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Assessment of Quality of Sand from Rivers Imo and Otamiri, Imo State for Construction Purposes

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ABSTRACT

This research presents assessment of quality of sand from Imo and Otamiri rivers, located in Imo State, south-east Nigeria for construction purposes. Tests carried out include sieve analysis, bulk density, specific gravity, organic content and California bearing test. The results classified the sand from both rivers as medium poorly graded, low compressibility, good drainage quality. The tests also revealed that the sand belong to Zone 2 of the grading curve of particle size distribution. The study further showed that sand from the two rivers have low California Bearing Ratio (CBR) values, which ranged between 0.15% and 0.22%. The pH value of sand from Otamiri river is 7 (Neutral), while sand from Imo River is slightly acidic with a pH value of 6.5. However the level of acidity does not pose a threat to any construction material. The Specific Gravity of Otamiri river sand averaged 2.57, which falls within the acceptable range of 2.50 and 3.00 for aggregates for construction purposes. The specific gravity of Imo river is 2.36, which is slightly below the given range. The research further revealed that sand from Imo river shows slight present of impurities which may be deleterious to chemical reaction of cement or bitumen. However, Otamiri river sand on the other hand, have little or no impurities. Sand from Imo River is slightly acidic and therefore not recommended for construction where steel materials are recommended or preferred, as this may aggravate corrosion and rust. Notwithstanding, with proper sorting, sand from both rivers are suitable for construction purposes.

Keywords: *Aggregate; Concrete; Construction; Fine-aggregate; River-sand; Sand.*

1 INTRODUCTION

When selecting sand for construction purposes, properties such as strength, porosity, void ratio, specific gravity, bulk density, moisture content, among others are usually considered. Fine aggregate or coarse sand consist of natural sand, crushed stone sand or crushed gravel stone dust. It should be hard, durable, chemically inert, clean and free from organic matter not containing any appreciable amount of clays balls or pellets and other harmful impurities such as alkaline, salt, mica, decayed vegetation hump or alkaline microbes (Dugal, 2001).

Gurcharahs (1983) reported that aggregate obtained from pits or diverged from river, creek or sea are most often not clean enough or well graded to meet the sand quality requirement. They require sieving and washing before they can be used in concrete production for construction purposes.

River sand is obtained from river stream and banks and is finer in texture than pit sand. This type of sand has rounded grains generally in while grey colour-river sand has many uses in the construction purposes such as plastering (Gurcharahs, 1983; Nelson and Bolen, 2008).

The concrete making properties of aggregation are influenced to some extent on the bases of geological formation of the parent rock together with the subsequent process of weathering and alternation (Nelson and Bolen, 2008). According to Arnold (1979), natural sand and gravel deposits occur as superficial (drift) deposits laid down either by rivers or as glacial and fluvio-glacial spreads, which are left behind when the ice sheets melted. Dugal (2001) reported that, the composition of sand is highly variable, depending on the local rock source and conditions of its formation. The white sands found in tropical and subtropical coastal shelves are eroded limestone and may contain coral and shell fragment in addition to other organic or organically fragmental materials, suggesting that sand formation depends on living organisms also.

Well sorted sand are useful for industrial application where sand with wide range grain size distribution is preferred for concrete manufacture. This is because a poorly sorted sand has less pore space and less cement is needed when it is used for concrete production (Gurcharah, 1983).

The Imo River, generally referred to as "Imo Mmiri" is located in South Eastern Nigeria and flows 150 miles (241 km) into the Atlantic Ocean. Its estuary is around 40 km wide, with an annual discharge of 4 km^3 and 26,000 hectares wetland. The Imo River tributaries are the Otamiri and Oramiukwa. The Imo River was expanded under the British colonial administration of Nigeria between 1907 and 1908 and later in 1911. Its geographical location is Ukwa East Abia State, with the coordinates 40° 53′ 56″ North, 7° 10′ 25″ East, The mouth of the river is at the

Atlantic Ocean's barge at Eastern Obolo, AkwaIbom State, Nigeria.

The second river selected is Otamiri River. Otamiri River is one of the major rivers in Imo States, Nigeria. The river takes its name from "Ota Mmiri". The river runs from Egbu, past Owerri and through Nekede, Ihiagwa, Umuagwo down to Ozuzu in Etche, Rivers State. From Etche it flows to the Atlantic Ocean. From the source to its confluence at Emabiam with the Uramiriukwa River, Otamiri River is 30 km in length (Onugha, 2013).

