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EFFECTS OF LEAD NITRATE ON THE GEOTECHNICAL PROPERTIES OF LATERITIC SOILS

Abdulmumin O. Abidoye
Department of Civil Engineering, University of Ibadan, Ibadan, Nigeria

Olaniyi Diran Afolayan
Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria

Isaac Ibukun Akinwumi
Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria

ABSTRACT

This study explored the effects of lead (II) nitrate on the geotechnical properties of two soil samples. The geotechnical properties of the natural soil samples were determined prior to their contamination with lead nitrate. The samples were then contaminated with 500 ppm, 1000 ppm and 2000 ppm of lead (II) nitrate and cured for 1, 14 and 28 days. The geotechnical properties of contaminated soil samples were determined after each of the curing periods. Results show that the maximum dry unit weights of the samples generally reduced with increasing concentration of lead nitrate and with increasing curing period. The optimum moisture contents of the samples increased with increasing curing period but reduced with increasing concentration of lead nitrate. However, an increase in the CBR after 28 days curing period was noticed for the samples as the concentration of the lead nitrate increased. The contaminated soil samples are suitable for use as subgrade and subbase materials for road pavement construction.

Key words: Contaminated Soil, Foundation, Geotechnical Engineering, Pollution.

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1. INTRODUCTION

Increasing use of fertilizers to increase agricultural yield and indiscriminate disposal of waste is increasing the pollution levels in soils. Aside the environmental impact of the pollution or contamination of soils, their physical and mechanical properties can get altered [5]. Soil contamination arises from variety of sources, which includes acid rain, improper waste disposal, among others [6, 7, 13, 17, 18, 20]. The properties of soil as engineering material depends on its surface texture, chemical composition, shape and size and surface electrical charges. Depending on the chemical composition, Kadiyali and Lal [11] stated that soil can exhibit enormous changes in the engineering properties especially soil with high content of clay material.

Many researchers have investigated the effects of soil contamination on the geotechnical properties of lateritic soils. Investigations have been conducted in the past to show how the geotechnical properties of soils were altered as a result of contamination of different soils by sodium and calcium salts [8], crude oil [2, 4], waste engine oil [3], lead nitrate and naphthalene [16], ferrous sulphate heptahydrate and lead nitrate [7], and leachate [13, 21]. Ojuri and Akinwumi [15] investigated the effects of nitrate contamination on the swell and compressibility properties of a clay soil and found that the swell and compressibility properties of the soil were over estimated as a result of nitrate contamination. Ojoawo et al. [14] found the nitrate pollution levels to be high especially in villages and rural areas and attributed this to the use of fertilizers for agricultural purposes in these areas.

Highway pavement are summarily classified into rigid and flexible pavement. Flexible road pavement is constructed in layers; the layers are subgrade, subbase, base and surfacing. The first three layers are typically constructed using soils depending on the expected traffic volume and intensity, and suitability of the soil in terms of specifications [1]. A commonly used soil class for road construction in tropical countries is lateritic soils; this is because they occur naturally and have been used successfully for pavement layer construction [10, 19]. Lateritic soils are important because they are widespread in tropical areas and subtropical climates [12].

Consequently, this study investigated the effects of lead nitrate on the geotechnical properties of two lateritic soils, while considering their use as road pavement layer materials.

2. 2. MATERIALs AND METHODs

Disturbed sample were collected from a borrow pit at Toll gate area, Ibadan, Nigeria. The samples were collected from two locations described by their Universal Transverse Mercator (UTM) northing and easting as 809709.9, 596446.7 and 809708.2, 596433.3, respectively.

The lateritic soils were contaminated with lead nitrate ($Pb(NO_3)_2$) salt at simulated concentration levels of 500, 1000, and 2000 parts per million (ppm) solutions. These levels were similar to those used by Ojuri and Oluwatuyi [16].

The geotechnical properties of the natural soil prior to contamination and after contamination were investigated. The natural moisture content, sieve analysis, Atterberg limits, compaction and California bearing ratio (CBR) tests were carried out on the uncontaminated soil samples. The effects of the lead nitrate contamination on the compaction characteristics and CBR of the lateritic soils were determined. The geotechnical properties tests were carried out in accordance with BS 1377 [9]. Standard Proctor compaction was used.

