RESEARCH ARTICLE OPEN ACCESS

Leachate Monitoring In The Extractive Industry: A Case Study Of Nigerian Liquified Natural Gas Plant.

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ABSTRACT
Activities of extractive industry (NLNG is typical) introduces some chemical substances into the groundwater. These change the groundwater signature and bioaccumulation of some of these classified as hazardous may result in various wealth challenges. Seven areas within the plant where identified by NLNG Six as high risk pollution areas and one (Nature Park) as no pollution risk area. Groundwater samples were collected from all seven areas and analyzed for the presence of Cu, Cr, Zn, nitrate, phosphate and PH. Samples from the no pollution risk area served as control. Results were compared with WHO limits. Except for Cr content which was stable, other results showed fluctuations with time, albeit on the increase, though all remained within WHO limits. Nitrate value is fast approaching limit and requires urgent attention. Unexpected high values of the measured parameters were observed at Nature Park (no pollution risk area) even beyond the high risk pollution areas. This precludes NLNG activities being responsible. The necessity of pre-activity groundwater quality assessment is thus established. Close monitoring of groundwater quality of the extractive industry zones is vital for the protection of source quality.
KEYWORDS: NLNG, Ground water, Pollution, Leachate, Monitoring, WHO Limits, Extractive Industry.

I. INTRODUCTION

Groundwater contamination through leaching is a serious environmental issue. Chemical substances naturally found in the environment are often anthropogenic and thus often appear in high concentrations above their natural values. As water from rain or other sources seep into the ground, it dissolves these chemicals and carries them into underground water supply. This is what is termed leaching. Leaching is generally associated with sanitary landfills and where ever hazardous chemical facilities and process chemicals are allowed to be in contact with the ground. Water chemistry is the principal mechanism for dissolution because water is a universal solvent. Factors that affect metal mobility include pH, DO, 0xidation-reduction potential, specific conductivity, temperature and soil condition. The task of remediation can be costly and difficult to perform. Design barriers against leaching are usually employed in landfills and industrial areas and often involve some form of impermeable layer as liner materials. The liner materials should possess low hydraulic conductivity (about10^{-6}mm/s) and a high cation exchange capacity [7,13,15]. The barrier is intended to minimize the migration of contaminant from the facility into the soil and thus protect groundwater quality as well as nearby surface waters. However, these measures may fail with time, endangering groundwater quality, hence the need for continues monitoring of quality parameters/presence of leaching chemical substances. Many such

chemicals when ingested above their tolerable limit are known to seriously impair human health. The cause of rise in concentration of these substances is usually anthropogenic. However, rise in concentration may not be owing to on-going human activities as may be evident in this study.

II. NEGATIVE HEALTH EFFECTS OF CHEMICALS LEACHING INTO GROUNDWATER

The primary anthropogenic sources of hazardous chemical substances are point sources such as mines, coal-burning power plant, smelters etc. These chemicals are associated with myriads of adverse health conditions ranging from allergic reaction to cancer. Protection of water sources from such substances is major reason for environmental protection agencies (EPAs).

Chromium: it is well documented that inhalation of chromium (particularly hexavalent chromium) can cause lung cancer. There is growing concern that ingestion of it may also cause the sickness. Water contaminated with CrVI is a worldwide problem making this a question of significant public health importance. Zhang and Li [21] reported increased stomach and lung cancer mortality with exposure.

Beaumont et al [4] suggested much the same. Allan and Craig [2] concluded that human ingestion of CrVI may increase the risk of stomach cancer.

Zinc: zinc is an essential element required by the human body. Its deficiency creates health problem among which is stunted growth in children. Zinc is thus relatively harmless and is considered to be non-toxic [13, 14]. A major route of entry into human body is by ingestion [15]. Although zinc is essential to the body excess beyond tolerable limit decreases copper levels which leads to slow growth and poor development of bones and nerves. Gastrointestinal toxicity complaints are associated with zinc toxicity. Upset stomach, vomiting and diarrhea can occur within 30minutes of ingesting large quantities of zinc. High dose of zinc have been associated with decrease in urine output and is the foremost reason for hospitalization associated with zinc toxicity [5, 12, 10]

Copper: excess copper above the tolerant level causes gastrointestinal distress, and with long term exposure may damage liver and kidney. Other health issues resulting from taking in excess copper include vomiting, diarrhea and nausea [17,18] .

