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Research Article

SEASONAL CHANGES IN LEVELS OF COPPER AND ZINC IN SOIL, FEED, FODDER AND SERUM OF LIVESTOCK FROM KOLHAPUR DISTRICT OF MAHARASHTRA

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Abstract: In the current study the Copper (Cu) and Zinc (Zn) content of soil, feed, fodder and serum in Kolhapur district of Maharashtra during different seasons of the year was estimated by using AAS (Atomic Absorption Spectrophotometry). Overall mean levels of Cu in soil, feed, fodder and serum samples from all tehsils were above the critical value. The overall mean Zn content of samples from all tehsils were above critical value, except overall soil Zn level in Panhala tehsil. With regards samples from different seasons (soil, feed, fodder and serum), the Cu levels were above critical values. With regards samples from different seasons (soil, feed, fodder and serum) the Zn levels were above critical values, except some samples (winter season soil of Panhala and Karveer; rainy season soil from Panhala, Karveer and Gandhinglaj samples; rainy season serum from Kagal and Gadhinglaj). Percent Deficient Samples (PDS) for Cu were 26.88% in soil, 15.18% feed, 11.76% in fodder and 25.99% in serum samples; whereas PDS for Zn were 31.18%in soil, 13.39% feed, 10.08% in fodder and 35.59% in serum samples, respectively. Highest PDS for Cu & Zn in serum were found in Karveer tehsil. In conclusion, it is necessary to supplement these minerals in ration by formulating area specific mineral mixture in order to sustain normal levels and maximize production of cattle.

Keywords: Copper, Zinc, Cattle, Mineral, Kolhapur

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Introduction

India is leader with regards to milk production [1]. India with 18% of the world's bovine population has 30 crore bovines [1]. Nevertheless, the highest position of India in milk production is not due to higher productivity of animals but because of higher livestock population. Individual productivity of animals is low which could be due to malnourishment and mineral deficiency [2]. Minerals have important role in animal nutrition for production and they are also essential for animal health [3]. Additionally, minerals play significant part in number of digestives, physiological and biosynthetic processes of animal body [4, 5]. Mineral deficiencies are responsible for a variety of suboptimal performances such as poor production 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 minerals (Cu and Zn) are important for udder immunity and thus defense against mastitis. Importantly, lower levels of Cu and Zn may result or predispose animals to repeat breeding and anoestrus [7].

In India milk producing animals are mostly maintained 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. Hence, it is important to access mineral contents from serum, soil, feed and forages in different seasons to estimate the year round mineral requirements of livestock of a particular area. The current study was undertaken to estimate the Cu and Zn content of soil, feed, fodder and serum from Kolhapur district during different seasons of the year.

Materials and Methods

Sample collection

The current study was conducted in Kolhapur district of Maharashtra. Representative samples of soil, feed, fodder and animal serum were collected randomly from Panhala, Kagal, Karveer and Gadhinglaj tehsils of Kolhapur district. Soil samples were collected with the help of pickaxe and trowel and processed for analysis of Cu and Zn. Soil samples were finely ground, sun dried properly and then stored in airtight polythene bags until analysis. Samples of concentrate mixtures/ ingredients and roughages were collected once during each season by visiting individual families. Feed and fodder samples were dried, ground and stored in airtight polythene packets until analysis. 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)[13], Trolson (1969)[14] and Kolmer *et al*., (1951)[15] respectively. Simultaneous digestions of reagent blanks were also undertaken. Atomic absorption spectrophotometer (AAS) was utilized for estimation of Cu and Zn in the samples (ELICO, Ltd, Hyderabad, India). The percent prevalence was calculated using reported critical values of corresponding minerals in soils, feed, fodder and animal (cattle). The data on mineral contents were subjected to statistical analysis as per Snedecor and Cochran, 1994 [16] 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 Kolhapur district during different seasons*

Soil (in ppm)					Feed (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Panhala	7.29 ± 0.64^{a}	6.33 ± 0.61^{b}	5.68 ± 0.64^{c}	6.43 ± 0.86^{a}	Panhala	23.50 ± 0.82^{a}	22.12 ± 0.28^{a}	11.80 ± 3.66^{b}	19.14 ± 1.31^{a}
Kagal	7.52 ± 0.72^{a}	5.74 ± 0.85^{b}	5.00 ± 0.51^{c}	6.09 ± 1.01^{a}	Kagal	19.70 ± 4.03^{a}	19.20 ± 0.71^{a}	18.64 ± 2.09^{a}	19.18 ± 2.04^{a}
Karveer	6.07 ± 0.59^{a}	5.36 ± 1.18^{a}	5.06 ± 0.56^{a}	5.06 ± 0.51^{b}	Karveer	21.20 ± 3.06^{a}	20.46 ± 2.39^{a}	19.85 ± 3.58^{a}	20.50 ± 2.12^{a}
Gadhinglaj	5.65 ± 0.71^{a}	1.53 ± 0.32^{b}	1.60 ± 0.94^{b}	2.93 ± 0.94^{c}	Gadhinglaj	25.26 ± 0.28^{a}	21.24 ± 0.32^{b}	17.84 ± 0.23^{c}	21.45 ± 0.80^{a}

