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BIOSPHERIC ORGANIZATION AS A "CONTINENTS – OCEANIC BASINS" SYSTEM

ABSTRACT. The functional characteristics of the biosphere are reflected in its binominale frame: continents – oceanic basins. The river-basin land, on the one hand, and pericontinental oceanic waters on the other hand, are the main components of the homeostatic mechanism of the biosphere. In the Archean and Early-Middle Proterozoic, seawater biofiltration did not exist. In the Late Proterozoic and part of the Early Paleozoic, biofiltration started to develop and the oceans have become the main heat-engine of the Earth. Today, the maximum concentration of productive phytoplankton and zooplankton – filter bio-systems – is in the pericontinental oceanic zones. This is a response to the maximal flow of nutrients from the land carried mainly with river flow. This is the main signal of a direct link between terrestrial and oceanic ecosystems. The feedback is the atmospheric precipitation induced by heat and moisture flows and carried from the oceans to the land within its primary river-basin part. These links are experiencing anthropogenic destabilization due to some misplaced priorities of sustainable development and its implementation.

KEY WORDS: biosphere, homeostasis, biospheric organization, frame of the biosphere, river-basin land, phytoplankton, biofiltration, anthropogenic destabilization.

INTRODUCTION

The influence of organic life on the global dynamics was discussed in the works of J. Lamarck (1744–1829), G. Cuvier (1769–1832), C. Lyell (1797–1875), J. Reclus (1830–1905), and F. Richthofen (1833–1905), V.V. Dokuchaev (1846–1903), and others. G. Marsh (1801–1882) have not only pointed to the anthropogenic disturbance of the balance of the living nature, but also the extermination of its most important part – the forest vegetation, i.e., anthropogenic land abiotization. Eduard Suess (1831–1914) suggested the term "biosphere" for the space with an abundance of organic life on the continents. V.I. Vernadsky identified the biosphere basing not on the phase criterion, as has been done before him (stone, water, gas, live), but included into the biosphere the sphere of the active life. This sphere embraces the lower atmosphere, most of the hydrosphere, and upper layers of the lithosphere. "Living matter penetrates the entire biosphere and largely creates it" [Vernadsky, 1980, p. 58]. In 1926, he formulated perhaps the most important law of the geological development: "Life is not a random occurrence in the external surface of the Earth. It is closely connected with the structure of the Earth's crust (the atmosphere-hydrosphere-lithosphere system, in the terminology of the first half of the XIX–XX centuries – S.G.), it is part of its mechanism and this part performs the functions of the greatest importance, without which it could not have existed" [Vernadsky, 1967, p. 212].

Today it is generally accepted that the biosphere is part of the geospace, which supports life due to the specific conditions and biogeochemical and biogeophysical impact of planetary biota on the abiotic substance. V.I. Vernadsky has termed the processes of biotic regulation as "organization of the biosphere" and the associated processes – biogeochemical.

THE FRAME OF THE BIOSPHERE

We will apply this term to the system "continents – oceanic basins." The continental crust is thick (30–40 km), consists of three-layers: the upper sedimentary, deeper granite (metamorphic-granite), and basalt (granulite-basic) at the base. According to Budyko et al. [1985], sedimentary layer of the continents consists of (in wt. %) clayey and shale (43.1 %), followed by sandy (21.0 %), carbonate (18.7 %), volcanic (14.6 %), siliceous (1.8 %) rocks and evaporites (0.8 %). The clay matter, carbonate, and siliceous rocks substances of rocks initially are almost entirely the products of biogeochemical reworking of matter. Sands are formed under different conditions. Their formation is a priori can be attributed equally to the action of biogeochemical processes and metamorphoses, not associated with the manifestations of living matter. Evaporites are chemogenic formations. ***Thus, about 75 % of the sedimentary rock layers of the continents are formed with the participation of living matter, i.e., they are the result of biotic and biogeochemical processes.***

The granite-metamorphic layer is composed of gneisses, schists, marbles, and diabase. The igneous rocks are dominated by granites. The Kola superdeep (12262 m) borehole in the rocks of this layer and below the surface to a depth of 7 km has uncovered the Proterozoic sandstones, dolomites, and diabase. Below lie the Archean (2.86 billion years of age) paragneiss (with marked predominance) and amphibolites. Paragneiss is metamorphosized clay rocks. The original clay matter is likely the result of activity of prokaryotes that formed mats on the land surface and were much more common in the Precambrian than now. "Though the amount of living matter is lost in comparison to the mass of abiotic and biogeochemical matter in the biosphere, the biogenic rocks (i.e., formed by living matter) make up a large part of its mass and extend far beyond the biosphere. Given the phenomena of metamorphism, they are transformed, losing all traces of life, into the granitic envelope and go beyond the biosphere. The granite shell of the Earth is the area of former biospheres" [Vernadsky, 1980, p. 215]. Geochemist T. Barth (1962) wrote: "first sediment – then granite." Potassium-rich metamorphic rocks and granites exhibit direct connection with strata of primary sedimentary clay composition [Marakushev et al., 1971]. ***Thus, the geological formations of the granitic layer are mostly old sedimentary rocks and the products of the past biogeochemical reworking*** [Sidorenko et al., 1980].

Below 6 km, the section of this borehole continues in paragneisses interbedded with amphibolites. The composition and origin of the lower granulite-basic layer of the continental crust have been mainly attributed to the deep transformation of mantle rocks of the oceanic crust; however, the details of the Kola superdeep borehole did not confirm this notion. The oceanic crust is thin (6–8 km) and consists of three layers: the thin upper sedimentary (a few hundred meters thick), middle basalt, and lower oceanic. The lower two layers are mainly mantle rocks. ***Thus, the continents have biogenic-geodynamic origin and the oceanic basins are of mantle-geodynamic one***.

THE OCEANIC BASINS ARE REPLACED BY THE CONTINENTS

Back in 1896, relying on the paleo-geographic data, V.P. Amalitsky (1860–1917) concluded that in the Phanerozoic (the last 550 million years), the continental area was expanding due to reduction in the size of the world's oceans [Simakov, 2004, pp. 162–164]. Thus, as far back as in the end of the XIX century, scientist have identified the main planetary geo-historical feature inherent, as established later, in the entire phase of geological development of the planet, although in a somewhat complicated form.

