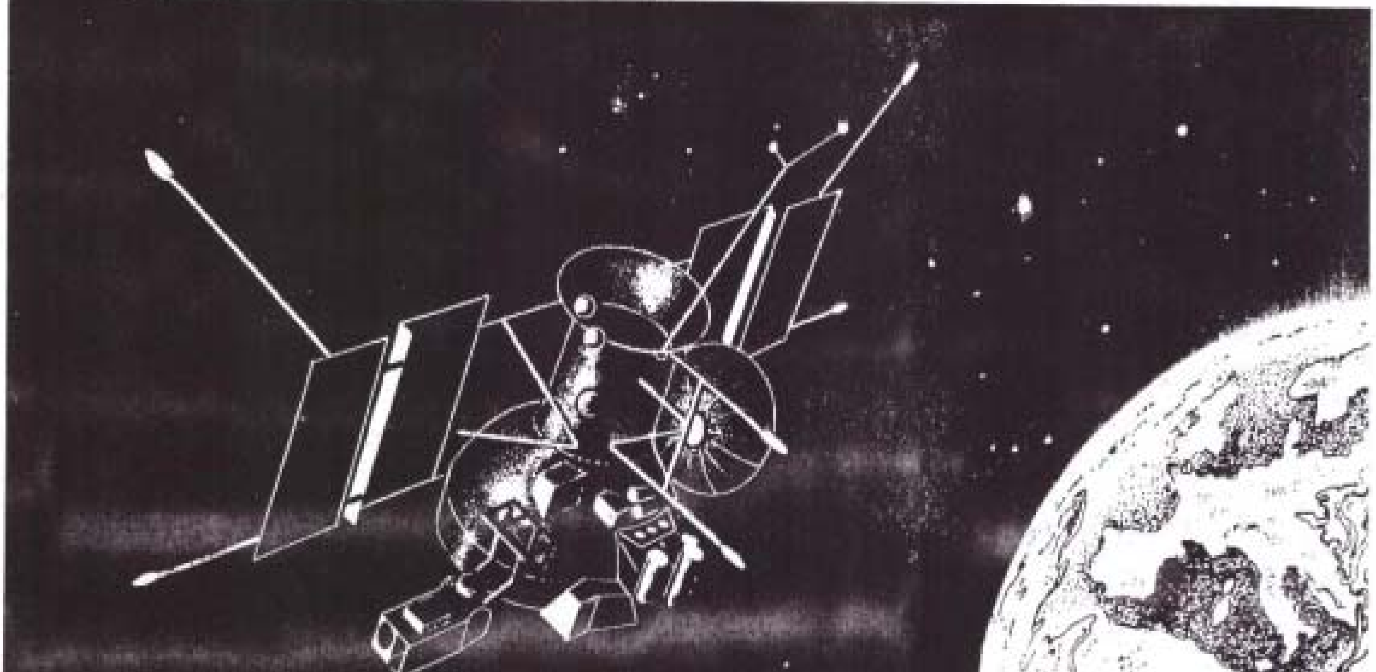
VOLUME 61 NUMBER 11 2004

ISSN 0040-2508

TELECOMMUNICATIONS AND RADIO ENGINEERING



Published by Begell House, Inc.

Telecommunications and Radio Engineering, 61(11):983-998 (2004)

APPLIED RADIO PHYSICS: SPACE, ATMOSPHERE, AND EARTH SURFACE RESEARCH

Atmospheric Electricity of Megapolises and Some Aspects of Atmosphere-Ionosphere Electrical Interactions

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ABSTRACT: Sources forming an atmospheric electrical field in a megapolis area are considered; main formulas allowing to estimate interrelations of main electricity components in the atmosphere above a megapolis are given; possible mechanisms for disturbances transferred from the lower atmosphere into the ionosphere and ecological aspects are analyzed.

INTRODUCTION

It is known that the Earth ionosphere is sensitive to outer effects, therefore the ionosphere parameters undegro 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 underground. Studying of 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 special features.

