POLLUTANT ELEMENTS IN SOIL- PLANT- ANIMAL SYSTEM IN INDIA AND FUTURE THRUST AREAS

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Increasing concentration of pollutant elements due to rapid industrialization and urbanization is now a global problem to soil, plant and animal health and affecting 40 % of the world population. Trace minerals of natural feeds is determined primarily by the mineral composition from the soil and secondly by the actual mineral composition of soil. Widespread deficiencies of Ca, P, Zn and Cu in south Karnataka, excessive Se and Mo in central part of Punjab, Arsenic in lower Indo-Gangetic plains of West Bengal through ground water are causing much toxicity to animal and humans. Clearly, closely linkage of agriculture to animal health must be accomplished if we are to find sustainable solutions to pollutant element deficiencies and associated diet related chronic disease affecting animal health. The deficiency/toxicity of minerals is an area problem. Although, geogenic trace elements toxicities have also caused wide health problems but higher concentration of pollutant elements in soils may lead to an excessive accumulation of metals by plants grown on such soils and may create animal- human health problems. Dysfunctional food systems are mainly responsible for this global crisis in animal- human health. Much of this malnutrition is the result of insufficient intakes of available trace elements in animal's diets. There are several ways in which agricultural factors can contribute to improve animal nutrition and health. Importantly, agricultural systems are the foundation upon which all nutrients enter into the animal food chain. Only through linking agricultural systems to animal nutrition can sustainable solutions. In this paper strategies and future thrust areas for research and for corrective measures of trace elements deficiencies and improvement of animal's health are discussed.

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Introduction

Heavy metals as environmental contaminants of terrestrial ecosystem are not a recent phenomenon. The concern over environmental pollution and its effect on plant and animal life has brought numerous regulations for waste disposal. In recent years, a great deal of concern has been shown on indiscriminate disposal or use of sewage/industrial effluent in agricultural land may pollute the soil with heavy metals and enter in the food chain and can lead to health hazards in animal and human beings. Trace elements are essential for plants, animal and human health. The deficiency of a nutrient results in non-functionality of an important metabolic activities in agriculture, animals and human lives. These are needed in small amount but are essential and indispensable like other essential nutrients from nutritional point of view.

Use of urban and industrial waste in agriculture processes may pollute the soil with heavy metals and may lead to health hazards in soil, plant, animals and human beings. Soil mineral status keeps on changing due to pressure on land for maximum crop production, fertilizer application and natural calamities, thus altering the mineral contents of feeds and fodders and hence their supply to the animals. Trace elements needed for plants are zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni) while animal need Fe, Zn, Cu, Mn, Se, I, Mo and Co.

Soil is the major source of trace elements entering the food chain. It is also a sink for elements from environmental sources.[14] Some localities have deteriorated soils due to the use and movement of groundwater containing heavy metals like As, Se etc to the soil surface. The problem is mainly associated with trace elements very greatly in different localities. For example, selenosis and fluorisis in animals in endemic form has been observed in several countries due to the excessive amount of Se and F in soil, water and agricultural products. Thus, knowledge of the sequence of events affecting the trace elements composition of soil, food and feed is necessary to understand in depth the soil- plant- animal interrelationship in determining the health hazards of animals and human beings. Trace element malnutrition is now a massive and rapid growing public health problem among all societies people below poverty line in many developing nations affecting about 40 % of the world population.[4,9] In view of the above, this paper summarizes the important contributions made by the team of scientist in India on monitoring the effects of heavy metal contamination in soil, plants and animals.

Pollutant elements in soils plants and animals

Zinc (Zn)

Zinc deficiency is widespread in soils of many countries and nearly 50% of the soil in the world is known to be Zn deficient.[16] Total and available Zn content in soils in India ranged between 7- 2960 $mg kg^{-1}$ and 0.1- 24.6 $mg\ kg^{-1}$, respectively with an average deficiency of 12 to 87 %.[17] Crops grown in these soils have low Zn content in seed and feeds. 49 per cent soils are deficient in Zn and nearly 1.6 million ha area is receiving 5 kg Zn ha^{-1} Y^{-1}. Zinc soil fertility is a good index of high Zn content in fodder and grains as significant correlation is found between available

Zn content of soils and Zn content in grain. However in many areas hidden deficiency has surfaced. Singh[7] reported that overall Zn deficiency is expected to increase from 48 % found in the year 1970 to 63 % by the year 2025 because more and more areas of marginal land are brought under intensive cultivation with out adequate micronutrient supplementation. The states of Punjab, Haryana, part of Uttar Pradesh and Andhra Pradesh have however shown a build up of Zn and decline in its deficiency. It is estimated that to correct Zn problem in soil and plants India would need 324 tons of fertilizer Zn ha^{-1} $year^{-1}$.

