oxyhydroxides from the weakly acidic surface layers down the lateritic profile and subsequent deposition further down the profile possibly as iron concretion or complete loss from the system through drainage by groundwater (Elueze and Kehinde-Philips, 1993; Sandipan et al., 2020).

The degree of laterization (formation of laterite) is estimated by the Silica –Sesquioxide (S-S) ratio [SiO2/ (Fe_2O_3+Al_2O_3]. Soils are classified by the S-S ratios. Therefore, an S-S ratio of 1.33 or below = laterite.

S-S ratio of 1.33–20 = lateritic soil.

An S-S ratio of 20 and above = non-lateritic i.e. tropical soil.

The ratio of the sample used for classifying the samples is in Table 1 and is denoted as AR. The slight deviation in the ratio obtained for the laterite samples from 1.33 could be a factor that depends on the parent rock composition and the formation conditions (Schellman, 2007). This also classifies the laterite samples as lateritic soil. The Silica– Sesquioxide of LA-EM which is 2.91 is closer to the pure laterite than LA-AB with a value of 3.14 for Silica –Sesquioxide. The pHs of the laterite samples are acidic. The two samples showed appreciable exchangeable bases in the order of Ca > Na > Mg > K (table 1). This order can be as a result of the appreciable carbonate that is present in each sample. A similar order of the exchangeable bases as shown in Table 1 above was obtained by Banjoko *et al.*, 1983 on some soils in Northern Nigeria. LA-EM has higher base saturation than LA-AB which suggested that cation exchange processes may provide a stronger capacity to buffer incoming proton additions in LA-EM than LAAB (Gong and Donahoe, 1996).

Analysis on heavy metal fractionation

Table 2: Fractionation of Mn (mean in mg/kg) in LA-AB

	Lalupon	5% Incubation		10% Incubation		20% Incubation	
Fraction	**Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**
1	0.37±0.04	0.57±0.57	0.59±0.03	0.54±0.17	0.94±0.04	0.45±0.18	0.49±0.05
2	1.11±0.10	1.14±0.02	2.08±0.05	1.11±0.25	2.09±0.23	0.90±0.19	1.70±0.01
3	5.90±0.58	5.78±0.08	4.37±0.13	4.81±0.04	4.23±0.03	5.21±0.41	4.83±0.21
4	2.06±0.13	1.96±0.05	3.92±0.12	2.10±0.38	3.55±0.17	1.83±0.43	3.73±0.55
5	2.56±0.43	2.75±0.08	5.30±0.02	2.90±0.71	5.99±0.13	2.27±0.22	5.88±0.19
6	1.98±0.61	1.59±0.74	2.00±0.21	1.65±0.59	1.72±0.12	1.78±0.31	2.55±0.11
7	20.78±0.46	9.06±10.25	6.03±0.26	15.85±o.57	6.87±0.10	14.30±1.41	8.00±0.76
Total	34.75±24.58	22.83±16.16	24.26±24.29	28.95±20.48	25.39±17.95	26.73±18.91	27.17±19.22

Table 3:Fractionation of Cr (mean in mg/kg) in LA-AB

Fraction	**Lalupon**	**5% Incubation**		**10% Incubation**		**20% Incubation**	
	Mean±SD	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**
1	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
2	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
3	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
4	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
5	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
6	0.05±0.07	0.30±0.04	0.00±0.00	0.02±0.03	0.00±0.00	0.02±0.02	0.00±0.00
7	6.28±0.70	8.58±1.58	25.08±3.57	4.20±4.63	34.12±6.43	11.30±2.52	51.62±3.76
Total	6.33±4.48	8.88±6.26	25.08±17.73	4.22±2.63	34.12±24.13	11.32±8.00	51.62±26.86

Key: F1 (fraction 1) = Mobile fraction. F2 (fraction 2) = Easily mobilizable fraction. F3 (fraction 3) = Metal forms bound to manganese oxide. F4 (fraction 4) = Metal forms bound to organic matter. F5 (fraction 5) = Metal forms bound to amorphous iron oxide. F6 (fraction 6) = Metal forms bound to crystalline iron oxide. F7 (fraction 7) = Residual fraction forms. ∑F1-7= sum of fraction 1-7 SD = Standard deviation.