Nitrate: nitrate interferes with the ability of the red blood cells to transport oxygen. Infants exposed to high concentrations of nitrate may turn "bluish" and may have difficulty in breathing because their bodies are not receiving enough oxygen. Careless human intervention can introduce high levels of nitrate into drinking water [16]

Phosphate: acute exposure to high level of phosphorus is characterized by three states; first state consist of gastrointestinal effects, second state is symptom free for two days and third state consist of rapid decline in condition with severe gastrointestinal (vomiting and abdominal pain) kidney, liver and central nervous system effect [18,19,20].

III. IMPORTANCE OF PRE-ACTIVITY ASSESSMENT OF GROUNDWATER QUALITY

Comprehensive ground water monitoring data should of necessity include pre-activity assessment of ground water quality (i.e. assessment before commencement of activity by the industry). Ground water can be influenced directly and indirectly by microbial activities which can transform both organic and inorganic constituents of groundwater. Thus pre-activity assessment to determine the sphere of influence of landfills and local industrial discharges of waste into the environment is inevitable.

Some of the information that may be obtained from pre-activity assessment includes; one, true source of groundwater quality changes can be easily traced. In the present study result show that certain increases in concentration cannot be attributed to NLNG. It is only a pre-activity assessment data that can show the sources of these increases. Two, Actual concentration changes as introduced by the existing industry can be measured if the previous value is known. Three, It will give a good indication of how far or how near to tolerable limits the potential pollutants are in the groundwater before commencement of activity. These information will generally guide for a well controlled industrial activity/process in order not to raise the existing concentration of pollutants.

IV. METHODOLOGY AND DATA COLLECTION

Data is secondary data obtained from water laboratory of NLNG Bonny. The data include one year span water quality analysis result of some key areas highly prone to pollution and one area of minimum human interference serving as control.
Sampling and analysis methods include all necessary preparatory steps to obtaining samples for laboratory tests. The tests were performed according to standard methods by use of inductively coupled plasma-mass spectrometry (ICP-MS).

V. RESULTS AND ANALYSIS

PH Table 1 shows result of pH measurements. Except for samples from Nature park which is clearly acidic, all other areas are near neutral or slightly alkaline but are within WHO limit. Processes and operations in these units must have been well controlled for product results to remain within acceptable standards. Nature Park may have shown the true situation of the groundwater pH within the NLNG plant. Another reason for the above results may be that the quantity of leaching material is significantly high enough to significantly affect the pH levels above the normal (i.e. if it is assumed that Nature Park represents the normal.)

Chromium: Table1 also shows the results of chromium measurements. Nature park which is an area of least human interference is assumed to preserve the true condition of the ground water. The value of chromium up to a maxim of 0.04 in Nature Park may be owing to previous unrecorded activities within the area. Value is however within WHO limit. All other areas have chromium value of 0.0 1mg/ an indication of well controlled usage of the element as it in a very hazardous chemical.

Zinc: results of zinc measurements are show in table1. Zinc content in the six areas range between 0.02–0.09mgper/l. Nature park shows value rang of 0.12–0.7mg/1 of water. NLNG activities may not have contributed to this high value since the most prone areas have far less values. Nature Park is suspect of past or present unrecorded activity in the area. Lead (Pb), which often occurs naturally with zinc and copper is contained in crude oil. Exploration activity may have been responsible for this high level of zinc at Nature Park.

Copper: Table 1 shows that average range of copper content in samples from the six prone areas is 0.03 mg/1 while Nature park samples contain 0.11 mg/1. Content is within WHO limit. Value at Nature Park further suggests that NLNG activity may not be responsible for these higher values.

Phosphate: Phosphate content in all the water samples are less than WHO limit. Minimum and maximum values are 0.2 and 1.4 mg/1, the maximum occurring at Nature Park and SO Tank 116400. Again pre-activity to NLNG may have been responsible.

Nitrate: Unusually high values of Nitrate are observed in the sludge catcher (14.62 mg/1) as shown in table1. These areas are put to heavy usage of cleaning chemicals and waste segregation. Nitrate build up in these areas should be expected.

VI. CONCLUSION

The extractive industry of which NLNG is typical introduces some chemical substances into the soil which ultimately pollute groundwater. Many of these substances are toxic to man and ingesting them beyond tolerable limit causes myriads of illnesses some of which are lethal. Close monitoring of groundwater quality is required.