Iron (Fe)

Status of total and available Fe content in Indian soils is high, ranging from 4000- 273000 mg kg^{-1}. Acid and laterite soils still had high available Fe content and its toxicity is common, influencing rice yield during excessive rains.[17] Iron deficiency ranges from 1.0 to 35 % with a mean of 12 % in Indian soils. Its availability is lower in soils in arid and semiarid regions to forage and grains had lower Fe content in these areas and show more chlorosis compared to those grown in soils of humid and sub humid regions. However, Fe soil fertility status is not a good index of high Fe content in fodders as no significant correlation is found between Fe content of soil and Fe content in forage crops.

Manganese (Mn)

Status of manganese in Indian soils is adequate varying from 37 to 11500 mg kg^{-1} and available status 0.6-164 $mgkg^{-1}$ to support optimum growth.[1] Its deficiency in soil ranges from 1.0 to 22% with an average of 5% for the country. In parts of Punjab, Haryana and Uttar Pradesh deficiency of Mn is increasing and as much as 22% soils are reported deficient in areas under rice-wheat cropping system with an average of 5 % for the country. Widespread hidden hunger of Mn in wheat and other summer crops is not only leading to low yields but lead to infertility in cattle due to low Mn content in fodder and grain.

Copper (Cu)

Copper deficiency in Indian soils is not a severe nutritional problem and only about 3-4 per cent soils were found deficient among, 2,50,000 soil samples tested. Total copper content in soil ranged from 1.8-960 mg kg^{-1} and that of available content 0.1 to 32 mg kg^{-1}. Thus by and large most soils do not respond to copper fertilization except peat and mollisol soils having high organic matter contents. Crop management factors do not affect copper concentration in edible parts of plants. Copper toxicity is reported in copper mining areas and field crops continuous application of copper based fertilizers or pesticides. By and large, parent materials and soil character determine the available Cu status: high organic matter and clay content as well as pH causes decrease in its availability. In many parts of the world Cu deficiency in soils, especially sandy or containing large amount of organic matter has been recorded.[2] Its deficiency is prevalent in the Rift valley of Kenya.[6]

Iodine (I)

The rate of return of I is slow and small in quantity and repeated cycles of I in nature leads to its deficiency in soils and the plants grown on such soils contain as low as 10 μg I kg^{-1} in soils having adequate I. Human population largely depended on the food produced in these areas suffer from I deficiency disorder (IDD). This is the reason for the occurrence of wide spread IDD in the population of mountainous or sub-mountainous as well as flood-plains and sandy leached soil tracts of the world such as India, Bangladesh, Nepal, Myanmar etc. Iodine level in the drinking water indicates its content in soil. Its level in the drinking water from severely deficient areas of Nepal is 2.0 μg $L^{-1}$and of India 0.1-1.2 μg L^{-1} as compared to 9.0 μg L^{-1} in mildly I-deficient Delhi areas.

Cobalt (Co)

Cobalt deficiency is wide spread in soil-plant-animal chain in several countries.[3] Cobalt status in Indian soils ranges between 20- 1000 mg kg^{-1} with an available status of 0.5- 10 mg kg^{-1}. Its deficiency occurred on soils containing 4.4 to 47.0 mg Co kg^{-1}; in marginal to deficient areas soils contain 3 to 4 mg kg^{-1}, and in deficient areas 1 to 2 mg kg^{-1} soil.

Molybdenum (Mo)

Most of the Indian soils are adequate in molybdenum (Mo) content but its deficiency was found more in acidic, sandy and leached soils. Total and available Mo in Indian soils ranges between 0.1 to 12 $mgkg^{-1}$ and available Mo content traces to 2.8 mg kg^{-1} soil. About 13% soils of India have tested low. Whereas about 45% samples from acidic soils have tested to be low in Mo in meeting crop requirements.

Fluoride (F)

Fluoride is commonly found in soil mineral as fluorapetite, fluorosilicates and is added through irrigation water and gypsum, phosphogypsum, apetite, phosphoric fertilizers in ample quantities. Fluoride is easily absorbed by plants and its deficiency is not commonly reported.

