WATER FOOTPRINTS OF BOTTLED WATER IN PAKISTAN

By

Dr. Asad Sarwar Qureshi and Atif Nawab[1]

ABSTRACT

The use of bottled drinking water in Pakistan has increased manifolds during the last 15 years. The bottled water consumption was 33 million litres in 1999, which increased to 70 million litres in 2003. It furthermore estimated the consumption for 2003, as 70 million litres or 0.5 litres per capita. Recent figures suggest a yearly consumption of about 2 litres per person bottled water. This seems very low compared to 43 litres per capita in Thailand and 15 litres per capita in Philippines. The current annual consumption of bottled water is estimated at 360 million litres, which is expected to increase to 500 million litres in 2025. The footprint of bottled water shows that one litre of bottled water has a water footprint of 15.40 litres. Water consumption by the industry comprises of 67% during material production, 16.5% in processes, 10% in energy and only 6.5% in the actual product. This means that to produce 360 million litres (330,000 cubic meter) of bottled water, we are using about 5.6 million cubic meter water. This amount will rise to 7.7 million cubic meter in 2025 if the present trend continued. Because maximum consumption of water is in material production, water footprint of the bottled water can be reduced through the optimization of water consumption in material production.

Keywords : *Bottled Water (BW), Water Footprint (WF), Polyethylene Terephthalate (PET), Real Water Content (RWC), Virtual Water Content (VWC)*

1 INTRODUCTION

Water is not only a key but a crucial resource in Pakistan with respect to two main aspects of its use: water for food and water for life. Water for industry is gaining increasing importance as well and sufficient water for the environment is crucial in maintaining the water cycle, eco-system integrity and the regeneration of the resource. In the context of a growing population, global warming and the associated shrinkage of glaciers, the competition among these four uses of water is steadily and substantially increasing. Consequently, adequate water management and, in particular Integrated Water Resources Management (IWRM), is essential for meeting growing demand of water for domestic, industrial and environmental purposes.

The Indus River basin forms the back bone of Pakistan's economy. It supplies water to the largest contiguous irrigation system in the world that provides 90% of the food production and contributes 25% to the GDP. But it is also one of those countries that could face severe food shortages which are intimately linked to water scarcity. Continuing high population growth rates with limited land and water resources has put enormous pressure on the economy and ultimately stability of the country. Hope lies in the fact that there is great potential for better water and land management.

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1. Senior Environment Specialist and Junior Engineer (Environment), National Development Consultants (NDC), Lahore, Pakistan. Email: sarwar65@yahoo.com

Population growth in Pakistan has been, and continues to be, high. The total population in 1950 was 40 million, which grew up to 80 million in 1980 and has reached to an estimated 185 million in 2010 (UN, 2009). More than 4 million people are added every year and according to UN estimates the population in Pakistan will reach to 250 million in 2025 and 335 million in 2050. The percentage of urban population will increase from the current 35% to 52% by 2025. As a result, water demand for domestic, industrial and non-agricultural uses will increase to 10% of the total available water resources by the year 2025 (Bhutta, 1999).

Contamination of surface and groundwater is common due to discharging of domestic and industrial wastewater in water bodies without any prior treatment. Resultantly, majority of the Pakistan's population is exposed to the hazard of drinking unsafe and polluted water. This has resulted in large scale shift to the bottled water, especially by the middle and upper classes of the society. However, bottled water is a very expensive alternative despite the fact that bottled water is not always healthy because of infrequent testing for contaminants and sporadic inspection of processing plants.

Bottled water consumption has been steadily growing in the world for the past 30 years. It is considered as one of the most dynamic sectors of all the food and beverage industry, where consumption in the world increases by an average 12% each year, despite its high price compared to tap water. In Pakistan, bottled water also has become hygienic and safe option for drinking water. However, very few people are aware of the fact that for the production of bottled water, huge amount of water and energy is required. In a country like Pakistan where water and energy both are scarce commodities, production of bottled water should be seen as a luxury rather than necessity. This paper tries to estimate energy demand and water demand for the production of bottled water. The study also highlight the annual bottled water demand and consumption in the country.

