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POTENTIALS OF DOMESTIC RAINWATER HARVESTING IN AKWA IBOM STATE, NIGERIA USING SUPPLY SIDE APPROACH

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ABSTRACT

Rainwater harvesting (RWH) is the technique of capturing and storage of rainwater for the need of man. The capturing and storage of rainwater varied from place to place and depends mainly on climatic condition. Historical data of rainfall for 20 years acquired between 1989 - 2008 was used in collaboration of Supply System Approach (SSA) for calculation of potential of RWH. The results indicated that mean monthly rainfall ranged between 18.39 - 378.63 mm and mean annual rainfall ranged between 145.6 – 440.7 mm, with rainfall throughout the months for 20 years events The maximum storage capacity needed to meet demand throughout the year at household level occurs in September as 98.3m^3 (983,000 litres) with total demand line for rainwater consumption as 18,000 litres above 20 litres recommended by the United Nations. This indicates the potential of rainwater harvesting to meet human hygienic conditions. Despite this, the problem confronting RWH is the low pH of atmospheric rainwater originating from incessant gas flaring by Mobil Producing Nigeria (MPN) operating onshore and offshore oil exploitations in Quo Iboe. Hence the recommendation the environmental laws should be enforced for compliance to stop gas flaring by re-injection of gas as well as gas revolution should be given top priority for socio-economic development. Also public participation in rainwater harvesting should be encouraged.

KEYWORDS: *Rainwater Harvesting, Low pH, Ambient Rainwater, Supply Side Approach*

INTRODUCTION

Water is one of the earth's most vital resources and is central to very day life. It is the most basic of human needs, used for hydration, hygiene, and sanitation. It is critical to nourishing and fostering life life and is also vital to human existence, social and economic development [[6]]. We usually take it for granted because of its availability; but when in scarcity it becomes our most precious resource. Every raindrop that fall from the cloud is very soft and the cleanest water sources in this world [[15]]. The falling raindrop acquires slight acidity as it dissolves carbon dioxide and nitrogen [[12]]. Rainwater is a part of hydrologic cycle; the never-ending exchange of water from the atmosphere to the ocean and back again as rainwater. Rainwater quality always exceeds the surface water and comparable to ground water because it does not come in contact with soil and rocks where it can dissolve salts and mineral which is harmful for potable and non-portable uses softness [[5]]. Water is at the heart of Millennium Development Goals (MDGs) Number 1, 3 and 7 and is indirectly associated with the success or otherwise Goals. But for Africa to meet MDGs, bold and targeted actions are required in water sector. To address this, the African Water Vision 2025 has set to development the full potential of Africa's water resources for sustainable, growth in the regional economic and social development of which rainwater harvesting (RWH) and storage forms a major component [[9]]. Rainwater harvesting is a broad term referring to the smallscale concentration, collection, storage, and use of rainwater runoff for productive purposes (Siegert, 1994; Kahinda et al, 2007). Water harvesting focuses on improving the productive use of rainwater on the local scale before the runoff water leaves the geographical unit in question [10;11;13]. Successful implementation of RWH should integrate socio-economic and environmental issues to ensure sustainability and protect fragile ecosystems. The results of rainwater harvesting in modification of ecosystems is clearly demonstrated by [19]. Rainwater harvesting played a significant role in promoting the ecological and environmental conservation. Rainwater is in itself a useful measure in soil and water conservation by capturing and storing runoff, which can directly contribute to the reduction of soil and water erosion. The study therefore focus on the assessment of rainwater potential in oil producing communities of Akwa Ibom state for water supply augmentation and ecosystems management for sustainable development.

MATERIALS AND METHODS

Environmental Setting

Akwa Ibom State is located between latitude 4^0 32′ and 5^0 5′ North and longitude 7^0 2′and 8^0 25. It has total population of 2,395,756 (87.89% rural and urban 12.11%), spread across landmass of 8,412 km^2. The rainfall varies from more than 3000 mm along the coast to about 2000mm inland, and the mean temperature varies between 25 – 28 ^OC. The state holds some of the largest reserves of oil and gas, both on- and offshore and these accounts for 28 percent of Nigeria's total crude oil export [4]. It is underlain by sedimentary formations of Late Tertiary and Holocene age.

