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RELATIONSHIP BETWEEN CERTAIN BODY ELECTROLYTES AND LEAD TOXICITY IN EXPOSED CATTLE

(With 10 Tables)

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(Received at 28/1/1992)

مستويات الرصاص في البيئة الصغرى للماشية في محافظة أسيوط

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نتيجة التعرض المزمن للملوثات البيئية وخاصة أبخرة الرصاص والذي تضاعف بثها من حولنا مئات المرات نظرا لتزايد وسائل المواصلات والتي تنفث فينا عوادمها لذلك أجري هذا البحث هادفا إلى دراسة مدى التأثيرات السامة للرصاص على الأبقار والوقوف على معدلاته في أجسامها وبالتحديد دم وبول هذه الحيوانات بالإضافة إلى نسبته في الأنسجة الرخوة (رئة ـ كلية ـ كبد ـ مخ ـ عضلات ـ قلب) والنسيج العظمي (الضلوع) وذلك لتحديد مستويات الرصاص والعناصر المرتبطة بها (الحديد ـ النحاس ـ الكالسيوم ـ الفسفور الغير عضوي ـ الصوديوم والبوتاسيوم) وقد بلغ عدد الحيوانات المستخدمة خمسون حيوانا تم تقسيمها إلى أربع مجموعات حسب الأعمار وأظهرت النتائج إرتفاع معدل الرصاص في الدم والأنسجة الأخرى في الأعمار ٩٦ ـ ١٢٠ شهر عن مثيلاتها في الأعمار الأصغر · أظهر العظم أعلى تركيز للرصاص به حتى وصل إلى ١٨٫٥٦ جزء في المليون · وإتضح من هذه الدراسة تزايد معدلات الرصاص مما يشكل خطورة على صحة الكائن الحي وكذلك وجود علاقة سلبية بين زيادة الرصاص في الأنسجة وما يترتب عليه من نقص في العناصر الأساسية الأخرى ·

SUMMARY

The study was carried out on fifty cows. Lead levels were estimated in urine and different tissues (blood, lung, kidney, liver, brain, muscles, heart and bone). Other related elements to lead (iron, copper, calcium, phosphorus, sodium and potassium) were estimated in both animal tissues and urine.

The results indicated a significant increase in lead content of cattle aging 96-120 months in comparison with the other three younger groups. A significant correlation between lead and all investigated elements was recorded in all examined tissues and urine.

INTRODUCTION

Lead is one of the oldest metals known to mankinds, as evidenced by discoveries of artifacts made from lead that date back to some 3000 years B.C. (BIDDLE, 1982).

Under normal environmental conditions, lead in blood of calves, goats and sheep remains rather constant at 0.1 to 0.13 ppm. Contents greater than 0.4 ppm and its appearance in faeces are good indication of recent high lead exposure (ALLCROFT, 1950).

Lead distribution in tissues is dependent on administration route and chemical form (National Academy of Sciences, 1972). Skeletal lead may be mobilized during along stress times as physical injury performing in sudden restriction of activity which causes decalcification of bone releasing stored lead. Neurogenic stress may also facilitate release of lead from bone (BUSCHNELL, et al. 1979).

The concentration of lead found in the various tissues depends considerably on route of enter, inhalation of lead dust or fumes results in relatively high concentration in the blood and tissues within a few hours or days, while oral ingestion of larger amounts over longer periods may give only low concentrations. The largest amount is found in the bone and the smaller amounts are found in the liver, kidney and the smallest amounts are found in heart, lungs, muscles and brain (ALLCROFT, 1951). The tissue distribution of lead depends on the mode of administration and chemical form of the poison. After acute oral administration to cows and calves the highest lead concentrations were found in the liver, kidney, spleen, bones, bone marrow, testes, heart and skeletal muscle. After intravenous administration, lead is accumulated mainly in the reticuloendothelial system, bone marrow, spleen and liver. In chronic poisoning the kidneys usually contain more lead than the liver. However, in general the bones store most of the lead that causes chronic poisoning (BARTIK and PISKAC, 1981).

MATERIAL and METHODS

A total number of fifty Egyptian cattle were investigated in this study. All animals were subjected to clinical examination to detect any toxic manifestation before slaughter in Assiut abattoir. Aging of the investigated animals is adopted using dental formula and then devided to four groups according to its age and sex. Tissue samples (lung, kidney, liver, brain, muscles, heart and bone), blood and urine were collected from all examined animals and chemically analysed for determination of lead, iron, copper, calcium, inorganic phosphorus, sodium and potassium.