Chromium (Cr)

Chromium in most of the Indian soils in general found in traces. Plant absorbs chromium though it not an essential elements for completing their growth and reproduction. It uptake is very small in normal unpolluted soils. Chromium concentration in leaf tissue is quite high in vegetable and cereal crops which are grown in soils polluted with sewage, chromite mining areas or industrial waste in peri urban areas. Baring heavily polluted soils with Cr from application of sewage sludge or industrial waste, its toxicity rarely occur.

Trace elements deficiency syndromes and disorders in animals

Diagnosis, assessment and prevention of trace mineral deficiency need a thorough understanding of the factors like age of animal, season, clinical signs, soil profile, and plant mineral content and feeding practices. Based on this preliminary information, further biological diagnostic tests can be followed for its confirmation. In general mineral deficiency is diagnosed by observing the clinical symptoms. But mineral deficiency signs are often confusing as the observed symptoms can be associated with more than one mineral and can be combined with the effect of protein and/or energy inadequacy, various types of parasitism, toxic plants, infectious disease or with deficiency of other micronutrients. Some minerals like Ca, Mg and P are found in body tissues and their deficiency symptoms are exhibited only after a period of time. Calcium and phosphorous deficiency can be observed more quickly, particularly in high producing animals and fast growing calves. Critical values of certain mineral in soil, plant and animals are provided in Table 1, which will be of much use in ascertaining the material deficiency. Certain naturally occurring mineral deficiency/ toxicity is directly related to soil characteristics as in case of fluoride, Se and Mo, but the level of mineral in soil does not necessarily indicate its availability to plants growing on the soil. Other limitation of plant mineral analysis is the biological availability and factors influencing the utilization like chelating agents, mineral antagonism etc. Therefore analysis of mineral content in body tissues is a better indicator of the mineral adequacy because mineral deficiency result in subnormal concentration of the element and will usually be associated with clinical signs, however for certain minerals due to homeostatic mechanisms the level may remain normal even during deficiency but will respond positively to supplementation. Research is being conducted for using biochemical markers like specific enzymes/tissues to assess the mineral status more precisely.

Diagnosis and assessment of mineral deficiency in animals

Zinc (Zn)

Zn deficiency disorder parakeratosis is associated with bone, joints and skin disorders. It was first detected in 1955 that manifests as thickening, hardening and fissuring of the skin in swine. The deficiency generally results from grazing of animals on forages contained 18 to 40 mg Zn kg^{-1} dry matter. Most of the forages from the Punjab and Haryana states of India contained less than 20 mg Zn kg^{-1} dry matter and their continuous feeding to growing calves and sheep affected growth and resulted in parakerotic skin lesion, poor feed efficiency and shedding of wool.[19] Wool shedding in corriedale sheep also observed at the Central Sheep Breeding Farm, Hisar.[11]

Iron (Fe)

Both in developing and developed countries Fe deficiency is generally recognized as the most common single nutritional deficiency in spite of that it is one of the most abundant minerals on earth. However, Iron deficiency in animals rarely occurs as its concentration in the fodder and feed is generally adequate to meet their requirement. Also fodders and pasture are often contaminated with soil or it is engrossed while grazing and thus supply significant amount of Fe to the animals. Manganese (Mn)

Widespread hidden hunger of Mn in wheat and other summer crops is not only leading to low yields but lead to infertility in cattle due to low Mn content in fodders and grain, glucose intolerance other malfunction which needs more detailed studies from animal and human health point of view. This was evidence by Singh[17] who recorded increased fertility due to Mn deficiency in cattle which were fed on fodder low in Mn grown in highly calcareous soils (free $CaCO_3$ 20-48%) around Pusa, Bihar. These workers found low blood serum Mn, prevalence of infertility and low productivity compared to cattle fed on fodders grown in Mn adequate soils.

