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Review Article

A Brief and Critical Review of Endemic Fluorosis in Domestic Animals of Scheduled Area of Rajasthan, India: Focus on Its Impact on Tribal Economy

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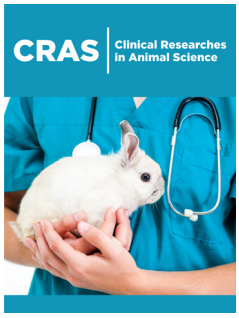

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Abstract

A special area has been created by the government of India by joining eight districts, namely, Banswara, Chittourgarh, Dungarpur, Pali, Pratapgarh, Rajasamand, Sirohi, and Udaipur out of 33 districts of the state of Rajasthan (India), which is called "scheduled area". Along with the area being very backward and underdeveloped > 70% of the population of this area is tribals. These people are very poor and backward socio-economically and are financially dependent on agriculture and domestic animals including cattle (*Bos taurus*), water buffaloes (*Bubalus bubalis*), sheep (*Ovis aries*), and goats (*Capra hircus*). In this area, not only the tribals but also their animals are suffering from the dreaded fluorosis disease by drinking fluoride-rich water. In fact, in this tribal area, almost all drinking groundwater and some perennial fresh water sources are contaminated with fluoride (F) in the range of 1.0-21.6ppm and 0.1-3.05ppm, respectively, which is higher than the recommended standard limits, 1.0 or 1.5ppm, in the country. Many industrial processes are also going on in this tribal area which are emitting F into the environment. Chronic F exposure through these sources numbers of domestic animals are suffering with mild to severe F poisoning. However, dental fluorosis is more prevalent and rampant in this area. At 1.5-4.4ppm of F in drinking groundwater, 28.3-70.2% and 25.7-64.1% animals of different species (mainly bovines and flocks) are found to be afflicted with dental and skeletal fluorosis, respectively. Lameness and ankylosis bone deformities are the worst conditions of chronic F intoxication in these animals. >82% bovine calves are also suffering with fluorosis in this area. However, bovine animals are relatively severely afflicted with chronic F poisoning compared to flock animals. In the present communication, various sources of F exposure, different forms of fluorosis, diverse determinants, susceptibility of F toxicity, bio-indicators and biomarkers of chronic F poisoning, impact of endemic fluorosis on tribal economy, and the prevention and control of fluorosis have been considered and briefly and critically reviewed. Along with this, the shortcomings of the research have also been highlighted. The findings of this review may contribute to the formulation and implementation of health plan for mitigation and control of fluorosis in domestic animals of scheduled area of Rajasthan (India).

Keywords: Bio-indicators; Biomarkers; Dental fluorosis; Fluoride; Food-born fluorosis; Groundwater, Hydrofluorosis; Industrial fluorosis; Scheduled area; Skeletal fluorosis; Tribals; Rajasthan; India

Introduction

Rajasthan is the largest state in India in which eight districts out of 33 districts, namely Banswara, Chittorgarh, Dungarpur, Pali, Pratapgarh, Rajsamand, Sirohi, and Udaipur have been carved out by the government of India as a special region called "Scheduled Area" (Figure 1). Along with this area being very backward and underdeveloped, >70% of the population in this area is tribals. Apart from traditional agriculture, these people also depend on cattle (*Bos taurus*), water buffalo (*Bubalus bubalis*), sheep (*Ovis aries*) and goats (*Capra hircus*) animals for regular income of the household. As per the recent Livestock Census 2019, the total livestock population in the country is 535.78 million. Out of this, the population of cow, buffalo, sheep, and goats is 35.95%, 20.45%, 13.87%, and 27.80%, respectively. In the state of Rajasthan, the total population of livestock is 56.8 million. Of which, 13.9 million are cattle, 13.7 million buffaloes, 7.9 million sheep and 20.84 million goats. Generally, the tribal people of this area use these animals for agriculture, milk production, and meat business.

