# Laboratory work № 1
# Radioactivity of the environmental objects evaluation

Every element has at least one unstable or radioactive isotope, but most have several. The nuclei of unstable isotopes undergo radioactive decay.

Radioactive decay is the process of is a spontaneous transformation of atomic nuclei of certain chemical elements (uranium, thorium, radium, californium etc.), which leads to a change in their atomic and mass numbers and is accompanied by the emission of ionizing radiation.

When moving up the periodic table, the atomic number increases as more protons exist in each element's nucleus.

When more protons are packed into the nucleus, more neutrons are required to overcome the resultant repulsive force. For elements with an atomic number less than 20, stable nuclei have either an equal number of protons and neutrons or one more neutron than proton. For example, carbon has 6 protons and 6 neutrons and fluorine has 9 protons and 10 neutrons. For elements with atomic numbers greater than 20, the ratio of neutrons to protons becomes increasingly greater than 1. All isotopes above bismuth, atomic number 83, are radioactive.

An unstable nucleus emits particles or electromagnetic radiation, or both, until a stable nucleus results. The main forms of radioactive decay include alpha (α),beta (β), and gamma(Y) decay.

α-radiation is a stream of positively charged α-particles (nuclei of helium atoms). Penetration of such particles is small & they are absorbed by aluminum foil with a few microns thickness. The danger is the ionizing power of α -rays. The ionization leads to a change in physico-chemical properties of the substance but in biological tissues it leads to the violation of their life.

β-rays is a stream of fast electrons (or positrons). Speed of moving such particle is near the speed of light. They have lower ionizing but greater penetrating ability as compared with α-rays; : Clothing absorbs up to 50% of β-emission but aluminum layer with thickness of 1 mm absorbs it completely.

γ-radiation is a short wave electromagnetic radiation having a high penetrating ability. To protect against γ -radiation a special radiation-protective materials such as heavy concrete, pure lead, special polymers are used.

On our planet exists natural level of radioactivity, **a background,** which surrounds us every day, which existed through all our planet history, and, undoubtedly, had influenced the evolution process, formation of ecosystems and species on our planet.

**There are exist two main sources of the natural radioactivity: minerals and rocks, which contain some amount of unstable isotopes, and external source – space radiation – galaxies, stars, and the closest star to our planet – the Sun.**

When a heavier nucleus splits in a process called nuclear fission, lighter nuclei are produced. The lighter nuclei are more stable. Whenever a process involves moving to a more stable state or configuration, energy is released. More stable nuclei **can also be obtained when lighter nuclei combine** to form a heavier nucleus in a process called **nuclear fusion.** The most common example of a fusion reaction takes place inside the sun, where hydrogen nuclei fuse to form helium. The continual fusion of solar hydrogen provides the energy that makes life on Earth possible.

As a result of human activity the natural background radiation changes, and technologically modified radiation background appears. Artificial radiation arising during testing of nuclear weapons are making these changes, in violation of operation of radioactive facilities (nuclear power plants, research institutes of an appropriate profile, etc.) & the formation of radioactive waste at nuclear power plants.

**The purpose of work** is to deepen the notion of radioactivity of different objects of the environment, to estimate the radioactivity of a particular object, to master the method of measurement of radioactivity.

**Equipment & devices**: an indicator of radioactivity "RADEX"

## The order of work

1. Measure radioactivity level for chosen object from your surroundings. Compare the number with the permissible level.

2. Materials – wood, ceramic, plastic, metals, find the chemical formulas for your measured object.

3. Find the 2-3 main chemical elements, from which consists your chosen material.

4. Write down possible radioactive isotopes, for your element. Write down, how much of protons, neutrons and electrons contains each isotope.

## Questions

1. Give the definition of a radioactivity.
2. What is the radioactive fusion?
3. Describe the $\alpha$- rays.
4. Describe the $\beta$- rays.
5. Describe the $\gamma$ rays.
6. What do you know about the natural sources of radioactivity?
7. What do you know about the antropogenic sources of radioactivity?

# Laboratory work № 2
## Determination of dissolved chemicals in water

Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form.

Dry residue characterizes content non-volatile solutes (mainly mineral) and organic substances in water, which have a boiling point higher than 105-110 ° C, non-volatile with water vapor and not decompose at this temperature.

