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Major Ion Chemistry and Quality Assessment of Groundwater in Maiduguri and Jere

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Abstract: ***Hydro-chemical conditions of groundwater in the upper aquifer system around Maiduguri and Jere local government area of Borno state were investigated. The geochemical processes controlling the concentrations and evolutions of the major ions in the aquifer indicates that water rock interaction is the major control. The concentrations of CA, Mg, SO4, and HCO3 are likely resulting from resolution of gypsum (CaSO4. 2H2), dolomite (CaMg(CO3)2), halite (NaCl) and magnesium sulphate (MgSO4) occurring in the aquifer matrix. However, other possible sources such as respiration or oxidation of organic matter and reduction of sulfate are attributed to higher concentration of HCO3 observed in some samples. The relatively higher concentration of Na, and Cl in the groundwater are most likely due to dissolution of halite (NaCl) which are probably occurring in the aquifer matrix. The plot of Na versus Cl was used to understand the overall Salinity in the groundwater, which is identified to be due primarily to the buildup of two major constituents (Na and Cl). Na excess relative to Cl in the samples is probably as a result of ion exchange of Ca or Mg for Na in the water and clay minerals which may probably be present in the aquifer materials. The relative high concentration of magnesium and calcium in the groundwater are most likely due to dissolution of dolomite (CaMg(CO3)2) which could be most likely source of these ions in the groundwater, since the mineral has ions as it's constituent. The relative concentration of calcium and sulphate in the groundwater are most likely due to dissolution of dolomite (CaMg(CO3)2) which could be most likely source of these ions in the groundwater, since the mineral has ions as it's constituent. The relative concentration of calcium and sulphate in the groundwater is most likely due to dissolution of gypsum (CaSO4.2H2) which could be most likely source of these ions in the groundwater. Various classifications of groundwater in the aquifer (Ca-Na-HCO3, Na-Ca-HCO3 and Na-HCO3 are important for regional hydrogeochemical studies. The assessment of water quality for domestic consumption shows that all the samples two or more of the ions above the WHO recommended limit. TDS values were used to understand the suitability of the groundwater for domestic consumption. The groundwater is considered good for consumption.***

Keywords: Groundwater chemistry; Hydrogeochemical processes; Water–rock interaction; Maiduguri; Jere; Major ions; Aquifer system; Ion exchange; Mineral dissolution; Water quality assessment; Salinity; TDS; Domestic consumption; Borno State; Nigeria.

I. INTRODUCTION

Water sustains life and its importance for the socio-economic growth can hardly be over-emphasized. Portable and safe drinking water is essential for the health and well-being of the community. Groundwater is the most important source of water supply. During recent years much of the emphasis is given at the considerations of its quality. As a consumptive way of human life, growing, urbanization, industrialization without adequate measures of waste disposal, agricultural activities, etc., the ground water environment is beingpollutedwithanever-increasing numberofpollutants.

Withthepassage oftime,thevastsubsurfacereservoiroffreshwater,whichafewdecadesago was relatively clean, is gradually being degraded.

In Maiduguri, groundwater quality is being seriously polluted due to unplanned disposal of liquid and solid wastes. In the area selected for study, groundwater serves one of the major sources of drinking water. Hence its quality is of great importance as it significantly affect the human health. Concentrationofvariouselementswhenpresentinmorethancertainspecified limits have considerable health hazard.

The recommended limits for concentrations of inorganic constituents in drinking water for human beings have been in use for many years. Acceptable standards vary from country to country.

Present study was undertaken for investigating chemical composition of groundwater, identifying the chemical evolution of groundwater, delineating the processes controlling the groundwater chemistry and assessing the groundwater quality for human uses.

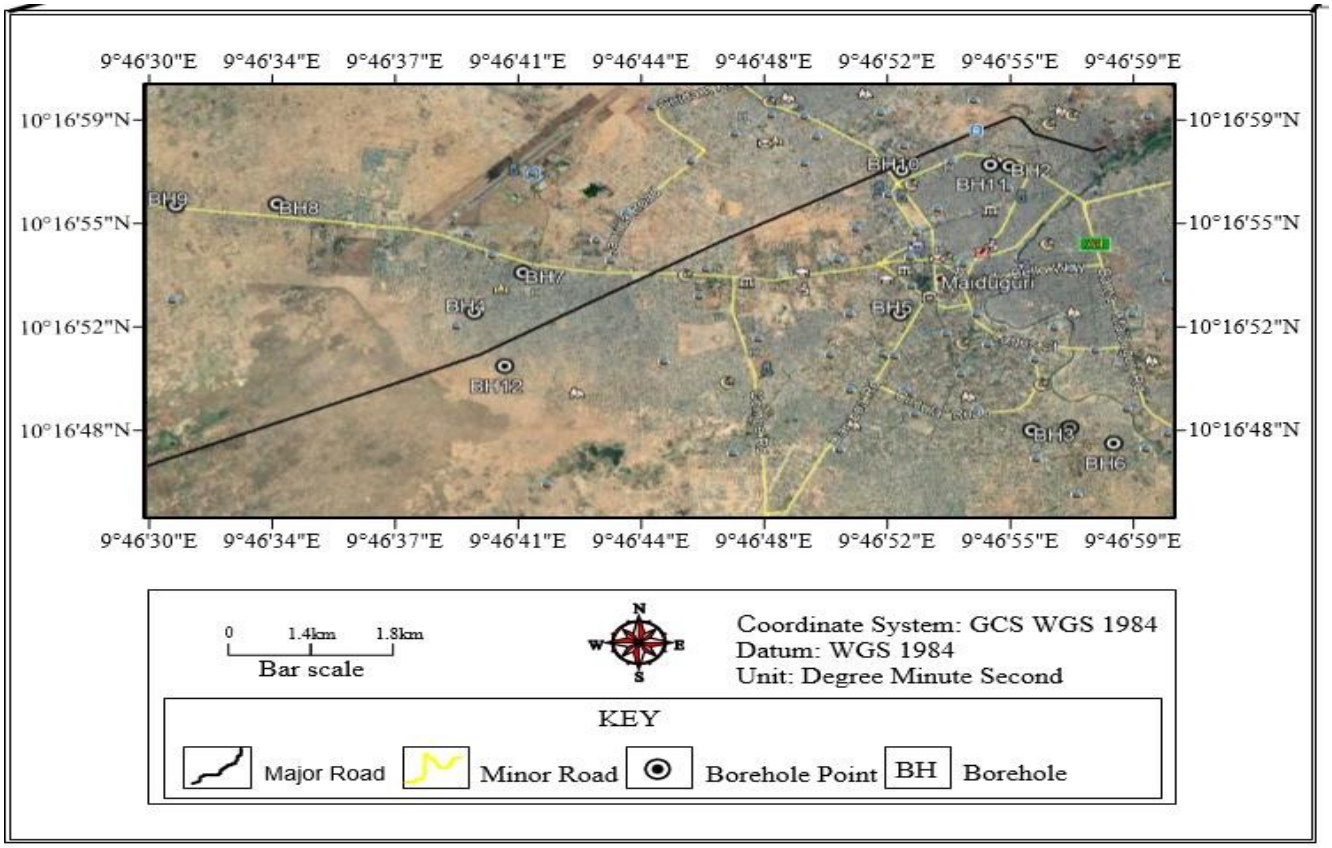
II. AIM AND OBJECTIVES

The study was conducted to determine the element present in the groundwater and theirimplicationonhuman environment and als of orthedeterminationofqualityof water consumed bypeopleliving within the city. The studyis carried out bytaking samples of water from shallow boreholes in the study area for laboratory analysis, with the objectives of;

