Metals and Metalloids

Refer lecturer for course updated notes.

Students are oblidged to follow the courses for evaluation process and presented notes are preliminary drafts for the whole evaluation process.

Metals

Lead (Pb)

- Pb is a heavy, low-melting, bluish-gray metal
- Accidental poisoning/ Chronic toxicity (industrial pollution)
- tetraethyl lead from gasoline-banned: the number of lead poisoning cases attributed to oil consumption has declined.
- Other sources: paint, linoleum, grease, lead object (e.g., shot, fishing sinkers, drapery weights); leaded glass; use of improperly glazed ceramic food or water bowls and contaminated foliage growing near smelters or along roadsides
- lead-based paint- renovation of old houses-exposure of small animals and children
- Improper disposal of lead-poisoned animal carcasses -nontarget scavenger animals.

Metals

Lead (Pb)

MOA

- substitute for other polyvalent cations (especially divalent cations such as calcium and zinc) important for cell homeostasis.
- metal transport, energy metabolism, apoptosis, ion conduction, cell adhesion, inter - and intracellular signaling, enzymatic processes, protein maturation, and genetic regulation
- Enters the blood and soft tissues and eventually redistributes to the bone.
- The degree of absorption and retention is influenced by dietary factors such as calcium or iron levels.

Metals

Lead (Pb)

- Poisoning common in dogs and cattle.
- Poisoning in other species is limited by reduced accessibility, more selective eating habits, or lower susceptibility.
- Cattle- Lead
- seeding and harvesting activities when used oil and battery disposal from machinery is handled improperly
- head pressing, violent movement, blindness, and salivation. These animals had considerably high Pb levels in their blood and milk.

Metals

Lead (Pb)

- Dogs is approximately 190 to 1000 mg/kg, chronic cumulative toxic dose is 1.8 to 2.6 mg/kg/day.
- Clinical Finding

gastrointestinal disturbances and nervous system dysfunction.

- Diagnosis

Complete blood count and radiographs. Chemical analysis of whole blood and liver/kidney

- Treatment

magnesium sulfate, EDTA or succimer chelation therapy, seizure control, and removal of lead material from the gastrointestinal tract.

Metals

Zinc (Zn)

- zinc -containing objects and products (pennies), metallic nuts, bolts, staples, galvanized metal (e.g., nails), pieces from board games, zippers, toys, and jewelry.
- zinc toxicosis, secondary to prolonged ingestion of a zinc oxide cream- severe Heinz body haemolytic anaemia, along with spherocytosis, left-shift neutrophilia, prolonged activated partial thromboplastin time, and mildly elevated blood urea nitrogen

Open Vet J. 2018; 8(4): 458–462.
Published online 2018 Nov 25. doi: 10.4314/ovj.v8i4.17

Zinc

- Rapid removal of the zinc object by endoscopy or laparotomy/gastrotomy
- IV fluid = maintain hydration and diuresis—acute renal failure is a serious sequela.
- Severe intravascular hemolysis—may require blood transfusion(s)/packed RBCs, oxygen-carrying substances (Oxyglobin)
- CaEDTA—100 mg/kg diluted in 5% dextrose SC, divided into 4 doses per day (treatment as for lead poisoning) if clinical improvement or reduced blood zinc is not accomplished by removal of zinc objects
- Penicillamine—110 mg/kg/day PO divided 6–8h for 5–14 days (treatment as for lead poisoning)—generally less frequently used
- Heparin—150 U/kg SC q6h; for DIC.
- H2-receptor antagonists (e.g., cimetidine, ranitidine, famotidine), proton pump inhibitors (e.g., omeprazole), and antacids used alone or in combination—may help reduce tomach acidity and the rate of release of zinc.
- Antiemetics

Metals

Mercury (Hg)

