Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
e-ISSN: 2395-3454

Vol. 18 | No. 5 (Special Issue) | pp. 1555-1560 | 2019

Original Research Paper

Open Access

Study on Calculation Method of Ecological Environment Flow Rate of Water Conservancy and Hydropower Project in Coal Mining Area

Ying Dong*, Xijun Wuand Ahmad Jalal Khan Chowdhury*****

*School of Civil Engineering, Yulin University, Yulin, Shaanxi, 719000, China

**Shaanxi Key Laboratory of Ecological Restoration in Shanbei Mining Area, Yulin University, Yulin, Shaanxi, 719000, China

***Department of Marine Science, Kulliyyah of Science, International Islamic University Malaysia 25200 Kuantan, Malaysia

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 15-08-2019
Accepted: 15-10-2019

Key Words:
Ecological environment
Water conservancy
Hydropower
Coal mining area
Flow calculation

ABSTRACT

The ecological environment is the basic natural condition related to human survival and development. Protecting and improving the ecological environment is the basis for ensuring social and economic sustainable development and a virtuous cycle of water resources, especially coal mining areas. This paper hopes to understand and master all kinds of calculation methods for the discharge of ecological flow in water conservancy and hydropower projects at home and abroad, analyse the advantages and disadvantages and application scope of various methods, and propose a more reasonable quantitative calculation method of ecological flow in combination with typical water conservancy and hydropower engineering research. The calculations show that most of the aquatic organisms have excellent habitat conditions when the river's inner diameter flow is 60% of the average annual river flow. It is hoped that it will play a reference role for other similar water conservancy and hydropower projects in China, realize the coordination of water resources development and river ecological protection, implement ecological water conservancy and ecological hydropower model, and solve the ecological problems that restrict the development of water conservancy and hydropower in China to a certain extent.

INTRODUCTION

For a long time, coal resources, as an important material basis for China's economic development, have made great contributions to economic development and social progress, and have also had a serious impact on the ecological environment of coal mining areas, bringing many problems that are difficult to avoid, such as surface subsidence, vegetation degradation, meteorite accumulation, river runoff reduction, groundwater source dryness and decline in cultivated land productivity. In view of the fact that China's energy consumption mainly depends on the status quo of coal resources and the trend of coal resource development gradually shifting to the ecologically fragile western region, this paper will analyse the cumulative effect of ecological environment in coal mining area from the perspective of sustainable development of mining area and adhering to the concept of "green development". Mechanism, analysis and discussion of measures and methods for adaptive management of cumulative effects of ecological environment in mining areas and seek mining development models that are suitable for China's national conditions, coordinated with coal resources development and ecological environment (Chen et al. 2016). The 21st century is a century of knowledge economy and global economic integration. The interaction between economic activities and ecological environment is deepening. Global population growth, resource shortage, environmental pollution and ecological deterioration have become common problems faced by mankind. More and more countries and regions regard ecological security as the basic strategy of national security, and seeking coordinated development of economy, population, resources and environment has become a global common action.

This paper studies the calculation of the ecological base flow of the river aquatic ecosystem in the coal mining area, and analyses the relevant calculation methods to obtain the ecological base flow in the coal mining area, which is the ecological environment of the water conservancy and hydropower project in the future coal mining area. The protection provides a good theoretical basis.

EARLIER RESEARCH

Since the 26th International Geological Congress proposed the geological environment issue in 1980, the awareness of the participation of the world's earth workers in environmental research has gradually strengthened (Xue et al. 2017, Ying et al. 2018). The geological institutions of many countries have gradually shifted their work to environmental geological work, and environmental geological research has been under

rapid development. The United States, Britain, Canada, Japan, Australia, Russia, France, Germany, China, India, Italy and other countries have carried out fruitful research according to the actual conditions of various countries, and formed many sub-disciplines, such as: environmental hydrogeology studies, environmental engineering geology, environmental geochemistry, disaster geology, seismic engineering geology, seismic hydrogeology, urban environmental geology, mining environmental geology, etc. These disciplines are further derived into sub-level branches. In research methods, 3s (geo information system (GIS), remote sensing (RS), global positioning system (GPS)) have been widely used as a technical support, forming a large group of subjects including basic theoretical research, applied research and technical methods. But as a gate science, environmental geology itself has not yet formed its own complete and mature theoretical system and working methods (Ding et al. 2016). Wu et al. (2016) studied the environmental problems of water and soil in Shenfu Dongsheng mining area and its control techniques, and discussed the mine water inrush, surface crack collapse, sand collapse, water source damage and vegetation death caused by deformation and destruction caused by mining roof rock. In addition, it has caused serious problems in water and soil environment such as increased desertification and water pollution (Thakur et al. 2016, Joe et al. 2019). It is proposed to establish a grading protection system for water source sites, and to cope with drainage roads to extract groundwater and other measures to protect the water environment (Sahoo et al. 2016). In terms of water environment pollution, Xiqin et al. (2001) proposed a method to meet the water quality protection standards and pollutant discharge concentrations according to river water quality protection standards, and to estimate the amount of water needed to meet environmental functions such as river dilution and self-purification.

