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Lead and cadmium poisoning of goats raised in cement kiln dust polluted area

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Abstract

The impact of cement kiln dust pollution on the environment was evaluated using the concentrations of heavy metals in the test and control sites as a guide. Clinical signs of toxicosis ranging from locomotor disturbances to complete posterior paralysis in goats raised in polluted area were observed. Soil lead (Pb) levels in test and control sites were 890±43.01 ppm and 105.75±3.76 ppm respectively and for contaminated soils fell within the range of toxic levels (500-1000 ppm). Pb concentrations in forages within the polluted area and the control were 420±153.9 ppm and 265.5±65.99 ppm respectively, and the Pb concentrations in soil and forages in polluted areas correlated positively. Cadmium (Cd) level in polluted soil was 28.75±6.57 ppm and in forages grown on the same soil 24.5±2.69 ppm. These figures for cadmium showed little clinical significance and are found below the toxic limit. The blood lead levels of goats in polluted and non-polluted areas were 0.511±0.12 ppm and 0.085±0.01 ppm respectively. This figure in polluted area is within the 0.35 ppm level regarded as diagnostic of heavy metal in toxication and only marginally different from the 0.4 ppm considered terminal. These results conclude that the cement kiln dust pollution is hazardous and is enough a reason for the relocation of the cement factory away from residential area if it becomes impossible to relocate man and animals.

***Key words**: Cement kiln dust, heavy metals, toxic, goats.*

Introduction

The manufacture of Portland and other cements has long been a primary part of the manufacturing sector in both developed and developing nation states. In Nigeria, the manufacture of cement and the use of cement in construction have been an integral part of the construction industry. Cement is used in industrial, commercial and infrastructural projects. To maintain quality control for cement products, the raw materials are pulverized to very fine discrete particle sizes and thoroughly mixed in controlled chemical proportions. The fuel burning to achieve the high temperatures combined with the fine particles of the raw materials results in the potential release of particulate matter which is defined as kiln dust. These dusts have been found a rich source of heavy metals[1]. The dust is emitted into the environment which now brings about considerable changes to the environment.The Food and Agricultural Organization (FAO/WHO) expert Committee on Food Additives established tolerable limits of Cd and Pb [2, 3]. The objective of this study was to provide baseline data on the levels of the contamination and thereby assess the impact of kiln dust from Shagamu cement production plant on animals in Sotubo village, Nigeria, located within 5 km radius of Shagamu Portland Cement Industry. This is with a view of considering possible implications of the heavy metal contamination traceable in the soil, forage, water and blood of goats owned by residents of the village.

Materials and Methods

Study site: The study site was Sotubo village, Shagamu, Nigeria, located within 5 km radius of the Shagamu Portland cement plant. Participatory rural appraisal methodology was used to extract information from livestock farmers resident in the village after which the specific site was chosen. The control site was the farm site of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria. The control site is about 75 km away from the test site.

Soil analysis: Samples of top soil were evaluated for heavy metal contamination as previously described [4]. Samples of top soil taken from different spots within the enclosed area where animals were kept were bulked to make four replicate samples per collection. The samples were crushed in ceramic mortar, passed through a 2 mm sieve and the fine soil fraction retained for chemical analysis. Samples of 10 g of each soil were weighed into a conical flask and 100 ml of 0.1 M ethylene diaminetetraacetic acid disodium solution (EDTA solution) added and the content shaken on a reciprocating mechanical shaker for 30 min. The solution was filtered through Whatman No. 1 filter paper and the filtrate analyzed on atomic absorption spectrophotometer (ASS) Perken Elmer Model 306 for lead and cadmium.

Forage analysis: Leaves were oven-dried at 80°C and the dried samples pulverized to fine powder in a SNA 505 (Peppink Deventer) laboratory stainless grinder for chemical analysis. Two grams sample of the ground leaves was ashed in a furnace for 5 hours at 600°C. The ashed sample was cooled to room temperature in a desiccator and dissolved in 5 ml volumetric flask. The solution was afterwards analyzed for lead and cadmium.

Water and blood analysis: Atomic absorption spectrophotometry[6] was used to determine the concentration of lead and cadmium in water samples. The evaluation of heavy metals in blood of goats as well as the evaluation of hemoglobin was according to standard procedure [7].

Results and Discussion

Seven goats in test location within 5 km radius of cement factory showed locomotor disturbances, ranging from a stiff gait which became apparent after lambs were driven for some distance, to complete posterior paralysis. These clinical signs were consistent with previous studies where swellings of the hock joint as well as lameness of the hindquarters characterize lead poisoning in horses, leading to eventual paralysis in the hindquarters [8]. Similarly, clinical picture in cadmium (Cd) toxicity follows the same course and hinges solely on locomotor deficiencies including staggering, disorientation, prostration and eventual death [9].

Hemoglobin concentration of goats exposed to cement kiln dust within the 5 km radius of the cement factory was 7.1±0.02 g/dl in contaminated environment and 8.26±0.09 g/dl in the control. This result in test goats raised in contaminated environment fell below the normal range of physiological values (normal 8.0-14.0) and compared with other reports where ingestion of lead (Pb) produced clinical anaemia with reduction in hemoglobin levels in blood. This reduction in Hb according to generally accepted hypothesis is because absorption of lead at excessive rates produced an inhibitory action on the mechanism for the synthesis of heme [10]. This inhibition mechanism arises mainly from inhibition of enzymes concerned with heme synthesis.

