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Factors of Human Activities Impact on the Nature in the Arctic Regions

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Abstract:

Ecological monitoring of the environment constitutes the basis for the study of natural objects and an integrated approach to the organization of both production and human activity at large. The purpose of the paper is to investigate the factors that influence human activity on the nature of the Arctic. The leading research methods for this problem are the method of analysing several factors of human activity on the dynamics of changes in nature, including the method of qualitative assessment, during which the general nature of the impact was identified. As a result, continuous observations were made of the state of the atmosphere. The data on the concentration of fine dust obtained from the Norilsk stationary post allow to identify the level of pollution. The assessment of impact factors was carried out, which allowed to determine the extent of impact on nature. The authors also conducted field work and tested 50 biological samples of wild reindeer in West Taimyr using the molecular genetic marker system. The novelty of the study is that organizational and methodological recommendations were developed for conducting production activities. The practical significance of the study is determined by the necessity of implementing the necessary scientific and administrative apparatus for the preparation and implementation of practical measures, since many theoretical aspects for further proposal of measures have not been sufficiently developed.

Keywords: nature conservation; depleted reserves; Nornikel; Ekovizor; wild reindeer.

JEL Classification: Q51; Q53.

Introduction

Norilsk is the northernmost city in the world with a population of more than 150 thousand people, the largest world-renown industrial centre located in the subarctic zone of the Krasnoyarsk Krai. Non-ferrous metal production of the Nornikel Mining and Metallurgical Company is concentrated on its territory. The organization of "green" production at the present stage of development is the most important component of the strategic management of any enterprise (Rusnak *et al.* 2018). The specificity of making strategic environmental decisions is that they are aimed at achieving and maintaining the optimal position of the enterprise in the competitive field and provide the requirements of the legislation that have consolidated the establishment of limits of responsibility for the environmental results of business operations (Topchiy and Tokarskiy 2018; Topchy 2018; Topchiy and Tokarskiy 2019a; Topchiy and Tokarskiy 2019b). These results are primarily of interest to investors, shareholders and other participants of the enterprise, including the public (Figure 1).

Figure 1. Geographical location of Norilsk

In 2004, Nornikel Mining and Metallurgical Company commenced the implementation of a program aimed at introducing the main management and production divisions to an integrated quality management and environmental management system that meets international standards. To this end, it became necessary to determine methodological approaches to the problem of environmental control and technological processes management at a metallurgical enterprise to minimize the negative impact on the natural environment of the region in severe Arctic conditions and create an efficient model for ensuring the environmental sustainability of Norilsk (Karmanovskaya 2009; Karmanovskaya *et al.* 2005; Pivnyak *et al.* 2013).

