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Improvement of Dredging Productivity in Niger Delta Using Predictive Method

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ABSTRACT

Dredging activities are becoming common as the demand for sand in urban development of cities, construction, dredging of rivers etc . This project was aimed at developing a method of executing dredging activities in the Niger Delta of Nigeria using predictive algorithm to improve productivity. The researcher was based on two major classification of grain sizes and these have different effects on the productions of the various sites used. This project was evaluated using all the necessary factors affecting production. Such as Pipe Line Length of discharge, digging Depth, Dredge capacity, ours of dredging, operational cost, quantity produced and grain size. A method was created to predict future dredging activities from data obtained from these sites in the Niger Delta. This would help current and future investors in the dredging industry in Nigeria to further understand the implication of dredging activities and the variables of production in sand dredging. The application can be compiled to be used on computer systems operating MATLAB and mobile devices as well.

KEYWORDS: Dredging activities, Niger Delta, grain sizes, variables of production, fine sand, medium grain, critical velocity, hydraulic transport, system losses.

INTRODUCTION

As the rate of construction projects in Nigeria are increasing, the demand for sand is also on the increase which has seen more dredging sites situated around the country for sand dredging. Dredging activities have gradually become a common business venture in Nigeria nowadays with a lot entrepreneurs investing heavily into it. The research work thrives to evolve proper prediction of sand dredging production activities for different grain sizes. Dredging means excavation of materials by floating equipment mostly from below water level (Cohme, 2007).

The ultimate target on all dredging contracts is to get a volume of material from position A to B in the most economical way (Dredge mechanical supervision and weekly reports Johnson, 2010). From the origin of civilization, people, equipment, materials and commodities have been transported by water. Ongoing technological development and the need to improve cost effectiveness have resulted in the need to enlarge or deepen many of our rivers and canals.

Nearly all the major sea ports in the world have at some time required new dredging works known as capital dredging to enlarge and deepen access channels, provide turning basin and achieve appropriate water depths along water side facilities. Efficient and effective project management technique in dredging industries is a major requirement for any dredging company as it will minimize the total time for a dredging activity and therefore prevent the cost incurred by delaying the project.

In fact, be it capital or maintenance dredging, remedial dredging, the construction of airport, harbours, land reclamation or offshore projects, maritime infrastructure construction are more accurate description of the activities of modern dredging companies (Cohen & Kolman, 2016). And these maritime construction projects require team work. A comprehensive project team may comprise project manager, contract experts, site investigators, scientist, engineers, dredge masters, skippers, financial planners and mechanics. In this context it has made companies and some educational institutions to promote understanding of dredging and maritime infrastructure construction. The dredging

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process comprise of excavation, transport of excavated materials and utilization or disposal of dredged materials. Dredges are truly modern marvels. Without them our harbors would silt up, no boat could pass and there would be no trade. In addition, they keep our rivers flowing by cutting through "s" curves and lessen the chances of flooding.

Improving project operation is the responsibility of the executer to utilize all the necessary resources in optimizing manner. Completing a project on time and within budget is not an easy task (Banger & Sharma, 2010). Project consist of numerous activities involving utilization of resources and new approaches in methodology and project management can save cost and avoid potential problems in project execution since many of the project task can be interdependent or independently executed in order to achieve the main objectives. Recent years, greater attention has been focused on the method of improving project operations to achieve the desired objectives and completing the project within allotted duration (Amer, 2014).

Creating a predictive model in dredging operation is the act of applying a mathematical procedure for planning, monitoring and controlling each dredging project by identifying each of the major activities required for the particular project. A myriad of details must be considered in dredging activities and how to coordinate all these activities in developing a realistic model and then in monitoring the progress of the project to improve operations. In most of the modeling, cost and productivity analysis will be used in predicting the implication of these activities in a dredging project (Sharma, 2009).

