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Solar Cells: Module Temperature and Maximum Power Tracking

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Abstract
Photovoltaic cell has become the most utilized renewable energy resource for the production of power directly from the sun radiations but it has comparatively lower efficiency than other power producing sources and is expensive too. Out of many reasons of lower efficiency of PV cells; some factors are studied in this work i.e. temperature of the module, maximum power point tracking (MPPT) and the efficiency of energy transformation. From the experimentation it was concluded that the rise in the temperature of solar cell, after an optimum level, declines its efficiency by 0.5% for each unit rise in temperature (/°C). So an appropriate method should be adopted to control the temperature of the panel. The energy conversion efficiency was increased with the reduction in the reflection of the incident rays coming from the sun, so that more photons are absorbed by the cell thus achieving increment in energy conversion and MPPT adjust the working point of PV cell under varying intensity of sunrays which is achieved when the tracker changes the solar cell's equivalent load.

Key Words: Module Temperature, Maximum Power Point Tracking, Energy Conversion Efficiency

1. Introduction

In late 1900s, as the journal "**Solar Energy Materials**" was issued, PV cells have been exceptionally enhanced. Global industries have been offered ascend by PV technology, these industries can generate numerous Giga watts (GW) of yearly additional nominal capacity (Smestad, 2008). The usage and supply of energy is hindered by many factors including the environmental ones like global warming, polluted air, acid precipitation, damage to forests and harmful substances emitting radioactive rays. Enhanced efficiency in "Energy conservation", less usage of fossil fuels and increased usage of biodegradable energy resources, combination of these things can help in devising feasible ideas for solving and prevent the above mentioned energy issues.

Power production by solar cell system has proved to be very helpful in solving many ecological problems thus it has gotten extraordinary consideration from researchers (Wai, Hang, 2008). Energy coming from sun is the solar energy and by converting this energy in using PV cell we get DC electricity. Different semiconductor materials are used for making PV cells. The materials which conduct electricity as it is exposed to heat energy or light energy are known as semiconductor materials. And when temperature is low, they act as an insulators. Solar cells transform the light energy to charge transporters once light strikes the cell. The separation of charge carriers that are positive i.e., holes and negative called electrons (produced by photons of sun light) is been done by the Electrical field which is present over the junction. In this manner, when the circuit is closed on an outer load, electric current is deduced or squeezed out. The efficiency of PV cells depends on certain parameters. This paper refers to the analysis of the parameters influencing the productivity of solar cells in accordance with the scientific literature. These parameters include variation in temperature of solar cell and utilizing MPPT along PV cell and energy.

2. Description of Solar cell

It is for the most part characterized as the electric voltage's presence between two electrodes appended to strong fluid framework after bright light fallen on to this framework. Voltage in this case called photo-voltage is produced over a p-n junction in a semiconductor which is a part of every PV panel. These photovoltaic cells are also named as solar cells. In **Figure 1** a traverse area through a PV cell is appeared. To consume most part of the solar spectrum, semiconductor materials should own this ability. Light absorbed by PV cell depends upon the absorption properties of the material and the area near the surface, more or less, would absorb the light. Electron hole pairs are created at the point when light quanta are integrated and they can achieve the junction if their recombination is counteracted where electric field causes isolation between them (Goetzberg, Hebling, Schock, 2003). In 1839, a French physicist, Edmund Bequerel, initially noticed the photoelectric phenomenon, he came to know that a little measure of electric current would be created by the specific materials when exposed to Sunlight (Singh, Ravindra, 2012) (Benghanem, Al-Mashraqi, Daffallah, 2006).

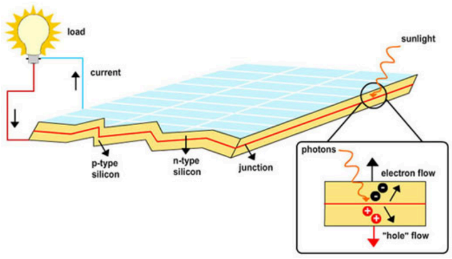

Figure 1: Schematic typical Solar cell

The Sun based impact of semiconductor material is the hypothesis of the PV cell. The process in which energy is absorbed by the semiconductor materials, after which electron hole pair comes in excited state producing electromotive form (emf) which is created by the bombardment of photons on the cell, is called solar effect. With the intensity of sunlight, variations occur in PV cell's current-voltage (IV) characteristics and cell temperature (^{O}C) is I=f (V, S, t). The equivalence PV cell circuit, as shown in **Figure 2**, which hypothesis of gadgets indicates, when the pure resistance is load [6].

