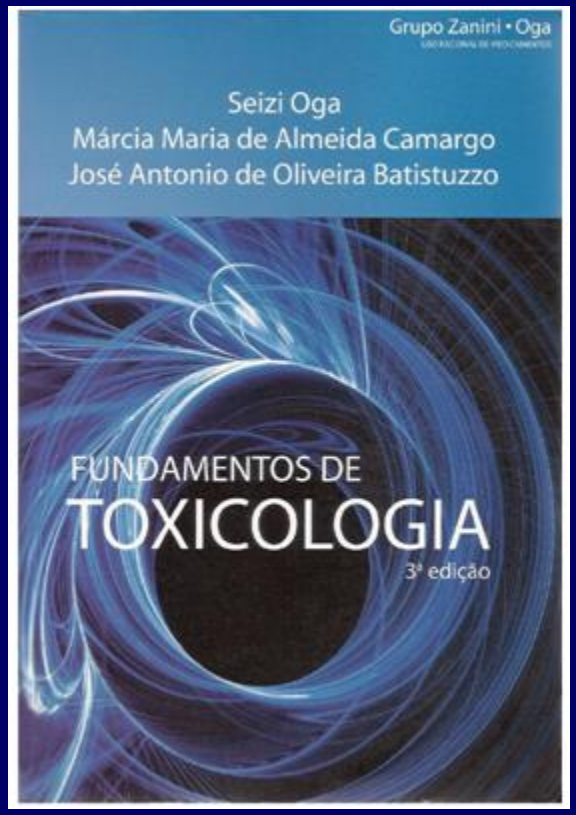
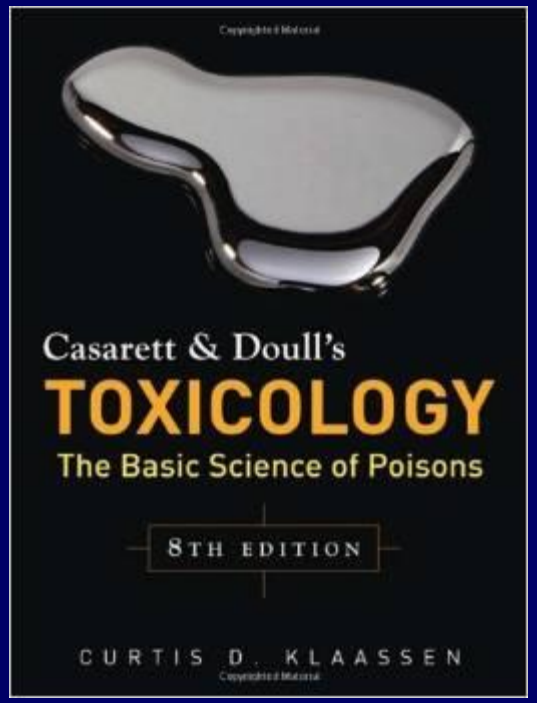
Disciplina: Toxicologia

# Toxicologia Ocupacional

AULA 2

Prof. Fernando Barbosa




-Textos fornecidos aos alunos

# Bibliografia

# Elementos essenciais e tóxicos ao homem

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **H** | | | | | | | | | | | | | | | | He |
| **Li** | Be | | | | | | | | | | | **B** | C | N | O | **F** | Ne |
| **Na** | **Mg** | | | | | | | | | | | Al | **Si** | **P** | **S** | **Cl** | Ar |
| **K** | **Ca** | Sc | Ti | **V** | **Cr** | **Mn** | **Fe** | **Co** | **Ni** | **Cu** | **Zn** | **Ga** | Ge | **As** | **Se** | **Br** | Kr |
| Rb | **Sr** | Y | Zr | Nb | **Mo** | Tc | Ru | Rh | Pd | Ag | **Cd** | In | **Sn** | Sb | Te | **I** | Xe |
| Cs | Ba | 57 a 71 | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr | Ra | 89 a 103 | | | | | | | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Maiores Essenciais** | | | | **Elementos-traço Essenciais** | | | | **Elementos Tóxicos** |
| | | | | | | | | |

# Principais fontes de exposição

(Pb) Fábricas de bateriais, tintas, pigmentos, cerâmicas, combustiveis

(Ag) Fotografias, equipamentos elétricos

(Hg) Amalgamas dentários, derivados de combustíveis fósseis lâmpadas fluorescentes, extração de ouro, produção de cloro, consumo de alimentos de origem marinha, peixes

