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Carbon Footprint and Water Footprint of Cashmere Fabrics

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Abstract
Given the serious problems of climate change, water shortage and water pollution, researchers have paid increasing attention to the concepts of the carbon footprint and water footprint as useful indices to quantify and evaluate the environmental impacts of the textile industry. In this study, assessment of the carbon footprints and water footprints of ten kinds of cashmere fabrics was conducted based on the PAS 2050 specification, the Water Footprint Network approach and the ISO 14046 standard. The results showed that knitted cashmere fabrics had a greater carbon footprint than woven cashmere fabrics. Contrarily, woven cashmere fabrics had a greater water footprint than knitted cashmere fabrics. The blue water footprint, grey water footprint and water scarcity footprint of combed sliver dyed woven cashmere fabric were the largest among the ten kinds of cashmere fabrics. The main pollutants that caused the grey water footprints of cashmere fabrics were total phosphorus (TP), chlorine dioxide, hexavalent chromium (Cr (VI)) and sulfide. The leading contributors to the water eutrophication footprint were total nitrogen, ammonia nitrogen, chemical oxygen demand and TP. These typical pollutants contributed 39% ~ 48%, 23% ~ 28%, 12% ~ 24% and 12% ~ 14% to each cashmere product's water eutrophication footprint, respectively. The leading contributors to the water ecotoxicity footprint were aniline, Cr (VI) and absorbable organic halogens discharged in the dyeing and finishing process.

Key words: *cashmere fabrics; carbon footprint; water footprint; environmental impact.*

Introduction

Among all the textile materials, cashmere is a precious natural textile material and is highly popular with consumers because of its softness, comfort, and excellent heat retention [1]. According to statistics, China produces about 70% of the world's cashmere, and the annual production of cashmere products exceeds 50 million pieces [2]. There are, however, serious environmental problems accompanying the manufacture of cashmere products. The environmental problems include greenhouse gas emission, fresh water resource consumption, and wastewater discharge, leading to degradation of the ecological environment [3]. At present, strengthening green production is an important aim of China's textile industry. Assessing the environmental impacts caused by greenhouse gases emission, fresh water consumption and waste water discharge in the production of cashmere products is meaningful for the sustainable development of the cashmere industry. Currently, the carbon footprint (*CF*) and water footprint (*WF*) have provided effective quantitative tools for evaluating environmental impacts caused by industrial production activities. As one of the footprint indicators, the concept of *CF* is widely used and universally understood to represent the amount of greenhouse gases directly or indirectly emitted into the environment by human activity [4]. The *WF* concept is defined as the potential environmental impacts related to water. There are two methodologies: the Water Footprint Network (WFN) approach, which focuses on water quantity, and the international standard ISO 14046, which considers both water quantity and water quality [5, 6].

Researches on the *CF*s and *WF*s of textiles and apparels, including cotton [7-15], bast fibre [16], wool [17, 18], silk [19-22], and viscose [20, 23-26] products have been reported in the past ten years. However, there have been few researches reported on the *CF* and *WF* of cashmere products. One example is Sun et al., who only calculated the blue *WF*, grey *WF* and indirect *WF* in the processing of cashmere knitwear. It concluded that the grey *WF* was the largest and that water pollution caused the most serious impact in the production process [27]. To fill this gap in the research of textiles' *CF* and *WF*, this paper aimed to quantify and evaluate the *CF* and *WF* of cashmere fabrics. Data used for *CF* and *WF* calculation were obtained from related Chinese standards for energy and water restrictions for the processing of cashmere fabrics. Therefore, the results can be used as benchmarks for the assessment of the *CF* and *WF* of cashmere fabrics. It is meaningful for cashmere fabric production enterprises to improve the management of energy and freshwater consumption as well as wastewater pollutant discharge.

Methods and data

The *CF* of the cashmere fabric production process was calculated according to the PAS 2050 specification. The WFN methodology and ISO 14046 standard were applied to calculate and assess *WF*s. In this study, the *WF*s included the blue, grey, water scarcity and water degradation footprints. Four kinds of knitted cashmere fabrics and six kinds of woven cashmere fabrics were selected for this research. The production processes are shown in ***Table 1***. *CK* represents knitted cashmere fabric, and *CW* – woven cashmere fabric.