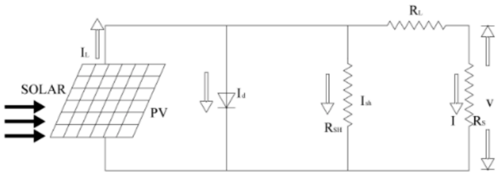

Figure 2: Equivalent circuit of **PV** cell

3. Efficiency factors of PV cell

3.1. Temperature of PV Cell

Due to increment in temperature the intrinsic semi conductor's band width contract and the voltage of open circuit (V_{OC}) diminishes taking after the voltage temperature of p-n junction that dependents on diode component q/kT .In this manner the temperature coefficient of PV cell is negative of V_{OC} (β).In addition the same photocurrent in light is given at the result of lower yield power because of the fact that the lower potential is required to free the charge carriers. Lower hypothetical maximum power $P_{max} = I_{SC} \times V_{OC}$ is a result of decrease in V_{OC} which is found by utilizing the tradition presented with the calculation of fill factor. Same short out current (I_{SC}) is given by the $P_{max}=I_{SC}\times V_{OC}$ [8].As the temperature expands the intrinsic semiconductor's band gap shrivels which means that the more incident energy is assimilated in light of the fact that a more noteworthy rate of occurrence light will have sufficient energy for the electrons of the valence band to travel towards conduction band (producing electrical energy). I_{sc} increments for given shielding, is a result of bigger photocurrent and the temperature coefficient of PV cell is positive of I_{sc} (α) (Mills, 2004).

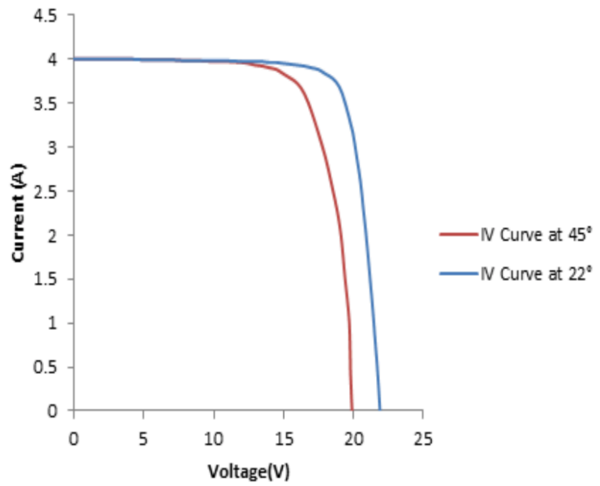

Figure 4: IV characteristic curve of PV module at different Temperatures

IV and power curves with the variation of temperature is been shown in **Figure 4** and **Figure 5** respectively [9]. Crystalline silicon cell-based modules have the temperature impacts that are the aftereffect of intrinsic characteristics. They tend to drop the voltage by creating high voltage, also on the other hand in high temperatures, voltage decrease. Any solar system lower in count should include this change in temperature's impact (Kawamura, Naka, Yonekura, 2003).

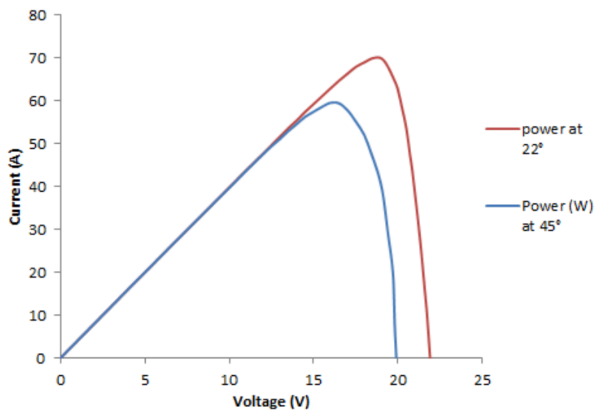

Figure 5: PV curve of solar cell at different temperatures

3.2. Efficiency of Energy Conversion of PV Cell

Efficiency (η, eta) of PV cell to convert energy depends upon output power that been achieved (in the form of percentage) by the taking the energy from photons and converting it into electrical one by connecting it in an electrical circuit and then storing it. This term is computed utilizing the proportion of the positive extreme point of power denoted by "$\mathbf{P_m}$", separated by the product of the surface region (**Ac** in m2) of the solar cell and solar irradiance denoted by “**E”** measured under standardized test conditions (taken as input measured in units watt per square meter, W/m^2).

But the efficiency of PV cell in energy conversion is low which demands two things, first one is the need of extensive areas for adequate insulated protection and the second one is our considerations about inimical proportions of required energies for cell generation in comparison to that of gathered energy (energy that’s been collected) (Teo, Lee, Hawlader, 2012). By the reduction in the reflection of incoming solar radiations, the efficiency of the solar cell can be improved in terms of energy conversion and this reduction in light reflection can be achieved by these two strategies:

1. To use a type of optical coating known as AR (antireflection) covering to lessen the deviation of light.

2. To finish the surface of the cell with such texture that confines the incoming light coinciding with it.

It’s been demonstrated that the ability to sense the spectrum of light of a SILICONE PHOTO DIODE could be improved fundamentally and expand its range having profound UV at its one end and covering the majority of visible light region of spectrum, this enhancement occurs when the light has any change or transformation in its wave-length. Based on its type solar module has an alternate spectral reaction. Along these lines, any variation in the input irradiance spectrum would impact the production of solar power. The estimation of solar spectrum is being done by using a black body of 5900K which turned out to be an expansive spectrum range with ultraviolet on its on end and near infrared at its other. The function of a semiconductor, then again, is to just convert the energy of small energy packets called photons from the incoming sunlight (having the energy equal to the band gap of semiconductor) into electrical one and achieve great efficiency. Energy of the photons should be equal to that of band gap, in case of high energy photons (having higher energy than that of the required amount) get their energies lessened to that of the gap energy by thermalization and in case of low energy photons, they are of no use as they don’t get retained or absorbed.

