ABSTRACT

Objective: The impact of geochemical seismic explosive energy on the turbidity of groundwater in Ohuru-Oza area, Niger Delta, Nigeria was investigated with dynamite energy source.

Methods: High explosive dynamite (trinitrotoluene) was used as the seismic energy source. A total amount of 84207 kg dynamite was detonated in 41, 949 source point in an area of 549.73 square kilometers of Ohuru-Oza area. Eleven boreholes were used for this study. The turbidity values were determined using a turbidimeter. A control sample was taken from the borehole stations by sampling a day before detonation of dynamite. Subsequently, sampling was carried out a day after dynamite detonation and then, on a fourth-nightly basis.

Results: The average turbidity value of the control (sample water before detonation) was 4.00 NTU. After dynamite detonation, the average measured turbidity values ranged from 3.54 to 4.54 NTU. The representative lithology are mainly non-plastics also categorized as the cohesionless sands. The Coefficient of permeability, K, at a depth of 13m was 4.0 cm/sec.

Conclusions: These variations from the control are not significant enough for dynamite to be said to have impacted on the turbidity value of the ground water. The control and test results values are both within the Federal Ministry of Environment, Housing and Urban Development (FMEnv&UD) limit of 10 NTU. The Coefficient of permeability showed that the rate of transport of fluids within the vadose zone and aquifers of the study area favoured the transmission and diffusion of any slight contamination.

Keywords: Seismic, groundwater, turbidity, Ohuru-Oza, contamination
Introduction

Commercial explosive are mixtures of carbons, hydrogen, oxygen and nitrogen. The maximum energy released upon detonation occurs when the explosive mix is formulated for oxygen balance. An oxygen-balanced mixture is one in which there is no excess or deficiency in oxygen, such that the gaseous products formed are chiefly water vapor, carbon dioxide and nitrogen. In actual blasting practice small amount of noxious gases such as nitric oxide, carbon monoxide, ammonia, methane and solid carbon are formed resulting in non-ideal detonation and somewhat less than ideal pressures and energies. Commercial explosive formulation attempts to achieve an oxygen-balanced mixture. Oxygen balance is an expression that is used to indicate the degree to which an explosive can be oxidized. If an explosive molecule contains just enough oxygen to convert its entire carbon to carbon dioxide, all of its hydrogen to water and all of its metal to metal oxide with no excess, the molecule is said to have a zero oxygen balance. The molecule is said to have a positive oxygen balance if it contains more oxygen than is needed and a negative oxygen balance if it contains less oxygen than is needed.

Dynamite explosives and environmental pollution have been a major issue to Scientist in the 21st century. The area used for burial and burning of explosives in Massachusetts revealed the highest concentration of Royal Demolition eXplosive (RDX). Explosives have been detected in wells outside of the impact area north of Snake Pond in Massachusetts. This area is close to the top of the groundwater mound of the Sagamore Lens of Cape Cod’s sole source aquifer. The long history of explosive military use has resulted in loss of private and public drinking water. Development of future drinking water supplies is uncertain.

Turbidity is a measurement of suspended particles in water based on the cloudiness or murkiness. Turbidity can be measured by its effect on the scattering light, which is termed as Nephelometry. Turbidity can be caused organic particles and inorganic particles. Turbidity in ground water is mostly inorganic and caused by natural geological factor. Organic and Inorganic pollutants gives water poor look, bad smell and taste, increase growth of microorganism, increase in chlorine content to be added, increase in the formation of dangerous trihalomethanes (THMs).

The Ohuru Oza area (Figure 1) is located approximately 20 km Northwest of Port Harcourt/Oyibo and approximately 4 km to the south of Aba. The majority of the area is located in Abia State. A small portion of the Western part of the area extends into Rivers State. This area covers an area of 534.15 square Kilometers.

We hereby report the impact of geochemical seismic explosive energy on the turbidity of groundwater in Ohuru-Oza area, Niger Delta, Nigeria.

Figure 1: Map of Nigeria showing Ohuru-Oza area (455 x 245).

Materials and Methods

Uphole drilling

The upheole was drilled to 60m depth using the rotary method and flushed continuously for 20 minutes to enhance stability. Each hole was cased with perforated 6 inch PVC pipe. The upheole lithology was sampled every 5 m or at the change in lithology. The grain size analysis was accomplished using the sieve method for the sands. No size analysis was carried out for the silt and clay. The source and receiver line number were used for
identification of the uphole locations while the coordinates was verified using a handheld Global Positioning System (GPS) set. The Meridian Platinum GPS was used after calibrations. The elevations of the uphole points were determined using the same instrument (Table I).

**Explosive detonation**

The energy source was the high explosive dynamite (TNT) and 6m Electric Detonators loaded in 5 hole pattern source array. In dry areas, the holes were thumped to a depth of 4m while in flooded/marshy terrain they were flushed to a depth of 6 metres. Each pattern hole was loaded with 0.4kg/l seismic, electric detonators (1 shot point = 5x0.4kg/l caps for five hole pattern). A total amount of 84207 kg dynamite was detonated in 41, 949 source point in an area of 549.73 square kilometers of Ohuru-Oza area.

**Water sampling and analysis**

The groundwater was sampled from 11 upholes in Ohuru-Oza. The sample locations were georeferenced using the survey coordinates of eastings and northings. The elevation of each sample location was determined by measurement of the Z-component of the coordinates. The water samples were taken from the boreholes at a depth of 12m to 15m (Table I). Water samples were collected and analyzed from each uphole before the commencement of dynamite detonation. The water samples were collected using small bottles using a rope.

