abundant oxides in the earth's crust. The elevated silica concentration in groundwater (> 20 mg/l, Table 1) is derived from silicate weathering (Equation 4).

$$2NaAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2Na^+ + 4H_4SiO_4 + 2HCO_3^- \quad (4)$$

(Albite (Kaolinite)

Based on (Equation 4), silicate weathering can also increase the concentration of HCO_3^- and Na^+ in the ground water. The contribution of silicate weathering on the increase of ground Na^+ can be also explained by the trends shown on scatter plots on Figure 9 to Figure 11.

ix. *Saturation Indices*

Saturation indices for quartz, dolomite and calcite were determined using the Phreeqc hydrogeochemical model (Parkhusrt and Appelo 1999). The calculations were conducted using thermodynamic data contained in the database of the Phreeqc for Windows software. Mineral equilibrium calculations for groundwater are useful in predicting the presence of reactive minerals in the groundwater system and estimating mineral reactivity.

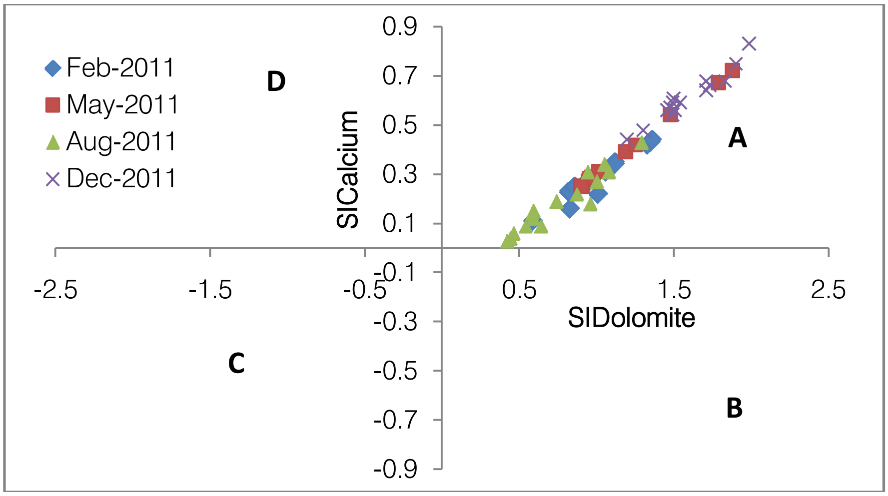

Figure 12 : Relationship between the Saturation Indices for Calcite and Dolomite; Quadrants Define: a-Dolomite and Calcite Supersaturation, B-Dolomite Undersaturation and Calcite Supersaturation, C-Dolomite and Calcite Undersaturation; and D-Dolomite Supersaturation and Calcite Undersaturation.

Figure 12 shows the relationship between the saturation indices of calcite and dolomite minerals for the groundwater samples collected during the monitoring period. Calcite and dolomite saturation are all positive indices and plot in quadrant A which implies that the groundwater had sufficient residence time for supersaturation to occur. The saturation index of calcite is lower than of the dolomite (SIdolomite/SIcalcite ≥ 2); hence the later is most likely to precipitate first. The groundwater is supersaturated with respect to quartz which is the most dominant mineral in the channel deposits. Groundwater samples have low concentrations of SO_4^{-2} in the range of 20-53 mg/l, thus the water is undersaturated with respect to gypsum (SI < -1.5). No gypsum minerals were detected in the channel deposits and hence the most likely source of SO_4^{-2} is the old waters.

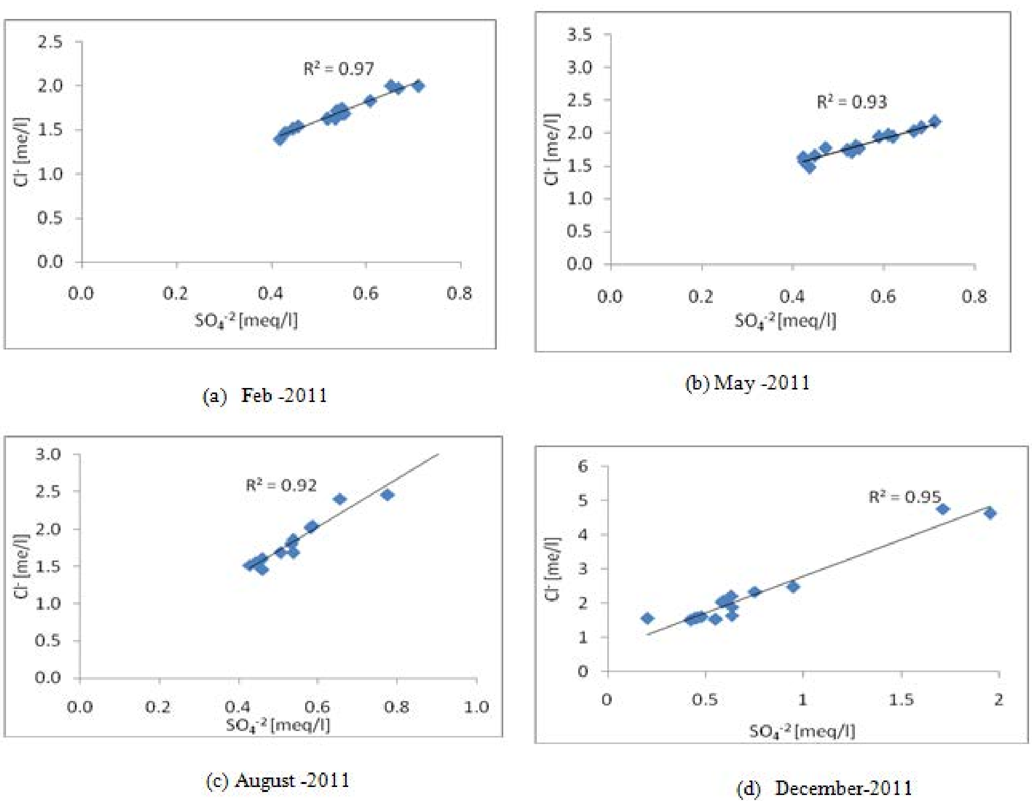

Figure 13 : Scatter Diagrams Showing Cl^- Against SO_4^{-2} Plots for Groundwater Samples Collected in: (A) February, (B) May 2011, (C) August and (D) Dec 2011.

x. *Sulphate and Chloride*

Figure 13 shows a scatter plot of chloride against sulphate ions. High correlation between chloride and sulphate ions can be a reflection of similar processes that are affecting the two ions. In shallow alluvial channel aquifers along the riparian zones, sulphate and chloride ions in groundwater can be both enriched due to the evapotranspiration process. Scanlon et al. (2009) reported high correlation (r = 0.85) of total sulfate and chloride inventories in profiles beneath natural ecosystems.

xi. *Groundwater Quality*

The groundwater quality is evaluated based on its suitability for drinking, agricultural, and domestic use using local and international guidelines. The possible influence that that hydrogeochemical processes has on the overall groundwater is described and explained. Elevated concentrations of Na^+ above the (SANS 1996) target concentration of ≤ 100 mg/l is due to the ion exchange and silicate weathering hydrogeochemical process. Ca^{+2} and Mg^{+2} exceeded the target levels of 32 mg/l and 30 mg/l respectively in the groundwater samples. The calcite weathering and dissolution processes are responsible for high Ca^{+2} and HCO_3^-. Dissolution and weathering of dolomite minerals in the sedimentary deposits contributes to high Mg^{+2} concentrations.

xii. *Hardness*

Classification of groundwater based on total hardness shows that 81 % of the water is hard. The total hardness value ranges from 240 mg/l-500 mg/l. The seepage groundwater sample has the highest total hardness and is mainly attributed to the accumulation of Ca^{+2} and Mg^{+2} cations along the flow path to the discharging zone. Table 4 shows the classification of groundwater based on the total hardness for the samples collected during the monitoring period.

Table 3 : Classification of Groundwater Based on Hardness (Sawyer and Mcmcartly 1967).

Total hardness as $CaCO_3$ [ppm]	Water class	Number samples
0-75	Soft	0
75-150	Moderate Hard	0
150-300	Hard	53
> 300	Very Hard	15

It is worth to point out that the total hardness is above the World Health Organization (WHO) (1993) standard of 100 mg/l. Although the total hardness exceed the international target water quality concentration levels, it does not does not constitute a serious threat because the hardness is only temporary. According to WHO (2010), water with hardness above 200 mg/l has potential to cause scale deposition in the water distribution system, heating and boiling equipment. On the hand, soft water (hardness < 100 mg/l) often result in the corrosion of pipes and this can lead to dissolving of heavy metals from the pipes in the drinking water (National Research Council, 1977).

xiii. *Irrigation Water Quality*

The suitability of groundwater for irrigation requirements is often determined using the Sodium Adsorption Ratio (SAR) parameter mainly because it can quantify the potential effects of alkali and sodium hazard on crops (Arumugam and Elangovan 2009). Figure 14 (for site 1) shows the classification of groundwater based on salinity and alkalinity hazard of irrigation (US Salinity Laboratory Staff, 1954).

The groundwater is characterised by high salinity (C3) and would suit soils with improved drainage to flush out the salts. From a irrigation requirement point of view, the groundwater has generally low Na^+ concentration and there is less risk of harmful Na^+ effects. High HCO_3^- concentration in the groundwater also has great potential to precipitate out of the calcium carbonate thereby increasing SAR in the groundwater. Total bicarbonate levels in the groundwater ranges from 373-613 mg/l and has a major contribution on elevated calcite and dolomite saturation indices.

The conductivity values ranges from 150 - 370 mS/m (SA Drinking water). The large variation in EC is mainly attributed to lithologic composition and anthropogenic activities prevailing in this region. Normally, irrigation water with an EC of < 70 mS/m causes little or no threat to most crops while EC > 300 mS/m may limit their growth (Tijani, 1996).

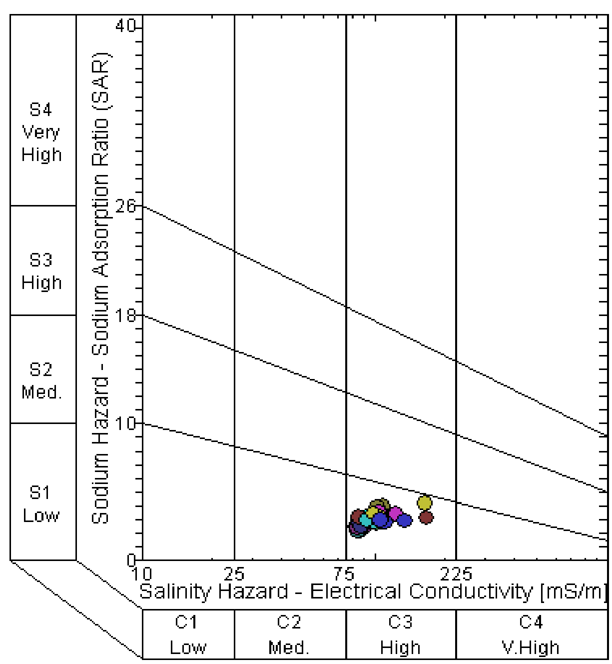

Figure 14 : Classification of Groundwater Based on Salinity and Alkalinity Hazard of Irrigation Requirements for Study Site 1.

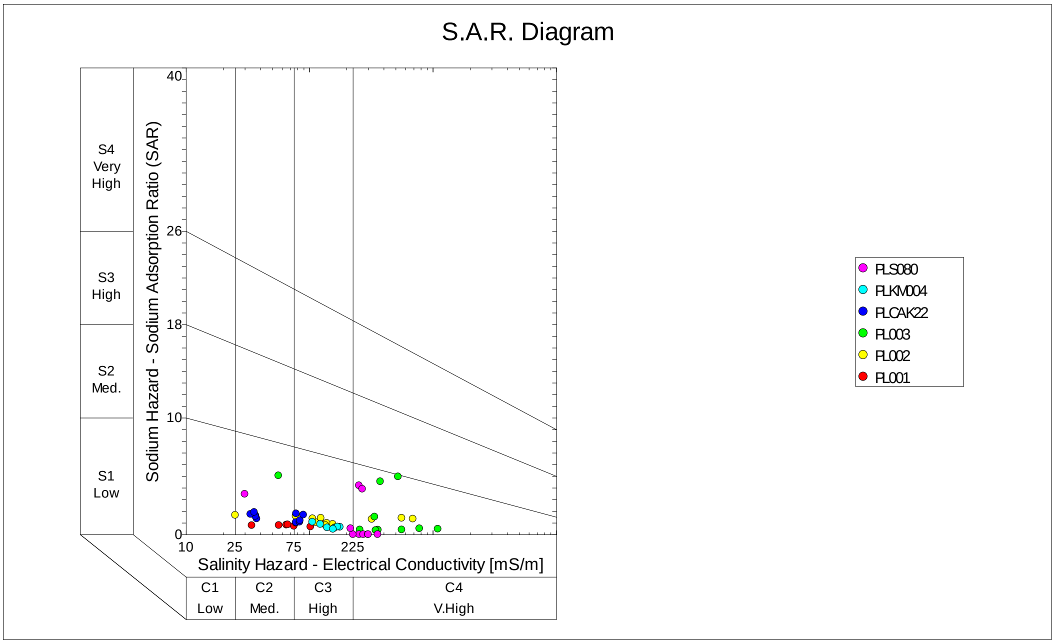

Figure 15 : Groundwater Classification for the Different Boreholes Sampled during the Wet and Dry Seasons in Pallisa District.

Based on the WISH classification for South African Drinking waters (2005) (for site 2) and the US Laboratory classification (modified after Richards, 1954) (see Figure 15) the salinity hazard for water samples in Pallisa District is low (2.2%), medium (21.7%), high (34.8%) and very high (41.3%). Most of the groundwater samples belong to high salinity hazard (C3) as per the salinity hazard classification in the study area. Nineteen samples fall in very high salinity (C4), sixteen samples fall in the high salinity hazard category (C3) while ten of the samples belong to the medium salinity hazard category (C2) and one in low salinity zone (C1).

Groundwater that falls in the low (C1) and medium salinity hazard class (C2) can be used in most cases without any special practices for salinity control. However, water samples that fall in the high salinity hazard class (C3) may have detrimental effects on sensitive crops and adverse effects on many plants. Such areas require careful management practices. Very high salinity water (C4) is not suitable for irrigation under ordinary conditions but may be used for salt tolerant plants on permeable soils with special management practices (Figure 16).

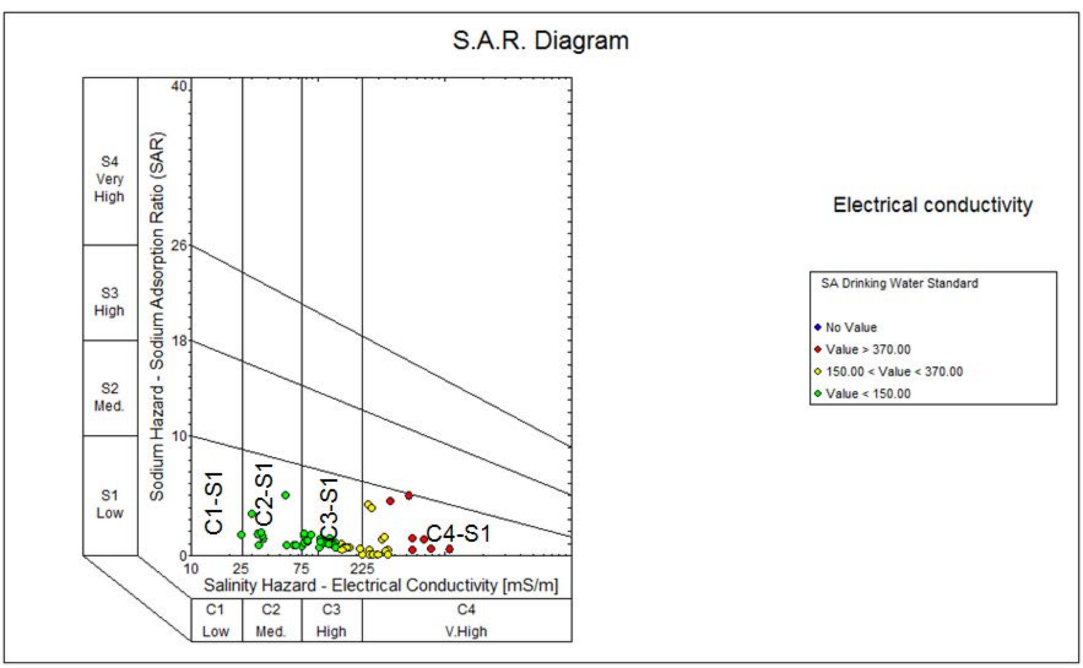

Figure 16 : Salinity Diagram for Classification of Irrigation Waters (after Lukas, 2003; Modified and Adapted from Richard, 1954; Wilcox, 1948 and 1995).

xiv. *Trace Elements*

Table 5 (for site 1) shows the maximum and minimum concentrations of trace elements analysed in the groundwater. The concentration levels of Fe^{2+} and Al^{3+} trace elements in the groundwater are all below the SANS (1996) target values. Manganese exceeded the water quality target value of (0.05 mg/l) in the groundwater samples and can be attributed to sources of manganese oxides in the sediments. In general, trace elements in groundwater are often dissolved in very small quantities, typically less than 1 mg/l (USGS 1993). The presence of Mn^{2+}, Fe^{2+} and Al^{3+} in low concentrations is due to the dissolution of natural tracer elements from the aquifer sediments under anaerobic conditions into the groundwater.

Table 5 : Maximum and Minimum Concentrations of Trace Elements Analysed in the Groundwater.

