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Airport Water Consumption Footprinting

Merve Özlem Vurmaz, Hülya Boyacioglu*

Department of Environmental Engineering, Dokuz Eylul University, Tinaztepe Campus Buca 35390 Izmir, Turkey

Abstract The study focused on water consumption footprinting and development of water efficiency plan for an airport located in Turkey. Airports are facilities having large water consumption, generally for non-potable purposes such as water cooling systems, fire control, cleaning and washing of vehicles, runways and aircrafts and also public uses (WC, food service). Research period covered 12 months and consumption data obtained from 116 water meters were evaluated for water footprinting. Along a year the airport served to about 12 million passengers and 81 thousand aircrafts. These passengers and aircrafts were served by various services by airport authorities. These services were linked by water consumption directly or indirectly. Study results showed that annual water consumption was about 436000 m^3/year. Irrigation, fire control system, cooling towers and terminal WC uses accounted high use with rate of 23%, 7%, 26% and 20 %. While water used for WC changed between about 6-8.5 L per pax, this value was between 1-1.5 L per pax for food consumption. Therefore passenger based uses fluctuated between 6.5-10 L per pax in the airport. Based on this analysis several methods were suggested to minimize water consumption. Among them “training and education of airport staff” was proposed as the most economical solution. Furthermore “improved water consumption monitoring” system could be suggested as applicable method considering economical and physical aspects and should gain priority. Then alternative measures could be chosen based on their economical and physical applicability.

Keywords Water Footprinting, Airport Water Footprint

1. Introduction

In parallel to population growth, high demand for water resulting droughts and unpredictable climatic patterns is becoming an alarming reality in many parts of the world. Increasing concerns regarding the consequences of climate change also emphasize the need for water resources management planning in order to guarantee that current and future demands [1].

Airport environments consume large amounts of water to maintain infrastructure and operations and, they rely on available potable and reclaimed water during construction and in daily operations, on the airfield and in the terminals. In most cases, large amounts of water are consumed at during the course of daily operations to support terminal operations such as restrooms, food service, and heating, ventilating, and air conditioning; airfield services such as deicing, construction, and firefighting; and maintenance activities such as vehicle cleaning and landscaping. This volume can also be met by alternative water sources (rainwater and treated effluent, e.g) [1,2].

Water-related issues are central to environmental programs at most airports. On a regular basis, airport staff make water management decisions to support permitting, regulatory compliance, development planning, infrastructure design, asset management, operations, and maintenance efforts [3].

Water efficiency efforts are becoming more critical because of the following reasons:

- climatic changes increasing the probability of variations in water availability from year to year
- cost of potable water
- the continued growth and expansion of urban centers threatening usable water amount [2].

The development of a water minimisation plan is an important element in the ongoing process of maximising the efficient use of water [4]. Implementing water efficiency practices can reduce costs and achieve a lower water footprint.

An airport’s water footprint is the amount of fresh water which is used to provide services. Water consumption in the airports has been assessed and total consumption and index of L/passenger were calculated in annual reports of many airports in the world [1,2].

Types of facilities, end uses in the airports and total water consumption per passenger at various airports are presented in Table 1 and 2.

Retrofit programs can greatly improve water efficiency at airports. Basic measures, such as water monitoring and water efficient amenities, are generally applicable to all airports while more complex and capital-intensive measures such as rainwater reuse and greywater recycling should be considered with detailed cost-benefit analysis in the context of the individual airport [5].

The study focused on water consumption footprinting and development of water efficiency plan for an airport located in Turkey.

Table 1. Types of facilities and end uses in the airports [2]

Facility	Example of End Uses
Terminals	Toilets, urinals, bathroom and kitchen faucets, dishwashers
Office Buildings	Window cleaning, Interior plant watering, toilets, urinals, faucets
Rental Car Center	Fleet vehicle washing, outdoor irrigation
Ground Transportation	Vehicle washing
Parking	Snow removal, street cleaning
Fire and Police Stations	Fleet vehicle washing, fire suppression
Hotels	Toilets, showers, ice machines, swimming pools, spas, laundry
Central Heating/Cooling Plant	Boiler, cooling
Maintenance and Services	Runway rubber removal, employee break rooms and restrooms
Airlines/Aircrafts/Cargo	Aircraft cleaning, on-board aircraft water, de-icing

Table 2. Total water consumption per passenger at various airports in the World

Airports	L/passenger	Reference
Bristol Airport	9.4	[6]
Amsterdam Airport	13.3	[7]
Gatwick Airport	17.08	[8]
Frankfurt Airport	21.7	[9]
Porto Alegra Airport	23	[1]
Salvador Airport	23	[1]
Madrid Barajas Airport	23.09	[10]
Recife Airport	24	[1]
Heathrow Airport	29	[11]
Lisbon Airport	43	[1]

2. Study Area

Study area comprises 4 terminals namely Domestic, International, VIP and CIP. Monthly terminal passenger capacities and number of flights as of 2016-2017 are presented in Table 3. From March 2016 to February 2017 the airport served to about 12 million passengers and 81 thousand aircrafts. These passengers and aircrafts were served by various services by airport authorities. These services were linked by water consumption directly or indirectly.

