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"OSH+ for the European Agriculture sector - Stimulating growth in rural areas through capacity building for providers (and beneficiaries) of occupational medicine and OSH services"

C2-Training Course for Occupational Medicine physicians

Module 14 - Chemical substances & Poisoning & Toxicology in Agriculture

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Funded by the Erasmus+ Programme of the European Union

CHEMICAL SUBSTANCES, POISONING AND TOXICOLOGY IN AGRICULTURE

The goal of Module 14 is to understand the health risks associated with chemical substances used or accidentally released in agriculture, to recognize, diagnose, treat and prevent poisoning. Sections are outlined here as follows:

1. Exposure to pesticides,
2. Exposure to organic dust,
3. Exposure to irritant gases and vapors,
4. Exposure to hydrocarbons, exhaust gases (CO) and mineral oils,
5. Exposure to organic solvents,
6. Exposure to biocides,
7. Accidental exposures,
8. Toxicity of plants,
9. Contaminants of agricultural systems.

Toxic materials are chemical substances or mixture that may cause harm to an individual if it enters the body.

Route of exposure:

- inhalation (most common);
- skin contact (through unprotected skin);
- ingestion (less common).

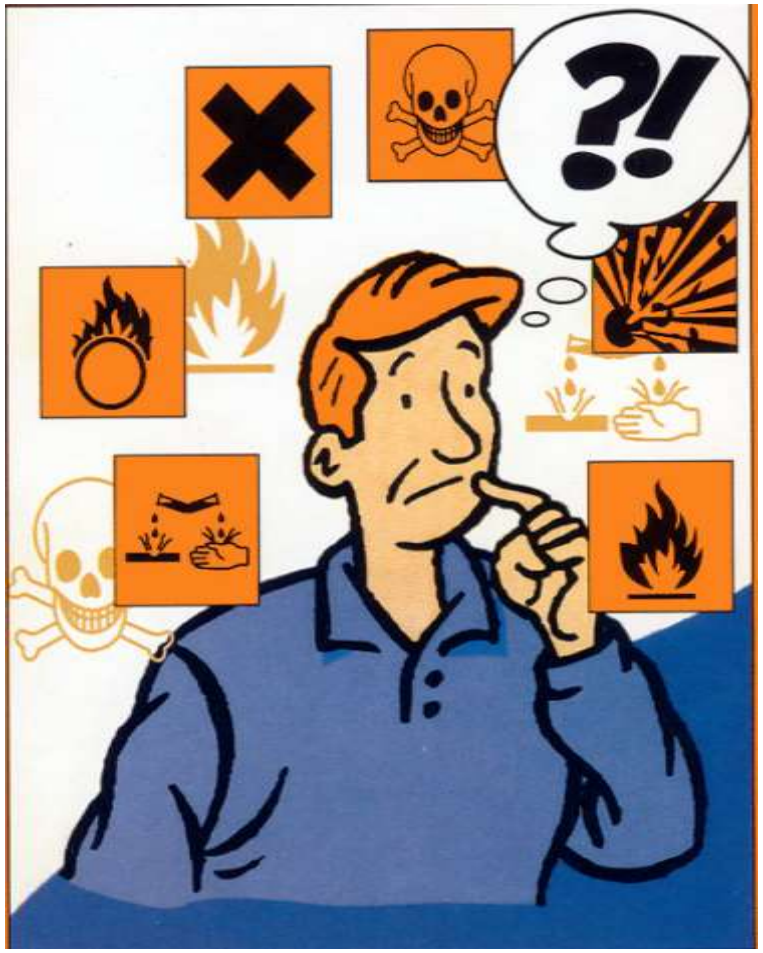
Health effects:

1. Occupational disease (poisoning),
2. Signs,
3. Symptoms,
4. Syndromes.

Chemical Name	Potential Health Effects / Symptoms
Isopropyl alcohol	mild central nervous system depressant; eye / respiratory tract irritation
Acetaldehyde	irritating to the respiratory tract, lung injury, severe eye irritation
Phosgene	obliterant bronchiolitis
Organophosphates compounds	bradycardia, hypersalivation, miosis
Amino- and nitro-derivatives	cyanosis, low blood pressure
Hydrogen peroxide (>35%)	may be fatal if swallowed