RESEARCH METHODS

Hydrology Law

At present, the research status at home and abroad mentioned that the most commonly used representative methods are 7Q10 method, Tennant method, NGPRP method, Basic flow method (Basic Flow) and so on.

7q10 method: From the perspective of controlling the discharge of pollution sources, the method uses the average water volume of the 90% guarantee rate for the last 7 days as the minimum flow design value of the river. Since the natural flow state basically exceeds the 7q10 flow rate, meeting this requirement can meet the sewage discharge requirements in the natural state. However, this flow has nothing to do with the growth of fish in the water. Under this flow, there is no further health level in the aquatic organism. For most rivers, the 7q10 flow is less than 10% of the annual average flow, so the effect of the flow determined by this method has limited impact on river ecological protection (Ren et al. 2016). In view of the backward development level in China, the water resources in the north and the south are quite different. Our country stipulates in the "Technical Principles and Methods for Formulating Local Water Pollutant Emission Standards" (gb3898-83) that the general river adopts the driest month in the past ten years. The average flow rate or 90% of the guaranteed rate is the smallest monthly average flow as the minimum design flow. Others use the multi-year average of the minimum monthly mean measured runoff of the river as the basic ecological environment water demand of the river (Bruno et al. 2016). Since the measured runoff is used, it is required to select the measured data when the human influence is small.

Tennant method: The method is based on extensive field investigations of the habitat and use parameters of many rivers in the eastern, western and central and western parts of the United States. The annual average runoff percentage is used to describe the flow status in the river according to the hydrological data. See Table 1 for details.

The law considers that the relationship between river aquatic biomass production and water volume is as follows:

The inner diameter of the river channel is 60% of the average annual river flow (i.e. 40% is water consumption outside the river), and most aquatic organisms have excellent to excellent habitat conditions in the main growth period. Under such flow conditions, river width, water depth and flow rate will provide an excellent environment for aquatic organisms to grow. Most rivers, including many rapid shoal areas, will be covered, and water flow will usually occur in the side channels that can be transported. The riparian beach will become a place where fish can swim, and it will become a safe burrowing area for wild animals. Most of the disasters, rapids and shoals will be moderately absent from the water, providing excellent breeding and growing environment for fish. Plants will have plenty of water, and in any shoal area, fish swimming will not be a problem (Wu et al. 2016).

The inner diameter of the river channel is 30% of the average annual river flow (i.e. 70% is water consumption outside the river), which is the amount of water needed to maintain good habitat for most aquatic animals. Under this flow condition, except for the extremely wide shoal, most of the river channels will be out of the water, and most of the side channels will have water flow. Many river banks will become active areas for fish and can also be a place for wildlife to burrow. Many of the river's currents and the depth of most of the disaster areas will be sufficient as a place for fish to move. The ridge less pusher will be reduced, but it is

Table 1: Status of river flows to protect fish, wildlife and related environmental resources.

Flow description	Recommended base flow during dry season (% average flow)	Recommended base flow in the flood season (% average flow)
Flood or maximum		200 (48~72/hour)
Optimum range	60~100	60~100
Well	40	60
it is good	30	50
Good	20	40
General or poor	10	30
Poor or minimum	10	10
Very poor	0~10	0~10

not expected to be a controlling factor in the number of fish populations (Defu et al. 2016).

The inner diameter of the river channel is 10% of the average annual river flow (i.e., 90% is water consumption outside the river), which is the minimum amount of water required for most aquatic organisms to survive. Under such flow conditions, the river width, water depth and flow rate will be significantly reduced, the quality of the aquatic ecological environment will be reduced, and nearly half of the river or normal wet weeks will be exposed to the water surface, and the exposed shallow shoal will be more. Most of the side troughs will dry up, and the pebbles and sands will be basically dry and waterless. The burrowing sites on the shores of fish and fur animals will disappear (Gu 2016). Some shallow waters have shallower water depths, so that fish can't move here and generally can only concentrate in the main trough. The shore plants will be short of water, and the larger fish will encounter difficulty in swimming.

