

Literature Review and Metrics Analysis of Environmental Color Based on Citespace

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Abstract:

This paper conducts a quantitative analysis and content review of 1,390 research papers on environmental color from the CNKI database spanning 2000 to 2025, using Citespace software. The quantitative results indicate that the number of publications in this field shows a fluctuating trend, going through three stages: initial growth, rapid growth, and fluctuating decline. There are few high-yield authors and stable collaborative teams, with scattered institutional collaborations. Keywords have evolved from “architecture” and “urban color” to “traditional villages” and “intelligent technology”. On this basis, this paper analyzes the research content from three aspects: theoretically, it reflects interdisciplinary integration, combining color geography, psychology, and Chinese traditional color systems; practically, it focuses on traditional color protection and modern translation, covering diverse scenarios; technically, it achieves a leap from qualitative description to quantitative analysis, with intelligent technologies driving research precision.

Keywords:

Environmental Color, Citespace, Literature Review, Quantitative Analysis, Research Trend

1. Introduction

Color is the most aesthetic phenomenon in nature and the most direct visual element for human beings to perceive the world. As early as over 2,400 years ago, China developed the five-color concept associated with the “Five Elements” philosophical ideology. During the Western Zhou Dynasty, this concept was linked to numerous natural and social phenomena, endowed with rich cultural connotations, and refined into the color representation of China’s “Five Cardinal Directions’ True Colors” [1]. From Newton’s optical experiments to modern color psychology, color research has formed a multidisciplinary system covering physics, psychology, design, and other disciplines. In the field of architecture and urban-rural planning, environmental color has gradually become a key medium connecting regional culture and spatial design, defined as “a systematic element in natural and artificial environments that conveys visual information, shapes spatial atmosphere, and influences human behavior through color combinations”. The theoretical origin of environmental color can be traced back

to the early 20th century. German colorist Johannes Itten proposed the “color contrast theory”, laying the aesthetic foundation for the application of environmental color; while French scholar Jean-Philippe Lenclos founded color geography in the 1980s, which systematically explored the shaping mechanism of regional natural and cultural characteristics on color formation for the first time. In Asia, Japan introduced European color geography in the 1970s, incorporated color as a landscape visual element into the protection field of traditional Japanese buildings, and began to apply electronic color measurement instruments and color quantitative analysis technologies to architectural color planning and design, providing more opportunities for non-professionals to participate in urban color design and management [2]. Subsequently, Japan promulgated the Landscape Law in 2004, incorporating color into the urban style control system; while the color policies of various cities in South Korea are mainly regulated by the Landscape Law and the Comprehensive Plan for Promoting Public Design [3]. In contrast, academic research on environmental colors in China started relatively late. The “Measures for the Administration of Urban Design” in 2016 explicitly required “strengthening the management of building colors”. Cities such as Beijing and Shanghai have successively issued local Standards. For example, the “Shanghai Guidelines for Building Color Planning” proposes “inheriting the color spectrum of white walls and black tiles in the water towns of the southern Yangtze River”, reflecting the emphasis on regional characteristics. However, policy promotion has been significant in recent years. The Ministry of Housing and Urban-Rural Development has clearly put forward the principle of “focusing on the coordination between regional cultural characteristics and environmental colors”, providing institutional support for the development of the industry.

2. Research Methods and Data Sources

2.1. Research Methods

CiteSpace is an information visualization software developed by Professor Chaomei Chen from Drexel University in the United States using Java language, which can perform scientific literature data analysis. Professor Chen Chaomei designed CiteSpace to provide researchers with a technical means that can collect the literature needed for research and classify and analyze these literature materials [4]. This paper uses CiteSpace software as an analysis tool to generate visualized maps of publication years, authors, institutions, as well as keyword co-occurrence, bursts, and clusters by analyzing relevant literature, intuitively displaying the relevant content of environmental color research.

2.2. Data Sources

The data for this study was sourced from the CNKI database. Using CiteSpace Software, a literature search was conducted with “environmental color” as the subject term or keyword, covering the time period from 2000 to 2025, resulting in 1,931 articles. To enhance the quality of the analysis, after manual screening and exclusion of newspapers and irrelevant literature, 1,390 valid articles were finally obtained.

3. Quantitative Analysis of the Research Results on Environmental Colors

3.1. Analysis of Publication Years

Based on the data in Figure 1, the number of published papers on environmental color research shows a significant fluctuating trend, which can be divided into three stages: the initial growth stage (2000-2006). The number of papers was 15 in 2000, dropped to 7 in 2001, then gradually recovered year by year, reaching 57 in 2006, reflecting that research in this field gradually gained attention during this stage. The rapid growth stage (2006-2013). It fluctuated between 57 and 83 from 2006 to 2013, reaching a peak of 83 in 2013, indicating that research in this field entered a relatively mature and high-output stage. The fluctuating decline period (2014-2025). It began to fluctuate and decline from 2014, dropping to 39 in 2021, showing an overall downward trend. Due to the shift of research focus, the field encountering bottlenecks, or the impact of the external environment, the output of literature has experienced a reduction.

