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Research Article

ASSESSMENT OF SEASONAL CHANGES IN COPPER AND ZINC CONTENT IN SOIL, FEED, FODDER AND SERUM OF LIVESTOCK FROM SOLAPUR DISTRICT OF MAHARASHTRA

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Abstract: This investigation was undertaken to assess the Copper (Cu) and Zinc (Zn) content of soil, feed, fodder and serum in Solapur district of Maharashtra, during different seasons of the year. AAS (Atomic Absorption Spectrophotometry) was used to estimate the mineral contents of samples. In all tehsils the overall mean content of Cu in soil, feed, fodder and serum samples was above critical value. In this study, overall mean Zn content in soil samples from all tehsils was below critical value whereas overall mean Zn content in animal sera of all tehsils was above critical value. Feed and fodder of Madha, feed from Mohol and feed from Akkalkote showed overall mean Zn values below critical value. The Cu content in soil, feed, fodder and serum samples from different seasons was above critical value. Percent Deficient Samples (PDS) for Cu were 3.96 in soil, 5.30 in feed,10.64 in fodder and 26.39 in serum samples; whereas PDS for Zn were 66.67 in soil, 59.09 feed, 41.84 in fodder, 14.81 in serum samples, respectively. Highest PDS for Cu in serum was seen in Mohol tehsil while highest PDS for Zn in serum was observed in Akkalkote tehsil. To conclude, it is necessary to supplement these area specific minerals depending upon deficiency in order keep animals healthy and maximize their production.

Keywords: *Copper, Zinc, Cattle, Mineral, Solapur*

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Introduction

India has 18% of the world's bovine population and is the leader with regards to milk production [1]. However, individual animal milk productivity has been reported to be low which could be due to malnourishment and mineral deficiency [2]. Minerals are essential for animal health and production [3]. Additionally, minerals play significant role in number of digestives, physiological and biosynthetic processes of animal body [4, 5]. Mineral deficiencies can result in suboptimal performances and reproductive inefficiencies [5, 6]. The mineral Copper (Cu) has role in immune defense, neutralization of free radicals, growth and reproduction [7, 8]. The mineral Zinc (Zn) is involved in immune functions, reproduction, growth, thyroid hormone secretion and preventing oxidative stress [7, 9]. Both Cu and Zn are crucial for udder immunity/ defense against mastitis. Importantly, lower levels of Cu and Zn may result or predispose animals to repeat breeding and anoestrus [7].

Milk producing animals in India are maintained mostly on grazing and crop residues available at farm, with little or no supplementation of mineral mixture [10, 11]. It was reported that Indian cattle reared under smallholder production system are deficient in most of the minerals [12]. The mineral content of soil, feeds and forage is area specific. Thus, it is essential to access mineral levels from serum, soil, feed and forages in different seasons to estimate the year-round mineral requirements of livestock of a particular area. Current investigation was undertaken to estimate the Cu and Zn content in soil, feed, fodder and serum samples of Solapur district through different seasons.

Materials and Methods

Sample collection

The present study was carried out in Solapur district of Maharashtra. Representative samples of soil, feed, fodder and animal serum were collected randomly from Jat, Tasgaon and Palus tehsils of Solapur district. Soil samples were collected with the help of pickaxe and trowel and processed for analysis of Cu and Zn as described previously [13-16]. Samples of concentrate mixtures/ ingredients and roughages were collected once during each season by visiting individual families. Feed and fodder samples were processed for analysis of Cu and Zn as described previously [13-16]. Serum samples were collected from animals (cattle and buffalo) of each visited farmer family under study, once in each season. The serum samples were stored at -20°C until analysis.