Lead concentration was estimated using lead electrode model 94-82, according to the method of CAMPIGLIO (1979), which attached to expandable ion analyzer EA 920, Orion research.

Calcium and inorganic phosphorus were determined according to the methods of GINDLER and KING (1972) and VOGLER (1965) respectively.

The determination of sodium and potassium was carried out after BAUER, et al. (1974) using flame photometer (Courning 400).

Iron and copper were determined after the method of TRINDER (1956) and GUBLER, et al. (1952).

The data obtained was statistically analysed, according to KALTON (1967). Multiple correlation was made by programing system according to (PC. Stat., 1985, the University of Georgia, Athens, Georgia) in computer center of Assiut University.

RESULTS

The investigated cattle showed no clinical signs of lead intoxication.

The levels of lead and related elements in cattle's blood, urine, lung, kidney, liver, brain, muscle, heart and bone were recorded in table 1-9. Correlation of lead with other elements (iron, copper, calcium, phosphorus, sodium and potassium), in all tissues of investigated cattle was recorded in table 10.

DISCUSSION

The analytical results of investigated cattle urine and tissues (Blood, lung, kidney, liver, brain, muscles, heart and ribs) revealed a direct relationship between lead levels and age of examined animals. The results of the present study revealed that lead levels significantly increased with the increased age of investigated animals.

The recorded levels of blood lead were 0.168, 0.202, 2.231 and 0.275 ppm for cattle in group 1, 2, 3 and 4 respectively. Normal blood levels of lead in goats, sheep, horses, cows and young calves was quoted by CLARK, et al. (1981) to be ranged from 0.05 to 0.25 ppm, also the same range was given by ALLCROFT (1951). Under normal enivironmental conditions, lead in blood of calves, goats and sheep remains rather constant at 0.1 to 0.13 ppm. Contents greater than 0.4 ppm are good signs of recent high lead exposure (ALLCROFT, 1950). Lead levels in blood of apparently healthy ruminants were 0.05 to 0.25 ppm but in poisoned ruminants more than 0.35 ppm (BUCK, 1975). MILHAUD and MEHENNAOUI (1988) reported that the blood lead level of cattles reared in uncontaminated area was 0.034 ± 0.01 ppm while in the blood of cattle reared in contaminated area was 0.343 ± 0.120 ppm, 0.531 ± 0.19 ppm and 0.564 ± 0.4 ppm.

Our results indicated a slignt rise above the previously recorded normal levels in groups 3 and 4. Hence the diagnostic significance of lead determination in the blood of ruminants is of low value (BARTIK and PISKAC, 1981).

Levels of lead in cattle's urine are reliable and never higher than 0.2 to 0.3 ppm also elevated urine levels are usually associated with elevated blood lead levels. This relationship does not necessarly hold (BLOOD, et al. 1983). The recorded urine levels of lead in our rescarch were 0.073, 0.085, 0.096 and 0.099 ppm for groups 1, 2, 3 and 4 respectively. DONAWICK (1966) recorded a lead level of non poisoned cow urine as 0.03 to 0.04 ppm. The values of lead in urine obtained in our results are considered under the acceptable category according to STOKIGNER (1981) who reported that the urinary lead levels of different categories were 0.08 ppm as normal, 0.08 to 0.15 ppm as acceptable, 0.15 to 0.25 ppm as excessive and more than 0.25 ppm as a dangerous level of lead in urine.

A significant increase in lung lead levels were recorded in relation to the advancing age of investigated cattle. The highest recorded level was reached as 5.918 ppm in group 4. The available literature ignore the lung as lead target tissue in animals. ADAUDI, et al. (1990) found that the lead of lung of Vulture was 0.120 ppm D.M. The high lead level recorded in our results may be attributed to the long exposure of cattle in group 4 (96-120 months) to polluted air as a considerable amounts of lead have been mobilize into the environment, industrial smelters, burning of garbage, petrol additives are the main sources of environemental lead.

The analytical results of lead in the kidney of cattle revealed that the highest level 4.912 ppm was recorded in group 4. Our results were higher than those obtained by CRAWFORD and CRAWFORD (1969) as 0.27 to 1.7 ppm in kidneys of healthy cows. KREUZER, et al. (1979) study the effect of pollution by lead in industrial areas, they found lead levels of 2.69 ppm and 1.83 ppm in slaughtered cattle kidneys. In contaminated areas lead levels in the liver of cows was recorded as 1.12 ppm (KREUZER, et al. 1979).