Classification of toxic and very toxic materials

- ***acute toxicity*** (e.g. LD50, LC50)
- ***skin irritation / corrosion***
- ***serious eye damage / eye irritation***
- ***respiratory or skin sensitization***
- ***mutagens***
- ***carcinogens***
- ***reproductive toxicity***
- ***specific target organ toxicity***
- ***aspiration hazard***
- ***chemical mixtures.***



EXPOSURE TO PESTICIDES

In the Romanian agriculture a wide range of chemicals generally called **pesticides** are used to control pests, respectively insecticides, herbicides, fungicides, bactericides, acaricides, rodenticides.

The term “pesticide” may communicate an **unintended negative perception** based on fear, therefore terms such as insecticide or herbicide, or even the class of chemical, are more appropriate.

Since acute intoxications are rare, accidentally and / or intentionally for suicide or homicide, **the cumulative risk to human health** is currently under discussion.

According to the National Institute of Public Health, there were about **12,823** exposed workers in Romania (handling plant protection products) in 2014.

From the broad array of chemicals available, only selected pesticides of particular importance to workers in **agrophytotechnics** and **horticulture** have been covered in this section.

Many toxic syndromes are complex and are not easy to recognize, so the most important element in diagnosis is an **awareness of the hazard.**

Categories (based on acute toxicity)

1. ***Category I (highly toxic):*** fumigants (formaldehyde, sulphur dioxide), organophosphates.
2. ***Category II (moderately toxic):*** carbamates.
3. ***Category III (slightly toxic):*** carbamates, pyrethroids, most herbicides and fungicides.
4. ***Category IV (practically non-toxic):*** bio-pesticides (neem tree oil).

Categories of plant protection products used in Romania

- *Organophosphates compounds* (potentially cancerous pC) – chlorpyrifos, dichlorvos, disulfoton, tetrachlorvinphos, pirimiphos, dimethoate (cat. I);
- *Carbamates and dithiocarbamates:* mancozeb, propineb, fenoxycarb, methiocarb (cat. II T), ziram (cat. II);
- *Synthetic pyrethroids:* cypermethrin, alpha-cypermethrin (cat. III);
- *Urea derivatives:* linuron (cat. II), rimsulfuron (T), Linurex (T);
- *Phtalimides* – captan (genotoxic);
- *Triazoles and imidazoles* – tebuconazole, propiconazole, cyproconazole;

Categories of plant protection products used in Romania

- *Quinazolines* – proquinazid;
- *Copper and compounds*: Alcupral, Champion, Cupritim;
- *Aluminum derivatives:* fosetyl-aluminium, aluminium phosphate (cat I T+);
- *Sulphur products* - Kumulus DF, Thiovit Jet, Critox, Sulfur, Microthiol Special, Sulfamat;
- *2,4-Dichlorophenoxyacetic acid and derivatives* (potentially cancerous pC): Dicopur;

History: Naphthalene was a household insecticide against moths, but also used by beekeepers (possibly carcinogenic; haemolytic). It was replaced with 1-naphthyl-*N*-methylcarbamate (Carbaryl).

Health effects on exposed workers

ACUTE
(neurological effects)
Organophosphates,
Aluminum phosphide,
Carbamates

CHRONIC
(cumulative risk)
Organophosphates,
Carbamates,
Pyrethroids

Allergies, Asthma:
Pyrethroids

Neurotoxicity:
Organophosphates **(plus mental disorders)**,
Aluminum derivatives

Genotoxicity:
Phthalimides

Cancer:
Organophosphates,
Derivatives
of 2,4 Dichloro-
Phenoxyacetic acid

Illness prevention

- Regulations and enforcement: distribution, marketing and use of pesticides, proper registration, certification and labeling.
- Engineering methods: avoidance, proper storage, separation.
- Hygienic work practices and personal protective equipment.
- Access to emergency room and clinical toxicology unit. The basic principles for treatment of acute poisonings include the following practices: skin and eye decontamination; respiratory function support and airway protection; gastrointestinal tract clearing / vomiting induction; administration of adsorbents / specific antidotes (activated charcoal / atropine).