Sample processing, mineral estimation and data analysis

The samples (soil, feed/ fodder and serum) were digested using the method described by Franeck (1992) [17], Trolson (1969) [18] and Kolmer *et al*., (1951) [19] respectively. Simultaneous digestions of reagent blanks were also undertaken. Estimation of Cu and Zn in the samples was done using Atomic absorption spectrophotometer (AAS) (ELICO, Ltd, Hyderabad, India). The percent prevalence was calculated using reported critical values of corresponding minerals in soils, feed, fodder and animal (cattle). Statistical analysis was carried out as per Snedecor and Cochran, 1994 [20] using Web Agricultural Statistical Package (WASP) of ICAR, Goa.

Table-1 *Mean ± SE levels of Copper (Cu) in soil, feed, fodder and serum samples of Solapur district during different seasons*

Soil (in ppm)					Feed (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Madha	7.54± 0.89^{a}	7.04± 0.15^{a}	6.84± 0.10^{a}	7.13± 0.39^{a}	Madha	25.32±0.89^{a}	21.30±1.03^{b}	21.20±0.83^{b}	20.34±0.86^{a}
Mohol	7.13±0.25^{a}	6.99±0.11^{a}	6.40±1.67^{a}	6.83±0.55^{a}	Mohol	21.82±0.58^{a}	14.76±2.26^{b}	18.13±0.30^{c}	16.77±0.58^{ab}
Sangola	7.35±0.05^{a}	6.98±0.11^{a}	6.93±0.83^{a}	7.05±0.34^{a}	Sangola	19.76±0.28^{a}	18.14±2.66^{a}	17.16±2.52^{a}	17.83±0.27^{b}
Akkalkote	7.32±.64^{a}	7.14±0.23^{a}	6.91±0.50^{a}	7.11±0.09^{a}	Akkalkote	23.49±2.61^{a}	20.55±0.43^{a}	17.67±3.14^{a}	20.27±0.53^{b}

Fodder (in ppm)					Serum (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Madha	19.77±4.42^{a}	18.44±1.12^{a}	15.68±3.49^{a}	17.35±2.61^{a}	Madha	1.18±0.24^{a}	1.10±0.16^{a}	1.09±0.22^{a}	1.13±0.12^{a}
Mohol	16.54±1.59^{a}	14.25±0.67^{a}	14.94±2.12^{a}	15.28±1.18^{ab}	Mohol	1.34±0.36^{a}	1.28±0.33^{a}	1.02±0.25^{a}	1.21±0.17^{a}
Sangola	13.48±0.98^{a}	12.43±0.39^{a}	10.43±1.22^{a}	11.89±0.75^{bc}	Sangola	1.17±0.28^{a}	1.05±0.25^{a}	0.90±0.20^{a}	1.03±0.14^{a}
Akkalkote	14.41±1.18^{a}	13.68±1.16^{a}	13.07±0.26^{a}	13.88±1.03^{c}	Akkalkote	1.28±0.26^{a}	1.24±0.31^{a}	1.11±0.32^{a}	1.21±0.17^{a}

Similar superscripts in rows indicate non-significant differences whereas, dissimilar superscripts indicate significant differences among the seasons at 5% or 1% level

Table-2 *Mean ± SE levels of Zinc (Zn) in soil, feed, fodder and serum samples of Solapur district during different seasons*

Soil (in ppm)					Feed (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Madha	1.9± 0.52^{a}	1.17±0.12^{b}	0.97±0.19^{b}	1.38±0.24^{a}	Madha	34.92±2.18^{a}	28.56±1.29^{b}	20.87±0.91^{c}	28.13±1.72^{a}
Mohol	2.26±0.34^{a}	1.18±0.11^{b}	0.75±0.23^{b}	1.43±0.23^{a}	Mohol	32.22±0.97^{a}	27.64±2.49^{b}	25.56±5.64^{a}	28.30±2.31^{a}
Sangola	1.73±0.05^{a}	1.53±0.14^{b}	0.63±0.14^{c}	1.38±0.14^{a}	Sangola	37.73±5.66^{a}	29.56±4.44^{b}	25.68±1.92^{c}	31.23±2.90^{a}
Akkalkote	1.19±0.11^{a}	0.99±0.08^{a}	0.62±0.22^{b}	0.97±0.07^{a}	Akkalkote	32.29±6.47^{a}	27.96±4.74^{b}	24.83±3.29^{b}	28.48±3.67^{a}