FORSCHNER and WOLF (1979) found that lead levels in liver of cattle less than 2 years was 0.393 ppm while in cattle more than 2 years was 0.305 ppm. Oppositley our results revealed that lead levels in cattle's liver were significantly increased with advancing age. The only posssibie explanation is the exposure of investigated animals to contaminated environment as the highest level (3.762 ppm) was recorded in cattle of group 4.

The results of lead levels in cattle brain revealed a significant increase of lead in group 4. The highest level recorded was 2.215 ppm. In spite of the knowldge that brain is one of the most predilection seat of lead, no available literature concerning lead levels in the brain of animals. The only available data was that recorded by CRAWFORD and CRAWFORD (1967) as 0.1-0.9 ppm in healthy human and 1.1-2.4 in lead intoxicated human.

The analytical results revealed that myofibrils lead levels were 0.234 ppm, 0.262 ppm, 0.412 pm and 0.585 ppm of cattle in groups 1,2,3 and 4 respectively. A lower levels were recorded by FORSCHNER and WOLF (1979) who found that lead levels in muscles were 0.034 ppm in cattle aging less than 2 years and 0.046 ppm in age of more than 2 years. In contaminated area the levels were recorded as 0.31 ppm (RUTTNER and JARC, 1979).

Our results of heart analysis showed that lead levels was ranged between 0.4-0.586 ppm. Concerning the absence of literature on lead in animal heart, the results indicated a significant increase in lead with the advancing age of examined animals. The only data on lead levels in heart was recorded by ADAUDI, et al. (1990) who found that the Vulture heart muscles contained a higher lead content 0.610 ppm and in pigeon in city area was 0.386 ppm and in rural area was 0.5 ppm.

Lead content in the bone of healthy cow was 3.6 ppm (CRAWFORD and CRAWFORD, 1969). A higher levels of lead were recorded in our investigation as 8.135, 9.9, 13.71 and 13.65 for the cattle of group 1,2,3 and 4 respectively. A recorded levels of intoxicated cow were 8-16 ppm (CRAWFORD and CRAWFORD, 1969) and 51.5 ppm (MILHAUD and MEHENNAOUI, 1988) also they found samples of cattle bone of 1 ppm.

From the previous results a significnat increase in lead levels were recorded in all studied tissues directly related to age, is a subsequent indication of continous exposure of cattle to lead. The concentration increase at high lead intakes in all tissues especially in the bones, liver, kidney and hair was reported by (KOPITA, et al. 1967).

The analytical results of elemental correlation between lead and other elements revealed a positive correlation between lead and iron in all investigated tissues and urine, this fact was insured by FRANGENBERG (1986) who found a positive correlation between lead and iron in muscles, liver, and kidney of calves either healthy or diseased, also the same result was obtained by SELL (1987) in liver, kidney and muscles of calves. Lead inhibits-Amino levulinic aicd dehydratase enzyme of the haem synthesis pathway which is a zinc dependent enzyme, so that inhibition of this enzyme by lead, leads to accumulation of iron in blood and other tissues (FINNELLI, et al. 1975).

A negative correlation was recorded in our results between lead and other elements (copper, calcium, phosphorus, sodium and potassium). A positive correlation between lead and copper was observed by FRANGENBERG (1986) and SELL (1987) in liver, kidney and muscles of healthy calfs. On the other hand this correlation was only negative in the liver of calves suffer from deficienty diseases.

The negative correlation between lead and calcium which recorded in our results may be explained by the observation of SOBEL, et al. (1940) who found that lead might have adverse effects on the formations of 1,25 dihydroxychole calciferol by renal tubular cells and thus cause a decreased intestinal absorption of calcium. This suggestion is supported by the known injurious effect of lead on the proximal renal tubular cells (GOYER and RAYNE, 1973). The results showed a negative correlation between lead and both sodium and potassium in all examined tissues but a positive correlation was recorded in urine, these results attributed to the interfere of lead with sodium reabsorption by the kidneys (GOYER and RAYNE, 1973) and impairing the energy dependent mechanism of red blood cells for controlling sodium and potassium exchange (ANGLE and MCINTIRE, 1974).

