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Defining a Sustainable Sand Budget for Burrow-pit Activities in Nigeria

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ABSTRACT

This paper reports the finding of the impact of sand mining within Ado Ekiti metropolis. Three locations were chosen from where field physical measurements and observations were made. Laboratory analysis such as compressive strength test and particle distribution analysis were conducted on samples collected at the locations. Global Position System (GPS) was used to determine the coordinates and elevations of the mine sites to produce the digitized topography maps of the sand mine sites using Arc GIS software. The volume of sand mine was determined thereafter. The result obtained from topography shows that the volume of sand mined in Afao, Ijan, and Federal Polytechnic Ado-Ekitiwere 3.62 metric Tonnes 1.34 metric Tonnes and 0.51 metric Tonnes respectively. The sample size classification showed that clay and silt content of all the location were 5% with sand range between 75 – 82%, and the gravel range between 13 – 20 %. Also the absorption test shows that Afao and Ijan have 11.76 % and 10.96% respectively while Federal Polytechnic Area of Ado Ekiti had 13.23% and 13.92% respectively. The conclusion drawn from the observation and analysis of the field data was that indiscriminate sand mining pose environmental threats to the life and properties of the people around the sites.

Key words: *Sand mine, Structural construction, ArcGIS, GIS, Climate change, Ado Ekiti*

INTRODUCTION

Soil, particularly clay, sand, gravel and minerals, is an important source of raw materials. It is a non-renewable natural resource with potentially rapid degradation rates and extremely slow formation and regeneration processes[8,18]. Sand is a soil resource consisting of very small pieces of rocks and minerals, derived from the process of weathering. The durability of river-borne coarser plastics (e.g. sand and gravel) and their sorting by fluvial action make them suitable raw materials for building constructions[6,12].

According to Many research reports had been presented concerning the environmental impacts of sand mining activities around the world[7,10,15,17,18,21,23]. The practice is becoming an environmental issue as the demand for sand as an important mineral resource is increasing in the construction industry.

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Goddard[6] and Hill and Kleynrans[7], suggested the sand mining budget to forestall the degrading effects on the environment. Robinson and Brown[17] and Schaetzl[19] claimed that sand mining and processing is a worldwide phenomenon. However it is more pronounced in the developed and fast growing nations in Asia and Latin America. Cases of wanton and indiscriminate mining in India were recorded in the reports of Kuttipuran[11]. Pereira[16], Saviour[18], Bagchi[2] and Kuttipuran[11] discussed howconstruction boom fuelled the demand for sand facilitating uncontrolled extraction which threatens existence of river systems in many parts of peri-urban regions of India.

Researchers in Africa such as Wachira[24] reported a study the impact of sand mining in Kenya. Hill and Kleynrans[7] showed the potential damaging effects of sand mining and processing could have on South African economy. Kondolf[12], Lupande[14] and Chimbodza[4] studied how demand for sand was triggered by massive construction of new buildings, extensions and renovations in Harare.

Kuttipuran1[1], Goddard[6], Bagchi[2] and Tillin *et al*[22], affirmed that sand is strategic toglobal economy because it is cheap and readily accessiblefor use as construction material for building strong structures, landscaping and road bases. Pereira[16], Lawal[13], andLupande[14] concluded in their reports that sand mining is the bedrock African economic development, without it, the construction industry will not function properly. Sand mining contribute to revenue generation and job creation for millions in Africa[13.14,18.]

