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ATMOSPHERIC ELECTRICITY OF MEGACITIES AND SOME ENVIRONMENTAL ASPECTS OF ATMOSPHERIC-IONOSPHERIC ELECTRICAL INTERACTION

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Abstract: Sources forming an atmospheric electrical field in a megacity zone are considered; main formulas allowing estimating interrelations of main electricity elements in the atmosphere above a megacities are given; possible mechanisms for disturbances transferred from the lower atmosphere into the ionosphere and ecological aspects are analyzed.

Key words: atmospheric electricity, megacity, atmospheric-ionospheric electric interaction, ecological aspects.

1. Introduction

It is known that the Earth ionosphere is sensitive to outer effects; therefore the ionosphere parameters undergo both regular and irregular variations. The regular variations are usually connected with effects of solar and space radiations. The irregular (both short-time and comparatively long-time ones) abnormal changes in the ionosphere parameters are subsequences of the processes occurring in the troposphere, on the Earth surface, and under it. The study of the problems pertinent to beginning and spatial-temporal dynamics of the atmospheric abnormal (i.e. different from the natural background) electrical fields has become urgent in the last years due to a number of reasons connected with radioactive contamination of the environment (see, for instance, [1, 2]), large forest fires, fires at oil- and gas-producing complexes (including transportation systems and reservoirs), fires in towns and cities as a result of the military operations (see, for instance, [3–12]), different kinds of accidents at chemical and other enterprises, etc. In this connection, processes influencing gradient changes of the electrical field potential in the troposphere are widely studied (see, for instance, [13–15]).

There are natural and anthropogenic factors whose mechanisms influencing the near Earth atmosphere have many common characteristic special features. The natural factors usually include three source-complexes:

1) tropospheric processes;

2) processes on ocean (see) surfaces and under them;

3) processes occurring in the lithosphere and on the Earth surface.

The first class includes, for instance, dust and sand storms, atmospheric fronts, waterspouts, tornados, cyclones, radioactive contaminations and others. The second includes, for instance, processes on ocean (sea) surfaces and under them, such as, sea and oceanic streams, different kinds of cataclysms (tsunami, typhoons, etc.), ocean (sea) surface evaporation, etc. The third includes earthquakes, volcanic activity.

The anthropogenic factors may by roughly subdivided into the following main groups:

1) large fires of different natures;

2) wars in different regions of the planet, accompanied by large fires and exhausts into the atmosphere of a great number of chemical substances, smoke and soot, and also acoustic energy as a result of a great quantity of explosives and inflammable materials;

3) rocket launchings, industrial and nuclear explosions (underground, surface and atmospheric ones). The nuclear explosions are not carried out presently; but over the known period of our history, they were applied to test and develop the nuclear weapon.

4) accidents at chemical and oil-refining enterprises;

5) megacities with their intensive industrial activities.

It should be noted that in the regions of megacities and large energy installations, man-caused pollution of the near Earth atmosphere, upward heat flows and infrasonic oscillations - as the estimations show – may lead to nonstationary processes in forming a three-dimensional charge of the atmosphere and to substantial deviations from the natural value of an uncompensated charge.

In the scientific literature, a question of forming electrical fields in and above the megacities covering rather a large area, S , on the Earth surface (e.g., for Kharkiv City, $S > 250$ km^2) remains to be practically not investigated. In connection with this fact, a question of electrical fields (of the gradients of the electric potential and conductivity) in the megacities, which have effects on the flora and fauna, especially on the health of people and animals on the whole, remains to be practically not investigated.

In the given paper, sources forming an atmospheric electrical field in a megacity zone are considered; the main formulas allowing estimating interconnections of the main electricity elements in the atmosphere above a megacities are presented; possible mechanisms for transferring disturbances from the lower atmosphere into the ionosphere, and ecological aspects are analyzed.

2. Sources of Atmospheric Electricity in Megacities

Consider the main factors which may be sources of atmospheric electricity within megacities. They may be roughly subdivided into the following 3 categories: 1 – electromagnetic; 2 – thermal-dust; 3 – chemical.