- Toanalyzetheevolutionofthehydro-chemicalparametersin groundwater.
- Todelineatetheprocessescontrollingthegroundwaterchemistry
- Toassessthequalityofgroundwaterfordomesticuse.

III. LOCATION AND ACCESSIBILITY

Maiduguri,theareaofstudyisthecapitalofBornostate,anditsituatedattheNorth- Eastern end of the country. It falls within sheet 90º NE of the Federal Survey of Nigeria.Thecityhaswithinlatitudes11º 48'Nto11º 55'Nandlongitudes13º 04'E to 13º 14'E.



Geologicmapofthestudyarea.

A. Relief and Vegetation

The Maiduguri metropolis is located within the semi-arid region of Nigeria. The surface Geology consists of fine-grained sand, silt and clay. They are neither cemented norlithified. Thesediments belong to quaternaryage and mayhave been deposited under transitional environment conditions (Thambyapilley 1982). The vegetationcanbedescribedasSahelSavannah (ThambyapillayG.G.R1988).This simplymeansthatithasascantyvegetationcover.ThetreespresentareAcasiaS.P. Neeme (mostly Xerophytes e.g., desert plants).

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B. Geomorphology and Drainage

Maiduguri metropolis is generally flat or plain with slight variation in relief. The Southern part around the airport rises up to 340mabovesea level and appears to be thehighestelevationofthewholeareas.Theselectedareameasures320mabovesea level. The area is generally float without any remarkable topographical features.

The only major river in the area is River Ngadda passing through Maiduguri metropolis and empties into Lake Chad.The River Ngadda is the major drainage pattern. This runs in a northern direction striking the Bama Bridge passing through Maiduguri North-East towards Lake Chad. RiverNgaddaflowsthroughasedimentary lowland and has a lot of meanders that has been cut byflowing streams, which are then filled by alluvial deposits.

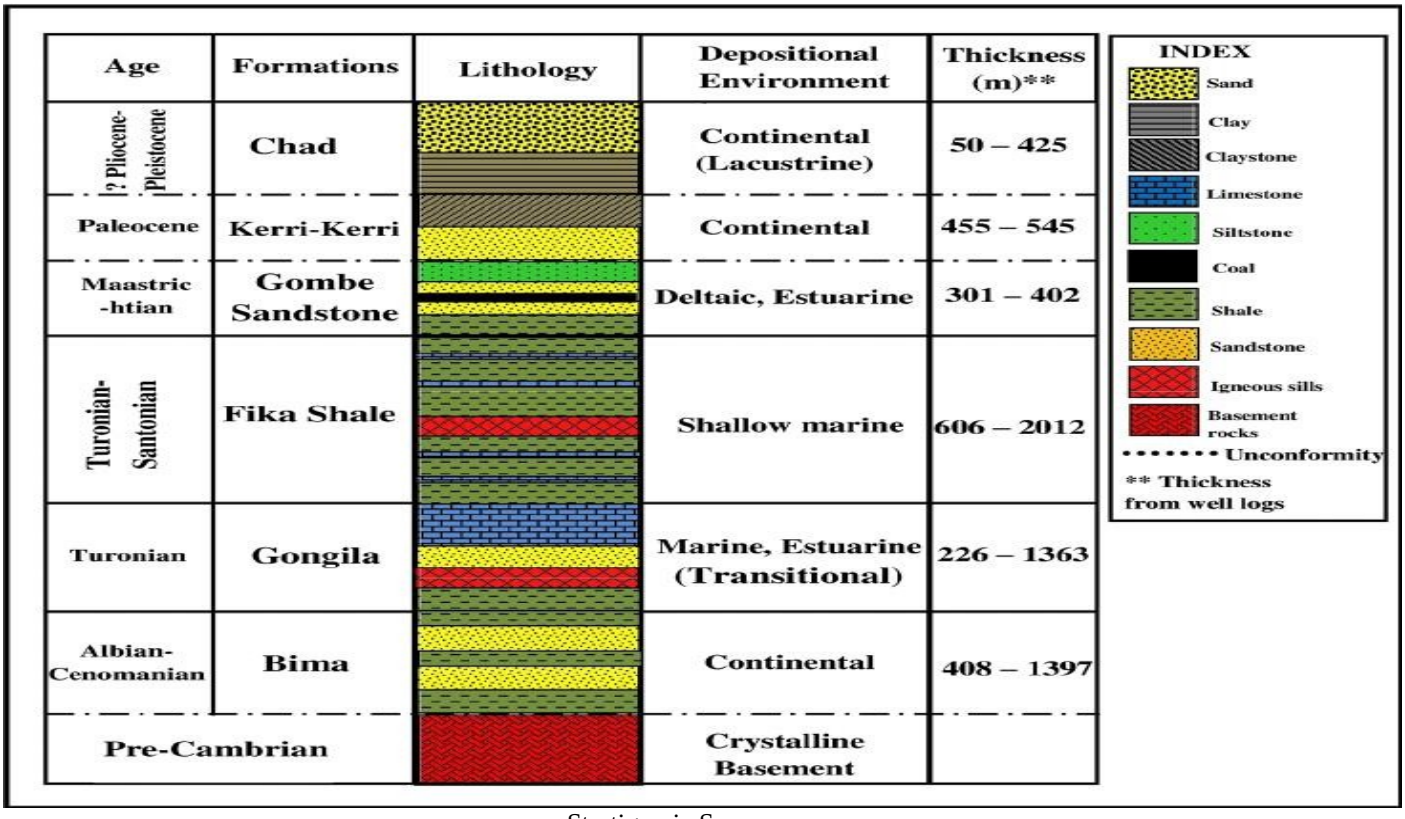
IV. LITERATURE REVIEW

A. THE BORNO BASIN

TheBornoBasinoccupiestheNorth-EasterncornerofNigeriaandislocated within latitude 10º 20-13º 14'N and longitude 9º 40'- 14º 50'E (Fig. 1). The Nigerian sector occupies about 900,000km2 and the Lake Chad is located at its centre. The Chad basin is the largest entra cratonic basin Africa. It is located to the East of the West African craton and lies between two other intracratonic basins, KufratotheNorth-EastandCharitotheSouth.ItextendsintopartsoftheRepublic of Niger, Chad, Cameroon, Nigeria and Central Africa. The Southern boundary of the Chad basin is the Zambuk ridge which separates the basin from the adjacent upper Benue Valley. The Zambuk ridge stretches North East wards from Gombe through Biu (Borno State).