The rise in concentration of these substances may not be the consequence of present activity of an industry. Therefore pr-activity groundwater quality assessment is necessary for a comprehensive groundwater monitoring data.

VII. REFERENCES:

[1.] Agency for toxic substances and diseases Registry (ATSDR) Toxicology profile for white phosphorous. Public wealth services, US Dept of Health and Human services, Atlantic G.A.. 1997.

[2.] Agency for toxic substance s and disease registry division of toxicology and environmental medicinal, Atlantic, GA, USA:2005. Toxicological profile for zinc.

[3.] Allen H Smith and Craig M Sterimus. Health effects of Arsenic and chromium in drinking water. Recent human findings. Annual report of public health Vol 30:107-122 2009.

[4.] Beaumont J.J Sedman R.M; Reynolds S.D Sherman C.D; Li L.H et al. cancer mortality in Chinese's pollution exposed to hexavalent chromium in drinking water, Epidemiology, 2008: 19:12-23(Pub med)

[5.] Brown, M.A; Thom, J.V; Orth, G.L, Cova p; Juarez, J food poisoning involving zinc contamination. Arch Environ health 1964,657-660[Pub med].

[6.] Fosmire, G.J; zinc toxicity. Am J. clinical nutr. 1990; 51:225-227 [Pub med]

[7.] Joseph J;B; Styles, J.R, Yuen, S.T and Cressary G (2001) Variation in clay mineral performance in the presence of loach ate. Proceeding of the eight international landfall symposium, Sardinia, Italy. Laura, M.P; lother, R and Hajo, h. essential toxin impact of zinc on human health.

[8.] Int. J. Environ Res. Public health (2010) 7(4) 1342-1365.

[9.] Lenntech (2011 d). cadmium (Cd)- chemical properties, health and environmental effects. Retrieved from periodic/element/cd.htm. Lillian Downy; Effect of too much zinc. .

[10.] Mclean J.E and Bledsoe, B.E Groundwater issue: Behariom of metals in soil. No. EP/ 54/ s (92/018) US EPA.

[11.] Ogiso T; Moriyama , K, Sasaki, S, Ishimura, Y, Minato, A, Inhibitory effect of high dietary zinc on copper abserbtion in rats chem.. pharm. Bill(Tokyo) 1974,22 55-60(pub med).

[12.] Quigley RM, Fernandez, F, and Rowe, R.K (1998) clay barriers assessment for impoundment of domestic waste leach-ate (Southern Ontario) including clay/leach-ate compatibility by hydraulic. Vol 25. PP 572-581

[13.] Ricardo Uauvy, Alejandro Mass and Magdalena Araya, estimating risk from copper excess in human populations. The American journal of chemical nutrition 2008.

[14.] Rowe, R.K, Caers, C.J, Reynolds, G and Chan, C.(2000). Design and construction of barriers system for the Halton landfall Canadian geotechnical. Journal, Vol 37, No 3, PP. 662-675.

[15.] Self J. R, and Waskom R.M Nitrate in drinking water. Wheatly River improvement group.

[16.] Sittig Handbook of toxic and hazardous chemicals and carcinogens 2nd Ed. Noyes publications, park Ridge, N.J.1985

[17.] US Dept of health and human services. Hazardous substances data bank (HSBDB) online database. Na. toxicology information programs, National library of medicine Bethesda, MD. 1993.

[18.] Wastney M.E Aamodt, R.L, Rumble, W.F Hen kin, R.J. kinetic analysis of zinc metabolism and its regulation in normal humans. Am. J. Physiology 1986;251;R 398-R408(Pub med).
[19.] Wilson SAK: progress leriticular degeneration: a familiar nervous diseases associated with cirrhosis of liver. Brian 1912; 295-509.
[20.] Zhang J.D, Li X.L chromium pollution of soil and water Jinzhou. Zhonghua Yu Fang Yi Xue Za Zhi1987; 21:262-264(pub med).

