CHAPTER V

SUMMARY

Mineral imbalances in soil-plant-animal system are responsible for poor health and productivity of livestock from large areas of world. Because the naturally occurring mineral imbalances in dairy animals are area specific, analysis of minerals in soils, plants and animals has been recommended to recognise mineral imbalances of livestock from a particular area. Based upon soil type, rainfall, temperature, vegetation and topography, the state of Punjab has been divided into five agro-eco subregions viz. Sub-mountain (Siwalik hills), North-eastern undulating, Piedmont and alluvial plain, Central alluvial plain and South-western alluvial plain. Considering the agro-ecological status of the South-western sub-region, which is characterised by high environmental temperatures, low rain fall, shorter fodder growing period length and poor quality of groundwater having high F contents, there is a possibility of existence of mineral imbalances in dairy animals of this region. Therefore, the present study was undertaken to assess mineral status of dairy animals in relation to soils and plants from this region, and to develop suitable control measure against the observed mineral imbalances in the dairy animals.

The present study was conducted in two phases. In the first phase, an epidemiological survey was conducted in Mansa and Ferozepur districts of the South-western region of Punjab. All the five blocks of Mansa district (Bhikhi, Mansa, Budlada, Jjunir and Sardulgarh) and four southern blocks of Ferozepur district (Abohar, Fazilka, Khuijan Sarwar and Jalalabad) were surveyed during the winter and summer seasons of a year. The soil, water and fodder samples along with blood and hair of the dairy animals from the selected districts were collected randomly and analysed for various macro and
micro-minerals. The dairy animals that were showing clinical signs suggestive of mineral imbalances were subjected to thorough haemato-biochemical investigations. In the second phase of the study, a therapeutic trial was conducted on the fluorotic buffaloes. The drinking water offered to fluorotic buffaloes was defluoridated with alum (1.5 gl⁻¹) and lime (200 mg l⁻¹) and effects of this treatment on mineral and heamato-biochemical status, and health of the fluorotic buffaloes were evaluated.

Study on general management of the dairy herds in Mansa and Ferozepur districts revealed that most of the dairy herds with respect to their herd strengths were of small size (<15 animals/herd), and particularly in Mansa district, there was no cattle in 45.4 per cent of the dairy herds. The feeding regime in most of the dairy herds constituted low availability of green fodder, inadequate concentrates and almost lack of mineral supplementation. Consequently, the health as reflected by body condition score in considerable dairy animal population was poor, and the average milk yield was also low.

Analysis of mineral status revealed deficiency of Ca, P, Mg, Cu, Zn and Mn, and excess of Mo, F and As in dairy animals from Mansa and Ferozepur districts. On the basis of plasma Ca levels, overall 15.0 per cent buffaloes and 14.3 per cent cattle in Mansa district were deficient in Ca. The Ca deficiency was considerably higher in buffaloes from Bhikhi block (34.2%). In Ferozepur district, the overall prevalence of Ca deficiency was 18.0 per cent in buffaloes and 19.8 per cent in cattle, and the deficiency was considerably higher in buffaloes (35.5%) and cattle (40.7%) from Khuian Sarwar block. Poor availability of green fodder, low levels of Ca in green and dry fodder and high F contents of drinking water could be responsible for hypocalcaemia in animals.
In Mansa district, the mean plasma Pi concentration of buffaloes was significantly (p<0.05) higher than that of cattle. The prevalence of hypophosphataemia was 10.4 per cent in buffaloes and 5.7 per cent in cattle, and the prevalence was comparatively higher in buffaloes from Mansa block (17.8%). In Ferozepur district, overall 9.0 per cent buffaloes and 8.5 per cent cattle were deficient in P. Deficiency of P and excess of Mo in green and dry fodder and general under-nourishment of the animals could be responsible for P deficiency in animals.

Mean plasma Mg concentration of buffaloes was significantly (p<0.01) higher than that of cattle both from Mansa and from Ferozepur district, and due to this, the prevalence of Mg deficiency was higher in cattle (Mansa 31.4%, Ferozepur 18.1%) than in buffaloes (Mansa 14.1%, Ferozepur 11.0%). In Mansa district, the Mg deficiency was considerably higher in buffaloes from Bhikhi (21.1%) and Budlada (21.2%) blocks. In Ferozepur district, the prevalence of Mg deficiency in buffaloes was comparable in Jalalabad (13.9%), Khuiam Sarwar (13.8%) and Fazilka (12.5%); however, none of the buffaloes in Abohar block was deficient in Mg. In cattle from Ferozepur district, the Mg deficiency was higher in Abohar (23.4%) and Jalalabad (22.2%) blocks. To aid in diagnosis, concentrations of Mg in hair of dairy animals were analysed, however, hair Mg contents did not reflect current Mg status of buffaloes and cattle. Deficiency of Mg in dry fodder, high levels of K and Fe in green fodder, and low availability of green fodder were probably responsible for the occurrence of hypomagnesaemia in the dairy animals.