System boundaries

System boundaries are the basis and key of *CF* and *WF* accounting. They can be divided into a time boundary and space boundary. For the production process chains of cashmere fabrics, the time boundary is divided into three parts: raw-material acquisition, product man-

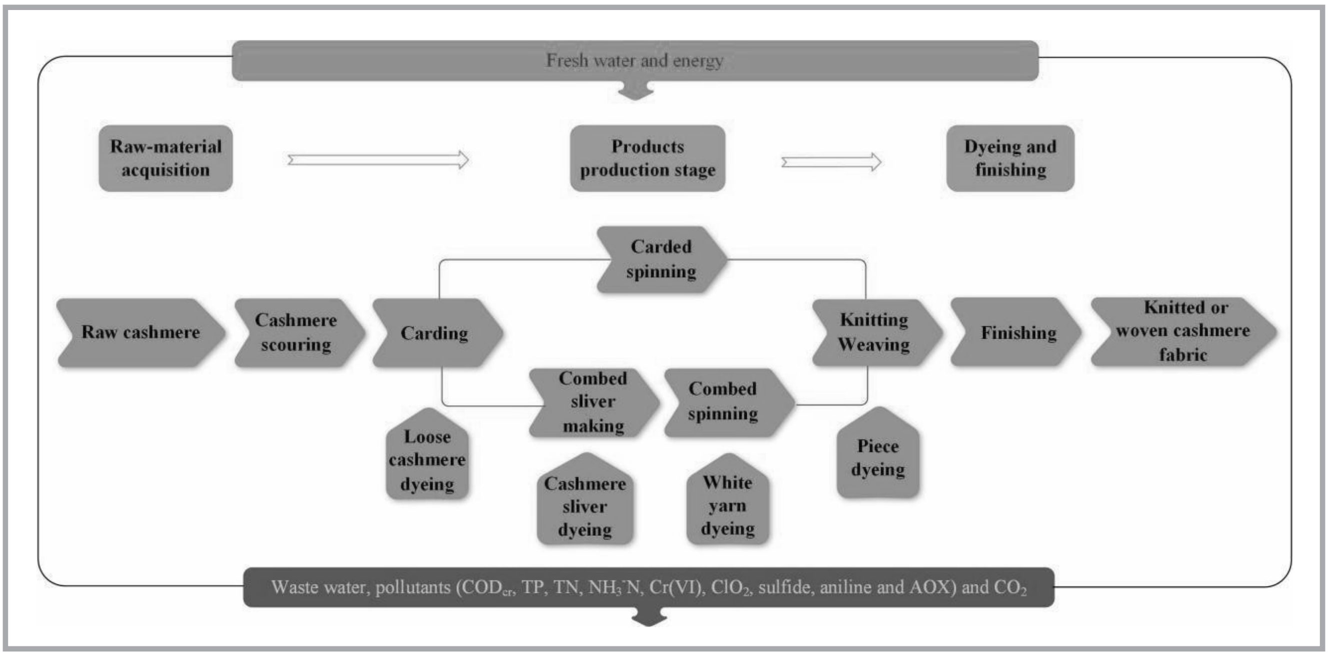

Figure 1. *System boundary of CF and WF calculation of cashmere fabrics.*

ufacture (i.e., cashmere scouring, spinning, knitting, and weaving), dyeing (i.e., loose cashmere dyeing, cashmere sliver dyeing, white yarn dyeing, piece dyeing) and finishing. The space boundary includes the input of fresh water and energy (electricity and steam), and the discharge of wastewater and significant pollutants (i.e., chemical oxygen demand (COD_{Cr}), total phosphorus (TP), total nitrogen (TN), NH_3^-N, chlorine dioxide, hexavalent chromium (Cr (VI)), sulfide, aniline, absorbable organic halogens (AOX), and CO_2 (see ***Figure 1***).

Calculation and assessment methods

Carbon footprint

CF refers to the consumption of energy from all activities in a production process multiplied by their corresponding emission factors [28, 29]. The *CF* (in kg CO_2) is calculated as follows:

$$CF = \sum_{i=1}^{n}\sum_{j=1}^{m} E_j \times f_j \qquad (1)$$

Where, E_j (in kg SCE) is the consumption of energy j, f_j (in kg CO_2/kg SCE) the carbon emission factor of energy j, and i is the production processes of cashmere fabrics, including cashmere scouring, carding, combing sliver making, spinning, knitting, weaving and finishing.

Blue water footprint

The blue water footprint (WF_{blue}) is the consumption of fresh water in the production process [5]. The WF_{blue} (in m^3) is calculated as follows:

$$WF_{blue} = \sum_{i=1}^{n} Q_i \qquad (2)$$

Where, i is the production process (i.e., cashmere scouring, dyeing, and finishing), and Q_i (in m^3) is the water consumption of process i.