**The amount of dry residue in surface water reservoirs for drinking and community use purpose should not exceed 1000 mg / l (in some cases may be up to 1500 mg / l).**

Ignited residue - a mass of matter remaining after ignition of dry residue at a temperature of ≈ 600 ° C. Ignition residue value gives an indication of water mineral composition, and a loss on ignition - amount of organic compounds.

The total mineralization and the dry residue may differ by a small amount (as a rule, not more than 10%). because of the loss of volatile organic chemicals through of the water evaporation.

Water Hardness is the presence of calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), strontium ($Sr^{2+}$), barium ($Ba^{2+}$), ferric ($Fe^{3+}$), manganese ($Mn^{2+}$) ions.

The most common sources of hardness in water are the minerals found in the aquifer: limestone, which is the source of calcium, and dolomite, which is the source of magnesium. Nevertheless, hardness can be caused by such other dissolved metals as aluminum, barium, strontium, iron, zinc and manganese.

Depending on the mineralization (mg / dm$^3$ = mg / l), natural waters can be divided into the following categories:

Ultra-fresh <0.2
Fresh 0.2 - 0.5
Waters with relatively high mineralization 0.5 - 1.0
Brackish 1.0 - 3.0
Salted 3 - 10
Waters of increased salinity 10 - 35
Brines> 35

In addition to natural factors there is big influence of industrial sewage and urban stormwater (when salt is used to combat icing of roads) on the overall mineralization of water objects.

**Total hardness of drinking water should be no more than 7 mEq / L**

A good taste of water is considered at a total salinity of up to 600 mg / l. Organoleptic indications of the WHO recommended an upper limit of mineralization of 1000 mg / dm$^3$ (ie to the lower limit of brackish water). Mineral waters with a certain salt content are good for health, but doctors recommend using them in limited quantities. On the other hand, ultra-fresh, distilled water, obtained as a result of water purification by reverse osmosis or distillation, is also not very good for health – the regular use of it leads to a violation of the salt balance and the washing out of the body of the necessary chemicals.

Russian standards allow for mineralization of 1000-1500 mg / $dm^3$

For technical water, the rates of mineralization are stricter than for drinking water, because even relatively small concentrations of salts spoil the equipment, settle on the walls of pipes and clog them.

**Purpose of the work** is to study the concept of mineralization of water and its permissible levels.

**Equipment and reagents:** scales, porcelain or quartz cups of 50 ml, paper filters, electric stove, 0.05 N. Trilon B solution*; 0.1N. sulfuric acid solution; ammonium buffer solution (pH = 10); dark blue chromium solution as an indicator

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* Trilon B = The disodium salt of ethylenediaminetetraacetic acid, $C_{10}H_{14}N_2Na_2O_8$

## The order of work

### 1. Determination of the dry residue

Take a porcelain cup. Using measuring cylinder, measure 20-50 ml of tested water and pour it into the cup.

Put the cup on the electric stove. Wait till the complete evaporation of the water from the cup. Take it off the stove immediately (using forceps) and leave for 5-10 min for cooling.

After the cooling, weigh the cup on the scales. Clean the cup from the dry residue (using filtering paper) and weigh the clean cup again.

Calculate the dry residue content (mg / L) according to the formula

$$x = ((a - b)\ 1000) / V,$$

Where a is the mass of the cup with a dry residue, mg;
b is the mass of empty cup, mg;
V is the volume of the analyzed sample of water, ml.

### 2. Determination of the total hardness of water

Using the measuring cylinder, add 100 ml of tested water to a conical flask.

Add to the water sample 3-5 ml of ammonia buffer solution and 7 ... 8 drops of indicator - chrome dark blue.

Prepare a burette with Trilon B solution.

Titrate the water sample with Trilon B solution until the color of the water in the flask changes from pink-red to blue-violet.

Total hardness of test sample, mEq / L, is numerically equal to the volume in ml of consumed 0.1N. solution of Trilon B, which was spent for the titration of 100 ml of water.

