Scholar Publishing Group
Water Pollution Prevention and Control Project
https://doi.org/10.38007/WPPCP.2020.010101
ISSN 2790-2730 Vol. 1, Issue 1: 1-10

Water Pollution Prevention and Control Grade Evaluation Based on Analytic Hierarchy Process and Fuzzy Comprehensive Evaluation

Carmen Ballester*

Laboratoire des Systèmes Electriques Industriels (LSEI), BP No. 32 El-Alia, Bab Ezzouar 16111, Algerie

**corresponding author*

Keywords: Water Pollution, Prevention and Control Grade Evaluation, Analytic Hierarchy Process, Fuzzy Comprehensive Evaluation

Abstract: With the rapid development of economy, the continuous growth of industrial and agricultural production demand and the rapid growth of the world population, Water Pollution (referred to as WP for convenience) has become one of the most important and urgent environmental problems for mankind. However, WP has become increasingly serious in the process of development, such as changes in the natural environment and the operation of social systems. This would not only aggravate the contradiction between supply and demand, but also affect environmental protection and economic development. Therefore, it is urgent to explore ways to reduce regional WP and strengthen the control and protection of water resources. Therefore, by analyzing the basic requirements of WP prevention and control, this paper studied the control unit of prevention and control, and then analyzed the standards of WP prevention and control. Finally, the corresponding control strategies were proposed. By comparing the specific effects before and after WP control, it could be seen that the treatment effect after WP control was 10.9% higher than that before. The degree of subordination was 10.3% higher than that before control, and the environmental bearing capacity was 11.4% higher than that before control. In short, the prevention and control of WP was of great significance to the development of environment and economy.

1. Introduction

WP is one of the main problems hindering social and economic development and threatening public health. The rapid development of cities, the acceleration of industrial concentration, the excessive use of fertilizers and pesticides, the long-term development and the rigid water resource

management model have led to the reduction of water environment potential, the abuse of water resources and the serious deterioration of water environment. With regard to the prevention and control of WP, it is difficult to confirm whether the effectiveness of prevention and control meets the standards, and it is urgent to apply scientific and accurate evaluation methods. In this regard, it is of great practical significance to carry out WP prevention and control assessment.

WP has a serious negative impact on the environment. Singh Nirala believed that since various chemicals produced and used in daily life would eventually pollute the water flow, it was challenging to provide clean water for drinking water or industrial water [1]. Mekonnen Mesfin M estimated the global anthropogenic phosphorus load and the relevant gray water footprint, and compared the gray water footprint of each basin with the runoff to assess the WP level [2]. Liu Yi combined the improved grey correlation model with the Kuznets environmental curve, and quantitatively and qualitatively studied the relationship between WP and economic growth in the No. 4 area in the south under the background of the five-year plan [3]. Lee Chang-Gu alleviated performance inhibition through the ability of symbiotic organics to remove oxidation. The high-efficiency titanium dioxide adhered to the polymer had strong affinity with some priority pollutants, which could improve the photocatalytic treatment efficiency of water and reduce energy demand [4]. Singh Upma discussed the potential impact of industrial wastewater on biological systems through Indian water bodies. Especially in the United States, rapid industrialization was a measure of a country's development [5]. Yan Yan evaluated how the accumulation of pollutants would provide important services for the urban ecosystem, and reduced the ecological risk of Xiamen's surface water, which exerted pressure on the water treatment system that controlled population growth and optimized industrial structure [6]. Xu Zuxin believed that the development of wastewater system lagged behind the pace of urbanization in developing countries and had a significant impact on the water quality of urban rivers. The experience of urban river restoration might be beneficial to other countries in the south [7]. The above studies described the harm of WP, but there were still some deficiencies in the research of prevention and control.