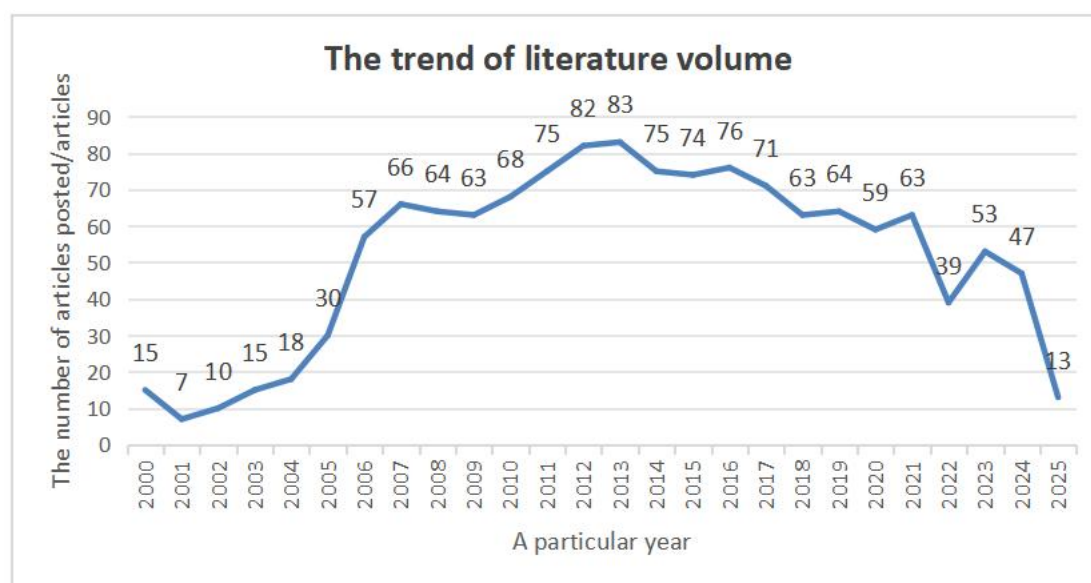


Figure 1. Trend of the number of papers published on environmental color research from 2000 to 2025.

3.2. Analysis of Article Authors

Using CiteSpace mapping and data, an analysis was conducted on authors in the field of environmental color research. Guohongyu ranked first with 10 publications, focusing primarily on urban and architectural environmental color studies. Following closely, Xinyifeng published 9 papers, Yangchunfeng 5 papers, while Cai Yunnan, Ding Yuan, and Wanyi each published 4 papers. A large number of other authors each contributed only 1 paper. Therefore, this indicates that there are relatively few high-yield authors in this field. The author co-occurrence map (see Figure 2) reveals the authors in the research field and their collaborative relationships. It contains 292 nodes, 63 connections, and a network density of 0.0015, with most collaborations being local and small-scale, suggesting that most scholars in this field conduct research independently without forming relatively stable collaborative relationships.

CiteSpace, v. 5.3.R1 (64-bit) Basic
November 6, 2025, 9:27:31 PM CST
CNR: D:\CNK\data
Timespan: 2000-2025 (Slice Length=1)
Selection Criteria: g-index (k=10), LRF=2.5, L/N=10, LBW=5, e=1.0
Network: N=292, E=4.3 (Density=0.0015)
Nodes Labeled: 1.0%
Pruning: Pathfinder
Excluded:

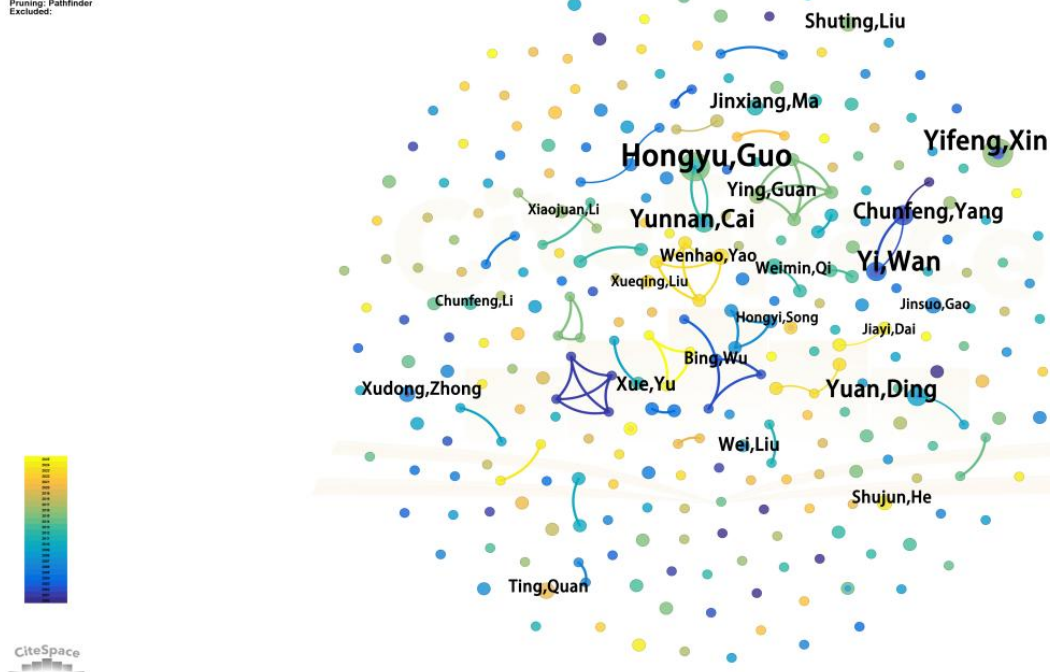


Figure 2. Co-author co-occurrence map of environmental color research.

3.3. Analysis of Document Issuing Institutions

As shown in the data of Figure 3, the number of publications by each institution in this field is counted. Among them, Xi'an University of Architecture and Technology has 16 publications, and the Research Office of Urban Environmental Art Design, School of Architecture and Urban Planning, Huazhong University of Science and Technology has 15 publications. The top two institutions are high-yield cores, highlighting the characteristic of disciplinary focus.

CiteSpace, v. 5.3.R1 (64-bit) Basic
November 6, 2025, 6:09:41 PM CST
CNR: D:\CNK\data
Timespan: 2000-2025 (Slice Length=1)
Selection Criteria: g-index (k=10), LRF=2.5, L/N=10, LBW=5, e=1.0
Network: N=247, E=13 (Density=0.0011)
Nodes Labeled: 1.0%
Pruning: Pathfinder
Excluded:



Figure 3. Co-occurrence Map of Environmental Color Research Institutions.

There are 247 nodes and 33 connections in the map, with a network density of 0.0011 among institutions. This indicates that the cooperation between research institutions is relatively scattered, and most research institutions are in a state of working alone. Among them, the top research institutions in terms of publication volume have strong strength and their research results have strong practical significance, while the research results of other institutions also play a positive role in environmental color.

3.4. Keyword Emergence Analysis

Keyword burst refers to keywords whose frequency increases suddenly within a certain period, which can show the temporal changes of a research hotspot, reveal the main dynamic changes of research hotspots, and predict the development trend of disciplines to a certain extent [5]. By screening keywords and drawing keyword burst maps, the start time, end time, and burst intensity of various hotspot keywords emerging in the past 20 years can be intuitively reflected [6]. After analyzing the burst keyword data from 2000 to 2025, a total of 10 burst words were obtained (as shown in Figure 4). In terms of time and intensity, it initially focused on architecture, cities, and architectural colors, then expanded to regional characteristics, and in recent years extended to diverse scenarios. The “traditional villages” have the highest intensity, reflecting the evolution of the research from basic spaces to characteristic fields and from macro scenarios to subdivided scenarios.

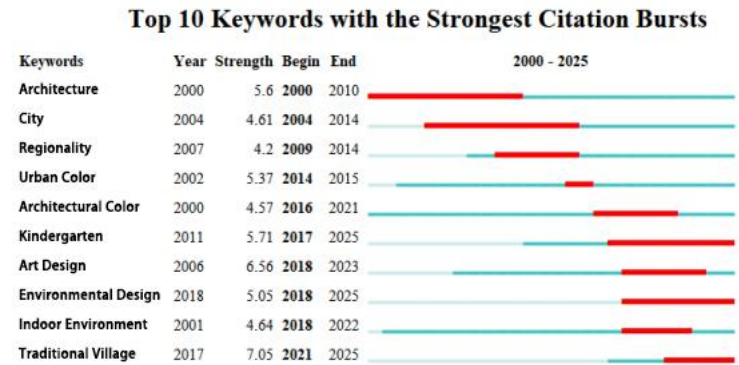


Figure 4. Keyword Emergence Map of Environmental Color Research.

3.5. Keyword clustering analysis

Cluster analysis mapping was generated using CiteSpace, and ten clusters were identified through the LLR algorithm (as shown in Figure 5), namely environment, environmental color, urban color, color design, traditional village, architectural color, city, people-oriented, interior design, and built environment. The cluster content can be categorized into three types: (1) Theoretical category, such as “environment” and “people-oriented”, which serve as fundamental theories for color or design research and provide theoretical support for various fields. (2) Practical category, such as “city”, “traditional village”, and “architectural color”, which involve color practices in different spatial scenarios and act as carriers for theoretical implementation. (3) Technical category, such as “color design”, which is researched using technical means including algorithm models and digitalization.

