Self-purification of the biosphere – aspect of surface water purification technology

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Abstract. The article is devoted to the aspects of surface water treatment under the external (meteorological) factors influence. The aspect of atmospheric thunderstorm activity, as the current technology of cleaning and disinfecting the Earth’s air-water basin, is considered from the standpoint of the cyanobacteria functioning and its lysis mechanism. In the thesis form, aspects of the development and creation of a nature-like technology for disinfecting liquid substances based on the principles of atmospheric electricity are proposed.

Introduction
Modern science considers the biosphere as a self-regulating planetary system of the living and nonliving. As a rule, in the biosphere there are four components: the atmosphere, the lithosphere, the hydrosphere, and living organisms. The components of the biosphere are in constant interaction. The hydrosphere role in the biosphere functioning is enormous: the main chemical reactions occur there, causing the biomass production and the biosphere chemical purification.

Each reservoir is a complex living system populated by bacteria, algae, higher aquatic plants, various invertebrates and vertebrates, and their main processes are regulated by the biological factors or depend on them significantly, eco-balance is achieved, integrated system activity is provided, ensuring reservoirs synergistic self-purification.

Formulation of the problem
Reservoirs self-purification to a certain extent depends on the external factors intensity: - solar radiation; - ultraviolet rays; - ambient temperature; - meteorological phenomena; - level of electric and magnetic fields. Based on the analysis of external factors influencing the viruses and environmental fauna, we can conclude on their factors activity effectiveness leading to the synergistic cleaning effect. Earlier studies show that the microorganisms biological activity is decreasing, the viruses activity level is growing or decreasing, the microbial cell is inactivated, such effects are characteristic for thunderstorm activity during decontamination of the Earth’s air basin [1].

The environmental protection improvement is closely connected with the creation of promising technological processes based on the natural disinfection processes. V.V. Putin came up with a proposal on the relevance and significance of the raised problem at a plenary meeting of the 70th
session of the UN General Assembly: “We propose to convene a special forum under the UN auspices, where we can look at the issues associated with the exhaustion of natural resources, habitat destruction, and climate change.”

**Analysis of scientific advances**

Existing ways of maintaining high quality of fresh water in natural reservoirs are diverse and multifaceted, but they are not always effective and cannot compete with natural self-purification technologies of freshwater ecosystems. Consequently, the nature-like technologies use for cleaning reservoirs subjected to the anthropogenic pollutions is a necessary and sufficient condition for removing the antagonism between biosphere and technosphere, and the approach deserves attention of both civil society and specialists and managers of different levels. Currently the problems associated with the water "bloom" in reservoirs have already been identified as serious global changes in the natural environment, leading to disruption of the functioning structure of air-water basins. Cyanobacteria produce secondary metabolites, which can be highly toxic to people and animals, and the UN recognized reservoirs “bloom” as one of the urgent problems of the modern world [2].

The biosphere existed before man appeared and can exist without him, but man cannot exist without the biosphere. The biosphere self-purification phenomenon is the natural neutralization of environmental pollutants and gives the level of civilization evolutionary development. Blue-green algae is almost impossible to destroy - it is unusually tenacious. The only way out is not to stimulate its reproduction artificially (pollution) and to use natural factors to develop its inactivation ways.

Considering the photosynthesis bacteria stages in terms of the disinfection possibilities, from the standpoint of their functioning, we can determine the grain, which is decisive in the blue-green algae life process [3].

There are natural phenomena capable of providing the biosphere self-purification from natural pollution. In our opinion, thunderstorm activity aspect of the atmosphere, as the current cleaning technology and the Earth’s air-water basin disinfection, deserves attention. After a thunderstorm, the weather improves, the air becomes clear, fresh and clean, saturated with ions formed during lightning discharges, and precipitates in an acid-base balance tend to a neutral state.

The analysis of the thunderstorm activity effects on the biosphere indicates the effectiveness of disinfection processes and the possibility of their transfer in production technology.

The bacteria structure indicates that when analyzing a possible event of bacterium lysis or inactivation, it is necessary to decide how to stop the functioning of the light and / or dark photosynthesis phase, and thereby stop and slow down the blue-green algae development. In view of the fact that chloroplast can be represented as a heterogeneous composition (material), due to the ongoing physical chemical processes, it should be noted that the depth and rate of reactions will be determined by the active material surface. The external electric field interaction with the structure generates ponderomotive forces, which lead to their damage and shells destruction at the interfaces between the media.