Theoretical Framework

The estimation of the amount of water that can be harvested depends on the area and type of catchment and rainfall depth and pattern of supply of rainwater per month or monthly rainwater yield may be estimated according to [18] as :

Monthly yield(m^3) = *Monthly rainfall*(m) x *Catchment Area* (m^2) x *Runoff Coefficient* …. (1)

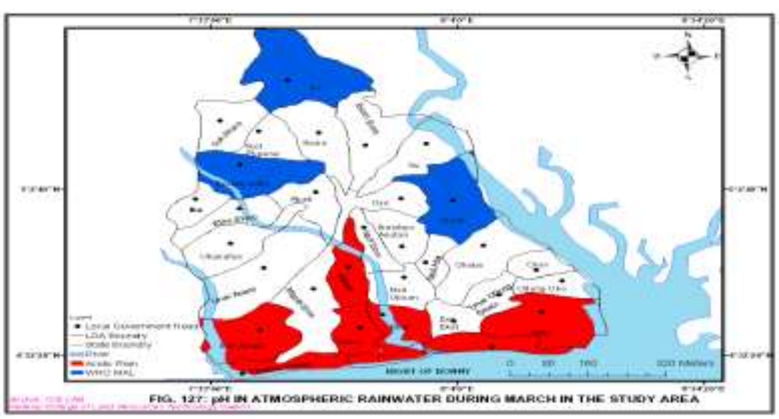

FIG. 127: pH IN ATMOSPHERIC RAINWATER DURING MARCH IN THE STUDY AREA

Fig.1: pH in Atmospheric Rainwater during March in the Study Area

From Fig 1. ambient rainwater harvested from the selected oil producing communities (Ikot-Abasi, Eastern-Obolo, Eket, Ibeno and Mbo) and the neighboring village like Etinan of Akwa Ibom State during the month of March indicated low pH in atmospheric rainwater which is acidic in nature reflecting atmospheric condition of oil communities in terms of air quality, while the northern part of the state meets World Health Organization Standards for potable water. The statement is in consonant with the finding of [17], who confirmed spatial and temporal formations of acid rain in parts of Akwa Ibom State, Nigeria. The result negate the finding of [20] who observed that atmospheric pollution in the rural areas is quite low and rainwater here is generally high. Ultimately, in Akwa Ibom State gas flaring was found to affects the soil thereby reducing the microbial populations [2], due to Mobil Producing Unlimited that flares and average of 42.8 million standard cubic feet (MSCF) of natural gas per day at Qua Ibo Terminal and several nearby onshore and offshore oil fields [3].

Rainwater Harvesting Potential: For rainwater harvesting, the simple model based on the runoff coefficient method was used. The coefficient of runoff (Cr) for any catchment is defined as the ratio of the volume of water that runs off to the volume of rain that falls on to the surface [8]. Runoff is by no means constant (Gould and Nissen,1999; Tripathi and Pandey, 2005). It was calculated by using the formula given below [8], reflecting Supply Side Approach (SSA) as follows:

$S = R \times A \times Cr$ ………… (2) Where R = Mean Annual Rainfall in m

A = Catchment Area in m^2

Cr = Coefficient of Runoff (0.9) for galvanized iron roofing sheet

Data collection techniques

Rainfall data for 20 years as an historical data ranging from 1988 - 2008 was collected from Akwa Ibom State Meteorological Stations, Uyo in March, 2010. Based on this, mean monthly and mean annual rainfall distributions were calculated and shown with charts. This was done in order to asses the potential of rainwater in the study area. And the potential of rainwater was calculated by using supply side approach by [8] in Equation (2). And Microsoft excel 2003 and 2007 were used for designing graphs to show the variations of spread sheets.

RESULTS AND DISCUSSION

Variation of Rainfall Data Regime in the Study Area (1989 -2008): Rainfall variability has been accepted as a useful parameter to estimate the reliability of rainfall over any area within a specific time [7]. Rainfall variation refers to the change that occurs in rainfall totals collected in any location. Using monthly rainfall records collected for twenty years intervals as between (1986 – 2008) . The following results were obtained:

TABLE 1: Mean Monthly Rainfall Distribution for the Study Area (mm) (1989-2008).