Grey water footprint

The grey water footprint (WF_{grey}) refers to the amount of water needed to absorb sewage generated by human activity [5]. The WF_{grey} (in m^3) is calculated as follows:

$$WF_{gray} = \sum_{i=1}^{n} \frac{L_i}{C_{\max,i} - C_{nat}} \qquad (3)$$

Where, L_i (in g) is the amount of pollutants in the water body of process i, C_{max} (in mg/l) the maximum concentration of pollutants permitted by the water-quality standard in process i, and C_{nat} (in mg/l) is the natural background concentration.

Water scarcity footprint

The water scarcity footprint (WF_{sc}) uses fresh water consumption and the regional water stress index (*WSI*) to evaluate the impact of production on water scarcity [30]. The WF_{sc} (in m^3 H_2O eq) is calculated as follows:

$$WF_{sc} = \sum_{i=1}^{n} \frac{WSI_j}{WSI_{gl}} \times Q_i \qquad (4)$$

Table 1. *Production processes of cashmere fabrics.*

Fabrics		Production process
CK	CK-1	Raw cashmere→cashmere scouring→carding→loose cashmere dyeing→carded spinning→knitting→finishing→carded knitted cashmere fabric
	CK-2	Raw cashmere→cashmere scouring→carding→loose cashmere dyeing→combed sliver making→combed spinning→knitting→finishing→combed knitted cashmere fabric
	CK-3	Raw cashmere→cashmere scouring→carding→combed sliver making→combed spinning→white yarn dyeing→knitting→finishing→combed knitted cashmere fabric
	CK-4	Raw cashmere→cashmere scouring→carding→combed sliver making→cashmere sliver dyeing→combed spinning→knitting→finishing→combed knitted cashmere fabric
CW	CW-1	Raw cashmere→cashmere scouring→carding→loose cashmere dyeing→carded spinning→weaving→finishing→carded woven cashmere fabric
	CW-2	Raw cashmere→cashmere scouring→carding→carded spinning→weaving→piece dyeing→finishing→carded woven cashmere fabric
	CW-3	Raw cashmere→cashmere scouring→carding→loose cashmere dyeing→combed sliver making→combed spinning→weaving→finishing→combed woven cashmere fabric
	CW-4	Raw cashmere→cashmere scouring→carding→combed sliver making→combed spinning→white yarn dyeing→weaving→finishing→combed woven cashmere fabric
	CW-5	Raw cashmere→cashmere scouring→carding→combed sliver making→combed spinning→weaving→piece dyeing→finishing→combed woven cashmere fabric
	CW-6	Raw cashmere→cashmere scouring→carding→combed sliver making→cashmere sliver dyeing→combed spinning→weaving→finishing→combed woven cashmere fabric

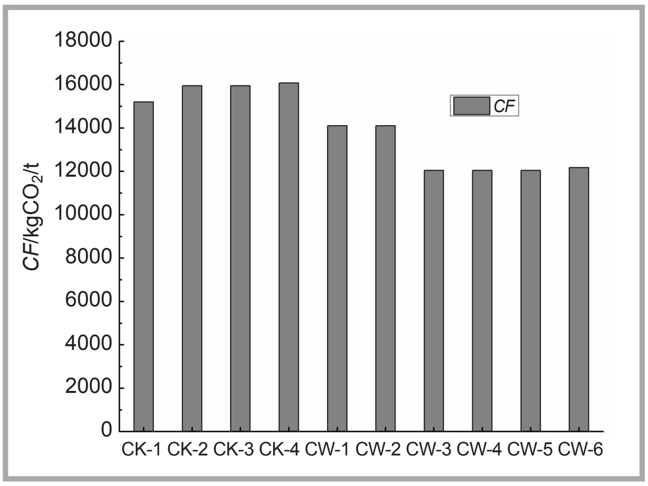

Figure 2. *CF of cashmere fabrics (per functional unit).*

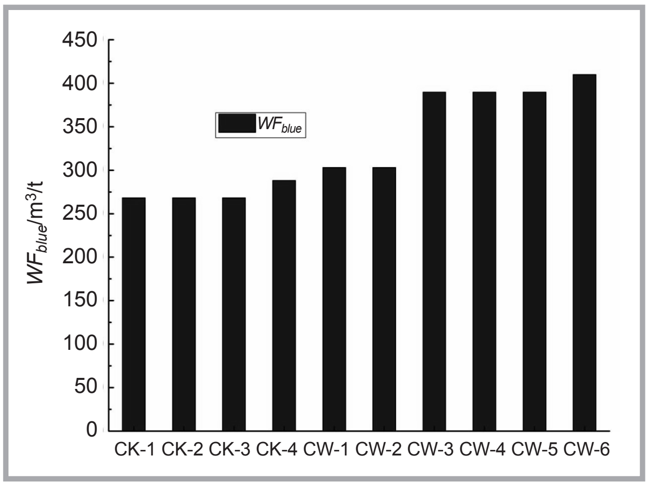

Figure 3. *WF_{blue} of cashmere fabrics (per functional unit).*

Where, WSI_j (dimensionless) is the water stress index of region j ($0.01 < WSI_j < 1$), WSI_{gl} (dimensionless) the global average water stress index, Q_i (in m^3) the water consumption of process i, and i is the stage of the production process.