Fractionation of the Mn, Cr, Zn, Pb and Ni present in LA-AB

The movement of metals from soil to different environmental compartments is strongly dependent on the concentration of their geochemical fractions in soils. Table 2 showed the distribution of manganese in the polluted soil and the incubation results for LA-AB. Lalupon bounded majorly to the residual fraction with a mean value of 20.78mg/kg. This is equivalent to 59.80% of the total manganese present in the polluted sample, organic matter is 7.37% and the crystalline iron oxide is 5.70%. The various speciation results in the table above were as well majorly bounded to the residual fractions. A close look at table 2 showed that the major bond of manganese to the residual fraction and the oxides of iron suggest that the metal under consideration may have long time availability if changes in soil chemistry and microbiology permit. The high residual fraction suggests stability (Agbeni, 2010). The organic matters contain higher concentration with three months than two months. The adsorptive layers of iron oxide immobilized better with the various three months than the corresponding two months but residual fraction was more consistent with the two months than the corresponding three months. The various occlusions at the oxide of irons can result from the pore sizes affecting the solid-state diffusion of the metals (Jakubus and Czekala, 2010). The 5% incubation showed an improved efficiency over the 10% and 20% respectively. The metal was more effectively occluded in the two months processes than what was observed in the three months results.

In the Lalupon soil and the results from the two months incubation, chromium majorly bounded to the residual fraction (Table 3). A small percentage was associated with the crystalline fractions. There were no adsorptions in the first five fractions. In the three months incubation results from the metal fractionation, Chromium bounded mainly to the residual fraction as well. Similar report was made by Jakubus and Czekala, 2010 that this could be due to the fact that the mobility of chromium in the environment was limited by the dominating (+3) oxidation state and gave the formed compound a low solubility especially with iron oxide and hydroxide. Also, Imai and Gloyna, (1990) reported that irrespective of the oxidation degree, the dominant part of chromium does bond firmly and was always difficult to dissolve. This majorly accounted for the dominance of chromium at residual fraction (Table 3).

Table 4 showed that zinc was majorly adsorbed in the residual fraction with a mean value of 19.98mg/kg which is equivalent to 62.30%, amorphous oxide contains 18.90%, organic matter has 8.70% and the easily mobilizable fraction is 5.27% . This suggested both lithogenic and anthropogenic source for the metal in the polluted site. Zinc was also found in the other fractions in relatively lesser percentages. Their fair distribution across the seven fractions suggested that it was one of the most mobile elements in soils and had displayed a similar trend in the samples under consideration (Jakubus and Czekala, 2001). Zinc was generally considered to be of low toxicity due to the wide margin between the usual environmental concentrations and toxic levels (Lisbeth *et al*., 2009). Zinc gave a total mean value of 32.07mg/kg but an unusual trend was noticed in the residual fraction of Table 4 (5%) which did not agree to every other result that were obtained for both LA-AB and LA-EM. Apart from this, Zinc showed a normal expected trend in all the results. The distribution cut across all fractions and this could result from the fact that it is one of the most mobile elements in soil. The mobile fraction was the least of all the seven –fractions steps for the Lalupon soil, two months and the three months incubation results. The exchangeable fraction was higher in the three months than the two months though not too wide for 5%, 10% and 20%. The two months bounded with higher mean values in manganese oxide than what was noticed in the results for the various three months. The two months bound better in the amorphous oxide than the two months.