The mechanism of transformation of the oceanic crust into the continental was discovered a few decades ago. The process involves the entire solid part of the Earth, i.e., lithosphere, together with asthenosphere that relates to the upper mantle. This change takes place in the subduction and collision mobile belts [Khain, Koronovsky, 2007]. First include the land adjacent to the oceanic border and the adjacent oceanic strip with deep trenches and island arcs along the trenches (though not in all places). The development of such structures occurs first, through the lithosphere downwarping (first stage) and the formation of many-kilometers thick rock, mainly of sedimentary and volcanic-sedimentary origin. At the second stage, downwarping gives place to uplift (inversion). Subduction of the oceanic plate to the deep-sea trench creates a powerful lateral pressure on the island arcs or similar coastal structures. The rocks are crushed into folds, and part of them is subjected to metamorphism, metasomatism, and remelting. Volcanism and deep magmatic processes intensify. The third stage (of intensive uplift) involves formation of fold mountain structures such as the Andean Cordillera mountain belt. Each complete cycle took 200–400 million years in the Phanerozoic; in the Precambrian, the cycle was longer. The subduction mobile belts of the Pacific Ring of Fire represent one of the examples of recent geologic transformation of the oceanic crust into the continental.

The collision type of transformation of the oceanic crust into the continental is inherent in the mobile belts of the Earth, where the oceanic lithosphere is located between two converging continental lithospheric plates. Here, the stages of subsidence, inversion, and uplift of the crust also take place. Within the downwarping segments of the crust, many-kilometers thick layers of sedimentary rock are accumulating and subjected to endogenous transformation, including folding under the pressure on the both sides of the continental plates. Later, the warped zone undergoes inversion and uplift with the formation of the collision fold mountain type like the Alpine-Himalayan mountain belt.

The continental crust is thicker and more stable and geologically far more diverse than the oceanic. The latter is less stable, with numerous faults and volcanoes, some submarine. Plumes are the places of particularly active volcanism, such as Iceland. There, subglacial volcanic activity is stimulated by excessive load of meltwater periodically accumulated in the craters. Excess water is a signal for the eruption and the formation of subglacial streams of enormous power. When the water load is removed, the eruption fades. Some scientists believe that the preventive evacuation of water from subglacial volcanic vents can prevent the eruption.

The trend of replacement of the oceanic crust by the continental one means that the evolution trends of abiotic and live matter are opposite. Abiotic matter releases the excess crystal-chemical energy inherent in the inert matter of mantle origin. Biotic matter becomes more complex and increases its energy potential associated with mineral associations of the granite-metamorphic layer and especially of the sedimentary, rock-rich, layer (clay, fossil fuels, and guano et al.), where the solar energy is deposited mainly due to the biotic factors. Both trends are coordinated and go with increasing speed, which, in particular, allows us to see the global ecosystem in the system "living matter – geospheres" (atmosphere, hydrosphere, lithosphere). Intensification of movement of biological matter indirectly affects the activity of the internal forces of the Earth, directed at the transformation of the oceanic lithosphere into the continental one [Gorshkov, 1975].

Consequently, the system "continents – oceanic basins" is a "calling card" of the existence of the global ecosystem, i.e., the biosphere of the planet Earth. At the same time it is the evidence of the existence of the planetary regulatory pressure of living matter on the forces of abiotic matter, the fact repeatedly pointed to by V.I. Vernadsky.

CONTINENTS ARE THE MAIN FOOTHOLD OF LIFE

What are the implications of the oceans being replaced by the continents for living matter? Below is a list of the main, mostly positive consequences: a) enhanced complexity of geographical conditions to which the biota usually responds with increase of biodiversity; b) greater terrestrial ecosystems' supply of photosynthetic radiation and greater intensity of biogeochemical and biogeophysical processes; c) strengthening of catastrophic events, including major meteorite disasters; d) concentration of almost all the planetary biomass (about 98 %); the biomass (not considering its anthropogenic reduction) per unit land area is higher than that in the ocean by two orders of magnitude; e) speciation outbreaks follow the great extinctions; growth of biocoenotic and biological diversity and of genetic pool of the planet; f) the existence of the most complex rain-forest biological communities with, according to various estimates, from 0.5 to 3 million species.

Let us turn to the figures. The potential terrestrial photosynthetic production is 180 billion tons of organic matter (dry weight) or 82 billion tons of carbon equivalent [Bazilevich et al., 1971]. This is the net primary productivity of the biosphere undisturbed by anthropogenic activity. In modern conditions, the terrestrial net primary productivity is 45 billion tons of carbon equivalent [Lisitzin, 2004].

The last satellite measurements have shown that the primary productivity of the ocean reaches 103 billion tons of carbon equivalent. According to Hampicke by the mid-1970s, the terrestrial phytomass decreased due to human activity by 41.5 %; soil humus decreased by 18 %. By the turn of the second and third millennia, 50 % of the terrestrial phytomass has been lost [Kondratiev, Krapivin, 2004]. The assessment of the total terrestrial phytomass is 466 billion tons C_{org}, which comprises 42.7 % of the potential C_{org} in 1090 estimated by N.I. Bazilevich et al. [1971]. According to FAO [FAO Production Yearbook, 2012], in the XXI century, the speed of deforestation comprises 6 million ha per year. By multiplying this estimate by 14 years and 86 t/ha of C_{org} (the calculated average phytomass per hectare of forest), we obtain a 7.2 billion tons decrease of the terrestrial phytomass due to deforestation for the period 2001–2014. ***From this, the terrestrial phytomass assessment in the beginning of 2015 is 459 billion tons C_{org}, i.e., 42.1 % of the potential.***

HOMEOSTATIC PROPERTIES OF THE RIVER-BASIN LAND

Numerous publications substantiated understanding of the river basins as the ecosystems of direct links and feedback. The pioneering work on basic climate geomorphology is important for understanding homeostatic features of the organization of the biospheric mechanism [Tricart et Caillex, 1965], as well as work on the isolation of the so-called dense biosphere (humid and semi-humid areas), sparse biosphere (semi-arid and arid areas), and bare biosphere (glaciers, snow, etc.) [Caillex, Tricart, 1959] This terminology is well suited for characterization of areas with different homeostatic functions discussed in this paper. The term dense biosphere identifies the territory of a well-developed and almost continuous vegetation cover. This is typical of river basins with dense river network (Fig. 1), if we do not consider their intensive use.