Ions	Minimum [mg/l]	Maximum [mg/l]	(SANS 1996) [mg/l]
Fe^{+2}	0.002	0.067	$\leq$ 0.1
Mn^{+2}	0.006	0.090	$\leq$ 0.05
Al^{+3}	0.008	0.049	$\leq$ 0.15

The hydrogeochemical investigation and analysis shows that there is no distinction between the groundwater chemistry of deep and shallow boreholes. The results of this investigation can be used to ascertain the existence of one aquifer system as had been observed during borehole drilling. During groundwater abstraction at the site, water comes from the high transmissivity gravel-sand deposits which are conceptually the main aquifer yielding layer. The groundwater samples from the seepage zone also exhibit similar hydrogeochemical trend to the rest of the groundwater samples collected from the boreholes. It is therefore evident that the shallow alluvial channel aquifer is losing groundwater into the river, thereby making the river a "gaining" one.

In addition, the discussion based on the study site 2 made it possible to collate available groundwater data and information in Pallisa District. This information has been used to assess the groundwater resources in the Kyoga basin. The boreholes within the interior of Pallisa District and the groundwater sampled from shallower depth are of a much better quality. No microbiological analyses were performed on the samples, but a H_2S test was used in the field and it gave an indication that some forms of bacteria are present. The shallow aquifer has modern age waters, and is rapidly recharged by precipitation that is prone to contamination by activities on the ground surface such as poor sanitation practices, overgrazing and farming practices including application of fertilizers. The source for this could be probably the extensive use of on-site sanitation systems (mostly the pit latrines) in many parts of the rural areas of Pallisa district. The investigation indicates that among major cations, Ca^{+} is generally dominant representing on average 64.11% of all the cations. The order of anions abundance is $HCO_3^- > Cl^- > SO_4^{2-}$.

Based on TDS, 46% of water samples are suitable for drinking purposes. Salinity diagrams reveal that except for the southern parts of study area; most of the groundwater samples are not suitable for irrigation purposes under normal condition. The salinity hazard for water wells is classified as medium, high and some show very high salinity. Alkali hazard also is classified from low hazard to very high. Therefore, salinity is the principal concern in irrigated agriculture in Pallisa area. The fluoride levels reflect the distribution of granite rather than the contamination sources. Geochemical data in Pallisa area indicates that the polluted sources degrade the groundwater quality along the downgrading zone.

VIII. Conclusion

The investigations of the hydrogeochemical processes in an alluvial channel and fractured granitic aquifers located in a typical Karoo basin of Southern Africa and eastern Uganda respectively were aimed at a comparative study in identifying and describing the groundwater evolution and its contribution to the overall groundwater quality. The XRF and XRD analyses were performed on representative geological samples to identify and quantify the major elements oxides and minerals in the sediments. The XRF and XRD analysis of geological samples shows that the channel deposits are dominated by SiO_2 element oxides and quartz minerals thus elevated concentrations of Si were found in the groundwater. Samples of groundwater were collected in July – October 2010, December 2010 - March 2011, May 2011, August 2011 and December 2011. The study utilized the conventional piper diagram, bivariate plots, WISH Program and PHREEQC hydrogeochemical model to analyze groundwater chemistry data. Detailed studies of the hydrogeochemical processes in the alluvial and granitic fractured aquifer systems have shown that dissolution of dolomite and calcite minerals, and ion exchanges are the dominant hydrogeochemical processes that controls the groundwater quality. The study shows the potential usefulness of simple bivariate plots as a complimentary tool to the conventional methods for analyzing groundwater hydrogeochemical processes.

The major conclusions obtained from the research conducted at the two study sites are:

- The groundwater evolution and quality of the alluvial channel aquifer is largely controlled by calcite and dolomite dissolutions, silicate weathering and ion exchange hydrogeochemical processes.

- The investigation revealed that the alluvial channel aquifer groundwater has evolved from Ca^{2+}-Mg^{2+}-HCO_3^- recharge waters that go through ion exchange with Na^+ in the clay-silt sediments to give a Na^+-HCO_3^- water type.
- Calcrete deposits are the source of Ca^{2+}, HCO_3^- and Mg^{2+} ions, while the clay-silt provides Na^+ cation exchange sites for Ca^{2+} which was detected in the sediments.
- The hydrogeochemical investigation and analysis shows no distinction between the groundwater chemistry of deep and shallow boreholes which implies the existence of one aquifer system.
- The groundwater chemistry of the alluvial channel aquifer and terrestrial aquifer is controlled by the interactions of recharging waters and minerals of the aquifer material, rather than by a chemical evolution of water along general directions of local groundwater flow and seasonal variations.
- The study shows the potential usefulness of simple bivariate plots as a complimentary tool to the conventional methods for identification and analyzing groundwater hydrogeochemical processes. The plots simplify analysis of the groundwater chemistry processes and should be used to complement conventional tools.
- The spatial variation in chemical, hydraulic and solute transport properties is attributed to aquifer heterogeneity which is largely depended on lithology and the formation processes.
- The boreholes plotting in the freshwater region have a Ca^{2+}/Mg^{2+}-HCO_3^- major ion composition. This is characteristic of freshly recharged groundwater that has equilibrated with CO_2 and soluble carbonate minerals under open system conditions in the soil zone and;
- The water from boreholes located in the area of recharge (boreholes located inland) is fresher than the ones located in the area of discharge (boreholes near Lake Kyoga).

IX. Acknowledgement

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Correlates of Urbanization and House Rent in Ilorin, Nigeria

By Ibrahim R. Babatunde, Adetona N. Adewale & Olawoyin O. Rachael
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Keywords: *correlates, urbanization, house rent, nigeria.*

GJSFR-H Classification : *FOR Code: 310103*

CORRELATESOFURBANIZATIONANDHOUSERENTINILORINNIGERIA

Strictly as per the compliance and regulations of :

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I. Introduction

Urbanization, which refers to the expansion in the proportion of a population living in urban areas, is one of the major social transformations sweeping the globe. Nigerian urban centres are perhaps the fastest growing cities in Africa (Onibokun 1987). The country has many large urban centres with too few well-planned cities and towns. There were at least 183 urban centres with population of 20,000 and above (NPC, 1953). The number of such cities rose to 210 by 1980 (NPC 1980), 235 by the 1990 (Aderamo 2010) and 250 by the year 2000 (NPC 1991). The percentage of people who live in urban centres of 20,000 and more increased from 11 percent in 1953 to 35 percent in 1991 while it rose to 45 percent in year 2002. In terms of shared population of people, while the population of the country increased from 30.4 Million to 81 Million between 1953 and 1991, the urban component in the same period increased from 3.2 Million to 32.2 Million. That is more than 10 folds within the 40 year period. (Aderamo,2010).

Unprecedented Urbanization has been a common feature of countries of developing world since the last century (Aderamo, 2010). This has been in form of rapid population growth and physical expansion of cities. Thus cities are no more able to provide the basic service especially housing to sustain their teeming population. While the situation in the cities are unsatisfactory in terms of housing requirement, the major problem of the rapid growth of urban centres in Nigeria is in the provision of basic facilities and services such as housing, water, electricity, transportation, sewage and drainage. When there is excessive pressure on urban service, the cities become inefficient, unworkable and unlivable (Aderamo, 2010). This study, however, seeks to examine the effect of urbanization on house rent in Ilorin Nigeria. It appraises the level of urbanization in Ilorin under historical periods of pre-colonial, colonial and post-colonial era.

II. Literature Review

Nigeria has a dense network of urban centres owing to a peculiar urbanization history - most of these cities having transformed in recent times, as a result of their political administrative reclassification. Many were recently designated as capital cities within the administrative structure of the country. Urbanization, a process of urban development, is marked by the relative increase in urban population as a proportion of the total. Its nature and consequences, which are well discussed in social discussions, are typified by large and increasing populations concentrated in the large cities. While Bish and Nourse (1975) for instance, see urbanization as the concentration of population and economic activities in large human agglomerations; Henderson (2002) sees it as an issue which in the last fifty years seems to have been accompanied by excessively high levels of concentration of urban population in very large cities.

Furthermore, Wikipedia (2009) opined that urbanization is characterized by physical transformation of the rural or natural landscape into urban land uses owing to massive population migration and stabilization of this population. In the developing world, urbanization - a demographic process, progresses at a rapid rate

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with regional and national patterns displaying peculiar characteristics; prominent among which are the absolute level – i.e. percentage of population living in cities as well as its relative speed of accumulation. In an earlier study, Akinbamijo (1996) submitted that the colluding forces of urbanization, modernization and economic development bring in spatial and dynamic problems that plague urban dwellers in Nigeria and third world cities. The trend generates a series of problems of which housing, basic sanitation and environmental pollution are paramount (Akinbamijo, 1996; 2004). Henderson (2002) opined that third world urbanization involves cities of unparalleled sizes, presenting major problems in health and quality of life, management and institution building and social cohesion among others. The process in the last 50 years is prominently demonstrated in the Asian megacities where the externalities of congestion and pollution, though relatively underpriced, include traffic accidents and health costs arising from high levels of air and water pollution as well as time that is lost to long commutes (Henderson, 2002).

In developing countries like Nigeria, urbanization parameters progress at a phenomenal rate without any articulated policy to stem its tide. The dynamics of the scenario in Nigeria is typified by the fact that while less than 15% of the total population lived in cities of 20,000 or more population by 1950, 25 years later - in 1975, this proportion increased to 23.4% and by 2000, the proportion had risen to 43.3%. The prognosis is that by 2015, more than half of the nation's population will live in urban centres (Mabogunje, 2007). In the strict sense, this will result from the interaction of demographic forces (external and internal) acting on given settlements, in response to the socio-economic, psychological and physical development demands. This pace is further implicated in the dynamics presented across some developing countries.

The Republic of Korea attained a 78% benchmark over a span of twenty years and Brazil attained same benchmark over a 30 year span, while the United States rose from 40% urbanization to the 70% benchmark over a span of 70 years (from 1900 to 1970). This has its untold implications as the societal learning required to adapt rural institutions to urban ones in the developing world became a crash course, leaving little or no room for adjustments (Henderson, 2002). Therefore, and in agreement with Owusu (2010), one can say that in many of these cities, pace of urban growth has far outpaced the capacity of metropolitan and municipal authorities to provide basic services that include adequate sanitation. This situation has been further compounded by weak local government structures and the lack of transparency and accountability in city governance.

Much as these urban concentrations are necessary for infrastructural and economic gains, the pace of growth is such that generates distortions in health and quality of life, social institution building, social cohesion, and urban governance. It also festers city management problems. Hence Okpala (1986) was forced to conclude that city administration hardly keeps pace with the scale and tempo of urbanization and its multifaceted implications in Nigeria. In this regard, health and other social services in existence are often neither equitably accessed nor distributed in manners that help those in greatest need; neither are they planned, designed or so implemented. The city growth dynamics has not allowed nor promoted societal learning required to adapt the emerging rural institutions and governance to urban one. Over time, population gains of urbanization have cumulated in various towns and urban spaces to drastically influence the population as manifestly seen in different forms of urban problems and maladjustments. Kreisel (1998) therefore cautioned on threats to human health that arise from the rapidly changing social and physical environments. These he says, have increased at unprecedented rates over the last couple of decades especially in the case of public health in the developing world.

III. Materials and Methods

The data used for the study were obtained from cross-sectional surveys. Secondary and primary sources of information gathered for the study were from secondary sources. Some of these data include population growth of Ilorin, number of industry and land consumption. The data from primary sources were obtained from random sampling of 150 household in the metropolitan area of Ilorin. The information on the trend of house rent for period of ten years (2003-2012) were obtained through structured questionnaire administered in the study area. Multiple regression analysis was used to examine relationship between urbanization and house rent.

IV. Study Area: Ilorin Metropolis

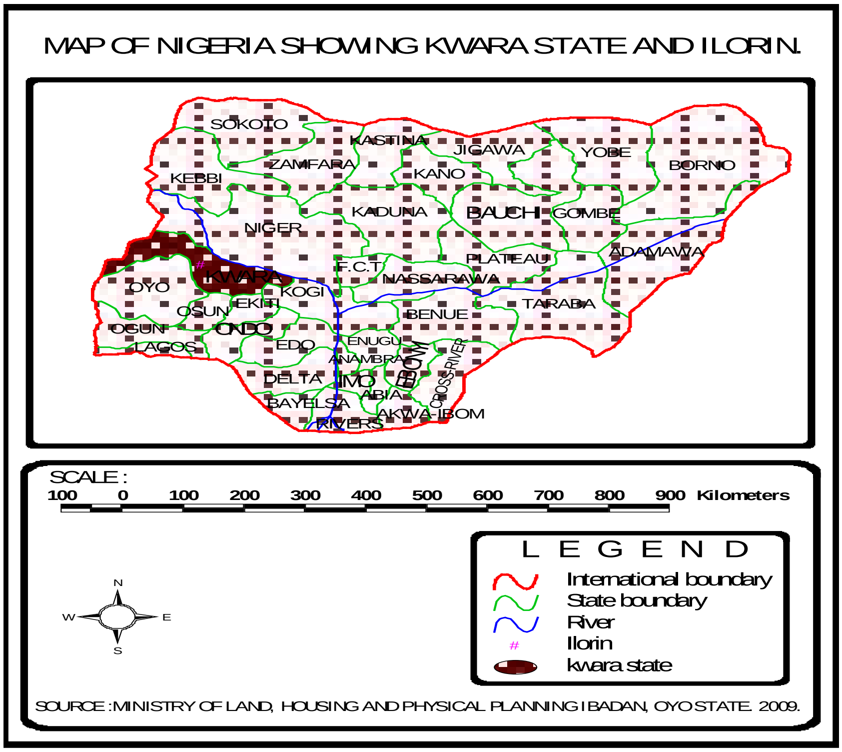

Figure 1 : Map of Nigeria Showing Kwarastate and Ilorin.

a) *Location*

The study area for this study is Ilorin Metropolis. It is the capital city of Kwara State, Nigeria. It lies approximately 8o7` North of the equator and 4o15` East of the Greenwich meridian. It also lies 306km Northeast of Lagos and 500km Southwest of Abuja. The population of Ilorin is 777,667 in which male constitute 296,821 and female is 386,886 (National Bureau of Statistics, Abuja, 2007).

V. Research Findings

a) *Urbanization of Ilorin: The Growth and Development*

Urbanization is a complex phenomenon. It is believed to be the major surrogate for growth and development characterized by population growth, industrial growth and pluralism of the population for the purpose of this study, the quantitative measurement of urbanization involved: the average rate of growth of the city over the period of 30 years (1991-2020). The average yearly additional land consumed in the city and pluralism of both the human and industrial population measuring the state of anomie and anonymity.

b) *Level of Urbanization in Ilorin*

The level of urbanization in Ilorin can be appraised under the following historical periods:

i. *Pre-colonial Period*

Ilorin was founded around 1600 to 1700 A. D. In 1911, the population of Ilorin was 36,000 and in 1921 it was 38,700, an increase of seven percent (7%) in ten years. In 1931, Ilorin had a population of 47,600 while in 1952 it was 41,000 (Evan krapf- Askari, 1969: Kwara state Government 1977). During this period there was relatively slow growth.

ii. *Colonial Period*

During the Colonial era, Ilorin was a provincial headquarters of Kabba province. The first estimate of the population of Ilorin after the establishment of the British colonial administration was made in 1911 and this put the population of Ilorin at 36,343. The 1953 census indicated the town's population to be 40,994. This period witnessed a relatively phenomenal growth.

iii. *Post-Colonial Period*

The most important factor that has influenced the urban development of Ilorin after the colonial period since 1960 is its selection as the capital of Kwara State when the latter was created in 1967. Thus the public administration has been one of the major functions of Ilorin since then; Ilorin experienced a relatively slow growth rate before it was made a state capital city in 1967. Ilorin is one of the fastest growing cities with highly heterogeneous population in Nigeria. Her population of 40, 994 in 1952/53 was found to have increased to 208,546 in 1963 (NPC, 1963) about 408 percent increase in 10years. By 1982 the population was estimated to have reached over 400,000 (Adedibu, 1989). The population figure according to the 1991 population census however puts it as 532,088. It has also been estimated to have reached 743,867 in 2000 (Ogunsanya and Aderamo, 1993). With a growth rate of 2.6%, however, the year 2003 figure was estimated to be 801,888 (Salawu, 2004). Moreover by the year 2020 the projected population of Ilorin will be about 3,518,771.

Table 1 : Population Growth of Ilorin 1931-2020.

Year	Total population	Rate of growth (%)
1931	100,592	1.4
1952	136,704	1.9
1963 1970 1980	208,546 254,094 324,937	2.5
1991	532,088	2.8
2006 *2010 *2015 *2020	2,365,353 2,682,963 3,059,149 3,518,771	3.2

*Sources: Census under colonial Administration 1930, Population census of Nigeria 1963, 1991, 2006, *Projected figure based on 1991 census at the rate of 2.6%.*

Table 1 shows that pace of urban growth is historically unprecedented with rates of growth typically increasing in late 19th century. For instance the 1991 National Census shows that Ilorin had a population of 532,088 while the 2006 census figures shows that the figure had increased to 864,755. Thus within 15 years the city's population had increased by 75% showing annual rate of 2.6% and it is believed that by year 2020 the population of Ilorin will reach 1,272,908.

c) Relationship between Urbanization and House Rent

For the purpose of this study, population figures of Ilorin were projected linearly for the period of ten years as shown in table 2. The trend of industrial development was also obtained as well as the land consumption rate for the period under study. All these were used as independent variable of urbanization. For the trend of house rent, as shown in table 3, rental fee was obtained for 1 Room, 1 Room self-contained, 2 Bed room, 3 Bed room and 4 bedrooms. This were summarized into a single variable of house rent and was used as dependent variable for the computation of multiple regression analysis, which explains relationship between urbanization and house rent in Ilorin metropolis.

