Water Supply Treatment Sustainability of Panching Water Supply Treatment Process - Water Footprint Approach

IOP Conf. Series: Materials Science and Engineering **318** (2018) 012028 doi:10.1088/1757-899X/318/1/012028

Water Supply Treatment Sustainability of Panching Water Supply Treatment Process - Water Footprint Approach

Edriyana A Aziz[1,2], Marlinda Abdul Malek[3], Syazwan N. Moni[1], Nabil F. Zulkifli[1], and Iqmal H. Hadi[1]

[1] Faculty of Civil Engineering & Earth Resources, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300, Kuantan, Pahang, Malaysia.

[2] Center for Earth Resources Research & Management (CERRM), Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300, Kuantan, Pahang, Malaysia.

[3] The Institute of Energy, Policy and Research (IEPRe), Universiti Tenaga Nasional, Malaysia.

Email: edriyana@ump.edu.my

Abstract. In many parts of the world, freshwater is scarce and overexploited. The purpose of this study is to determine the water footprint of Water Supply Treatment Process (WSTP) at Panching Water Treatment Plant (WTP) as well as to identify the sustainability of the Sg. Kuantan as an intake resource due to the effect of land use development. The total water footprint (WF) will be calculated by using WF accounting manual. The results obtained shows that the water intake resource is still available but it is believed that it will not be able to cope with the increasing WF. The increment of water demand percentage by 1.8% from 2015 to 2016 has increased 11 times higher of the water footprint percentage, 19.9%. This result shows that the water consumption during the water supply treatment process is two times higher than the demand thus it shows the inefficient of the water management

1. Introduction

Human activities consume and pollute a lot of water [1]. Globally, most of the water use occurs in agricultural sector, but there are also extensive water consumed in the industrial and domestic sectors [2]. Irrigation, bathing, washing, cleaning, cooling and so on are specific activities of water consumption and pollution [1]. Increasing total water consumption and pollution are generally because of increasing population [3].

Nowadays, in Malaysia, population growth and increasing urbanization, industrialization and agriculture have led to high demand for water, therefore, contributes to water pollution, and also would create water scarcity [4]. Thus, in moving towards a developed nation status, the country's water system should be jointly headed in that direction. Besides, urban areas are likely to face water stress driven by various factors such as water pollution, population growth, poor area planning, economic growth that leads to increasing demand, climate change and inefficient infrastructure (Childers, Pickett, Grove, Ogden, & Whitmer, 2014).

Over the past decades, WF concept which has been developed by Water Footprint Network (WFN) significantly is developing plenty of publications and researches which are used in water resource management and other journals [3], [5]–[11].

Thus, using WF as a tool is important to highlight the amount of water uses and the connection to global water resources in accordance to sustainability distresses. Therefore, to date, water supply treatment process has never been assessed its overall water consumption to produce a treated water from the water intake. In particular to the WF of other product that may be taking place in the WTP covered area, this study will be a baseline or first data set of a production chain. This is because, product's WF is the sum of WF of the various processes involved to produce product either goods or services. Hence, WF of water supply treatment process will be assessed significantly to improve water resources management in accounting overall water consumption according to all types of water. Currently, in water management, volume of blue water intake is recorded before this resource undergoing the series of in-line processes to produce a treated water. However, the recorded value is only blue water intake and not considering the overall water consumption along the process. Therefore, WF will act as a tool to account overall water consumption which includes blue, green and grey WF concurring to WF definition in the WF Manual [12].

2. Methodology

Kuantan is the state capital of Pahang that have increasing population. Thus, this study was conducted at the 2nd major WTP in Kuantan district; Panching WTP which is located at 3.834534, 103.201831, where its water intake is from Sg. Kuantan as shown in Figure 1. The Panching WTP has a capacity of 160 million litres per day, covering around residential area as well as 5600 hectares of industrial area.

2.1. Data Collection

In this study, data such as rainfall intensity, river flowrate, temperature and water intake volume were collected from Department of Drainage and Irrigation (DID), Malaysia Meteorological Department and Pengurusan Air Pahang Berhad (PAIP) respectively. Meanwhile the land use development of Kuantan district was collected from the Majlis Perbandaran Kuantan (MPK).

2.2. Water Footprint Accounting

The aim of water footprint accounting in this study is to quantify water footprint in each single process of water supply treatment at Panching Water Treatment Plant (WTP). In general there are three types of water footprint which is WFgreen, WFblue and WFgrey. Before the water footprint calculation, type of water footprint involves at each processes was identified.

