SCREENING OF FRESH ANIMAL MILK FOR LEAD CONTAMINATION

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Fresh milk samples of buffalo, goat and cow from different urban and rural locations falling within and outside the proximity of the highways of Punjab and NWFP were analysed for lead using the atomic absorption method. The possibility of anthropogenic contamination of lead in the milk samples was explored. Lead concentration of varying levels was found in the milk of animals habitating near highway locations in both the provinces. In general, maximum lead level was found in the goat milk, while the minimum in buffalo milk. The average concentration were 0.082, 0.098 and 0.173 mg l^{-1} for near highway and 0.062, 0.044 and 0.142 mgl^{-1} for off-highway animals in the milks of buffalo, cow and goat, respectively. The provincewise comparison showed more contamination of lead in the milk of animals from NWFP. Compared with international standards, the local milk was found unsafe in terms of lead content.

Key words: Lead in milk, Animal milk analysis, Milk contamination.

Introduction

In recent years human exposure to elevated levels of lead in food and drinks has caused serious health concern (Husain *et al* 1996). The vehicular (Singh *et al* 1997), industrial (Dey *et al* 1996; Zhou *et al* 1977)and smelter emissions fossil fuel combustion are well recognized sources of lead in the human environment. Although there is no simple relationship between the source strength and ambient concentrations of lead vapour, substantial amounts of lead are present in the air (Dey and Swarup 1996). The diversion is largely dependent upon meteorological conditions. When incorporated in soil, lead has very low mobility, hence soils remain polluted over a long period of time. Lead immobilied in soils is complexed with organic matter (Chukwuma 1996; Jung and Thornton 1997). Plants grown on lead rich soils incorporate lead either via dry deposition (Wyers and Veitkamp 1997), impaction and diffusion or via wet deposition through rain and rainwash, thus effecting the total body burden of lead in grazers (Doganoc 1996).

Elevated levels of lead in water arise principally from industrial discharges, highway run off and weathering processes in areas of natural lead mineralization or where a large traffic density is encountered. Concentration of lead in water is dependent upon its chemical nature and geographical area (Conio *et al* 1996, Watt *et al* 1996; Vilagines *et al* 1996). Ruminant animals that graze in locations closer to highways are more vulnerable to lead intake as they use the affected water and contaminated fodder.

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In line with the facts described above, the present investigations was undertaken to evolve baseline data on the concentration of lead in the milk of grazing animals. The study would provide data based information on the quality of milk to relevant authorities so that legislative measures could be enforced to reduce the milk pollution and upper safe limits could be set for the consumption of the contaminated milk.

Experimental

Milk sampling was done in two phases, during March through June 1997. Phase I comprised sampling from Peshawar to Lahore, covering all possible locations falling in close vicinity to the main GT road while phase 2 comprised sampling from off highway sites (Fig. 1) In both cases independent sites, a few kilometers apart, were selected so that representative samples could be obtained. In total, 146 buffalo, 32 goat and 20 cow milk samples were collected, both from near and off highway (Table 1 and 2). Pyrex glass bottles (50 ml capacity), previously acid washed, rinsed thrice with distilled water and finally dried in an electric oven at 80°C for 8 h were used for sampling. No additives or preservatives were used and the samples were transported to laboratory immediately for further processing and analysis. To each 20.0 ml of the sample, 5.0 ml of 25% HCl was added with continuous stirring and the mixture was left overnight. Later, it was thoroughly stirred and filtered using Whatman No.41 filter paper (Annon 1997). The filtrate was directly aspirated onto a Shimadzu atomic absorption spectrophotometer (model AA-670), operating in automatic background compensation mode.

