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# The Need to Decarbonise the Energy Sector to Reduce Pollution and Its Negative Impact on Human Health

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**Abstract.** *One of the most polluting industries is the fossil fuel energy industry. The production of energy from lignite has direct pollution (stack of thermal power plants emissions) or indirect pollution (caused by coal mining). The main pollutants are suspended particles, heavy metals, and other toxic substances. In areas where the limits of these pollutants are exceeded, there is a high risk of population-level health problems, such as circulatory, respiratory, nervous, and immune systems. In the current state of the scientific literature, there are studies that demonstrate the connection between the pollution caused by the coal energy industry and the negative health effects in people who have been exposed to increased amounts of these emissions. However, few studies address this topic in Gorj County. The research methodology used in this paper includes an initial presentation of the polluting substances found in the area, the possible diseases that result, and the correlation between them.*
*The study identified the main diseases that can affect the population in areas where the pollution limits for certain substances are exceeded. It also features a graphic representation by means of a map of the areas with a higher risk of the occurrence of these diseases. This paper aimed to study the need to decarbonize the energy sector from the point of view of the impact on human health. The work has both a theoretical contribution by creating the literature that addressed this topic, and a practical one, representing an information resource for decision-makers in the development of health, environmental, economic, or energy policy. The results highlight the need for increased attention in protection, monitoring, staff allocation, treatment provision, and budget allocation to protect the health of the population in these areas.*

**Keywords**: pollution, energy, emissions, human health, decarbonisation.

## Introduction

Pollution is one of the main problems of the 21st century. One of the most polluting industries is the coal-based electricity production industry. Emissions resulting from the energy production process, but also from the exploitation process, are found in the air, water, and soil, which have negative effects on human health. The main conditions associated with pollutants resulting from the process of producing energy from coal, from exploitation to obtaining energy, are respiratory and cardiovascular conditions.

There are various studies that address these issues of the negative impact of coal mining and energy production activities and the existing polluting emissions in these areas. But, this field

DOI: 10.2478/picbe-2023-0008
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is insufficiently studied and researched in the specialised literature. Therefore, more studies are needed to analyse the negative effects of pollution on human health.

In Romania, in the area of Gorj County, there has been an increase in the number of annual deaths among the population. Thus, the need to protect the population is essential and is therefore addressed in this paper. The research aims to highlight the need to decarbonise the fossil fuel energy sector, particularly lignite, due to pollutant emissions. These emissions have negative effects on the human body, increasing the risk of diseases, such as cardiovascular, pulmonary, respiratory, intestinal, and so on.



This article further presents a review of the literature related to the works that have as their subject the negative effects on human health of pollution caused by the activity of producing energy from coal, the methodology used to carry out the study, the results and discussions based on the data collected through the study, and finally the conclusions based on the research.

## Literature review

The topic of the negative effects of coal energy production on people's health has often been addressed in international literature. Although the production of energy from coal has decreased in recent years, globally, coal remains one of the main sources of environmental pollution. Lignite is the fuel with the greatest negative effects on human health (HEAL, 2018).

Emissions caused by the production of energy in coal-fired power plants contribute significantly to the increase in the number of diseases caused by environmental pollution. Most chronic diseases in Europe are mainly respiratory and cardiovascular diseases. In 2013, Romania and Germany occupied the 2nd place in the top of the pollution generated by coal-fired thermal power plants, the two countries being, together with Poland, responsible for more than half of the impact on health (HEAL, 2013).

In 2019, according to estimates, 7% of all deaths in Romania were caused by air pollution, especially with fine particles of matter (PM2.5) and exposure to ozone. This share is significantly higher than the average of deaths caused by air pollution in EU countries (4%) (OCDE, 2021).

Among the categories of people vulnerable to these emissions that affect their health, there are children, pregnant women, the elderly, and those suffering from asthma or lung diseases that may worsen because of exposure to pollution. In addition to diseases of the circulatory and respiratory systems, the development of the brain and nervous system are also affected. Emissions discharged at the stack of the thermal power plant can travel long distances, thus affecting not only the local population, but also those located tens of kilometres away. (Burt, et al., 2013)

Heavy metal emissions resulting from the production process also lead to serious diseases, such as skin and lung cancer, cardiovascular disease, and genetic mutations, all of which can result in death (Munawer, 2018). The presence of toxic elements, such as Cr, Mn, Cu, and As, and heavy metals, such as Cd, Ba, Hg, and Pb, in soil and water can cause serious damage to human health. Soil and groundwater contamination being a real environmental and health problem due to their persistence, toxicity, bioaccumulation, and non-biodegradability (Ahmad, et al., 2021)

## Research methodology

The research involved several stages (Figure 1). The first stage consisted in taking and analysing soil and water samples from the village of Roşia de Jiu. In the second stage, other analyses from the area of Gorj County were investigated in the specialised literature, in which exceeding of the permissible limits for certain pollutants were identified. Furthermore, the research presented the negative health effects caused by these pollutants. Finally, the correlation was made between the

polluting substances identified in the area and the negative health effects, and a risk map was made for certain diseases in the studied area.

