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Global changes and hydrosphere

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Increasing population led to the increasing demand to food, raw materials, water and energy. Anthropogenic demands provoke land use structure changes, intensification of its exploitation, deforestation, fossil fuel combustion and related carbon dioxide production. Those phenomena are changing water and energy fluxes of biosphere, and conditions for life. Actual climate change is a result of other global changes both natural and anthropogenic. It is mostly felt as a change of ecosystem temperature, increase of precipitation intensities and totals, as well as their irregular distribution in time and space. Flood periods are followed by long periods without precipitations. Water consumption is increasing; it is renewable resource, but water resources are unevenly distributed and often polluted, therefore unsuitable for use as fresh water. Increasing population as well as increasing consumption of resources lead to the imbalance between our planet production and consumption. To preserve good conditions for population of the Earth, it is necessary to decrease consumption of energy, raw materials and food to reach equilibrium between Earth´s ecosystem production and consumption of the ecosystem products.

KEY WORDS: ecosystem, biosphere, hydrosphere, global changes, climate change

Introduction

The Planet Earth surface area is 520×10^6 km^2, land comprises less than one third of our planet surface (149×10^6 km^2). Area of arable land comprises 12% of dry land only, (19.8×10^6 km^2), thus creating ecosystem of crops, which is the basic source of food for mankind. Animals, fish and plants are important part of food supply too. It could be a surprise, that the deserts area is approximately the same as the area of arable land. Forests cover a major part of land (60×10^6 km^2), which represents 38% of the land`s surface. Land glaciers are covering the area 15.7×10^6 km^2, which is a little bit less than is the area of arable land. The rest of dry land is covered by steppes, savannas, non-vegetated surfaces in Antarctic zone, residential zones, industrial areas, water surfaces, non-permeable surfaces like roads and buildings. Earth is populated approximately by 1.5 million of animal species, and about one million of them are insects, therefore our planet is often called as "planet of insects". Existence of individual animal species is dependent on other animal or plant species. It means that elimination one of species can lead to extinction of another. Any animal and plant species are important element in food chain link of animals and human beings. During a period of time 1600–1975 about 136 species of birds and 68 species of mammals went extinct, but in 20th century 85 mammals' species disappeared from the planet of Earth for good.

According to the Food and Agricultural Organization (FAO), up to 60% of worlds ecosystems are degraded and used in unsustainable way. In European Union, only 17% of biotopes preserved by European legislative are in favourable state. Therefore this geological era is proposed to be indicated as anthropocene (Crutzen, 2002).

In Slovakia, there are only 14.68% of natural ecosystems in natural state, which is exceptionally low value. The rest of ecosystems are highly modified (Izakovičová and Špulerová, 2018), and 75.1% of mammals were living in unfavourable conditions in 2017, (MŽP SR, 2018). Therefore, protection and preservation of all the assortment of existing animal and plant species is so important for mankind.

The only anomaly among living species of the Earth is human beings. It is the only living species, which can adapt to changing conditions, and to change environment in such a way, that it not only preserves, but even increases its population in an uncontrolled way. As it was mentioned before, man is changing the biosphere of the planet and thus endangers mankind as well as the rest of living organisms (Kutílek et al., 2013). Some philosophers assume existence of human beings on the Earth as anomaly, and danger for functional planet (Münz, 2019). Human's activity significantly influences our ecosystem. Selected indicators are showing the increasing rate of human activity since the beginning of industrial revolution in an exponential way (population, global HDP, water consumption, cars

number, paper production, etc.) Those processes are influencing the state of ecosystem, characterized by indicators like land use changes, carbon dioxide concentration, rain forests clearing, soil degradation, biodiversity, air temperature, floods, droughts and many others (Nemešová, 2007).

Area of living species is biosphere, which is subsystem of hydrosphere. Hydrosphere is an area of water presence on the Earth (subsurface water, surface and atmospheric, as well as sea water). Hydrosphere is an area about 10 km below Earth surface and about 40 kilometres above the Earth surface (Rejmers, 1985). Biosphere is a part of hydrosphere; it comprises area where organisms are living, as well as living organisms itself. It is thin, very vulnerable area, characterized mostly by influx of photosynthetic active radiation, suitable biosphere temperature, specific properties of an atmosphere and other properties needed for photosynthesis.

