Indian Journal of Animal Sciences **88** (5): 540–545, May 2018/Article

Trace mineral status of buffaloes (*Bubalus bubalis*) from North-West Himalayan region in relation to fodder levels

R SINGH[1], N SHARMA[2], R K BHARDWAJ[3] and K HUSSAIN[4]

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir 181 102 India

Received: 30 August 2017; Accepted: 14 December 2017

ABSTRACT

To know the status of trace minerals in buffaloes from various agro-climatic zones of Jammu division, a baseline survey was conducted. A total of 193 buffalo blood and 169 fodder samples offered during various seasons were collected and analyzed. The average values of Cu, Zn, Fe, Mn and Co in buffalo plasma samples were 14.86, 31.27, 56.05, 1.98 and 3.35 µmol/l, respectively. Sub-clinical deficiency of Cu, Zn, Fe and Mn was recorded among 34.42, 3.22, 7.05 and 11.97% buffalo population. Fodder sample analysis revealed wide variation in the level of trace elements among different fodders and also areas. Level of iron in fodders was adequate; however, Cu deficiency was prevalent among corn stover (55.55%), fodder tree leaves (50%) and *Pennisatum typhoides* (22.22%). Zn deficiency was recorded among *Sorgum* spp. (68.75%), corn stover (66.66%), wheat straw (82.5%), *Pennisatum typhoides* (37.5%), tree leaves (33.33%) and *Trifolium alexandrium* (15.38%). Mn deficiency was recorded among *Sorgum* spp. (62.5%), corn stover (66.66%), wheat straw (30.76%) and *Pennisatum typhoides* (44.44%). Study concluded that area specific mineral mixtures need to be supplemented for enhancing the productive and reproductive potential of buffaloes.

Key words: Buffalo, Fodder levels, Mineral status, North-West Himalayan region

Minerals are inorganic dietary constituents required for various metabolic processes in the body. Availability of minerals to animals in appropriate quantities is a major factor determining the health and productivity. Reports on mineral responsive conditions among dairy animals in India are available but systematic reports based on base line surveys from different agro-climatic zones are lacking. With this view in mind, a baseline survey was conducted in 5 districts of Jammu Division to know the status of copper (Cu), zinc (Zn), manganese (Mn), iron (Fe) and cobalt (Co) in buffaloes and its relationship with fodder levels.

MATERIALS AND METHODS

A baseline survey was conducted among buffaloes reared under various management system under different agro-climatic zones of Jammu division involving 5 districts, i.e. Jammu and Kathua (sub-tropical zone), Udhampur and Rajouri (intermediate zone) and Poonch (temperate zone) having mean height 300–4000 meter above MSL. Blood samples (193) from 30 villages covering 20 blocks and 122 households were collected. Based on age, animals were categorized in to three groups, viz. groups- 1, 2 and 3 comprising <3, 3–6 and >6 years age, respectively.

Sample collection: Blood samples were collected in heparinized mineral free glass vials (dipped overnight in 2N HCl) and plasma was separated immediately after collection. Plasma samples were stored at –30°C for subsequent analysis.

Plasma analysis: Three ml of each plasma sample was analysed for trace mineral analysis by digesting in distilled concentrated nitric acid AR (15 ml) and perchloric acid (Merck) (3 ml) followed by one cycle of hydrogen peroxide AR (3.0 ml of 30%). The concentrations of micro-elements, viz. Cu, Fe, Zn, Mn and Co were measured by Polarized Zeeman Atomic Absorption Spectrophotometer (Z-2300, Hitachi).

Fodder samples: Fodder samples were collected from the farmer's field during the field visits to the dairy farms at the time of sampling. Dry roughage fed to animals during the sampling season was also collected from the manger. Samples of green non-leguminous fodders like *Sorgum* spp. (17), Corn stover (leaves and stalks of maize *Zea mays. L*) (19), *Trifolium alexandrium* (berseem) (14), *bajra* (*Pennisatum typhoides*) (10), wheat straw (42), rice straw (23), local grasses (29), fodder tree leaves (9), green fodder wheat (*Triticum aestivum*) (3) and oats (*Avina sativa*) (3) collected from various districts. The fodder samples were allowed to air dry for few days. Samples were then dried in hot air oven at 65°C overnight. The forage samples were