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean (mm)	18.39	37.93	129.35	190.28	286.83	300.99	310.05	336.79	378.63	268.17	102.29	23.71

Source: Field work, 2010

From Table 1, climatic data assembled for twenty year period showed the mean monthly rainfall distribution in the study between 1989 – 2008, ranged between minimum of 18.39 mm in January and maximum of 378.63 mm in September. Rainfall was observed through out the twelve months of the year for 20 years duration with different volumes based on rainfall intensity as shown in the Fig 2. It is worthy to note that there is a gradual and constant increase in rainfall from January and the peak in the month of September. From the month of September, there is a sudden decrease in the quantity/volume of rainfall till the month of December.

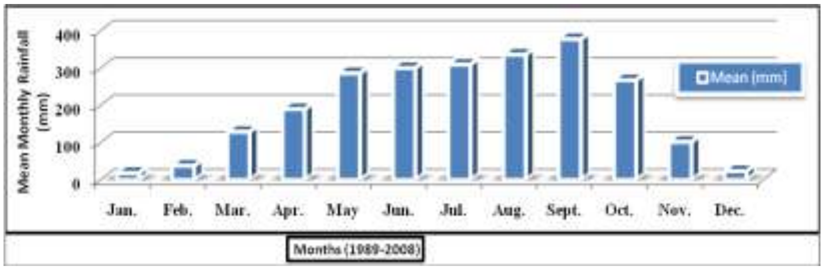

Fig. 2 : Mean Monthly Rainfall Distribution for the Study Area (1989-2008)

TABLE 2 : Mean Annual Rainfall Distribution for the Study Area (mm) (1989-2008)

S/N	Year	Mean (mm)
1	1989	198.6
2	1990	145.6
3	1991	198.3
4	1992	167.4
5	1993	440.7
6	1994	191.6
7	1995	221.6
8	1996	205.0
9	1997	182.2
10	1998	223.7
11	1999	195.8
12	2000	224.9
13	2001	200.6
14	2002	200.3
15	2003	179.3
16	2004	180.1
17	2005	234.2
18	2006	397.7
19	2007	258.6
20	2008	183.7
Source: Fieldwork, 2010		

From Table 3 , it is seen that the mean annual rainfall for the period of twenty years (1989 – 2008) ranged between 145.6 – 440.7 mm, with the year of 1990 having the lowest annual mean value of rainfall and the year of 1993 having the highest annual mean value of rainfall as shown in Fig.2.

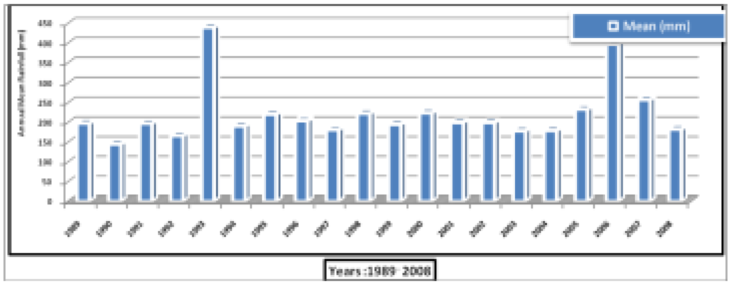

Fig.3: Mean Annual Rainfall Distribution for the Study Area (1989 -2008)

POTENTIAL OF RAINWATER HARVESTING (RWH) IN THE STUDY AREA

Table 3 shows the spreadsheet calculation for the study area. Mean figures for the rainfall data were used to simplify the calculation signifying a typical field approach to rainwater harvesting storage sizing. Rainwater harvesting potential was evaluated by using Supply Side Approach (SSA) which involve: runoff, area of catchments and coefficient of runoff for galvanized iron roofing sheets (0.9) which is constant[8]. The estimation of rainwater available from rooftop for harvesting is calculated by multiplying the roof area (Length x Breath) (150 m^2) with coefficient (0.9) and the mean monthly historical rainfall data. Table 3 shows the calculation for domestic rainwater harvesting (DRWH) sizing the storage capacity. It takes into consideration the accumulated inflow and outflow from the storage systems and the capacity of the storage system is calculated as the greatest excess of water over and above consumption. Water will have to be stored to cover the shortfall during the dry period. It is then observed that, average monthly rainfall for 20 years rain event determine the volume of rainwater to be harvested for domestic uses and this was based on the consumption level which was found to be 18 m^3 (18,000 litres) as shown in Table 3.