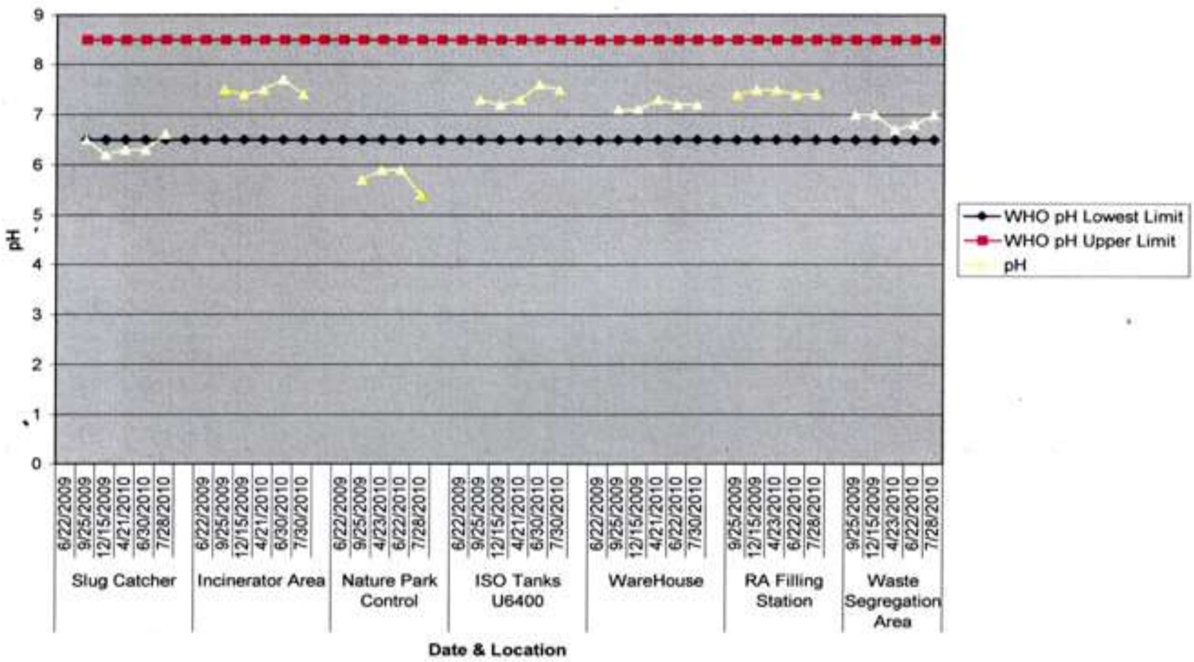

Figure 1: Graphical Presentation of Ground Water pH Results in NLNG Bonny

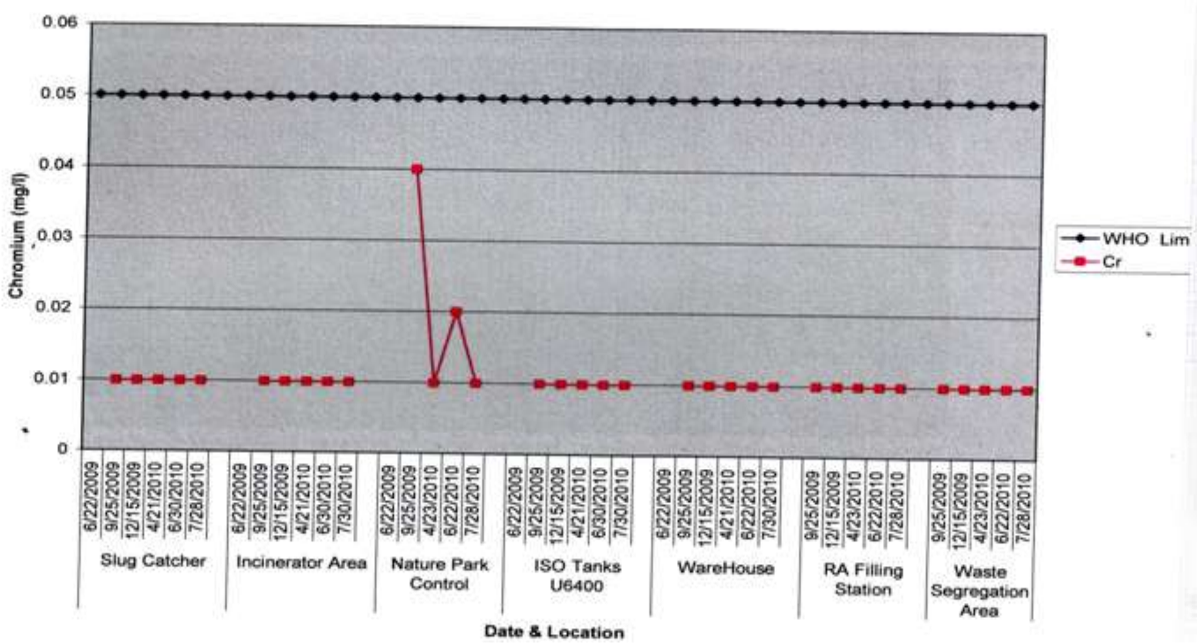

