Analysis of the Influence of Underground Coal Mining on the Environment

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Abstract The use of coal is an indispensable part of China's industrialization process. China is a big coal country and the consumption of coal has been above 60%. The interaction of various factors makes the underground mining of coal more and more serious. At the same time, the depth of mining is increasing. The lack of appropriate management measures after the mining of coal seams has resulted in the collapse of the overlying rock formations in most of the goafs and the formation of **fissures** and gullies on the surface. The movement of the overlying strata also destroys the aquifers in the strata, causing the groundwater to be lost and the coal mining water to be discharged without treatment, so that harmful impurities penetrate into the groundwater. Not only does it have a great impact on the environment, it also causes irreparable damage to human daily life. In the previous studies, this article gives a more succinct description of the influence of underground coal mining on surface, groundwater, atmosphere and biology. Use the analytic hierarchy process to identify the most serious environmental impacts. In addition, the causes of the impacts and the ways of summing up are explained in light of their own majors.

1. Introduction

China is one of the countries with the most abundant coal content in the world. It is a country with large coal resources and has a complete coal category. This explains the percentage of total national resources consumed from the perspective of the side. The use of coal has always been very high. By the end of 2014, the State Council promulgated The “Energy Development Strategic Action Plan 2014-2020” pointed out that China’s path to optimize energy structure is to reduce the proportion of coal consumption, increase the proportion of natural gas consumption, vigorously develop renewable energy such as wind power, solar energy, and geothermal energy, and develop nuclear power safely. By 2020, non-fossil energy will account for 15% of primary energy consumption; natural gas will account for more than 10%; coal consumption will be controlled within 62%; and oil will account for the remaining 13% [1]. Moreover, China has used coal for thousands of years and is one of the earliest countries in the world to discover and use coal. In the first century BC, coal was used for iron smelting and copper smelting. Although China's industrialization of coal mining started relatively late, but in just a few decades the country's development in all aspects are at full speed, including the industrialization of coal mining. Coal mining technology, theory, equipment and a series of aspects are now at the forefront of coal mining in the world. With the need of China's economic development

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and the dependence of industrialization on coal resources, the annual output of coal is also a long-standing one.

In the golden decade of the coal industry, the annual coal output is nearly 4 billion tons [1]. Therefore, coal seams that are shallow and deep underground in China are gradually mined. The coal mine has been deepened from a depth of 200 to a depth of 500 meters, a depth of 1,000 meters, and so on. The rapid economic development will certainly also cause damage to the environment. In China, there is a long history of coal mining and use. As the industry's leading energy source, its production, transportation, and utilization have an important role in promoting industrial economic development. In the early stages of reform and development, China's emphasis on economic development also caused damage to the ecological environment. Because a variety of natural resources coexist in the coal mining area, they together constitute the "organic environment of the coal mine area" as an organic whole [2]. Therefore, due to the impact of coal mining damage, all kinds of resources and environmental elements that are isomeric to coal resources are subject to disturbances in terms of quality and quantity. While promoting social development, it also leads to a variety of environmental pollution problems, which are manifested in the following three aspects: 1 During the process of coal mining, coal preparation, coal washing, transportation, and combustion, some harmful gases harmful to the environment will be released. Into the air; 2 underground mining of coal mines is used to extract coal seams that are underground, and underground goafs are formed. There will be no supporting overburden rock in the goafs, and then a series of Fall will form the collapse of the surface. The collapse of the surface not only caused unevenness of the ground, but also caused great harm to the people's lives. At the same time, the location of the rock itself, where the collapsed portion also changed, is the original position. For example, damage to the aquifer of the subsidence area causes the loss of groundwater, etc.; 3 Coal gangue and other abandoned materials produced during the mining process occupy a large amount of land. Yes, the farmer cultivates land and reduces crop production. The spontaneous combustion characteristics of coal gangue have great fire hazards. Fly ash causes loss of biodiversity and landscape damage to surrounding vegetation in the mining area [3]. All these have resulted in the waste of resources in certain mining areas, the declining economic development, the unbalanced ecological balance, and the intensified social problems in towns and villages.