The prevention and control of WP is of great significance to the improvement of water quality. He Mingjing studied the application of bio-coal in urban wastewater treatment, industrial wastewater treatment and rainwater management to maximize social and economic benefits [8]. Li Zhou discussed the impact of river length system on reducing agricultural WP. The government should reduce the pressure on fertilizer sources and prevent fertilizer from flowing into surface water. In addition, the central government should strengthen cooperation between upstream and downstream governors [9]. According to the mixed application of membrane technology with other types of water treatment methods such as adsorption, advanced oxidation process and biological activated sludge, Martini Sri discussed the latest development of membrane technology for sewage and wastewater purification [10]. In order to help develop WP intervention measures taking into account the rapid growth of African cities, Chen Sophia Shuang adopted economically feasible surface water quality monitoring methods as soon as possible to assess the impact of urbanization on river water quality [11]. Ahmed Shahid suggested that young people in New Delhi to study WP, its causes, its impact on health and its understanding of solutions, and established an appropriate waste management system before waste flowed into rivers [12]. The above studies described the advantages of WP control, but there were still some deficiencies in the level assessment.

In order to study the specific effect of WP prevention and control, this paper studied the subordination degree of WP prevention and control through analytic hierarchy process and fuzzy comprehensive evaluation, and then carried out comparative experiments to study the specific evaluation results of WP prevention and control system. Through the comparison of experiments, it could be seen that the WP prevention and control effect after the optimization of prevention and control improved a lot. Compared with other documents, this paper focused on the classification of

WP prevention and control, and studied the prevention and control effect of WP.

2. Basic Requirements and Control Unit of WP Prevention

2.1. Basic Requirements for WP Prevention

The unique natural conditions and the increase of human activities have led to the deterioration of water quality [13]. The following requirements should be followed in the prevention and control of WP, as shown in Figure 1. The first is the total amount control: On the one hand, the protection of drinking water sources and rare animals and plants is an important basis for determining the role of water environment in preventing WP. Only by taking water environmental protection as one of the main objectives of WP prevention and control can water environmental benefits be more effective. Second, measures should be adjusted to local conditions. With regard to the ecological characteristics and functions of regional water, in the process of residents' economic and social development, it is necessary to fully adjust the relationship between resources and environment, and reasonably determine the scope of regional industrial design and development, so as to reasonably utilize the potential of the water environment and avoid improper allocation of functions. It is necessary to reduce the cost of WP control, and maximize the use of resources, so as to achieve economic development and shared benefits. The third is the consistency: WP planning should be subject to the environmental planning at the next higher level, and emphasize the coordination, complementarity and improvement of regional planning, so as to fully consider the overall coordination and comprehensive role of WP planning in environmental management. The fourth is the operability: Prevention and control of WP is a very important strategic task. The goal of improving water quality proposed in the measures should meet the objective needs of current WP prevention measures and future development, especially the development of urbanization. The results of these measures are conducive to management and public participation in monitoring.