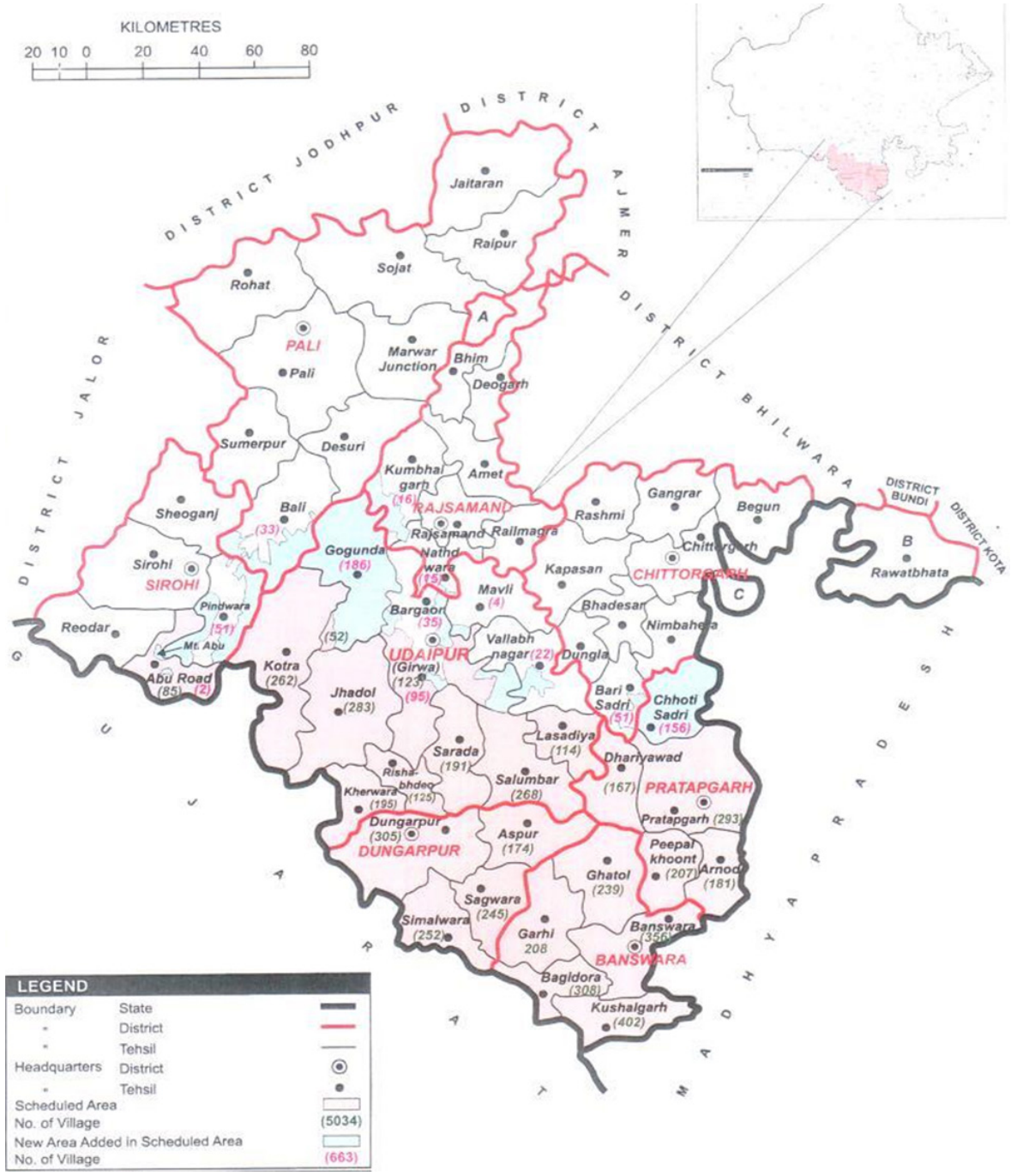

Figure 1: Map showing scheduled area of Rajasthan (as per notification of Government of India, 2018).

80 decades ago, in the scheduled area of Rajasthan, tribal people used to feed water to their domesticated animals including cattle (*Bos taurus*), water buffaloes (*Bubalus bubalis*), sheep (*Ovis aries*), and goats (*Capra hircus*) from nearby fresh water sources, open-wells, ponds, rivers, etc. But since thousands of hand-pumps and bore-wells have become available in the area, the tribals have started watering their livestock from these sources. In fact, "Dracunculus Eradication Programme" has been the reason behind the high number of these drinking water sources in the scheduled area of Rajasthan [1]. Because the drcunculiasis disease caused by infection of human nematode, dracunculus worm (*Dracunculus medinensis*), was endemic especially in this area, hand-pumps and bore-wells were dug at various places to break the life cycle of this worm [2-4]. But at that time responsible people did not know that there was F chemical in the groundwater of these drinking water sources.