B. GEOLOGY OF CHADBASIN

The Borno basin is a broad sediment refilled depression, initiated by a strong epeirogenic movement during the mid-Mesozoic time when continental sedimentation commenced. The geological history started during the upper cretaceous (Albian) when an over 600m thick of Marine sediments were deposited on the pre-Cambrian basement, known as the pre-Bima formation. Matheisis 1974 in Kogbe (1976) Geology of Nigeria. Reyment (1965) describes the stratigraphy andlitho-stratigraphyofthedifferentdepositionalsedimentintheBornobasin.The stratigraphic sequence is shown in the Table below and the litho-stratigraphy is also outlined accordingly.



Stratigrapic Sequence

C. BIMAS AND STONE

ThelateJurassic-earlyCretaceousperiodismarkedbymainlyfluviatesedimentsas represented by the Bima sandstone. This pre-lift sequence has not been adequately dated due general lack of fossil evidence. It is probably upper Albian to lower Turonian.
TheBimasandstoneoverliesthecrystallineBasementcomplexunconformably.Theformationvariesinthicknessandthinsalongthe Zambukridge.Thesedimentsrange frompoorlysortedandthicklybeddedfeldspathicsandstonesandconglomerates,to fluviatile and deltic deposits. The thickness is about 3000m.

D. GONGILA FORMATION

This formation is a transitional sequence between the continental Bima sandstones and the Marine Fika shales. The base of the formation is distinguished by the appearanceof marine limestone overlying the Bima sandstone alternateswithshale andsandshale.TheformationislowerTuronianinageasindicatedbythepresence of Turonian Ammonites, Regments (1965). Its thickness is about 420mBarber and Jones(1960).

E. FIKASHALES

These are marine shales of upper Turonian to Senonian in age. The formation thickness towards the Centre of the basin and varies laterally and vertically in thickness from 100m in Potiskum to 50 around Maiduguri. Fika shales overlie the Gongila formation and consist of the blue-black shales, occasionally gypsiferous with thin limestone intercalations. This formation is exposed around Fika town in Yobe State.

F. GOMBE SANDSTONE

The Gombe sandstone is a sequence of estuarine and deltaic sandstone, shales, siltstones and iron stone. It is slightly inclined west wards dipping at less than 10◦, but the overlying Kerri-Kerri formation is horizontal. Therefore, there is a distinct angular unconformity. This sandstone unit was deposited as a result of regressive phase. The formation has a thickness of about 320m and its trichian in age.

G. KERRI-KERRI FORMATION

The kerri-kerri formation resets unconformable on the cretaceous sediments. It is a continental sequence composed of quartz, poorly sorted sandstone, sandy clay and silt (Kogbe1976). Ooliticinterites are observed at the base of the Chad formation and this marks the top ofthe Kerri-kerri formation. Thesedimentation was followed by a period of uplift and erosion (Matheis 1976). The sediments are barren of fossils, its thickness is about 130m and age is Paleocene to Miocene.

H. CHAD FORMATION

Thisistheyoungestlithostratigraphicunit.Itisavariablesequencethatincludesallquaternarysedimentsunderlyingthesurfacedeposits.Thisformationisessentialan argillaceous sequence in which arenaceous horizons occur. The Chad formation is thusasequenceoflacustrineandfluviatileclaysandsandsofquaternary/Pleistocene age. TheBama ridge consist part ofthis formation. It overlies the country North and East part Abakire and extend across the plain of Borno province to Lake Chad and beyond. Barber (1965), it has an average thickness of 500m. The formation varies lithologicallybothlaterallyandverticallyandtheclayunitsdepictdepositionunder turbulent conditions. The Chad formation is further sub-divided into the following members.

1) Uppersandstonemember S1
2) Upperclaymember CL1
3) Middlesandmember S2
4) Lowerclaymember CL2
5) LowersandstonememberS3

- *Lowersandstonemember(S3)*

It is composed of about 85-125m of light brown gravels, medium to coarse sandstone,sandyclayandclays,wellsorted,sub-roundedtosub-angularquartz.The transitions to the underlying formation Kerri-kerri are difficult to define with precision. It may be assumed that the boundary with the Kerri-kerri formation is refined by the presence of ironstone and sandstone.

- *Lowerclaymember(C12)*

This clay member is present between the lower sand member (S3) and the middle sand member (S2). It is encountered at depth 245-438m. Besides the unit is composed of clayey sand, with few gravel grains and some fragments of dark grey to blue-grey clay. Some ironstone-stained sand grains are also present, sometimes the clay fragments are varied.

- *Middlesandstonemember (S2)*

Itisencounteredfromdepthof226mandcanbeupto103mthick.Thisunitconsist of alternating beds of sands, sandy-clay and clay. The unit is composed of gravel, medium to coarse sand, yellowish, reddish, well sorted to moderately sorted, sub- rounded to sub-angular quartz. Few clays and silty-clay beds with shale fragments, grains of feldspars, iron ore and mica are probably present with fragments of granites.

- *Theupperclaymember(Cl1)*

This claymemberseparates theuppersand memberfromthe middlesand member. Itisencounteredatdepth of 18mandcomposedofgravellysilt, lightgreywithsome shale fragments. Sand grains with lateritic fragments, dark-grey clay with few carbonaceous plates.

- *Theuppersandstonemember (S1)*

ThisisthetopmostsandhorizonintheChadformation.Itisencounteredatdepthof 30m-90m and occurs as encountered lenses within the clay and clay silt. The sand of this member varies from fine to very coarse and may contain gravel. They are poorlygradedandfragmentsoffeldsparsarecommonatsomehorizon,butthebulk constituents are quartz. The grains are angular to sub-angular and may be iron stained.

I. ALLUVIALDEPOSITS

The youngest deposits are the river alluvium, deltaic and lagoonal clay-flats that blankets vast areas. With respect to supply of water, this formation is of great economicimportance.Ithasathicknessofover700minMaiduguriandzoneswhere the fluvio-lacustrine deposits are complete. Water bearing levels consisting mostly of sands and clayey sands are concentrated in three well defined horizons called AQUIFER.