**Measurement of turbidity**

The turbidity was determined the same day the samples were taken. The power supply of the turbidimeter was switched on. 1 NTU button was pressed and was coincided with zero using the focusing template. 1 NTU button was pressed again and was coincided using the focusing template. A standard Formazine solution of was placed on the turbidimeter in path of rays and the scale was brought to 9 NTU. The water sample was taken in a test and placed in a turbidimeter. The readings were recorded.

**Measurement of permeability**

Coefficient of permeability was measured using the constant head permeameter. Soil sample was placed in the cylinder. A measurement was taken between the two tapings in the cylinder connected to the manometers. Water from the reservoir was allowed to flow through the sample at a constant rate. As soon as the water begins to flow, the stop clock reading begins. Water flowing the sample was collected with the measuring cylinder. The differences of heads from the manometers were measured. The time was recorded using the stop clock. This was repeated for two other samples. Coefficient of permeability (K) was calculated using Darcy’s Law (eq.1).

\[
K = \frac{QL}{AXtH} - eq.1
\]

Where Q=Quantity of water passing through sample during time \( t \) (cm\(^3\)/sec), \( A \)=Cross-sectional area of sample (cm\(^2\)), \( L \)=Length of sample (cm), \( H \)=Difference of head (cm)

**Soil porosity determination**

The soil was placed into a mould of volume \( V_T \) = 1000 cm\(^3\). The weights of the sample and

<table>
<thead>
<tr>
<th>Upphole No.</th>
<th>Upphole location</th>
<th>Easting</th>
<th>Northing</th>
<th>Elevation (Z)</th>
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<tbody>
<tr>
<td>OZ1</td>
<td>1061/5200</td>
<td>525050.19</td>
<td>100529.08</td>
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<td>OZ2</td>
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</table>
mould (Mₜ) were determined. The sample is then dried in an oven at temperature 105°C and re-weights (Mₛ). The weight of water Mₜw, weight of solid Mₛ, and volume of voids Vᵥ was determined based on eq. 2 and 3 respectively.

\[ Vᵥ = Vₜ - Vₛ \]  
\[ Vₛ = \frac{Mₛ}{Gₛ \gammaₚ} \]

Gₛ=specific gravity of solid, \( \gammaₚ = \text{density of water.} \) Note Gₛ taken as 2.66 and \( \gamma = 1 \text{g/cm}^3 \)

From these, porosity values were calculated from eq. 4.

\[ \text{Porosity, } \varphi = \frac{Vᵥ}{Vₜ} \times 100\% \]

**Results and Discussion**

The dynamite detonation density was 150.86 kg/Km². The results of groundwater turbidity in Ohuru-Oza area are presented in Table II. The water samples taken from the boreholes before detonation of dynamite served as control and were designated as day-zero samples. The turbidity averages over the sampled period is shown in Figure 2. Ohuru-Oza area borehole lithologic Log is presented in Figure 3 while Sieve analysis and grain size distribution curve, (13m depth) of Ohuru-Oza area is presented in Figure 4.

The average turbidity value of the control (sample water before detonation) was 4.00 NTU. After dynamite detonation, the average measured turbidity values ranged from 3.54 to 4.54 NTU. The highest recorded average value of 4.54 NTU was obtained on day-57 after dynamite detonation. Thereafter the average turbidity value remained fairly stable with a slight increase in value compared to the control. The lowest average value of 3.54 NTU was recorded on day-99. These variations from the control are not significant enough for dynamite to be said to have impacted on the turbidity value of the ground water. The control and test results values are both within the Federal Ministry of Environment, Housing and Urban Development (FMEnv&UD) limit of 10 NTU. Similar daily variations have been observed in areas where there was no dynamite detonation.
Table 2: Borehole water turbidity (NTU) analysis results in Ohuru-Oza (OZ) area.

<table>
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<tr>
<th>Day</th>
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<th>OZ2</th>
<th>OZ3</th>
<th>OZ4</th>
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<th>OZ8</th>
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</tbody>
</table>

The representative lithology of Ohuru-Oza area as revealed by the borehole logging consists of 0-2m laterite soil, 2-5m medium and fine sand, 5-27m medium to coarse sand, 27-60m coarse sands and gravelly mix (Figure 3). These lithotypes are mainly non-plastics also categorized as the cohesionless sands. Sieve analysis results from Ohuru-Oza area showed an average of 2% passing for grain size 0.075, 4% passing for 0.15 grain size, 30% passing for grain size 0.30, 82% passing for grain size 0.60, 98% passing for grain size 1.18 and 100% passing for grain size 2.36. The Coefficient of permeability, K, at a depth of 13m was 4.0 cm/sec. This epitomized good pore spaces and viable interconnectivity that enhance Flowage. The sieve analysis of the sample at a depth of 13m showed 26% medium sand, 52-68% coarse sand and 2% fine gravel.

Conclusions

The turbidity values showed no significant difference in the sampled areas compared to the control average which was taken before dynamite detonation. The grain size analysis and the subsequent permeability coefficient respectively showed that Ohuru-Oza area, Niger delta region has characteristics elastic and non-plastic permeable lithology, commonly loose sands, which are sufficiently permeable to transmit any occurring contamination of the groundwater. It terms of turbidity studies, the control and test results values are both within the Federal Ministry of Environment, Housing and Urban Development (FMEnv&UD) limit of 10 N.T.U.

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References

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