The Impact of Climate Parameters on Leachate Quality and its Effects on Water Quality of River Benue at Yola, Nigeria

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Abstract

This study analyses meteorological data and leachate parameters impact on water quality in River Benue of Yola. Climate parameters were collected from Upper Benue River Basin Development Authority (UBRBDA), Yola from 2004-2014; while leachate and water samples were collected from the beneath of decayed waste dumpsites and from three other locations along River Benue (upstream, middle stream, downstream) respectively. Pollutants in form of heavy metals (Cr, Cd, Pb, Cu, Fe, Zn, Ni, As, Mn, Mg) and other conventional pollutant parameters (DO, BOD, COD, TSS, TDS, TS, pH, NO^-_3, Turb.) were determined in the laboratory using: Atomic absorption spectrophotometer (AAS), BOD, COD reactors, pH meter, Turbidity meter, Nitrate testing equipment and some reagents. Available results showed that the mean annual minimum and maximum temperatures of the area were 22.56 ºC and 34.34 ºC. Total annual rainfall during the study year was 1015.3 mm. There was decrease in the concentration of Pb and BOD from 4.3 mg/l to 0.4716 mg/l and from 14.2 mg/l to 8.0082 mg/l as they were transported downstream due to reaction with micro-organisms and sediments. This implies that there was dilution of the wastes in the river and the presence of increased values of temperature, moisture content, relative humidity, solar intensity and rainfall amount all influenced the leachates production at dumpsites. This impacts on the quality of water in the Benue river as most of the concentration levels of pollutants obtained were higher than the standard threshold requirements.With urbanization and population wastes management policies should be formulated to minimize pollution and safeguard public health.

Keywords: Pollution, Leachates, Climate Parameters, Water Quality, River Benue

INTRODUCTION

There is much controversy over climate change today; some researchers are of the view that climate change is a natural process that affects all other components of the climate, because even in the absence of man, the natural environment undergoes continual change. This may be on a time-scale of millions of years as with continental drift and mountain-building, changes in sea level, the natural eutrophication and siltation of shallow lakes. While other people believe that human activities are responsible for all the changes in our environment. Whatever the level of controversy that exists, it is a scientific fact that climates have actually changed throughout the earth's history with the most recent ice age, global warming resulting from greenhouse effects, the increasing number of cases of outbreak of air and waterborne infections from soil and both surface or groundwater pollution (Martins, 2001). Cumulative effects of changes observed in the environment at a global scale are driven by such activities as indiscriminate dumping and disposal of solid, industrial, municipal, agricultural and other sources of wastes in open surroundings and waterways (Aniko et al., 2009). This is in line with the prediction of scientists some twenty five years ago that, the earth surface is expected to become warmer by emissions from polluted environment; global warming is also expected to increase the intensity of mean annual temperature by 1°-2 °C and progressively to 1.5- 4 °C by the end of this century (Martins, 2001; Scrudato and Pagano, 2012).

Today, the wastes from manufacturing companies and the products themselves have been mixed with common household refuse and co-disposed in landfills, streams and rivers throughout the world. Leachate derived from these mixed wastes has been responsible for contaminating water supplies. As a result, water pollution, according to an estimate "APHA", 2005, caused 14,000 deaths each day in the world. Roy (2007) wrote that, poor ventilation at the waste dumpsites with stacking patterns that block air movement can lead to accumulation of carbon dioxide (CO_2), H_2O, NH_3, H_2, H_2S, CH_4,etc, through the secretion of enzymes as a result of bacterial activities on the organics. Waste can also decay due to extreme exposure to temperature levels; relative humidity, temperature of waste, moisture content of waste, biochemical activities and respiration rateall affect the decay rate of waste to give out bad odour (Tuberose, 2011).Recently, local fruits and vegetables market that engages in commercial quantities have become a source of environmental pollution.Some spoiled and remnant vegetables are dumped close to the market and the decay of theserelease emissions that pollute the atmosphere. The only existing waste management strategy was burning of the wastes and direct discharges into available open drainages.