Plants (their seeds) and a man (if there is enough sources of energy) can survive in all the temperature interval present on the Earth (-88°C to +58°C). Biomass, which is the first element in nutrition chain of animals is product of photosynthesis, which can perform in the air temperature interval 0°C to +40°C, but optimum air temperature is about 30°C, depending on plant species. Therefore, the existence of human being on the Earth is limited by environment (ecosystem) properties, suitable to produce biomass, which is the source of energy of all living organisms of the Earth.

The share of arable land is approximately 12% of the land surface of the Earth (with possible increasing of it up to 14%). It is clear, that Earth`s biomass production is limited and can supply only limited number of population. The same is valid for supply by water, energy and especially for non- renewable resources like oil, raw materials, gas, etc.

The aim of this contribution is to demonstrate the effect of global changes on the Earth's ecosystem and on the hydrosphere particularly, with special attention to the water regimen of Slovakia.

Global changes and climate change

Global changes refer to planetary scale changes in the Earth system. Global changes comprise change in an environment, human society and economy. In principle, any activity in the ecosphere is influencing the Earth globally, but it is assumed that „global change" is such a change which can be clearly identified at global scale. All those changes can contribute to well known effect called „climate change" which is only one of many particular global changes, and could contribute to creation of new conditions for life (Nemešová, 2007).

Risks for the ecosystems on the Earth

Natural (non-anthropogenic) risks

Significant decrease of solar radiation is not expected in the next million of years. The time interval during which solar energy income of the Earth will cover the necessary rate of energy needed to preserve actual state of our planet life is limited. Calculations show, that the Sun's fuel could last the next 4 billion years. Today's average rate of solar radiation income to the upper boundary of the Earth`s atmosphere can be expressed by the so called Solar constant: 1,360 Wm^{-2}. It is expected, that Sun radiation rate will be decreasing, depending on the quantity of remaining fuel. Conditions for preserving existing state of life can cease long before total burn out of the Sun.

Collision of the Earth with space object is not excluded, it can have a fatal consequence for the life on the Earth.

Volcanic activity can significantly change energy balance of the Earth, by clouds of aerosols following volcanic eruption, they can last in an atmosphere from two to three years. Absorption and reflexion of radiation by solid particles can lead to summer cooling and winter warming (Kirchner et al., 1999). Currently, there are 26 active volcanoes, but there are about 1500 potentially active volcanoes worldwide.

Anthropogenic risks

Increasing population

It was estimated, about 180 million people inhabitating the Earth two thousand years ago. In 1820, there were about one billion people, and about 110 years later (in 1930) there were approximately 2 billion of people. In 2019 lived on the Earth 7.75 billion of people. During the last 90 years there was a gain of 5 billion. It is assumed, that in 2050 the number of inhabitants will increase to about 10 billion, then, their number is assumed to be slowly decreased. Approximately 6 billion of them live now in Asia and Africa. Even now, Africa is generating a population gain higher than 3% every year, i. e. gain higher than 50 million per year. It is expected, that in sub-Saharan Africa and Asia there will live more than three quarters of Earth`s population by 2050. Sub-Saharan Africa and some Asian countries are economically known as developing countries with a low GDP. This trend in population generates pressure on increase of food production, as well as on production of raw materials, fresh water and energy. In those countries there is shortage of arable land, fresh water, fertilizers and energy. Deficit of resources to intensify agriculture in countries with the highest population increase is main reason of increasing emigration, mostly to Europe. Some researchers assume even the decrease of inhabitants number at the end of this century, as it is observed in Europe even now. Precondition of such trend is relatively high standard of living, but this can hardly be expected in near future in Africa and Southern Asia.

Climate change

The climate is a generalized characteristic of weather, typical for a particular area; it can be characterized by averaged meteorological characteristics, such as an air temperature, wind velocity, and precipitation. There are no doubts, that climate of the Earth has been changing. During the last century the average temperature of the Earth increased about 1°C. Climate change is not homogeneous across the globe; it is more intensive in southernmost and northernmost parts of the Earth.