**Write down the results of the laboratory work, make necessary calculation, write a conclusion.**

## Questions

1. What is the TDS?
2. What is the dry residue, at which temperature we can get it?
3. What is the water hardness&
4. How are mineral waters formed?
5. Acceptable levels of mineralization for drinking water. What's the difference in mineralization level for technical water?
6. The consequences of low mineral content water consumption

## Laboratory work № 3
## Determination of ammonia content in the air

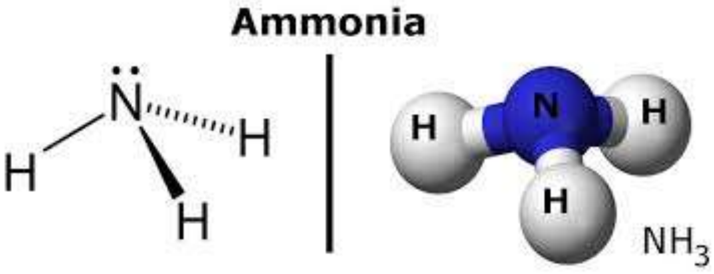
A chemical indicator is a substance that undergoes a distinct observable change when conditions in its solution change. This could be a color change, precipitate formation, bubble formation, temperature change, or other measurable quality.

**Examples of indicators**

| Indicator | Neutral solution | Alkaline solution | Acidic solution |
|---|---|---|---|
| methylorange | Violet | Blue | Red |
| litmus | Orange | Yellow | Red-pink |
| phenolphthalein | Colorless | Crimson | Colorless |

**Ammonia** is a compound of nitrogen and hydrogen with the formula $NH_3$.

The molecule has the form of a triangular pyramid with a nitrogen atom at the apex.



The global industrial production of ammonia in 2014 was 176 million tons.

Ammonia is one of the most important products of the chemical industry. Big part of the ammonia produced in the industry goes to the preparation of nitric acid, nitrogen fertilizers, dyes. Ammonia is also used to produce explosives. Widely used aqueous solutions of ammonia: As a weak volatile base, it is used in chemical laboratories and industries, in medicine, a 10% aqueous solution of ammonia is known as hydrous ammonia. With the help of ammonia, baking soda is obtained.

When evaporated, ammonia absorbs a large amount of heat, so it is used in refrigeration plants.

Large amounts of ammonia are formed in the air of livestock premises as a result of the decomposition of organic substances containing nitrogen (urine, feces).

Ammonia is a toxic substance. In acute poisoning, ammonia affects the eyes and the respiratory tract, at high concentrations, a fatal outcome is possible. It causes a strong cough, suffocation, a high concentration of vapors - excitement, delirium. Upon contact with the skin, ammonia causes burning pain, swelling, burns with blisters. In chronic poisoning occur indigestion, catarrh of the upper respiratory tract, impaired hearing.

A mixture of ammonia and air is explosive.

The maximum permissible concentration of ammonia in the air of the working area is 20 mg / m$^3$.

**Purpose of the work** is to determine the concentration ammonia in the atmosphere by chemical analysis

**Equipment and devices:** flask with the volume of 50 ml, syringe, the absorption solution

## The order of work:

### Determination of ammonia

Using small measuring cylinder, add 50 ml of absorption solution to the flask.

Take the syringe, write down its volume.

Fill it with air and release the air through the absorption solution. Repeat until the solution became colorless.

Calculate the concentration of ammonia using formula:

$$C_{NH_3} = \frac{1020 \cdot V_1}{V_2 \cdot 1000},$$

Where $C_{NH_3}$ is the concentration of ammonia in mg/m$^3$; V1 is the volume of the absorption solution, ml; V2 is the volume of the air, used for decoloration of the solution, ml.

Compare the obtained results with permissible level, make a conclusion.

## Questions

1. Chemical composition of the atmosphere (in lectures)
2. The structure of the atmosphere (in lectures)
3. What is a chemical indicator, examples.
4. The ammonia – formula, sources of formation.
5. Ammonia hazard
6. Permissible level of $NH_3$ for working area

# Laboratory work № 4
# Determination of nitrate content in plant bodies

**Theory:**

The atmosphere contains nitrogen in amount of ≈ 78%

Nitrogen becomes available to living organisms after assimilation in soils with nitrogen-fixing bacteria that live on the roots of some plant species, as well with help of blue-green algae in the hydrosphere.

Nitrogen has many valence states available and can exist in the environment in different forms, depending the oxidizing ability of the environment. The oxides of nitrogen represent the most oxidized and the least thermodynamically stable forms.

Ammonia can exist in gaseous form in the atmosphere but rather rapidly returns to the soil and waters as ammonium, $NH_4^+$ .

