# Sustainability of biosphere: implication of artificial matter in biogeochemical cycles

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Biosphere is unique realm of the earth's crust, which is occupied by life. The life is concentrated only in this external thin layer of our planet. All organisms are always divorced by the acute, impassable bound from inert matter. The main forms of biogenic migration concerned with the substance of living matter are determined by four factors: genetic properties of living organisms, intensity of biogenic flux of atoms, technique of activity of living organisms, and changes in order of atoms induced by the insertion of new substances in the biosphere. The latter is the most effective and strong factor of biogenic migration that was placed on the footing of the theory of biogenesis and technogenesis.

The current period of the evolution of biosphere is determined by intensive development of technosphere. Technogenesis leads to degradation of living conditions of ecosystem; it is accompanied with development of power-consuming production, and conjugation between concentration of some chemical elements, and dissipation of others. Owing to anthropogenesis a number of substances (artificial isotopes and organic matter) were produced. This matter is not exists in nature and/or not proper to geochemical media. Anthropogenic factor led to specific changes in biosphere: global (e.g. climatic), and local (appearance of new or mutation of existed species). The behavior of man-caused elements is substantially differ from their nature analogues that determined by form of their entry into environment and leads to formation of artificial anomalies. Therefore anthropogenic activity leads to the technogenically evolution of biosphere and infraction of main geochemical principle of invariability of biosphere and geochemical cycles of chemical elements.

Technogenic evolution of biosphere leads to a number of global problems:

- Poisoning of air, water and soil with industrial and agricultural sub-products, that leads to deficiency of clean freshwater, and, probably, oxygen of air, lack of environmentally appropriate areas at the Earth
- Deficit of foodstuff caused by demographical problem and soil erosion
- Depletion of mineral resources and energetic shortage
- Geological, geochemical, and climatic disbalance in nature

- Thermal pollution of Planet.

E. Le Roy and P. Chardin predicted the transformation of biosphere to new evolutional state, when intellect activity of Mankind is becoming the determinative factor of development. This state was named noosphere. Now we are consider that Technosphere is intermediate modern stage between biosphere and noosphere. Evolution of biosphere is going by following scheme:

$$biosphere \overset{technogenesis}{\longrightarrow} technosphere \overset{noogenesis}{\longrightarrow} noosphere.$$

Contemporary process of transformation of technosphere to noosphere has been named as *noogenesis*. Global problems of technogenesis caused to reconsideration of usual approach to biogeochemical investigation and unfold biogeochemical researches on a considerably broader scale. The new scientific branch, which studies interferences of living and non-living matter on the formation of chemical and cenotic composition of biosphere in the conditions when Man is becoming the main geological force has been named *biogeochemistry of noosphere*.

The strategic task in this field is the determination of criteria of transformation of quantitatively parameters in qualitatively ones: reflection of changes in chemical composition of living and non-living matter peculiar to unsaturated zone on the cenotic composition of biogeocenose under the anthropogenic impact. The modern global task is the determination of limits of biosphere capacity to artificial by-products and environmental capability to self-clearing taking into account synergetic effects. The solution of this problem will determine future possibility of Mankind life at the Earth.

The survival of our technogenic civilization is dependent on liquidation of antagonism between technosphere and biosphere by the development in nearest future of nonwaste technologies and transformation of already accumulated wastes to the state, which blend with natural biogeochemical cycles.

Technosphere is characterized by catastrophically development. The Exclusion Zone created after Chernobyl Catastrophe combined into local artificial area most of characteristic features of technosphere. The explosions at the Reactor No. 4 of the nuclear power station of Chernobyl in Ukraine provided a point source for distribution of artificial transuranium elements and fission products and a unique opportunity to trace the mechanisms by which they are distributed. The possibility to distinguish artificial contaminants and natural analogues provided opportunity for determination of their balance distribution and temporal redistribution as well as a quantity of matter involved into biogeochemical cycles.

For the balance calculations we have utilized the *Geochemical Transition Factor*

*(GTF)* that represents the quantity of substance, which is accumulated by plants from the area unit. We are considered the *biogeochemical flux* of matter as quantity of substance, which is transferring during the time unit through the area unit of conditioned interface between biotic and abiotic constituents of landscape.

