

Effect of cement kiln dust exposure on haematological and liver function parameters of sheep raised around sokoto cement factory

Abstract

The effect of cement dust kiln was assessed using haematology and liver function of sheep in the test and control sites. The concentration of heavy metals in blood and water samples were also evaluated. A total of twenty one sheep were sampled for this study, comprising of 7 each for the 3 sites studied. GB and KK sites were situated about 200m and 800m away from the factory respectively, while CS site was an unpolluted environment (5km away) from the factory. Haematology results revealed a significantly lower ($P < 0.05$) haemoglobin concentration, RBC counts, and packed cell volume of sheep raised in the study sites compared to the control site. Blood lead concentrations for sheep raised in the polluted area (GB and KK) and CS were 0.0344 ± 0.1671 ppm, 0.01367 ± 0.00775 ppm, and 0.01085 ± 0.00586 ppm respectively which fall within the allowable range for lead in ruminants though higher in the polluted sites. Blood cadmium concentrations of sheep raised in the test site (GB and KK) and the control site were 0.000305 ± 0.0003323 ppm, 0.000671 ± 0.0008613 ppm, and 0.00046 ± 0.0001131 ppm respectively which also fell below the toxic limit in animals. The liver function parameters varied insignificantly ($P > 0.05$) between the exposed sheep compared to the unexposed sheep in the control site. Lead and cadmium concentrations of water in the exposed sites (GB and KK) and control site fell below the allowable limits of lead and cadmium in water (0.05 ppm). From this study it is concluded that exposure to cement kiln dust had an effect on hematology as well as liver function parameters of sheep raised in settlements around the cement factory compared to those raised in clean unpolluted areas.

Volume 4 Issue 5 - 2018

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Received: May 22, 2018 | **Published:** October 04, 2018

Introduction

With increased industrialization and the need to produce finished products to keep up with global trend, many pollutants are dispersed into the environment. Cement is a very important material in the construction of houses and infrastructure which is key to economic growth.¹ In cement factories, combustion of fuel to achieve high temperatures combined with the release of particles of raw materials leads to production of kiln dust which is rich in heavy metals. This dust emitted brings about considerable environmental pollution with potential health effects on humans and animals within that area. This exposes both human and animal populations around the area on daily basis to low levels of environmental contaminants. The spread of emissions and waste from cement factories have been reported to have deleterious health effects.^{2,3} In the present study, we hypothesized that sheep raised around or in areas close to cements factories are exposed to cement kiln dust and these have deleterious effect on hematology and liver function. This study was carried out on sheep raised in areas around Sokoto Cement Factory, Sokoto Nigeria.

Materials and methods

Experimental site

Gidan Bailu (GB) and Kiraki (KK) were the two studied sites are located about 200meters and 800meters away from Sokoto cement factory (SCF) respectively. A farm in Arkilla quarters located about 5 kilometers away from SCF was taken as control site (CS). Sokoto cement factory is situated in Wamakko Local Government Area of

Sokoto State. The state is located in the North-western zone of Nigeria and lies between latitude 12.5°S and longitude 5.2° E. It has the land area of approximately 56,000 square kilometers. It is bordered in the north by Niger Republic, Zamfara to the East and Kebbi state to the south west.⁴

Experimental animals and design

A total of 21 sheep were used for the experiment. Seven each were sampled from the three sites. They were managed semi intensively, allowed to graze around the factory during the day while provided with feed and water when returned in the evening.

Blood sample collection

8 mL of blood was collected from the animals via jugular venopuncture using a sterile 10 mL syringe. 2ml was transferred into labelled sterile bottles containing ethylene diaminetetraacetic acid (EDTA) for the determination of haematological parameters while the remaining 6 ml for serum analysis were transferred into plain bottles and transported on ice to Clinical Pathology Laboratory, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto (UDUS). The coagulated blood samples were then immediately centrifuged at 2000g for 10 minutes and supernatant sera were harvested and stored at 4°C until used. The blood and sera samples were labeled accordingly.