The mean lead levels in contaminated test soils (Group 1) was 890±43.01 ppm as against 105.75±3.76 ppm in the control (Group 2) study site (Table 1). This high level of Pb at the study site (890±43.01 ppm) fell within the range of Pb levels in other contaminated soils previously described (500-3,000 ppm) [11] and is significantly different (P<0.05) from Pb levels evaluated in control site not exposed to the contamination. Comparable sources of lead contamination in other studies include lead particles and chips from lead-based paints, automobile emissions from leaded fuel and in places where mining produces high quantity of waste in form of tailings deposited as top soil heaps on soil surface, thereby becoming a major source of heavy metal contamination [12]. However, the mean cadmium levels in the test and control sites were 28.75±6.57 and 21.75±2.94 ppm respectively (Table 1). These levels showed little definite implication and may be because involvement of Cd in heavy metal intoxication is marginal [13], even though atmospheric deposition as in this study has been implicated a major source of soil cadmium [14].

The mean lead concentrations in forage samples grown in contaminated and control sites were 420±153.94 and 265.5±65.99 ppm respectively (Table 2). This high Pb concentration seen in forages grown in contaminated soils fell within the toxic zone [4] and is significantly different (P<0.05) from that of the control. This high lead concentration of forages in contaminated soils is similar to those reported [15, 16] in outbreaks of Pb toxicosis. Previous works showed that Pb concentration of up to 800 ppm in pastures have been reported in paddocks 1.6 km away from smelters [17]. Cd levels in soil and forages also are positively correlated and this is because Cd in animal feeds are related to soil and fertilization practices where plant foods are grown [18, 19].

Table 1. Lead and cadmium concentration of soil samples in test (Group 1) and control (Group 2) study sites.

	Pb (ppm)		Cd (ppm)	
	Group 1	Group 2	Group 1	Group 2
	950	102	33	25
	840	104	29	23
	860	105	18	17
	910	112	35	22
Mean	890.00 [a]	105.75 [b]	28.75 [a]	21.75 [b]
SD	±43.01	±3.76	±6.57	±2.94

Values with different superscripts along each row differ (P<0.05).

Table 2. Lead and cadmium concentration of forage samples in test (Group 1) and control (Group 2) study sites.

	Pb (ppm)		Cd (ppm)	
	Group 1	Group 2	Group 1	Group 2
	390	205	26	9.8
	670	307	23	8.0
	250	352	21	15.3
	370	198	28	12.8
Mean	420 [a]	265.5 [b]	24.5 [a]	11.47 [b]
SD	±153.95	±65.99	±2.69	±2.80

Values with different superscripts along each row differ (P<0.05).

Table 3. Lead and cadmium concentration of water in test (Group 1) and control (Group 2) study sites.

	Pb (ppm)		Cd (ppm)	
	Group 1	Group 2	Group 1	Group 2
	0.043	0.050	0.012	0.007
	0.041	0.004	0.013	0.004
	0.065	0.044	0.015	0.007
Mean	0.049 [a]	0.032 [a]	0.013 [a]	0.006 [b]
SD	±0.01	±0.02	±0.0012	±0.0014

Values with different superscripts along each row differ (P<0.05).

Samples of water in test sites and the control study site away from atmospheric contaminants revealed Pb contents of 0.049±0.010 and 0.032±0.020 ppm and Cd contents of 0.013±0.001 and 0.006±0.0041 ppm in test and control sites respectively (Table 3). For Pb, the control and test sites were not significantly different (P>0.05). The Pb and Cd levels also fell below the allowable limits (0.05 ppm Pb). This may be because most of the water was running streams which carry the cement kiln dust deposits away to distant places.

The mean blood lead level in goats raised in contaminated environment was 0.511±0.12 ppm while it was 0.085±0.016 ppm in goats raised in the control environment (Table 4). There was a significant difference (P<0.05) between the mean blood levels in both groups. This level of 0.511±0.12 ppm with the attendant clinical signs of toxicosis is consistent with previous works where a terminal blood level was about 0.4 ppm in horses [13]. It has also been proven that in relation to clinical diagnoses of lead intoxication, blood lead levels in excess of 0.35 ppm are normally regarded to be of diagnostic significance [20]. Low Cd levels in the blood of goats in the test and control studies may be explained by similar works where there was low dietary uptake of Cd into blood in lactating dairy cows [21].

Table 4. Lead and cadmium concentration in blood of goats raised in test (Group 1) and control (Group 2) study sites.

	Pb (ppm)		Cd (ppm)	
	Group 1	Group 2	Group 1	Group 2
	0.56	0.102	0.021	0.022
	0.552	0.100	0.025	0.011
	0.300	0.063	0.022	0.007
	0.635	0.075	0.031	0.008
Mean	0.511 [a]	0.085 [b]	0.024 [a]	0.012 [b]
SD	±0.126	±0.0165	±0.0038	±0.0059

Values with different superscripts along each row differ ($P<0.05$).

Conclusions

The high levels of cement kiln dust contaminant in the air is traceable to the soil and the forages and therefore form the basis for the high blood Pb and Cd levels of animals within the cement factory area. This high level of heavy metals in the blood is the reason for the manifestation of clinical signs as well as clinical anaemia. Previous investigators have reported same result where mean concentration of lead in blood and urine in human correlated with the severity of the exposure to lead as indicated by the progressive increase in the lead contents of the surrounding air [22] and that the average concentration of lead in the blood provides a good information as to the biologically active lead burden [23, 24]. The production of clinical signs in animals within cement kiln dust polluted area may be seen as a high toxic index in humans and should form the basis for relocating the cement factory, if it becomes impossible to evacuate man and animals within the axis of the cement factory [25].

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