Effect of Natural Radionuclides on the Processes Occur in the Environmental Objects. Studying the Cleaning Methods of Water Contaminated with Organic Emissions and the Methods for Cleaning of Soil Contaminated with Heavy Metals and Radionuclides

Khagani Mammadov

Institute of Radiation Problems of the National Academy of Sciences of Azerbaijan
Azerbaijan Republic, AZ1143, Baku sity, H.Javid avenue, 121

Abstract: *The distribution of **radionuclides**, heavy metals and other xenobiotics in the soil, green grass cover and drinking water sources of the country were studied. Brief information is given on methods for cleaning samples of soils from heavy metals and radionuclides. By systematic studies have established that the degree of assimilation of the K^{40} isotope by the green grass from water is approximately 7 - 10 times higher than the degree of assimilation of radioactive isotopes of other elements. At comprehensive analysis of photosynthesis should be taken into account the role of gamma radiation of the natural radioisotopes Na^{22} and K^{40} in this process, especially at its initial stage. Radioisotopes Na^{22} and K^{40} are identified in all samples of water, soil, vegetation products without exception. This conclusion is consistent with the revealed facts of increasing plant fertility in soils with relatively high concentrations of natural radioisotopes, observation of photosynthesis in the mating membrane of extreme halobacteria, in under thick layers of water, in the presence of only long-wave infrared rays or in the absence of chlorophyll and oxygen.*

Keywords: *Background, radionuclides, heavy metals, water, grass, photosynthesis.*

I. INTRODUCTION

(Size 10 & Normal) Studying the distribution of toxic elements, the various forms of the presence of chemical elements in minerals, determining the amount of oxides, hydroxides, carbonates, nitrates, nitrites, sulfates, phosphates in the soil is an urgent task to solve and allow us to estimate problems related to environmental safety [1-6].

There is a need for systematic measurements and studies to obtain results on the distribution of radionuclides, heavy metals and other xenobiotics in the soil, vegetation, water reservoirs of the country, trends in the direction of the emergence of zones of environmental crisis, information for predicting changes and the rate of change in the environment.

The ability to clean by various methods local areas of the earth contaminated with radionuclides and heavy metals and to study the options for implementing these processes are the most important tasks of radiochemistry [6-11].

II. METODICAL PART

Radiometric measurements were carried out using the İnSpector-1000 and Radiagem-2000 radiometers (manufactured by Canberra and equipped with alpha, beta and gamma detectors) and the İdentiFİNDER radiometer identifier (manufactured by Thermo Scientific). Gamma spectrometer with HPGe detector (manufactured by "Canberra"), atomic absorption AA-6800 spectrometer (manufactured by "Shimadzu"), Expert-3L and XRF X-ray fluorescence spectrometers were used in the process of physical-chemical analysis of minerals obtained by evaporation of water samples, weakly acid and weakly alkaline extracts of soil samples, by heating and treatment by nitric acid solution of green grass samples [1-7].

For conducting microbiological rapid tests, we used express test napkins - certified ISO 9001 and 13485 quality control systems - manufactured by R-Biopharm (Germany). To determine the number and types of microorganisms in stationary laboratory conditions, we used selective nutrient media produced by Hi-Media (India) and Condalab (Spain), incubators with an automated thermostat and colony counters [3-5].

After a written description in the journal of taken samples, visual inspection, weighing, drying, cleaning from random foreign objects or pebbles by passing through sieves, the soil samples taken were treated with distilled water, weak solutions of acid and alkali with periodic mixing and filtration, isolation of sparingly soluble particles in a centrifuge

with further evaporation to obtain minerals, heavy metals and radionuclides [11-15].

III. DISCUSSION OF THE RESULTS

The results of the analysis of water samples are shown in tables 1 and 2. The results of the analysis of the minerals of vegetation samples are given in tables 3 and 4. The results of the analysis of soil samples (concentration of macronutrients and micronutrients) are shown in tables 5 and 6.

