

A water footprint of tap water: case study on the Maha Sawat water treatment plant, metropolitan waterworks authority, Thailand

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Abstract:

This study assesses water footprint (WF) of tap water from the Maha Sawat Water Treatment Plant (MS-WTP), Metropolitan Waterworks Authority (MWA), Thailand. The method for water accounting is based on water footprint network method in combination with life cycle assessment concept. The data used in the assessment is collected from the MWA with yearly basis of fiscal year 2013. This cradle-to-gate assessment comprises of the operational water footprint (the amount of blue water usage and loss in process) and the supply-chain water footprint (the amount of blue water embodied in electricity and chemicals). The total WF of tap water from the MS-WTP is about 1.6024 m³ per 1 m³ of tap water. The hotspot is in the distribution system which should be the leakage in pipeline network. The MWA also concerns about this issue and has the policy to reduce the water loss in pipeline system. When considering the water stress index (WSI) of the Mae Klong basin, the water deprivation of MS-WTP tap water is 0.0288 m³H₂Oeq. The full capacity expansion of MS-WTP will increase the WSI of the Mae Klong basin from 0.008 to 0.024 which is still classified as the low water stress. The WF gives more clearly about the efficiency of water usage and the hotspot process. The WF can help increase the public awareness of water usage. Future studies should extend the assessment scope to all of water treatment plants of MWA and the analysis should be based on monthly basis in order to capture the seasonal effect.

Keywords: Potable Water; Water Footprint Treatment Plant; Waterworks

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1. Introduction

Water scarcity is now an important issue in many areas and tends to be more severe locally and globally. The Metropolitan Waterworks Authority (MWA) has responsibility for providing tap water to serve people in an essential economic area of Thailand, including Bangkok, Nonthaburi and Samut Prakarn. At present, the approximate water demand in these areas is 4.83 million m³/day and it increases gradually. The MWA draws raw water from Chao Phraya and Mae Klong Rivers. The water intake location from Chao Phraya river is located in Sam Lae in Pathum Thani province, where as that of Mae Klong river is located in Mae Klong Dam in Karnchana Buri province. Both raw water sources are also used for irrigations, domestics and industries in its own basin or upstream area. The expansion of mentioned activities in area of raw water resources require higher amount of freshwater which may affect the level of freshwater availability to serve as raw water supply. The assessment of the efficiency of water resources usage and their potential impact is required. The water footprint (WF) is the appropriate tool because it can be used to determine both direct and indirect water use along the production supply chain. In addition, the hotspot of water usage can be determined. In the initial stage of this study, the Maha Sawat Water Treatment Plant (MS-WTP) is selected in this study. The objectives of study are: (1) to assess the water footprint of potable water produced from the MS-WTP, (2) to identify the hotspot, which is represented by highly water consumption, in the water supply system.

2. Methodology

This study assesses the water footprint by using the Water Footprint Network approach (Hoekstra *et al.*, 2011) combining with Life Cycle Assessment concept (ISO14046). The MWA's water supply system can be divided into two parts, the western side and eastern side. For eastern side, the tap water is served by the Bangkhen and Samsen WTP, while the western side is served by the Maha

Sawat and Thonburi WTP. Hence, the system boundary of study covers all western side of MWA's services area which the MS-WTP is settled. It starts from raw water withdrawal from natural water resources and become the tap water that is distributed to the customers or called as "cradle-to-gate". The functional unit in this study is defined as one cubic meter of tap water which meets the MWA water quality standard. The yearly basis (fiscal year 2013) data is used in the calculation. In water accounting, this study uses the chain summation approach which is suitable for production system that contains only one product (Hoekstra *et al.*, 2011). The water footprint comprises of green, blue and grey. The green water footprint is measured from amount of rain water consumed in production process, especially in crop products. The blue water is measured from amount of surface water or ground water consumed in production process. The grey water footprint is the amount of water that is used for diluting the polluted water to meet the general standard (Hoekstra *et al.*, 2011). The water footprint accounting in this study, the grey water is excluded, only the blue water is accounted and it comprises of two main elements: 1) the operational water footprint, the raw water that is withdrawn from natural water body and acts as the raw material for water supply production, and 2) the supply-chain water footprint, the embodied water of other input material (Ercin *et al.*, 2010) that is necessity for water supply production such as electricity, alum, polymer (use for increasing the efficiency of coagulation and flocculation process), and chlorine. The inventory phase (water footprint accounting) and the analysis are assessed by the references i.e. the ecoinvent database. For the life cycle impact assessment, this study examines only potential mid-point impact on Mae Klong basin by using the water stress index (WSI) and the water deprivation (WSI-weighted water volume consumed). The WSI for all Thailand's river basins have already assessed by Gheewala *et al.* (2013), which follows the Pfister *et al.* (2009) method. Therefore, this study does not re-assessment the WSI for the Mae Klong river basin but to review and examine the change of the WSI in case of MWA fully expands the production capacity of the MS-WTP. The WSI and water deprivation are calculated by the method proposed by Pfister *et al.* (2009).