The Otamiri watershed covers about 10,000 km^2 with annual rainfall 2250 - 2500 mm. The Otamiri River is joined by the Nworie River at Nekede in Owerri, a river which flows through an alternating sequence of sand, sandstones and caly-shales. Random sand samples from the bank of Otamiri River between Chokocho and Umuanyaga, Etche Local Government Area, Rivers State showed that 86% of the sand particles are within the ideal range for glass making (Onugha, 2013). However, application of the sand for construction purposes is still been explored.

This study was therefore conducted to assess the quality of sand using standard laboratory tests on twenty samples each from both Imo River and Otamiri River. The experimental investigation was carried out to determine the suitability of these rivers sand for construction purposes.

2 MATERIALS AND METHOD

The data were obtained from sand samples collected from the upstream and downstream of the two selected rivers. The first river is Imo River, with Owerri-Nta and Obowo points as the chosen locations. The second river is Otamiri River, with Nekede and Obinze points as the selected locations. Both rivers are located in Imo State, Nigeria. The samples were collected between 5th and 8th August, 2016. Clean samples were properly bagged in a waterproof leather sacks, labelled and transported to the Civil Engineering laboratory, Federal Polytechnic Nekede Owerri, Imo State. Tests carried out include sieve analysis, Atterberg limits, Specific gravity, California bearing ratio, Acidity, Organic content, and Silt content determination.

Sieve analysis was carried out to determine the grain size distribution of the sand fractions from the selected locations on both Imo River and Otamiri River using 8 inches woven wire sieves and mechanical sieve shaker according to BS 1377 (1990).

The colour of the samples were observed and characterized according to Munsell soil colour Diagram and Munsell Soil Colour Chart (Whitlow, 1995).

Atterberg Limits tests were also conducted to determine the plasticity and consistency of the sand samples from the two rivers by using Casagrade type mechanical liquid limit apparatus. Specific gravity and water absorption of soil fraction passing 4.75 mm sieve were also determined using density bottle.

The California Bearing Ratio (CBR) test was conducted on the sand samples at optimum moisture content (OMC) determined from the modified compaction test. The test was conducted using a Cylindrical Mould (CBT Mould) with inside diameter 150 mm and height 175 mm, provided with a detachable extension collar 50 vmm height and a detachable base plate 10 mm thick (BS 1377, 1990; Arora, 2010; Arora, 2012).

The acidity test of the samples was carried out to determine the acidity, alkalinity or neutrality of the samples according to Fu (2000).

Organic content determination was carried out to determine the presence of organic impurities in the soil samples by the use of Sodium Hydroxide.

Silt content test was carried out to determine the cleanliness of sand by establishing the percentage of silt present in a natural sand. Too much silt will affect the mix design and thereby weaken the concrete (Atkinson, 1993).

3 RESULTS AND DISCUSSION

3.1 ENGINEERING PROPERTIES OF SAND FROM IMO RIVER: OWERRI-NTA AND OBOWO LOCATIONS

These samples from Imo River were represented as Sample A and B. Sand from Owerri –Nta and Obowo locations are labelled as sample A and sample B respectively. The Index and Engineering properties of the sands were summarised in Table 1. The pH value of both samples is 6.50 showing that the sand is slightly acidic. However, this level of acidity may not pose serious threat to construction materials. The Specific Gravity of the samples averaged 2.36. This value fall below the stipulated range of 2.50 - 3.00 for construction aggregate (B.S. 882, 1973; B.S. 812, 1992).

From the sieve analysis, sample from both locations of Imo River, i.e. Owerri-Nta and Obowo fall within zone 2 of grading curves shown in Figures 1 – 2. This indicates that the sand can be used as fine aggregate for construction purposes according to classifications in B.S 882, (1973, 1992); B.S 812, (1990); Neville (2003); Neville and Brook (1987). The average moisture contents of the samples range from 3.43 - 7.00%. The sand from both locations is medium poorly graded, with low compressibility and good drainage quality.

The samples were not really clear in sodium hydroxide solution, which indicated the presence of impurities. Sample A has a plasticity Index of 18% while sample B has a plasticity Index of 22% as shown in Figures 3 – 4. The Samples colours are within 8/6 pale brown and 7/6 brownish yellow according to Munsell soil colour Chart (Whitlow, 1995).