All the data for the aboved mentioned variable were standardized using percentages before they were entered into the regression models.

Table 2 : Annual Growth Trend of Urbanization in Ilorin.

Year	Population	Percentage (%) of total Population	Number of Industry	Percentage (%) of total number of Industry	Land consumption	Percentage (%) of total Land consumption
2003	20187	8.80	9	5.96	0.0054	7.28
2004	20751	9.05	9	5.96	0.0056	7.55
2005	21333	9.30	12	7.95	0.0061	8.22
2006	21931	9.56	14	9.27	0.0067	9.03
2007	22554	9.84	14	9.27	0.0076	10.24
2008	23176	10.10	15	9.93	0.0079	10.65
2009	23824	10.40	17	11.26	0.0083	11.19
2010	24492	10.70	18	11.92	0.0086	11.59
2011	25177	10.97	20	13.24	0.0089	11.99
2012	25883	11.28	23	15.23	0.0091	12.26
Total	229,308	100	151	100	0.0742	100

Source: Author's Fieldwork, 2013.

Table 3 : Trend of House Rent 2003-2010 in Naira (Housing Characteristics).

Year	1 Room	(%) of total for 1 Room	1 Room self-contained	(%) of total for self-contained	2 Bed room	% of total for 2 bed room	3 bed room	% of total for 3 bedroom	4 bedroom	% of total for 4 bedroom
2003	200	2.48	10,000	2.85	2,4000	4.21	30,000	4.36	36,000	4.45
2004	200	2.48	15,000	4.28	28,000	4.91	36,000	5.24	40,000	4.95
2005	250	3.11	20,000	5.71	36,000	6.31	48,000	6.98	50,000	6.18
2006	500	6.21	25,000	7.14	40,000	7.00	55,000	8.00	60,000	7.42
2007	700	8.69	30,000	8.57	48,000	8.41	60,000	8.73	72,000	8.91
2008	800	9.93	40,000	11.42	60,000	10.50	64,000	9.31	85,000	10.51

2008	800	9.93	40,000	11.42	60,000	10.50	64,000	9.31	85,000	10.51
2009	900	11.18	45,000	12.85	65,000	11.38	84,000	12.22	95,000	11.75
2010	1,000	12.42	50,000	14.28	80,000	14.01	90,000	13.10	100,000	12.37
2011	1,500	18.63	55,000	15.71	90,000	15.76	100,000	14.55	120,000	14.85
2012	2,000	24.84	60,000	17.14	100,000	17.51	120,000	17.46	150,000	18.56
Total	8,050	100	35,0000	100	571,000	100	687,000	100	808,000	100

Source: Author's Fieldwork, 2013.

i. *Regression Analysis of the Effect of Urbanization on House Rent*

To determine the effect of urbanization on housing in Ilorin metropolis, the trend of house rent was regressed (Multiple Regression) on the three identified components/factors of urbanization (i.e. (i) annual growth rate; (ii) industrial growth; and (iii) Land Consumption. The results of Multiple Regression Analysis are shown in tables 4.1, 4.2 and 4.3 below:

Table 4.1 : Regression Model Summary.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.995[a]	.991	.986	.59519

a. Predictors: (Constant), Land consumption, Industrial growth trend, Annual Population growth trend

Table 4.2 : Test of Significance of Regression model.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	230.120	3	76.707	216.535	.000[a]
	Residual	2.125	6	.354		
	Total	232.245	9			

a. Predictors: (Constant), Land consumption, Industrial growth trend, Annual Population growth trend

b. Dependent Variable: Housing Characteristics

With F- value of 216.535 and P- value of 0.000 in table 4.2, it is observed that the relationship between urbanization and housing is significant. Moreover, with correlation coefficient (R) of 0.995 and coefficient of Multiple Determination (R^2) of 0.991, as shown in table 4.1, one observes that about 99% of variation in trend of house rent may be attributed to a magnitude increase in urbanization trend. In other words, close to 99% of the variability in observed trend of urbanization is explained by trend of house rent in the study area. The remaining 1% as observed here may be due to other factors that affect housing characteristics like socio-economic, quality of neighbourhood among others.

Table 4.3 : Regression Coefficients.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-50.604	14.567		-3.474	.013
	Annual Population growth trend	6.607	2.261	1.087	2.922	.027
	Industrial growth trend	.445	.408	.263	1.092	.317
	Land consumption	-.992	.592	-.362	-1.674	.145

a. Dependent Variable: Housing Characteristics

To determine the weight of each of the components/factors of urbanization, reference is made to their regression coefficients as shown in table 4.3. Using the standardized beta coefficients, the constant "a" would disappear and the regression equation is of the form:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3$$

Becomes:

$$Y \text{ (i.e. Trend of house rent)} = -0.362x_3 + 0.263x_2 + 1.087x_1$$

That is, the regression coefficients for factor 1, factor 2 and factor 3, as obtained from table 4.3 are 1.087, 0.263 and -0.362 respectively, which shows that factor 1 (Annual Population growth rate trend) is of more effect than factor 2 (industrial growth trend), while factor 3 (land consumption) is of less effect than the two above in explaining trend of house rent in the study area. And with P-values of 0.027, 0.317 and 0.145 for factor 1, factor 2, and factor 3 respectively. It is also observed that with probability of 0.027, only factor one (population growth trend) has a significant relationship with housing characteristics in terms of increase in trend of house rent in the study area.

Findings from multiple regression analysis as observed above shows that housing problem is prevalent in many of Nigerian urban centres. This is an enduring feature of urbanization process. As a result of urbanization, there is now tremendous pressure on housing so much so, that the gap between housing supply and demand in Nigeria continues to widen.

According to Megbolugbe (1983), the most outstanding of all urban problems, caused by the rapid expansion of urban population, is that of providing housing facilities for the teeming urban population in Nigeria.

VI. Conclusion and Recommendation

This study has shown that the rapid increase in population of Ilorin has contributed to the physical growth of the town in term of spatial expansion. Also, most visible and obvious consequence of urbanization in Ilorin is rapid deterioration of housing and living condition, high cost of rentage and this is traceable to the fact that urbanization leads to explosive population growth.

In order to arrest the drift from rural areas to urban centres government should place emphasis and a higher priority on the establishment of rural industries, the creation of other forms of employment and the provision of more adequate infrastructural and other services in the rural areas.

Also there should be integrated National programmes for spatial distribution of population and to this effect priority consideration should always be given to the preparation of National plan which will make provision for a more equitable system of distribution of development in all areas.

In addition, rural areas should be made attractive with incentives to site industries, provide conducive environment for the enjoyment of other basic necessities of life.

It is noteworthy at this juncture that all causes of rural-urban migration should be looked into by the government and see that they are resolved. If the situation could be abated and reversed it will remove some pressures on urban resources, therefore urban areas will be depopulated and the visible consequence of urbanization will be reduced.

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Analysis of Water Quality using Physical- Chemical Parameters: Case of watershed Sebkha Oran

By Boualla Nabila & Benziane Ahmed
University of Sciences and Technology U.S.T.O.MB, Algeria

Abstract- Oran is relatively a city with the worst quality of the water. Recently, the growing populations may put stress on natural waters by impairing the quality of the water.

Unfortunately, certain stretches of the watershed are polluted. It has scarce physicchemical data on its water resources that could assist in making robust decision in mitigating the impact of human societies on natural waters; which may not only preserve natural areas, but improve the quality of life of her growing population. In an attempt to study the environmental impact on water quality, an investigation was carried out to monitor the water quality over a period from 04 to 20 July 2011. So fifty samples were collected and analyzed. The water physico-chemistry prior was consistent with that of researches done previously in that area. The average value of different parameters are: pH 6.8, electric conductivity 6,06 (dS/m), chloride 1780 (mg/l), sodium 1811(mg/l), sulfate 631 (mg/l), nitrate 27 (mg/l), magnesium 177 (mg/l), calcium 321 (mg/l) and bicarbonate 327(mg/l).

Higher values of the physical-chemical parameters of water obtained in the present study sites indicate that the results obtained fell within the maximum allowable limit set by the World Health Organization for drinking water.

Keywords: *physical-chemical parameters, pollution, salinity.*

GJSFR-H Classification : *FOR Code: 869899p*

ANALYSISOFWATERQUALITYUSINGPHYSICALCHEMICALPARAMETERSCASEOFWTARESHEDSEBKHAORAN

Strictly as per the compliance and regulations of :

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I. Introduction

The increasing demand on water, either for the drinkable water supply, or for the agricultural and industrial custom, requires a very thorough hydro-chemical study to protect better and manage this resource.

Here, it is about the pouring watershed sebkha of Oran, a region characterized by a dry half climate where raises the problem of the salinity and an over-exploitation of subterranean waters.

During this work, we shall limit to give some geological information and hydro chemical of basis with interpretations which can be discussed. This incites us to begin other more thorough studies.

II. Materials and Methods

a) Geographical Situation

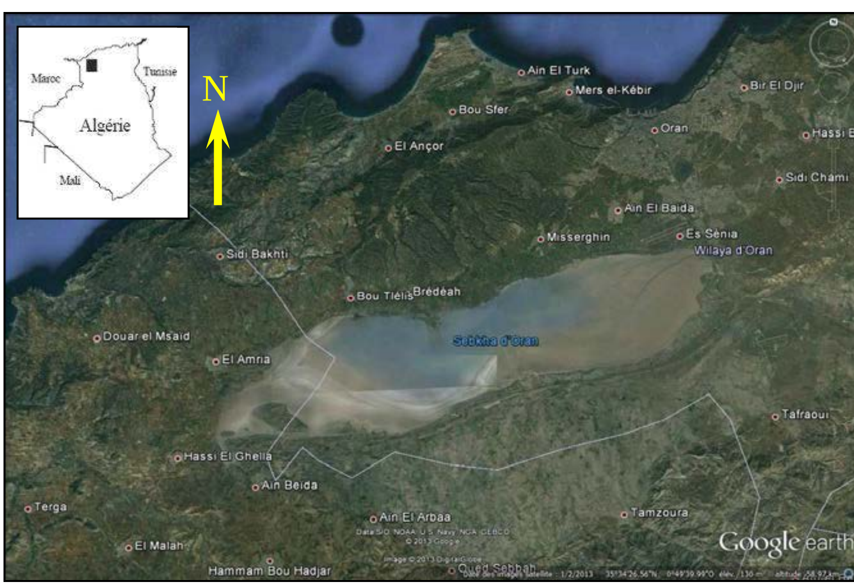

Figure 1 : Demarcation of the Study Zone. (Image Google Earth 2013).

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III. Water Sampling and Measurement of Physic-Chemical Parameters

The various physical-chemical parameters were determined through the techniques listed in the table 1.

Table 1 : Equipment and Methods.

Physic-chemical parameters	Equipment and methods
pH	pH-portable meter, HANNA instrument HI 9811
Electrical conductivity	
Cl^-	Volumetric
HCO_3^-	
Mg^{+2}	
Ca^{+2}	
Na^+	Spectro-photometry
SO_4^{2-}	Spectrometry
NO_3^-	

IV. Results

In the present approach, we made an estimation of some physical-chemical parameters of the treatment period and the possible risks of degradation of the quality of waters in the sebkha watershed of Oran (Table 2).

Table 2 : Chemical Composition Averages Waters in the Watershed of Sebkha of Oran.

	Unit	Average	Min.	Max.	Standard deviation	Median
pH		6,85	5,1	7,6	0,42	6,9
CE	(dS/m)	6,06	0,98	15,82	3,44	6,16
Cl^-	(mg/l)	1779,05	130,53	6480,2	1486,22	1625,51
SO_4^{-2}		630,47	406	1662	253,11	565,78
Na^+		1811,3	297	6853,7	1396,64	1468,14
Ca^{+2}		320,92	183,27	740	123,51	302,91
Mg^{+2}		176,97	98,94	405,14	69,1	166,69
HCO_3^-		327	152	954	139	313
NO_3^-		27,4	3	112	24,64	20

V. Discussion

The quality of waters of the region is moderately to enough charged. The values of the electric conductivity spread out of 980 in 15820µS / cm. It is important to indicate that this salinity evolves generally in the direction of the ground water flow. It is weak near the recharge areas and a high near the sebkha (Unesco, 1978).

Indeed during the period of low-water mark (period of taking of our sampling), the increase of the temperature favors the evaporation of waters of the surface and the evapotranspiration of subterranean waters, what is often translated by a progressive increase of the salinity of the solutions of the vadose zone (Benziane, 2012).

The most plentiful hydro-chemical facies are of sodium chloride to calcium sulfate type.

It shows the influence of the leaching of the salty grounds and that of the gypsiferous trainings.

Considering the various temporal and spatial values of the chemical elements, the contents, the evolution and the origin of the salinity, we judged with a global statistical analysis to release the big lines of the chemistry of the region.

a) *Analysis and Interpretation of Scatter Diagrams Representing the Various Relations between the Chemical Parameters*

Two dominant families of water are met in the studied watershed:

- Family of calcium sulfate waters;
- Family of sodium chloride waters.

To explain some existing relations between the chemical elements, certain graphs were represented.

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i. *Couple Cl^- / SO_4^{-2}*

Taking into account the dominance of the chloride and sulfate facies, it is important to verify the relation between these two elements.

The graph shows a dispersal of points indicating a proportional evolution both Elements thus having a common saliferous origin (Figure 3).

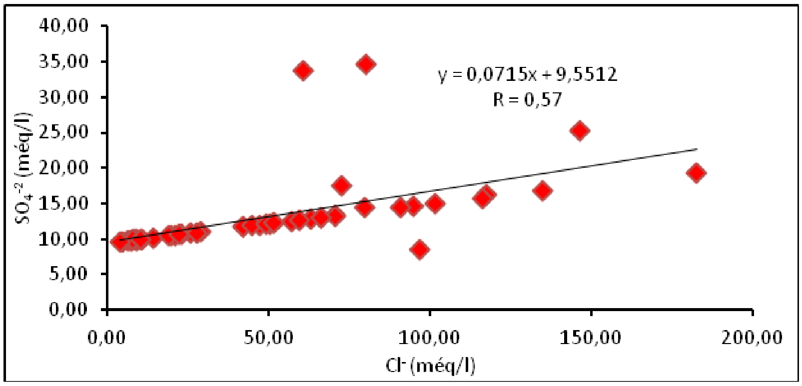

Figure 3 : Relation Cl^- - SO_4^{-2}

ii. *Cl^- / SO_4^{-2} / Conductivity*

The influence of these two elements on the electrical conductivity of the water was verified in the assistant of the graph (Figure 4). We note that the conductivity is influenced by the chlorides that by sulfates.

The representation schedules watch that 80 % of points present a report upper to 1, indicating a dominance of the chloride ions in relation to gypsum. A dominance of the chloride ions which is understandable by the leaching of gypsiferous-marl grounds, and that the origin of sulfates is especially due to an artificial pollution by fertilizers used in agriculture.

To indicate, that the plains of Boutlélis, Messerghine as well as M'léta present capacities in one intensive agriculture as prove studies of 1974 on capacities agropedological of the plain of M'léta.

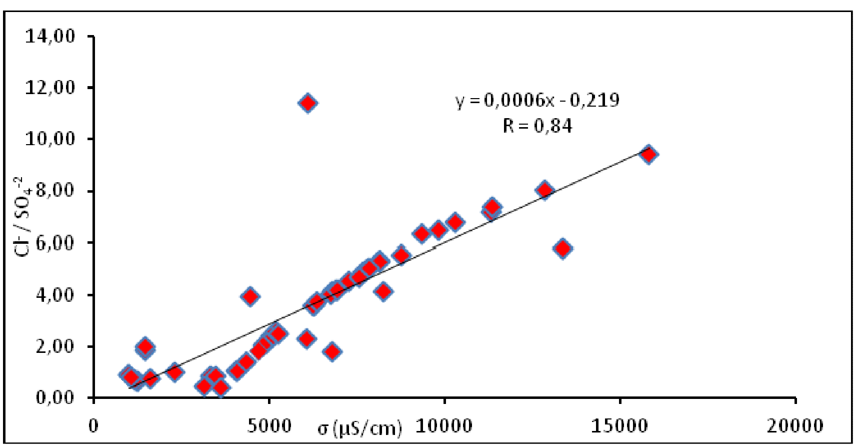

Figure 4 : Relation (Cl- / SO_4^{2-}) – Conductivité

iii. *Couple SO_4^{2-}/Mg^{2+}*

The examination of this relation shows a proportional evolution of sulfates and magnesium (Figure 5). This relation translates the dissolution of a sulfate of magnesium of saliferous origin.

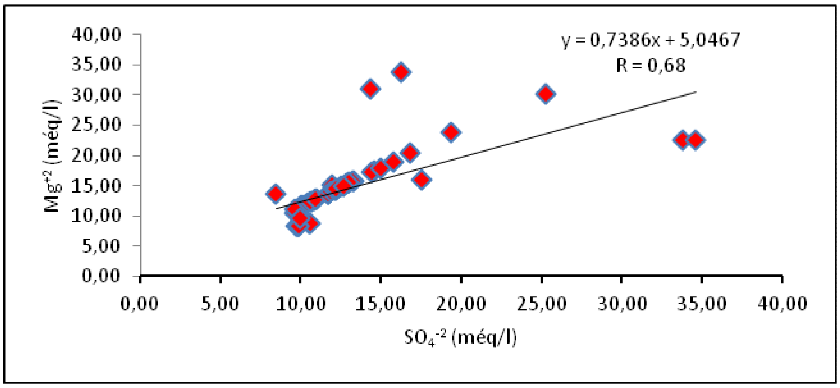

Figure 5 : Relation SO_4^{-2} - Mg^{+2}

iv. *Diagram Ca^{+2} / (HCO_3- + SO_4^{-2}) - Na^+ / Cl^-*

The studies of ionic exchange in geological formations revealed, that generally, during the process of exchange, one of the ions is very strongly retained against any movement of the other ones. It is a preferential adsorption known by selectivity of ionic exchange (Assa, 1976).

