A seasonal geo-spatial study of unconsolidated surface stream sediment grain size of Anambra Basin

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Abstract. This study is aimed at identifying the characteristics of unconsolidated sediment in the Anambra drainage basin. Grain size parameters determined were: skewness, mean size, sorting, and kurtosis. A measurement of 100gramms of sediment samples were collected at 12 sampled station in rainy and dry season and were oven dried for sieve analysis. At the rainy and dry seasons, sediments mean size (MZ) were dominated by sand which spanned from coarse to fine. Sorting (δ₁) ranged from poorly to moderately sorted while skewness (SKi) were positive to negative, while kurtosis (KG) was between leptokurtic to very leptokurtic. The sediment grain size showed no variation with respect to season because p>0.05 (mean size (p = .138), sorting (p = .301) and skewness (p = .956).

Keywords: sediment, skewness, mean size, sorting, kurtosis

1. Introduction

River basin is a dynamic body of systematically linked up stream channels which receives the rains and the aftermath of runoff processes from the banks and the stream channels orchestrated by mechanisms of transport leading to the generation of sediments. According to [1] rivers are characterized by change. It under goes a lot of changes at different times; day-to-day, annual, seasons and perennial scale. Studies on the sediments of Anambra basin have been propelled by the desire to provide insight into the river sediment grain size. Anambra drainage basin lies entirely within an unconsolidated sedimentary rock formation. Apparently, river sediments are fundamentally affected by a range of activities that profoundly shape their characteristics. Stream sediments are generated from interplay of varied activities within the river basin ranging from anthropogenic to non-anthropogenic activities that influence the physiography of the basin. River sediments is a fascination to researchers while studying its grain-size distribution.
has continually gained currency. This is because, with in a drainage basin, over land surface processes that takes place is a function of physical forces operating within the environment [2] together with the increased volume of precipitation and higher energy force of water as it transport from the upper reaches of the basin [3].

Grain size gives insight in the source of sediment and the spatial spread of the location of the fluvial medium which transported the sediment. [4] stated that it is vital in earth science because the prevailing processes can be inferred from it. [5] utilized it in Nankai trough and pointed out that the environment is of clay-silt composition while [6]enunciated that Maed’agua environment is dominated by sandy-gravel, sandy-mud and mud. It also allows quantitative and qualitative discussion on the sediment [7]. There are different methods of grain size determination .They range from arithmetic method which has some limitation since it favors the larger particles more than the fine fragments. Another one is the moment method. This method is less popularized due to ambiguity of figures in explaining tailed distributions [8] [9][10]. The widely accepted method of determining sediment grain size is the [8]. It does not have preference for coarse or fine sediment, rather it was designed in the order of Udden and Wentworth of 1914 and 1922 respectively whose measurement is in phi units after the transformation of Logarithm values [8][11][7]. Thus, the most widely accepted for determining variables –skewness, kurtosis, mean size and sorting is the[8] because it exerts same affinity for sediments despite the nature of their distributions with significant accuracy. Other researchers, [12][13][14][3][13][15][16] and [17] have effectively determined sediment grain from [8]. They reiterated that grain size distribution is a vital tool that facilitates the delineation of depositional environment, serves as exploratory tool, important in soil mapping, and can also be utilized for reconstructing the environment. This is because the character of sediments are indelibly molded by the environment of deposition which is very vital in prediction of landform and in the interpretation of processes [18]. The present study is aimed at determining the sediment grain size in the Anambra drainage basin in the rainy and dry season. This is considered timely because the research site is prone to erosion despite its vast coverage of the agrarian middle belt and parts of south eastern Nigeria.

2. Study Area

The Anambra River originates at Ankpa in Kogi state. From there, the river meanders through other states southward to empty into the River Niger at Onitsha. The longitudinal and latitudinal locations of the drainage basin extends from 6°00’N to 7°30’N and 7°00’E to 7°30’E (Fig.1). It is situated in a weakly consolidate sedimentary basin, of quaternary, tertiary and cretaceous Formation with different geologic age (Fig. 2). Anambra river is within Aw tropical climate with significant rainy and dry seasons. The intensity and duration of rainfall in the basin is high. The mean annual rainfall ranges between 1750-2050mm [19][20]. The peak of rainfall is usually between May and July shortly before the little dry season or August break. Temperature gets to 30°C at the peak of dry season with the least mean monthly minimum temperature of 22°C at the most of rainy periods. Pressure recording span from 1010 to 101.29 mbar[21]. The relief the drainage basin ranges between 0-200meters above sea level [22] at the western flank while the eastern flank is marked with escarpment and higher elevation greater than 200meters. The basin is a sixth order drainage basin with a dendritic pattern and has a viable potential for water resource planning and development. [22] classified the soil to be dominated with ferralitic, lithosols, juvenile and hydromorphic soil.
Fig. 1: Location of the Basin
Fig. 2: Geology of the Basin
3. Materials and method

Twelve sediment samples were collected from different sub basins sampled within Anambra basin at the wet season and dry seasons. The sediments were collected at different sub basins as contained in Figure 3. From the twelve samples collected, 100gramms of each of the samples were disintegrated, oven-dried and then sieved for 15 minutes. Sieving was done on a Rho-tap sieve shaker, after which, the particles retained were weighed. The four parameters-skewness, kurtosis, mean size and sorting calculation was based on [8] as showed in table 1.