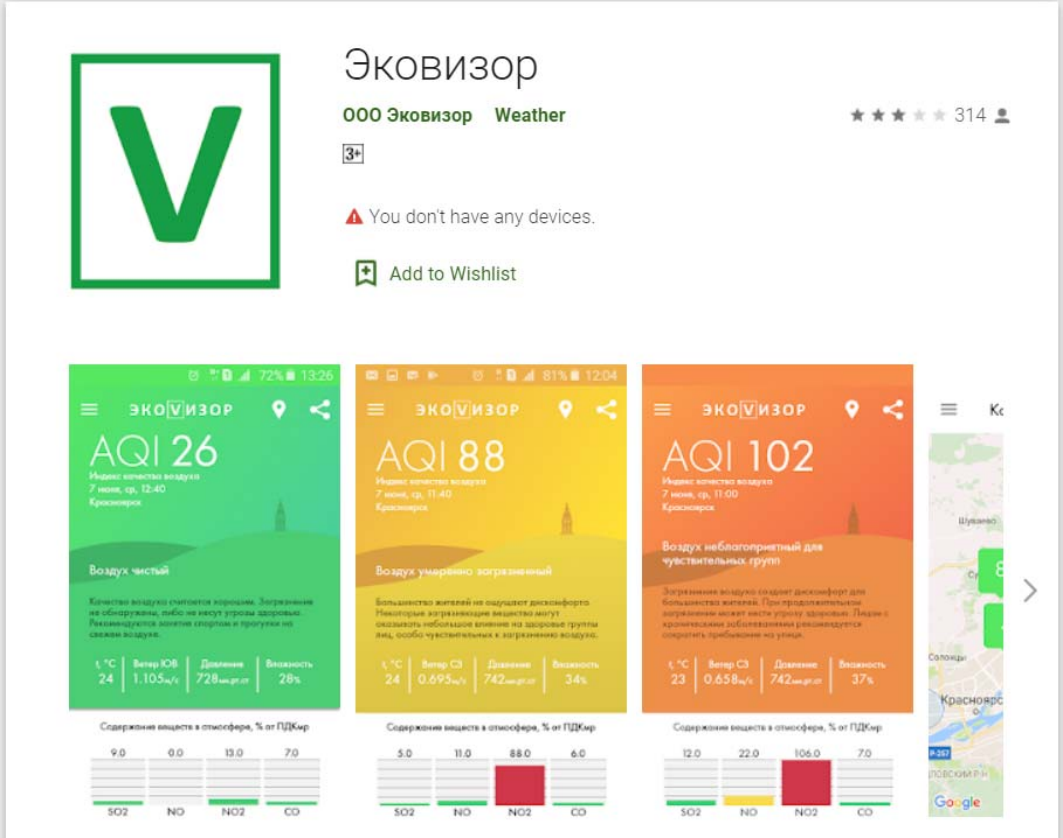
Currently, based on the Noosfera environmental education centre (a project of the Norilsk State Industrial Institute), a model of public environmental monitoring of the environment is under development, and the search for solutions to maintain a reasonable interaction between human activities and the environment, including rational and integrated use of natural resources, is ongoing (Anamova 2013; Kryvonos *et al.* 2017; Bespalov *et al.* 2019). These solutions are very diverse, as is the interaction itself. If we generalize them, then we can formulate the main directions – the conservation and restoration of natural resources, including their rational use; prevention of direct and indirect harmful effects of human activity on nature and, ultimately, on human health (Arystan *et al.* 2009; Yessilbaeva *et al.* 2015; Burkitbaev *et al.* 2015; Tatsiy *et al.* 2017; Burkitbaev *et al.* 2018; Volovik *et al.* 2018). In addition, it is necessary to strive to maintain a balance between the development of production and the sustainability of the natural environment, as well as to improve environmental quality management tools (Gubina *et al.* 2018; Elesin *et al.* 2019; Elesin *et al.* 2018; Karmanovskaya 2006; Karmanovskaya and Shulgin 2017; Karmanovskaya *et al.* 2018b; Karmanovskaya *et al.* 2018c).

1. Materials and Methods

The scientific basis for the study of natural objects and an integrated approach to the organization of both production and human activities in general is environmental monitoring. Considering the factors of the impact of human activity on nature, we shall divide them into qualitative and quantitative. During a qualitative assessment, we shall highlight the general nature of the impact – chemicals, radiation; exposure parameters – intensity, concentration, speed, particle size; action time – continuously for a long time, in different seasons of the year, day or night; the nature of the effect on a natural object – movement, destruction, changes in the quality, increases or decreases, enhancement or weakening. It is possible to identify other characteristics of the effects depending on each specific research purpose.