The findings of low lead levels in blood and high lead content in all examined tissues recorded in our results were clarified by CARSON, et al. (1973) who stated that no clinical symptome was noticed in spite of the increase of lead blood levels from 0.064-0.32 ppm in sheep dosed 4.5 mg/kg ration for twenty seven weeks. Also, MILHAUD, et al. (1978) reported that lead blood levels of 0.4 ppm with a reduction of ALA-D activity, induce subacute intersitital nephritis, in spite of no obvious clinical symptoms, after exposure to lead by 10 mg/kg body weight daily for 5 months in young calves. This recorde also explained by the higher levels of excreted elements (copper, calcium, iron, sodium and potassium) in urine of investigated cattle.

In conclusion, the high levels of lead estimated in cattle tissues especially lung, liver, kidney and muscles in addition to other environmental sources of lead (air, water and plants) constitute hazards to human consumers in Assiut Governorate. Moreover, the effect on consumer may contribute through disturbing the levels of essential elements (calcium, phosphorus, sodium and potassium) in vital foods like meat and meat products.

REFERENCES

Adaudi, A.O.; Gbodi, T.A. and Aliu, Y.O. (1990): The lead content of plant and animals as indicators of environmental contamination. Vet. Hum. Toxicol., 32: 454-458.

Allcroft, R. (1950): Lead as anutritional hazard to farm livestock IV. Distribution of lead in the tissues of bovine after ingestion of various lead compounds. J. Comp. Pathol., 60: 190-208.

Allcroft, R. (1951): Lead poisoning in cattle and sheep. Vet. Record No. 37, Vol. 63: 583-590.

Angle, C. and mcIntire, M.C. (1974): Red cell lead, whole blood lead and red cell enzymes. Environ. Health. perspect., 7: 133-137.

Bartik, M. and Piskac, A. (1981): Poisoning by lead and its compounds in veterinary toxicology. Elsevier scientific publishing company, Amsterdam, oxford, New York, p. 108-118.

Bauer, J.D.; Ackermann, P.G. and Toro, G. (1974): Clinical laboratory methods. Saint Louis C.V. Mosby Co., 8th ed.

Biddle, G.N. (1982): Toxicology of lead primer for Analytical chemists. J. Assoc. of Anal. Chem., Vol. 65, No. 4: p. 947.

Blood, D.C.; Radostits, O.M. and Henderson, J.A. (1983): Diseases caused by chemical agents in veterinary medicine. 6th ed. the English language Book Society and Bailliere Tindall. p. 1091-1098.

Buck, W.B. (1975): Toxic. materials and neurologic disease in cattle. J. Am. Vet. Med. Ass., 156: 72-78.

Buschnell, P.J.; Shelton, S.E. and Bowman, R.E. (1979): Effects of confinement stress on blood lead concentration in young monkeys. Bull. Env. Cont. Toxicol., 22: 819-826.

Campiglio, A. (1979): Potentiometric microdetermination of lead (II) with the ion selective lead electrode and its application of organic lead compainds. Mikrochim. Acta, 1: p. 267.

Carson, T.L.; Van Gelder, G.A.; Buck, W.B.; Hoffman, L.J.; Mick, D.L. and Long, K.R. (1973): Effects of low level lead ingestion in sheep. Clin. Toxicol., 6: 389-403.

Clarke, M.L.; Harvey, D.G. and Humphreys, D.J. (1981): Veterinary toxicology. 2nd ed. Bailliere Tindall. p. 55-59.

Crawford, M.D. and Crawford, T. (1969): Lead content of bones in a soft and hard water area. Lancet, 1: p. 699.

Donawick, W.J. (1966): Chronic lead poisoning in a cow. J.A.V.M.A., Vol. 148, No. 6: 655-661.

Finnelli, V.N.; Klauder, D.S.; Karaffa, M.A. and petering, H.G. (1975): Effect of lead on some elemental content in animals. Biochem Biophys. Res. Commun., 65: 303-311.

Forschner, E. and Wolf, H.O. (1979): Fremdstoffuntersuchungen an gezieltin proben Monitoring in Rahmen des verbraucherschutzes fleischwirtsch, 59: 872-878.

Frangenberg, J. (1986): Untersuchungen uber schwermetallgehalte (cd, pb, zn, cu, fe und ca) in fleisch und organen von erkrankten Kalbern. inaugural-Dissertation. Zur Erlangung des Doktorgrades beim fachbereich veterinarmedizin der Justus-Liebig-Universitat GieBen.

Gindler, E.M. and King, J.D. (1972): Rapid colourimetric determination of calcium in biological fluid with thymol blue. Am. J. Clin. Pathol., 58: 376.