Leachates been the free flowing liquid from these dumpsites migrate to contaminate agricultural soils and water in River Benue that is used for irrigation and other purposes (Burmamu et al., 2018). This is unfortunate as this valuable resource is just adjacently down the slope of the market. Similarly, rain water on the dumpsites can initially derive their contaminants and infiltrate as leachate into the soil, evaporate, or as surface runoff, would contaminate the soil and water.Additionally, soils which the leachates flow through can become polluted with heavy metals and other hydrophobic organic contaminants (HOC) from these dumpsites (Adepelumi et al., 2001). This study focuses on characterization of meteorological data and leachate with respect to River Benue water quality. Besides, with these dumpsites, there is reduction of land use at the research area leading to social and environmental impact. Hence there is a need for this research around the market environment to demystify the climate parameters of the area and pollutants released by the leachates from these waste dumpsites with the aim of determining the types and concentration levels of contaminants generated from these dumpsites.

The major objectives of this study are to:study climate parameters, determine heavy metal concentrations and other contaminants from the research area that influence the quality of water in River Benue of Yola.

MATERIALS AND METHODS

Description of Study Site

Gwari market is a vegetables market located at the north western part of Jimeta-Yola town, the headquarters of Adamawa State. The market area lies between Latitudes 9º16' and 9º17'N of the equator and Longitudes 12º00' and 12º26'E of Greenwich Meridian. The landscape is a low sloping area with topography elevation of 500 ft above Mean Sea Level which have varying aquifer potentials (UBRBDA, 2010). The market, was established in Jimeat-Yola bye pass in 1999 in compliance with the State's urban renewal and expansion programme. This was to meet needs of consumers and economic returns to the farmers. Non point source (NPS) runoff drains through the decayed vegetables waste dumpsites as leachates to River Benue down the slope (Fig. 1).

