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Remediation Amid Continuous Crude Oil Pollution: A Look Ahead on the Use of Phytostabilizer as a Proactive Containment and Remediation tool, a case study of Bodo Creek in Ogoni, Niger Delta

Chidinma Uzochukwu

World Bank PhD Scholar, Department of Petroleum Geology, World Bank Africa Centre of Excellence in Oilfield Chemicals Research (ACE-CEFOR), University of Port Harcourt, Nigeria.

Email: joysplendid@gmail.com

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Abstract:

Crude oil pollution has become an uncontrollable variable in Ogoni; hence, the need for deployment of proactive containment measure to contain oil spill and reduce its impact on the environment. To show the effectiveness of phytostabilizers in containing spill and limiting migration of spilled crude oil, Bodo creek in Ogoni was chosen as the study area. The study focused on areas that are dominated with chikoko sediment and these represented a matured underground root system of a phytostabilizer. 19 surface and 19 subsurface chikoko samples were obtained from 19 different locations within Bodo creek and were analysed for TPH using GC-FID. IBM SPSSwas used to carry out an independent sample t-test statistical analysis to check if their means are significantly different. The result of the t-test showed that there were significant differences in the values with mean value for surface samples (Mean = 1971.63) being higher than mean value for subsurface sample (Mean = 402.68) indicating that chikoko sediment inhibited vertical migration of the spilled crude. The magnitude of the differences in the means (Mean Difference = 1568.947) was highly significant. This study, therefore, have shown that phytostabilizers are effective in containing and limiting vertical migration of spilled crude.

Keywords —**Remediation, Phytoremediation, Phytostabilizer, Chikoko, Bodo Creek, Bodo project, Oil spill, Vertical migration of spilled crude oil, Crude oil pollution, Ogoni, Niger Delta.**

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1.INTRODUCTION

It will not be out of place to say that crude oil pollution has become an uncontrollable variable in Ogoni considering that awareness campaign on the negative impact of pipeline vandalism, crude oil theft, and illegal refining activities has failed to put a stop on these activities. This is not in any way to say that cessation of these activities is not achievable, it is however, a work in progress. While we await the attainment of zero or near zero pipeline vandalism, crude oil theft, and illegal crude oil refining, there is need for the deployment of proactive containment and remediation measures to contain oil spill even without human intervention thereby reducing the spread and its negative impact on the environment. The Exxon Valdex oil spill of march 24, 1989 is considered the worst oil spill in the world in terms of damage to the environment; this is probably because it is said to have occurred by 12:04am and the impacted area is accessible only by helicopter, plane, or boat; thus, a lot of damage would have been done on the environment before human intervention. Bearing in mind that most of these crude oil illegal activities are perpetrated at night when immediate human intervention may not be feasible especially in Ogoni and that there is also the problem of protracted negotiations - as pointed out in UNEP report on environmental assessment of Ogoniland [1]. Knowing that protracted negotiations imposed by community members on the oil spill response team over access to the impacted area delays responses to spills resulting in a far greater environmental impact; can we put in place green infrastructure to contain the spill and limit the spread prior to human intervention?

Phytoremediation has been used extensively as an approach to remediating crude oil impacted media but it is yet to be viewed as a proactive measure of containing and limiting oil spill spread. Phytostabilizers are plants that can reduce mobility of contaminants in the soil through adsorption onto roots, adsorption and accumulation by roots or precipitation within the root zone. Vegetation is used to provide stabilization of migration of contaminants by leaching, erosion, or dispersion along with soil, water, or air to prevent pollution to groundwater and surrounding environments (Ernst, 2005). These abilities make phytostabilizer a tool that can be deployed to proactively avoid crude oil spill spread and reduce contaminant concentration in the long run.