Fodder (in ppm)					Serum (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Panhala	21.90 ± 0.88^{a}	16.43 ± 6.83^{a}	20.03 ± 5.89^{a}	19.46 ± 3.46^{a}	Panhala	1.15 ± 0.3^{a}	1.13 ± 0.23^{a}	1.07 ± 0.22^{a}	1.12 ± 0.14^{a}
Kagal	23.34 ± 9.96^{a}	20.98 ± 0.71^{a}	21.91 ± 4.45^{a}	22.08 ± 3.05^{a}	Kagal	1.11 ± 0.21^{a}	1.00 ± 0.2^{a}	1.08 ± 0.22^{a}	1.06 ± 0.12^{a}
Karveer	29 ± 1.14^{a}	23.73 ± 6.76^{a}	20.94 ± 4.58^{a}	24.56 ± 2.77^{ac}	Karveer	1.11 ± 0.37^{a}	1.05 ± 0.37^{a}	0.86 ± 0.28^{a}	1.01 ± 0.18^{a}
Gadhinglaj	35.10 ± 4.77^{a}	31.37 ± 8.03^{a}	24.62 ± 1.48^{a}	30.36 ± 3.23^{b}	Gadhinglaj	1.23 ± 0.29^{a}	1.12 ± 0.25^{a}	0.90 ± 0.17^{a}	1.09 ± 0.14^{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 Kolhapur district during different seasons*

Soil (in ppm)					Feed (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Panhala	1.67 ± 0.14^{a}	1.31 ± 0.07^{b}	0.74 ± 0.11^{c}	1.24 ± 0.14^{b}	Panhala	41.28 ± 1.12^{a}	38.81 ± 2.85^{a}	37.65 ± 2.06^{a}	39.25 ± 1.61^{a}
Kagal	2.79 ± 0.62^{a}	2.17 ± 0.53^{a}	1.72 ± 0.06^{a}	2.10 ± 0.29^{a}	Kagal	43 ± 2.55^{a}	41.16 ± 1.56^{a}	36.45 ± 1.57^{b}	40.20 ± 1.59^{a}
Karveer	1.95 ± 0.24^{a}	1.45 ± 0.47^{a}	0.45 ± 0.73^{a}	1.69 ± 0.30^{ab}	Karveer	52.98 ± 0.55^{a}	39.26 ± 2.16^{b}	32.91 ± 2.23^{c}	41.72 ± 2.11^{a}
Gadhinglaj	2.21 ± 0.49^{a}	1.69 ± 0.51^{a}	1.09 ± 0.42^{a}	1.74 ± 0.33^{ab}	Gadhinglaj	52.32 ± 1.12^{a}	33.72 ± 2.99^{b}	39.8 ± 1.39^{c}	41.95 ± 2.54^{a}

Fodder (in ppm)					Serum (in ppm)				
Tehsils	Sum	Winter	Rainy	Overall	Tehsil	Sum	Winter	Rainy	Overall
Panhala	53.8 ± 2.27^{a}	44.8 ± 4.62^{b}	42.51 ± 2.44^{b}	47.04 ± 3.64^{a}	Panhala	1.13 ± 0.15^{a}	1.10 ± 0.08^{a}	0.93 ± 0.15^{a}	1.05 ± 0.12^{a}
Kagal	53.87 ± 2.58^{a}	40.4 ± 1.50^{b}	37.7 ± 4.2^{b}	43.99 ± 2.42^{a}	Kagal	1.28 ± 0.06^{a}	1.11 ± 0.09^{a}	0.74 ± 0.07^{b}	1.04 ± 0.08^{a}
Karveer	56.8 ± 6.54^{a}	35.87 ± 4.32^{b}	38.22 ± 3.12^{b}	43.63 ± 4.84^{a}	Karveer	1.29 ± 0.15^{a}	0.85 ± 0.05^{b}	0.82 ± 0.23^{b}	0.99 ± 0.11^{a}
Gadhinglaj	48.94 ± 4.50^{a}	46.67 ± 6.11^{a}	32.38 ± 14.02^{b}	42.66 ± 42.66^{a}	Gadhinglaj	1.42 ± 0.09^{a}	1.14 ± 0.06^{b}	0.77 ± 0.10^{c}	1.11 ± 0.09^{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 Kolhapur district*

