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# ASSESMENT OF IRON, COBALT AND MANGANESE IN SOIL AND FORAGE: A CASE STUDY AT A RURAL LIVESTOCK FARM IN SARGODHA, PAKISTAN

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**Abstract**

This investigation was carried out at a rural livestock farm in district Sargodha, Pakistan to assess the effects of different seasons on the flow and status of some essential minerals from soil to forage. Soil and forage samples were taken concurrently for four months after one month interval and analysed for Fe, Co, and Mn levels after wet digestion. The results showed that there was a non-significant effect of sampling periods on soil Co, Fe, and Mn with an inconsistent variation in Co and Fe, and a consistent variation in soil manganese at sampling intervals. All mean values of soil Fe and Mn were higher than the requirements of forage crops, while the reverse was true for soil Co in this investigation. The effect of sampling periods on forage Fe and Co was found to be non-significant, while the reverse was true for forage Mn with a consistent increase in forage Fe and decrease in Co and Mn with the time of sampling. The higher transfer factor from soil to forage for Fe and Mn in December and Co during the month of January was observed during this study. From this pattern of nutrient transfer from soil to forage, a toxic range of these nutrients is possible for the animals at any time during the year. So supplementation with a specific balanced mineral mixture containing minerals which antagonize Co, Mn and Fe in animal's digestive tracts is immediately warranted at this animal farm.

## Introduction

Various plant species in a pasture are a sound source of supply of mineral nutrients to grazing animals therein. Inadequate supply of mineral nutrients hampers the productivity of ruminants. For assessing the adequate requirement of animals for mineral nutrients, proper analysis of the mineral levels in animal body, forages and soil is essential. Although grazing livestock satisfies its mineral needs from forages, they cannot fully satisfy the requirements of animals regarding mineral elements (McDowell, 1977). Environmental factors affect the mineral status of forages of various types. The mineral level of forages and fodders has very low relationships with soil contents as various other factors influence the absorption of minerals by the forages from the soil (Reid & Horvath, 1980). Many soil-plant factors, like pH, drainage, fertilization, forage species variability, forage maturity and interaction among different minerals affect the mineral status of forage plants (Gomide, 1978; Reid & Horvath, 1980). Mineral deficiency in animals causes many diseases including hyperkeratosis, change in skin color, bone defect, kidney and nervous system damage (McDowell, 2003).

It has long been reported that pastures deficient in some plant nutrients such as copper (Cu), cobalt (Co) and iron (Fe) cause nutritional anemia or "salt sick" disease in cattle (Becker, 1965). In dry areas, ruminants mainly graze on native grasses, crop residues and by-products of agro-industry. Ruminants grazing in these conditions suffer from mineral deficiency (Vijchulata *et al.,* 1983; Hayashi *et al*., 1985; Fujihara *et al*., 1992). Keeping in view the above facts the present study was conducted mainly focusing on the status of iron, cobalt, and manganese and their transfer from soil to forages with respect to the requirement of grazing ruminants. This information will be used to formulate the mineral supplements for grazing livestock to maximize their production in Pakistan and other countries with similar climatic conditions.

## Materials and Methods

**Description of study area:** This study was conducted at a Rural Livestock farm in Sargodha, Punjab, Pakistan, located at a distance of 12 km in northern side to Tehsil Bhalwal. In summer, temperature during the day time ranges from 24 to 49ºC, while during winter the minimum temperature lowers down to 8ºC. The relative humidity ranges from 30 to 48%, although Sargodha does not experience any snowfall, however, frost in winter commonly occurs.

In the study area, ruminants are reared on local vegetation, forages and wastes of agriculture products. Five composite samples of each of soil and forage were collected randomly from the pastures at the farm. Soil samples were taken from 5 different sites from three different places within the pasture at a depth of 15 cm to 20 cm. Forage samples were also taken concurrently along with the soil sampling after careful observation of the grazing behaviour of the ruminants. The total number of representative samples of each of soil and forage were 20, collected during each sampling. Four samplings were done each after one month interval in the months of October, November, December, and January during the winter season.