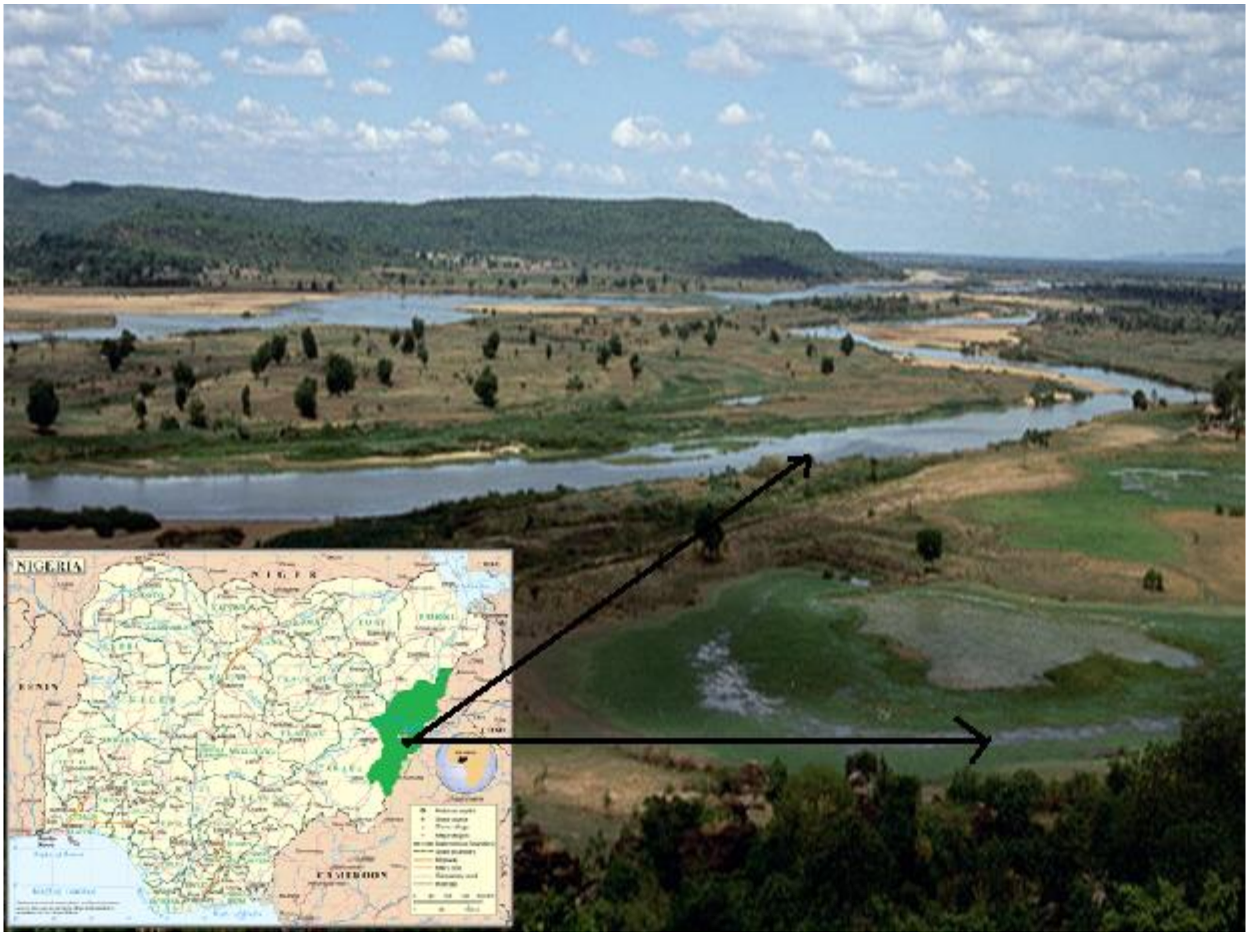

Figure.1: Map of Nigeria showing Imagery locations of Yola, River Benue and Lake Geriyo

Method of Data Collection

Climate data were collected from departments viz: Meteorological Unit of UBRBDA, Yola, Adamawa State Water Board, Yola, and GIS Unit of Ministry of Land Surveying, Yola. The field data collection was done at the study area where River Benue water samples were collected at three locations (upstream, middle and downstream) at 500 m intervals according to the 1.5 km stretch spanning over the research area and leachates were collected beneath the dumpsites. Samples collected were replicated three times at each point both during dry and rainy seasons. The analyses of the contaminant concentrations and other parameters were carried out in the Multi-User Science Research Laboratory; General Purpose Laboratory of Soil Science in the Research Institute; Public Health Laboratory of the Department of Water Resources and Environmental Engineering, all at Ahmadu Bello University, Zaria.

Method of characterization of climatic data

Climate parameters of the study area that include: daily and monthly mean maximum and minimum temperature (°C), monthly mean relative humidity (%), monthly mean total wind speed (km/day), dominant wind direction, monthly total rainfall data (mm), monthly total sunshine hours/solar intensity, monthly mean moisture content (%) and monthly total evaporation (mm) data were collected from Meteorological Station of Upper Benue River Basin Development Authority (UBRBDA), Yola covering 1982 to 2014.Some of these parameters: temperature, relative humidity, moisture content, solar intensity and precipitation influence the decay process of waste dumpsites while other parameters influence gaseous emission rates from dumpsites.

Determination of Contaminants from Leachates of Decayed Dumpsites

Dumpsites leachate being free flowing liquid that is derived from the decomposition of wastes is formed when water reaching the surface of the refuse dumps through run-off, precipitation, or deliberately introduced infiltrates through the soil cover along with dissolved contaminants. Migrating leachates within dumpsite transports particulate and soluble materials thus, contributing to non point source (NPS) of contamination in River Benue down the slope of waste dumpsites. As leachates migrate, the primary factors controlling dilution include; the density difference of the leachates and river water, the leachate and groundwater migrating velocities, the diffusion and dispersion coefficients of the various constituents contained in the leachates and the soil properties.

Sampling Methods

In order to determine the contaminants contained in the leachate of dumpsites such as heavy metals and other pollutants, 20 cm diameter augered wells were drilled at locations in proximity to the dumpsites and large containers were put directly under the dumpsites. Leachate samples were collected from each of these monitoring drilled wells and containers after six (6) month of rainfall from March to September, 2014 and were transferred into clean sampling plastic bottles (a sum collection system). The water quality indicators tested for include: pH, other conventional parameters and heavy metal concentrations. All collected samples were digested and filtered using (0.45 μm) size and stored at 4 ℃ until analyzed. The analysis was conducted with atomic absorption spectrophotometry (AAS 5000) machine using reagents that include: nitric acid; hydrochloric acid; hydrofluoric acid; distilled or deionised water. The same method that was applied in analyzing heavy metals in water samples from River Benue was adopted for analysis of toxic metals in leachate from dumpsites according APHA (2005) standard method.