The soil samples were contaminated with 500 ppm, 1000ppm and 2000 ppm concentrations of lead nitrate after which they were sealed in air-tight polythene bags and cured. Tests were however carried out on the contaminated samples after each of 1, 14 and 28 days curing periods.

Three specimens each of 27 kg weight were obtained from both Samples 1 and 2. Each of the specimens was then contaminated with lead nitrate at 500 ppm, 1000 ppm and 2000 ppm.

The three specimens were used for the CBR and compaction tests after the first day, 14 days and 28 days of contamination. Six (6) kilograms of each of the soil sample categories was taken for the CBR tests, while 3 kg was taken for the compaction test.

3. RESULTS AND DISCUSSION

Table 1 presents the geotechnical properties of the soil samples collected which include: natural moisture content, the liquid and plastic limits, plasticity index, maximum dry unit weight, optimum moisture content (OMC) and CBR of the Samples 1 and 2. The natural moisture contents of the soil samples are 15.45% for Sample 1 and 15.0% for sample 2.

In order to classify the soil Samples 1 and 2, grain size analysis was carried out. Figure 1 shows the grain size distribution curves. D_{10}, D_{30} and D_{60} were obtained from the results plotted on the semi-logarithms graph, which was used to determine C_u and C_c. Using the criteria for coefficients of uniformity and curvature for sand, sample 1 was found to be poorly graded while sample 2 was found to be well graded.

The liquid limits of Sample 1 and 2 are 36% and 40.5%, respectively, while their plastic limits are 30.3% and 33.1%, respectively. The liquid limits of both samples indicate that they are of low plasticity.

Table 1 Geotechnical properties of uncontaminated lateritic soil

	Sample 1	**Sample 2**
Natural Moisture Content (%)	15.45	15.0
Liquid Limit (%)	36	40.5
Plastic Limit (%)	30.3	33.1
Plasticity Index (%)	5.7	7.4
Maximum dry unit weight (kN/m^3)	18.6	17.7
Optimum Moisture Content (%)	9	11%
California Bearing Ratio (%)	53.98	40.08

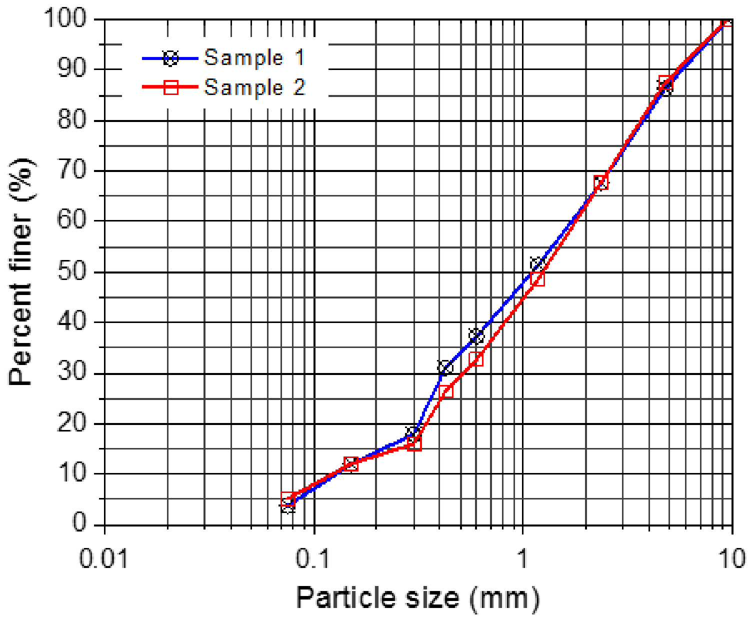

Figure 1 Particle size distribution of the soil samples

According to the result of this study, the maximum dry unit weight for the uncontaminated Samples 1 and 2 are 18.6 kN/m^3 and 17.7 kN/m^3, respectively. The variation of the maximum dry unit weight with the concentration of lead nitrate in the soil Samples 1 and 2 are presented in Figures 2 and 3, respectively. They show that the maximum dry unit weight initially decreased with increase in the lead nitrate concentration before increasing. Though the trends did not give well-defined patterns, there was a general decrease in maximum dry unit weight. Figures 4 and 5 present the variation of OMC with the concentration of the lead nitrate for Samples 1 and 2, respectively. The pattern of the variation of the OMC of the soil sample was, similarly, not well-defined but generally increased with increasing percentage of the lead nitrate concentration.