The WF blue indicates 'consumptive water use' or in the other words, fresh surface water or groundwater. The WF blue can be represented as the following equation:

$$WF_{blue} = BWE + BWI + LRF \quad (1)$$

BWE= Blue water evaporation
BWI = Blue water Incorporation
LRF = Lost Return flow

The unit of the blue process water footprint is water volume per unit of time. In this study, the LRF was not considered in the calculation.

The WFgreen in other hand refers to the precipitation that does not runoff or recharge to the groundwater but is stored in the soil or temporarily stays on top of the soil. However in this study, the WF green is considered as a water that being incorporated in the open tank area of the WTP. The WFgreen can be represented with the following equation:

$$WF_{green} = GWE + GWI \quad (2)$$

GWE= Green water evaporation
GWI = Green water Incorporation

The unit of the green water footprint process is water volume per unit of time. Time refers either to the day, week or year.

The degree of freshwater pollution that can be associated with the process involves in the WTP is called grey water footprint (WFgrey). It refers to the volume of water that is required to assimilate pollutants to such an extent that the quality of ambient water remains above water quality standard. The WFgrey can be calculated by dividing the pollutant load (L, in mass/time) by difference between the ambient water quality standard for that pollutant.

2.3. River Water Availability

The river water availability is crucial in order to ensure the sustainability of water supply to consumer. Water availability is referring to the existing volume of the river. Climate change is a factor that contributes to the changes of river water volume. In this study, the volume of river was obtained from the volumetric flowrate (Q) provided by DID.

2.4. Effect of Land Use

Land use decisions can potentially affect both water quantity and water quality. Nevertheless the decisions are not always well-coordinated. The strong connection between water availability and land use decisions, including the need to develop land use regulations that can be used to reduce future water consumption. Major change in land use development such as consequence of population growth, increasing and changing food demands, and expanding biofuel cultivation need to regulate to control the water supply sustainability.

Over the past two years, the population of Kuantan has increased rapidly. Treated water from Panching WTP is distributed to 2 sub-districts which are Penor and Kuala Kuantan. Table 1 and 2 show the land use of Penor and Kuala Kuantan.

Table 1. Land use of Penor sub-district

Type of land use	Hectre 2004- 2010 (Ha)	Land use 2004-2010 (%)	Hectre 2004-2010(Ha)	Land use 2010-2015 (%)
Residential	1243.63	5.57	2853.18	18.37
Forest Tree	12437.45	55.77	11188.84	50.17
Agricultural	4688.56	21.02	3517.16	15.77
Tourism	1132.97	5.08	1240.70	5.56
Others	2797.39	12.56	3500.12	10.13
Total	22300.00	100.00	22300.00	100.00

Table 2. Land use of Kuala Kuantan sub-district

Type of land use	Hectre 2004- 2010 (Ha)	Land use 2004-2010 (%)	Hectre 2004-2010(Ha)	Land use 2010-2015 (%)
Residential	3358.03	8.94	8567.16	22.83
Forest Tree	7668.61	20.43	5238.29	13.95
Agricultural	15590.23	41.54	12925.05	34.44
Commercial	132.67	0.35	647.08	2.07
Industrial	1498.8	3.99	1677.66	4.47
Others	9275.66	24.75	8468.76	22.24
Total	37524.00	100.00	37524.00	100.00

In this study, the effect of land use development to the sustainability of Panching Water Supply Treatment Process (WSTP) was obtained by the comparison between water availability and water footprint.

3. Result and Discussion

3.1. Water Footprint Accounting

Table 3 shows the types of water footprint involved in each process at Panching WTP.

Table 3. Water footprint types for each process at Panching WTP

Process	WF_{blue}	WF_{green}	WF_{grey}
Screening	✓	✓	
Aeration	✓	✓	
Mixing Chamber	✓	✓	
Flocculation	✓	✓	
Sedimentation	✓	✓	
Filtration	✓	✓	✓

At this WTP, only filtration process having all three types of WF due to pollutants discharge (backwash).