The researches of radionuclide distribution in meadow ecosystems show that only insignificant part of artificial pollution is involved into biogeochemical cycles. In meadow ecosystem from $n \cdot 10^{-4}$ to $n \cdot 10^{-2}$ part of $^{137}$Cs and $^{90}$Sr is cycling between soils and plant. The intensity of biogeochemical flux for $^{137}$Cs and $^{90}$Sr have an opposite directions. Between $n \cdot 10^{-5}$ and $n \cdot 10^{-4}$ part of $^{137}$Cs is included to higher trophic chains. Intensity of biogeochemical flux to cow milk raises accordingly the biomass productivity.

Bioproductivity of forest ecosystem is substantially higher. About 23 % of $^{137}$Cs is distributed between living layers, 30 % corresponded to litter layer, and about 50 % contains in mineral layers of soil. The main part of radionuclide containing in organic matter is corresponded to primarily fallouts. Probably decomposed litter contains a great part of primary fallouts, which were presented by hot particles of fuel and condensative origin. No more than15 % of Cs-137 was found in tree canopy. On the whole we can conclude that about 90 % of caesium-137 contains in non-living organic and inorganic matter of pine-tree forest. And only 13 % is included now in active biological cycling.

Am-241 is the only isotope, which accumulated in natural environment. Its half-decay is 433 years against of parent isotope Pu-241 with half-life about 14 years. Therefore we are pay special attention to this radionuclide, because in nearest century it will become significant dose-formative after the decay of comparatively short living isotopes. Comparing with other transuranic elements Am has the highest mobility and bioavailability in natural ecosystems. About 3 % of Am-241 is included in active biogeochemical cycling. The main reserve of this isotope is related to primary fallouts, which contained now in decomposed litter and mineral soil layers.

Carbon is principal structural component of organic molecules. Therefore environmental distribution of carbon isotopes is of great significance. The main part of total Carbon is involved in biogeochemical cycles in forest ecosystem. The part corresponded to non-living matter is about 10 %.

Anthropogenic activity leads to a considerable imbalance of Carbon isotopes in the pine-tree ecosystem that primarily depends on the properties of anthropogenic fallout. Radiocarbon of artificial origin (arising from the accident) is equally distributed now between living and non-living constituents of the forest ecosystem. The distribution of carbon between different biotic levels of the forest ecosystem demonstrates that

accidental emission is substantially less bioavailable than emissions from natural and global sources. It is evident that a sizable part of $^{14}C$ was released during the accident as Uranium-Graphite hot particles. These particles have been relatively stable during the 20-years since the accident and are contained in soil and decomposed litter. The latter is the nearest source for secondary emission of $^{14}C$, especially in the case of forest fire. In natural conditions secondary $^{14}C$ emission from soil and decomposed litter is absorbed by higher layers of litter and moss. Present-day secondary cycling of $^{14}CO_2$ of accidental origin in the forest is limited by the soil-litter-moss layer.

Limitation of anthropogenic activity within contaminated area led to recovery of natural peaty landscapes. The modern autorehabilitation processes are more rapidly and deeply than man-caused conversion of the environment in past. The biodiversity in the evacuated zone, which covers more than 4,000 square kilometres in Ukraine, Belarus and Russia, is higher there than before the accident. Some 100 species on the IUCN Red List of threatened species are now found within the abandoned area. Around 40 of these, including some species of bear and wolf, were not seen there before the accident.

Experience of geoecological investigations gives rise to conclusion about comparative sustainability of the modern state of biosphere in spite of catastrophically development of technosphere. Recovery of natural ecosystems is more rapidly and deeply than man-caused conversion of the environment in past. Certain catastrophically processes are not led to global changes in biosphere that determined by sustainability of biogeochemical fluxes and insignificant quantity of artificial matter involved to biogeochemical cycles.

We are know at least two examples during the Earth history when biosphere was partially annihilated: in Jurassic and Glacial epoch. Now Man has become the main geological force. The overdraft of limits of biosphere capacity to anthropogenic loading may resulted in annihilation of Mankind. We are able to crush ourselves during the artificial transformation of biosphere. Nevertheless even if Mankind will be annihilated, biosphere will be remain and sooner will recovery to sustainable state.

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