NGPRP method: The NGPRP method divides the year into a dry year, a wet year, and a standard year, and takes the standard annual group 90% guaranteed rate flow as the minimum flow. The advantage is that the difference between drought years, wet years and standard years is considered. This method combines climatic conditions with frequency factors but lacks biological basis.

The basic flow method is to determine the required flow according to the change of river flow. The specific method is to calculate between 1 and 2, 2 and 3, ... 99 and 100 points according to the minimum flow series of 1, 2, ... 100 days of the average year. The flow rate changes, and the flow rate corresponding to the maximum flow change is set as the basic flow required by the river. The method can reflect the difference in ecological environment water demand between seasonal rivers and non-seasonal rivers with the same annual average flow rate, and the calculation is easy, but lacks biological data (Duis & Coors 2016).

Hydraulics method:

***Wet week method*:** The wet-week method is a standard setting method for habitat protection types. The method is based on the assumption that protecting the wet weeks of aquatic habitats in critical areas will also provide adequate protection for habitats in non-critical areas. Use the wet week (see Fig. 1) as the quality indicator for the habitat, by plotting the relationship between the wetted area and the flow in the critical habitat area (usually mostly shoal), according to the turning point in the wet-week flow relationship diagram (see Fig. 2). Determine the recommended flow value for the river.

***R2-Cross method*:** The R2-Cross method is a model set by the standards of habitat retention type and is developed by experts from the Colorado Water Resources Bureau. The R2-Cross method considers that the main ecological function of river flow is to maintain river habitats, especially shoal habitats, which use river width, average water depth, average flow rate, and wet-week rate to assess the protection level of river habitats. Determine the river target flow. The recommended value of river target flow is based on the assumption that shoals are the most critical type of river habitat and protecting shoal habitats will also protect other aquatic habitats such as waterholes and waterways.

Hydrological-biological analysis: This method is directly from the relationship between river flow and biomass or population change, to determine the demand of the organism for river flow, and the impact of flow changes on the biological population. The research object is usually fish, ridge less pusher (insect, crustacean, mollusks, etc.) and large stolen goods (higher plants). Multivariate regression statistical methods are often used to establish the relationship between initial biological data (species biomass or diversity) and environmental conditions (flow, flow rate, water depth, chemistry, temperature). Representative methods are:

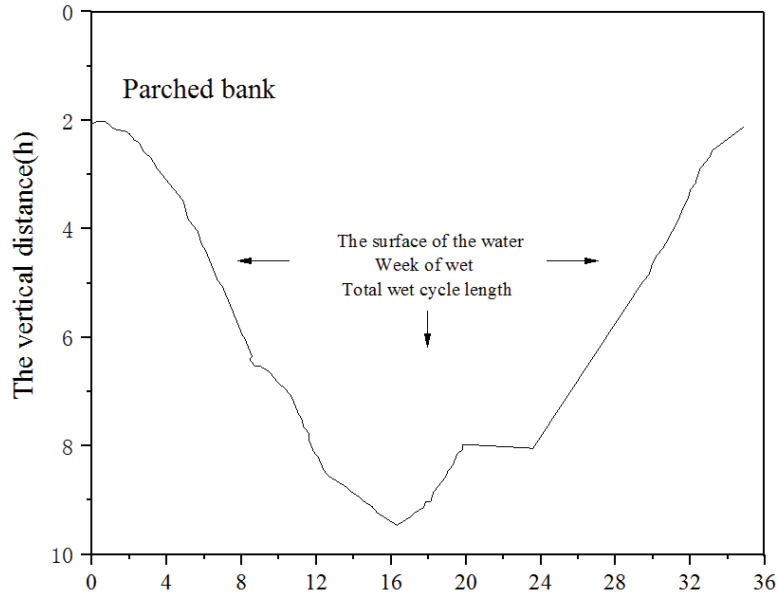

Fig. 1: Definition of wet cycle.