The natural factors usually include three source-complexes:

1) tropospheric processes;

ISSN 0040-2508

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 arbitrary 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) megapolises with their intensive industrial activities.

It should be noted that in the regions of megapolises 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 challenge of forming electrical fields in and above the megapolises 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. It immediately follows that a question of electrical fields (of the gradients of the electric potential and conductivity) in the megapolis, which have effects on the flora and fauna, especially on the health of people and animals on the whole, remains also to be not investigated.

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

SOURCES OF ATMOSPHERIC ELECTRICITY IN MEGAPOLISES

Consider the basic factors which may be sources of atmospheric electricity within a megapolis. They may be roughly subdivided into the following 3 categories: 1 – electromagnetic, 2 – thermal-dust, and 3 – chemical.

The first will include:

– extensive high-voltage electric power transmission 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 increasing in the distributed bulk 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 megapolis area in a relatively even manner);

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

– urban electrical lighting 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 electric 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 one in a megapolis area;

– 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 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 megapolis area);

– 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 megapolises) 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 a megapolis (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 effects than those of large fires;

– breakdowns in heating and sewage systems (it is characteristic of this source to provide them within a megapolis, 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 atmospheric electrical field near Earth).

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 a megapolis depending on seasons and days.

Note that in some instances, within megapolises, 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 atmospheric electrical field near Earth.

POSSIBILITIES OF ESTIMATING CHANGES IN ATMOSPHERIC ELECTRICITY IN A MEGAPOLIS AREA

Calculating of changes in atmospheric electricity in a megapolis area 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 megapolis area, taking into account simultaneous combined effects of the factors mentioned, will be correct.

For instance, for aerosol contributors, 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 $\rho(x, y, z)$ of a space charge, the electrical field intensity, $E(x, y, z)$, may be calculated in an arbitrary point of space surrounding a megapolis.

An interrelationship of the basic electricity elements (considering the main $N_{\pm}, \mu_{\pm}, E_{\pm}$ characteristics of the density, mobility and intensity of the electrical field of positive and negative ions, respectively) in the atmosphere (in particular above the megapolis) 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]:

$$\frac{dN_{\pm}}{dt} + V_{\infty}\nabla N_{\pm} = \nu - \alpha_{\pm} N_{+} N_{-} - \beta_{\pm} N_{\pm} N_{a} + \mu_{\pm} \frac{d(E_{\pm} N_{\pm})}{dz} + \frac{d}{dz}(K_{T} \frac{dN_{\pm}}{dz}) \quad . (1)$$

Here, the second summand of left part 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:

$$\frac{\partial N_{+}}{\partial t} = \nu - \alpha_{\pm} N_{+} N_{-} + \frac{\partial (K_{T} + D_{+})}{\partial z} \frac{\partial N_{+}}{\partial z} - e\mu_{+} \frac{\partial (EN_{+})}{\partial z},$$

$$\frac{\partial N_{-}}{\partial t} = \nu - \alpha_{\pm} N_{-} N_{-} + \frac{\partial (K_{T} + D_{-})}{\partial z} \frac{\partial N_{-}}{\partial z} + e\mu_{-} \frac{\partial (EN_{-})}{\partial z}, \quad (2)$$

$$\frac{\partial E}{\partial z} = \frac{e(N_{+} - N_{-})}{\varepsilon_{0}},$$

where ν is the ion formation intensity, $\alpha_{\pm}$ is the ion recombination coefficient, $D_{\pm}$ is the diffusion coefficient, and N_{a} is the aerosol density. Note, for completeness sake, 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 air; and condensate formed by means of bipolar air-ionization (see, for instance, [19]).

