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On the Problems of Acid Precipitation in the Modern World

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Abstract:

This article discusses the problems of acid precipitation in the modern world. An analysis of the problem of acid rain in different regions and countries of the world is given. The article considers the factors that cause acid precipitation in the atmosphere, and also analyzes the problems of acid rain and the negative impact on the environment. Some recommendations for solving this problem are given.

Keywords: rainwater, acid rain, sulfur and nitrogen oxides. acidity index, acid-forming particles, inhibition of foliage and needles, toxic acids.

INTRODUCTION

As is known, ordinary rain water is a slightly acidic solution. This occurs because natural substances in the atmosphere, such as carbon dioxide (CO2), react with rainwater. The optimal pH value for rainwater should fluctuate within the range of 5.6 ... 5.7, but in real life, the acidity of rainwater in one area may differ from the acidity of rainwater in another area. This primarily depends on the composition of gases contained in the atmosphere of a particular area, such as sulfur oxide and nitrogen oxides.

As a rule, it is not possible to visually distinguish acid rain from rain with a normal pH level. But if you live in a large city with a lot of vehicles and industrial enterprises, then rest assured that the rain, fog or snow that is observed in your city is most likely saturated with toxic acids. But even if you are a happy inhabitant of the countryside, and the nearest city is hundreds of kilometers away, then you should not count on the safety of precipitation. Acid precipitation is a real problem for almost all countries in the world at the present stage. The normal pH of precipitation is 5.6, while acid rain and fog have a level within the pH of 2.5-5. The main sources of acid precipitation are sulfuric (H2SO4) and nitric (HNO3) acids, which are contained in such precipitation. Acids, in turn, are formed as a result of the chemical reaction of sulfur oxides and nitrogen oxides with water. The

above-mentioned oxides are an obligatory component of any atmospheric air in large cities, as they are components of emissions from industrial enterprises and motor vehicles.

LITERARY RESEARCH

By the term "acid rain" science means any meteorological precipitation (including snow and hail), during which a strongly acidic reaction occurs. Among the sources of this phenomenon are the activities of heavy industry enterprises (especially metallurgy), which emit large amounts of nitrogen oxide and sulfur into the atmosphere. In addition, acid rain is caused by the activity of thermal power plants and the exhaust gases of vehicles.

The process of acid precipitation occurs in the following sequence: when hydrogen chloride and nitrogen or sulfur oxides get into the air, they react with solar radiation and droplets of water floating in the air. As a result, acid is formed - sulfuric, sulfurous, nitric or nitrous. After this, the acid falls to the ground in the form of precipitation. The acid can take the form of rain, snow, hail, fog and cause serious damage to fauna, flora and open water bodies in all regions of planet Earth. Acid rain, appearing in the atmosphere, causes great damage to forests, comparable to deforestation.

During the operation of automobile engines, thermal power plants, and other factories and plants, nitrogen and sulfur oxides are emitted into the air in large quantities. These gases enter into various chemical reactions and, as a result, acid droplets are formed, which fall as acid rain or are carried as fog. Acid precipitation can fall not only as rain, but also as hail or snow. Such precipitation causes 5-6 times more harm, since it has a higher concentration of acids.

The impact of acid precipitation on the environment is expressed in the following:

- the ecosystem of reservoirs changes, which leads to the death of fish and algae;
- water from polluted reservoirs cannot be used due to the increased concentration of toxins in its composition;
- damage to foliage and tree roots, which leads to their death;
- soil where increased acidity of precipitation is constantly noted becomes unsuitable for the growth of any plants.

The term "acid rain" was first introduced in 1882 by the English scientist Robert Smith [1] in his book "Air and Rain: The Beginning of Chemical Climatology". His attention was drawn to the Victorian smog in Manchester. Although scientists at that time rejected the theory of acid rain, today no one doubts that acid precipitation is one of the causes of the death of forests, crops and vegetation. In addition, acid rain destroys buildings and cultural monuments, pipelines, makes cars unusable, reduces soil fertility and can lead to the seepage of toxic metals into aquifers.

