LITHOSPHERE POLLUTION

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Artist's impression of a major impact event. The collision between Earth and an asteroid a few kilometres in diameter may release as much energy as several million nuclear weapons detonating simultaneously.

Aerial view of Barringer Crater in Arizona.
Atmosphere, hydrosphere and lithosphere are Earth cover’s component parts in which life forms can exist.

Life distribution zone is biosphere
LITHOSPHERE

The hard and rigid outer layer of the Earth – the lithosphere – is up to 200 km deep, and it comprises the Earth’s crust and the outer part of the upper mantle.

Earth’s crust – planet’s hard cover in average is 35-40 km thick

Lithosphere by formation is heterogeneous and complicated

Ocean crust

Continental crust

Lithosphere

Upper mantle
Abundance (atom fraction) of the chemical elements in Earth's upper continental crust as a function of atomic number. The rarest elements in the crust (shown in yellow) are not the heaviest, but are rather the siderophile (iron-loving) elements in the Goldschmidt classification of elements. These have been depleted by being relocated deeper into the Earth's core. Their abundance in meteorid materials is higher. Additionally, tellurium and selenium have been depleted from the crust due to formation of volatile hydrides.
Abundance of the chemical elements in Earth's
Clarkes numbers expressing the average content of the chemical elements in the earth’s crust, the hydrosphere, the earth as a whole, celestial bodies, and other geochemical and cosmochemical systems.

A distinction is made between weight clarkes (expressed in percent; in g per ton; or in g per g) and atomic clarkes (expressed as a percentage of the number of atoms).

A summary of the data on the chemical composition of the various rocks composing the earth’s crust to a depth of 16 km was carried out for the first time by the American scientist F. W. Clarke in 1889.

The figures he obtained for the percentage content of the chemical elements making up the earth’s crust were refined somewhat by A. E. Fersman. Upon Fersman’s proposal the figures were called Clarke numbers, or clarkes.
CHEMICAL COMPOSITION OF THE EARTH

The mass of the Earth is approximately $5.98 \times 10^{24}$ kg. Due to mass segregation, the core region is believed to be primarily composed of iron (88.8%), with smaller amounts of nickel (5.8%), sulphur (4.5%), and less than 1% trace elements.

The geochemist F. W. Clarke calculated that a little more than 47% of the Earth's crust consists of oxygen. The more common rock constituents of the Earth crust are nearly all oxides; chlorine, sulphur and fluorine are the only important exceptions to this and their total amount in any rock is usually much less than 1%.

The principal oxides are silica, alumina, iron oxides, lime, magnesia, potash and soda. The silica functions principally as an acid, forming silicates, and all the commonest minerals of igneous rocks are of this nature.

From a computation based on 1,672 analyses of all kinds of rocks, Clarke deduced that 99.22% were composed of 11 oxides. All the other constituents occur only in very small quantities.
CHEMICAL COMPOSITION OF THE LITHOSPHERE

- Oxygen (47%)
- Silicon (29.5%)
- Aluminium (8.05%)
- Iron (4.65%)
- Calcium (2.96%)
- Sodium (2.5%)
- Potassium (2.5%)
- Magnesium (1.87%)
- Titan (0.45%)

84.55% + 14.93% = 99.48%

- Rare elements
  0.01 - 0.0001%

- Microelements
  less as 0.001%
LITHOSPHERE POLLUTION

Chemical elements in the form of mineral resources are taken out lithosphere. Under processing, burning, etc., processes pollution comes back to lithosphere.

Man-made goods as a garbage returns to lithosphere.
POLLUTION

The litter problem on the coast of Guyana.
If pollutants are on surface of soil, there are three possibilities:

1) Polluting substance are distributed or wash away, for example, with rain water, therefore damage for soil is minimal

2) Polluting substance (if evaporable) can evaporate, without polluting soil surface and deeper layers, but polluting the air

3) Polluting substance can infiltrate into soil, similarly, as water infiltrates into soil, therefore soil will be polluted.
Law “On Pollution” says:

Polluted place – soil, entrails of the Earth, water, sludge, buildings and activities indoor, production units or other objects, where are used polluting substances.
Polluted Lachine Canal in Montreal, Canada.

A litter trap catches floating rubbish in the Yarra River, east-central Victoria, Australia.
Polluted places are appraised by special methodology with point system. More points draw attention to dangerousness and necessity to make recovery of the place.

Ministry of Environment and Regional development from 2004 has data base, with information about approximately 3500 potentially polluted place and polluted places in Latvia.

Data base is available in home page of the Environmental, geological and meteorological centre of Latvia.
In Latvia more polluted places are in Riga, but majority of potentially polluted places are in Vidzeme region.