Fodder (in ppm)					Serum (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Madha	29.47±2.08^{a}	22.67±1.72^{b}	28.88±5.43^{c}	28.62±3.42^{a}	Madha	1.56±0.09^{a}	1.51±0.14^{a}	0.82±0.04^{b}	1.38±0.20^{a}
Mohol	41.54±3.20^{a}	28.72±1.29^{b}	40.28±6.10^{a}	37.34±3.86^{a}	Mohol	1.44±0.13^{a}	1.18±0.11^{a}	1.11±0.07^{a}	1.28±0.10^{a}
Sangola	36.16±5.26^{a}	34.19±1.83^{a}	32.62±1.88^{a}	34.49±2.64^{a}	Sangola	1.7±0.05^{a}	1.09±0.08^{a}	0.85±0.04^{b}	1.05±0.19^{a}
Akkalkote	36.66±5.80^{a}	35.73±2.13^{a}	22.8±1.03^{b}	30.92±3.63^{a}	Akkalkote	1.35±0.08^{a}	1.13±0.43^{a}	0.97±0.05^{a}	1.20±0.19^{a}

Similar superscripts in rows indicate non-significant differences whereas, dissimilar superscripts indicate significant differences among the seasons at 5% or 1% level

Table-3 *Percent Deficient Samples (PDS) found in different tehsils of Solapur district*

Copper							Zinc						
Tehsil	Critical value	Madha	Mohol	Sangola	Akkalkote	Overall		Critical value	Madha	Mohol	Sangola	Akkalkote	Overall
Soil	0.6 ppmᵠ	3.85 (26)	6.67 (28)	4.17 (24)	00.0 (23)	3.96 (101)	SOIL	1.5 ppmᵠ	76.92 (26)	62.07 (28)	41.67 (24)	86.96 (23)	66.67 (101)
Feed	8 ppmϯ	0.00 (33)	3.23 (31)	8.82 (34)	8.82 (34)	5.30 (132)	FEED	30 ppmϯ	60.61 (33)	48.39 (31)	55.88 (34)	70.59 (34)	59.09 (132)
Fodder	8 ppmϯ	90.9 (33)	21.05 (38)	11.11 (36)	0.00 (34)	10.64 (141)	FODDER	30 ppmϯ	60.61 (33)	28.95 (38)	33.33 (36)	47.06 (34)	41.84 (141)
Serum	0.6 ppmᵠ	22.22 (54)	35.19 (54)	25.93 (54)	22.22 (54)	26.39 (216)	SERUM	0.8 ppmᵠ	7.41 (54)	11.11 (54)	12.96 (54)	27.78 (54)	14.81 (216)

ᵠMcDowell et al., 1984; ϯMcDowell et al., 1985, Figures shown in parenthesis represent the number of samples.