Haematological indices

The haematological indices evaluated were packed cell volume

(PCV), haemoglobin concentration (Hb), red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), total white blood cell count (WBC), and differential WBC count. The PCV was determined using the microhaematocrit method. The microhaematocrit method is Blood was allowed into the microhematocrit tube by capillary action was centrifuged at 12000g for 5 min. After centrifugation, the proportion of cells to the whole column (i.e. the PCV) was measured using a reading device (Hawksley® micro-haematocrit reader).The Hb was determined according to Lewis SM.⁵ The RBC, WBC and differential WBC counts were determined using the Neubauer haemocytometer after appropriate dilution and the MCHC, MCH, MCV were calculated from PCV, Hb and RBC values as described by Lewis SM.⁵

Liver function test

The liver function parameters evaluated were total protein, total and conjugated bilirubin, albumin, alanine transaminase (ALT), aspartate transaminase (AST), and alkaline phosphatase (ALP). 2 ml of each serum samples were used for the liver function test. The activity of the liver enzymes were determined using a spectrophotometer at a wavelength of 540nm.

Heavy metals determination

Cadmium (Cd) and Lead (Pb) were the heavy metals determined. 2ml of each serum samples were digested by adding 3ml of 60% HNO₃ and 1 ml of 35% H₂O₂ to the sample in a digestion tube. Digestion tubes with contents were covered and put in microwave oven for extraction. The microwave unit was calibrated to a temperature of 200°C and digestion was allowed for 25 minutes. The digested samples were analyzed for the presence of Cd and Pb at wavelengths 228.8nm and 283.3nm respectively. An Atomic Absorption Spectrophotometer type AA-6300 with ROM version of 1.09 with a deuterium background collector and a Xenom lamp as radiation source was used in the determination of the above trace metals. The actual concentration of Cd and Pb from each samples were calculated using the formular:

$$\text{Actual concentration} = \text{Concentration/Dilution factor (1/5)}$$

Atomic absorption spectrophotometry was used to determine the concentration of lead and cadmium in the water samples. This analysis was carried out at the Energy Research Laboratory, Usmanu Danfodiyo University, Sokoto.

Water sample collection

18 ml of water sample were collected from the study area, 6ml from each study sites (GB, KK and CS). Within each study area, 3ml each were collected from two different locations. The samples were stored in a sterile bottles, labelled and transported to the laboratory for analysis to detect the presence of heavy metals by Atomic Absorption Spectrophotometry.

Statistical analysis

Data obtained from this experiment were expressed as mean±SEM. One way analysis of variance, followed by Tukey's post hoc test was used to compare the mean haematological, liver function and heavy metal values between the 3 study sites P<0.05 was considered significant.

Results

Haematological analysis

Table 1 showed the mean erythrocytes indices of sheep raised in the 3 sites studied. The PCV, RBC and Hb of sheep from the CS were significantly higher than those from GB and KK sites. MCH of the sheep from CS was significantly lower than those from GB and KK sites while no statistical difference was observed with MCHC of the sheep raised in the three sites. Also no significant difference in PCV, RBC, Hb and MCH were observed between the sheep raised in GB and KK sites. The MCV of sheep from CS was lower when compared to GB and KK sites with KK value been significantly higher than GB and CS values respectively. Table 2 showed the mean total and differential WBC count of sheep raised in the 3 sites studied. The total WBC count of the sheep from CS was significantly higher than those raised in GB and KK sites. However, no significant difference was observed between the sheep raised in GB and KK sites. The mean differential WBC counts had no significant (P > 0.05) difference for sheep raised in the 3 sites.