Given the geometric dimensions of the printed page in table columns were entered, only some of the "macroelements" (Si, Al, C, N, Na, K, Ca, S, Cl, Mg, Sr) and trace amounts of "microelements" (Fe, Zn, Mn, İ, Br, F, Co, Cr, As, Cu, P, Ba, Sn, Zr, Ra, Eu, Th, etc.) defined in the composition of soil minerals.

About 30-35% (300-350 g / kg) of the total mass of soil samples consists of water. The amount of oxygen in the composition of dried soil samples is 240-260 g (in wet soil this indicator is approximately 50% or 500 g), the amount of carbon is 18-20 g., silicon 310-330 g., aluminum 62-80 g., i.e. the total amount of moisture, oxygen, carbon, silicon, aluminum is 980 - 990 g / kg (350 + 240 + 18 + 310 + 62 = 980 g. or 300 + 260 + 20 + 330 + 80 = 990 g). The quantity of Mg compounds in water reservoirs is observed in the range of 6-25 mg / l, in plants 50-60 mg / kg. In some plant samples, P is found in trace amounts. Concentrations of Mg compounds equals 80-90 mg / kg and the trace amounts of "microelements" As, Sn, Cu, Cr, Zr, Mo, Br, Ba below 1 mg / kg are observed in soil samples.

As can be seen from Table 5, the total amount of "macroelements" and "microelements" that determine the soil fertility is only 10-20 g / kg.

The analyses performed show that the mineral balance of the samples of drinking water varies in the interval 0.3-3.5 g / l, the mineral balance of the water of the Caspian Sea is 13.5-14.0 g / l. The mineral composition of water samples (taken from water reservoirs, rivers, springs, water lines, e.g. water ways), plants (green grass samples of pastures and flat areas, minor additives from young leaves of trees and shrubs in the bulk of green grass, taken from the plain edges of forests) and soil was determined and the results of the analyses are shown in tables 1, 3 and 5.

Only elements with concentrations that vary by region were shown in the tables for clarity and readability. Having relatively stable concentrations of light elements / Si, C, Al, P, Mg / and trace concentrations of heavy / Ti, Zr, Ba, Sn, Cu, Mo , Co, Eu, Ra, Th / elements are not considered in these tables.

Unlike distilled water, dilute acid and dilute alkaline solutions emit relatively large amounts of heavy metals and radionuclides from soil samples (5-10 times more depending on the concentration of acid and alkali).

As a rule, the comprehensive sensory, physicochemical and microbiological (E_c=0-3/liter) indicators of water samples taken at all times of the year from the water supply lines (water ways) of the regions of the country meet the requirements of standards 2874-82, AZS 216-2006, AZS 282-2007 for "Drinking Water" [3, 5].

The analysis showed that in underground and spring waters the number of detected (in one liter) colonies of *Escherichia coli (Ec)* varies in the range of 3-15 and this number remains practically constant during the year. The use of water from these sources us drinking water is permissible only after filtration and boiling.

In the water of wells dug in the artisanal way and in the water of the Kur River, the number of *Ec* in one liter of water varies in the range of 15-30. In rainy weather, microscopic fungi, *Ec*, *Coliform*, pathogenic Nag-*vibrios*, *Salmonella, Staphylococcus, Streptococcus* are detected in the water of the Araz and Kur Rivers and in coastal water of the Caspian Sea [3-5].

The concentration (radiation activity) of the Na^{22} isotope in minerals of drinking water supplied through the water ways for the population and organizations of the country is 0.32 Bq/l and 0.28 Bq/l, respectively, the isotope concentration of K^{40} is 0.18 Bq/l and 0.16 Bq/l (these values are characteristic low values for natural spring waters), the dose rate of gamma radiation from the background of these cities is 0.045-0.071 μZv/h and 0.011-0.045 μZv/hour, respectively.

According to the "Law of the Republic of Azerbaijan on Radiation Safety of the Population", the permissible value (PV) of the average annual dose for the population is 1 mZv, which is equivalent to the absorbed dose rate (PV = 0.12 μZv/h).