Figure 2: Graphical Presentation of Ground Water Chromium Results in NLNG Bonny

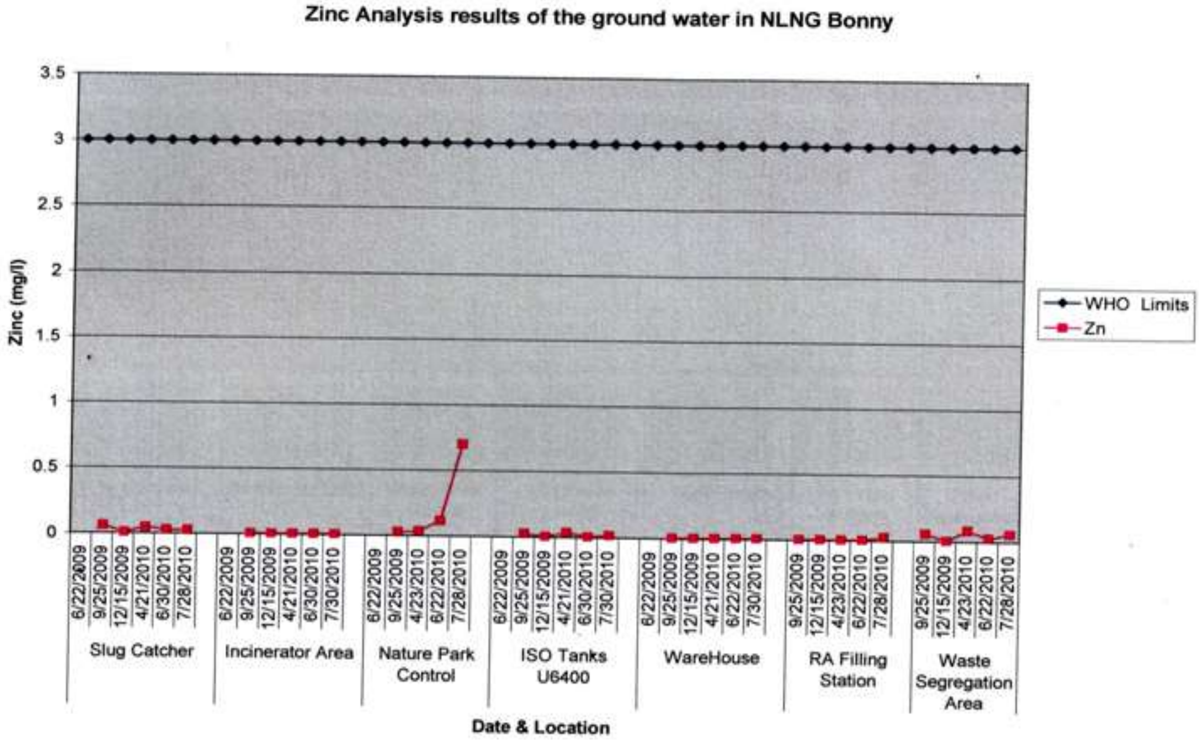

Figure 3: Graphical Presentation of Ground Water Zinc Results in NLNG Bonny

