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Original Research Article

Monitoring of Sand Concentration in Some Oil Wells in the Niger Delta Area of Nigeria

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ABSTRACT

The quantity of sand from five oil wells A, B, C, D, and E were determined by Sieving process. 20 Liters of crude oil from each of the wells were separated into five 5-liter poly cans with each poly can containing 4 liters of crude samples, 1-liter petroleum ether and 1 ml demulsifier. Crude oil samples from each well were sieved with a 70-mesh size (106 μm size) sieve to recover sand particles. This process was carried out for each of the wells for eight (8) consecutive days and wells were allowed a period of rest for three (3) months. The process was then repeated for another eight (8) consecutive days. Results obtained after sixteen (16) days of analyses show that the quantity of sand produced from each of these wells follow the trend $E > C > A > B > D$. Results obtained for the % increase in sand produced from wells A, B, C, D, and E were; 9.434, 12.180, 20.440, 20.000 and 20.000 % respectively. Results obtained from the extrapolated sand produced from wells A, B, C, D, and E with respect to their daily crude oil production were: 210,278.000, 85,800.000, 411,711.000, 17,150.000 and 577,500.000 g respectively.

Keywords: Crude Oil, Oil Well, Reservoir, Viscosity, Water Cut, Sieving

Introduction

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An oil well can be defined as a cavity drilled through the earth to produce petroleum hydrocarbons to the surface, a well designed to produce only gas is referred to as a gas well [1]. The success of crude oil production from an oil well is largely dependent on several factors including the ability of managing sand production from such formations. Shallow geological formations with little or no ability to naturally bond individual sand grains together have a higher tendency of sand production however sand challenges can also be faced in deep formations [2]. The ability to control the overwhelming sand production from an oil well is dependent on the availability of an appropriate technology to accurately evaluate the initiation conditions, estimate the influx rate and the volume of sand production from the well. Fluid flow in oil or gas wells are determined by reservoir rock consistency, stress state and completion type around the well and this flow increases when the wellbore pressure is lower than the reservoir pressure resulting in the application of drag forces which ultimately leads to sand production [3, 4]. Generally sand production in oil wells can either occur naturally as a result of the formation (oil production) or by human activities (fluid injection) which causes agitation of the formation. Sand production in oil wells can be stimulated during the first flow of a formation fluid due to detachment of sand grains arising from gas turbulence and drag from the fluid [5]. Other factors that can lead to sand production includes changes in production rate, alteration in gas/liquid ratio and breakthrough of formation water. Sand production in oil reservoirs can be caused by both internal and external factors. The internal causes of sand production in reservoirs are the stress rate of the wall rock borehole and the rock tensile strength basically supported by the strength of the rock, on the other hand the external causes of reservoir sand production are the reservoir fluid pressure as well as other properties of the reservoir fluid such as the water cut [6]. Sand production can lead to a number of challenges including wellbore instability, formation and casing damage or collapse, downhole and surface equipment failure and environmental challenges in the disposal of sand produced amongst others [4].

The quantification of sand produced from oil wells is very key in determining the appropriate technology suitable in curbing the effects of the sand in the well, production equipment and the environment. The aim of this study is to monitor sand produced from selected oil wells in the Niger Delta area of Nigeria within the period of seven (7) months. Sand quantification in crude oil samples can be achieved either by a sieve with appropriate mesh size or with a petroleum centrifuge, while sieves of specific mesh sizes can only be employed in quantifying sand

particles with corresponding sizes, petroleum centrifuge can be employed in the quantification of sand particles of all sizes. The use of sieves with small mesh sizes are however suitable in the quantification of large sand particles whereas sieves with large mesh sizes cannot be employed in the quantification of smaller sand particles [7]. Sand particles are initially reported in volume (millilitres) with the use of a petroleum centrifuge before conversion to weight in grams using *equation 1* while sand particles are directly reported in grams with the use of the sieving process as indicated in *equation 2*. The sand quantification used in this study was achieved through the sieving process, the selected oil wells are suspected sand producing wells owing to the impact of the oil produced on the oil export pumps, formation casing and other production equipment. This study essentially monitors the approximate quantity of sand from each of these wells using analytical techniques

$$\text{Weight of sand} = \text{Density of dry sand (g/cm}^3\text{)} \times \text{Volume of sand (cm}^3\text{)} \dots(1)$$

$$\text{Where Density of dry sand} = 1.631 \text{ g/cm}^3$$

$$\text{Weight of Sand (g)} = (\text{Weight of beaker + Sand}) - \text{Weight of beaker} \dots(2)$$

Experimental

Crude oil samples were obtained at two different periods within seven months from five different wells suspected with high potential of sand production within the Niger Delta area of Nigeria. The first set of samples were analyzed within the first two months and then after a space of three months the second set of samples were analyzed within the period of another two months making a total of seven months. Equipment used for sand quantification of crude samples were a 70 mesh size (106 μm size) sieve, weighing balance, oven, desiccator and magnetic straw, other equipment used were Anton Paar viscometer and Petroleum centrifuge. Glass wares used for analyses were centrifuge bottles, beakers, wash bottles and measuring cylinders while reagents used were petroleum ether, F46 demulsifier and 33% Hydrochloric acid (HCl) [6].