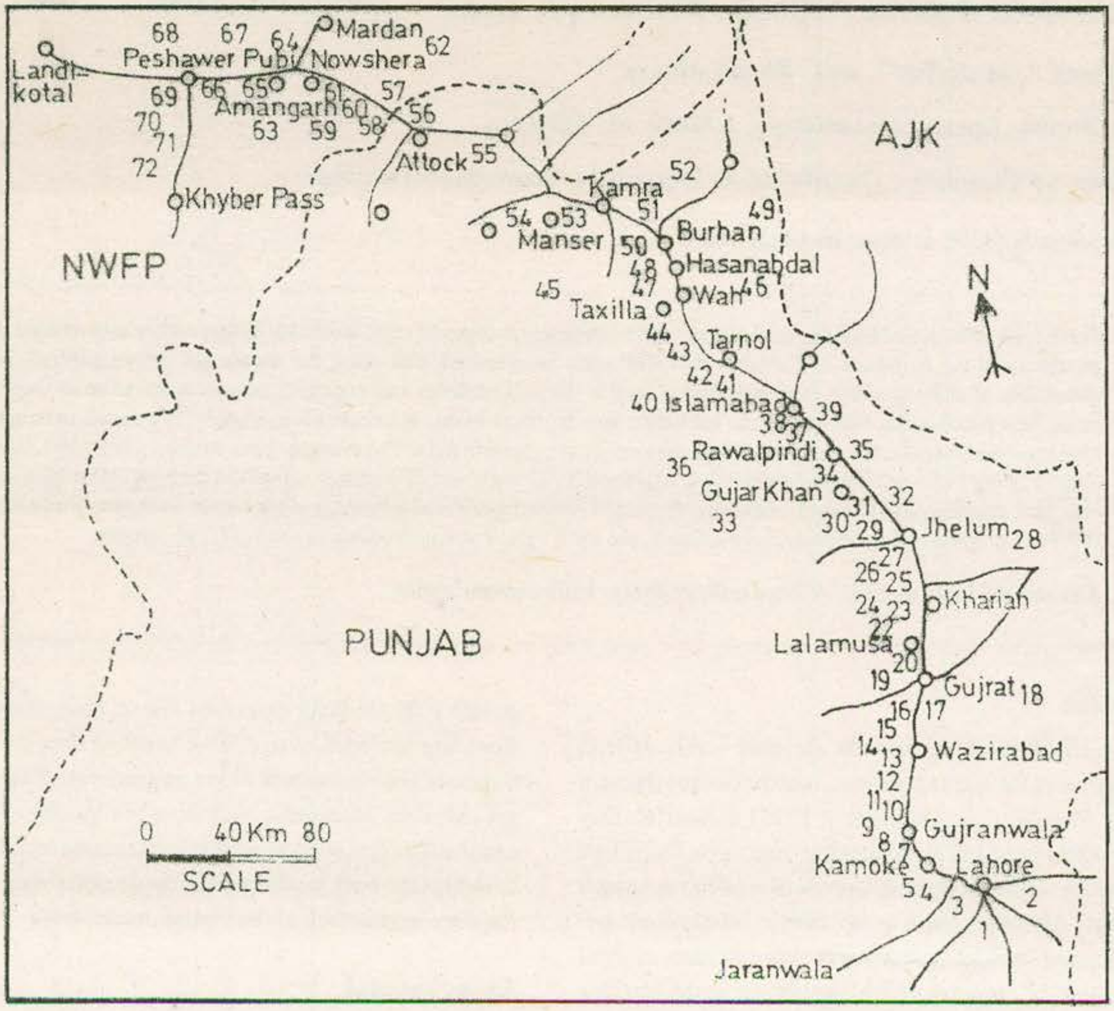

Fig 1. Location of sampling sites.

All reagents used were of high purity (min 99.9% guaranteed) spectroscopic grade. These were checked for any probable lead contamination at the detection level of the metal prior to use. All glassware was throughly washed once with detergent solution and later thrice with distilled water, then soaked in 10% nitric acid, rinsed with distilled water and kept for 6 h in an electric oven at 80°C prior to use. Deionised water was used for the preparation of solutions and blanks. The blanks were run under the same analytical conditions as the samples.

