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RESEARCH ARTICLE

RISK MANAGEMENT RELATED TO THE PRESENCE OF LEAD IN DRINKING WATER: A LITERATURE REVIEW

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Abstract

Background: Lead is classified as a toxic element because of its adverse health effects. World Health Organization fixes its tolerance limit at 10µg/l. Lead in drinking water mainly comes from the dissolution of lead present in pipes, especially in old buildings.
Resources and procedures: Through a literature review, we analyzed articles dealing with lead intoxication through drinking water. Used key words for the search were: lead, water and lead intoxication. The aim is to focus on the causes of this intoxication, the different consequences on the body, the standards in use and the prophylactic measures regarding this toxic element.
Results and comments: Saturnism is a disease corresponding to acute or chronic lead intoxication. Once absorbed, lead diffuse rapidly in soft tissues and more slowly in the skeleton. Lead presents a cumulative toxicity with generalized effects, classified in group IIIB. Screening is based on blood lead levels, induced lead poisoning or radiology exams. Treatment is based on lead fixation in a non-toxic form and its elimination under methodical control. Water pollution comes from natural or anthropogenic origins and several methods and tips can reduce the risk of lead exposure. The most common technique for the determination of lead is inductively coupled plasma atomic emission spectrometry.
Conclusion: In order to reduce as much as possible the risks linked to lead water pollution, it is essential to raise awareness of all stakeholders on the risks related to lead exposition and to sensitize them about preventive measures to be implemented.

Introduction:-

Lead is the most common heavy element. It has been classified as a toxic element because of its adverse health effects. Lead in drinking water mainly comes from the dissolution of lead present in pipes, especially the connection pipes between some houses and the municipal distribution network (MFS, 1992). This problem, which has always existed, was very little discussed, but with the recent standards of the World Health Organization that fix the lead tolerance limit at 10 µg/l, the issue of water pollution by this element has become of interest again (WHO, 2017). Lead concentrations in drinking water distributed through lead pipes, especially those constituting some of old buildings potable water network, pose a risk to the health of the population (Desnous, 1998).

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Materials And Methods:-

Through a literature review, we analyzed articles dealing with lead intoxication through drinking water. Used key words for the search were: lead, water, lead intoxication. The objective was to provide an update on the risk of lead intoxication related to drinking water lead contamination, the causes of this intoxication, the different consequences on the body, the standards in use as well as the prophylactic measures regarding this toxic element.

Results And Comments:-

Lead intoxication

Saturnism is a disease corresponding to acute or chronic lead intoxication. Individuals are more or less sensitive to this kind of intoxication, depending on their age, exposure duration, certain genetic predispositions and possible deficiencies in certain nutrients and trace elements (DGS, 2002; Labat and Lhermitte, 2007).

The total lead daily intake in drinking water is estimated at 9,8% for children and 11,3% for adults among other sources of lead exposure. Absorption increases following fasting or with iron, calcium, phosphorus or vitamin D deficiencies (Desnous, 1998).

Once absorbed by the organism, lead diffuse rapidly in soft tissues and more slowly in the skeleton. In this last case, it could be at the origin of chronic toxicity. Fig 1 shows the average lead half-life after penetration in the organism (ARS, 2017; DGS, 2002; Labat, and Lhermitte, 2007).

It should be noted that lead presents a cumulative toxicity with generalized effects, classified in group IIIB (possibly carcinogenic substances for humans), whose consequences are very diverse as shown in Fig 2 (ARS, 2017; DGS, 2002; MFS, 1992).

More important consequences for children under 6 years old have been described because 50% of the lead passes into the bloodstream compared to only 10% in adults. In this vulnerable population, it is a question of a cerebral process and intoxication may begin during intra-uterine life (DGS, 2002).

Screening

- Blood lead levels: It is predictive of health risks and therefore triggers screening, medical and social management of lead intoxication. The World Health Organization (WHO) and most European Union countries set a blood lead level < 100 µg/L in the absence of current or past specific exposure (DGS, 2002).
- Induced lead poisoning(Calcium EDTA or sodium edetate test): It's the best indicator of internal lead dose in chronic intoxication. It makes it possible to appreciate the quantity of mobilizable lead and the test is considered positive if:
  - ✓ For adults, more than 800 µg/L of lead is eliminated in 5 hours;
  - ✓ For children, more than 170 µg/L of lead is eliminated in 5 hours.
- Radiology …

Specific treatment

It is based on the principle of lead fixation in a non-toxic form and its elimination under methodical control, thanks to chelators capable of mobilizing lead fixed in the tissues (Mohamed-El-Hacene, 2021):

- The BAL (British anti-Lewisite) or Dimercaprol administered by the strict intramuscular route and preferably mobilizing soft tissue lead;
- Calcium EDTA administered by slow infusion over one hour, active on bone lead;
- The DMSA (Dimercaptosuccinic acid) which is an oral chelator that, like BAL, preferentially promotes lead excretion from soft tissue.

Sources of lead pollution in water

The concentration of lead in natural groundwater and surface water is generally low (less than 10 µg/l and often less than 1 µg/l). However, acidic or weakly mineralized waters can become enriched with lead. Water pollution can have several origins (ARS, 2017; Desnous, 1998; DGS, 2002; Labat and Lhermitte, 2007).