The measurement's result show that the values of the total ionization radiation (absorbed dose rate) in many areas of the country (0.03-0.12 mZv/h) do not exceed the maximum permissible value. The local areas of the country where the absorbed dose rate of the total radiation (0.15-0.85 μZv/h) is much higher than the PV were defined as a result of radiometric measurements. Such sources that create high dose rates include granite-marble coating of interior details of underground transport communications, radionuclides in building stone materials, gray, brownish-red and black granite-marble coatings of entrance steps and front walls of several architectural buildings of national importance, plaques, monuments and radioactive sources used in industrial enterprises.

TABLE I

Concentrations of the Mineral's Components of Samples Taken from Water Sources of the Azerbaijan Regions

Regions	Components, *mg/l*									
	Sul-phates	Chlo-rides	Na; K	Ca /all carbonates/	J	Sr	NO$_3$; NO$_2$	Fe; Mn	Zn	As
Yardimli /water of river/	28	34	34; 20	301	0,02	1,5	4; 0,1	0,7; 0,1	0,003	0
Lerik /water of river/	30	33	33; 20	288	0,01	1,6	0,9; 0,1	0,8; 0,2	0,003	0

TABLE II

Activity of Radionuclides in Water Samples Taken from the Water Sources of Rregion of Azerbaijan

Regions	Isotopes, *Bq/l*									
	$_{11}$Na^{22}	$_{19}$K^{40}	$_{26}$Fe^{60}	$_{27}$Co^{57}	$_{30}$Zn^{65}	$_{38}$Sr^{91}	$_{50}$Sn^{113}, $_{50}$Sn^{126}	$_{63}$Eu^{152}, $_{63}$Eu^{154}	$_{88}$Ra^{226}	$_{90}$Th^{228}
Yardimli	1,2	0,18	0,38	0,34	0,05	0,18	0,04; 0,1	0,3; 0,3	0,24	0,02
Lerik	1,1	0,2	0,32	0,32	0,05	0,16	0,01; 0,03	0; 0,3	0,24	0,002

TABLE III

Concentrations of Chemical Components in the Minerals of Vegetation Samples Taken in Regions of the Country

Regions	Components, *mg/l*									
	Sul-phates	Chlo-rides	Na; K	Ca /all carbonates/	J	Sr	NO$_3$; NO$_2$	Fe; Mn	Zn	As
Yardimli	240	70	160; 7680	8220	0,5	19	67; 2,0	250; 10	0,8	0
Lerik	260	68	160; 7700	8100	0,5	15	60; 1,7	264; 12	0,8	0

TABLE IV

Activity of Radionuclides in Plant Samples Taken from Green Plains and Pastures of Regions of the Country

Region	Isotopes, *Bq/kq*									
	$_{11}$Na^{22}	$_{19}$K^{40}	$_{26}$Fe^{60}	$_{27}$Co^{57}	$_{30}$Zn^{65}	$_{38}$Sr^{91}	$_{50}$Sn^{113}, $_{50}$Sn^{126}	$_{63}$Eu^{152}, $_{63}$Eu^{154}	$_{88}$Ra^{226}	$_{90}$Th^{228}
Yardimli	2,0	2,5	0,65	0,58	0,10	0,34	0,10; 0,2	0,36; 0,42	0,38	0,03
Lerik	1,8	2,8	0,57	0,54	0,10	0,30	0,03; 0,1	0,20; 0,42	0,38	0,005

TABLE V

Concentrations of Components of Soil Samples Taken from Fruitful and Sandy Soil Plots in the Country's Regions

Regions	Components, *mg/l*									
	Sul-phates	Chlo-rides	Na; K	Ca /all carbonates/	J	Sr	NO$_3$; NO$_2$	Fe; Mn	Zn	As
Yardimli	790	84	164; 8820	8870	0,9	21	206; 3,0	332; 18	2,4	0
Lerik	780	80	170; 8210	8560	0,9	22	212; 2,9	333; 23	2,2	0

