Original Research

Heavy Metal Residues in Soil and Water of North-24 Parganas (West Bengal) and its effect on Chevon Quality

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Rec. Date:	May 13, 2019 09:26
Accept Date:	Jul 02, 2019 09:40
DOI	10.5455/ijlr.20190513092637

Abstract

Heavy metal toxicity is a major form of environmental pollution. Their tendency for bio-accumulation and bio-magnification in the food chain affects human health. An investigation was carried out in North-24-Parganas of West Bengal. Soil, water and chevon samples were collected from targeted areas over a span of six months and were analyzed for the presence of lead, arsenic, iron and zinc applying atomic absorption spectrophotometry. Soil samples revealed high concentration of iron and zinc whereas water samples indicated high concentration of iron and arsenic. These levels did not impact the overall edible quality of meat because concentration of lead and arsenic were below detection limits and concentration of iron and zinc were mostly below maximum permissible limit. Thus advocating, chevon quality from goats reared in areas having high heavy metal residual content is largely within acceptable limits, however continuing elevation of levels may cause reverse impact in future.

Key words: Arsenic, Chevon, Iron, Heavy Metal, Lead, Micro-Nutrients, Zinc

How to cite: Mahapatra, G., Biswas, S., Patra, G., & Bhattacharyya, D. (2019). Heavy Metal Residues in Soil and Water of North-24 Parganas (West Bengal) and its Relation to Chevon quality. International Journal of Livestock Research, 9(8), 145-153. doi: 10.5455/ijlr.20190513092637

Introduction

Environmental pollution is a major global problem posing serious risk to animals as well as humans. There is an increasing concern about environmental pollutants being emanated into livestock production system (Rajaganpathy, 2006). Heavy metals from manmade pollution sources are continuously released in the aquatic and terrestrial eco-system. Heavy metals like lead and arsenic are significant environmental pollutants. Elements like iron and zinc are essential in small quantities but when exceeding a specific concentration, they tend to become toxic (Peralta-Videa *et al.*, 2009). Other major pathway for soil and water pollution is through atmospheric deposition of heavy metals from point sources (*viz.* metalliferous mining, smelting and industrial activities) and non-point sources of contamination (*viz.* fertilizers, pesticides, sewage sludge, organic manure and compost) (Singh, 2001). Additionally, foliar uptake of atmospheric heavy metals from emission gas and absorption from soil as well as surface deposits has been identified as an important pathway of heavy metal contamination in vegetable crops (Kaur, 2006). Contamination with heavy metals is a serious threat because of their toxicity, bio-accumulation and bio-magnification in the food chain (Demirezen *et al*., 2006).

High levels of heavy metal residues in the soil and water of West Bengal have been a matter of concern (Chakraborti *et al.,* 2001). Gupta *et al.* (2008) has reported significant levels of arsenic residues in vegetables grown on waste water. Such contaminated agricultural products may lead to chronic toxicity in human beings (Roy Chowdhury, 2002). Farm animals are also an important indicator for environmental pollution (Kottferova *et al.,* 1995). Exposure of farm animals to heavy metals is a major public health concern because these animals are reared for milk and meat (Inam *et al.*, 2000) and consumption of such polluted food can have direct physiological and toxicological effect on human health. The role of livestock for income generation, food supply and financial security for the rural population is well documented (Tanusha *et al.,* 2019). Goat rearing is a counterpart of mixed farming systems. Grazing on contaminated soil has resulted in higher levels of toxic metals in raw meat (Sabir *et al.*, 2003) as well as meat products (Gonzalez-Weller *et al.*, 2006).This study was proposed to ascertain the concentration arsenic, lead, iron and zinc in the soil, water and meat of goats reared in North-24 Parganas, thus establishing a relationship between the concentration of heavy metals in the environment and determining the safety of goat meat for human consumption.