3.3. Tracking of Maximum Power Point (MPPT)

Right now, PV cell efficiency span around **39.9%** which is comparatively low and it ought to be enhanced ought to be enhanced with different strategies. The critical technique which is used for this purpose is MPPT which is maximum power point tracking. The DC to DC high efficiency converter works in the combination with MPPT, representing a favorable yield power. The cell generated current at short circuit (where voltage is zero) is equivalent to that of produced by the photons symbolically represented as I_L. The V_{OC} , is the voltage in an open circuit where current is zero, could be calculated without much of a stretch. In case of open or short circuit no power is obtained. The energy conversion device produce maximum power “P_{max}” shown as a point in the figure of IV characteristic curve and its position speaks to the biggest range of the rectangle appeared.

At the point when there is less yield voltage of array of PV cells, there would be little variation of yield current accordingly to voltage, hence in this case we can say that PV cell is a source that provides constant current. But if the voltage value of a PV cell is over significant value and keeps up its increment while the value of current declining rapidly at the same time then in this case the PV cell would be in resemblance to that of constant voltage source. With the continuous increment in the voltage values there would be a maximum power point in the yield or output power. The maximum power point tracker works in a way that the PV array or solar cell gives maximum output power by working on its maximum power point while the temperature and solar irradiance or intensity of sun radiations are varying which is achieved when the tracker varies the solar cell’s equivalent load (Ma, Wu, Sun, Liu, 2009).

4. Conclusion

The elements influencing the efficiency of a PV cell are inspected in this paper. These elements include variation in temperature of cell, utilizing MPPT along PV cell and energy transformation efficiency of the cell. Inherent characteristics of a PV cell results in the form of temperature impacts. When temperature is low, high voltage is produced, and high temperature causes voltage to decline. Energy conversion efficiency can be increased as a result of decreased reflection of incident light. To make variations in PV cells arrangement’s taken load is the functionality of MPPT which in result enhance the output power by allowing PV modules to work at their optimum point (maximum power point).For the enhancement of PV cell efficiency it’s very important to have positive variations in these factors. It is economical to achieve immense advantages of the electrical power produced by PV modules when these cells work at favorable conditions. The optimum conditions for the working of PV cells that's been deduced from this paper are:

1. To decrease the cell temperature by using some cooling method either by using a Thermoelectric module or floating of panel into a liquid.
2. To use anti-reflection covering to decrease the reflection of sunlight causing increased energy conversion efficiency.
3. MPPT would make the PV cell to work at its maximum power point. Working of PV cells on the combination of these optimum conditions would cause an increase in its efficiency.

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Analysis of Ground Water Quality for Wudil Town Kano State, Nigeria

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Abstract
The need for potable water is necessary for the well-being of any community. The study was conducted to evaluate the groundwater quality of Wudil town Kano state (Nigeria). Groundwater samples were collected from 4 boreholes (wells) from high and low densely populated areas and analyzed for 10 water quality parameters, based on the analysis conducted it was observed that almost 70% of the parameters analyzed exceeded the prescribed limit for both WHO and NSDWQ standards for the case of the samples collected from densely populated areas, while the results of the samples for the low densely populated areas were found to be in conformity with the two standards. 25% were found to be within the two standards standard for the samples from both areas, while the remaining 5% were below the standards for the two areas respectively.

Key Words: Contamination, Groundwater Quality, Physicochemical Characteristics

I. INTRODUCTION

Ground Water originates from precipitation which infiltrates and goes down to water-bearing beneath the earth crust. It is well known that human health and survival depends upon the use of uncontaminated and clean water for drinking and other purposes. Most human activities involve the use of water in one way or other such as food, production, nutrition is dependent on water availability in adequate quantities and good quality (Howari F.M., 2005). It is estimated that approximately one-third of the world's population uses groundwater for drinking purposes and today more than half the world's population depends on groundwater for survival (Mohrir A., 2002). Data has shown that groundwater was less susceptible to bacterial regrowth (Niquette et al. 2001). The water supply for human consumption is often directly sourced from groundwater without biochemical treatment, and the level of pollution has become a cause for major concern (Sinha, 2004).

Groundwater resource is under threat from pollution either from human lifestyle manifested by the low level of hygiene practiced in the developing nations (Ikem, A. et al., 2002). With increasing industrialization, urbanization and growth of population, India's environment has become fragile and has been causing concern (Mohapatra and Singh, 1999). Pollution of water is due to increased human population, industrialization, use of fertilizers in agriculture and man-made activity (Rao et al., 2012).