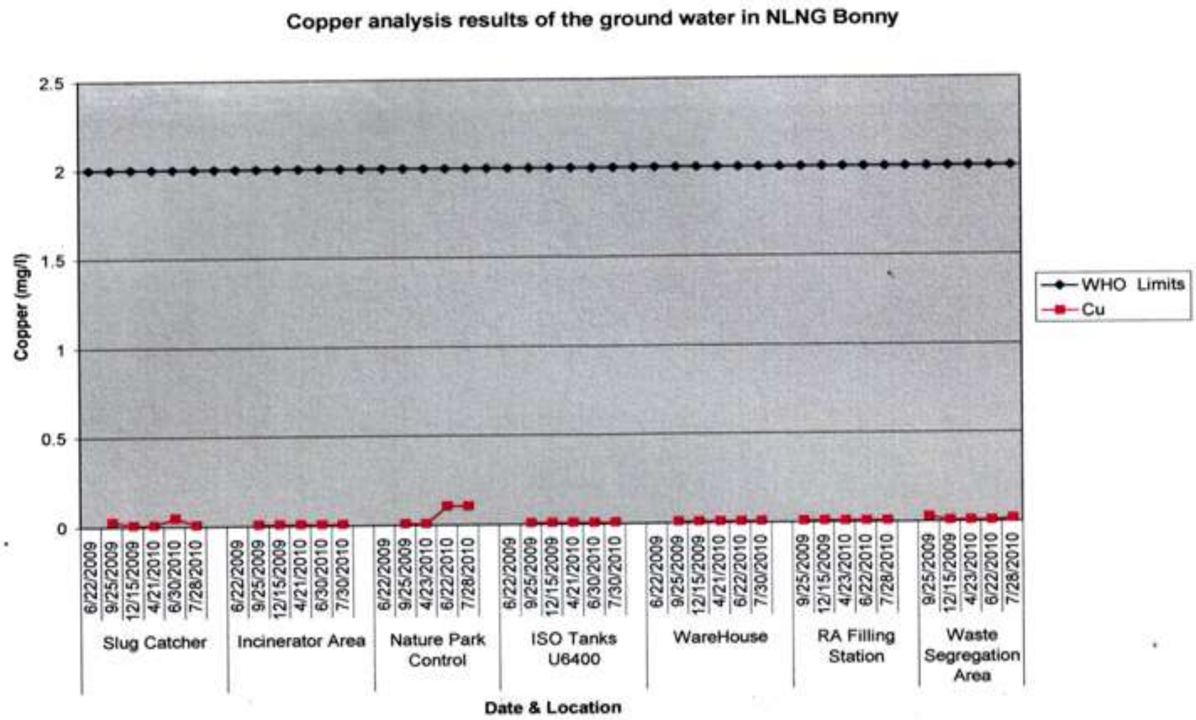

Figure 4: Graphical Presentation of Ground Water Copper Results in NLNG Bonny

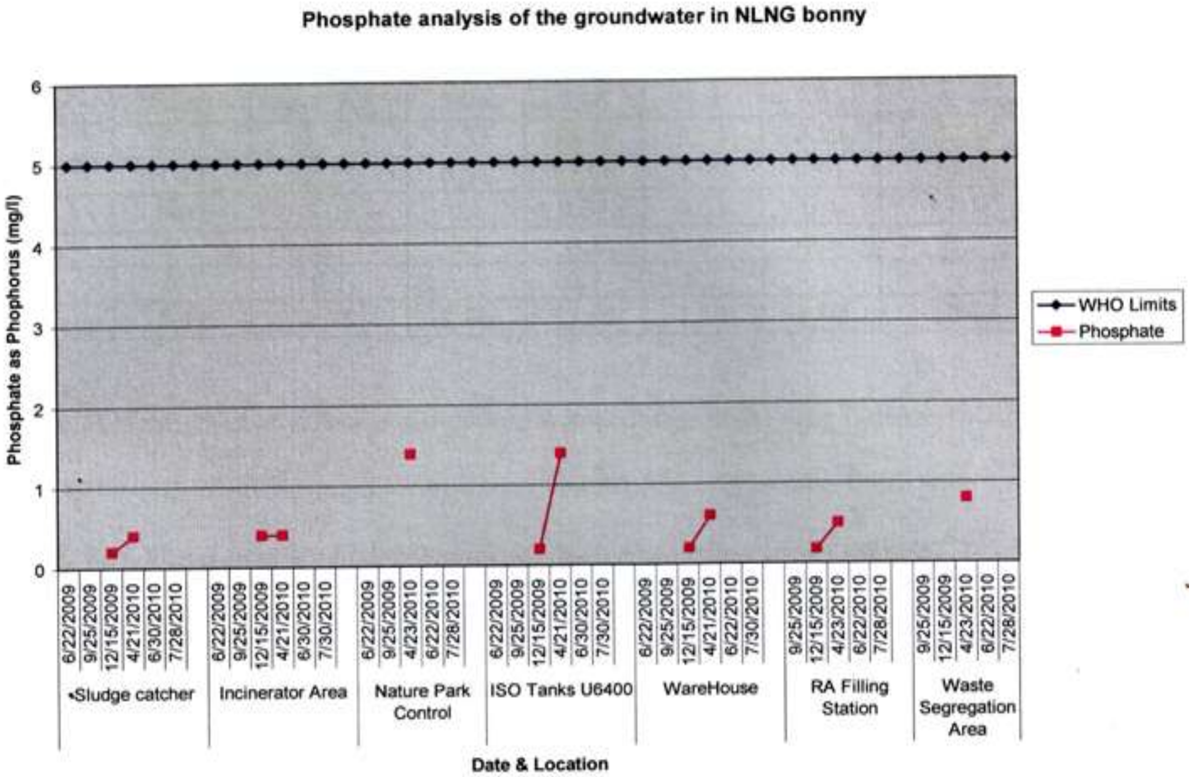