Based on the approbation of the dispersing heterogeneous structures methodology in an electric field and the results of staging experiments on water disinfection [4], the electric field at the Earth’s surface is $E \approx 120–150 \text{ V/m}$, with precipitation, the field intensity can change dramatically, reaching $10,000 \text{ V/m}$. In this case, the air ionization occurs as a result of several factors including electrical discharges in the atmosphere (thunderstorm). Following the analogy methods, based on the analysis of the effects of thunderstorm activity on the biosphere, using the principles of similarity in modulating disinfection processes, the determining factors influencing the inactivation mechanisms and bacteria lysis and microorganisms were identified. Then technological solutions will display the thunderstorm activity stages (refer with Figure 1).
Figure 1. Associative reproduction scheme of the thunderstorm activity effects in disinfection technology

The water to be purified is gradually processed by crossed electric and magnetic fields, with the combination of the main mechanistic factors influencing the effects of Ranke and Schauburger, following processes are observed: - polarization, electric coagulation, electroflotation, electrophoresis, electric separation, cavitation, electrochemical effects, ponderomotive dispersion;
- separation of fast and slow microvolumes (heat - cold), cavitation, turbulence, gas saturation;
- synergistic effects interaction (processes activation) - ozonization, electromagnetic $\alpha$, $\beta$, $\gamma$ radiation effects, the acoustic effect of a shock wave.

Justification of the obtained scientific results
Without going into the description of the impact processes caused by the device, let us dwell on the process aspects the caused by the electric field force.

The force effect of the electric field is the forces at the interface between the media sufficient to disperse organic and inorganic substances and pathogens and water clusters. On the basis of previously obtained research data, in order to understand the mechanism of the electric field effect on heterogeneous structures in this article, we formulate this action in the form of an axiom. "At the interface of heterogeneous structures placed in an external electric field, ponderomotive forces arise, directed from a medium with a higher to a medium with a lower dielectric constant, proportional to the square of the electric field strength" [5].

The acting force on the interface unit can be determined by the following expression:

$$ F = \frac{1}{2} \varepsilon^2 (\varepsilon_1 - \varepsilon_2) \cdot d \cdot \varepsilon_0 $$

Where: $d$ - is the interface thickness; $\varepsilon_0$ - is the electric constant [F m]; $\varepsilon_1$ - is the relative dielectric constant of the first boundary layer; $\varepsilon_2$ - is the relative dielectric constant of the second boundary layer; $E$ – is the electric field [V / m]; $F$ – is the force acting on the media interface [kg/m$^2$].

The bacterium structure indicates its multi-layer, heterogeneity (refer with Fig. 2), each layer has its own dielectric permeability ($\varepsilon$). The dielectric membrane permeability is for the phospholipid region, $\varepsilon = 2.0 - 2.2$; for the hydrophilic region, $\varepsilon = 10 - 20$.

Cell wall - it is home to between 5 to 50% of cell dry substances, with its dielectric permeability $\varepsilon = 3 - 4$. Cytoplasm - $\varepsilon = 80$. 
Figure 2. Cyanobacterium cell structure

(1-folded photosynthetic membrane; 2 - folded membranes; 3 - circular DNA; 4 – nutrient; 5 - small ribosomes; 6 – cytoplasm; 7 - plasma membrane; 8 - cell wall; 9 - sticky mucus layer; 10 – flagellum)

Consequently, the electric field force effect on the bacterial cell, due to the difference in dielectric permeability of the cell wall and its membranes, indicates the force development, according to the above expression (1), for the phospholipid area from the membrane side (7) on the cell wall (8), for hydrophilic area is the opposite. Thus, knowing the strength membrane characteristics and the cell wall, it can be stated that at a defined field strength level, their destruction will occur and the bacteria lysis as a result.

When the membrane is damaged, the pigment is not able to carry out the absorbing light quanta function of their transition to the excited state and energy transfer to other photosystem molecules. Chlorosomes are intracellular intracytoplasmic membrane formations, if damaged, their light-harvesting systems cease to function, and therefore bacterial photosynthesis cannot proceed. At the same time, the structure of the chloroplast is heterogeneous and under the influence of an electric field undergoes deformations, breaks and other damage, thereby stopping both at the stage of the light and at the dark phase, i.e. throughout photosynthesis, the process of functioning and development of blue-green algae.

Summary
In such conditions, it can be stated that the bacteria lysis is inevitable. Based on the above aspects of the blue-green algae death, it is not difficult to create an installation for the surface water treatment using the biosphere disinfection principles through atmospheric electricity, according to the proposed scheme (refer with Fig. 1)

Modern theoretical advances, experience and observation of natural technologies allow us to develop new green directions for production processes, ensuring the creation of comfortable modern environmental conditions for humans on Earth. In addition, they allow introducing fundamentally new nature-like technologies that do not cause damage to the surrounding world, but exist with it in harmony, and allow you to restore the balance disturbed by man between the biosphere and the technosphere.

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