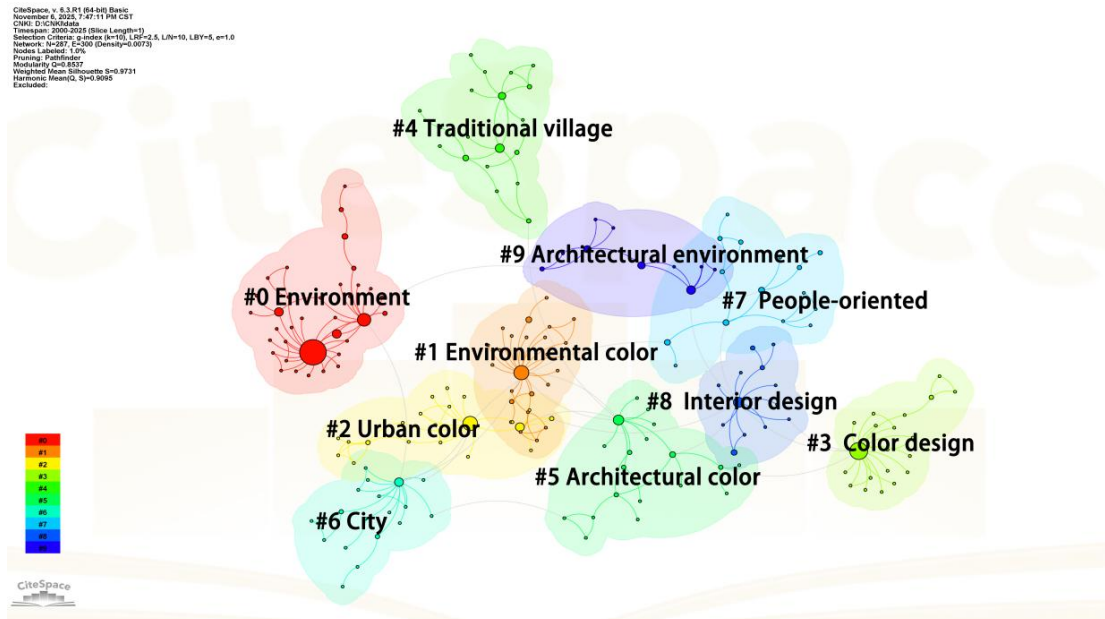


Figure 5. Keyword Clustering Map of Environmental Color Research.

3.6. Co-occurrence analysis of keywords

As an interdisciplinary field in urban construction and design, environmental color research continues to deepen with evolving practical needs and academic advancements. According to the data in Figure 6, “color”, “color design”, “urban color”, and “environmental color” emerge as the top four keyword nodes.

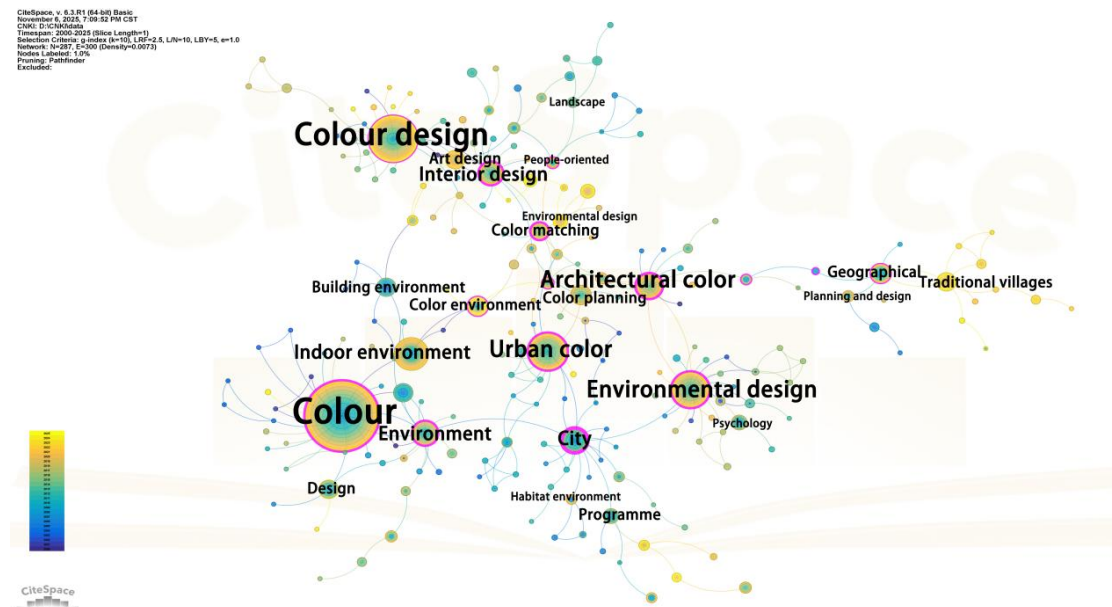


Figure 6. Co-occurrence map of keywords for environmental color research.