On the schematic map "Organization of the biosphere" (Fig. 2), the terrestrial formations include: river-basin system (a – fully functional, b – weakened by cryogenic processes) or dense biosphere, and the territories of various degrees of aridity; the latter include desert-aeolian territorial system, as well as transitional systems between the river-basin and desert-aeolian, subjected to aridity to varying degrees. This is the sparse biosphere. One can also see some river sections that intersect, in varying degrees, arid territory. Here, as a rule, they lose part of the river flow. The schematic map (Fig. 2) is divided into two parts. Its oceanic part is a copy of the map "Filtering capacity of zooplankton" created by A.P. Lisitzin. The part that reflects the land was developed by S.P. Gorshkov. The map was included in the oral report by A.P. Lisitzin, S.P. Gorshkov, and V.I. Byshev at the jubilee session "150th anniversary of the birth of V.I. Vernadsky" (May 7, 2013) at the Faculty of Geography of the Lomonosov Moscow State University.

Large river basins represent landscape and geological bodies covering part of the

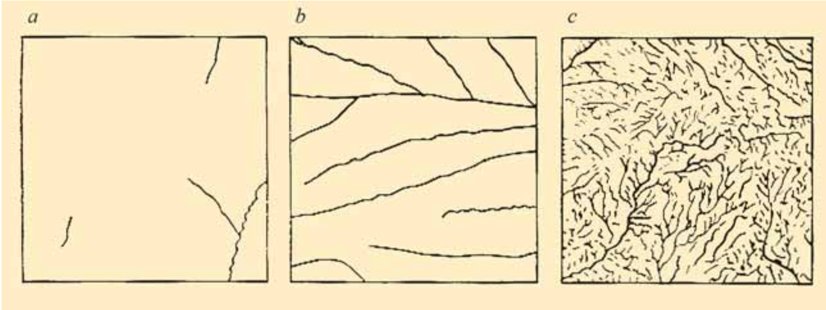

Fig. 1. The difference in the density of the hydrological network of three catchment areas located in the areas of:

a – arid climate in the south-east of the state of Nevada; b – semiarid climate in the west of the state of Kansas; c – humid climate in eastern Indiana [Gorshkov, 1982]

subsurface space within the zone of active water exchange, associated with the river discharge of the basin. A large river basin has three functional components which are as follows:

1) The system of catchment areas of small rivers with relatively homogeneous landscape and geological conditions within each. Catchment areas may differ from each other

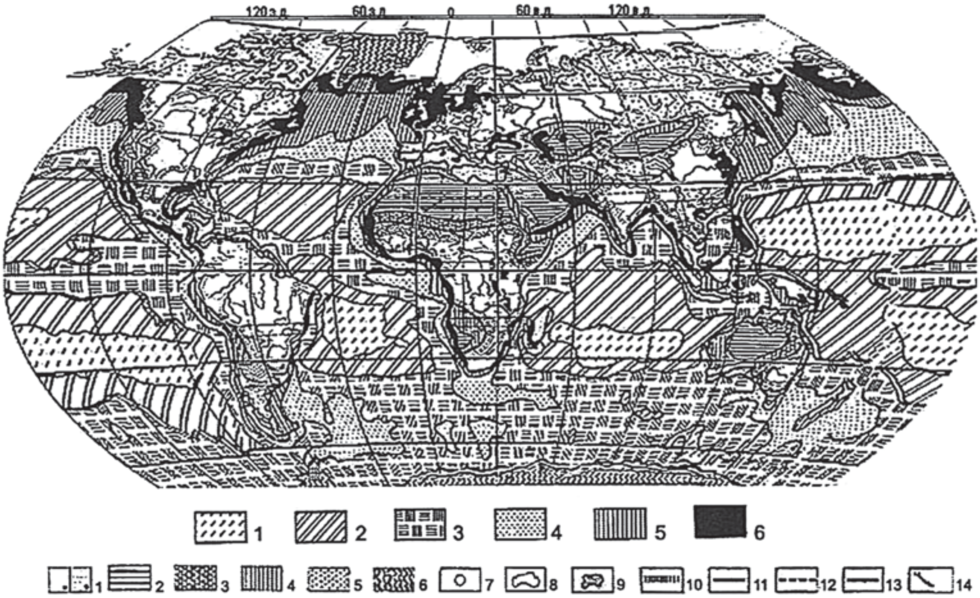

Fig. 2. Model of the biospheric structure. Authors A.P. Lisitzin (ocean) and S.P. Gorshkov (land). Ocean: The top row of characters. The biomass of meristic zooplankton biofilter in the layer 0–100 m (mg/m^3):

1 – < 25; 2 – 25–50; 3 – 50–100; 4 – 100–200; 5 – 200–500; 6 – > 500. Land: The bottom row of characters. Terrestrial systems: 1 – river-basin (transformed by biota) a) adequate; b) weakened by cryogenic processes; 2 – desert-aeolian (slightly transformed by biota); 3–5 – transition between the river-basin and desert-aeolian systems: 3 – subjected to strong anthropogenic desertification; 4 – affected by anthropogenic desertification; 5 – replaced river-basin systems through anthropogenic desertification; 6 – glacial-nival (practically not transformed by biota); 7 – urban industrial and transportation hubs; 8–9 – aquatic system: 8 – lakes with a natural water level; 9 – lakes with anthropogenically altered water level; 10–13: boundary between land and oceanic systems (shore): 10 – accumulative; 11 – abrasive; 12 – abrasive-accumulative; 13 – relatively stable; 14 – boundary of the cryolithozone.

by their zonal-geographical or altitudinal-belt features. Being quite similar in these criteria, they can be identified as adjacent cells in the hierarchical structure of the basin. The network of catchment areas carries flows of organic-mineral matter to the valley network.