J. STRUCTURALSTYLES

SeismicreflectiondataintheNigeriansectoroftheChadbasininvolvethebasement and results in horsts, grabens and related features. Movement along basement fault is translated into high angle faults within the overlying sediments. Detached faults whichprobablydevelopedinresponsestobasinaldeformationalsoboundwithinthe basin, such that there is an overall upward increase in fault. Frequently from the basement, there is a notable preponderance of high angel normal fault and paucity of reverse faults. This is indicativeofthedominance oftensional movement within the basin.

In cross sectional view, most of the faults can be seen to terminate beneath the regionalangular Tertiarysedimentation. Inplaceview,two majorfaultsystemsare recognised with the Nigerian sector of the Chad basin. These systems are: -

1) Laterally persistent, northeast-southwest trending faults that is numerically subordinate to the north-east-South tending faults.
2) Whereastheformersystemsaffectboththebasementandtheoverlyingsediments, the later system is restricted to the sediments.
3) The Northwest- Southeast trending faults in response to changes in the stress system after the santonian deformation.

K. PREVIOUS WORK

ThereaunderstudycomprisesoftheChadformationofBornoBasin.Thegeology of the Borno Basin has been extensively studied by the distinguished scholars (Federal Ministry of Mines and Power) Nigeria. Most of the research works in this formation has been centred on the geology, hydrogeology and hydrology of the Borno basin respectively. Some of the previous works include those of Matheis(1976)tittled“AshortReviewofthegeologyoftheChadBasininNigeria”,Kogbe(1076),“GeologyofNigeria”Reyment(1965),“AspectsofthegeologyofNigeria”Canned(Nig)Ltd(1976).

"AnnualreportfromboreholedrilledatFika"BarberandJones(1963)"Welllithologicalunitofboreholesdrilledat Maiduguri",andanessay submittedtotheDepartmentofGeologyUniversityofMaiduguri,byBashir(1982) captioned "The Geology of the Chad formation in Nigeria (unpublished).

The Chad formation is subdivided into several stratigraphic units, three which are water bearing (Aquifers). These are the upper, middle and lower sandstones members.Theunderground waterin theuppersandstones occurin thephreaticand confinedstate,whileinthemiddleandlowersandsitiswhollyconfined.Theupper member aquifer appears to be poorly permeable and the artesian aquifer of the middlememberisnotconnectedwiththephreaticzone.Itisparamounttonotethat it is middle aquifer sediment logical characteristic that forms the work of this volume. For Lithological log of these aquifers see the table below:

Table1:Welllithologiclogoftheupperaquifer

Depth From	(m) To	Description
111	144	Clay,yellowish-greywithironstainsslightlysandy. Clay, yellowish-grey shale, inter beds
144	240	Clay,yellowish-greyverysandy
240	247	Sand,brown-whitefinetomediumslightlyclayed Sand, brown coarse sub rounded, Feld spathic Sand, brown, coarse sub rounded.
247	299	Sand,brown,mediumtocoarseslightlyclayey.
299	286	Sandbrown,mediumtocoarseveryclayeyandshaley. Clay, yellowish grey, very sandy.
286	294	Clay,yellowish,sandyslightlyshaley.
294	309	
309	316	
316	399	
399	349	

V. METHODOLOGY

Groundwater samples were collected from thirty-two (32) boreholes within Maiduguri metropolis and some part of Jere and analyzed to reveal their physical and chemical characteristics. Purposive sampling was employed for obtaining data in the study area. This sampling technique was employed to sample and some specifically targeted boreholesin areas with characteristics such as population densityand proximity to some activities perceived by pollute groundwater. Based on the aim of the study, which is understand the qualityof groundwater especially its physicochemicalasrelates todepth, population density, activities perceived to causegroundwaterpollution and analyzed the evolution of hydro-chemical parameters in groundwater, the samples of the study area (32 locations). Prior to collection of the water sample, the 75ml plastic containers that were used for collecting and storage of samples for physicochemical analysis were washed with de-ionized water, and then three times with the sample water in order to avoid anycontamination. Then, the water samples were collected fromboreholes after 5 to 10 minutes of pumping to ensure the sample were through representatives of the aquifer. Field parameters such as PH, TDS and EC were measured with potable digital HANNA conductivity meters (model HI 98129). The water samples were analyzed for Ca, Mg, Na, K, Mn, Cl, SO4 and HCO3 were analyzed using UV/VIS spectrometer (lamder 35) and Cl, using titrimetric method according to APHA (1998).

A. Samplepreservation

The borehole water samples were preserved immediately after collection withconcentratednitricacid. Thiswasdone byadding10mlnitricacidto1literofwater sample. The resultant solutions were kept in a refrigerator for further analysis.

B. DeterminationofmajorionscontentbyAAS

Preparation of calibration curve

Calibrationcurvewerepreparedtodeterminetheevolutionandconcentrationoftheions in the sample solution. The instrument was calibrated using series of working standard. The working standard solutions of each major ion were prepared for standard solutions oftheirrespectiveionsandtheirabsorbanceweretakenusingtheAAS.Calibrationcurve for each major ion to be analyzed was prepared by plotting the absorbance as a function of major ion standard concentration.

C. Determinationofmajorioncontentofeachsample

Concentration of the major ions present in the sample was determined by reading their absorbanceusingAAS(Buckscientificmodel210GP)andcomparingitontherespective standard calibration curve. The major ion determination by absorption/concentration mode and the instrument readout was recorded for each solution manually. The same procedure was employed for the determination of elements in digested blank (soil only) solutions and for the spiked samples.

D. materials

Theequipment'sandinstrumentsusedinthestudywereallcalibratedtochecktheirstatus before and in the middle of the experiment. Apparatus such as volumetric flasks, measuringcylinderanddigestionflaskswerethoroughlywashedwithdetergentsandtap water and the rinsed with deionized water. All glass wares were cleaned with 10% concentrated nitric acid ($HNO_{3)}$in order to clear out any major ion on their surfaces and then rinsed with distilled-deionized water. The digestiontubed were soaked with 1% (w/v)potassiumdichromatein 98%(v/v)$H_2SO_4$and volumetricflask in 10%(v/v)HNO_3 for24hoursfollowedbyrinsingwithdeionizedwater andthendriedinovenandkeptin dust free place until analysis began. Prior to each use, the apparatus was soaked and rinsed in deionized water.

E. ReagentsandChemicals

Reagents and chemicals used for the laboratory works were all analytical grade: deionizedwater(chemicallypurewithconductivity1.5µs/cmandbelowwaspreparedin thelaboratory)wasusedfordilutionofsamplesandintermediatemetalstandardsolutions prior to analysis and rinsing glassware and bottles.

