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RESEARCH ARTICLE

HYDRO-TELLURIC FLUOROSIS IN MOROCCO: TOXICITY, FLUOROPATHY AND CURRENT STATE OF PREVENTIVE ASPECTS

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Abstract

Prolonged exposure to fluorides causes chronic fluoride intoxication in humans and animals, which the main manifestation is, osteodental fluorosis. In Morocco, fluorosis affects a large number of animals, particularly ruminants, and constitutes a serious handicap in contaminated regions, both economically and in terms of health. It is identified by a change in the color, structure and orientation of the teeth, and by a change in the structure and texture of the bones. Regardless of the animal species affected, fluorosis appears after a relatively long period of exposure, from several months to several years, by disorders of phosphocalcic metabolism resulting in osteodental changes associated with various general symptoms. These lesions compromise the grip, chewing and movement of the animals, and thus cause malnutrition, a drop in productivity and sometimes may lead to death. These disturbances have the characteristic of being irreversible, since once installed, no treatment allows to eliminate them in a definitive way, prevention is therefore the only way to alleviate. In order to face this fluoride intoxication, farmers use mainly empirical methods, such as transhumance, the purchase of animals from fluoride free zones or their sale at a young age before the appearance of dental lesions. The reduction of ingestion by using water sources and feed with low fluoride content as well as the supplementation of minerals (Al, Mg, B, Ca) and vitamins (the case of vitamin C) to limit absorption, are also practiced. However, aluminum-based licking salt blocks and supplemented feed enriched with minerals and vitamins are no longer used due to the lack of financial means of some breeders and state financial support. While the preventive effects of calcium, magnesium and boron, have still not been the subject of clinical studies in ruminants. Decidedly, the lack of vulgarization and the socio-economic level of the population, as well as the lack of financial support, constitute the main obstacles in the ultimate goal of counteracting hydrotelluric fluorosis.

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Introduction:-

The chronic hydrotelluric fluorosis commonly called Darmous or Darghmous is a disease due to chronic fluorine intoxication in phosphate mining areas.

Like other minerals, fluorine is beneficial in small quantities but toxic in large quantities. As validated by the quotation of Paracelsus 'Nothing is poison, everything is poison, only the dose makes the poison'. Therefore, the excessive consumption of fluorine during a long period causes chronic fluorosis.

This pathology is considered as a major toxicological problem in Morocco, it generates important sanitary and economic consequences and which is manifested by functional disorders manifested by functional and lesional disorders affecting mainly the osteo-dental system, and leading to metabolic and cellular disorders.

All of these disturbances have repercussions on the animal's performance and its general condition, and therefore on its economic value and its productions.

Dental and bone damage leads to difficulties in gripping and moving in the animals and in the later stages death generally occurs due to malnutrition.

Economically, the death of animals at a young age, the drop in production and reproduction performance and the difficulties of marketing affected animals constitute a heavy economic burden for the breeders, who find themselves forced to abandon the practice of breeding, knowing that it is a primordial ways of subsistence for the population in these regions.

Throughout the world, the phosphate, phosphoric acid, phosphate fertilizer and charcoal burning industries fertilizers and coal combustion are the main source of air pollution by fluorinated derivatives.

In this same context, the consumption of water and grass by smoke and dust from the industries producing phosphate fertilizers, leads to the development of chronic fluorosis chronic fluorosis in cattle.

This review will cover the various studies on its epidemiology, socio-economic impact of CE carried out in Morocco, as well as the main constraints hindering formulation of suitable control strategies.

Materials and Methods:-

The present study was conducted based on a synthesis of the available literature on animal fluorosis in Morocco. To do so, for animal data, we consulted the database of the Agricultural Documentation Center of the Agronomy and veterinary Hassan II Institute, which contains all the veterinary thesis. International databases as Google Scholar and PubMed were also consulted for studies carried out in fluorosis in Morocco, in both English and French languages. The English keywords used were :Fluorine, hydro-telluric fluorosis, preventive measures, Morocco. The French keywords were Fluor, fluorose hydro-tellurique, moyens de prévention, Maroc. The data obtained were compiled in excel tables with their corresponding authors and dates of publication. The analysis of the results obtained from this database were processed and used.