2) The valley network as a system of large valleys in conjunction with the main valley. They combine discharge from the catchment areas and valley network elements, and the lower reaches of the valley serve the main integrator of the signal for the entire river basin.

3) The mouth part is the area where the integral signal of the river basin is combined with the signal of the adjacent oceanic part [Gorshkov, 2001]. According to A.P. Lisitzin [2004], it is the marginal filter. We will discuss this below.

At the global level, the homeostatic structure of habitat is mainly identified through analysis of the interaction of the two main components of the biosphere, i.e., the continental and large-island area, on the one hand, and the world's oceans, on the other (see Fig. 2). They are connected through the global water cycle and thermal redistribution, which are, in turn, largely functionally connected with river discharge to the ocean (direct link). The response to the signal from the land is the transfer of atmospheric moisture and heat from the ocean to the most humid terrestrial segment, i.e., to the river basins of the external discharge (feedback). This is largely provided by the advection of warm oceanic waters to the cold oceanic segments and vice versa, which dramatically increases the area of suitable habitat on the earth.

The figures of the annual water exchange between the ocean and the land are as follows. Evaporation from the surface of the planet is 577 thousand km^3 (505 thousand km^3 from the surface of the ocean and 72 thousand km^3 from the land). Precipitation falling within the area of the external river discharge is estimated at 95 thousand km^3; river discharge from these areas is 42 thousand km^3 [World..., 1974]. The area of the river basins with the external discharge have the area of about 103 million km^2 and are characterized by the presence of the great rivers that are absent only in Australia. The figure is obtained by subtracting the areas of Antarctica (14 million km^2) and Greenland (2 million km^2) from the total area of the external discharge of 119 million km^2, since iceberg discharge prevails there [World..., 1974]. Water of the rivers of the external discharge, as a rule, represent the channels of information between the river basins with the dense biosphere and the ocean, even if in transit they run through territories with the sparse biosphere. The land of river basins possesses several distinct homeostatic functions.

Anti-destructive homeostatic function. The highest efficiency of the creative action of the dense biosphere is inherent in wet tropics. Here, "all geomorphological dynamics changes due to the intermediate position of the "dense biosphere"" [Cailleux, Tricart, 1959, p. 43]. In hot humid climate, annual rainfall may exceed 2000 mm. It rains almost daily. Nothing on the planet can compare with the mighty manifestations of life in rain forest. "On one hectare here you can put 42 000 species of insects, 750 species of trees, and 1500 species of other life forms" [Newman, 1989, p. 25]. Density of rain forest is three to four times greater than the density of temperate forest. The soil, due to its highly porous structure, absorbs almost completely moisture which reaches it. Therefore, the planar surface runoff and soil erosion caused by it are practically absent. In the valleys of small rivers, destruction and creep of loose mass occurs [Tricart, Cailleux, 1965].

Under these conditions, "most of the rivers even during floods carry only 5–10 % of their maximum sediment load" [Cailleux, Tricart, 1959, p. 50]. The composition of river suspended material is mainly silty-clay. Runoff of dissolved matter in most of the rivers exceeds that of suspended sediment [Cailleux, Tricart, 1959; Corbel, 1964]. According to the data on the mineral runoff of local rivers, the speed of natural denudation in hot wet climatic conditions for mountainous areas and plains is 0.092 and 0.021 mm/yr, respectively [Corbel, 1964]. These facts indicate weak denudation and a broad manifestation of the biogeochemical weathering almost universally in these conditions [Tricart, Cailleux, 1965].

In the temperate zone, in the presence of the dense biosphere, biogeochemical weathering is less active in winter and can be combined with freezing of soils and rocks. During snowmelt and heavy rainfall, subsurface runoff is active; in some locations, it reaches the surface. Slope processes are weakened and rivers have a negative balance of deposits, i.e., the input of deposits from the slopes and from other sources is lower that the carrying capacity of the river. On the plains, rivers often flow as a single channel, forming meanders, and accumulate interlayer (perstrative) alluvium of the normal type [Gorshkov, 1982]. In the humid plains of the forest and steppe zones of the temperate zone, the denudation speed is estimated at approximately 0.030 mm/yr [Dedkov et al., 1977]. The overall speed of natural denudation in the mountains of the temperate zone is assessed at 110 mm/yr [Corbel, 1964].

In the permafrost zone of the subarctic and temperate zones, the dense biosphere is weakened, although due to the low evaporation, drainage system is also dense. The territories are characterized by high level of waterlogging and lake percentage. The upland areas are covered by stone seas and solifluction flows. These permafrost formations feed the rivers by water in summer because of subsurface ice melting. Overall, sparse forests, forest-tundra, and southern and typical tundra with polar day regime during short summer and, further south, summer with very short white nights on the depositional plains, can be rightly perceived as the "dense biosphere," i.e., having closed vegetation cover. This situation does not exist on the denudation plateaus and mountains, dominated by stone seas (kurums) and permanent snow and glaciers in some elevated places. Vegetation is localized in the bottoms of the valleys and on bottom parts of the slopes [Gorshkov, 1982].

Even in the area of island permafrost, small rivers are usually pushed by soliflual or block flows to warmer and steep slopes. The positive sediment balance is associated with the large rivers of the permafrost zone, for example, Indigirka. This is not true for Ob and Yenisei, whose large part of the flow is outside the permafrost zone. The natural denudation of the mountains and plains of the cold zone is assessed at 0.385 and 0.018 mm/yr, respectively [Corbel, 1964]. The first figure is true for the mountains with active glacial activity. However, in the areas with only ground icing and subsurface ice, e.g., on the Central Siberian Plateau, the figures should be an order of magnitude less, somewhere in the range of 0.030–0.040 mm/yr [Lisitzin, 1974].