F. softwareused

Microsoftexcelwasusedfortheplottinganddistributionofthevariouselementsinthe study areas.

VI. RESULTS AND DISCUSSION

A. FIELD RESULTS

AtotalnumberofThirty-two(32)sampleswerecollectedatdifferentlocationsfrom water bearing formation on various boreholes.

SampleDescriptionandlocationofthesamples (table 2):

LOCATION NAME	SAMPLE NO	LATITUDE	LONGITUDE	ELEVATION
MAIRI	SP1	$11^0 49' 17"$	$13^0 11' 45"$	320M
	SP2	$11^0 49' 18"$	$11' 41" 13^0$	320M
	SP3	$11^0 49' 24"$	$13^0 11' 42"$	320M
	SP4	$11^0 48' 47"$	$13^0 11' 18"$	320M
	SP5	$11^0 49' 15"$	$13^0 11' 21"$	320M

KALERI (TORA BORA)	SP1	$11^0 49' 52"$	$13^0 11' 37"$	320M
	SP2	$11^0 49' 53"$	$13^0 11' 48"$	320M
	SP3	$11^0 49'54"$	$13^0 11' 56"$	320M
LONDON CIKI	SP1	$11^0 50' 21"$	$13^0 11' 12"$	320M
	SP2	$11^0 50' 27"$	$13^0 11' 13"$	320M
	SP3	$11^0 50' 33"$	$13^0 11'07"$	320M
COSTOM	SP1	$11^0 51'21"$	$13^0 10'05"$	320M
	SP2	$11^0 51'25"$	$13^0 10'8"$	320M
GWANGE	SP1	$11^0 49'43"$	$13^0 10'35"$	320M
	SP2	$11^0 49'55"$	$13^0 10'34"$	320M
	SP3	$11^0 49'52"$	$13^0 10'30"$	320M
	SP4	$11^0 49'42"$	$13^0 10'15"$	320M
	SP5	$11^0 49'43"$	$13^0 10'11"$	320M
	SP6	$11^0 49'54"$	$13^0 10'10"$	320M
	SP7	$11^0 49'44"$	$13^0 10'07"$	320M
	SP8	$11^0 49'55"$	$13^0 10'06"$	320M
	SP9	110 49' 45"	130 09' 58"	330M
	SP10	110 49' 37"	130 10' 19"	320M
BOLORI	SP1	110 51' 26"	130 08' 04"	320M
	SP2	110 51' 25"	130 07' 57"	320M
	SP3	110 51' 20"	130 07' 51"	320M
	SP4	110 51' 38"	130 07' 37"	330M
	SP5	110 51' 30"	130 07' 46"	320M
	SP6	110 51' 25"	130 26' 40"	320M
	SP7	110 51' 24"	130 07' 47"	320M
	SP8	110 51' 16"	130 07' 41"	320M
	SP9	110 51' 24"	130 08' 02"	320M

B. LABORATORY RESULTS

AtotalnumberofThirty-two(32)sampleswereanalyzedfordifferentlocations from water bearing formation on various boreholes.

Table3:physio-chemicalanalysesofgroundwatersamplesaroundMaiduguriandJere(mg/1)

S/N	Sample ID	Latitude	Longitude	pH	TDS	EC	Na	Ca	K	Mg	Mn	Cl	SO4	HCO3
1	MR 1	110°49'17"	130°11'45"	7.1	107	290	24	79	17	171.0	0.0	40.0	11	129.98
2	MR 2	110°49'18"	130°11'41"	7.3	90	240	28	48	17	2.25	0.1	26.0	12	207.4
3	MR 3	110°49'24"	130°11'42"	6.8	57	180	9	71	13	2.59	0.1	38.0	10	116.25
4	MR 4	110°48'47"	130°11'18"	6.8	66	200	14	64	14	1.71	0.0	30.0	8	123.43
5	MR 5	110°49'15"	130°11'21"	6.8	113	330	19	110	17	2.03	0.0	46.0	11	109.84
6	KLR 1	110°49'52"	130°11'37"	7.5	202	220	24	45	20	2.53	0.1	28.0	110	179.12
7	KLR 2	110°49'53"	130°11'48"	7.3	225	700	41	180	32	157.	0.0	60.0	8	168.09

										0				
8	KLR 3	110°49’54”	130°11’56”	7.2	97	280	22	67	16	1.99	0.1	34.0	10	141.54
9	LDC 1	110°50’21”	130°11’12”	7.6	657	240	17	57	23	1.58	0.0	40.0	11	165.93
10	LDC 2	110°50’27”	130°11’13”	6.8	672	910	24	280	30	1.53	0.0	114.0	13	152.87
11	LDC 3	110°50’33”	130°11’07”	6.7	1453	2930	56	540	49	0.33	5.5	37.2	14	188.82
12	CTM 1	110°51’21”	130°10’05”	7.4	97	231	28	42	11	2.8	0.1	30.0	6	158.87
13	CTM 2	110°51’25”	130°10’08”	7.8	86	324	14	99	14	1.87	0.1	18.0	8	511.43
14	GWG 1	110°49’43”	130°10’35”	7.5	163	420	48	110	33	1.7	0.0	50.0	10	138.87
15	GWG 2	110°49’55”	130°10’34”	7.3	352	760	70	140	44	1.3	0.1	84.0	12	222.87
16	GWG 3	110°49’52”	130°10’30”	7.1	169	360	42	57	22	1.42	0.0	42.0	30	154.65
17	GWG 4	110°49’42”	130°10’15”	7.2	143	390	31	95	20	1.12	0.1	54.0	15	190.49
18	GWG 5	110°49’43”	130°10’11”	1.2	412	890	66	170	27	0.88	9.5	45.0	11	190.67
19	GWG 6	110°49’54”	130°10’10”	7.3	967	304	25	270	14	0.69	0.1	102.0	9	183.91
20	GWG 7	110°49’44”	130°10’07”	7.1	675	280	44	23	16	2.19	0.0	38.0	12	161.39
21	GWG 8	110°49’55”	130°10’06”	7.1	342	400	60	30	23	2.5	0.1	48.0	8	173.83
22	GWG 9	110°49’45”	130°09’58”	7.8	765	910	62	95	16	1.33	0.1	80.0	7	354.67
23	GWG 10	110°49’37”	130°10’19”	7.6	657	240	17	57	23	1.58	0.0	40.0	11	165.93
24	BLR 1	110°51’26”	130°08’04”	7.8	69	190	28	23	17	2.78	0.1	22.0	5	243.45
25	BLR 2	110°51’25”	130°07’57”	7.2	79	220	29	39	15	2.52	0.1	32.0	7	185.74
26	BLR 3	110°51’20”	130°07’51”	7.4	98	220	28	42	11	2.8	0.1	30.0	6	158.87
27	BLR 4	110°51’38”	130°07’37”	7.8	76	260	13	100	12	1.87	0.1	18.0	8	511.43
28	BLR 5	110°51’30”	130°07’46”	7.5	211	240	16	86	12	1.93	0.0	30.0	7	180.56
29	BLR 6	110°51’25”	130°26’40”	7.3	243	220	12	97	12	1.45	0.1	28.0	8	211.56
30	BLR 7	110°51’24”	130°07’47”	7.8	322	190	28	23	17	2.78	0.1	22.0	5	243.45
31	BLR 8	110°51’16”	130°07’41”	7.2	417	210	22	37	18	1.82	0.1	22.0	11	209.78
32	BLR 9	110°51’24”	130°08’02”	7.5	94	250	24	50	21	2.95	0.1	26.0	10	211.46

