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THE CITY AND THE FUNCTIONS OF URBAN SOILS

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First cities developed during the Holocene. Thus, the urban civilization exists already for 8–10 thousand years. Thus, Jericho (Palestine) – the most ancient continuously inhabited city in the world – was built ca. 9000 BCE. Cities and towns form the urbosphere within the technosphere, thus making the city a giant specific ecosystem. The urban equivalent of the landscape is called cityscape. The following cityscape elements can be found in the city.

Key words: cityscape, urbosphere, soils of towns, technosphere, degradation of soils in city.

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МІСТО ТА ФУНКЦІЇ МІСЬКИХ ҐРУНТІВ

Перші міста сформувалися в біосфері у голоцені. Вік міської цивілізації вже 8–10 тис. років. Найдавніше із діючих міст – Ієрихон, приблизно 9 тис. років. Міста та селища утворюють урбосферу та техносферу і представляють собою специфічні екосистеми. Місто еквівалентне природному ландшафту. У ньому можна знайти найрізноманітніші екосистеми.

Ключові слова: міський ландшафт, урбосфера, ґрунти міста, техносфера, деградація ґрунтів міста.

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ГОРОД И ФУНКЦИИ ГОРОДСКИХ ПОЧВ

Первые города сформировались в биосфере в голоцене. Возраст городской цивилизации уже 8–10 тыс. лет Самый старый из действующих городов – Иерихон , около 9 тыс. лет Города и поселки образуют урбосферу и техносферу и представляют собой специфические экосистемы. Город эквивалентен природному ландшафту. В нем можно найти самые разные экосистемы.

Ключевые слова: городской ландшафт, урбосфера, почвы города, техносфера, деградация почв города

The urban civilization accompanies human development through most of its history. There are historic evidences that early cities appeared already in ancient times, at least 10 thousand years ago. Of currently existing cities the most ancient is Jericho (Jordan). Its habitation is dates back more than 7 thousand years. The most ancient cities of the Russian civilization are around 1000 years old (Velikiy Novgorod, Staraya Russa). The town of Derbent in the Caucasus is said to be more than 2000 years old. In Western Europe, some cities emerged more than 3 thousand years ago. Increasing agricultural productivity and growing population under conditions of shrinking readily available arable lands force people to move from rural areas to the cities. This process was observed already in ancient times. However, once some cities successfully develop, others gradually decline. Sometimes cities were deserted after being destroyed by aggressive invaders (Troy, Babylon). However, history knows examples when cities were abandoned without a clear reason (Latin America, India) or after sharp deterioration of living conditions. The latter can be exemplified by cases of Chernobyl and Pripyat (Ukraine) and Times Beach (the US). One of the reasons of city decline is sharp deterioration of the quality of soils in cities.

URBAN SOILS

Early studies of soils in cities were conducted already by V. V. Dokuchaev (soils of Saint Petersburg). However, the most comprehensive research of soils was conducted quite recently by G. V. Dobrovolskiy, M. N. Stroganova, T. V. Prokofyeva and A. D. Myagkova.

The classification of urban soils was developed. Briefly all soils were divided in four groups. The 1st group is morphologically intact soils. The 2d group is soils with disturbed morphology but with some horizons preserved. The 3d group is completely disturbed soils (soil-like bodies). The 4th group is man-made soils (under planted trees, lawns, beds of flowers etc.).

Soils can be also classified by the degree of pollution, although almost all urban soils are polluted to some extent. Pollution takes place permanently, so urban soils contain a great number of various pollutants. Some works (Privalov) show that there is certain dependence between the type of pollution and some particular health problems (including those typical for children). Relationships between soils and sanitary conditions of cities were established already by Potenkofer and Gantimurov. These relationships were studies in details by Yu.N. Ashin and T.A. Zubkova.

The objective of this paper is to discuss possible roles of soils in the life of cities.

SPECIFICS OF CITIES

Globally there are 7 cities with population over 15 million (Mexico City, Shanghai, Karachi, Istanbul, Tokyo, Mumbai and Buenos Aires) and more than 10 cities with population over 10 million (Dacca, Delhi, Manila, Moscow, Seoul, Kinshasa, Sao Paolu etc.). More than 100 cities have more than 1 million inhabitants. The growth of a city apparently creates serious problems for its inhabitants.

One of the main features of cities is the input of various products fabricated outside of the city – a great matter cycling. The city with more 1 million inhabitants, which occupies the area of 1000 thousand km^2, creates intensive matter cycling at all its lands (Tables 1 and 2).