Mean plasma Cu concentration of cattle was significantly (p<0.01) lower than that of buffaloes from Mansa and Ferozepur districts. In Mansa district, the overall prevalence of Cu deficiency was 58.2 per cent in buffaloes and 88.0 per cent in cattle. Block-wise,
the Cu deficiency was comparatively higher in buffaloes from Sardulgarh (79.2%), Bhikhi (71.0%) and Jhunir (63.6%) than those from Budlada (46.0%) and Mansa (35.5%) blocks. In Ferozepur district, prevalence of Cu deficiency was 52.4 per cent in buffaloes and 58.9 per cent in cattle. In both the species, the plasma Cu levels were higher in Khuiian Sarwar than in Fazilka and Jalalabad blocks.

Significant positive correlation was observed between plasma Cu and ceruloplasmin (Cp) levels of buffaloes (p<0.01, r²=0.27) and cattle (p<0.01, r²=0.40). Prevalence of Cu deficiency on the basis of plasma Cp levels was comparatively higher than that calculated on the basis of plasma Cu concentrations, which was suggestive of occurrence of conditioned Cu deficiency in dairy animals due to high Mo in fodder. Similar to plasma Cu and Cp, the hair Cu levels were significantly (p<0.01) lower in cattle than in buffaloes from Mansa and Ferozepur districts. Overall 70.2 per cent buffaloes and 88.5 per cent cattle from Mansa district, and 48.9 per cent buffaloes and 71.7 per cent cattle from Ferozepur district had low hair Cu levels (i.e. <6.5 ppm), which was suggestive of occurrence of widespread chronic Cu deficiency in dairy animals. The probable causes of Cu deficiency in dairy animals were low Cu, high Mo, low Cu:Mo ratio and high Fe contents of forages, and high F in drinking water from Mansa and Ferozepur districts.

Based upon plasma Mo levels, the prevalence of Mo excess in Mansa district was 7.7 per cent in buffaloes and 8.6 per cent in cattle. In buffaloes, the prevalence was higher in Jhunir (25.5%) and Sardulgarh (17.9%) blocks, whereas it was low in Budlada block (1.9%). None of the buffaloes from Bhikhi and Mansa blocks had Mo excess. In Ferozepur district, prevalence of Mo excess was 11.6 per cent in buffaloes and 5.1 per
cent in cattle. In buffaloes, the prevalence was considerably higher in Khuian Sarwar (35.5%), whereas, it was low in Abohar (5.0%) and Fazilka (4.0%) blocks. None of the buffaloes from Jalalabad block had Mo excess. In cattle, the Mo excess was observed in Abohar (8.5%) and Khuian Sarwar (7.4%) blocks only. In spite of high Mo contents of green and dry forages, the plasma Mo levels in most of the dairy animals were normal, which could be due to poor absorption Mo at the gastro-intestinal levels.

The overall prevalence of Zn deficiency was 23.9 per cent in buffaloes and 21.2 per cent in cattle from Mansa district. Block-wise the prevalence was higher in Sardulgarh (35.9%) and Jhunir (35.6%), intermediate in Bhikhi (23.7%) and Mansa (18.2%), and lower in Budlada (9.8%). In Ferozepur district, the prevalence of Zn deficiency was 30.9 per cent in buffaloes and 32.5 per cent in cattle. Deficiency of Zn in dairy animals was probably due to poor green fodder availability, deficiency of Zn in green and dry fodder, and higher F contents of drinking water.

Mean plasma Fe levels in buffaloes and cattle from Mansa and Ferozepur districts were higher than the upper critical limit of 2.50 µgml⁻¹ suggested by Kincaid (1999). Higher Fe contents of forages appeared to be the cause of the elevated plasma Fe levels.