Pb was majorly bounded to the easily mobilizable fraction, residual fraction and organic matter with mean values of 2770mgkg^{-1}, 2392mgkg^{-1} and2210mgkg^{-1} respectively on soil (Table 5). It was the most abundant element of all the metals of interest that polluted the site accounting for 98.89%. Lead was highest with easily mobilizable fraction, this suggests that it must have been redistributed between the soil's liquid and solid phase over time and had been readily transferred into the easily mobilizable fraction over a time scale of months or years (Nowack *et al*., 2010). This is possible because of its ability to exhibit variable states of +2 and +4. However, the crystalline metal phases are low (F5 and F6). This must have resulted from the fluctuations of the soil pH over a period of time because Nowack *et al*, 2010, suggests that the formation of these crystalline metal phases occurred within few months in soils with a neutral or alkali pH. Pb showed more redistribution pattern in the exchangeable fraction of the two months than found in the 3 months of the 5%. With the 10% and 20% (Table 5), the three months showed an improved distribution trend. The iron oxide fractions were the least among the seven fractions. A comparison of Lalupon soil with the results of oxides of iron in the two months of 10% and that of 20% showed that adsorption had occurred to a certain extent. However, lead was distributed more since a lot were found in the easily exchangeable fractions. The mobile phase was relatively low as noticed in other metals. Fractionation of the Ni that is present in LA-AB

The total concentration of Ni in the polluted sample was small compared to Zn, Pb and Mn (Table 6). It bounded majorly to the residual fraction (94.18%) and amorphous iron oxide (2.82%) (Table13). This according to Usman *et al*., (2005) resulted from the ability of iron hydroxide especially at neutral pH in lowering the nickel content in the solution. Kobya, (2004) suggested that nickel ends up in the soil where they were strongly attached to particles containing iron or manganese. Under acidic conditions, nickel was more mobile in soil and may seep into groundwater. From the Lalupon soil to the various results for incubations, Ni did not bound any of the mobile fractions. Similar trend occurs with the manganese oxide. There was good immobilization strength for the binding agents as we transverse from the two months to the three months speciation. This was noticed in the two fractions of the oxides of iron from 5, 10 and 20 percentages. The redistribution trend was low compared to what was obtainable in the metals considered so far. This signified that the metal was not as distributed as the trend observed in Pb, Mn and Zinc (Nowack et al., 2010). The mean contents of the various fractions for the 5% signified that LA-AB at 2 months immobilized better than LA-AB at three months, the 10% showed that the two months had a better immobilization efficiency considering the oxides of iron in particular.

Table 4: Fractionation of Zn (mean in mg/kg) in LA-AB

Fraction		**2 months**	**3 months**	**2 months**	**3 months**	**2 months**	**3 months**
	Mean±SD	**Mean±SD**	**mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**
1	0.20±0.02	0.30±0.01	0.36±0.07	0.26±0.06	0.27±0.06	0.29±0.08	0.38±0.09

2	1.69±0.32	2.11±0.05	1.62±0.05	2.13±0.25	1.44±0.23	1.98±0.23	1.79±0.31
3	0.38±0.01	0.59±0.02	0.25±0.07	0.43±0.02	0.33±0.07	0.43±0.04	0.25±0.07
4	2.79±0.13	3.22±0.20	39.35±8.20	3.02±0.38	5.57±2.60	2.71±0.30	3.23±0.35
5	6.06±0.03	5.99±0.40	25.29±4.22	6.26±0.71	18.12±1.23	5.60±0.59	10.60±2.08
6	0.97±0.09	1.08±0.09	0.45±0.12	0.83±0.59	0.72±0.08	0.65±0.23	0.31±0.02
7	19.98±0.24	3024.09±.00	14.34±1.50	16.57±0.57	12.54±0.74	14.45±1.04	13.19±1.16
Total	32.07±22.06	3037.36± 0.77	81.65±57.75	29.49±20.85	38.99±27.57	25.60±18.11	29.74±21.03

