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Toward sustainability

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ABSTRACT

Today, many areas of the world are experiencing significant level of water stress where the competing demands of municipal drinking water, irrigation water, and industrial use of water are creating issues that need to be addressed. Veolia is promoting the use of a "Water Impact Index" similar to the "Carbon Footprint" as a method of qualifying the impact of water projects. This "Water Impact Index" takes into account the volumes and the qualities of water extracted and released along with the local hydrological context or water stress conditions. For many, the most critical aspect is the water stress situation requires an increased production of useable water from the limited water supply, while maintaining a reasonable cost of water. Evaporation and crystallization technologies have been available for a long time, but the costs of the evaporation and crystallization process are not insignificant, and there is a need to address how to concentrate water at a lower overall cost. This has led to a number of alternative approaches to the solution of the water recovery issue. New processes along with combinations of processes have been developed utilizing both the pressure-driven and electrically-driven membranes to achieve substantially higher recovery of water, while avoiding scaling and fouling issues.

Keywords: Water impact index; Carbon footprint; Water footprint; High recovery processes

1. Introduction

Seventy percent of the planet is covered by water, but only 0.7% of the global water resource is available as freshwater to us, and it is very unevenly distributed across the planet.

Unlike oil, for which there are multiple energy options, freshwater has no substitute. And unlike oil, our needs for water cannot be sustainably addressed by transporting water from water rich areas to water-poor and high-demand areas. Over the next three decades, projected population and economic growth levels will, locally, push to the limit of the stress on this finite resource. In turn, limits in freshwater availability could become the world's main growth limitation factor as areas such as Southern California have already begun to experience.

There are solutions to this forming crisis. They will require that we become smarter in the way we manage water, which begins with understanding the impact we are having on this crucial resource. In short, we must become more aware of water.

Freshwater availability has been predicted to become a major limitation factor for growth of cities

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and industries in many locations around the world, and the need to understand and quantify the impact on water resources is essential to maintaining their sustainability and future prosperity because there is no substitute for water. This reality requires an understanding of the factors needed to make the most appropriate sustainable decisions.

Just as historians have connected the rise of great cities and economies with water (and in some cases, their demise), access to quality water resources is increasingly a focal point for those who plan for the future. In the developed world, urban planners, engineers, regulatory officials, environmentalists, politicians, and those in charge of manufacturing operations are now focusing attention on whether their communities or operations will continue to have reliable access to the water necessary to ensure their continued development. Meanwhile, in the developing world, officials continue to grapple with the lack of infrastructure for basic access to water or sanitation that slows their ability to develop their societies and economies. It can even quite literally mean the difference between life and death.

Are concerns about freshwater resources overblown? Are these matters for people far removed from our respective safe havens, especially for those located on lakes and riverways? Not when considering the EPA that has already cited 36 states in the USA as facing water shortages and that industrial companies and investors are placing water risks on top of their list of strategic issues to address.

Consider the following:

- In the developing world where infrastructure is lacking, close to 1 billion people do not have proper access to healthful water, and 2.6 billion people are without sanitation systems. This triggers an incredible storm of health issues and water-borne fatalities, not to mention freshwater pollution and water resource pressure.
- At the same time, leakage rates in distribution networks in developed countries can exceed 50%, while the lack of proper maintenance of wastewater and stormwater collection networks leads to growing pollution.
- Eighty percent of all childhood deaths and illnesses in developing countries are directly or indirectly caused by lack of proper access to water or sanitation.
- By 2050, 75% of the world's population will live in cities with increasing pressure on already strained water resources.
- Global demand for water will increase by 40% in just 20 years—and is projected to double in rapidly developing countries.
- Seventy percent of today's water withdrawals are used in agriculture. Population growth will lead to further significant withdrawals for agriculture, while fertilizing practices, if inappropriately managed, lead to an increasing source of water pollution affecting ground and surface water fresh resources.
- Climate change impacts will make the availability of freshwater resources more unpredictable. This includes droughts, floods, and increased sea levels that can cause salt water intrusion in groundwater reserves.

As populations shift more toward urban areas, current water and wastewater treatment programs may not be sufficient to address this and other trends involving climate change, energy consumption, pollution, and the impact of human activity on ecosystems. In an age when our development often occurs further away from a local water resource or our use pushes them to their limit, ecosystems are being even further stretched.

Current budgetary and economic challenges lay atop hard facts already on the table. As each drop of water becomes more precious, many cities are finding their leakage rates increasing. Even in North America, some cities can't account for up to half of their water production.

Mandates exist but cities are clearly struggling in a ping-pong match between the EPA's demand to do the right thing and the cities' lack of resources or lack of political will result in situations where mayors are often trapped between their citizens' long-term needs and short-term expectations.

The US Conference of Mayors estimates that the EPA's projected funding gap ($500 billion over 20 years) represents only 10–20% of what is needed ($2.5–4.8 trillion over the next 20 years).