Thetableabove,showstheresultsofthechemicalanalysesofthegroundwaterin the studyarea. The results show that the PH value of the water sample ranges from 1.2 to 7.8mg/l, TDS ranges from 57 to 1453mg/l, and EC ranges from 180 to 2930mg/l. these parameters fall within the optimum required range.

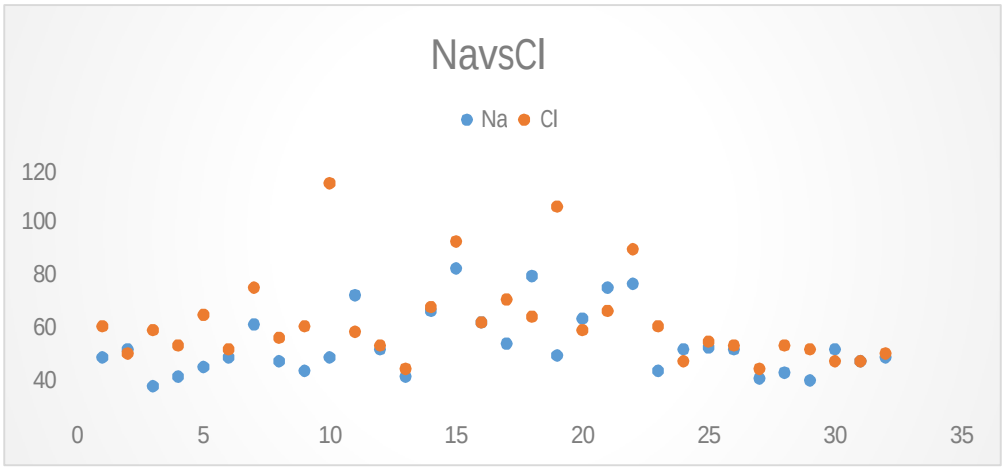
The major ions analyzed in the samples includes sodium (Na), potassium (K), calcium ((Ca), magnesium (mg), manganese (Mn), chloride (cl), sulphate (SO4), bicarbonate (HCO3). The concentrations of each of the major ions have ranges. Sodium ranges from 9 to 70mg/l, calcium ranges from 23 to 540mg/l, potassium ranges from11 to 49mg/l, manganese ranges from0 to 9.5mg/l, magnesiumranges from0.33 to171mg/l, chloride ranges from18 to 114mg/l, sulfate ranges from5 to 110mg/landbicarbonaterangesfrom109.84to511.43mg/l.almostalltheionsfall within the required range.

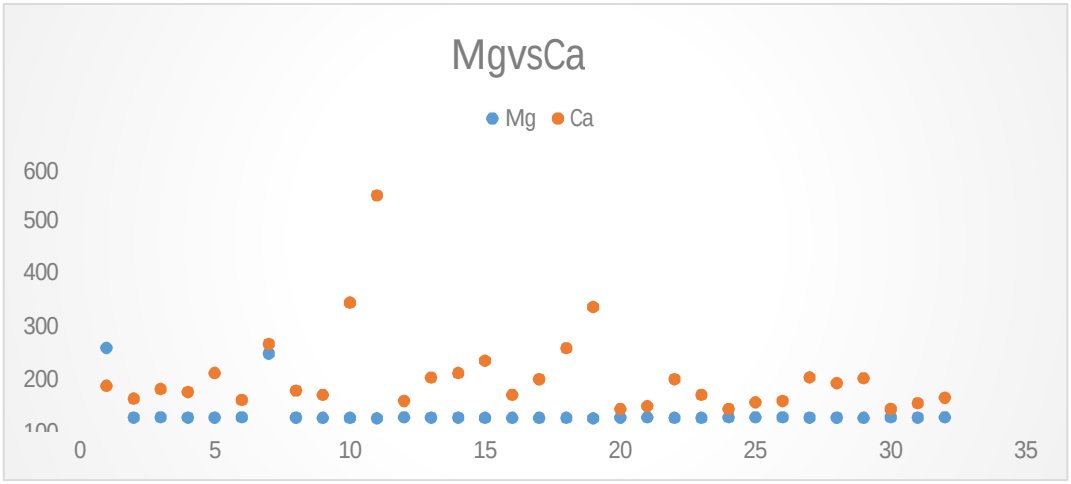
C. EVOLUTIONANDCHARACTERISTICSOFTHEHYDROCHEMICAL PARAMETERS.

Thecompositionsofgroundwaterarecontrolledbythechemistryofthemedium through which it passes the composition of groundwater furtherawaychangesduetorushingbyrepeatedinfiltrationevents(freezeandcherry,1979)andwaterrockinteraction(Edmunds*etal.*,1982).T herefore,it’simportanttonotethatthe discussionwillbeinsuchawaythatthebehaviorofeachionwillbetracedasit travels along the flow paths and suggestions will also be given as to the geochemical processes controlling such behavior.

1) Sodiumversus chloride

Sodium(Na)andchloride(Cl)concentrationsshowvaluesrangingfrom9to70mg/l and 18 to 114mg/l respectivelyin samples collected in (Table3). Theplot ofNa vs Clconcurrentincreaseanddecreaseconcentrationandalongflowpaths(figure below).The relationship between sodium and chloride is suggesting common source and most likely due to dissolution of the (NaCl).