Results and Discussion:-

Bioaccumulation and toxicity

Fluoraemia is considered to be an indicator of the fluoride content of the diet, reflecting the levels of fluoride absorption (Crombet, 1980; Caldera et al., 1988). In normal cases, blood fluoride levels are less than 0.3 ppm, whereas they can reach 1.9 ppm in cases of fluorosis. The lethal dose of fluoride has been set at 15 ppm (the literature reports lethal doses of between 7 and 16 mg/kg body weight (Martinez-Mier, 2011).

Levels in the environment:

Water

According to a study carried out in Morocco in 2014, which involved thirty wells spread over 19 towns. The values found vary from 0.42 to 8.95 ppm (El Jaoudi, et al., 2014).

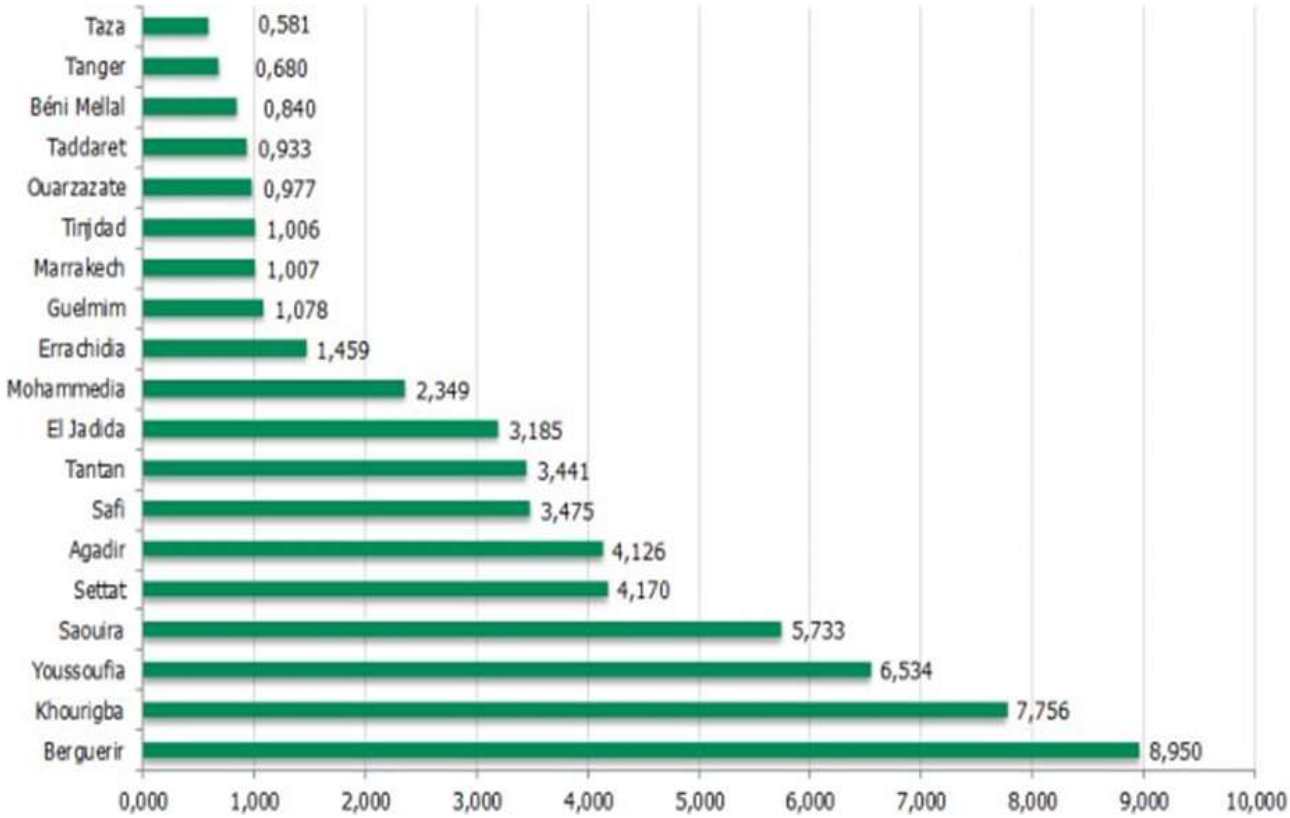

Figure 1:- The distribution of F concentrations (mg/L) by cities in well water in Morocco (El Jaoudi, et al., 2014).