The carrying over of all the water points on the diagram (Figure 6) shows that 84 % of these points have sudden a basic exchange, 10 % present a deficit in Na+ and in Ca^{+2}, and 6 % present an excess in Ca^{+2} compared with the ions HCO_3- and SO_4^{-2}. The excess in Na^+ which comes along by a deficit in Ca^{+2} show the responsibility of the basic exchange in the increase of the contents in Na^+.

A: Excess in Ca^{+2}, b: Deficit in Na^+ and Ca^{+2}, c: Deficit in Cl^- and in Ca^{+2}: basic exchange.

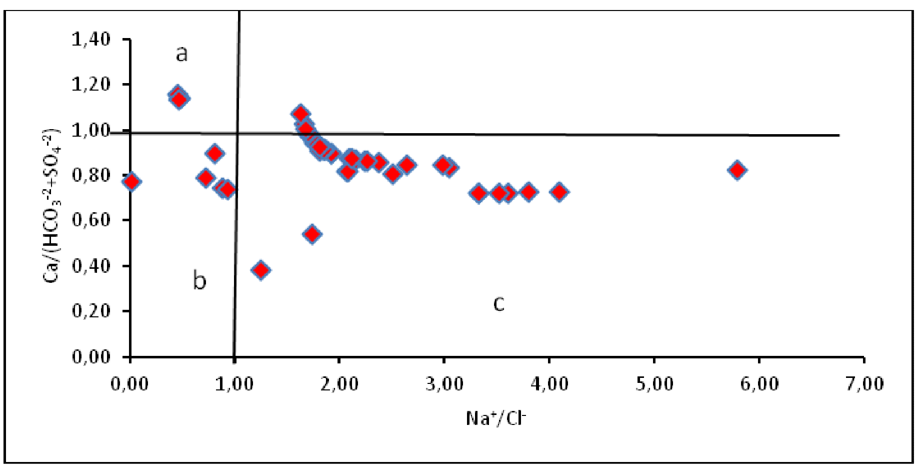

Figure 5 : Basic Exchange

During their subterranean routes, waters come into contact with various formations geological that have the property to exchange their ions for those contained in the waters.

v. *Origin of the Calcium*

The figure 6 shows the evolution of the calcium according to bicarbonates. The points positioning on the right of slope 1 indicate the origin carbonated of the calcium ions.

However, the other points show an excess of the calcium further to the dissolution of the gypsum.

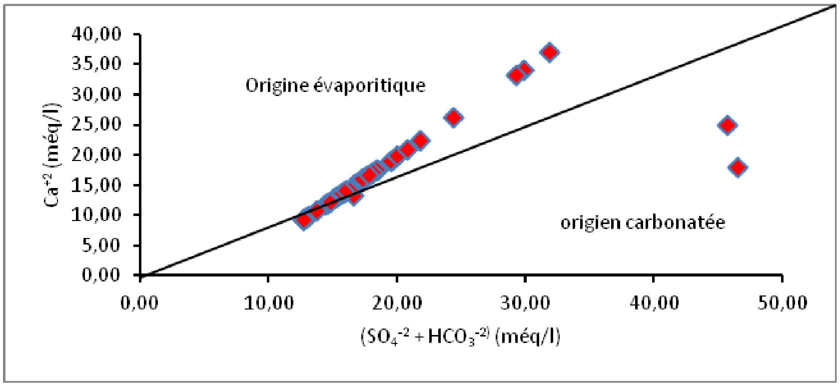

Figure 6 : Evolution of the Calcium.

b) Treatment Statistics of the Data (Principal Components Analysis (P.C.A)

A statistical study in principal components analysis (P.C.A) is made on the matrix of data formed by 9 variables (pH, Conductivity, Ca^{2+}, Mg^{2+}, Na^{2+}, HCO_3^-, SO_4^{2-}, Cl^-, NO_3^-) and 50 observations.

The interpretation of the analysis will be made according to the information order given by the software (SPSS V17) (Table 3).

This analysis was pushed up to 3 factors and 99, 65 % of the variance was able to be expressed. Only the first two axes are considered in the description of the correlations between variables.

Table 3 : Correlation between Chemical Elements

Correlation	pH	Conduc	Cl^-	SO_4^{2-}	Na^{2+}	Ca^{2+}	Mg^{2+}	HCO_3^-	NO_3^-
pH	1,000								
Conduc	-,475	1,000							
Cl^-	-,338	**,942**	1,000						
SO_4^{2-}	-,094	**,504**	**,568**	1,000					
Na^{2+}	-,348	**,832**	**,832**	**,443**	1,000				
Ca^{2+}	-,395	**,829**	**,820**	**,599**	**,497**	1,000			
Mg^{2+}	-,372	**,815**	**,812**	**,677**	**,480**	**,984**	1,000		
HCO_3^-	-,193	**,464**	**,466**	**,657**	,182	**,680**	**,728**	1,000	
NO_3^-	,254	-,271	-,178	,268	-,169	-,179	-,090	,012	1,000

The analysis of the factorial plan 1-2 shows that more than 59 % of the total variance is expressed. The analysis in this plan is thus acceptable (Athamena, 2006) (Table 4).

Table 4 : Total Variance Explained.

Component	Total	% of Variance	Cumulative %
1	1,529E7	94,980	94,980
2	543511,891	3,377	98,357
3	208036,263	1,293	99,650

i. *A Significant Positive Correlation was Observed between*

Cl^--Conduc, Na^+-Conduc, Ca^{+2}-Conduc, Mg^{+2}-Condcu, Mg^{+2}- Cl^-, Na^+- Cl^-, Ca^{+2}- Cl^-, Mg^{+2}- Ca^{+2}, HCO_3^-- Mg^{+2}.

ii. *A Moderately Significant Positive Correlation was Observed between*

SO_4-Conduc, Cl^-- HCO_3^-, SO_4^{-2}- Cl^-, Na^+- SO_4^{-2}, and Ca^{+2}- SO_4^{-2}.

These connections testify of the salty influence on the chemistry water of the region.

The results allow making a first typological approach of the various variables according to their affinities and their groupings on the first two principal components analysis from their contribution.

The factor 1 represents 97,980% of the variance and it is determined by the chemical elements: the conductivity, Cl^-, Ca^{2+}, Mg^{2+}, Na^+, $HCO_3^-$and SO_4^{2-}. This allows us to consider the factor F1 as factor of mineralization. Associated with evaporates (Ca SO_4, Ca SO_4 $2H_2O$, Mg SO_4, Ca Cl, and Mg Cl) (Figure 7).

The factor 2 represents 3,377 % of the variance is strongly determined by bicarbonates HCO_3^- and Ca^{2+}. It is thus the factor of deep waters of origin (Table 4 and Figure 7).

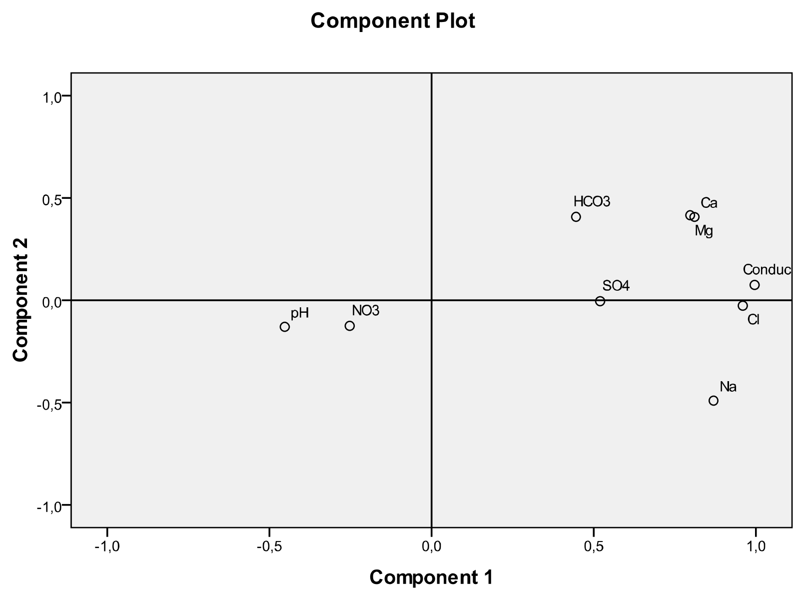

Figure 7 : Projection of Variables on the Factorial Plan 1-2.

VI. Conclusion

In this first approach of the study of the groundwater inside the studied zone, the quality of the groundwater, in this zone seems to be distorted by sources of superficial pollution. The diversity of the results obtained in the various station makes however difficult the formulation of a quality diagnosis of the valid water for the whole studied sector.

Generally, the analysis of physical-chemical data allowed deducting that in wells protected are placed far from the sources of pollution. The evolution of the chemical elements (Na^+, Cl^-, Ca^{+2}, $SO_4{}^{-2}$, HCO_3^-), who characterize the main geological formations of the watershed, showed the dominance of the saliferous ions (Na^+, Cl^-) and gypsiferous ions (Ca^{+2}, SO_4^{-2}) compared to carbonated (Ca^{+2}, HCO_3^-).

The studied parameters displace these subterranean waters of the usable water to drink.

This shapes well the state envisaged during our period of sampling. The drinkable water supply was satisfied with the water of desalination. Subterranean waters and of surface serves only for the irrigation and the breeding.

This balance assessment also highlighted the phenomenon of basic exchange between the waters of the tablecloth and the clayey passages, the latter was revealed by the increase of the contents in Na^+ with regard to Cl^-.

The feasibility of the basic exchanges of Na+ - Ca^{+2} or Na^+ - Mg^{+2}, for a low percentage of clay in the carbonated rocks could end in considerable changes of the concentrations in Na^+, Ca^{+2} and Mg^{+2} in waters salted by basic exchange. Furthermore, it is in connection with the pluviometrical regime, in the intense evaporation, in the pumping, in the irrigation and in the intensive and extensive use of fertilizers.

The causes of pollution of infested water are mainly due to raw waste water circulating in the small canals used to evacuate the waste water or for the irrigation, which infiltrates up to the groundwater. The second cause of pollution would result probably from fertilizer and sometimes from the flow of manure of sheepfolds and from cowsheds.

Fertilizers are leaching from the water which pulls towards the tablecloth bacteria and other soluble substances.

A supervision of the quality of the water of the tablecloth seems obviously desirable, but a more complete analysis of the mechanisms of contamination of the groundwater could be envisaged only by widening the number of samples and the frequency of the takings, as well as the number of moderate parameters (Sullivan, on 1982).

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Calibration of Waterloss Impacts on Water Distribution and Accessibility in Akure, Nigeria

By Olotu Yahaya, Alimi L. O, Rodiya. A. A & Omotayo F. S
Auchi Polytechnic, Nigeria

Abstract- Safe drinking water is a necessity for life. Providing quality drinking water is a critical service that generates revenues for water utilities to sustain their operations. Population growth put an additional strain on the limited resources. The annual volume of water lost is an important indicator of water distribution efficiency, both in individual years, and as a trend over a period of years. Application of deterministic simulation model on public water supply variables reveals the volume of non-revenue water (NRW) and its cost effects have further created a complex system for the availability, distribution and affordability of the utility. Gradual annual increase in public water supply (AWS) from $9.0 *10^6 m^3$ to $14.4 * 10^6 m^3$ had negative effect on annual water accessed(AWA) with $R^2 = 0.096$; and highly significant with annual water loss (AWL) with $R^2 = 0.99$. This development indicates that water loss mainly through leakages and bursts is a function of public water supply. Hence, estimated volume and cost annual revenue water (NRW) in Akure is 6 million m3 and 15.6 million USD respectively. Critical analysis shows that the lost annual revenue could be used to provide education and health services for a period of 6-month in the region.

Keywords: *water, NRW, simulation, distribution, resources, public, cost.*

GJSFR-H Classification : *FOR Code: 969999p*

CALIBRATIONOFWATERLOSSIMPACTSONWATERDISTRIBUTIONANDACCESSIBILITYINAKURENIGERIA

Strictly as per the compliance and regulations of :

Calibration of Waterloss Impacts on Water Distribution and Accessibility in Akure, Nigeria

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Abstract- Safe drinking water is a necessity for life. Providing quality drinking water is a critical service that generates revenues for water utilities to sustain their operations. Population growth put an additional strain on the limited resources. The annual volume of water lost is an important indicator of water distribution efficiency, both in individual years, and as a trend over a period of years. Application of deterministic simulation model on public water supply variables reveals the volume of non-revenue water (NRW) and its cost effects have further created a complex system for the availability, distribution and affordability of the utility. Gradual annual increase in public water supply (AWS) from $9.0 * 10^6 m^3$ to $14.4 * 10^6 m^3$ had negative effect on annual water accessed(AWA) with $R^2 = 0.096$; and highly significant with annual water loss (AWL) with $R^2 = 0.99$. This development indicates that water loss mainly through leakages and bursts is a function of public water supply. Hence, estimated volume and cost annual revenue water (NRW) in Akure is 6 million m^3 and 15.6 million USD respectively. Critical analysis shows that the lost annual revenue could be used to provide education and health services for a period of 6-month in the region.

Keywords: water, NRW, simulation, distribution, resources, public, cost.

I. Introduction

The accessibility and even distribution of potable water is a serious global issue. Safe drinking water is limited, the population growth, industrial and social advancement have further complicated the already scarce utility through overstressing the provision of potable water and infrastructural mechanisms for water distribution such as reticulation pipeline networking system, reservoir construction, fitting of flowmeter e.t.c. Ensuring safe, adequate and affordable water supply is becoming an ever more pressing issue for government, water professionals and researcher across the globe. More than 75% of the drinking water infrastructure in Edo North has been in service for decades without replacing with integrated and efficient system this leads to significant source of water loss through leaks, cracks, expiration and damage (Idogho et al., 2013).

Gathering, converting and distribution of safe drinking water is a serious challenge in Nigeria and some other developing nations, these constraints occurred as water loss due to leakages in conveyance pipeline, wastages, theft, improper billing and metering systems (May,1994). The annual volume of water lost is an important indicator of water distribution efficiency, both in individual years, and as a trend over a period of years. High and increasing water losses are an indicator of ineffective planning and construction, and of low operational maintenance activities (Lambert, 1999). Water loss from a utility's distribution system is a serious constrain which is always associated with loss of revenue and production efforts. Water losses in the distribution system require more water to be treated, which requires additional energy and chemical usage, resulting in wasted resources and total loss of revenues (Mckenzie, 2001). Determining how much water is being lost and where losses are occurring in a distribution system can be a difficult task. Without consistent and accurate measurement, water losses cannot be reliably and consistently managed (Benser and Camper, 2011).

The confusion over inconsistent terms and calculations has led to the development of better tools and methods to track water losses from distribution systems. This scenario has an increasing effect on socio-economic development of entire region of Akure and its environs. Having considered the huge budgetary allocation for publication water supply and distribution, it is important to device technically-based approaches of reducing water loss through physical or real and apparent water losses and also improves water quality at the end-point or delivery stage. Water loss reduction (WLR) often represents an efficient alternative to exploiting new resources, which frequently involves cost-intensive measures, such as new dams, deep wells, seawater desalination or even transferring water from one river basin to another. Therefore, water loss reduction and pressure management contribute to sustainable and integrated water resources management (IWRM). However, this research study is focused on the estimation and analysis of the effects of water losses on public water supply and distribution (PWSD) in relation to social-economic development and integration in Akure, Nigeria.

II. Materials and Methods

a) Study Area

Akure is made up of 18 districts and located in the South-western Zone of Nigeria. Akure lies between

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longitudes 4”30” and 6” East of the Greenwich Meridian, 5” 45” and 8” 15” North of the Equator. This means that the city lies entirely in the tropics. It is bounded North by Ilara Mokin; in the East by Obanle; in the West by Ondo and Oda in the South. Population: 763,000 comprising Male (56%) and Female (46%). The map of the city is shown in Fig. 1.

Fig. 1 : Map of Akure (Source: Google, 2013).

b) Water Loss Modelling

Many drinking water utilities around the world do not give instantaneous respond to leaks problems until the situation becomes complicated. Leaks can effectively be corrected using sensitive optimization modelling approaches which involves monitoring of real-time leaks problem, computerization of adequate pressure system, provision for eddy losses to prevent pipe burst (Fanner,2009). However, soil conditions for example can have a great effect on the real losses as well as to the ability for them to be identified and located at the ground surface. Apparent and physical losses are computed as follows:

$$\mathrm{WL}\epsilon = \mathrm{NRW}\tau - \mathrm{KWS}\beta \quad (1)$$

Where NWRι is total Non- Revenue Water; **WLρ** is real Water Loss; and **WL** is apparent Water Loss (Idogho et al., 2013).

i. *Unavoidable Real Losses (Url)*

Output of various studies conducted shown that it is impossible to eliminate real losses from a water distribution system. Therefore Unavoidable Real Losses is therefore computed as follows:

$$\boldsymbol{URL = 18 \times Lm + Nc + 25 + Lp \times P} \quad (2)$$

Where; Lm = main length in Km;
Nc = number of service connections;
Lp = total length in Km; and
P = average pumping pressure.