(Tl) Semicondutores, lentes e componentes eletrônicos

(Mn) Atividades de mineração

(Cr) Pigmentos de tintas, eletrogalvanoplastia

(Pt) Catalizador em indústrias químicas

(Sn) Soldadores

(Cd) fumo, alimentos de origem marinha

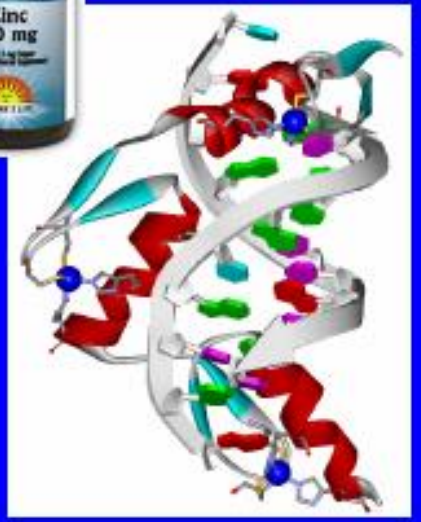
# TABELA PERÍODICA BIOMÉDICA

## Fármacos contento elementos químicos







# ATSDR-Agency for Toxic Substances & Disease Registry

Classificação de 2019

| Substância | Colocação |
|---|---|
| **Arsênio** | **1** |
| **Chumbo** | **2** |
| **Mercúrio** | **3** |
| Cloreto de vinila | **4** |
| Bifenilas policloradas | **5** |
| Benzeno | **6** |
| **Cádmio** | **7** |
| Benzo(a)pireno | **8** |

# Elementos essenciais e tóxicos ao homem

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **H** | | | | | | | | | | | | | | | | He |
| **Li** | Be | | | | | | | | | | | **B** | **C** | **N** | **O** | **F** | Ne |
| **Na** | **Mg** | | | | | | | | | | | Al | **Si** | **P** | **S** | **Cl** | Ar |
| **K** | **Ca** | Sc | Ti | **V** | **Cr** | **Mn** | **Fe** | **Co** | **Ni** | **Cu** | **Zn** | **Ga** | Ge | **As** | **Se** | **Br** | Kr |
| Rb | **Sr** | Y | Zr | Nb | **Mo** | Tc | Ru | Rh | Pd | Ag | **Cd** | In | **Sn** | Sb | Te | **I** | Xe |
| Cs | Ba | 57 a 71 | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | **Pb** | Bi | Po | At | Rn |
| Fr | Ra | 89 a 103 | | | | | | | | | | | | **VB** | | | |