Soil

In Morocco, the soil in Darmous areas contains very high quantities of fluorine compared with those in unaffected areas (Amouzigh, 1982, cited by El Alaoui Ismaili, 2015). Values were reported by Abdennebi (1982) of the order of 1652 ± 961.5 ppm in Khouribga and 1562 ± 849 ppm in Settat. Hichami (1996) reported levels of the order of 950 ppm in the El Borouj region, whereas in non-phosphate areas, this value does not exceed 500 ppm.

Acute toxicity

Acute fluoride toxicity in animals is rare and is caused by accidental ingestion of fluorine-containing insecticides or other chemicals such as sodium fluoride, sodium fluorosilicate and hydrofluoric or fluorosilicic acid (Zuo et al., 2018).

The LD50 of fluorine in rats is 50 ppm (CNESST, 2018). An experimental study conducted by Kessabi et al. in 1985, in which 4 batches of sheep were given a single intragastric dose of 0.5, 1.0, 1.5 and 2 ppm of fluorine respectively, revealed renal, hepatic, enteric and metabolic effects.

Chronic toxicity

Ingestion of repeated small doses of fluoride causes what is defined as chronic fluoride poisoning over the long term, and while osteodental fluorosis is what we most often hear about, there are many other manifestations of chronic fluoride poisoning of varying degrees of severity, some of which can even be life-threatening. We will only detail the main effects (Singh et al., 2014).

Fluoropathies

Prolonged exposure to fluorides causes chronic fluoride poisoning in humans and animals, the main manifestation of which is osteodental fluorosis (Ouchtabii, 2010).

Fluorosis in Morocco

The name given to this disease is Dar-Ghmous or Darmous: a word of Berber origin meaning, "tooth loss".

Table 1:- Studies carried out on fluorosis in Morocco.

Date of study	Authors and studies
1917	Fluorosis was first reported to the livestock department in the Ben Ahmed region.
1929	Velu reproduced fluorosis by feeding sheep natural phosphates.
1934	Gaud, Charnaut and Langlais studied seasonal variations in fluoride uptake.
1936	Speder, a radiologist in Casablanca, described the skeletal changes in people suffering from fluorosis.
1948	Charnaut, a toxicologist at the Rabat Institute of Hygiene, demonstrated that the fluorine in water from phosphate zones exists in the form of calcium fluoride (CaF2), and concluded that it is the plants in Darmous zones that are the main causes of fluorosis in animals.
1984	In an epidemiological study, Kessabi and Abdennebi established the areas where Darmous is rife, and showed that fluoride levels in water vary from 2 to 14 ppm depending on the region.
1987	In 1968, the commissioning of the JorfLasfer complex, known as Morocco-Phosphorus III-IV, led to the first symptoms of fluoride poisoning appearing in the douars.
2021	A study: Perception et pratiques d'élevage pour atténuer la fluorose chez les ovins dans trois communes de la province de Khouribga-Maroc wascarried out by El Amiri Bouchra et al.

Clinical presentation and lesions

Damage to the general condition is due, firstly, to the presence of dental lesions which make it difficult to grasp and chew feed, and secondly, to lameness which prevents the animals from moving.

Mortality in affected animals may be due either to food deprivation as a result of their inability to grip feed properly, or to severe lameness or loss of teeth (Swarup et al., 2001). In cases of fluorosis, the cellular structures of the kidney and liver tissues are damaged. Studies have been conducted into the role of oxidative DNA damage, oxidative stress and apoptosis in elucidating the cellular mechanisms caused by fluoride toxicity (Efe et al., 2020).