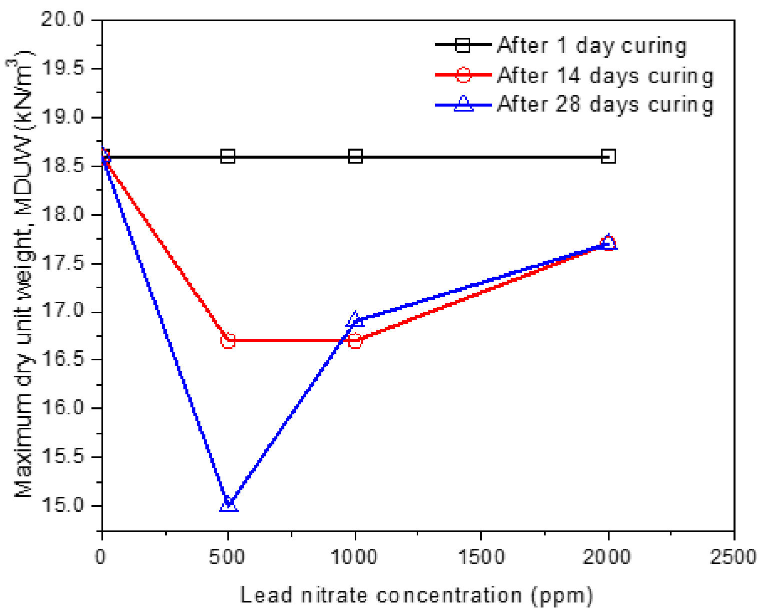

Figure 2 Variation of maximum dry unit weight with lead nitrate concentration for Sample 1

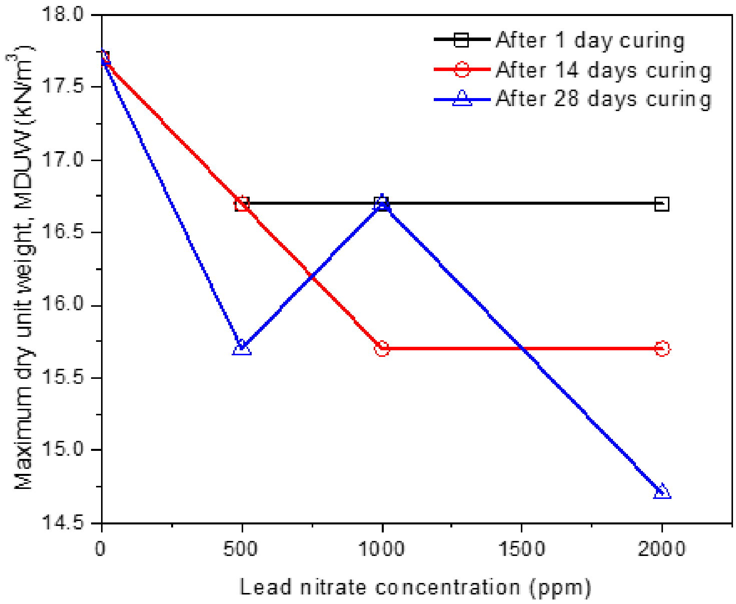

Figure 3 Variation of maximum dry unit weight with lead nitrate concentration for Sample 2