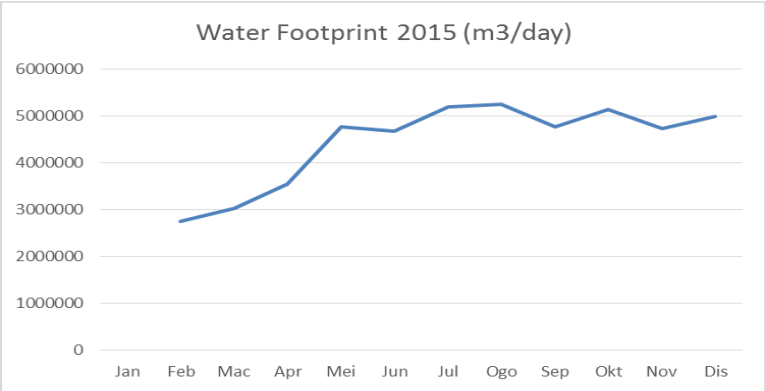

Figure 1 : Water Footprint in 2015

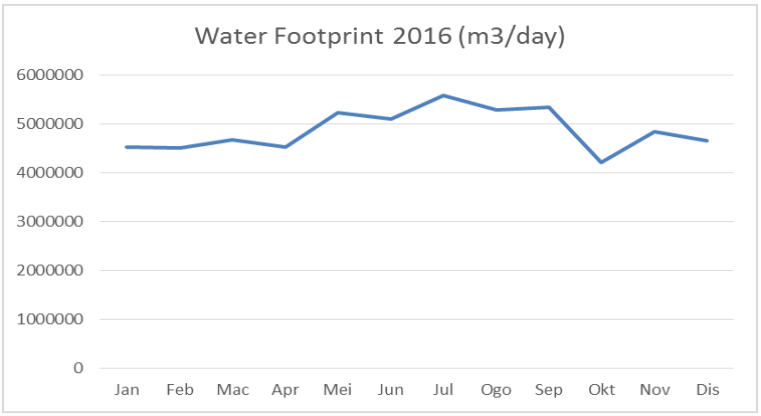

Figure 2. Water Footprint in 2016

In February 2015, the lowest water footprint amount was calculated with the value of 2,760,322 m^3/day as the plant was at the early stage of its operation and no backwash was indicated as WFgrey. Thus, WFblue and WFgreen were involved at that time. From the both graphs as shown in Figure 1 and Figure 2, the trend was gradually increased until the middle of the year and remain constant towards the end of year 2015 however there was a slightly decreased in year 2016. The decrement towards the end of year 2016 might due to the decreasing precipitation, thus affecting the water intake level.

3.2. Water Availability

Figure 4 shows the water availability of the Sg Kuantan in year 2015 and 2016 respectively. It shows that the water availability decreased from 2015 to 2016 with amount of reduction 1,134,147 m^3/day. This might due to the decreasing amount of precipitation, thus the volume of Sg Kuantan was affected.

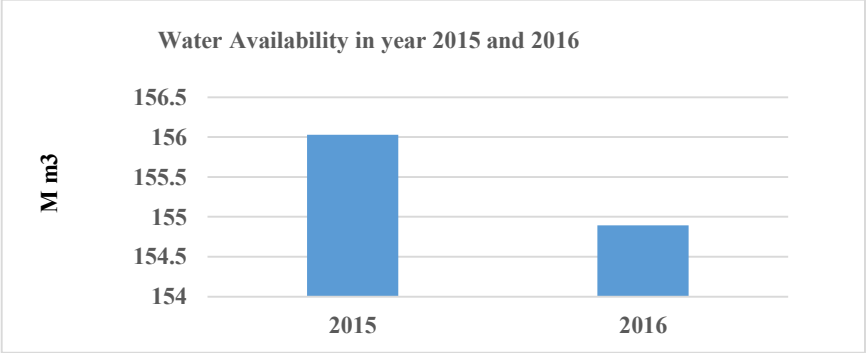

Figure 3 : Water Availability of Sg Kuantan 2015 and 2016

3.3. Land Use Development

From Table 1 and 2, it is clearly shows that there was a multiplication of growth in residential and industrial activities. It is believed that the increased of land used activities affected the water demand for the Panching WTP. Figure 5 shows the total water demand in year 2015 and 2016.

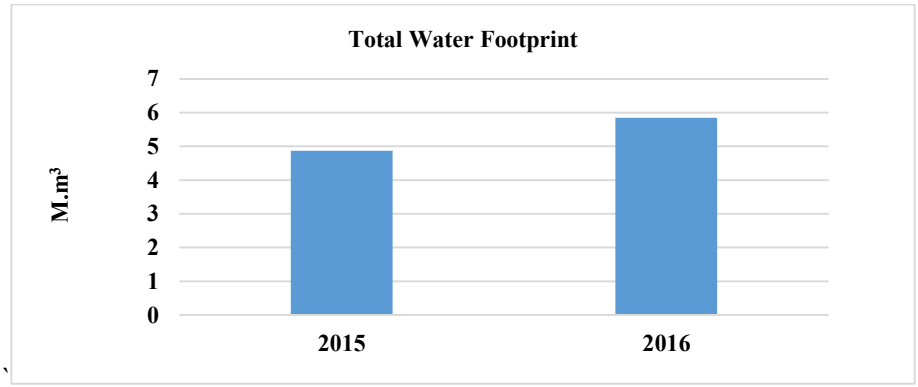

Figure 4 : Total water demand in year 2015 and 2016

Table 4. Percentage of water footprint based on water demand

	Total Water footprint x10^6 (m^3/yr)	**Total Water demand x10^6 (m^3/yr)**	**Total Water Intake x10^6(m^3/yr)**	**Percentage of water footprint based on water demand (%)**
2015	48. 7	44.3	44.2	9.93%
2016	58.4	45.1	52.0	29.5%