Goyer, R.A. and Rayne, B.C. (1973): Pathological effects of lead. Int. Rev. Exp. Pathol., 12: 1-77.

Gubler, C.J.; Lahey, M.E.; Helen, A; Cartwright, G.E. and Wintrope, M.M. (1952): "Studies on copper metabolism". A- Method for the determination of copper in whole blood R.B.Cs. and plasma. J. Biol. Chem., 196: 209.

Kalton, G. (1967): In "Introduction to statistical ideas from social socientists. 2nd Ed. Acad. prèss (London).

Kopita, L.; Byers, R.K. and Shwachman, H.N. (1967): Lead in hair of childern with chronic lead poisoning. N. Engl. J. Med., 276: 949.

Kreuzer, W.; Bunzl, K. und Krache, W. (1979): Untersuchungen uber den Blei und cadmiumgehalt in fleisch und organen von schlachtrindern. 2. Rinder aus einem bleischussigen Gebiet fleischwirtsch., 59: 1529-1542.

Milhaud, G.E. and Mehennaoui, S. (1988): Indicators of lead, zinc and cadmium exposure in cattle. 1. Results in a polluted area. Vet. Hum. Toxicol., 30 (6): 513-517.

Milhaud, G.; Mialot, M.; Pinault, L. und Parodi, A.L. (1978): Evaluation experimentale de la toxicite due plomb pour less bovins. Rec. Med. Vet., 154: 943-949.

National Acedemy of Sciences. (1972): Lead. Air borne lead in perspective. committee on biologic effects of atmospheric pollutants. Division of medical sciences, National research council, Natl. Acad. Sci., Washington, D.C.

Ruttner, O. and Jarc, H. (1979): Ruckstandsuntersuchungen in osterreich. 1- Mitteilung: untersuchungen uber Beli-, Cadmium and chromgehalt in Rindfleisch aus oberosterreich wien. Tieraztl. Mschr. 66: 259-262.

Sell, D. (1987): Untersuchungen uber die Gehalt und wechselbeziehungen von cadmium, Blei, Eisen, kupher, zink und calcium in leber bzw. Niere oder Muskulatur bei kalbern. Ph.D. of justus - Liebig. Universitat GieBen.

Sobel, A.E.; Yuska, H.; Peters, D.D. and Kramer, B. (1940): Influence dietary calcium and phosphorus upon the action of vitamin D in experimental lead poisoning. J. Biol. Chem., 132: 239-265.

Stokigner, H.E. (1981): "The metals" in patty's industrial Hygiene and toxicology, 3rd edition, Vol. 2 A toxicology, editors clayton, G.D. and clayton, F.E. John Wiley and Sons; New York, Chichester, Brisbane, Toronto, Singapore, p. 1687-1724.

Trinder, P. (1956): Determination of blood serum iron and total iron binding capacity. J. Clin. Path., 9: 170.

Vogler, P. (1965): Probleme der phosphatanalytik in der limnologie und ein neues verfahren zur Bestimmung von gelostem orthophosphat neben kondeusierten phosphaten und organischen phosphorsäre - estern. Int. Revue ges. Hydrobiol., 50: 33-48.

Table (1)

Lead levels and related elements (Mean ± S.E.) in the blood of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (Ug/100ml)	Copper (Ug/100ml)	Calcium (mg/100ml)	Phosphorus (mg/100ml)	Sodium (mmol/L)	Potassium (mmol/L)
18-24	male	14	0.168[c] ± 0.016	127.385[c] ± 1.248	75.238[a] ± 2.192	9.739[a] ± 0.276	6.639[a] ± 0.320	133.142[a] ± 1.157	5.935[a] ± 0.118
27-36	male	10	0.202[bc] ± 0.020	129.58[c] ± 1.245	70.631[a] ± 1.918	8.399[a] ± 0.259	6.522[a] ± 0.211	130.6[a] ± 2.381	4.110[b] ± 0.281
48-72	female	10	0.231[b] ± 0.007	142.49[b] ± 2.260	62.973[b] ± 2.042	7.387[ab] ± 0.341	5.935[ab] ± 0.342	121.9[b] ± 1.037	3.7[bc] ± 0.189
96-120	female	16	0.275[a] ± 0.012	157.681[a] ± 2.760	49.984[c] ± 1.535	6.374[b] ± 0.246	5.218[b] ± 0.242	116.937[b] ± 3.544	3.250[c] ± 0.069
	Total	50	0.222 ± 0.009	140.360 ± 2.148	63.794 ± 1.750	8.024 ± 0.240	5.960 ± 0.193	125.200 ± 1.596	4.264 ± 0.172

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Signicance at P 0.05).