Table 5 Fractionation of Pb (mean in mg/kg) in LA-AB

	Lalupon	**5% Incubation**		**10% Incubation**		**20% incubation**	
		2 months	**3 months**	**2 months**	**3 months**	**2 months**	**3 months**
Fraction	**Mean±SD**		**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**
1	48.05±22.98	60.10±29.84	114.50±6.79	60.55±17.32	111.75±0.64	47.50±1.84	121.66±2.76
2	2770.25±245.91	2747.50±590.43	4964.60±99.56	2515.00±770.75	4547.95±120.84	2597.50±	4328.70±153.87
3	336.30±41.41	341.25±73.89	45.16±1.47	251.50±22.63	24.86±1.94	223.50±159.97	16.64±2.09
4	2210.75±149.55	2167.50±109.60	2015.90±23.48	2005.00±106.07	1741.70±135.48	1625.00±56.57	1970.30±46.39
5	107.50±9.91	111.50±26.87	484.75±39.24	94.60±18.67	201.15±1.23	80.40±12.45	271.25±12.50
6	14.19±2.21	17.54±4.06	31.55±5.44	10.86±0.95	58.36±58.36	8.26±0.93	17.04±1.65
7	2392.70±173.52	1897.50±823.78	1256.63±80.08	2122.50±236.88	1042.25±84.50	2137.50±342.95	1305.75±29.34
Total	7879.74±5571.82	7342.89±5195.39	8913.09±6302.51	7060.01±4992.18	7728.01±5464.54	6719.66±745.86	8031.33±5679.022

Table 6 Fractionation of Ni (mean in mg/kg) in LA-AB

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
		2 months	**3 months**	**2 months**	**3 months**	**2 months**	**3 months**
Fraction	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**
1	0.00±0.00	0.00±0.00	0.00±0.00	0.000.00	0.00±0.00	0.00±0.00	0.00±0.00
2	0.22±0.01	0.21±0.02	0.30±0.06	0.27±0.05	0.18±0.04	0.26±0.01	0.25±0.00
3	0.14±0.05	0.07±0.10	0.00±0.00	0.04±0.04	0.00±0.00	0.05±0.07	0.00±0.00
4	0.31±0.06	0.26±0.07	0.38±0.06	0.27±0.06	1.14±0.26	0.27±0.01	0.46±0.11
5	1.21±0.08	1.23±0.00	1.73±0.21	1.16±0.03	1.71±0.05	0.90±0.09	2.71±0.43
6	0.61±0.07	0.29±0.02	0.49±0.06	0.28±0.04	0.44±0.01	0.38±0.04	0.43±0.04
7	40.48±0.39	3.59±0.52	24.75±0.52	3.96±1.94	30.12±0.23	8.06±7.21	45.91±0.80
Total	42.98±28.62	5.65±4.00	27.64±19.55	5.98±4.23	33.59±23.75	9.93±7.01	49.76±35.19

Table 7 Fractionation of Mn (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
Fraction	**Mean±SDs**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**
1	0.37±0.04	0.56±0.18	2.43±0.47	0.56±0.15	1.91±0.14	0.59±0.16	0.98±0.05
2	1.11±0.10	1.11±0.03	2.43±0.47	0.96±0.01	1.91±0.14	1.16±0.32	2.12±0.28
3	5.90±0.58	5.06±0.62	4.72±0.57	4.17±0.11	6.16±0.38	5.19±0.12	5.34±0.02
4	2.06±0.13	2.35±0.28	4.21±0.16	1.94±0.09	4.24±0.43	1.85±0.38	3.54±0.47
5	2.56±0.43	2.69±0.40	5.38±0.03	2.46±0.16	5.50±0.31	2.88±0.14	8.08±0.14
6	1.98±0.61	1.88±0.45	10.69±0.09	1.17±0.51	1.52±0.70	1.61±0.98	3.87±0.48
7	20.78±0.46	15.05±0.35	3.07±0.21	1.67±0.06	10.11±0.33	18.15±3.89	8.70±0.44
Total	34.75±24.58	28.69±20.29	32.92±23.29	12.91±9.14	31.33±22.17	31.42±22.22	32.62±23.07

Table 8: Fractionation of Cr (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% incubation**		**20% incubation**	
Fraction	**Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**
1	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
2	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
3	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
4	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
5	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
6	0.05±0.07	0.00±0.00	0.00±0.00	0.08±0.02	0.00±0.00	0.05±0.07	0.00±0.00
7	6.28±0.70	9.80±4.64	37.64±3.55	7.12±1.17	37.98±1.80	7.79±0.13	6.49±2.73
Total	6.33±4.48	9.80±6.57	37.64±26.62	7.19±5.09	37.98±26.86	7.84±5.54	6.49±4.59