2 Water for basic needs in Pakistan

2.1 Access to Sanitation and Safe Drinking Water

Water supply systems in Pakistan's urban centres are based on either using surface water or groundwater abstraction through tubewells. The cities which depend on surface water for their drinking water needs include Islamabad, Karachi and Hyderabad. Lahore, Peshawar, Faisalabad, Abbotabad and Quetta are mostly supplied by groundwater. Nearly all cities depending on surface supplies face moderate to acute shortages, but Lahore and Peshawar are somewhat better off due to a high yielding aquifer.

Majority of population in Pakistan do not have access to safe drinking water and sanitation. Due to incremental increase in public sector investments, the access to piped water has increased from 25% to 29% of the population between 2001 and 2005 (GoP, 2006). However, there is large variation in rural and urban areas. Access to water supply in the urban areas is limited to about 83% of the population. About 57% of the people have piped supply to their homes whereas in other mainly poor areas people get water either from community taps, hand pumps, wells or pay heavy cost to the water vendors.

Only about 53% of the rural population has access to drinking water from public water supply sources (WWF, 1997). The remaining population gets their drinking water supply from streams, canals, village ponds and springs that is untreated and unsafe for human consumption.

According to WHO, access in Pakistan to an improved water source increased from 83% in 1990 to 91% (WHO, 2010). In the meantime, improved sanitation coverage increased from 37% to 59% (Table 1). In urban areas, access to safe clean water through house connections is limited to 49% of the population whereas this ratio for rural areas is only 15%. Most rural water is supplied from groundwater except in saline groundwater areas where irrigation canals are the main source of domestic water. The access to proper sewerage conditions is even worse with only 40% for urban and merely 6% for rural population.

Table-1. Access to water and sanitation in Pakistan.

		Urban (34% of the population)	**Rural (66% of the population)**	**Total**
Water	Broad definition	96%	89%	91%
	House connection	49%	15%	27%
Sanitation	Broad definition	92%	41%	59%
	Sewerage	40%	6%	18%

2.2 Drinking Water Quality

The present water use for municipal and industrial supplies in the urban sector is of the order of 5.3 BCM. Most urban water is supplied from groundwater except for the cities of Karachi and Hyderabad and part of the supply to Islamabad. The demand for municipal and industrial supplies in urban areas is expected to increase to about 14.0 BCM by the year 2025. The total non-irrigation water use is expected to increase to 18.9 BCM. As a result, irrigation water will face increasing competition from the municipal and industrial sector.

In the country about 2,122 million gallon per day of sewerage is being thrown in the water bodies. Drainage network is collecting agriculture waste along with untreated industrial and municipal effluent and discharging it into the rivers. This has resulted in deterioration of river quality especially for the downstream users. About 36% of the groundwater is highly non-saline with complaints of presence of heavy metals. Most of the household drinking water is supplied through public tubewells in big cities such as Karachi, Lahore and Faisalabad and in rural areas canal flows are discharged into village ponds for use by animals and humans for all domestic purposes (WWF, 1997).

According to the Pakistan Environmental Protection Agency, the most imminent threat to drinking water is bacterial contamination through contact with sewage (GoP, 2008a). The data collected and analyzed by Pakistan Council of Research in Water Resources (PCRWR) from sixteen different tubewells in Lahore during 2002 to 2006 shows that

concentrations of arsenic and Iron were found above the standards of WHO guidelines (Kahlown et al., 2008). Similar is the situation in other big cities. This poor quality of drinking water is causing serious problems for the people living in these areas. In 2006, major outbreak of water borne disease epidemics swept Faisalabad, Lahore, Karachi and Peshawar as a result of sewage and industrial waste leak into drinking water through damaged pipes. People mostly complain about the problems with smell, taste and appearance of water. Bitterness and saltiness are common issues in rural areas whereas bitterness and muddiness are common issues in urban areas. As a result, Hepatitis, Renal diseases, Malaria and Gastric conditions are common diseases prevailing in the rural and urban areas. The situation has become so worse that in big cities like Lahore, one out of every 5 persons is diagnosed as Hepatitis.