- zinc -containing objects and products (pennies), metallic nuts, bolts, staples, galvanized metal (e.g., nails), pieces from board games, zippers, toys, and jewelry.
- Hg toxicosis has been reported in cats, pigs, calves, horses, and laboratory animals (rats, mice, mink, ferrets, and guinea pigs) but rarely in dogs.
- fever attack, salivation, diarrhea, bloody feces, depression and anorexia, lacrimation, decrease in milk production, and cramps.
- Anemia on all mucous membranes and petechial hemorrhages on the nasal and vaginal mucous membranes, cardiac disturbance, and swelling of lymphnodes were also noted in the severe cases.
- In some instances, epistaxis, bloody milk, and nephritis were also observed. In another incidents, renal problems have been reported in dogs

Metals

Copper (Cu)

- zinc -containing objects and products (pennies), metallic nuts, bolts, staples, galvanized metal (e.g., nails), pieces from board games, zippers, toys, and jewelry.
- Cu intakes of 20-100 mg/kg in sheep and young calves, and 200-800 mg/kg in adult cattle.
- Chronic Cu toxicity occurs when high levels of Cu are ingested over a period of time but at doses below the acutely toxic level.
- Sheep are the most susceptible species to chronic Cu toxicity because their liver cells have a high affinity for Cu and they excrete Cu into the bile at a very low rate, leading to a build-up of liver Cu concentration over time.

Arsenic

- Arsenic (As) is a nonmetal or metalloid in group V of the Periodic Table, but is referred to as arsenic meta
- Arsenic is a ubiquitous toxic element that is concentrated in soil and water as a result of industrial activities
- organic, inorganic, trivalent, and pentavalent forms, and combines with many elements such as oxygen, hydrogen, sulfur, nickel, copper, and lead
- Arsenic is found as inorganic and organic forms with valences of +3 and +5. Arsenite (As^{+3}) is more toxic than arsenate (As^{+5}). Toxicity varies with factors such as oxidation state of the arsenic, solubility, species of animal involved, and duration of exposure.

Arsenic

- Commercial use of arsenic has been declining since the 1960s. Commercial products have included wood preservatives, pesticides, herbicides (weed killers, defoliants), fungicides, cotton desiccants, cattle and sheep dips, paints and pigments, antifouling paints, leaded gasoline, and fire salts
- Dogs and cattle are intoxicated more frequently than other animals; yet sporadic instances of poisoning have been observed in sheep, cats, horses, and pigs

Arsenic

- sudden death, diarrhea, ataxia, dehydration, respiratory distress, decreased milk production, increased salivation
- Azotemia, increases aspartate aminotransferease, hyperbiluribinemia, increased creatine kinase, increased alkaline phosphatase, hypocalcemia, increased c-glutamyl transferase, increased hematocrit, hematuria

- Diagnosis: silver diethyldithiocarbamate colorimetric procedure, AAS
- Acute arsenic toxicosis is a rare, sporadic condition in cattle.
- The cases with a favorable outcome were treated with sodium thiosulfate at higher dosages than the regimen described in other reports (40 mg/ kg IV q8h and 80 mg/kg PO q24h instead of 20–40 mg/kg IV q8h

Selenium

- narrow margin of safe- toxic concentrations in the diet being approximately 10- to 20-fold
- Selenium in the diet at >5 ppm may produce mild clinical effects after prolonged exposure of ≥30 days. Concentrations of 10–25 ppm would be expected to produce severe clinical signs with prolonged exposure.

Selenium

- acute selenosis
- subacute selenosis (i.e., blind staggers type
- chronic selenosis (i.e., alkali disease type).
- Acute poisoning occurs when high Se content plants are consumed in large quantities within short period. Accidental acute poisoning occurs as consequence of errors in formulation of a Se supplemented diet.
- In acute toxicosis, the blood and serum Se concentrations were .34 ppm, and in chronic toxicosis .12 ppm

Glas Srp Akad Nauka Med. 1992;(42):131-44.

[Selenium toxicity in domestic animals].

[Article in Serbian]

Mihajlović M.

Selenium

Acute selenosis

- garlic breath due to the pulmonary excretion of volatile Se metabolites.
- lethargy, excessive salivation, vomiting, dyspnea, muscle tremors and respiratory distress.
- congestion of the liver and kidney, fatty degeneration and focal necrosis of the liver, endocarditis and myocarditis.