In rural India, the groundwater of 23, out of 37 states and union territories is found to be contaminated with fluoride (F) with varying amount [5]. In Rajasthan and its scheduled area drinking groundwater is also highly contaminated with F (Figure 2); [1,6-10]. It is well known that drinking water containing F above the threshold level 1.0 or 1.5ppm [11-13] for prolonged period causes

dreaded fluorosis (hydrofluorosis) disease not only in humans [11,14] but also in various species of wild [15-17] and domestic animals [18-28]. Chronic F exposure through industrial fluoride pollution is also causes fluorosis in man and animals [29-35]. In the scheduled area of Rajasthan, chronic F poisoning in the form of hydrofluorosis at different F levels in drinking groundwater has been extensively studied in tribal people [36-46] and their domesticated animals, bovines and flocks [47-57]. In the present communication, various sources of F exposure, different forms of fluorosis, various determinants, relative susceptibility of F toxicity, bio-indicators and biomarkers of chronic F poisoning, impact of endemic fluorosis on tribal economy, and preventive measures and control of fluorosis have been considered and briefly and critically reviewed. Along with this, the shortcomings of the research have also been highlighted. The findings of this review may contribute to the formulation and implementation of health plan for mitigation and control of fluorosis in domestic animals of scheduled area of Rajasthan (India).

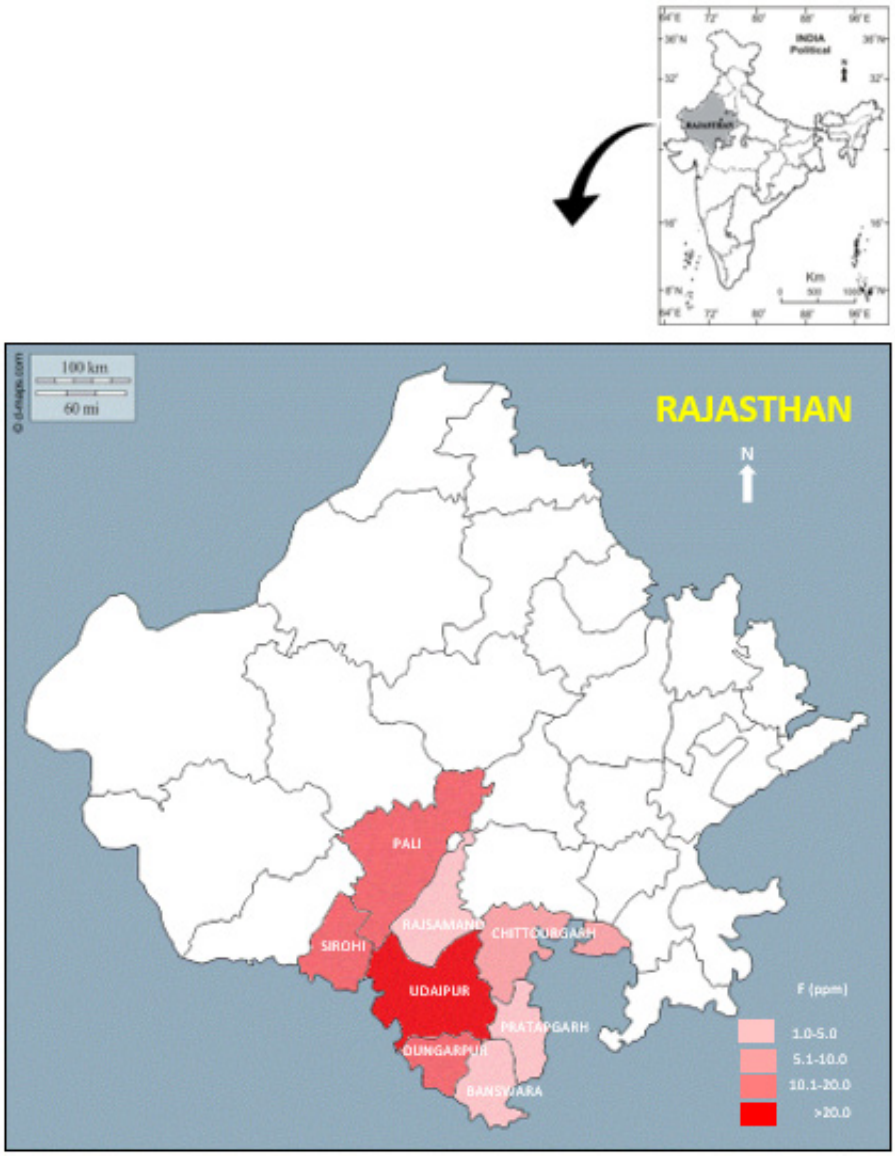

Figure 2: Map showing F distribution in eight districts of scheduled area of Rajasthan (India).