Omar (2009) asserted that organizations exist for the objective of maximizing

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profits and providing better services to clients at the right time. Most organizations do not focus on what needs to be done in order to reach the project goal through project improvement. Not knowing or recognizing the set of activities, precedence relations and the responsibility of the various project subparts greatly affects operations and hence reducing on its performance. It's therefore necessary for an organization to have an effective and well-coordinated project management team to set up a comprehensive Dredge Management Plan (DMP) to improve its operations and profit because the business environment is rapidly changing, highly competitive and directly affects the performance of the organization. Since dredging operation is capital intensive, scheduling activities haphazardly in dredging operation affects the operations negatively by causing downtime, lack of maintenance at the right time and waste of resources and manpower. Considering the high level demand for fund in dredging operation, this is therefore prompting the researcher to carry out the study on modeling to dredging operations in Nigeria specifically in the Niger Delta region.

2.0 MATERIALS AND METHODS

Arguably the most important factor that must be determined is the rate of production sustained by the dredge and dredging crew. The production rate of a dredging is defined by Bray *et al*. (1997) as the amount of material moved per unit of time. Once the production rate is determined, the time it will take to complete a project can be estimated. The more time a project takes, the more resources and labor will be required to complete it and the more costly it will be. Therefore, an accurate estimate of the

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production rate is required before there can be an effective cost estimate.

3.1.1 Data Collection Source

Data for this project was collected during dredging production on various sites in Niger Delta using Trailing Suction Hopper Dredge (TSHD). The sites covered in this project include;

i. Okrika Local Government Area (Amadi-ama)
ii. Ahoada East Local Government Area (Akinima)
iii. Obio/Akpor Local Government Area (Choba)
iv. Abua/Odual Local government Area

The dredging on these sites were carried out by Ellicot Dredges Nigeria Limited and Chuka Dredging Company of Nigeria respectively. The duration for the average data collected was for a period of 6 months on each site.

3.2 Methods

3.2.1 Hydraulic Transport

The transportation of solid material suspended in liquid, or hydraulic transport, is of major interest for the dredging industry. The efficient operation of hydraulic dredges depend on accurate calculation of the power required to pump slurry mixture, and the rate at which sediment can be removed. In the context of a trailing suction hopper dredge, these calculations are utilized for slurry pumped through the drag arm, into the hopper bin, and out to a shore reclamation project. The hydraulic transport components are broken down into three components: critical velocity, energy lost to the system, and power supplied by the pump (Hardya, 2016).

3.2.2 Critical Velocity

A fluid must maintain a certain velocity through a pipe to prevent particles suspended in that fluid from falling out of suspension and becoming stationary on

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the bottom. If the slurry does not maintain this critical velocity (Vc) the sediment will settle out, restrict flow, critical velocity. Matousek (1995c) developed the following equation based on the nomograph presented in Wilson *et al*. (2006) to determine the critical velocity in horizontal slurry pipe flow. And likely clog the pipe. The velocity maintained by the system should not fall below the

$$v_c = \frac{\left[\frac{\mu_s(SG_{so} - SG_f)}{0.66}\right]^{0.55} . D^{0.7} d_{50}^{1.75}}{d_{50}^2 + 0.11 D^{0.7}} \quad (3.1)$$

Where

μ_s = dimensionless coefficient of mechanical friction between particles

SG_{so} = Specific gravity of the solids

SG_f = Specific gravity of the fluid

D = Inner pipe diameter (m)

d_{50} = Median particle diameter (mm)

3.2.3 System Losses

From Matousek, (1995a), the Inner losses (H_m) can be computed as;

$$H_m = K\frac{V^2}{2g} \quad (3.2)$$

Where.