These terms dominate the literature collection, generating extensive radial connections that form an intricate structural network. The main content of environmental color can be categorized into three areas: (1). Environmental color theory. “Color” ranks first as the core of basic theory, serving as the framework for color cognition. “Urban color” and “environmental color” are theories that link color with urban and environmental contexts, acting as bridges connecting color and space.

(2). Environmental color practice. Keywords such as “color design” and “interior design” embody the underlying application logic of color in spatial design and environmental creation. Through design practice, color theories are translated into indoor and outdoor spatial scenarios. (3). Environmental color technology. “Color planning” implies technical logic, where technologies like color sampling and matching simulation provide support for the implementation of plans. Keywords such as “color application” and “planning and design” require technical assistance such as color measurement and digital visualization to be realized.

4. Research Content of Environmental Colors

4.1. Theoretical Research on Environmental Colors

4.1.1. Research on Color Geography

Color geography originated from the Western “new geography” ideological trend in the 1960s. French colorist Jean-Philippe Lenclos established color geography by integrating color science and geography across disciplines. Through more than 30 years of practical investigations, he found that the root cause of differences in color aesthetics lies in geographical factors, and proposed that the core research direction should focus on the correlation between regional environment and color phenomena. Initially focusing on 15 regions in France, he systematically collected color data of buildings and surrounding environments through methods such as material extraction, color reproduction, brightness level Recording, on-site sketching, and photographing, analyzed the influencing factors of landscape color quality, and gradually constructed the core concept of “landscape color characteristics”, laying a theoretical foundation for the discipline.

Chinese scholars have verified and expanded this theory in traditional village research. Taking Huizhou traditional villages as samples, Su Jianming and Liu Xueqing continued Lankow’s field research and Data Analysis methods, revealing that the color pattern of “white walls and black tiles” is the result of the coupling of local climate, landform and culture, which perfectly interprets the symbiotic relationship between nature and humanity in “landscape color characteristics” [7]. Xie Yushan’s research on traditional villages in Leizhou area, based on Lankow’s cognition of “single cause of regional color”, proposed a dual mechanism combining geographical adaptation layer and cultural coding layer: low-saturation colors and red clay tiles at the geographical level adapt to the local environment; at the cultural level, red ancestral halls and blue coastal villages echo regional beliefs, enriching the connotation of “landscape color characteristics” [8].

With the development of disciplines, the “color family theory” proposed by Lancolor has also been extended in the research of towns and cities in China. Dai Jiayi, Lu Xu, etc. extracted the dominant color of “ochre roof + light gray wall” in Qingshangou town, which not only conforms to the harmony principle of “color family”, but also reveals its correlation with local iron ore resources and Manchu residential aesthetics [9]. Guo Yuyi Translation integrates the “color family” with historical inheritance. By analyzing Jimo Ancient City, it points out that the system of “blue bricks, gray tiles + vermilion accents” is not only suitable for the climate of the Jiaodong Peninsula but also carries the culture of Qilu, promoting the “landscape color characteristics” to a dual interpretation of function and culture [10].

Currently, facing the problem of weakened uniqueness of colors caused by globalization, modern color geography research has achieved dual breakthroughs on the traditional basis: on the one hand, introducing technologies such as GIS and big Data Analysis, for example, Dai Jiayi quantified the colors of traditional villages through k-means clustering algorithm; on the other hand, expanding the research perspective to ecosystem, and deeply participating in urban color planning practice, constructing color system according to block function positioning, such as Jimo ancient city properly integrating traditional bright colors while protecting the base color, realizing the unity of color function and cultural expression, making color geography move from theoretical research to practical application, and completing the disciplinary upgrade from “description” to “guidance” [11].

4.1.2. Color Psychological Effects

Early studies on color psychology focused on the general laws of visual perception. Experimental studies by Vicente L et al. confirmed that in the initial stage of environmental visual perception (within 20 seconds), the proportion of color perception is as high as 80%, while that of shape is only 20%; after 2 minutes, the proportion of color perception gradually decreases to 50%-60%, and after 5 minutes, the two tend to be balanced [12]. This law has laid a foundation for differentiated research on different groups and promoted the deepening of color psychology from “general conclusions” to “group adaptation”.

In studies on children, Peng Zhimou, Zhang Ruiying and others conducted research on primary school indoor environments and found that bright yellow and green color systems conform to children’s early visual characteristics, can activate brain activity, and increase classroom participation enthusiasm by more than 30%. Yellow prolongs attention duration and green relieves learning fatigue, which confirms the key role of color perception in children’s cognition [13]. Gu Shujun’s kindergarten environment research supplemented that although overly bright high-saturation red and orange can attract attention in the short term, they can cause excessive excitement of children’s sympathetic nerves. The proportion needs to be controlled not to exceed 20% and matched with low-saturation neutral colors, clarifying the design boundaries of children’s color environment [14]. Yu Xiaojun’s research further pointed out that soft blue-green color system can reduce separation anxiety in young children, and color design with natural elements can promote cognition development, extending children’s color psychology from “short-term behavior guidance” to “long-term mental health” [15].