To show the effectiveness of phytostabilizers in containing spill and limiting migration of spilled crude oil, Bodo creek in Ogoni, eastern Niger Delta, was chosen as the study area. The study focused on areas that are dominated with chikoko sediment (fig. 1) beyond 30cm depth. Chikoko is the local name given to a mat of undercomposed fibrous roots, mangrove rootlets, and dead mangrove plants forming a thick peaty layer [2]. In the study area, chikoko sediment dominate the former mangrove areas. Chikoko sediment in this study represents a matured underground root system of a phytostabilizer.

Fig. 1: Chikoko sediment within Bodo creek

1.1Location and description of study area

Bodo creek is located in Gokana Local Government area of Rivers state along the eastern part of the Niger Delta. It is an intertidal environment with interlinking meandering water channels that are drained by adjoining creeks in nearby communities. The topography is flat to gentle slope.

Bodo creek is dominated by mangrove areas. Observed mangrove species in the study area include red mangrove, white mangrove, and black mangrove but red mangrove is dominant. Mangrove trees in most sections of the study area have been completely destroyed by crude oil spill incidents rendering the area deforested. However, replanting of dead mangrove is ongoing in the study area and regeneration has also been spotted in many locations that the spilled crude has been significantly reduced by the ongoing cleanup activity in the area. Sediment type in the study area include mud, chikoko, sand, and silt, but the dominant is mud and chikoko. In the mangrove areas including the destroyed mangrove areas, the sediment may be found mixed with chikoko and as such can be classified as sandy chikoko, muddy chikoko, etcetera or vice versa as the case may be depending on which is more than the other. There are also areas that the sediment is completely chikoko up to about 0.3m depth and beyond. Mud dominates the mangrove areas while the former mangrove areas are dominated by chikoko. The shoreline area is dominated by sand and clay sediments. Nypa palm (Nypa fruticans) are also present in the study area, however, because they are invasive species, their removal is part of the ongoing clean up and re-vegetation activities in the area so as to give room for replanting/re-vegetation and growth of mangrove without invasive species-imposed limitations.