The first stage of the research consisted of taking soil and water samples in 2022 from the village of Roșia de Jiu. The water sample was taken from the well that is used as a source of water supply by the locals. The water sample was placed in a clean plastic bottle. A soil sample was also taken from a garden near a coal conveyor belt. The garden is used for growing food for consumption (tomatoes, corn, quinces, etc.). Taking the sample consisted of digging from the topsoil and storing it in a glass container. On the same day, the samples were taken to an accredited laboratory for analysis. Later, the results received were compared with the water and soil quality standards in force, respectively Law no. 458/2002 regarding the quality of drinking water and Order MAPPM no. 756/1997.



In the second stage, research was carried out in the specialised literature for studies in which compliance analysis of pollutants were carried out in Gorj County. The selected studies generally aimed to analyse the impact on water, soil and air quality caused by lignite mining operations or emissions from coal-fired power plants. Information was used from these studies regarding the pollutants that exceeded the permissible limit values and by how much.

The research also used data from official documents, such as the Environmental Report for the year 2021 of the Oltenia Energy Complex, available on the APM Gorj website, in which the emissions of $SO_2$, $NO_x$ and dust are available. The information about the Rovinari thermal power plant was selected, after which this information was compared with the new BAT emission limits that went into law in July, 2021. Thus, it turned out that it does not meet the allowed $NO_x$ limit values from 2021. (Complexul Energetic Oltenia, 2022).

According to the document "The Management Plan of the Jiu Hydrographic Basin", the waters from the Lupoaia mine discharged into the Lupoaia stream have ammonium, suspensions, and calcium exceedances (Administrația Națională Apele Române, 2020).

During the third stage, the goal was to determine the adverse health effects that exposure to increased amounts could have for each of the air, soil, or water emissions for which permissible limit values were exceeded. The maximum permissible limits in the case of soil are considered normal values, not those of sensitivity or for which intervention is necessary.

In the final stage, the correlation was made between the polluting substances that exceeded the permissible limits and the negative health effects caused by the exposure to these types of pollutants. The purpose of this stage is to study which diseases may have a greater prevalence as a result of exposure to these types of pollution.

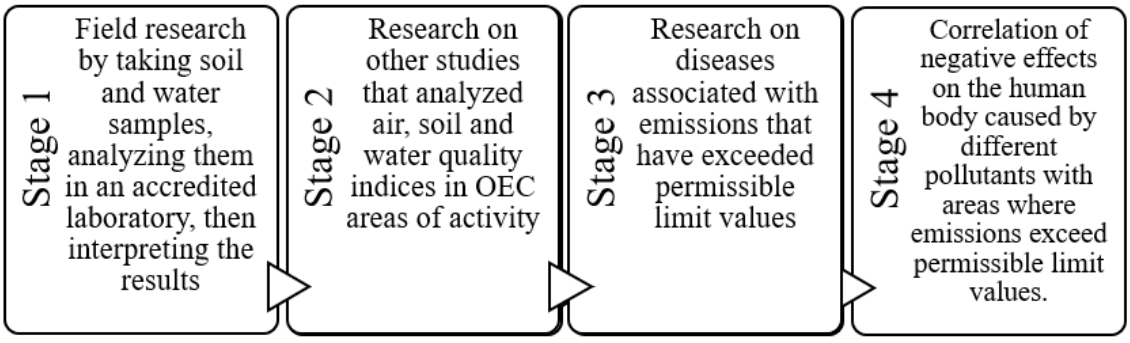



**Figure 1. Stages of conducting the research**

Source: Authors' own research.

## Results and discussion

In order to more easily study and represent graphically, the areas were divided into three pollution zones, namely Zone A, represented by the Rovinari thermal power plant, Zone B, represented by the Rovinari mining basin and Zone C, represented by the Motru mining basin. The areas were divided by mining basins (the Rovinari mining basin and the Motru mining basin) and according to the type of activity (in area A, energy is produced in the Rovinari thermal power plant, and areas B and C are lignite mining areas).