Results and Discussion

The concentrations of lead in the milk of various animals are given in Table 1 and 2, averaged over triplicate runs for each sample. The average precision in triplicate samples was better than ±1.5%. The data in Table 1 indicates an average of 0.082 mgl^{-1} of lead in the buffalo milk samples obtained from locations close to the highway. Lead level of milk was in general, higher in buffaloes habitating close to the highway than that for the off highway animals. However, a few exceptions were encountered, for which the plausible explanation could be based on the contribution of point sources of lead pollution in the immediate vicinity of a given location. The maximum lead (0.228 mgl^{-1}) was found in a near highway site in the buffalo milk sample MB-15 and the minimum (0.023 mgl^{-1}) in a near highway location sample MB-40 (Singh *et al* 1997). The occurrence of these extreem concentrations of lead at two locations close to highway clearly evidenced the contribution of environmental effects towards the uptake of the metal by the animals. This observation was substantiated by the fact that the location S-15 was situated in close vicinity to an industrial site where a large flux of vehicles was normally operative day and night for transporting the raw materials to and from the industry. As lead is invariably present in the automobile exhaust, the levels of the metal would even rise beyond the average background in areas such as site 40 where natural typical rural environment exists, free from any indus-

Table 1
Concentration of lead (mgl^{-1}) in the buffalo milk from various locations of Punjab and NWFP.

		Buffalo milk	
Site	Sample code	Near highway	Off highway
S-01	MB-01	0.028	0.019
S-02	MB-02	0.029	0.017
S-03	MB-03	0.038	0.290
S-04	MB-04	0.062	0.032
S-05	MB-05	0.138	0.096
S-06	MB-06	0.018	0.028
S-07	MB-07	0.039	0.022
S-08	MB-08	0.062	0.067
S-09	MB-09	0.105	0.086
S-10	MB-10	0.038	0.019
S-11	MB-11	0.145	0.099
S-12	MB-12	0.103	0.112
S-13	MB-13	0.024	0.144
S-14	MB-14	0.152	0.139
S-15	MB-15	0.228	0.149
S-16	MB-16	0.115	0.129
S-17	MB-17	0.100	0.163
S-18	MB-18	0.197	0.163
S-19	MB-19	0.095	0.019
S-20	MB-20	0.074	0.068
S-21	MB-21	0.063	0.106
S-22	MB-22	0.132	0.112
S-23	MB-23	0.197	0.003
S-24	MB-24	0.091	0.069
S-25	MB-25	0.038	0.061
S-26	MB-26	0.010	0.052
S-27	MB-27	0.093	0.073
S-28	MB-28	0.091	0.101
S-29	MB-29	0.113	0.028
S-30	MB-30	0.121	0.066
S-31	MB-31	0.122	0.102
S-32	MB-32	0.133	0.119
S-33	MB-33	0.070	0.110
S-34	MB-34	0.077	0.067
S-35	MB-35	0.069	0.028
S-36	MB-36	0.040	0.005
S-37	MB-37	0.075	0.019
S-38	MB-38	0.067	0.059
S-39	MB-39	0.107	0.019
S-40	MB-40	0.023	0.028
S-41	MB-41	0.038	0.061
S-42	MB-42	0.169	0.058
S-43	MB-43	0.034	0.019
S-44	MB-44	0.053	0.029

(Contd......)

(Table 1 continue)

