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THE IMPACT OF CRITICAL INFRASTRUCTURES ON ENVIRONMENTAL FACTORS

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Abstract: *The usefulness of critical infrastructure is identified by the goods produced and services provided to society, with great efforts, including the protection of the environment and human health. In this article, the impact of critical infrastructures on the environment is examined from the perspective of environmental factors. Thus, the impact of critical infrastructures on the main environmental factors is examined from the perspective of air, water and soil pollution. Nowadays, the effects of environmental factors, including those produced by critical infrastructure, were seen most strongly in both climate change and the human health. This shows a series of chain reaction effects on nature, plants, animals and people around the world. The endeavor of several states and relevant organizations consists in the considerable effort to mitigate these effects.*

Keywords: *critical infrastructures; environmental factors; air pollution; water pollution; soil pollution.*

Introduction

Critical infrastructures and the environment are in constant interaction, characterized by dynamic risk and sustainability. This article highlights both the main environmental factors affected by the functionality of critical infrastructures under normal conditions and the impact of critical infrastructures on the environment. The literature reveals an interdisciplinary analysis that includes the most significant environmental factors influenced by critical infrastructures. It should also be noted that there are currently a multitude of critical infrastructures designated by states in many areas of activities with a high impact on the environment. Moreover, current policies and strategies for environmental protection and how critical infrastructures have adapted to their requirements are particularly important.

Environment quality must be constantly maintained. The measures taken on protecting the environment and mitigating the effects of pollutants are key elements of environmental policies and strategies. Typically, any critical infrastructure sectors or subsectors faces a number of issues related to the impact of this critical infrastructures on the environment. Both the prevention, in accordance with the legislation in force, and the reaction, in case of an event with substantial environmental impact, are important for a critical infrastructure. A critical infrastructure operate within normal parameters in conditions of normality. In terms of environmental protection, each critical infrastructure, through its responsible staff, is aware of the environmental impact, wherever appropriate. In this respect, the infrastructure responsiveness must be emphasized when regulatory changes occur at international and national level, as a result of some understandings, agreements, partnerships, etc. Thus, through investments, human and financial efforts or certain restrictions, infrastructures align with the new environmental protection requirements. Hereinafter, the potential effects of critical infrastructure on the main environmental factors are analyzed, i.e. on air, water and soil.

Air pollution

Air pollution consists of substances in the atmosphere that are harmful to the health of humans and cause serious environmental damages. They can be gases, solid particles, liquid droplets, or biological molecules.[1] In general, gases contain nitrogen oxides, sulfur oxides, hydrocarbons and carbon monoxide, which are released directly into the atmosphere. In

[1] C. Lavanya et all, *Review article outdoor air pollution and health: A comprehensive review*, International Journal of Recent Scientific, 2014, available on https://www.researchgate.net/publication/324647363_ REVIEW_ ARTICLE_OUTDOOR_AIR_POLLUTION_AND_HEALTH_A_COMPREHENSIVE_REVIEW/link/5d5bc2c2a6fdcc55e819a711/download.

addition to these pollutants, also called primary pollutants, secondary pollutants like ozone can form in the atmosphere.[2] Air pollution originates from natural and anthropogenic sources. In this article, suitable anthropogenic sources are analyzed from the perspective of critical infrastructures. Thus, the burning of fossil fuels, industrial waste treatment process based on the use of solvents can be considered as sources of pollution caused by critical infrastructures.

Nowadays, coal, oil and natural gas resources continue to play a dominant role in global energy systems, even though these fossil fuels have a negative impact on the environment, population and significantly affect climate change. Thus, the energy sector is a key sector in providing services to domestic and industrial consumers. This indicates the presence of many energy producers, dependent on countless non-renewable and renewable resources. Regarding the production and provision of essential services, several countries have designated their critical infrastructures in the energy sector, by applying sector-specific or cross-sectoral criteria for designating critical infrastructures.

Worldwide, according to the British website Carbon Brief[3], after 2000, coal-fired power capacity to around 2,000 gigawatts, after explosive growth in China and India. At present, efforts are directed towards reducing coal consumption by offsetting renewable energy consumption. According to the International Energy Agency's sustainable development scenario[4], coal's share in the global power generation mix will fall to 28% in 2030, compared to 37% in 2019 and 35% in 2020.