The first will include:

– extensive high-voltage power lines (it is typical of them to provide constant present corona charges spatially distributed along the power line, their intensity increasing under unfavourable weather conditions);

– transformer substations of industrial enterprises (they cover rather large areas, being characterized by considerable increase in the distributed three-dimensional charge and the electromagnetic field in their zone and vicinity);

– television and transmitting stations of all ranges, including the telephone ones (we characterize them as constantly functioning and relatively localized sources of powerful nonstationary electromagnetic fields radiating a megacity zone in a relatively even manner);

– power lines of urban electrical transport (it is typical of them to be extensive and dense with their relatively even spatial distribution in a megacity zone, and with a great number of corona charges due to short circuits and bad network contacts, especially under unfavourable weather conditions);

– urban electrical transmission networks (it is characteristic of them to cause a permanent nonstationary electromagnetic background distributed near the Earth surface in an approximately even manner).

It is known that atmospheric dust (in a wide sense of this term it includes both natural-soil dust and products of technogenic activity of people, subsequences of fires, etc.) is a source of nonstationary atmospheric electricity [16]. Therefore we attribute the following main sources to the *second category*:

– components, coming into the atmosphere when heat-power stations are operating, which include gas and dust products of different burned combustible substances; thermal flow and aqueous vapor. The presence – along with large heat-power stations – of a great number of small structures of such types (boiler systems of enterprises, districts, etc.) allows to consider this pollution source as an unevenly distributed in megacities;

– thermal and gas pollution of the atmosphere by ground transport when burning benzine, gas and diesel fuel (it is typical of it to cause the atmosphere to be considerably saturated with combustion products and provide a relatively uneven level of pollution depending on the time of the day);

– heat-dust components of operating industrial enterprises having industrial furnaces, foundries, etc. (as a rule, it is characteristic of them to provide a high density degree of different dust components, often with an uneven time distribution in a megacity zone);

– ground dust itself (its most important component being dust of motor-roads and pavements) which as a result of the constant presence of different horizontal and upward (often strong ones, which is typical of megacities) air flows is both a source of atmospheric pollution and that of nonstationary atmospheric electricity [16];

– gas-heat radiation of buildings and asphalt covering of roads and parameters (effects of this component are mainly observed in summer at a comparatively high air temperature when different gas components are exhausted into the atmosphere from hard coatings of buildings and the Earth surface, thermal convection occurring as well);

– fires and garbage burning within megacities (usually, this source occurs in spring and autumn when there is mass burning of different, often ecologically very harmful for the fauna and flora, garbage and fallen leaves). Often this source has no less effect than those of large fires;

– breakdowns in heating and sewage systems (it is characteristic of this source to provide them within megacities, covering comparatively large areas and being accompanied by blow-outs of heated water and vapor. Heated water and vapor, as known, are sources of modifying the near Earth atmospheric electrical field).

The third category includes:

– blow-outs and leakages of chemical substances, inadequate refining of different waste at enterprises of chemical, textile, confectionery and other branches of industry (as a rule, it is typical of this source to provide a relatively high degree of atmospheric pollution, space-time unevenness, the presence of not only relatively passive aerosols but chemically – and hence electrically – active components).

The sources mentioned above often have different effects on the atmospheric electricity in and over megacities depending on seasons and days.

Note that in a number of cases, within megacities, there may occur generation and amplification of acoustic and infrasonic oscillations (for instance, as a result of a strong amplification of air circulation caused by winds), which also contribute to distribution of charges in the atmosphere and to modification of the near Earth atmospheric electrical field.

3. Possibilities of Estimating Changes in Atmospheric Electricity in a megacity zone

Calculation of changes in atmospheric electricity in a megacity zone is a very difficult task due to a great number of various sources of atmospheric electricity and their different characters of influencing the near Earth atmosphere. Therefore real ones are only generalized estimations on the basis of model calculations and estimations for all – as far as possible – the sources mentioned above. It should be noted that an approach to estimating changes in atmospheric electricity in a megacity zone, taking into account simultaneous combined effects of the factors mentioned, will be correct.

