Analysis on research status of water footprint of ceramic tile (board)

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Abstract: At present, the saving of industrial water and the reduction of wasting water have become an important part of China's ecological civilization construction. Ceramic tiles (board) are a key category of building materials. Scientific accounting of their water consumption is of great significance to the implementation of the national water-saving strategy. Therefore, in this paper, the current situation of water footprint research analysis of ceramic tiles (board) have been concluded and summarized, mainly including the related standards of water footprint and accounting methods, the results show that water footprint evaluation standard of ceramic tiles (board) products is missing, and the method (ISO system) of water footprint calculation is suitable for accounting of ceramic tiles (board).

1. Introduction

As an important natural resource for human survival, water is related to the safety and development of human society. China is one of the countries with the most deficient water resources per capita in the world, and the spatial distribution of water resources is uneven. Over the years, due to the extensive development model of traditional industries, it has increased the lack of domestic water resources and pollution, which is not conducive to effectively supporting the rapid development of the national economy, and even restricts economic development to a certain extent. Therefore, build a comprehensive water resource management and control system that integrates source control, process water efficiency improvement, and end pollution prevention and control, while making full use of internationally accepted technical means and market mechanisms such as evaluation and certification to build water resources based on the concept of water footprint[1]. The concept is of great significance for guiding and promoting the optimal allocation of water resources, economizing use, increasing income, and pollution prevention. Among them, water footprint refers to an index that quantifies the potential environmental impact of products related to water.

The building materials industry is one of the important industries related to national economy and people's livelihood, and is of great significance for improving the living conditions, governing the improvement of the ecological environment and supporting the virtuous circle of economic development. As a typical manufacturing industry mainly based on kilns and mineral products processing, the building materials industry has a high degree of dependence on water resources, energy and other resources. Because the building materials industry has always existed extensive production, slow replacement of process technology equipment, relatively low concentration, for example water consumption and water pollution, should not be underestimated. As a typical building material product, ceramic tiles (boards)[2] consume a lot of water resources and produce a large
amount of sewage during the production process. Therefore, this paper has analysed the current status of the water footprint of ceramic tiles (boards), mainly including ceramic tiles (boards) status of water footprint standard and status of water footprint calculation method of ceramic tiles (boards).

2. Analysis of the current status of water footprint standards for ceramic tiles (boards)
In recent years, water footprint research has become a hot spot in domestic and foreign research, and has achieved certain results. Many developed countries such as Europe and the United States incorporated water footprints into their environmental protection policies earlier to cope with water resource crises and strengthen water resource management. For example, as early as 2008, Spain followed the EU Water Framework Directive to incorporate water footprint evaluation into its domestic planning; at the same time, the Dutch House of Representatives requested that “the government should require domestic enterprises to publish their water footprint related reports in economic policies When there is a significant impact on water-scarce regions, companies’ water footprint should be reduced”; In 2013, Argentina’s Buenos Aires Province issued regulations requiring water charges to be based on the water footprint; India also adopted water footprint is included in its new national water policy. The federal government requires industrial water users to report their water footprint when conducting regular water audits; In 2015, the Mexican Ministry of Environment and Resources/National Water Resources Commission revised the water law Water footprint measures water efficiency. In addition, ISO established the international standard for water footprint ISO14046: 2014 “Environmental management-Water footprint-Principles, requirements and guidelines” in 2014[3].

With the increase of foreign water footprint research results, domestic water footprint research is also closely followed. Among them, in 2017, the release of the equivalent conversion ISO 14046 implemented the national recommended standard GB/T33859-2017 “Environmental Management Water Foot: Principles, Requirements and Guidelines for Traces” [4], which is the international standard for equivalent conversion ISO14046 Environmental Management Water Footprint Principle, Requirements and guidelines. Afterwards, the China National Institute of Standardization led the preparation and release of GB/T 34341-2017 “Guidelines for the Evaluation and Reporting of Organizational Water Footprint"[5] and GB/T 37756-2019 “Guidelines for the Evaluation and Reporting of Product Water Footprint"[6]. The domestic application development provides a certain foundation. However, the above standards only propose general principles and requirements for water footprint accounting and evaluation, and are not specifically subdivided into various industries. Due to the particularity, diversity and complexity of product design, raw material use, and production processes in various industries, the evaluation of product water footprint still requires further research, analysis, and preparation of industry product water footprint accounting and evaluation standards based on specific industry conditions. At present, there is no relevant standard for the evaluation of the water footprint of ceramic tiles (boards) in China.