Leak volume is the function of time (t) and flowrate (R); this development is therefore evaluated as:

$$\boldsymbol{Lv = t(W + L + P) * R} \quad (3)$$

The expression in equation (3) is modified to produce sensitive leak volume value as:

$$\boldsymbol{Lv = t\mu(W + L + P) * R} \quad (4)$$

Where;
Lv = Leak volume (m3);
t = Time (sec);
μ = Flow constant (0.88);
W = Awareness;
L = Location; and
P = Repairs.

c) Water Supply and Demand Formation

Water resources involve simulating systems made up of many component parts that are interrelated. The hydrological system is driven by stochastic variables (i.e., precipitation, evaporation, demand) and involves uncertain processes, parameters, and events. The challenge when evaluating water supply and resource systems is to find an approach that can incorporate all the knowledge available to planners and management into a quantitative framework that can be used to simulate and predict the outcome of alternative approaches and policies (Butler, 2009). While developing a system, the starting point can also be some specific consumption that does not necessarily include leakage. In that case the leakage percentage has to be added in the following way:

$$\mathbf{Qph} = \frac{Qav.day}{f}\left(k1k2 + \frac{1}{100-l}\right) \quad (5)$$

Factor, f, in the equation is a unit conversion factor while l represents the leakage percentage of the total quantity supplied to the system; is the quantity of water demand at the peak hour, while, Qav. day is the average quantity of water demanded daily. Therefore, annual average water supply is computed using the relationship on equation (5):

$$\boldsymbol{AWS = cPiAvNd} \quad (6)$$

Where C = Coefficient of target population;
Pi = Total population;
Av = Average total water volume;
Nd = Number of water supplied days.

The volume of annual water supply that could finally be assessed by the targeted population is evaluated using the interconnectivity between annual water supply *(AWS)* and annual water loss *(AWL)* as related in equation (6):

$$\boldsymbol{AWA = AWS - AWL} \quad (7)$$

Where;
AWA = Annual water assed (m^3).

d) Water Cost Index Computation

It is very important and useful to calibrate the water supply-cost benefit ratio in order to monitor and improve on the service delivery of the utility (Idogho et al., 2013). The Rickards Real Cost Water Index serves as a benchmark for helping measure hundreds of critical projects on a like-for-like basis (Bond and Richard, 1997). Index values reflect estimated water production costs measured in US dollars per cubic meter for a variety of major global water infrastructure projects ranging from retail water utilities to wholesale water utilities. However, Water Cost index is calculated using Richard's relationship as follows:

$$\mathrm{WCI} = \frac{\mathrm{Tp}}{\mathrm{Td}} \quad (8)$$

Where;

Tp = Total cost of production is calculated as the sum of operating costs, capital costs, and identified subsidies;

Td =Total delivered freshwater volume (in m^3) is the amount the producer reports as delivered, and excludes water lost either due to system leakage, pilfering, or other forms of loss. This penalizes producers with a large fraction of production volume being lost due to system inefficiency;

WCI = Water Cost Index

e) Data Analysis

Data on waterloss variables were generated using a set of modelled relationships from the measured data. The generated outputs were subjected to statistical and dynamic simulation processes. Excel software and Sigma Plot were used for spread sheet calculations and graphical representations.

Plate 1 : Leakage from the Burst Pipeline

III. Results and Discussion

a) Calibration of Water Supply; Loss and Accessible Variables

Many drinking water utilities around in Akure, Nigeria respond to leaks development only after receiving report of water erupting from a street or a complaint from a customer about a damp basement. Leakage control requires a proactive leakage management program that includes a means to identify hidden leaks, optimize repair functions, manage excessive water pressure levels, and upgrade piping infrastructure before its useful life ends. The result in Table. 1 shows the Public water supply system in Akure for a period of 10-year (2003-2012). The volume of annual water loss and accessed was simulated using the public water supply data obtained from the Ondo State Water Corporation. The result in Table 1 indicated that there is an increase in volume of water supply from year 2003 down to 2012. The output of simulation iteration shown that the increase in annual water supply (AWS) had negative effect on annual volume of water accessible (AWA) with R^2=0.096; and strong agreement exist between annual water supply (AWA) and annual water loss with the R^2=0.999 as shown in Fig. 1 and 2 respectively. In 2007, equilibrium exists among the public water supply variables; with the annual water supply (AWS) of value $10.8 *10^6 m^3$; annual water loss (AWL) is $5.4 *10^6 m^3$ and annual water accessed (AWA) is $5.4 *10^6 m^3$ respectively. The implication of this development is that half of annual water supply is lost to leaks.

Table 1 : Public Water Supply and Loss.

N/S	Year	AWS (m^3*10^6)	AWL (m^3*10^6)	AWA (m^3*10^6)
1	2003	9.0	3.2	5.9
2	2004	9.6	3.8	5.8
3	2005	10.0	4.5	5.5
4	2006	10.3	4.8	5.5
5	2007	10.8	5.4	5.4
6	2008	11.0	5.7	5.3
7	2009	11.3	6.1	5,2
8	2010	11.8	6.7	5.1
9	2011	12.1	7.1	4.9
10	2012	14.4	8.6	5.8

Source: (OSWC, 2013; Simulation output).

Note: AWS = Annual water supply (m^3): AWL = Annual water loss (m^3)
AWA = Annual water accessible (m^3)

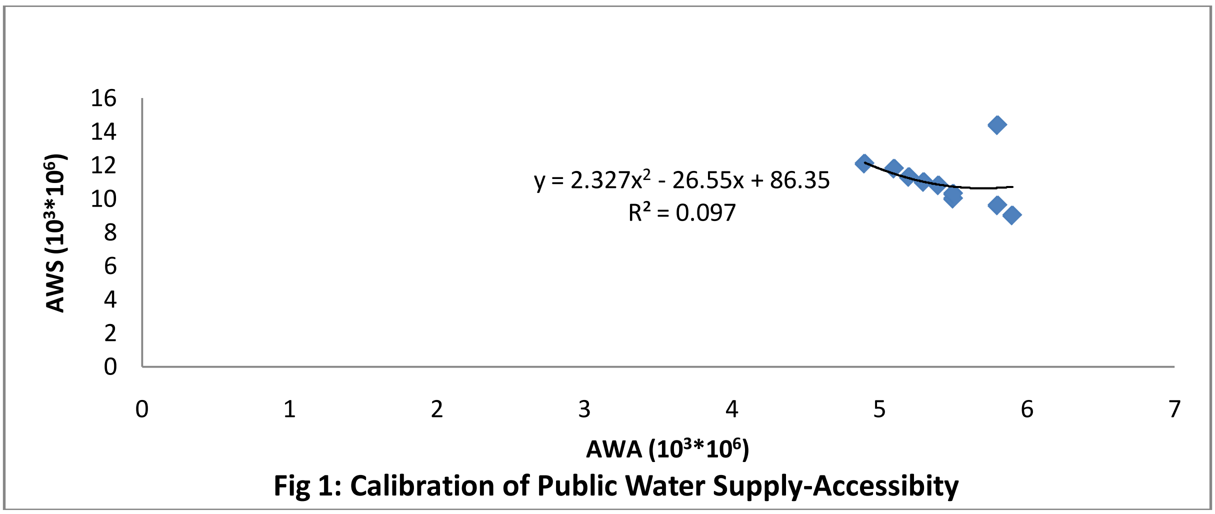

Figure 1 : Calibration of Public Water Supply-Accessibity

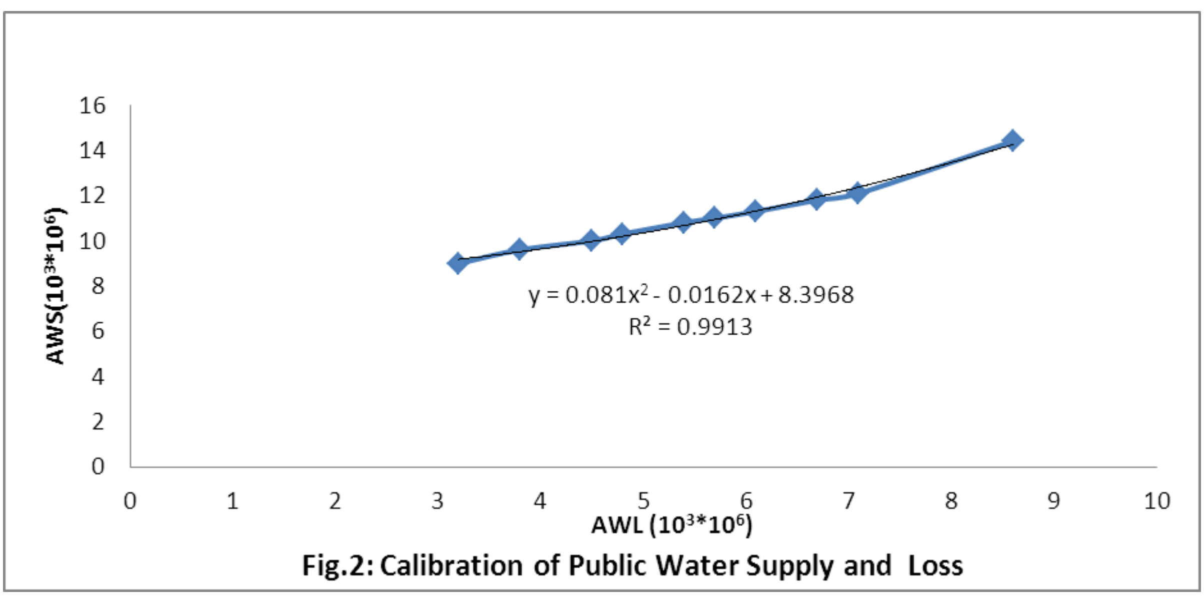

Figure 2 : Calibration of Public Water Supply and Loss

Most drinking water infrastructure in Akure, Nigeria has been in service for many years and this could be a significant source of water loss through leaks. The pipelines got weak and usually burst if there is any pressure variation. Since pipelines were not properly marked, a lot of them could also be destroyed during road and construction of other infrastructure amenities. This type of water loss is referred to as Real/Physical loss. In addition to leaks, water could be "lost" through unauthorized consumption (theft), administrative errors, data handling errors, and metering inaccuracies or failure; and this is referred to as Apparent loss. Based on the output of simulation RUNS, multiple modelling of optimized public water supply accessibility function was formulated as follows:

$$Y = \mu_0 + \alpha 1(AVjan.) + \alpha 2(AVfeb.) + \alpha 3(AVmar.) + \alpha 1(AVapril.) + \cdots \dots \dots \dots . + \alpha 12(AVdec.) + \alpha 13(Ndjan.) + \alpha 14(Ndfeb.) + \cdots \dots \dots \alpha 24(Nddec) + \alpha 25(Pijan.) + \alpha 26(Pifeb.) + \cdots \alpha 36(Pidec.) + \alpha 37(C) + \alpha 37(LeakP) + \alpha 38\,(BurstP) + \alpha 39(PresureS) + \alpha 40(PipelineP).$$

Where;

Y = Public water supply accessibility;

Av = Average volume of water supply (m3);

Nd = Number of days for water supply;

LeakP = Leakage from the pipe conveying water;

BurstP = Burst of pipeline;

PressureP = Pressure in the pipe;

C = Coefficient of the target population.

b) Water Cost Benefit Estimates

It is important to establish sound relationship on water production cost, cost of water loss or Non-Revenue Water in order to monitor the degree of utility distribution and its impact on the end-user for possible optimization for better service delivery. Evaluation of water production varies from geographical location to another; and also depends on the hydrological formation of the region. The results in Table. 2 show the cost of water production; water loss and billed water (i.e water that finally reached the consumers). The true cost of water production in individual geographic areas, which includes operating, capital, and "hidden economic" costs. Highest cost of annual water loss of 30.1 million USD was estimated in 2012 compared 4.8 million USD in 2003. However, there was a progressive increase in the investment of water production from 13.5 million USD in 2003 to 50.4 million USD in 2012. Strong relationship exist between cost of annual supply of water (CAWS) and cost of annual water loss (CAWL) with R^2=0.931.

Table 2 : Water Production Cost and Loss Index.

N/S	Year	CAWS (Million$)	C AWL (Million $)	CAWA (Million $)	WLI
1	2003	13.5	4.8	8.7	0.35
2	2004	19.2	7.8	11.4	0.40
3	2005	22.0	9.9	12.1	0.45
4	2006	24.7	10.8	13.9	0.43
5	2007	28.1	14.0	14.0	0.50
6	2008	30.8	16.0	14.8	0.51
7	2009	33.9	18.3	14.4	0.53
8	2010	37.8	21.4	16.4	0.56
9	2011	41.1	22.7	18.4	0.55
10	2012	50.4	30.1	19.9	0.59

Source: (OSWC, 2013; Simulation output)

Note: CAWS = Cost of annual water supply ($): CAWL = Cost annual water accessible ($):
CAWS = Cost of annual water loss ($): WLI: Water loss index

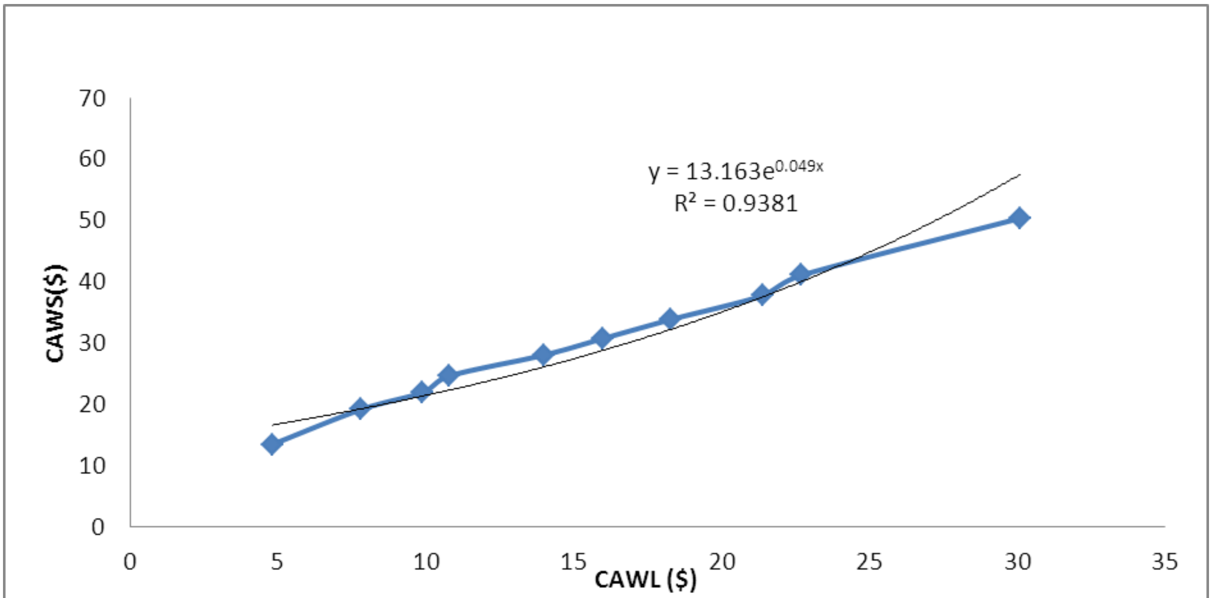

Figure 3 : Cost Benefit of Public Water Supply- Loss

Akure is estimated to have an annual Non-Revenue Water (NRW) (i.e mostly from real loss) volume of 6 million m3. This represents approximately 15.6 million USD in revenue that water utilities lose every year.

IV. Conclusion

Ensuring safe, sufficient and affordable water supply is becoming an ever more pressing issue for politicians and water professionals. This development has become a serious problem in most of the developing countries. Effective public water supply system is a productive function of many related variables such as non-revenue water (NRW). Annual water loss mainly through physical processes is estimated to revenue loss of 15.6 million USD. This value of fund could be applied for 30% budgetary allocation for Education and Agricultural section for the city. In addition, 60,623 people could be provided with potable water at the rate of 75 litres per person per day annually. Integrated water auditing model (IWAM) is a pivotal step in calibrating an effective water loss management program. Constructive application of the formulated model coupled with the introduction of automated metering device, burst and leak detector will produce a quantified understanding of the integrity of the distribution system and address sound plan to resolve water losses.

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Forest Land use and Cover Change in Ho Municipality of the Volta Region, Ghana

By Selase Kofi Adanu, Emma Archer Van Garderen, Jennifer Lalley, Sesime Kofi Adanu & Dziwornu Kwami Adanu

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Abstract- Forests comprise an essential life support of the rural people of Ghana. This is particularly the case in the Ho Municipality area, as far as the provision of fertile land for food crop production, timber for housing, medicine, and creating suitable micro climates conducive for rainfall are concerned. Small scale industrial activities, trading and the services sector have recently expanded the scope of employment option in the Ho Municipality. The agricultural sector continues, however, to be a leading employer. Production pressure on forest cover in the area due to agriculture and related activities have accelerated deforestation, destroyed animal habitat and contributed to the loss of valuable tree species. While farmers are aware of accelerated forest cover loss, they do not have access to accurate data on the extent and rate of deforestation in order to understand deforestation dynamics to plan remedial measures. In view of the data gap, the study described here was designed to assess the nature, extent and rate of deforestation in the Ho Municipality in Ghana. Data analysis was undertaken by classifying Land sat images from 1975 to 2001 and through analysis of questionnaire data. Study results show loss of forest cover by 6562 hectares from 1975 to 1991, and a further loss of 2949 hectares from 1975 to 2001. It is evident that the accelerated pace of deforestation has negatively affected the biophysical environment.

Keywords: deforestation, image classification, accuracy assessment, change detection, land use, land cover.