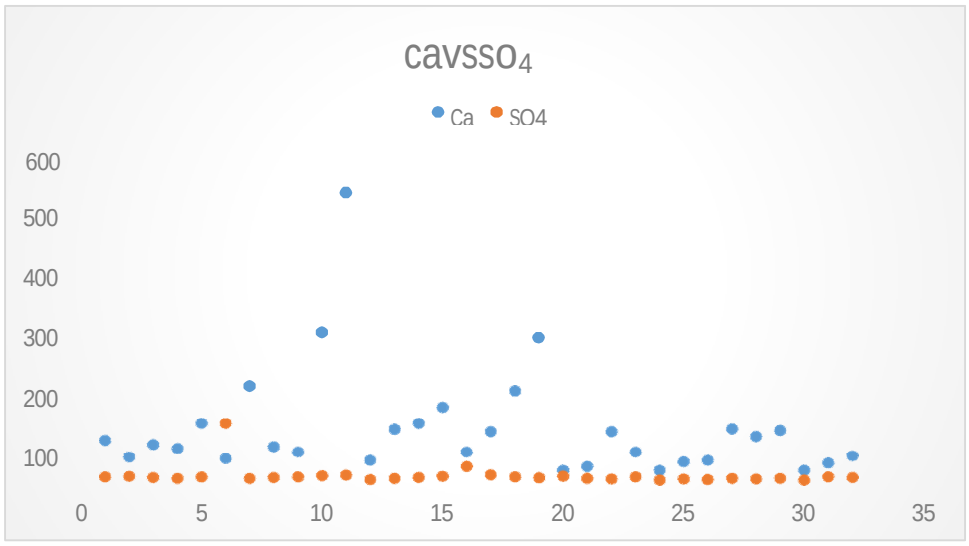


2) Magnesiumver Suscalcium

Magnesium (Mg) and calcium (Ca) concentrations show values ranging from 0.33 to 171mg/l and 23 to 540mg/l respectively in samples collected in (Table 3). The plot of Mg vs Ca has concurrent linear increment and linear increase and decrease withlittlescatterpointsforcalciumalongflowpaths(fig.4).Thepossiblesourceof these ions in groundwater could be explained by the dissolution of dolomite CaMg(CO3)2) . The plot of Mg and Ca (fig. above) show a progressive increase with each other. The linear relationship observed suggesting common evolution for Mg and Ca ions. Therefore, the dissolution of dolomite could be most likely source of these ions in the groundwater, since the mineral has the ions as its constituents.

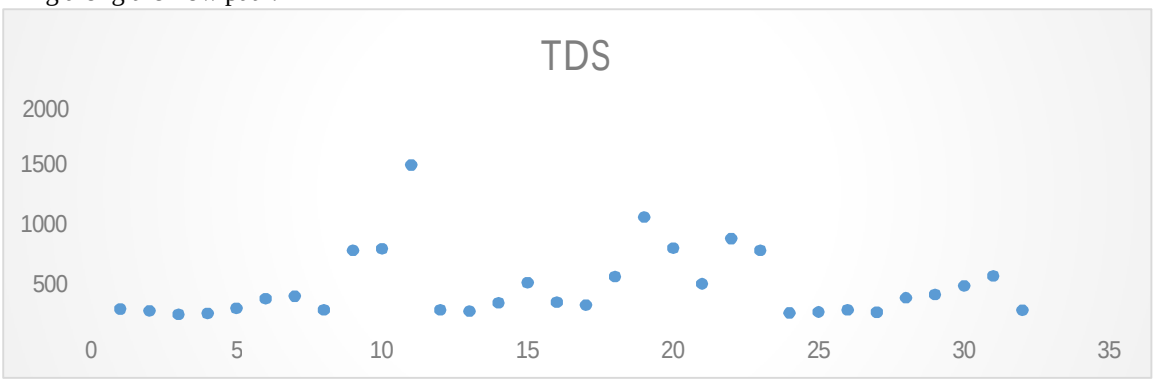
3) Calcium (Ca) and sulfate (SO_4)

Calcium (Ca) and sulfate (SO_4) concentrations show values ranging from 23 to 540mg/land5to110mg/l respectivelyinsamplescollectedin(Table3).Theplotof Ca vs SO_4 has a linear increment and concurrent linear increase and decrease with little scatter points for sulfate along flow paths. This shows some evolution characteristics between them (fig. below). The possible source of these ions in groundwater could be explained by the dissolution of gypsum $CaSO_4.2H_2O$.



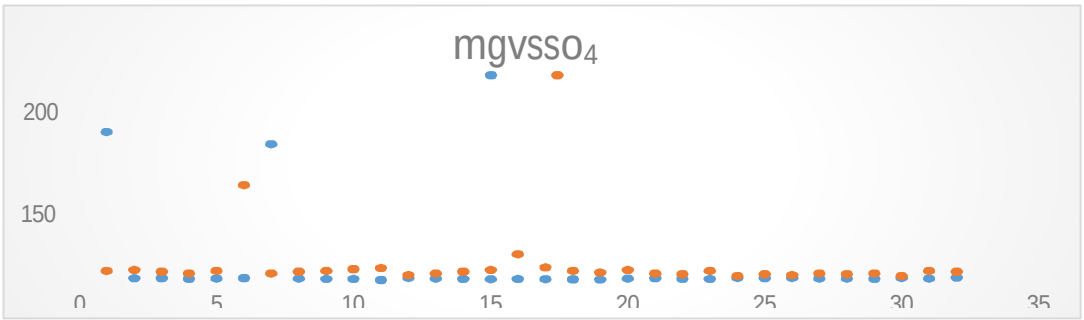
4) Totaldissolvedsolid(TDS).

Total dissolved solid concentrations show values ranging from 57 to 1453mg/l in samplescollectedin(Table3).TheplotofTDShasaconcurrentlinearincreaseand decrease with little scatter points along flow paths. The variability in the TDS observedintheplotcouldbeexplainedrelativetotheareaofrechargeanddischarge. The high TDS valueobserved in the plot of presumed discharge zone could be due to water rock interaction and increase residence time, whereas, the lower values of the plot could probably be explained by the fact that the water is in initial stage of flow and might not have enough time to dissolve the mineral occurring along the flow path.



5) magnesiumversus sulfate.

Magnesium (mg) and sulfate (SO_4) concentrations show values ranging from 0.33 to171mg/land5to110mg/lrespectivelyinsamplescollectedin(Table3).Theplot of Mg vs SO_4 concurrent linear increase in concentration along flow paths (fig. below). Therelationshipbetween magnesiumand sulfateis suggesting common sourceand most likely obtained from sea water.



D. QUALITYOFGROUNDWATERFORDOMESTIC USE

In this study, the quality of the quality analysis of borehole water from various locations in Maiduguri metropolitan and some part of jere was investigated to determine the condition of groundwater in the council following recent reflux of people with resulting increase in human activities.