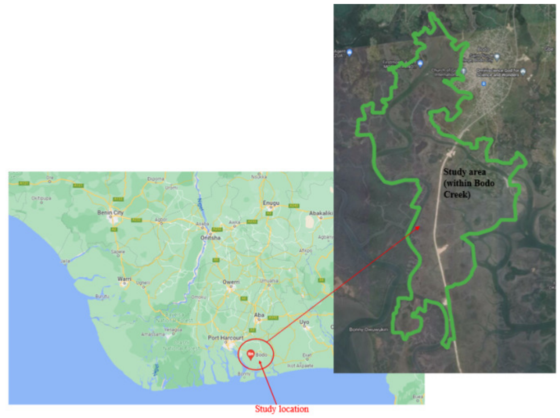

Figure 2: Location of the study area

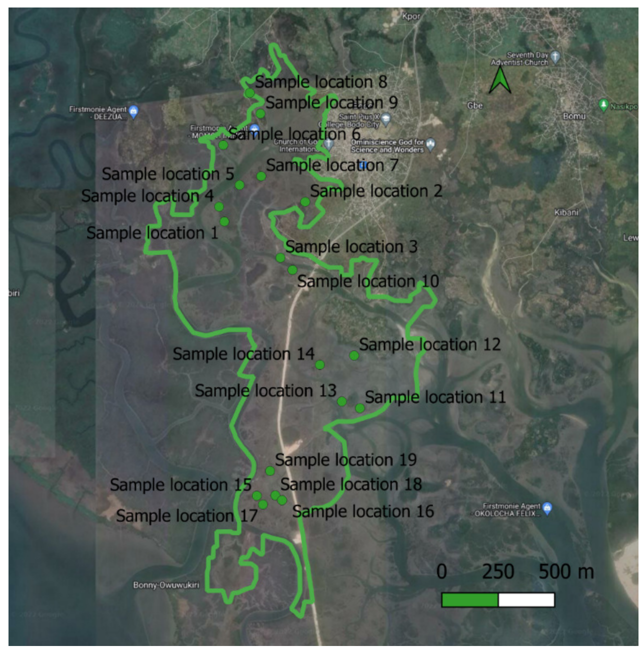

Figure 3: Study area showing sample location points

2. MATERIALS AND METHODS

The study was carried out at 19 different locations within Bodo creek. In each location, 3 pits separated by a distance of about 5m were dug to a depth of about 30cm. Two chikoko samples were obtained from each site, one composited surface sample taken from 2cm to 5cm depth and one composited sub-surface sample taken from 15cm to 25cm depth. These samples were subjected to laboratory analysis for Total Petroleum Hydrocarbon (TPH) using GC-FID (Gas Chromatography – Flame Ionization Detector).

IBM SPSS statistics version 20 was used to carry out an independent sample t-test statistical analysis on the obtained TPH values of the two groups of samples (surface and subsurface samples) to check if the mean of one group is statistically significantly different from the mean of the other group.

3. RESULTS AND DISCUSSION

38 chikoko samples (19 surface sample and 19 subsurface samples) were obtained from 19 different sites/locations within Bodo creek. The two groups of obtained chikoko samples (surface and subsurface samples) were analysed for TPH. TPH results from laboratory analysis for the two groups of data are shown in table 1.

TABLE I
TPH VALUES OF SURFACE AND SUBSURFACE CHIKOKO SAMPLES

	Surface sample (TPH in mg/kg)	**Subsurface sample (TPH in mg/kg)**
Sample Location 1	1367	420
Sample location 2	927	171
Sample location 3	650	172
Sample location 4	4447	919
Sample location 5	1088	169
Sample location 6	4869	266
Sample location 7	2767	181
Sample location 8	4690	691
Sample location 9	1593	504
Sample location 10	2550	1014
Sample location 11	1082	418
Sample location 12	2828	262
Sample location 13	2032	466
Sample location 14	1037	701
Sample location 15	1249	348
Sample location 16	630	195
Sample location 17	957	70
Sample location 18	939	314
Sample location 19	1759	370

3.1 Statistical analysis

Statistical analysis was performed on the two groups of data using IBM SPSS software. An independent sample t-test was carried out to compare the mean TPH values for surface samples and subsurface samples. The mean was chosen instead of the median to be the single value that is representative of the entire data set because it contains a piece of information from every data in the data set. However, the mean may not be the true representative of the data set if the data set is skewed or contains outliers. Skewness and potential outliers can be checked with box and whisker plot [3]. In this study, skewness presence in each data set (ground sample and subsurface sample) was checked with box and whisker plot and line graph while the presence of outliers was checked with a column plot and confirmed with box plot.

For surface samples, the column and box plot (fig. 4a and 5a) show that there are no potential outliers in the data set. The box and whisker plot indicated positive skewness but this was not supported by the line graph. Even though the line graph (fig. 6a) does not indicate a normal distribution (bell shape curve) that is free of skewness, the variation in the data set does not indicate positive or negative skewness. Having ruled out potential outliers and skewness, the statistical analysis centered on the mean TPH value.