The CBR value ranges between 0.15% and 0.22% and the details are shown in Figures 5 – 6. These values are very low. The CBR is used to rate the performances of soil for use as bases and sub-grade (Coduto, 1999).

TABLE 1: PROPERTIES OF SAND FROM IMO RIVER

Properties of Sand	Location	
	Owerri-Nta	Obowo
Acidity	6.50	6.50
Uniformity coefficient (Cu)	2.33	2.60
Coefficient of curvature (CC)	0.86	0.94
Plasticity index (%)	18.00	22.00
Percentage fine (%)	27.10	19.30
California Bearing Ratio (C.B.R) %	0.16, 0.22	0.15, 0.19
Organic content	Presence of impurities	Presence of impurities
Specific gravity	2.59	2.13
Sand zone	Zone 2	Zone 2
Moisture content %	3.43	7.00
Silt content %	0.3	1.34
Water absorption	0.05	0.12
Munsell soil colour	8/6 (very pale brown)	7/6 (brownish yellow)

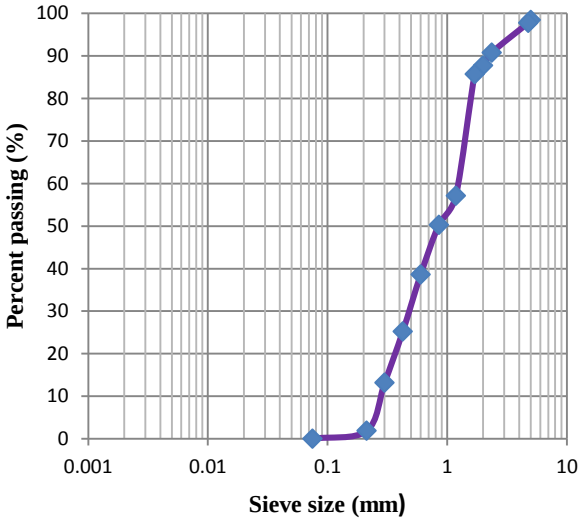


Figure 1: Sieve Analysis of sand from Owerri-Nta Location on Imo River

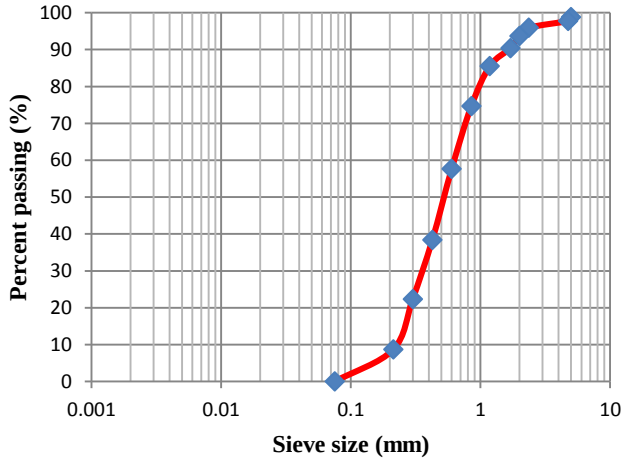
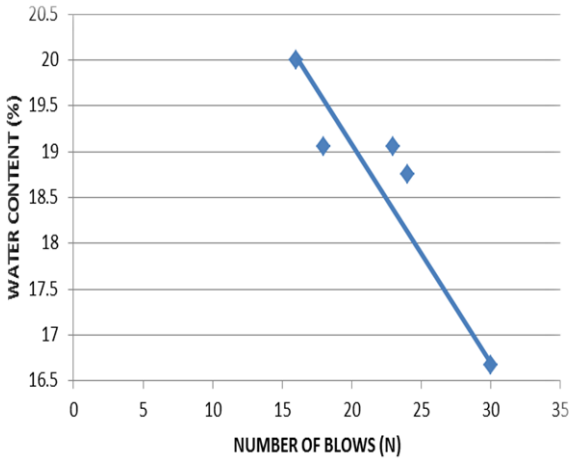
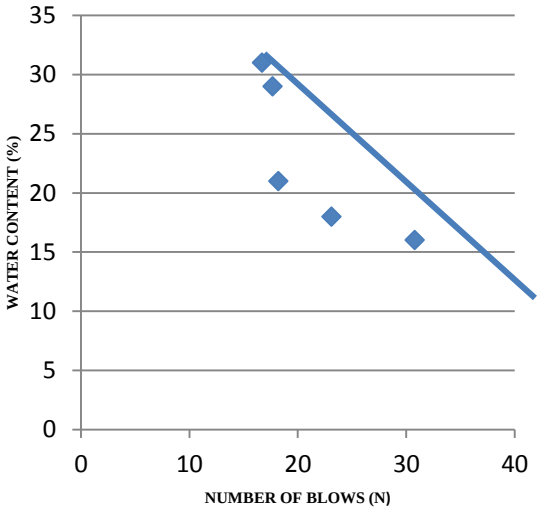