The study aimed to design "Water Efficiency Plan" for the airport. In this scope firstly water consumption footprinting has been implemented. Then water efficiency plan was developed. The main target was to determine the most water consumed activities/facilities within the airport and propose efficiency plan to minimise these uses.

Overall objective was water saving considering climate change effects in near future in this region and also economic aspects. Research period covered 12 months and consumption data obtained from 116 water meters were analysed. Since frequency of the records of these water meters (installed to water supply line and water distribution line) showed difference, water uses in whole facility was evaluated by examining annual total consumptions. Data was presented in Table 4.

3. Passenger based Water Consumption of the Terminals

Water is supplied to domestic and international terminals via different lines. However, there was water transfer between terminals (for WC use). Since both terminals are linked, food providing companies in terminals served to whole passengers (domestic and international). Therefore water footprinting of WC and food service uses has been conducted based on the total water consumption value and also total number of passengers in the airport.

Number of passenger versus water consumption rates (WC use and water consumption of food services in total) was plotted (see figure 1) and the graphic showed that there was a linear correlation between both variables (R^2=0.85). Monthly change of L per pax (liter per passenger) values for WC use and food consumption together are shown in Figure 2.

Table 3. Monthly terminal passenger capacities and number of flights [12]

	Passenger			**Aircraft**		
	Domestic	International	Total	Domestic	International	Total
March	792.962	117.422	910.384	5292	996	6288
April	814.659	136.144	950.803	5169	1195	6364
May	873.803	188.190	1.061.993	5510	1425	6935
June	813.950	192.792	1.006.742	5270	1593	6863
July	825.257	305.005	1.130.262	5473	2404	7877
August	894.152	323.756	1.217.908	5492	2396	7888
September	827.882	260.469	1.088.351	5400	2023	7423
October	856.320	206.113	1.062.433	5582	1608	7190
November	831.378	94.264	925.642	5382	722	6104
December	820.920	96.878	917.798	5488	734	6222
January	800.479	89.773	890.252	5218	693	5911
February	764.176	80.199	844.375	5087	628	5715
Total	9.915.938	2.091.005	12.006.943	64363	16417	80780

Table 4. Annual water consumtion rates of the water supply and distribution line

Water supply line		Water distribution line		
Water meters coded as WM (set on the line from supply system)	Water consumption m^3/yr	Water meters coded as WD (set on the line to end users)	Water consumption m^3/yr	% share
WM-1 (from surface water)	106600	WD-1 (water to out of terminal area)	68258	0.157
WM-2 (from surface water)	103770	WD-2 (water to domestic terminal)	7005	0.016
WM-3 (from ground water	63295	WD-3 (water to cooling towers)	112175	0.257
WM-4 (from ground water)	63728	WD-4 (water to reservoirs used for WC)	9150	0.021
WM-5-6-7-8 (from ground water directly to irrigation)	98267	WD-5 (water to aircraft)	372	0.001
		WD-6 (water to international terminal offices)	2006	0.005
		WD-7 (water to international terminal)	20530	0.047
		WD-8 (water to Irrigation)	98267	0.226
		WD-9 (water to international terminal)	4417	0.010
		WD-10 (water to domestic terminal)	84813	0.195
		Unaccounted amount (water to fire control system)	28667	0.066
Total	435660			

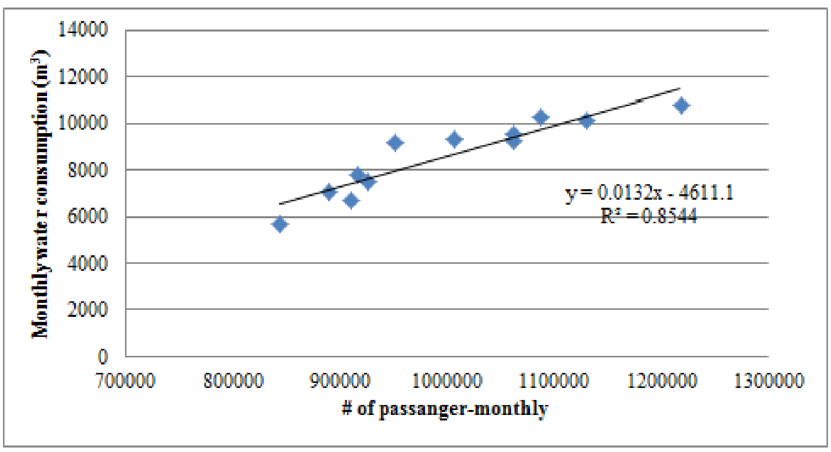

Figure 1. Relationship between number of passangers and water consumption values (WC+Food consumption)