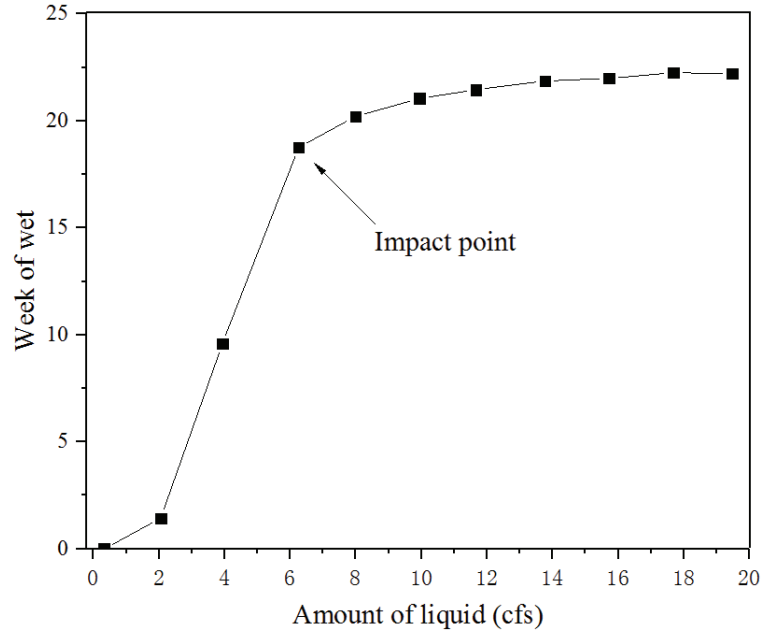

Fig. 2: Wet cycle flow rate relationship.

***Rcharc method*:** The Rcharc method studies the ecologically acceptable flow state of rivers based on the relationship between water depth and flow rate and changes in fish populations.

***Basque method*:** Basque method is based on the continuous theory that the species diversity in the middle and upper reaches of the river increases with the increase of flow rate. According to Manning's formula, the relationship between wet period and flow rate is established, and then the wet-week changes of the river without ridge pusher are utilized. The relationship determines the minimum and optimal flow.

***Stromberg and Patten*:** Stromberg and Patten established a regression equation for flow and growth of kapok trees in large plant research and determine the minimum flow criteria accordingly.

***Gregor and Friedman method*:** The change of wetland species is related to the inundation time of the riparian zone, and the relationship between the riparian zone and the water volume is judged by the change of tree species in the riparian zone, so as to determine the amount of water needed to protect the riparian zone vegetation.

RESULT ANALYSIS

Hydrology law: The greatest advantage of the hydrological method is that it does not require on-site measurements. It can be applied to rivers with hydrological data and waterless data. However, when applying hydrological methods to a certain area, it is necessary to analyse whether the flow standards conform to local rivers. The situation, combined with local river management objectives, adjusts the flow criteria. However, there are also shortcomings. For example, the objects studied by Tennant method are mostly small-scale rivers. For large rivers, the ecological water demand should be smaller, so the seasonal changes of flow are not considered, and there is no distinction between dry years, abundant years, and peaceful waters. The difference in years does not take into account the shape of the river.

Hydraulics method: The advantage of the hydraulics method is that only simple on-site measurements are required, and detailed species habitat relationship data is not required, and the data is readily available. The disadvantage is that it does not reflect seasonal variations and is usually not used to determine the flow of seasonal rivers, but it can provide a hydraulic basis for other methods, so it can be used in combination with other methods. The wet-week method is affected by the shape of the river. For example, the growth and change points of the wet-cycle flow curve of the triangular channel are not obvious and difficult to discriminate, while the wide-shallow rectangular channel and the parabolic channel have obvious changes in the wet-cycle flow relationship, so the method is applicable to both rivers, and the shape of the riverbed is required to be stable and does not change with time. Otherwise, there is no stable wet-circumference flow curve and there is no fixed growth point. The R2-Cross method is based on the Manning equation and determines the relevant parameters based on the measured data of a river section and represents the entire river. This method is relatively more complicated than the hydrological method, and it is easy to produce errors by using a river section hydraulic parameter to represent the entire river.

Hydrology-biological analysis: Although these methods relate flow to biological relationships, flow is not the only factor that determines changes in biological populations and biomass, and there are many other influencing factors, especially water quality, so this approach does not fully explain the flow and biology and the intrinsic relationship of the population. In addition, the application of the law is also vulnerable to the limitations of biological data, and the lack of understanding of the interaction between the influencing factors also limits the application of the law. Moreover, these methods are the results of research on specific rivers, and they are not very popular, and the reference and promotion applications are of little significance.