Glas Srp Akad Nauka Med. 1992;(42):131-44.

[Selenium toxicity in domestic animals].

[Article in Serbian]

Mihajlović M.

Subacute selenosis ("blind staggers")

exposure to large doses of Se over a longer period of time and manifests with neurological signs (e.g., blindness, ataxia, disorientation) and respiratory distress.

- This form of selenosis is most frequently observed in grazing animals that have consumed Se-accumulated plants.

Glas Srp Akad Nauka Med. 1992;(42):131-44.

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Mihajlović M.

Chronic selenosis ("alkali disease")

- moderate levels of Se (more than 5 mg/kg and less than 40 mg/kg) for period of weeks or months.
- horses, cattle and swine are: loss of hair (horses and cattle lose long hair from the mane and tails), emaciation, hoof lesions and lameness.
- In advanced cases liver cirrhosis, atrophy of the heart and anemia occur.
- In swine symmetrical poliomyclomalacia of cervical and lumbal/sacral spinal cord segment has been seen.
- Sheep seen to be more tolerant and get milder form of the disease.
- They lose appetite and have reduced gain.
- In growing chicks reduced gain and feed intake, rough feathers, and characteristics of nervousness has been observed.
- Reduced egg production, embryonic deformations and reduced hatchability has been observed in hens.

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Selenium

- Feed supplements, resulting in final selenium content of 0.2–0.3 ppm, are added to diets to prevent deficiency and resultant diseases such as white muscle disease in cattle and sheep, exertional myopathy in horses, hepatosis dietetica in pigs, and exudative diathesis in chickens

Nitrate and nitrite

- potential danger to grazing animals.
- Ruminants are especially vulnerable because the ruminal flora reduces nitrate to ammonia, with nitrite (~10 times more toxic than nitrate) as an intermediate product.
- Nitrate reduction (and nitrite production) occurs in the cecum of equids but not to the same extent as in ruminants.

- Nitrates may cause inflammation of the gut when eaten in large quantities, but their main importance is as a source of nitrite. Nitrites cause respiratory distress due to interference with oxygenation of blood; death may follow.
- Pigs are the species most susceptible to nitrite poisoning, followed by cattle, sheep and horses.
- Young pigs also have GI microflora capable of reducing nitrate to nitrite, but mature monogastric animals (except equids) are more resistant to nitrate toxicosis because this pathway is age-limited.

Increased nitrate in plants

- Plants absorb nitrogen from the soil in the form of nitrates, which are then converted into proteins and other nitrogen-containing substances.
- Normally plants contain relatively small amounts of nitrate as such, because the conversions take place fairly rapidly inside the leaf.
- However, during periods of drought the amount of nitrate in the soil can increase greatly because of lack of leaching, reduced uptake by plants, and decomposition of organic matter.
- After the drought breaks nitrate uptake by plants may be high. While high concentrations of nitrate are not toxic to plants, animals grazing on such plants may suffer from poisoning.
- moisture stress, decreased light (cloudiness, short day length), and low temperatures. The use of nitrogenous fertilisers, and spraying plants with hormone-type herbicides (such as 2,4-D) can also cause a build-up of nitrate levels in plants.

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Plant factors

Under certain soil and environment conditions, plants can contain high levels of nitrates