Methods for Determination of other Water Quality Parameters

The parameters that were measured from the samples include: DO, BOD, COD, TSS, TDS, TS, pH, EC, T ℃, Nitrate, turbidity. All the chemical analyses of the parameters above were carried out according to the standard methods of (APHA, AWWA, WPCF, 2005). Fresh water and leachate samples were collected and stored in iced coolers before been transported to the laboratory for water quality examination according to the methods of (Folk, 1994 and Egereonu et al, 2012).Dissolved oxygen (DO), chemical oxygen demand (COD), and biochemical oxygen demand (BOD) were determined by oxygen consumed (OC) or dichromate oxygen consumed (DOC) methods (Loring and Rantala, 1992). The samples were collected in dry season months of March, April, May, and wet months.

Experimental Procedure for Determination of Heavy Metals (mg/l)

Instrumental calibration was carried out prior to metals determination by using standard solutions of metal ion prepared from salts. Commercial grade (Master Standard) 1000 mg/l at 1000 ppm and Stock solutions (100 ppm) of Zn, Cr, Pb, Fe, Hg, Cd, As, Pb, Cu, Ni, Mn, Mg,etc were diluted in 25 cm^3 standard flask and made up to the mark with deionised water to obtain working standard solutions of 1.0 ppm, 2.0 ppm, 3.0 ppm, 4.0 ppm, 6.0 ppm, and up to 10.0 ppm of each metal ion.Water sample was filtered through a filter paper of pore size 0.45 μm and 100 ml distilled water was added for dilution. Total dissolved metals in the samples were obtained through microwave digestion with 4ml concentrated nitric acid and 1 ml of hydrogen peroxide. Atomic absorption spectrometer (AAS 500)was calibrated, before testing the heavy metals. The essence of digestion before analysis was to reduce organic matter interference and convert metals to a form that can be analysed.

RESULTS AND DISCUSSION

Results on Characterization of Climate Data of the Research Area

The major results of the monthly mean climate data for 2004 - 2014 from the study area were presented in graphs and tables.. The climate data were part of the factors that influenced the disintegration, spoilage and decay of vegetable waste at the dumpsites. From Figure1, it can be observed that the highest temperature at the study site was recorded in March, 2004 with the value of 43 ºC. Close to this was 42 ºC in March, 2013 while 41 ºC each were recorded in April, 2005 and in March, 2005 respectively. The lowest temperature of 30 ºC was recorded in July, August, September and December. Generally, there was a characteristic pattern of temperature increase from January to May due to dry season, but the values begin to drop down from June towards December of each year depicting the variation of climate conditions of the years. When the temperature is high, it encourages fast biodegrading of the wastes in dumpsites, increases leachate production and their emissions pollute the entire environment adding to green house effect.