For instance, for aerosol sources, a distribution of the space charge may be obtained from the formula for a distribution of their average mass density, $< M > (x, y, z)$. Using the known distribution of the density $r(x, y, z)$ of the space charge, the electrical field intensity, $E(x, y, z)$, may be calculated in an arbitrary point of space surrounding megacities.

An interconnection of the main electricity elements (considering the main $N_{\pm}, m_{\pm}, E_{\pm}$ characteristics of the density, mobility and intensity of the electrical field of positive and negative ions, respectively) in the atmosphere (in particular above megacities) with other atmosphere characteristics may be traced when considering an equation of the balance of atmosphere ions (the case of monomobile ions and aerosols) [17]:

$$\frac{dN_{\pm}}{dt} + V_{\infty}\nabla N_{\pm} = n - a_{\pm}N_{+}N_{-} - $$
$$- b_{\pm}N_{\pm}N_{a} + m_{\pm}\frac{d(E_{\pm}N_{\pm})}{dz} + \frac{d}{dz}(K_T\frac{dN_{\pm}}{dz}) . \quad (1)$$

Here the second left part summand describes the advective transfer; in the right part the first, second and third summands describe the ion formation intensity, recombination and adsorption of the ions with aerosols, respectively; the latter two summands take into account the ion transfer in the electrical and turbulent fields.

For calculating the density kinetics of ions of the negative and positive signs, $N_{\pm}$, and the electrical field, E, in a horizontally-stratified atmosphere, the following equation system [18] can be used:

$$\frac{\P N_{+}}{\P t} = n - a_{\pm}N_{+}N_{-} +$$
$$+ \frac{\P(K_T + D_{+})}{\P z}\frac{\P N_{+}}{\P z} - em_{+}\frac{\P(EN_{+})}{\P z},$$
$$\frac{\P N_{-}}{\P t} = n - a_{\pm}N_{+}N_{-} +$$
$$+ \frac{\P(K_T + D_{-})}{\P z}\frac{\P N_{-}}{\P z} + em_{-}\frac{\P(EN_{-})}{\P z}, \quad (2)$$
$$\frac{\P E}{\P z} = \frac{e(N_{+} - N_{-})}{e_0},$$

where n is the ion formation intensity, $a_{\pm}$ is the ion recombination coefficient, $D_{\pm}$ is the diffusion coefficient, N_a is the aerosol density.

Note that in order to have a complete picture, equations (1) should be added with summands accounting for convectional and turbulent spreads of an ion cloud; a physical-chemical state of a natural aerosol; ions of water soluted substances, transferred into the air; and condensate formed by means of bipolar air-ionization (see, for instance, [19]).

Solution of system (2) in a stationary case allows obtaining such estimations as $E \approx 100 – 200$ V/m, which is comparable with the empirical values from [20].

The density of vertical electric current is defined by such its components as the conductivity current, diffusive and convectional currents:

$$J = ZE_z - z_1 e[(K_T + D_M)\frac{\P N_{\pm}}{\P z} + N_{\pm}V_{\infty}]. \quad (3)$$

Here E_z is the electrical field intensity, K_T and D_M are the coefficients of turbulent and molecular diffusions, $N_{\pm}$ is the density of aeroions, V_{∞} is the wind velocity, (ez_1) is the ion charge, z_1 is the number of charges, Z is the air electrical admittance defined by characteristics of aeroions with opposite signs: by the charge (ez_1) and mobility spectrum, $m_{\pm}$:

$$Z = \int_0^{\infty} N_{+}(m)m_{+}dm + \int_0^{-\infty} N_{-}(m)m_{-}dm , \quad (4)$$

In the real atmosphere, light ions make a predominant contribution to the conductivity ($m_{\pm}$ = 0.5 – 5 cm^2/(V sec));

therefore in practice records for the polar conductivities, $l_{\pm}$ are used, using the average mobility values and single charges (z_1 =1):

$$l_{\pm} = qN_{\pm}\overline{m}_{\pm},$$

where $q = e z_1$ = 1.6 10^{-19} coulomb, $\overline{m}_{-}$ =1.3 и $\overline{m}_{+}$ ≈ ≈ 1.8 cm^2/(V sec) .