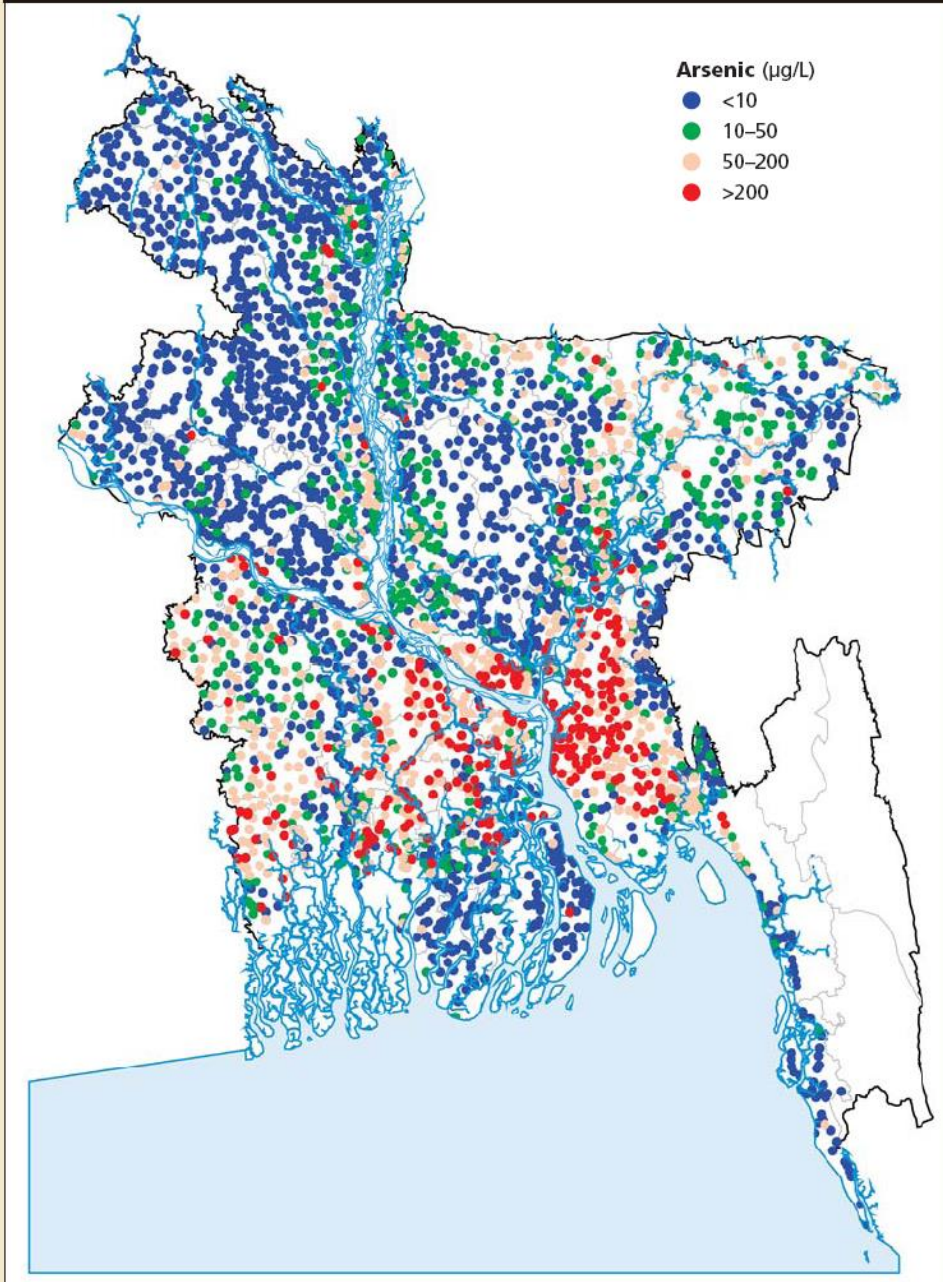
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Maiores Essenciais** | | | | **Elementos-traço Essenciais** | | | | **Elementos Tóxicos** |
| | | | | | | | | |

Arsênio: IARC, Grupo 1 carcinogênico (humanos)

# Bangadlesh- Arsênio

Arsenic in the drinking water leaves its mark on the hands.

# Arsenic concentrations in Bangladeshi tubewells




Source: British Geological Survey. 2001. Arsenic Contamination of Groundwater in Bangladesh. Available: http://www.bgs.ac.uk/arsenic/bangladesh/reports.htm.