Fluoride Sources of Risk in the Scheduled Area

Overall, three major sources of F exposure or risk are prevalent in the scheduled area of Rajasthan, with potential and active roots for chronic F intoxication in domesticated animals of tribals. These are:

i. F-contaminated drinking water,

ii. industrial fluoride emissions, and

iii. fluoridated foods.

However, the first source of F exposure is the primary source that is most common and widely prevalent in this tribal area, while the others are secondary and tertiary sources of F toxicity, respectively, and are confined to the particular location or region.

F-contaminated drinking water

In the villages of scheduled area, among different drinking water sources, deep bore-wells and hand-pumps are the most common drinking water sources for both tribal people and their domesticated bovine and flock animals. Though, for drinking water, some seasonal and perennial water sources (ponds and reservoirs) are also available for these animals. In the scheduled area, water of hand-pumps and deep bore-wells are, generally, contaminated with F in the range of 1.0-21.6ppm [1,6-10] which is higher than the recommended standard or threshold value 1.0 or 1.5ppm in the country [11-13]. In this area, water of some seasonal ponds and perennial reservoirs is also found to be contaminated with F in the range of 0.1-3.05ppm [9]. The distribution of F in drinking groundwater of eight districts of scheduled area has been shown in Figure 2. This has been unanimously accepted that drinking of such F-rich water for a long time becomes toxic and is injurious to animal health. In the scheduled area, not only domesticated animals but also tribal people are also afflicted with chronic F poisoning in form of hydrofluorosis due to consumption of fluoridated groundwater for drinking and cooking purposes [36-46].

Industrial F emission

In recent years, in the scheduled area of Rajasthan, another possible source of F exposure is an industrial F emission. In this region, number of industrial activities such as Hindustan Zinc Smelter, phosphate and chemical fertilizer factories and manufacturing or production of bricks, glass, plastic, cement and hydrofluoric acid are considerably discharging F in both gaseous and particulate /dust forms into their surrounding environments which create an industrial F pollution. Fluoride emitted by the industry not only contaminates the surrounding soil, air, and drinking water reservoirs but also contaminates vegetation, agricultural crops, diverse food-chains and ecological webs, and many other biological communities on which tribal people and domestic animals are generally dependent on them for food. The long-term inhalation and/or ingestion of industrial F also causes diverse mild to severe toxic effects in the form of industrial and neighborhood fluorosis in domestic animals and tribal people, respectively [29-35].

Fluoridated foods

Besides the fluoridated drinking water and industrial F emission, other anthropogenic sources of F exposure are feed supplements such as mineral and phosphate supplements or commercial phosphorous lick to domesticated animals. But these sources are uncommon and restricted to those tribal people who can afford to purchase these feed supplements for their domesticated animals. In fact, these feed supplements contain high amounts of F therefore, these are also potential sources for the development of food-born fluorosis in domesticated animals [18]. However, this food-borne fluorosis in domesticated animals is yet to be reported in the Scheduled Area of Rajasthan. However, few reports are available on this entity in other parts of the country [58,59]. Green grasses and crop feeds (fodder) irrigated with F- rich water are also contain F in varying amount and are also sources of chronic F exposure for domestic animals. In fact, these are contributing sources and cumulative to the principle F exposure or fluoridated drinking water and having significant role in increasing of severity F toxicity in animals. The milk of fluoridated animals also contains high amounts of F which is also a potential source for the development of fluorosis in calves, lambs, and children [60-64]. But data on food-born fluorosis are not enough in the country. Therefore, more research studies on food- born fluorosis in domesticated animals are highly suggestive. Data from such studies are useful in health risk assessment in domestic animals as they are economically very important for tribal people.

Fluorosis in Domestic Animals in Scheduled Area

Whatever may be the sources of F exposure to domestic animals, once F enters the body, it is absorbed by the digestive and/or respiratory tract. From these F reaches different organs or tissues or every part of the body through the blood circulation system. More than 50% of F is absorbed from the digestive and respiratory tract, leaving the body through excretory products (faeces and urine) and sweat, while the rest remains in the body where it accumulates slowly in various biological or organ systems. However, due to its high affinity with calcium, its maximum amount is deposited in calcified skeletal and dental tissues and minimum in non-calcified tissues or soft organs. The accumulation of F in various organs affects their physiology and architecture and ultimately triggers the generation of various adverse reversible and non-reversible toxic health effects in the body. These toxic changes are collectively known as fluorosis [11]. If fluorosis is the result of drinking F-enriched water, the term is usually referred to as "hydrofluorosis". Similarly, fluorosis resulting from exposure to F through industrial F pollution and fluoridated foods is also known as "industrial fluorosis" and "food-borne fluorosis", respectively. Whatever F- induced toxic damage or malformations appear in the teeth (dental fluorosis) and bones (skeletal fluorosis), they are generally permanent and non-reversible. These deformities are lifelong or permanent and most of them are visible from the eyes. However, F^- induced changes in various soft tissues or organs (non-skeletal fluorosis) are reversible and disappear after the source of F exposure is removed.