Sample Collection and Preparation

Sampling of 20 liters crude oil from each well was carried out in five (5) pieces of 5 liters poly cans with each polycan containing 4 liters of the crude, this is important because it is easier to homogenize samples in smaller containers than samples in bigger ones. Add 1 ml of F46 demulsifier and 1 Liter of petroleum ether to each 5 liter poly can of sample to break emulsions and make crude samples thinner (lighter) in order to ease the sieving process. Getting rid of all the emulsions is very key to avoid sands from clustering to the oil emulsion. Shake mixture vigorously to ensure homogenization and then allow to stand undisturbed for 24 hours to enable sand to settle at the bottom of the poly cans. Sand analyses were done on a daily basis for all 5 Wells and then repeated after 3 months for another eight days

2.2 Sand Quantification by Sieving Process

Carefully decant 4 liters from the upper layer of 5 liters crude / petroleum ether mixture (4 L crude + 1 L Petroleum ether). Decant the remaining 1 liter at the bottom of the poly can gradually into a 70 mesh size (106 μm size) sieve placed on a beaker and then carefully sieve to recover sand and other solid residues. The sieving process can be facilitated with either petroleum ether or xylene however petroleum ether is preferred because it is more environmentally friendly. Carefully recover all the solid deposits from the sieve at the end of the process into an already weighed beaker (you may use a solvent to ensure total recovery). Stir the sand and other solid particles recovered with a magnetic straw to get rid of all magnetic particles, also treat with 33% HCl to get rid of scales and other salt particles, allow sample to settle and then decant acid and solvent mixture. Place sand sample in an oven at a temperature of 105 $^{\circ}\text{C}$ for 45 minutes, cool in a desiccator for 15 minutes and then weigh [7].

The weight of sand can be calculated using *equation 2*:

Results and Discussion

Table 1. Daily Sand Production

Weight of dry Sand (g)								
Wells	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
A	2.400	2.400	2.410	2.405	2.415	2.405	2.420	2.425
B	1.370	1.370	1.375	1.390	1.400	1.400	1.400	1.420
C	3.620	3.650	3.650	3.600	3.720	3.700	3.850	3.850
D	0.280	0.280	0.285	0.285	0.292	0.296	0.296	0.299
E	4.200	4.250	4.300	4.300	4.400	4.400	4.450	4.450

Table 1 shows the weekly sand production for each well obtained within the first eight weeks

Table 2. Daily Sand Production After 3 Months

Weight of dry Sand (g)								
Well	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16
A	2.435	2.444	2.445	2.505	2.500	2.510	2.600	2.650
B	1.480	1.480	1.495	1.490	1.520	1.525	1.560	1.560
C	3.900	4.110	4.250	4.350	4.350	4.450	4.500	4.550
D	0.300	0.300	0.310	0.320	0.325	0.335	0.345	0.350
E	4.500	4.550	4.600	4.600	4.650	4.660	4.670	5.250

Table 2 shows the daily sand production for each well within the last eight days after wells were left 3 months without sand analyses

Table 3. Parameters of Crude Samples and Percentage increase in Sand

Well	Crude Viscosity @ 15.56 °C (mm ² /s)	Crude Water cut (%)	Sand Increase (%)
A	2.8600	14.0000	9.4340
B	2.7800	13.5000	12.1795
C	2.9400	20.5000	20.4396
D	2.6900	10.0000	20.0000
E	2.9500	22.0000	20.0000

Table 3 shows the viscosity and the water cut of the crude samples obtained from each of the wells as well as the percentage increase in sand between Day 1 and Day 16

$$\% \text{ Increase in Sand} = \frac{\text{Weight of Sand}_{\text{highest}} - \text{Weight of Sand}_{\text{lowest}}}{\text{Weight of Sand}_{\text{highest}}} \times 100\% \dots (3)$$

Where:

Weight of sand_{highest} = Highest weight of sand on a specific day

Weight of sand_{lowest} = Lowest weight of sand on a specific day

Table 4. Extrapolated Daily Sand Production / Well Capacity

Well	Crude Prod (L/d)	Weight of dry Sand / 20 L Crude (g)	Weight of dry Sand / Prod (g)
	(N)	(M)	
A	1587000.000	2.650	210278.000
B	1100000.000	1.560	85800.000
C	1810000.000	4.550	411775.000
D	980000.000	0.350	17150.000
E	2200000.000	5.250	577500.000