Table 9: Fractionation of Zn (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
Fraction	**Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**
1	0.20±0.02	0.28±0.02	0.45±0.09	0.30±0.08	0.52±0.08	0.33±0.07	0.40±0.06
2	1.69±0.32	2.25±0.14	1.88±0.21	2.44±0.62	1.60±0.09	2.01±0.95	1.74±0.23

3	0.38±0.01	0.49±0.05	0.59±0.17	0.43±0.12	0.41±0.14	0.48±0.07	0.32±0.02
4	2.79±0.13	2.74±0.33	13.05±2.57	2.38±0.38	5.56±1.92	2.39±0.48	4.01±0.21
5	6.06±0.03	5.90±0.59	33.91±0.27	5.70±0.70	35.33±5.06	6.40±0.04	24.61±2.41
6	0.97±0.09	0.70±0.12	0.26±0.07	0.81±0.15	0.70±0.19	1.00±0.21	0.32±00
7	19.98±0.24	15.67±0.67	10.15±0.38	18.00±o.74	14.02±0.83	17.62±2.03	12.27±0.87
Total	32.05±22.60	28.02±19.82	60.29±42.64	30.06±21.32	58.14±41.11	30.21±21.39	43.66±30.88

Table 10: Fractionation of Pb (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
Fraction	**Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**
1	48.05±22.98	43.70±11.60	75.70±5.10	47.60±2.12	133.36±5.56	73.50±11.38	171.05±9.97
2	2770.25±245.91	3177.50±399.52	3910.55±50.28	2667.50±31.82	3658.20±89.38	2720.00±410.12	3519.90±130.67
3	336.30±41.41	240.50±49.50	204.90±20.93	229.25±46.32	33.31±16.67	289.50±36.06	28.54±0.74
4	2210.75±149.55	2017.50±81.32	2803.25±124.80	2397.50±781.35	2314.25±122.68	2510.00±926.31	2223.05±34.58
5	107.50±9.91	116.15±48.58	829.50±108.89	81.95±3.61	412.15±38.68	139.40±17.25	360.55±66.54
6	14.19±2.21	11.55±4.00	5.28±1.04	24.69±9.34	56.80±7.78	30.76±12.92	21.67±2.52
7	2392.70±173.52	2390.00±14.14	967.25±64.70	2117.50±24.75	1003.80±15.84	2740.00±1025.30	769.62±59.57
Total	7879.74±5571.82	7996.90±5654.66	8796.44±6220.03	7566.00±5349.97	7611.88±5382.36	8503.17±6012.53	7094.39±4996.31

Table 11: Fractionation of Ni (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
Fraction	**Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**
1	0.00±0.00	0.00±0.00	0.15±0.01	0.00±0.00	0.19±0.03	0.00±0.00	0.00±0.00
2	0.22±0.01	0.26±0.03	0.25±0.00	0.26±0.06	0.26±0.07	0.30±0.02	0.53±0.05
3	0.14±0.05	0.00±00	0.19±0.03	0.00±0.00	0.18±0.02	0.00±0.00	0.09±0.01
4	0.31±0.06	0.34±0.11	0.57±0.11	0.31±0.08	0.41±0.07	0.31±0.08	0.46±0.01
5	1.21±0.08	1.14±0.15	1.91±0.11	1.02±0.05	2.28±0.19	1.20±0.02	1.65±0.10