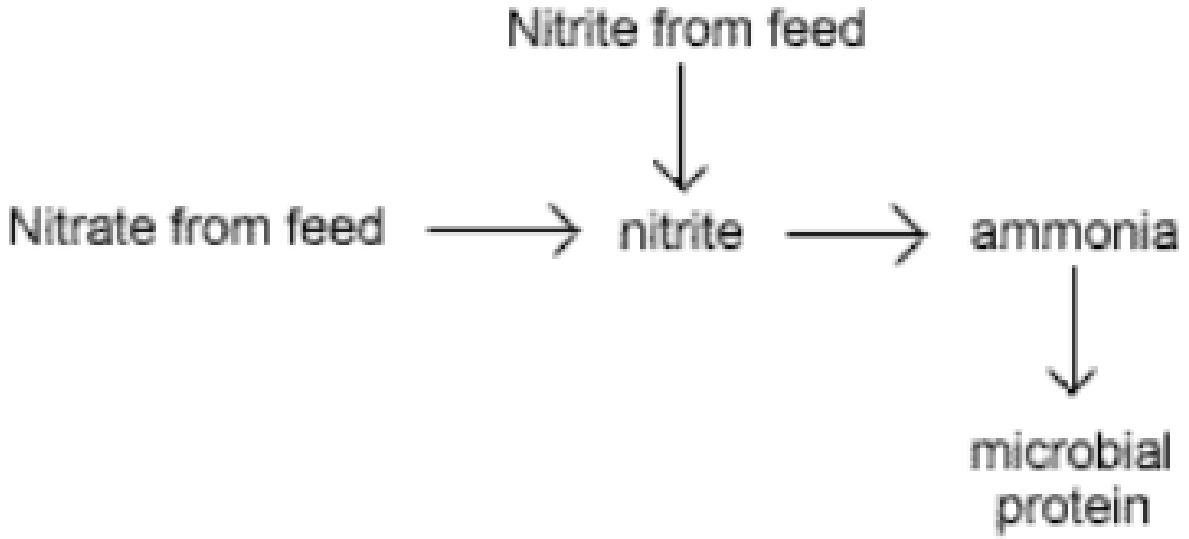
Factors that facilitate uptake of nitrate by plants include:

- use of nitrogen-containing fertilisers;
- low soil sulphur and molybdenum;
- areas where stock have congregated and urinated/defaecated (e.g. yards).

Factors which cause nitrate to accumulate in the plant include:

- drought;
- cloudy or cold weather;
- herbicide application – especially phenoxy herbicides such as 2,4-D;
- wilting.

RUMINANT:



NON-RUMINANT:

dpi.nsw.gov.au/__data/assets/pdf_file/0006/111003/nitrate-and-nitrite-poisoning-in-livestock.pdf

- tissue hypoxia and low blood pressure as a consequence of vasodilation.
- Rapid, weak heartbeat with subnormal body temperature, muscular tremors, weakness, and ataxia are early signs of toxicosis when methemoglobinemia reaches 30%–40%.
- Brown, cyanotic mucous membranes develop rapidly as methemoglobinemia exceeds 50%.
- Dyspnea, tachypnea, anxiety, and frequent urination are common.
- Some monogastric animals, usually because of excess nitrate exposure from nonplant sources, exhibit salivation, vomiting, diarrhea, abdominal pain, and gastric hemorrhage.
- Affected animals may die suddenly without appearing ill, in terminal anoxic convulsions within 1 hr, or after a clinical course of 12–24 hr or longer. Acute lethal toxicoses almost always are due to development of ≥80% methemoglobinemia.

Signs of nitrate poisoning are:

- diarrhoea and vomiting;
- salivation;
- abdominal pain.

Signs of nitrite poisoning usually appear 6–24 hours after the toxic material is consumed. These include:

- rapid, noisy and difficult breathing;
- blue/chocolate-coloured mucous membranes;
- rapid pulse;
- salivation, bloat, tremors, staggering;
- dark, chocolate-coloured blood;
- abortions – pregnant females that survive nitrate/nitrite poisoning may abort due to a lack of oxygen to the foetus; abortions usually occur 10–14 days after exposure to nitrates;
- weakness, coma, terminal convulsions, death.

Post-mortem findings

From nitrate poisoning:

- severe reddening and stripping of the stomach and intestinal linings.

From nitrite poisoning:

- dark red or coffee-brown blood that clots poorly;
- pinpoint haemorrhages in internal organs and on internal surfaces;
- accumulation of blood in the stomach wall.

dpi.nsw.gov.au/__data/assets/pdf_file/0006/111003/nitrate-and-nitrite-poisoning-in-livestock.pdf

- Methylene blue converts the methaemoglobin back to oxygen-carrying haemoglobin
- Slow IV injection of 1% methylene blue in distilled water or isotonic saline should be given at 4–22 mg/kg or more, depending on severity of exposure.
- Lower dosages of methylene blue can be used in all species, but only ruminants can safely tolerate higher dosages.
- If additional exposure or absorption occurs during therapy, re-treating with methylene blue every 6–8 hr should be considered.
- Rumen lavage with cold water and antibiotics may stop the continuing microbial production of nitrite.

