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Evaluating the Effect of Rainfall and Temperature Variability on Groundwater Table of Maiduguri, Nigeria

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ABSTRACT

Climate change has great influence on groundwater table. Ground water is the main source of water for drinking and irrigation in low rainfall arid and semi-arid areas where there are no sufficient surface water sources. The relationship between rainfall variability and groundwater is more complicated and poorly understood. The investigation uses 30 years (1982-2012) record of hydro-meteorological data. Over the same time, there has been a small, but significant increase in mean air temperature, which has resulted in a small increase in potential evapotranspiration. The Climate variability was evaluated using a simple approach, which considered variability as the difference between the mean monthly values of climatic elements and depth to water table within the times. The result of these findings, show mean monthly rainfall, maximum temperature, relative humidity and depth to water table ranged between 195.2 - 0.1mm, 1404.5 - 1012.20C, 76.9 - 14.1% and 22.7 - 6.2m respectively. In order to reduce their effects on groundwater level, more trees should be planted so that the amount of solar radiation reaching the earth surface will be reduced. Continuous studies on variability in climate need to be done to ascertain further extent on climate variability on the groundwater that will occur, as relevant planning could be maintained.

INTRODUCTION

Groundwater, one of the most important natural resources globally, is an important part of the global freshwater supply (Aizebeokhai, 2011). Ground water is the main source of water for drinking and irrigation in low rainfall arid and semi-arid areas where there are no significant surface water sources. Ground water is slow to respond to changes in precipitation regimes thus, acts as a more resilient buffer during dry spells. In fact, worldwide, more than 2 billion people depend on groundwater for their daily supply (Kemper, 2004). Furthermore, ground water forms the largest proportion (up to 97%) of the world's fresh water supply.

Maintaining surface water system through flows into lakes and base flow to rivers, ground water performs the crucial role of maintaining the biodiversity and habitats of sensitive ecosystems (Tharme, 2003). The role of ground water is becoming more prominent and yet it is poorly understood, as the development of groundwater supplies is particularly important for remote, rural communities to enable equitable access. In some places, it is under threat (Furey and Danert, 2014).

Increasing temperature and changing patterns of precipitation are among the many consequences, which are attributed to climate change (Dammo *et al.*, 2016). Temperature increase also affects the hydrologic cycle by directly increasing evaporation of available surface water and vegetation transpiration. Consequently, these changes can influence precipitation amounts, timings, and intensity rates and indirectly affect the flux and storage of water in surface and subsurface reservoirs (i.e. lakes, soil moisture, groundwater) (Toews, 2003). The effects of global warming on groundwater will depend on the ground water system, its geological location and changes in hydrological variables (Alley, 2001; Sophocleous, 2004; Huntington, 2006). Knowing how climate change will affect groundwater resources is thus important as it will allow water resources engineers to make more rational decision on water allocation and management and enable the formulation of mitigation and adaptation measures (Sallivan, 2001). De-vegetation particularly due to grazing and extraction of firewood destroys the plants that hold the soil together causing further soil deterioration. Firewood extraction is an important anthropogenic factor as firewood is the main source of domestic energy in the region (IPCC, 2007). There is general over exploitation of the aquifers as indicated by the falling water levels and the reduction in borehole yields (LCBC, 2010).

MATERIALS AND METHODS

Rainfall, Temperature, Relative humidity, Sunshine and water table data over a period of 30 years (1982 – 2012) were obtained. Rainfall, temperature, relative humidity, and sunshine data were compared to the ground water level data and analyzed graphically using the mean monthly rainfall, temperature, relative humidity and sunshine data and the mean monthly depth to water table, to ascertain their effects on the ground water table.

RESULTS AND DISCUSSION

Table 1 shows the climate data collected over the study period. Where, RF represents Relative Humidity, GW; Groundwater and TP; Temperature.

Table 1: Mean of Annual Monthly Rainfall (mm) and Depth to Water Table (m) data

Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
RF	0.0	0.0	0.5	4.9	30.6	82.6	94.5	195.2	98.6	15.7	0.0	0.1
GW	17.8	22.7	21.4	19.0	18.2	15.2	14.3	6.2	6.8	7.9	11.2	14.8
TP	1018.2	1012.2	1197.9	1224.3	1283.0	1095.4	1404.5	1013.6	1352.4	1159.3	1071.6	1038.7

Source: Ministry of Water Resources, Maiduguri, Borno State.

The seasonal variability of rainfall associated with the currently prevailing climatic change has spontaneously affected groundwater levels from year to year. Figure 1 shows the rainfall distribution for a period of 12 months. Increase in water table starts gradually from April and attains peak in August then decreases in October at which the depth to water table is shallow. Thus, indicating that rainfall affects the depth to water table.