Dental lesions

Dental lesions are the first to be noticed when people are exposed to fluoride. They can appear even at relatively low levels of fluoride in the diet (Shupe, 1980; Shupe et al., 1973).

When dental lesions, especially those of the molars, become so severe as to affect prehension and mastication, the animals die of starvation or cachexia (Wang et al. 1992 cited by Choubisa, 2018).

Photo 1:-Comparison between healthy teeth and teeth affected by fluorosis (Zouarhi, 2009).

Photo 2:-A form of severe calf fluorosis characterized by brownish discoloration of the calf's front teeth.(Choubisa, 2018).

The bone signs of fluorosis are more serious and disabling than the dental signs, as they compromise the mobility of the affected animal. Affected bones may show exostoses, osteosclerosis, osteoporosis and osteophytosis (Choubisa, 2012).

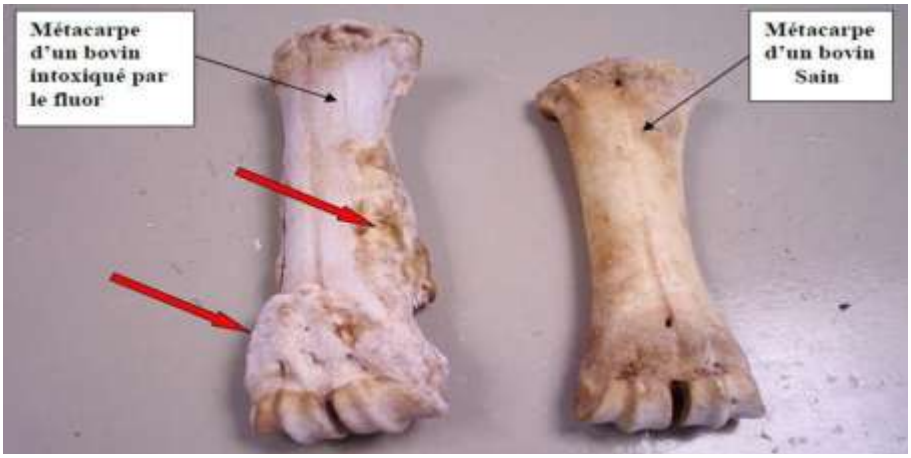

Photo 3:-Comparison of a metacarpus with exostoses and a healthy metacarpus (Amlal, 2007).

Photo 4:- A bovine showing poor general condition, stiffness and lameness (Lu &Kacew, 2013).

Blood fluoride levels are not a good indicator of fluoride intoxication (Bennis et al., 1993), but they are considered to reflect the fluoride content of the diet, and therefore essentially the absorption of the toxicant (Caldera et al., 1988). Normally, blood fluoride levels in ruminants vary from 0.19 to 0.30 ppm, but can reach 1.9 ppm in experimental fluorosis (Crombet, 1980 cited by Kessabi 1984).

Animals with fluorosis show hypocalcaemia and hypomagnesaemia (Belfaqih, 1986). In 1981, Hamliri noted hyperkalaemia, while natraemia showed no significant variations.

Diagnosis

Epidemiological diagnosis

This is a very important diagnostic tool. Fluorosis affects all animal species and humans that live or have lived in phosphate mining regions where the soil and water are rich in fluoride (Zouagui, 1973; Abdennebi, 1982), as well as in areas close to industries releasing excessive levels of fluoride.

Epidemiological diagnosis

The concept of epidemioclinical diagnosis is based on the detection of symptoms of fluorosis and their association with epidemiological data for the area in which these symptoms have been noted. The observation of dental damage, which is the first sign observed in mammals, with difficulty gripping and weight loss, in an endemic region or near an industrial facility that discharges fluorides, should directly suggest fluorosis (Livesey& Payne, 2011).