Fig. 3: Sampling locations
Table 1: Formula for calculation of the Grain size Parameters

| PARAMETER | FORMULAR | QUALITATIVE DESCRIPTION |
|-----------|----------|--------------------------|
| MZ        | $\Phi_{16} + \Phi_{50} + \Phi_{84}$  \(\frac{3}{4}\) | 0 – 2   Coarser sand  
|           | 1 – 2   Medium sand  
|           | 2 – 3   Fine sand    |
| $\delta_1$| $\Phi_{84} - \Phi_{16} + \Phi_{95} - \Phi_{5}$  \(\frac{4}{6.6}\) | Very well sorted  < 0.35  
|           | Well sorted   0.35 – 0.50  
|           | Moderately well sorted 0.50 – 1.0  
|           | Poorly sorted 1.0 – 2.0  
|           | Very poorly sorted 2.0 – 4.0  
|           | Extremely poorly sorted > 4.0  |
| Ski       | $\Phi_{16} + \Phi_{84} + 2\Phi_{50} + \Phi_{5} + \Phi_{95} - 2\Phi_{50}$  
|           | \(\frac{2(\Phi_{84} - \Phi_{16})}{2(\Phi_{95} - \Phi_{5})}\) | Very positively skewed +0.3 to + 1.0  
|           | Positively skewed +0.1 to + 0.3  
|           | Symmetrical + 0.1 to – 0.1  
|           | Negatively skewed -0.1 to –0.3  
|           | Very negatively skewed -0.3 to –1.0  |
| KG        | $\Phi_{95} - \Phi_{5}$  \(\frac{44 (\Phi_{15} - \Phi_{25})}{44}\) | Very platykurtic  <0.67  
|           | Platykurtic  0.67 – 0.90  
|           | Meso kurtic 0.90 – 1.11  
|           | Leptokurtic 1.11 – 1.50  
|           | Very Leptokurtic 1.50 – 3.00  
|           | Extremely leptokurtic >3.00  |

4 Results and Discussion

Result of the grain size analysis for rainy and dry season is shown in Table 2a&b while the illustration is in figures 4 and 5 respectively.

The mean size of the sampled sub basins in the dry and wet seasons ranged from 2-3 which entails that the sediment are mainly made up of fine sand in the dry season but in the rainy season, more particles show coarseness. Such coarseness could be attributed to the higher degree of surface soil loss and accelerated run off occurring in the different erosion surfaces which is attributed to surficial process [23][24]. Furthermore, repeated wetting and drying of any exposed surface caused variation in the stability of the earth material because of the planes of existing weakness that allows the fragmentation of the unconsolidated surfaces upon the impact of mechanical action of rain on the soils within the basin [25].
Table 2a: Result of the Sediment Grain size Analysis in Rainy Season

| Location         | Mean Size | Sorting | Skewness | Kurtosis |
|------------------|-----------|---------|----------|----------|
| Ankpa Sub basin  | 0.8       | 1.5     | 0.29     | 2.79     |
| Obele subasin    | 2.06      | 1.04    | 0.1      | 1.42     |
| Adada sub basin  | 2.1       | 1.29    | 0.16     | 1.31     |
| Oji Subasin      | 2.1       | 1.18    | 0.24     | 1.18     |
| Mamu Subbasin    | 2.07      | 1.15    | 0.99     | 1.06     |
| Ezu subasin      | 2.08      | 0.52    | 0.025    | 1.47     |

Source: Field work 2013

Table 2a: Result of the Sediment Grain size Analysis in Dry Season

| Location         | Mean Size | Sorting | Skewness | Kurtosis |
|------------------|-----------|---------|----------|----------|
| Ankpa Sub basin  | 2.02      | 1.03    | 0.12     | 1.83     |
| Obele subasin    | 2.25      | 1.32    | 1.19     | 1.26     |
| Adada sub basin  | 2.70      | 1.00    | 0.18     | 1.22     |
| Oji Subasin      | 2.06      | 1.18    | 0.25     | 1.12     |
| Mamu Subbasin    | 2.03      | 1.06    | 0.10     | 1.09     |
| Ezu subasin      | 2.57      | 1.05    | 0.10     | 1.26     |

Source: Field work 2014
Fig. 4: Variation in the Grain Size Distribution of Sediments in the Rainy Season.
Fig. 5: Variation of the Stream Sediment in the Dry Season
As regards sorting, the grain size spanned from poorly sorted to very poorly sort in the dry and wet seasons. The sorting value obtained was from 1.04 to 1.5 in rainy season while in dry season, it ranged from 0.52 to 1.32 (Table, 2a & b). The analysis shows that the sediments in the rainy season was also poorly sorted. Poor sorting portrays that the sediments were deposited when the velocity of the river water is faced with some turbulence and variability thereby producing sediment deposition that is interlaced with different sizes [24]. Thus, the Anambra river sediment is mainly poorly sorted at the dry and wet seasons.