The reasons of climate change

Natural reasons of climate change

Natural reasons of climate change are due to changes of interrelations between the Earth and the Sun, resulting in the rate of solar energy delivery change. Among those reasons are irregularities of Earth`s orbiting, the changes of the angle of Earth axis in relation to the ecliptic, wobbling of the Earth`s axis during its orbiting. Even the Sun is periodically changing its radiation rate (Kutílek and Nielsen, 2010). Those phenomena dominated in climate change in pre-industrial age (up to 19th century). The ice age ended at about 10 thousand years ago, a medieval warm period (9–13 century) and little ice age (14–19 century) were mostly results of natural (non-anthropogenic) change of climate.

Anthropogenic reasons of climate change

are anthropogenic activities, mostly during the last two centuries and they are becoming more intensive (Kutílek, 2008). The most important reason of anthropogenic climate change is related to land use changes. The production of carbon dioxide by fossils burning and permafrost thawing are contributing to climate change, too.

Land use changes

Probably the most important contribution of human activities to the climate change is continuous change of land use by increasing population. The most important activities are deforestation of rain forests (Brazil, Africa, South Asia), elimination of wetlands, increasing area of arable land, overgrazing, monoculture agriculture, increasing urban and industrial areas as well as transportation facilities (highways), (Kutílek, 2008). Those activities are characterized by elimination or modification of natural surfaces, followed by the change of their water and energy balance structure. Obvious result is decrease of evapotranspiration totals and increase of local runoff. Solar energy not used to water phase change is heating biosphere and thus contributing to global warming. Tropical rain forests are characteristic by high precipitation totals (more than 3,000 mm of water layer per year), and by high income of solar energy (average income is 350 Wm^{-2}; for comparison, on the territory of Slovakia this income is 125 Wm^{-2}). High income of water and energy is resulting in extremely high annual evapotranspiration totals more than 2500 mm of water layer per year (in Slovakia, there is evaporated approximately 500 mm water layer per year) (Shuttleworth, 1988, Novák, 2012). What does it mean for water and energy balance of the Earth?

Intensive deforestation of rain forest and its change to agricultural land, buildings, transport infrastructure is changing properties of evaporating surface, especially their albedo. If it will go in this way, to the end of this century all the tropical forests will be cleared and replaced by another surfaces. The most important is, that evapotranspiration rate will decrease significantly, approximately to one half of the previous state. Therefore, about half of the solar energy reaching soil surface at constant rate will be not used as latent heat of evapotranspiration, but will be heating biosphere and thus increasing its temperature. This is the primary reason of warming with adjective „global“, because it is contributing to temperature increase locally and around the globe.

The most important „glasshouse“ gas is water vapour, because it disperses long wave radiation of the Earth in all the spectrum range more effective than carbon dioxide, with its relatively narrow range of its dispersion. Concentration of water vapour is proportional to air temperature. Increasing temperature of atmosphere increases water vapour concentration and thus increase the „greenhouse“ effect of the atmosphere. Currently, atmosphere (water vapour and carbon dioxide as its component) is increasing biosphere temperature to about 33°C. Without this function of atmosphere there will be average air temperature -18°C, instead of current 15°C. The problem, we are dealing with is actual increasing of this effect, so we should try to eliminate anthropogenic effects on air temperature. Until now (2020) this additional increase of greenhouse effect on average air temperature is about 1°C. The biosphere is very sensitive area and increase of greenhouse effect can dramatically change conditions of life on the Earth.

It was estimated, that about 60 percent of dry land of the Earth is anthropogenically modified. Usually, natural (green) surfaces are replaced by artificial ones, like fields, residential areas, transportation infrastructure. Common feature of such changes is evapotranspiration decrease and runoff increase. The sensitivity of climate change on land use modification is proportional to water and energy fluxes changes in particular areas. This is the case of rain forests (RF). About 90 percent of incoming radiation is consumed as latent heat of evapotranspiration (Shuttleworth, 1988). Areas, replacing rain forests evaporate much less and the difference between consumption of solar energy by RF and by cleared areas is heating environment.

According to FAO, about 100,000 km^2 of RF is eliminated over the globe annually (majority of it, about 60,000 km^2 of RF is cleared in Amazonia). Then, energy saved by decreasing of evapotranspiration is 82 MW km^{-2} (or 82 W m^{-2}). This enormous quantity of energy can heat boundary layer of the atmosphere and thus contributing to the increase of air temperature. Recalculating this amount of energy saved by evapotranspiration decreasing to the Globe area, it gains 0.016 Wm^{-2}, which is comparable to the contribution of the carbon dioxide concentration increasing.