Copper (Cu)

In India Cu deficiency or marginal Cu deficiency has been recorded at 60 farms. Its deficiency caused leucoderma (vitilogo), depigmentation of hair and skin around the brisket, neck, face, hind limbs and abdomen in buffaloes in India.[15,18] Also Cu deficiency caused "falling disease" in milch cows. In the livers of affected animals contained low level of Cu 32.6 mg kg^{-1} as compared to the normal concentration of 55.7 mg Cu kg^{-1} in healthy cows.[19]

Table1. Critical values of trace minerals (ppm) for assessment of status

Element	Soil	Feed/Fodder	Animal body	
			Normal level (Serum)	**Deficient**
Fe	2.5	50	1-2	<1 <40 (liver-wet weight)
Cu	0.3	8	0.65-1.2 125-600 (liver, DM)	<0.2-0.6 <33-125 (liver-wet weight)
Zn	1	30	1-2 25-200 (liver, DM)	<0.6-0.8 <25-40 (liver DM)
Mn	5	40	6-70 ppb >13 (liver, DM)	<5 ppb <7 (liver, DM)
I	-	0.1-0.2	0.1-0.4 total I 0.04-0.13 (Protein bound) 20-100 ppb T 4.	<0.05-0.10 <0.03-0.05 (protein bound) <7-30 ppb T 4
Co	-	0.08-0.1	-	<0.5 mg cm^{-3} (rumen fluid) <0.05 (liver) Vitamin B12 ,0.1-0.2 ppb
Mo	-	0.5	-	-
Se	-	0.1	0.2-1.2 (whole blood) 1.2-2.5 (liver DM)	<0.2-0.5 (liver, DM) <0.06-0.2 (whole blood) <0.03

Iodine (I)

Iodine deficiency has been reported in goats in certain districts of Punjab. Deficient levels of I in drinking water have caused endemic goiter in animals and birds[10] in many part of the world also.

Cobalt (Co)

In the chain of soil-plant animal, plant act as accumulator of Co for its conversion into Vitamin B_{12} in ruminants. It is essential for cattle, buffalo, sheep and goat. Ruminants required about 0.1 mg Co kg^{-1}. Under grazing conditions lams are most sensitive to Co deficiency, followed by mature sheep, calves and mature cattle. In cattle its deficiency associated with ground water podzols and gley (low humic or poorly drained) soils of the Atlantic Coastal Plain[8], sandy soils and wet climate. However, very meager information in this respect is available in India.

Molybdenum (Mo)

Molybdenum deficiency in animals is reported more in eastern high rainfall zone of India, where soils are low in Mo content. In north parts of West Bengal hair and hooves falling problem is reported widely in cattle due to low Mo in alluvial leached soils. Molybdenum toxicity in animals and humans is reported in some parts of Punjab, which affects copper utilization in the body due to Mo-Cu interaction.[13]

Chromium (Cr)

Chromium is essential trace elements for human and plays an important role in human and animals mainly in regulation of the glucose tolerance factor, in combination with nicotinic acid and some proteins which are required for every bodily function. In animals sufficient Cr been found to increase growth and longevity. Deficiencies are believed to be a factor in arteriosclerosis and hypertension and possibly in diabetes and cataract. Tetravalent chromium is toxic whereas hexavalent is essential and beneficial to human health.

Fluoride (F)

Fluoride is essential for the normal growth and development of bones in animals. Fluoride toxicity is reported in humans and animals in the form of fluorosis in arid regions mainly in Rajasthan, Gujarat, part of Haryana, Andhra Pradesh and Utter Pradesh where irrigation water containing very high amounts of fluoride than 0.1 mg F L^{-1} in urine.

Effect of trace elements deficiency in soils on animal health

The mineral content of soils depends not only on the parent material but also on the complexity of pedogenic factors like laterization, calcification and salinization of the total mineral concentration in soils, only a small fraction is taken up by plants. The “availability” of minerals in soils depends upon their effective concentration in soil solution. Several factors influence the uptake of minerals by crops and pastures from the soil. These include 1) soil acidity 2) soil moistures 3) soil temperatures 4) plant variety 5) fertilization 6) organic matter and microbial activity of soil. For trace mineral absorption the pH has the most marked effect on the availability. Alkaline soils lead to an increased biological availability of some trace elements such as Se and Mo. With decreasing soil pH, Se is less available, but the uptake of some cationic metals like Cu is increased. Soil leaching, erosion and long duration crops lead to a depletion of trace minerals. Crop management and climatic conditions also influence the eventual trace mineral level in feeds.

Sometimes, the level of Cu, Zn, Mn, Fe and Co in crops is sufficient for optimum yields but is not adequate to meet the needs of livestock animals.[5] Selenium is a trace mineral that is not required by most of the cultivated crops, even then maximum crop yields is obtained on soils with traces of Se. However, if livestock are fed with the low Se feed, they could suffer from serious muscular disorders and other diseases. White muscle disease due to Se deficiency is probably the most common and serious disorder found in calves and lambs.