Water pollution may result in transmission of infectious. The implications of waterborne bacteria and virus infection include polio, hepatitis, cholera, diarrhea, typhoid, etc. (Khan, T.A, 1997). Thus, contamination of drinking water from any source is of primary concern due to the danger and risk of water diseases. The World Health Organization (WHO*)* reported that 40% of deaths in developing nations occur due to infections from water-related diseases and an estimated 500 million cases of diarrhea, occurs every year in children below 5 years in parts of Asia, Africa, and Latin America (WHO, 2011).

In Northwest zone, Nigeria, the pollution of groundwater was traced to shallow water table that intercepts pit latrines and soaks away pits (Niquette et al. 2001) the water used for drinking purpose should be free from toxic elements, living and non-living organisms and an excessive amount of minerals that may be harmful to health. Pollution caused by fertilizers and pesticides used in Agriculture often dispersed over large areas is a great threat to fresh groundwater ecosystems. The probability that any particular chemical may occur in significant concentrations in any particular setting must be assessed on a case-by-case basis. The presence of certain chemicals may already be known within a particular country, but others may be more difficult to assess. The rate of human activities and the associated problems necessitate the need for regular assessment of the water bodies. (Niquette et al. 2001)

In Wudil groundwater is one of the main sources of water used intensively for domestic and agricultural purposes; human activities in developing countries including Nigeria contribute immensely to the poor quality of groundwater. The problems of water quality are much more acute in areas which are densely populated, with localization of industries. Importantly, groundwater can also be contaminated by naturally occurring sources. A number of chemical contaminants have been shown to cause adverse health effects in humans as a consequence of prolonged exposure through drinking water from various sources much of ill health which affects humanity, especially in the developing countries can be traced to lack of safe and wholesome water supply Kumar A (2004)

Water for human consumption must be free from living and non-living organisms, toxic elements and chemical substances in concentration large enough to affect health. Water system council (2007). The addition of various kinds of pollutants through sewage, industrial effluents, agricultural runoff, etc., into the water mainstream, brings about series of changes in the physicochemical characteristics of the water, which have been the subject of several investigations Water system council (2007).

In this study, different samples were collected from high and low densely populated areas to analyze the groundwater quality from the study area in wudil town from Kano state (Nigeria) through testing water quality parameters by comparing the results obtained with standards set internationally by world health organization and Nigerian standard drinking water quality in order to detect potential quality deviation.

II. STUDY AREA

Area of Study Wudil town is located on la titude 11.570317N, 11.869425N and longitude 8.779696E, 8.936728E of the Greenwich meridian as shown in figures 1 and 2. The 2006 population census put the population of the area at 185,189 with an estimated landmass of 458 km^2 The geology of Wudil falls within the Northern Nigerian basement complex rocks, consisting of non intrusive rocks formed during the Precambrian period (Olofin, 1987; Olofin and Tanko, 2002), as well as igneous and sedimentary structures. The major landforms that can be identified within the area are the river channels, a low terrace, the high terrace and the uplands plains (Olofin (1987). The three soil types found within the region are Lithosols, Hydromorphic and Regosols (Baba1979). The natural vegetation of the area is woodland, characterized by moderately tall grasses and scattered trees that are deciduous in nature. The present climate of the region is basically wet and dry season classified by Koppens as the Aw. The mean annual rainfall is about 850mm. But great temporal variations exist in the amount of rainfall (Olofin, 1987). The area lies within the seasonally fluctuating inter-tropical discontinuity (ITD) zone. The maximum rainfall is recorded in August with a sharp decline in September and an abrupt end in October; in some cases the onset of rainfall is irregular. The mean annual temperature in the area is about 26°C, but mean monthly temperature value ranges between 21℃in the coolest months of December/ January and 31℃ in the hottest months of April/May.