Present address: [1]Professor and Head (rajivrajiv101@gmail.com), [2,3]Assistant Professor (drneelesh_sharma@yahoo.co.in, sonu7800@gmail.com), [4]Associate Professor (kafil.hussain @gmail.com), Division of Veterinary Medicine, Faculty of Veterinary Sciences and Animal Husbandry.

ground to pass a 1 mm screen mesh. About 0.5 g of dried crushed material powder was digested with 6 ml of double distilled nitric acid AR and 2 ml of 30% perchloric acid over a hot plate. After digestion, the material was cooled down and the volume was made up to 10 ml with double distilled water and stored in clean air tight polyethylene bottles till further analysis. Cu, Fe, Zn and Mn were analyzed by using Polarized Zeeman Atomic Absorption Spectrophotometer (Z-2300, Hitachi). Statistical comparison of data was done as per Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Copper: The overall mean value of copper in plasma samples of buffaloes was within normal range of 9.5–23.6 µmol/l as reported by McDowell (2003) for cattle. Similar

Table 1. Plasma trace mineral status and percentage prevalence of deficiencies in Buffaloes

(mean±S.E.)

	Jammu	Kathua	Udhampur	Rajouri	Poonch	Total
			Cu (critical level Marginal: 7.9-9.59 mmol/l, Low: <7.9 mmol/l)			
Group-I	16.33±2.11 (20.00; M:13.33; L: 6.66)	8.70±0.34 (M:100)	9.07±0.78 (M:50)	12.51±2.36 (44.44; M:33.33; L: 11.11)	11.17±0.62 (Nil)	13.46±1.20 (32.35; M:26.47; L: 5.88)
Group-II	17.34±2.16 (37.50; M:16.66; L: 20.83)	9.58100 (M)	12.16±1.14 (Nil)	15.95±2.19 (21.21; M:6.06; L: 15.15)	13.80±0.927.14 (M)	15.81±1.21 (24.32; M:10.81; L: 13.51)
Group-III	18.17±2.57 (31.57; M:13.15; L: 18.42)	7.83±1.51 (M:66.66)	6.83±0.90 (60.00; M:40.00; L: 20.00)	11.01±2.12 (75.00; M:25.00; L: 50.00)	12.13±1.32 (22.22; M:11.11; L:11.11)	14.57±1.48 (45.33; M:20.00; L: 25.33)
Total	17.55±1.48[a] (31.16; M:14.28; L: 16.88)	8.45±0.63[ab] (85.71)	10.18±0.66[ac] (44.44; M:33.33; L: 11.11)	13.86±1.41[b] (41.93; M:16.12; L: 25.80)	12.79±0.65[abc] (10.71; M:7.14; L: 3.57)	14.86±0.81[bc] (34.42; M:17.48; L: 16.93)
			Zn (critical level <12.2 mmol/l)			
Group-I	30.26±2.47 (Nil)	18.65±3.86 (Nil)	15.85±0.08 (Nil)	39.91±5.28 (16.66)	26.97±5.05 (Nil)	30.17±2.19 (3.22)
Group-II	24.79±1.82 (Nil)	16.57 (Nil)	25.20±0.94 (Nil)	43.69±3.62 (12.00)	29.70±4.38 (Nil)	34.30±2.21 (4.76)
Group-III	27.50±2.44 (3.22)	20.88±6.53 (Nil)	17.18±2.21 (Nil)	31.51±4.27 (Nil)	34.12±8.24 (Nil)	28.69±2.07 (1.63)
Total	27.30±1.38[a] (1.49)	19.31±2.93[b] (Nil)	18.85±1.74[ac] (Nil)	39.05±2.56[abc] (9.09)	30.63±3.46[c] (Nil)	31.27±1.30[bc] (3.22)
			Fe (critical level <17.9 mmol/l)			
Group-I	73.00±15.46 (8.33)	54.0±8.32 (Nil)	44.59±12.99 (Nil)	51.56±6.19 (Nil)	26.37±4.47 (20.00)	62.25±13.32 (6.66)
Group-II	67.06±12.03 (4.76)	67.54 (Nil)	44.33 (Nil)	46.32±2.81 (6.06)	41.10±7.81 (7.69)	51.93±4.29 (5.79)
Group-III	72.99±8.85 (8.33)	87.27±17.19 (Nil)	70.64±17.68 (Nil)	44.48±2.27 (Nil)	31.68±11.04 (33.33)	60.22±5.19 (8.45)
Total	71.19±6.39[a] (7.24)	72.89±10.44[b] (Nil)	57.57±10.91 (Nil)	46.48±1.88[ab] (3.22)	35.23±5.29[ab] (18.51)	56.05±3.04 (7.05)
			Mn (critical level <0.37 mmol/l)			
Group-I	2.41±0.53 (8.33)	4.44±0.87 (Nil)	2.53±0.67 (Nil)	0.63±0.21 (55.55)	3.09±0.57 (Nil)	2.18±0.32[1] (20.00)
Group-II	3.12±0.60 (5.26)	4.55±2.22 (Nil)	2.25±1.09 (Nil)	1.06±0.12 (23.52)	2.40±0.09 (Nil)	2.01±0.21 (12.67)
Group-III	2.29±0.29 (Nil)	2.30±0.54 (Nil)	1.85±0.37 (Nil)	1.09±0.16 (25.00)	1.92±0.21 (Nil)	1.85±0.15[1] (7.57)
Total	2.57±0.26[a] (3.27)	3.66±0.67[ab] (Nil)	2.12[abc]±0.34 (Nil)	1.01±0.08[abcd] (28.57)	2.34±0.13[bde] (Nil)	1.98±0.12[abde] (11.97)
			Co (mmol/l)			
Group-I	6.01±1.42	1.70±0.54	6.04±2.68	0.84±0.29	4.56±0.50	4.36±0.80[1]
Group-II	4.94±1.00	2.08	8.30±1.50	0.61±0.10	4.13±0.31	3.10±0.43[1]
Group-III	3.86±0.78	2.59±0.32	3.32±0.82	0.71±0.09	3.78±0.35	3.08±0.42[1]
Total	4.68±0.57[a]	2.14±0.29[ab]	5.03±1.08[bc]	0.67±0.07[abcd]	4.08±0.20 [bde]	3.35±0.29[abcde]