Figure 2: Sieve Analysis of sand from Obowo Location on Imo River



Liquid Limit = 18.0; Plastic Limit = 0; Plasticity Index = 18.0

Figure 3: Atterberg Limits of sand from Owerri-Nta Location on Imo River



Liquid Limit = 22.0; Plastic Limit = 0; Plasticity Index = 22.0

Figure 4: Atterberg Limits of sand from Obowo Location on Imo River

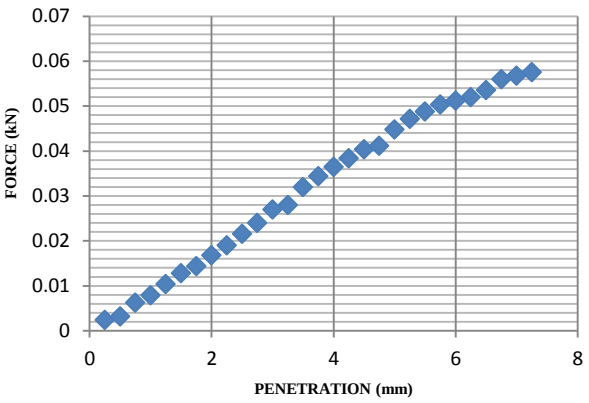


Figure 5: California Bearing Ratio of sand from Owerri-Nta Location on Imo River

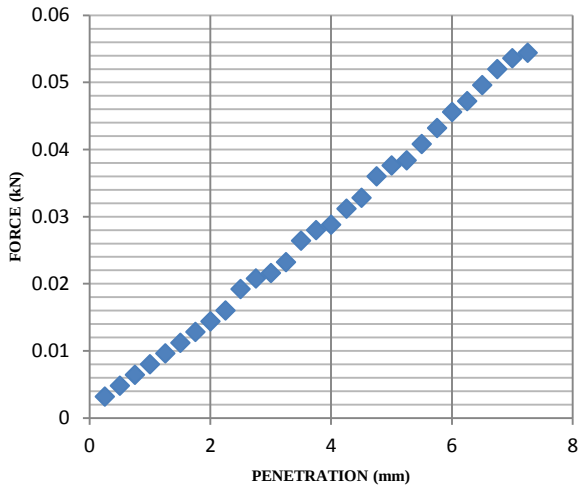


Figure 6: California Bearing Ratio of sand from Obowo Location on Imo River

3.2 ENGINEERING PROPERTIES OF SAND FROM OTAMIRI RIVER: NEKEDE AND OBINZE LOCATIONS

These samples from Otamiri River were represented as Sample C and D. Sand from Nekede and Obinze locations are labelled as sample C and sample D respectively. The Index and Engineering properties of the sands were summarized in Table 2. The pH value of both samples is 7.00 showing that the sand is neither acidic nor alkaline. The sand is neutral and would not pose any threat to construction materials. The Specific Gravity of the samples averaged 2.57. This value fall within the stipulated range of 2.50 - 3.00, indicating that the sand is suitable for use as construction aggregate.

From the sieve analysis, like the sample from Imo River, sand from Nekede and Obinze location of Otamiri River fall within zone 2 of grading curves shown in Figures 7 – 8. Therefore, the sand can be used as fine aggregate for construction purposes according to classifications in B.S 882, (1973, 1992); B.S 812, (1990); Neville (2003); Neville and Brook (1987). The average moisture contents of the samples range from 4.18 - 5.87%. The sand from both locations on Otamiri River is medium poorly graded with low compressibility.

The samples were very clear in sodium hydroxide solution, which indicated no presence of impurities. Plasticity Index of sample C and D is 24% and 22% respectively as shown in Figures 9 – 10. The Samples colours are within 8/2 white and 8/4 white respectively for Nekede and Obinze location sand along Otamiri River according to Munsell soil colour Chart (Whitlow, 1995). Both samples were non-plastic sand with zero plastic limit.