COPPER						ZINC						
Tehsil	Critical value	Panhala	Kagal	Karveer	Gadhinglaj	Overall		Critical value	Panhala	Kagal	Karveer	Gadhinglaj	Overall
SOIL	0.6 ppmφ	12.00 (25)	25.00 (24)	30.00 (20)	41.67 (24)	26.88 (93)	SOIL	1.5 ppmφ	24.00 (25)	16.67 (24)	40.00 (20)	45.83 (24)	31.18 (93)
FEED	8 ppm†	23.33 (30)	17.86 (28)	12.00 (25)	6.90 (29)	15.18 (112)	FEED	30 ppm†	26.67 (30)	7.14 (28)	4.00 (25)	13.79 (29)	13.39 (112)
FODDER	8 ppm†	18.18 (33)	20.00 (30)	8.33 (24)	0.00 (32)	11.76 (119)	FODDER	30 ppm†	3.03 (33)	10.00 (30)	12.50 (24)	15.63 (32)	10.08 (119)
SERUM	0.6 ppmφ	21.74 (46)	26.09 (46)	32.43 (37)	25.00 (48)	25.99 (177)	SERUM	0.8 ppmφ	36.96 (46)	39.13 (46)	45.95 (37)	22.92 (48)	35.59 (177)

φMcDowell et al., 1984; †McDowell 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 samples (soil, feed, fodder and animal serum) is presented in [Table-1 and 2], respectively. Further, statistical analysis was done by applying 'Completely randomized Design' (CRD) for evaluating the influence of season. The average Cu and Zn levels of soil samples from all the tehsils of Kolhapur district were compared with the critical level of 0.6 ppm and 1.5 ppm, respectively, as suggested by McDowell *et al*. [17]. The comparison revealed that mean soil Cu values of all tehsils were above the critical level. In this study, overall soil Cu levels of Pahnala tehsil were higher compared to other tehsils. For Panhala and Kagal tehsils, significant differences were observed in mean soil Cu values in three different seasons whereas mean soil Cu levels in different seasons were non-significant in Karveer tehsil. Except for Gadhinglaj tehsil, 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 Pune [18], Thane creek [19] and Gujarat [20]. Also, these findings are in accord with findings reported from Southwestern Punjab-Pakistan [21] and Tehran-Iran [22]. Both these studies reported higher Cu values in summer than winter. With regards to Zn, overall mean soil Zn values of tehsils, except pahnala, were above the critical level (1.5ppm) [17]. The mean soil Zn level in summer season from of all tehsils was above critical value. The mean soil Zn values in all seasons from Kagal tehsil were above critical value. The winter samples from Karveer and panhala tehsils and rainy season samples of Karveer, Panhala and Gadhinglaj 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 tehsils. This soil Zn pattern is in agreement with previous report from Thane creek [19]. Overall PDS (Percent Deficient Samples) of Cu in soil from Kolhapur district was 26.88% [Table-3]. Nevertheless, similar percentage (27.5%) of soil Cu deficiency has been from Kashmir [23]. Highest Soil Cu PDS were seen in Gadhinglaj tehsil (28%) and lowest in Panhala tehsil (0%). Overall PDS Zn in soil of Kolhapur district was 31.18% and highest soil Zn PDS were from Gadhinglaj tehsil (45.83%). For soil Zn, higher deficiencies have been reported from Pune (63.21%) [18], Haryana (59.12%)[24] and Kashmir (60%)[23].

Feed minerals

The average Cu content of animal feed samples from different tehsils of Kolhapur district were compared with the critical level (8 ppm) suggested by McDowell *et al*. [Table-1,2] [25]. Findings of this study revealed that mean Cu values in feeds of all tehsils were above the critical level. Highest mean Cu value was observed in summer samples of Gadhinglaj tehsil whereas the lowest mean Cu value was observed in rainy season samples of Panhala tehsil. Highest feed Cu values were seen in summer, followed by winter and then by rainy season. This observation is in agreement with previous report from Maharashtra [18]. 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. [25]. The overall mean Zn values of feeds samples from tehsils of Kolhapur district were above the critical level. The highest mean Zn values were seen in summer samples from Karveer tehsil. Except Gadhinglaj tehsil, 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 [18]. Overall PDS of Cu in feed from Kolhapur district was 15.18% [Table-3]. In this study, highest and lowest Cu PDS was seen in Panhala and Gadhinglaj tehsil, respectively. Overall PDS of Zn in feed from Kolhapur district was 13.39%. Deficiency of Zn in feed has also been reported from Pune district [18] and Mathura district, India [26]. On the other hand, contrast findings have been reported from Rajasthan; where most of the feeds were not deficient for Zn [27].