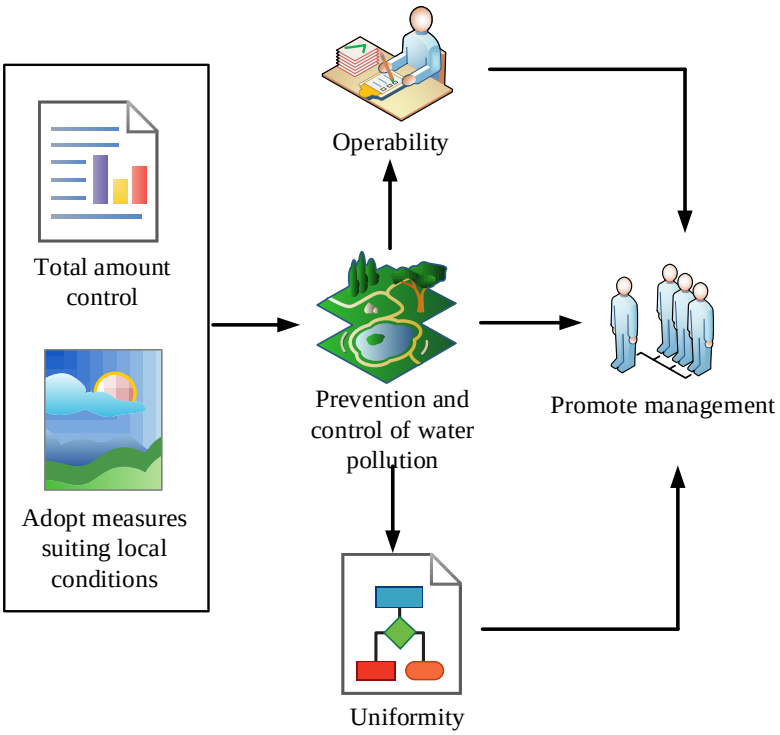


Figure 1. Basic requirements for WP prevention

2.2. Control Unit for WP Prevention

The WP module is an operation module composed of water and source, which is divided into different functions. Water is the sum of all pollutants released to the receiver according to the requirements of the water management function. According to the administrative management, water quality characteristics and pollution source distribution, the pollution source is divided into appropriate control and reception areas. The main functions of each control equipment are analyzed and described, including main functional areas and standard professional categories or water standards applicable to each functional area. According to the requirements of water resources management function, WP elements are classified, and administrative classification, water characteristics and pollution source distribution characteristics are considered simultaneously. The division principle is as follows: Each module can be evaluated by different control methods. For different pollutants and different protection purposes, an area can be divided into several control areas to meet the requirements of solving various environmental problems. In other words, different control units can be used for different control purposes. Each of them must have a complete pollutant discharge list and must systematically control the water quality. The interaction between control devices must be quantified by introducing and discharging pollutants to achieve the balance between water quality and substances.

3. Criteria for Evaluation of WP Prevention and Control Grade System

WP caused by emerging pollutants is increasing [14]. The purpose of WP assessment is to fully consider various problems that may occur in the WP planning at the beginning of prevention and control, and avoid the negative social impact that may occur after the implementation of the plan. As shown in Figure 2, WP monitoring as part of the assessment must meet the following criteria. The first is scientific and objective. WP control shall be evaluated scientifically, objectively and impartially, and the potential impact of water resources development planning and implementation shall be fully considered, thus providing a reference basis for use and protection decisions. Second is temporary intervention. Before the final adoption of the plan, the WP assessment should be carried out as soon as possible in order to optimize the intervention in the whole planning process. Third is integrity. WP assessment should include a comprehensive assessment of all urban and rural areas, and planning projects should be integrated, coordinated and audited throughout the region. Fourth is public participation. WP prevention and control assessment is a complex system, which needs to collect a large amount of data and information and the active participation of the public. The ultimate goal of WP is to create a favorable environment. Fifth is business ability. The assessment of WP control should be as simple, practical and realistic as possible, and the assessment indicators should be more practical. Sixth is sustainable development. The prevention and control of WP is long-term, so the environmental impact planning of sustainable development must be fully considered to ensure the sustainable use of water resources.

