IT is assumed that an individual consumes about 2 litres of water every day for drinking. But have you ever wondered how much water is consumed when we eat an apple or a slice of bread?

The food we consume contains calories. A medium-sized apple has approximately 95 calories, a slice of bread has 66 calories and a cup of black tea has about 3 calories. To produce these items, we need a certain volume of water. An apple requires 70 litres, a slice of bread requires 42 litres and a cup of black tea requires 28 litres of water.

So, when we eat these food products we are also consuming water in its indirect form. This indirect water incorporated and used by humans is called ‘virtual water’. It is defined as the volume of water used to produce the goods as well as services that we consume and use.

We call it ‘virtual water’ as the water is no longer physically contained in the product. This applies not only to food products but also to other goods such as jeans, pencils, smartphones, etc. So, virtual water is the largest volume of water we consume every day, larger than the water we use for drinking, washing, bathing, sanitation, etc.

This concept was first introduced by Prof. Tony Allan from the King’s College London in 1993. He proposed this concept when he was researching on ‘how countries with water scarcity can meet their water needs?’ Countries in North Africa and the Middle East have less water resources and hence cannot produce all the food products that they need. They import the food that cannot be produced in the home country.

Alan noticed that by importing food these countries are indirectly
importing the water that is not available within their country. His discovery is considered one of the pioneering in linking agricultural production and water use. For this, he was awarded the prestigious Stockholm World Water Prize in 2008. This prize is equivalent of the Nobel Prize for water research.

Though this concept was introduced in the year 1993, it was not globally recognized as an important part of water resources management until the ‘International Expert Meeting on Virtual Water Trade’ that was held at IHE Delft Institute for Water Education, the Netherlands in December 2002.

**Water in our Food**

The water used to produce these food items is not universally constant. This is because the availability of resources and technology varies from country to country. Depending on the rainfall, temperature, evapotranspiration, cropping pattern, water available in the country for agriculture, infrastructure available for irrigation such as canals, etc., the water required for producing a crop differs. Professor Arjen Y. Hoekstra from the University of Twente, Netherlands along with his team quantified the volume of water that is virtually contained in each crop and animal product from each country with the help of computer programming models.

Let us see how these virtual water numbers vary by country. These values are generally expressed as the number of litres required to produce one kilogramme (kg) of the food product. The global average virtual water required to produce one kg of potatoes is 317 litres. Australia requires 184 litres, France requires 157 litres, Mexico requires 290 and United Arab Emirates requires 351 litres to produce a kg of potatoes. For India, this is 321 litres.

Similarly, it takes 2,122 litres to produce a kilo of apple in India while the world average is 906 litres. These values are higher for cereals and animal products. Just as the production of crops depends on climate, the animal production depends on the fodder (food that animals eat), the rate at which the animals can convert the fodder into desired output such as milk, eggs, etc. and the life span of the animals.

The type of animal farming such as industrial, grazing and mixed systems also has an impact on the virtual water content of these animals. Industrial systems are those in which the animals are reared in closed spaces and the fodder is supplied to the animals. In grazing system, as the name indicates, the animals can graze the pastures and greeneries. Mixed system is a combination of these two types. To grow a goat, we need 5965 litres in the grazing system, 3148 in the mixed system and 1739 in the industrial system.

Obviously, the industrial system uses less water than the other methods. An average of the three methods is normally used to denote the virtual water of an animal because the details of the farming system are usually not well documented. Therefore, the weighted average for a live goat is
3393 litres. Likewise, a chicken will use 8046 litres in a grazing system, 4277 in a mixed system and 2459 in the industrial system. The average for a live chicken is 3708 litres. These values represent the global average.

Secondary and tertiary products resulting from the primary crop will include more virtual water as it requires additional water during processing. For example, wheat is a primary product. To produce wheat in India we need 2,315 litres/kg. Wheat flour and bread are secondary and tertiary products of wheat. This requires 2,343 litres/kg and 2,037 litres/kg respectively. Virtual water values for all crop and animal products are compiled and available as open-access in the Value of Water Research Report Series No. 47 and No. 48 published by UNESCO-IHE.

The 321 litres of water required to produce a kg of potatoes in India does not come from a single source. That means, the type of irrigation decides what type of water is used to produce the product.

The major sources of water for irrigation are rainwater, groundwater and surface water or it could be a combination of these different water types. This source of water used to produce a product can also be measured. So, eventually virtual water is classified into three types: green, blue and grey water.

Green water is the rainwater used for irrigation, blue water is the total of groundwater and surface water and grey water is the volume of water required to carry off the pollutants produced during the process. In other terms, grey water is the litres of water polluted during the production of a crop due to use of fertilizers, pesticides etc. So, 321 litres of virtual water required to produce a kg of potato in India typically contains 244 litres of rainwater, 40 litres of groundwater and/or surface water and produces 37 litres of grey water.