WHODrinkingWaterStandardTable:

Parameters	units	WHOStandards
PH	-	6.5-8.5
EC	95µs/cm	400
TDS	mg/l	500-1000
Na	mg/l	200
K	mg/l	20
Ca	mg/l	100
Mg	mg/l	50
Mn	mg/l	0.1-0.5
Cl	mg/l	250
$S0_4$	mg/l	250
HCO3	mg/l	125-350

The result shows that the PH values of groundwater in all the locations ranges between1.2to7.8mg/l whichwaswithinworldhealthorganization(WHO)standard for drinking water. Electrical conductivity (EC) of the sample ranges from 180 to 2930mg/l95µs/cm and was within the world health organization (WHO) standard for drinking water, while the total dissolved solid (TDS) was ranged from 57 to 1453mg/l and where all within the stipulated limit. The major ions analyzed in the samples includes sodium (Na), potassium (K), calcium ((Ca), magnesium (mg), manganese (Mn), chloride (cl), sulphate (SO4), bicarbonate (HCO3). The concentrations of each of the major ions have ranges.Sodium ranges from 9 to 70mg/l, calcium ranges from 23 to 540mg/l, potassium ranges from 11 to 49mg/l, manganese ranges from 0 to 9.5mg/l, magnesium ranges from 0.33 to 171mg/l, chloride ranges from 18 to 114mg/l, sulfate ranges from 5 to 110mg/l and bicarbonate ranges from 109.84 to 511.43 mg/l. almost all the ions fall within the required range.

VII.SUMMARY AND CONCLUSION

Thestudyareaislocatedinnorthernpartof Maidugurimetropolis,andsomepartof Jere local government area of Borno state. The geology of the area is sedimentary, the study was conducted to determine the element present in the groundwater and theirimplicationonhumanenvironmentandalsoforthedeterminationofqualityof water consumed by people living within the city.

The physical and chemical analyses carried out on the water samples where to determinethePH,totaldissolvedsolid(TDS), electricalconductivity(EC),calcium, magnesium, potassium, sodium, sulphate, bicarbonate, manganese, chloride. The result of the physical and chemical quality of the groundwater from the study area were obtained. The data obtained from the chemical analysis were presented in form of scatter (X, Y) or bubble chart to show relationship between two different parameters.

Theanalysisoftheresultshowsthatthedissolutionofhalite,dolomite,gypsumandcalcitethatmayoccurwithintheaquifermatrixcouldberesponsibleforthe release ofsomeofthemajorionobserved.Therelativelyhighconcentrationofsomemajor ions in some samples could be attributed to ion-exchange processes.

VIII. RECOMMENDATION

The issue of supplying safe and reliable water is very serious issue because no development can be achieved without its provision. As such, it is important to note that each individual has a role to play most especially in the affected areas by not disposing water pollutants that are capable of infiltrating down to the groundwater level with resultant pollution.

Care has to be taken in unplanned digging of pits (latrines) and dumping of refuse or waste near boreholes and other water sources. All these inject toxic chemicals into the water source.

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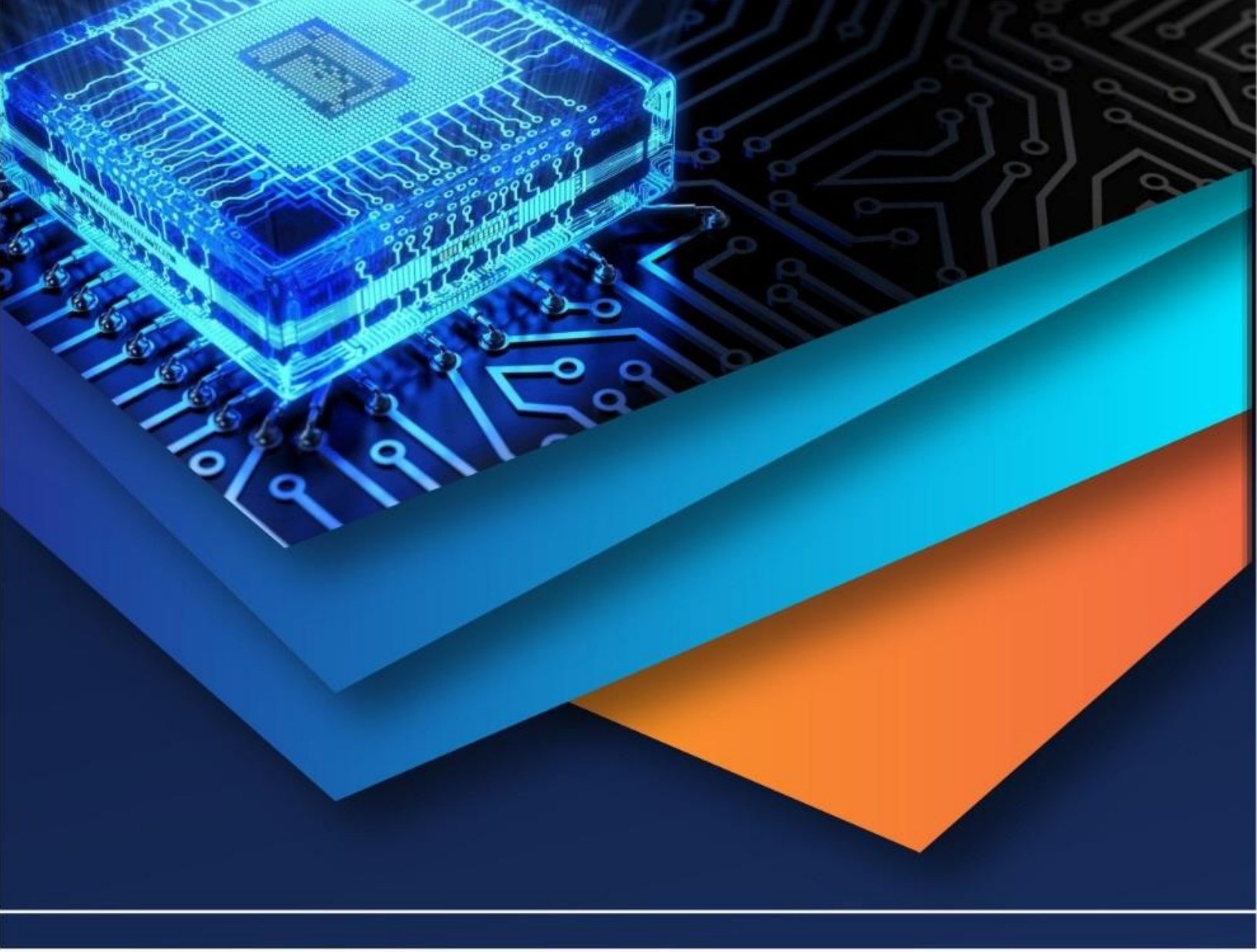

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