We know 241 polluted places and 2622 potentially polluted places in Latvia.
POLLUTED PLACES IN RIGA
POLLUTED PLACES IN RIGA REGION

- Air pollution
- Noise pollution
- Soil pollution
- Surface water pollution
- Cross-country water pollution
- Groundwater pollution
- Landscape degradation
Goudron (flux oil; oil tar) ponds are situated in area, used for extraction of artesian drinking water, therefore threat supplement Riga city with high quality of drinking water, especially site – Rembergi.

Goudron ponds formed in 1950-1980, when Riga’s Oil processing and lubricant factory to throw out as far as 16 000 tons of sulphur-acidic goudron annually. That pseudo-solid substance was industrial waste by processing medical and veterinary creams and lubricants.
Pollution of the goudron ponds by infiltration is reach 70-90 m deep layers, where are reserves of ground and artesian water. Pollution moves in direction of river Gauja with speed 25-35 m/y.

Polluted volume of underground waters is 108 000 m³, but total pollution distribution areal is more as 280 ha.

Without recovery polluted water reach river Gauja in 65 years.

Calculations demonstrate, that recovery expenses will be approximately 20 378 000 Ls.
Chemical pollution from goudron ponds migrate in direction of river Gauja, to arouse threats of ecological catastrophe.
Toxic liquid waste landfill is situated approximately 4 km from Olaine. That site seriously threat towns Jaunolaine and Olaine by groundwater polluting.

On 1973-1980 there has been deposited liquid, pseudo-solid and solid waste from factory “Latbiofarm” and “Biolar” in amount as far as 16 000 t/y. Toxic substances: ammonia chloride, pyridine, butanol, isopropanol, sodium acetate and other toxic substances.
Aerodrome “Rumbula” – hardly polluted site in Riga

Aerodrome “Rumbula” in Soviet time has been used for military and public needs. There was huge reservoirs of fuel and lubricants. Unfortunately all territory management was quite bad.

Oil products, infiltrate through sand and reach groundwater level, where formed thick floating oil layer.
Pollution, which is quite high, is localized in five areas.

Risk is very high, as pollution via groundwater can reach river Daugava, but later – Baltic sea.

Pollution is located in three phases:
- in soil (absorbed),
- on groundwater surface (floating),
- dissolved (in water)
Chernobyl, Ukraine
Radioactive pollution after incident on Nuclear Power plant

Sumgait, Azerbaijan
Pollution from chemical industry

Oroja, Peru
Pollution from mining

Kabwe, Zambia
Pollution from Pb and Zn processing

Vapi, India
Industrial pollution

Sukinda, India
Pollution from Cr mines

Tjaning, China
Pollution from Pb processing

Norilsk, Russia
Pollution from heavy metals processing

Linphen, China
Pollution from coal mines

Dzerhynsk, Russia
Pollution with chemicals

Dzerhynsk, Russia
Pollution with heavy metals processing

Norilsk, Russia
Pollution from heavy metals processing

Linphen, China
Pollution from coal mines

Dzerhynsk, Russia
Pollution with heavy metals processing

Norilsk, Russia
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Dzerhynsk, Russia
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Linphen, China
Pollution from coal mines
Soil pollution

Soil contamination or soil pollution is caused by the presence of human-made chemicals or other alteration in the natural soil environment.

This type of contamination typically arises from the failure caused by corrosion of underground storage tanks (including piping used to transmit the contents), application of pesticides, oil and fuel dumping, disposal of coal ash, leaching of wastes from landfills or direct discharge of industrial wastes to the soil.

The most common chemicals involved are petroleum hydrocarbons, lead, polynuclear aromatic hydrocarbons (such as naphthalene and benzo(a)pyrene), solvents, pesticides, and other heavy metals. This occurrence of this phenomenon is correlated with the degree of industrialization and intensities of chemical usage.

According to a scientific sampling 100,000 square kilometers of China’s cultivated land have been polluted, with contaminated water being used to irrigate a further 21,670 square kilometers and another 1,300 square kilometers covered or destroyed by solid waste. In total, the area accounts for one-tenth of China’s cultivatable land, and is mostly in economically developed areas.

An estimated 12 million tonnes of grain are contaminated by heavy metals every year, causing direct losses of 20 billion yuan (US$ 2.57 billion).
Oil – complex hydrocarbons mixture (carbon 84-87 %; hydrogen 12-14 %)
Oil spills happen when people make mistakes or are careless and cause an oil tanker to leak oil into the ocean. Equipment breaking down may cause an oil spill. If the equipment breaks down, the tanker may get stuck on shallow land. When they start to drive the tanker again, they can put a hole in the tanker causing it to leak oil.