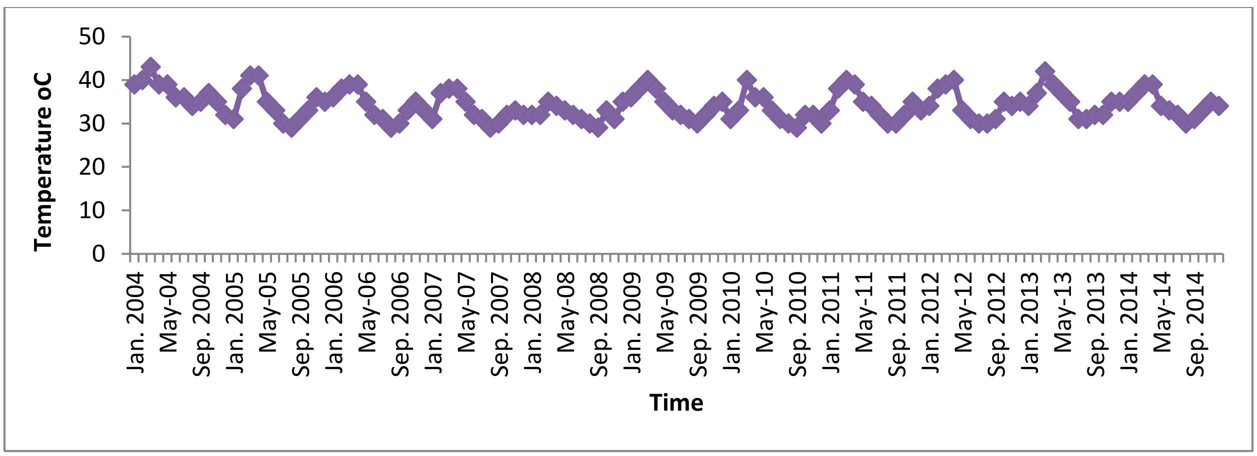

Figure 1: Summary of Monthly Mean Temperature in ºC for 2004 – 2014

This agrees with Mohammed et al (2011) assertion that when the temperature of landfill is above certain critical threshold (40 ºC), the soil beneath the landfill is not able to effectively attenuate many contaminants. These pollutants flow into River Benue and affect the water quality. The maximum temperature in 2014 was 39 ºC.

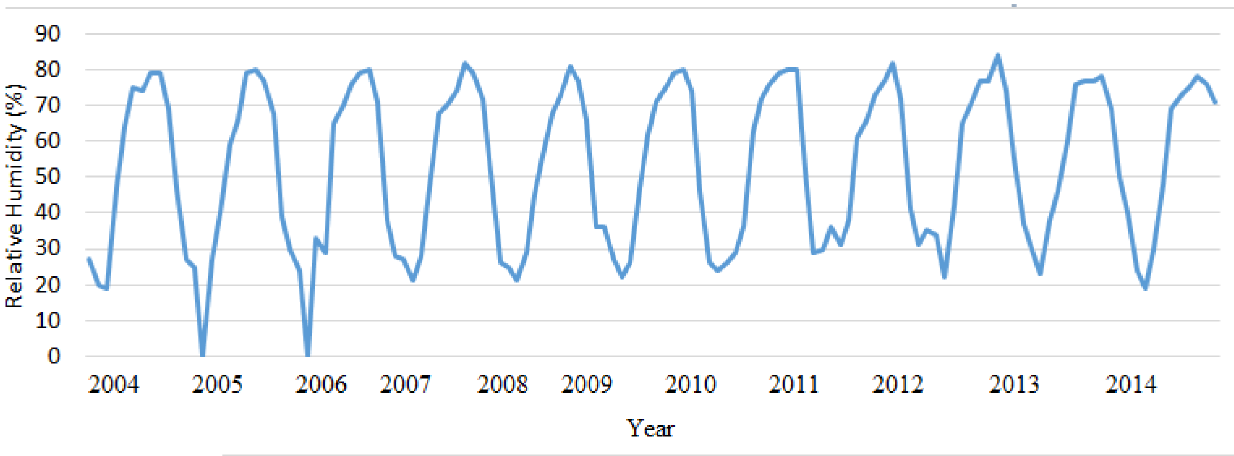

Figure 2: Monthly Mean Relative Humidity (%) for 2004 – 2014

As indicated in the Figure 2, the highest relative humidity of 84% was recorded in 2012 while 82% was recorded in 2011 and 2007 respectively. 81% relative humidity was also recorded in 2008. Similarly, 19% was the lowest relative humidity recorded in 2004 and 2014 while a close value of 20% was recorded in 2004. However, there was this high relative humidity for the decade because of high rainfall precipitation which saturated the atmosphere and hence absorbed the intensity of solar radiation. This situation may encourage high moisture contents in the dumpsitesleading to increase in bacterial activities which caused increase in decay of waste dumps and production of more leachates.Furthermore, from Figure 3, the highest evaporation of 611.57 mm, 587.16 mm and 501.61 mm were recorded in 2011; January, 2012 and December, 2011 respectively indicating the dry months of the decade which resulted into high total evaporation because the atmospheric environment was dry and so could derive more water from the ground surface.

