ADDRESSING THE WATER FOOTPRINT CONCEPT: A DEMONSTRABLE STRATEGY FOR PAPERMAKING INDUSTRY

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Since the introduction of the water footprint concept in 2002, in the context of humankind's ever-increasing awareness of the valuable global freshwater resources, it has received more and more attention. The application of this relatively new concept has been expected to provide ecological and environmental benefits. For the water-intensive papermaking industry, it seems that water footprint needs to be addressed. The water footprint of cellulosic paper can be divided into three components, including its green water footprint, blue water footprint, and grey water footprint, which may be accounted for by considering the individual contributions of wood or non-wood materials, pulp production processes, effluent discharge to the receiving water bodies, process chemicals and additives, energy consumption, etc. In the literature, the accounting of water footprint during the whole production chain of cellulosic paper is already available, and relevant research findings can provide useful insights into the application of the concept; however, further development of the accounting methodologies is much needed, so that the quantitative and qualitative evaluation of water footprint can be internationally recognized, certified, and standardized. Although there are ongoing or upcoming debates and challenges associated with the concept, its application to papermaking industry may be expected to provide various encouraging possibilities and impacts.

Keywords: Water footprint; Papermaking; Cellulosic paper; Concept; Green water footprint; Blue water footprint; Grey water footprint; Pulp production process; Effluent discharge; Possibilities; Challenges

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Concept of Water Footprint

Globally, water usage practices have received more and more attention not only from researchers but also business/government policy-makers. It is widely accepted that the valuable freshwater resources of the earth need to be used reasonably, and this is strategic in achieving ecological, environmental, and economical balances. Undoubtedly, human beings cannot live without fresh water. However, freshwater resources are increasingly challenged by the activities and appropriations of human society. Literally and conceptually similar to the famous and relatively widely used concept of a carbon footprint, the water footprint is a concept created and introduced in 2002 by Arjen Hoekstra, who is now Professor in Multidisciplinary Water Management at the University of Twente (Netherlands) and Scientific Director of the Water Footprint Network (http://www.waterfootprint.org). For application to a specific commercial product, the water footprint is defined as the total amount of water that is needed to

produce it over the whole production chain. This concept can be quite useful for the rational use and management of freshwater resources. The water footprint can be divided into three components, *i.e*., green water footprint, blue water footprint, and grey water footprint:

- Green water footprint is the volume of water evaporated from rainwater stored in or on the vegetation, or stored in the soil as soil moisture.
- Blue water footprint refers to evaporated surface and ground water.
- Grey water footprint is the volume of polluted ground and surface water, calculated as the volume of water required to dilute pollutants to such an extent that water quality remains above agreed quality standards.

Water Footprint of Cellulosic Paper

The application of the water footprint concept to cellulosic paper is a fairly new thing. Globally, UPM and the Water Footprint Network are now among the first to have done water footprint case studies for a forest product such as cellulosic paper. Although the relevant research findings available in the literature are somewhat preliminary, quite recently the use of the water footprint concept has received much attention from the global pulp and paper sectors.

Although the determination of water footprint of cellulosic paper is for now a rather complex task, at least the following aspects need to be considered:

- Lignocellulosic materials including wood and non-wood materials are used as starting materials for the production of paper. Thus, the contribution of water footprint of these materials needs to be accounted. In this regard, the water footprint may include both green and blue components. Here, the green water footprint mainly refers to rainwater evaporated during the growth period of plants, whereas the blue water footprint is essentially associated with the ground water from which plants tap. The water footprint associated with these lignocellulosic materials may be determined by considering freshwater evapotranspiration rate, wood yield, *etc*.
- For the conversion of wood or non-wood materials to pulp, the resultant water footprint can include both blue and grey components. The blue water footprint mainly refers to the water evaporated during the pulp production process, *e.g*., the drying process of wet pulp to produce pulp-board. On the other hand, the grey water footprint is associated with the pulping effluent discharged to the receiving water bodies.
- During the papermaking and/or paper coating process, usually different chemicals or additives are used for various purposes. These may include fillers/pigments, strength agents, sizing agents, pitch-controlling agents, binders, pH-controlling agents, *etc*. The water footprint of these chemicals or additives needs to be considered. Depending on the specific production processes of different chemicals or additives, the water footprint may include green, blue, and grey components.
- During the papermaking and/or paper coating process, the relevant effluent and the drying of paper contribute to water footprint as grey water footprint and blue water footprint, respectively.