Negative Environmental Impacts of Sand Mining Worldwide

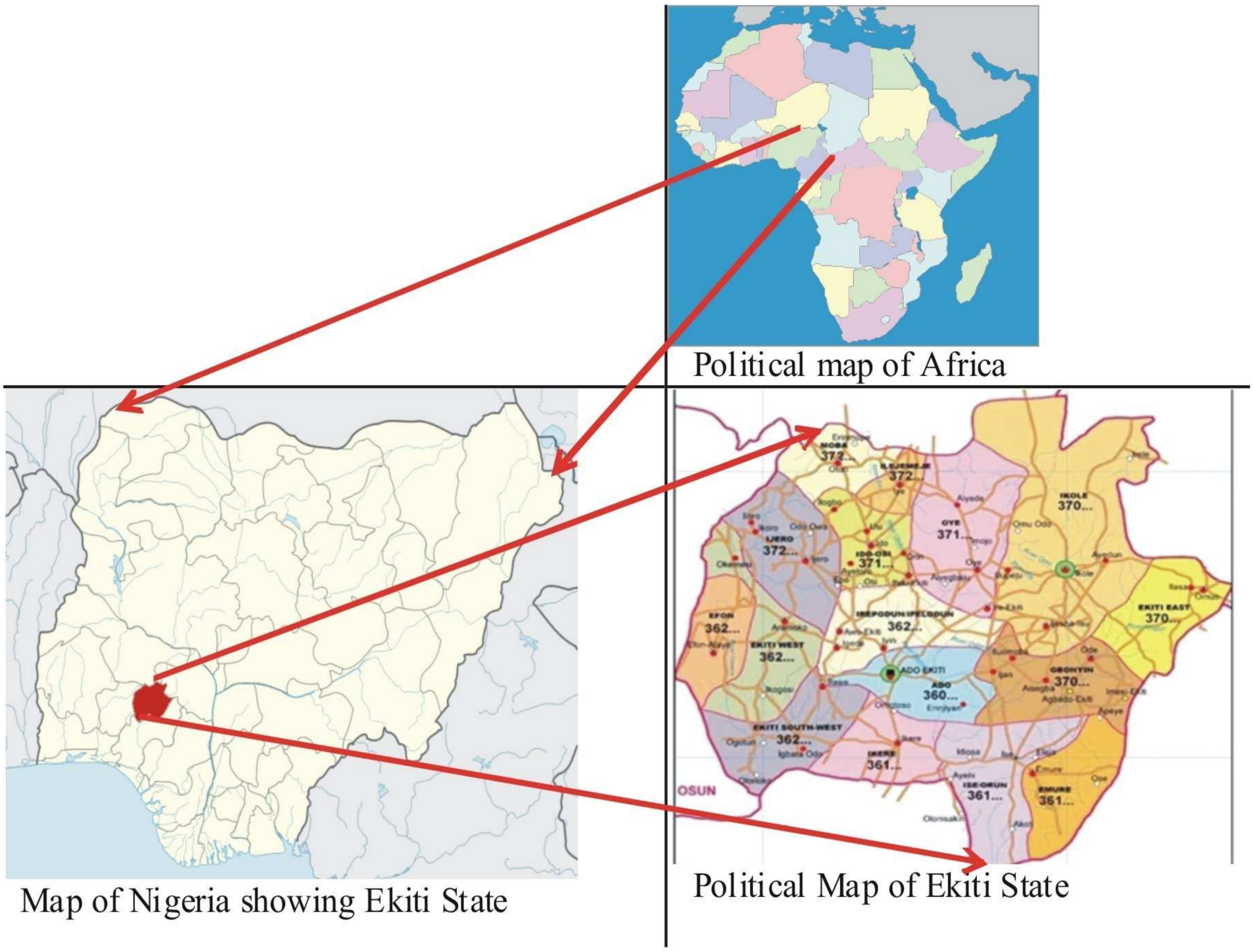
Kondolf[12] and Bagchi[2] said stream mining activities causes bed degradation of rivers known as channel incision, distorts natural flow velocity and threatens groundwater resource. According to Stebbins[20], Schaetzl[19], Hill and Kleynrans[7] sand mining cause destruction of aquatic and riparian habitat in stream. While Schaetzl[19], Kuttipuran[11], Kgosisejo[9] and Lawal[13] studied the effect of sand miningon the extra heavy vehicles and traffic on roads and noise and air pollution to the villages near mining sites. Wokorach[25], Stebbins[20], Goddard[6] noted that as mining could lead to loss of protection provided by soil as it filters out pollutantsthat can contaminate drinking water and affect people’s health. Kuttipuran[11], Stebbins[20], Aromolaran[1]and Saviour[18] figured out that sand mining can cause destruction of soil structure and profile,complete removal of vegetation and destruction of topsoil and subsoil in the environmentleading to reduction in fauna and flora population.

Bagchi[2], Lupande[14], Lawal[13] and Pereira[16] claimed that water accumulates in the open pits during the rainy season could drown domestic animals and lure children to swim and get exposed to accident. Ekosse[5] and Central Statistics Office of Botswana[3] reported the environmental impacts of mining to soils around mining areas in Botswana and observed from soils and organicchemical properties around mining areas. The report saffirmed that there was demineralisation and pollution of soils which led to formation of dead zones and stunted growth in plants.