Solving of system (2) in a stationary case allows to obtain 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:

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

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, and Z is the air electrical admittance defined by characteristics of aeroions with opposite signs: by the charge (ez_1) and mobility spectrum, $\mu_\pm$:

$$Z = \int_0^\infty N_+(\mu)\mu_+ d\mu + \int_0^{-\infty} N_-(\mu)\mu_- d\mu \quad (4)$$

In the real atmosphere, light ions make a predominant contribution to the conductivity ($\mu_\pm = 0.5 - 5$ cm^2/(V sec)); therefore in practice there are used records for the polar conductivities, $\lambda_\pm$, through the average mobility values and single charges ($z_l = 1$):

$$\lambda_\pm = qN_\pm\mu_\pm,$$

where $q = ez_l = 1.6\ 10^{-19}$ coulomb, $\mu_- = 1.3$ and $\mu_+ \approx 1.8$ cm^2/(V sec).

The atmospheric column resistance is calculated using data on a height distribution of the total electrical conductivity of air. The contribution of different atmospheric layers 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 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 the megapolis) and lead to amplifying effects of the electrical field formed in a megapolis area 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, J, and the $\vec{E}$ field becomes nonlinear

$$J = \sigma E + (\sigma_k / E_k)\alpha E, \quad (5)$$

here σ, σ_k are the linear and nonlinear conductivities of the atmosphere, $\sigma << \sigma_k$, $\vec{E}_k$ is the critical charge-ignition field, α is the coefficient. In [22], after making estimations, it has been shown that a contribution of the nonlinear effects to forming charged structures is large in consequence of this the electrical field in the ionosphere will be appreciably strengthened.

MODELS OF ATMOSPHERE-IONOSPHERE ELECTRICAL INTERACTIONS

Problems of electrical fields penetrating into the ionosphere are dealt with in a great number of references (see, e.g., [23-26]). 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 basic parameters of the ionospheric D-region are simulated. A problem of atmosphere-ionosphere electricity interrelations is solved in publications, as a rule, by the two techniques: the first includes a model construction and a 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 atmosphere near Earth), and the other is the low boundary of the ionosphere ($z \sim 60$–65 km by day and $z \sim 80$–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

Based on the 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 $\geq$ 100km on condition that the value $|E_z| \approx 10^3$ V/m occurs in the epicentre. As shown from the estimations, such fields are real only in local regions in a megapolis area with characteristic sizes of ~ 100 – 1000 m, and therefore the source considered 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 the penetrating electrical field generated by a local megapolis region in a near Earth layer of the atmosphere.

Changes in atmospheric gas density

Earlier it has been noted that in specific cases within megapolises, generation and amplification of the 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 megapolis 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]) and their amplification and generation take place.

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

Disturbances of global electric circuit parameters

In a megapolis area, electrical properties of the near Earth atmosphere change considerable and air conductivity becoming higher compared with that in the regions outside a megapolis. A large spatial expansion of the megapolis leads to considerable increases in conduction current in the disturbed atmospheric regions since, as known, a 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]).

Atmospheric convection and turbulence intensification

In a megapolis area, a considerable amplification of the atmospheric convection often occurs, the atmospheric turbulence takes also place at rather high altitudes [37]. These factors lead to increasing the convection current, as a result of which transferring of disturbances is possible to the ionosphere (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.

ECOLOGICAL ASPECTS

As a rule, ecological effects mean yjr 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 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 taking place (in particular, a great number of physiological state damages of living organisms - including human beings - being observed. Comparing with such sources, conditions in megapolises 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 set of the problem, which provides a problem of complex monitoring of the near the Earth atmosphere in and over a megapolis to be topical.

According to the preliminary estimations, the ion density increase up to 10^5–10^6 cm^{-3} in the atmosphere above a megapolis 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 the megapolis and to institute the regular monitoring with purposes of studying, predicting and taking into account of atmospheric electricity influencing ecological surroundings and people's health in the megapolis.