Dental fluorosis

The earliest visible pathognomonic or clinical symptom of chronic F intoxication (fluorosis) in humans and animals is discoloration of the teeth or dental molting, commonly referred to as dental fluorosis [11]. This is the most sensitive, irreversible, easily recognizable, and indexive sign of chronic F poisoning. In the scheduled area, dental fluorosis is the most common and rampant in tribals as well as in their domesticated animals. This entity can be easily identified by the presence of bilateral striated, condensed or diffused and varying degree of horizontal light to deep brownish staining strips on the surface of anterior teeth (Figures 3 & 4) of flourosed animals [23,55,56]. These well stained strips are visualized more sharply and contrast in calves or immature animals (Figure 3A-3C). In some cases, dental fluorosis also appears as brown spots, patches, and fine dots on the enamel of teeth. In its

advanced stage, gingivitis and excessive tooth wear with obvious loss of teeth supporting the alveolar bone are also caused by chronic F intoxication which is more prevalent in older animals (Figure 4A-4D). In scheduled area, well layered light to deep black tooth staining was also found in some buffalo calves instead of brownish yellow [48]. Recently, such finding has also been reported in cattle calves of Thar Desert of Rajasthan [22]. The reason behind this difference in staining is still not understood.

Figure 3: Moderate to severe dental fluorosis in bovine calves (A-C) and juvenile (D) and sheep (E) and goat (F) characterised with stiatification with deep brownish staining which is clearer in cattle (A and B) and buffalo calves (C).

Figure 4: An advance stage of dental fluorosis in bovines of higher age group showing irregular striatification with deep brownish staining, pronounced loss of teeth supporting alveolar bone with recession and swelling of gingival, and excessive wearing of teeth giving a wavy appearance.

In the tribal villages of scheduled area where F concentration is 1.5-4.4ppm in drinking water, the highest prevalence of dental fluorosis in cattle, buffaloes, sheep, and goats was found to be 50.6%, 70.2%, 28.3%, and 32.9%, respectively [53]. In these villages, >82% bovine calves have also been found to be afflicted with dental fluorosis (Figure 4A-4C) [23]. Whatsoever, F^- induced

disfigure of teeth reduces the lifespan of these animals. When these dental lesions become severe enough to cause difficulty in grazing and mastication, the animals die at a young age from hunger and cachexia [11,65].

Skeletal fluorosis

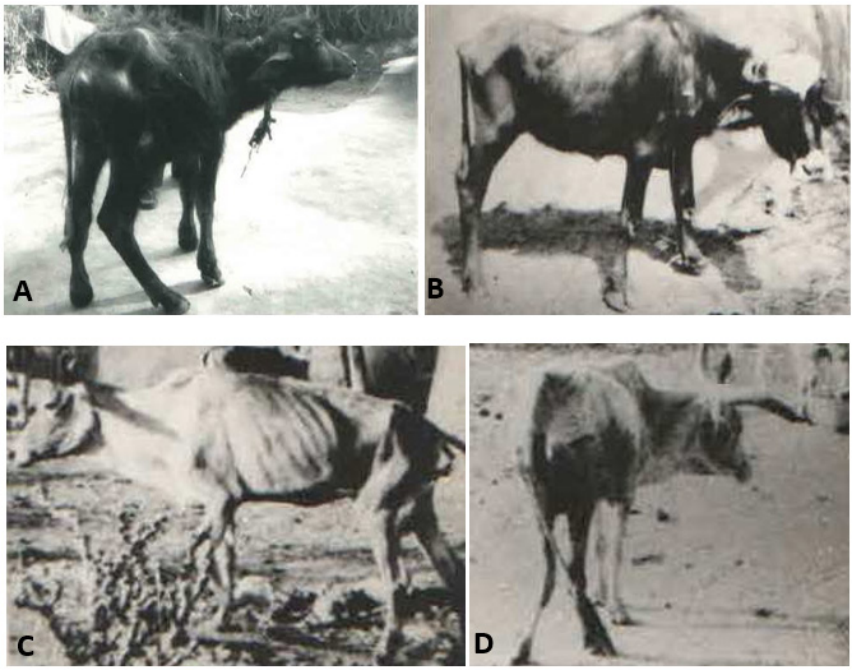

Figure 5: Severe skeletal fluorosis in domesticated bovines showing lameness, enlarged joints, debility, invalidism, hoof deformities, wasting of body muscles and bony lesions in the mandibles, ribs, metacarpus and metatarsus regions. Ankylosis deformity is also found in cattle (C and D).