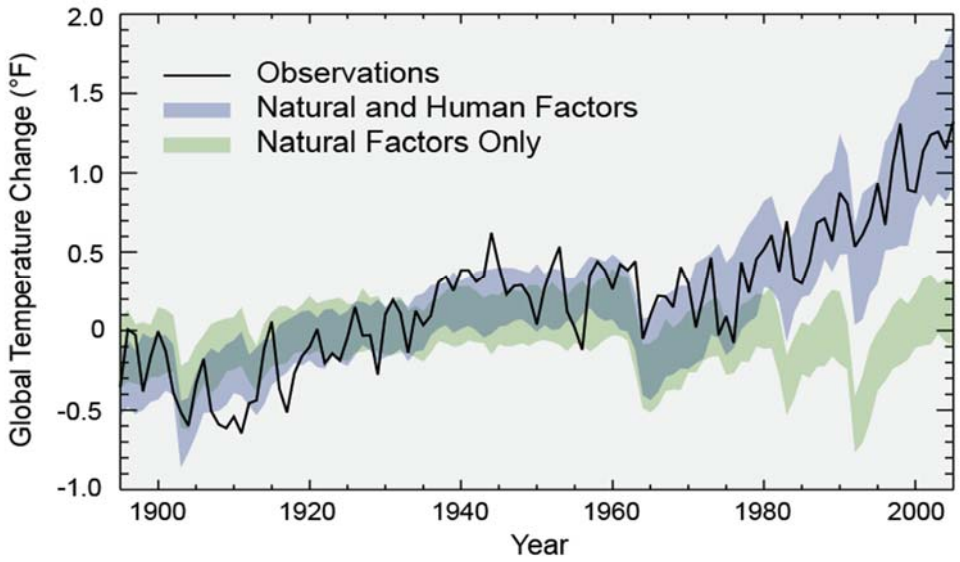
Since 2017, we have been conducting continuous observations of the state of the atmosphere. Each owner of a smartphone can receive data from a stationary post on-line. To do this, one needs to download (for free) “Ekovizor” – the first Russian mobile application of environmental orientation on Google Play or AppStore. The computer program automatically converts the data on the concentration of fine dust (in micrograms per cubic meter of air) obtained from the Norilsk stationary observation post into the international AQI (Air Quality Index) and displays the level of pollution on a scale from 1 to 500, where the green zone (atmospheric air, meeting the sanitary requirements of the World Health Organization) corresponds to indicators from 1 to 50, yellow – from 50 to 100, red – over 100. The Ekovizor application allows users to familiarize themselves with the relevant medical recommendations (this is especially relevant for people suffering from respiratory diseases). Furthermore, the application has a section “People’s Control”: any smartphone user will be able to independently evaluate the atmospheric air, and these data will be laid over a map of the city (Figure 2).

Figure 2. Ekovizor application



Quantitative assessment of impact factors has the ultimate purpose of determining the extent of impact on nature. Quantitative indicators here will be the size of the space in which the factor is detected. In terms of the scale of the spanning space, factors are possible that act only at the point of impact – withering in oil spills, death of animals from the effects of transport, etc.; acting in the place of production and at a known distance from it – harmful substances in water bodies, air pollution and lithosphere, etc. (Kruzhilko *et al.* 2019a; Kruzhilko *et al.* 2019b); action extends over vast distances – persistent chemical pollution in the atmosphere or hydrosphere, long-lived radioactive substances, etc.

Figure 3. Separating human and natural influence on Climate



Other quantitative indicators will be:

- the degree of filling of this space with a factor;
- the total number of elementary or complex factors in the investigated space;
- the degree of exposure to the factor of a natural object;

- the degree of damage to a natural object from the impact of human activity.

The total number of factors (elementary and complex) is an important quantitative indicator of the degree of human impact on nature (Figure 3). The degree of exposure to the factor of the studied objects (or even elements of nature) is of importance in identifying anthropogenic effects on discrete objects, such as populations of organisms. This degree of coverage can be expressed in terms of the percentage of individuals affected. As an example, we shall provide the following indicators of the degree of coverage of the elements of nature: the percentage of ploughed soil, the percentage of cut trees, the percentage of cutting area to the entire forest area, the percentage of animals caught (or shot), the percentage of the area of the reservoir with chemical pollution. Taimyr is home to the largest population of wild reindeer. Therefore, the conservation of Taimyr biodiversity is very important. We carried out field work and tested 50 biological samples (skin samples) of wild reindeer of the West Taimyr using the molecular genetic marker system based on AG-inter-microsatellite loci using PCR analysis. The results of the paper demonstrate that animals of two genotypes enter the studied migration flow of West Taimyr.