In Mansa district, prevalence of Mn deficiency was 22.3 per cent in buffaloes and 22.9 per cent in cattle. The deficiency was higher in buffaloes from Bhikhi (38.9%), Sardulgarh (32.4%) and Mansa (22.5%) blocks than in those from Jhunir (7.0%) and Budlada (4.0%) blocks. In Ferozepur district, the prevalence of Mn deficiency in buffaloes and cattle was 8.7 and 15.9 per cent, respectively, and the Mn deficiency in both the species was observed only in Fazilka and Jalalabad blocks. Low dietary intakes
of Mn due to deficiency of Mn in dry fodder and poor availability of green fodder along with high Fe intakes could be responsible for occurrence of Mn deficiency in animals.

In Mansa district, the prevalence of fluorosis was 95.3 per cent in buffaloes and 100.0 per cent in cattle. However, the plasma F level in none of the buffaloes and cattle was high enough (i.e. >1.0 µgml⁻¹, Suttle et al 1972) to produce clinical fluorosis. In Ferozepur district, the overall prevalence of fluorosis was 92.0 and 95.7 per cent in buffaloes and cattle, respectively. Similar to Mansa district, this widespread fluorosis was mild in severity (i.e. plasma F 0.1-1.0 ppm). High F contents of drinking water were probably responsible for this widespread subclinical fluorosis. The effects of this subclinical fluorosis (plasma F 0.1-1.0 ppm) on haemogram and plasma mineral status were similar in buffaloes and cattle. The PCV and TEC values, and plasma Pi, Zn and Mn concentrations were significantly lower, whereas, the plasma Mo concentrations were significantly higher in the subclinically fluorotic buffaloes and cattle as compared to their non-fluorotic counterparts.

The hair As levels in 100.0 per cent buffaloes and cattle from Mansa, and 96.4 per cent buffaloes and 100.0 per cent cattle from Ferozepur district were higher than the upper critical limit of 0.5 ppm, which indicated marginal dose exposure of As to animals. None of the dairy animals from Mansa and Ferozepur districts suffered from I deficiency.

Season of the year had significant (p<0.05) influence on plasma Ca, Mg, Mo, Zn, I and F concentrations of buffaloes. The plasma Ca, Mg, Mo and F concentrations were higher in summer, whereas, plasma Zn and I concentrations were higher in the winter season. In cattle, season of the year had significant (p<0.05) influence on plasma Pi, Cu,
Mo, Zn, Fe, Mn and F levels. Plasma Pi, Cu, Zn and Mn levels were higher in winter, whereas plasma Mo, Fe and F levels were higher in the summer season.

To study effects of high F in drinking water on the mineral status of buffaloes and cattle, the animals were grouped as non-hydrofluorotic (drinking water F≤1 ppm) and hydrofluorotic (drinking water F>1 ppm). The plasma Ca and Cu concentrations were significantly (p<0.05) lower, whereas, plasma Pi and F concentrations were significantly (p<0.05) higher in the hydrofluorotic buffaloes. In cattle, plasma Mo and Zn levels were significantly (p<0.05) lower, whereas plasma F levels were significantly (p<0.05) higher in the hydrofluorotic group as compared to the non-hydrofluorotic group.

The mineral status of buffaloes and cattle of different age groups viz. Group I (< 1 year), Group II (1-3 years), Group III (3-6 years) and Group IV (> 6 years) was assessed. The overall effect of age on plasma Ca, Mg, Cu, Mo, Fe, Mn and I concentrations of buffaloes and cattle was non-significant. However, plasma Pi levels decreased with the advancement of age in buffaloes (p<0.01) and cattle (p<0.05). The prevalence of Zn deficiency was lower in calves (Group I) than in comparatively older animals (Groups II, III and IV) both in buffaloes and in cattle. The plasma F levels increased significantly (p<0.01) with the advancement of age in buffaloes and cattle.

The plasma Ca and Mg concentrations of lactating buffaloes and cattle did not differ from their non-lactating counterparts. However, plasma Pi concentrations were significantly (p<0.05) lower in the lactating buffaloes as compared to their non-lactating counterparts. Moreover, lactation had significant (p<0.05) influence on plasma Cu, Mo, Zn and Mn concentrations of buffaloes, however no such effects were seen in cattle. Plasma Cu, Mo and Mn concentrations were lower, whereas, plasma Zn concentration
was higher in the lactating buffaloes than in the non-lactating buffaloes. Plasma F concentrations were significantly (p<0.05) higher in lactating buffaloes and cattle as compared to their dry counterparts.

