



Mineral profile of water buffaloes under different physiological and production status in Western Maharashtra

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ABSTRACT

The present study was undertaken to assess the mineral status of buffaloes in different physiological and production status in 4 districts of Western Maharashtra. Blood samples randomly collected from lactating buffaloes, non-lactating buffaloes and buffalo calves were analyzed for minerals including calcium, phosphorus, magnesium, copper, zinc, iron and cobalt. The mean concentration of plasma macro-minerals was within the normal range with marginal deficiency of calcium. Micro-mineral analysis revealed significant deficiency of copper, zinc and cobalt in lactating buffaloes followed by non-lactating buffaloes and least in buffalo calves. Marginal deficiency of plasma iron was observed and was non-significantly different among different physiological groups of buffaloes. The present findings indicate the significance of developing area specific mineral mixture.

Key words: Buffalo, Mineral profile, Physiological state, Western Maharashtra

The significance of mineral nutrition relative to maintenance of productivity and prevention of deficiency has been recognized for quite some time (McDowell 1992). Due to changing trends, livestock as well as agriculture farming has been evolving as a common cause for developing deficiency of one or more minerals in animals thereby affecting their fertility and productivity (Guyot *et al.* 2009, Horvath and Reid 1980). The mineral status of animals depend on the type of feed, physiological status of animal, soil and fodder mineral composition in that region and agro-climatic conditions in the region (Sharma *et al.* 2004). The sum of maintenance, lactation, pregnancy and growth requirements is the true requirement of tissue for mineral also called as requirement for absorbed mineral, which must be supplied in diet (NRC 2001).

Focus on maximum production (output) without optimal nutrition (input) over a period of time culminates in mineral imbalance in the body (throughput) leading to physiological and pathological consequences with high mortality, unthriftiness, unsatisfactory growth and decline in production and fertility of farm animals. To overcome severe economic losses occurring due to mineral deficiency, regular assessment of mineral profile is an important management strategy (Herd 2011).

Taking these facts into consideration, the present work

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was undertaken for assessment of mineral profile of water buffaloes with respect to different physiological and production status.

MATERIALS AND METHODS

Study area and subjects: Western Maharashtra comprises Kolhapur, Sangli, Satara, Solapur and Pune districts coming under several agro-climatic zones, viz. western ghat zone, sub montane zone (transition zone 1), western Maharashtra plain zone (transition zone 2), and western Maharashtra scarcity zone (Department of Agriculture 2013). There are wide variations in the topography, soil type, temperature and rainfall among various districts as well as among tehsils of a district. Typically, the water buffaloes are major contributor to milk production in the area. Therefore these water buffaloes were taken as possible animals suffering from imbalance. A total of 172 blood samples of buffaloes in different stages (lactating, non-lactating and calves) from four districts of Western Maharashtra (Table 1) were analyzed for calcium, phosphorus, magnesium, copper, zinc,

Table 1. Total number of plasma samples analyzed from Western Maharashtra

District	Lactating buffaloes	Non-lactating buffaloes	Buffalo calves	Total
Satara	21	12	7	40
Solapur	16	11	8	35
Sangli	24	18	13	55
Pune	22	12	8	42
Total	83	53	36	172

iron and cobalt. Random blood samples from water buffaloes belonging to different physiological and production status were collected from four districts of Western Maharashtra. Blood was collected in heparinized vials and subjected to centrifugation for harvesting plasma. Collected plasma samples were properly labeled and subsequently stored and later processed for analysis of macro- and micro-minerals.

Estimation of plasma macro-minerals: Plasma calcium (Ca) was estimated by O-Cresolphthalein Complexone (OCPC), end point assay (Span Diagnostics Ltd., India). Plasma inorganic phosphorus (iP) was estimated by UV Molybdate, end point assay (Span Diagnostics Ltd., India). Plasma magnesium (Mg) was estimated by Calmagite method (Crest Biosystems, India).