Complete personal protective equipment

EXPOSURE TO ORGANIC DUST

One of the most ubiquitous and important hazardous exposures in: agriculture (grain, cotton, flax, hemp, tobacco, soy dust), forestry (wood dust), zootechnics (animal feed).

Complex composition:

- Grain dust, for ex: fragmented kernel, small leafs, insect remnants, silica, bacteria, fungi, and chemical residues.

Main components: plant and animal allergens (proteins and glycoproteins such as proteases, ligand-binding proteins, structural proteins, pathogenesis-related proteins, lipid transfer proteins, profilins, calcium-binding proteins, seed storage proteins, tropomyosins, etc….).

Risk factors of hazardous respiratory exposures: working inside livestock buildings and other agricultural structures that allow concentration of exposures.

Illness

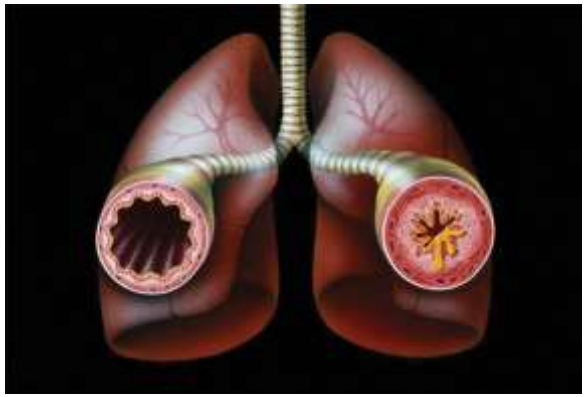
Pathology: allergic symptoms (watery eyes, runny nose, itchy throat); noninfectious febrile illness; cough or chest tightness; acute and chronic bronchitis; rhinitis; asthma; dermatitis. Pathology usually relies on a “common syndrome”.

Important: the knowledge and ability to gain an *accurate occupational history* leads to accurate recognition, diagnosis, treatment, and prevention.




Illness

Health effects on exposed workers



Organic Dust Toxic Syndrome:
(*influenza-like illness*)
Silo unloader's syndrome,
Farmers,
Woodworkers

Hypersensitivity Pneumonitis:
Farmer's lung,
Bird breeder's lung,
Sericulturist's lung
Wood worker's lung

Rhinitis, Asthma, Bronchitis, Chronic Obstructive Pulmonary Disease

Irritant and allergic dermatitis:

Woodworkers

Prevention

- avoiding exposure, even changing profession or occupation, smoking cessation,
- use of respirators,
- recognizing small airway obstruction as the “early sign”,
- technical methods: addition of fungicides in water-based products; treatment of hay with buffered propionic acid.

EXPOSURE TO IRRITANT GASES AND VAPORS

Workers at risk: animal care workers, silo fillers.

Irritant, toxic, and asphyxiating gases:

- ***Ammonia:*** is released by the organic matter during degradation (animal waste, liquid fertilizer pits, urine of animals kept in enclosed spaces);
- ***Oxides of nitrogen:*** can be released into poorly ventilated silos shortly after the storage of fermentable cereals or cereals originated from nitrogen fertilized land;
- ***Hydrogen sulphide:*** is released by the decomposition of organic matter from wells, drainage channels, pig farms, or from the compost of commonly used edible fungi cultures - genus *Agaricus*. This toxic gas generally results from the fermentation of organic matter in tanks / enclosed spaces, and accumulation in high concentrations may cause asphyxia in the absence of oxygen;
- ***Active chlorine*:** releases by the solving of chlorate derivatives (lime chloride, hypochlorite) in aqueous solution. These substances are used as disinfectants in zootechnics and water treatment of wells.