S-45	MB-45	0.064	0.046
S-46	MB-46	0.028	0.047
S-47	MB-47	0.035	0.019
S-48	MB-48	0.038	0.034
S-49	MB-49	0.042	0.091
S-50	MB-50	0.044	0.028
S-51	MB-51	0.059	0.037
S-52	MB-52	0.032	0.029
S-53	MB-53	0.036	0.017
S-54	MB-54	0.032	0.020
S-55	MB-55	0.038	0.019
S-56	MB-56	0.092	0.027
S-57	MB-57	0.082	0.085
S-58	MB-58	0.027	0.011
S-59	MB-59	0.035	0.041
S-60	MB-60	0.109	0.105
S-61	MB-61	0.042	0.120
S-62	MB-62	0.062	0.097
S-63	MB-63	0.136	0.131
S-64	MB-64	0.126	0.019
S-65	MB-65	0.186	0.018
S-66	MB-66	0.068	0.018
S-67	MB-67	0.081	0.018
S-68	MB-68	0.130	0.022
S-69	MB-69	0.113	0.102
S-70	MB-70	0.082	0.084
S-71	MB-71	0.095	0.022
S-72	MB-72	0.150	0.039
S-73	MB-73	0.199	0.109

MB; Buffalo milk

trial impact. The off highway situation, on the other hand, was distinctly different. The average lead concentration in off highway buffalo milk samples was 0.062 mgl^{-1}), with a maximum concentration (0.163 mgl^{-1}) in sample MB-18 and the minimum (0.017 mgl^{-1}) in samples MB-02 and MB-53. The location for MB-18 was in close vicinity to a metallurgical factory while those of samples 02 and 53, were remotely located from urban area.

The data pertaining to cow milk (Table 2) showed an almost similar behaviour as was observed in the case of buffalo milk. The minimum lead concentration (0.050 mgl^{-1}) was found in the nearhighway sample MC-06 belonging to location S-45 close to a flour mill (Szkoda *et al* 1996; Swarup *et al* 1997). The corresponding maximum lead concentration (0.177 mgl^{-1}) was found from location S-28, a remotely located site. On the contrary, the off highway maximum lead concentration (0.101 mgl^{-1}) from site S-09 in close vicinity of a Ceramic Industry. The corresponding minimum concentration (0.014

Table 2
Concentration of lead (mgl^{-1}) in the cow and goat milk from various locations of Punjab and NWFP.

Site	Sample code	Near highway	Off highway
Goat milk			
S-01	GM-01	0.204	0.187
S-04	GM-02	0.169	0.109
S-09	GM-03	0.197	0.201
S-14	GM-04	0.155	0.137
S-28	GM-05	0.151	0.103
S-36	GM-06	0.194	0.071
S-39	GM-07	0.191	0.069
S-43	GM-08	0.201	0.195
S-45	GM-09	0.183	0.181
S-46	GM-10	0.213	0.209
S-47	GM-11	0.177	0.139
S-52	GM-12	0.103	0.107
S-55	GM-13	0.019	0.104
S-62	GM-14	0.222	0.190
S-69	GM-15	0.199	0.180
S-71	GM-16	0.210	0.102
Cow milk			
S-02	MC-01	0.106	0.023
S-09	MC-02	0.104	0.101
S-28	MC-03	0.177	0.073
S-36	MC-04	0.094	0.014
S-39	MC-05	0.038	0.034
S-45	MC-06	0.050	0.034
S-46	MC-07	0.126	0.073
S-47	MC-08	0.094	0.070
S-55	MC-09	0.109	0.099
S-70	MC-10	0.082	0.018

GM; Goat milk, MC; Cow milk

mg l^{-1}) in sample MC-04 was collected from a remotely located site (S-36). It could, therefore, be inferred that samples from the off highway locations were less contaminated as compared with the ones pertaining to near highway locations. The comparison of lead levels is depicted in Fig. 2.

The data in Table 2 pertaining to the distribution of lead in various near highway samples of goat milk showed an average of 0.173 mgl^{-1} with a maximum of 0.222 mgl^{-1} in GM-14 and a minimum of 0.094 mg l^{-1} in GM-06 (Gajewska *et al* 1996). The off highway situation was found to be less critical since an average concentration of lead was found at 0.142 mgl^{-1} with a maximum of 0.209 mgl^{-1} and a minimum of 0.069 mgl^{-1}, in sample GM-10 and GM-07, respectively. The location S-39 was on top of a small hill thus exhibited the minimum observed concentration of lead as compared with the sampling site S-46 which was in close proximity to Pakistan Ordanance Factories.