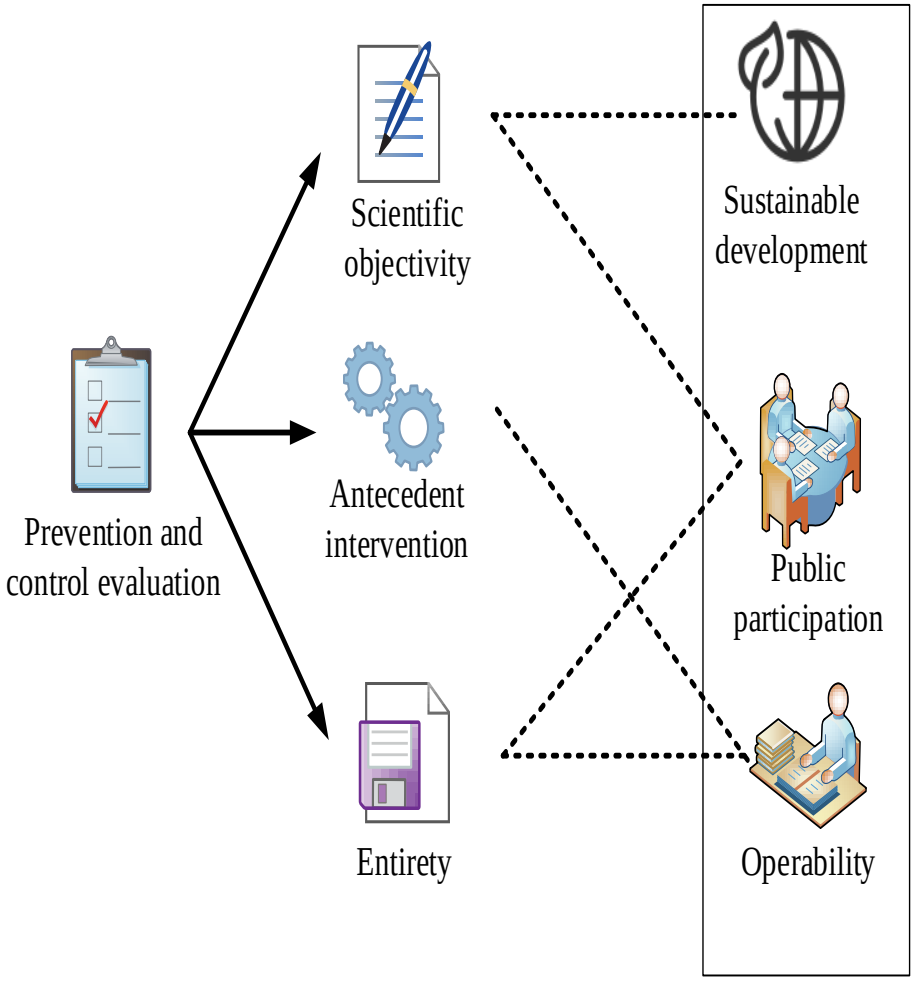


Figure 2. Evaluation criteria of WP prevention and control grade system

4. Application of Analytic Hierarchy Process and Fuzzy Comprehensive Evaluation in WP Control Grade

In order to study the prevention and control effect of WP, this paper classified the prevention and control effect of WP. The weight of prevention and control grade index is calculated by constructing a comparison matrix. The membership degree of WP prevention and control is calculated by fuzzy comprehensive evaluation combined with evaluation criteria. First, the comparison matrix A of WP prevention is calculated.

$$A=\begin{bmatrix} a_{11} & a_{12} & \Lambda & a_{1m} \\ a_{21} & a_{22} & \Lambda & a_{2m} \\ \mathrm{M} & \mathrm{M} & \Lambda & \mathrm{M} \\ a_{n1} & a_{n2} & \Lambda & a_{nm} \end{bmatrix} \tag{1}$$

Among them, a_{nm} is the importance of comparing n with m. The weight of control grade index is calculated as follows:

$$B_n = \left(\prod_{m=1}^{n} a_{nm} \right)^{1/n} \Big/ \sum_{m=1}^{n} \left(\prod_{m=1}^{n} a_{nm} \right)^{1/n} \tag{2}$$

Among them, m is the standard of WP prevention and control, and n is the level of WP prevention and control. Finally, the fuzzy comprehensive evaluation algorithm is used to calculate the membership degree of WP prevention and control grade as follows:

$$c_{nm} = \begin{cases} 0 \\ \dfrac{S_n - T_{n,m-1}}{T_{n,m} - T_{n,m-1}} \\ \dfrac{T_{n,m+1} - S_n}{T_{n,m+1} - T_{n,m}} \end{cases} \tag{3}$$

Among them, S_n is the actual value of importance and T_{mn} is the standard value of importance.

5. Ways to Improve the Evaluation Effect of WP Control Grade

According to the evaluation effect of prevention and control, this paper proposed several ways to improve the implementation effect of WP prevention and control, as shown in Figure 3. First, organizational leadership should be strengthened. A sound organization and management system, supervision policy and system, and control management system should be established. Necessary legal, economic, administrative and technical means should be fully utilized to ensure effective implementation of pollution control measures and achieve water quality objectives. Second, policy guarantee should be enhanced. The comprehensive evaluation system can monitor the prevention and control, and provide technical support for emerging prevention and control problems, so as to improve the prevention and control gap. It can also timely adjust the prevention and control objectives and indicators, and prevent and control problems incompatible with society, so as to promote economic development and environmental protection. Third, supervision and management should be strengthened. Local laws and regulations should be strictly observed to control WP. The integrated management of the priority water supply system in the region should be incorporated into the legalization process, and legal instruments should be formulated to eliminate the barriers to cleaner production, and control, manage and implement them. Policymakers can take relevant measures to prevent ecological risks [15]. In combination with the special measures for water treatment and environmental protection, the law enforcement of environmental protection groups should be strengthened, and the inspection frequency should be increased, thus focusing on the inspection of abnormal operation of sewage treatment plants and sewage theft and other illegal acts. Environmental protection services at all levels are administrated according to law and supervision is strengthened. The main pollution sources and treatment plants should strengthen the control of the official document system, and increase the frequency of environmental monitoring and inspection, so as to establish a regular reporting system.