MATERIALS AND METHODS

Study Area: The study was conducted in the Peri-urban areas of Ado Ekti, the capital town of Ekiti State of Nigeria (fig. 1). Three zones of the areas were air-marked viz; Afao road, Ijan, The Federal Polytechnic Ado-Ekiti environs in Ado Ekiti suburbs. The research comprised both field data collection and simulations. ArcGIS 10.1 was used for quantitative analysis of the field data. Measurement of depth, width of pits and widening of rivers at sampled collection points were taken using GIS. The study began with digitization of Ekiti state map. Then, the geographic coordinate and other details using Global Positioning System (GPS) handheld instrument (Garmin 76) at the outer, edge and inner part around the sand mining area were conducted.

Fig. 1: The Map of the Study Area (Goggle Map, 2015)[26]



Finally,data was collated in a database that was super-imposed on the digitized map. The volume of sand excavated from the sand mines was estimated using Simpson rule:

$$Volume = L\left[\left(\frac{A_1+A_n}{3}\right) + 2(EAodd) + 4(EAeven)\right] \quad ……………………..(eqn.1)$$

Laboratory tests were conducted on the soil samples collected from the sites includes; Sieve Analysis, Water Adsorption test, Specific gravity, Silt test, Compressive Strength Test, Abrasion Test and Impact Test.

Field measurements

4 sites, viz: Afao road, Ijan, The Federal Polytechnic Ado-Ekiti environsin Ado Ekiti suburbs. The data collected was analysed with mapping software (ArcGis 10.1) (adopting a triangulated irregular network (TIN), a digital data structure used in a geographical information system (GIS) for the representation of a surface) to create maps of the sites for interpretations.

Fig. 2: Map of Sand-mine site Ado Ekiti-Afao Road

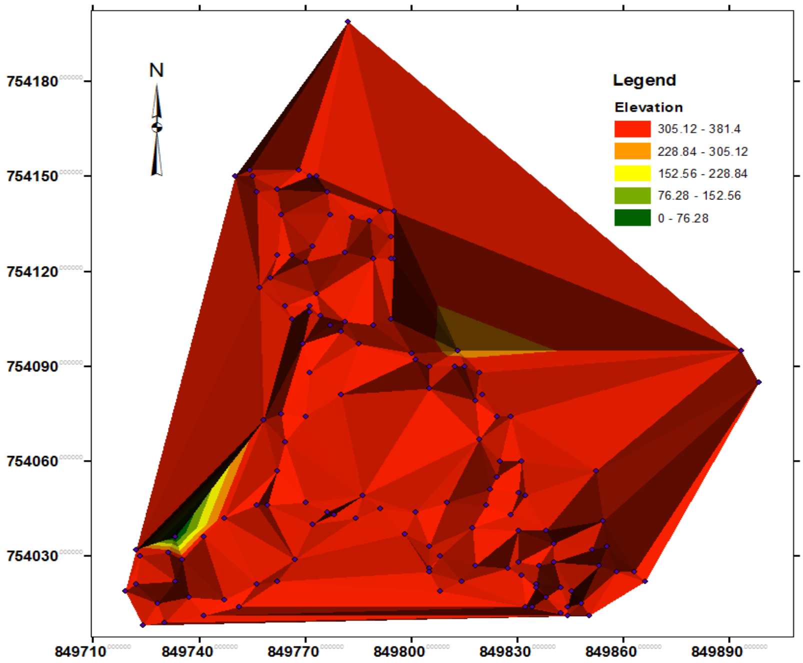


Fig 2.0 shows the mining area of Ado-Afao, which produced fig 4.4.0 showing the shallow part of the mining site area, with least elevation of 310 m and maximum elevation of 356 m.