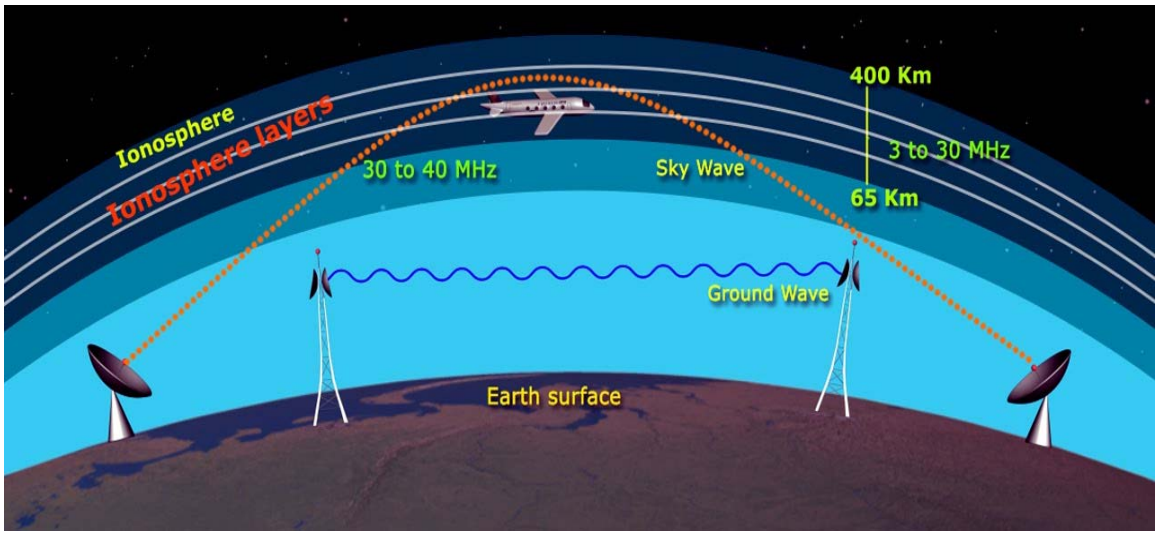
It is possible to determine the categories within the population by an in-depth study of the genotype of wild reindeer of the Taimyr Peninsula. To obtain more in-depth data on the level of genetic diversity of the studied species, it is necessary to conduct a comparative analysis of the gene pools of wild and domestic Taimyr reindeer populations. By conducting genetic studies of the entire Taimyr population, one can trace the mechanism of molecular evolution (Kolpashchikov *et al.* 2008).

2. Results and Discussion

Identification of the degree of damage caused by human exposure to objects (elements) of nature is an extremely important task. By damage we understand qualitative and quantitative changes in an object (element) of nature that have negative consequences for human. With that, the economic effect is not factored in. Qualitative damage, for example, for soil, water and air is expressed in their pollution, for organisms – in the appearance of foreign chemicals in their bodies, in physiological and morphological changes, changes in genetic heredity. A quantitative assessment of qualitative damage can be performed through the percentage of a qualitatively changed volume of the protected object to its entire volume in the region chosen by the researcher (Karmanovskaya *et al.* 2018a; Baymuratov *et al.* 2018; Skrypniuk *et al.* 2019).

The interaction of anthropogenic factors starts from the moment they penetrate nature and can sometimes continue for a long time, even for millennia. A consequence of the interaction of factors can be an increase or a weakening of the effect of each of them on the element of nature that we are studying. It is known that in some cases, the interaction of chemical compounds discharged into water leads to the formation of inert substances or substances that are more toxic to wildlife than the initial ones. For example, the Minamata disease, which occurred after discharging chemical waste into the ocean (Japan).