The atmospheric column resistance is calculated using data on a height distribution of the total electrical conductivity of the air. The contribution of different atmospheric areas to the resistance R is distributed as follows [21]: the near Earth layer – 10 %, the exchange layer (0.1–2 km) – 60 %, the upper troposphere and stratosphere – 30 %. The global total resistance of the Earth atmosphere is 200–240 Ohm. The maximum conductivity and hence the minimum resistance of an the air column are achieved at sunrise, the maximum R value occurring at 14–16 LT.

The factors considered in the previous section may cause charged structures to be lifted to higher altitudes (if compared with a zone outside megacities) and lead to amplifying effects of the electrical field formed in a megacity zone on the ionosphere. Since the electric atmosphere strength decreases with height, a regime of strong electrical field close to corona charges may be realized in some regions of the charged structures. Under these conditions, a connection between the electric current, $\vec{J}$, and the $\vec{E}$ field becomes nonlinear

$$\vec{J} = s\vec{E} + (s_k / E_k)a\vec{E}, \quad (5)$$

here s , s_k are the linear and nonlinear conductivities of the atmosphere, $s << s_k$, $\vec{E}_k$ is the critical charge-ignition field, a is the coefficient. In [22], after making estimations, it has been shown that a contribution of the nonlinear effects to formation of charged structures is large, due to which the electrical field in the ionosphere will be markedly strengthened.

4. Models of Atmosphere-Ionosphere Electrical Interactions

A great number of references (see, e.g., [23–26]) deal with problems of electrical fields penetrating into the ionosphere. In particular in [23, 24], a problem of the electrical field going into the ionosphere from the troposphere is solved; in [25, 26], possible changes in the main parameters of the ionospheric D-region are modeled. A problem of atmosphere-ionosphere electricity interrelations is solved in publications, as a rule, by two techniques: the first includes model construction and calculation of electrical fields, E, going from the atmosphere into the ionosphere (as to the vertical component, E_z , see, for instance, [23, 24]); the second is based on a hypothesis that the Earth-ionosphere system is a global spatial capacitor in which one of the plates is the Earth surface (and the near Earth atmosphere), and the other is the low boundary of the ionosphere (z ~ 60–65 km by day and z ~ 80–90 km by night) [21, 27, 28].

However, up to the present, problems of disturbances transferred from the lower atmosphere to the ionosphere and magnetosphere have been studied insufficiently. Consider briefly the following possible main mechanism.

Disturbances of a vertical electrostatic field

On the basis of calculations of an electrical field penetrating the ionosphere, which is generated by a local region of the seismic source in the near Earth atmosphere, it is shown that the electric field intensity at the ionospheric heights has a considerable value (0.3 – 03.7 V/m) only for large-scale sources with characteristic sizes of ≥ 100 km on condition that the value $|E_z| \approx 10^3$ V/m occurs in the epicentre. As shown by the estimations, such fields are real only in local regions in a megacity zone with characteristic sizes of ~ 100 – 1000 m, and therefore the considered source does not seem to be able to lead to changes in the field intensity, E_z, at the ionospheric heights (and to the electron density disturbances recorded by the radiophysical techniques at these heights) by means of penetrating the electrical field generated by a local megacities region in a near Earth layer of the atmosphere.

Changes in atmospheric gas density

Earlier it has been noted that in a number of cases within megacities, generation and amplification of acoustic and infrasonic oscillations are possible, total power of acoustic radiation becomes tens of times larger than that under undisturbed conditions. Changes in the atmospheric gas density near the Earth surface in a megacity region rather efficiently penetrate the ionospheric heights, i.e. disturbances from the lower atmosphere are transferred to the upper one, to the ionospheric heights, where, as a result of interactions with magnetically-active plasma, their transformation into waves of different types occurs (see, for instance, [22, 29–33]) (their amplification and generation occur).