Table 1

Matter input (million tons per year) to cities with over 1 million inhabitants

Name of matter	Amount
Pure water	470.0
Air	50.2
Minerals and construction materials	10.0
Coal	3.8
Crude oil	3.6
Raw materials for black metallurgy	3.5
Natural gas	1.7
Liquid fuels	1.5
Mineral and chemical raw materials	1.2
Raw materials for colored metallurgy	1.0
Technical plant raw materials	1.6
Raw materials for food industries, ready-to-use food	1.0
Energy and chemical raw materials	0.22

Table 2

Atmospheric emissions (thousand tons per year) in cities with over 1 million inhabitants

Name of matter	Amount
1	2
Water (vapor, aerosols)	10800
Carbon dioxide	1200
Sulphurous anhydride	240
Carbon monoxide	240
Dust	180
Hydrocarbons	108
Nitrogen oxides	60
Organic compounds	8
Chlorine, hydrochloric acid aerosols	5
Hydrogen sulphide	5
Ammonia	1.4

Continued of the table 2

1	2
Fluorides (recalculated per fluorine)	1.2
Carbon disulfide	1.0
Hydrogen cyanide	0.3
Lead-containing compounds	0.5
Nickel (with dust)	0.042
Surface-active agents (including benzo[a]pyrene)	0.08
Arsenic	0.031
Uranium (with dust)	0.024
Cobalt (with dust)	0.018
Mercury	0.0084
Cadmium (with dust)	0.0015
Beryllium (with dust)	0.0012

In natural ecosystems, the respective area (100 thousand km^2) annually receives 1-4 million tones of water, 2-5 million tones of organic residues and 50-200 thousand tones of dust. This shows that in terms of matter cycling the city exceeds natural ecosystems. It even exceeds local geological matter cycles, of course, except in areas with volcanic activity.

Natural ecosystems emit into the atmosphere significant amounts of water (1600 thousand tones) and carbon dioxide (5 thousand tones per 1 thousand km^2). Emissions of all other components are many times less.

Atmospheric emissions and general matter cycling in cities is by many times greater than those in natural ecosystems. The matter cycling in cities is greater than local geological matter cycling and is comparable with planet's matter cycling.

THE CITY AS A SPECIFIC ECOSYSTEM

The city is a habitat for numerous human-beings, other animals and plants. The city can be considered a relatively large urban ecosystem. The latter consists of smaller lower-level urban ecosystems such as:

1. City streets
2. City yards
3. City buildings
4. City managed roadside vegetation
5. Green spaces and boulevards
6. Parks
7. Industries
8. Dumps and
9. Sewage water treatment stations.

Urban ecosystems in cities are very specific and even characterized by own biota. For example, various organisms dwell in ecosystems of city buildings. Birds, wasps and other insects inhabit mansard roofs. Basements are inhabited by mice, rats, mosquitoes and ants. Ticks, flies and mosquitoes can be found in apartments. A big variety of domestic animals (hamsters, turtles, dogs, cats, birds, fishes etc.) is kept in apartments. Domestic plants can be found in apartments and on stairways. Fungi and microflora are present everywhere.

Urban ecosystems of city yards. Green space in yards can be represented by trees, shrubs and herbaceous plants. Yards are used to walk domestic animals. Some birds like crows, sparrows, jackdaws and pigeons permanently live in yards, while some birds could be found there on occasion: tits, bullfinches, Bohemian waxwings, common magpies. Some insects (butterflies, mosquitoes, wasps, flies, ants etc.) could often live here. Soil fauna and microflora, including pathogenic ones, dwell on unsealed patches. Noteworthy, in the 19th century jackdaws were quite abundant on crosses of churches, while in 20th and 21st centuries they were outcompeted by crows. This shows that urban ecosystems are characterized by natural competition among species.

Urban ecosystems of streets, lanes and squares. The most typical biological elements here are individual trees planted in special pits along paved roads. Lawns and beds of flowers could be established along many streets and near buildings. Typical street inhabitants are birds, insects, dogs, cats, sometimes rats and mice. One sometimes may observe riding horses. Streets could have patches of unsealed soil. Each tree and isolated lawns can be considered as an ecosystem.

Boulevards, green spaces and waste lands are urban ecosystems with man-made and disturbed soils. Living organisms here are represented by birds, insects and other invertebrates living in soil and on plants, trees, lawns and beds of flowers.