For the research on the elderly group, combined with the physiological characteristics of visual function degradation in the elderly, a dual adaptation theory of psychology and physiology is constructed. Based on machine learning, Guo Huagui, Zhang Minghuan, et al. collected physiological indicators and subjective evaluations of the elderly regarding street colors, and found that low-saturation warm colors (beige-orange, light brown) are positively correlated with a sense of pleasure. These colors not only conform to the elderly’s preference for soft colors but also evoke warm associations, enriching the physiological dimension of color psychology [16]. The research on elderly care facilities by Fei Ye, Zhu Shuo, et al. further quantified the standard for color brightness contrast (30%-50%). For example, light beige walls (brightness 70) paired with light brown furniture (brightness 40) not only meet the perceptual needs of the elderly after visual degradation but also avoid fatigue caused by excessive contrast, promoting the precision of elderly-friendly color theory [17].

4.1.3. Chinese Traditional Color Philosophy

Centered around the “Five Colors Concept”, Chinese traditional color philosophy, rooted in the theory of Yin-Yang and Five Elements, links the colors green, red, yellow, white, and black to natural laws and ethical order. For contemporary interpretation, it is essential to first establish a profound understanding of its philosophical connotations. In her 2007 work *Color Concepts in Ancient Chinese Philosophy*, Wang Limei pointed out that the Five Colors are not merely visual symbols but rather carriers of the “unity of man and nature” ideology. For instance, yellow symbolizes the stability of the central “Earth Virtue”, while red is associated with the vitality of the southern “Fire Virtue”. This research provides a crucial basis for interpretation, clarifying that interpretation must first grasp the philosophical logic behind colors rather than merely extracting their superficial representations [18].

Wang Jinghong further developed a practical framework for interpretation. Using the colors of Beijing during the Ming and Qing dynasties as a case study, she proposed a translation path of “color deconstruction - symbol extraction - modern reconstruction”. She emphasized the need to strip away the hierarchical attributes of traditional colors and extract their adaptive logic in relation to function and culture [19]. This framework has been continuously refined through subsequent practices. In 2023, she applied it to the renovation of an old factory building: using low-saturation warm gray tones to translate the “Earth virtue” inclusiveness mentioned by Wang Limei, and incorporating local low-brightness red to convey the vitality of “Fire virtue” [20]. Meanwhile, in accordance with the standardization requirements of the “Urban Color Design Guidelines” (GB/T42648-2023), the translation of traditional color philosophy not only stays true to its cultural roots but also meets the needs of modern spaces [21].

4.2. Research on Environmental Color Practice

4.2.1. Policies, Regulations, and Standards

Environmental color practice requires the guidance and regulation of policies, regulations, and standards. In many places and related fields in China, targeted documents have been gradually introduced, providing a basis for color planning, design, and control, avoiding “color pollution”, and ensuring the inheritance of regional color characteristics.

At the local level, some cities have already carried out special color planning and management practices. In the process of urban renewal in Quanzhou City, to address the color coordination issue between the protection of historical and cultural blocks and the construction of modern urban areas, relevant color control policies have been issued, requiring that the proportion of “red brick and white stone” colors in newly-built buildings in historical blocks should not be less than 70% of the building facade, while restricting the brightness and saturation of advertising colors in modern commercial blocks. In addition, Guangzhou City has designated three types of color Control zones: historical, modern, and ecological, and formulated corresponding color guidelines respectively: the historical style zone protects the color system of qilou buildings; the modern style zone encourages the use of low-saturation blue-gray colors to reflect a modern sense; and the ecological style zone uses green and earthy yellow colors to echo the natural environment, providing an operable “Guangzhou model” for urban color management [22].

In terms of industry standards and technical specifications, Guo Hongyu and Cai Yunnan proposed a dual standard system of “color database + control guidelines” in their research on urban color planning. They suggested using GIS technology to build an urban color database to Record color parameters of elements such as buildings, streets, and landscapes, while specifying color usage taboos for different functional zones [23]. In addition, the book “Urban Environmental Color Management and Planning Design” proposes to classify urban colors into three categories: architectural color, landscape color, and advertising color, and formulate corresponding Control ranges for lightness and saturation respectively, providing theoretical reference for the formulation of local policies [24].

4.2.2. Color Feature Recognition

The collection of environmental color feature recognition should be carried out in accordance with the characteristics of different scenarios. Gou Aiping, Gao Jiaqi, et al. took the Liuchunhu area in Quzhou as the research object, used ColorImpact4 Software and web data crawling to extract local environmental elements and regional colors, conducted data analysis from both RGB and HSB aspects, explored the correlation between regional colors and climate change, and provided color data support for landscape planning. This method is applicable to the scenario of natural environment color feature recognition, focusing on the associated collection of environmental elements and colors [25].