Estimation of plasma micro-minerals: All the plasma samples were wet digested as per Kolmer *et al.* (1951). Final volume (0.5 ml) of filtrate was made up to 15 ml with triple distilled deionized water after making solution lukewarm. During digestion of plasma samples, simultaneous digestion of reagent blanks were also undertaken with final volume of 15 ml to have blank.

Atomic Absorption Spectrophotometer (Model No. ECIL 4141) manufactured by Electronic Corporation of India (ECIL), Hyderabad was used for analysis of plasma micro-minerals. The concentration of minerals was expressed in parts per million (ppm). At least 3 standards (Sigma Aldrich) for each micro-mineral of known concentration were used for calibration and then the unknown test samples were analyzed. Final reading was calculated after compensation of the dilution factor.

Statistical analysis: Values obtained from different groups of buffaloes for macro- and micro-minerals were analyzed for mean, standard error and analysis of variance (ANOVA) by using SPSS software (Version 16). The significance was observed at $P < 0.05$.

RESULTS AND DISCUSSION

The mean values of plasma macro- and micro-minerals are presented in Tables 2, 3.

Macro-minerals

Plasma calcium (Ca): Mean \pm SE values of plasma calcium (mg/dl) in lactating, non-lactating buffaloes and buffalo calves were 8.78 ± 0.18 , 9.19 ± 0.11 and 9.14 ± 0.19 respectively. Significantly ($P < 0.05$) lower plasma calcium was observed in lactating and non-lactating buffaloes of Satara district compared to buffalo calves. Among buffalo calves, significantly ($P < 0.05$) lower calcium was observed in Sangli district followed by Pune and Solapur district compared to Satara district. No significant difference was observed in plasma calcium values between lactating and non-lactating buffaloes of four districts.

The mean plasma Ca concentrations among lactating buffalo revealed marginal deficiency compared to the normal physiological range of 9–12 mg/dl (Underwood and Suttle 1999). The present study revealed slightly lower plasma Ca concentrations in lactating buffaloes compared to non-lactating buffaloes and buffalo calves which was in agreement with Bhagat *et al.* (2017). The lower plasma Ca levels in lactating buffaloes might be observed due to high demand of absorbed Ca per litre of milk produced. As per NRC (2001), lactating cattle needs 1.37 g of Ca/kg of milk produced in addition to maintenance requirement.

Plasma inorganic phosphorus (iP): Mean \pm SE values of plasma inorganic phosphorus (mg/dl) in lactating, non-lactating buffaloes and buffalo calves were 4.68 ± 0.12 , 4.91 ± 0.18 and 4.89 ± 0.12 respectively. Significantly ($P < 0.05$) lower plasma iP was observed in lactating buffaloes of Satara district compared to non-lactating buffaloes and buffalo calves which was in agreement with Sharma *et al.* (2015) and Bhagat *et al.* (2017). No significant

Table 2. Mean \pm SE (mg/dl) values of plasma calcium, inorganic phosphorus and magnesium in buffaloes from different districts of Western Maharashtra