Figures in parenthesis indicate percentage of animals deficient. Means marked with similar superscript (a, b, c) differ significantly (P<0.05) in a row. Means marked with similar superscript 1, differ significantly (P<0.05) in a column.

levels of plasma Cu, i.e. 14.7 µmol/l, 13.20 µmol/l and 12.68 µmol/l were reported by Randhawa (1999), Singh *et al.* (2004) and Chhabra (2006) among buffaloes of Punjab. However, other workers have quoted higher values of 30 µmol/l (Singh 1989) and 21.84 µmol/l (Randhawa 1993) in buffaloes. Differences observed in Cu levels could be due to different geographical areas, dietary Cu level, method of sample collection and analytical technique employed. As observed in present study, Singh *et al.* (2004) and Chhabra (2006) also reported no influence of age on blood Cu levels. However, age related increase in Cu level had been documented by Das *et al.* (1997).

The overall prevalence of hypocupraemia was 34.42% (Table 1) of which 17.48% animals were marginally deficient (level 7.9–9.59 mmol/l) and 16.93% were having levels <7.9 µmol/l. Various earlier workers had also reported hypocupraemia in buffalo population of different states of India (Siddique 2011, Sharma *et al.* 2008, Das *et al.* 2009). Devi *et al.* (2014) and Indira and Samuel (2014) reported Cu deficiency among dairy animals of Kerala and Andhra Pradesh. Singh *et al.* (2004), Randhawa *et al.* (2009) and Mircha (2009) had reported comparatively lesser prevalence of hypocupraemia,, i.e. 7.37, 10.13 and 25.3%, respectively, from Punjab. Ozukum (2011) recorded higher prevalence rate (47.63%) of hypocuprosis. Prevalence of copper responsive conditions like haemoglobinuria, leucoderma and chronic diarrhoea in buffaloes from neighbouring state of Punjab is well documented (Randhawa 1993).

District-wise analysis revealed higher level of copper in buffaloes from Jammu (17.55±1.48 µmol/l) followed by Rajouri (13.86±1.41 µmol/l), Poonch (12.79±0.65 µmol/l), Udhampur (10.18±0.66 µmol/l), and Kathua (8.45±0.63 µmol/l) districts (Table 1). District-wise prevalence of hypocupraemia was also higher in subtropical zone of Kathua (85.71%) from areas adjoining Punjab followed by Udhampur (44.44%) and Rajouri (41.93%), Jammu (31.16%) and Poonch (10.71%). The findings of present study, therefore, suggest that primary hypocupraemia is prevalent in buffalo population of Jammu.