Figure 5: Graphical Presentation of Ground Water Phosphate Results in NLNG Bonny

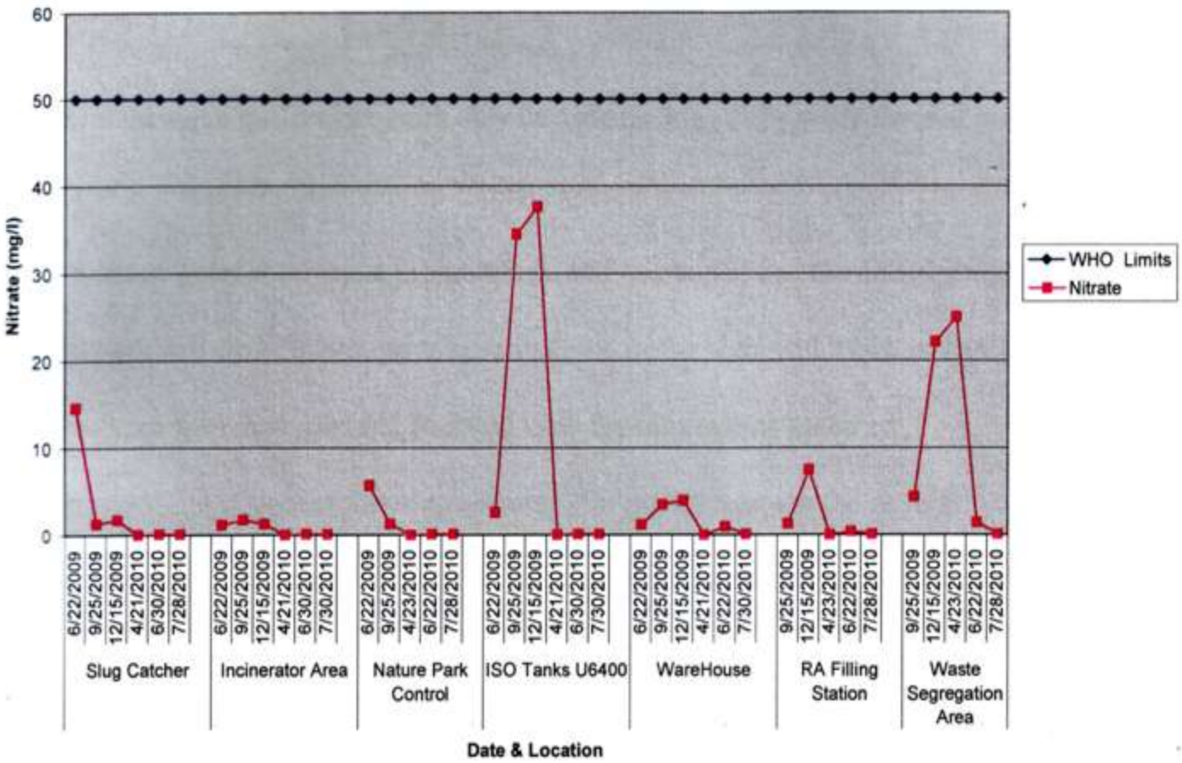

Figure 6: Graphical Presentation of Ground Water Nitrate Results in NLNG Bonny