Energy contribution by the above mentioned evapotranspiration decreasing cannot be dispersed homogeneously around the Globe. Therefore the majority (it is not known how much) of this saved energy will be heating in particular dry land area and thus increasing local air temperature and changing climate. As a result, climate of „newly modified“ territory will be changed too, with less precipitation, because local evapotranspiration will decrease and this contribution to formation of precipitation will be decreased, too.

On the territory of Slovakia, such land use change cannot influence the air temperature (or climate) as strongly as it

can be in area of RF. To replace forests by fields and impermeable surfaces (roads, buildings), additional 20 MW km^{-2} (or 20 W m^{-2}) of energy can be spent on heating of boundary layer of the atmosphere. Fact is, that on territory of Slovakia the share of green surfaces (especially forests) is increasing, which is positive feature. But arable land is changing to transportation infrastructure or another impermeable surfaces like factories and stores, thus changing the best arable lands to impermeable surfaces with low evaporation rates and intensive local runoff.

One more hypothetical (but realistic) example of the influence of land use change on energy fluxes in the atmosphere. About 5 percent of Slovak territory is covered by impermeable layers (buildings, transportation infrastructure) contributing to the climate change. So called „heat islands" are created by towns with an air temperature higher about few degrees of Celsius than their surroundings. Assuming, 1 percent of the Earth dryland is covered by impermeable layers, and evaporation from them will be half of those from neighbouring natural areas, it can increase the heat flux recalculated to the dryland by 0.18 W m^{-2}, which is about the same quantity as is result of carbon dioxide contribution per decade. This illustration would like to demonstrate, the importance of state of the land surface in formation of climate.

Fossil fuels burning

Fossil fuels (oil, gas, coal), as well as renewable sources (biomass) burning is producing greenhouse gas carbon dioxide (CO_2). This gas, as a part of the atmosphere, disperses energy of long - wave radiation of the Earth to all directions and thus increasing temperature of the biosphere. Production of CO_2 in Europe has significantly decreased, but world production of it is still continuously increasing.

Carbon dioxide concentration is changing. From 318 ppm in 1960 (ppm means parts of CO_2 molecules, per million of all air particles), to 420 ppm at 2020. But, also greenhouse gas water vapour concentration increases, because it also depends on air temperature and ranges from 6,000 ppm (at 0°C) to 20,000 at 20°C. Nevertheless, absorption spectrum of water vapour is much broader than this spectrum for carbon dioxide.

The role of carbon dioxide as a greenhouse gas was early understood, but problem was to evaluate quantitatively the role of increasing carbon dioxide concentration in an atmosphere on infrared energy fluxes emitting by CO_2 back to the Earth's surface. A few years ago there were published results of measurements how much infrared light radiated by the Earth is returned back by the carbon dioxide in an atmosphere and thus increasing the greenhouse effect (Feldmann et al., 2015). From results of thousands measurements performed in Oklahoma and Alaska during the decade 2000–2010 was found, that back radiation due to increased carbon dioxide concentration is 0.2 Wm^{-2} per decade (0.02 Wm^{-2} per year). Since the start of industrial revolution it is about 1.82 W m^{-2}. Is it significant quantity to change climate? The average income of solar energy on the Earth is 350 W m^{-2}. It is necessary to compare this result with possible influence of land use change on energy balance of the Earth.

Permafrost thawing

Permafrost is permanently frozen subsoil, thawing at the surface in summer; it is characteristic of Arctic tundra, covering about 24% of Northern hemisphere. Thickness of permafrost layer is up to 80 m. As a result of temperature increasing, permafrost containing significant part of frozen organic matter is thawing, and releasing methane (CH_4), which is also product of animals, and carbon dioxide (CO_2) as a result of organic matter decomposition. Especially methane (0.00018% of the atmosphere) is responsible for 1/6 of global warming in the last decades (Knoblauch et al., 2018).

The influence of global change on hydrosphere

Increasing population of the Earth and their demand on consumption of food, raw material, energy and water is the main reason of accelerated non-reversible changes of the environment. Related anthropogenic activities are important reason of soil degradation, desertification, deforestation, soil erosion and overgrazing which are amplifying climate change. On the contrary, climate change is contributing to the enhancing of land use change.