Considering the critical level of 10 ppm in diet, 11.76% (2/17) *Sorgum* spp. samples, 55.55% (10/18) corn stover, 22.22% (2/9) *Pennisatum typhoides*, 50% (4/8) fodder tree leaves, 10.25% (4/39) wheat straw and 13.04% (3/23) paddy straw samples were deficient in copper (Table 2). Barseem samples were adequate in Cu. The higher prevalence of copper deficiency among buffaloes from Kathua district could be attributed to low levels of copper in fodders like corn stover and fodder tree leaves fed to animals at time of sampling. Copper deficiency in 50.79 and 58.89% of fodder samples from Punjab were reported by Siddique (2011) and Singh (2013). Sharma *et al.* (2006) reported average value of 10.75±0.52 ppm in fodder samples from Uttar Pradesh.

Zinc: The overall mean value of Zn in buffaloes was 31.27±1.30 µmol/l (Table 1) which was higher than the normal range quoted by Radostits *et al.* (2010) for cattle (12.2 to 18.2 µmol/l). Various other workers have also reported significantly ($P<0.05$) lower level of Zn in buffaloes from different parts of country like Singh *et al.* (2004) (25.50±1.13 µmol/l); Chhabra (2006) (15.46 µmol/l) and Siddique (2011) (24.52 µmol/l). No definite pattern in the level of Zn with age was noticed which was similar to the findings of Randhawa (1999) and Singh *et al.* (2004). Overall prevalence of Zn deficiency was 3.22%. Singh *et al.* (2004) also reported that 2.53% buffaloes from sub-mountaineous regions of Punjab were deficient in Zn. Chhabra (2006) and Ozukum (2011) reported deficiency of zinc in buffaloes (19–21%) from Punjab.

The animals from Udhampur and Kathua district had low level of zinc, i.e. 18.85 and 19.31 µmol/l, respectively compared with 27.30, 30.63 and 39.05 µmol/l in buffaloes from Jammu, Poonch and Rajouri districts (Table 1). Considering the critical level of 40 ppm in diet, 68.75% (11/16) *Sorgum* spp. samples, 15.38% (2/13) barseem, 66.66% (12/18) corn stover, 37.50% (3/8) *Pennisatum typhoides*, 33.33% (2/6) fodder tree leaves, 82.5% (33/40) wheat straw and 13.04% (3/23) paddy straw samples were deficient (Table 2). Chhabra (2006) reported significantly lower average values of Zn in fodder samples from Punjab during winter (7.93 ppm) compared to summer fodders (17.39 ppm). Singh (2013) reported zinc deficiency (critical level <30 ppm) in 30% of fodder samples from Punjab. Sharma *et al.* (2006) reported average value of 25.67 ppm in fodder samples from Uttar Pradesh.

Iron: The level of iron in plasma samples of buffaloes was considerably higher compared with normal range of 17.9 – 35.8 µmol/l reported in cattle (Radostits *et al.* 2010). Various other workers have reported comparable mean value of plasma iron like Lall *et al.* (1994) (60.7 µmol/l), Randhawa (1993) (65.48 µmol/l) and Randhawa *et al.* (2009) (62.2 µmol/l). Singh *et al.* (2003) reported higher levels (158.00 µmol/l) of iron among buffaloes from sub mountainous regions of Punjab. Thus, it can be concluded that elevated level of iron in plasma samples could be due to excess dietary level. Kaneko *et al.* (1999) attributed elevated iron level to refractory anaemia, haemolytic anaemia, iron overload and liver disease.

District-wise, the buffaloes from sub-tropical zone (Jammu and Kathua districts) had significantly higher level of plasma iron, i.e. 71.19 and 72.89 µmol/l, respectively compared to Rajouri (46.48 µmol/l) and Poonch (35.23 µmol/l). The overall prevalence of iron deficiency was 7.05% (Table 1). Thus, results of present study revealed that iron deficiency is rare in livestock due to generally adequate level in pasture. All the fodder samples analyzed were having higher levels of iron (>50 ppm). High dietary Fe affects utilization of Cu, P, Zn and Mn minerals (Suttle 2010). Singh (2013) reported average value of 190.92 µmol/l in fodder samples from Punjab. In addition, the majority of Fe incorporated in tissues is effectively recovered and recycled thereby reducing the maintenance requirement of animal for Fe (NRC 2001).