Note that it is rather a complicated problem to make concrete estimations for this mechanism.

Disturbances of global electric circuit parameters

In a megacity zone, electrical properties of the near Earth atmosphere change is considerable, air conductivity is becoming higher if compared with that in the regions outside megacities. A large spatial expansion of megacities leads to considerable increases in conduction current in the disturbed atmospheric regions since, as known, the near Earth layer of the atmosphere has the largest resistance in a global electric circuit. Therefore a process of disturbances being transferred to the ionosphere may be also realized as a result of disturbances of the global electric circuit (see, e.g., [2, 34–36]).

Amplification of atmospheric convection and turbulence

In a megacities area, a considerable amplification of the atmospheric convection often occurs; the atmospheric turbulence, taking place also at rather high altitudes, develops [37]. These factors lead to increasing the convection current, as a result of which transferring of disturbances to the ionosphere is possible (see, for instance, [37]). A characteristic transferring time seems to be ~1–10 days. Note that the most probable confirmation of this mechanism is the experimental data obtained during the military operations in the Persian Gulf and Kosovo [7–8]. This mechanism of transferring disturbances should be studied in the future.

5. Ecological aspects

As a rule, ecological effects mean considerable deviations of the environment parameters from the natural undisturbed values, which negatively influence the flora and fauna of the planet.

It is known that in the regions of natural cataclysms (for instance, in the regions where strong earthquakes and volcano eruptions, etc. are going to occur), where lithosphere-atmosphere-ionosphere interactions were discovered, short duration changes in the inhabitable environment parameters take place (in particular, a great number of physical state damages of living organisms, including human beings, are observed.) Compared to such sources, conditions in megacities are remarkable for long-time activities of the factors of atmosphere-ionosphere interactions. In scientific publications, effects of such factors are not practically investigated with such a statement of the task, which provides a problem of complex monitoring of the near the Earth atmosphere in and over megacities to be topical.

According to the preliminary estimations, the ion density increase up to 10^5–10^6 cm^{-3} in the atmosphere above megacities should lead to the electrical field intensity becoming 2–3 times larger. In connection with this, it is extremely important to measure the electrical field in the atmosphere above megacities and organize regular monitoring with purpose of studying, predicting and taking into account the atmospheric electricity influence on ecological surroundings and people's health in megacities.

The megacity ecological effects are connected with:

1) masses of combustion products, including exhaust gases of ground transport (smoke, soot, heavy metals), gushed out into the near the Earth atmosphere;

2) changes in the electrical field of the near the Earth atmosphere;

3) generation and amplification of electromagnetic and acoustic wave processes;

4) pollution of inhabitable environment in megacities by means of gas-dust components caused the above-mentioned sources.

Let us briefly consider effects of these factors.

Combustion products and gas-dust components gushed out into the atmosphere

The most essential ecological consequences are connected with gushing-outs of fine dust, smoke, soot, including exhaust gases of ground transport, fumes of asphalt surface of roads, pavements and buildings roofs, which besides direct negative effects on the flora and fauna in megacities, screen the solar radiation.

Strong winds, creating vertical draughts, contribute to getting aerosols up to the stratosphere over a large area. Smoke, dust and soot lead to strong scattering and absorption of solar radiation. At the same time, a powerful absorbing (screening) layer is formed. The mass of aerosols may come to ~1–10 kt. The time of aerosols presence in the stratosphere is tens of days, which leads to considerable ecological consequences.