Reckless overexploitation has created an irreversible situation for the environment. Therefore, domestic and foreign research scholars have gradually developed the study of subsidence of goaf. The scope of the study is also relatively extensive and mainly includes related majors such as geology, environment, and mining [4]. The study of the mechanism and theory of ground subsidence caused by coal mining began in the 19th century. At that time, scholars at home and abroad proposed some relatively shallow theories and understandings. For example: Oesterr's natural slope theory, Fayol's circular arch theory, Jlcinsky's bisector theory, etc. These theories are relatively one-sided [5]. However, with the development of the era, the theory of surface subsidence has gradually formed a relatively mature set of theoretical systems. China's research on it is relatively late relative to that of foreign countries, beginning in the middle of the 20th century. Although the study started late, it has independently developed and applied the most widely used probability integration method in China by studying the combination of some foreign theoretical knowledge and our country's actual development. The probability integration method is a computer method used to predict the landmark settlement deformation curve. The overlying rock formations in the goafs not only caused the ground surface to collapse, but also brought about a series of other reactions. For example, the pollution of groundwater caused by coal mining, the destruction of underground aquifer by surface subsidence, and the impact of water resources destruction and pollution on biological systems are inevitable.

2. Impact on the surface

The general situation of coal mining in some areas of China is that underground mining causes the roof of the coal bed to fall, causing the ground to descend and forming a collapse. As a geological disaster, subsidence is the main way to destroy the ecological environment during the mining process of major coal production bases. The subsidence area accounts for more than 75% of the total underground coal mining area [5]. China is a developing country with coal as its main energy source. The formation of ground subsidence during the mining process also has a great impact on human life. After the coal seam is mined underground, a goaf is left underground. The collapse of overlying strata under the joint action of stress and gravity on the overburden strata of the mined-out region generally occurs in three zones: the fallow zone, the fissure zone and the curved subsidence zone, and the fall zone: the rock mass after the fracture. Irregular and deranged, the arrangement is extremely irregular, the loose coefficient is relatively large, generally 1.3-1.5, and can be reduced to 1.03 right after re-compacting; fractured zone: the rock is still arranged neatly after fractured rock, the broken expansion coefficient is smaller Bending sinking belt: The rock layer from the top of the cracked belt to the ground surface is called the bending belt. Its characteristic is that the rock layer has continuity and integrity in the moving process, and the subsidence between the upper and lower parts of the vertical section is very small. A hard and hard key layer may appear away from the horizon. With the exploitation of coal seams, the mined-out area gradually becomes larger, and overlying strata will continue to fall under the action of gravity and other stress combinations, and the scope of surface subsidence will not be expanded.

There are many types of surface subsidence, such as cracks, pits, landslides, landslides, etc. [6]. Surface subsidence has the most direct impact on the residents living above, and a series of surface deformations caused by subsidence have a tremendous impact on human life, travel and personal safety. Landslides, subsidences and deep pits not only caused irrecoverable damage to residents' houses but also caused damage to the arable land of farmers. The destruction of arable land indirectly caused the direct economic losses of farmers and affected the improvement of people's living standards. Cracks formed on the surface are also very influential to people's travel. They may go home from work in the afternoon or be a good road. When they go to work the next day, they find that the road sinks down and there are even large cracks. Therefore, the impact of surface subsidence on people's daily life is most directly reflected. Take Shanxi Province as an example. Shanxi Province is a large coal producing province. Therefore, the area of goafs in Shanxi Province is also very large. According to statistics, the area of goafs in Shanxi Province is nearly 30,000 square kilometers, which is nearly the size of Taiwan Province. Therefore, there is no doubt that Shanxi is called "the Hanging Temple"[7].