Results and Discussion

Soil status

Values (mean ± S.E.) of Cu and Zn in different samples (soil, feed, fodder and animal serum) are presented in [Table-1 and 2], respectively. In current study, the statistical analysis was carried out using 'Completely randomized Design' (CRD) for evaluating the influence of season. The average Cu and Zn levels of soil samples from all the tehsils of Solapur district were compared with the critical level of 0.6 ppm and 1.5 ppm, respectively, as suggested by McDowell *et al.* [21]. The comparison revealed that overall mean soil Cu values of all tehsils were above the critical level. In this study, overall soil Cu levels of Madha tehsil were higher compared to other tehsils. For soil Cu values non-significant differences were observed in different seasons. In all tehsils, highest soil Cu values were seen in summer, followed by winter and then by rainy season. These results are in agreement with previous report from Maharashtra [13-16, 22] and Gujarat [23]. Also, these findings are in accord with findings reported from Southwestern Punjab-Pakistan [24] and Tehran-Iran [25]. Both these studies reported higher Cu values in summer than winter. With regards to Zn, overall mean soil Zn values of all tehsils were below the critical level (1.5ppm) [21]. The mean soil Zn level of tehsils in summer season, except Akkalkote, was above critical value. The winter soil samples of all tehsils were below critical value, except Sangola. The rainy season samples from all tehsils were below critical value. Similar to soil Cu pattern, highest soil Zn values were seen in summer, followed by winter and then by rainy season in all tehsils. This soil Zn pattern is in agreement with previous report from Thane creek [22], Satara [14], Sangli [16] and Kolhapur [15]. Overall PDS (Percent Deficient Samples) [Table-3] of Cu in soil from Solapur district was 3.96%. Nevertheless, much higher percentage (27.5%) of soil Cu deficiency has been from Kashmir [26]. In the current study highest Soil Cu PDS was observed in Mohol tehsil (6.67%) while it was nil in Akkalkote tehsil. Overall PDS Zn in soil of Solapur district was 66.67% and highest soil Zn PDS were from Akkalkote tehsil (86.96%). For soil Zn, similar PDS has previously been from Maharashtra (63.21%) [13], Haryana (59.12%) [27] and Kashmir (60%) [26].

Feed minerals

The average Cu content [Table-1 and 2] of animal feed samples from different tehsils of Solapur district were compared with the critical level (8 ppm) suggested by McDowell et al. [28]. Findings of this study revealed that overall mean Cu values in feeds of all tehsils were above the critical level. Highest mean Cu value was observed in summer samples of Madha tehsil whereas the lowest mean Cu value was observed in rainy season samples of Sangola tehsil. Highest feed Cu values were seen in summer, followed by winter and then by rainy season, except Mohol tehsil. This observation is in agreement with previous report from Maharashtra [13-16]. The average Zn content of animal feed samples from different tehsils of Sarata district were compared with the critical level (30 ppm) suggested by McDowell *et al.* [28]. The overall mean Zn value of feeds samples from Sangola were above the critical level while values from Madha, Mohol and Akkalkote were below critical value. The highest mean Zn values were seen in summer samples from Sangola tehsil. In this study, highest feed Zn values were seen in summer, followed by winter and then by rainy season. Similar results have been reported previously from Maharashtra state [13-16]. Overall PDS [Table-3] of Cu in feed from Solapur district was 5.30%. In this study, Cu PDS from Madha, Mohol, Sangola and Akkalkote was 0.00%, 3.23%, 8.82% and 8.82% respectively. Overall PDS of Zn in feed from Solapur district was 59.09%. Deficiency of Zn in feed has also been reported from Pune district [13] and Mathura district, India [29]. On the other hand, contrast findings have been reported from Rajasthan; where most of the feeds were not deficient for Zn [30]. Highest PDS of Zn were seen in Akkalkote tehsil.

This was followed by Madha (60.61%), Sangola tehsils (55.88%) and Mohol (48.39%). Lowest feed Zn PDS was observed in Mohol tehsil.

Fodder minerals

The average Cu content [Table-1 and 2] of animal fodder samples from different tehsils of Solapur district were analyzed in comparison with the critical level (8 ppm) suggested by McDowell *et al*. [28]. Results of this study revealed that overall mean Cu values in fodder of all tehsils were above the critical level. These findings are in agreement with previous report from Maharashtra [13-16]. Highest mean Cu content was observed in summer fodder samples of Madha tehsil whereas the lowest mean Cu was observed in rainy season fodder of Sangola tehsil. With regards to the mean Cu levels in fodder samples from all tehsils, non-significant differences were seen in different seasons.

The overall Zn content fodder samples from Mohol and Sangola tehsil were above the critical level (30 ppm) [28]. On the contrary, overall Zn content fodder samples from Madha and Akkalkote tehsil were below the critical level Highest mean Zn level were seen in summer fodder samples from Mohol tehsil whereas the lowest mean Zn level were seen in winter fodder samples from Madha tehsil. In all tehsils, fodder Zn values were higher in summer compared to rainy season.