TABLE VI

Results of Radiometric Measurements and Activity of Radionuclides in Soil Samples Taken from Country's Regions

Regions (background - $\mu Zv / h$; alpha rays Bq_{eq} / sm^2)	Isotopes, Bq / kq									
	$_{11}$Na^{22}	$_{19}$K^{40}	$_{26}$Fe^{60}	$_{27}$Co^{57}	$_{30}$Zn^{65}	$_{38}$Sr^{91}	$_{50}$Sn^{113}, $_{50}$Sn^{126}	$_{63}$Eu^{152}, $_{63}$Eu^{154}	$_{88}$Ra^{226}	$_{90}$Th^{228}
Yardimli (0,14; 0,01)	3,0	2,4	1,10	0,90	0,16	0,50	0,15; 0,3	0,60; 0,64	0,62	0,04
Lerik (0,13; 0,01)	2,7	2,5	0,90	0,88	0,16	0,52	0,08; 0,2	0,37; 0,62	0,58	0,01

TABLE VII

Comparison of the Rates of Elementary Reactions for Radiolysis of Oxygen-Containing Water Contaminated with Organic Substances, Oil Products (RH, ROH) in Volume to which was Added the Mass of Cut Wood Chips

n	Reactions	W_n/W_3
(1)	$RH \xrightarrow{\ \ } H^\cdot + R^\cdot$ $(ROH \xrightarrow{\ \ } H^\cdot + RO^\cdot)$	10^{-8}
(2)	$H_2O \xrightarrow{\ \ } H, ^\cdot OH, e^-_{aq}, H^+_{aq}, H^-_{aq}$	0,03-0,3
(3)	$H^\cdot + RH \leftrightarrow R^\cdot + H_2$ $(H^\cdot RH)$	1
(4)	$H^\cdot + R^\cdot \longrightarrow RH$	$10^{-5} - 10^{-6}$
(5)	$H^\cdot + H^\cdot \longrightarrow H_2$	1 - 10
(6)	$H^\cdot + H_2O \longrightarrow ^\cdot OH + H_2$	2 - 20
(7)	$R^\cdot + RH \rightarrow products$	$10^{-8} - 10^{-11}$
(8)	$R^\cdot + H^\cdot RH \rightarrow products$	$10^{-18} - 10^{-20}$
(9)	$R^\cdot + R^\cdot \rightarrow products$	$10^{-14} - 10^{-17}$
(10)	$^\cdot OH + RH \longrightarrow R^\cdot + H_2O$	100
(11)	$^\cdot OH + R^\cdot (RH) \longrightarrow HORH (R^\cdot)$	$10^{-4} - 10^{-5}$
(12)	$H^\cdot + OH^\cdot \rightarrow H_2O$	10 - 100
(13)	$H^\cdot + O_2 \rightarrow HO_2^\cdot$	$10^5 - 10^8$
(14)	$RH + HO_2^\cdot \rightarrow R^\cdot + H_2O_2$	$10^{-5} - 10^{-6}$
(15)	$2HO_2^\cdot \rightarrow 2^\cdot OH + O_2 (H_2O_2 + O_2)$	$10^{-3} - 10^{-4}$
(16)	$H_2O_2 \xrightarrow{\ \ } 2^\cdot OH$	$10^{-9} - 10^{-10}$
(17)	$R^\cdot + HO_2^\cdot \rightarrow HOOR (O_2 + RH)$	10^{-7}
(18)	$H_2O_2 + RH \rightarrow ^\cdot OH + R^\cdot + H_2O$	10^{-8}
(19)	$RH + O_2 \longrightarrow R^\cdot + HO_2^\cdot$	$10^{-13} - 10^{-15}$
(20)	$R^\cdot + O_2 \longrightarrow RO_2^\cdot$	$10^4 - 10^6$
(21)	$RH + RO_2^\cdot \longrightarrow R^\cdot + ROOH$	$10^{-7} - 10^{-8}$
(22)	$R^\cdot + RO_2^\cdot \longrightarrow ROOR$	$10^{-8} - 10^{-10}$
(23)	$RO_2^\cdot + RO_2^\cdot \longrightarrow products$	$10^{-9} - 10^{-12}$
(24)	$RO_2^\cdot + HO_2^\cdot \longrightarrow ROOH + O_2$	$10^{-4} - 10^{-6}$
(25)	$H_2O_2 + R^\cdot \longrightarrow RH + HO_2^\cdot$	$10^{-9} - 10^{-10}$
(26)	$H^\cdot + HO_2^\cdot \rightarrow H_2O_2 (2^\cdot OH)$	1-10