As a result of solar radiation being screened, the Earth surface will lack, for instance, 10^{21}J energy for 10 days. Approximately the same energy will be released in the atmosphere. Such disturbances of the energy balance are very important for the ground surface and the atmosphere since there are changes in the thermal and dynamic conditions of the atmosphere and in the character of the atmosphere interacting with the ground surface, when compared with the space outside megacities. It is important that manifestations of ecological consequences (being often essential and irrevocable) will be observed far beyond megacities for a long time

Changes in the near theEarth atmospheric electrical field

Changes in the near the Earth atmospheric electrical field in a megacity region, as noted above, will lead to changes in the atmospheric layer conductivity of the near the Earth surface over a considerable area. Since this atmospheric layer has the largest resistance in the global electric circuit, the disturbances of the electrical parameters will occur in these circuits, causing a number of secondary processes in the atmosphere, ionosphere and magnetosphere of the Earth [2–4, 34–39]. The latter, in their turn, influence the near Earth environment on a global scale. It is difficult to predict their effects on the inhabitable environment, however they may be essential.

Generation and acceleration of electromagnetic and acoustic wave processes

As a result of generation and acceleration of the electromagnetic and acoustic wave processes in megacities, a power flow of the wave radiation becomes tens of times larger than that under undisturbed conditions. The total power of this radiation is defined by a part h_a of the P power, transformed into the acoustic radiation power, P_a. Observations have shown that on the average $h_a \approx 0.3$ % [10, 30]. For instance, according to [33], the acoustic radiation power flow is $\Pi_{a0} \approx 0.3–1$ mw/m^2. When the square of a separate source is 10^4 m^2, the power value being $P_{a0} = \Pi_{a0}S =$ = 3–10 w. If we take a megacity area of 300 km^2 to be estimated, the acoustic radiation power will be about $P_{a0} = \Pi_{a0}S \approx 60–400$ kw. When there are a lot of sources, which is characteristic of a megacity, over the same area, the acoustic radiation power increases up to $P_a \approx 1$ Mw (the estimations were made according to the methods from [4]). Note that $P_a > P_{a0}$. A large part of the acoustic radiation energy is due to the low frequency acoustic-gravitational waves, i.e. the inner gravitational waves, which effectively penetrate as high as the ionospheric altitudes (up to 200–300 km), dissipate and play an appreciable part in changing dynamic conditions of the middle and upper atmospheres of the Earth.

It is very difficult to calculate the capacity of the sources mentioned in Section 2. Let us consider some of them.

Sources of electromagnetic radiation

The electric current power, P_e, transmitted over the high-voltage transmission lines (TL) is about 1 Mw – 1 Gw, the total length of lines being $L_e \sim 10^2$ km. For transmission lines of the ground electrical transport and municipal electrical lightning network, P_e and L_e values will be ~ 1Mw, 1–10 Mw and ~ 10^2–10^3 km and 10^3–10^4 km, respectively. As noted earlier, the relatively high density (thickness) of the distribution within megacities is characteristic of the latter ones. Such systems are capable of radiating electromagnetic energy at 50 or 60 Hz or their harmonics. Since the part of electrical energy lost over the transmission lines is (losses caused by heating of wires and radiation are taken into account), as a rule, not less than 10 %, the total energy released by this source in megacities will be essential. The part of the power radiated into the surrounding space is unknown but we may believe it to be not very small (rather fairly large, since the 70-s of the XX century different effects connected with the voltage changes in TLs [29] have been repeatedly observed). In [40, 41] on the basis of the statistical analysis applied to the geomagnetic field variations for a hundred of years, their amplifications on Saturdays and Sundays were discovered (as well as considerable variations in the ionospheric plasma parameters). This effect appeared on the boundary of XIX–XX centuries and seemed to be connected with radiating powerful TLs. This complex of the ionospheric-magnetospheric effects was called “day off effects” [42–46]. The TL radiation also causes the increase in the activity of VLF-choruses above the industrial regions [47]. The heightening of the radio noise level within 0.6–6 MHz is described in [48]. In [40, 49], attempts to discover geospace effects caused by the influence of the ground radio means were carried out. The effect discovered in [40] seems to have been caused by synchronous switching of numerous radio systems [50, 51]. In these papers large-scale (not less than 100 km) ionospheric effects caused by influence of the powerful radio radiation are described. A great number of powerful radio means concentrated in the industrially-developed zones of megacities lead to such effects on a global scale.