Haematological investigations revealed that the prevalence of anaemia was considerably higher in cattle than in buffaloes from Mansa and Ferozepur districts. Both in buffaloes and cattle, there was overall lowering of haematological profile and increased prevalence of anaemia in summer season than in winter season. Moreover, there was overall significant (p<0.05) decline in haemogram of lactating buffaloes and cattle as compared to their non-lactating counterparts. However, the haemogram of hydrofluorotic (drinking water F contents >1 ppm) buffaloes and cattle did not vary from their non-hydrofluorotic counterparts (drinking water F contents ≤1 ppm).

The most common health problems reported in adult buffaloes and cattle from Mansa and Ferozepur districts were low milk yield, anestrous, repeat breeding and weakness. Considerable population of the dairy animals was suffering from mastitis, lameness, leucoderma, malformation of bones, bony exostosis, poor digestion and obstetrical problems also. In calves, ill-thrift and depigmentation of hair coat was very common.

The anestrous buffaloes had significantly (p<0.05) lower plasma Ca, Mg, Zn, Mn, Cp, urea nitrogen and serum albumin, and higher plasma As concentrations as compared to their cyclic counterparts. The anestrous cattle had significantly (p<0.05) lower plasma Pi and Zn concentrations as compared to the cyclic cattle. The results were suggestive of multi-mineral and protein deficiency as the cause of anestrous in the dairy animals. The repeat breeding buffaloes had significantly (p<0.05) lower plasma Mg, Zn, Fe, Cp,
glucose and higher As concentrations as compared to healthy buffaloes, whereas, in repeater cattle, plasma Cp concentrations were significantly (p<0.05) lower as compared to healthy cattle.

In comparison to apparently healthy calves, the plasma Pi and Zn, and Hb and TEC concentrations were significantly (p<0.05) lower in the ill-thrift buffalo calves. Although, plasma Cu concentration did not differ much between apparently healthy and ill thrift calves, but the activity of plasma Cp was significantly (p<0.05) lower in the later, suggesting functional Cu deficiency in the ill thrift calves. The mineral profile, haemogram, protein-energy status and liver function tests of depigmented calves did not differ from that of apparently normal calves, which suggested that the depigmentation of hair coat in calves was non-nutritional.

In the lame buffaloes, plasma Pi, and Hb and PCV concentrations were significantly (p<0.05) lower, and serum globulin levels were significantly (p<0.05) higher as compared their non-lame counterparts. Significantly (p<0.05) higher creatine kinase in the lame cattle as compared to that of non-lame cattle was suggestive of tissue damage. In leucodermic buffaloes, the Cu status was poor as reflected by non-significantly lower plasma Cu and significantly (p<0.05) lower plasma Cp levels, which was suggestive of Cu deficiency as the cause of leucoderma in buffaloes. Moreover, the weak buffaloes had significantly (p<0.05) lower plasma Pi and Cp, and higher plasma As concentrations along with significantly (p<0.05) lower Hb, PCV and TEC values as compared to apparently healthy buffaloes. Further, plasma ALP, AST and GGT concentrations of weak buffaloes were significantly (p<0.05) higher from that of the apparently normal buffaloes, suggesting hepatic damage or other internal tissue injury in
the weak buffaloes. The cattle showing weakness had significantly (p< 0.05) lower plasma Pi and Hb, and higher plasma cholesterol concentrations as compared to the apparently healthy cattle.

Analysis of mineral status of green and dry fodder from Mansa and Ferozepur districts revealed widespread deficiency of Ca, P, Cu, Zn and Co and excess of Mo and Fe in these forages. The Ca, P, Cu, Zn and Co contents in 23.9, 28.3, 50.0, 19.6 and 20.8 per cent green fodder from Mansa and 7.4, 6.5, 60.0, 24.1 and 13.5 per cent green fodder from Ferozepur district, respectively were lower than the dietary requirements of dairy animals. Moreover, 41.5 and 29.5 per cent green fodder from Mansa and Ferozepur districts, respectively had excess of Mo. Apart from this, most of the dry fodder samples from Mansa and Ferozepur districts were deficient in Ca, P, Mg, Na, K, Cu, Zn and Mn, and had excess of Mo. Season of the year had significant influence on Ca, Mo and Mn contents of the green fodder. The Ca levels were higher in winter, whereas, the Mo and Mn levels were higher in the summer season.