**Processing of samples for analysis:** Soil samples were air-dried, crushed and sieved though 2 mm sieve. Both soil and forage samples were dried at 70ºC in an oven and ground with the help of Wiley mill and sieved through 1 mm mesh. Dried soil samples were subjected to Mehlic-1 extracting solution method (0.05 N HCl+0.025 N $H_2SO_4$) following Rhue& kidder (1983).For determination of trace minerals in forage samples, 1 g of sample was digested with $H_2SO_4$ and $H_2O_2$. Fe, Co and Mn of soil and forage samples were analyzed with an atomic absorption spectrophotometer (Anon., 1980).

**Statistical analysis:** The obtained data was subjected to statistical analysis (Steel & Torrie, 1980) and statistical significance was tested at 0.05, 0.01 and 0.001 levels of probability using the SPSS software.

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## Results and Discussion

**Soil-Fe:** Analysis of variance exhibited non significant effect of sampling intervals on soil Fe concentration (Table 1). The values differed from 6.93 to 8.05 mg/kg during all sampling periods. The higher value was found at sampling period 1 and the lowest in sampling period 2 (Table 2) with an inconsistent elevation and depression at different periods. All mean values of soil Fe at different samplings periods were far greater than the critical value of 2.5 mg/kg as established by Rhue & Kidder (1983). These values were lower than those reported earlier by Khan *et al*. (2007) in Pakistan while working in the similar animal ranch in semi-arid region and were similar to those soil Fe levels reported previously by Espinoza *et al*. (1991) in central Florida. The Fe values of our investigation were also lower than those reported by Aregheore *et al*., (2007).

**Soil-Co:** Analysis of variance shows non-significant effect of sampling periods on soil Co concentration (Table 1). Mean soil Co concentrations varied from 0.665 to 0.789 mg/kg during all sampling intervals. Soil Co concentration was lower at 1$^{st}$ sampling period and higher at 3$^{rd}$ sampling period during our investigation (Table 2). The soil Co concentration increased from sampling period 1 to 3 but from 3$^{rd}$ onwards it dropped suddenly. All mean soil Co values were higher than the critical level of 0.1mg/kg as described by McDowell *et al*., (1983). The values reported in the present study are higher than those earlier reported by Kumaresan *et al*., (2010). These values corroborate with the findings of Khan *et al*., (2005).

**Soil-Mn:** A non-significant effect of sampling period on soil Mn concentration is evident from Table 1. Mn values consistently increased with the time of sampling. The values ranged from 54.75 to 69.38 mg/kg among sampling periods. The lowest value of Mn in soil was found during period 1 and the highest during the 4$^{th}$ sampling period (Table 2).

However, these values were above the critical level of 5 mg/kg suggested by Rhue & Kidder (1983). Prabowo *et al*., (1990) reported similar soil Mn concentrations in Indonesia. However, the values of the present study were lower than those reported by Espinoza *et al*., (1991). It has been reported that soil pH and organic matter may cause increased solubility of Mn for plants (Espinoza *et al*., 1991; Pastrana, 1991), which might have been the major factors for maintaining the levels of Mn in both soil and forage at the farm.

**Forage-Fe:** Sampling periods had a non-significant effect on forage Fe (Table 1). Forage Fe concentration ranged from 165.38 to 180.76 mg/kg. Forage Fe values were higher at sampling period 1 and lower at period 4 (Table 2). All mean forage values were above the recommended value i.e., 50 mg/kg (Jones, 1972). There was an abrupt decrease in forage Fe from period 1 to 4. Previously relatively lower forage Fe concentrations than those of the present study had been reported by McDowell *et al*., (1982), but higher by Prabowo *et al*., (1990) in Indonesia and by Orden *et al*., (1999) in the Philippines. Forage Fe concentrations in forage were extremely higher for the grazing animals which may cause toxicity to the animals.