All the water on Earth can cover its surface by the layer of 2,800 metres thick; as a part of it, the thickness of fresh water layer would be about 70 metres. Technically, all the water on the Earth can be treated by known technologies to fresh water; but it needs complicated and expensive technology.

Sea level changes are mostly results of climate change. Increased temperature of the atmosphere is responsible for two important effects: glaciers and icebergs melting, and water expansion with increasing water temperature.

The sea level since the beginning of 20th century has risen about 20 cm, during the last 20 years it was 5 cm (Vinas and Rasmussen, 2015). According to NASA in the time interval 1992–2019 sea level risen in average about 7.4 cm (Holgate, 2007). The rise of sea level is not smooth, but its rise is sensitive to short term fluctuations of weather. There are even short time intervals of sea level decrease, but in general, there is the tendency of sea level increase. Potential rise of sea level due to Greenland glacier melting (1.7×10^6 km^2) is 6 metres, melting of Antarctic continental glacier (14×10^6 km^2) could cause sea level rise up to 58 metres. Complete melting of those glaciers is not expected in near future. Real values of sea level rise are about 5 mm per year, during this century it is expected sea level rise about 50 cm.

Coefficient of thermal expansion of water is around 1×10^{-4} m K^{-1} (its value depends on temperature too). It means the sea level will rise 0.0001 of water layer thickness when temperature of water will rise about 1°C. The average sea depth is approximately 2800 meters, then the increase of water temperature about 1°C can rise sea level due to thermal expansion of water about 28 cm. This is not expected in near future. Usually, the sea level rise is associated with increasing of inundated land area, followed by evaporation increase. Additional

consumption of energy as latent heat of evaporation can contribute to air temperature decrease, which works as autoregulation mechanism of Earth temperature.
Water cycle is basic process to preserve life on the Earth. Approximately 90% of incoming energy from the Sun is used to change liquid or solid state of water to water vapour by evaporation from seas or rain forests. Evapotranspiration of the dry land is usually less intensive, because low soil water content is frequently limiting evapotranspiration rate. In general, more than 50% of solar energy reaching the Earth`s surface is consumed by the process of evapotranspiration, but seas and RF are consuming about 90% of solar radiation reaching the Earth´s surface as latent heat, and therefore is so important to keep RF areas in good state.
Without consumption of solar energy by evapo-transpiration, temperature of biosphere would increase to the level not compatible with life on Earth. As it will be shown later, anthropogenic changes of land surfaces can significantly contribute to modification of water and energy balance equation structure and strongly influence climate of the Earth. Consumption of energy by evapotranspiration from surface of the globe (latent heat of evaporation) is equivalent to 2×10^4 of all energy, transformed by the Earth´s plant stations. Therefore, evapotranspiration is the main consumer of energy on Earth and is creating favourable conditions for life (Novák, 2012).
Other basic feature of the water cycle of the Earth is permanent cleaning (distillation) of water by evaporation. Natural water cycle works as gigantic distillation system powered by solar energy. First phase of it is evapotranspiration. Result of its function is clean, distilled water, permanently returning to the Earth surface by precipitation. To do so, it is necessary to keep atmosphere clean, because precipitation during the fall to the surface is dissolving the stuff in the atmosphere. The most dangerous kind of precipitation were so called „acid rains", the water is dissolving sulphur in the air as a product of coal burning, so the result is a low concentration sulphur acid. Such rain was devastating plants and small animals. So, one of the main precondition of good water quality preservation is clean atmosphere. Water infiltrating the soil, groundwater and rivers is dissolving minerals containing in the surface soil layers. Water with concentration of minerals less than 500 mg per litter which meets additional 82 criteria according to Slovak standards, can be used as fresh water (Nariadenie vlády SR číslo 354/2006 Z.z.).

Is there enough fresh water for all of us?