District	Calcium			Inorganic Phosphorus			Magnesium		
	Buffalo		Calves	Buffalo		Calves	Buffalo		Calves
	Lactating	Non-lactating		Lactating	Non-lactating		Lactating	Non-lactating	
Satara	9.10 ± 0.23^x (8.24–9.92)	9.21 ± 0.13^x (8.77–9.65)	9.96 ± 0.26^{by} (9.18–10.86)	4.52 ± 0.16^x (3.88–5.05)	4.87 ± 0.21^{abxy} (4.05–5.37)	5.28 ± 0.17^y (4.75–5.88)	2.18 ± 0.16 (1.75–2.81)	2.86 ± 0.3 (1.95–3.96)	2.86 ± 0.32 (1.65–3.51)
Solapur	9.04 ± 0.47 (7.27–10.4)	9.05 ± 0.26 (8.31–9.77)	9.17 ± 0.37^{ab} (8.33–10.9)	4.42 ± 0.22 (3.66–5.16)	4.4 ± 0.25^a (3.83–5.27)	4.82 ± 0.25 (3.83–5.92)	2.23 ± 0.19 (1.78–3.1)	2.47 ± 0.3 (1.7–3.3)	2.56 ± 0.19 (1.93–3.36)
Sangli	8.09 ± 0.39 (6.6–9.39)	9.29 ± 0.35 (8.3–10.28)	8.29 ± 0.24^a (7.54–9.06)	4.62 ± 0.2 (3.92–5.18)	5.75 ± 0.61^b (4.4–7.4)	4.65 ± 0.31 (3.83–5.96)	2.41 ± 0.2 (1.85–3.11)	2.43 ± 0.29 (1.66–3.1)	2.4 ± 0.18 (1.76–2.81)
Pune	8.86 ± 0.29 (7.53–10.21)	9.22 ± 0.18 (8.75–10.03)	9.13 ± 0.32^{ab} (8.43–10.13)	4.98 ± 0.28 (3.62–6.05)	4.69 ± 0.13^a (4.16–5)	4.80 ± 0.16 (4.27–5.31)	2.27 ± 0.12 (1.85–3.11)	2.39 ± 0.24 (1.96–3.56)	2.29 ± 0.2 (1.78–2.91)
Overall mean	8.78 ± 0.18 (6.6–10.4)	9.19 ± 0.11 (8.3–10.28)	9.14 ± 0.19 (7.54–10.9)	4.68 ± 0.12 (3.62–6.05)	4.91 ± 0.18 (3.83–7.4)	4.89 ± 0.12 (3.83–5.96)	2.27 ± 0.08 (1.75–3.11)	2.54 ± 0.13 (1.66–3.96)	2.54 ± 0.11 (1.65–3.51)

^{a,b}Mean \pm SE in a column with different superscripts differ significantly ($P < 0.05$). ^{x,y}Mean \pm SE in a row with different superscripts differ significantly ($P < 0.05$). Values in parenthesis represent range.

Table 3. Mean±SE (µg/ml) values of plasma copper, zinc, iron and cobalt in buffalo in different districts of Western Maharashtra