Thus, the areas with the dense biosphere have a combination of seemingly two opposites: a) their weakened denudation manifested in underutilization of the sediment load of rivers, and b) thoroughly dissected by rivers network surface. The second feature is particularly noticeable in the humid parts of the temperate zone. Here, due to the lower density of the tree canopy, approximately 5 % and 15 % of the rainfall is involved in the surface and subsurface runoff, respectively. Fig. 1c shows a dense river network in an area with coniferous-deciduous forests in the state of Indiana, USA, in the temperate zone [Gorshkov, 1982].

Environment-forming homeostatic function. At relatively high rainfall during the growing season, there is a rapid return of the bulk of the moisture to the atmosphere. This return is due to transpiration and evaporation from natural canopy, i.e., due to evapotranspiration. The share of evaporation in evapotranspiration on bare surfaces is low due to projective cover close to 100 %. A perfect example is the zone of equatorial tropical rain forests with almost daily precipitation. The high speed of the water cycle is a consequence of the maximum, among photosynthetic organisms, leaf area size of the local forest communities and the tiered structure of projective cover. This provides for a high share of biological and physical evaporation of moisture from the vegetation canopy. Here, 80–90 % by weight of precipitation returns to the atmosphere after a few hours. Only 10–20 % of the precipitation is absorbed into the soil, enters runoff, and then, in about a month, the atmosphere [Krenke, Zolotokrylin, 1984].

The share of physical evaporation of rainfall intercepted by canopy of broadleaved evergreen, broadleaved deciduous, and conifer forests is estimated at 13 %, 19 %, and up to 22 %, respectively [Diego et al, 2010.]. Overall, the geosystems of the equatorial rain forests support year-around the most suitable for producers, and, consequently, for the entire wildlife habitat, conditions. They reduce the surface temperature. The lowest average monthly temperature is + 25 °C; the highest is + 27 °C. The moisture content in the soil and underlying rocks is optimal. On plains, excess moisture content in soil and groundwater on the clearings, meadows, and arable lands leads to waterlogging, and in the mountains – to catastrophic landslides.

One of the most important indicators of the environment-forming homeostatic function of the dense biosphere during the growing season is surface temperature as an indicator of the release of sensible heat. Evaporation (latent heat flux) accounts for 2.47 MW/ha, 1.23 MW/ha, and 1.00 MW/ha in the zones of tropical rain forest, summer-green forest, and taiga, respectively. These figures are 0.91 MW/ha for meadows, pastures, and steppes, 1.18 MW/ha for arable land, and 0.61 MW/ha for land not used in agriculture. The average estimates were made for the land area of 13.31 billion hectares (i.e., without Antarctica and Greenland) [Krenke, Zolotokrylin, 1984].

Water-regulating homeostatic function. This function was studied by O.I. Krestovsky [1986]. Using the river basin in the subzones southern taiga of European Russia as an example, it has been established that on clear-cut areas, the speed of snow melting, the size of runoff, and flood levels increase. At the same time, the lowest river water-level and groundwater recharge decrease. Transpiration falls to the minimum. During the juvenile and young forest phases, river discharge decreases rapidly and falls to the minimum; at the same time, transpiration increases to the maximum. With forest maturing, runoff increases and transpiration falls. Flood peak becomes lower, the water level in low-water period higher, and groundwater recharge reaches the ordinary level. ***The characteristics of river discharge and groundwater balance in catchment areas follow the physiological phases of forest vegetation*** [Krestovsky, 1986].

Adaptive-reduction homeostatic function. This function is most commonly manifested in the river basins of the temperate zone. Here, during the vegetation period, there is a sufficient heat period for large-scale farming, despite the presence of snow cover in winter. In such conditions, deforestation of catchment areas and establishment of meadows, arable land, and settlements is accompanied by rapid snowmelt, increasing surface runoff, abnormally high and rapid floods, reduced groundwater recharge and their runoff, increase of sheet and gully erosion and sediment discharge to hydrographic network, and transformation of small river valleys into gulches, which represents a response to a sharp decrease of the normal rate of their discharge in summer. A quick response of the catchment areas of small rivers to the events listed above is partially carried into the network of large valleys as abnormally high floods, low summer and winter dry-weather periods, as well as the increased sediment load in all parts of the river basin. It changes from the dense dendritic to the truncated-primitive [Nezhihovsky, 1971]. ***In general, agricultural development not only significantly reduces the water-regulating function of the dense biosphere, but also leads to a reduction in the release of its***

latent heat flow, i.e., to the weakening of the thermal and moisture regulating potential of the territory. Facts of degeneration of small rivers due to deforestation by arable land, plantations, pastures, and land with man-maid structures are well known in the eastern and in the central parts of the United States.