Laboratory diagnosis

This is the definitive diagnosis and involves determining the fluoride content of fodder, water, blood, urine, skeleton and teeth. In healthy animals, blood fluoride levels are 0.045 ppm (or less than 0.10 ppm), while urine fluoride levels are 2.20 ppm. However, in cases of fluorosis, these levels are 1.2 ppm and 60-80 ppm respectively (Swarup et al., 2001).

Preventive aspects of fluorosis

Although the scientific literature to date indicates that the manifestations of fluorosis are irreversible, it has been observed that the ingestion of calcium, vitamin C or vitamin D effectively protects against fluoride toxicity to a certain extent (Hassani, 2019).

History of prevention

The various preventive approaches most widely used or studied in Morocco, and the challenges to be met in controlling this hydrotelluric fluorosis, are summarised in the table below.

Table 2:- Main stages in the programme to combat fluorosis in Morocco carried out by the Ministry of Agriculture and Hassan II Institute of Agronomy & Veterinary Medicine.

Years	Stages
1985-1986	Experimentation on the "Krakra" breeding farm with the distribution of aluminum sulfate lick blocks. The aim was to identify the characteristics of the disease and the efficacy of the solutions tested.
1989-1994	Program extended to 70 breeders covering 12,000 head of sheep.
1995-1996	Involvement of the Association Nationale des Éleveurs d'Ovins et Caprins (ANOC) and Germancooperation (GTZ).
2008-2009	Involvement of the BeniMeskine association for human development and an Italian nongovernmental organization: experimentation with a fertilizer feed based on aluminum sulfates. 2017-2018
2017-2018	Work carried out with the aim of combating hydro-telluric fluorosis by Kli(2017), Es-sofi(2018).

2020-2021	A study: Perception et pratiques d'élevage pour atténuer la fluorose chez les ovins dans trois communes de la province de Khouribga-Maroc wascarried out by El Amiri Bouchra et al.

Conclusion:-

Hydro-telluric fluorosis is a chronic intoxication by fluorine which is endemic in phosphate-producing areas. It is due to the presence of an excessive quantity of this element in the soil, water and/or plants.

Fluorosis affects humans and most animal species, particularly ruminants, and, after a fairly long period of discrete evolution, results in irreversible and incurable osteodental manifestations.

In Morocco, transhumance is practised to prevent young animals at the teething stage from being exposed to fluoride, by moving them to fluoride-free areas. However, this practice is becoming less and less common, although it is still the most popular means of combating fluorosis among livestock farmers.

Fluorosis can also be prevented by reducing the intake of fluorides, through the use of low-fluoride feed and water.

Due to a lack of financial resources, lack of availability on the market and lack of dissemination among farmers, the use of aluminium-based licking blocks or compound feed enriched with minerals and vitamins as a means of preventing chronic fluorosis is almost non-existent. However, farmers are proposing that they should also be subsidised by the State.

The consequences of prolonged exposure to aluminium (toxicity, residues, effects on the consumer of meat from animals, etc.) are very serious.