When countries are at war, one country may decide to dump oil into the other country’s oceans. Terrorists may cause an oil spill because they will dump oil into a country’s ocean. Many terrorists will do this because they are trying to get the country’s attention, or they are trying to make a point to a country.

Illegal dumpers are people that will dump crude oil into the oceans because they do not want to spend money on decomposing their waste oil. Because they won’t spend money on breaking up the oil (decomposing it) they will dump oil into the oceans, which is illegal. Natural disasters (like hurricanes) may cause an oil spill, too. If a hurricane was a couple of miles away, the winds from the hurricane could cause the oil tanker to flip over, pouring oil out.
Oil and oil products can be in different state of aggregation in the lithosphere:

- Gaseous phase among soil and ground participles
- Liquid phase among soil and ground participles
- As solution in the soil and ground pores
- Adsorption layer on the soil and ground participles
- Diffused in the deeper layer of soil and ground
TRANSFORMATION OF THE OIL IN THE LITHOSPHERE

Processes:

Chemical
- Oxidation
- Reduction
- Hydrolyse
- Photolysis

Physical-mechanical
- Evaporation
- Sorption
- Dissolving
- Change of density or viscosity

Biological
- Biodegradation
- Biotransformation
- Bioaccumulation
- Changes in toxicity
Main industrial pollution sources:

- Chemical factories
- Metallurgy complexes
- Integrated plants for building materials
- Thermo-electro plants

Chimneys throw out industrial pollution in the air, which are transported by wind over long distances, but eventually precipitate on the earth's surface.
Untreated effluent flows from the Assalaya sugar factory to the White Nile.

Fuel oil spillage at the Rabak cement factory, in White Nile state.

The destroyed excavator has hundreds of birds nests.

Used asphalt drums dumped on the outskirts of Port Sudan.
POLLUTION WITH HEAVY METALS

Definitions of the heavy metals are different:

**Chemistry** – metals with density more as 3.5 g/cm³

**Environmental** – metals with density more as 5 g/cm³

Dangerous elements:

- Arsenic (As)
- Mercury (Hg)
- Copper (Cu)
- Zinc (Zn)
- Chromium (Cr)
- Selenium (Se)
- Cadmium (Cd)
- Nickel (Ni)
- Lead (Pb)
- Tin (Sn)
- Antimony (Sb)
- Bismuth (Bi)
- Cobalt (Co)
POLLUTION SOURCES WITH HEAVY METALS

Main sources:

- Industry
- Agriculture (fertilizers, applying lime, irrigation)
- Household and industrial solid waste storage
- Burning of the fossil fuel
- Use of mobile vehicles
Pesticides

Food and Agriculture Organization (FAO) has defined the term of *pesticide* as:

any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit. Also used as substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport.

<table>
<thead>
<tr>
<th>Type of Pesticide</th>
<th>Target Pest Group</th>
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<tbody>
<tr>
<td>Algicides</td>
<td>Algae</td>
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<tr>
<td>Avicides</td>
<td>Birds</td>
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<tr>
<td>Bactericides</td>
<td>Bacteria</td>
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<td>Fungi</td>
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<tr>
<td>Insecticides</td>
<td>Insects</td>
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<tr>
<td>Miticides or acaricides</td>
<td>Mites</td>
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<tr>
<td>Molluscicides</td>
<td>Snails</td>
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<td>Nematicides</td>
<td>Nematodes</td>
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<tr>
<td>Rodenticides</td>
<td>Rodents</td>
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<tr>
<td>Virucides</td>
<td>Viruses</td>
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Environmental and economical effect by pesticides use

Environmental effect
Pesticide use raises a number of environmental concerns. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water and soil. Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Pesticides are one of the causes of water pollution, and some pesticides are persistent organic pollutants and contribute to soil contamination.

In addition, pesticide use reduces biodiversity, reduces nitrogen fixation, contributes to pollinator decline, destroys habitat (especially for birds), and threatens endangered species.

Pests can develop a resistance to the pesticide (pesticide resistance), necessitating a new pesticide. Alternatively a greater dose of the pesticide can be used to counteract the resistance, although this will cause a worsening of the ambient pollution problem.

Economics
Harm Annual US Cost
Public Health $1.1 billion
Pesticide Resistance in Pest $1.5 billion
Crop Losses Caused by Pesticides $1.4 billion
Bird Losses due to Pesticides $2.2 billion
Groundwater Contamination $2.0 billion
Other Costs $1.4 billion
Total Costs $9.6 billion

Human health and environmental cost from pesticides in the United States is a total of $9.6 billion.