FRAGMENTARY HOMEOSTASIS OF ARID LAND

The stability of the processes of external dynamics in the areas of the dense biosphere contrasts the unstable high activity of exogenous processes in the areas of semi-arid, arid, and hyper-arid climate. In the sparse biosphere of the temperate and hot zones there is intense denudation (although not always). In endorheic areas (30 million km^2), the area of nearly 1.2 million km^2 is associated with the bulk of the Volga River basin with the dense biosphere. The land of varying degrees of aridity, not included in endorheic areas, occupies 18–20 million km^2. Dry steppe and semi-arid parts of the temperate zone are characterized by low levels of projective cover. Thus, V.N. Zolotokrylin [2003] assumed in his studies in the Central Asia and Kazakhstan 40–50 % and 30–40 %, for dry steppes and semi-deserts, respectively, as representative indicators of cover. Such areas are subjected to strong surface runoff, gulling, mudflows, deflation, corrasion, thermal and frost weathering, and infiltration pull of mineralized water to the surface with the formation of accumulative salt crusts (caliche, carbonic calcium gypsum, drywall, silcretes). Gullies and ravines represent repositories for sometimes tumultuous streams. Vast inclined relief can be covered by water current several times a year. Most of the sediment is usually deposited in the form of deluvium, proluvium, and valley alluvium. The bulk of the discharge products remain at the locale denudation bases. These include small erosional networks, and sometimes also the belt of channel-floodplain complexes of large rivers. Sediment influx into a permanent river network, as a rule, is small; it is often only 10 % [Pots, 2001]. Therefore, the natural rate of denudation within the semi-arid and arid areas, defined using data on river mineral discharge, is underestimated. Denudation degradation of plains in such conditions has been estimated at 0.011 mm/yr, while in the mountains it is 0.228 mm/yr [Corbel, 1964]. The rate of degradation of surface slopes by sheet erosion in dry steppes within plains is 0.020 mm/yr; in the desert zone of the Colorado Plateau it is 0.11 mm/yr, and on the hills in the semi-desert area in the state of New Mexico, USA, composed of loose sediments, it is 0.48 mm/yr [Gorshkov, 1982]. Some sites in the states of Kansas and Nevada, USA, represent examples of the level of sparseness of the river network in the semi-arid dry-steppe and arid semi-desert conditions of the temperate belt (see. Fig. 1a and 1b) where sparse and sporadic river networks differ from those in the dense biosphere. Local rivers feed mainly from occasional rainfall and snowmelt. In areas with the sparse biosphere and extra-arid and almost bare deserts, where rain falls every few years, the sand in the surface layer is moved by dust storms. During such storms, silt and finer particles often migrate with the air masses many hundreds of kilometers away, and sometimes even farther. On its way, aeolian fertilization affects the euphotic layer of the Atlantic Ocean and, in the end, the heavily washed soils of wet subtropics of Florida and the Amazon [Gorshkov, 2001]. Thus, the areas of the sparse biosphere that possess homeostatic characteristics occur only on the land along large transit rivers with forest corridors, sufficiently water-rich river deltas, irrigated land, oases, reservoir borders, freshwater lakes, and also in well-verdured cities. ***The water-land objects listed above have higher water supply, green cover, and latent heat flow compared with arid and semi-arid areas. Water-land objects make up the fragments of natural-anthropogenic ecological frame of the areas with dry climates.***

PRODUCTION-BIOFILTRATION HOMEOSTATIC MECHANISM OF THE OCEANS

Below, we provide the fragments from the "Living Ocean" concept by A.P. Lisitzin [2004] that represents a major contribution to the study of the biosphere, in particular, to understanding of the biogeochemical and biogeophysical mechanisms in the system "continents – oceanic basins."

The flow into the mouths of rivers that run into the ocean is associated with the biogeochemical mechanism in the river-basin terrestrial part: 1.75 billion tons of sediment and 2.7 billion tons dissolved matter per year [Gorshkov, 2001]. Only 7–10 % of the sediment immediately reaches the ocean. Its bulk (at least 16.7 billion tons) is deposited in the marginal filter [Lisitzin, 2004], i.e., in deltas and estuaries. On the river-ocean boundary, i.e., within the marginal filter, gravitational sorting of clastic material, coagulation and flocculation of the finest particles and colloids, and deposition of 90–93 % of sediment transformed in these ways, take place. Significant water clarification enhances phytoplankton photosynthesis and the formation of organic matter [Lisitzin, 2004]. In addition, the ocean receives: with direct underground runoff from land – 1 billion tons of dissolved substances in clastic form, 2.4 billion tons of moraine material from shelf glaciers, 1 billion tons of shore abrasion products, 2 billion tons of aeolian dust, and 1 billion tons of dumping [Gorshkov, 2001].

In the pericontinental upper active layer of the ocean, there is the densest concentration of phytoplankton and plankton crustaceans-biofilters. During feeding, they strain suspensions that practically do not sediment from water. The suspensions aggregate in digestive tracts of crustaceans into pellets, i.e., aggregates of silty and sandy fractions, and quickly sediment. The rate of sedimentation of the pellets is 500–600 m/day, compared with 0.07–2 m/day for fine particles prior to their involvement in the biofiltration. Organisms-biofilters also involve dissolved matter into pellets. The entire volume of the oceans, from the surface to the bottom, is completely subjected to biofiltration over six months.

The deposited pellets disintegrate. Only 5 % of the newly formed suspension reaches ocean floor; less than one percent is incorporated into the bottom sediments. The main part of the original material is returned to the water – to the deep ocean reserve, and, then, through upwelling – to the top active layer [Lisitzin, 2004]. Oceanic biosystems operate due to repeated use of biogenic and biophilic elements. This mechanism is a consequence of the fact that river discharge from land supplies only 15 % of necessary biogenic elements [Lisitzin, 2004]. Only the repeated recovery of biogens in the active layer and the underlying ocean waters in the system "producer-consumer-decomposers" provides higher bio-productivity of the world's oceans, compared with the continents [Gordeev, 2012].

The primary productivity of the oceans, as mentioned above, is 103 billion tons of Corg/yr, while that of the continents is about 45 billion Corg/yr, i.e., about 2/3 of the primary productivity is associated with the ocean. The phytoplankton and zooplankton biomass is 25.0 billion tons and 1.5 billion tons, respectively; at the same time phytoplankton regenerates 660 times annually, while zooplankton – only 2.5 times.

The maps by A.P. Lisitzin [2004] "Primary Production of the Ocean" and "Zooplankton Systems Filtering Capacity" show: a) the highest primary productivity of phytoplankton and zooplankton systems filtering capacity are associated with waters adjacent to the continents; b) the lowest primary productivity of phytoplankton and zooplankton systems filtering capacity are associated with the oceanic areas in tropical zones, isolated from any major land fragments and with an extreme deficit of meteoric precipitation. The adjacent subequatorial waters have higher parameters than the above-mentioned ranges. Probably the tropical habitats suffer from the absence of any significant flow of nutrients from rain moisture, in contrast to the adjacent equatorial waters receiving such "manna from heaven."