Illness and Prevention

Pathology: acute poisonings (pharyngo-laryngo-tracheo-bronchitis, obliterant bronchiolitis - *silo filler's disease* - and acute pulmonary edema);

conjunctivitis; Reactive Airways Dysfunction Syndrome.

Prevention: efficient ventilation, construction of manure pits outside the confinement building, use of breathing apparatus.

EXPOSURE TO HYDROCARBONS, EXHAUST GASES (CO) AND MINERAL OILS

Workers at risk: agricultural mechanics.

Chemical substances:

- CO (asphyxiating gas) ⟶coma, decease.
- Mineral oils: irritant dermatitis, contact eczema, photodermatitis, hyperkeratosis and skin cancer (oils with a high content of polycyclic aromatic hydrocarbons, poorly refined or aged through heating).

Prevention:

efficient ventilation, protective gloves.

Iritant

Toxic

EXPOSURE TO ORGANIC SOLVENTS

- **Classes**: aliphatic (hexane, cyclohexane) and aromatic hydrocarbons (benzene, toluene, xylene); alcohols (methanol); ketones (acetone, methyl ethyl ketone); esters; ethers; organic acids; trichlorethylene and tetrachloroethylene.
- **Operations at risk:** degreasing, cleaning, painting, varnishing, maintenance, construction, renovation in all sectors of agriculture.
- **Health effects:** *respiratory and skin irritant*; *neurotoxicity* (e.g., n-hexane, tetrachloroethylene, toluene); *hepatotoxicity*; *cancer* (e.g., benzene, carbon tetrachloride, trichloroethylene), and *genotoxicity* (e.g., 2-ethoxyethanol, 2-methoxyethanol, methyl chloride).
- **Prevention:** use of gloves and protective creams, ventilation, complete individual protection in case of spray painting.


Iritant


Toxic

EXPOSURE TO BIOCIDES

Used as: disinfectants, fungicides and rodenticides in zootechnics, in animal feed and cereal storage, agriculture settings, buildings, etc.

Toxic substances:

- **Formaldehyde** (irritant and potential carcinogen);
- **Solid, liquid, and gaseous Rodenticides:** (hydrogen cyanide, sulphur anhydride, carbon sulphide, hydrogen phosphorous, and chloropicrin).
- **Chloropicrin:** suffocating gas (acute pulmonary edema).

Prevention:

- Manipulation of rodenticides: only by authorized workers.
- Manipulation of disinfectants: as mentioned on the package.

Other biocides used as disinfectants

- **Disinfectants for beekeeping tools and equipment (apiary hygiene): washing soda, sulphur dioxide** (produced by burning sulphur strips)**, acetic acid** = irritant and corrosive substances;

- **Disinfectants used in animal disease control programs (sanitizers): ammonium hydroxide** (in poultry and rabbits farms)**, calcium oxide, chlorhexidine** (in cleaning dairy equipment and in aquaculture)**, chlorine disinfectants** (broad spectrums of antibacterial and antiviral action)**, iodine and iodine-based compounds, quaternary ammonium compounds, sodium hydroxide, phenolic compounds** (in horse facilities)**, inorganic and organic acids, glutaraldehyde, sodium carbonate.**

- **Ozone, bromides** and other fumigants are being studied as alternatives.

Common chemical substances used in agriculture (1)

No	Chemical substance	Chemical formula	Category to which the substance belongs	Agriculture sector in which the substance is used	Substance is used for
1	Sulphur dioxide	SO2	Fumigant (irritant gas)	Apiculture	for the gasification of backup combs; kills the larvae and butterfly wax
2	Naphthalene	C10H8	Insecticide (toxic)	Apiculture	blocks the biological cycle of the wax moth
3	Paradichlorobenzene	C6H4Cl2	Fumigant insecticide (toxic)	Apiculture	provides protection against the wax moth
4	Galezon		Preservative	Apiculture	it destroys the wax moth
5	Galerin		Preservative	Apiculture	it destroys the wax moth
6	Glacial acetic acid	CH3COOH	Biocide (corrosive)	Apiculture	destroys both the wax moth and spores of *Nosema apis*
7	Formaldehyde	CH2O	Biocide (toxic)	Sericulture Cattle raising Sheep raising Pigs raising Poultry	for disinfection of rooms and equipment
8	Freshly ground lime suspension (calcium oxide)	CaO	Disinfectant	Sericulture Cattle raising Sheep raising Pigs raising Poultry	for disinfection of rooms and equipment