Additional cost includes the registration process and the cost of purchase pesticides. The registration process can take several years to complete the 70 different types of field test and can cost between $50–70 million for a single pesticide. Annually the United States spends $10 billion on pesticides.
POLLUTION WITH PESTICIDES

Pesticides – especially synthesized chemicals with lethal effect on living organisms (bacteria, mildew (*pelējums*), fungi, plants, animals, *etc.*)

In the world are used ~ 30,000 pesticides

Agriculture and forestry for plants protection every year are using 200-2000 g pesticides per hectare

Lot of pesticides are use for growing cotton, buckwheat (griķi) and oil plants (rape)
RISK OF PESTICIDES

Pesticides kill innocent species too!
Have negative impact on different elements of the ecosystem!

Many of pesticides are very stable, therefore can accumulate in the trophical chains:

- Soil
- Plants
- Plant’s consumers
- Predators

WARNING PESTICIDES
FIRE WILL CAUSE TOXIC FUMES
LITHOSPHERE RADIOACTIVE BACKGROUND

Minerals of lithosphere own natural radioactive background due to natural radioactive elements, their isotopes or radioactive isotopes of chemical elements:

- Uranium ($^{238}\text{U}$, $^{235}\text{U}$)
- Radium ($^{226}\text{Ra}$)
- Thorium ($^{232}\text{Th}$)
- Potassium ($^{40}\text{K}$)
- Rubidium ($^{87}\text{Rb}$)
- Calcium ($^{48}\text{Ca}$)

One of the uranium disintegration product is radon (Rd) – radioactive noble gas, without colour and odour, which release out of ground or stones.

Radon gas can accumulate in the building’s cellars, caves and mining shafts, to develop higher background of radiation.
Substantial sources of the radioactive waste are military industry and armies.

Radioactive pollution of lithosphere with radioactive elements can arouse:

- Tests of nuclear weapon
- Incidents in the Nuclear Power Plants
- Extraction, enrichment and processing minerals of the radioactive elements
- Incorrect storing of the radioactive waste
Artificial radioactive isotopes to reach lithosphere together with first nuclear tests, which polluted soil and ground with $^{90}$Sr, $^{137}$Cs, etc.

104 kT nuclear bomb test in USA.
At the Chernobil NPP catastrophe (April 26, 1986) in atmosphere come in radioactive substances with total radioactivity $10^{18}$ Bq, what is equal approximately 30-40 nuclear bombs explosion.

Movement of radioactive clouds in atmosphere after Chernobil NPP catastrophe:
1) April 26, 1986
2) April 27, 1986
3) April 29, 1986
4) May 2, 1986
Chernobil NPP catastrophe to bring about pollution with radioactive isotopes in enormous part of the Europe.

Content of $^{137}$Cs in moss *Sphagnum magellanicum* did help to measure concentration of the radioactive isotopes after falling down in Latvia after Chernobil NPP catastrophe.
After Chernobil NPP catastrophe majority of the radioactive pollution with air came and fall down in Russia, Ukraine and Belarus.
POSSIBILITY TO PURIFY POLLUTED SITES

To not to endanger human health and conserve nature, there is necessity to clean-up polluted places and areas.

For that reason activities are planned and to carry out, starting with information collection and measurements about real situation on the site.
Soil, ground, and groundwater can provide self-purification. As result lithospheres' soil, ground, groundwater, etc. in entirety of different processes can renew primary quality and characteristic functions or property.

Self-purification can happened different way:

- by oxidation processes
- through biodegradation
Biodegradation is purification of soil by microorganisms (fungi, yeast, or bacteria). As result, to go on process in which toxic and hazardous substances are taking down or transform into less toxic substances.

Microorganisms are feeding by pollutants and through metabolism processes convert these substances into CO$_2$ and H$_2$O, which later comes in environment.
Biodegradation *in situ* mean soil purification on the site, where pollution has happened.

**Biostimulation** – promotion of the natural soil organisms biological activity.

**Bioventilation and biovaporization** – in soil of polluted area are infused air and nutrients for soil bacteria development promotion.

**Bioaugmentation** – in polluted site of soil artificial way are introduced microorganisms, which promote destruction of pollutant.

Typical bioventilation system.
Ex situ biodegradation means gathering of soil in the polluted place and transportation for cleaning site.

1) **Pseudo-liquid phase** – polluted soil in container are mixed with water, nutrients, microorganisms and oxygen.

2) **Solid phase** – liquid are separated from mass of soil, are realised composting, but acquired compost are dig back in soil.

Ex situ biodegradation is more expensive as in situ, but is more quick and easier controlled, as well as, are available for greater number of different pollutants.
THANK YOU FOR ATTENTION!