The Cu & Zn PDS [Table-3] was seen in varying extent in all tehsils of Solapur district. Madha tehsil had the highest Cu PDS level (90.9%). Overall prevalence of both Cu & Zn PDS in fodder of Solapur district was 10.64% and 41.84%, respectively. Cu PDS of Solapur district is much lower compared to Cu PDS reported from Northern India (65.63%) [31]. In 2014, a study from Kerala State has reported Cu PDS of 38.66% and Zn PDS of 38% in animal fodder [32]. Highest Zn PDS was seen in Madha tehsil while it was lowest in Mohol tehsil.

Serum minerals

Overall average Cu content [Table-1 and 2] of serum samples of different seasons from different tehsils of Solapur district were above the critical level (0.6ppm) suggested by McDowell *et al.* [21]. Highest mean Cu content was present in summer samples of Mohol tehsil; whereas the lowest mean Cu was observed in rainy season serum of Sangola tehsil. For all tehsils, highest mean Cu values were seen in summer, followed by winter and then by rainy season. These results agree with previous findings published from Maharashtra [13-15]. With regards to the mean Cu levels in serum samples from all tehsils, non-significant differences were seen in different seasons.

The average Zn levels in sera of all seasons from Solapur district were above CV (0.8 ppm) [21]. Serum of summer and rainy season from Madha tehsil had highest and lowest mean Zn levels, respectively. For all tehsils, highest serum mean Zn values were seen in summer, followed by winter and then by rainy season. Similar trends of serum Zn levels have been published previously from Maharashtra [13-15].

Overall PDS [Table-3] of Cu & Zn in serum from Solapur district was 26.39% and 14.81%, respectively. In 2014, PDS of 46.87% for serum Cu and 40.00% for serum Zn has been reported from Kerala State [32]. A higher serum Cu PDS has been reported from Northern India (68.71%)[31] and Kashmir valley [33]. Highest PDS for Cu in serum was seen in Mohol tehsil (35.19%) of Solapur district while highest PDS for Zn in serum was observed in Akkalkote tehsil (27.78%).

Lower Cu & Zn content seen in soil, feed, fodder and serum samples in rainy season could be due to leaching of soils [34].

Conclusion

Finding of the current investigation revealed seasonal variations in levels of Cu and Zn mineral in soil, feed, fodder and serum samples from Solapur district. Soil, feed, fodders and serum samples of animals of Solapur district were deficient in Cu & Zn to varying extent. Hence area wise supplementation of these minerals may be provided in mineral mixture.

Application of research

Findings of this research can be used for formulation of Solapur specific mineral mixtures.

Research Category: Veterinary Science

Abbreviations: Copper (Cu), Zinc (Zn), Percent Deficient Samples (PDS), AAS (Atomic Absorption Spectrophotometry), Web Agricultural Statistical Package (WASP), completely randomized Design (CRD)

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Study area / Sample Collection: Solapur district

Cultivar / Variety / Breed name: Domestic cattle

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Ethical approval: Therapeutic intervention at KNP College of Veterinary Science, Shirwal 412 801, Maharashtra Animal and Fishery Sciences University, Nagpur, 440001, India.