The CBR value of Otamiri River sand ranges between 0.16% and 0.19% as shown in Figures 11 – 12. Like the sand from Imo River, the CBR is low.

TABLE 2: PROPERTIES OF SAND FROM IMO RIVER

Properties of Sand	Location	
	Nekede	Obinze
Acidity	7.00	7.00
Uniformity coefficient (Cu)	2.50	4.14
Coefficient of curvature CC	1.07	0.72
Plasticity index %	24.90	22.20
Bulk density Mg/m3	1.56	1.58
Percentage fine (%)	25.47	25.20
California Bearing Ratio (C.B.R) %	0.16, 0.19	0.13, 0.19
Organic content	NONE	NONE
Specific gravity	2.63	2.51
Sand zone	Zone 2	Zone 2
Moisture content %	4.18	5.87
Silt content %	1	0.09
Water absorption	0.01	0.09
Munsell soil colour	8/2 (white)	8/4 (white)

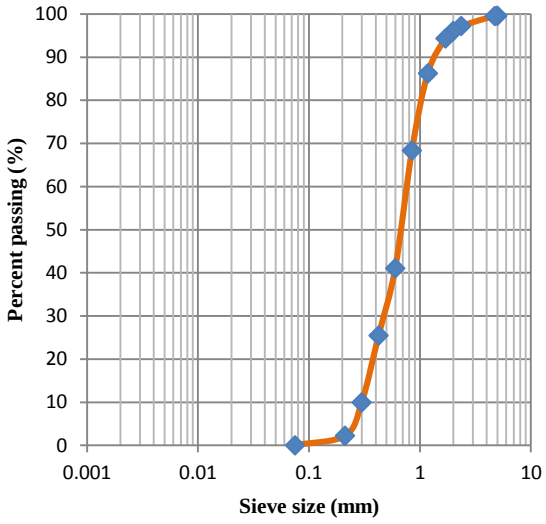


Figure 7: Sieve Analysis of sand from Nekede Location on Otamiri River

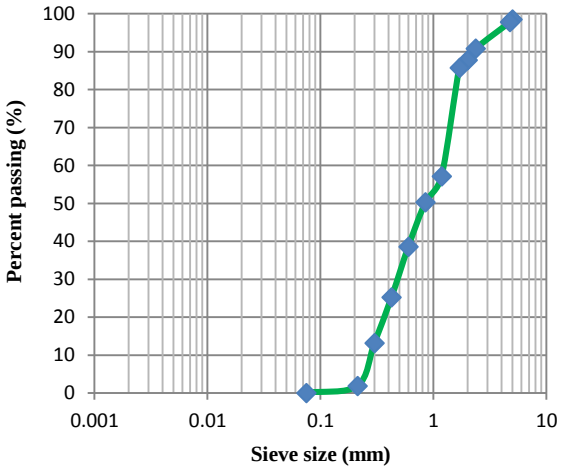
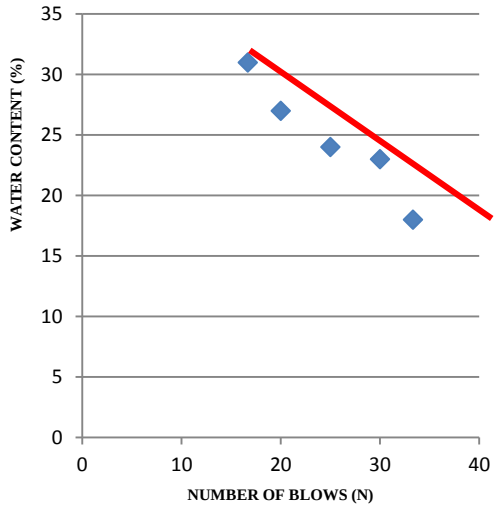
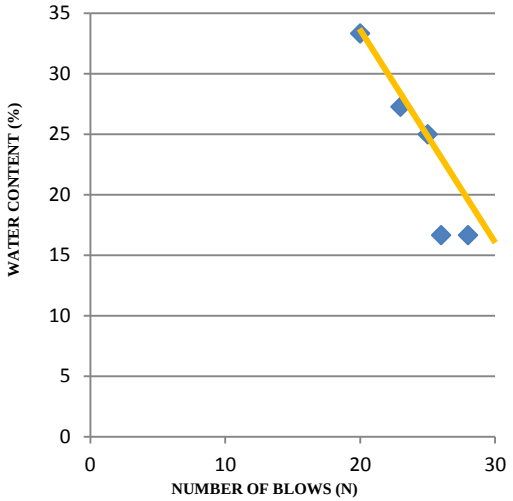