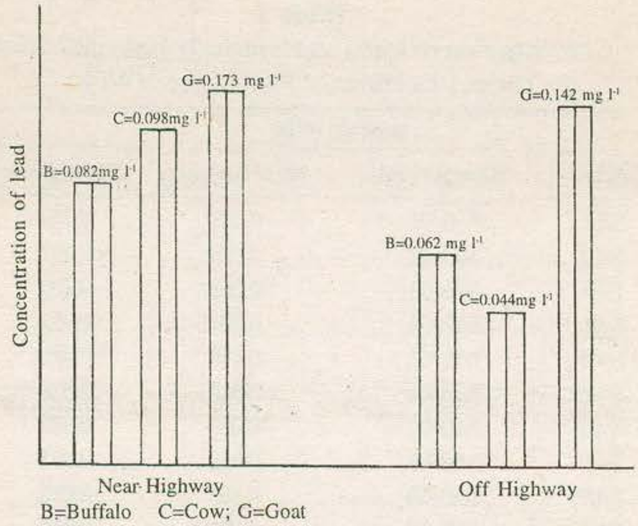

Fig 2. Comparative evaluation of average levels of lead in the milk of various animals.

The province wise comparison was quite revealing. The buffaloes belonging to near highway locations of Punjab showed 1.2 fold enrichment of the metal as compared with the off highway animals. Similarly, for NWFP the average lead content of milk in near highway and off highway locations showed an enrichment ratio of 1.6. As a result the buffalo milk NWFP and greater spread of lead distribution as compared with that of Punjab. The observation of comparatively high lead content in the NWFP buffalo milk, was further supported in the cow milk, lead averaged to 0.075 mgl^{-1} in the Punjab cow milk while it average to 0.082 mg l^{-1} in NWFP cow milk. A similar situation was in the case of goat milk from Punjab and NWFP with average lead at 0.167 and 0.183 mgl^{-1}, respectively.

The data suggest that the grazing animals are particularly vulnerable to the metal contaminating their fodder through fall out and natural contact. The food chain also incorporates drinking water which for animals is often made available from ponds and lagoons openly exposed to the metal pollution. However, the atmospheric fall out of lead is not the only basis for a significant contribution of the metal in the milk of these animals but the mineralogical aspects are as well equally important. In NWFP the massive land area is characterized by hilly tracks and mountanious regions rich is ore and mineral ingredients of varied types. The contribution of these sources towards metal uptake by crops, in general, and plants and vegetation, in particular, thus becomes understandable in terms of the observed elevated metal levels in milk.

The lead content of cow milk in U.K., was reported (Annon 1997) at 0.020 mg l^{-1}, compared against our level of 0.082 mg l^{-1} for the cow milk from NWFP and 0.074 mg l^{-1} from Punjab. Our levels therefore, are about four times higher than the reported values. The maximum upper limit for the average daily intake (ADI) of lead in UK (Annon 1997) is 16 $\mu g\ day^{-1}\ kg^{-1}$ for an adult person. Evaluated on the basis of this standard the lead content in local buffalo, cow and goat milk are unsuitable for human consumption since the buffalo milk contains four times, the cow milk about five times and the goat milk about ten times higher levels of lead as against allowed ADI. In addition, the cumulative effect of food commodities ingested by the local people should also be taken into consideration while calculating a safe daily dose, not exceeding 16 µg level. The most critical part of this observation pertains to the consumption of milk by children for whom the permitted daily intake allowance is still lower by a factor of 50%.

It can be concluded from the present investigation that the quality of local milk in terms of its lead content is not good. The buffalo, cow and goat milk contain lead in the same order of increase enrichment. The local fresh milks, whether belonging to near highway or off highway sites contain elevated levels of the toxic metal and do not conform to safe ingestion by humans on the basis of allowed safe limits laid down by international agencies. Further exploratory work in this direction is underway.

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