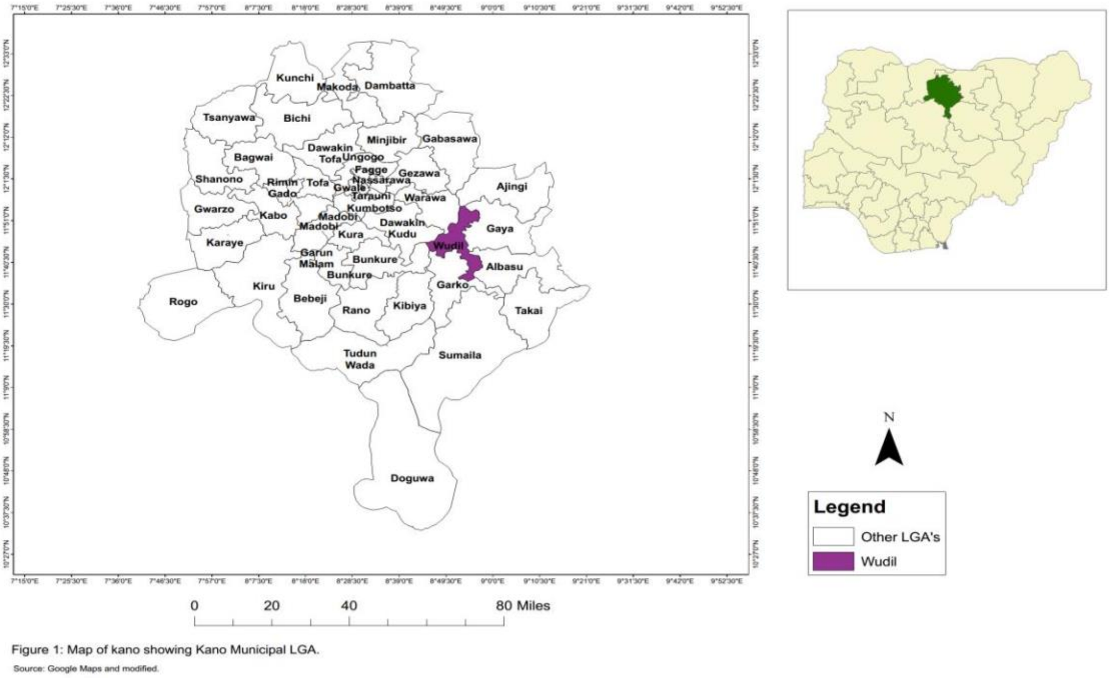

Fig. 1: Map of Kano State in Nigeria showing Wudil Town

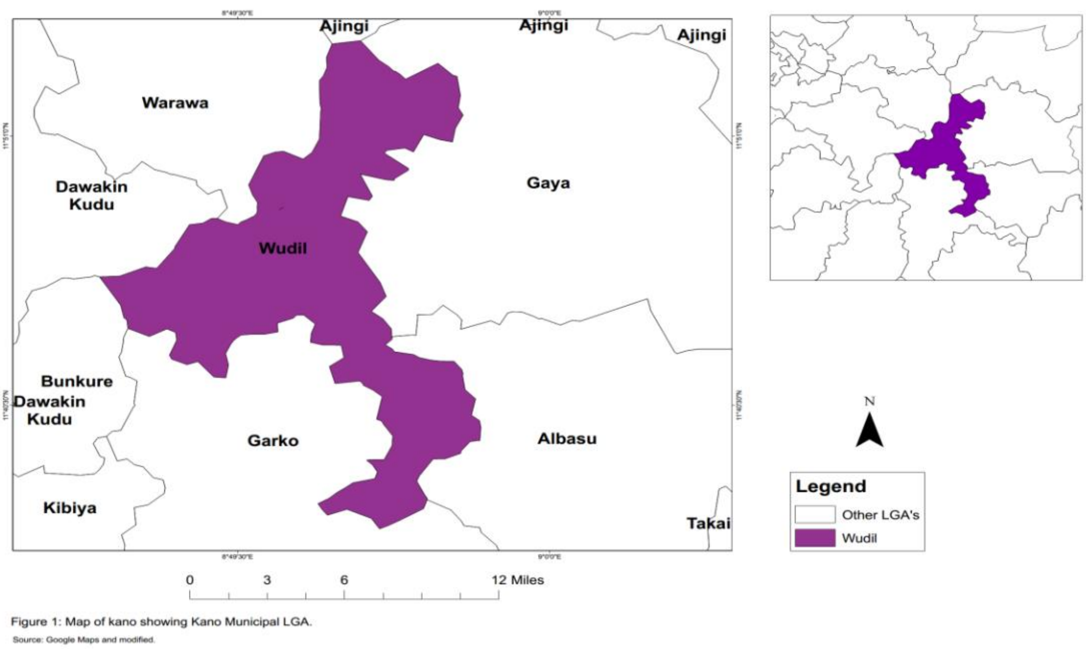

Fig. 2: Map of the Study Area (Wudil Town)

III. MATERIALS AND METHOD

Water samples were collected from boreholes (well) located in a high densely populated area like Unguwar Dafawa and Layin Yan Washi and low densely populated area like Layin Sabon Garin Bochieyle Layin Rijiya and Layin Masallaci in Wudil town, Kano State Nigeria. These samples were collected as per the standard methods prescribed for sampling. Plastic bottles of 1.5 liter capacity with stopper were used for collecting samples. Each bottle was washed with 2% Nitric acid and then rinsed three times with distilled water. Samples were analyzed to determine the concentrations of pH, Turbidity, Temperature, Total Dissolved Solids (TDS), Magnesium, Acidity, Electrical conductivity, Total Hardness, color, Alkalinity and Calcium in the laboratory of the Department of Civil Engineering Kano state university of Technology (KUST). The water samples were collected from the following areas shown in table 1.

Table 1: Samples Location

SAMPLE LOCATION	SAMPLE CODE
UNGUWAR DAFAWA	A
LAYIN YAN WASHI	B
SABON GARIN BOCHIEYLE LAYIN MASALLACI	C
SABON GARIN BOCHIEYLE LAYIN RIGIYA	D

mMeasured by a based model no: LPV 2550 t. 97, 2002 make HACH USA. Electrical conductivity (EC) and total dissolved solids (TDS) were measured with digital EC-TDS analyzer model No: CM 183, make Elico, India. Turbidity was measured by using Nephalo-meter model No: 2100 Q-01 make Hach USA. Calcium, Magnesium.Acidty, Alkalinity concentrations were determined by a spectrophotometer, using UV-Vis laboratory spectrophotometer (Model No: DR 5000) make Hach, USA. All the general chemicals used in the study were of analytical reagent grade (Merck/BDH).