Survey on micronutrient status in green and dry fodder to support animal health in Vadodara district of Gujarat indicated that though most of the soils are adequate in available Fe, Mn and Cu to support crop yields and need Zn fertilization to get good yields, but these dry fodder were tested and were found low in Fe (61%), Zn (72%) and Cu (87%) and that of Fe (17%), Zn (5%) and Cu (23%) in green fodder respectively, where as concentrations of Fe (90%), Zn (36%) and Cu (9%) mg kg^{-1} dry matter and Fe (70%), Zn (50%) and Cu (45%) for green fodder were considered critical, respectively. Table 2 shows State and zone wise mineral deficiency status for better animal nutrition suggested.

Haryana and most of the other states in the country also have low Zn, P and Fe whereas deficiencies of Mn are emerging fast in intensively cultivated crops in sandy alkaline soils.[12] When feed and fodders produced on such deficient soils were fed to cattle, the animals showed higher percentage of deficiency in their blood serum, hair and milk as given in table 5**.** The deficiency of Ca, P, Cu and Zn was found widespread. Deficiency of minerals commonly ranged from 23 to 57% in Ca, 2 4-69% in P,

20-60% in Zn and 33-64% in Cu in blood serum and milk samples. Animal hair also showed Mn deficiency.[12]

Similar study intended to assess the effect of micronutrient status in soil-plant-animal continuum, revealed that soil of Dahima village of Hisar, Haryana, and found deficiency of 74.45% in Fe, 68.9% in P and 4.8% in Zn and the fodders grown on these soils did not meet the normal mineral requirement of animal body **(**Table 3**).**

Analysis of animal blood plasma serum revealed maximum deficiencies of Cu (37.5%) followed by P (12.5%).

Table 2. Mineral nutrient deficiencies in various states for normal animal nutrition

State	**Zone**	**Mineral deficiency**
Arunachal Pradesh	Hilly and Mountain	Na, K, Mg, Cu, Mn
Assam	i) Lower Brahmaputra valley ii) Upper Brahmaputra valley; iii) Barak valley, iv) Central Brahmaputra valley v) North Bank Plain vi) Hill zone	P P, Ca, Cu P, Ca, Cu Ca, P, Mg, Cu Ca, P, Cu Ca, P, Mg, Cu
West Bengal	i) Northern Hill zone ii) Terai zone iii) New Alluvial zone iv) old Alluvial zone; v) Red Laterite zone vi) Coastal Saline zone	Ca, P, Cu Ca, P, Zn, Mn Ca, P, Cu, Zn Ca, P, Zn Ca, P, Zn Ca, P, Cu, Zn, Mn
Jharkhand/ Bihar	i) South-Wersteern Semi-arid zone ii) Central Plain zone iii) Eastern Plain Zone	P, Cu, Zn, Co, Mn P, Mg, Cu, Zn, Fe Ca, P, Cu, Co, Mn
Uttar Pradesh	i) Bundelkhand zone ii) Bhabar and Tarai zone iii) Western Plain zone iv) Central Plain zone v) Vindhyan zone	Ca, P, Cu, Zn Ca, Cu, Mn, Co Ca, P, Cu, Zn, Mn P, I, S, Zn P, Zn, Fe
Uttaranchal	i) Hill zone (Rainfed) ii) Tarai-Bhaber zone (Irrigated)	Ca, P, Cu, Co Ca, Cu, Co
Gujarat	i) Rainfed ii) Irrigated, iii) Arid zone, iv) Semi arid zone v) Hilly	Ca, Zn Zn Ca, P, Zn Ca, P, Zn Zn
Punjab	Irrigated	Ca, P, Cu, Zn
Madhya Pradesh	i) Northern Hill zone; ii) Kymore Plateau and Satpura Hills zone iii) Vindhya Plateau, iv) Central Narmada Valley v) Grid zone, vi) Bundelkhand zone vii) Satpura Plateau viii) Malwa Valley, ix) Nimar Valley x) Jhabua Hills zone	P, Zn P, Zn P, Zn, Fe P, Zn, Mn P, Zn, Fe, Mn P, Zn, Fe, Mn P, Zn, Fe P, Zn, Fe P, Zn, Mn Zn, Fe, Mn
Rajasthan	i) Semi arid zone ii) Arid zone	Ca, P, Zn Zn, Cu
Haryana	Irrigated	Ca, P, Cu, Zn, Mn
Himachal Pradesh	i) Shivalik Hill zone ii) Mid Hill zone, iii) High Hill zone iv) Cold Dry zone	Ca, Zn, K Ca Ca Ca, P, Zn, Cu
Maharashtra	i) North Konkan Coastal ii) Western Ghat iii) Transition zone-1, iv) Transition zone-II	Ca, P, Mg, Fe Cu, Zn Ca, P, Mg, Cu, Fe, Zn Ca, P, Mg, Cu, Fe, Zn
Karnataka	i) North East Transition zone ii) North East Dry zone iii) Northern Dry zone; iv) Central Dry zone, v) Eastern Dry zone vi) Southern Dry zone vii) Southern Transition zone viii) Northern Transition zone ix) Hilly zone x) Coastal zone	Ca, P Ca, Zn Ca, P, Mg, Cu, Zn Ca, P, Mg, Cu, Zn Ca, P, Mg, Cu, Zn Ca, P, Zn Ca, Cu, Zn Ca, P, Cu, Zn, Fe Ca, P, Cu, Zn Cu, Zn
Kerala	i) Northern zone,	Ca, P, Mg, Cu, Mn