Figure 4. Electromagnetic wave propagation

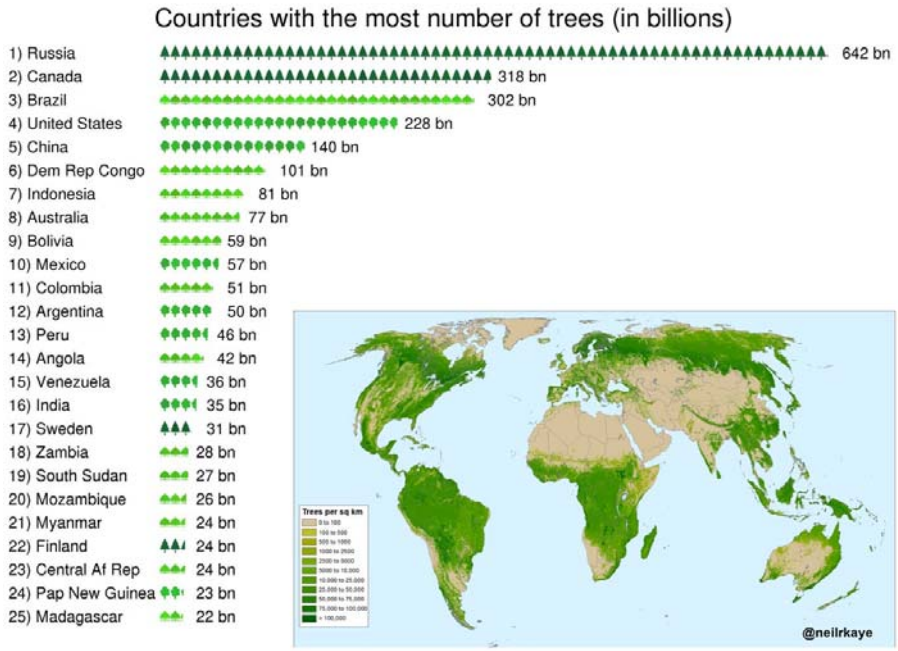


Some factors can neutralize the effects of others. For example, planting a forest over time neutralizes its destruction in the process of logging or burning, and fish farming to some extent neutralizes the effects of intensive fishing. The interaction of anthropogenic and natural factors has not been subjected to special study, despite its crucial importance. The results of the interaction can seriously vary. In many cases, anthropogenic factors only complement the natural factors related to them by nature. For example, dusting the atmosphere with emissions from thermal power plants enhances its natural dusting with wind (Kulikova 2009). It should be noted that several factors of human activity (radio waves, synthetic chemicals, vibrations, etc.) generally have no analogues in nature (Figure 4). Thus, we can outline primary factors –

anthropogenic, and secondary, which emerge under the influence of the primary factors (Miroshnichenko and Karmanovskaya 2010).

To solve many issues related to nature conservation, it is important to have a generalized idea of the power and breadth of the impact of anthropogenic factors on nature, which can be notionally called the intensity of anthropogenic impact. For territories similar in natural conditions, it is proposed to use the sum of percent of the area of the studied territories exposed to the main complex factors as an indicator of the anthropogenic impact intensity (in this case, the activities of people can be arbitrarily taken for them).

Figure 5. Countries with the greatest number of trees (2019, in billions)