- Natural Origin: Earth's crust: 13 to 16 mg/kg (lead salts, sulfides, halides...), volcanic emissions, forest fires, meteorite fumes and radioactive decomposition of uranium, thorium and radon.

- Anthropogenic origin: Lead ore smelters (area of influence = 10 km), different industries (electric accumulators, chemical products, glassware...), incinerators, motor vehicle exhaust and urban water network as detailed on Fig 3 (Desnous, 1998; Seux et al., 1994).
These origins pollute both rivers and groundwater.

Water treatment techniques
Several methods can be used to treat water for domestic use: Decanting, coagulation with aluminum sulfate or ferric sulfate, filtration and lime softening at high pH (MFS, 1992).

Methods of lead determination in water
The most common technique for the determination of lead is inductively coupled plasma atomic emission spectrometry, which is characterized by its rapidity and the relative absence of interference with other sample components. Moreover, there are other techniques for the determination of lead in water such as Atomic Absorption Spectrometry (MFS, 1992).

Tips and preventive measures for consumers
Some simple tips can significantly reduce the risk of lead exposure:
- To let he water run before using it for drinking or cooking as shown on Table 1 (Seux et al., 1994);
- To use only cold water for food preparation (Desnous, 1998);
- To use bottled water for young children and pregnant women.
Other technical solutions can be presented such as the use of substitution materials as an alternative to traditional materials that can increase lead levels in drinking water as shown on Table 2 (Desnous, 1998; MATEE, 2005; Seux et al., 1994).

Conclusion:-
In order to reduce as much as possible the risks linked to lead water pollution, it is essential to respect some directives that recommend:
- To raise the awareness of property developers, trades and consumers on the risks related to the use of certain products or sanitary plumbing materials;
- To design a renewal plan for all existing lead connections;
- To sensitize consumers about the interest of preventive measures.

Table 1:- Total lead concentrations after different stagnation and flow times.

Flow time before sampling	Stagnation time		
	2 hours	**4 hours**	**17 hours**
0 minutes	580 µg/L	730 µg/L	1842 µg/L
2 minutes	36 µg/L	71 µg/L	87 µg/L
4 minutes	-	-	45 µg/L
6 minutes	-	-	15 µg/L
10 minutes	-	-	-

Table 2:- Alternative materials to those that may increase lead levels in drinking water.

Lead-releasing materials	Recommended alternative materials	Observations
Lead connections	Food grade blue stripe polyethylene	Highly permeation sensitive material
Lead stearate stabilized PVC pipe	PVC pipes stabilized with pewter salts	In principle, stabilization with lead salts is forbidden in most of countries.
Galvanized steel pipes	Galvanized steel pipes should be reserved for slightly corrosive water	- Lead : < 1% - Cadmium : <0, 1%
Pewter soft solder	- **Soft solder:** Use alloys Sn-Cu ouSn-Ag - **Strong solders:** Use alloys Cu-P ou Cu-Ag-Sn-Zn	Preferably use products that contain the minimum amount of

(40%Sn + 60%Pb)		lead

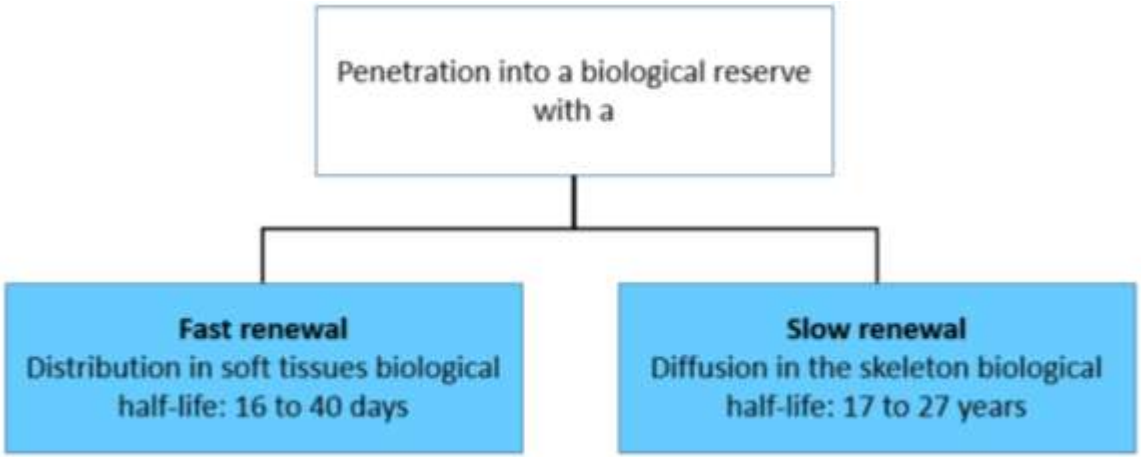

Fig 1:- Average lead half-life after penetration in the organism.