TABLE 3: Rainwater Harvested in the Study Area between(1989-2008)

Months	Mean Monthly-Rainfall (mm)	Monthly Rainfall Harvested (Litres) (000)	Total Rainfall Harvested (Litres) (000)	Demand based on total utilization (Litres) (000)	Monthly Total Demand (Litre)(000)	Difference between column 4 and 6 (Litres) (000)
Oct.	268.168	36	36	18	18	18
Nov.	102.29	13.8	50.0	18	36	14
Dec.	23.77	3.2	53.2	18	54	-1
Jan.	183.9	2.5	55.7	18	72	-16
Feb.	37.93	5.1	60.8	18	90	-29
Mar.	129.35	17.5	78.3	18	108	-30
Apr.	190.28	25.7	104.0	18	126	-22
May	286.83	38.7	142.7	18	144	-1
Jun.	300.985	40.6	183.3	18	162	21
Jul.	210.05	28.4	211.7	18	180	32
Aug.	336.79	45.5	257.2	18	198	77
Sept.	378.63	51.1	308.3	18	216	98 .3
Total		308		216		
Source: Field work ,2010						

Figure 4 shows the comparison of rainwater harvested and the amount that can be supplied to consumers using all the rainwater which is harvested. Here it is noted that there is only one rainy season. The first month that the rainfall on the roof meets the demand is the month of March. If we assumes that the tank or the storage system was empty at the end of February, graph of cumulative harvested rainwater and cumulative demand are drawn and the maximum storage capacity or requirement is then calculated.

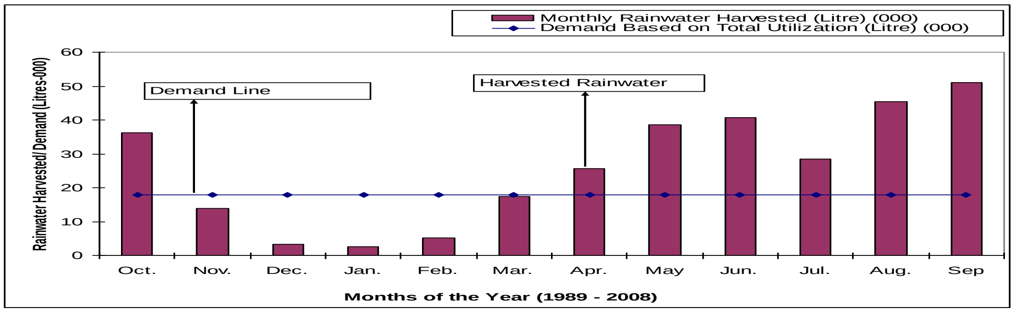

Fig. 4 : Comparison of Rainfall Harvested with Demand Based on Total Utilization

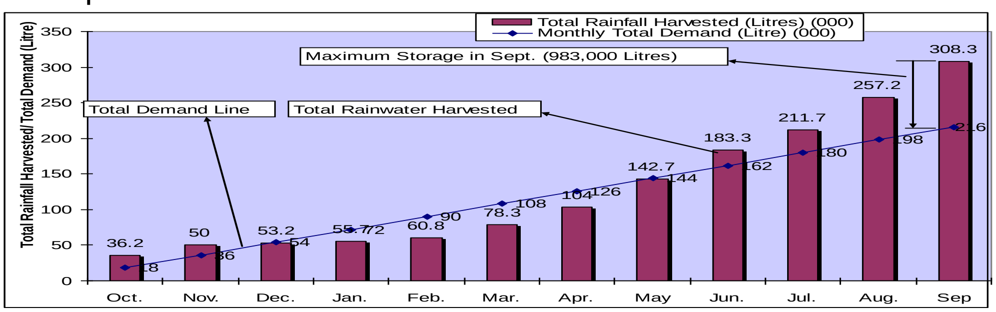

Fig.5: Rainwater Harvested with Maximum Storage Requirement in September

Figure 5 show variability of harvested rainwater from the catchments for the period of 20 years. The line drawn across represents total demand for harvested rainwater for each month, and the bars represent total rainwater harvested for 20 year period in the study area. The months of January -16 m^3 (-16,000 litres), February -29 m^3 (-29,000 litres), March -30 m^3 (-30,000 litres), April -22 m^3(-22,000litres) and May -1m^3 (-1000 litres) were below line of total demand (cumulated for a period of 20 year respectively). And this indicate that there will be deficits during these months which coincided with the dry season, hence, storage capacity to meet daily demand during the dry season. The month of October 18 m^3 (18,000 litres) marks the beginning of rainfall and has the lowest rainwater harvested of 36,000 litres and November 14 m^3 (14,000 litres) are the months indicating marginal storage for the years. Hence harvested rainwater will have to be stored to cover the shortfall during the dry period. The maximum storage capacity needed to meet demand throughout the year at household level occurs in September as 98 m^3 (983,000 litres) .