Within the European Union, Poland is the most fossil fuel dependent country. In addition to its status as biggest coal energy producers în EU, Poland's energy power depends on 80% of coal sources. Resistance to reducing coal consumption comes from several actors, such as trade unions, coal companies, the government and some sectors of civil society. Their arguments are business losses, higher unemployment rates, rising energy prices and uncertain consequences for energy security.[5]

The efforts to reduce air pollution are essential for air quality in normal quality standards. European Union has managed, through the implementation of environmental policies and the involvement of the European Environment Agency, to reduce emissions of air pollutants in recent years. EU considers that air pollution is a local, pan-European and hemispheric issue, and the circulation of atmospheric pollutants can impact air quality in other areas.[6] The fast increasing exploitation of wind and solar energy in EU, has forced coal and gas into decline, leading in the end to shutting down nuclear power plants.[7] EU environmental policy is dynamic and focused on pressing global issues. Therefore, the EU plays an important role in achieving the objectives of the Paris Agreement on measures on limiting global warming and mitigating climate change.

Water pollution

Water is an essential resource that sustains all life-forms, food, economic growth, health and well-being. Basically, water is impossible to be replaced in most of its uses, and it can be quite easy to spill, transport, store and recycle.[8] Humans can survive a few days without food, but they can only survive a short amount of time without water. Two thirds of the earth surface is covered by water of which about 98% is sea water and is unusable for drinking because the

[2] E. Schraufnagel et all, *Air Pollution and Noncommunicable Diseases*, 2019, available on https://journal.chestnet.org/article/S0012-3692(18)32723-5/pdf, accessed 22.01.2021.

[3] https://www.carbonbrief.org/mapped-worlds-coal-power-plants, accessed 24.01.2021.

[4] https://www.iea.org/reports/world-energy-outlook-2020/outlook-for-electricity#abstract, accessed 24.01.2021.

[5] Hanna Brauers, Pao-Yu Oei, *The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels*, Energy Policy, Volume 144, 2020, available on https://doi.org/10.1016/j.enpol.2020.111621, accessed 11.02.2021.

[6] https://www.eea.europa.eu/ro/themes/air/intro, accessed 21.01.2021.

[7] https://ember-climate.org/project/eu-power-sector-2020, accessed 14.02.2021.

[8] Romeo Singh, Asha Gupta, *Water pollution-sources, effects and control*, 2017, available on https://www.researchgate.net/publication/321289637_WATER_POLLUTIONSOURCESEFFECTS_AND_CONTROL, accessed 01.02.2021.

high concentration of salt. However, only 2% of the planet's water is freshwater, respectively 1.6% is stored in glaciers and the rest of it can be found underground, in lakes and rivers.[9] Taking into account these facts, it is important to use rationally freshwater resources and to protect water resources and ecosystems from pollution.

Water pollution has been, is and will be an environmental problem, with global implications and effects on public health. According to several authors[10], the sources of water pollution are multiple and are divided into natural and artificial sources. In general, natural sources of water pollution occur as a result of geological phenomena, such as the flow of water through areas of soil erosion or areas with soluble or radioactive rocks. The sources of artificial pollution are more numerous, such as wastewater or landfills. Wastewater may be classified into urban, industrial, meteoric, radioactive wastewater, animal farms wastewater, ship wastewater, etc. Landfills come from both urban and rural areas, and from industrial waste. Industrial waste might be ash coals used in coal-fired power plants, mine tailings, ferrous slag, wood waste, or waste from wastewater treatment plants.

Analyzing all these sources of artificial pollution, an obvious correlation can be made with the activity of certain critical infrastructures, especially those in the energy sector and the chemical industry sector. Thermoelectric power plants, emit pollutants into the atmosphere, and in surface water and ground water. In terms of radioactive pollution[11], nuclear power plants, nuclear weapons testing and the use of radioactive sources are the main sources of water pollution caused by human activity. For example, radionuclides found in drinking water come from three radioactive series – uranium, thorium and actinium - and include the naturally occurring elements radium, uranium and the radioactive gas radon that may cause different types of biological damage.

The main sources of artificial radionuclides are nuclear explosions, continuously monitored emissions and accidental emissions from nuclear power plants.[12] Explosions based on nuclear energy are nuclear fission or nuclear fusion. Controlled emissions involve personal dosimetry and environmental radiation monitoring in the proximity of nuclear power plants. Accidental releases of radiation may occur as a result of nuclear power plant accident, which affects the plant and causes contamination of the population and the environment. According to the International Scale of Nuclear Events – INES[13], the nuclear accident is classified between 4 and 7, and the events classified on levels 1,2 and 3 represent incidents, where human exposure does not exceed the allowed limit.