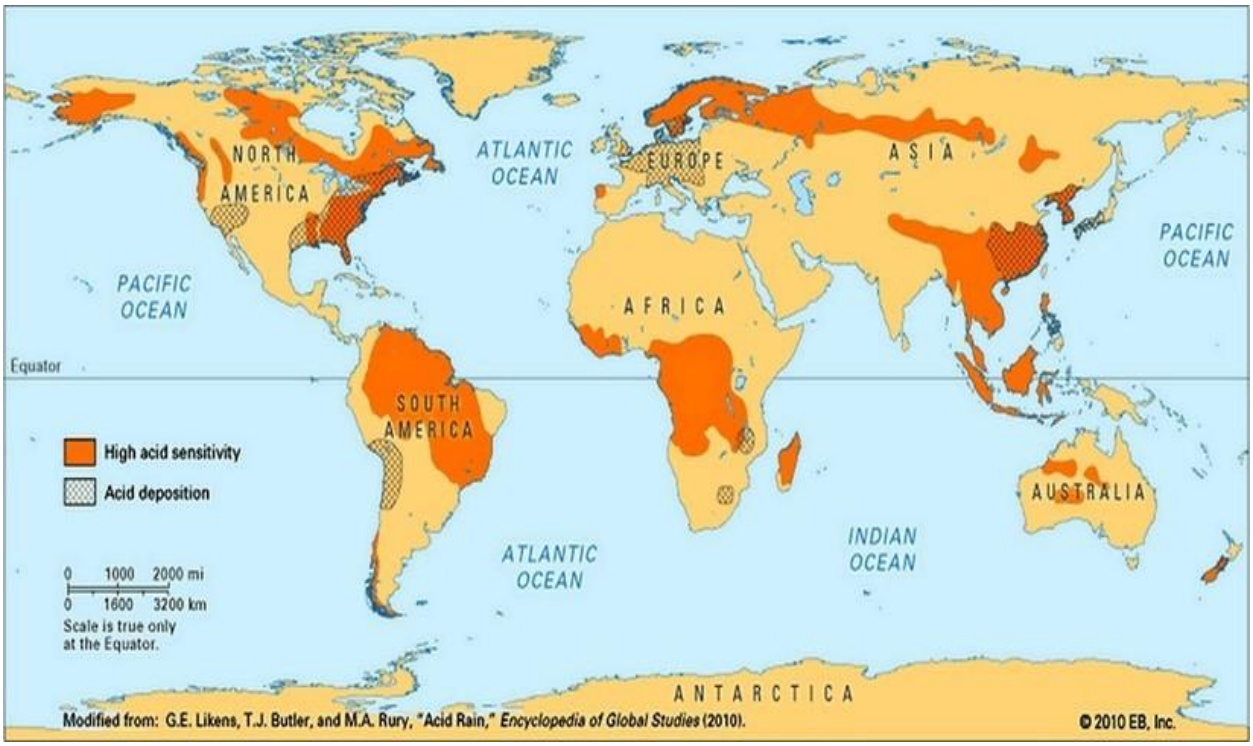

Figure 1. Illustration of acid precipitation in different countries of the world.

The materials of the authors G.E.Likens, T.J. Butler and M.A. Rury [2] present information, which illustrates (Fig. 1) the most dangerous areas of the planet Earth, where the level of acid precipitation exceeds the permissible limits. The figure shows in orange the regions where acid precipitation regularly falls, in gray shading - the main places of formation of toxic oxides. From this figure it follows that the main share of emissions into the atmosphere of sulfur and nitrogen oxides falls on those countries where industrial production is highly developed, which causes atmospheric air with acid precipitation.

According to G.E. Zaikov [3], it is necessary to save nature from acidification. As the author states: this will require a sharp reduction in emissions of sulfur and nitrogen oxides into the atmosphere, but primarily sulfur dioxide, since it is sulfuric acid and its salts that account for 70-80% of the acidity of rains that fall at large distances from the site of industrial emissions.

The source materials [4] note that in India, the frequency of acid rainfall has been increasing over the past 40 years. The industry of this country is responsible for huge emissions of sulfur dioxide. It is expected that emissions of this compound and nitrogen dioxide in India will grow at least until 2030. In addition, due to excessive use of fertilizers and pesticides, local farmers add ammonia and chemically active nitrogen compounds to the atmosphere, which further increases the acidity of precipitation. In general, according to experts, today sulfur dioxide emissions in the western parts of the world are decreasing, and the situation with acid rain there is improving. At the same time, in the east, in the regions of South and Central Asia, the situation is worsening due to the growth of the industrial sector and increasing population density.

Taylor Echolls [5] believes that acid rain is responsible for serious environmental damage around the world, and is most common in the northeastern United States, Eastern Europe, and increasingly in parts of China and India. According to the Environmental Protection Agency (EPA), acid rain can be particularly harmful to the young growth of many plant species and wildlife. He also notes that acid rain is a serious environmental hazard, and if left unchecked in countries with weak emission laws, it can negatively affect animal and plant life, as well as the structure of buildings, for generations.