3. Impact on groundwater

The groundwater environment is a splendid link between geological environment and ecological environment. It has extremely important ecological functions. Coal mining has an important influence on water bodies, especially groundwater. In order to produce coal safely, the mine must exclude a large amount of mine water, and the discharged mine water has the most serious pollution to groundwater. In the early stage of coal mining, the coal seam is shallow, the stratum structure is less, and the amount of spalling water is less, so it has less impact on the water environment. However, with the deepening of the depth of coal mining and the deepening of the thickness of coal mining, the impact on groundwater has become more and more serious.

First: Improve groundwater conditions in mining areas. Underground mining is the excavation of coal seams buried hundreds of meters underground. This undoubtedly undermines the geological composition of the entire primary rock formation, which results in the destruction of the distribution and condition of the underground aquifers in the mining area, and destroys the hydrology of the entire mining area. Happening. During the mining process, as the coal is mined, the overburden

collapses and new compaction results in newly formed cracks in the rock formation. This causes the water in the aquifer above the coal seam to be gradually "pulled out", forming a funnel that forms a descending aquifer of the underground aquifer in the goaf area, which causes the aquifer in the goaf area to change from pressure bearing to pressureless. The flow direction of groundwater also changes from horizontal flow to vertical flow, and the original groundwater conditions are destroyed [8].

Second: change the existing groundwater storage place. After the coal was mined, the overburden collapsed. Therefore, with the formation of collapsed original rock formations above the goaf, the original rock formations were misplaced. As a result, the original surface of the water-retaining layer and the aquifer is destroyed, so that the water in the original aquifer is permeated through the fracture to other rock layers until a new aquifer is formed in the undamaged aquitard. This resulted in a reduction of the natural base flow of the original aquifer and a drop in the water level. Decreasing the water level of the aquifer will reduce the corresponding surface water flow system and affect the surface water flow.

Third: Coal mining causes water pollution. The consumption of water by coal mining is very large, especially in the coal seams adjacent to the aquifer. The groundwater seeps into the mining area. To prevent the occurrence of water damage, the water needs to be discharged, and most of the discharged water is returned to the underground aquifer. As a result, the groundwater is doped with a large amount of calcium and magnesium compounds to form hard water, resulting in a significant decrease in water quality. These hard waters, which are upstream, flow into rivers and seas through the water circulation and deteriorate their water quality. These contaminated currents not only have an impact on the organisms therein, but also pose a great safety risk to the residents' water use and livestock drinking water [9].

4. The optimal solution to the choice

The analytic hierarchy process, abbreviated as AHP, is a commonly used analytical method to solve multi-objective decision making. It was proposed by Saaty, an American operational researcher, in the 1970s. The basic idea of this method is to decompose complex multivariate problems into multi-level multi-factors and then make comparative judgments based on the importance degree between the two indicators, and establish relevant matrix judgment calculations to obtain the weights of different programs. The choice plan provides the basis. The general steps for creating an AHP are shown in Figure 1[10]:

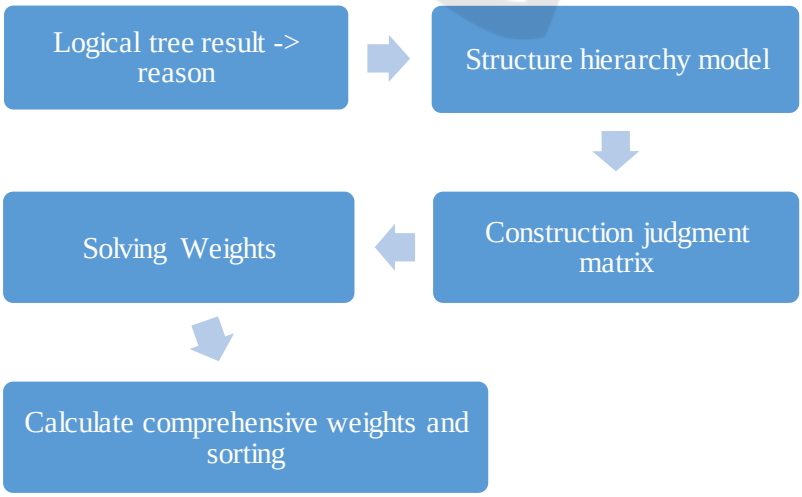

Figure 1. Analytic hierarchy structure.