Table 4. shows the extrapolated daily sand production based on the daily crude production for each well using sand production at Day 16 as a reference

$$\text{Daily weight of sand produced per well (g)} = \frac{M \times N}{P} \dots \dots \dots (4)$$

Where:

M = Weight of sand produced per 20 liters of crude sample (Day 16)

N = Volume of crude produced per well (Day 16)

P = Volume of reference sample (20 Liters)

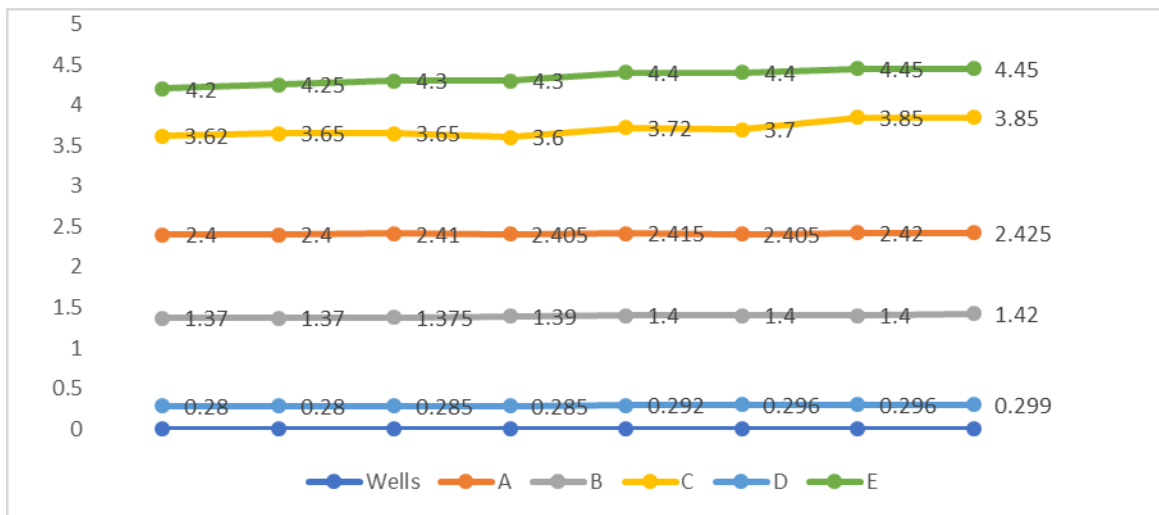


Figure. 1. Graphical Representation of Sand evolution within the first eight days

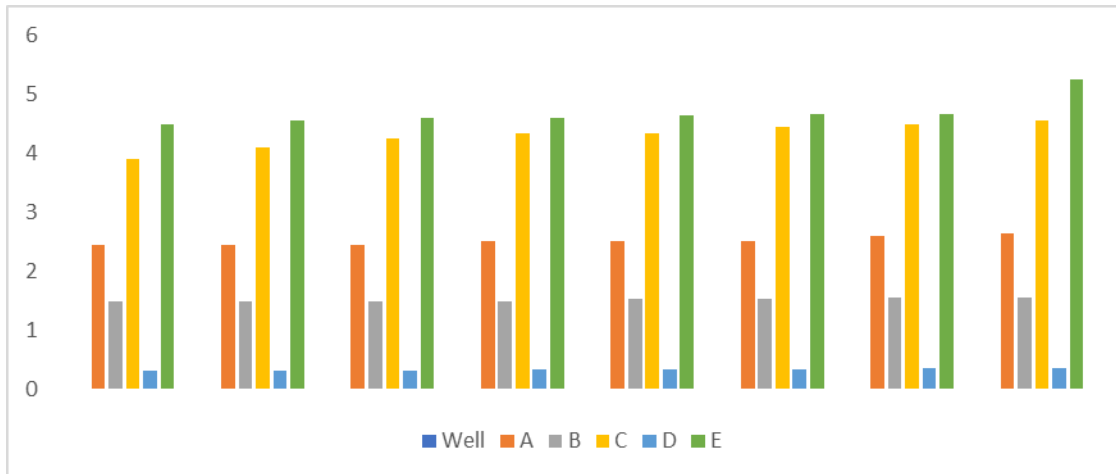


Figure 2. Sand evolution within the last eight days (after 3 months) using Bar Charts