(27)	$H^\cdot + H_2O_2 \rightarrow ^\cdot OH + H_2O$	0,1-0,01
(28)	$^\cdot OH + HO_2^\cdot \longrightarrow H_2O + O_2$	1-10
(29)	$^\cdot OH + ^\cdot OH \longrightarrow H_2O_2$	10-100
(30)	$^\cdot OH + H_2O_2 \rightarrow HO_2^\cdot + H_2O$	0,1-0,01
(31)	$e^-_{aq} + RH \rightarrow products$	$10^{-1} - 10^2$
(32)	$e^-_{aq} + H_2O \rightarrow products$	$10^1 - 10^2$
(33)	$e^-_{aq} + H^+_{aq} \rightarrow H^\cdot + H_2O$	$10^2 - 10^3$
(34)	$OH^-_{aq} + H^+_{aq} \rightarrow H_2O$	$10^2 - 10^3$
(35)	$e^-_{aq} + e^-_{aq} \rightarrow H_2 + 2OH^-_{aq}$	$10^2 - 10^3$
(36)	$e^-_{aq} + ^\cdot OH \rightarrow OH^-_{aq} + H_2O$	$10^2 - 10^3$
(37)	$e^-_{aq} + ^\cdot H \rightarrow H_2 + OH^-_{aq}$	$10^1 - 10^2$
(38)	$^\cdot OH + OH^-_{aq} \longrightarrow O^- + H_2O$	$10^1 - 10^2$
(39)	$O^- + RH \longrightarrow R^\cdot + OH^-_{aq}$	$10^{-2} - 1$
(40)	$H^+_{aq} + RH \rightarrow products$	$10^2 - 10^3$
(41)	$OH^-_{aq} + RH \rightarrow products$	1 - 100
(42)	$H_2O^+ + H_2O \rightarrow H_3O^+ (H^+_{aq}) + ^\cdot OH$	1-10
	$W_3 = 5 \cdot (10^{-6} - 10^{-7})$ M/s, $W_1 = 3 \cdot (10^{-13} - 10^{-15})$ M/s [7-12]	

The comparison of the indices of tables 2, 4 and 6, as well as the spectra obtained by gamma spectroscopy of minerals of water, vegetation and soil samples, shows identical values for the activity of the K^{40} isotope in 1 kg soil and in 1 kg vegetation samples. These values are 7-10 times exceeding the corresponding activity value of the K^{40} isotope for 1 liter of water taken from the same site. This ratio for other elements varies in range 1,4-1,7. These values show that the process of assimilation by plants the K^{40} isotope from water and soil samples is more efficient than the process of assimilation by plants other natural radioactive elements.

As is known, photosynthesis is the largest biochemical process on Earth and it is a complex chemical process of converting light energy and infrared radiation into the energy of chemical bonds of organic substances with the participation of photosynthetic pigments (plant chlorophylls, bacteriochlorophyll bacteria, archaea bacteriorhodopsin).

The established low values of the energy of light quanta allow us to conclude that the nature of

the course of photosynthesis is complex and the complex mechanisms of the process of splitting water molecules in plants are proposed. In one year, green algae release $3.6*10^{11}$ tons of oxygen into the Earth's atmosphere, which is about 90% of all oxygen produced during photosynthesis on Earth. The binding energy of the hydrogen atom with the hydroxyl group of the water molecule is 5 eV / molecule [5,6].