Common chemical substances used in agriculture (2)

No	Chemical substance	Chemical formula	Category to which the substance belongs	Agriculture sector in which the substance is used	Substance is used for
9	Caustic soda (sodium hydroxide)	NaOH	Cleaning agent (caustic)	Sericulture Aquaculture Heliciculture Cattle raising Sheep raising Pigs raising Poultry	for disinfection of rooms and equipment
10	Lime chloride	Ca(ClO)2	Disinfectant	Sericulture Cattle raising Sheep raising Pigs raising Fish-farming	for disinfection of rooms and equipment; in fish-farming it is given to destroy the low-value fish and to correct the pH of the soil
11	Chloramine	NH2Cl	Biocide (oxidant)	Sericulture	for disinfection of rooms and equipment
12	Cetrimonium bromide	C19H42BrN	Germicide, fungicide, disinfectant	Sericulture	for disinfection of rooms and equipment
13	Copper acetate sulphate	Cu(CH3COO)2	Antiseptic, disinfectant	Sericulture Cattle raising Sheep raising Pigs raising	for disinfection of rooms and equipment; treatment of pododermatitis (cattle raising); treatment of necrobacillosis (pigs raising)

Common chemical substances used in agriculture (3)

No	Chemical substance	Chemical formula	Category to which the substance belongs	Agriculture sector in which the substance is used	Substance is used for
14	Slaked lime (calcium hydroxide)	Ca(OH)2	Disinfectant	Fish-farming	given to destroy the low-value fish and to correct the ph of the soil
15	Sodium chloride solution	NaCl	Disinfectant	Fish-farming Aquaculture	to remove parasites from fish; for disinfection of ponds
16	Superphosphate	P2O5	Synthetic phosphate (fertilizer)	Fish-farming	to enhance the development of natural food
17	Organic nitrogen fertilizers (type 12/12/123)	N	Organic nitrogen (fertilizer)	Heliciculture	fertilizer
18	Malathion	C10H19O6 PS2	Insecticide, acaricide	Heliciculture	used to control pests
19	Lime powder		Disinfectant	Cattle raising Sheep raising Pigs raising Poultry	disinfection of rooms and equipment

ACCIDENTAL EXPOSURES

- ***Veterinary products:*** these may be drugs or animal feed additives. It is important to be aware of the toxic risk, to avoid self-administration or inadequate contact.
- ***Snakes / insects toxins:*** can be accidentally transmitted to workers in agrophytotechnology and forestry, or to beekeepers when some poisonous species sting or bite. In some geographic areas in Romania (south-west, Dobrogea, Moldova) where viper lives, medical offices must be equipped with antitoxin.

TOXICITY OF PLANTS

Workplaces at risk: horticulture.

Pathology:

Irritant or allergic dermatitis:

- Contact eczema in some tulip, narcissus and hyacinth cultivators during harvesting, sorting or packaging bulbs is called "tulip finger“. Additional to contact eczema, saponosides in tulips bulb are responsible for the occurrence of conjunctivitis and bronchial asthma.
- Phytophototoxic contact dermatitis by simultaneous exposure to a plant containing photodynamic substances (furocumarin) and to solar radiation. Example: vegetables in the family *Umbelliferae* (carrots, celery, domestic parsnip, fennel, wild parsnip).

Certain plants used in horticulture such as Leander (*Nerium oleander*) or yew (*Taxus genus*) can be toxic by cardiac effects.