Quantification of sand in oil wells through consistent sand monitoring involves estimating the volume or weight of sand present at the surface facilities. Producing fluids obtained from oil wells which could either be in form of oil and gas contains smooth or fine sand particles in form of silt as well as coarse or load bearing sand particles. These fine sand particles are usually less than 70 mesh size and their production is quite useful to the wellbore permeability and is often not required to stop however production of coarse sand particles above 70 mesh size can cause a lot of problems to the oil wells and other production facilities [8]. From Table 1 and 2 it can be deduced that the quantity of sand produced from each well increased as the day increases however there were few instances where sand quantities were consistent within each passing day this goes to show that the sand quantity in a well is not possibly reduced or exterminated with time without any concerted effort instead there is the possibility of an increase as seen between day 1 and day 16 for each of the wells. The wells were left for 3 months without sand analyses to also confirm the effect of time on the quantity of sand produced by each of the oil producing wells that is the sand evolution with time. On the 16th day (that is the eighth day after 3 months of no analyses) results obtained from Table 2 showed that *well E* had the highest sand quantity

while *well D* had the least sand quantity. Figure 1 shows the graphical representation of sand evolution within the first eight days while figure 2 shows the sand evolution within the last eight days after 3 months of no analyses using bar charts. It is important to note that the percentage increase in the sand quantity for each of the Wells is not constant though *well D* had the least weight of sand on the 16th day, Table 3 shows that *well A* had the least percentage increase in sand within the period under review. Whilst the quantity of sand produced by an oil producing well is important, the percentage increase in sand production within a period of time which can be obtained using equation 3 is also critical as it unveils the prevalent risk imposed on the well in the near future owing to sand production. Table 2 shows that the weight of sand produced from *well A* is higher than those produced by *well B* and *D* however the percentage increase in sand production in *wells B* and *D* are higher than that of *well A* which implies that if all factors remains constant and if the percentage increase in sand production remains consistent the sand production in *wells B* and *D* may equilibrate or even surpass that of *well A* with time. In order to appreciate the quantity of sand produced by each of these wells it is important to extrapolate the daily sand production on the 16th day with the crude oil production of each of the wells per day using equation 4. Table 3 shows the daily crude oil production of each of the Wells as well as the extrapolated weight of dry sand using weight obtained from the 20 liters crude sample as reference.

One of the factors that determines the quantity of sand produced by an oil well is the level at which sand grains are bonded to each other and the tightness of the soil particle matrix within the reservoir, these concepts are known as cementation and consolidation. The degree of cementation and consolidation within the reservoir increases with the age of the reservoir hence newer reservoirs are more prone to sand production than the older ones [9]. It is usually the aim

of oil well operators to configure new wells for maximum production and this usually have a devastating effect on the sand production due to damage and wearing away of the sand face resulting from detachment of sand grains from the body of the formation rock. The actual ages of the wells in this study were not ascertained however other factors such as crude viscosity and water cut were used as indicators to explain the quantity of sand produced from each well. Apart from the age of the well, another factor that determines the quantity of sand produced from an oil well is the viscosity of the reservoir fluid, the higher the viscosity of reservoir fluids the greater its ability to drag sand particles towards the well bore due to its high drag force as compared to low viscous fluid [10]. The viscosities of crude oils obtained from the five wells were shown in Table 3 results obtained indicates that *wells C* and *E* produced oils with the highest viscosities which explains why they had the highest sand production compared to the other wells.

Another important factor that determines the quantity of sand produced from an oil well is the quantity of water production from the well. The water cut of the crude oil produced from each of the wells were shown in Table 3, results obtained unveils that *well E* produced crude with the highest water cut. Increased water production from an oil well increases its sand production due to a number of reasons which includes decrease in capillary pressure resulting in the retention of sand particles within the reservoir rock, increase in frictional flow effects due to flow from more than one phase (oil and water), high pressure gradient at the sand face due to high fluid rate to maintain the net oil production as well as dissolution and removal of cementing in reservoir rocks by water [11].

Conclusion

The quantity of sand produced by oil wells is determined by a number of factors, the age of the reservoir determines the quantity of sand produced by the well as newer reservoirs produces more sand than the older ones due to the fact that sand grains are more tightly bonded to each other and to the soil matrix in older reservoirs compared to the newer ones. Other factors that determines the quantity of sand produced by an oil well are the viscosity and the water cut of the reservoir fluid. The quantity of sand produced by an oil well increases with increase in the viscosity and water cut of the reservoir fluid. Oil wells with high sand quantity can lead to a number of challenges including wellbore instability, formation and casing damage or collapse, downhole and surface equipment failure and environmental challenges in the disposal of sand produced amongst others. An in-depth knowledge of the quantity of sand produced by an oil well gives a better understanding of the appropriate technology required to accurately evaluate the initiation conditions, estimate the influx rate and the volume of sand produced from the well and this is very key in controlling the sand production and inhibiting the adverse impact on production equipment and the environment.

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