Table 1 Mean erythrocyte indices of sheep raised from the three studied sites (n=7)

| Erythrocyte Indices | GB | KK | CS |
|----------------------------|-------------------------|--------------------------|-------------------------|
| PCV (%) | 26.43±2.23 ^a | 23.57 ±2.64 ^a | 34.86±3.44 ^b |
| RBC (×10 ⁶ /μl) | 8.73±1.69 ^a | 7.00±0.97 ^a | 13.4±0.89 ^b |
| Hb (g/dl) | 8.64±1.02 ^a | 7.37±0.90 ^a | 11.2±1.20 ^b |
| MCHC g/l | 30.26±1.3 ^a | 30.08 ±1.7 ^a | 30.20±0.7 ^a |
| MCV (fl) | 31.0±3.42 ^a | 33.78 ±1.68 ^b | 26.05±0.95 ^c |
| MCH (Pg) | 10.0±0.78 ^a | 10.43 ±0.90 ^a | 8.37±0.37 ^b |

Mean ±SEM on the same row with different superscripts are significantly different (P < 0.05)

Table 2 Mean total and differential WBC values of sheep raised from the three studied sites (n=7)

| WBC parameters | GB | KK | CS |
|------------------------|-------------------------|--------------------------|-------------------------|
| WBC×10 ³ /l | 9.31±2.94 ^a | 7.63±1.47 ^a | 11.8±2.8 ^b |
| Neutrophils | 55.43±10. ^a | 51.71±14.3 ^a | 48.43±9.34 ^a |
| Eosinophils | 0.86±0.9 ^a | 0.43±0.79 ^a | 0.43±0.53 ^a |
| Lymphocyte | 42.20±11.1 ^a | 40.57±14.68 ^a | 49.43±10.2 ^a |
| Monocyte | 1.43±1.27 ^a | 1.00±0.00 ^a | 1.57±0.79 ^a |

Mean ± SEM on the same row with different superscripts are significantly different (P < 0.05)

Liver function parameters

The liver function parameters for the sheep raised in the three sites were shown in Table 3. There was no statistically significant difference in total protein, albumin, conjugated bilirubin, ALT and ALP of sheep raised in the three sites. Although sheep from KK site have higher values for all the parameters evaluated. The total bilirubin and AST of sheep raised in KK site were significantly higher than sheep from GB and CS.

Table 3 Mean liver function parameters for sheep raised in the three sites (n=7)

| Liver function parameters | GB | KK | CS |
|------------------------------|-------------------------|-------------------------|-------------------------|
| Total bilirubin (mg/dl) | 0.428±0.12 ^a | 1.100±0.44 ^b | 0.345±0.12 ^a |
| Conjugated bilirubin (mg/dl) | 0.04±0.00 ^a | 0.11±0.07 ^a | 0.04±0.00 ^a |
| Total protein (g/dl) | 6.28 ±0.35 ^a | 6.14±0.39 ^a | 6.28±0.42 ^a |
| Albumin (g/dl) | 2.83±0.36 ^a | 3.14±0.25 ^a | 2.9±0.13 ^a |
| AST (U/l) | 14.8±6.26 ^a | 26.4±5.64 ^b | 18.0±3.74 ^a |
| ALT (U/l) | 7.60±4.1 ^a | 11.20±1.10 ^a | 8.80±1.1 ^a |
| ALP (U/l) | 22.0±18.7 ^a | 36.4±13.9 ^a | 12.6±5.72 ^a |

Mean ± SEM on the same row with different superscripts are significantly different (P < 0.05)

Heavy metals screening

Table 4 showed the results for the Cd and Pb level in blood of

Table 5 Heavy metal concentration in water sampled at the three study sites (n=7)

| Heavy metals (ppm) | GB | KK | CS |
|--------------------|---------------------------------|---------------------------------|--------------------------------|
| Pd | 0.04029±0.001937 ^a | 0.01396±0.007071 ^a | 0.00761±0.009631 ^b |
| Cd | 0.000305±0.0003323 ^a | 0.000671±0.0008613 ^a | 0.00046±0.0001131 ^a |

Mean ± SEM on the same row with different superscripts are significantly different (P < 0.05)