Assuming „business as usual", i.e. discharge of rivers will not change, and one billion (1×10^9) people by 2050, then the discharge of water in rivers can cover approximately 10,000 litres of fresh water for one person and one day. WHO recommends a minimum consumption of 70 litres of water per person per day. The average actual discharge of the Amazon River only can deliver 1,300 litres/person/day, which represents about 16 times of minimum consumption quantity per person and day. Why we are dealing with rivers only? The rest of precipitation (about two thirds of total precipitation from the dry land) evaporates, mostly as a transpiration participating in biomass production. Therefore, rivers discharge recharging groundwater in surrounding collectors represents real resources of mankind consumption, assuming good quality of river water.
In conclusion, there is enough fresh water for everybody even in the future. But, fresh water resources are not distributed evenly over the globe and are not available everywhere. Correction of uneven geographic distribution of water, e.g. by desalinisation of salt water, can be realised by the richest countries only. On the other hand, a lack of fresh water can lead to existential problems (lack of water for irrigation), to health problems and generate pressure on emigration.

Water and Slovakia

Average river discharge from the Slovak territory is approximately 400 m^3s^{-1}, or 6,400 litres per capita and day. The average discharge of the Danube River at Bratislava profile is 2,000 m^3s^{-1}, which represents five times the amount of all the Slovak rivers discharge. Of course, Danube as an international river body cannot be exploited without limits according to international agreements. Water from Danube is infiltrating and thus recharging groundwater, mainly in the upper part of Žitný ostrov. Therefore, the upper part of Žitný ostrov was declared a protected water resource area (Chránená vodohospodárska oblasť); it is one of ten protected water resource areas in Slovakia. According to Slovak Hydrometeorological Institute (SHMÚ) and Slovak Agency of Environment Protection (SAŽP), (Kollár, 2001), the estimated potential capacity of fresh water resources of Slovakia is 146.7 m^3s^{-1}, and as a part of it, the estimated capacity of groundwater resources is 79 m^3s^{-1}. Žitný ostrov resources of groundwater itself are estimated by 25 m^3s^{-1}. Estimated capacity of readily existing resources of water in Slovakia (surface and groundwater resources) is 32,800 l s^{-1}, which covers about three times the contemporary fresh water consumption – 12,800 l s^{-1}. Actual public fresh water consumption in Slovakia is approximately 80 litres per capita and day, just above the minimum consumption limit recommended by WHO. This is result of economic stimulation of fresh water consumption, because the price of fresh water is relatively high. Groundwater resources cover 80% of fresh water consumed in Slovakia. The quality of fresh water depends on its protection against pollution. The main risks of Žitný ostrov groundwater pollution are over fertilizing, intensive application of herbicides and pesticides as well as illegal waste dumping.

What can be expected in water and energy resources in Slovakia?
Forests in Slovakia belong to temperate climatic zone forests, their area is increasing and covers about 42% of Slovak territory. But, reduction of arable land area (14,400 km^2, i.e. 29% of Slovak territory) is significant. Enlarged are impermeable surfaces (buildings,

communications, industrial objects), in the last decades, which can lead to local runoff increase and decrease of evaporation, followed by the temperature increase.

As a result of a climate change, there was measured air temperature increase during the last century about 1°C. This gain increases potential evapotranspiration, i.e. maximum possible under given meteorological conditions. Global increase of evaporation, particularly from oceans and seas is resulting in increased precipitation totals around the world. Evapotranspiration in Slovakia during the past 30 years increased about 10%; but potential evapotranspiration increased even more, reflecting higher temperature of the atmosphere (Pekárová et al., 2017). As a result, the runoff – especially in southern parts of Slovakia – is decreasing and recharge of groundwater by infiltration from rivers is decreasing too. Therefore, there is an urgent need to retain as much water as possible in catchments. The effective method of water retention increase are relatively big water reservoirs (with volume of several million cubic meter) and managed aquifer recharge (ISO/TR 13793:2014).

Arrangement of small water reservoirs is not a good solution. In reservoirs with a small retention volume, water quickly increases its temperature, followed by eutrophisation and overgrowing. Water in such reservoirs cannot be used even for irrigation and communal consumption. Suitable method to increase retention of water is artificial infiltration of water from channels or rivers to recharge groundwater. Utilisation of infiltration basins with permeable bottom to recharge groundwater are often used in some countries.

Other frequent myth is the idea of increasing retention of water in the landscape by forestation. Forestation of land is good idea, because green woody surfaces with relatively high rate of transpiration are consuming solar energy, thus decreasing ambient temperature, as well as incorporating carbon dioxide in the process of photosynthesis, they are decreasing outflow, and they are important anti – erosion element, but they are not accumulating water. On the contrary, water retention by forests is small, because forests are intensifying water circulation. About one third of precipitation in coniferous forests is intercepted and evaporated (in leafy forests it is about one fifth of precipitation), this part of precipitation even do not reach soil surface. This phenomenon is not felt negatively, because forests are usually located in mountains with high precipitation totals. But, the runoff is decreased by this phenomenon significantly.