With these challenges in mind, our decisions must consider many factors—not just whether water comes from our tap today—and we must consider the true cost of water.

2. A new model—water impact index

Water is a very local resource and, unlike oil, there are no alternatives to water.

Oil and natural gas can be transported over long distances, but transporting large quantities of water is not a practical option, especially considering sheer weight and the associated energy required to move such a heavy liquid. In Wisconsin, oil equivalent consumption is eight tons per year on a per capita basis—water consumption is about 2,140 tons per year per capita.

Current sophisticated water footprints focus almost exclusively on volume—a very good indicator to raise awareness, but not sufficient to represent the impact on a water resource. For instance, we know that approximately 2,900 gallons of water are required to make one pair of blue jeans. But, what is the impact on a given freshwater resource—a reservoir, lake, river, etc.? Two examples illustrate this point.

First, looking at two products—tomato sauce and peanuts—strictly by the volume of water needed, peanuts would appear to have a much higher water use impact than tomato sauce. However, according to a study [1] on water stress-weighted footprinting, the opposite is true. Tomato sauce has a 10-fold greater impact on water resources than peanuts, because tomatoes require more fertilizer and are produced in water-stressed areas with a significant reliance on irrigation.

In terms of sheer water usage, the production of peanut candies requires six times more water than the production of tomato sauce. However, the tomato sauce impact is 10 times higher when factoring in water stress.

A second example: the volume of water needed to produce one pound of beef—1,857 gallons—appears to be the same regardless of whether the beef comes from a water-rich or water-poor areas. But the impact on the water resource in two different states or, for that matter, two different areas of one state (East and West Texas, for example) can vary considerably.

The Water impact index expands on existing volume-based water measurement tools by incorporating multiple factors such as volume, resource stress, and water quality. It examines the impact of human activity on water resources and provides a methodology for establishing positive and negative implications of how water resources are managed. The new tool provides additional parameters needed to make informed choices about effective water management (Fig. 1).

Through the Water impact index, decision-makers can factor in three essential elements—quantity of water used, level of stress upon water resources, and overall water quality—and develop a much more detailed, holistic, and inter-related understanding.

The Water impact index considers both direct and indirect influences of an activity from "cradle to grave"—whether managing a textile production facility or a wastewater treatment facility. It incorporates the volume and quality of the water extracted and released back into the environment and adds the Water Stress Index (which accounts for the level of stress on the resource). This new index gives us the water impact—and it includes indirect elements from the production chain, such as energy, raw materials, chemicals, and waste generated (Fig. 2).

Through the Water impact index, one can better evaluate how water users (humans and ecosystems) could be deprived of water resources through mismanagement of water or wastewater systems.

The Water impact index accounts for the impact of water resources generated by a human activity. It enables evaluation of how other water users (both humans and ecosystems) could potentially be deprived of this resource—expressed in Gallon-WII-equivalent.

3. Water–carbon analysis

Carbon and water represent two major areas of impact on the environment that have broad economic and social ramifications.

Producing energy and undertaking industrial activity require fresh water, and energy is needed to produce, move, and treat water. This interdependence is often referred to as the "water-energy nexus."

Viewing carbon and water together provides a more comprehensive picture of the challenges to sustainability. Using less energy and less water results in lower pollution, less stress on ecosystems and water resources, and preserving the balance for future generations. Also reduction of energy and chemical consumption can limit wear and tear on assets and equipment, which can save money—an economic benefit for water utilities and the public.

One goal of this water–carbon analysis is to foster greater collaboration and continued dialog around water and carbon measurements. As environmental efficiency grows in importance, organizations will be able to use this tool to determine business locations that create a smaller footprint. Similarly, water managers can recognize and adopt best practices that are meaningful for the environment, customers, and capital and operating budgets. Such actions, in turn, will help cities, businesses, and organizations make the best possible decisions regarding sustainability when weighed against environmental outcomes and economic viability (Fig. 3).

Since the quantity and quality of the water have a significant impact on the water impact index there is a considerable interest in approaches toward zero liquid discharge. A variety of approaches using membranes have been developed with the aim of reducing the size of evaporator crystallizer equipment, if not to try to eliminate such equipment since these are generally considered to be energy intensive and have a significant carbon footprint.