Analysis of the skewness values (Table,2a & b) within the sub basins of the Anambra drainage basin reveal that their skewness spanned between positive skewness to negative skewness. Most of the basins such as Ankpa sub basin(0.29),Obele sub basin(0.1),Adada sub basin(0.16), Oji sub basin(0.24),Mamu sub basin(0.99) has positive skewnesss with their skewness interval ranging from 0.1to 0.29 while Ezu sub basin(-0.25), recorded a negative skewness in the rainy season. In the dry season, their skewness interval ranged from 0.10 to 0.25. Thus, Ankpa sub basin(0.12),Obele sub basin(1.19),Adada sub basin(0.18), Oji sub basin(0.25),Mamu sub basin(0.10) and Ezu sub basin(0.10).

In line with our findings, [26][27] reported that where fluvial deposits are positively skewed, it usually results from particle interlayering on the sediment transported at the bottom of the fluvial current. The above phenomenon is therefore obvious in the drainage basin understudy.

The kurtosis of the drainage basin under study spanned between leptokurtic to very leptokurtic. The rainy season, the sediments distribution were as follows: Ankpa sub basin(2.79),Obele sub basin(1.42),Adada sub basin(1.31), Oji sub basin(1.18),Mamu sub basin(1.06) and Ezu sub basin(1.47)(Table 2a). This shows that Ankpa and Mamu sub basin had very leptokurtic sediment while others were leptokurtic. In the dry season , only Ankpa sub basin(1.83) was very leptokurtic whereas others were leptokurtic viz ;Obele sub basin(1.26),Adada sub basin(1.22), Oji sub basin(1.12),Mamu sub basin(1.9) and Ezu sub basin(1.26)(Table 2b).

4.1 Paired sample T-test for the Sediment Grain size Variable in the Rainy and Dry Season

The paired sample t-test (3a &3b) for the grain size showed that there is no significant difference in variables examined at the dry season and wet season because p>0.05.

Table 3a: Paired sample T-test for the Sediment Grain size Variable in the Rainy and Dry Season

|                | Season | N  | Mean | Std. Deviation |
|----------------|--------|----|------|---------------|
| Mean Size      | Rainy  | 6  | 1.87 | 0.52          |
|                | Dry    | 6  | 2.22 | 0.26          |
| ()Sorting      | Rainy  | 6  | 1.19 | 0.18          |
|                | Dry    | 6  | 1.03 | 0.28          |
| Skewness       | Rainy  | 6  | 0.34 | 0.33          |
|                | Dry    | 6  | 0.32 | 0.43          |
| Kurtosis       | Rainy  | 6  | 1.64 | 0.61          |
|                | Dry    | 6  | 1.64 | 0.61          |
Table 3b: Paired sample T-test for the Sediment Grain size Variable in the Rainy and Dry Season

|               | Paired Differences |       |       |       |       |       |
|---------------|--------------------|-------|-------|-------|-------|-------|
|               |                    | Mean  | Std. Deviation | Std. Error | Lower | Upper |
| Mean size     | Rainy – Dry        | -0.35000 | 0.48613 | 0.19846 | -0.86016 | 0.16016 | -1.764 | 5 | .138 |
| Sorting       | Rainy – Dry        | 0.15333 | 0.32599 | 0.13308 | -0.18877 | 0.49543 | 1.152 | 5 | .301 |
| Skewness      | Rainy – Dry        | 0.01500 | 0.63730 | 0.26018 | -0.65380 | 0.68380 | 0.058 | 5 | .956 |
| Kurtosis      | Rainy – Dry        | - | - | - | - | - | - | - | - |
|               | T                  |       |       |       |       |       |
| Mean size     | 5                  |       |       |       |       |       |
| Sorting       | 5                  |       |       |       |       |       |
| Skewness      | 5                  |       |       |       |       |       |
| Kurtosis      | -                  |       |       |       |       |       |

The Tables 3a and 3b present the result on comparison of mean size, sorting, skewness and kurtosis between the rainy and dry season. There was no significant difference between both seasons for the parameters: mean size (p = .138), sorting (p = .301) and skewness (p = .956). The mean size, sorting and skewness for both seasons were comparable. It therefore implies that seasons do not affect the lithofacies of the basin. Since the samples are a representation of the host rock.

5. Conclusion

On the whole, the sediment analysis of the grains has given us a clue to the lithofacies of the study area. It can be said to be poorly sorted. Thus sediments are of different sizes, with mean size which spanned from coarse to fine sand, the skewness spanned from positively to negative skewness while kurtosis was between leptokurtic to very leptokurtic. Furthermore, Anambra drainage basin did not exhibit variation with respect to seasons-rainy and dry.

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