References:-

1. **AbdennebiE.H.(1982):**LeDar-Ghmous:Etudeépidémiologique,cliniqueetconséquenceséconomiques.ThèseDoct.Vét.,IAV HassanII,Maroc.
2. **Amlal,M.(2007).**Contributionàl'étudeanalytiqueettoxicologiquedelafluoroseindustrielledansla régiondeJorfLasfar.Thèse Doct.Vét.,IAV HassanII,Rabat.
3. **AmouzighM.(1978).**Contributionàl'étudedelacorrélationsol-eau-planteenrégionphosphatiére.ThèseDoct.Vét.,IAVHassanII,Rabat.
4. **Belfakih A. (1986)**. Contribution à l'étude comparative de la fluorose hydrotélluriqueetindustrielle : Aspects épidémiologiques et perturbations biochimiques. ThèseDoct. Vét., IAVHassanII,Rabat.
5. **Bennis, A., et al., (1993).** Plasma biochemestry of adult goats with chronic fluoride poisoning in Morocco. Fluoride, 26(4), 241-246.
6. **Caldera R. et al., (1988).** Maternal fetal transfer of fluoride in pregnant women. Biol. Neonate., 54, 263-269.
7. **Choubisa, S. (2012).** Fluoride in Drinking Water and its Toxicosis in Tribals of Rajasthan, India. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 82(2), 325-330.
8. **Choubisa, S. (2018).** A brief and critical review on hydrofluorosis in diverse species ofdomestic animalsinIndia.EnvironmentalGeochemistryandHealth,99-114.
9. **CNESST.(2003).** RépertoireToxicologique:Fluor.
10. **CrombetM.(1980)**.Etudeexpérimentaledelafluorosecaprine.ThèseDoct.Vét.Alfort.
11. **El Amiri B. et al. (2021).** AFRIMED AJ –Al Awamia (133). p. 01-17
12. **Efe, U., et al., (2020).** Apoptotic and Oxidative Mechanisms in Liver and Kidney Tissues of Sheep with Fluorosis.
13. **El Jaoudi, R., et al., (2014).** Teneur en fluorures des eaux de puits des régions rurales au Maroc. Tropical Dental Journal, 37, 42-48.
14. **Es-sofi,M.(2018).**Donnéesactuellessurlasécuritédel'utilisationdel'aluminiumdanslaprévention delafluorose chronique.ThèseDoct.Vét.,IAV HassanII,Rabat.
15. **Hamliri A. (1981).** Fluorose expérimentale du mouton : aspects biochimiques. Thèse Doct.Vét.,IAVHassanII,Maroc.

16. **HassaniHamza(2019).**AspectspréventifsdesfluorosesauMaroc:Revuebibliographique,ThèseDoct.Vét.,IAVHassanII,Maroc.
17. **Kessabi, M. (1984).** Métabolisme et biochimie toxicologique du fluor. Rec.Méd. Vét., 135,497-510.
18. **Livesey, C., & Payne, J. (2011).** Diagnosis and investigation of fluorosis in livestock andhorses.InPractice,33,454Ŕ461.
19. **Lu,F.C.,&Kacew, S.(2013).**-ToxicEffects.Lu'sBasicToxicology,58–75.
20. **Martínez-Mier, E. Angeles (2011):** Fluoride: Its Metabolism, Toxicity, and Role in DentalHealth.Journal of Evidence-BasedComplementary& Alternative Medicine 201217: 28originallypublishedonline4December2011.
21. **Ouchtabii,A.(2010).**Contributionàl'étudedelafluorosed'origineindustrielledanslesrégionsde JorfLasfaretdeSafi.Thèse Doct.Vét.,IAV HassanII,Rabat.
22. **Shupe JL (1980).** Clinicopathological features of fluoride toxicosis in cattle. J Anim Sci51:458–746.
23. **Shupe, J.I., et al., (1973).** The effects of fluoride on dairy cattle. II. Clinical and pathologicaleffects.Am.J.Vet.Res.,24:264-279.
24. **Singh, N., et al., (2014).** A comparative study of fluoride ingestion levels, serum thyroidhormone&TSHlevel derangements,dentalfluorosisstatusamongschoolchildrenfromendemic andnon-endemicfluorosisareas.Springerplus,3(7),1-5.
25. **SwarupD.,et al., (2001)**Clinic-Epidemiological observations of industrial bovinefluorosisinIndia.IndianJ.Anim.Sci.,71:1111-1115.
26. **Wang,J.,Hong,J.,&Li,J.(1995).**StudiesonalleviationofindustrialfluorosisinBaotougoats.Fluoride,28(3),131-134.
27. **Zouagui,H.(1973):**Contributionàl'étudedelafluorosechezlesgrandsetpetitsruminantsauMaroc.Thèse deDoct.Vét.,Toulouse,France.
28. **Zouahri,F.(2009)**EssaidelapréventionduDarmous,fluorosehydrotellurique,utilisantunalimentenrichienaluminium. ThèseDoct.Vét.,IAV HassanII,Maroc.
29. **Zuo,H.,Chen,etal.,.(2018).**Toxiceffectsoffluorideonorganisms.LifeSciences,198(October2017),18–24.