Climate change is accompanied by increasing risk of local floods. Forests interception capacity with its maximum up to 6 mm water layer cannot prevent floods, because rain intensity is often higher than 10 mm per hour and such precipitation total is often higher than 100 mm. If the soil is fully saturated with water from previous precipitation events, practically all the precipitation can outflow and result is „flash flood“ (Pekárová et al., 2011). The floods in last years were observed even in the small, forested catchments.

Idea about „green landscape“ is good solution. Green canopies are consuming energy to transpirate, absorbing carbon dioxide in photosynthesis, they are important anti – erosion element, suitable environment for animals and what is for people most important - produce biomass as the basic element of food chain of all living organisms.

Ecosystem stability and climate change

There is no doubt: current global changes (climate change, land use change, fossil fuels burning, interactions of the Earth and outer space) are strongly influencing biosphere (ecosystem) and its components: plants and living organisms. Climate is the most important phenomenon responsible for distribution of vegetation and living organisms across the Globe. Flow of water and energy is determined by the input of energy from the Sun. Global warming increases temperature of the ecosystems in the range 1°C to 4°C and changes their properties. In principle, those phenomena are initiating shift of plant and animal species to the poles direction. Plant species (including crops) were changing their territories, even in the past, but the rate of global changes (and climate as their part) are accelerating and suggests that such changes can be realised relatively fast, up to ten times faster, than it was previously, following warming after the last glacial maximum. It is not clear if plant communities (and animals as well) would be able to follow relatively rapid shift of climate zones. It is expected, that some plant species will not be able to follow climate change speed and will die out, because they will not be able to adapt to such climate change. This so called „filtration“ effect will be proportional to the rate of such changes. It is expected, that areas with natural conditions suitable to alpine and arctic plant and animal species will be smaller, fragmented and isolated, so it is expected that some of them die out (Malcolm and Pitelka, 2000). Displacement of so called invasive plants observed in the last decades even in Slovakia is probably the effect of climate zones shift to northern direction.

Conclusions

Global changes refer to planet scale changes in the environment, human society and economy. Climate change is only one of many particular global changes. Reasons of such changes are natural and anthropogenic. Natural reasons of climate change depend mainly on interactions among the Earth and outer space.

Since the nineteenth century, increasing population caused pressure to increase consumption of food, raw material and energy, therefore started the so called industrial revolution, induced great scale land use change, emission of greenhouse gases, replacing natural surfaces by artificial ones. This activity changed the structure of mass and energy fluxes in the ecosystem. It was estimated, about 60 percent of the Earth`s surfaces are anthropogenically modified. Those anthropogenic changes of land surface led to the decreasing evapotranspiration and a part of solar energy previously spent as latent heat of evaporation is increasing the Earth`s temperature. By combustion of fossil fuel, carbon dioxide is produced and its concentration in the atmosphere is increasing. Part of planet`s long – wave radiation catched by the CO_2 molecules is dissipated back

to the Earth surface and thus increasing ecosystem temperature. According to the measurement, the average annual increase of back long-wave radiation is 0.02 W m^{-2}. Clearing of forests – especially rain forests – decreased evapotranspiration, carbon dioxide sequestration and thus secondary contributes to global temperature increase; the annual increase of energy rate flux per year is 0.016 W m^{-2}. Assuming, that 1% of land is anthropogenically changed, then the „saved" energy flux is 0.0022 W m^{-2}. Sum of those three anthropogenically induced fluxes is 0.038 W m^{-2}; which can contribute to the increasing of the Globe atmosphere temperature. For comparison, the average solar energy flux to the Earth surface is 350 W m^{-2}.

Increasing demand on food, raw materials and energy creates pressure on their production. Arable land areas, needed to produce biomass as a basic source of food are limited as well as areas suitable for cattle breeding. Deposits of raw materials are limited and it is expected to be exhausted in the next century. Results of analysis have shown, that renewable resources of energy can cover about ten per cent of expected demand at the end of this century (Makarieva, et al., 2008).