Manganese: The overall mean value of Mn in buffaloes was below the normal range of 3.30 to 3.50 µmol/l in cattle (Radostits *et al.* 2010). Siddique (2011) reported similar

Table 2. Trace mineral status of fodder samples from various districts of Jammu division.

District	*Sorgum* spp.	Corn stover	Barseem straw	Bajra	Wheat	Rice straw	Leaves of fodder trees	Local grasses
Copper (ppm)								
Jammu	13.0±1.22 (n=16)	15.20±1.41 (n=2)	23.54±2.51 (n=10)	11.28±1.30 (n=5)	14.0±1.08 (n=12)	41.57±7.99 (n=7)	Nil	10.8±0.83 (n=5)
Kathua	–	5.64±0.20 (n=5)	–	–	12.0±2.02 (n=7)	15.60±4.39 (n=6)	10.05±1.21 (n=4)	–
Udhampur	13.40 (n=4)	11.20±2.17 (n=6)	15.20 (n=1)	14.75±1.60 (n=4)	24.92±2.26 (n=8)	18.4±1.24 (n=3)	20.70±7.74 (n=4)	15.50±1.50 (n=2)
Rajouri	–	–	–	–	47.74±5 .43 (n=10)	–	–	46.95±7.47 (n=4)
Doda	–	10.40±5.60 (n=2)	–	–	–	28.0 (n=1)	–	30.73±4.33 (n=15)
Poonch	Oats 38.33±6.25 (n=3)	27.10±15.1 (n=2)	46.53±14.69 (n=3)	Green Wheat 35.66±11.20 (n=3)	23.50±8.90 (n=2)	30.30±5.82 (n=6)	–	19.53±2.33 (n=3)
Total	13.02±1.15 (n=17)	11.46±2.12 (n=18)	27.87±4.23 (n=14)	12.82±1.13 (n=9)	25.02±2.75 (n=39)	28.24±3.66 (n=23)	15.37±4.14 (n=8)	27.32±3.18 (n=29)
Zinc (ppm)								
Jammu	36.72±4.34 (n=15)	26.50±1.14 (n=3)	66.0±9.19 (n=10)	36.44±4.96 (n=5)	26.93±5.68 (n=13)	69.34±12.29 (n=7)	Nil	43.04±2.02 (n=5)
Kathua	–	23.6±4.31 (n=6)	–	–	27.42±4.45 (n=7)	39.63±6.26 (n=6)	21.26±10.66 (n=3)	–
Udhampur	63.20 (n=4)	57.76±20.13 (n=6)	54.2 (n=1)	67.80±16.25 (n=3)	25.37±5.96 (n=8)	65.93±21.54 (n=3)	93.33±5.00 (n=3)	29.90±1.1 (n=2)
Rajouri	–	–	–	–	52.98±7.77 (n=10)	–	–	53.20±4.4 (n=4)
Doda	–	65.70±31.5 (n=2)	–	–	–	78.80 (n=1)	–	61.36±5.85 (n=15)
Poonch	Oats 41.33±4.91 (n=3)	40±17.6 (n=2)	54.0±5.0 (n=2)	Green Wheat 27.06±3.36 (n=3)	29.90±0.1 (n=2)	67.70±4.67 (n=6)	–	38.33±1.52 (n=3)
Total	38.37±4.39 (n=16)	41.81±8.28 (n=18)	63.24±7.15 (n=13)	48.2±8.36 (n=9)	33.37±3.44 (n=40)	61.13±5.41 (n=23)	57.60±17.08 (n=6)	52.52±3.64 (n=29)
Iron (ppm)								
Jammu	188.30±26.23 (n=16)	108.60±19.80 (n=2)	410.0±40.56 (n=10)	156.16±17.43 (n=5)	238.75±20.60 (n=12)	310±31.79 (n=6)	Nil	211.2±31.88 (n=5)
Kathua	–	174.24±8.91 (n=5)	–	–	213.2±25.29 (n=7)	289.93±39.23 (n=6)	237.60±50.86 (n=4)	–
Udhampur	420.2 (n=1)	389.40±97.47 (n=6)	426.6 (n=1)	369.05±57.12 (n=4)	291.62±27.29 (n=8)	334.06±44.04 (n=3)	277.6±12.53 (n=4)	323.8±27.8 (n=2)
Rajouri	–	–	–	–	187.36±30.49 (n=11)	–	–	249.90±24.40 (n=4)
Doda	–	101±5.60 (n=2)	–	–	–	176.8 (n=1)	–	224.34±24.67 (n=15)
Poonch	Oats 126.66±18.14 (n=3)	123.9±20.7 (n=2)	435.6±53.6 (n=3)	Green Wheat 13.6±20.63 (n=3)	1166.70±31.9 (n=2)	211.2±40.51 (n=6)	–	221.8±68.21 (n=3)
Total	202.16±28.16 (n=17)	227.91±44.61 (n=17)	417.31±30.27 (n=14)	250.77±45.02 (n=9)	227.40±13.53 (n=41)	274.78±20.30 (n=22)	257.6±25.39 (n=8)	232.22±15.93 (n=29)
Manganese (ppm)								
Jammu	42.36±9.99 (n=15)	25.4±5.52 (n=3)	85.84±12.88 (n=10)	38.92±10.01 (n=5)	32.78±2.01 (n=12)	279.16±48.07 (n=6)	Nil	56.15±11.65 (n=4)
Kathua	–	35.53±10.76 (n=6)	–	–	63.62±4.27 (n=7)	234.73±45.31 (n=6)	65.46±12.63 (n=3)	–
Udhampur	42.4 (n=1)	35.93±6.27 (n=6)	44.8 (n=1)	42.25±7.45 (n=4)	51.4±8.98 (n=8)	364.66±49.48 (n=3)	48.53±6.76 (n=3)	81.8±22.0 (n=2)
Rajouri	–	–	–	–	31.58±4.44 (n=10)	–	–	46.15±4.99 (n=4)
Doda	–	40.1±2.90 (n=2)	–	–	–	17.8 (n=1)	–	60±9.60 (n=15)
Poonch	Oats 48.0±16.07 (n=3)	71.8	132.73±35.37 (n=3)	Green Wheat 99.26±37.70 (n=3)	29.6±10.40 (n=2)	349.86 (n=6)	–	41.73±25.16 (n=3)
Total	42.36±9.35 (n=16)	36.50±4.61 (n=18)	92.95±12.84 (n=14)	40.40±6.12 (n=9)	41.66±3.09 (n=39)	286.10±25.29 (n=22)	57.00±7.44 (n=6)	57.07±5.82 (n=28)