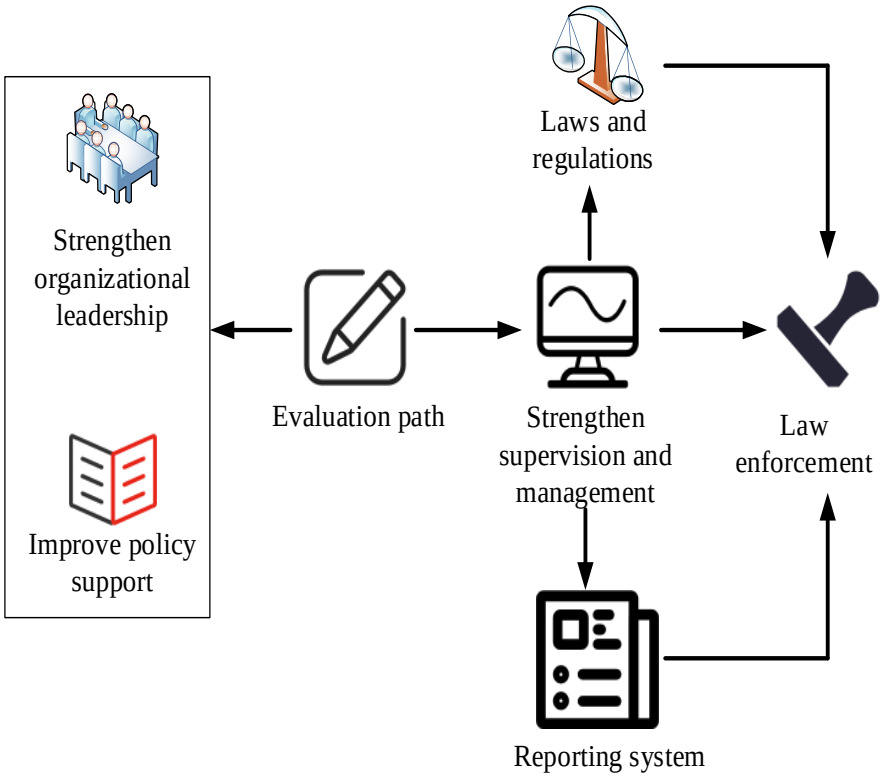


Figure 3. Ways to improve the evaluation effect of WP prevention and control grade

6. Experimental Evaluation of WP Prevention Grade

In order to study the specific effect of WP prevention and control, this paper evaluated the management and supervision ability, legal binding force and monitoring and forecasting ability of WP prevention and control, and then used fuzzy comprehensive evaluation and analytic hierarchy process to study the subordinate degree of WP prevention and control and water environmental carrying capacity. Therefore, this paper first investigated the management and supervision capacity, legal binding force and monitoring and forecasting capacity of a certain area before and after the optimization of WP prevention and control. The specific investigation results were shown in Table 1.

