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Actual influence cost estimation of water resources in coal mining and utilization in China

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Abstract

As the dominating energy supply, coal supports the rapid economic growth in China. However, coal mining and utilization inevitably cause consumption of and pollution to water resources. Given the close interaction between coal and water resources, quantitative analysis on the mechanism of coal mining and utilization influences on water resources should be conducted for sustainable development of coal industry in China. This paper summarizes and analyzes the influences of coal mining and utilization on water resources. Quantitative indicators are used to quantify relevant influences and transform the influences from material amount to monetary amount to gain the summation of the influences in the entire process. Results show that mining of coal per ton generally causes depletion of 1.32 m³ water resources, pollution to 0.88 m³ water resources, and destruction of 0.17 m² water ecological environment on the average, thereby making a comprehensive cost of approximately 50.61 yuan. Taking thermal power industry as an example, per-ton-coal utilization means depletion of water resources of 26.35 m³ and the comprehensive cost of 86.61 yuan. To utilize coal resources scientifically and to respond to the objective requirements of protecting water resource environment, establishing a region/category-based environmental taxation system is proposed to guide the coal industry in developing a highly water-saving but less-water-pollution method.

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1. Background

In 2015, China's total consumption of primary energy accounts for 23.4% of the world's total and contributes to 34% of the net growth of global energy consumption [1]. Limited to the natural conditions of rich coal but less gas, coal dominates in China's energy consumption structure. For example, China's coal consumption accounts for 64% of its total energy consumption in 2015 [2]. Although it fuels the rapid development of China's economy, coal consumption also causes certain problems on resources and environment. To utilize well the coal resources and provide impetus to sustainable development of China in the future, research about the influence of coal mining and utilization process on water resources and ecological environment should be conducted to provide practical significance.

China is also confronted with severe water utilization problems. The difficulty in high total quantity but low per capita level of water resources has been a challenge for the sustainable development of water resources in China. According to the UN's statistics in 2014, China's total water resources are at 2.84 trillion m³, which ranks 5th in the world; however, China's per capita hold of water resources is 2,018 m³/person only, which ranks 121st in the world, thereby indicates considerably severe water resource supply problem [3]. To respond to the complicated water resource environment problem and protect and high efficiently utilize water resources, China proposed the "Three Red Lines" control indicators from the angles of total water consumption control, water consumption efficiency control, and water quality compliance rate limitation to supervise problems in water resource utilization in an all-round manner [4].

Coal mining and utilization are inevitably accompanied with water resource consumption and pollution. Water and coal, as two resources, influence each other, and they are closely related. China features reverse distribution of water resources and coal resources in space as a whole, under which coal mining capacity is significantly constrained with water resource; additionally, regional water resource conditions directly influence the development of coal industry [4-5]. High coincidence of high-energy-consumption industry and high-water consumption industry exists in coal consumption process, of which the fresh intake of water by three sectors of electric power and heating power production and supply, ferrous metal smelting and rolling processing, and chemical raw material and product manufacturing accounts for over 60% of the total from the industrial field [6]. Furthermore, the three sectors report a total coal consumption accounting for approximately 61.1% of total industrial coal consumption, and they are major energy consumption segments [7].

2. Analysis of the influencing mechanism

2.1. Mechanism of the influences of coal mining on water resources

All existing research indicated that in the process of coal mining and washing, both quantity and quality of groundwater and surface water are severely influenced. The process also exerts remarkable influences on local geologic and hydrologic environment.

The most direct influence of coal mining on water resources is the destruction of hydrologic and geologic environment. Coal mining can cause formation of mine pit. Correspondingly, the rock mass around the site can generate stress distribution, which results in upper rock mass deformation, displacement, and destruction, as reflected by visual crack, collapse, other surface deformations, and land subsidence.

Influences of coal mining on water resource quantity can be classified as direct and indirect. In mining process, discharge from coal mining opens the originally closed river basin, thereby changing the water-bearing stratum's structure and groundwater seepage state in mining area. During mining in mine shaft, surface runoff, base current, and undercurrent dewater the massive mine shaft water surge. Groundwater flow changes from the lateral movement under natural state to vertical movement to jointly cause severe groundwater loss and directly influence the total water resource quantity. In addition, coal excavation can destruct water-bearing stratum, decrease the groundwater level, and change the groundwater transport mode that can result in the loss of groundwater. Consequently, failure in atmospheric precipitation and in surface runoff and ground runoff circulation is observed; surface water is also not supplemented, finally lowering the surface water quantity.

Coal mining-caused water pollution comes from the mine pit and mine shaft water during excavation, coal slim water from washing, and coal dump leaching water. The rock mass destruction in coal mining process can influence the

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