Fig. 3: Transect of the Developed Map of Sand Mine Site along Ado Ekiti-Afao Road

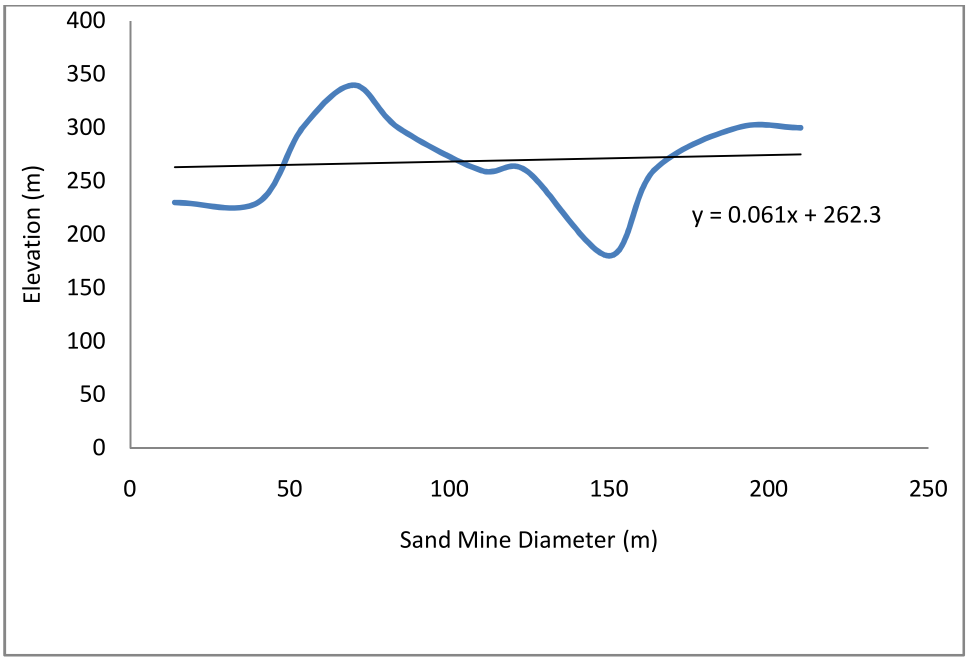


Fig 3: Showing the average depth area of the whole sand mining area in Ado-Afao with least elevation of 190 and maximum elevation of 340 m.From this figure, the estimated total volume of sand mined in the site was 362.4 Tonnes.The average slope of the surface within the dugout was 0.62. This was capable of inducing erosive runoff flow in event of heavy rainfall. If the mined area is to be retrofitted by levelling the dugout to an elevation 250 m above sea level, maybe for water storage or waste landfill, it will require about 14.0 Tonnes of cutting and 1,046 Tonnes of sand filling.