IV. RESULTS AND DISCUSSION

A. pH

The pH of a solution is the negative logarithm of Hydrogen ion moles per liter. pH is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium. The pH ranged from 6.2 to 7.0 for all the samples, out of which two of the samples (C and D) had values between 6.8 -7.0 Within the NIS and the WHO Standards. While the remaining samples (A and B) had the values of 6.2 and 6.3 respectively which are below the two standards. 50% of the samples were below the standard limit (6.5 to 8.5) this could be attributed to the contamination of water with acid from agricultural and domestic activities.

B. *Temperature*

The maximum water temperature was observed 27.9^{0}C in S_A and minimum 21 .9^{0}C in S_C with an average value of 24.4^{0}C. The variation in temperature may be due to different timing of collection and influence of season (Jayaraman et al., 2003). Temperature controls behavioral characteristics of organisms, the solubility of gases and salts in water, No other factor has so much influence as temperature (Welch 1952).

C. Turbidity

The turbidity level ranges from 0 to 8 NTU, sample A having the highest turbidity value of 8 NTU which exceeded the limit for the two standards. Whereas other three samples (B, C, and D) were below the values recommended by WHO and NDWS permissible limit of 5 NTU. The high value recorded for turbidity may be as a result of the dissolution of solid phases into the underground water. It may also be as a result of precipitated calcium carbonate in hard water. Turbidity in water can stop light from reaching submerged plants and can raise water temperature. Turbidity may also contain particles that are toxic or help to accumulate toxic substances in water.

D. Colour

The values obtained ranges between 0-177 Pt-Co. Sample A having the highest color unit of 177 Pt – Co, followed sample B with a value of 107 Pt-co, sample D with 59 Pt-co and sample C with zero Value. The unusual high intensity of color at the source may be caused by the presence of iron and manganese, humus and peat materials. Colour is a physical parameter that is not necessarily related to toxicity or pathogenic contamination of water. Nevertheless, harmful color can create psychological rejection and fears, leading to limitation of water intake with consequent effects on personal health.

There is a relationship between turbidity and color values as shown in figure1. This is because when turbidity is not removed, "apparent color" is noted and it is possible that removing turbidity (filtration or centrifugation) may remove some true colors.

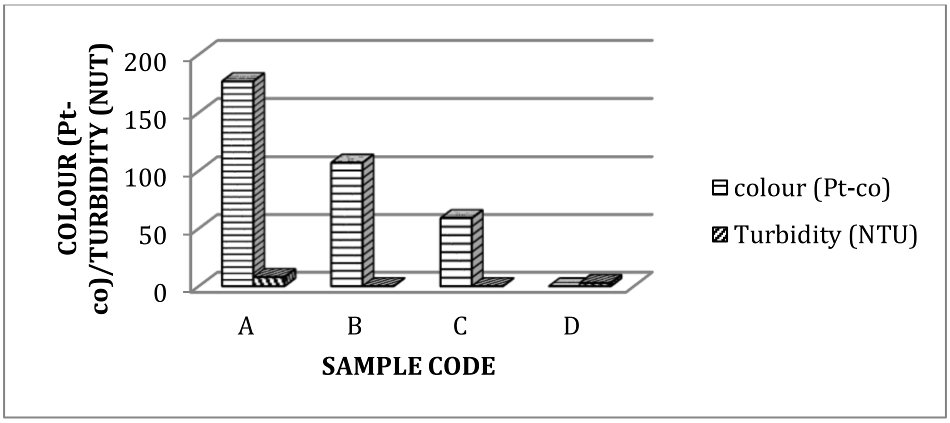

Figure: 1: Colour and turbidity of water samples

Table 2: Comparisons of the Range of the Samples to WHO and NDWS Standards of the high densely populated area (sample code of A and B)

S/N	Parameter	Permissible Limits as per the Standard		Experimental Results of the 2 Samples Range	Samples Exceeding Permissible Limit
		WHO	NSDWQ		No.
1	PH	6.85 – 8.5	6.5 – 8.5	6.2-6.3	A and B
2	Temperature	≤ 26	≤ 26	25.5-27.9	A
3	Electrical Conductivity	-	1000	2019-2360	A and B
4	Turbidity	5 – 25	≤ 5	8.0-0.0	A
5	Total Hardness	500	200	217-289	A and B
6	Total Dissolved Solids	1000	500	1270-1310	A and B
7	Manganese	250	-	139-152	None
8	Calcium	250	-	78-137	None
9	Alkalinity	500	100	104.5-260	A and B
10	Acidity	6.5	-	120.2-170.5	A and B

E. Conductivity

Sample D has the conductivity of 1658 µs/cm which lies slightly within the range, while the other three samples A, B and C have the highest values of 2360 µs/cm, 2019 us/cm,1958 us/cm respectively, these values did not agree with the NDWS and the WHO standard limit, usually samples with the highest conductivity values has the highest concentration of sodium. This is because conductance of water increases with salts.