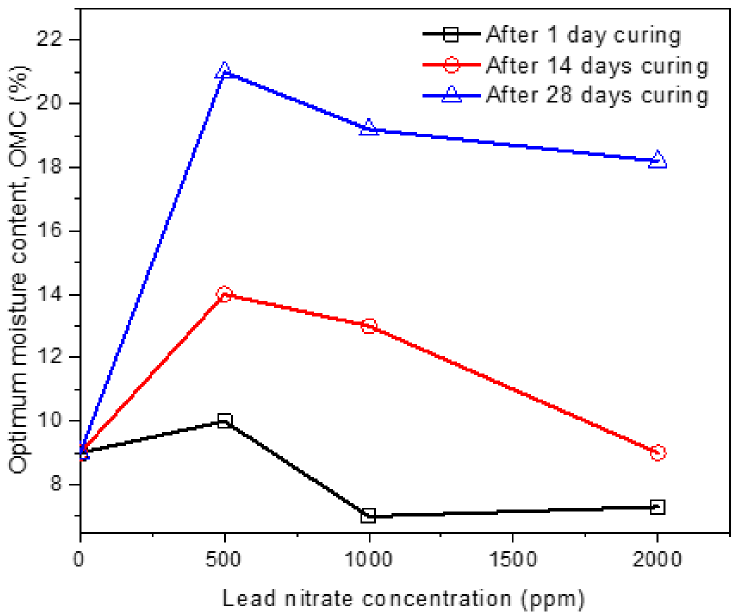

Figure 4 Variation of OMC with lead nitrate concentration for Sample 1

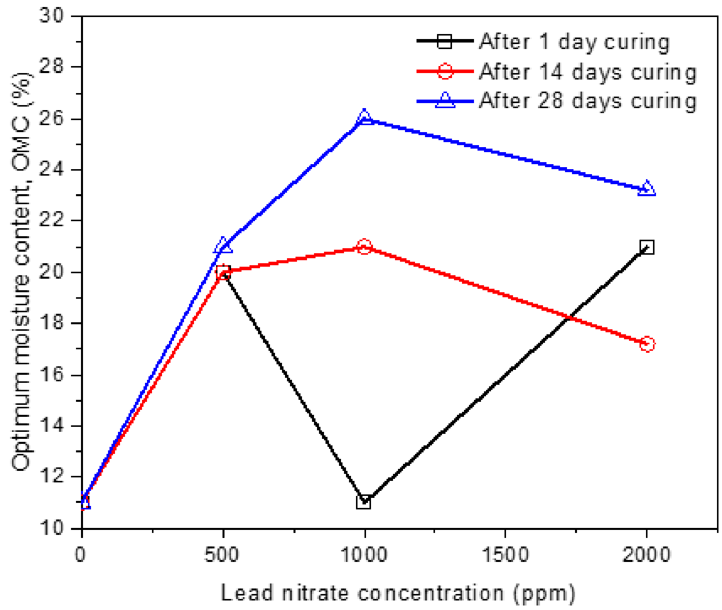

Figure 5 Variation of OMC with lead nitrate concentration for Sample 2

From the results of the uncontaminated samples presented in Table 1, the California bearing ratio for sample 1 is 53.98% while that of sample 2 is 40.08%. This shows that Samples 1 and 2 are good materials that can be used as subbase material in road construction. Figures 6 and 7 present the variation of the California bearing ratio for Samples 1 and 2 with change in lead nitrate concentration.