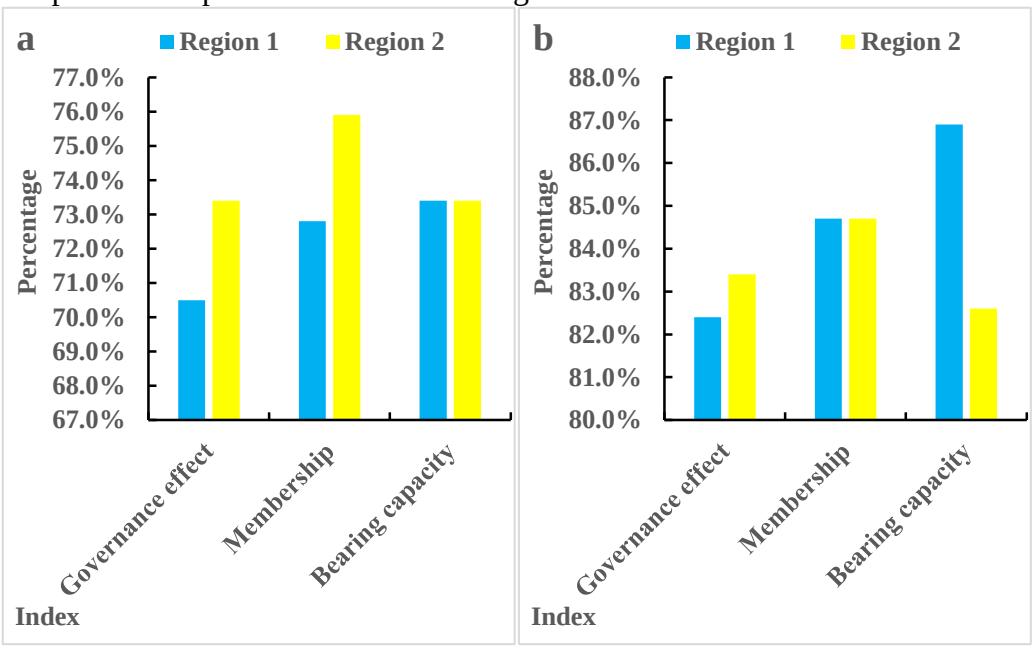
Table 1. Index changes of a region before and after WP control optimization

	Management and supervision ability	Legal binding force	Monitoring and forecasting capability
Before optimization	78.4%	68.1%	71.8%
After optimization	86.7%	85.8%	88.6%
Difference	8.3%	17.7%	16.8%

According to the data described in Table 1, before the optimization of WP prevention and control methods, the management and supervision capacity was 78.4%. The legal binding force was 68.1%, and the monitoring and forecasting capacity was 71.8%; after the optimization of WP control methods, the management and supervision capacity was 86.7%. The legal binding force was 85.8%, and the monitoring and forecasting capacity was 88.6%. Through comparison, it could be

seen that the management and supervision capacity of WP prevention and control methods after optimization was 8.3% higher than that before optimization. The legal binding force was 17.7% higher than that before the optimization of WP prevention and control, and the monitoring and forecasting capacity was 16.8% higher than that before the optimization of WP prevention and control. The optimized prevention and control methods could effectively improve the management and supervision capacity, legal binding force and monitoring and forecasting methods, and could also timely deal with WP areas, thus promoting the development of the environment.

Finally, according to the analytic hierarchy process and fuzzy comprehensive evaluation, the treatment effect, subordination degree and environmental carrying capacity of WP prevention and control in the two regions were analyzed and then compared with those before WP prevention and control. The specific comparison was shown in Figure 4.



a. Before WP prevention *b. After WP prevention*

Figure 4. Comparison of treatment effect, membership and environmental bearing capacity before and after WP prevention

It could be seen from Figure 4a that before WP control, the treatment effect of area 1 was 70.5%. The degree of subordination was 72.8%, and the environmental carrying capacity was 73.4%; the control effect of area 2 was 73.4%, and the degree of subordination was 75.9%. The environmental carrying capacity was 73.4%, and the overall treatment effect was 72%. The membership degree was 74.4%, and the environmental bearing capacity was 73.4%. It could be seen from Figure 4b that after WP control, the treatment effect of area 1 was 82.4%. The degree of subordination was 84.7%, and the environmental carrying capacity was 86.9%; the control effect of area 2 was 83.4%, and the degree of subordination was 84.7%. The environmental carrying capacity was 82.6%, and the overall control effect was 82.9%. The degree of membership was 84.7%, and the environmental carrying capacity was 84.8%.

By comparing the specific effects before and after WP control, it could be seen that the treatment effect after WP control was 10.9% higher than that before. The degree of subordination was 10.3% higher than that before control, and the environmental bearing capacity was 11.4% higher than that before control. It could be seen that after the prevention and control of WP, the carrying capacity of the water environment would increase, and the degree of membership would also increase. These

proved that the implementation effect of WP prevention and control was good.