Water eutrophication footprint

The water eutrophication footprint (WF_{eu}) is one of the methods used to assess the impact of water degradation. It evaluates the eutrophication effect of nitrogen (NO_3^- equivalent) and phosphorus (PO_4^{3-} equivalent) in water. In this study, the PO_4^{3-} equivalent was used to calculate the characteristic factors of water eutrophication pollutants in the production process of cashmere [31]. The WF_{eu} (in kg PO_4^{3-}eq) is calculated as follows:

$$WF_{eu} = \sum_{i=1}^{n}\sum_{j=1}^{m}(M_{\text{j}} \times CF_{eu,j}) \tag{5}$$

Where, M_j (in kg) is the mass of pollutant j, $CF_{eu,j}$ (in kg PO_4^{3-} eq) the characteristic factor of eutrophication pollutant j, and i is the stage of the production process (i.e., cashmere scouring, dyeing, and finishing).

Water ecotoxicity footprint

Another method to evaluate water degradation is the water ecotoxicity footprint (WF_{ec}), which is used to evaluate the impact of toxic substances in water bodies on the water environment [31]. The WF_{ac} (in m^3 H_2O eq) is calculated as follows:

$$WF_{ec} = \sum_{i=1}^{n}\sum_{j=1}^{m}(M_{j} \times CF_{ec,j}) \tag{6}$$

Where, M_j (in kg) is the mass of pollution j, $CF_{ec,j}$ (in m^3 H_2O eq) the characteristic factor of ecotoxicity pollutant j, and i is the stage of the production process.

Data collection

In this study, 1 ton of produced cashmere was chosen as the functional unit. Data of energy consumption and water consumption in production processes were derived from the standard T/CNTAC 38-2019 Technical specification for eco-design product assessment of cashmere goods [32]. Data of the discharged wastewater pollutant were derived from China's national standards: GB 28937-2012 Discharge standards of water pollutants for woolen textile industry [33] and GB 4287-2012 Discharge standards of water pollutants for dyeing and finishing of textile industry [34].

Table 2. *Characteristic factors for water degradation footprint calculation.*

Footprint	Substance	Characterisation factor	Unit
Water eutrophication footprint	COD_{cr}	0.022	kg PO_4^{3-}eq/kg
	TP	3.06	
	TN	0.42	
	NH_3-N	0.383	
Water ecotoxicity footprint	aniline	5	m^3 H_2O eq/mg
	Cr (VI)	1	
	AOX	0.00094	

The CF was calculated with the carbon emission coefficient of raw coal, which is 2.492 [28]. In China, the main production area of cashmere fabrics is Inner Mongolia [35]. The water pressure index of Inner Mongolia is 0.297 and the global water pressure index 0.602 [36].

The characteristic factors of wastewater pollutants used for water degradation footprint calculation were referred to Heijungs et al. [37], and the factors are shown in ***Table 2***.

Results and discussion

Carbon footprints of cashmere fabrics

The *CF*s of cashmere fabrics are shown in ***Figure 2***. Electricity and steam are major energies in the production of cashmere fabrics. It can be seen that the *CF*s of knitted cashmere fabrics were generally larger than those of woven fabrics, with CK-4 having the largest *CF* (i.e., 16,073.40 $kgCO_2/t$). This was mainly because the energy consumption of the cashmere knitting and finishing process was greater than that of the weaving and finishing process. The *CF* of the combed cashmere knitting and finishing process was about 1.85 times larger than that of the carded weaving and finishing process. The *CF*s of the combed knitted cashmere fabrics (i.e., CK-2, CK-3 and CK-4) were larger than that of the carded knitted fabric (CK-1). In contrast, the *CF*s of the carded woven cashmere fabrics (i.e., CW-1 and CW-2) were larger than those of the combed woven fabrics (CW-3, CW-4, CW-5, and CW-6). This was the result of the energy consumption of the carded woven cashmere fabrics' finishing processes being about 1.87 times higher than that of the combed woven fabrics'