V = Mean velocity of slurry

K = Constant

g = Acceleration due to gravity

For Horizontal flow,

$$i_{m(horizontal)} = \frac{fV^2}{2gD} + 0.22(SG_{so} - 1)V_{50}^{M} c_v v^{-M} \quad (3.3)$$

where.

$$i_m = v_{50} = w \sqrt[w]{\frac{8}{f}} \cosh\left[\frac{60 d_{50}}{D}\right] \quad (3.4)$$

$$w = 0.9v_t = 2.7\left[\frac{(\rho_s - (\rho_f)g\mu}{(\rho_f{}^2}\right]^{\frac{1}{3}} \quad (3.5)$$

Where.

f = Friction factor for water

v_{50} = velocity of fluid for which 50% of solids are suspended

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M = Particle size parameter normally equal to 1.7

C_v = Concentration of solids by volume

v_t = Particle terminal velocity (m/s)

ρ_s = Density of solid

ρ_f = Density of fluid

μ = Dynamic viscosity

Friction factor, $f = \frac{0.25}{\left[log\left(\frac{\varepsilon}{3.7D}+\frac{5.74}{R^{0.9}}\right)\right]^2}$ (3.6)

ε = Pipe surface roughness (mm)

R = Reynolds number

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RESULTS AND DISCUSSION

4.1 Result of Statistical Analysis of the Dredging Sites

The data for various sites of dredging operations in Niger Delta were analyzed and computed to obtain the pipe length, hours of dredging, output per hour of dredging, digging depth etc. The results from dredging Companies can be found on Table 4.1 – 4.4.

Table 4.1: Production Data for Fine Sand (0.1 mm)

Phase	Pipe Length(m)	Digging Depth(m)	Output m^3/hr	Hours of Dredging	Operational Cost / Hr	Quantity Produced (m^3)
1	750	3.05	970	268	64887	259960.00
2	1200	6.1	850	285	64887	242250.00
3	1800	9.14	710	184	64887	130640.00
4	2800	12.2	578	252	64887	145656.00
5	3200	15.24	456	218	64887	99408.00
6	3500	18	398	235	64887	93530.00

The production rate (output) for dredging of fine sand (0.1mm) was at its highest at the lowest digging depth of 3.05m with a pipe length of 750m discharge. The dredging activities were divided into phases to easily monitor the process with respect to digging depth changes and pipe length increment. From Figure 4.1, the output for dredging was found to be reducing as the pipe length was increasing.

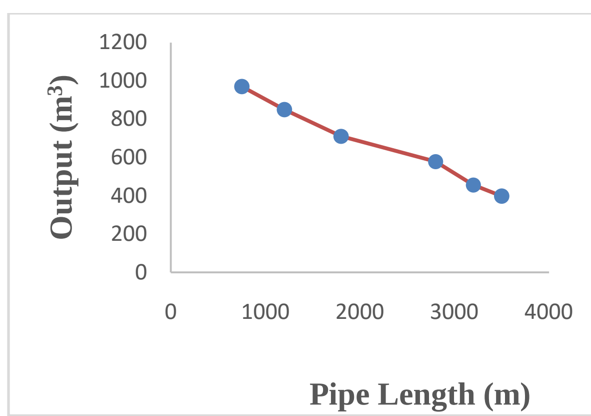

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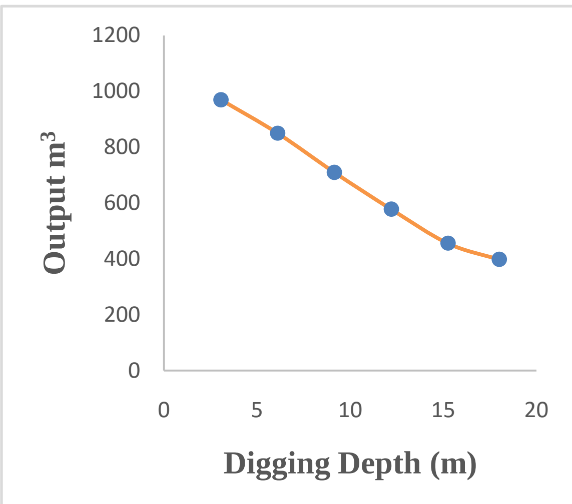
Figure 4.1: Dredging of Fine Sand with Pipe Length and Output.