The basic idea of building a hierarchical model is to divide the results, causes, and solutions of complex problems into upper-middle and lower-level relationships. The bottom layer is the solution to the problem; the middle layer is the influencing factor to the result; the top layer is the most ideal solution to the problem. The results of this paper are mainly to select the optimal measures to reduce the impact of coal mining on the environment. According to the hierarchical relationship analysis of the AHP, the top level is the optimal measure to reduce environmental impact; the middle level indicates that the factors influencing the results mainly include surface subsidence, underground book pollution, air pollution, and vegetation destruction. The lowest level is the solution, as shown in Figure 2:

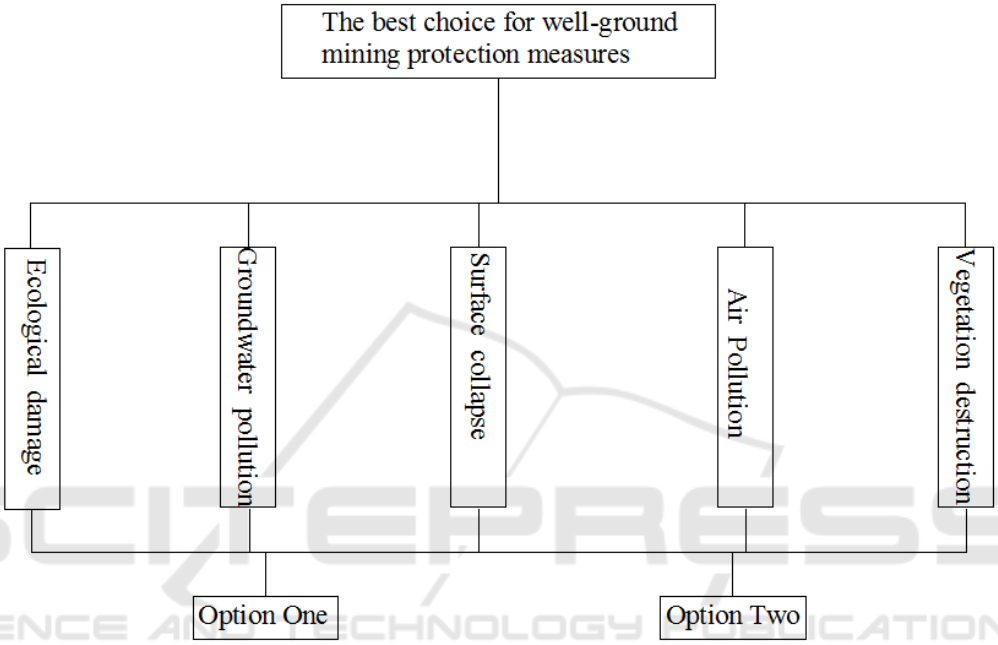

Figure 2. hierarchical analysis tree.

Followed by the construction of the judgment matrix. For the five factors in the middle tier, the impact of the pairwise comparison on the topmost target tier, the judgment matrix is:

$$A=\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & a_{ij} & a_{2n} \\ \vdots & a_{ji} & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (1)$$

After the judgment matrix is established, it is also necessary to check the consistency. First, the maximum eigenvalue of the matrix A and its maximum eigenvector are calculated, and the consistency index CI=(λ_{max}-n)/(n-1) is calculated, if the consistency ratio CR= When CI/RI<0.10, the matrix A has consistency. The consistency reference values are shown in Table 1.