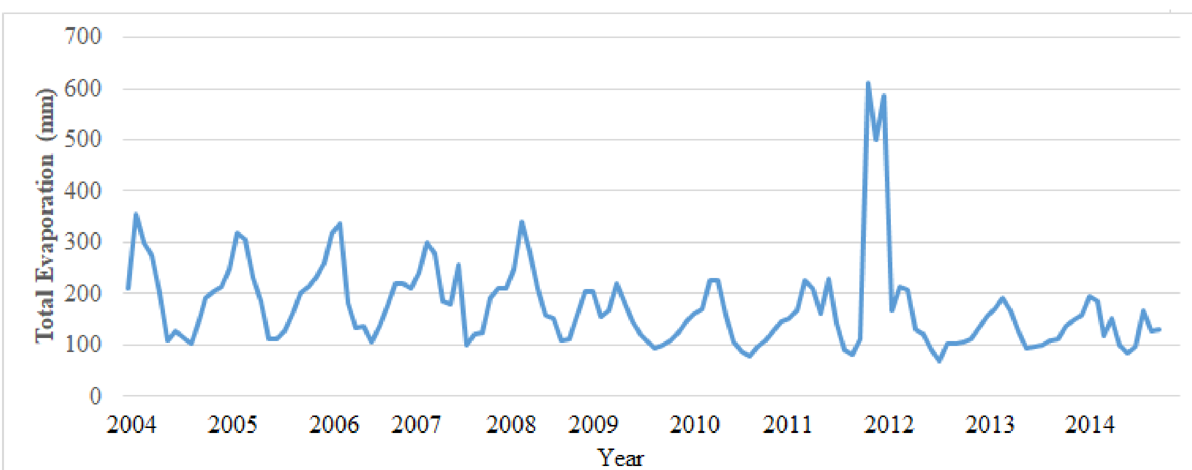

Figure 3: Monthly Total Evaporation (mm) for 2004 - 2014

The lowest value of total evaporation of 69.9 mm were recorded in 2012; 80.9 mm in 2011 and 86.4 mm in July, 2010 indicating the wet months of the years. Generally, in the rainy season, when the atmosphere was saturated with moisture, the air evaporates less water than when the atmosphere was dry because it has more capacity to take in more water from the ground surface. The maximum relative humidity for both leafy and fruit vegetables to undergo biodegradation ranges from 60 – 80% (Baiyewu and Amusa, 2005). This encourages moisture absorption to the point where mould growth occurs resulting into wilting and decay; hence gaseous emissions to atmosphere and leachate accumulation and transport.