***Pollution area A - Rovinari Thermal Power Plant***

In the case of the emissions of the Rovinari thermal power plant, exceedances of the limit values for NOx were noted (CEO, 2022). $NO_x$, in reaction with compounds in the atmosphere, leads to the appearance of smog (ground-level ozone) and nitrogen dioxide ($NO_2$). Exposure to $NO_2$ worsens symptoms among asthmatic children, coughs and decreases lung functions. High levels of $NO_x$ prevent lung development and lead to chronic obstructive pulmonary disease, cardiac arrhythmias, and ischemic strokes. At high concentrations, it causes inflammation of the respiratory tract (Burt, et al., 2013; HEAL, 2013).

Analyses regarding wastewater quality show significant exceedances of ammonia by more than four times the permitted limit, copper exceedances more than 32 times the permitted limit, selenium (Se) exceeding four times the permitted limit, and mercury (Hg) two times (Gurică & Georgescu, 2021).

Exposure to high concentrations of ammonia (NH3) in the air causes irritation to the respiratory system and can cause skin and eye burns. Ammonia entering the body through breathing and swallowing can cause burns in the mouth, throat, and stomach. Even inhalation of low concentrations of ammonia can cause coughing and irritation of the nose and throat (HEAL, 2013; Department of health, 2011).

Copper can enter the human body if water or food prepared with copper-contaminated water is consumed. Even though copper plays a role in the proper functioning of the physiological function of the human body, a high level of copper in the body can cause nausea, vomiting, diarrhoea, somatic cramps, or headaches. Exposure to high concentrations of copper can lead to negative effects on the liver, intestine, stomach, kidneys, vascular disease or affect male fertility (Ahmad, et al., 2021); (Department of health, 2023).

The consumption of selenium is beneficial for the body, as it is an important nutrient for the reproductive system, the proper functioning of the thyroid gland and the immune system. However, ingesting too much selenium can lead to nausea, diarrhoea, brittle nails, hair loss, and nervous system problems. An extremely high intake of selenium in the body can cause breathing difficulties, kidney failure, heart failure, and heart attacks (Fairweather-Tait, et al., 2011; National Institutes of Health, 2019).

The main cause of human exposure to mercury (Hg) is due to the consumption of fish and shellfish contaminated with methylmercury. The substance can reach the bloodstream, from where it is distributed in all tissues and can cross the protective blood-brain barrier. It can also easily cross the placenta in pregnant women and risks harming the brains of foetuses. In children, even low-level exposure leads to learning disabilities, and in adults it can lead to adverse effects such as neurological, renal, gastrointestinal, genetic, cardiovascular, developmental disorders and even death (New Hampshire department of Environmental Services, 2019).

The analysis for heavy metal concentrations in soil showed significant exceeding of the limits in the case of Chromium (Cr) and Vanadium (V), exceeding twice the maximum permissible

limits. In the case of cobalt (Co) and lead (Pb), the exceedances were almost double the permissible limits. As for Copper, Nickel, Zinc, Barium, and Cadmium, the limits were exceeded by approximately 69%, 70%, 23%, 83% and 10%, respectively (Gurică & Georgescu, 2021). Although it plays an important role in human metabolism, depending on the state of oxidation, chromium's impact on human health is significant, being highly carcinogenic and causing cardiovascular, liver and kidneys disease (Ahmad, et al., 2021). Exposure to Vanadium can irritate the skin and eyes and cause headaches and dizziness, and repeated exposure to large amounts of Vanadium can lead to anaemia. Inhaled, it leads to irritation of the nose, throat, and lungs (New Jersey Department of Health and Senior Services, 2007).



Cobalt is a carcinogen substance. Exposure leads to skin allergy. Exposure to cobalt dust causes eye, nose and throat irritation and affects the respiratory system. Cobalt can also adversely affect the heart, thyroid, liver, and kidneys, and with long-term exposure can cause fibrosis of the lungs leading to death (Tóth, et al., 2016; New Jersey Department of Health and Senior Services, 2005).