District	Copper			Zinc			Iron			Cobalt		
	Buffalo			Buffalo			Buffalo			Buffalo		
	Lactating	Non-lactating	Calves	Lactating	Non-lactating	Calves	Lactating	Non-lactating	Calves	Lactating	Non-lactating	Calves
Satara	0.55±0.02 ^x (0.4-0.75)	0.68±0.05 ^{axy} (0.4-1.1)	0.80±0.12 ^y (0.45-1.4)	0.95±0.08 ^b (0.45-2)	1.02±0.12 ^b (0.5-1.8)	1.23±0.11 ^c (0.81-1.7)	1.56±0.1 ^a (0.7-2.5)	1.56±0.1 ^a (0.9-2)	1.45±0.18 (0.8-2.15)	0.06±0.003 (0.04-0.1)	0.079±0.003 ^b (0.04-0.098)	0.052±0.007 (0.024-0.089)
Solapur	0.61±0.05 ^x (0.25-1.1)	0.95±0.03 ^{by} (0.7-1.05)	0.84±0.05 ^y (0.65-1.15)	0.7±0.07 ^a (0.4-1.6)	0.84±0.07 ^{ab} (0.55-1.2)	0.91±0.1 ^{ab} (0.65-1.3)	2.30±0.15 ^{by} (1.25-3.7)	1.73±0.18 ^{abx} (0.75-2.55)	1.68±0.2 ^x (0.85-2.6)	0.054±0.004 (0.03-0.11)	0.066±0.004 ^{ab} (0.03-0.085)	0.061±0.008 (0.03-0.11)
Sangli	0.56±0.07 ^x (0.3-1.5)	0.87±0.08 ^{by} (0.45-1.2)	0.68±0.08 ^{xy} (0.35-1.1)	0.63±0.04 ^a (0.35-1.2)	0.70±0.06 ^a (0.35-1.2)	0.67±0.06 ^a (0.4-1)	1.30±0.14 ^a (0.65-2.2)	1.61±0.19 ^a (0.55-2.45)	1.55±0.14 (1.1-2.6)	0.064±0.007 (0.032-0.13)	0.071±0.011 ^b (0.039-0.16)	0.058±0.005 (0.036-0.085)
Pune	0.62±0.04 ^x (0.4-1.1)	0.93±0.04 ^{by} (0.7-1.2)	0.89±0.02 ^y (0.8-1)	0.7±0.06 ^{ax} (0.45-1.75)	0.89±0.05 ^{abxy} (0.6-1.15)	1.01±0.07 ^{bcy} (0.85-1.5)	1.69±0.14 ^a (0.85-3.15)	2.19±0.17 ^b (0.9-2.9)	1.75±0.2 (1.05-2.5)	0.064±0.003 (0.045-0.12)	0.052±0.003 ^a (0.028-0.075)	0.061±0.005 (0.048-0.095)
Overall mean	0.58±0.02 (0.25-1.5)	0.85±0.03 (0.4-1.2)	0.80±0.04 (0.35-1.4)	0.76±0.03 (0.35-2)	0.87±0.04 (0.35-1.8)	0.94±0.05 (0.4-1.7)	1.70±0.07 (0.65-3.7)	1.78±0.08 (0.55-2.9)	1.61±0.08 (0.8-2.6)	0.06±0.002 (0.032-0.13)	0.067±0.003 (0.028-0.16)	0.058±0.003 (0.024-0.11)

^{a, b}Mean±SE in a column with different superscripts differ significantly (P<0.05). ^{x, y}Mean±SE in a row with different superscripts differ significantly (P<0.05). Values in parenthesis represent range.

difference was observed in remaining three districts among different buffalo groups. Plasma iP was significantly (P<0.05) lower in non-lactating buffaloes of Pune and Solapur district followed by Satara district while significantly (P<0.05) higher plasma iP was observed in non-lactating buffaloes of Sangli district. No significant difference (P<0.05) in plasma iP values was observed in lactating buffaloes and buffalo calves among different districts.

The mean plasma iP concentrations in buffalo were with in normal range of 4-6 mg/dl (NRC 2001). No significant difference was observed in plasma iP concentrations in buffaloes and calves from four districts of study area. Compared with Ca, plasma iP varies diurnally between 4 and 6.5 mg/dl (Forar *et al.* 1982). McAdam and O'Del (1982) reported only small week to week variations in plasma iP concentrations in lactating cattle with slight to significantly higher plasma iP concentration throughout lactation in young lactating cattle.

Plasma magnesium (Mg): Mean±SE values of plasma magnesium (mg/dl) in lactating, non-lactating buffaloes and buffalo calves were 2.227±0.08, 2.54±0.13 and 2.54±0.11 respectively. The overall Mg concentration in plasma samples of buffaloes were within normal range of 1.8-2.4 mg/dl (NRC 2001). Range of plasma Mg in different categories of buffaloes indicates adequate Mg concentration in blood. No significant difference (P<0.05) was observed among different groups and different districts with respect to plasma magnesium concentration.

Maintenance of normal plasma Mg concentration is totally dependent on absorption of dietary Mg (Radostits *et al.* 2000). Cool climate pastures growing rapidly and having high moisture reduces the Mg uptake and hence commonly deficient in Mg (NRC 2001). Garg *et al.* (2007) reported adequate Mg concentration in forages of Kolhapur district of Western Maharashtra. Normal plasma Mg in buffaloes of study region indicates the adequacy of dietary Mg. Also wallowing habit of buffaloes in mud, contamination of pasture plants could result in significant consumption of soil minerals like Mg by buffaloes (Limpoka *et al.* 1982).