In this study the WF of Panching WTP was highly dependent to water demand. Table 4 shows that when the water demand increased the water footprint was also increased. The increment of water demand percentage by 1.8% from 2015 to 2016 has increased 11 times higher of the water footprint percentage to 19.9%. This result shows that the water consumption during the water supply treatment process is two times higher than the demand thus it shows the inefficient of the treatment process involved in the Panching WTP; the water intake value was not in accordance to the water demand.

4. Conclusion

As a conclusion, although the volume of Sg. Kuantan is available as intake resource for Panching WTP, but the volume is decreasing from year 2015 to 2016. Unfortunately, the WF is increasing from year 2015 to 2016. If this scenario keeps continue to occur, the water resource will not be able to sustain. Land use development must be well-regulated in order to ensure the sustainability of water supply in Kuantan district. In addition to that, the consumer should aware to their daily water consumption as it affecting the water demand. Furthermore, the management of water supply treatment process must be managed efficiently.

5. Acknowledgement

This study will not be able to succeed without committed authorities who supplied all the information needed. Thus, an appreciation should be given to Pengurusan Air Pahang Berhad (PAIP), Majlis Perbandaran Kuantan (MPK) and Department of Statistic, Malaysia. Last but not least, a special thanks to Fundamental Research Grant Scheme (FRGS) for funding my research. This study was conducted under FRGS Grant, RDU160155.

References

[1] M. M. Mekonnen, M. Pahlow, M. M. Aldaya, E. Zarate, and A. Y. Hoekstra, "Sustainability, Efficiency and Equitability of Water Consumption and Pollution in Latin America and the Caribbean," pp. 2086–2112, 2015.
[2] J. S. Wallace, "Increasing agricultural water use efficiency to meet future food production," *Agric. Ecosyst. Environ.*, vol. 82, no. 1–3, pp. 105–119, 2000.
[3] A. E. Ercin and A. Y. Hoekstra, "Water footprint scenarios for 2050 : A global analysis," *Environ. Int.*, vol. 64, pp. 71–82, 2014.
[4] R. Z. R. Z. Abidin, "Water Resources Management In Malaysia – The Way Forward," *Board Eng. Malaysia*, p. 56, 2003.
[5] D. Chico, M. M. Aldaya, and A. Garrido, "A water footprint assessment of a pair of jeans : the in fl uence of agricultural policies on the sustainability of consumer products," *J. Clean. Prod.*, vol. 57, pp. 238–248, 2013.
[6] M. M. Aldaya, P. Martínez-Santos, and M. R. Llamas, "Incorporating the water footprint and virtual water into policy: Reflections from the Mancha Occidental region, Spain," *Water Resour. Manag.*, vol. 24, no. 5, pp. 941–958, 2010.
[7] J. S. Li and G. Q. Chen, "Water footprint assessment for service sector: A case study of gaming industry in water scarce Macao," *Ecol. Indic.*, vol. 47, pp. 164–170, 2014.
[8] F. Abnisa *et al.*, "How to get published," *Biomass and Bioenergy*, vol. 5, no. 1, pp. 1–10, 2014.
[9] L. Ruini, M. Marino, S. Pignatelli, F. Laio, and L. Ridolfi, "Water footprint of a large-sized food company: The case of Barilla pasta production," *Water Resour. Ind.*, vol. 1–2, pp. 7–24, 2013.
[10] P. Chooyok, N. Pumijumnog, and A. Ussawarujikulchai, "The Water Footprint Assessment of Ethanol Production from Molasses in Kanchanaburi and Supanburi Province of Thailand .," *APCBEE Procedia*, vol. 5, pp. 283–287, 2013.
[11] R. P. Marano and R. A. Filippi, "Water Footprint in paddy rice systems . Its determination in the provinces of Santa Fe and Entre Ríos , Argentina," *Ecol. Indic.*, vol. 56, pp. 229–236, 2015.
[12] A. Y. Hoekstra, A. K. Chapagain, M. M. Aldaya, and M. M. Mekonnen, *The Water Footprint Assessment Manual*. 2011.