3. Results and discussion

The raw water is withdrawn from the Mae Klong Dam and conveyed to the MS-WTP through the raw water canal. The treated water from MS-WTP will be transferred to the surrounding pump station via the transmission conduit. Then, pump station will distribute the treated water through the pipeline networks to serve the domestic and non-domestic in MWA's western side services area. The schematic diagram of MWA's western side services area is shown in Fig. 1(a) and the simplified diagram in this study is shown in Fig. 1(b). The operational water footprint is assessed from water input and output of each process. The supply-chain water footprint is the water embodied in electricity and chemicals usage of water production, transmission and distribution system. The water embodied in electricity derived from the ecoinvent database with adjusting by the specific sources for Thailand's electricity production (natural gas 67.42%, coal 19.21%, hydro-power 10.29% and other about 3.08%; EPPO, 2013)). The water embodied in chemicals (alum and chlorine) are also assessed from the ecoinvent database. The result of the WF assessment is shown in Table 1. The total WF of 1 m³ of the tap water is 1.6024 m³ which is comprised of 1.6004 m³ operational water footprint, 0.0020 m³ supply-chain water footprint (0.0019 m³ from electricity and 0.0001 m³ from chemicals). When comparing between each process, the highest proportion of WF is in the distribution system which is greater than 20% of total WF. This should be the water loss in pipeline system. To increase the efficiency of water usage or in the other hand, to reduce the water loss is the most significant. The water loss reduction policies, i.e. the replacement or rehabilitation of the old pipeline and improvement of the monitoring system, should be urgently implemented. The amount of the supply-chain water footprint is relatively small comparing with the operational water footprint. However, the amount of the supply-chain water footprint will be varied due to the raw water quality. The yearly basis data cannot capture the seasonal effect on raw water quality impact. As a result, to study about the indirect blue water footprint, the data should be monthly basis.

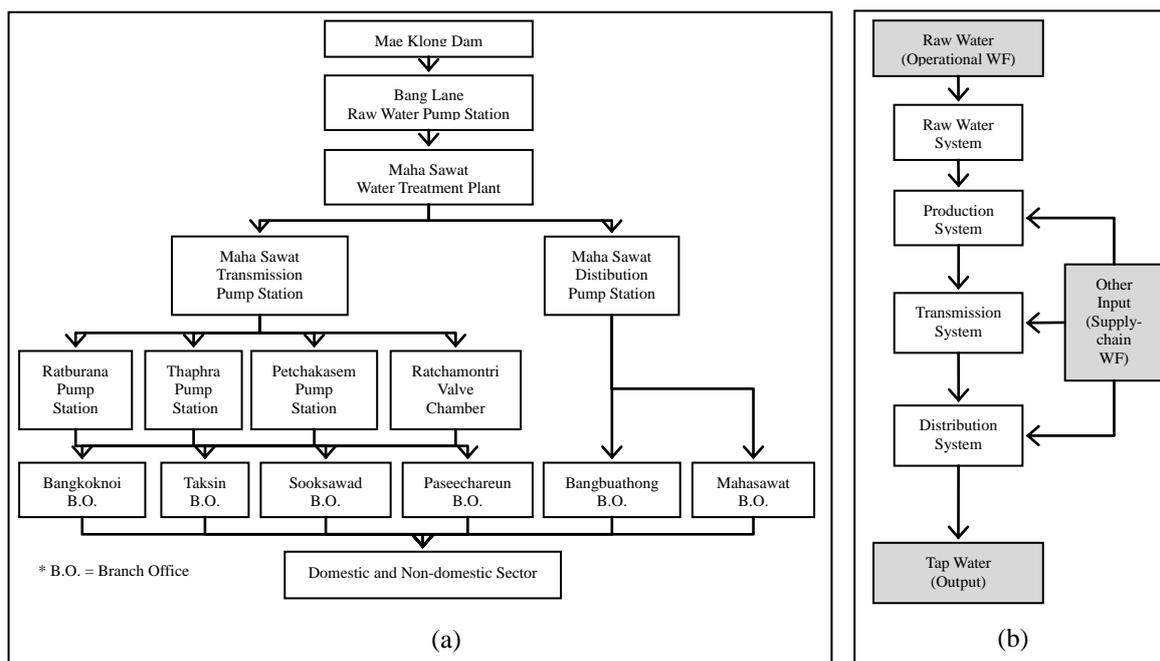


Fig. 1 Maha Sawat Water Treatment Plant and MWA's Western Side System.