levels (1.83 µmol/l) in buffaloes from Punjab. Wide range in the level of Mn in buffaloes (non-detectable to 8.08 µmol/l) had also been reported by Bedi and Khan (1989). Randhawa (1993) and Singh *et al.* (2004) reported mean values of 10.04 and 3.48 µmol/l in buffaloes which were significantly (P<0.05) higher than the values observed in present study. Significantly lower values of 0.45 and 0.82 µmol/l were reported by Randhawa (1999) and Chhabra *et al.* (2007) in buffaloes from Punjab. Hidiroglou (1997) reported considerable variation in Mn level from normal animals due to analytical inadequacy, dietary concentration and individual variability (Underwood and Suttle 1999).

Age related significant (P<0.05) decline in level of Mn in plasma samples of buffaloes was observed which could be due to its important roles in reproduction. Thus, Mn-deficiency can be described as cause of reduced fertility, delayed oestrus and poor growth commonly observed in present study. Overall prevalence of Mn deficiency was 11.97% among the buffaloes after considering the critical level of 0.37 µmol/l in plasma as recommended by Hidiroglou (1979) for cattle. Age wise, 20% of Group- 1 animals were deficient in Mn compared with 12.67 and 7.57% in Group- 2 and Group- 3 animals, respectively (Table 1). District-wise, animals from intermediate zone of Rajouri showed low levels of manganese with highest prevalence (28.57%) of deficiency compared with other district animals. Poor nutrition could be responsible for the higher prevalence of deficiency.

Considering the critical level of 40 ppm in diet, 62.50% (10/16) *Sorgum* spp. samples, 66.66% (12/18) corn stover, 44.44% (4/9) *Pennisestum typhoides*, 16.66% (1/6) fodder tree leaves, 30.76% (12/39) wheat straw and 9.09% (2/22) paddy straw samples were deficient in manganese (Table 2). Barseem samples were adequate in Mn. Chhabra (2006) reported lower average values of Mn in fodder samples from Punjab during winter (15.60 ppm) compared to summer fodders (19.25 ppm). Singh (2013) reported manganese deficiency (critical level <30 ppm) in 22.22% of fodder samples from Punjab.