Micro-minerals

Plasma copper (Cu): Mean±SE values of plasma copper (µg/ml) in lactating, non-lactating buffaloes and buffalo calves were 0.58±0.02, 0.85±0.03 and 0.8±0.04 respectively. No significant difference (P<0.05) in plasma Cu was observed in lactating buffaloes and buffalo calves among different districts while significantly (P<0.05) higher Cu concentration was observed in non-lactating buffaloes of Solapur, Sangli and Pune district. Significantly (P<0.05) lower Cu concentration was observed in non-lactating buffaloes of Satara district. Among different buffalo groups, significantly (P<0.05) lower Cu was observed in lactating buffaloes while significantly higher (P<0.05) Cu was observed among buffalo calves from Satara, Solapur and Pune districts and non-lactating buffaloes from Solapur,

Sangli and Pune districts. Copper deficiency was highest in lactating buffaloes (46.98%) followed by non-lactating buffaloes (35.84%) while lowest deficiency (16.66%) was observed in buffalo calves among all the districts of study area. The overall prevalence of Cu deficiency in buffaloes of study region was 37.2%. Kumar (2006) reported 44.37% prevalence of Cu deficiency in bovines of Bihar while Hussain (2006) revealed 36.20% prevalence of Cu deficiency in bovines of Vidarbha. Devi *et al.* (2014) and Indira and Samuel (2014) also reported deficient status of Cu in dairy animals of Kerala and Andhra Pradesh. Copper deficiency is the second most common mineral deficiency of cattle around the world (Wikse *et al.* 1992). Higher prevalence of Cu deficiency in buffaloes of different physiological status might be due to dietary deficiency of copper. The major symptoms of Cu deficiency like anemia, depigmentation of hairs, decreased weight gain, infertility were observed in buffaloes from study area.

Plasma zinc (Zn): Mean \pm SE values of plasma zinc (μ g/ml) in lactating, non-lactating buffaloes and buffalo calves were 0.76 ± 0.03 , 0.87 ± 0.04 and 0.94 ± 0.05 respectively. Significantly ($P<0.05$) higher plasma Zn concentrations were observed in lactating buffaloes of Satara district while significantly lower values were observed in Solapur, Sangli and Pune districts. With respect to non-lactating buffaloes and buffalo calves, significantly ($P<0.05$) higher Zn values were observed in Satara district while significantly ($P<0.05$) lower Zn values were observed in Sangli district. Plasma Zn status of Pune district revealed significantly ($P<0.05$) higher concentration of Zn in buffalo calves while significantly ($P<0.05$) lower values were observed in lactating buffaloes. The overall prevalence of Zn deficiency was highest in lactating buffaloes (34.93%) followed by 20.75% in non-lactating buffaloes while lowest prevalence of 16.66% in buffalo calves.

Mean concentration of plasma Zn in lactating buffaloes was significantly lower than their non-lactating counterparts and calves. The Zn content of milk is about 4 mg/kg and so lactational requirement of Zn may be very large in lactating animals compared to non-lactating bovines (Osis *et al.* 1972, Schwarz and Kirchgessner 1975). The plasma concentration of Zn in bovines of Western Maharashtra ranged between 0.35–1.8 μ g/ml against critical limit of 0.6–0.8 μ g/ml (McDowell 1987) with overall 26.74% prevalence of Zn deficiency. The deficient Zn status in buffaloes of study region might be attributed to deficiency of Zn in soil and fodders of that area as well as increased dietary requirements to meet demands of lactation (Anton *et al.* 2013). Hussain (2006) reported 61.2% prevalence of Zn deficiency in bovines of Vidarbha region of Maharashtra. Devi *et al.* (2014) and Indira and Samuel (2014) also reported lower concentrations of serum Zn in dairy animals of Kerala and Andhra Pradesh.