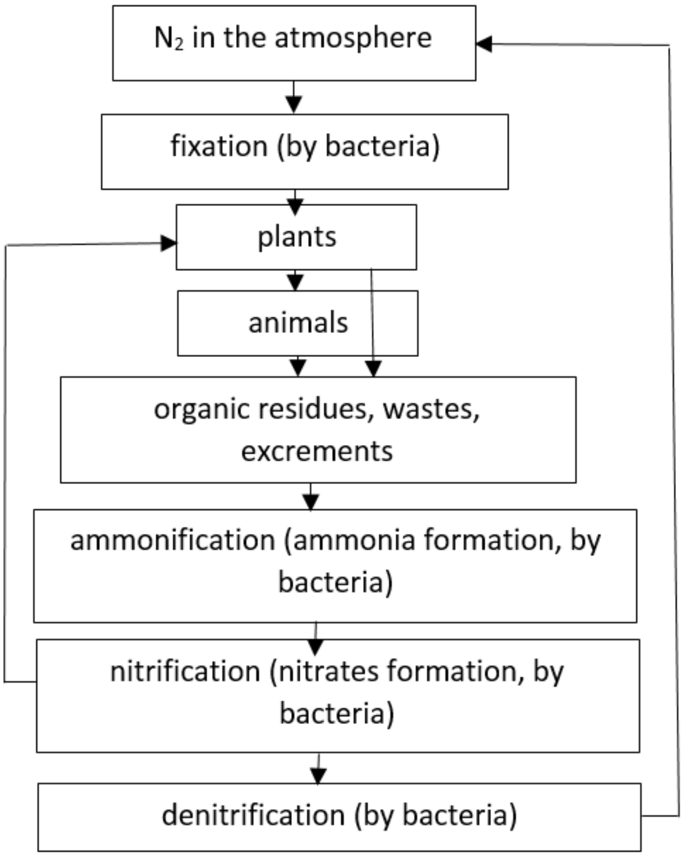
**Fixation** of atmospheric $N_2$ leads to ammonia, $NH_3$. In aerobic soils and aquatic systems $NH_3$ is progressively oxidized by micro-organisms from nitrite to nitrate. The latter is taken up by some biota and used as a nitrogen source in synthesizing amino acids and proteins, the most thermodynamically stable form of nitrogen.

After the death of the organism, microbiological processes will convert organic nitrogen to ammonium (**ammonification**) which is then available for oxidation.

Conversion of ammonia to nitrate is termed nitrification, whilst **denitrification** involves conversion of nitrate to $N_2$.

High concentration of nitrites and nitrates in water and food harms human health through the formation of met-hemoglobin, in which oxygen is strongly associated with hemoglobin, which reduces the ability of red blood cells to carry oxygen. The high nitrate content in water bodies causes rapid growth of phytoplankton leading to **eutrophication** of water reservoir.

The Nitrogen Cycle



**The purpose of work** is to explain the notion of migration of nitrogen in the biosphere & to determine the content of nitrate nitrogen in plants.

**Reagents**: nitrate tester, nitrate-measuring device, silver chloride and nitrate-selective solution $KNO_3$, 1% solution of potash alum.

## The order of work

1. Prepare a sample of a plant material (potato, banana, apple, etc.)
2. Wash the sample, grind (or grate) it.
3. Put 5-10 g of the plant mass into a conical flask.
4. Add 50 ml of 1% potash alum solution into the flask and mix for 2 minutes.
5. Measure nitrates amount using laboratory nitrate-measuring device.
6. Compare your numbers with permissible levels (table 1).

Make a conclusion.

Table 1

## Sanitary standards and permissible levels of nitrates in vegetable products

| Product | Permissible levels, mg/kg | Product | Permissible levels, mg/kg |
|---|---|---|---|
| Potato | 250 | Bow onion | 600 |
| Carrot: early | 400 | Sweet pepper | 200 |
| >> late | 250 | Apples | 60 |
| beet | 1400 | Pears | 60 |
| Onion | 80 | | |

## Questions

1. The concentration of nitrogen in the atmosphere.
2. How does the nitrogen become available to the living organisms?
3. Draw the nitrogen Cycle.
4. What harm nitrates can cause to a human body? To water bodies?
5. What is eutrophication?