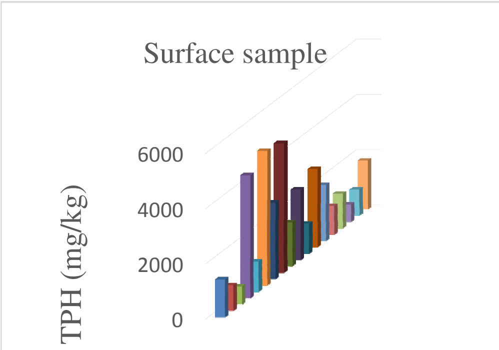

Fig. 4a: Column plot of TPH values for surface chikoko samples

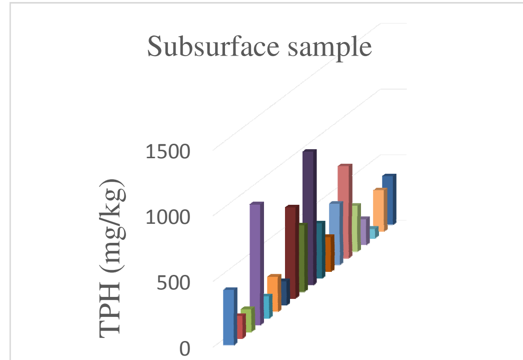

Fig. 4b: Column plot of TPH values of subsurface chikoko samples

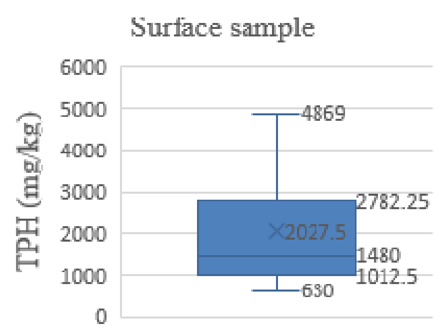

Fig. 5a: Box plot of TPH values of surface chikoko samples

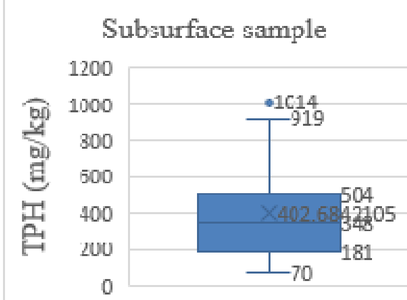

Fig. 5b: Box plot of TPH values of subsurface chikoko samples

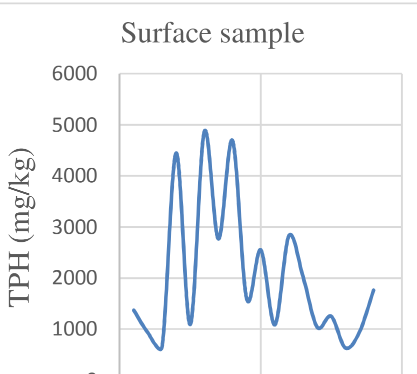

Fig. 6a: Line graph of TPH values of surface chikoko samples

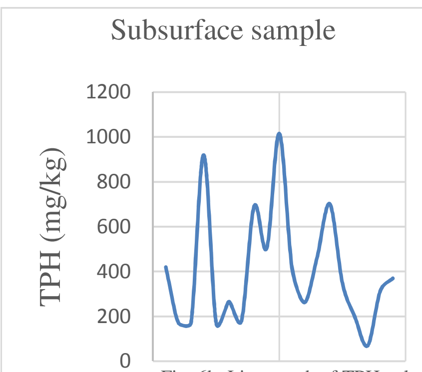

Fig. 6b: Line graph of TPH values subsurface chikoko samples

For subsurface samples, the column plot (fig. 4b) indicated no outliers whereas the box and whisker plot (fig. 5b) indicated potential outlier which was considered to be insignificant since is one out of 19 data in the data set and that each data is independent on the other in the data set. Even though the line graph (fig. 6b) does not indicate a normal distribution (bell shape curve) that is free of skewness, the variation in the data set does not indicate positive or negative skewness. Having ruled out significant outliers and skewness, the statistical analysis centered on mean TPH value.