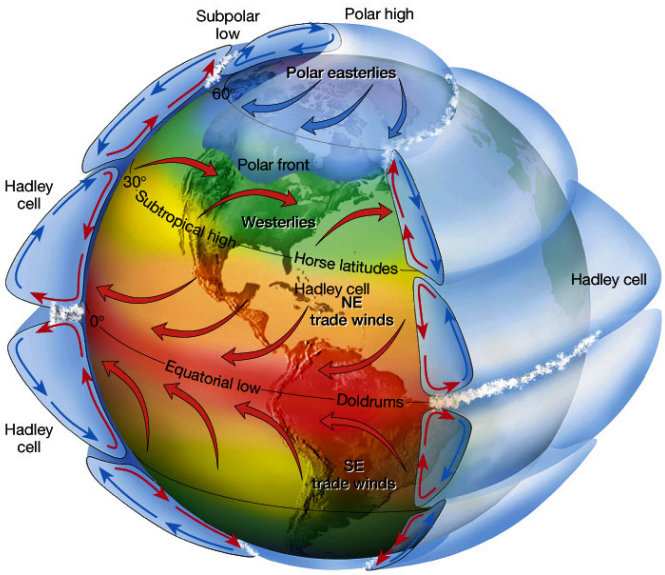


For the forest zone, for example, it is advisable to summarize the percentages of the cut down forest area, the cultivated area undergoing grazing and haying, hunting, occupied under the structures and settlements of the area subject to industrial pollution of the territory (Plaskova *et al.* 2017; Prodanova *et al.* 2017; Prodanova *et al.* 2019). For the compared territories, the list of complex factors may not coincide due to differences in the development of the economy (Rudenko 2017; Rudenko 2018; Rudenko 2019). For example, Figure 5 shows the ranking of countries with the most trees (it is worth noting that Russia takes first place in it). The restorative abilities of wildlife can even increase with some intensification of anthropogenic impacts due to increased fertility, which is based on the phenomenon of self-regulation of numbers, which is quite well-studied by ecologists. It should be noted that the intensity of self-healing of wildlife is not the same in different parts of the planet. For example, in the harsh conditions of the Arctic, where our city of Norilsk is located, it is lower than in the European part of the Russian Federation, and even more so in its southern regions (Zhilavskaya *et al.* 2020).

With the participation of wildlife, atmospheric restoration is possible. Thus, oxygen reserves are constantly replenished with the vital activity of plants, they also reduce the amount of carbon dioxide formed during natural processes and industry (Figure 6). Several contaminants in the form of particulate matter or aerosols are eliminated from the atmosphere by rainfall and by gradual precipitation. The so-called self-purification of river water under the influence of organisms, as well as due to precipitation and adsorption of dissolved substances on the surface of the soil, is well known. But these important atmospheric and water features, which were called regenerative, have a certain limit. As a result, in several regions of the planet, atmospheric and water pollution increases, since the intensity of their pollution ended up being higher than the regeneration intensity (Kulikova 2009).

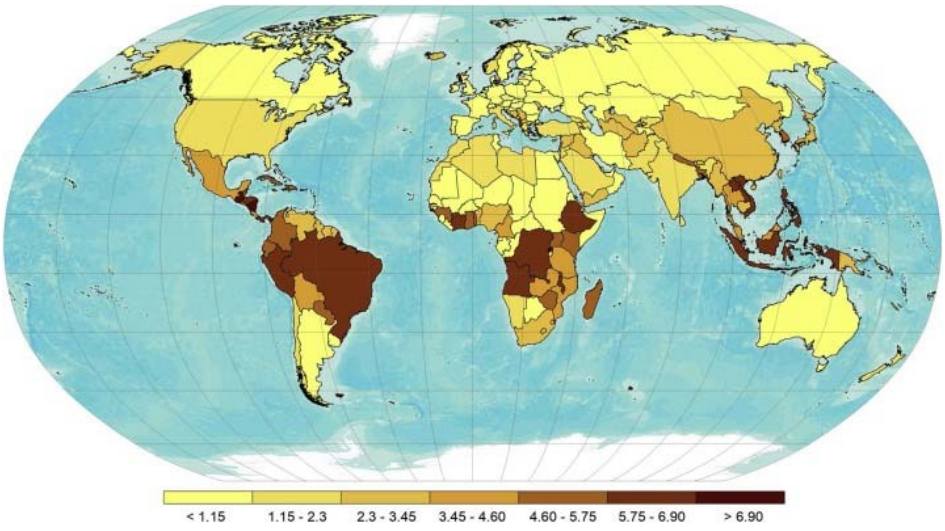
The restorative abilities of inanimate nature are extremely diverse. Many of them (minerals) are restored so slowly that it cannot be factored in. Soil erosion is a major environmental problem. It reduces land productivity through the loss of topsoil and nutrients, and reduced soil fertility (and therefore crop yields) and adds to global warming as it unlocks carbon dioxide (CO_2) emissions to the atmosphere. Destroyed soils can be restored, depending on the thickness of the layers and scale of the terrain, for tens, hundreds and thousands of years, for example, disturbed lands are restored hundreds of years (Figure 7). Soil erosion is also an economic problem, as it leads to increased food prices.