Fig. 4: Generated Map ofSand Mine Site area in Ado-Ijan road mining site

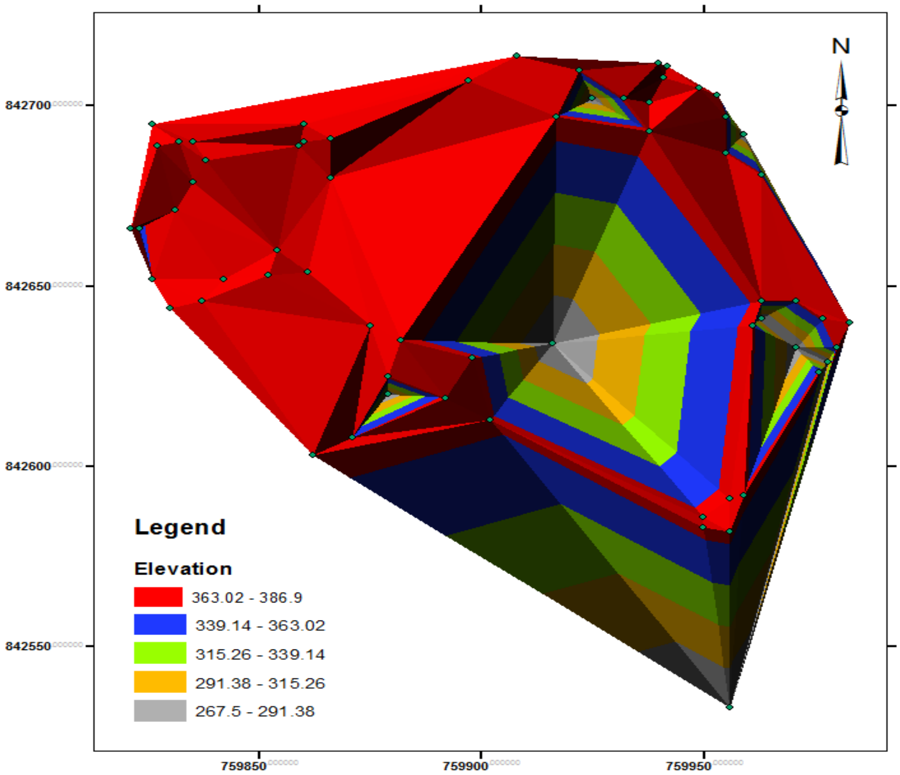


Fig 4 shows the sand mine site along Ado-Ijan axis of the study area.It shows the deepest part of the mining site area with least elevation of 280 m and maximum elevation of 390 m. From this figure again the estimated total volume of sand mined in the site was put at 1,342.50 Tonnes.

From the section of this map Fig 5was produced to shows the low, high points of the dugout and the average depth area of the whole sand mining area in Ado-Afao. The average slope within the dugout was 2.9 (a slope that could encourage erosive runoff flow. The average depth represents a retrofitted dugout of 419,000 cubic metres in volume which could be used for beneficial purposes. It could hold up to 410,000,000 Litres of water.This rescue will require 700 Tonnes of sand cut off and 1,110.0 Tonnes of sand-fill if the mined area is to be filled to an elevation 350 m.