F. Total Dissolved Solid (TDS)

Total dissolved solids of the water samples range from 828 to 1310 mg/L for all the samples. Sample A, B, and C having the highest values of 1310 mg/L, 1270 mg/L and 1197mg/L These samples did not agree with the NDWS and the WHO standard limit, while sample D has a value of 828 mg/L which is in conformity with the two standards. The higher the concentration of electrolytes in water the more is its electrical conductance. Total dissolved solids and conductivity can be used to delineate each other. In this study, conductivity is proportional to the dissolved solids as shown in figure 2.

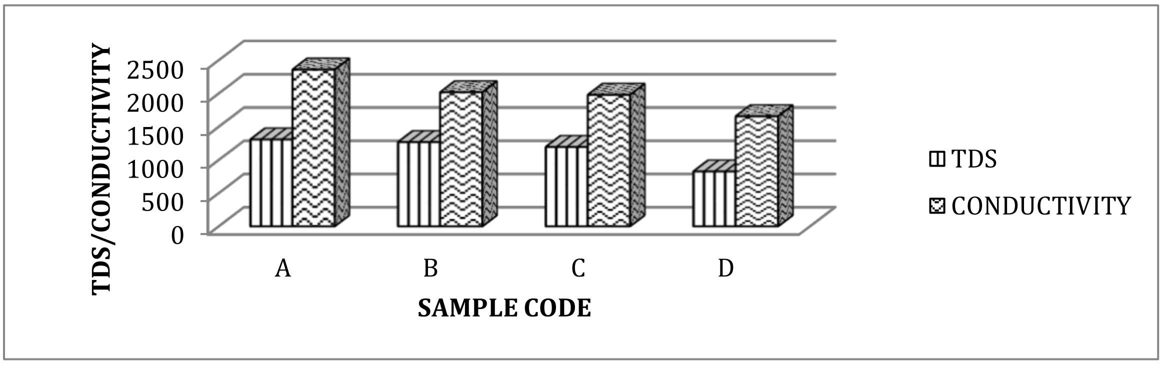

Figure 2: Total dissolved solids (TDS) and conductivity 0f water sample

Table 3: Comparisons of the Range of the Samples to WHO and NDWS Standards of the low densely populated area (sample code of C and D)

S/N	Parameter	Permissible Limits as per the Standard		Experimental Results of the 2 Samples Range	Samples Exceeding Permissible Limit
		WHO	NSDWQ		No.
1	PH	6.85 – 8.5	6.5 – 8.5	6.8-7.0	None
2	Temperature	≤ 26	≤ 26	21.9-22.2	None
3	Electrical Conductivity	-	1000	1658-1981	C and D
4	Turbidity	5 – 25	≤ 5	0.0	None
5	Total Hardness	500	200	154-162	None
6	Total Dissolved Solids	1000	500	828-1197	C
7	Manganese	250	-	40-103	None
8	Calcium	250	-	59-112	None
9	Alkalinity	500	100	144-231.6	C and D
10	Acidity	6.5		180-295	C and D

G. Total hardness, Calcium hardness, and Magnesium hardness

Hardness is one of the important properties of underground water from a utility view for different purposes. The water samples showed moderate hardness, ranging from 154 to 289 mg/ L.Water could be considered to be very hard if the value exceeds the NDWS and the WHO permissible limit. It is well known that hardness is not caused by a single substance but by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium ions, although other ions like barium, iron, manganese, strontium, and zinc also contributed. Very hard water is not good for drinking and is associated with rheumatic pains and gouty condition. Such water does not lather with soap and produces deposits in scaling in pipes, and steam boilers hardens vegetables and would not allow it to cook well. When used for bathing it tends to harden the skin or make the skin rough due to impregnation of insoluble calcium and magnesium soaps.

The calcium and magnesium levels ranged between 59 to 137 mg/L and 40 to 152 mg/L respectively. In this study, the total hardness was positively related with calcium and magnesium hardness as shown in figure 3, Samples A, B, C, and D have the values for the total hardness as (289,217,154,162) mg/L, calcium hardness as (137, 78, 112, 59) mg/L and magnesium hardness as (152, 139, 40,103) mg/L respectively. This is as a result of the significant effect of magnesium and calcium ions on the hardness of water.