A very high concentration of Pb in the blood can have negative effects on the bone, endocrine, and immune systems. It can also cause high blood pressure, affect kidney, and heart function, and reduce intelligence in children and adults. The concentration of copper (Cu), which greatly exceeded the limit value in wastewater, is also exceeded in the soil analyses. Excess Cu has harmful effects on the liver, intestine, and stomach. Ingested in higher concentrations, it can lead to dermal damage, skin cancer, and vascular disease (Ahmad, et al., 2021). Contact with nickel can lead to allergies, and excess nickel can negatively affect the immune and reproductive system. Accumulation of nickel in the body through chronic exposure may be responsible for pulmonary fibrosis, kidney and cardiovascular disease, and cancer of the respiratory system (Genchi, et al., 2020); (Tóth, et al., 2016). Although essential for plants and humans, zinc is toxic in large amounts, causing gastrointestinal and immunological problems (Plum, et al., 2010). Short-term exposure to barium can cause diarrhoea, vomiting, difficulty breathing, and dysregulation of blood pressure. Ingestion of Ba can adversely affect heart rhythm, lead to paralysis and even death. Cd, if present in excess, can damage the lungs, liver, and negatively affect the immune system of the body (Ahmad, et al., 2021).

***Pollution area B – Rovinari mining basin***

In the Rovinari mining basin, the analysis regarding air pollutants concentration demonstrated an increased concentration in the case of suspended particles (PM10), the average value of the analysis performed being almost double the admissible limit value, and the maximum being almost three times the admissible limit value (Gurică & Georgescu, 2021).

Particles in suspension are responsible for chronic inflammation, increase blood viscosity and coagulability, cause vascular accidents or worsen pre-existing heart failure. It also negatively affects the cardiovascular system causing cardiac arrhythmias, acute myocardial infarction, congestive heart failure, but also the nervous system causing ischemic vascular accidents. Long-term exposure leads to the development of lung cancer and increases the risk for developing a variety of cardiovascular diseases, including hypertension and atherosclerosis (CEO, 2020; HEAL, 2013).

Regarding the water analyses, ammonium values with double values compared to the permissible limits were discovered (Gurică & Georgescu, 2021). Even inhalation of low concentrations of ammonia can cause coughing and irritation of the nose and throat. Exposure to high concentrations of ammonia in the air causes irritation to the respiratory system and can cause skin and eye burns (Department of health, 2011).

From the analysis of the pollutants in dumps and soil concentration, it was possible to observe exceedings in the values of the concentration of chromium (Cr) by more than 4 times the limit considered normal, and in the case of vanadium (V) by 2 times the limit. Exceedances of approximately 65% higher in the case of Barium (Ba) and approximately 10% in the case of lead (Pb) were also observed (Gurică & Georgescu, 2021).



Ingestion of Ba can cause changes in heart rhythm or paralysis in humans. Short-term exposure to Ba can cause vomiting, diarrhoea, breathing difficulties, dysregulation of blood pressure, and muscle weakness. The Cr is highly carcinogenic, depending on its oxidation state, causing cardiovascular, liver and kidney diseases (Ahmad, et al., 2021).

Exposure to Vanadium can irritate the skin and eyes and cause headaches and dizziness, and repeated exposure to large amounts of Vanadium can lead to anaemia (New Jersey Department of Health and Senior Services, 2007). Lead can enter the human body through food consumption. Even relatively low exposure to lead can adversely affect the brain and nervous system, especially in children (Tóth, et al., 2016).

In Roșia de Jiu village, in the water analyses, it was found that the concentration of nitrates was exceeded by approximately 35% compared to the allowed limit value. High levels of nitrate in drinking water may cause colon cancer, and may increase the risk of thyroid disease. Also, it may cause defects of birth and affect the oxygen level in blood causing weakness, excess heart rate, fatigue, and dizziness (Schullehner, et al., 2017; Wisconsin Department of Health Services, 2019).

In the case of soil analyses, zinc exceedances of almost 3 times higher than the maximum allowable values were found along with copper exceedances by 60% above the allowable value, nickel exceedances by 15%, lead by more than 20%, and by 7% in the case of manganese. Zinc is an essential element in the human body, but it is toxic in excess amounts, causing gastrointestinal and immunological problems (Plum, et al., 2010). An excessive amount of copper in the body has negative effects on the stomach, intestine, liver, immune system, neurological system, and reproductive capabilities (Ahmad, et al., 2021). Excess nickel can negatively affect the immune system as well as the reproductive system, and chronic exposure can lead to lung, kidney, cardiovascular disease, and even respiratory tract cancer (Genchi, et al., 2020). Higher concentrations of manganese in the human body can cause male infertility, neurological disorders, birth, and bone defects. Excessive concentration of Pb in the blood can cause high blood pressure, affect the bone system, the immune system, the endocrine system, and affect the functioning of the kidneys and heart. Even relatively low exposure to lead can affect the brain and nervous system (Ahmad, et al., 2021; Tóth, et al., 2016).