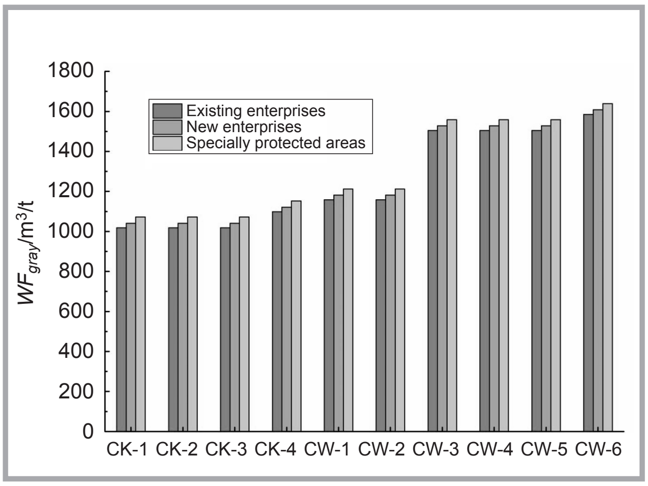

***Figure 4.** WF_{grey} of cashmere fabrics (per functional unit).*

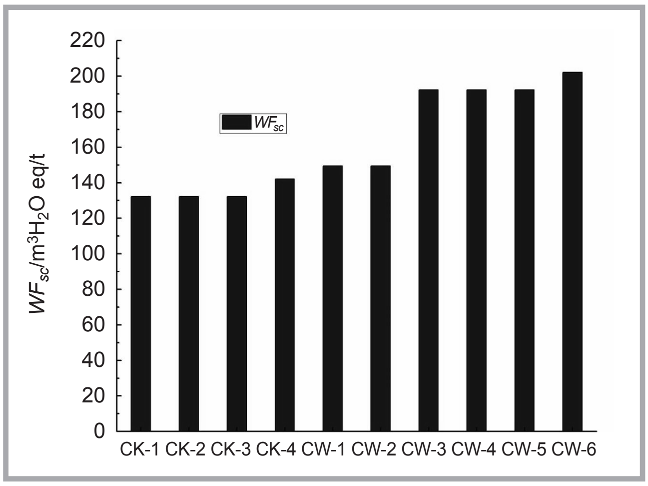

***Figure 5.** WF_{sc} of cashmere fabrics (per functional unit).*

finishing processes.

Blue water footprints of cashmere fabrics

As shown in ***Figure 3***, the WF_{blue} of the ten kinds of cashmere fabrics were as follows: CW-6 > (CW-3 = CW-4 = CW-5) > (CW-1 = CW-2) > CK-4 > (CK-1 = CK-2 = CK-3). The WF_{blue} of CW-6 was approximately 1.53 times larger than that of CK-1, CK-2 and CK-3. The woven cashmere fabrics required the largest water consumption. In particular, the finishing process of woven cashmere fabrics required a large amount of fresh water, approximately 1.50 times larger than that of the finishing process of knitted fabric. The results also showed that for the same kind of cashmere fabric (knitted or woven), the WF_{blue} of the combed sliver dyed fabrics (i.e., CK-4 and CW-6) were larger due to the large amount of fresh water consumed in the sliver dyeing stage.

Grey water footprints of cashmere fabrics

The WF_{grey} of cashmere fabrics are shown in ***Figure 4***. It should be noted that the characteristic pollutants that caused the WF_{grey} were TP for the cashmere scouring process and TP, Cr(VI), chlorine dioxide, and sulfide for the dyeing and finishing processes. It can be seen from ***Figure 4*** that CW-6 had the largest WF_{grey}, which was approximately 1.50 times larger than that of CK-1, CK-2, and CK-3. Cashmere fabrics produced in enterprises located in specially protected areas had a larger WF_{grey}. This was caused by the strict limitation of wastewater pollutants in the cashmere scouring, dyeing and finishing processes in the specially protected areas.

Water scarcity footprints of cashmere fabrics

The WF_{sc} of cashmere fabrics are shown in ***Figure 5***. The WF_{sc} of CW-6 was the largest (i.e., 202.11 m^3/t), 1.53 times larger than those of CK-1, CK-2, and CK-3. As can be seen from ***Figure 5***, the WF_{sc} of the combed woven cashmere fabrics (i.e., CW-3, CW-4, CW-5, and CW-6) were significantly larger than those of other products, ranging from approximately 43 m^3 H_2O eq/t to 70 m^3 H_2O eq/t. This was mainly caused by the following two reasons: (1) the production process of the combed cashmere fabrics involved the combed sliver making process, while that of the carded cashmere fabrics did not; and (2) the water consumption in the cashmere finishing process was generally higher than that in the knitting process.