Figure 6. Atmospheric circulation



This economic cost is most keenly felt by the most vulnerable populations of the world. Restoring depleted groundwater reserves takes many years and decades. Similar facts suggest that the restoration abilities of inanimate nature are immeasurably lower than the currently achieved degree of exposure to anthropogenic factors, which leads to its further change, to the depletion of several resources (Miroshnichenko and Karmanovskaya 2010).

Figure 7. Estimated annual absolute land productivity losses in 2019 (%)



This conclusion is true in relation to wildlife (biosphere), the existence of which is seriously threatened. The urgency of the task of managing the production and the nature of the impact of anthropogenic factors is evident. The management of anthropogenic factors should be understood as the regulation of their selection, distribution in space, qualitative and quantitative features to ensure optimal conditions for the development of society. The main way of management will be the cessation, reduction or increase of production factors, which is already quite widely used in many states. For instance, in 2016, the Nickel Plant was closed in Norilsk. This 74-year-old enterprise emitted 350.000 tonnes of sulfur dioxide each year. Norilsk Nickel, the main employer in this industrial city 180 miles north of the Arctic Circle, initially denied any spill into the Daldykan – but later admitted that heavy rain had caused a filtration dam to flood into the river. The incident suggested that, despite Norilsk Nickel's efforts, environmental concerns are far from resolved in what has long been called Russia's most polluted city. The results of environmental studies in the plant area before 2016 and after are interesting. According to our observations, today we can talk about improvements in the ecosystem and its restoration (Kubekova *et al.* 2016).

The second, quite significant way is the neutralization of one factor by another: deforestation is neutralized by planting, fish harvesting by its cultivation, landscape destruction by restoration, etc. Sometimes the activated factor is specially moved to the area where it will cause the least harm to nature, as it is done with the waste of some industrial enterprises, all kinds of household pollution, and some other factors (Krechetov *et al.* 2018). The management of factors

includes a change in their qualitative features, which can be done even in the process of some regulation of their economic activities. For example, by changing the technological process at an industrial enterprise, the quality of such important complex factors as industrial effluents and ventilation emissions can be significantly improved (Kakhramanov *et al.* 2017; Formalev *et al.* 2017a; Formalev *et al.* 2017b; Gendler and Savenkov 2017; Formalev *et al.* 2018; Rabinskiy and Kuznetsova 2018; Formalev *et al.* 2019a; Formalev *et al.* 2019b). Ploughing without soil overturning sharply reduces the intensity of anthropogenic wind erosion of the cultivated soil (Figure 8).There are already quite a lot of similar examples (Karmanovskaya *et al*. 2011).

To manage anthropogenic factors, it is necessary to have a good idea of how to bring them into action, qualitative and quantitative features, and the nature of direct and indirect effects on nature, their interaction between themselves and with natural factors. Managing anthropogenic factors requires the necessary scientific and administrative apparatus for the preparation and implementation of practical measures.

Conclusions

In our studies, we shall analyse not only the dynamics of changes in nature under the influence of human activity factors, but also develop organizational and methodological recommendations for conducting production activities (wastewater treatment, the use of industrial wastes, improving the quality of production control). The accumulated facts, analysis and generalizations indicated that due to the saturation of nature with anthropogenic factors, including those completely new to it (soil ploughing, haying, trapping and shooting animals, plant collection, chemical and radioactive contamination, etc.), conditions for the evolution of organisms, the struggle for existence and natural selection have become completely different than in the past. To survive and leave enough offspring, organisms need other adaptation mechanisms and rates of evolutionary changes.