Table (2)

Lead levels and related elements (Mean ± S.E.) in the urine of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (Ug/L.)	Copper (Ug/L.)	Calcium (ppm)	Phosphorus (ppm)	Sodium (mmol/L.)	Potassium (mmol/L.)
18-24	male	14	0.073^{c} ± 0.001	21.992^{b} ± 0.661	9.642^{d} ± 0.259	12.942^{b} ± 0.414	1.603^{a} ± 0.068	137.785^{d} ± 1.621	177.785^{b} ± 2.929
27-36	male	10	0.085^{b} ± 0.001	23.360^{b} ± 1.056	11.630^{c} ± 0.696	13.140^{b} ± 0.676	1.674^{a} ± 0.114	153.600^{c} ± 2.372	178.300^{b} ± 1.909
48-72	female	10	0.096^{a} ± 0.006	27.260^{a} ± 1.072	15.070^{b} ± 0.447	15.910^{a} ± 0.145	1.129^{b} ± 0.055	164.100^{b} ± 1.320	179.000^{b} ± 2.149
96-120	female	16	0.099^{a} ± 0.001	29.493^{a} ± 0.615	17.737^{a} ± 0.502	16.362^{a} ± 0.332	1.121^{b} ± 0.016	171.562^{a} ± 1.538	189.875^{a} ± 1.599
	Total	50	0.088 ± 0.002	25.720 ± 0.597	13.716 ± 0.529	17.670 ± 0.304	1.368 ± 0.047	156.960 ± 2.104	182.000 ± 1.338

S.E. = Standard error.

Means which are not significantly different are fcllowed by the same letter (Signicance at $P < 0.05$).

Table (3)

Lead levels and related elements (Mean ± S.E.) in the lung of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g.)	Potassium (Umol/g.)
18-24	male	14	2.546^{d} ± 0.099	37.400^{d} ± 2.060	6.062^{a} ± 0.293	7.192^{a} ± 0.164	0.247^{a} ± 0.007	492.140^{a} ± 11.630	367.800^{a} ± 24.900
27-36	male	10	3.361^{c} ± 0.159	57.800^{c} ± 1.760	5.527^{a} ± 0.112	6.698^{a} ± 0.150	0.234^{a} ± 0.010	434.008^{b} ± 14.690	280.000^{b} ± 14.500
48-72	female	10	4.430^{b} ± 0.093	94.450^{b} ± 3.820	4.563^{b} ± 0.150	3.674^{b} ± 0.476	0.211^{b} ± 0.017	416.000^{b} ± 7.180	234.000^{b} ± 10.000
96-120	female	16	5.918^{a} ± 0.269	173.210^{a} ± 10.080	3.310^{c} ± 0.182	2.862^{c} ± 0.150	0.210^{b} ± 0.001	318.750^{c} ± 9.430	230.000^{b} ± 11.500
	Total	50	4.165 ± 0.216	96.350 ± 8.680	4.774 ± 0.192	5.004 ± 0.298	0.225 ± 0.003	409.800 ± 11.130	279.400 ± 11.800

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Signicance at $P < 0.05$).

Table (4)

Lead levels and related elements (Mean ± S.E.) in the kidney of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g.)	Potassium (Umol/g.)
18-24	male	14	2.600^{bc} ± 0.079	180.946^{c} ± 4.541	27.700^{a} ± 0.414	7.266^{a} ± 0.206	0.318^{a} ± 0.010	248.570^{a} ± 6.120	369.200^{a} ± 5.100
27-36	male	10	2.700^{c} ± 0.174	185.180^{bc} ± 1.932	25.940^{b} ± 0.584	6.466^{b} ± 0.422	0.289^{b} ± 0.016	248.000^{a} ± 8.235	335.000^{b} ± 16.400
48-72	female	10	3.410^{b} ± 0.103	195.840^{b} ± 5.968	21.500^{c} ± 0.826	5.200^{c} ± 0.146	0.226^{c} ± 0.004	231.000^{a} ± 8.905	319.000^{bc} ± 10.800
96-120	female	16	4.912^{d} ± 0.251	215.450^{a} ± 2.346	18.074^{d} ± 0.516	4.480^{d} ± 0.070	0.215^{c} ± 0.001	183.435^{b} ± 2.945	303.100^{c} ± 6.200
	Total	50	3.522 ± 0.168	195.816 ± 2.784	23.028 ± 0.636	5.802 ± 0.194	0.260 ± 0.007	224.100 ± 5.075	331.2 ± 5.800

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Signicance at $P < 0.05$).