Materials and Methods

The investigation was carried out in Barrackpore (22.76°N 88.37°E), Barasat (22.72°N 88.48°E) and Bashirhat (2°39′26″N 88°53′39″E) of North- 24 Parganas, West Bengal, India for a period of six months. Composite samples of soil were collected from a depth of 15 cms, dried at 105$\pm$5˚C, ground, sieved through a 2 mm mesh and stored in sterile polyethylene bottles until further analysis. Water used to irrigate plants and feed animals were collected, preserved and analyzed as per APHA (1995) guidelines. Castrated Black Bengal goats of 40 weeks age, were purchased locally from the marginal farmers rearing them. They were fasted overnight with free access to water, slaughtered. From each carcass meat from leg, loin and shoulder were collected, vacuum packed and frozen at -20˚C until further analysis.

All samples were digested by tri-acid (Datta *et al.*, 2010). The digest was slowly evaporated to near dryness, cooled and dissolved in 2.0% HNO3. It was then filtered through Whatman Filter Paper no. 42 and diluted to a volume of 50 ml with 2.0% HNO3. This solution was then analyzed by atomic absorption spectrophotometer (GBC,932 Plus- AAS, Australia) in flame mode using air-acetylene flame for lead, iron

 DOI 10.5455/ijlr.20190513092637

and zinc and graphite hydride mode for arsenic, using air-acetylene flame for arsenic. The absorption of these elements was compared to standard absorption and the residue levels were expressed as ppm for Pb, Fe and Zn and ppb for As.

Total number of samples analyzed were 180 (five samples each for soil, water, shoulder muscle, thigh muscle and loin muscles, for each month; here n=30). For each table, the data are expressed in parts per million (ppm); parts per billion (ppb) and below detection limit (BDL), wherever applicable. Each S. No. refers to the consecutive months of samples collected in the 6 months period. All the data obtained were analyzed statistically to draw valid conclusion in SPSS (version 16.0) software. Data related to the effect of different wholesale cut were analyzed by one-way ANOVA according to Duncan's multiple range test (Duncan, 1955). The results were expressed in terms of mean and standard error (SE) of mean. A probability value of $p<0.05$ was described as significant and $p<0.01$ was noted highly significant.

Results and Discussion

Arsenic (As)

The data pertaining to As content in different samples are presented in Table 1. Arsenic content in the soil of Barrackpore, Barasat and Bashirhat ranged from 4.063-8.688 ppm, 4.85-5.48 ppm and 4.64-5.44 ppm, respectively. All values were within acceptable limits and in accordance to the observations made by Roy Chowdhury *et al.* (2002). It was noted that the concentration of arsenic in surface water of Barasat and Bashirhat ranged from 0.319-0.488 ppm and 0.0291-0.482 ppm, respectively. These values were in coherence to that observations made by Bera *et al.* (2010) and Chakraborti *et al.* (1998). Water samples from Barrackpore showed 4.413 - 8.141 ppm of As. The BIS (1991) standards allow a maximum of 0.05 ppm of As in drinking water. Exhibiting that most of the values recorded for water samples of barrackpore exceeded safety limit. The residual concentration of arsenic in the shoulder, thigh and loin muscles of goats reared in all three areas were BDL.

Lead (Pb)

The data representing the Pb content in different samples are presented in Table 2. Lead content in the soil of Barrackpore, Barasat and Bashirhat ranged from 2.67-9.45 ppm, 7.56-11.8 ppm and 7.4-12.9 ppm, respectively. All values were within acceptable limits, as mentioned by Roy Chowdhury *et al.* (2002). The concentration of lead for water samples of Barrackpore were BDL whereas for Barasat and Bashirhat it ranged from 0.001-0.009 ppm and 0.002-0.015 ppm, respectively. As per BIS (1991), these values were within maximum permissible limit and were in coherence with the findings of Kar *et al.* (2008). The lead concentration recorded for all the chevon samples were BDL.