These values are higher for staple crops of India such as rice and wheat. Variation in the virtual water content does not only exist among the crops and livestock from different nations, but also within a country. Some parts of a country receive more rainfall and have abundant resources for agriculture than others. Therefore, virtual water also differs accordingly. Take for example wheat production: Andhra Pradesh needs 3,312 litres, Uttar Pradesh requires 1,877 litres, West Bengal uses 1,911 litres and Gujarat takes up 2,760 litres of water.

Trading Water

Now, how important are these values? They have a major impact in the trade of commodities. Virtual water serves as a simple way to communicate the trade of water through import and export of food products between countries.

In the year 2013, India exported 8.98x10^7 kg of wheat to Malaysia. Indirectly India has exported 1.89x10^{11} litres of its water resources, which is the water used to produce 8.98x10^7 kg of wheat in India. This implies export to one country only. India exported in total 6.38x10^9 kg of wheat to 44 countries in 2013 which leads to export of 1.34x10^{11} litres of water.

The most significant point to note here is India exports the largest blue water (groundwater and surface water) as virtual water. Today, water is an expensive commodity, especially blue water. By exporting more blue water, India may be losing its precious water resources. It is agreed that blue water is a renewable resource, however, it is not a healthy scenario when the rate of depletion of the resource is higher than the rate it has been replenished.

India not only exports water, but also imports for its own needs from other countries. In 2013, India imported 4.08x10^6 kg of grapes from nine countries. In doing so, India imported 1.76x10^9 litres of water resources. When we subtract all the virtual water that is imported by the nation and all the virtual water that is exported, it gives the net virtual water i.e. the virtual water that remains in the country.

Net virtual water computed for all the countries in the world has helped to identify countries that consume more water from other countries and countries that export more virtual water. On an average India exports 59x10^3 litres/year and imports 33 x10^3 litres/year. Subtracting these two values gives the net virtual water of 26 x10^2 litres/year as export. After the United States of America and China, India is the third largest nation to export virtual water. Japan, Netherlands, China and Indonesia have been the largest virtual water importers.

Among the virtual water traded...
between several countries in the world, 67% is from crop products used as food for humans, e.g. rice, wheat, oil, nuts, spices, vegetables, fruits, chocolates, etc. Animal products such as milk, cheese, butter, eggs, meat, etc. contribute to 23%. Industrial products such as cotton, jute, leather, etc. contribute to 10%. This again proves that humans consume more water than that is physically visible to the human eyes.

Two things are essential for agriculture: land and water. Some countries do not have enough of these resources and are not able to meet the needs of their own population. It is also impossible to physically transport the water from surplus regions to scarce regions. Instead virtual water trade helps countries overcome the problem.

Kumar and Jain (2011) analysed the virtual water trade between the Indian states and found that instead of transfer of water from states having surplus water to deficient states, it was vice-versa. This means that states that do not have abundant water resources still produce crops that require large amount of water (also called ‘water-intensive’ crops). If this situation continues, it will lead to unavailability of water resources for future generations.

**Water Footprint**

Prof. Hoekstra coined a term in relation to virtual water – ‘water footprint’. This is the total water consumed by an individual or by all the individuals in a country. This gives an idea of how much water is required by a person for one year. This value for India accounts to 5,69,000 litres/person/year.

It is possible to reduce the water footprint by changing the food habits. This is generally based on the cultural habits and economic development of a country. It is obvious that a meat-based diet has more virtual water than a vegetarian diet.

Dr. Davy Vanham from the European Commission has conducted several studies on the diet of various European countries. He found that the growing demand for animal products has increased the water-use and it is necessary to move to a vegetable-rich diet to preserve water resources. Similarly, it is easy to argue that water-intensive crops such as nuts, spices and oil should be grown in countries that have large water resources and should be transported to other countries and vice-versa. However, it is easier to propose such ideas than to implement them. In real life, this is interconnected with other issues such as land availability, labour, energy, etc.

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**Future Perspective**

Water scarcity is not a stand-alone problem, but related to climate change, groundwater depletion, etc. In recent times, virtual water has helped us to understand this issue in a better way. India is not a water-abundant country, but has been exporting large quantities of virtual water. Though exports are essential for the economic growth of the country, such unsustainable use will lead the nation to a critical water situation.

Now, what can a nation do to address this issue? Many governments in the world are adopting virtual water in their trade policies. Perhaps it is time that India should also be including this concept in our trade relationships with other countries.

How can we contribute as individuals? As an individual, we should be aware not only of the water we drink, but also that we eat. Before we throw away any food, we are usually reminded of the starving people who do not have access to food. It is now prudent that we also think about the amount of water used to produce the food before we let it go waste. It may be a small step, but it will go a long way.

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