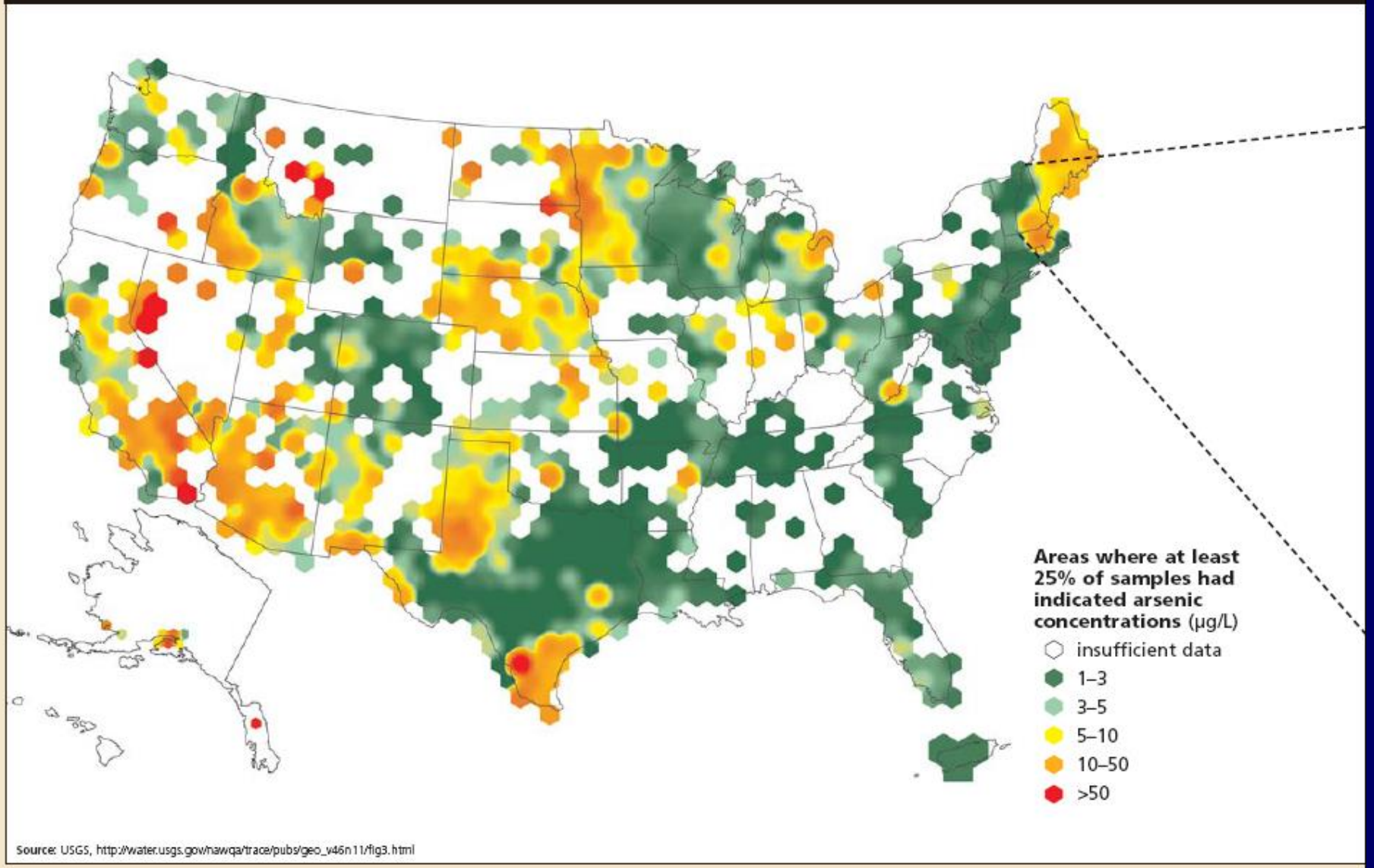

**Good intentions gone awry.** Villagers drill a tubewell in Bangladesh (left). Encouraged as a solution to pathogenic contamination of surface waters, such wells have resulted in exposure of millions to arsenic, leading to the need for alternative water sources (above).

**Coal catastrophe.** Cyclists on their way to work in Guizhou Province, China, pass through smoke pouring out of a coal-burning cooking stove. Exposure to the arsenic-rich coal burned in this region has resulted in endemic arsenicosis.

**Fool's gold?** Gold mining in areas of Ghana such as the Ashanti Goldfields in Obuasi results in the release of airborne arsenic particles that also have been linked to food and water contamination.

# Arsenopirita

## Arsenic concentrations across the United States . . .




Source: USGS, http://water.usgs.gov/nawqa/trace/pubs/geo_v46n11/fig3.html

# Arsênio e seus compostos

Produção anual 60.000 toneladas

| | |
|---|---|
| Arsenito | $AsO_2^-$, $AsO_3^{3-}$ |
| Arsenato | $H_2AsO_4^-$, $HAsO_4^{2-}$, $AsO_4^{3-}$ |
| Ácido arsênico | $H_3AsO_4$ |
| Trióxido de arsênio | $As_2O_3$ |
| Pentóxido de arsênio | $As_2O_5$ |
| Arsina | $AsH_3$ |
| Ácido Monometilarsônico (MMA) | $CH_3AsO(OH)_2$ |
| Ácido dimetilarsínico (DMA) | $(CH_3)_2AsO(OH)$ |
| Arsenobetaína | $(CH_3)_3As^+CH_2COO^-$ $X^-$ |
| Arsenocolina | $(CH_3)_3As^+CH_2CH_2OH$ $X^-$ |

**Formas inorgânicas de arsênio são mais tóxicas**

Principais formas de arsênio em ambiente de trabalho

# Toxicidade do As

| Espécies químicas | LD50 (mg/kg) |
|---|---|
| Arsenite (As(III)) | 14 |
| Arsenate (As(V)) | 20 |
| Arsine ($AsH_3$) | 3 |
| Monomethylarsonic Acid (MMA) | 700 - 1800 |
| Dimethylarsinic Acid (DMA) | 700 - 2600 |
| Arsenocholine | > 10000 |
| Arsenobetaine | > 10000 |