Cobalt: The overall mean value of cobalt in plasma samples of buffaloes was 3.35±0.29 µmol/l (Table 1). Earlier study conducted on buffaloes from sub-mountainous regions of Punjab reported average value of 11.54 µmol/l. Randhawa (1999) reported mean plasma level of 9.68 µmol/l in buffaloes from unorganised dairy farms. Sharma (1995) reported lower values of 0.17 µmol/l in buffaloes from rural herds. Comparatively higher plasma Co concentration was non toxic because of reported high tolerance of domestic animals to this element. Considering the critical level of <0.03 µmol/l as recommended by Radostits *et al.* (2010), cobalt deficiency in plasma samples was observed in 3.22% of animals (Table 1). Comparatively higher incidence of 19 and 7.59% were reported by Randhawa (1999) and Singh *et al.* (2001) in buffaloes, respectively. McDowell (2003) had listed co-deficiency as one of the many mineral imbalances reported in India. Hussain (2006) reported 45.68% prevalence of Co deficiency in bovines of Maharashtra while Kumar (2006) reported 48.44% prevalence of Co deficiency in bovines of Bihar.

Age related significant (P<0.05) decline in level of cobalt from 4.36 µmol/l in <3 years age group to 3.10 µmol/l and 3.08 µmol/l in 3–6 years and >6 years age groups, respectively was observed (Table 1). Randhawa (1999) reported higher incidence in animals of >6 years age (21.7%) compared to <3 years age (9.52%). Contrary to present findings, McDowell (2003) reported that young animals are most susceptible which could exhibit signs of unthriftiness. Significant difference in the level of cobalt in plasma samples of buffaloes from various districts was observed. The mean value of cobalt in plasma samples of buffaloes from Udhampur (5.03±1.08 µmol/l), Jammu (4.68±0.57 µmol/l) and Poonch (4.08±0.20 µmol/l) were considerably higher than animals from Kathua (2.14±0.29 µmol/l) and Rajouri (0.67±0.07 µmol/l) districts. Therefore, animals from intermediate belt of Kathua and Rajouri districts need to be supplemented with cobalt.

Thus sub-clinical deficiencies of Cu and Mn are prevalent among buffalo population of Jammu region. Fodder analysis revealed wide variation in the level of trace elements among different fodders and also areas. Adequate levels of Fe with low Cu, Zn and Mn among fodder samples were recorded. The study concludes that area specific mineral mixtures need to be framed and supplemented for enhancing the productive and reproductive potential of buffaloes.

REFERENCES

Bedi S P S and Khan S A. 1989. Trace element status of feeds, fodders, animals and soil of Barielly district (UP). *Indian Journal of Animal Nutrition* **6**: 355–58.

Chhabra S. 2006. 'Studies on mineral imbalances in dairy animals with special references to copper, manganese and iodine status in Punjab.' Ph.D dissertation, GADVASU, Ludhiana, India.

Chhabra S, Randhawa S S, Dhliwal P S and Dhillon S K. 2007. Trace mineral profile in dairy cattle. *Indian Veterinary Journal* **84**(8): 878–79.

Das G, Sharma M C and Joshi C. 2009. Status of soil, fodder and serum (cattle) mineral in high rainfall area of NE region. *Indian Journal of Animal Sciences* **79**(3): 306–10.

Das U, Roy S, Roy S, Roy B N, Ghosh S P and Desarkar M K. 1997. Some blood constituents of crossbred cattle in two agro-climatic zones of West Bengal. *Indian Journal of Animal Health* **36**: 11–13.

Devi G, Sharma M C, Dimri U, Shekhar P and Deepa P M. 2014. Micro-mineral status of soils, fodder and cattle from Idukki and Ernakulam districts of Kerala state, India and their interrelation. *International Journal of Advanced Research* **2**(7): 11–15.

Hidiroglou M. 1979. Manganese in ruminant nutrition. *Canadian Journal of Animal Science* **59**: 217–36.

Hussain K. 2006. 'Soil-fodder-animal mineral interaction with special reference to biochemical profile in bovines of Vidarbha region of Maharashtra and efficacy of formulated mineral mixture on health and production.' Ph.D. thesis, IVRI, Izatnagar.