METHODOLOGY

Any rainwater has a certain level of acidity. In a normal situation, this indicator corresponds to a neutral pH level of 5.6-5.7 or slightly higher. Slight acidity is explained by the content of carbon dioxide in the air, but it is considered so low that it does not cause any harm to living organisms. The pH indicator varies in different bodies of water, but in an undisturbed natural environment, the range of these changes is strictly limited. Natural waters and soils have buffering capabilities; they are able to neutralize a certain part of the acid and preserve the environment. However, it is obvious that the buffering capabilities of nature are not unlimited. Thus, the causes of acid rain are associated exclusively with human activity and cannot be explained by natural causes.

According to experts, acid precipitation is most often observed after a long period of hot and dry weather. That is, typical summer thunderstorms and showers that come after the scorching sun and a long period of clear weather contain a high amount of aggressive acids. A single case, of course, is not capable of radically changing the environmental situation, but regular precipitation and the cumulative effect make themselves felt.

Acid precipitation is the result of environmental pollution with toxic substances. Compounds of cobalt, aluminum, cadmium, lead, solutions of nitric and sulfuric acid get into rain moisture and fog. Under the influence of acid precipitation, toxic substances that get into water bodies and fall out as precipitation lead to the death of fauna, a decrease in crop yields, and poison people who drink liquid. The damage they cause to nature and cultural heritage is quite significant: tropical forests are depleted, architectural monuments are destroyed, crop yields suffer, flora and fauna are harmed, and human health is damaged.

Almost all pollutants that initially enter the atmosphere eventually settle on the surface of land and water. Settling aerosols may contain toxic heavy metals - lead, cadmium, mercury, copper, vanadium, cobalt, nickel. Usually they are slow-moving and accumulate in the soil. But acids also enter the soil with rain. When combined with them, metals can turn into soluble compounds available to plants. Substances that are constantly present in soils also turn into soluble forms, which sometimes leads to the death of plants. An example is aluminum, which is very common in soils, the soluble compounds of which are absorbed by tree roots. Aluminum disease, which disrupts the structure of plant tissues, is fatal for trees.

It should be noted that acidic precipitation washes away the nutrient salts necessary for plants, containing nitrogen, phosphorus and potassium, which reduces soil fertility. An increase in soil acidity due to acid rain destroys beneficial soil microorganisms, disrupts all microbiological processes in the soil, makes it impossible for a number of plants to exist and sometimes proves favorable for the development of weeds.

The prerequisites for an increase in the acidity of atmospheric waters arise from industrial emissions of large volumes of sulfur oxides and nitrogen oxides. The most typical sources of such pollution are car exhaust gases, combustion products of metallurgical industries and thermal power plants (TPP). Unfortunately, the current level of development of purification technologies does not allow filtering out nitrogen and sulfur compounds formed as a result of burning coal, peat and other types of raw materials used in industry. As a result, such oxides enter the atmosphere, combine with water as a result of reactions under the influence of sunlight and fall to the ground in the form of precipitation, which is called "acid rain".

The term "acid rain" refers to all types of meteorological precipitation - rain, snow, hail, fog, sleet, the pH of which is lower than the average pH of rainwater. Sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emitted by human activity are transformed in the earth's atmosphere into acid-forming particles. These particles react with atmospheric water, turning it into acid solutions, which lower the pH of rainwater.

Acid rain was first recorded in Western Europe, particularly Scandinavia, and North America in the 1950s. Today, this problem exists throughout the industrial world and has acquired particular significance due to increased man-made emissions of sulfur and nitrogen oxides. Over the course of several decades, the scope of this disaster has become so widespread and the negative consequences so great that in 1982, a special international conference on acid rain was held in Stockholm, attended by representatives of 20 countries and a number of international organizations. The problem remains acute to this day and is constantly at the center of attention of national governments and international environmental organizations. On average, the acidity of precipitation, which falls mainly as rain in Western Europe and North America over an area of almost 10 million square kilometers, is 5-4.5, and fogs here often have a pH of 3-2.5. In recent years, acid rain has begun to be observed in industrial regions of Asia, Latin America, and Africa. For example, in the Eastern Transvaal (South Africa), where 4/5 of the country's electricity is generated, about 60 tons of sulfur fall per square kilometer per year in the form of acid rain. In tropical regions, where industry is practically undeveloped, acid rain is caused by the release of nitrogen oxides into the atmosphere due to the burning of biomass.