The megapolis 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 Earth atmosphere;

2) changes in the near Earth atmosphere electrical field;

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

4) pollution of inhabitable environment in a megapolis 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 emission of fine dust, smoke, soot – including exhaust gases of ground transport –, fumes of asphalt surfacing, pavements and building roofs, which – besides direct negative effects on the flora and fauna in a megapolis – screen from 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 scatter 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 present 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 occur changes in the thermal and dynamic conditions of the atmosphere and in a character of the atmosphere interacting with the ground surface, when compared with the space outside a megapolis. It is important that manifestations of ecological consequences (being often essential and irrevocable) will be observed far beyond a megapolis for a long time.

Changes in near Earth atmospheric electrical field

Changes in the near Earth atmospheric electrical field in a megapolis region, as noted above, will lead to changes in the atmospheric layer conductivity near the Earth surface over a considerable area. Since this atmospheric layer has the largest resistance in the global electric circuit, there will occur disturbances of the electrical parameters in this 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 global scales. It is difficult to predict their effects on the inhabitable environment, however we cannot rule out possibilities that 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 waves processes in a megapolis, 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 η_a of the P power, transformed into the acoustic radiation power, P_a. Observations have shown that on the average $\eta_a \approx 0.3\%$ [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 megapolis square of 300 km^2 to be estimated, the acoustic radiation power will be about $P_{a0} = \Pi a_0 \; S \approx 60–400$ kw approximatelly. When there are many sources – which is characteristic of a megapolis – over the same square, 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 falls on the 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 energy of the sources mentioned in Section 2. Let us consider certain of them.

Sources of electromagnetic radiation

The electric current power, P_e, transmitted over the high-voltage electric power transmission lines (TL) is about 1 Mw – 1 Gw, the total length of lines being $L_e \sim 10^2$ km. For trasmission 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 the megapolis is characteristic of the latter ones. Such systems are capable to radiate an electromagnetic energy at 50 or 60Hz or their harmonics. Since 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 the megapolis will be essential. Part of 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 (considerable variations in the ionospheric plasma parameters being also discovered). 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 increasing in 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 influence of the ground radio means were carried out. The effect discovered in [40] seemingly haves been caused by synchronous switchings of numerous radio systems [50,51]. In these papers there are described large-scale (not less than 100 km) ionospheric effects caused by influence of the powerful radio radiation. A great number of powerful radio means concentrated in the industrially-developed zones of the megapolises leads to occurring such effects on global scales.

Heat-dust and chemical sources

Strong winds within a megapolis cause a convection and atmospheric turbulence, which are accompanied by generating noise acoustic radiation and acoustic-gravitational waves (AGW) (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 $\sim 10^3$ sec, the number of cells is $\sim 10^3$. Then the effective volume of a convective source is $\sim 10^{10}$ m^3, the total effective kinetic energy and power will be $\sim 10^{13}$ J and $\sim 10^{10}$ w, respectively. It is known that about 0.1% of the kinetic energy [32] (on the basis of the observations, it is usually assumed to be 0.1–0.3% in a fire zone [10-12] is transformed to acoustic energy, then the acoustic power, P_a , will be $\sim 10^7$ 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],

$$P_a = k_a \rho \sigma_v^3 V M^5 / l, \tag{6}$$

where $k_a \approx 100$, ρ is the air density, σ_V 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 15m/sec, $\rho \approx 0.2$ 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 megapolis region, the acoustic power flow is ≈ 0.3–1 mw/m^2 [32,33].

CONCLUSION

1. Thus, megapolises of 200 – 300 km^2 have appreciable, often essential effects in the Earth – near Earth atmosphere – ionosphere system, leading to irreversible 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 megapolis area, 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 megapolis region in a near Earth layer of the atmosphere.
3. Changes in the near Earth atmospheric electrical field in a megapolis region lead to the appreciable changes in the tropospheric conductivity of an atmosphere layer near the Earth surface over a considerable area. This has become 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 Earth environment on global scales. It is difficult to predict their effects on the hospitable medium, 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 megapolis region 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 falls on 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 a megapolis, screen the solar radiation, which may lead to causing secondary, considerably more energetic, processes on global scales. Manifestations of ecological consequences are essential, often being irrevocably far beyond a megapolis area for a long time.

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