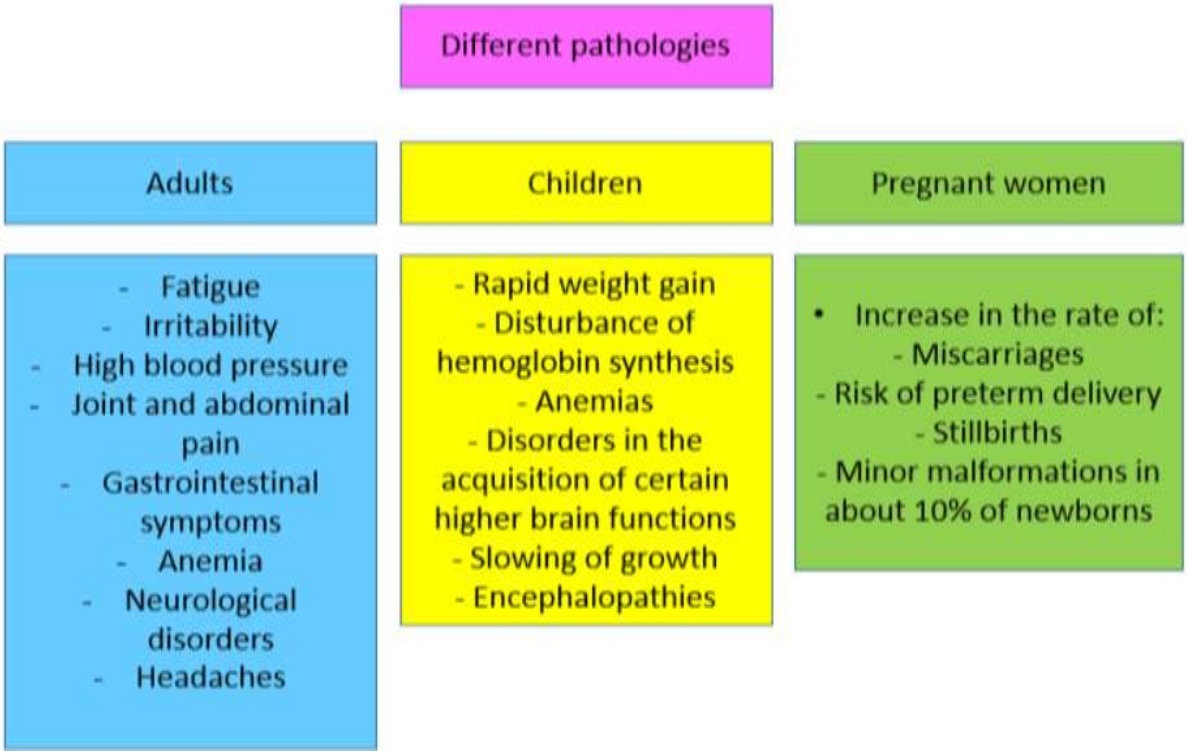

Fig 2:- Lead cumulative toxicity effects.

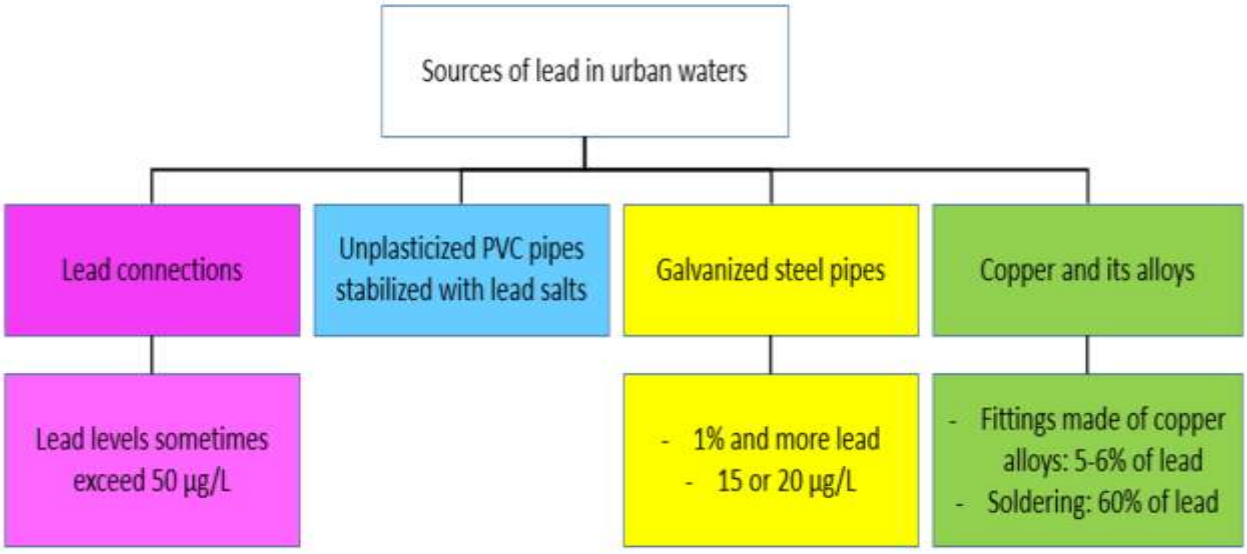

Fig 3:- Origin of lead in urban water.

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