A specific feature of acid precipitation is its transboundary nature, caused by the transfer of acid-forming emissions by air currents over large distances – hundreds and even thousands of kilometers. This is largely due to the "high chimney policy" once adopted as an effective means of combating ground-level air pollution. Almost all countries are simultaneously "exporters" of their own and "importers" of others' emissions. The "wet" part of the emissions (aerosols) is exported, while the dry part of the pollution falls in the immediate vicinity of the emission source or at an insignificant distance from it. The exchange of acid-forming and other air polluting emissions is characteristic of all countries in Western Europe and North America. Great Britain, Germany, and France send more oxidized sulfur to their neighbors than they receive from them. Norway, Sweden, and Finland receive more oxidized sulfur from their neighbors than they emit through their own borders (up to 70% of acid rain in these countries is the result of "export" from Great Britain and Germany). The territory of Canada also suffers from acid precipitation, the cause of which is air masses from the neighboring country of the USA. Transboundary transfer of acid precipitation is one of the reasons for the conflictual relations between the USA and Canada. For this reason, even agricultural countries that do not make a large contribution to atmospheric pollution can suffer from acid precipitation, the cause of which will be their close and distant neighbors.

Toxic substances formed over cities are carried over long distances by air masses. Of course, their concentration decreases over time, as polluting particles are dispersed, but they eventually fall to the ground along with precipitation. Neighboring countries suffer from transboundary transfer of air masses, which often causes mutual claims and conflicts. For example, Scandinavian countries such as Sweden and Norway are hostages of their geographical location, since it is to them, along with the dominant westerly winds, that a significant amount of nitrogen and sulfur oxides produced in the United Kingdom, France and Germany fall. Acid precipitation often falls in the countries of Northern Europe, for which we should thank our neighbors from Western Europe. A similar situation is observed in the European part of Russia, where, according to experts, about 40% of sulfur falling with precipitation comes from Poland, Ukraine, Germany and other European countries.

The main threat to trees and other forest plants is acid rain, which falls due to the emission of sulfur dioxide by power plants. These emissions have the ability to be transported over long distances from the immediate site of emission. In the last 20 years alone, earthlings have lost about 200 million hectares of valuable forests. Of particular danger is the depletion of tropical forests, which are rightly considered the lungs of the planet. Under the influence of acid rainfall, forests dry out, and dieback develops over large areas. Acid increases the mobility of aluminum in soils, which is toxic to small roots, and this leads to the suppression of foliage and needles, and the fragility of

branches. Coniferous trees suffer especially, because needles are replaced less often than leaves, and therefore accumulate more harmful substances over the same period.

The Earth and plants suffer the most from acid rain: soil productivity decreases, the supply of nutrients is reduced, and the composition of soil microorganisms changes. Acid rain causes increasing damage to agricultural crops: plant covering tissues are damaged, cellular metabolism changes, plants slow down their growth and development, their resistance to diseases and parasites decreases, and crop yields decrease.

In the 1970s, the development of a Memorandum of Understanding between the United States and Canada to reduce air pollution and acid rain began. At the UN Conference on the Environment in Stockholm in 1972, countries initiated international cooperation to address these issues. The Geneva Convention on Long-Range Transboundary Air Pollution, adopted in 1979, formed the basis for a set of measures to reduce air pollution and acid rain in Europe. In fact, this document became the first legally binding international agreement on this topic.

Thanks to the measures taken, the frequency of acid rainfall in Europe and eastern North America has decreased. If in the 1970-80s the pH of rain in the latter region could drop to 2.1, now, thanks to control, the maximum acidity of rain is recorded on average at 3.7.

CONCLUSIONS

In my opinion, one of the ways to solve the problem of acid rain is to reduce harmful industrial emissions into the environment, or take all measures to use cleaning filters and equipment at all enterprises where sulfur oxides and nitrogen oxides are emitted. This will give much more significant results than it seems at first glance. Along with this, it is necessary to improve the technology of cleaning from pollution, cleaning filters and facilities. The most long-term, expensive, but also the most promising solution to the problem is the creation of environmentally friendly enterprises in the future. All modern technologies should be used taking into account the assessment of the impact of activities on the environment.

Modern types of transport cause a lot of harm to the atmosphere. It is unlikely that people will give up cars in the near future. However, new environmentally friendly vehicles are being introduced today. These are hybrids and electric cars. Cars such as Tesla have already won recognition in different countries of the world. They run on special batteries. Electric scooters are also gradually gaining popularity. In addition, we should not forget about traditional electric transport: trams, trolleybuses, metro, electric trains.

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