Heat-dust and chemical sources

Strong winds within megacities cause a convection and atmospheric turbulence, which are accompanied by generation of noise acoustic radiation and acoustic-gravitational waves (AGW) (and, in particular, infrasound). Let us estimate an acoustic power flow for them. For the atmospheric convection, we believe the following: the characteristic size of a convective cell is ~ 10 m, the vertical rise velocity is 10 m/sec, the rise time in the lower atmosphere is ~10^3 sec, and the number of cells is ~10^3. Then the effective volume of a convective source is ~10^{10} m^3, the total effective kinetic energy and power will be ~10^{13} J and ~10^{10} w, respectively. It is known that about 0.1 % of the kinetic energy is transformed into acoustic energy [32] (on the basis of the observations, it is usually assumed to be 0.1–0.3 % in a fire zone [10–12]), then the acoustic power, P_a , will be ~10^7 w, the acoustic power flow on the atmosphere boundary being ~1–5 w/m^2. In reality due to the average “spreading” effect, the power flow is ~1 w/m^2. For the atmospheric turbulence accompanied by generating noise acoustic radiation, according to [32],

$$P_a = k_a r s_n^3 VM^5 / l, \qquad (6)$$

where $k_a \approx 100$, r is the air density, s_n is the mean square value of the turbulent velocity, V is the volume of the vortex of the l size, M is the Mach number. Assuming, for instance, for the 10 km altitude the wind velocity to be 15 m/sec, $r \approx 0.2$ kg/m^3, $\sigma_v \approx 10$ m/sec and $l = 100$ m, we have $P_a \approx 2$ w, the flow density near a source being ~$1.5 \cdot 10^{-4}$ w/m^2. Taking into account that a number of such cells may be ~10^3, the total flow-accounting for the averaging effect is ~1 mw/m^2. Under natural conditions outside the megacity zone, the acoustic power flow is $\approx$0,3 – 1 mw/m^2 [32, 33].

6. Conclusion

1. Thus, megacities of 200–300 km^2 have appreciable, often essential effects in the Earth – near the Earth atmosphere – ionosphere system, leading to irrevocable changes in it. Their manifestation in this system is complex: they considerably influence the ecological surroundings, atmospheric electricity distribution, global electric circuit parameters, heat balance of the atmosphere and its dynamics.

2. In vicinity of a megacity zone, the atmospheric electrical field is tens-hundreds of times larger than the background value and may be $|E_z| \approx 10^2 - 10^3$ V/m. However, such disturbances of the vertical electrostatic field cannot lead to changes in the E_z field intensity at the atmospheric heights (and to disturbances of the electron density recorded by radiophysical techniques at these heights) by means of straight penetrations of the electrical field generated by a local megacity region in a near the Earth layer of the atmosphere.

3. Changes in the near the Earth atmospheric electrical field in a megacity region cause appreciable changes in the tropospheric conductivity of an atmosphere layer near the Earth surface over a considerable area. This leads to disturbances of the global electric circuit parameters, which initiate a number of secondary processes in the atmosphere, ionosphere and magnetosphere of the Earth. The latter ones, in their turn, influence the near the Earth environment on a global scale. It is difficult to predict their effect on the habitat, but it cannot be ruled out that they may be essential.

4. As a result of generating and amplifying the electromagnetic and acoustic wave processes in the atmosphere in a megacity zone and above it, the wave radiation power flow becomes hundreds of times larger if compared with the background conditions. A large part of the acoustic radiation energy is due to the low frequency acoustic-gravitational waves which effectively penetrate the ionosphere heights (up to 200 – 300 km), dissipate and play an appreciable part in changing dynamic conditions of the middle and upper atmosphere of the Earth.

5. Considerable ecological consequences are connected with the stratosphere absorbing blow-outs of fine dust, smoke, soot (including exhausted gases of ground transport), vapours of asphalt coverings, pavements and building roofs, which, in addition to straight negative effects on the flora and fauna in megacities, screen the solar radiation, which may cause secondary, considerably more energetic, processes on a global scale. Manifestations of ecological consequences are essential, often being irrevocable far beyond a megacity zone for a long time.

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