**Forage-Co:** There was a non significant effect of sampling period on forage Co (Table 1). The values ranged from 0.42 to 0.60 mg/kg (Table 2). Forage Co concentration was higher during sampling period 3 while lower at period 1 (Table 2). However, these values were higher than the critical level i.e., 0.01 mg/kg (NRC, 1984). Forage Co levels found in our investigation were higher than those earlier reported by Khan *et al*., (2007) in Pakistan and Espinoza *et al*., (1991) in Florida. It has been reported that there are various factors that interfere with the absorption of Co in livestock, and Co deficiency is the most limiting element for animals grazing in different regions of Punjab, Pakistan.

**Forage-Mn:** Forage Mn concentrations were affected significantly ($p$<0.001) by the sampling intervals (Table 1). Forage Mn was highest at sampling period 1 and lowest at the last sampling period i.e. 4$^{th}$. Its values ranged from 153.43 to 215.20 mg/kg (Table 2). Forage Mn concentration however, decreased sharply from period 1 to 3 followed by a gradual decrease up to period 4 during the entire study. Mean Mn values were all above the critical level of 20 mg/kg as reported by McDowell (1985). For ruminants these values were above the findings of earlier researchers (Khan *et al*., 2006) in different regions of the world. However, these values fall in the range as reported by Pastrana *et al*., (1991) in Columbia.

**Table 1. Analysis of variance for Fe, Co and Mn concentrations in soil and forage at different sampling intervals.**

| Source of variation (SOV) | df | Mean squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | Soil | | | Forage | | |
| | | Fe | Co | Mn | Fe | Co | Mn |
| Sampling period | 3 | 1.07$^{ns}$ | 0.014$^{ns}$ | 184.68$^{ns}$ | 221.19$^{ns}$ | 0.033$^{ns}$ | 4446.59** |
| Error | 16 | 0.30 | 0.005 | 79.63 | 113.99 | 0.015 | 364.01 |

**Table 2. Micro-minerals in soil, forage and blood plasma (mean + SE) related to sampling intervals.**

| Mineral | Sampling periods | Soil (mg/kg) | Forage (mg/kg) | Transfer factor |
|---|---|---|---|---|
| Fe | November | 8.05 ± 0.54 | 180.76 ± 18.92 | 22.45 |
| | December | 6.93 ± 0.328 | 173.61 ± 10. 8 | 25.05 |
| | January | 7.42 ± 0.232 | 168.90 ± 20.04 | 22.76 |
| | February | 7.60 ± 0.277 | 165.38 ± 20.32 | 21.76 |
| Co | November | 0.665 ± 0.007 | 0.424 ± 0.081 | 0.63 |
| | December | 0.731 ± 0.016 | 0.447 ± 0.057 | 0.61 |
| | January | 0.789 ± 0.013 | 0.602 ± 0.040 | 0.76 |
| | February | 0.696 ± 0.057 | 0.526 ± 0.022 | 0.75 |
| Mn | November | 54.75 ± 5.96 | 215.29 ± 16.93 | 2.21 |
| | December | 59.90 ± 8.17 | 193.80 ± 18.68 | 3.93 |
| | January | 62.33 ± 6.84 | 157.06 ± 17.51 | 3.23 |
| | February | 69.38 ± 5.26 | 153.43 ± 18.13 | 2.52 |

## Conclusions

Based on the current exploration it can be concluded that soil and forage Fe, Co, Mn were found to be enough for the requirements of forage as well as for grazing livestock being reared at livestock farm but the levels of these minerals far below the tolerance range of the animals. However, the transfer trend of these elements from soil to forage is very high so, the toxicity due to their higher levels can be expected for the grazing ruminants during any time of the year. Therefore a mineral mixture with a balanced proportion of these elements may be considered a dire need for the animals to avoid the possible toxicosis because of potential higher amounts of these minerals in the forages consumed by animals.

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