Fig. 5: Transect of the Developed Map of Sand Mine Site along Ijan-Ekiti Road

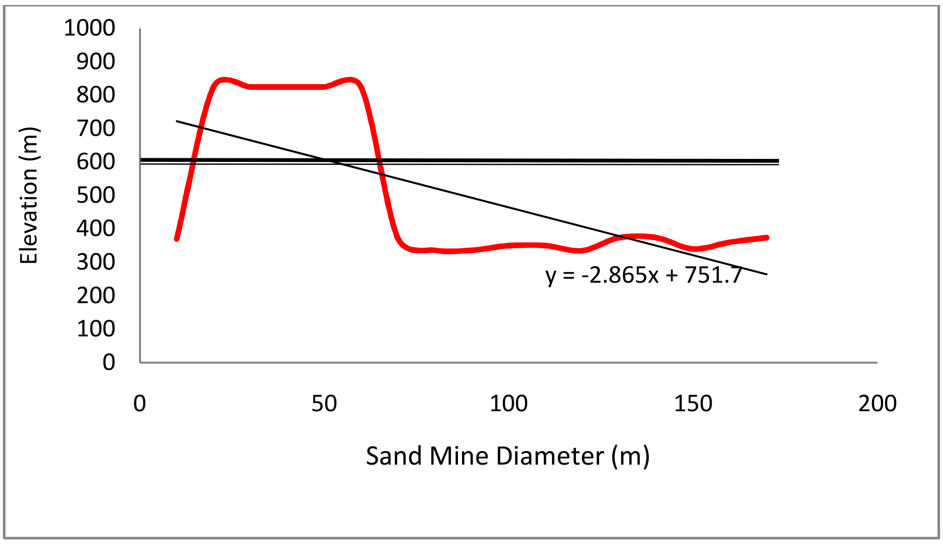


Fig. 6: Map of Sand Mine Site area in The Federal Polytechnic Area of Ado Ekiti

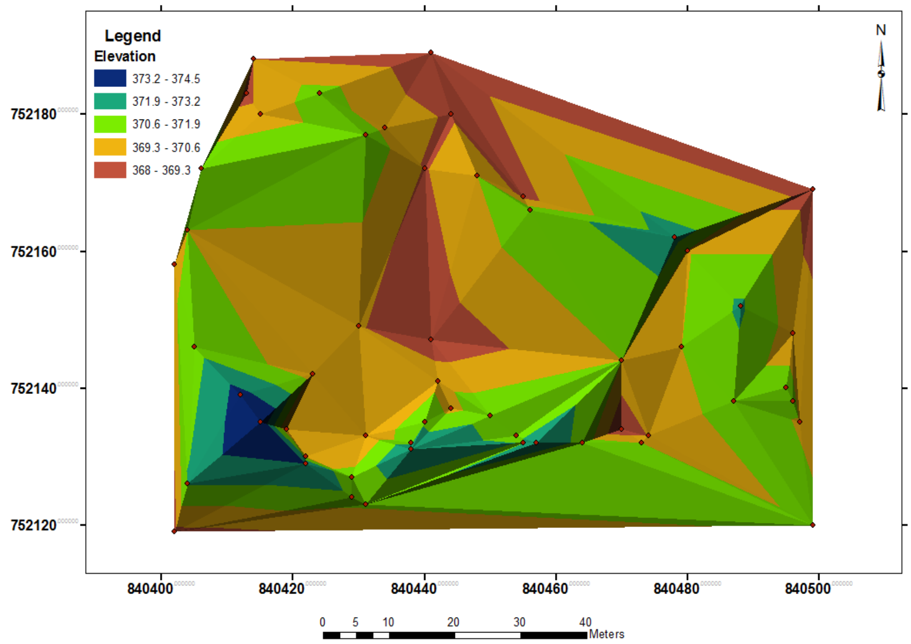
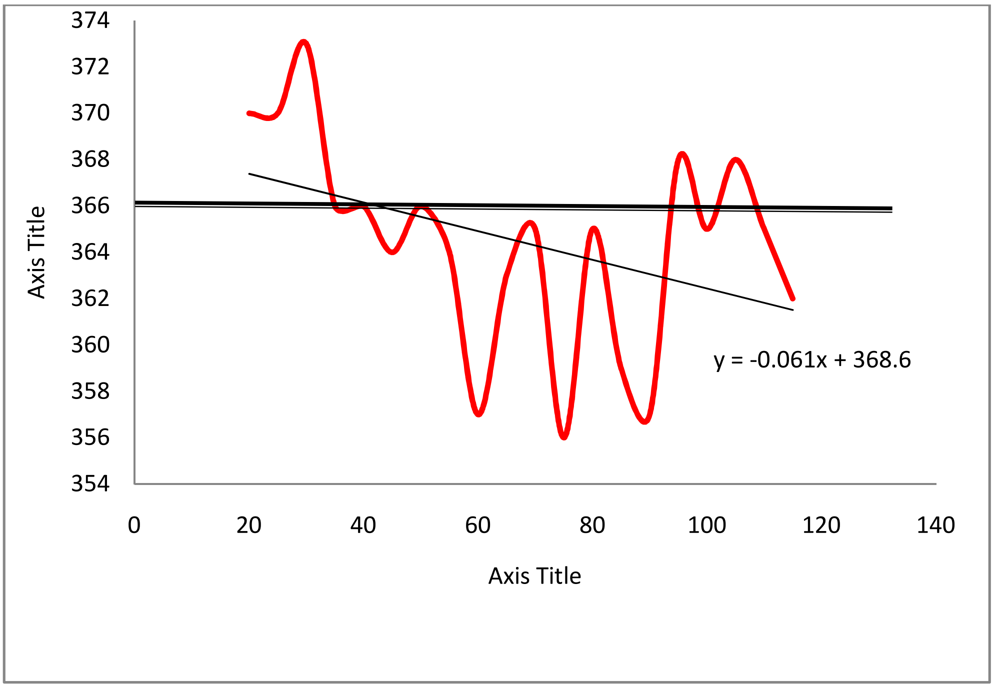


Fig 6 shows the sand mine sitein the vicinity of Federal polytechnic Ado Ekiti. The dugout had both shallow and deep parts with least elevation of 265 m and maximum elevation of 385 m above sea level. The gradient of the slope so created with this excavation was in the neighbourhood of 0.62. This slope will encourage water flow of at least 320 km/hr. This flow velocity far outweighs the maximum safe flow for non-erosive runoff.

Fig 7 is the section of produced from the developed map of the Federal Polytechnic sand mine site. It shows the average depth area of the whole sand mine site with the least elevation of 336 m and maximum elevation of 386 m.

Fig. 7: Transect of the Developed Map of Sand Mine Site along Federeal Polytechnic Area



The total volume of sand mined in the site was estimated at 1,342.50 Tonnes. The excavation had created a surface depression of 24,020 m^3. This is capable of retaining 10,480,000 litres of water. To reclaiming this site for any economic purpose could involve levelling. To level the dugout to an elevation of 366 m above sea level, 700 Tonnes of sand will be cut and 1,110.0 Tonnes of sand-fill will be done.