DOI 10.5455/ijlr.20190513092637

Table 1: Residual concentration of arsenic

Area	Barrackpore					Barasat					Bashirhat				
Parameter	Soil (ppm)	Water (ppm)	Chevon(ppb)			Soil (ppm)	Water (ppm)	Chevon(ppb)			Soil (ppm)	Water (ppm)	Chevon(ppb)		
S. No.			S	T	L			S	T	L			S	T	L
1	4.063±1.025	7.788±0.017	BDL	BDL	BDL	5.42±1.401	0.488±0.072	BDL	BDL	BDL	4.64±1.128	0.461±0.132	BDL	BDL	BDL
2	8.688±1.51	4.413±0.015	BDL	BDL	BDL	4.85±1.122	0.467±0.174	BDL	BDL	BDL	5.20±1.214	0.226±0.142	BDL	BDL	BDL
3	6.201±1.302	8.141±0.062	BDL	BDL	BDL	4.96±1.115	0.328±0.054	BDL	BDL	BDL	5.35±1.16	0.0291±0.051	BDL	BDL	BDL
4	5.610±1.105	6.618±0.035	BDL	BDL	BDL	5.28±1.254	0.325±0.012	BDL	BDL	BDL	5.44±1.362	0.482±0.016	BDL	BDL	BDL
5	6.623±1.153	6.467±0.024	BDL	BDL	BDL	5.16±1.352	0.409±0.068	BDL	BDL	BDL	4.85±1.424	0.285±0.144	BDL	BDL	BDL
6	7.250±1.024	7.250±1.024	BDL	BDL	BDL	5.48±1.029	0.319±0.135	BDL	BDL	BDL	5.32±1.441	0.315±0.001	BDL	BDL	BDL

S- shoulder, T- thigh, L- Loin

Table 2: Residual concentration of lead

Area	Barrackpore					Barasat					Bashirhat				
Parameter	Soil	Water	Chevon(ppm)			Soil	Water	Chevon(ppm)			Soil	Water	Chevon(ppm)		
S. No.	(ppm)	(ppm)	S	T	L	(ppm)	(ppm)	S	T	L	(ppm)	(ppm)	S	T	L
1	8.21±0.003	BDL	BDL	BDL	BDL	10.3±0.005	0.006±0.001	BDL	BDL	BDL	10.2±0.001	0.004±0.003	BDL	BDL	BDL
2	6.46±0.009	BDL	BDL	BDL	BDL	11.8±0.004	0.004±0.002	BDL	BDL	BDL	11.5±0.002	0.002±0.004	BDL	BDL	BDL
3	9.45±0.003	BDL	BDL	BDL	BDL	9.62±0.003	0.001±0.002	BDL	BDL	BDL	12.9±0.005	0.012±0.005	BDL	BDL	BDL
4	2.67±0.003	BDL	BDL	BDL	BDL	7.56±0.006	0.007±0.005	BDL	BDL	BDL	7.4±0.002	0.015±0.004	BDL	BDL	BDL
5	5.49±0.002	BDL	BDL	BDL	BDL	10.9±0.005	0.009±0.002	BDL	BDL	BDL	12.5±0.003	0.008±0.006	BDL	BDL	BDL
6	4.60±0.008	BDL	BDL	BDL	BDL	11.4±0.005	0.008±0.003	BDL	BDL	BDL	8.6±0.002	0.007±0.005	BDL	BDL	BDL

S- shoulder, T- thigh, L- Loin

DOI 10.5455/ijlr.20190513092637

These findings were contrary to those made by Robinson (1994) who reported lead concentration to the extent of 29 ppm in goat meat from Chennai city.

Iron (Fe)

The observations related to the Fe content in different samples are presented in Table 3. Iron content in soil of Barasat and Bashirhat ranged from 6210-6921 ppm and 5428-8210 ppm, respectively. Both these values were considered to be with in normal range and in accordance with the findings of Roy chowdhury *et al.* (2002). On the contrary, concentration of Iron in the soil of Barrackpore ranged from 11907-19997 ppm, much higher than normalcy. Surface water of Barrackpore, Barasat and Bashirhat contained Iron in the concentration of 1.031-6.0551 ppm, 0.651-1.744 ppm and 0.653-2.635 ppm, respectively. These observations were in coherence to the findings of Kar *et al.* (2008) but exceeded the BIS (1991) standard which allows a maximum of 0.3ppm of iron in drinking water. The muscle samples exhibited iron content in the different wholesale cuts of chevon for Barrackpore, Barasat and Bashirhat ranged from 14.964-30.069 ppm, 15.601-32.635 ppm and 10.383-32.380 ppm, respectively. All the values were below the maximum permissible limit of 3000-5000 ppm for muscle foods. These findings in meat were in coherence to the findings made by Iwegbue *et al.* (2008).