3. Analysis of the current status of water footprint standards for ceramic tiles (boards)
At present, a number of domestic and foreign research institutions have devoted them to the research on water footprint and have achieved certain results. See Table 1 for the main water footprint research institutions at home and abroad and their application results.

| No | Institute | Content | Results | Application |
|----|-----------|---------|---------|-------------|
| 1  | Water Footprint Network, University of Twenty, the Netherlands | Based on the theoretical system of green water footprint, blue water footprint and grey water footprint, calculation and calculation | Water Footprint Assessment Manual - Setting the Global Standard | Accounting and evaluation of water footprint in agriculture, industry, consumption and other fields |
evaluation of water footprint of countries, regions, organizations, products, consumption, etc.

|   |   |   |   |
|---|---|---|---|
| 2 | ISO/TC20, Environmental management, Subcommittee SC5, Life cycle assessment | It stipulates the theory, requirements and guiding principles for assessing and reporting water footprint. Suitable for products, processes and organizations based on life cycle assessment | ISO 14046 Environmental management - Water footprint - Principles, requirements and guidelines | International standard for water footprint accounting and evaluation, providing guidance for calculating and reporting water footprint |
| 3 | China National Building Material Testing and Certification Group Co., Ltd. | Green building materials products and departments' full life cycle assessment technology and application | Won the first prize of 2017 "China Building Materials Federation · China Silicate Society Building Materials Science and Technology Award" | Provide support for the construction of current green buildings, green building materials and green manufacturing systems |
| 4 | China National Institute of Standardization | The translation method is equivalent to transform ISO14046, Preparation of GB/T 37756 | GB / T 33859-2017 Environmental Management Water Footprint Principles, Requirements and Guidelines, GB/T 37756-2019 Product Water Footprint Evaluation and Reporting Guidelines | — |
| 5 | Donghua University | Accounting and Evaluation of Water Footprint of Textile Products | Calculated the water footprint of more than 80 textile products, declared 7 patents for water footprint accounting and evaluation methods, and published 20 research papers such as SCI and EI | It has been promoted and applied in more than 30 large and medium-sized textile enterprises such as cashmere, silk, printing and dyeing fabrics, and provides references for water saving and emission reduction in the production process of enterprises |
| 6 | Zhejiang Sci-Tech University | Accounting and evaluation of industrial water footprint | The concept of reference water footprint is proposed, | Provide benchmarking reference for water |
At present, the calculation methods of product water footprint mainly include Water Footprint Network (WFN) [7] and ISO (International Standardized Footprint). Among them, WFN calculates the amount of water resources required by all known population (a country, a region or a person) to consume all products and services within a certain period of time, including green water footprint, blue water footprint and grey water footprint, is mostly used for agricultural related products. ISO is an indicator that quantifies the potential environmental impact associated with water, including water scarcity footprint and water degradation footprint, which are mostly used in industrial products. The research object of this article is ceramic tiles (boards), so this article only briefly introduces ISO.

3.1. Water scarcity footprint
The water scarcity footprint is an indicator that quantifies the potential environmental impact of products related to water scarcity without assessing water quality. The calculation formula of water scarcity footprint is as follows:

$$WSF = \sum_{i=1}^{n} V_i$$

In the formula:
- $WSF$ —For water-sparse footprints, the unit is cubic meters (m³);
- $V_i$ —For the consumption of fresh water in various stages of the production process, the unit is cubic meters (m³);
- $i$ —For each stage of the ceramic tile production process.

3.2. Water degradation footprint
The water degradation footprint refers to an index that quantifies the potential environmental impacts associated with negative changes in water quality that are produced during the production and processing of products. The water degradation footprint includes water acidification footprint, water eutrophication footprint and water toxicity footprint.

The general formula for calculating the water degradation footprint is as follows:

$$WDF_k = \sum_{j=1}^{n} (\sum_{i=1}^{n} \alpha \times M)$$

In the formula:
- $WDF_k$ —For the water degradation footprint at the stage of the production process, the unit is different according to the characteristic factor;
- $\alpha$ —It is the characteristic factor of the characteristic pollutants in the water degradation footprint of the ceramic tile production process stage;
\( M \) —It is the discharge amount of the characteristic pollutants of category \( i \) in kilograms (kg);

\( i \) —It is the type of pollutant;

\( j \) —For each stage of the ceramic tile production process;

\( k \) —It is a type of water degradation footprint.

3.3. Checklist for water footprint data of ceramic tiles (boards)
The data needed to calculate the water footprint of ceramic tiles (boards) is shown in Table 2.

| Water scarcity footprint | The total amount of fresh water consumed in the production process |
|--------------------------|---------------------------------------------------------------|
| Water degradation footprint | Wastewater discharge, chemical oxygen demand, five-day biochemical oxygen demand, \( \text{NH}_4^+ \), \( \text{SO}_2 \), Total phosphorus (TP), total nitrogen (TN), Copper, zinc, chromium, nickel, lead, cadmium and other pollution loads |
| Other | Types of energy (including purchased gas, coal, electric energy and other energy sources) and consumption, product types, product output, product output value; types and consumption of raw and auxiliary materials |

4. Conclusion
The paper has concluded that the related standards of water footprint and accounting methods, showing that water footprint evaluation standard of ceramic tiles (board) products is missing, and the method (ISO system) of water footprint calculation is suitable for accounting of ceramic tiles (board).

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