The decrease was observed steadily to create a relationship between pipe length and production output of the pump. From Figure 4.2, it is also observed that production rate reduces with a reduction in the digging depth. The reduction was as a result of shortages of fine sand (0.1) grain size on the seabed during the



dredging operations.

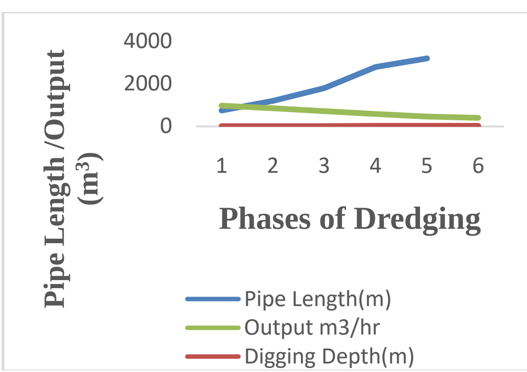


Figure 4.3: Dredging of Fine sand with Pipe Length, Digging Depth and Output

The of medium grain size (0.3mm) was also part of the dredging activities on a different dredging site in the Niger Delta. Table 4.2 shows the dredging data obtained from the medium grain size from site.

Table 4.2: Production Data for Medium Grain Sand (0.3 mm)

Phase	Pipe Length(m)	Digging Depth(m)	Output m^3/hr	Hours of Dredging	Operational Cost / Hr	Quantity Produced (m^3)
1	700	3.05	880	218	64887	191,840
2	1100	6.1	790	184	64887	145,360
3	1500	9.14	670	213	64887	142,710
4	1900	12.2	530	168	64887	89,040
5	2100	15.24	470	184	64887	86,480
6	2300	18	398	122	64887	48,556

Similar to the fine sand grain, the medium grain also has the same sets of digging depth applied in its six (6) phases of dredging. From Figure 4.4, the pipe length and output were observed to be inversely proportional.

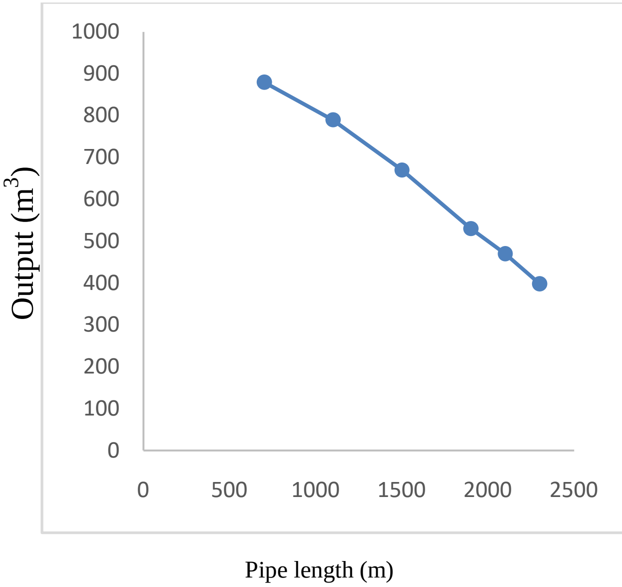


Figure 4.4: Dredging of Medium Grain with Pipe Length and Output

The digging depth and output also showed a similar inverse shape on the graph found on Figure 4.5. There is a trend in the rate of production and the depth of the suction digging on seabed level during dredging.

5.1 Conclusion

The research involved collection of data across four major dredging sites within the Niger Delta region of Nigeria for sampling and analysis. From the data, the volume of sand dredged, rate of dredging (output), digging depth, pipe length and other variables were evaluated mathematically. The dredging involved two sizes of sand which includes; fine sand (0.1mm) and medium grain (0.3mm). The production rate from these sites, cost of crew and production were computed using the available data from these dredging sites. A mathematical model was formulated to show the relationship between output of dredger, work hours and production rate, production cost and other variables needed in determining the production profitability of dredging.

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