Fractionation of the Mn that is present in LA-EM

Table 7 showed the mean and standard deviation of Lalupon soil sample, 5%, 10% and 20% **i**ncubation result for Mn. The mobile fraction was the least with mean values ranging from 0.37-1.19 mg/kg for the Lalupon soil sample and the incubated results. The exchangeable fraction was not so significant for the two and three months although some were more than the other. The three months of the 5, 10 and 20 percent were slightly higher than the corresponding two months. This implies that as the duration of incubation increases, the metal becomes more redistributed. A close look at the table above showed that the major bond of manganese to the residual fraction, the oxides of iron suggests that the metal under consideration may have a long-time availability if changes in soil chemistry and microbiology permits. The high value at the residual fraction suggests stability. The 5%, 10% and 20% all have low values for the easily available fractions (the mobile fraction and the exchangeable fraction), the manganese oxide, amorphous iron oxide and crystalline iron oxide have high mean values for all the percentages under consideration. The residual fraction is only low with 3 months 5% and 2 months 10%. The redistribution trend of this metal showed that some of the results of the speciation for the various incubation are higher than the mean content of the polluted site. This implies that the laterite samples contained this metal in a small amount as well. The three months result showed higher mean values (mg/kg) for the various mobile fractions and the exchangeable fractions while others are higher for the two months.

Fractionation of the Cr that is present in LA-EM

There was no adsorption in the mobile fraction, exchangeable fraction**,** manganese oxide fraction, organic matter, amorphous oxide. However, chromium adsorbed at the crystalline iron oxide fraction and the residual fraction in the two months while it only occluded at the residual fraction in the three months this further strengthened the ideal of Imai and Gloyna, (1990) that it was difficult to remove chromium from its concentrated fraction. The bound fraction of chromium to the residual fraction enhances its stability. The three months had higher amount in their residual fraction than the corresponding two months. Table 8 showed that the mean content for the polluted soil was 6.33mg/kg at the residual fraction while each of the result adsorbed higher, this suggested that the laterite samples used as binding agents contained this metal as well.

Table 10: Fractionation of Pb (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
Fraction	**Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**	**2 months Mean±SD**	**3 months Mean±SD**
1	48.05±22.98	43.70±11.60	75.70±5.10	47.60±2.12	133.36±5.56	73.50±11.38	171.05±9.97
2	2770.25±245.91	3177.50±399.52	3910.55±50.28	2667.50±31.82	3658.20±89.38	2720.00±410.12	3519.90±130.67

3	336.30±41.41	240.50±49.50	204.90±20.93	229.25±46.32	33.31±16.67	289.50±36.06	28.54±0.74
4	2210.75±149.55	2017.50±81.32	2803.25±124.80	2397.50±781.35	2314.25±122.68	2510.00±926.31	2223.05±34.58
5	107.50±9.91	116.15±48.58	829.50±108.89	81.95±3.61	412.15±38.68	139.40±17.25	360.55±66.54
6	14.19±2.21	11.55±4.00	5.28±1.04	24.69±9.34	56.80±7.78	30.76±12.92	21.67±2.52
7	2392.70±173.52	2390.00±14.14	967.25±64.70	2117.50±24.75	1003.80±15.84	2740.00±1025.30	769.62±59.57
Total	7879.74±5571.82	7996.90±5654.66	8796.44±6220.03	7566.00±5349.97	7611.88±5382.36	8503.17±6012.53	7094.39±4996.31

Table 11: Fractionation of Ni (mean in mg/kg) in LA-EM

	Lalupon	**5% Incubation**		**10% Incubation**		**20% Incubation**	
Fraction	**Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**	**2 Months Mean±SD**	**3 Months Mean±SD**
1	0.00±0.00	0.00±0.00	0.15±0.01	0.00±0.00	0.19±0.03	0.00±0.00	0.00±0.00
2	0.22±0.01	0.26±0.03	0.25±0.00	0.26±0.06	0.26±0.07	0.30±0.02	0.53±0.05
3	0.14±0.05	0.00±00	0.19±0.03	0.00±0.00	0.18±0.02	0.00±0.00	0.09±0.01
4	0.31±0.06	0.34±0.11	0.57±0.11	0.31±0.08	0.41±0.07	0.31±0.08	0.46±0.01
5	1.21±0.08	1.14±0.15	1.91±0.11	1.02±0.05	2.28±0.19	1.20±0.02	1.65±0.10
6	0.61±0.07	0.26±0.01	0.34±0.07	0.32±0.06	0.22±0.02	0.43±0.04	0.31±0.04
7	40.48±0.39	4.71±2.71	40.23±1.27	2.98±0.44	33.34±1.83	3.63±0.09	6.11±0.32
Total	42.98±28.62	6.71±4.74	43.63±30.86	4.89±3.46	36.87±26.08	5.87±4.15	9.14±6.47