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FORESTLANDUSEANDCOVERCHANGEINHOMUNICIPALITYOFTHEVOLTAREGIONGHANA

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I. Introduction

Deforestation is globally recognized as one of the world's leading environmental problems affecting productivity of the forest environment and loss of biodiversity (Brook et al., 2003; Sodhi et al., 2004). Global deforestation may occur at dramatic rates, involving changes in land use, vegetation cover change and species translocations (Sutherst, 2006). Tropical forest cover loss is estimated to be accelerating at a rate of 13 million hectares per year, (European Commission, 2013). Such deforestation rates could result in future substantive forest cover loss due to driving forces such as farming, animal grazing and logging (National Geographic Society, 2013). Furthermore, deforestation accounts for the loss of 70% to 90% of the world's genetic resources, tree species and 50 to 100 animal species (Myers, 1994). Human activities are central to the phenomenon of global deforestation, since population growth, land policy, cultural values, science and technology are key factors contributing to global deforestation (Seabrook, et al, 2006).

Deforestation is defined as a progressive phenomenon that results in the conversion of forest areas to pasture and degraded habitats (Panta, et al, 2008). Removal of trees in the forests per se does not constitute deforestation since removal of trees comprises part of normal forest management activities (Martin, 2008). Deforestation, however, takes place when trees are cleared, and neither natural succession nor replanting of the cut trees occurs (Rudel, 2005). Analysis of deforestation often focuses on the extent of forest loss, while less attention is paid to issues of fragmentation due to uncertainty concerning ecological effects of fragmentation on biodiversity (Kupfer, 2005). Forest fragmentation refers to the entire process of forest loss, isolation or change in the spatial configuration of forest remnants due to deforestation (Fahrig, 2003; Fahrig, 1997 and Kleinn, 2002).

In Ghana, deforestation has comprised a critical environmental issue since the 1930s due to diverse driving forces (Benneh, et al, 1990). The colonial forest policies of the past, for example, forcefully took forest lands from individual land owners and families. Those affected by such colonial land policies resorted to exploiting the forest cover indiscriminately, regardless of the negative effects on forest cover (Agbosu, 1983). During the 1960s and 1970s, cultivation of cocoa as an export commodity has further contributed to forest cover change (Dei, 1990). From 1981 to 1985, Ghana's annual deforestation rate was estimated at 1.3%. At this time, timber was the third largest export commodity contributing between 5% and 7% of Ghana's Gross Domestic Product (GDP), (International Institute for Environment and Development [IIED], 1987). Anthropogenic causes of deforestation contributed to a reduction of Ghana's forest cover from 8.2 million hectares to an estimated 0.836 million hectares of forest in 2000, indicating an annual deforestation rate of 2.8%

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(EPA, 2004). From 1990 to 2005 a quarter of Ghana's total forest cover was lost (Boafo, 2013). The loss in forest may result in complete disappearance of forests in 25 years due to lack of collaboration between stakeholders and policy makers to intervene to reduce deforestation (Boafo, 2013). In spite of the challenges mentioned, there was, however, a decline in the rate of deforestation in 2007, resulting in 60,000 hectares of forest gain due to re-planting of trees and tree protection in forest reserves by the Forestry Commission of Ghana. Despite the gain in forest cover, however, it is not likely that Ghana would be able to meet its 35% forest cover target set for 2015 by the Millennium Development Goal 7 (Ladson, 2010).

Accuracy in detecting and quantifying deforestation in Ghana has become more achievable with the application of remote sensing to forest change, effectively becoming available in the late 1980s. Prior to this, acquisition of accurate statistical data on vegetation cover change in Ghana was challenging, as such most deforestation reports were merely descriptive. During this period, foresters themselves served as a major source of quantitative data on forest cover change representing mainly the forest reserves. To bridge the data gap, remote sensing image analysis of forest cover is thus considered a useful complementary approach. Most studies in the areas used satellite multi-spectral data which is cost effective and reliable (Imbernon and Branthomme, 2004; Jones et al, 2008).

In view of the advantages of remote sensing to study change in forest cover, more studies have evolved over the years to estimate deforestation. For example, NDVI image analysis from 2000 to 2008 shows evidence of land degradation with particular reference to deforestation in Ghana (Centre for Remote Sensing and Geographic Information Services [CERSGIS], 2010). A participatory GIS and remote sensing study in Bolgatanga and Talensi- Nabdam districts of northern Ghana further revealed changes in vegetation health and cover from 1990s to 2004, accounting for 600km^2 of degraded land which negatively affected food crop production (Agyeman, 2007). As far as the Volta Region is concerned, however, few studies have been undertaken using remote sensing. In the Ho Municipality in particular, application of remote sensing to forest cover change is quite new. As a result, this study is aimed at providing reliable quantitative data for planning and policy making.

II. Study Area

The Ho Municipality is located approximately between latitude 6° 30' N and 6° 55' N and longitude 0° 30' E and 0° 12' E in the Volta Region (Figure 1). The Ho Municipality covers a total land area of 2,660 sq kms and shares boundaries with North Tongu in the south, Abutia in the west and Ketu district in the east. Two districts were recently carved out of the Municipality, hence the land area has since reduced. The population is approximately 235, 331 (Ghana Statistical Service, 2000), comprising 28.9% of the population in Volta Region. The population growth rate is 3% per annum (Ho District Assembly Profile). The mean monthly temperature ranges fall between 32°C and 22°C, and the annual maximum and minimum temperatures fall between 37.8°C and 16.5°C respectively. There are two periods of rainfall in the district which are from March to July and from mid August to October each year, and total annual rainfall ranges from 750 mm and 1020 mm (Ho District Assembly Profile).

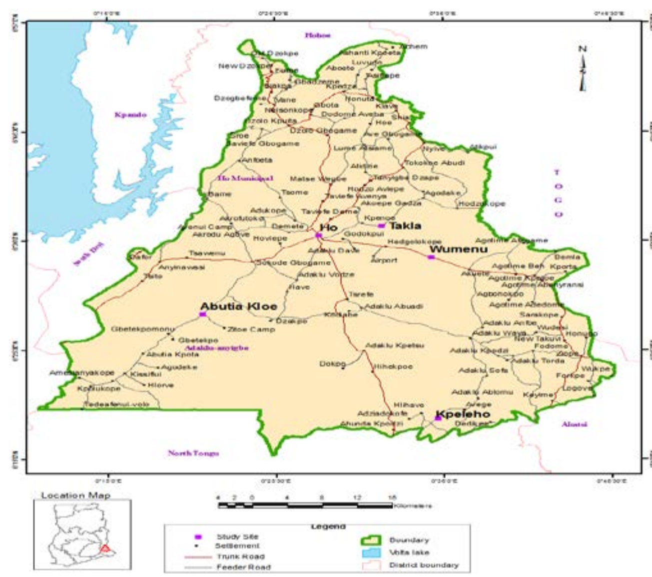

Figure 1 : Map of Study Area Ho Municipality.

III. Methodology

a) Data Sources and Classification Scheme

Landsat MSS 1975, Landsat TM 1991 and Landsat ETM$^+$ 2001 ortho-rectified imageries covering Takla, Wumenu, Abutia Kloe and Agbokofe were classified using Maximum likelihood supervised classification method to arrive at changes in land use and cover. The classification scheme used was the AFRICOVER scheme. AFRICOVER defines land cover as the observed physical cover, as seen from the ground or through remote sensing, such as the vegetation (natural or planted) and human constructions (buildings and roads) that cover the earth's surface (FAO, 1997). The AFRICOVER classification scheme recommended the use of classifiers that are hierarchically arranged, starting with a broad level class allowing for more detailed sub-classes as vegetated and non-vegetated areas (FAO, 1998). Questionnaire data was also analyzed to identify key drivers of deforestation in the Municipality.

b) Accuracy Assessment

Classified images are associated with errors. To reduce these errors, post classification refinements are done using an error matrix approach, to compare two thematic maps (such as the ground truth map and the automated image classification map) (Canadian Centre for Remote Sensing, www.ccrs.nrcan.gc.ca). The error matrix is computed as the total number of correct class predictions (sum of diagonal cells) divided by total number of cells (Verbyla, 1986). Accuracy assessment of classified images is undertaken to verify the extent to which classified imagery is accurate, by using different approaches. Other methods used include the producers and users accuracy that includes calculating percentage accuracies and validating accuracy results using Kappa statistics such as used in this study (Sexton et al., 2013). These assessments make it possible to correct conservative and optimistic biases in image classification due to misclassification of land cover classes.

For this study accuracy was assessed using the error matrix and the result validated using Kappa coefficient values. According to Congalton, (1996), Kappa coefficient values are categorized into 3 main groupings: a value greater than 0.80 (80%) represents strong agreement, values between 0.80 and 0.40 (80% to 40%) represent moderate agreement, and values below 0.40 (40%) represent poor agreement. The accuracy result for 1975 image was 92%, and a Kappa coefficient value of 0.8659 meeting the significant acceptable level. Assessment of accuracy for the 1991 classified image produced an overall accuracy of 89% and Kappa coefficient value of 0.8409 (again, indicating that the result is acceptable). Finally, accuracy for 2001 classified image was an overall accuracy of 86% and a Kappa coefficient value of 0.7794, which is within acceptable error margin.

c) Detection of Change in Land Cover

Change detection refers to monitoring land surface change over time using repetitive coverage and consistent data generated from satellite images as such image data sets are cost effective and reliable for estimating forest condition and broad scale land cover change (Jones et al, 2008; www.ciesin.Org/TG/RS/-chngdet.html). Land cover change detection can be done using different methods such as the tasseled cap method, principal component and regression analysis method (Healey, et al, 2005; Muchoney and Haack, 1994; Cohen, 2003). For this study, a change detection statistical method was used as it has the capability of clearly showing the distribution and extent of land covers types considered useful for the spatial assessment of the extent, nature and accurate quantification of the rate of land cover changes (Schneider et al, 2008). The spatial resolution of satellite images are important for the identification of objects and detecting changes in land cover types. It is for this reason that a mudium resolution Landsat images were used for the study (Swinne and Veroustraete, 2008; Julien and Sobrino, 2008, Yu et al., 2011).

IV. Results

a) Analysis of Classified Imageries 1975, 1991 and 2001

Analysis for Landsat MSS 1975, TM 1991 and ETM+ 2001 images show land cover classes for riparian forest, woody/grassland vegetation, settlements and bare areas (Figure 2). The analysis is based on pixel values and actual vegetation cover changes in hectares. Pixel values are the individual picture elements of objects classified as forest, woody/grassland vegetation, settlement and bare areas. An aggregation of these pixels provides a composite view of the cover types and further quantitative analysis of the pixels provide actual values of cover types in hectares to determine the extent of change. The forest cover in 1975 was quite extensive, coupled with dense woody/grassland vegetation, but the forest cover declined in 1991 and 2001 as shown by the classified images (Figure 2). Extensive grassland vegetation and bare areas classified depict deforestation and degradation caused by anthropogenic activities. For example; presence of fire scares in the 1991 imagery suggests the adverse effect of bushfires on the vegetation.

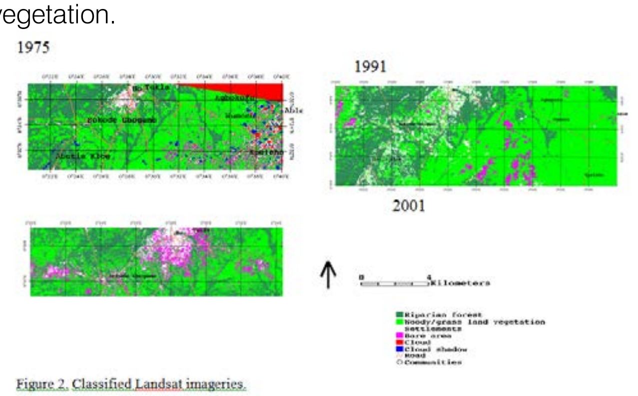

Figure 2 : Classified Landsat imageries.

i. Detection of Change from 1975 to 1991

The change detection statistical pixels report for 1975 and 1991 shows initial state classes (1975 classified image pixels) in columns and the final state classes (1991 classified image pixels) in rows (Table 1). Results show land cover types that remained static (riparian forest) and land cover classes that changed from one state to the other. Areas of change included 23294 pixels classified as riparian forest in the initial state but changed to woody /grassland vegetation in the final state image.

Table 1 : Change Detection Statistics Pixel Report from 1975 to 1991.

Classes	Riparian forest	Woody/grass vegetation	Settlements	Bare area	Row total	Class total
Riparian forest	8855	4623	124	221	13823	14388
Woody/grass land vegetation	23294	34950	1175	3236	62655	65488
Settlement	1371	1995	1058	600	5024	5564
Bare area	1068	9888	350	2877	14183	14730
Class total	34588	51456	2707	6934	0	0
Class change	25733	16506	1649	4057	0	0
Image difference	-20200	14032	2857	7796	0	0

As shown in the bottom row, the image difference for riparian forest cover is negative 20200, indicating a decrease in the class size for riparian forest cover compensating for the increase in woody/grassland vegetation by 14032 pixels. Positive image difference figures of 2857 and 7796 show increases in the class sizes for settlements and bare area pixels respectively. In terms of absolute values, riparian forest decreased by 6562 hectares, woody/grassland vegetation increased by 4558 hectares while 2532 and 928 hectares of increases were recorded for bare areas and settlements respectively (Figure 3).

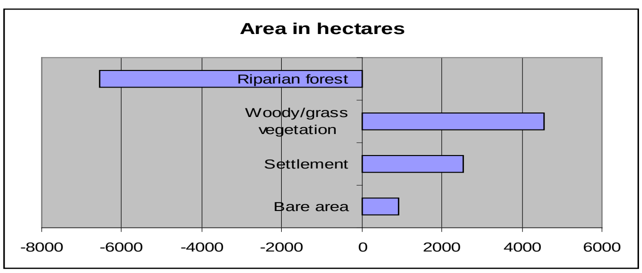

Figure 3 : Change Detection Image Difference Statistics Report from 1975 - 1991.

In terms of the rate of change in cover, 58% of riparian forest cover was lost. In the case of the woody/grassland vegetation, settlements and bare areas, 27.2%, 105.5% and 112.4% positive changes occurred, meaning an increase in the area of these respective land covers (Figure 4). The causes of deforestation investigated using questionnaires revealed multiple factors driving such change, including agriculture expansion, and commercial production of charcoal since the 1970s by Sissala migrant from

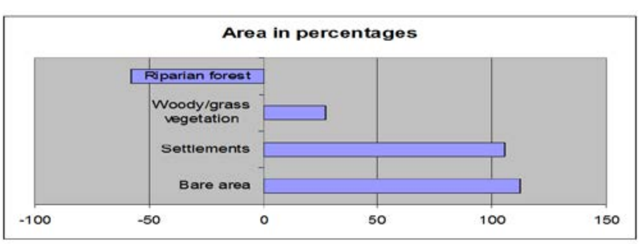

Figure 4 : Change Detection Image Difference Statistics in Percentages from 1975 – 1991.

Upper West Region to the Ho District. It was further evident that a major fire in 1983 resulted in significant vegetation loss. The burnt vegetation has, however, made it further possible for farmers to cultivate original forest and woody lands that could have regained their cover during the rainy season.

ii. *Change Detection Statistics Report For 1975 – 2001*

The change detection statistical report for the period 1975 to 2001 shows initial state classes (1975 image) in columns, while the final state classes (2001 image) are in rows (Table 2).

Table 2 : Change Detection Statistics Report 1975 – 2001.

Classes	Riparian forest	Woody/grass vegetation	Settlements	Bare area	Row total	Class total
Riparian forest	8726	12225	501	2467	23919	26613
Woody vegetation/grass land	18216	37615	1896	7360	65087	71032
Settlement	2452	3039	1487	1183	8161	9277
Bare area	6296	14276	1032	3036	24640	27268
Class total	35690	67155	4916	14046	-	-
Class change	26964	29540	3429	11010	-	-
Image difference	-9077	3877	4361	13222	-	-

The image difference pixels count for riparian forest is negative 9077, indicating a decrease in the riparian forest cover, accounting for the positive increase of woody/grassland vegetation by (3877). The analysis shows loss of 2949 hectares of forest in 26 years (Figure 5), which is in contrast to gains in woody/grassland vegetation by 1259 hectares, increases in settlement sizes, and bare areas by 1416 hectares and 4295 hectares respectively.

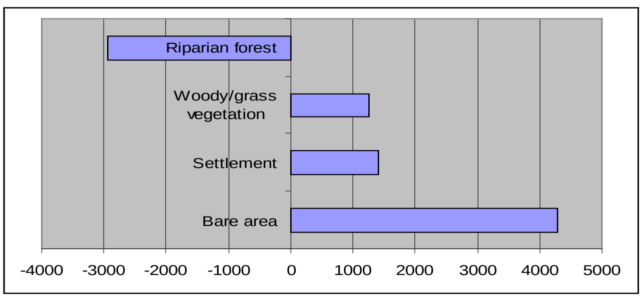

Figure 5 : Change Detection Image Difference Statistics Report from 1975 to 2001.

The rate of change in the land cover between 1975 and 2001 was 25% (Figure 6). In 26 years, it is clear that deforestation has been caused by rapid increases in the municipal population, increased woodfuel extraction, attitudes to lighting of bushfires, timber extraction and use of weed killers which terminated the growth of plants. These driving forces have resulted in dramatic deforestation rate of 50% from 1975 to 1991 compared to a less dramatic loss of 25% from 1975 to 2001. The less dramatic later loss of forest cover may have been due to an afforestation project embarked upon in the mid 1990s by FORUM. The FORUM project ensured that degraded forest reserves and off reserves were reforested and some grassland vegetation turned to woodlots to provide households with wood energy (thereby reducing.