Water borne infections such as cholera, typhoid fever and dysentery also burdens the public health system and can impose significant economic losses. Safe water alone can reduce diarrhea and other related diseases by up to 50%, but an estimated 62% of Pakistan's urban population and 84% of the rural population do not treat their water. Water borne diseases cost the national exchequer 2 percent of GDP annually due to lack of safe drinking water and poor sanitation. Link between water quality and health risks are well established. The ADB has advised Pakistan to increase its water sector spending to a minimum of one per cent of GDP from the current 0.25 per cent. It is a small price to pay for improved quality of life, millions of young lives saved, increased productivity and generating an economic return to boost prosperity (ADB, 2002).

3 BOTTLED WATER – LAST RESORT FOR SAFE DRINKING WATER

Due to increasing shortage of safe drinking water, millions of people around the globe has turned to bottled water (of course who could afford). Resultantly, bottled water consumption has grown exponentially over the past ten to fifteen years. Available statistics show that consumption of bottled water in countries with available safe tap water, e.g. North America and Europe, increased from 20 up to 80 percent between 2000 and 2003 and is lead by an average consumption of 112 litres per capita in Europe. In 2003, for example, global bottled water companies produced 153 billion litres of water, an increase in production of 27 percent compared to 2000. This reflects a production value in sales of USD 45.8bn. This means that the bottled water industry has literally created its own water culture, pursuing customers – for example in the US – to pay up to 10,000 times more for bottled water than for tap water. This culture is usually referred as one of "*health, wellness and pleasure*" in which bottled water also serves "*increasing mobile lifestyles*".

But apart from the "bottled water culture", bottled water is one of the few sources of safe drinking water in developing countries. Economic development and globalization work together to meet demands for safe drinking water by a new middle class. Therefore, since 1998, growth rates of up to 50 percent yearly are common in countries in Asia, the Transcaucasia, Middle East and North Africa. Global consultants, like Zenith, report that total sales reached 25,270 million litres in 2000, more than double the level of 1995. The Asian region now represents 23% of global consumption, with its largest markets in China, Indonesia and Thailand.

Bottled water in Pakistan is not considered a 'beverage'. Beverage processing includes carbonated soft drinks – where Pakistan has the lowest per capita consumption in the world, fruit juices, syrups and juice flavoured drinks. Pakistan has low consumption of bottled water. The Government of Pakistan described the market for bottled water, with 33 million litres of consumption per annum in 1999. It furthermore estimated the consumption for 2003, as 70 million litres or 0.5 litres per capita. The bottled water market in Pakistan has witnessed annual growth rates of 40 percent. In 2000, it had the fastest worldwide growth in bottled water estimated at 140%. Recent figures estimate a yearly consumption of about 2 litres per person bottled water, compared with Thailand's 43 litres and Philippines 15 litres per capita consumption, this seems relatively low (Shalini et al., 2014). Taking Pakistan's population into account, one has to estimate current annual consumption of 360 million litres. With the projected growth rates, Pakistan's population will reach to 250 million by 2025. If the current usage of bottled water remains constant, estimated consumption of bottled water will reach to 500 million litres of water by 2025.

4 WATER FOOTPRINT OF BOTTLED WATER

The water footprint is an indicator of direct and indirect uses of water. This includes Real Water Content (RWC) and Virtual Water Content (VWC), which is the water required for manufacturing the raw material, water used in processes and in energy generation for production purpose. Water footprint is also divided into Green water footprint (Rain Water), Blue water footprint (Ground or Surface water) and Grey water footprint. "Water Neutral" a terminology which means to reduce the water footprint of an activity as much as possible and offset the negativity.