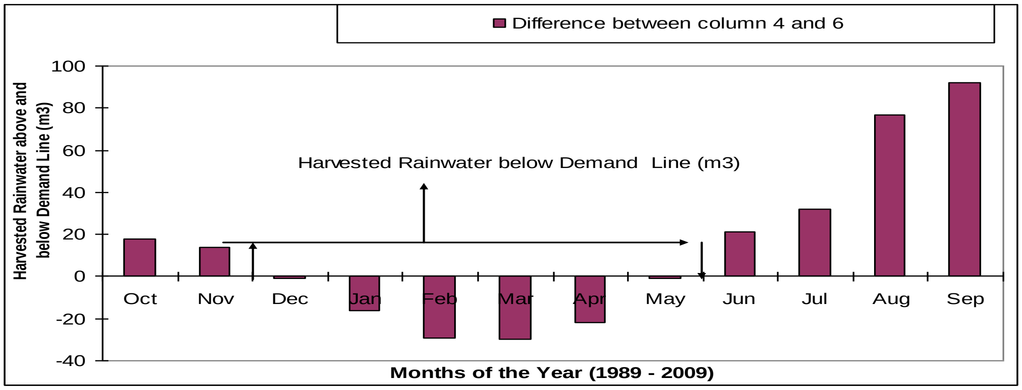

Fig.6: Identification of Harvested Rainwater below and above Demand Line

According to United Nations, it is assumed that 20 liters/capita/day water is inevitable for the rural communities in the developing countries [1]. The United Nation targets it as minimum water requirement for all domestic purpose including personal hygiene also. The norms were set during International Drinking Water Supply & Sanitation Decade (IDWSS). Out of this 20 liters/capita/day water, 10 liters/capita/ day is only for drinking and cooking purpose. From the results, it is then observed that rainwater harvesting potential is eminent in the study area, since the total demand line for rainwater consumption is 18,000 litres with the maximum storage month of September more than 20 litres recommended by the United Nations. But the months of January, February, March and April are deficit in terms of the volume of rainwater for storage (Figure 6).

SUMMARY AND CONCLUSION

Rainfall variability has been accepted as a good parameter to estimate the potential of rainwater harvesting over any area within the specific time frame. From the result, it is observed that rainfall data collected for a period of 20 year rain events (1989- 2008) as an historical record had the mean monthly rainfall distribution in the study between 1989 – 2008, ranged between minimum of 18.39 mm in January and maximum of 378.63 mm in September, and annual rainfall ranged between 145.6 – 440.7 mm, with the year of 1990 having the lowest annual mean value of rainfall and 1993 having the highest annual mean value of rainfall respectively. Above all, throughout 20 year rain event, there was no month rain has not fallen indicating reliability for constant rainfall with different intensity. The month of October 18 m^3 (18,000 litres) which is the starting point of rainfall had the lowest rainwater harvested tendency of 36,000 litres and November 14 m^3 (14,000 litres) are the months indicating marginal storage for the years. The maximum storage capacity needed to meet demand throughout the year at household level occurred during the month of September as 98.3 m^3 (983,000 litres) , with total demand line for rainwater consumption as 18,000 litres above 20 litres recommended by the United Nations. From the result, it could be concluded that, rainwater harvesting is promising during the month of September with the highest storage capacity that can augment other water sources like pipe born water, bore hole, streams etc. , because coastal area of Akwa Ibom State are suffering from salt water intrusion . If rainwater is practiced, it will go a long way helping in intercepting runoff that would have caused land degradation in the area. The problems envisaged is low pH of atmospheric rainwater due to incessant gas flaring by Mobil Oil Company in the area [17].

RECOMMENDATION*:*

Based on the result of the study, it is recommended that:

(i) Gas flaring should be stopped through gas-reinjection and gas revolution for social and economic development.

(ii) Akwa Ibom State Government with collaboration with Federal Ministry of Environment should enforce environmental laws for compliance by oil companies

(iii) Public Participation: Awareness should be created by government on important of rainwater harvesting for ecosystems sustainability and augmentation of other water sources.

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