Parks are remnants of natural ecosystems, often strongly modified by humans, or new artificial ecosystems. Parks are habitats of numerous native and introduced species – alien for particular natural conditions. Biological diversity in cities could be higher than in nearby natural ecosystems because of abundant alien species introduced to urban ecosystems.

BIOSPHERIC FUNCTIONS OF CITIES

As a totality of different ecosystems, the city plays a special organizing role in the biosphere.

1. The city accumulates food products and various kinds of natural resources in general (fuel, mineral resources);
2. The city produces waste;
3. The city is congestion of pathogenic microorganisms;
4. The city is congestion of "parasitic" invertebrates;
5. The city is congestion of a diverse genetic fund;
6. The city is the source of major ideas of progress in technologies, thinking, health care and social relations;
7. The city is an island almost at homeostatic conditions (in residential apartments "climate is constant");
8. The lifespan of humans in city is longer than in rural areas.

Being a spatial element of the biosphere, the city in various ways influences conditions of biosphere functioning:

1. It changes climate (climatic characteristics, temperature, amount and composition of precipitation, illumination);
2. It changes radioactive background and magnetic field;
3. Not only the city pollutes itself, it also pollutes nearby ecosystems;
4. Natural ecosystems of a new type, strongly impacted by recreation, develop around the cities.

Climate change:

1. The average temperature in cities is by 2-4 degrees above that in nearby natural ecosystems.
2. In some places in cities, soils become wetter, i.e. the amount of precipitation increases.
3. Indoor temperature is by tens of degrees higher than outdoor temperature.
4. Flooding regime in river valleys is disturbed inside the city and at some distance from it.
5. Groundwater discharge increases, thus changing hydrological regime of the area.
6. Discharged sewage waters cause heat, biological and chemical pollution of city freshwater ecosystems.

Zoos and botanical gardens in cities are keepers of a diverse genetic fund. D. Darrel even proposed a semi-utopist project to use them for preserving all planet's diversity.

The proximity of natural ecosystems to the city stimulates outdoor recreation activities and visits of natural ecosystems. This results in development of a network of paths, recreation areas, distortion of animals, changes in flora and even destruction of patches of vegetation. Picnics often cause fires.

The city is a special element of antroposphere. There is no theory of city decline so far, while there are recent examples of vanishing and decline of cities. The main reason of vanishing cities in the past were invasions followed by taking people into slavery, destroying and robbing houses etc. Among other reason the following could be listed:

1. Lack of water.
2. Unemployment related to destruction (decline) of city's main industrial activities.
3. Break off with rural population, which supplied city with food.
4. Development of pathogenic microorganisms and epidemics.

Cities, as a rule, were established on rivers, typically on high bank. Nevertheless, flooding as well as earthquakes could also destroy the city.

Can the humankind exist without cities? It is possible if the size of population does not exceed that after expelling from Eden. Population growth (which is the case already for 7 thousand years) made cities a necessary social element of anthroposphere. It is characterized by overuse of energy and water, high pollution, concentration of everything, including waste. This raises the question, is any internal (immanent) reason for city decline or only external ones, listed above?

The biosphere is characterized by successions – alternation of communities within the same ecosystem. This is why natural ecosystems could exist at current climatic fluctuations almost forever. There is some alternation, replacement and change of urban ecosystems. According to the ecosystem evolution, urban ecosystems do not have internal reasons for dying, … unless:

- They are supplied with water;
- They are supplied with energy;
- They are supplied with water; and
- People have jobs.

Once one of these conditions is breached, the city nears extinction.

Studies of animals and plants in cities show that urban ecosystems are still rich with plant and animal species, even not accounting for species introduced by humans. Hence, the city is the same component of the biosphere as other ecosystems. In principle, the city cannot be treated separately from the biosphere.

SOILS AND THE CITY

One of the reasons of cities decline is destruction of natural soils in cities, partly because of pollution. Soils play an important role in preventing development of pathogenic organisms.

As shown above, four main groups of soils occur in cities.

1) ***Natural soils*** are preserved in park (forest parks).

They perform their ecological functions only to some extent, or, more precisely, manifestations of ecological functions are restricted by human pressure. (Almost no restoration of natural zonal ecosystems takes place, seed pool in soil does not work, soil partly loses its sanitary functions, and the diversity of soil fauna decreases. Nonetheless, soils preserve their structure and order of horizons. Nevertheless, properties of these horizons can be sufficiently changed by chemical pollution.

2) ***Disturbed natural soils*** are preserved beneath sealed surfaces, in yards, wastelands, boulevards, green spaces, some lawns and under trees along streets.