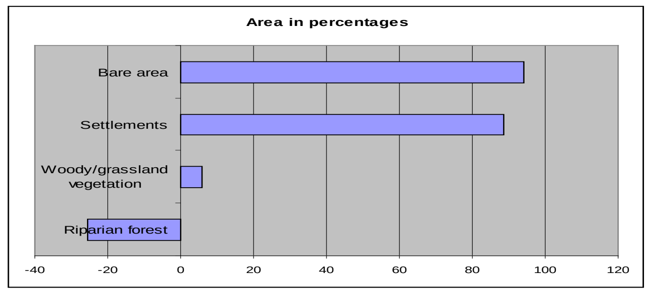

Figure 6 : Change Detection Image Difference Statistics from 1975 to 2001.

pressure on the forest cover). In terms of the woody/grass land vegetation cover, a 5.7% increase occurred, while 88.7% and 94.1% increases occurred for settlements and bare areas respectively. The increased percentage change for bare areas is likely due to bushfires that exposed the soil surface to wind erosion during the dry season and water erosion during the rainy season.

V. Discussion

Analysis of Landsat imagery revealed changes in the nature, extent and rate of deforestation, as well as other land cover classes from 1975 to 2001. The nature of land cover changes were varied. Accordingly, transition from forest to woody/grass vegetation, to settlement and bare areas occurred, while a loss of 6562 hectares of forest from 1975 to 1991, and 2949 hectares of forest loss from 1975 to 2001 was evident. It should be observed that an additional study in Adaklu Traditional area (a major charcoal and fire wood producing area in the Ho Municipality) indicated significant deforestation over 25 years (Adanu, 2009). The rate of deforestation is of concern estimated at 58% from 1975 to 1991, with a further more moderate loss of 25% from 1975 to 2001 due to multiple factors such as converting forests to farmlands, extensive exploitation of wood energy and effects of fire on forest lands. Apart from the decrease in forest cover, there were gains in woody/grass vegetation by 27.2%, settlements by 88.7% and bare areas by 84.1% from 1975 to 2001. A similar study at the Barekese catchment area in the Ashanti

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region of Ghana showed a 43% loss of open canopy forest, 32% increase of grasslands and 70% increase of open areas from 1973 and 2000 (Boakye *et al*., 2008). At the national level, an analysis of the vegetation cover in all ecological zones of Ghana using NDVI imagery from 2000 to 2008 produced results confirming loss of closed canopy forest by 12,607 square kilometers in 2000, and a further loss of 11,748 square kilometers in 2008 (CERSGIS, 2010).

Verification of the accuracy of classified image pixels showed overall accuracies of 92%, 89% and 86% for the 1975, 1991 and 2001 images respectively, an indication that the results are within an acceptable error margin.

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Agriculturally used Wetlands in Kenya and Tanzania: Characterization based on Soil and Water Resources Availability

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Abstract- Wetlands in Eastern Africa present an important and so far largely undocumented potential in terms of area and agricultural production. This potential is linked to the availability of water and the quality of soil resources. This study characterized representative wetlands and categorizes their diversity based on soil, hydrology and socio-economic attributes. A multidisciplinary regional assessment of more than 50 wetlands and over 150 wetland subunits was conducted in 2008 and 2009 in four regions of East Africa. The wetlands were located within the major landscape units comprising (i) the floodplain in the semi-arid highlands; (ii) floodplain in the sub-humid lowlands; (iii) inland valley swamps in the humid mid-hills; and (iv) inland valley swamps in the humid highlands. Based on multivariate statistical approaches of their biophysical and socio-economic attributes, the wetlands were categorized into five cluster groups which were further differentiated based on land use intensity, soil parameters and hydrology.

Keywords: cluster group, floodplain, hydrology, inland valley, land use, wetlands.

GJSFR-H Classification : *FOR Code: 090509, 969999p, 961403p*

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Abstract- Wetlands in Eastern Africa present an important and so far largely undocumented potential in terms of area and agricultural production. This potential is linked to the availability of water and the quality of soil resources. This study characterized representative wetlands and categorizes their diversity based on soil, hydrology and socio-economic attributes. A multidisciplinary regional assessment of more than 50 wetlands and over 150 wetland subunits was conducted in 2008 and 2009 in four regions of East Africa. The wetlands were located within the major landscape units comprising (i) the floodplain in the semi-arid highlands; (ii) floodplain in the sub-humid lowlands; (iii) inland valley swamps in the humid mid-hills; and (iv) inland valley swamps in the humid highlands. Based on multivariate statistical approaches of their biophysical and socio-economic attributes, the wetlands were categorized into five cluster groups which were further differentiated based on land use intensity, soil parameters and hydrology. These cluster groups included (i) permanently flooded wetlands under extensive use with moderate C and N contents; (ii) permanently flooded swamps located in remote areas that were largely unused and had high contents in C and N; (iii) seasonally flooded wetlands under medium use intensity for upland food crops and rainfed lowland rice and which had low to moderate soil nutrient and C contents; (iv) completely drained wetlands under intensive subsistence crop production and low soil N and P; and (v) seasonally wet valley bottoms under permanent and year-round horticultural production and high input use hence high C and N contents. Thus, the permanently flooded wetland soils and those under subsistence food production with organic inputs had more C and N than seasonally flooded, completely drained and intensively cultivated wetlands.

Keywords: cluster group, floodplain, hydrology, inland valley, land use, wetlands

I. Introduction

In many parts of Africa, agricultural use of wetlands is intensifying. More and more people are forced to seek new land as a result of land shortages and fertility degradation of upland areas (Wood and van Halsema, 2008). In Eastern Africa, wetlands present an important and so far largely undocumented potential in terms of area and agricultural production. This potential is linked to the availability of water and the quality of soil resources. Recent estimates suggest that wetland cultivation in East Africa provides between 10 to 40% of the annual food needs of the rural population. However, during food shortage periods, its contribution can rise to 100% in some areas (Schuijt, 2002; Rebelo et al., 2010). In the highly populated humid highlands and mid-hill areas, in particular, the dependence on wetlands for food security is larger than in the more sparsely populated lowland plains in the semi arid zones (Dixon and Wood, 2003). Soil attributes as well as agricultural uses are affected by hydrology of the wetland systems. The wetland soils are either formed under flooded conditions or altered by them. Other characteristics of the soil such as texture and organic matter composition and content may also be influenced by the hydrology of the wetland (Tiner, 1999). Farming in wetland areas is characterized by adaptations to various hydric regimes. Extensive inundation seems to restrict human activities in some areas and is responsible for the maintenance of natural vegetation and various soil parameters in other parts of the wetlands (Dixon, 2003). For example, the timing of the wet season's rains and the subsequent flood determine the planting of rice and other wetland crops within floodplain wetlands. The depth and duration of inundation influences the crop varieties that are sown, while the area of inundation controls the location and extent of this form of cultivation (Thompson and Polet, 2000). Several wetland classification approaches in Africa exist. For example, Roggeri (1995) and Windmeijer and Andriesse (1993) classified wetlands based on geomorphological and ecological units which included sources of water and nutrients. Other classifications were based on soil and terrain characteristics (Koohafkan et al., 1998) which resulted to categorization of permanently flooded soils as Gleysols and seasonally flooded and stratified soils as Fluvisols. Although several other studies have been carried out within the East Africa region such as West Usambara in Tanzania (Ndakidemi and Semoka, 2006) and the Laikipia plains in Kenya (Thenya, 2001) none of these studies explicitly investigated the soil diversity and

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characteristics in wetland systems. Furthermore, there is no classification system of the agriculturally used wetlands or their distribution in East Africa.

Thus, this study is aimed at categorizing the wetlands into groups based on biophysical and socio-economic attributes and to assess the major soil attributes (C, N, and P) concentrations as affected by land use and hydrology in the wetland types.

II. Materials and Methods

a) Study Area and Wetland Selection

The study region in East Africa was characterized by a gradient from lowland plains to the highlands with undulating topography, which ranged between 300 and 2300m above sea level (masl). Details of site parameters, the major biophysical and socio-economic descriptors and the dominant agricultural activities are presented in Table 1 and the location of the study areas shown in Fig. 1. Further details can be obtained from (Mwita et al., 2012)

The first field reconnaissance was conducted in May 2007 while detailed studies were carried out in 2008 and 2009. The reconnaissance survey was aimed at identifying potential sampling locations and consisted of guided visits by several stakeholders. Additionally, exploration trips were organized using topographical maps and satellite images beginning at the lowland and culminating at the highlands. During this reconnaissance survey, observation of wetland extents, diversity, public access and river/stream characteristics were recorded in conjunction with a review of existing maps.

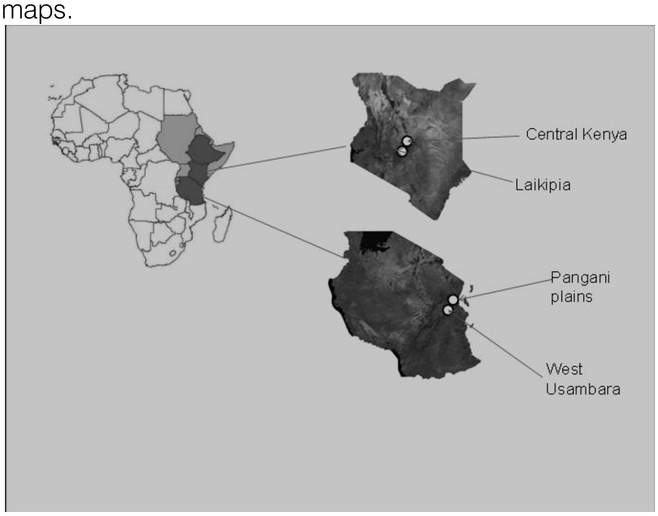

Fig. 1 : Map of the Study Region in East Africa (Kenya And Tanzania). Arrows and Name Tags Identify the Specific Study Areas-Central Kenya and Laikipia in Kenya and West Usambara and Pangani Plains in Tanzania

Areas considered primary candidates for wetland sampling were identified and marked. The following landscape units and associated study sites were selected (1) the semi-arid highlands in Kenya comprising the Laikipia plateau; (2) the sub-humid lowlands of Pangani plains in Tanzaniae; (3) the humid mid-hills in West Usambaras in Tanzania; and (4) the humid highlands in Central Kenya) (Fig. 1). These landscape units were estimated to cover >30% of the East African land area and are hence representative of the environmental and agro-ecological diversity of the region.

b) Characteristics of the Study Sites

In addition to the climate and the parent rock, sites differed regarding population density, average farm size and market accessibility. The two mountainous sites at Mount Kenya and the Usambara Mountains had high population densities, good market access and tended to experience land shortages (small farm sizes), while the two floodplain environments were located in less populated rural environments and farm sizes tended to be large. Within all four study areas, agriculture is the main economic activity. Both the dominant food and cash crops differ as a result of altitude and rainfall. Thus, maize, beans and vegetables are mainly restricted to the highland areas, while rice is typical for the tropical lowlands in Pangani plains (Jaetzold et al., 2006; MOA-URT, 2006). In the adjacent uplands, coffee and tea are typical cash crops in the high rainfall environments while sisal and cotton are restricted to the semi-arid and sub-humid zones. Livestock systems in the adjacent uplands are largely linked to land availability with zero-grazing dairy systems in Central Kenya and the Usambara Mountains and free ranging in the Rift Valley and the Pangani plains.

c) Sampling Strategy

Field sampling was then carried out between February and July 2008. A multi-stage approach was used to select the pilot sites as outlined by Sakane et al., (2011). Selected wetlands were sub-divided into 'sub units' based on (i) hydrological regime: comprising the upland zone and hydro-morphic fringe (the seasonally flooded sections) and central zone (or bottom valley) (ii) major land use, management practices and cropping intensity (unused with natural vegetation, grazing, fallow, subsistence crops, horticulture, and anaerobic cropped fields). The sub units ranged in size between 20-300m^2. In each sub unit, 9-20 soil cores were obtained from ±2-15 cm depth using a 5-cm diameter stainless steel hand-held soil auger. The soil was mixed together, air dried and sieved to pass through a 2mm sieve. The sampling approach was designed to address the diversity of the soils in various land uses under different hydric regimes.

d) Soil Chemical and Physical Analysis

Soil samples were analyzed for organic C, total N and available P contents, and textural classes at the World Agroforestry Centre (ICRAF), Plant and Soil

Laboratory using standard methods described in ICRAF, (1995) lab manual and near infrared spectroscopy (NIR) (Shepherd and Walsh, 2007).

e) Variable Definitions

Data collected included soil information on nutrient levels, hydrology, land use and socio-economic environments. Soil information comprised soil texture, soil contents of N, C and P, land use intensity, use types and hydric regime within the wetland sub units. Land use intensity was defined based on field observations on use type at the time of sampling, existence of drainage infrastructure, number of cropping seasons, production orientation, and related crop management including tillage and input use. Wetland use types were either cropped or unused (not cultivated) while flooding regime comprised the permanent flooded or seasonally wet categories. The variables used to define the wetland characterization process were biophysical (soil parameters C, N, P, hydric regimes), land use types, and socio-economic attributes as described in Sakane et al., (2011) and Kamiri et al., (2013).

i. Data Analysis

Several multivariate techniques were used to determine whether the wetlands and wetland subunits belonged to the same group and whether the variation in the wetlands was associated with land use types, hydrology, soil and socio-economic factors. Cluster and disriminant analysis were performed to derive a wetland typology or characterization which grouped together related wetlands based on socio-economic and biophysical attributes. In addition, principal component analysis (PCA) was conducted to determine the main factors explaining the variable patterns and loadings. These cluster groups were then related to current types of land uses and finally the cluster groups were examined based on the soil parameters C, N and P.

III. Results

a) Size and Distribution of Agriculturally Used Wetlands in East Africa

East Africa has a diversity of wetlands most of which are under agricultural use. They vary in size and land uses based on a variety of factors. In this study fifty one (51) wetlands which were a representation of the wetlands in Kenyan and Tanzania were surveyed. The wetlands were subdivided were subdivided into 157 sub units based on dominant land use, soil type and soil moisture. Wetland type and size varied between environments with individual areas ranging between 0.5 ha and 458 ha. The two dominant wetland types comprised inland valley swamps and floodplains, with inland valleys accounting for 87% of all wetlands but covering only 58% of the wetland area (2115 ha). While the inland valleys dominated the humid mid-hills and highlands, floodplains were the dominant wetland type in the semi-arid and sub-humid zones.

The inland valley swamps had sizes ranging from 0.5 ha to 35 ha (average = 17 ha), while the floodplains ranged between 10 ha to 458 ha (average = 79 ha) (Table 2).

b) Characterization of Wetland Land Uses

The studied wetlands were observed to undergo an evolution from unused state (undisturbed) to extensively use either through grazing or continuous cropping. Our investigation into ways in which wetlands are used revealed that wetlands in the studied regions could be categorized into several classes based on current land uses. These included:

1. Wetlands which had not been cultivated are undisturbed (or were under natural wetland vegetation);
2. Wetlands which were partially cleared and drained, under grazing;
3. Partially drained wetlands which were under grazing and partial cultivation (under anaerobic conditions);
4. Fully drained wetlands which were under intense cultivation and in some instances irrigation (grown with upland crops);
5. Wetlands which had previously been cultivated but have been abandoned or extensively grazed.

The largest share of undisturbed wetland sites representing 24% of the total wetland land uses occurred in the highlands of Kenya Table 3. The largest share of the anaerobic crop cultivation was observed in the Pangani plains and in Central Kenya representing 48% and 44% respectively while cultivation of upland crops under aerobic soil conditions dominated the west Usambara areas (73%). Overall, the largest share of wetland area (43%) was used for the cultivation of upland crops after complete drainage of the fields while abandoned and grazed land accounted for less than 20% of the wetland land uses.

c) Wetland Characterization Based on Soil and Hydrologic Properties

Carbon and N levels were differentiated between the unused and cropped land uses in flooded (permanently or seasonal) condition. These values were relatively high in the unused than in the cropped (and flooded) wetlands and ranged between 16.3 to 25.5 g kg-1 for C and 1.4 to 3.1 g kg-1 for N. High levels of C and N contents in the cropped seasonally wet areas were linked to management whereby crop residue incorporation is only possible in dry soil but not in flooded soil. Differences in P were however minimal between the land uses and the hydric regimes and ranged between 9.9 to 12.9 mg P kg-1 in the flooded soils and 12.0 to 12.9 mg P kg-1 in the seasonally wet soils.

Differentiation of wetlands based on hydrology showed that majority of the wetland subunits were seasonally wet (56%, n=157) with most of these occurring in the floodplain areas and fringe of inland valleys. Cultivation in the permanently flooded fields was mainly for wetland crops such as rice (Oryza sativa) in the lowlands and taro (Colocasia esculenta) in the highlands while in the seasonally wet areas, vegetable and cereal-legumes were the main crops.

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d) Wetland Clusters Based on a Combination of Variables

Five major wetland cluster groups were identified by a combination of land use, hydrology, soil and socio-economic attributes using hierarchical cluster analysis method.