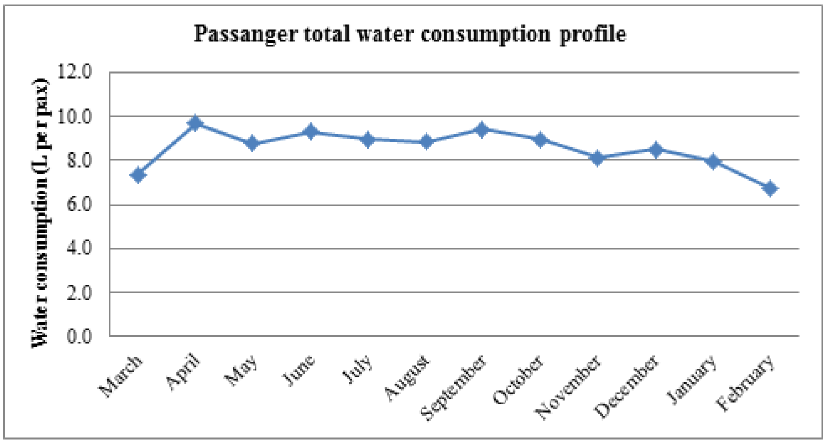

Figure 2. Monthly change of L per pax values

While water used for WC changed between about 6-8.5 L per pax, this value was between 1-1.5 L per pax for food consumption. Therefore passanger based uses was fluctuated between 6.5-10 L per pax in the airport (see Figure 3).

Monthly change in water consumption for WC use and food consumption was quite similar to changes in number of passangers (see Figure 4-5)

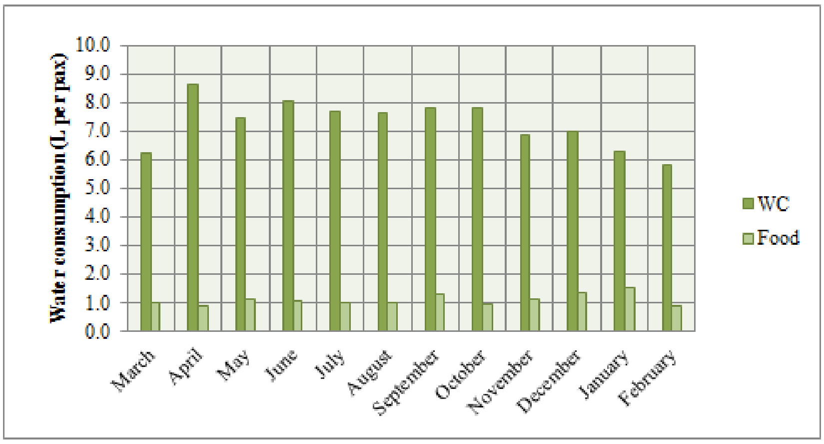

Figure 3. L per pax values for WC use and food consumption

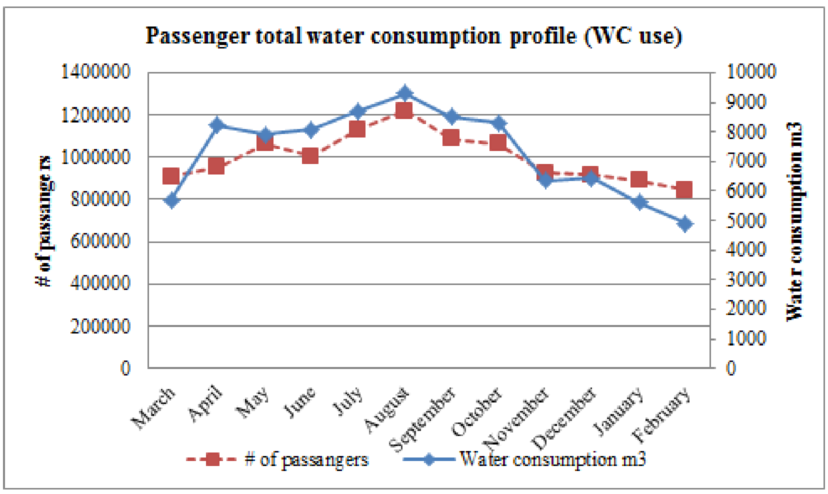

Figure 4. Passanger & total water consumption profile (WC use)