The result of the sieve analysis of the soil samples taken from all thesand mining sites revealed that the soil there had particles size distributionof silt and clay content of 5% and 80% sand content. This result suggests that the exposed soil surface was highly susceptible to easy detachment and transportation; a condition that could lead to accelerated erosion of the area so studied.

Fig. 8: Cummulative Excavation (Tonnes) and the Resulting Surface Depression (m^3)

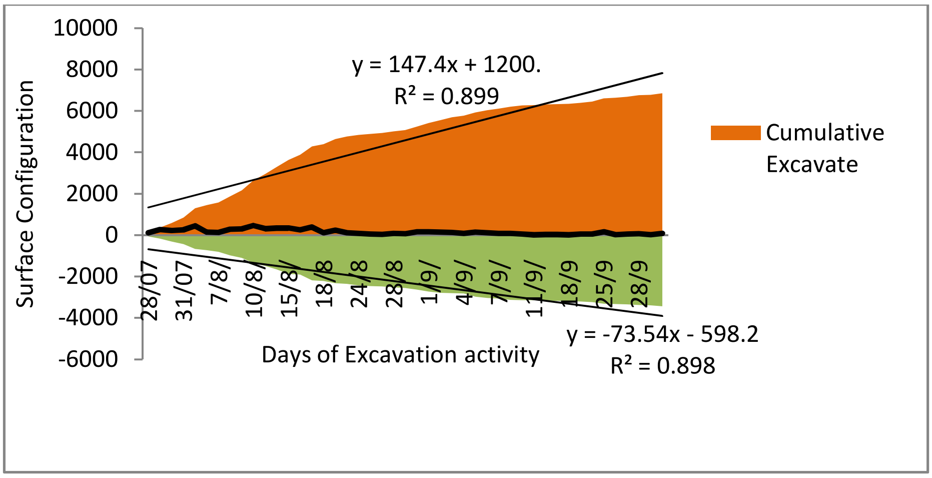


Fig 8 shows the earth surface depression developed from the sand excavation activities in site along Ijan road. The average daily haulage from the site was 120 Tonnes (estimated from the tipper lorry with 10 Tonnes capacity). In order to reduce the consequential environmental harzards associated with sand mining, the number of truck traffic should be reduced to maximum of 6 per day. If the traffic frequency must be more than 6 per day then the lorry truck should be limited to 5 Tonnes. Another strategy is to reduce the total length of time that sand mining activity should take in a site.

CONCLUSION

The study on impacts of sand mining within Ado Ekiti metropolis revealed both positive and negative effects. It highlighted the views of environmental degradations, accidents caused and general damage to ecosystem. The research justified that Ado Afao and Ado Ijan road sand is the soil component mined most out of the three locations maybe due to its compressive strength of 2.35 N/mm^2 and 1.3 N/mm^2 and its suitability for many construction uses.

Recommendations

Based on the field measurement and the test carried out in the laboratory, Ado Afao and Ado Ijan road mining site can be used for dam construction, water storage reservoir for irrigation purpose due to large volume of sand that has been mined, however if these locations are to be used for these purposes, the level of cut and fill will be minimum. Also sand mined from Ado Afao and Ado Ijan having been conformed to the standard specifications for the laboratory test carried out is preferred for used in construction of various structures e.g. building, dams, bridge, foundations etc.

It is important to have an Environmental Assessment Management and Monitoring Program. Close monitoring ensures that there is proper mining and no sand recruitment downstream. Department of Roads and Transport with help of Police Service should restrict tipper trucks transporting sand through the villages. Constructing temporary roads out of villages to reduce air and noise pollution is necessary.

Mining operations must be conducted in a manner that minimizes or eliminates adverse impacts on both in stream components of ecosystems comprising of biota and habitats. Authorities are to strengthen laws on not allowing people to enter mining areas through close monitoring of the mining activities in all areas.

Restriction of mining time and days to normal working hours that is 07:30 am-4:30 pm on week days is important to reduce illegal mining when there is tight security.

Covering sand with nets: when transporting the resources to be a prerequisite to reduce damage of other motorists' windscreens from falling stones.Compensation of farmers: whose animals drown in pits and die from measles after eating waste should be done by the miners.

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