Photosynthesis can be represented in the following image and equation:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$
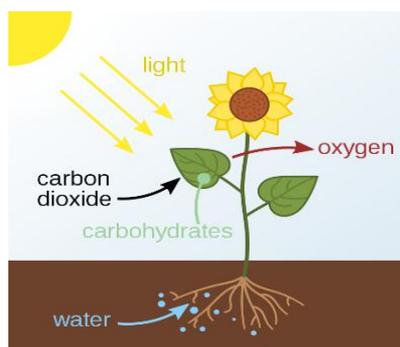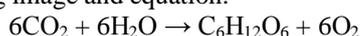
Two types of pigments were found in living organisms (the retinal vitamin A derivative is less common, and chlorophylls are involved in photosynthesis in most organisms).

In accordance with this, chlorine-free and chlorophyll photosynthesis are isolated. The efficiency of chlorophyll-free photosynthesis is relatively low (one H^+ is transferred to one absorbed quantum of light). This process is found in the mating membrane of halobacteria. As a result of the operation of the light-dependent proton pump (bacteriorhodopsin) of the membrane, the energy of sunlight transforms into the energy of the electrochemical gradient of protons on the membrane. Chlorophyll photosynthesis is more energy efficient. At least one H^+ is transferred to each absorbed light quantum against the gradient, and energy is stored in the form of reduced compounds (ferrodoxin, etc.). Oxygen-free chlorophyll photosynthesis (purple, green bacteria and heliobacteria) proceeds without oxygen evolution. Oxygen chlorophyll photosynthesis (higher plants, algae, cyanobacteria, etc.) is accompanied by the release of oxygen. In the initial (photophysical) stage of photosynthesis, light quanta are absorbed by pigments, they transition to an excited state and energy is transferred to other molecules of the photosystem (plastoquinone). In the photochemical stage, charge separation occurs in the reaction center. The chlorophyll molecule transferring its electron to plastoquinone turns into a radical-cation and under its influence the water molecule loses its electron ($H_2O - e- \rightarrow H^+ + \cdot OH$). Hydroxyl radicals formed under the influence of positively charged manganese ions are converted into

oxygen and water ($4 \cdot OH \rightarrow O_2 + 2H_2O$). In the chemical stage, light quantum is absorbed by another chlorophyll molecule and it transfers its electron to ferrodoxin. Next, biochemical reactions of the synthesis of organic substances using energy accumulated at the already described light-dependent stages take place.

The energy of gamma rays (1.45 MeV) emitted by the K^{40} isotope is many times higher than the value of the binding energy of hydrogen with a hydroxyl group in water molecules (5 eV). In addition, K^{40} isotopes were found without exception in all the samples taken from the environment, and the geometric dimensions of the studied vegetation specimens were directly proportional to the activity (concentration) of K^{40} detected in them.

We concluded that along with the multi-stage processes of splitting water molecules in the proposed photosynthesis mechanisms, the cause of the splitting of hydrogen atoms from water molecules, in addition to the complex process of photolytic decomposition of water, is also the radiolytic decomposition of water under the influence of gamma rays of natural isotopes (in mostly K^{40}, having the greatest activity / concentration / in vegetation).

A comparative analysis of the geometric, qualitative, organoleptic characteristics of the vegetation cover of different areas is in good agreement, proportional to the concentration of K^{40} in these plants. The high energy of gamma rays irradiated with K^{40} and the relatively high activity (relatively high concentration) are the reason for the increase in the current concentration of radicals in the mass of the plant, which is equivalent to the acceleration of high-barrier endothermic process of the splitting of hydrogen atoms from water molecules.

The analysis of numerous samples of water, soil, vegetation, livestock products showed the presence of Na^{22} and K^{40} radioisotopes in all samples, without exception.