In the last seven years, a significant risk in Romania has occurred by increasing the incidence of ambrosia allergy (*Ambrosia artemisiifolia*) reported by family doctors and highlighted by the media channels. Ambrosia species have expanded into grain and sunflower crops, as well as abandoned agricultural land, being considered among invasive and dangerous species for the public health.

Prevention: protective clothing, changing to clean clothes and gloves when they become contaminated, and washing exposed areas of the skin before meals and at the end of the workday.

Ambrosia artemisiifolia

CONTAMINANTS OF AGRICULTURAL SYSTEMS

- Pesticides (herbicides like glyphosate – banned in 2016) and fertilizers (nitrogen, phosphorus), organic compounds, degreasing substances, toxins, additives to animal feeds (trace elements Na, K, Cu, Zn), and heavy metals (Hg, As, Pb, Cd);
- Microbes (*H. pylori, Campylobacter, Salmonella, Cryptosporidium* and *Listeria*) – in long-term applications of animal manure;
- Pharmaceuticals, steroids, antibiotic-resistant genes and prion proteins.

Risk to human health: increasing the concentration of these substances in drinking water, surface water and soil. **Water pollution** is by far the most important general environmental concern in rural areas and nitrates are the “footprint”.

Nitrate toxicity

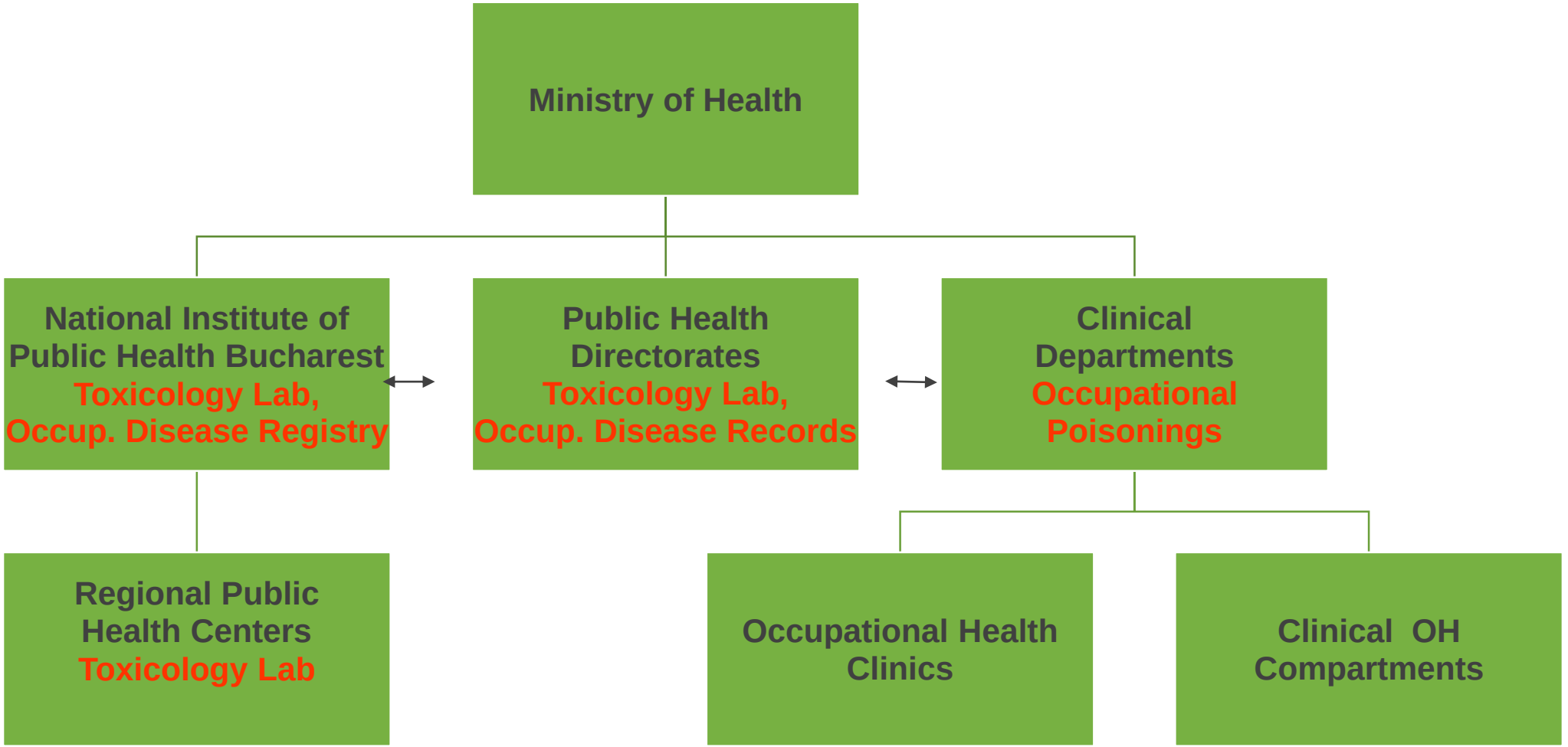
- Sources: nitrogen cycle with accumulation of nitrate (highly soluble and susceptible to contaminate well water).
- Risk areas in Romania: Dolj, Mehedinti, and Botosani County.
- ***Methemoglobinemia:*** infants (especially those under 6 months) are much more susceptible than adults. “Blue baby” syndrome: cyanosis, asphyxia, even death.
- Increased risk for stomach cancers and perhaps other cancers.