Plasma iron (Fe): Mean \pm SE values of plasma iron (μ g/ml) in lactating, non-lactating buffaloes and buffalo calves were 1.70 ± 0.07 , 1.78 ± 0.08 and 1.61 ± 0.08 respectively. With respect to lactating buffaloes, plasma Fe concentrations

were significantly ($P<0.05$) higher in Solapur district while significantly lower ($P<0.05$) concentrations were observed in Satara, Sangli and Pune districts. Significantly ($P<0.05$) higher plasma Fe values were observed among non-lactating buffaloes of Pune district while significantly ($P<0.05$) lower Fe values were observed in Satara and Sangli districts. No significant ($P<0.05$) difference in plasma Fe values among different groups of buffaloes was observed in Satara, Sangli and Pune districts. While in Solapur district, significantly ($P<0.05$) higher Fe values were observed in lactating buffaloes compared to non-lactating buffaloes and buffalo calves. The prevalence of iron deficiency was 8.43% in lactating, 5.66% in non-lactating buffaloes and 5.55% in buffalo calves.

The overall prevalence of Fe deficiency in buffaloes of study region was 6.97%. The mean plasma Fe concentration in buffaloes ranged between 0.55–2.6 μ g/ml against critical limit of 0.89 μ g/ml (McDowell 1987). Iron deficiency in adult cattle is very rare because of their reduced requirements and the ubiquitous availability of Fe in nature and soil contamination of forages that ensures the fulfillment of Fe requirements of cattle (Underwood 1981). Bhagat *et al.* (2017) revealed adequate concentrations of serum Fe in dairy animals from Sindhudurg district. Also the majority of Fe incorporated in tissues is effectively recovered and recycled thereby reducing the maintenance requirement of animal for Fe (NRC 2001). The higher plasma Fe concentrations in buffaloes might be attributed to adequate Fe content in soils and fodder. Negligible deficiency of Fe in bovines had been reported by Kumar (2006) in Bihar (4.06%) and by Hussain (2006) in Vidarbha (7.9%).

Plasma cobalt (Co): Mean \pm SE values of plasma cobalt (μ g/ml) in lactating, non-lactating buffaloes and buffalo calves were 0.06 ± 0.002 , 0.067 ± 0.003 and 0.058 ± 0.003 respectively. No significant ($P<0.05$) difference in plasma Co values were observed among different districts as well as in groups of lactating buffaloes and buffalo calves. In non-lactating buffaloes, significantly ($P<0.05$) higher plasma Co values were observed in Satara and Sangli district while significantly ($P<0.05$) lower values were observed in Pune district. The per cent prevalence of Co deficiency was 24.09, 18.86 and 22.22% in lactating, non-lactating buffaloes and buffalo calves respectively.

The plasma Co concentration in buffaloes ranged between 0.01–0.16 μ g/ml against the critical limit of 0.02–0.16 μ g/ml (McDowell 1992). The overall prevalence of Co deficiency in buffaloes was 27.32% with highest deficiency in lactating buffaloes. Cobalt deficiency is the most severe mineral limitation to the grazing livestock in tropical countries (McDowell and Conrad 1990). Hussain (2006) reported 45.68% prevalence of Co deficiency in bovines of Vidarbha while Kumar (2006) reported 48.44% prevalence of Co deficiency in bovines of Bihar. Sharma and Joshi (2004) reported Co deficiency in soil, fodder and bovine serum samples from Garwhal region of Uttarakhand state.

Study concluded that deficiency of calcium and micro-

minerals is prevalent in lactating buffaloes compared to non-lactating buffaloes while mineral deficiency was least in buffalo calves. Higher deficiency of Cu, Zn and Co in different groups of buffaloes indicates dietary deficiency and traces the importance of fortification of diet with deficient micro-minerals in order to avoid deficiency and subsequent losses in production, growth and reproduction of buffaloes in the study region.

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