Water eutrophication footprints of cashmere fabrics

As shown in ***Figure 6***, cashmere scouring, dyeing, and finishing had a major influence on water eutrophication. Among the ten kinds of cashmere fabrics produced in different kinds of enterprises, the WF_{eu} of the carded woven cashmere fabrics (i.e., CW-1 and CW-2) were the largest, followed by the combed woven cashmere fabrics (i.e., CW-3, CW-4, CW-5, and CW-6). Knitted cashmere fabrics (i.e., CK-1, CK-2, CK-3, and CK-4) had a much smaller WF_{eu}. The WF_{eu} of woven cashmere fabrics was approximately 4 times to 6 times larger than that of the knitted fabrics. Cashmere fabrics produced in the existing enterprises had the largest WF_{eu} values. Knitted cash-

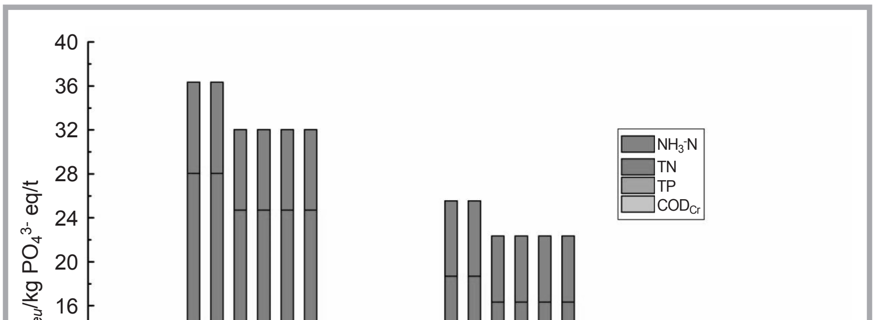

***Figure 6.** WF_{eu} of cashmere fabrics (per functional unit).*

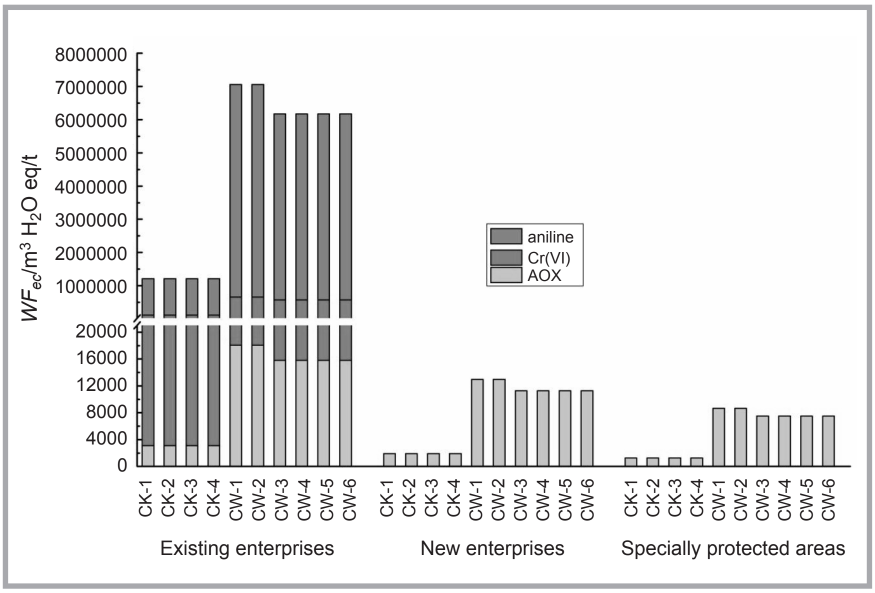

Figure 7. *WF_{ec} of cashmere fabrics (per functional unit).*

mere fabrics (i.e., CK-1, CK-2, CK-3, and CK-4) that were produced in the enterprises located in specially protected areas had the smallest WF_{eu}. The main contributors to the WF_{eu} were COD_{Cr}, TP, TN, and NH_3^-N. Among these wastewater pollutants, TN generated the largest WF_{eu}, contributing 39%~48% for each WF_{eu}, followed by NH_3^-N (contributing 23%~28%), COD_{Cr} (contributing 12%~24%) and TP (contributing 12%~14%).