Illness prevention

- Testing drinking water from wells (*table below: Minimum water quality parameters*),
- Inspecting the wells,
- Safe disposal of chemical containers,
- Environmental reconstruction (restoration of natural biocoenosis),
- Advanced policy development to manage this concern is needed.

Chemical parameters	Accepted value	Microbiological parameters	Accepted value
pH	6.5 ≤ pH ≤ 9,5	Coliform bacteria	0 / 100 ml
Ammonium	0.50 mg / L	*Escherichia coli*	0 / 100 ml
Nitrites	0.50 mg / L	*Enterococcus*	0 / 100 ml
Nitrates	50 mg / L		
Chlorides	250 mg / L		
Organic load CCO-Mn	5 mg O_2 / L		

Romanian Occupational Health Institutions (Public)



CONCLUSIONS

As exposure to chemical agents is the most significant risk factor and the most unpredictable with regard to the effects it can have on human life and health, several tools must be used in order to properly control it:

- Exposure monitoring,
- Implementing safe and protective measures,
- Ensuring hygiene conditions for hand washing,
- Monitoring worker's health,
- Continuous updating of workers' information, skills, training and skills levels,
- Chemical substances must be kept in their original containers, stored in ventilated rooms and handled by people that have been trained for this purpose,

CONCLUSIONS

- ***Hazard Communication Standard:*** **Safety Data Sheets (SDS)** provide useful information on chemicals, describing the hazards the chemical presents, and giving information on handling, storage and emergency measures in case of an accident. The chemical manufacturer, distributor, or importer provide Safety Data Sheets for each hazardous chemical to downstream users to communicate information on these hazards.

Sections of SDS: 1-8 contain general information about the chemical, identification, hazards, composition, safe handling practices, and emergency control measures (e.g., fire fighting). Sections 9-11 and 16 contain other technical and scientific information, such as physical and chemical properties, stability and reactivity information, toxicological information, exposure control information, and other information including the date of preparation or last revision. The SDS must also state that no applicable information was found when the preparer does not find relevant information for any required element.

CONCLUSIONS

Employers must ensure that the SDSs are readily accessible to employees for all hazardous chemicals in their workplace. This may be done as follows:

- employers may keep the SDSs in a binder or on computers as long as the employees have immediate access to the information without leaving their work area when needed and a back-up is available for rapid access to the SDS in the case of a power outage or other emergency.
- employers may want to designate a person responsible for obtaining and maintaining the SDSs.
- If the employer does not have an SDS, the employer or designated person should contact the manufacturer to obtain one.

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