As is known, after completion of reactions in spurs, the values of the primary radiation-chemical yield of water gamma radiolysis products at pH = 4–9 are: $G(H^+aq) = 3.4$; $G(e^-aq) = 2.9$; $G(H) = 0.6$; $G(\cdot OH) = 2.9$; $G(\cdot O) = 0.0067$; $G(H_2) = 0.45$; $G(H_2O_2) = 0.75$; $G(OH^-aq) = 0.6$ ion / 100 eV [7].

The value of $G(H^+aq)$ is 4.25 H^+ / 100 eV [7]. Taking into account the average value of K^{40} activity in 1 kg of plant mass (1.2-3.0 Bq / kg), exposure to this isotope during the year leads to the formation of (2.5 quanta / (sec.kg)) * (4.25 H^+aq / 100 eV) * (1.46 * 10^6 eV / quanta) = 15 * 10^4 H^+aq / s.kg = 4.7 * $10^{12}H^+$ / (year. kg).

As can be seen from Table 2 in addition to K^{40} radioactive isotopes of other elements also detected in plant mass. Thus, the total value for 1 kg of plant mass formed during one year under the influence of natural gamma rays of all isotopes and cosmic radiation will be 10^{15} H^+_{aq}. This is lower than the

value of the resulting H^+ ions which were participated in photosynthesis.

In the 1980s, the radiation-chemical chain process of hydrogen conversion into carbon monoxide was studied [8-10].

Similar to the radiation-chemical process $H_2 + CO_2 \rightarrow CO + H_2O$, where after the radiation initiation of the process ($H_2 \rightarrow \cdot H + \cdot H$ or $H_2^* + CO_2 \rightarrow CO + \cdot OH + \cdot H$) begins in the energy region above the potential barrier of the limiting reaction stage of the chain process ($H\cdot + CO_2 \rightarrow CO + \cdot OH; \cdot OH + H_2 \rightarrow H_2O + \cdot H$), and in the presence of K^{40} and Na^{22} take place closed cycles of elementary reactions ($H\cdot + CO_2 \rightarrow CO + \cdot OH; \cdot OH + RH \rightarrow H_2O + \cdot R$ or $H^+ + CO_2 \rightarrow CO^+ + \cdot OH, R^+ + CO_2 \rightarrow CO^+ + RO\cdot; H^+ + RR \rightarrow R^+ + RH, CO^+ + RR \rightarrow RCO + R^+$) after radiation initiation (formation of radicals, atoms and ions) with the following cliff type reactions ($R\cdot + R\cdot \rightarrow RR$, $R\cdot + CO \rightarrow RCO\cdot, R\cdot + \cdot OH \rightarrow ROH, CO^+ + e- \rightarrow CO$) serving the synthesis of organic molecules, e.g. photosynthesis take place [3-5, 8-10].

Initiation of the process of decomposition of organic contaminants occurs in the entire volume of contaminated water because of the high penetrating possibility property of the ionizing rays of ^{60}Co. This process can also take place in the mass of cut wood chips added to contaminated water. Hence, the process of radiation treatment of water contaminated with organic contaminants or petroleum products will be more efficient. In order to more understandably represent the main directions of the process, it is necessary to compare the rates of elementary reactions from the scheme for the radiation conversion of organic contaminants in oxygen-containing waters, given in Table 7 [7-15].

The value of the absorbed dose rate of ionizing radiation in the case of our installation with a ^{60}Co isotope is 0.33 Gy/s or $2.06 \cdot 10^{15}$ eV/g·s. Taking into account   concentrations of organic pollutants (10-1000 µg/kg) of wastewater of the country's manufacturing plants the conversion rate of these pollutants according to reaction (1) is $3 \cdot (10^{-13} - 10^{-15})$ M/s. For comparison the rate of reaction (3) is equal to $5 \cdot (10^{-6} - 10^{-7})$ M/s. The ratio of the rates of each elementary reaction to the rate of reaction 3 (W_n / W_3) are estimated taking into account the rate constants, the values of the primary concentrations of the initial and intermediate products. Reactions (1) and (2) are reaction initiation reactions, reactions (4), (5), (8), (9), (11), (12), (17), (22), (23), (24), (28), (29), (33), (34) are the chain termination reactions.