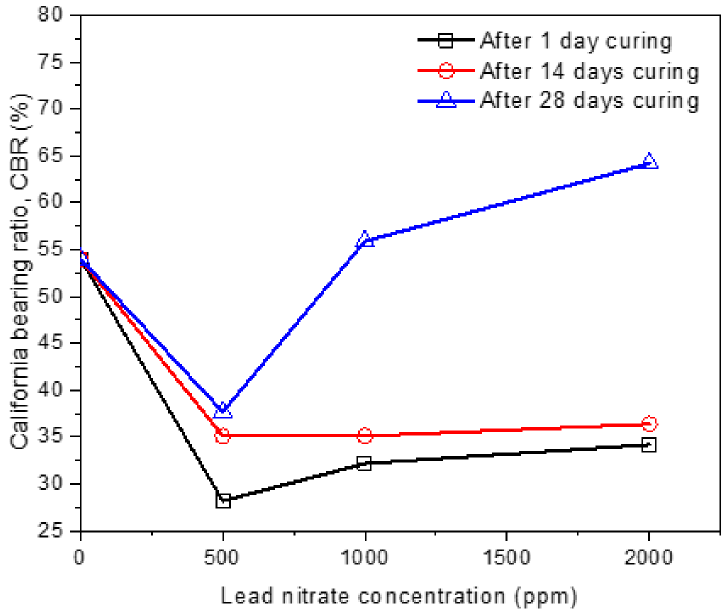

Figure 6 Variation of CBR with lead nitrate concentration for Sample 1

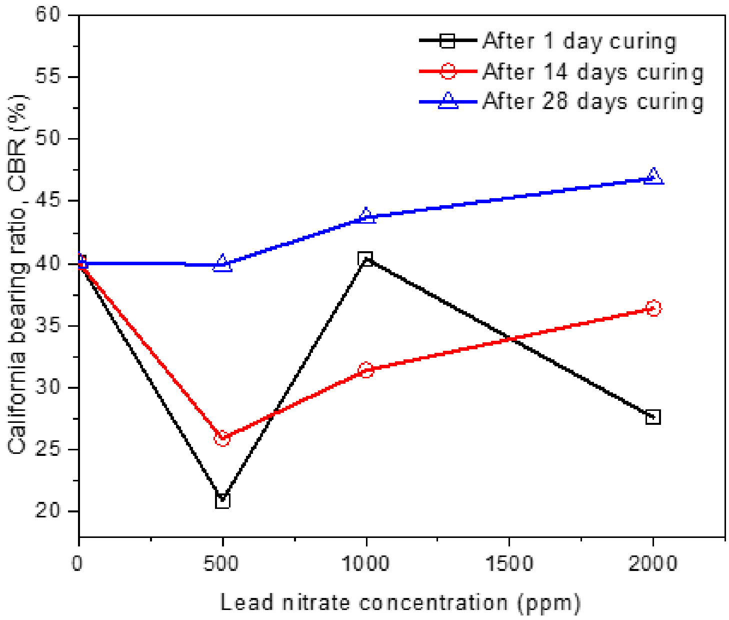

Figure 7 Variation of CBR with lead nitrate concentration for Sample 2

For Samples 1, the CBR values of the uncontaminated soil samples decreased after contamination with 500 ppm concentration of lead nitrate and at first day of curing. Afterwards, the CBR increases as the concentration increases. This was, however, not wholesomely the trend for Sample 2. After 28 days of curing, the CBR increased with increasing concentration of lead nitrate. This was similarly observed by Ojuri and Oluwatuyi [16] that the unconfined compressive strength (UCS), which is also a measure of bearing capacity of a soil, increased when the lateritic soil was contaminated with lead nitrate.

From the Figures 2 and 3, the maximum dry unit weight generally reduced with curing age for Samples 1 and 2. This, however, was not the case for Sample 1 for the 1000 ppm of lead nitrate contamination as there was a slight increase in maximum dry unit weight after the 14 days curing period. Also, an increase was also observed for Sample 2 as the maximum dry unit weight increased for 1000 ppm contamination of lead nitrate after the 14 days curing period.

The OMC increased with curing age for all concentrations and for the two soil samples (Figures 4 and 5). The OMC for all the contamination levels ranged from 10% to 26%. The increase in OMC may be attributed to the increase in specific surface area and texture as a result of the lead nitrate.

For both samples 1 and 2, the CBR generally increased for all curing ages (Figures 6 and 7). However, the general trend was not noticed for Sample 2 when contaminated with 1000 ppm of contaminant as there was a decrease in the CBR value from 40.41% after the first day of contamination with 1000 ppm concentration to 31.39% after the fourteenth day. However, it later increased to 43.69% after the twenty eighth day.

Increase in CBR value of the soil is an indication of improvement of the strength properties of the soil. The CBR of the contaminated soils indicate that the soil is suitable for use as subbase materials in accordance to Federal Ministry of Works [10].

4. CONCLUSIONS

The aim of this research work was to investigate the effects that the contamination of two lateritic soil with lead nitrate has on their geotechnical properties. The following were concluded:

- The uncontaminated samples are classified as well graded and poorly graded sandy soils for Samples 1 and 2, respectively,
- The maximum dry unit weight of the soil samples generally reduced with increasing lead nitrate concentration and curing period, while the OMC of the soil generally increased with the curing age but reduced with increasing lead nitrate concentration,
- The CBR of the soil generally increased with increasing lead nitrate concentration and curing period, and
- The contaminated samples were good for use as subbase materials for road pavement construction.

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