The influence of even a short-term influx of biogenic substances from the outside causes equally rapid growth of phytoplankton. A similar, in term of rate and scale, decrease of the fertilization effect adequately returns phytoplankton and the associated pyramid of heterotrophs to the previous lower level of productivity. Such was the case during the two largest in the past decade (in 1998 and 2010) floods on the river Yangtze. The data of oceanographic observations show that the total primary productivity in the East China Sea after the floods could provide fishery catches approximately three times higher than in their absence. Icebergs from glaciers in Antarctica, drifting in the Southern Ocean, supply fresh water, dust, and mineral particles to the surface waters of the ocean along the paths of their movement. It affects the phytoplankton growth conditions. Satellite observations and computerized data on the movement of icebergs in the Weddell Sea from October to March in 1999–2004 pointed to the likelihood of increased phytoplankton biomass by about one-third in the euphotic layer along the paths of movement. The settled volcanic ash from the eruption in August 2008 in the Aleutian Islands caused one of the largest phytoplankton blooms in the northern zone of the subarctic Pacific Ocean. ***Thus, the production-biofiltration activity of the ocean is the direct result of biogenic substances inflow capacity (P and Si). The main supplier of nutrients is river flow. A smaller role is played by upwelling.***

Critical factors for the growth of phytoplankton include also sunlight and seawater temperature. Each factor acts individually, but their effect is integrated. The most critical factor is the availability of Si, followed by the water temperature and light. According to G.P. Erhard and J. Sezhen [1984], the increase in the primary and, consequently, the gross productivity in the ocean terminates as soon as the oxygen content in the water stops growing and starts decreasing. A more dynamic aquatic environment is richer because it contains more oxygen. These conditions are, in particular, characteristic of coastal and shallow water as sources of seafood.

Excessive amount of biogenic substances causes biogeochemical poisoning of waters. This fact urges refinement of the assessments that diminish the importance of terrestrial sources of nutrients as a leading factor in the effect of the direct link and feedback within the biogeochemical connection between the continents and the oceans. The statement that the primary productivity of the oceans is more than twice the production of the continents clearly follows from the fact there is an extremely rapid repeated recycling of nutrients in the ocean compared with the continents. At the same time, in the most productive pericontinental waters, biofiltration capacity is more than 20 times higher than that in the oceanic deserts (see. Fig. 2).

Ocean is the main heat engine of the Earth. The most important turning point in the evolution of living and abiotic matter is associated with the energy balance of the ocean in the late Proterozoic – early Cambrian. During this period, animals-biofilters, first plankton followed by benthos, emerged in the ocean and, possibly, in other bodies of water. This is evidenced by the presence of numerous pellets in the deposits of this age. Prior to this age-interval, deep penetration of sunlight into water bodies of the Earth was prevented by turbidity. Its elimination by organisms-biofilters radically reduced the albedo of the ocean and other bodies of water, making them deeply penetrated by sunlight. Due to this factor, the primary productivity of phytoplankton had increased many times, and at the end of the Proterozoic – early Cambrian, the great skeletal explosion took place. It was promoted by a dramatic increase in the oxygen content of the aqueous environment, especially in the oceans [Barskov, 2010].

The established homeostasis in the biosphere was repeatedly interrupted during glaciation phases and the fall of giant meteorites. This was precisely the case during the cold peak of the last ice age when the mean global temperature was 5 °C lower than today and sea levels fell to the level –90 m, or even lower: –120 m. The loss of terrestrial phytomass was 50 % or greater. The atmosphere contained only half of the main biogen – CO_2. Dust pollution over the Andes and the Himalayas was up to 100 times or greater higher than at present; over the Antarctica, it was 30 times higher. This was established from the ice cores from boreholes in the mountain and continental glaciers. Despite the environmental stress, the biosphere stability was sufficient for restoration of the full homeostatic mechanisms.

Now the world ocean has the highly productive and efficient biofiltration pericontinental margin. This is the main mechanism supporting the high clarity of global waters and, accordingly, its main function as the Earth's main heat engine. The ocean is the main redistributor of moisture and heat on the planet in the ocean-land system, where the main share of the thermal and moisture flow on land is associated with the dense biosphere of river basins. At the same time, most of the river-basin land is the main supplier of the ocean nutrients – biogens. They represent fuel that is constantly supplied to the biogeochemical system of the ocean.

The solar radiant energy entering the upper boundary of the Earth's atmosphere is 342 W/m^2. The albedo of the Earth is about 30 %. The Earth Mother Gaia functions due to the remaining 70 % of the radiant solar energy. At the same time, 19 % of operational energy is intercepted and consumed in the atmosphere and 51 % is distributed between the oceanic surface (38 %) and land (13 %) [Kononovich, Moroz, 2001].

Specificity of the redistribution of heat and moisture on the planet is most dependent on the state of the oceanic biogeochemical mechanism. This is evidenced by a comparison of the previously mentioned key figures for the water balance of the Earth (evaporation from the surface is 577 000 km^3/yr, including 505 000 km^3/yr from the oceans) with the scale of the dynamics of the oceanic currents. The thermal and moisture transfer by the oceanic currents is estimated at much higher levels: 21 million km^3/yr. This number seems valid, because, for example, the Kuroshio Current transfers 1 400 000 km^3/yr, Gulfstream – 900 000 km^3/yr, and the California current – 500 000 km^3/yr [Oceanographic Encyclopedia, 1974].

The figures confirm that the ocean is rightly referred to as the heat engine of the Earth. This function is provided by the biogeochemical processes on land and in the ocean. "If not for biofiltration, the waters of the world would have had different thermal properties. The main heat engine of the Earth – the ocean – would have had less capacity than it possesses" [Gorshkov, 2007, p. 53].

The danger of disturbance of the homeostatic properties of the ocean. This section widely cites a brilliant book "Plankton. Composition. Ecology. Pollution" by G.P. Erhard and J. Sezhen, which was published in Paris in 1978, and translated into Russian in 1984. The last 9th and 10th chapters contain information about the dangers associated with the flow of pollutants into the ocean and discuss ways to confront the degradation of the global area.

The ocean is subjected to the following contamination dangerous for its inhabitants: 1. hydrocarbon pollution; 2. chemical pollution (mercury, lead, cadmium, pesticides, acids, alkalis, and detergents); 3. organic waste pollution; 4. bacterial and viral pollution; 5. radioactive pollution; 6. thermal pollution; 7. synthetic plastic material pollution. The negative impacts on the ocean include also the destruction of the coasts.