This classification scheme was tested by discriminant analysis whereby 96% of the original five group cases were classified correctly. The percentages of their predicted group membership were 96, 95, 93, 96 and 100% for cluster groups 1, 2, 3, 4, and 5, respectively as described by Sakane et al., (2011). The cluster groups identified included:

Table 1 : Topographical, Biophysical and Agricultural Characteristics of the Study Regions in East Africa (Tanzania and Kenya)

Country	Tanzania		Kenya	
Wetland location	Pangani plains	West Usambara	Laikipia plateau	Central Kenya highlands
Wetland type	Floodplain	Inland valley	Floodplain	Inland valley
Longitude	$38^0$19'32"E to $38^0$21'28"E	$38^0$13'54"E to $38^0$16'22"E	$36^0$34'59"E to $36^0$32'26"E	$37^0$6'7"E to $37^0$5'57"E
Latitude	$5^0$4'29"S to $5^0$6'57"S	$4^0$38'18"S to $4^0$40'12"S	$0^0$19'16"N to $0^0$15'17"N	$0^0$27'58"S to $0^0$28'51"S
Altitude (masl)	300-400	800-1200	1900-2280	1200-1780
Annual rainfall range (mm)	500-800	1200-1500	400-1000	950-1500
Temperature range (^{0}C)	19-35	9-30	14-29	11-27
Soils-uplands[a]	Acrisols, Luvisols	Nitisols, Acrisols	Planosols	Nitisols
Bottom valley[a] soils	Fluvisols Vertisols,	Gleysols Fluvisols	Fluvisols Planosols	Gleysols Histosols
Parent material	alluvial sediments	Granite and gneiss, colluvial	Basalts, granite	volcanic
Soil Texture	Sandy clay, Clay	Sandy clay loam to clay loam	Clay and clay loam	Clay loam to clay
Main activity	Subsistence cropping, rice cultivation	vegetables, fruits, market oriented	Cattle ranching, subsistence oriented farming	Subsistence cropping
Population density (persons km^{-2})	74 - 83	133 - 241	192 - 603	40 -160
Market accessibility [b]	Medium	High	Low	Medium

a: FAO-UNESCO, (1997) , b: Time taken to reach the market: High (0-2 hours); medium (2-4 hours)

Cluster Group 1: These were wide, permanently flooded valleys and highland floodplain that were largely unused but with some extensive grazing and some subsistence food crop cultivation on the wetland fringe during the dry season. Average size was 21ha, were commonly found in floodplain areas at an altitude range of 400-1500masl. Soil nutrient levels were moderate to high while variation within the group was large. Carbon ranged from 8.0 to 69.6 g C kg-1 whereas N content ranged between 0.9 - 10.9 g N kg-1. The semi-arid to sub-humid adjacent upland areas were used for ranching and extensive cattle rearing.

Cluster Group 2: This cluster comprised the permanently flooded inland valley wetlands, which were narrow and unused or under natural wetland vegetation and with limited access. Average wetland size were small (12 ha). Soil concentrations of C, N and P were high at 36.9 and 4.6 g kg-1 C and N respectively, and available P of 26 mg kg-1 (Fig. 2). Soil variability within the group was considerable with C ranging between 10.3 - 70.8 g C kg-1 and N between 0.7 - 12.0 g N kg-1. These wetlands were located in rural areas with low to moderate population density and poor market accessibility. Most of the adjacent upland areas were covered by forest.

Table 2 : Selected Biophysical Characteristics of the Wetlands Studied in East Africa (Tanzania And Kenya).

Variable	Inland valleys	Floodplains
Proportion of sample size (n = 157)	87%	13%
Altitude range (masl)	1490 ± 58	887 ± 163
Average wetland size (ha)	17.0 ± 2	79.9 ± 23.2
Adjacent upland slopes	Gentle to steep	None
Parent material	Gneiss, granite and volcanic material	Sediments, granite
Soil texture	Clay to Clay loam	Sandy clay to clay
Major land uses	Horticulture, mixed cropping	Rice, grazing and mixed cropping

±*Standard Error of the Mean*

Cluster Group 3: Comprises large inland valleys and lowland floodplains with moderate land use intensity, mainly for subsistence cropping. This cluster group had the largest group size and comprised large wetlands with an average size of 56 ha. They were seasonally flooded and segments of the wetland were cultivated to food crops on the valley fringes and rainfed lowland rice in the permanently flooded sections. Due to their large sizes, pressure on these wetlands was low. Soil C and N concentrations were low at average of 17.3 g C and 1.6 g N kg-1 and available P of 15.9 mg P kg-1 (Fig. 2). Dominant soil types are the heavy clays (Vertisols) in the lowland areas and Gleysols on the valley fringes.

Table 3 : Relative Proportion of Agricultural Land Uses in Reference to Total Wetland Land Use Types in Selected Areas in East Africa.

	Tanzania		Kenya	
	Pangani plains	West Usambara	Laikipia	Central Kenya
Land use type[1]	% of total wetland land uses			
Natural vegetation-(unused areas)	7	7	24	6
Grazed	25	13	18	9
Anaerobic crops	48	0	0	44
Aerobic crops	11	73	48	38
Abandoned fields	9	7	10	3

Unused: Uncultivated areas with natural wetland vegetation; grazed: grazed areas recently cleared of natural wetland vegetation; Anaerobic: fields grown to anaerobic crops such as rice or taro; Aerobic: completely drained and grown to upland crops; Abandoned: areas left to fallow after cultivation.

Cluster Group 4: These wetlands were narrow inland valleys, moderate in size (average = 26 ha), seasonally wet and intensively used for horticultural production. The majority occurred at high altitudes of 1600 to 2400 masl. Due to their high use intensity, soil nutrient levels were low with total soil C and N of 17.0 and 1.6 g kg-1 respectively (Fig. 2). Soil available P was below critical level of 10 mg P kg-1 (Okalebo et al., 2002).

The wetlands were dominated by sandy clay to clay texture and were completely drained for intensive upland crop production. Due to low soil carbon and nutrient levels (N and P), some of these wetlands had been abandoned to fallow and some of them were under grazing.

Table 1 : Soil Hydrologic Regimes and Land Use Intensity Effect on Wetland Soil Characteristics in the Studied Wetlands in East Africa

	Permanently flooded (n = 69)		Seasonally wet (n = 88)	
Soil variables	Unused† (n=15)	Cropped (n=15)	Unused (n= 37)	Cropped (n=45)
Total C (g kg^{-1})	25.5 ± 2.2	16.3 ± 1.4	22.3± 2.4	22.5 ± 1.7
Total N (g kg^{-1})	3.1 ± 0.4	1.4 ± 0.1	2.2 ± 0.3	1.8 ± 0.2
Available P (mg kg^{-1})	12.9 ± 0.8	9.9 ± 1.1	12.9 ± 0.8	12.0 ± 1.0

± Standard error of the mean (n = 69-88)

†Land use defined as unused (no cropping, natural wetland vegetation, permanent flooded) and cropped (drained, high intense cropping)

Cluster Group 5: The group comprised the intensively used lower sections of inland valley bottoms. They occurred mainly in the mid hills at an altitude range of 1300m to 1835m and were small in size (average = 15 ha). These wetlands had originally been permanently flooded but were completely drained for intensive horticultural crop production with a high use of external inputs both organic and inorganic. Due to their permanent year-round use, and intense use of fertilizers, soil fertility level was moderate to high with C and N contents of 26 and 1.9 g kg-1 respectively. However, soil available P was generally low with a mean value of 10.2 mg P kg-1 (Fig. 2). The soils in this cluster group are of sandy clay texture, and are mainly found in highly populated highland areas with good market access.

e) Comparative Assessment of Wetland Soil Properties

The changes in soil C and N contents for the different wetland groups were then placed in a larger context by examining the observed values of each parameter in a cluster, relative to the range of values for all the cluster groups. This was done by comparing the box plots for different wetland groups (Fig. 2). For organic C and N, the median levels for cluster group 1 (permanent flooded with low use intensity) are clearly falling above the range of the other wetland groups (>25 g C kg-1 and >1.9 g N kg-1) (except group 5) hence the wetlands in this cluster group (1) were segregated on their own with unique characteristics such as flooded conditions and high C and N as shown in Fig. 3. In cluster group 3 and 4, majority of wetlands are seasonally wet with a C content <20.0 g C kg-1 and N <1.9 g N kg-1 reflecting lower soil resource availability. Phosphorus was however not differentiated according to the wetland groups though most wetlands in cluster group 4 and 5 had P below the critical P level of tropical soils (10 mg P kg-1 - Okalebo et al., 2002). High variability in soil attributes resulted to outlier values (either high or low values plotted above or below the box plots in Fig. 2 which were exceptional cases and were included in this data analysis to allow for the interpretation of soil variability within the wetlands.

IV. Discussion

Wetlands were successfully categorized into clusters using biophysical, socio-economic (Sakane et al., 2011) and soil quality attributes.

Because soil characteristics vary independently along environmental gradients, it was not surprising that there were substantial overlap of cluster groups assigned to different sub units occurring in the same wetland. Nevertheless, we were successful in identifying the factors correlated with soil variations in these wetlands.

Our results suggest that flooding (or no flooding) as well as land use (cropped or no cropped) can affect soil chemical characteristics of the wetland soils in East Africa.

a) Wetland Categorization Based on Soil Properties and Moisture

The wetland characterization based on soil and moisture regimes was developed in recognition of the diversity among wetlands in terms of use intensity, management and soil characteristics.

This characterization gave insight into how wetlands are grouped in terms of the soil resource base and the influence that land uses and hydrology have on the soil properties. Although every wetland is unique, the wetlands within each group had more similar attributes than wetlands in other groups or clusters. The biophysical and socio-economic conditions under which the inland valley and floodplain wetlands existed contrasted strongly in each region. Whereas floodplain wetlands were found on relatively low and flat topography, the wetland sizes were equally large (79 ha) which contrasted with inland valleys wetlands on narrow, and often small sizes (17 ha) but forming the majority of the wetlands.

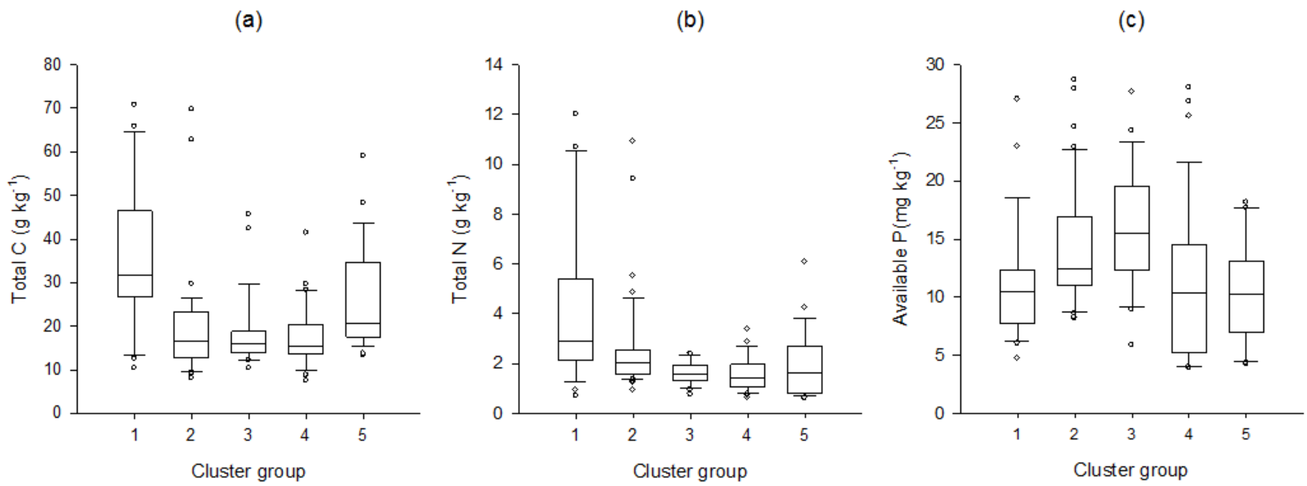

Fig. 2 : Ranges of (A) Total Soil C, (B) Total N and (C) Available P for Wetland Cluster Groups Identified in East Africa *Cluster Groups:* 1= Wide permanently flooded inland valleys and highland floodplain with extensive use for grazing and subsistence crops cultivation; 2 = Narrow permanently flooded inland valleys under natural vegetation; 3 = Large inland valleys and lowland floodplains with sporadic to seasonal flooding under medium land use intensity; 4 = Wide seasonally wet valleys and highland floodplains with intensive use; 5 = Narrow completely drained valley bottoms with intensive horticultural land use.

In Sub-Saharan Africa the inland valleys form close to 36% of the total wetland area (Balasubramanian et al., 2007). Most inland valley wetlands are concentrated in high altitude areas with fertile soil including the Gleysols (when drained) Entisols and Fluvisols on the valley fringes and superior rainfall (usually above 700mm) and are therefore important sites for horticultural and subsistence crop production (Schuijt, 2002). The wide and flat floodplains have been used for extensive grazing (Thenya, 2001), fallowing and for cultivation of cash crops. In other areas floodplain wetlands are extensively used for rice cultivation both as lowland rice and irrigated rice (Balasubramanian et al., 2007). Wetland uses are however highly influenced by the ability of adjacent upland areas to sustain food crop production. Therefore in instances of steep slopes like those realized in this study (>45%) production is likely to be lowered by high erosion rates (Labin et al., 2003) and hence leading to shifts from upland cropping to relatively flat wetland areas for cultivation. It is thus evident that utilization of these wetlands because of their sizes in relation to potential resources will have a role in agricultural development in increasing crop area and food production.

b) Biophysical Characteristics

The main wetland types were associated with geomorphological characteristics of the location and were reflected in soil types and hydrologic regimes. Most inland valleys developed on gneiss and volcanic base rock, had permanent to seasonal flooding regimes with water originating from springs or (subsurface) interflow. Floodplains, on the other hand, predominated on sediments and granite, were sporadically or seasonally wet by overflowing rivers and were characterized by sandy clay and Vertisols. The fertile soils dominating the inland valleys are derived from volcanic rocks and are usually clay in texture while the less fertile alluvial deposits arising from overflow of rivers and streams are dominating in the floodplains (Tiner, 1999).

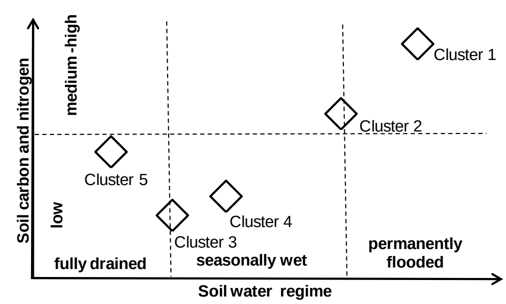

Fig. 3 : Schematic Presentation of Soil Cluster Groupings in Relation to Hydric Regime and Soil Parameters (C And N).

Within the wetlands, hydrology and land use (cropping, inputs and management) were observed to influence the C and N content of the soils. In the inland valley systems, comprising the narrow highland swamps, and associated valley bottoms, soils have deeper profiles, are more fertile with flooded or seasonally wet conditions.

These wetlands are cropped with different crops depending on the hydrology. They may include vegetables and cereals on the valley margins while the more flood intolerant crops such as taro are cropped on the valley centre. In contrast, soils in the floodplain areas are in some cases less fertile with incidence of seasonal or sporadic flooding and higher proportions of sand (Windmeijer and Andriesse, 1993).

Land use vary depending on the wetland type with greater diversity in the floodplain than in the inland valleys which could be attributed to the wetland size and accessibility as available land in the wetlands could allow for diversification of land uses (Rebelo et al., 2010). Wetland use has also been linked to distance from the market (Drechsel et al., 2001). Wetlands located in remote areas are usually unused and in some instances partially grazed or cultivated on the margins (Kiai and Mailu, 1998). Results of hydric regimes and land use relationships in the present study were generally consistent to previous published descriptions of floodplain wetlands and inland valleys in that land use and hydrology are highly correlated with soil characteristics (Dixon, 2003). These results also emphasize the suggestions by Balasubramanian et al., (2007) and Wood and van Halsema, (2008) that wetlands are relatively fertile when compared to upland areas. However, our results also indicate that land use types and intensity of use may be important in structuring the soil characteristics within a wetland sub unit.

Factors that tend to be responsible for an increase of organic C in wetland soils and particularly in the flooded and unused wetlands in Cluster group 1 and 2 could be summed up as lower rate of decomposition in anaerobic conditions, and a high level of litter fall from the wetland vegetation (Handa et al., 2012). Alternate wetting and drying and tillage may stimulate microbial activity and cause rapid decomposition of organic matter thus resulting to reduced C contents in cultivated wetlands such as those observed in Cluster group 3 and 4.

Cluster groups identified as those under low or extensive use (Cluster 1) contained high C contents which were above 25 g C kg-1 while those which had been under intensive use (Cluster 3 and 4) reported remarkably low C and N concentrations. Among these wetlands were those under natural vegetation (unused) and those under extensive use for subsistence cropping or for grazing. Low N and P levels (<2 g N kg-1 and <10 mg P kg-1) were an indicator of possible N and P deficiency in majority of the intensively cultivated wetlands (Becker et al., 2007).

V. Conclusion

Five cluster groups were identified which differentiated the wetlands according to hydrology, socio-economic attributes and differed in soil characteristics. Wetland hydrology (flooding or no flooding) as well as land use (no use or cultivation) determined soil chemical characteristics in the wetlands. Soil C and N were the most important factors in differentiating and categorizing the wetland types. High C and N contents in wetland soils were associated with flooded conditions which were unused or were under low use intensity. Completely drained wetlands were in most instances intensively cultivated which resulted to low contents of soil C, N and P.

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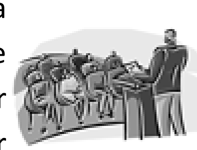

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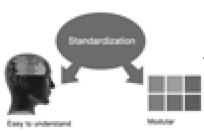

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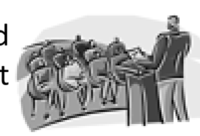

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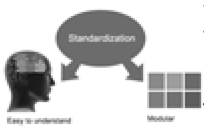

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"

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4. Manuscript's Category,

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18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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