In the Tismana career, exceedances of the limit values for nickel were observed in the soil, by approximately 55% and zinc by approximately 84% compared to the allowed limits (Matei, et al., 2022). High concentrations of nickel in the body can have negative effects on the immune and reproductive systems. It can also cause lung, kidney, or cardiovascular diseases. An excess amount of zinc in the body can cause immunological and gastrointestinal problems (Plum, et al., 2010).

According to the results, in the Roșia mine, an average exceeding of the copper concentration was found in the soil samples with a value more than double the allowed limit value, the maximum value reached being almost 7 times the allowed limit. It was also found that the concentration of zinc was exceeded, being on average approximately 1.7 higher than the allowed limit, the maximum value being 3 times higher than the allowed limit in some cases (Cazalbașu & Căpăţînă, 2016). Copper helps physiological function of the human body, but a high level of copper in the body can affect the intestine, liver and damage the stomach. Ingested in higher concentrations it can lead to skin cancer, dermal lesions, and vascular disease (Ahmad, et al., 2021). Zinc is

essential in the body, but toxic in excess, causing gastrointestinal and immunological problems (Plum, et al., 2010).

The study on air quality in the Pinoasa mine revealed exceedances of dust limits (PM10) up to 5.6 times higher than the permissible limit value (Căpăţînă, 2012). Particles in suspension, negatively affects the cardiovascular system causing cardiac arrhythmias, acute myocardial infarction, congestive heart failure, affects the nervous system causing ischemic vascular accidents, and in the long term leads to the development of lung cancer (HEAL, 2018; CEO, 2020).



***Pollution area C – Motru mining basin***

In the analysis of the water discharged from the Lupoaia mine, ammonia exceedances 58% higher than the permissible limit value and calcium exceedances 328 times higher than the permissible limit were found (Administrația Națională Apele Române, 2020). Ammonia entering the body through breathing and swallowing can cause burns in the mouth, throat, and stomach (HEAL), 2013; Department of health, 2011). Regarding the negative effects of a very large amount of calcium in the human body, some studies state that too much calcium can increase the risk of cardiovascular problems. There is a risk that in large doses it can cause blood clotting and lead to cardiovascular disease (School of public health, 2023).

In the analyses regarding suspended emissions from the Roșiuța coal deposit, values were exceeded with an average of almost 3 times higher than the limit, and the highest value exceeded the limit value by 3.7 times (Cazalbaşu, 2019). Particles in suspension, negatively affects the cardiovascular system causing cardiac arrhythmias, acute myocardial infarction, congestive heart failure, affects the nervous system causing ischemic vascular accidents, and in the long term leads to the development of lung cancer (CEO, 2020; HEAL, 2013).

The three areas where pollutants and associated diseases were analysed are shown in Figure 2.

Figure 2 is the graphical representation of the summary of diseases with increased risk of incidence caused by pollution in the Gorj area.