The price of bottled water is tremendously high, compared to tap water. Most of the price of a bottled water consumers actually pay corresponds to its transport, marketing and retailers' profits. Bottled waters end up being an average 500 to 1000 times more expensive than tap water. The ratio for bottled water to tap water ranges from a low of about 240 times more expensive (cheap bottled water: expensive tap water) to over 10'000 times more expensive (expensive bottled water: cheap tap water). Typically 90% or more of the cost paid by bottled water consumers goes to things other than the water itself -- bottling, packaging, shipping, marketing, retailing, other expenses, and profit (Shalini et al., 2014).

The water footprint consists of two components: the operational water use (direct water use) and the water use in the supply chain (indirect water use) (Gerbens-Leenes and Hoekstra, 2008). In this study, production included RWC of 1 litre and VWC which is the water required in the production processes, energy, material and transport of one litre of product (Bottled water). As most of the industries are distributing their products locally, here WF of transportation is omitted.

WATER FOOTPRINT (WF) = (RWC) + (VWC)

Where

VWC = VWC (material) +VWC (process) +VWC (Energy)

Bottled water is sold in various convenient packs like half litre, 1-litre bottles and 20 litre jars. Major material used to manufacture bottles and jars are plastic. Although PVC is still used, Polyethylene terephthalate (PET) is increasingly used for many reasons: it is brighter than PVC, very transparent and it almost looks like glass. PET is shatter-resistant and easy to work on. Its light weight (20% lighter than PVC) enables to reduce plastic quantities needed to make a bottle. It is compressible, so volumes of waste are smaller. PET is in addition easy to recycle or remanufacture. As the container capacity increases manufacturers likely to toggle from PET to polycarbonate for rigidity and safety which required 40% more energy than PET bottles. PET resin is a combination of the ethylene glycol and terephthalic acid. The resin pellets is then melted to form “Preforms” (Test tube shaped, cap threaded) which is then blown into final PET bottles (Bousted, 2005). There are some plants which have blowing activities in their industries and some ready-made blown bottles.

As per the LCA, production of 1 kg of virgin PET resin required 294 litres of water as the PET material is hygroscopic in nature (Arena et al., 2003). The weight of a one liter PET bottle is about 24 grams which means that single bottle requires 7.35 litres of water (Madival, et al., 2013). The filled bottles are packed in the plastic material, a six bottle packing material requires about 1.7 litres of water.

The energy implication and water footprint of the bottled water are major issues of concern. Energy is required for PET resins formation and blowing of performs, water processing (Sand filtration, RO, Ozonation, bottling etc.), transportation and then for collection and recycling. Water footprint comprises production of raw polymer, carton material, processing, and transportation.

Energy is required in the production of raw PET material and production of PET bottles, which is provided by various means like gas, petroleum and local electricity network. The Life Cycle Assessment (LCA) of PET shows required energy of 77 MJ/kg/1 for virgin PET, manufacturing of perform and turning them into bottles required an additional 20 MJ / kg (Gleick and Cooley, 2009). The energy required for production of single one litre capacity PET bottle is around 2.5 MJ. The packaging production requires 4.5 MJ of energy per case for 12 bottle capacity carton or 2.25 MJ for 6 bottle carton (Ghalib and Bassing, 2004).

The energy required for diverse processes involved in pretreatment of water prior to filling in the bottles includes washing, sand filtration, reverse osmosis etc (Figure-1). According to the present study the energy requirement in aforementioned treatments are ranging from 0.009 MJ to 0.20 MJ per litre of production. So the average energy consumption for treatment procedure is 0.08 MJ / litre. The water treatment involves sand filtration, reverse osmosis, UV treatment, Ozonation; in spite of extensive treatment processes it required only 0.0001 to 0.02 MJ / l^{-1} of energy [4].

Therefore the total energy required for processing of PET, packing material and other treatments is equal to 4.95 MJ/kg (2.5 + 2.25 + 0.20) or equivalent to 2.51 litres.