The elementary reactions (7), (8), (9), (11), (17), (20, 21, 22, 23, 24) are reactions, which are necessary for the formation of new products of the process. The ratio of the rates of these elementary reactions to the rate of elementary reaction (3) for irradiation of water contaminated with organic compounds shows that the rates of reactions (11) and (24) forming new organic compounds have comparable values and these values far exceed the

rates of other product-forming reaction. Consequently, the main channels for the radiation conversion of organic compounds in water are the formation of hydroxyl-substituted derivatives, organic peroxides and the products of their mutual recombination, mainly connected by an oxygen bridge.

As can be seen from Table 7, the macromolecules of the organic matrix of the wood chips are actively involved in the reaction process by means of the reactions (10), (11) and (14), which are characterized by high velocities / $W_{10} / W_3 = 100$, $W_{11} / W_3 = 10^{-4} - 10^{-5}$ and $W_{14} / W_3 = 10^{-5} - 10^{-6}$ / and ultimately the hydroxyl-substituted and peroxide radicals of organic compounds (petroleum products) in the presence of wood chips are joined not only to other hydroxyl-substituted radicals, but also to macro radicals of the organic matrix of wood chips.

This fact is confirmed by higher values of the weight of organic compounds (petroleum products) detected on the surface of wood chips when they are removed from irradiated water. These values at an absorbed dose of 10 kGy are 1.5-2.2 times higher than the weight of organic compounds (petroleum products) adsorbed on the surface of wood chips in non-irradiated water, held under identical conditions.

IV. CONCLUSION

Taking into account the multiplicity of intermediate products of water radiolysis (the radiation-chemical yields of which are given above), the little exothermicity (2.8 kJ / mol) of the total reaction of the radiolytic conversion of a mixture of hydrogen and carbon dioxide into carbon monoxide and water, the possibility of multiple participation of radiolysis products of water and the organic matrix ($H\cdot, \cdot OH, R\cdot, H^+, H^+_{aq}, e^-_{aq}, R^+, CO^+$) in the above repeated cycles of elementary reactions that occur with the resumption of the starting radicals and ions a direct contribution of water's radiolysis radicals and ions in the course of many elementary reactions occurring in the plant mass, the role of gamma radiation of the natural radioisotopes also should be considered in a comprehensive analysis of photosynthesis.

When airflow is injected into the experimental tank containing 10 m^3 of contaminated water, wooden chips, with a total weight of 10 kg, float around the entire volume of the reservoir, which favors the adsorption of oil products from their entire volume of water.

Dilute acid and alkaline solutions effectively release heavy metals and radionuclides from the soil samples.

The participation of natural radioisotopes in the process of photosynthesis is confirmed with the presence of Na^{22} and K^{40} radioisotopes in all samples of water, soil, vegetation, livestock products taken from environmental objects, with the revealed facts of increasing plant fertility in soils with relatively high concentrations of natural radioisotopes, observation of photosynthesis in the mating membrane of extreme halobacteria, under thick layers of water and in the presence of only long-wave infrared rays or in the absence of chlorophyll and oxygen.

Relatively high values of the weight of removed oil components during irradiation of the reservoir indicate in addition to the physical adsorption on the surface of wood chips there is the chemical sorption, too. This important effect can be taken into account in radiation purification of water contaminated with various organic compounds, crude oil and phenol.

Weak solutions of acids and alkalis were used for the separation of heavy metals from soil samples. After filtration and evaporation of soil extracts in the obtained minerals the total activity of radioactive elements was found to be identical to the activity of radionuclides in the studied initial soil samples. Therefore, a conclusion was drawn on the effectiveness of cleaning soil that has been contaminated with radioisotopes by sequentially treating it with solutions of weak acids and alkalis. The correct application of this method allows us to restore soil fertility.

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