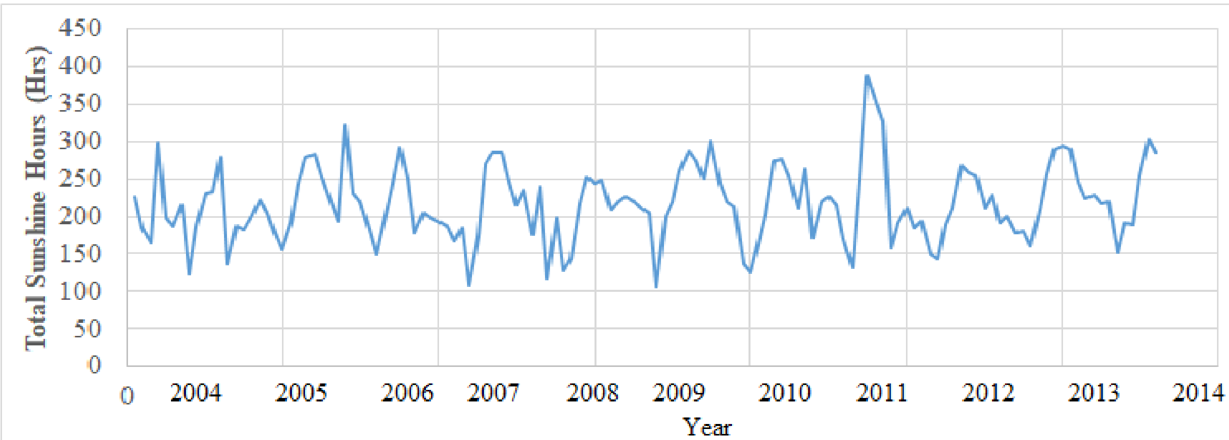

Figure 4: Monthly Total Sunshine Hours (HRS) for 2004 - 2014

Figure 4 showed that the highest total monthly sunshine hours recorded were: 387.2 hrs in 2010; 352.5 hrs in 2011; 327.7 hrs in 2012; 322.7 hrs in 2006 and 300. 7 hrs in 2010. Furthermore, the lowest sunshine recorded within the years was: 106.3 hrs in 2009; 116.5 hrs in 2008; 123.4 hrs in 2004 and 126.3 hrs in 2010. It can be observed that all the highest values of sunshine hours were recorded in dry seasons while the lower values were recorded in the wet season. Therefore, high sunshine hrs means increased solar intensity which can encourage metabolic activities and decay process in the vegetable wastes dumpsites. Lower values such as (106.3 and 116.5 hrs) may not have significant effect on the metabolism of leachates in dumpsites.

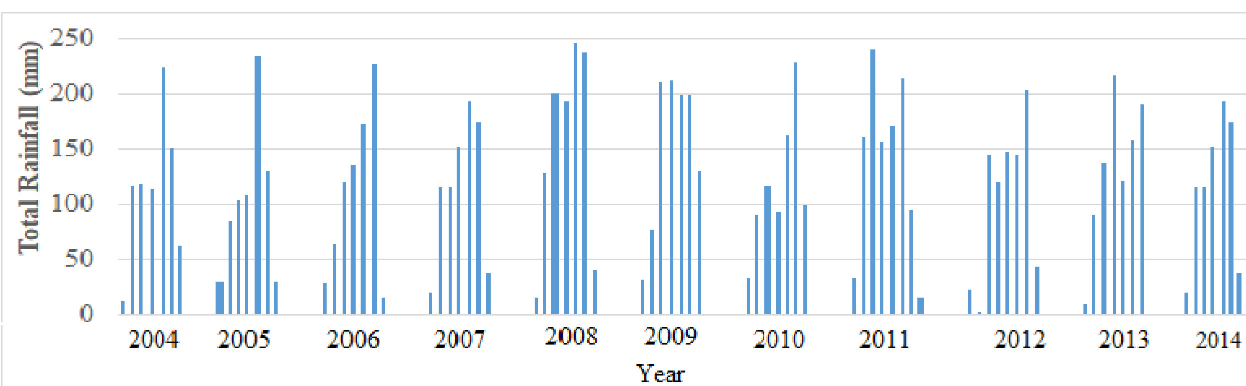

Figure 5: Monthly Total Rainfall Data (mm) for Ten Years: 2004 – 2014

The highest monthly rainfall received throughout the decade was 269.2 mm in 2007; 250.6 mm in 2007 and 246.5 mm in 2009. The lowest rainfall values were 1.7 mm in 2013; 9.4 mm in 2014 and

12.4 mm in 2004. This indicates that the area has a tropical climate with a mean total annual rainfall of 1085.2 mm for 81 days in 2012; 1063.6 mm for 72 days in 2010 and 1063.4 mm for another 72 days in 2009. High rainfall encourages moisture migration and runoff water into the dumpsites which combines with other chemical and biological factors to give rapid decay process, hence high leachates production, accumulation and transformation.

Results of Water Quality Parameters and Leachates Sample Analysis

Leachates collected directly under the decayed waste dumpsites and water from River Benue were also analysed to determine the concentration of pollutants and other water quality indicators in the environment. The concentration values of BOD were lowestat sample D due to less organic accumulation and storage of these pollutants at the study area.A plot of these results against the sample points gives (Figure 6) which indicated that TS was the most polluted parameter followed by TDS, TSS, BOD, COD, and insignificant DO because its values were very low.