Table 1 The water footprint analysis

System	Unit: in yearly basis						
	Direct Blue Water (m ³)	Indirect		WF fraction		Water Footprint	
		Electricity (m ³)	Chemical (m ³)	Direct	Indirect		
				Elec.	Chem.		
Raw Water System							
Input	563,237,776	941	-				
Output	541,092,970	-	-				
Water usage	22,144,300	941	-	0.0080	0.0000	-	
Production System							
Input	541,092,970	208,395	22,838				
Output	526,009,529	-	-				
Water usage	22,144,300	208,395	22,838	0.0626	0.0006	0.0001	
Transmission System							
Input	392,863,670	191,552	-				
Output	377,780,229	-	-				
Water usage	15,083,441	191,552	-	0.0426	0.0005	-	
Distribution System							
Input	526,009,529	271,010	-				
Output	353,688,806	-	-				
Water usage	172,320,229	271,010	-	0.4872	0.0008	-	
TOTAL				0.6004	0.0019	0.0001	1.6024
				The water deprivation (= WSI x WF)			0.0288

Note: 1. The electricity and chemical convert to water by using data from eco-invent database

For mid-point impact assessment, the MS-WTP draws raw water from the Mae Klong river. Therefore, the impact from water withdrawal should be assessed in the Mae Klong river basin. The WSI of Mae Klong basin studied by Gheewala *et al.* (2013) is 0.018. Therefore, the water deprivation (the impact of water consumed to downstream users and ecosystems) of the MS-WTP tap water is 0.0288 m³H₂Oeq which is relatively low comparing with the agricultural sector.

The future development may increase the water demand both on its own basin and withdrawal to the MS-WTP. The MWA has the plan to increase the production capacity of the MS-WTP phase by phase. The current production capacity of the MS-WTP is about 1.6 million m³/day. For full expansion, its production capacity will reach up to 3.2 million m³/day. This requires the addition amount of the raw water about 584 million m³/year. This study assesses the WSI of Mae Klong basin by assuming that all parameters are still the same as the current situation when increasing only the amount of raw water required for full expansion of the MS-WTP. The result of assessment is shown in Table 2. The WSI increases from 0.018 to 0.024 which is still in the low stress category. This may imply that the current situation of water usage in the Mae Klong basin has no signal of water shortage. However, the water demand in the Mae Klong river basin might also increase during the MS-WTP expansion. Hence, further analysis should include the forecasted water demand of all other sectors.

Table 2 The comparison of WSI in Mae Klong Basin

Case	Water Demand	Water Availability	VF	WTA	WTA* ^{3/}	WSI	Category
Base Case ^{1/}	1,138.82	35,178	2.7	0.03	0.09	0.018	Low Stress
MS-WTP is fully expanded ^{2/}	1,722.82	35,178	2.7	0.05	0.14	0.024	Low Stress

Note: ^{1/} from study of Gheewala *et al.* (2011)

^{2/} Assume the water demand in Mae Klong basin is the same as present but increasing only the future demand for raw water withdrawal for MS-WTP

^{3/} WTA* is calculated by equation (2) non-SRF

4. Conclusion

This study is the preliminary assessment of WF of MWA focusing only on the MS-WTP. The WF of tap water from MS-WTP is 1.6024 m³. The highest proportion of the water footprint is in the distribution system which it should be the water leakage in pipeline system. The reduction of water leakage in pipeline system is the significant policy and should be urgently implemented. The supply-chain water footprint is a small proportion comparing with total WF. However, It is still important and for capturing the seasonal effect, the analysis should be based on monthly basis data. To complete the study of WF for tap water, the further study should assess WF for the whole MWA system and the data should be monthly basis. The mid-point impact of MS-WTP tap water using the water deprivation is indicated that the current water usage of MS-WTP is low impact to downstream users and ecosystem. In case of full expansion of MS-WTP, the WSI of the Mae Klong river basin will increase from 0.018 to 0.024 which is still in the low stress category. For further study, the end-point impact such as impact on human health and the loss in biodiversity should be developed. Moreover, the Thailand's life cycle database needs to be improved. The government, authority or related agencies should co-operate to increase the input and output data in order to create the appropriate life cycle database of Thailand for future research and development.

5. Acknowledgement

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