	ii) Central zone, iii) High Range areas iv) Special problem areas v) Southern zone	Ca, P, Mg Ca, P, Mg Ca, P, Mg, Cu, Mn Ca, P, Mg
Tamil Nadu	i) Rainfed, ii) Coastal iii) Irrigated iv) Arid zone	Ca, P, Cu, Zn Ca, P, Cu, Zn Cu, Zn, Mn P, Cu, Zn
Andhra Pradesh	i) Rainfed zone ii) Coastal zone iii) Arid zone	Ca, P, Cu, Zn, Mn Ca, P, Cu, Zn Cu, Zn, Mn
Bihar	i) Zone-I, ii) Zone-II iii) Zone-IIIA iv) Zone-IIIB	Zn, Fe, Cu, Mn & Co Zn, Fe, Cu, Mn & Co Zn, Fe, Mn & Co Zn, Fe, Cu & Mn

Table 3. Average Percentage of mineral nutrient deficiency in blood serum, hair and milk in cattle in Haryana

Deficiency percentage based on	Ca	P	Cu	Zn	Mn
Serum mineral status	48.1	31.6	40.0		
Hair mineral status basis	30.1			50.3	47.6
Milk mineral status basis	42.8	53.9	29.0	42.9	

None of the human blood plasma samples showed mineral deficiency in the selected farmers and animals. Regular use of Zinc in Haryana by the farmers to rice-based cropping system has resulted in build up zinc fertility and improvement in zinc status in animal and humans. However, in eastern and northeastern regions of India, deficiency of Ca, Zn, Cu and Mo has been widely reported in children and cattle as 25 million h.a. acidic soils had lower status of these elements. Molybdenum deficiency in northern parts of West Bengal caused a drastic fall in hooves and hairs in cattle.

Trace elements fortification in feeds for animals and toxicity

Trace elements toxicity is also causing problems both to human and animals. Among these toxicity of F, NO_3, Mo, As, Se, Ni, Al, Cr and Fe are common in several areas as shown in Figure 1**.** Excessive selenium and molybdenum in certain parts of Punjab, arsenic in lower Indo-Gangetic plains of West Bengal through ground water are causing much toxicity to animal and human.[5,18] Fluoride toxicity, as dental fluorosis, expressed in the form of pigmentation with yellow, brown or black colouration, mottling, irregular wearing, erosion, pitting of enamel on teeth was reported by Sahoo et al. in sheep. 36% out of 1271 sheep monitored around national aluminum company smelter plant in Orissa. Fluoride discharged resulted in contamination of well and pond waters within 5 km of NALCO that ranged from 0.50-1.83 mg L^{-1} and 0.52-3.86 mg L^{-1} above the permissible limits. Fluoride affected sheep blood had significantly higher ceratine, alkaline phosphates in blood serum, but less glucose, cholesterol protein. Fluoride content in the urine, serum, bone, teeth of healthy and fluorotic sheep was 10.02 mg L^{-1} which is 10 times higher than those in healthy animals and critical level of 0.1 mg FL^{-1}, more than 90% of the total fluorides are taken by bony tissues, which however depends upon intake, age, sex, bone type and nature of bone (Table 4).