Jin Yu, Lu Xu, et al. targeted the town of Hengdaohezi, a cold-region town in Northeast China, and extracted urban color information based on the Chinese Color System. VR technology was used to realize remote color experience, and eye-tracking technology was combined to quantify the public’s color perception. Experiments are conducted from the overall to the local level to understand the characteristics of subjects’ color perception at different spatial scales. In scenarios where public preferences for urban color perception are explored, this approach enables accurate collection of public attention and emotional feedback regarding colors at different spatial scales [26].

Lyu Mei, Wang Xiangquan, et al. selected University Avenue in Berkeley, California, USA, and used Google Street View images to collect the colors of street buildings. They employed physical psychology methods and M-S color harmony theory to study the quality and harmony of street building colors, proposing a new method for street color analysis and Evaluation. This method is applicable to scenarios of identifying color characteristics of urban street buildings [27].

4.2.3. Color Application in Multiple Scenarios

(1) Industrial Scenarios

Color application in industrial scenarios should balance safety, functionality, and environmental harmony. Based on building hazard levels, Li Zongyu and Qin Hua proposed a differentiated color strategy: high-risk areas use yellow-black color matching to delineate hazard boundaries; general production areas adopt low-saturation light gray walls with light blue Equipment to reduce visual fatigue and facilitate fault identification [28]. In his research on modern aluminum plant environmental design, Wang Qingsong suggested that the factory exterior should use light gray with silver white to reflect industrial attributes and reduce visual impact on

the surrounding ecological environment, while using orange for Identification of facilities such as piping and stairs in the plant area to improve operational safety [29].

(2) Commercial Scenarios

In commercial scenarios, color is centered around attracting foot traffic and conveying brand tone, with different color strategies applied to various types of commercial spaces. Taking a commercial pedestrian street as an example, Wu Xiaojiao, Yan Yitong, and others proposed a “base color + accent color” model. Light beige is used as the base color for street pavements and building facades to create a comfortable shopping atmosphere, while high-saturation red and yellow serve as accent colors (accounting for $\leq 20\%$) in shop signs and landscape ornaments to avoid excessive visual stimulation [30]. In her research on the application of color psychology, Liu Shuyi pointed out that color matching in commercial spaces needs to balance “identifiability” and “comfort”. When the ratio of light gray base to theme color is controlled at 7:3, it not only ensures the overall harmony of the space but also stimulates consumers’ shopping interest. This conclusion provides a quantitative reference for color zoning design in shopping malls [31].

(3) Cultural Scenes

The application of colors in cultural scenes centers on inheriting culture and highlighting the spirit of the place, with a focus on the historical authenticity and cultural symbolism of colors. Taking the Macao Historic Centre as an example, Tan Yuanlong and Zhang Ya'ou proposed the “authenticity” principle for color restoration of historical buildings. They collected residual pigment samples from historical buildings to recreate the “beige walls + dark green window frames” of the colonial period, while prohibiting the use of modern high-gloss coatings to ensure that the color texture is consistent with the historical style [32]. From the perspective of color geography, Lu Lin, Wang Qianqian, and others suggested that the guiding colors of museums should align with the cultural connotations of their collections. For instance, the Shaanxi History Museum uses “earth yellow + vermilion” to echo the Loess culture and the cultures of the Qin and Han dynasties; the Suzhou Museum adopts “pinkish white + dark gray” to match the elegant aesthetic of the water towns in the Jiangnan region [33].

(4) Medical and elderly care scenarios

Colors in medical and elderly care settings need to balance psychological healing and physiological adaptation, focusing on the positive impact of colors on emotions and health. In medical settings, the logical application of color psychology proposed by Chen Yinying in the design of outdoor sports environments for kindergartens is also applicable to children’s medical spaces; soft colors such as light blue and light green with cartoon patterns can alleviate children’s medical anxiety; adult wards are mainly in light beige to avoid color interference with condition observation [34]. In elderly care settings, Ren Hongguo and Chai Qingru proposed that nursing home bedroom walls adopt light brown with light orange bedding, which can not only arouse the warm perception of the elderly, but also facilitate the elderly to identify furniture boundaries through brightness contrast (35%) and improve living safety [35]. In their study on campus landscape colors in special education schools, Dong Chiying and Li Zhaoyan proposed that the campus environment of special education schools should be improved and the mental health and growth of special students should be promoted by organizing spaces through colors, establishing emotional transmission,

exerting stress responses on students' physiology and psychology, and playing an auxiliary therapeutic role [36].