Soil pollution

Generaly, infrastructures in the industrial sectors release pollutants into the atmosphere, water and soil. Soil is affected by the gaseous pollutants and radionuclides that are released into the atmosphere and create the so-called atmospheric deposition that occurs as acid rain. According to several specialists[14], soil pollution is caused by improper disposal of waste or even direct dumping of waste on the ground and into the soil. Here there are mentioned

[9] Rozina Khatun, Water Pollution, *Causes, Consequences, Prevention Method and Role of WBPHED with Special Reference from Murshidabad District*, International Journal of Scientific and Research Publications, Volume 7, Issue 8, pp. 269-277, 2017, available on http://www.ijsrp.org/research-paper-0817/ijsrp-p6832.pdf, accessed 23.01.2021.

[10] Constantin Munteanu, Mioara Dumitraşcu, Romeo-Alexandru Iliuţă, *Ecologie şi protecţia calităţii mediului*, Editura Balneară, 2011, available on http://bioclima.ro/ECO.pdf, accessed 02.02.2021.

[11] L. Bonavigo, M. Zucchetti, H. Mankolli, *Water Radioactive Pollution and Related Environmental Aspects*, Journal of International Environmental Application & Science 4(3), pp. 357-363, available on https://www.researchgate. net/publication/290435820_Water_Radioactive_Pollution_and_Related_Environmental_Aspects, accessed 03.02.2021.

[12] Ion Chiosilă, Laslo Toro, Vasile Cuculeanu, *Radioactivitatea mediului înconjurător – aspecte teoretice şi practice*, available on https://www.researchgate.net/publication/305316571, accessed 05.02.2021.

[13] INES – The Unternational Nuclear and Radiological Event Scale, User, s Manual 2008 Edition, IAEA, Vienna, 2009, available on https://www.iaea.org/publications/10508/ines-the-international-nuclear-and-radio logical-event-scale-users-manual, accessed 05.02.2021.

[14] N. Rodríguez-Eugenio, M. McLaughlin, D. Pennock, *Soil Pollution: A Hidden Reality*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2018, available on http://www.fao.org/3/I9183EN/ i9183 en.pdf, accessed 08.02.2021.

industrial processes, due to which fluids containing heavy metals and chlorine are discharged into rivers, lakes and oceans, causing thermal pollution that can affect the aquatic ecosystems. Industrial sites are prone to dust, waste disposal or drainage from raw material, or fire. In addition to the negative impact on the environment, critical infrastructure can significantly affect the economy, human health and well-being of the people. The impairment of human health is caused by pollution produced by energy infrastructure.[15] Also, the negative effects of acid rain on agricultural crops and economic activities in the area represent the result of pollution created by energy infrastructure.

For critical infrastructures that produce, operate or store hazardous chemicals, it is particularly important to apply the proximity principle, a basic principle of protection of environmental ecosystems. Chemical waste collection and storage facilities are recommended to be as close as possible to the areas where there are such infrastructures, even if unwanted events that may occur in the future can create chain reactions. These effects can be prevented by developing and introducing threat scenarios in the security plans of critical infrastructure operators.

Hazardous waste management involves extremely difficult long-term work, with the application of procedures that require very high costs, increased energy consumption while reducing the use of hazardous chemicals. Moreover, hazardous waste sector involves many different specialised actors, energy resources and technologies for the extraction, transport and land remediation.[16]

Given the diversity of critical infrastructure sectors and subsectors, hazardous waste is a problem that must be managed under the law, by those infrastructures that produce, transport or manage it, because there is always a risk to environmental factors. The impact of hazardous waste on the soil is different, depending on the activity profile of critical infrastructures. Most states have regulated by law the process of collection and management of hazardous waste, and non-compliance with the regulations entails drastic sanctions. There are many methods of disposing of waste after it was collected in specially designed facilities, with the exception of radioactive waste that undergoes a long-term conservation and monitoring process.

Conclusion

The impact on environmental factors is not constant, ranging from low to very high, depending on the activity of critical infrastructures and the measures taken by them to prevent, reduce or eliminate the side effects. Looking on the three environmental factors analyzed in this article, we can notice that air, water and soil pollution are closely related due to the circulation of matter in nature. Therefore, a critical infrastructure can produce effects on several environmental factors.

The impact of critical infrastructure on the environment becomes much greater in case of an unwanted event. In this context, the events that have occurred so far have shown the extent of the economic damage and how serious the consequences are for the population. Events such as Chernobyl or Fukushima are important lessons to be learned for all those are involved in managing such infrastructures that provide essential services to society. Therefore, the impact of undesirable events led to the establishment of sectoral criteria for the identification and designation of critical infrastructures. Once this process has been completed, the environmental protection aspects are taken into account the operator's security plan for that critical infrastructure. At the same time, environmental protection is included in the agenda of all the responsible authorities that have to preserve and protect the right to a safe, healthy and ecologically-balanced environment.

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