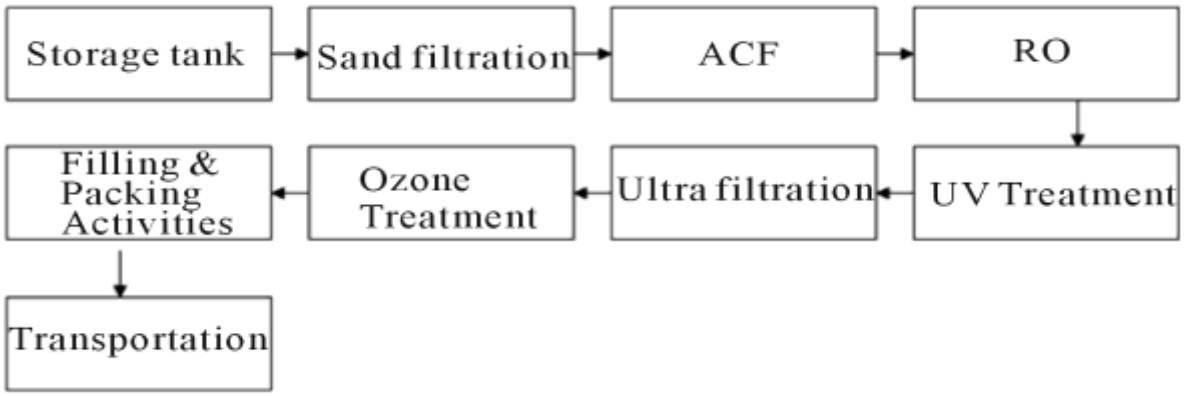

Figure-1. Flow diagram of bottled water treatment units.

The water consumption in the energy requirement for different processes also needs to be considered. Most of the thermal power plants (coal or oil) requires 520 and 450 gallons of water for production of one MWh of energy. About 1.31 litres of water goes in the energy requirement for the PET bottle production. One kilogram of packing material needs around 1.26 KWh or 4.5MJ of energy. Therefore, energy required in PET bottle production, packing material and energy required in water treatment processes makes up the virtual water content (energy). So the total energy requirement for one litre of bottled water is 2.95 MJ (equivalent to 1.54 litres). Therefore VWC for one liter of water is:

VWC (material) = 7.35 + 1.7 + 1.31 = 10.36

VWC (process) = 2.5 + 2.25 +0.20 = 4.95 (equivalent to 2.50 litres)

VWC (energy) = 1.54

Therefore

VWC : VWC (material) + VWC (process) + VWC (energy)

VWC = 10.36 + 2.50 + 1.54 = 14.40 litres

WATER FOOTPRINT (ONE LITRE WATER) = RWC + VWC = 1.00 + 14.40 = 15.44 litres

In summary, the water foot print for one litre of bottled water is 15.50 litres of water. The percentage distribution of water usage in this industry are 67.5% in the material, 16% in processes, 10% in energy and only 6.5% in actual product.

5 CONCLUSIONS

In Pakistan, bottled water industries are growing rapidly in current years and would follow the same trend in future. It is estimated that to produce one litre of bottled water,

we need 15.44 litres of water. The most of the water is consumed in material production and processes whereas only 6.5 percent goes to actual water. More than 90% of the cost paid by the consumers actually goes to material manufacturing and processes involved in bottle making. It is estimated that the bottled water consumption in Pakistan will increase to 500 million litres (7.7 million cubic meters) by 2025. Most of the water used in this industry comes from groundwater. With the declining groundwater tables and deteriorating groundwater quality, it can be serious challenge to meet this demand. Energy required to pump this much groundwater would be another problem in future.

Like any other industrial activity, bottled water is not completely innocuous to the environment. On the one hand, quality standards and controls as well as spring protection could help better protecting water quality at a larger scale. The choice of packaging materials should increasingly consider environmental parameters. The manufacturing, recycling or incinerating bottles of water implies energy needs and some outlets in air and water of polluting particles. Transporting bottled water throughout the world also implies energy needs as well as fuel combustion. Therefore government should promote safe drinking water through taps to discourage the use of bottled water.

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