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References

[1] Press Information Bureau http,//pib.nic.in/ (2016).
[2] Sharma M.C., Joshi C., Gupta S. (2003*) Indian Journal of Veterinary Medicine*, 23,4-8.
[3] McDonald P., Edwards R.A., Greenhalgh J.F.D., Morgan C.A. (2009) *Pearson Education Ltd.*
[4] Boland M.P. (2003) *Advances in Dairy Technology*, 15,319-330.
[5] Chojnacka K., Saeid A. (2018) *Recent Advances in Trace Elements, Wiley*, 2018.
[6] Mohebbi-Fani M., Nazifi S., Ansari-Lari M., Namazi F. (2010) *Comparative Clinical Pathology*, 19,37-41.
[7] Yatoo M.I., Saxena A., Deepa P.M., Habeab B.P., Devi S., Jatav R.S., Dimri U. (2013) *Veterinary World*, 12,963-967.
[8] Hefnawy A.E., El-khaiat H. (2015) *Int J Agro Vet Med Sci*., 9,195-211.
[9] Rose J. (2016) *Trace elements in health, a review of current issues, Butterworth-Heinemann*, 2016.
[10] Garg M.R., Bhanderi B.M., Sherasia P.L. (2008) *Animal Nutrition and Feed Technology*, 8,53-64.
[11] Kharb R., Kumar G., Dhama K., Akbar M.A. (2017) *Journal of Experimental Biology*, 5,6.
[12] Kumaresan A.M., Bujarbaruah K.M., Pathak K.A., Brajendra, Ramesh T. (2010) *Tropical Animal Health and Production*, 42,569-577.
[13] Patodkar V.R., Jadhav S.N., Bhong C.D., Barate A.K., Mehere P.V. (2018) *International Journal of Agriculture Sciences*, 10(14),6765-6768.
[14] Patodkar V.R., Jadhav S.N., Bhong C.D., Barate A.K., Mehere P.V. (2019) *International Journal of Agriculture Sciences*, 11(17),8964-8966.

[15] Patodkar V.R., Jadhav S.N., Bhong C.D., Barate A.K., Mehere P.V. (2019) *International Journal of Agriculture Sciences*, 11(17),8979-8982.
[16] Patodkar V.R., Jadhav S.N., Barate A.K., Yadav Y.B., Mehere P.V. (2019) *International Journal of Agriculture Sciences*, 11(17), 8996-8999.
[17] Franeck M. (1992) *Environmental Pollution*, 76,251-257.
[18] Trolson J. (1969) *Research Station Swift Current, Saskatchewan, Canada.*
[19] Kolmer J.A., Spaulding E.H., Robinson H.W. (1951) *Appleton Century Crafts, New York*, 1090,1091.
[20] Snedecor G.W., Cochran W.G. (1994) *Iowa State University Press, Oxford and IBH, New Delhi*.
[21] McDowell L.R., Conard J.H., Ellis G.L. (1984) *Pretoria, South Africa*, 67-68.
[22] Singare P. (2011) *Interdisciplinary Environmental Review*, 12(4),298-312.
[23] Upadhyaya A., Oza P., Jadeja B. (2016) *Imperial Journal of Interdisciplinary Research*, 2(11).
[24] Khan Z.I., Hussain A., Ashraf M., McDowell L.R. (2006) *Asian-Aust J Anim Sci*., 19(8),1139-1147.
[25] Delbari A.S., Kulkarni D.K. (2011) *Bioscience Discovery*, 2(3),333-340.
[26] Bhat M.S., Shaheen M., Zaman R., (2011) *Vet World*., 4(12),550-553.
[27] Sharma M.C., Raju H.S., Joshi C., Kaur H. (2003) *Asian-Aust J Anim Sci*., 6(4),519-528.
[28] McDowell L. (1985) *Inc Orlando, Florida.*
[29] Garg M.R., Bhanderi B.M., Sherasia P.L. (2009) *Animal Nutrition and Feed Technology*, 9,209-220.
[30] Gupta V.P., Kumar V., Roy D., Kumar M. (2016) *Indian Journal of Animal Research*, 50(2),203-206.
[31] Sharma M., Joshi C., Pathak N., Kaur H. (2005) *Research in Veterinary Science*, 79(2),113-123.
[32] Devi G., Sharma M., Dimri U., Shekhar P., Deepa P. (2014) *Int J of Advanced Research*, 2(7),11-15.
[33] Yatoo M., Saxena A., Gopalkrishnan A., Kumar S., Sujatha V., Murugan M., Sharma M. (2016) *Adv Anim Vet Sci*., 4(2s),1-4.
[34] Pfander W. (1971) *Journal of Animal Science*, 33(4),843-849.