Figure 6: Moderate and severe skeletal fluorosis in domesticated bovines (A and B) and flocks (C and D) characterised with lameness, enlarged joints, debility, invalidism, wasting of body muscles and bony lesions in the mandibles, ribs, metacarpus, and metatarsus regions.

Excess accumulation of F in various skeletal bones and their associated muscles and ligaments causes mild to severe deformities and are more dangerous and highly painful. In fact, these deformities are highly significant because they reduce or limit mobility in humans and animals at a very young age due to different architectural changes in the bones, such as periosteal exostosis, osteosclerosis, osteoporosis, and osteophytosis [66-70]. These changes manifest clinically as vague aches and pains in the body and joints that are associated with stiffness or rigidity and lameness, stunted growth, obvious bone lesions, and a cracking or snapping sound in the legs when walking in animals [48]. In addition, these progressive and irreversible bony changes become more severe as the animal progresses in age or in animals of higher age. Excess accumulation of F in muscle also reduces or restricts normal bone movement, causing lameness in animals. Although intermittent lameness, enlarged joints, debility, invalidism, hoof deformities, wasting of body muscles, and bony exostosis or lesions in the mandibles, ribs, metacarpus, and metatarsus regions are well recognized in the fluorosed animals (Figures 5 & 6) [48,55]. Cases of ankylosis have also been observed in animals due to drinking fluoridated water in scheduled areas, in very advanced stages of skeletal fluorosis (Figure 5). Such findings have been reported previously [71]. But such cases of severe form of skeletal fluorosis are very rare in the country.

In many tribal villages of scheduled area where F concentration is between 1.5-4.4ppm in diverse drinking water sources, the highest prevalence of skeletal fluorosis in cattle, buffaloes, sheep, and goats was found to be 42.7%, 64.1%, 25.7%, and 29.1%, respectively [51]. In these villages, >10% bovine calves are also found to be afflicted with mild to severe skeletal fluorosis (Figure 5A, 5B) [9].

Non-skeletal fluorosis

Whatever F induced manifestations in various organs are referred to as non-skeletal fluorosis. In fluoride and fluorosis endemic tribal villages of scheduled area, the most common F induced health complaints in domesticated animals have been reported as muscles/body weakness, frequently intake of water (polydipsia), frequent tendency to urinate (polyuria), gastrointestinal discomforts (loss of appetite, bloating, colic pain, constipation, intermittent diarrhea, etc.), allergic reactions, irregular reproductive cycles, abortion, still birth, etc. [19,21,55]. Interestingly, these health consequences are temporary and are mostly reversible after withdrawal of F exposure or removing the animals from F endemic area to non-fluoride endemic area. However, these health complaints in animals are only observational and not conclusive from experimental studies. Research work on fluorotoxicosis in excretory and male and female reproductive systems in different species of domestic animals is not scientifically fully justified and yet sufficient. F-induced effects on reproductive organs, endocrines glands, gametogenesis, embryogenesis, and brain are also not well studied and not at level of satisfactory in these domestic animals. Hypothyroidism in domestic animals has not yet been reported. Therefore, well-designed scientific experimental studies are highly needed to unravel the exact mechanisms involved at the molecular level for chronic F intoxication in different organs as well as endocrine glands in different species of domestic animals living in different ecosystems, arid and humid.

Determinants and Susceptibility of F Toxicosis

The prevalence and severity of fluorosis varies greatly among animals of the same or different species living either in the same or different geographic provinces, with drinking water having approximately the same F concentrations. This may be possible and indicates that some factor or determinant is involved in controlling or inducing F toxicity. In addition to the frequency of the main determinant F concentration and its duration and risk factors, other are chemical components in drinking water, age, sex, habits, food components, environmental factors, individual sensitivity and biological response or tolerance, and genetics can also significantly accelerate F toxicosis in both animals and humans [72-78]. These findings on determinants are more useful in the implementation or commencement of fluorosis control campaign. However, more studies are still needed for the understanding of correlation of these determinants with severity of chronic F intoxication in different species of animals rearing in the different geographical provinces having almost identical F concentration in drinking water or source of F exposure.