CONCLUSION

Coal resources are an important resource in China. Coal is inseparable from all aspects of our life. However, the exploitation of coal has brought many problems, especially in terms of the environment. Therefore, it is crucial to calculate the ecological environment flow of water conservancy and hydropower projects in coal mining areas. Based on the actual situation of coal mining area, this paper proposes a method for calculating river ecological base flow at home and abroad, which can be divided into hydrology method, hydraulic method and hydro-bioanalysis. Among them, the hydrological method includes 7Q10 method, Tennant method, NGPRP method, Basic flow method, Basic method. Hydraulic method, R2-Cross method, and hydrological-biological method includes RCHARC method, Basque method, Stromberg with the Patten method, the Gregor and Friedman methods. These calculation methods have their own advantages and disadvantages. This paper studies and expounds these advantages and disadvantages and hopes to help the ecological environment of water conservancy and hydropower projects in coal mining areas, so that we can better protect us while rationally excavating coal.

REFERENCES

Bruno, M.C., Cashman, M.J., Maiolini, B., Biffi, S. and Zolezzi, G. 2016. Responses of benthic invertebrates to repeated hydropeaking in semi-natural flume simulations. Ecohydrol., 9(1): 68-82.

Chen, A., Wu, M., Chen, K.Q., Sun, Z.Y., Shen, C. and Wang, P.Y. 2016. Main issues in research and practice of environmental protection for water conservancy and hydropower projects in China. Water Science and Engineering, 9(4): 312-323.

Defu, L., Zhengjian, Y., Daobin, J., Jun, M., Yujie, C. and Linxu., S. 2016. View on the mechanism and its controlling methods of the algal blooms in the tributaries of three Gorges reservoir. J. Hydraul. Eng., 47(3): 443-454.

Ding, W., Shi, D., He, W., Jiang, G., Jiang, P. and Li, Y. 2016. Hydro dynamic characteristics of engineering accumulation erosion under side slope runoff erosion process in fields scouring experiment. Transactions of

the Chinese Society of Agricultural Engineering, 32(18): 153-161.

Duis, K. and Coors, A. 2016. Micro plastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects. Environ. Sci. Eur., 28(1): 2.

Gu, Z., Duan, X., Bing, L., Hu, J. and He, J. 2016. The spatial distribution and temporal variation of rainfall erosivity in the Yunnan plateau, southwest China:1960-2012. Catena, 145: 291-300.

Joe, E.J., Tongkul, F. and Roslee, R. 2019. Behaviour of channelised debris flow in the crocker range of Sabah, Malaysia: A Case Study at Ulu Moyog, Penampang. Geological Behavior, 3(1): 28-32.

Ren, D., Xu, X., Hao, Y. and Huang, G. 2016. Modelling and assessing field irrigation water use in a canal system of Hetao, upper yellow river basin: application to maize, sunflower and watermelon. J. Hydrol., 532: 122-139.

Sahoo, P.K., Equeenuddin, S.M. and Powell, M.A. 2016. Trace elements in soils around coal mines: current scenario, impact and available techniques for management. Curr. Pollut. Rep., 2(1): 1-14.

Thakur, P.K., Aggarwal, S., Aggarwal, S.P. and Jain, S.K. 2016. One-dimensional hydro dynamic modelling of GLOF and impact on hydro power projects in Dhauliganga river using remote sensing and GIS applications. Nat. Hazards, 83(2):1-19.

Wu, F., Xuan, W., Cai, Y. and Li, C. 2016. Spatio temporal analysis of precipitation trends under climate change in the upper reach of Mekong river basin. Quatern. Int., 392: 137-146.

Xiqin, W., Changming, L. and Zhifeng, Y. 2001. Method of resolving lowest environmental water demands in river course (I): Theory. Acta Scientiae Circumstantiae, 21(5): 544-547.

Xue, L., Zhang, H., Zhang, L., Chi, Y. and Sun, C. 2017. Impact of water conservancy projects on eco-hydrological regime of Tarim river based on improved RVA method. J. Hohai Univ., 45(3):189-196.

Ying, H.S., Anuar, M.S. and Mohd Nor, M.Z. 2018. Drying, colour and sensory characteristics of 'Berangan' Banana (Musa Accuminata) flesh dried using a microwave oven. Malaysian Journal of Halal Research, 1(1): 10-14.