Water ecotoxicity footprints of cashmere fabrics

From ***Figure 7*** it can be seen that the WF_{ec} of the ten kinds of cashmere fabrics were as follows: carded woven cashmere fabrics (i.e., CW-1 = CW-2) > combed woven cashmere fabrics (i.e., CW-3 = CW-4 = CW-5 = CW-6) > knitted cashmere fabrics (i.e., CK-1 = CK-2 = CK-3 = CK-4). The main wastewater pollutants that caused water ecotoxicity in the dyeing and finishing processes for cashmere fabrics were aniline, Cr(VI) and AOX. The contribution of aniline to the WF_{ec} was approximately 355 times larger than that of AOX and 10 times larger than that of Cr(VI). Moreover, because of the strict limitation of aniline and Cr(VI) in new enterprises and those located in specially protected areas, AOX was the main contributor to the aquatic ecotoxicity for these two kinds of enterprises. The values of their WF_{ec} were the smallest compared to existing enterprises, about 1.278~1.918 m^3 H_2O eq/t and 7.520~12.972 m^3 H_2O eq/t.

Conclusions

The *CF* and *WF* are useful tools for the identification of the environmental impacts of relevant carbon emission, freshwater consumption and wastewater pollution. In this paper, the *CF*s and *WF*s of ten kinds of cashmere fabrics were calculated from raw-material acquisition to the final fabrics. Although all cashmere fabric production processes contributed to the total *CF*s and total *WF*s, dyeing and finishing processes (i.e., included knitting, dyeing and finishing, combed woven dyeing and finishing, and carding woven dyeing and finishing) were the key processes causing larger carbon emission, freshwater consumption and wastewater pollution. In comparison, the combed woven dyeing and finishing process had the least *CF*, while the knitted dyeing and finishing process had the least *WF*s among all the dyeing and finishing processes.

This paper provided benchmarks for the assessment of cashmere fabrics' *CF*s and *WF*s. It is meaningful for the producers to implement appropriate management to reduce carbon emission, water consumption and water pollution for the realisation of the green production of cashmere fabrics. However, with respect to the different quantisation units of *CF* and *WF*, it is hard to conclude which kind of cashmere fabric is more environment friendly in this study. Comprehensive evaluation of *CF* and *WF* can be conducted in the future research in order to select a greener product.

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References

1. Ji Y, Li L. Discussion on the Status of Cashmere Spinning. *Chemical Fiber & Textile Technology* 2009; (2): 34-37.
2. Liu CP, Xiao HF. China's Cashmere Price in 2015 and Its Prospect for 2016. *Agricultural Outlook* 2016; (4): 8-10.
3. Zhang ZH. Discussion on Treatment Process of Wastewater Containing Heavy Metal Chromium in Cashmere Industry. *Petrochemical Industry Application* 2015; 34(7): 125-127.
4. Wiedmann T, Minx J. A Definition of 'carbon footprint'. *Journal of the Royal Society of Medicine* 2009; 92(4): 193-195.
5. Hoekstra AY, Chapagain AK, Aldaya MM, Hoekstra MMM. The Water Footeprint Assessment Manual: Setting the Global Standard. London, UK, 2011.
6. ISO 14046: 2014. Environmental Management-Water Footprint-Principles, Requirements and Guidelines.
7. Chapagain AK, Hoekstra AY, Savenije HH, Gautam R. The Water Footprint of Cotton Consumption: an Assessment of the Impact of Worldwide Consumption of Cotton Products on the Water Resources in the Cotton Producing Countries. *Ecological Economics* 2006; 60(1): 186-203.
8. Wang LL, Wu XY, Ding XM, Wang LH, Yu JM. Case Study on Industrial Carbon Footprint and Industrial Water Footprint of Cotton Knits. *Dyeing & Finishing* 2012; 38(7): 43-46.
9. Dong YH, Qian JF, Xue WL. Research on Carbon Footprint of Cotton Textiles. *Shanghai Textile Science & Technology* 2012; 40(4): 1-2, 50.
10. Chico D, Aldaya MM, Garrido A. A Water Footprint Assessment of a Pair of Jeans: the Influence of Agricultural Policies on the Sustainability of Consumer Products. *Journal of Cleaner Production* 2013; 57: 238-248.
11. Yan Y, Jia J, Wang LH, Du C, Liu XL. The Industrial Water Footprint of Several Typical Cotton Textiles in China. *Acta Ecologica Sinica* 2014; 34(23): 7119-7126.
12. Zhang YY, Wang W. Application and Research of Carbon Footprint Calculation in Cotton Fabric. *Shandong Textile Science & Technology* 2014; 55(2): 32-34.
13. Li XY, Xu WJ, Zhu JZ, Yang YA. Calculation Method of Cotton Carded Yarn Carbon Footprint. *Cotton Textile Technology* 2014; 42(9): 19-23.