7. Conclusion

In the context of WP, the government should pay attention to the identification of risk sources, including dynamic management of the types and quantities of hazardous chemicals and important hazard sources, especially the identification of plants around water sources or along rivers. In order to strictly prevent wastewater treatment from exceeding the standard and discharging illegally, the number of patrol inspections has been increased, and the water quality monitoring and WP early warning system should be established. In addition, according to the grade assessment of WP prevention and control, WP prevention and control need to be carried out for a long time, and also need policy support. It is necessary not only to strengthen supervision, but also to strictly crack down on WP enterprises. It is necessary to timely treat WP areas, and carry out corresponding prevention and control, so as to achieve the goal of ensuring water quality.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Singh Nirala, Bryan R. Goldsmith. Role of electrocatalysis in the remediation of water pollutants. ACS Catalysis. (2020) 10(5): 3365-3371. https://doi.org/10.1021/acscatal.9b04167

[2] Mekonnen Mesfin M, Arjen Y. Hoekstra. Global anthropogenic phosphorus loads to freshwater and associated grey water footprints and water pollution levels: A high‐resolution global study. Water resources research. (2018) 54(1): 345-358. https://doi.org/10.1002/2017WR020448

[3] Liu Yi, Liyuan Yang, Wei Jiang. Qualitative and quantitative analysis of the relationship between water pollution and economic growth: a case study in Nansi Lake catchment, China. Environmental Science and Pollution Research. (2020) 27(4): 4008-4020. https://doi.org/10.1007/s11356-019-07005-w

[4] Lee Changgu. Porous electrospun fibers embedding TiO2 for adsorption and photocatalytic degradation of water pollutants. Environmental science & technology. (2018) 52(7): 4285-4293. https://doi.org/10.1021/acs.est.7b06508

[5] Singh Upma. Water Pollution due to Discharge of Industrial Effluents with special reference to Uttar Pradesh, India-A review. International Archive of Applied Sciences and Technology. (2018) 9(4): 111-121.

[6] Yan Yan. Ecological risk assessment from the viewpoint of surface water pollution in Xiamen City, China. International Journal of Sustainable Development & World Ecology. (2018) 25(5): 403-410. https://doi.org/10.1080/13504509.2017.1422567

[7] Zuxin Xu. Urban river pollution control in developing countries. Nature Sustainability. (2019) 2(3): 158-160. https://doi.org/10.1038/s41893-019-0249-7

[8] Mingjing He. Waste-derived biochar for water pollution control and sustainable development. Nature Reviews Earth & Environment. (2020) 3(7): 444-460.

[9] Li Zhou, Lingzhi Li, Jikun Huang. The river chief system and agricultural non-point source water pollution control in China. Journal of Integrative Agriculture. (2020) 20(5): 1382-1395. https://doi.org/10.1016/S2095-3119(20)63370-6

[10] Martini Sri. Membrane technology for water pollution control: a review of recent hybrid mechanism. Jurnal Rekayasa Kimia & Lingkungan. (2020) 17(1): 83-96. https://doi.org/10.23955/rkl.v17i1.23610

[11] Chen, Sophia Shuang. Assessment of urban river water pollution with urbanization in East Africa. Environmental Science and Pollution Research. (2020) 29(27): 40812-40825. https://doi.org/10.1007/s11356-020-18082-1

[12] Ahmed Shahid, Saba Ismail. Water pollution and its sources, effects & management: a case study of Delhi. Shahid Ahmed and Saba Ismail. International Journal of Current Advanced Research. (2018) 7(2): 10436-10442.

[13] Xiaodong He, Peiyue Li. Surface water pollution in the middle Chinese Loess Plateau with special focus on hexavalent chromium (Cr6+): occurrence, sources and health risks. Exposure and Health. (2020) 12(3): 385-401. https://doi.org/10.1007/s12403-020-00344-x

[14] Morin-Crini Nadia. Worldwide cases of water pollution by emerging contaminants: a review. Environmental Chemistry Letters. (2020) 20(4): 2311-2338.

[15] Yankui Tang. Emerging pollutants in water environment: Occurrence, monitoring, fate, and risk assessment. Water Environment Research. (2019) 91(10): 984-991. https://doi.org/10.1002/wer.1163