"In 1972, the Convention on the Prevention of Marine Pollution was signed in Oslo. According to this document, it must not be disposed into the sea from vessels and aircraft: a) halogenated hydrocarbons and other substances capable of forming them as a result of interaction with seawater, with the exception of non-toxic and that can be decomposed into harmless components; b) organic silicon compounds and other substances capable of forming them; c) carcinogenic substances; d) mercury and its derivatives; e) plastic not capable of biodegradation and floating on the surface of the ocean, or suspended in the water layer and which can be an obstacle for navigation, fisheries, or any other legitimate uses of the marine environment" [Erhard, Sezhen, 1984, p. 206].

Below also is the excerpt from S. Bertino addressed to all the people: "The sea is to some extent a part of us. Thanks to it, we live; thanks to it, there is the ongoing development of our civilization; thanks to it, it rains, and warmth replaces cold; and in a few years thanks to it, people who suffer today from malnutrition will receive proteins, whose lack is already beginning to be felt today. So let us take care of the ocean and stop our reckless actions, leading to the destruction of life on the Earth. ***Tomorrow, and possibly already today, it may be too late to do anything."***

"So let us not delay, immediately starting now, the protection of plankton of lakes, rivers, and seas, this veritable "sea manna". Without it, all the diverse underwater world could not exist, and without it, life on the Earth would be impossible at all" [Erhard, Sezhen, 1984, p. 211–212].

The destruction of rain forests and their replacement with plantations of palm oil for biodiesel production in the so-called green economy is detrimental to biodiversity. The concept of sustainable growth, developed by the United Nations in 1983–1987, is now in need of serious revision. Thus, the issue of anthropogenic greenhouse warming, which contradicts the laws of physics must be fully closed: the colder atmosphere is not capable to additionally warm a warmer underlying surface due to thermal long-wave radiation emitted from the Earth to space. This only occurs with the Earth's adequate redistribution of the absorbed radiant solar energy in the areas of temperature inversion, i.e., where the air mass warmer than the underlying surface.

Production of bio-diesel and bio-ethanol from crops leads to an increase of market prices for food. Hence, these aspects of the green economy are not conducive to the achievement of one of the most important objectives of sustainable development – alleviation of poverty and poorness. A positive factor in this struggle is the construction of nuclear power plants and hydroelectric power plants in poor countries.

Also, we must realize that in the event of a significant interception of river flow of nutrients by hydrotechnic structures, discharge diversion mechanisms, and irrigation systems, the negative impacts may be associated not only with the bioresource potential of the ocean. A major reduction of the capacity of heat engine of the Earth, whose functions are performed by the oceans, is very probable. Some dangerous activities in this respect are already taking place.

The discharge of the Colorado River in the southwestern United States and northwestern Mexico is completely allocated. The second in China, in terms of river water content, the Yellow River most of the year, sometimes for ten months, does not reach the mouth. The flow of the Indus, Euphrates, Tigris, Jordan, Dnieper, Black Irtysh, and several other rivers is reduced by one-half or more. The main factor of the irretrievable river discharge consumption is irrigation. Because of it, the ocean loses about 10 % of river water. This is a cause for reduction of the flow of nutrients into the ocean, and in the near future threatens to weaken the functions of the pericontinental production-biofiltration continental margin. The direct link between the land, particularly its river-basin system, and the ocean, especially its pericontinental production-biofiltration margin, should be managed at the regional and global levels, because its state is one of the most important factors in the development of nature and humanity, and therefore their sustainable development.

CONCLUSION

The functional characteristics of the biosphere are manifested in its two-element organization (continents – oceanic basins) and in the major functional components of the homeostatic mechanism, among which are the river-basin land and the pericontinental production-biofiltration oceanic margin. From 3.8 billion to about 0.67 million years ago, the ocean was turbid and cold; the development of living organisms in its waters and on land was delayed at the level prokaryotes (bacteria and cyanobionts), and only in the range of 1.5–1.7 billion years ago, eukaryotes (nuclear organisms) – plants appeared. The transformation of the ocean that started 0.67 billion years ago and continued over the next hundred million years or a little longer was accompanied by the great skeletal explosion. Due to the emergence of planktonic crustaceans, the production-biofiltration mechanism in the world ocean was launched. The ocean became clear and turned into an intense absorber of solar heat.

The emergence and development of the Earth's main heat engine of biogeochemical and biogeophysical genesis was accompanied by increased advection of heat and moisture transfer across the globe. This expanded the boundaries of the biosphere in the Paleozoic by several times and led to the formation of a complex mechanism of biospheric organization. The geo-history of the biosphere had alternating phases of homeostasis and bifurcation. They corresponded to the manifestations of the planetary impacts, favorable and adverse for the development of the global ecosystem. The adverse impacts include glaciation eras and falls and explosions of large cosmic bodies.

Now, planetary conditions are favorable for the functioning of the biosphere. However, the uncontrolled development of the civilization represents a powerful destabilizing factor. It is necessary to protect the production-biofiltration mechanism of the biosphere. Cutting off the flow of biogenic substances carried by river flow (or replace it, or dilute it) from the ocean by dams is unacceptable. Abiotization of land, especially its deforestation, must be halted and reversed. The irrigation of land should be conducted in a reasonable manner, which will improve the state of the hydrologic cycle and land cover. It is time to stop all armed conflicts and to reallocate funds to peaceful sectors of the economy. Population explosion, typical of poor countries, is the cause of destruction of their life-support systems. While the world is divided into the rich north (golden billion) and the poor south, it is impossible to stop the destruction of the biospheric mechanism.

The human union with nature, according to J. Reclus, is only possible in the world of social peace and harmony. Meanwhile, the mankind is faced with increasingly complex and difficult to control challenges, one of which is the need for management of the system "river-basin land – pericontinental production-biofiltration oceanic margin," which determines the stability of the Earth's main heat engine. ■

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