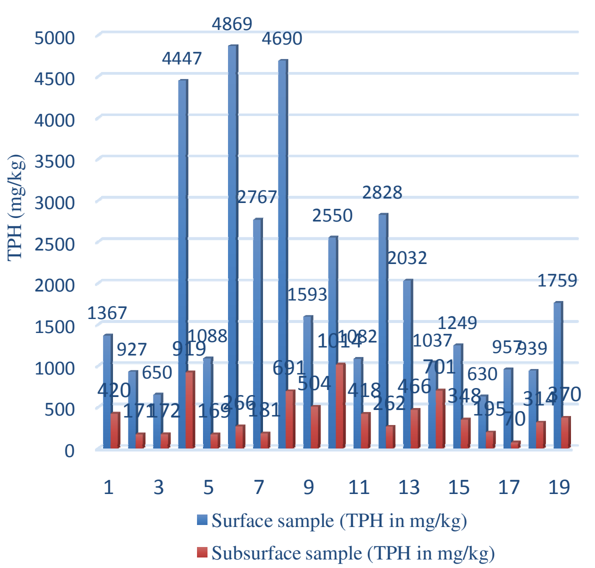

Fig. 7: Comparison of TPH values of surface and subsurface chikoko samples

3.1.1 Independent t-test analysis

TABLE 2
IBM SPSS OUTPUT OF THE INDEPRNDENT T-TEST ANALYSIS

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	23.327	.000	4.896	36	.000	1568.947	320.425	919.096	2218.799
Equal variances not assumed			4.896	19.318	.000	1568.947	320.425	899.038	2238.857

Equal variances in surface and subsurface TPH values were not assumed considering that Levene's test for equality of variances indicated a significant value that is less than the probability value of 0.05 (Sig. = 0.000). Checking the 2-tailed significant value against the probability value and confirming with existence or non-existence of zero crossing of the 95% confidence interval; there is a significant difference between the surface and subsurface mean TPH value of the chikoko sediment as the 2-tailed significant value indicated no exceedance of the probability value (2-tailed Sig. = 0.000) and the confidence interval did not cross zero (95% Confident Level: 2218.799 to 2238.857). The significant difference indicated by the independent sample t-test was further confirmed by a 3D clustered column plot of the two set of data (fig. 7).
The high mean difference of 1568.947 with mean value for surface samples (Mean = 1971.63) being significantly higher than mean value for subsurface samples (Mean = 402.68) indicates that chikoko sediment inhibited vertical migration of the spilled crude.

4. CONCLUSIONS AND RECOMMENDATIONS

This study has shown that phytostabilizers are effective in containing and limiting vertical migration of spilled crude thereby reducing the damage the spill could have had on the environment especially in shielding the underlying groundwater from being contaminated and as such reducing the risk to health of people that are dependent on the groundwater for their daily water needs. Considering that shallow unconfined aquifer is widespread in Ogoni, phytostabilizers needs to be deployed. Also, continuous increase in spill incidents in Ogoni calls for a proactive containment approach that requires no immediate human intervention. This, however, does not replace oil spill response team and the role they play in combating spill and ensuring that spill incidents pose less of a threat to the environment. Phytostabilizer is simply a green infrastructure put in place to contain spill ahead of oil spill response team thereby reducing damage to the environment. Phytostabilizers are to spill areas what mangrove is to coastline areas as mangrove receives more of the impact that natural disaster such as flooding would have had on coastline areas beyond the mangrove thereby reducing damage ahead of the arrival of the intervention team. The use of phytostabilizers as a proactive spill containment tool will drastically reduce the threat spill impact poses to the environment and to human health. Upon occurrence of spill incident, phytostabilizers is expected to trap or contain spill that would otherwise flow out to surrounding environment or penetrate to groundwater. This will be much needed in areas with high rainfall and wide spread shallow unconfined aquifer like Ogoni where any delay in containing and cleaning up an oil spill may result to crude oil being washed away traversing farmlands and impacting groundwater.

4.1 Recommended deployment method

Deployment of phytostabilizer as a proactive spill containment and remediation tool in any area, will require the following;

1. Generation of a map of the study area showing crude oil transmission pipeline. Since oil spill in the Niger Delta especially in Ogoni is mainly due to pipeline sabotage and crude oil theft, the map will help narrow down areas that are prone to crude oil spill incident.
2. Generation of hydrogeological map of the study area. This will enable delineation of groundwater flow direction which usually serve as possible route for oil spill spread or lateral migration.
3. Planting of phytostabilizers within the areas identified to be prone to oil spill incident and along groundwater flow direction.

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