Fractionation of the Zn that is present in LA-EM

The mobile fractions were negligible in terms of mean concentration in the seven fractions; this was strictly followed by the exchangeable fraction. This denoted that the metal was not easily accessible to plants, Animals and so on. The Lalupon soil was majorly available at residual fraction and the amorphous iron oxide. A good proportion was present in the organic matter and the crystalline iron oxide. The laterites showed good adsorption strength in the 2 months of the 5% and the 2 months of the 20% (F5 and F6). The bonding of this metal to fraction 3-7 much more than the other two fractions was a positive development as against its presence in the exchangeable fraction. This implied that the metal would not be easily available to be redistributed in the water solution of the soil. Zn bounded the carbonate specie and therefore exhibited amphoteric nature which implies that it reacted with the carbonates in the soil as an acid and exists as carbonate bound species. However, a reduction in the acidity of the soil can lead to the release of this metal. The manganese oxide and oxides of iron were significant meaning that Zn was in a reducible form and only the microorganisms that are capable of reducing the Fe (III) to Fe (II) will cause the release of this metal. If this happened, Zn becomes mobile and bioavailable. The principle behind this speciation trend and preference for Fe/Mn bound specie are low polarization and high stability of Fe^{3+}.The 2 months of 5% showed that that laterite adsorbed better than the corresponding 3 months (F5 and F6). This similar trend was observed in the 10% as well. The crystalline iron oxide fraction of the 2 and 3 months showed that the metal was adsorbed on the iron and manganese hydroxide fractions.

Fractionation of the Pb that is present in LA-EM

The mobile fraction and the easily mobilizable fractions were high for the Lalupon soil but the exchangeable fraction was much more significant. The trend also cut across each incubation period. The organic matter content was very high for both Lalupon and all the speciation results. The iron oxide fractions and the manganese bound specie were low and the residual fraction was also very high for both Lalupon and the various results for incubation. This implies that at the polluted site the metal was in a redistribution trend. The low values observed for both Lalupon soil sample and the various speciation results for incubation suggest that this metal was available to metals probably as a result of the action of microorganisms (microbial decomposition, conversion of Fe^{3+} to Fe^{2+}, redox potential and so on) and the various management practices. This leads to the redistribution of the metal which is found in the exchangeable fraction than by the laterite sample. However, the higher value at the various residual fractions showed that stability since it was part of the silicate that was quite stable over time.

Fractionation of the Ni that is present in LA-EM

The distribution of Ni among the geochemical fractions was dominated by the residual fractions. The Lalupon soil had a total mean value of 42.98mg/kg. The 5% of the 2 months showed a total mean content of 6.33mg/kg and the three months contained a mean value (mg/kg) of 43.63. The 10% showed a total mean content of 4.89mg/kg for the 2 months and 36.87mg/kg for the 3 months. The 20% contained a total mean value of 5.87mg/kg for its 2 months and 9.14mg/kg for the three months. This showed that there were more Ni contents at each three months the respective two months. The mobile fractions of the 3 months of 5% and 10 % contained very little amount whereas there were no adsorptions in the other fractions. The exchangeable fractions were very low in all the speciation studies. The major contents were in the residual fractions and oxides of iron. The higher and quicker release of Ni at the residual fraction can be attributed to the metal complexation by soluble organic compounds (Gong and Donahoe, 1996).