Zinc (Zn)

The data reporting the Zn content in different samples are presented in Table 4. Zinc content in the soil of Barasat and Bashirhat ranged from 38.2-49.5 ppm and 34.5-52.8 ppm, respectively which according to Roy Chowdhury *et al.* (2002) was considered to be normal. The zinc concentration for soil of Barrackpore was 380.5-1141.2 ppm, a value much higher than normalcy. Zinc concentration in surface water of Barrrackpore, Barasat and Bashirhat ranged from 0.0572-0.299 ppm, 0.053-0.095 ppm, and 0.007-0.111 ppm, respectively. All these values were in coherence to the findings of Kar *et al.* (2008) but exceeded the BIS (1991) standards. Zinc concentration in meat samples ranged from 14.865 to 54.305 ppm, most of the values were below maximum permissible limit except a few samples obtained from Barrackpore area which pertained to $p > 0.05$, hence considered as non-significant. Similar studies conducted by Coleman *et al.* (1992) and Jayasekara *et al.* (1992) reported fresh meat samples having zinc below 50 ppm, on the contrary a study conducted by Langsland *et al.* (1987) showed zinc level of 57 ppm in sheep muscle. Gonzalez-Weller *et al.* (2006), Robinson (1994), Abu Donia (2008) and Coleman *et al.* (1992) have established the presence of heavy metal residue in meat and meat products.

  DOI 10.5455/ijlr.20190513092637

Table 3: Residual concentration of iron

Parameter	Soil	Water	Chevon(ppb)			Soil	Water	Chevon(ppm)			Soil	Water	Chevon(ppm)		
S. No.	**(ppm)**	**(ppm)**	**S**	**T**	**L**	**(ppm)**	**(ppm)**	**S**	**T**	**L**	**(ppm)**	**(ppm)**	**S**	**T**	**L**
1	16447.32± 0.803	1.031± 0.482	25.947± 0.253	17.168± 0.199	21.105 ±0.172	6740 ±0.829	1.234± 0.569	22.185± 0.287	32.635± 0.17	19.331± 0.191	6840± 0.524	1.589 ±0.576	14.061 ±0.199	26.354± 0.172	21.652 0.132
2	11907± 0.543	2.402± 0.624	19.177± 0.172	21.957± 0.149	20.956± 0.168	6524± 0.565	1.744± 0.48	21.202± 0.19	21.138± 0.232	15.601± 0.157	6651± 0.625	0.653± 0.479	10.838± 0.149	24.568± 0.206	22.852± 0.125
3	13860± 0.495	6.0551± 0.579	22.725± 0.206	24.701± 0.144	15.839± 0.178	6648± 0.648	2.345± 0.685	18.249± 0.177	19.074± 0.196	24.080± 0.165	7351± 0.798	1.584± 0.612	19.185± 0.144	22.654± 0.268	19.648 ±0.174
4	19997± 0.85	1.255± 0.6	30.069± 0.268	16.998± 0.218	14.964± 0.172	6210± 0.687	0.651± 0.601	18.75± 0.34	26.165± 0.222	18.336± 0.371	5428± 0.813	1.413± 0.611	18.651± 0.132	23.581± 0.194	20.484± 0.118
5	17567± 0.548	1.999± 0.473	21.392± 0.19	24.515± 0.184	19.479± 0.215	6320± 0.521	1.234± 0.462	32.38± 0.134	21.851± 0.199	30.383± 0.271	6591± 0.685	2.635± 0.493	19.74± 0.218	25.168± 0.186	21.428± 0.135
6	18269± 0.801	4.512± 0.527	24.568± 0.16	22.458± 0.187	18.632± 0.16	6921± 0.801	1.413± 0.473	24.896± 0.317	20.628± 0.417	22.654± 0.169	8210± 0.169	1.365± 0.463	15.242± 0.235	24.694± 0.187	23.58± 0.18