Table (5)

Lead levels and related elements (Mean ± S.E.) in the liver of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g.)	Potassium (Umol/g.)
18-24	male	14	2.828^{b} ± 0.110	120.435^{c} ± 1.496	232.000^{a} ± 7.410	3.497^{a} ± 0.078	0.325^{a} ± 0.012	96.642^{a} ± 2.334	397.800^{a} ± 11.600
27-36	male	10	2.960^{b} ± 0.140	126.990^{c} ± 2.140	224.100^{a} ± 10.150	3.574^{a} ± 0.171	0.285^{ab} ± 0.017	94.200^{ab} ± 2.613	364.000^{a} ± 13.000
48-72	female	10	3.620^{a} ± 0.262	138.970^{b} ± 2.778	179.900^{b} ± 5.570	3.213^{a} ± 0.168	0.247^{b} ± 0.017	86.400^{bc} ± 2.397	315.000^{b} ± 15.800
96-120	female	16	3.962^{a} ± 0.208	146.600^{a} ± 2.603	139.180^{c} ± 4.010	2.508^{b} ± 0.111	0.181^{c} ± 0.012	78.936^{c} ± 3.225	293.100^{b} ± 14.500
	Total	50	3.376 ± 0.115	133.824 ± 1.915	190.300 ± 6.530	3.139 ± 0.088	0.255 ± 0.010	88.440 ± 0.345	341.000 ± 9.200

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Signicance at $P < 0.05$).

Table (6)

Lead levels and related elements (Mean ± S.E.) in the brain of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g)	Potassium (Umol/g)
18-24	male	14	1.323[c] ± 0.073	103.640[c] ± 3.930	8.000[a] ± 0.384	4.892[a] ± 0.485	0.032[a] ± 0.006	84.060[a] ± 3.190	37.070[a] ± 3.170
27-36	male	10	1.501[c] ± 0.065	126.300[bc] ± 2.940	7.839[a] ± 0.261	4.170[ab] ± 0.145	0.020[b] ± 0.001	71.230[b] ± 3.470	35.100[a] ± 1.940
48-72	female	10	1.832[b] ± 0.076	146.400[b] ± 14.110	5.580[b] ± 0.335	3.520[bc] ± 0.280	0.017[b] ± 0.001	61.950[b] ± 0.645	24.400[b] ± 2.320
96-120	female	16	2.215[a] ± 0.077	216.68[a] ± 7.660	4.037[c] ± 0.117	2.987[c] ± 0.103	0.011[b] ± 0.001	48.750[c] ± 0.394	21.370[b] ± 00.450
	Total	50	1.746 ± 0.064	152.900 ± 7.610	6.216 ± 0.283	65.770 ± 2.435	0.020 ± 0.002	13.154 ± 0.487	29.120 ± 1.440

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Significance at $P < 0.05$).

Table (7)

Lead levels and related elements (Mean ± S.E.) in the muscles of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g)	Potassium (Umol/g)
18-24	male	14	0.234^{c} ± 0.011	89.471^{c} ± 1.628	12.264^{a} ± 0.464	3.094^{a} ± 0.202	0.387^{a} ± 0.006	64.284^{a} ± 3.366	379.200^{a} ± 14.100
27-36	male	10	0.262^{c} ± 0.013	95.970^{c} ± 1.490	10.760^{b} ± 0.508	2.803^{a} ± 0.166	0.251^{bc} ± 0.025	59.000^{ab} ± 2.894	323.000^{b} ± 11.600
48-72	female	10	0.412^{b} ± 0.038	106.020^{b} ± 2.951	7.230^{c} ± 0.408	1.857^{b} ± 0.242	0.298^{b} ± 0.021	54.400^{b} ± 2.696	288.000^{c} ± 10.000
96-120	female	16	0.585^{a} ± 0.020	117.975^{a} ± 2.540	7.212^{c} ± 0.504	1.556^{b} ± 0.114	0.250^{c} ± 0.008	42.374^{c} ± 1.020	222.500^{d} ± 4.600
	Total	50	0.388 ± 0.024	102.982 ± 2.022	9.136 ± 0.609	2.296 ± 0.128	0.298 ± 0.011	53.328 ± 2.058	299.000 ± 10.100

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Significance at $P < 0.05$).