Highest PDS of Zn were seen in Panhala tehsil. This was followed by Gadhinglaj (13.79%) and Kagal tehsils (7.14%). Lowest PDS was observed in Karveer tehsil.

Fodder Minerals

The average Cu content of animal fodder samples from different tehsils of Kolhapur district were analyzed in comparison with the critical level (8 ppm) suggested by McDowell *et al*. [Table-1,2] [25]. 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 [18]. Highest mean Cu content was observed in summer fodder samples of Gadhinglaj tehsil whereas the lowest mean Cu was observed in winter season fodder of Panhala tehsil. With regards to the mean Cu levels in fodder samples from all tehsils, non-significant differences were seen in different seasons. The average Zn content fodder samples from different tehsils of Kolhapur district were above the critical level (30 ppm) [25]. Highest mean Zn level were seen in summer fodder samples from Karveer tehsil whereas the lowest mean Zn level were seen in rainy fodder samples from Gadhinglaj tehsil. Except in Karveer tehsil, highest fodder Zn values were seen in summer, followed by winter and then by rainy season. With exception of Gadhinglaj tehsil [Table-3], PDS was seen in varying extent in all tehsils of Kolhapur district. Kagal tehsil had the highest Cu PDS level (20.00%). Overall prevalence of Cu & Zn PDS in fodder of Kolhapur district was 11.76% & 10.08%, respectively. Cu PDS of Kolhapur district is much lower compared to Cu PDS reported from Northern India (65.63%) [28]. In 2014, a study from Kerala State has reported Cu PDS of 38.66% and Zn PDS of 38% in animal fodder [29]. Highest Zn PDS was seen in Gadhinglaj tehsil while it was lowest in Panhala tehsil.

Serum minerals

Average Cu content of serum samples from different tehsils of Kolhapur district were above the critical level (0.6ppm) suggested by McDowell *et al*. [Table-1,2] [17]. Highest mean Cu content was present in summer samples of Gadhinglaj tehsil; whereas the lowest mean Cu was observed in rainy season serum of Karveer tehsil. Except Kagal tehsil, 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 [18]. With regards to the mean Cu levels in serum samples from all tehsils, non-significant differences were seen in different seasons.

Except for rainy season serum samples from Kagal and Gadhinglaj tehsil, the average Zn levels in sera of all seasons from Kolhapur district were above CV (0.8 ppm) [17]. Mean Zn content of serum samples of summer season from Gadhinglaj tehsil was highest whereas that of rainy season samples from Kagal tehsil was the lowest. In all tehsils, highest serum mean Zn values were seen in summer, followed by winter and then by rainy season. These results of serum Zn levels agree with previous findings published from Maharashtra [18].

Overall PDS of Cu & Zn in serum from Kolhapur district was 25.99% and 35.59%, respectively [Table-3]. In 2014, PDS of 46.87% for serum Cu and 40.00% for serum Zn has been reported from Kerala State [29]. A higher serum Cu PDS has been reported from Northern India (68.71%) [28] and Kashmir valley [30]. Highest PDS for both Cu & Zn was seen in Karveer tehsil.

Lower levels of Cu & Zn observed in rainy season samples (soil, feed, fodder and serum) could be due to leaching of soils [31].

Conclusion

This study revealed seasonal fluctuations of Cu and Zn in soil, feed, fodder and serum samples from Kolhapur district. Soil, feed, fodders and serum samples of animals of Kolhapur district were deficient in Cu & Zn to varying extent. Thus, area wise supplementation of these minerals may be provided as mixture containing Zn and Cu.

Application of research

Findings of this research can be used for formulation of Kolhapur 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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Research project name or number: Assessment of mineral profile relationship of animals, soil, feeds and fodders in the state of Maharashtra for improvement of livestock production potential.

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Study area / Sample Collection: Kolhapur district

Cultivar / Variety / Breed name: Domestic cattle

Conflict of Interest: None declared

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