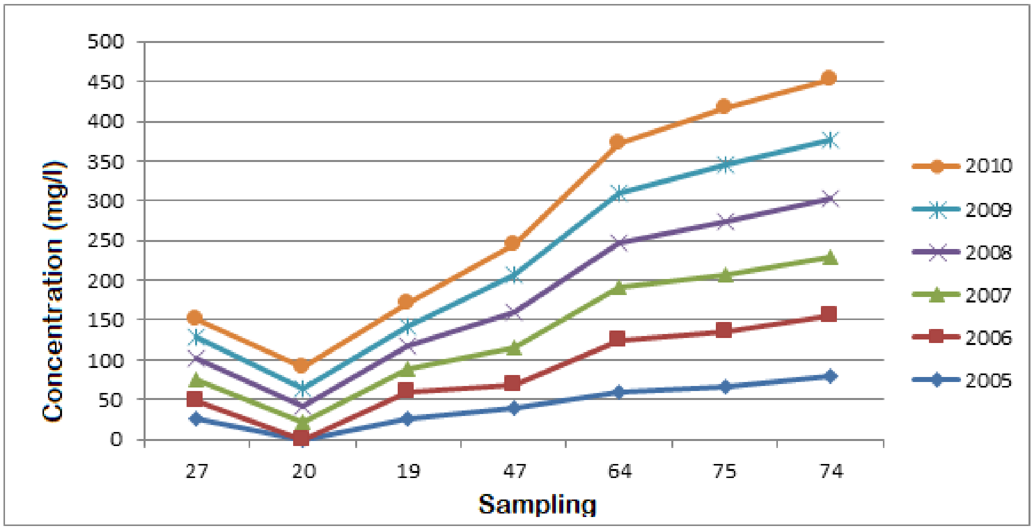

Figure 6: Graph of Water Quality Parameters Concentrations (mg/l) against Sample Points

A – Water samles collected from under the bridge at Yola; B – Water sample collected directly 500 m from the bridge downstream at Yola; C – Water sample collected at 1 km away from the bridge (downstream); D – Water sample collected at 1.5 km from the bridge (downstream); E – Leachates collected directly under the decayed vegetable wastes of the in-situ experimental pit; and F – Leachates collected directly under the decayed vegetable wastes of the case study dumpsites. All results obtained were compared with the World Health Organisation (WHO, 2008) Drinking Water Quality Standard.

CONCLUSION

The study was carried out to elucidate the effects of climate parameters on decayed waste dumpsites at Gwari international market, Yola with a view to evaluating leachate concentrations that affect water quality in River Benue downstream of the study area for effective planning and control of environmental pollution. The study site is a low lying area having a slope of 0.03 and the primary mode of transport for landfill contaminants is through leachate to surface and groundwater resources. Field work and laboratory analyses were employed in the research where characterization of climate data of the study area was carried out. Leachate samples were collected from the contaminated sites and analyzed for the presence of heavy metals and other various pollution parameters with the aid of some equipment including: geotechnical facilities, pH meter, turbidity meter, electrical conductivity meter, etc. Water samples were equally collected from beneath of waste dumpsites and three other locations along River Benue in Yola and analyzed for various water quality variables using AAS machine, BOD reactors, reagents, and many other equipment and instrumentation in the laboratories.

Results showed that the mean annual minimum and maximum temperatures of the area were 22.56 ºC and 34.34 ºC. Total annual rainfall during the study year was 1015.3 mm while there was decrease in the concentration of Pb and BOD from 4.3 mg/l to 0.4716 mg/l and from 14.2 mg/l to 8.0082 mg/l respectively downstream due to dilution, flow regime and turbulence. This implies that there was dilution of the wastes in the river and the presence of increased values of temperature, moisture content, relative humidity, solar intensity and rainfall amount all influenced the leachates production at dumpsites thereby having impact on the quality of water in the Benue river. The study contributes significantly by providing useful information to various stakeholders for effective policy formulation towards improving the quality of environment in Yola. It has also put on course extensive data base in the field of climate parameters, leachates and water quality context. This study when implemented will assist the policies of National Environmental Sustainability Regulations and Enforcement Agency (NESREA) and Federal Environmental Protection Agency (FEPA) of the Federal Government of Nigeria to reduce environmental pollution by 20% by the year 2020.

The key recommendation from this research is that with urbanization, population and the current demand for luxury in Nigeria, it is time to conduct further researches on impacts of climate change on qualities of available water resources covering a period of not less than two decades in order to safeguard public health. The wastes at the present study dumpsites should be evacuated by relevant government authorities.

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