Total metal concentration of the soil

The total metal concentrations of Zn, Pb, Ni, Mn and Cr in the polluted soil as well as the two laterite samples were determined by aqua regia and these cations were analyzed with AAS (Atomic Absorption spectrophotometry). The pseudo total metal concentration of the 5%, 10% and 20% incubation were calculated and the results were compared with the speciation results in table 12 (A) and 12 B above. The result obtained for the pseudo total metal was close to that obtained for the speciation result. The potential of laterite soils as an alternative binder was studied on a heavy metal polluted soil. This was done using variable proportions (5%, 10% and 20%) of the laterite for two and three months under incubation study with the polluted soil. The Zeinen and Brummer fractionation scheme was used in the environmental assessment of Pb, Zn, Cr, Mn and Ni in incubation analysis. The results obtained showed that manganese and Zinc bounded majorly to the residual fraction, iron oxide, amorphous oxide and manganese oxide fractions and they had the least mean content in the residual fraction. This signifies that the metal may have long term availability if changes in the soil chemistry and microbiology permit. The chromium and Nickel were bounded majorly to their residual fractions. This implies stability for them because they are part of the silicate that is quite stable over time. The lead (Pb) occurred more in the easily mobilizatible fraction than other fractions. This implies that the metal is in the redistributive phase and can penetrate the groundwater and find its way into the soil solution. The manganese and zinc held much more to the adsorptive phases of the laterite samples than Pb, Ni, and Cr.

Conclusion

The potential of laterite soils as an alternative binder was studied on a heavy metal polluted soils . this was done using variaable proportions (5%, 10% and 20%) of the laterite for two and three months under incubation study with the polluted soil. The Zeinen and Brummer fractionation scheme was used in the environmental assessment of Pb, Zn, Cr, Mn and Ni in incubation analysis. The results obtained showed that manganese and Zinc bounded majorly to the residual fraction, iron oxide, amorphous oxide and manganese oxide fractions. They had the least mean content in the residual fraction. This signifies that the metal may have long term availability if changes in the soil chemistry and microbiology permit. The chromium and Nickel were bounded majorly to the residual fractions. This implies stability for them because they are part of the silicate that is quite stable over time. The lead (Pb) occurred more in the easily mobilizable fraction than other fractions. This implies that the metal is in the redistribution phase and can penetrate the groundwater and find its way to the soil solution. The manganese and zinc held much more to the adsorptive phases of the laterite sample than Pb, Ni and Cr.

Table 12: Total metal concentration in incubated results: Comparison of total metal concentration and the sum of metal fractions as determined by Zein and Brummer (1989) for 3 months speciation scheme for the polluted site.

	5% LA-EM		5% LA-AB		10% LA-EM		10% LA-AB		20% LA-EM		20% LA-AB	
Heavy metal	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg))	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg)
Mn	26.83	28.70	22.06	22.85	11.66	12.93	28.17	28.96	29.56	31.43	25.95	26.74
Cr	8.69	9.81	8.07	8.88	6.08	7.20	3.41	4.22	7.72	7.84	10.51	11.32
Zn	27.76	28.03	3037.01	3037.37	29.88	30.15	29.13	29.49	29.76	30.23	25.26	25.62
Pb	7996.45	7996.90	7346.58	7347.39	7565.55	7566.00	7059.20	7060.01	8501.34	8503.17	6710.65	6711.66
Ni	6.71	6.71	5.65	5.65	4.89	4.89	5.98	5.98	5.87	5.87	9.92	9.92

Table 12: Comparison of total metal concentration and the sum of metal fractions as determined by Zein and Brummer (1989) for 2 months speciation scheme for the polluted site

	5% LA-EM		5% LA-AB		10% LA-EM		10% LA-AB		20% LA-EM		20% LA-AB	
Heavy metal	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg))	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg)	Total (mg/kg)	∑Fraction (mg/kg)
Mn	31.06	32.93	23.53	24.29	29.48	31.35	24.60	25.39	30.76	32.63	25.95	27.18
Cr	36.52	37.64	24.27	25.08	36.80	37.98	33.31	34.12	5.87	6.49	50.81	51.62
Zn	60.03	60.30	81.31	81.67	57.87	58.14	38.63	38.99	43.40	43.67	29.38	29.76
Pb	8796.00	8796.45	8912.64	8913.09	7611.43	7611.80	7727.25	7728.01	7085.40	7085.85	8030.53	8031.74
Ni	43.04	43.64	27.65	27.65	36.88	36.88	33.59	33.59	9.15	9.15	49.76	49.76

Pseudo- total metal was calculated as (∑fractions- total)

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