14. Gao XL, Lu JQ, Zhu JZ, Wang DT. Calculation and Analysis on Overall Energy Consumption and Carbon Footprint of Cotton Fabric Product. *Shanghai Textile Science & Technology* 2016; 44(10): 53-54.
15. Li JH, Ding XM, Wu XY. Study on Accounting and Assessment of Cotton Carbon & Water Footprint. *Cotton Textile Technology* 2019; 47(10): 73-77.
16. Yang ZP, Zhang JC, Zhang H, Zhang XX, Gao ZQ. Assessing of Carbon Footprint of Hemp Product According to PAS2050. *Journal of Textile Research* 2012; 33(8): 140-144.
17. Feng WY, Zhang QJ, Ding XM. Calculation of Industrial Carbon Footprint of Worsted Wool Fabric. *Wool Textile Journal* 2015; 43(5): 62-65.
18. Ren J, Ding XM, Li F, Wu XY. Water Footprint Calculation in Different Sections of Wool Dyeing and Finishing Products. *Wool Textile Journal* 2019; 47(12): 23-26.
19. Astudillo MF, Thalwitz G, Vollrath F. Life Cycle Assessment of Indian Silk. J. *Journal of Cleaner Production* 2014; 81: 158-167.
20. Zhong L, Liu RA, Liu ZW, Cao L, Li YP. Water Footprint Calculation and Assessment of Textiles in Industrial Parks. *Environment and Sustainable Development* 2016; 41(6): 40-43.
21. He WW, Li Y, Wang XP, Wang LL. Calculation and Assessment of Benchmark Water Footprint of Silk Products. *Advanced Textile Technology* 2018; 26(2): 41-45.
22. Yang YD, He WW, Chen FL, Wang LL. Water Footprint Assessment of Silk Apparel in China. *Journal of Cleaner Production* 2020; 260: 121050.
23. Zhao NH, Zhou X, Dong F. Carbon Footprint Assessment of Polyester Textiles. *Dyeing & Finishing* 2012; 38(14): 42-45.
24. Zhu JX, Li Y, WangLL. Water Environmental Load Assessment of Viscose Staple Fiber Based on Water Footprint. *Advanced Textile Technology* 2018; 27(5): 67-72.
25. Zhu JX, He WW, Li Y, Wang LL. Calculation and Assessment of Benchmark Water Footprint of Viscose Fiber. *Shanghai Textile Science & Technology* 2019; 47(11): 90-93.
26. Zhu JX, Yang YD, Li Y, Wang LL. Water Footprint Calculation and Assessment of Viscose Textile. *Industria Textile* 2020; 71(1): 33-40.
27. Sun LR, Tian J, Ding XM, Wu XY. Calculation of Product Water Footprint of Cashmere Knitting Goods. *Wool Textile Journal* 2018; 46(9): 5-7.
28. Wang LL. Research and Demonstration of Carbon Footprint and Water Footprint of Textiles and Clothes. Donghua University, 2013.
29. Wu M. Carbon Footprint Evaluation of Textiles and Apparel Based on Their Lifecycles. *China Textile Leader* 2018; (6): 26-28.
30. Ridoutt BG, Pfister S. A Revised Approach to Water Footprinting to Make Transparent the Impacts of Consumption and Production on Global Freshwater Scarcity. *Global Environmental Change* 2010; 20(1): 113-120.
31. Bai X, Hu MT, Zhu CY, Ren XJ, Pao W. Evaluation of the Water Footprint of Industrial Products Based on ISO 14046 Using Cables as an Example. *Acta Ecologica Sinica* 2016; 36(22): 7260-7266.
32. T/CNTAC 38-2019. Technical Specification for Eco-design Product Assessment Cashmere Goods.
33. GB 28937-2012. Discharge Standards of Water Pollutants for Woolen Textile Industry.
34. GB 4287-2012. Discharge Standards of Water Pollutants for Dyeing and Finishing of Textile Industry.
35. Liu CP, Xiao HF. Features and Trends of China's Cashmere Production. *Agricultural Outlook* 2017; 13(3): 38-41.
36. Ridoutt BG, Pfister S. A Revised Approach to Water Footprinting to Make Transparent The Impacts of Consumption and Production on Global Freshwater Scarcity. *Global Environmental Change* 2010; 20(1): 113-120.
37. Heijungs RG, Guinee JB, Huppes G. Environmental Life Cycle Assessment of Products: Guide and Backgrounds. Leiden, The Netherlands, 1992.

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