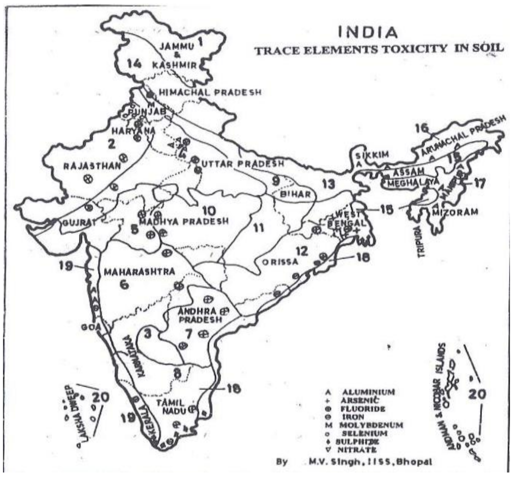

Figure 1. Areas suspecting trace elements toxicity in soil and animals

Thus, for ensuring better nutrition of animals and humans, bio-fortification of micronutrients in staple food crops are urgently needed. Since soils have enough iron, copper and manganese reserves, identifying plant varieties or crop species capable to higher absorption and translocation into seed are highly desired. Influence of micronutrient deficiencies on anatomical changes in plants, mechanisms of uptake and translocation among crop species and varieties need to be studied. Thus, these processes can be used as a tool for identifying efficient and inefficient plants. Besides screening of efficient varieties, agronomic interventions influencing biofortification, balance between micronutrient into shoot for loading higher concentration in seed have immense value for improving bioavailability of trace elements in animal model for reducing malnutrition.

Table 4. Mean fluoride content in the urine, serum, bone and teeth of healthy and fluorotic sheep

Sample	Fluorotic sheep	Healthy sheep
Urine (mg L^{-1})	10.02+-1.19	0.96+-0.13*
Serum (mg L^{-1})	0.61+-0.8	0.09+-0.02
Bone (mg L^{-1})		
Rib	8746+-54.9	658+-38.1*
Radius	7922+-50.4	612+-31.3*
Mandible	9481+-96.9	738+-29.9*
Teeth (mg kg^{-1})		
Incisor	4125+-60.4	320+-18.7*
Molar	4457+-66.6	364+-22.6

Similarly, cattle fed with fodder and concentrate low in Mn in calcareous soil belt had low blood serum than that of the optimum level and suffered more with infertility and low productivity. Thus, from animal health point of view, fodders and feeds need more mineral fortification either at field level keeping in view the soil fertility status or at feeding stall.

Conclusion

In the last few decades our knowledge about pollutant elements problems of soil, plant and animal, related either to the deficiency or toxicity of essential trace elements as well as toxicity of non-essential trace elements, as a result of their movement through the food chain. Their deficiency emanates as a result of their low content in soils and/ or depletion from soil due to high turnover rate with adoption of modern agricultural technologies. The information regarding the endemic diseases resulting specially from the deficiency of I, Zn, Cu, Fe, Se and F with the characteristics of geographic distribution has increased with time. Overcoming the deficiency or imbalances of minerals have improved in the productive efficiency of livestock to a great extent. Though, polluting elements have not received much attention neither in soil nor in the formulating diets, yet their long term practical impact on production, reproduction and immunity should not be ignored.

Thrust areas and Future strategies

- There is need for developing systematic database using GPS to monitoring health hazards from heavy metals pollution and trace elements toxicities in soil, plant, human and animal chain.
- Maps of trace elements deficiency and toxicity need to be produced to create awareness of such areas for taking remedial measures by the people, planners and policy makers.
- Enriching seed and feed with micronutrient for recharging micronutrient malnutrition and enhancing nutritional security of the country.
- To induce deficiency/toxicity symptoms for diagnosis micronutrient and trace elements deficiencies in field crops.
- Developing customized fertilizer for crops. Cropping system and certain agro ecological zones, soils.
- Studying relative supplementation of trace elements from fodders to animal is very much desired.
- Investigations are needed on plant anatomical and rhizoshheric changes responsible for the variability in absorption, translocation and uptake of trace elements by seed and fodder of food crops.
- Creating mass awareness about pollutant elements in soil-plant-animal continuum and remedial measures.
- To establish optimum level of elements for good health of animal and humans.
- A joint multi-disciplinary team consisting of soil scientist, nutrition scientist, physiologists, veterinary and medicine doctors may be constituted to establish definite quantitative association of animal and human health.

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