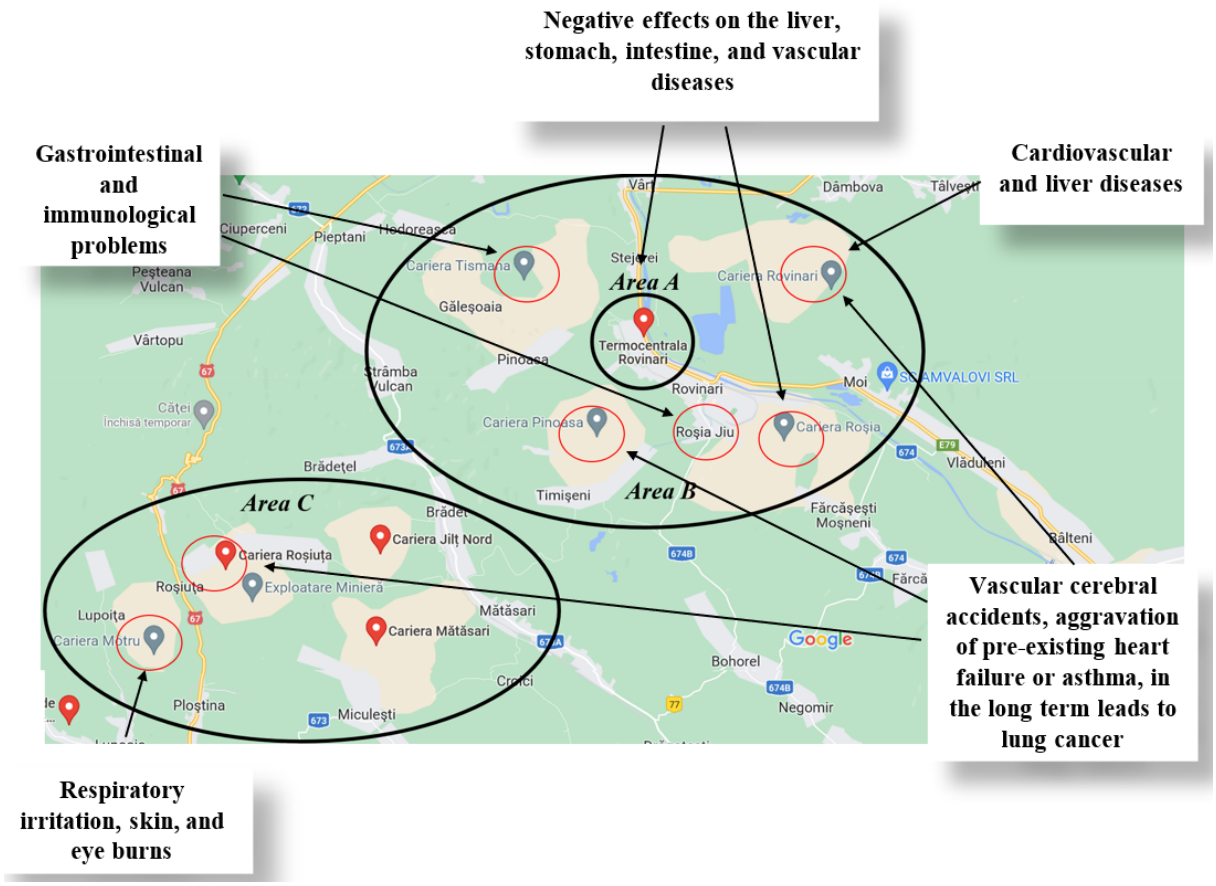



**Figure 2. Two-dimensional representation of the distribution of risk and health factors**

Source: Authors' owns research.

## Conclusion

Following the research carried out, the need to decarbonise the energy sector in order to reduce the negative impact on human health is clear. Decarbonisation of the energy sector will lead to reduced thermal power plant emissions. Coal mines will be closed and greened, which will lead to the reduction of suspended particles and thus to the reduction of the incidence of circulatory and respiratory system diseases.

The analysis carried out consisted of identifying the pollutants that endanger the health of the inhabitants of the coal mining and energy production areas, studying the possible diseases caused by these emissions, and then establishing the best possible zonal distribution by associating the main diseases with the pollution areas.

Following the analysis carried out in this study, it was found that the inhabitants of villages or towns located in the vicinity of coal mining or energy production areas are at greater risk of developing cardiovascular, respiratory, gastrointestinal diseases, and so on, due to the pollution in the area. These results could constitute a basis for the foundation of health policies that establish the necessary specialised personnel, analysis for the early detection of such diseases and the necessary treatments, but also the necessary budget to be allocated for all of this. The information can also be useful for decision makers in the environmental and energy production sectors.

To reduce the impact on the environment and human health, the decarbonisation law establishes the general framework. Moreover, there is a decarbonization plan for the main company

that carries out energy production from lignite in Gorj County. This decarbonisation plan envisages the end of coal power generation, the construction of eight photovoltaic parks on former mine lands and ash deposits, and the opening of two CCGT gas-fired power plants.

Also, reducing these emissions will lead to an increase in life expectancy among residents, to a decrease in the number of hospitalizations and medical leaves for the treatment of these diseases, and thus to the relief of the state budget.



Currently, no studies have been conducted to evaluate the cumulative impact on the health of the inhabitants and the environment of the entire exploitation perimeter. Existing studies only analyse some perimeters. Another important aspect is the fact that the forms of pollution are through several sources - water, soil, and air - and the means of penetration of these harmful substances into the body are multiple: through inhalation, swallowing, through the skin. They can thus have a cumulative effect that is much stronger than the separate effects studied in this paper. Also, the possible mixtures of substances that can form in the human body through the accumulation of these various types of pollutants are also unknown.

In the future, it is necessary for research to be continued. This study could be the beginning of a series of studies that will analyse the cumulative impact of all these forms of emissions, what effects can occur as a result of mixing these substances in the body, and especially how people's health is affected by the long exposure to these pollutants.

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