S- shoulder, T- thigh, L- Loin

Table 4: Residual concentration of zinc

Area	Barrackpore					Barasat					Bashirhat				
Parameter	**Soil**	**Water**	**Chevon(ppm)**			**Soil**	**Water**	**Chevon(ppm)**			**Soil**	**Water**	**Chevon(ppm)**		
S. No.	**(ppm)**	**(ppm)**	**S**	**T**	**L**	**(ppm)**	**(ppm)**	**S**	**T**	**L**	**(ppm)**	**(ppm)**	**S**	**T**	**L**
1	76.6± 0.3	0.0572± 0.103	48.250± 0.146	27.360± 0.254	46.370± 0.281	44.5± 0.253	0.065± 0.103	49.22± 0.28	45.145± 0.303	45.69± 0.161	51.5± 0.254	0.058± 0.102	15.31 ± 0.107	43.851± 0.268	24.735± 0.116
2	457.5± 0.251	0.0896± 0.154	38.235± 0.147	22.080± 0.302	15.505± 0.209	48.2 ± 0.299	0.084± 0.157	54.305± 0.213	33.765± 0.325	24.73± 0.18	38.2 ± 0.283	0.111± 0.154	14.99± 0.102	46.328± 0.361	29.689± 0.134
3	380.5± 0.282	0.118 ± 0.214	42.790± 0.163	22.315± 0.215	39.325± 0.245	42.6± 0.259	0.095± 0.214	44.37± 0.293	47.625± 0.275	28.765± 0.169	34.5± 0.362	0.064± 0.104	18.642± 0.108	36.891 ± 0.216	27.168± 0.12
4	860.5± 0.362	0.299 ± 0.451	42.540± 0.125	25.565± 0.268	14.865± 0.217	40.6± 0.282	0.083± 0.452	48.905± 0.189	29.89 ± 0.296	37.425 ±0.174	48.9± 0.252	0.036± 0.151	17.832± 0.108	39.548 ± 0.246	35.284± 0.13
5	1141± 0.254	0.291± 0.441	42.275± 0.158	30.825± 0.267	19.115± 0.278	49.5± 0.363	0.053± 0.441	50.015± 0.175	27.415± 0.30817	26.405 ±0.234	52.8± 0.297	0.007± 0.211	22.546± 1.029	37.258 ± 0.223	32.546 ± 0.2
6	785.2± 0.364	0.254± 0.325	44.528± 0.168	28065± 0.272	28.352± 0.229	38.2± 0.254	0.082± 0.036	47.895± 0.168	35.681± 0.287	27.389 ±0.176	36.4± 0.283	0.095± 0.216	24.682± 0.015	44.581 ± 0.261	38.642± 0.211

S- shoulder, T- thigh, L- Loin

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On the contrary studies conducted by Nkansah *et al.* (2014) revealed presence of both Pb and As in chevon samples but the values were below maximum permissible limits, similarly Rooke *et al.* (2010) and De Smet *et al.* (2016) established that the response in muscle to increased dietary concentrations of zinc and iron is mostly absent. Rudy (2009) stated that mutton obtained from sheep upto the age of 8 months (approximately 40 weeks) raised in a polluted environment has Pb and As content at Below Detection Limit. All these outcomes reasoned the outcomes of this investigation.

Conclusion

Chevon obtained from goats up to 40 weeks age group, is safe for consumption even if procured from areas having high heavy metal concentration either in soil or water or both. However, continuing elevated levels may cause reverse impact in future.

Acknowledgement

We are grateful to the Director of Central Inland Fisheries Research Institute (ICAR), Barrackpore, Kolkata, India for providing the opportunity to conduct experiments and analyze data at their facility.

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