Figure 8: Sieve Analysis of sand from Obinze Location on Otamiri River



Liquid limit = 24.9; Plastic limit = 0; Plasticity Index = 24.9

Figure 9: Atterberg Limits of sand from Nekede Location on Otamiri River



Liquid Limit = 22.2; Plastic Limit = 0; Plasticity Index = 22.2

Figure 10: Atterberg Limits of sand from Obinze Location on Otamiri River

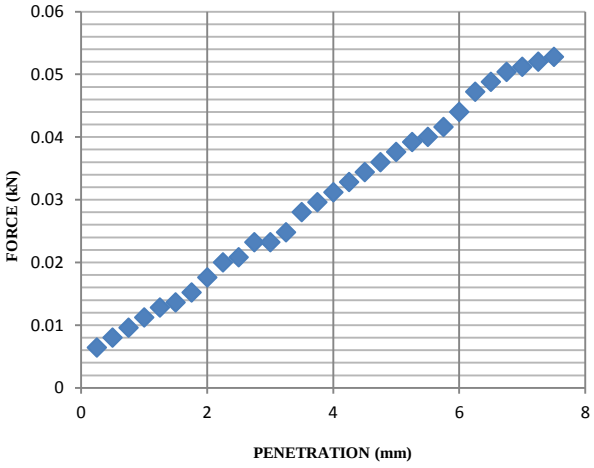


Figure 11: California Bearing Ratio of sand from Nekede Location on Otamiri River

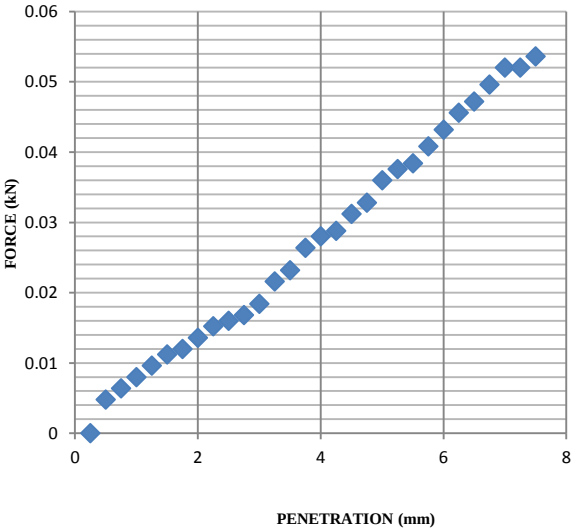


Figure 12: California Bearing Ratio of sand from Obinze Location on Otamiri River

4 CONCLUSION

The main conclusions drawn from the assessment of quality of sand from Imo River and Otamiri River, Imo state for construction purposes are:

Sand from Imo River and Otamiri River, both of which are located in Imo State, Nigeria can be described as medium poorly graded sand with low compressibility. However, it has good drainage quality.

From the properties, sand from Imo River and Otamiri River are classified under Zone 2 of the grading curve on particle size distribution. Soil in this zone is therefore recommended for use as fine aggregate in concrete production.

The study further revealed that the sand from Imo River and Otamiri River have low CBR values, which ranges between 0.15% and 0.22%. The sand is suitable as fine aggregate for construction purposes.

Sand from Imo River is slightly acidic with average pH value of 6.5. However, this level of acidity does not pose serious threat to construction materials. On the other hand, sand from Otamiri River is neutral with a PH value of 7. Sand from both rivers are therefore suitable for construction purposes.

Sand from Imo River shows slight presence of impurities. This may be deleterious to cement or bitumen. Nevertheless, with proper sorting, it may still be useful for other construction applications. Otamiri Sand on the other hand showed absence of impurities, which makes it a readily suitable aggregate for construction purposes.

Sand from Imo River is slightly acidic, it is not recommended for construction where steel members are used, without modification of its acidity property. Using it under this condition may aggravate corrosion and rust, and thereby affect the service life of the structural member for which it was used.

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