Indeed, major manifestations of chronic F intoxication have emerged as a global animal health problem. Unfortunately, besides considerable outstanding developments in veterinary sciences, a complete cure or reversal of osteo-dental fluorosis is still not known. However, in an experimental condition some of chemical substances like molybdenum (Mo), phosphate (P), sulphate (SO_4^{2-}), etc. have been reported to induce chemicals intestinal absorption of F while other chemical like calcium (Ca), vitamin A, C and D reduce its absorption [11]. Experimentally, it has been well studied that Ca, ascorbic acid (vitamin C) and vitamin-D_3 chemical factors have potential to reduce the F toxicity [76].

A large observational survey study conducted in bovines and flocks living in tribal villages in the scheduled area with low F content (1.5-1.7ppm) in drinking water showed that grass eaters bovines had the highest prevalence and severity of osteo-dental fluorosis as compared to the plant eaters flocks [77,79]. This indicates that bovines are relatively more susceptible to F poisoning than flock animals. Natural alleviation of F toxicity in plant eater animals living in high F endemic areas has also been reported [55,56,75]. In fact, flock animals typically eat small, delicate fresh leaves, legumes, and small fruits of trees and shrubs that contain substantial amounts of calcium (Ca) and ascorbic acid (vitamin C) nutrients. Both nutrients interfere with F metabolism and ultimately reduce the F toxicity. Similarly, in dromedary camels, F toxicity is also found less due to high content these nutrients in their natural foods [80]. Although the reversibility of dental fluorosis by supplementation of these nutrients in humans is still controversial, its further advancement can be checked by supplementation of Ca and vitamin C nutrients [76]. This indicates that both these nutrients can alleviate the F effects but cannot reverse dental and skeletal deformities.

Furthermore, in survey studies [9], it has been observed that bovine calves have higher susceptibility and sensitivity and lower tolerance to F compared to lambs and kids of flocks. Therefore, bovine calves are found to be suffering from severe fluorosis. Interestingly, in the study, none of lambs and kids were found to be afflicted with either dental or skeletal fluorosis. From this, it can be concluded that flock animals are naturally protected from chronic F poisoning due to the presence of rich amounts of Ca and vitamin C nutrients in their feed [79,80]. However, differences in the prevalence of fluorosis between goats and sheep are due to differences in sensitivity to F and the amount, duration, and frequency of F ingestion. Sheep animals are generally well adapted to arid environments and require relatively less amount of water for their survival. Hence, they have less and irregular F exposure resultant to lower F toxicity as in the case of dromedary camels [20,80].

Bio-Indicators and Biomarkers for Fluorosis

Any bio-indicator should have low resistance or tolerance to fluorosis, but high sensitivity or susceptibility to F exposure and give early signs of F intoxication. Recently, a large study was performed in mature and immature animals belonging to different species of animals residing in the scheduled area of Rajasthan where drinking water sources are naturally contaminated with F [81]. Interesting that among these animals, immature ones were found to be more susceptible to chronic F toxicosis and revealed its early clinical sign in the form of dental fluorosis. However, bovine calves are relatively more ideal bio-indicators for chronic F intoxication as these showed an early clinical sign of dental fluorosis [81].

Biomarker or biological marker generally refers to a measured characteristic that can be used as an indicator of some biological state. The term also sometimes refers to a substance whose presence indicates the existence of living organisms. These biomarkers are often measured and assessed to investigate normal biological processes or pharmacological responses to therapeutic intervention. F content in environmental samples such as feed and fodder indicate persistence of F contamination in the environment [82,83]. However, F contents in biological samples (milk, urine, blood serum, nails, teeth, bones, etc.) are also better biomarkers for chronic F intoxication in man and animals in contrast to morbidity and mortality [84-89]. Nevertheless, the presence of F in blood serum and urine is the most ideal method for the indication of current status of chronic F poisoning [14,90].