They partly preserve their ecological functions. Once abandoned they may restore basic zonal properties. Very often they are polluted with various toxic compounds and pathogenic microorganisms.

3) ***Man-made soils*** develop beneath planted trees and some lawns.

Soil-like bodies occur near technological facilities of factories, workshops, gasoline stations, construction places and dumps. They almost lack basic ecological functions, are often toxic for plants, soil fauna and even microorganisms. Therefore they may preserve pathogenic microorganisms.

Can be change of soils be a cause of city decline?

1. City completely change the soil pattern in the area;

2. City partially destroy and partially disturb soils in the area;
3. Physical and chemical properties of soils in the area are changed;
4. Water, temperature and gaseous regimes of soils in the area are changed;

The original soil pattern of the city area corresponds to zonal soil pattern and is formed as a result of interaction of elementary landscapes on floodplains, slopes and watersheds.

City development destroys most of soils (soil of floodplains, slopes and watersheds) or bury them under mineral substratum, paved surface, construction waste etc. Superficial soil horizons are being compacted by humans, machines, buildings etc. Soil pH increase due to growing alkalization.

Some soils completely loose humus horizon, while others are characterized by increased humus content and higher thickness of humus horizon. The composition of soil biota, including bacteria and microorganisms, sharply changes.

Natural regimes of soil also change:

1. Winter soil temperatures become higher, thus making the climate milder, because of higher air temperature and increased temperature inside soil due to underground communications.

2. Water regime sharply changes. The water content in soil increases due to additional watering and water discharge. Sealed surfaces prevent evaporation of water from soils. Hydromorphic soil-like bodies (waterlogged grounds) are developed. Flooding in river valleys does not occur within the cities. The pattern of water distribution along slopes also changes.

Gaseous regimes of soils and atmosphere change. Gases toxic for humans could accumulate in canalization wells. This means that city emits significant amounts of alien gases into the atmosphere. All urban ecosystems emit into the atmosphere not only gases, which do not occur in natural atmosphere as well as gases, whose concentration becomes simply above normal values. Since there is permanent exchange of matter between atmosphere and soils and soil-like bodies, if they have pores, could contain "unusual" gases such as CO, CH_4, ethylene, CO_2, N oxides etc.

Urban soils contain increased contents of nitrogen, phosphorous and potassium. While nutrient regime is favorable, pollution and technogenic dust adversely affect plants. Thus, technogenic dust along streets is toxic for plants.

The role of chemical pollution can be illustrated by the fate of American city Times Beach. The city is the place of one of the most terrible environmental catastrophes in the US. Since 1972 to 1976 American authorities sprayed waste oil on roads to prevent dust formation. Unfortunately, someday waste oil was used that contained dioxin, a toxic carcinogenic compound. Dioxin penetrated into soil; rains and flooding distributed it throughout the area. Liquidation of the town in 1983 cost American government USD 36.7 million. After multiple attempts to clean the town the area became the Route 66 State Park.

Ukrainian towns Chernobyl and Pripyat had similar fate. Radioactive pollution in 1986 forced people to abandon these towns. However, plants and animals not only continue to inhabit the cities and the nearby area, but even increased in numbers. Vegetation slowly takes over streets and squares.

What is the role of soils in sustainability of cities? A dilemma is being proposed. Until the city is capable to improve its soils, it is sustainable. Once the city becomes incapable of maintaining its soils, it begins to decline.

Some districts in cities could completely lose natural soils. However, city parks with natural soils could still preserve a pool of natural microorganisms, thus keeping soil clean from pathogenic microorganisms. The system of health care in cities partly mitigates the impact of pathogenic organisms, although the number of the last steadily increases.

By preserving natural soils in landscape we preserve human settlements being part of this landscape. Therefore, conservation of patches of the biosphere with natural soils is a necessary condition for survival of humans as a species. This concept is debatable but plausible. Convincing evidences are not available so far, although this is an intriguing line of research. Under current conditions fighting against pathogenic organisms is organized very well, especially in cities. The system of disease prevention is quite developed.

However, could it be true that in the past, before the development of the modern system of health care, abandoned and destroyed cities could be the consequence of various health problems of local people? This is especially applicable to countries with warm climate, where earth's first civilizations emerged.

CONCLUSIONS

1. Cities are an obligatory component of anthroposphere. Humankind cannot exist without them.
2. Cities change all natural elements and their ecological functions, while creating homeostatic conditions for humans.
3. Natural soils in cities are being destroyed that may lead to unpredictable results, the death of city in first turn.

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