Table 1. Reference values of the consistency index RI.

n	1	2	3	4	5	6
RI	0	0	0.58	0.90	1.12	1.24

According to the meaning of Saaty's mid-1 to 9 scales and the meaning of the reciprocal. Comparing the above five conditions, we can see that 1 means that two elements are equally important; 3, 5, 7 and 9 indicate that one element is slightly more important, obviously more important, more strongly important, and absolutely more important than the other element; 2,4, 6,8 represents the median of two adjacent odd-numbered scales [11]. According to the above-mentioned coal mine safety evaluation index system, the first-level indicators obtained after the comparison of the two pairs are the following:

$$A_{5*5}=\begin{bmatrix} 1 & 5 & 7 & 2 & 3 \\ 1/5 & 1 & 6 & 3 & 2 \\ 1/7 & 1/6 & 1 & 1/5 & 1/7 \\ 1/2 & 1/3 & 5 & 1 & 2 \\ 1/3 & 1/2 & 7 & 1/2 & 1 \end{bmatrix} \quad (2)$$

The weight vector calculation method of the analytic hierarchy process includes: a geometric average method, an arithmetic average method, a feature vector method, a least squares method, and the like. Each calculation method has its own algorithm. This paper uses the geometric average feature, arithmetic average feature and eigenvector of matrix A to solve. Calculation formula:

$$\omega_i = \omega_{i1} + \omega_{i2} + \omega_{i3} \quad (3)$$

$$\omega_{i1} = \prod_{j=1}^{n} s_{ij}{}^{1/n} / \sum_{i=1}^{n} (\prod_{j=1}^{n} s_{ij})^{1/n} \quad (4)$$

$$\omega_{i2} = \frac{1}{n} \sum_{j=1}^{n} (S_{ij} / \sum_{i=1}^{n} S_{ij}) \quad (5)$$

$$\omega_{i3}=S*W=\lambda_{max}*W \quad (6)$$

$$w = mi / \sum_{i=1}^{n} mi \quad (7)$$

$$m_i = \sqrt{\prod_{i=1}^{n} a_{ij}} \quad (8)$$

n represents the number of influencing factors in the middle layer. a_{ij} is the ith row and jth column elements in matrix A. W is the weight vector; m_i is the geometric mean of each row of matrix A. ω_{i1} represents the geometric weight. ω_{i2} is the arithmetic weight vector. ω_{i3} Representing feature vector weights. λ_{max} is the matrix maximum eigenvalue [12].

According to the above calculation scheme, the surface subsidence has the greatest influence on the optimal measure selection, followed by groundwater pollution, atmospheric pollution, vegetation destruction and ecological environment damage.

Of course, there are many successful examples of coal mine ecological governance. For example, the Xinan Coal Mine of the Yimei Coal Group is an example of successful coal mine ecological environment governance. Xin'an Coal Mine follows the working concept of “eco-nature, afforestation economy, Jiangnan style, and low-carbon habitability”. Efforts have been made to build a modern coal mining that integrates "ecological mining areas and tourism-oriented mines". The perfect combination of "production development, affluent life, and good ecology" has been achieved. The success of the environmental management of the Xin'an coal mining demonstrated the results of different coal production and environmental protection before our eyes. So that we can feel a different mining environment. It's refreshing.

5. Conclusions

The above calculations show that the main impact of underground mining on the environment is the formation of goafs from underground mining, which causes the collapse of overlying rock formations and the collapse of the surface. The surface collapse causes a series of re-breaks and forms the greatest damage to the environment. Therefore, in order to better reduce the destruction of

underground mining and better protect the environment, coal mining underground mining design should adhere to scientific mining, improve the original lighting policy and design using more environmentally friendly mining methods. Fully consider the overburden of the overlying strata and establish a scientific, rational, safe, and environmentally friendly mining mechanism. Such as filling mining, mining coal mining and other mining methods and so on. Fill mining is the use of waste generated during coal mining as a fill to fill gobs. This not only solves the problem of waste disposal but also has a good preventive effect on surface subsidence. At the same time, the destruction of surface cracks, collapses, etc. shall be filled or built in time to improve the building structure of residents' houses and increase the anti-deformation characteristics of the houses in the collapsed areas. For the detection of overburden and aquifer conditions during mining, the principle of reuse of mine water is applied, and the excess mine water is softened and discharged.

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