Fluorosis

- natural contamination of rock, soil, and water or from industrial waste or smelting processes.
- Maximum tolerance levels in animal feeds range from ~20–50 mg/kg (dry weight) in most species. In poultry, as much as 200 mg/kg can be tolerated
- level exceeds 100 ppm of chronic fluorosis. fluorine in ration utilizing the source of fluorine as rock Pathogenesis & Necropsy Findings phosphate or cryolite likely to cause diseases in cattle
- Calcium fluoride or sodium fluorosilicate is relatively non-toxic and an intake of 400 mg to 2 gm/kg of body weight is necessary to have fatal effects
- Sodium fluoride is nearly twice toxic and general level of 50 ppm of dry ration should not be exceeded

Fluorosis

ppm, moderate effects at 49 ppm level. Where as bony light lesions are observed at 27 ppm, moderate at 49 ppm level and marked at 93 ppm. Milk production in dairy cows is not affected at 50 ppm of fluorine in the diet up to fourth lactation. Fluorine in excess of 2 ppm in water is toxic to animals.

Minor teeth lesion occurs at 5 ppm, while when the level exceeds of 10 ppm the excessive wear and tear of tooth occurs. More systemic effects occur when the water contains 30 PPM of fluorine. Chronic intoxication occurs when bore water contains 12 – 19 ppm fluorine.

When daily intake of fluorine is 0.5 to 1.7 mg/kg body wt. in the form of sodium fluoride produces dental lesions in growing animals without affecting general health, whereas the adult animals can tolerate double the dose of the above intake i.e. 1 to 3.5 mg/kg. body weight per day is sufficient to cause severe dental fluorosis without affecting growth rate or reproductive function. An intake of 1 mg/kg body weight is the maximum safe limit for ruminants. An intake of 2 mg/kg body weight produces clinical signs after continued ingestion.

In case of pregnant cows the fluorine content of bones of new born calves depends on the dam's intake of fluorine in the last 3-4 months of pregnancy.

Veterinary World, 2010, Vol.3(11):526-527

Fluorosis

- The primary manifestations are mottling of teeth (dental fluorosis) and andosteosclerosis of the skeleton (skeletal fluorosis).
- Nonskeletal fluorosis or toxic effects of chronic fluoride exposure in soft tissues, such as gastrointestinal discomforts, neurological disorders, impaired endocrine and reproductive functions, teratogenic effects, apoptosis, genotoxic effects, excitotoxicity, etc., have also been reported in man as well as in domestic animals
- Acute toxicity arises by inhalation of fluorine smoke, vapors, dust from volcanic eruptions, and dust from industries that use aluminum, Cu, enamel, glass, iron, steel, superphosphate, etc.
- It also may be due to accidental ingestion of large amounts of fluorine

Fluorosis

- There was decrease in milk yield in buffaloes and in cattle

Control and Prevention

1. Removal of source of fluorine intoxication.
2. Acute cases require gastro intestinal sedatives and demulcents.
3. To neutralize residual fluorine in the alimentary tract calcium salts are given intravenously.
4. Feed mineral supplements should not be incorporated more than 2% of the grain ration. An intake of 1-1.5 mg/kg body weight fluorine is the maximum safe limit advisable without causing major deleterious effects on health in ruminants.
5. Bone meal is a rich source of fluorine, hence must be used cautiously in the feed. Water from deep wells and artesian bores should be checked for fluorine content before use and allow to settle for at least 6 hrs before use.
6. Aluminum sulfate @ 30 gms or in higher doses should be given daily for prevention of chronic fluorosis.

Veterinary World, 2010, Vol.3(11):526-527