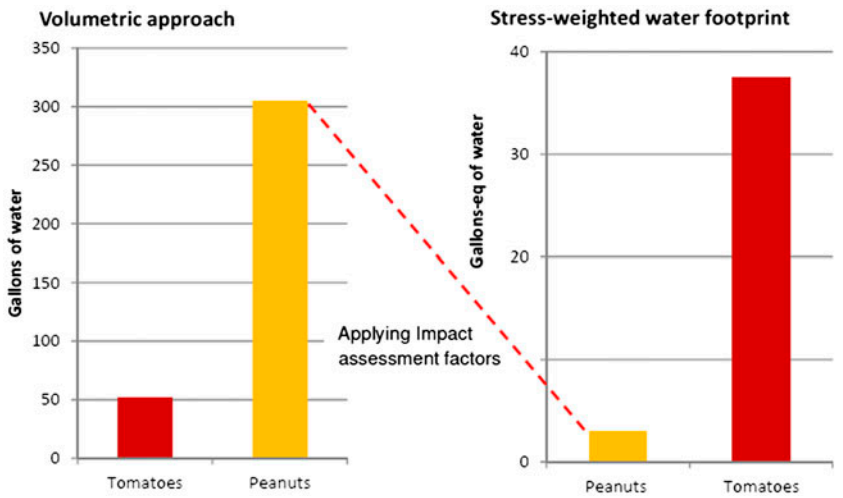

Fig. 1. Why go beyond a volumetric approach?

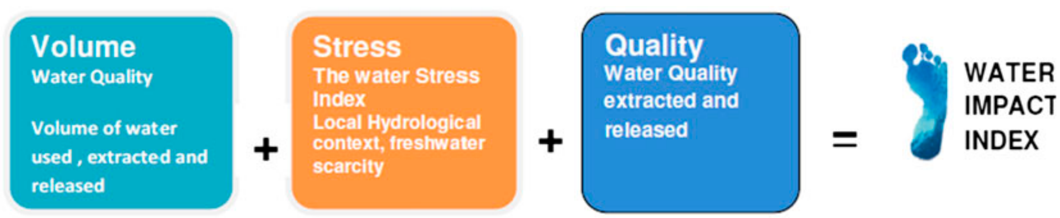

Fig. 2. A new metric for assessing water impacts.

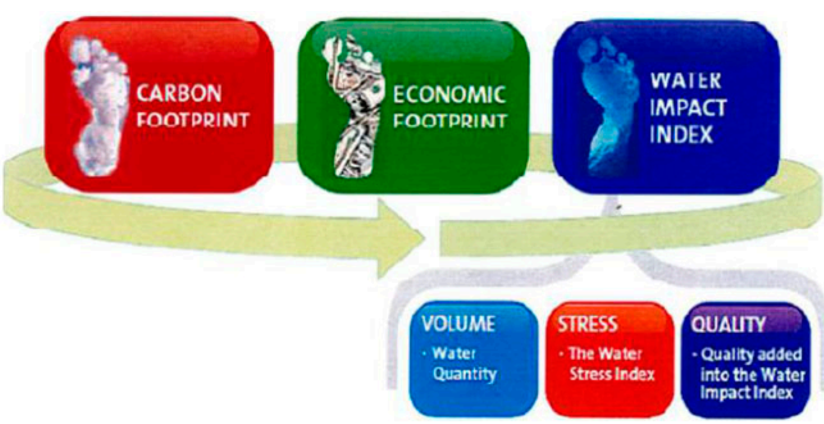

Fig. 3. The water–carbon analysis.

For many, the most critical aspect is the water stress situation requiring an increased production of useable water from the limited water supply, while maintaining a reasonable cost of water.

Veolia has been developing ZDD or zero discharge desalination which is a process combining reverse osmosis with an ion substitution electrodialysis system to generate two streams with very high concentrations of salts that have high solubility. When these two streams are mixed together, sparingly soluble salts are created that could be recovered potentially for beneficial reuse. This process can reduce the amount of waste water to 1–2% depending on the TDS of the feed water.

The GE AquaSel system is described as a non-thermal brine concentrator which utilizes a combination of electrodialysis with a chemical precipitation process to recover usable water from the concentrate of an RO system. With the process offered by GE, the amount of concentrate is reduced to around 1% depending on the quality of the feed water.

Recently Desalitech has been offering a version of reverse osmosis described as closed circuit desalination which effectively operates as a short-cycle batch RO system allowing high levels of water recovery and potentially some significant advantages in handling both scaling and fouling conditions.

Other technologies such as forward osmosis and membrane distillation are also active in high water recovery situations.

For many businesses, it is necessary for them to look to alternative water sources such as treated municipal waste water for the source of water for their operation, as is the case in several power facilities and petrochemical complexes.

4. Conclusion

There is no question that human and environmental preservation requires sensible use of water resources, but we also come to a point where economic growth will also dramatically depend on it.

The challenge—for cities, governments, and companies—is to find solutions that make a minimum impact on the environment not only in terms of water resources, but also when it comes to energy use, while maintaining and promoting economic growth.

The challenge for scientists and engineers in the membrane world is to find ways to treat water that meet sustainability targets for now and into the future.

Reference

[1] B.G. Ridoutt, S. Pfister, A revised approach to water footprinting to make transparent the impacts of consumption and production on global freshwater scarcity, Global Environ. Change. 20(1) (2010) 113–120.