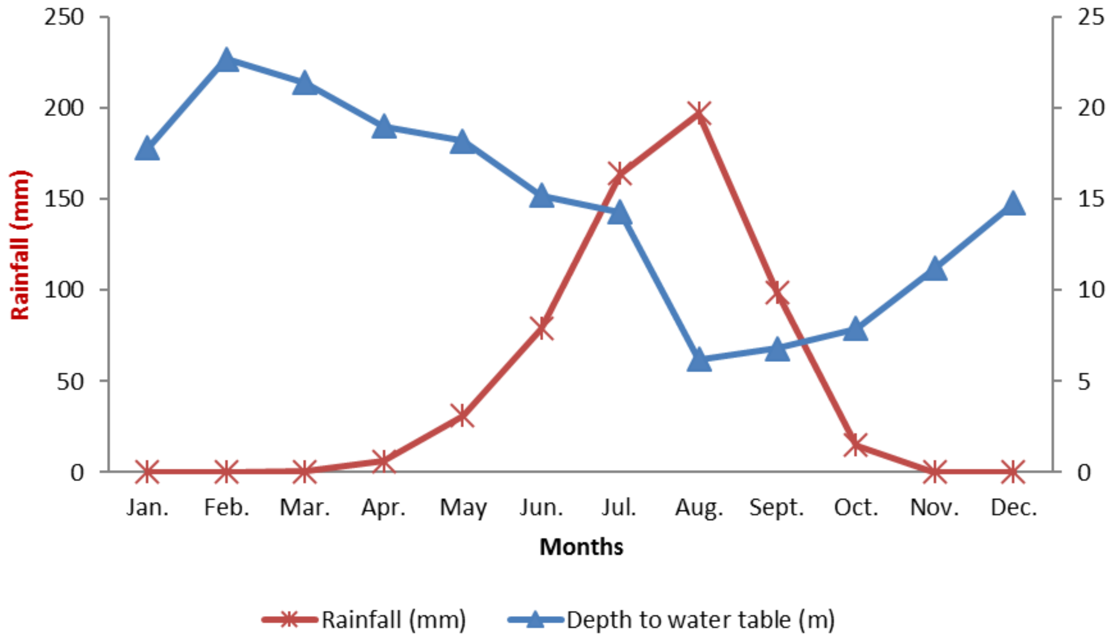

Figure 1: Relationship between the mean monthly rainfall data and mean monthly depth to water table.

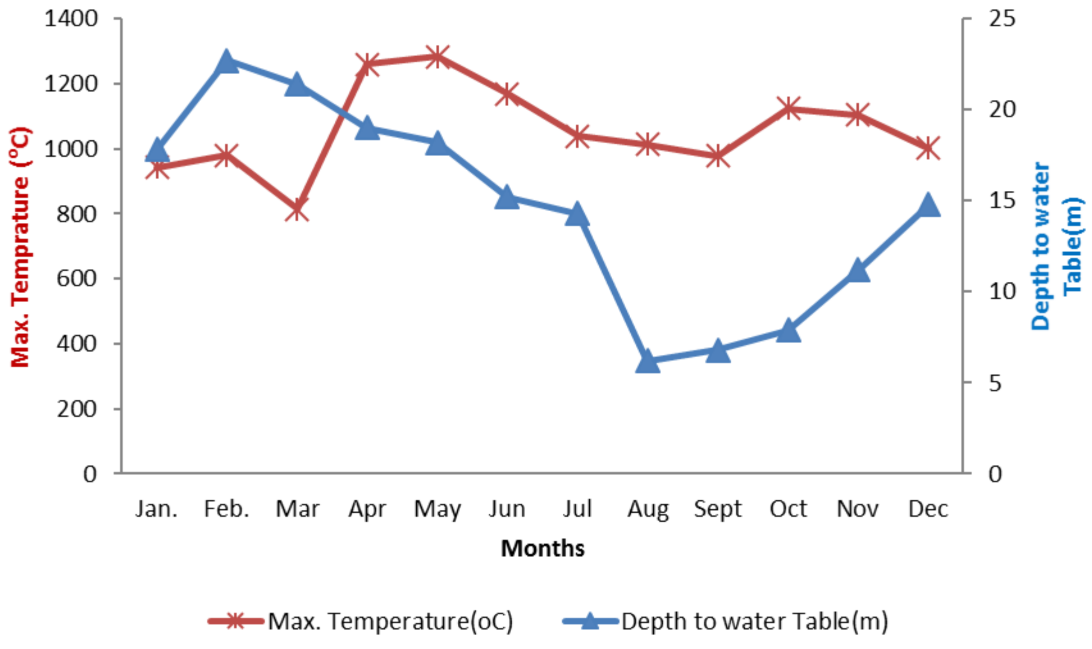

Figure 2: Relationship between the mean maximum temperatures and mean monthly depth to water table.

Figure 2 shows temperature changes and its effects on the depth of water table. The air temperature distribution for this period presented above showed that the temperature increased gradually from January which records the highest depth to water table, reaching its maximum in May and then decreased in August at which the depth to water table becomes shallow.

CONCLUSION

Between the periods of 1982 to 2012, there has been a significant increase of about 1.5^{0}C in mean air temperature. The mean monthly rainfall and temperature ranged between 195.2 - 0.1mm and 1404.5 - 1012.2^{0}C respectively. The changes in climate observed in Maiduguri have resulted in an increase in the calculated seasonal Evapotranspiration of over 100mm during the period of study, primarily due to the increase in wind speed.

However, the following recommendations were made;

i. More trees should be planted within the premises of Borno state so that the amount of solar radiation reaching the earth surface can be reduced.

ii. Continues studies on variability in climate need to be done to know the further extent of climate variability on the groundwater so that relevant planning could be put in place.

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