Discussion

The decrease in PCV, RBC and Hb of sheeps in the GB and KK sites suggests that cement dust may have a harmful effect on the hematopoietic system. The decrease seen in the PCV, Hb and PCV of sheep in GB and KK sites fall below the normal range of physiological values and is suggestive of anaemia.⁶ The present findings on haematological parameters are in agreement with Jude et al.⁷ where a fall in PCV, RBC and Hb concentration in cement factory workers. This decrease in RBC count seen in sheep in GB and KK sites may be as a result of reaction of the cells with toxic substances.⁸ The MCHC was insignificantly lower in all the three study sites. However, the decrease in MCHC though insignificant in this study may be attributed to impairment of heme biosynthesis in bone marrow causing a fall in hemoglobin concentration. The rise in neutrophils in sheeps from GB and KK sites may suggest a response to toxic effect of cement dust or irritants⁹. Mojiminiyiet al.² and Yahaya et al.¹⁰ reported an increase in neutrophil counts in cement factory workers exposed to cement kiln dust. However, Jude et al⁷ stated that neutrophils counts did not reveal any statistically significant alteration between test and control groups. Findings from the present study revealed that cement kiln dust had no significant effect on liver function parameters in sheep raised in the exposed and control site. The levels of AST,ALT and ALP observed in GB, KK and CS are still within the normal range of the liver enzymes in circulation (AST 49-123 U/l, ALT, 16-44 U/l and ALP, 27-156 U/l)¹¹ and hence are not indicative of liver impairment. This may be because sheep raised around the cement factory are not kept for a very long period of time as they are disposed during festivities while replacing with others. Also the liver

sheep raised in the 3 sites studied. Pb level in sheep raised in CS and KK sites were significantly lower than the sheep in GB site. Although no significant difference was observed between the sheep raised in KK and CS. however, the Pb level in sheep raised in KK site was higher than those in CS. Cd level in sheep raised in CS was significantly lower than the sheep in GB and KK sites. Although no significant difference was observed between the sheep raised in GB and KK sites. However, the Cd level in sheep raised in GB site was higher than those in KK site (Table 5).

Table 4 Mean heavy metal concentration in blood from sheep raised in the three studied sites (n=7)

| Heavy metals (ppm) | GB | KK | CS |
|--------------------|---------------------------------|------------------------------|---------------------------------|
| Pd | 0.0344±0.1671 ^a | 0.01367±0.00775 ^b | 0.01085±0.00586 ^b |
| Cd | 0.0006029±0.000382 ^a | 0.0004±0.00022 ^a | 0.002029±0.0001572 ^b |

Mean ± SEM on the same row with different superscripts are significantly different (P < 0.05)

has a high functional reserve capacity and only shows dysfunction when about 50% of the hepatocytes are affected. Contrary to the findings from this study, elevated serum levels of AST, ALT, and ALP above normal ranges have been reported in cement workers by this may be attributable to the fact that these factory workers had a closer exposure to the cement kiln dust. The concentration of lead in blood of ruminants, pigs and horses considered normal is 0.05 to 0.25ppm.¹² The Pb in KK and control sites were not significantly different though higher in GB. This variation in blood concentration of lead is probably due to differences in amount and sizes of particles of lead absorbed.¹³ This result agrees with the findings of Ade-Ademilua and Obalola³, and Gbadebo and Bankole¹⁴, where it was stated that high Cadmium and Lead concentrations in air borne particles around West African Portland Cement Factory, Sagamu, Ogun state, Nigeria. Also Yang¹⁵ stated that an area within 0-2km of a cement factory is a high danger zone. Increased serum lead and cadmium levels were observed in cement factory workers and residents living near cement factory when compared to unexposed controls.¹⁶ The difference may be due to duration and route of exposure since people who live around the factory are exposed for a longer time and also the concentration of substances exposed to. Both Pb and Cd levels in the water sampled at the three study sites fell below the allowable limits (0.05ppm). This may be because most of the water the animals drink in the control sites is tap water sourced from the same water treatment plant about 5km away from the factory, and the open water in the GB and KK sites were running streams which may likely carry the cement kiln dust deposits away to distant places with little amount dissolved in the streams.

Conclusion

The present data showed that exposure of sheep to cement kiln dust has negative effect on haemopoetic system with no significant effect on the differential white blood cells count and liver function parameters. However, care should be taken in locating animals too close to a cement factory site though they may not be in the critical area but inhalation of dust particles in those areas may lead to deleterious health effects over time.

Acknowledgments

None.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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