There is enough fresh water even for growing population of the Earth, but fresh water resources are not distributed evenly over the Globe and are not available everywhere, therefore it can be expected tensions related to the water resources. In Slovakia, there are used about one third of readily existing water resources only, therefore even in conditions of climate changes there is enough fresh water for all. The weak point is in regional and local availability of fresh water. There is need for completing and enhancing the water supply infrastructure.

To preserve environment of the planet sustainably suitable for life, it is necessary to achieve equilibrium between production of the ecosystem and its consumption by living organisms. Until now, civilisation is consuming much more, than sustainable productivity of Earth`s ecosystem can bear.

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References

Crutzen, P. J. (2002): Geology of Mankind. Nature, v. 415, 23.

Feldman, D. R., Collins, W. D., Gero, P. J., Torn, M. S., Mlawer, E. J., Shippert, T. J. (2015): Observational determination of surfavce radiative forcing by CO_2 from 2000–2010. Nature, 519, 339–343.

Holgate, S. J. (2007): On the decadal rate of sea level change during the twentieth century. Geophysical Research Letters, 34. 10.1029/2006GL028492.

ISO/TR 13973:2014(E). Artificial recharge to groundwater. Technical Report, 32p.

Izakovičová, Z., Špulerová, J. (2018): Dopad globálnych megatrendov na krajinu a jej ekosystémy. Ústav krajinnej ekológie SAV, Bratislava.

Kirchner, I. G., Stenchikov, H. F., Graf, A. A, Robock, J. A. (1999): Climate model simulation of winter warming and summer cooling following the 1991 Mount Pinatubo volcanic erruption. J. Geophys. Res.,104, 19,039–19,055.

Knoblauch, C., Beer, C., Liebner, S., Grogoriev, M. N, Pfeifer, M. N. (2018): Methan production as a key to the greenhouse budget of thawing permafrost. Nature Clim. Change, 8, 31–312.

Kollár, A. (2001): Water resources, their exploitation and protection. Život. Prostr., 35, 160–162. (In Slovak.)

Kutílek, M. (2008): Global warming rationally. Dokořán, Praha, 185 p. (In Czech.)

Kutílek, M., Nielsen, D. R. (2010): Facts about global warming. Catena Verl. GMBH, Reiskirchen, Germany, 227 p.

Kutílek, M., Landgráfová, R., Navrátilová, H. (2013): Homo adaptabilis (Lidé jsou přizpůsobiví). Dokořán, Praha, 158 p. (In Czech.)

Makarieva, A. M., Gorskhov, V.G., Li Bai-Lian. (2008): Energy budget of the biosphere and civilisation: Rethinking environmental security of global renewable and non-renewable resources. Bilogical Complexity, v.5, 281–288.

Malcolm, J. R, Pitelka, L. F. (2000): Ecosystem and global climate changes. Pew Center on Global Climate Changes, Arlington, Va.

Műnz, T. (2019): Are we leaving? Petrus, Bratislava, p. 228. (In Slovak.)

MŽP SR (2018): The state of an environment in Slovak republic in 2017. Annual Report, Ministry of Environment, Slovak republic, (MŽP SR), Bratislava, SAZP SR.

Nemešová, I., (2007): Climate change as a part of global change. Meteorol. Zprávy, 60, 1–6. (In Czech.)

Novák, V. (2012): Evapotranspiration in the Soil – Plant – Atmosphere System. Springer Science + Business Media, Dordrecht, 253 p.

Pekárová, P., Miklánek, P., Pekár, J. (2017): Hydrological balance structure changes of Slovakia. In: 24th Int. Poster Day Transport of water, chemicals and energy in the SPAC, Inst. Hydrol. SAV, Bratislava, 204–210.

Pekárová, P., Svoboda, A., Novák, V., Miklánek, P. (2011): Historic hydrology and integrated management of catchment and landscape. Vodohospodársky Spravodajca, 54, 4–7. (In Slovak.)

Rejmers, N. F. (1985): Alphabet of nature: Biosphere. Horizont, Praha, 176 p. (In Czech.)

Shuttleworth, W. J. (1988): Evaporation from the Amazonian rainforest. Proc. Roy. Soc., London, B233, 321–346.

Vinas, M. J., Rasmussen, C. (2015): Warming seas and melting ice sheets. News, August, 25.

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