Analysis of water quality in Mansa district revealed that 53.5 per cent drinking water samples had high F contents (>1.0 ppm), however in only 9.5 per cent of the water samples, the F levels were high enough (>2.5 ppm) to produce clinical fluorosis in animals. The F levels were significantly (p<0.05) higher in superficial and deep water than in the surface water. The As contents in 1.3 per cent water samples were unfit for livestock use (i.e. >200.0 ppb, NRC 1974), but for human use, the percentage of unfit samples (>10.0 ppb, EPA 2004) was quite high (62.3%). The pH of drinking water in Mansa district varied from 7.95 to 9.62, and 20.3 per cent of the water samples had highly alkaline pH (>9.0). Moreover, based upon water salinity levels, overall 83.3 per
cent water samples were acceptable (<3000 ppm), 16.7 had marginal levels (3000-5000 ppm), and none of the water samples was risky (5001-7000 ppm) and unacceptable (>7000 ppm) for livestock use.

In Ferozepur district, overall 21.0 per cent water samples had high F contents (i.e. >1.0 ppm), however in only 6.2 per cent of the water samples, the levels were high enough (>2.5 ppm) to produce clinical fluorosis in animals. The F levels were highest in superficial water, comparatively low in deep water and lowest in the surface water. The As contents in all the water samples were fit for livestock use, however, 71.2 per cent water samples were unfit for human use. The pH of drinking water varied from 7.59 to 9.60, and the pH was highly alkaline (>9.0) in 21.7 per cent of the water samples. Based upon the water salinity levels, 1.4 per cent water samples were risky, however, none of the water samples was unacceptable (>7000 ppm) for livestock use.

Soil total Ca, Mg, Cu, Mo, Zn, Fe, Mn and Co levels were adequate in Mansa and Ferozepur districts. The Fe contents of soils were very high, which could be the reason for high Fe contents of forages. A low correlation was observed between soil, plant and animals plasma mineral levels for various elements in cattle and buffaloes.

There was significant (p<0.01) effect of drinking water defluoridation on plasma F, Ca, Cu and Zn concentrations and urinary F excretion of the fluorotic buffaloes. The plasma F concentrations and urinary F excretion decreased progressively with the advancement of the treatment. The concentrations of plasma Ca, Cu and Zn were significantly higher on day 135 of the treatment as compared to those on the beginning of the treatment. There was no effect of the treatment on haemogram of the fluorotic buffaloes, however, plasma ALP levels reduced significantly (p<0.05) on day 135 of the
treatment in the treated buffaloes. None of the buffaloes under the treatment group suffered from stiffness, however, there was no significant effect of the treatment on milk yield of the fluorotic buffaloes was observed during the trial period.

Conclusions

1. Widespread deficiency of Cu, Zn, Ca, P, Mg, Mn, and excess of Mo is prevalent in dairy animals of Mansa and Ferozepur districts of South-West Punjab. High levels of hair As in the dairy animals suggest exposure of toxic As to them.

2. Inadequate green and mineral feeding, mineral imbalances in fodder, and high F in drinking water are important causes of mineral imbalances in the dairy animals.

3. Buffaloes and cattle tend to maintain significantly higher plasma Ca, Mg, Mo and F, and plasma Mo, Fe and F, respectively in summer season. The plasma Zn and I of buffaloes, and Pi, Cu, Zn and Mn of cattle tend to be higher in winter season.

4. Widespread cattle population in Mansa and Ferozepur suffers from subclinical anaemia, which tends to be higher in summer season and in lactating cattle.

5. Large population of the dairy animals is also affected by subclinical fluorosis, which has adverse effects on P, Zn, Mn and haematological status of the animals. Moreover, the high F (>1 ppm) in drinking water reduces plasma Ca and Cu of buffaloes, and Zn and Mo of cattle. It also increases plasma Pi and F of buffaloes.

6. Plasma Pi decreases and plasma F increases with the age of buffaloes and cattle. Moreover, lactating buffaloes tend to maintain significantly lower plasma Pi, Cu, Mo and Mn, and higher Zn and F concentrations than the dry buffaloes.

7. Poor status of essential minerals like Cu, Ca, Mg, Zn, Mn and P is probably responsible for reproductive impairment, lameness and weakness in the dairy animals.
8. Leucoderma in buffaloes is due to deficiency of Cu; however, depigmentation of hair coat in buffalo calves from this area is Cu independent.

9. The quality of drinking water for livestock in Mansa and Ferozepur is poor having high levels of F, As and pH. The defluoridation of drinking water with alum and lime is effective in reducing F toxicity, and improving Ca, Cu and Zn status, and health of fluorotic buffaloes.