The variability, which represents the material for selection, was largely determined by human activity, which led to the appearance of diverse and powerful mutagenic factors in the environment (radioactive substances, pesticides, industrial pollution, etc.). In this regard, in the modern period of evolution of living, it is necessary to comprehensively study anthropogenic mutagenesis, anthropogenic conditions for the struggle for existence, anthropogenic natural selection, artificial selection in populations of wild organisms, and generally anthropogenic evolution of wildlife. Only with a special study of these phenomena will it be possible to correctly understand and anticipate changes in species, biocenoses and the entire organic world of the Earth, to develop measures to control the evolution of wildlife.

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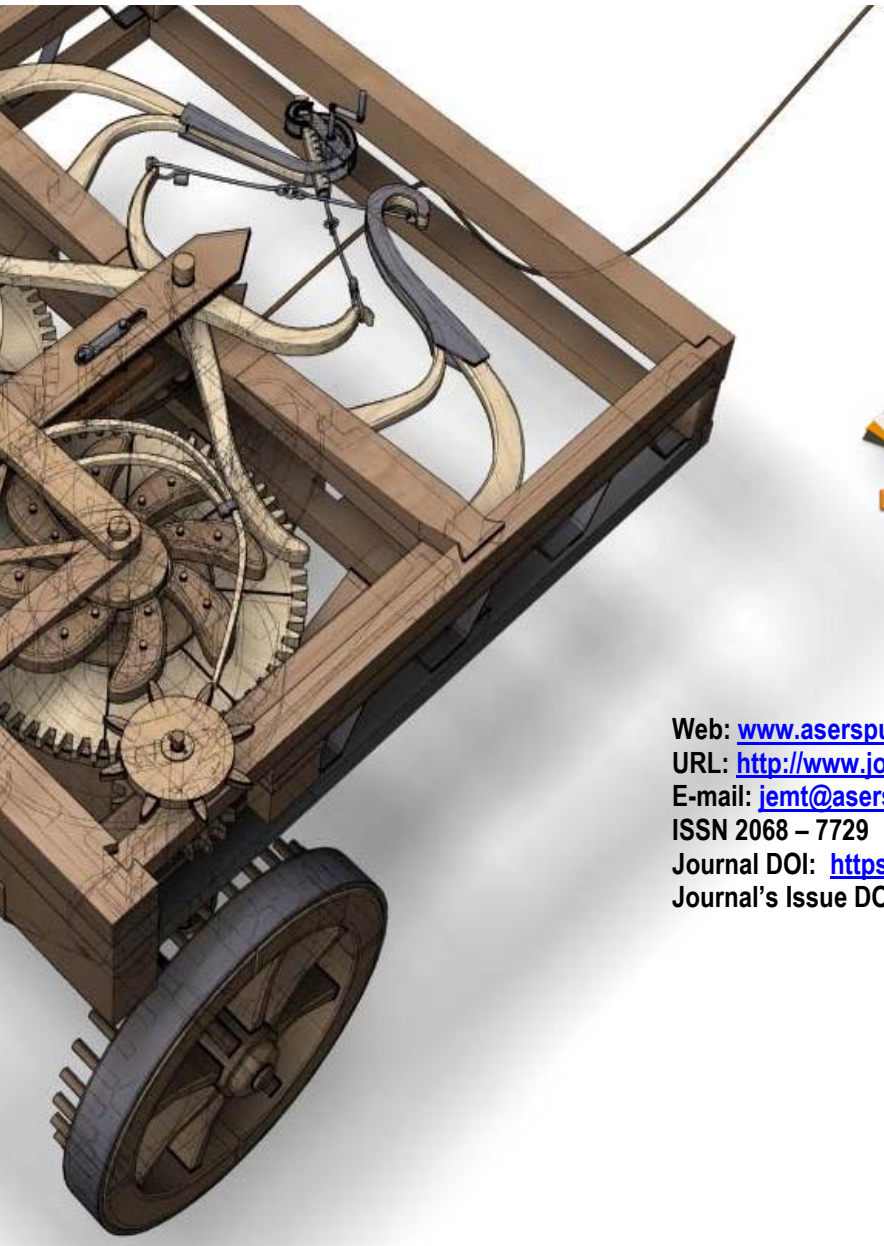

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