4.3. Research on Environmental Color Technology Methods

4.3.1. Environmental Color Collection Technology

Environmental color collection needs to balance data accuracy and scene Applicability, and existing technologies can be divided into three categories: traditional manual, digitization instruments, and smart vehicles image. Traditional manual collection centers on standard color cards (such as Munsell color cards and CBCC China Building Color Cards), directly comparing and recording the color numbers and positions of environmental colors. It is easy to operate and low in cost, suitable for small-scale key areas. As early as 2006, Wang Jinghong completed the color collection of building facades in residential clusters through manual color card comparison combined with photography [37]. Digitization instrument collection relies on Equipment such as spectrophotometers and portable color difference meters to obtain quantitative indicators such as spectral data and CIELab values. Spectrophotometers can eliminate subjective errors and are suitable for high-precision scenarios, while portable color difference meters facilitate large-area complex curved surface collection. In 2024, Dai Jiayi used it to collect HSB values of rural buildings and natural environments [11]. Smart image collection is based on street view images and satellite images, extracting color Information through Software such as Photoshop and ColorImpact. In their 2023 research, Lü Mei, Wang Xiangquan, et al. used Google Street View images to collect street building colors in Berkeley, California, and extracted RGB values in batches [38]; Jin Yu, Lu Xu, et al. also introduced VR technology, simulating urban spaces through VR Equipment and combining eye movement data to determine collection priorities [39].

4.3.2. Environmental Color Analysis Technology

Color analysis requires mining data patterns through scientific methods, with its core components including quantitative statistics, model construction, and semantic analysis. Quantitative statistics utilizes tools such as Excel and SPSS to calculate color proportions, brightness, or saturation distributions across different functional zones, and to generate histograms or heatmaps. Li Muhang and Bai Dan converted color data from Mogou Village, Henan Province into HSB values, revealing the dominant tone of “predominantly earthy yellow with low-saturation accents” [40]. Model construction relies on color theories and algorithms: k-means clustering can group similar colors into clusters. In her research on rural colors in Qingshangou Town, Dai Jiayi applied the k-means clustering algorithm to classify collected color data of buildings and vegetation, identifying three core color clusters: “warm yellow building colors, greenish - blue vegetation color, and grayish-brown pavement colors,” which clearly illustrate the spatial distribution characteristics of rural colors. The Munsel-Spencer theory and M-S color harmony theory can assess color matching harmony [11]. Semantic analysis extracts color semantic associations through questionnaires or text mining. In their 2024 research, Lu Xu, Wang Mengyun, et al. designed questionnaires using the semantic differential method to construct an evaluation system for color perception of urban streetscapes [41].

4.3.3. Technology for Environmental Color Application Design

Driven by intelligent technologies such as VR and AI, the technology for environmental color application design is continuously innovating, and digital means are used to improve the accuracy and adaptability of color schemes.

In terms of color scheme simulation and preview, VR technology plays a crucial role. According to the research by Guo Guangtong and Xu Na, designers can build a 1:1 virtual environment using VR technology and import the initial color scheme into it. Taking hospital ward design as an example, by wearing VR Equipment, users can immersively experience different color matching schemes, such as “light blue + off-white” or “light green + warm yellow”. The system simultaneously Records data such as user stay duration and line of sight focus, providing intuitive basis for scheme optimization and effectively solving the problem that traditional renderings make it difficult for users to intuitively perceive the actual effect of colors [42].

AI technology demonstrates exceptional performance in color scheme generation and optimization. Shen Jie and Xu Lijun proposed constructing a color design optimization model by integrating multi-source information such as environmental data, emotional needs analysis, and user feedback. By inputting spatial function parameters, the model can automatically retrieve suitable ranges of hue, lightness, and saturation from the color database. When inputting parameters related to “Jiangnan water town homestays”, the model extracts typical color elements from regional culture, such as the color values of white walls and black tiles, and integrates modern design concepts to generate multiple alternative schemes. Meanwhile, the model predicts user satisfaction for each scheme based on historical project data, significantly improving design efficiency and scheme quality [43].

5. Conclusions

This paper conducts a bibliometric analysis of 1390 environmental color research papers in the CNKI database from 2000 to 2025 using CiteSpace software, clearly presenting the academic status quo of the field, including fluctuating publication output, scarcity of high-yield authors and stable collaborative teams, and decentralized institutional collaboration. It also reveals the evolution trend of keywords from “architecture” and “urban color” to “traditional villages” and “intelligent technology”. Meanwhile, by sorting out the research content from three aspects of theory, practice and technology, it is found that the theoretical level shows significant characteristics of interdisciplinary integration, the practical level covers multiple scenarios with gradually improved policy standards, and the technical level has achieved a leap from qualitative to quantitative research. On the whole, China’s environmental color research has established a multi-dimensional framework, but there are still problems such as weak collaborative networks and insufficient research depth in some scenarios. In the future, collaboration between scholars and institutions can be strengthened, the application of intelligent technologies in color research can be deepened, and environmental color research can be further integrated with regional cultural inheritance and actual spatial needs, promoting the development of this field in a more systematic and precise direction.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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- (3). 2025 Henan Provincial Soft Science Research Program Project “Research on the Multimodal Display Strategy of ‘Yellow River Culture’ in Traditional Villages of Henan Empowered by Digital Intelligence” (252400410518).

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