- The energy consumed during the whole production chain has its water footprint, which needs to be considered.

UPM-Kymmene's recent results showed that the total water footprint of one A4-sheet of wood-free uncoated paper was 13 liters and for wood-free coated paper 20 liters, consisting of 60% green water footprint, 39% grey water footprint, and 1% blue water footprint. This indicates that green water footprint and grey water footprint can account for a large proportion of the total water footprint. However, these findings are only in a preliminary manner, as discussed in the published report, and further development of the accounting methodologies is still much needed.

Potential Possibilities and Impacts Associated with Application of Water Footprint Concept to Papermaking Industry

Since its creation, the benefits of the water footprint concept have been well recognized. For the application of such a relatively new concept to the papermaking industry, at least the following potential possibilities and impacts may be expected:

- The concept can at least raise the papermakers' awareness regarding the protection of global freshwater resources, which may help to lead the industry to a sustainable and environmentally friendly future.
- The use of recycled pulp fibers may significantly reduce the green water footprint of cellulosic paper due to the saving of wood or non-wood materials. Therefore, from the water footprint point of view, papermakers would be more motivated to work on paper recycling.
- As effluent discharge to receiving water bodies can result in the production of grey water footprint, waste water treatment and its increased reuse in the production chain should be encouraged. Ideally, if no effluent is discharged, the grey footprint would be significantly reduced, that is, approaching zero.
- As the papermaking industry is one of the water-intensive industries, the application of the concept would minimize its local impact on water resources.
- Once the concept is successfully applied, trading of paper products produced in water-rich to water-scarce regions may be motivated, so that a more reasonable distribution of freshwater resources throughout the world may be achieved.

Possible Trends and Challenges

As discussed above, it may be expected that the application of the water footprint concept to the papermaking industry may provide promising possibilities and impacts. In this context, some businesses may consider making advertisements about the low water footprint of their products in the future. Water footprint may be combined with carbon footprint to play an as-yet unimagined role in the industry. Moreover, environmental legislation from governments relative to the water footprint may also be available when the concept matures to an acceptable degree. The application of the concept may be a demonstrable strategy for fostering sustainable development of the papermaking industry.

However, there might still be some ongoing or upcoming challenges. There are still some debates over the positive impacts of the concept. Some people may think that it

is just a lot of hot air, not something of real significance. On the other hand, for the water footprint assessment, a number of potential issues need to be considered, for example:

- Water footprint impacts have been defined so far based on just the volume of water affected. In addition to this data, are there other impacts/parameters that can be used for the evaluation? Under what situations can a focus just on water volumes give a distorted view?
- When conducting a calculation of water footprint of a specific activity, what should be included and what should be excluded from the analysis? For example, the importance of water treatment prior to effluent discharge can be dependant upon mill location or the quality of receiving water bodies, so one issue may arise as to how to include such possible factors in an analysis.
- For the production of cellulosic paper, the process flow sometimes can be rather complex. In such a case, how to deal with the lack of required data?
- What about the role of energy source in water footprint? If energy derived from lignocelluosic biomass is used, based on the current methodologies, the water footprint may increase significantly. How can this be accounted for?
- In what situations is the water footprint concept useful, and in what situations should the concept need to be ignored or supplemented by other approaches?

It follows that accounting methodologies of water footprint of cellulosic paper indeed need to be developed to a degree of being internationally recognized, certified, and standardized, so that the data can be accurate, comparable, and convincing. Sustainability analysis may also need to be integrated into the water footprint evaluation.

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