Indira D and Samuel A. 2014. Mineral status of diary buffaloes in West Godavari district of Andhra Pradesh in India. *International Journal of Innovative Research and Development* **3**(5): 358–61.

Kaneko J J, Harvey J W and Bruss M L. 1999. *Clinical Biochemistry of Domestic Animals*. Harcourt Brace and Co. Asia P/C Ltd., Singapore.

Kumar P. 2006. 'Status of mineral in soil-fodder-animal in relation to immunity in bovine of Bihar state and evaluation of efficacy of area specific mineral supplementation'. Ph.D. thesis, IVRI, Izatnagar.

Lall D, Gupta R, Gupta V K and Gupta R. 1994. Blood serum levels of certain mineral elements in lactating buffaloes in relation to forages and soil content. *Indian Journal of Animal Nutrition* **11**: 233–36.

McDowell L R. 2003. *Minerals in Animal and Human Nutrition*. pp. 33–92. 2nd edn. Elsevier Science, B. V. Amsterdam, The Netherlands.

Mircha R. 2009. 'Baseline survey and therapeutic studies on mineral deficiencies in cattle and buffaloes in relation to soil and plant mineral content in Moga district of Punjab.' M.V.Sc. dissertation, GADVASU, Ludhiana, India.

NRC. 2001. *Minerals. Nutrient requirements of domestic animals. Nutrient Requirements of Dairy Cattle.* 7th edn, pp. 105–161. National Academy Press, Washington DC.

Ozukum S. 2011. 'Surveillance, clinico-haematological and therapeutic studies on mineral imbalances in dairy animals of Bathinda district of Punjab.' M.V.Sc. dissertation, GADVASU, Ludhiana, India.

Radostits O M, Gay C C, Blood D C and Hinchcliff K W (Ed). 2010. *Veterinary Medicine: A Textbook of Diseases of Cattle, Sheep, Pig, Goat and Horses*. W B Saunders Harcourt Publishers Ltd, London.

Randhawa C S. 1999. 'Epidemiological, immunopathological and therapeutic studies in dairy animals with reference to copper and iodine.' Ph.D. dissertation, Punjab Agricultural University, Ludhiana, India.

Randhawa C S, Pal H, Randhawa S S and Uppal S K. 2009. Influence of age, season, lactation on haematology and iron biochemistry of crossbred cattle. *Indian Journal of Animal Sciences* **79**: 1007–10.

Randhawa S S. 1993. 'Clinico-biochemical studies on phosphorus, copper and molybdenum status in dairy animals with hemoglobinuria, pica and leucoderma and their interaction with agro-ecological conditions.' Ph.D. dissertation, C S Azad University of Agriculture and Technology, Kanpur.

Sharma M C, Joshi C and Das G. 2008. Therapeutic management of copper deficiency in buffalo heifers: Impact on immune function. *Veterinary Research Communication* **32**(1): 49–63.

Sharma S P. 1995. 'Epidemiological, clinico-biochemical and therapeutic studies on fluorosis in diary animals in Punjab.' M.V.Sc. dissertation, Punjab Agricultural University, Ludhiana, India.

Siddique N. 2011. 'Clinico-biochemical indicators of mineral deficiencies in farm animals.' M.V.Sc dissertation, GADVASU, Ludhiana, India.

Singh R. 1989. 'Studies on physiological and biochemical constituents of blood during different stages of pregnancy in buffaloes (*Bubalus bubalis*).' M.V.Sc. dissertation, Punjab Agricultural University, Ludhiana, India.

Singh R, Randhawa S S and Arora C L. 2004. Trace element status of buffaloes from sub-mountainous region of Punjab in relation to soil and fodder. *Indian Journal of Veterinary Medicine* **24**(1): 23.

Singh S. 2013. 'Studies on efficacy of area specific mineral mixture on general health, production and reproduction in dairy animals of central zone of Punjab.' M.V.Sc. dissertation, GADVASU, Ludhiana, India.

Suttle N F. 2010. *Mineral Nutrition of Livestock*. 4th edn. Commonwealth Agricultural Bureau International, London.

Underwood E J and Suttle N F. 1999. *The Mineral Nutrition of Livestock*. pp. 185–212. CABI Publishing, CAB International, Wallingford, Oxon, UK.