Table (8)

Lead levels and related elements (Mean ± S.E.) in the heart of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g)	Potassium (Umol/g)
18-24	male	14	0.400^{b} ± 0.038	226.400^{c} ± 4.844	17.128^{a} ± 1.348	3.766^{a} ± 0.281	0.362^{a} ± 0.005	192.140^{a} ± 9.570	358.500^{a} ± 13.800
27-36	male	10	0.436^{b} ± 0.051	228.200^{c} ± 4.772	14.120^{ac} ± 1.118	3.984^{a} ± 0.298	0.338^{ab} ± 0.022	167.500^{ab} ± 16.915	326.000^{ab} ± 23.400
48-72	female	10	0.501^{ab} ± 0.029	265.920^{b} ± 8.300	12.860^{bc} ± 0.510	3.517^{ab} ± 0.347	0.290^{bc} ± 0.028	161.500^{b} ± 7.990	318.000^{ab} ± 7.200
96-120	female	16	0.586^{a} ± 0.027	307.824^{a} ± 6.872	10.536^{b} ± 0.528	2.973^{b} ± 0.143	0.276^{c} ± 0.014	147.185^{b} ± 4.420	291.800^{b} ± 15.300
	Total	50	0.488 ± 0.024	260.720 ± 5.948	13.692 ± 0.600	3.506 ± 0.136	0.315 ± 0.009	166.700 ± 5.280	323.000 ± 8.500

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Significance at $P < 0.05$).

Table (9)

Lead levels and related elements (Mean ± S.E.) in bony tissue (ribs) of investigated cattle

Age (months)	Sex of animal	No. of animals	Lead (ppm)	Iron (ppm)	Copper (ppm)	Calcium (Umol/g)	Phosphorus (Umol/g)	Sodium (Umol/g)	Potassium (Umol/g)
18-24	male	14	8.135^{d} ± 0.321	160.650^{c} ± 3.980	3.731^{a} ± 0.239	17.086^{a} ± 0.294	0.474^{a} ± 0.018	104.784^{a} ± 3.699	85.100^{a} ± 4.600
27-36	male	10	9.900^{c} ± 0.177	171.200^{c} ± 5.680	3.204^{a} ± 0.164	16.980^{a} ± 0.351	0.397^{a} ± 0.019	86.100^{b} ± 5.079	82.300^{a} ± 3.300
48-72	female	10	13.710^{b} ± 0.634	207.900^{b} ± 8.250	2.954^{ab} ± 0.469	13.481^{b} ± 0.478	0.389^{a} ± 0.051	73.800^{c} ± 3.102	79.200^{a} ± 5.100
96-120	female	16	18.650^{a} ± 0.470	245.180^{a} ± 5.160	2.378^{b} ± 0.171	12.005^{c} ± 0.277	0.282^{b} ± 0.027	66.750^{c} ± 1.866	50.200^{b} ± 2.800
	Total	50	12.698 ± 0.602	199.280 ± 5.770	3.037 ± 0.148	14.707 ± 0.366	0.380 ± 0.018	82.680 ± 2.736	71.700 ± 2.900

S.E. = Standard error.

Means which are not significantly different are followed by the same letter (Significance at $P < 0.05$).

Table 10: Correlation of lead with other elements in all investigated cattle tissues

	Blood	Urine	Lung	Kidney	Liver	Brain	Muscles	Heart	Ribs
Iron	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***
Copper	(-)***	(+)***	(-)***	(-)***	(-)***	(-)***	(-)***	(-)**	(-)**
Calcium	(-)***	(+)**	(-)***	(-)***	(-)***	$(-)^N$	(-)***	$(-)^N$	(-)***
Phosphorous	(-)***	(-)**	(-)***	(-)***	(-)***	$(-)^N$	(-)***	(-)***	(-)***
Sodium	(-)**	(+)***	(-)***	(-)***	(-)***	(-)***	(-)***	(-)**	(-)***
Potassium	(-)***	$(+)^N$	(-)***	(-)***	$(+)^N$	(-)***	(-)***	$(-)^N$	(-)***

** Significant at $P \leq 0.01$

*** Significant at $P \leq 0.001$

(-) Negative correlation

(+) Positive correlation

(N) No significance