# Exposição ocupacional ao arsênio

-Minas
-Eletrônicos (com gálio)
-Soldadores
-Catalizador para produção de óxido de etileno
-Semicondutor
-Indústria têxtil
-Indústria cerâmica ($As_2O_5$)
-Fabricação de fogos de artifício ($As_4S_4$)
-Praguicidas

Annals of Agricultural and Environmental Medicine, Vol 24, No 2, 312–316
www.aaem.pl

ORIGINAL ARTICLE

# The history of arsenical pesticides and health risks related to the use of Agent Blue

**Vladimir Bencko[1], Florence Yan Li Foong[1]**

[1] *Institute of Hygiene and Epidemiology, First Faculty of Medicine, Charles University, Prague, Czech Republic*

**Abstract**

Arsenicals in agriculture. Beginning in the 1970s, the use of arsenic compounds for such purposes as wood preservatives, began to grow. By 1980, in the USA, 70% of arsenic had been consumed for the production of wood preservatives. This practice was later stopped, due to the US Environmental Protection Agency (EPA) ban of the arsenic-and chromium-based wood preservative chromated copper arsenate. In the past, arsenical herbicides containing cacodylic acid as an active ingredient have been used extensively in the USA, from golf courses to cotton fields, and drying-out the plants before harvesting. The original commercial form of Agent Blue was among 10 toxic insecticides, fungicides and herbicides partially deregulated by the US EPA in February 2004, and specific limits on toxic residues in meat, milk, poultry and eggs, were removed. Today, however, they are no longer used as weed-killers, with one exception – monosodium methanearsonate (MSMA), a broadleaf weed herbicide for use on cotton. Severe poisonings from cacodylic acid caused headache, dizziness, vomiting, profuse and watery diarrhea, followed by dehydration, gradual fall in blood pressure, stupor, convulsions, general paralysis and possible risk of death within 3–14 days.

The relatively frequent use of arsenic and its compounds in both industry and agriculture points to a wide spectrum of opportunities for human exposure. This exposure can be via inhalation of airborne arsenic, contaminated drinking water, beverages, or from food and drugs. Today, acute organic arsenical poisonings are mostly accidental. Considerable concern has developed surrounding its delayed effects, for its genotoxic and carcinogenic potential, which has been demonstrated in epidemiological studies and subsequent animal experiments.

**Conclusions.** There is substantial epidemiological evidence for an excessive risk, mostly for skin and lung cancer, among humans exposed to organic arsenicals in occupational and environmental settings. Furthermore, the genotoxic and carcinogenic effects have only been observed at relatively high exposure rates. Current epidemiological and experimental studies are attempting to elucidate the mechanism of this action, pointing to the question whether arsenic is actually a true genotoxic, or rather an epigenetic carcinogen. Due to the complexity of its effects, both options remain plausible. Its interactions with other toxic substances still represent another important field of interest.

# Metabolismo do arsênio

Espécies inorgânicas: As (V), As (III)

½ vida= 10h

As (V) → As (III) *in vivo* → *(sangue)*

Metilado (S-adenosilmetionina)

As (III) -> ácido monometilarsônico (MMA)

Metilação primária

**fígado**

Metilado (Metiltransferases)

MMA → Ácido dimetilarsínico (DMA)

Metilação secundária

Compostos orgânicos de arsênio → Excreção urina

Maioria não é metabolizada

10-20% Inorgânico
MMA (10-20%)
DMA (60-80%)

# Toxicidade de arsênio e seus compostos

-Afininidade por grupos tiol (-SH)

-Pode inibir a respiração mitocondrial
competindo com fosfato durante a fosforilação oxidativa

↓ na produção de ATP e ↑ Produção de $H_2O_2$

Estresse oxidativo
(EROS)

(carcinogênese)

Danos oxidativos
ao DNA
(base 8-oxo-guanina)

# Efeitos tóxicos esperados da exposição ao arsênio

-Doenças cardiovasculares

-Neuropatia

-Efeitos hematopoiéticos

-Doenças do trato respiratório

-Doenças no fígado

# Fatores que podem afetar a toxicidade de arsênio

## Agente:

-Propriedades físico-químicas
**(tamanho, solubilidade)**
-Forma orgânica ou inorgânica
-Estado de oxidação
(As (III) > As (V) > DMA)

## Trabalhador:

-Idade
-Sexo
Mulheres metabolizam mais rápido As(III)
-Nutrição
Deficiência de enzimas antioxidantes
Selênio (efeito competitivo, faz parte de enzimas antioxidantes Seleproteína P e glutationa peroxidase )
-Doenças