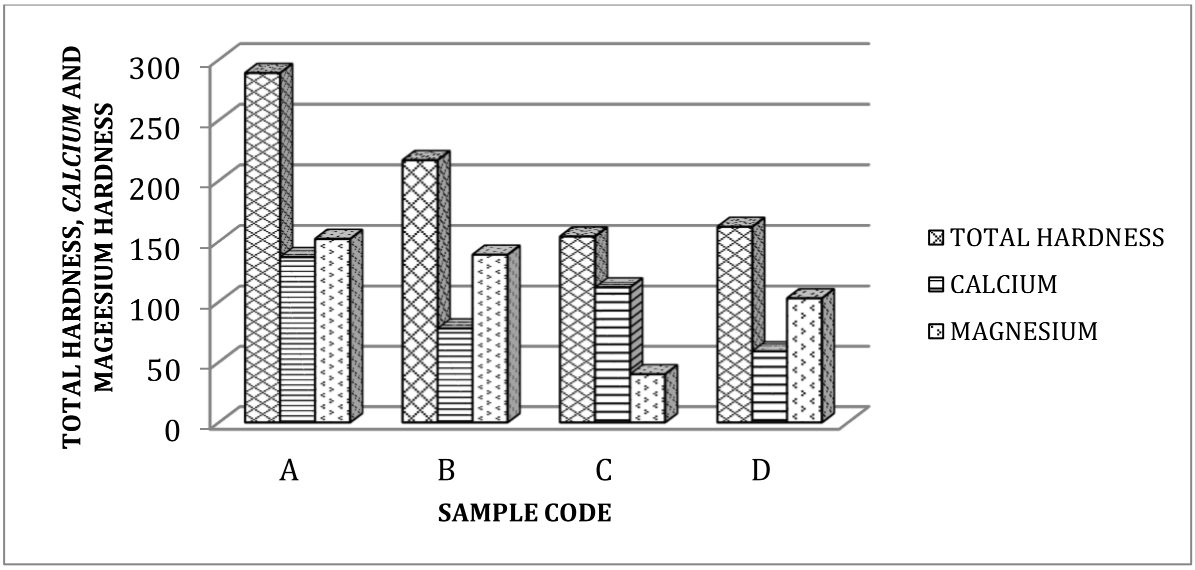

Figure 3: Total Hardness, Magnesium and Calcium Hardness of Water Samples

H. Total Alkalinity

The alkalinity for the samples ranged between 104.5 to 260.5 mg /L. Sample A and C were having the highest values of 260.5 mg/L and 231.5mg/L, while sample B and D had the least values of 104.5mg/L and 144mg/L respectively. All the samples were below the range of permissible limit of WHO of 500mg/L but exceeded NIS permissible limit of 100mg/L, the constituents of alkalinity in the neutral system include mainly carbonate, bicarbonate and hydroxide components.

I.Total Acidity

The acidity for the samples ranged between 120.1 mg/L to 295mg/L. Sample D, C, and B were having the highest values of 295mg/L, 180mg/L and 120.1 respectively, while sample A has the least value of 120.1mg/l. All the samples were out of range of the permissible level of the two standards.

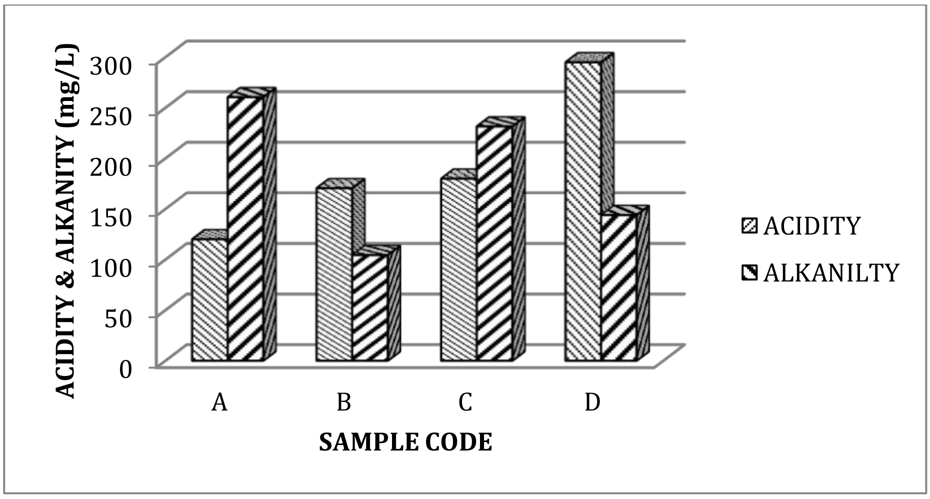

Figure 4: Acidity and Alkalinity of Water Samples

V. CONCLUSION

The present study clearly reveals that the sample collected from a high densely populated area is not suitable for the utilization of water. From the present study, the following conclusions were drawn:-

- The pH values of the high densely populated area exceed prescribed limit of both WHO and NSDWQ standard limit while low densely populated area value was within the prescribed limit.
- One of the temperature value of a high densely populated area exceeds limit while low densely populated area value does not exceed the prescribed limit.
- The electrical conductivity for both areas was exceeded the standard limit of WHO and NSDWQ.
- Turbidity value of high densely populated area exceeded the limit while low densely populated areas were within the prescribed limit.
- The hardness values of high densely populated area exceed limit according to NSDWQ while low densely populated area was within the limit.
- The calcium and magnesium for both two areas were not exceeded the prescribed limit.
- The total alkalinity values for both two areas were exceeded according to NSDWQ but according to WHO the values were within the limit.
- The total acidity value for the areas was exceeded the both prescribed limit of WHO and NSDWQ.

There is an immediate and urgent need for the implementation of a better water quality management policy incorporating the following recommendations:

VI. RECOMMENDATIONS

- Federal and the State Government are to construct and develop good boreholes which penetrate into the aquiferous zones while the local Government councils are to monitor the sanitary conditions of the communities.
- Proper planning and management sa r e required to mitigate the problem of drinking water contamination in the study area.

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