Impact of F and Endemic Fluorosis on Tribal Economy

The economic condition of the tribal people of scheduled area of Rajasthan is very poor. Economically, they are mainly dependent on traditional agriculture and animal husbandry. Despite the availability of sufficient essential resources and advanced equipment for modern farming, most of the tribal people are unable to use and purchase them for their farming due to poor economic conditions. Therefore, these people are heavily dependent on domesticated oxen for their traditional agriculture. But most of these bulls suffer from a severe form of incurable skeletal fluorosis disease. In general, these flourosed animals are physically weak and unable to walk properly due to having of F- induced lameness. As these animals are not useful for farming purposes, the tribal people have no option except to buy new bulls and cause them unintended economic loss. On the other hand, people like to buy lame animals in the market less. Due to this reason, tribal people are forced to sell them at low prices. Due to not getting proper price for these animals in the market, the economic condition of these people becomes weaker. On the other hand, irrigation with fluoridated water also reduces agricultural crop production [91] which also causes significant economic losses to tribal farmers. The tribal people of this area also do milk business for daily or household income. That's why these people breed and raise cow-buffalo for milk production. Due to chronic F toxicosis, the production of milk in these animals is reduced, due to which these people have to suffer economic loss due to less income. Due to poor quality of meat of fluorosed buffalo, sheep, and goats, the tribal people do not get good prices in the market. This is also a cause of huge loss to tribal subjects.

Interestingly, neither tribal people nor veterinarians in scheduled areas know the negative aspect of dental fluorosis in animals. In fact, dental fluorosis mitigates the lifespan of animals. When dental fluorosis is more severe than due to difficulty in grazing and mastication, the animals die at a young age from starving and emaciation [11,65]. Yet, the death of animals at a young age has greater economic consequences for tribal people of scheduled area of Rajasthan [56,75].

In fact, both F and fluorosis weaken the economic condition of the tribal people. But neither the tribals nor the concerned government departments are aware of the type of economic loss. Therefore, it is absolutely necessary to take all possible measures so that the tribal individuals of this area do not suffer financial loss due to causative factors, endemic fluoride and fluorosis. It is difficult to state that due to fluoride and fluorosis how much economic loss is caused to the tribal individuals of this scheduled area. But it can be evaluated after doing scientific research on this aspect. This type of assessment is more important and necessary in making health and economic policy in underdeveloped and backward scheduled area of Rajasthan.

Prevention and Control of Fluorosis in Scheduled Area

Most of the tribals do not know that there is no cure for fluorosis disease yet. Due to superstition, these people treat animals suffering from fluorosis in their traditional way which is very cruel. In this, the neck, shoulder, back and neck of the animal suffering from fluorosis are burnt or stained with a hot iron rod. But these animals die quickly due to secondary infection in deep wounds on the body. But with a little effort this disease can be checked easily. For this, first it is necessary to prevent F from entering the animal's body. Therefore, F- free healthy foods and drinking water should be provided to animals. It is also important,

generating general awareness in the tribals and veterinarians regarding the preventive measures of chronic F poisoning in animals. Defluoridation of fluoridated water can be done by adopting appropriate defluoridation techniques. Although several defluoridation techniques are available. However, one of them, Nalgonda defluoridation technique is most appropriate, suitable, and effective and also less costly [92]. In the scheduled area this technique has been adopted but its success rate is still very poor and at many places it is a total failure due to lack of proper monitoring, maintenance, responsibility, and handling. However, harvesting and conservation of rainwater are the most ideal methods to get regular F- free drinking water for domesticated animals. Another effective option is to provide treated fresh or surface water for ponds, reservoirs, dams, rivers, etc. instead of groundwater to domesticated animals which contain F in the range of 0.01-0.3ppm [11,93]. Shifting of animals from F endemic or industrial F pollution area to non-F endemic or non-industrial F pollution area is also one of the ways for prevention and control of F intoxication in domestic animals.

Conclusion

More than 70% of the tribal people living in the scheduled area of Rajasthan are economically poor and economically dependent on agriculture and animal husbandry. In general, tribal people rear bovine and flock animals for their agriculture and household income. But due to chronic F exposure through F-contaminated drinking water and industrial F pollution, most of these animals are suffering from dangerous fluorosis disease. Lameness and ankylosis deformities in these animals are the worst condition of this disease. F and endemic fluorosis are not only affecting the health of the tribal people and their domesticated animals but also affecting the economy of the tribal people. But this disease could be checked by providing F- free healthy foods and drinking water. General awareness about this disease in tribal people is also important for its prevention and control in tribals and their reared animals. In the scheduled area, an epidemiological survey studies on chronic F intoxication in diverse species of domestic animals is highly suggestive to know the current status of various fluoroses. During the survey studies, biological (urine, blood serum, milk, hair, teeth, bones, etc.) and environmental (soils, grass, water, cereals, vegetables, etc.) samples should also be collected and analyzed for evidence of F content which indicates the current status of fluorosis. Findings of these studies are useful in making health policy to control fluorosis in this backward and underdeveloped tribal area. The significance of the present review is to provide scientific information about the F and its toxicosis in diverse species of domestic animals which is useful in framing of future health plan for the mitigation of chronic F poisoning in this tribal area.

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