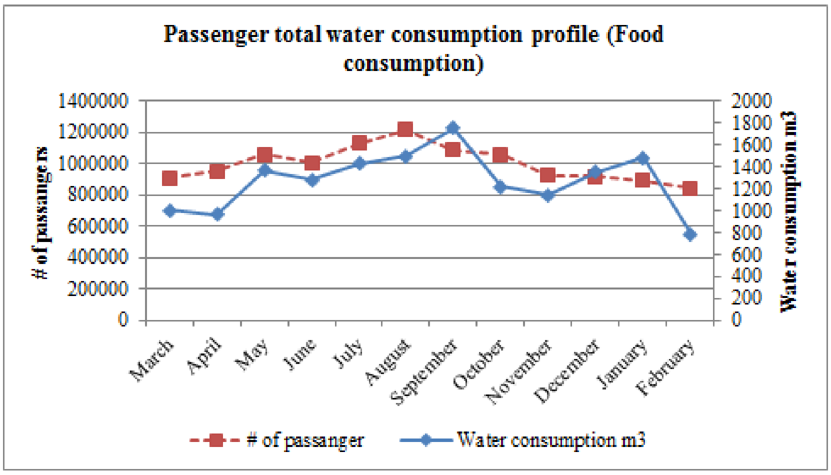

Figure 5. Passenger & total water consumption profile (Food consumption)

4. Water Efficiency Plan for the Airport

Water meter records were evaluated and results showed that within the airport, there were number of particularly high users/activities which are presented in Table 5.

Irrigation, cooling towers and wc use comprised about 76% of the total use. Therefore priority should be given minimization of the consumption for these activities. These measures and their applicability in terms of economical and physical factors are presented in Table 6.

Table 5. High water users/activities in the airport

Water users/activities	Annual consumption (m3)	Share in total consumption (%)
Irrigation	98267	0.23
Fire system	28667	0.07
Cooling towers	112175	0.26
Terminal WC use	87968	0.20

Table 6. Water efficiency solutions and their applicability

Water users/activities	Water efficiency solutions	Economical applicability	Physical applicability
Irrigation	Use of artificial grass	1*	5
	Automatic irrigation systems installation (Available)	3	5
	Rainwater harvesting for irrigation	3	2
	Use of sub-surface irrigation (Available)	3	3
Fire system (Pressure testing of the fire fighting system is carried out regularly and requires potable water. At present fire testing water is discharged to stormwater system and not re-purposed.)	Collection of fire testing water for re-use or re-purposing for non-potable use is proposed. (Available)	3	3
Cooling towers (Cooling towers also use high volume water. Current system recirculates water for a set number of times and must then dispose of the water)	Changing chillers	1	1
	Optimising cooling tower makeup water consumption, convert open loop evaporative humidifiers with closed loop versions, replace open loop water cooled condensers by air cooled, or closed-loop water cooled condensers	1	1
Terminal WC use	Increasing rainwater and greywater capacity	3	1
	Replacing restroom fixtures with high-efficiency ones	2	5
General comments	Use gray water for landscaping; capture and collect rain water for non-potable uses	1	1
	Training and education of airport staff;	5	3
	Improved water consumption monitoring	3	3

* 1:very low	2:low	3:medium	4: high	5: very high

5. Conclusions

During the research period (from March 2016 to February 2017) the facility served to about 12 million passengers and 81 thousand aircrafts. These passengers and aircrafts are served by various services by airport authorities. These services are linked by water consumption directly or indirectly. Annual water consumption was about 436000 m^3/year in total.

Within the Airport, there were a number of particularly high users/activities:

- Irrigation (23% of the total use)
- Fire control system (7% of the total use)
- Cooling towers (26% of the total use)
- Terminal WC use (20% of the total use)

While water used for WC changed between about 6-8.5 L per pax, this value was between 1-1.5 L per pax for food consumption. Therefore passanger based uses was fluctuated between 6.5-10 L per pax in the airport. This value was below world average rates.

Based on this analysis, the airport authority should consider following projects in near future:

- Use of artificial grass
- Rainwater harvesting for irrigation
- Changing chillers
- Replacing restroom fixtures with high-efficiency fixtures
- Increasing rainwater and greywater capacity (for WC use)
- Revising the operations of cooling towers
- Use gray water for landscaping; capture and collect rain water for non-potable uses
- Training and education of airport staff
- Improved water consumption monitoring

Economical and physical applicability of these methods were also assessed based on judgement of airport technical staff. It was concluded that the most economical measure was “training and education of airport staff” to minimise water consumption. Furthermore physical applicability of “replacing restroom fixtures with high-efficiency ones and use of artificial grass” were relatively higher than the other proposed methods.

6. Discussion

Airports are potential environments for implementing programs aiming conserving water due their large consumption, generally for non-potable purposes such as water cooling systems, fire control, cleaning and washing of vehicles, runways and aircrafts and also public uses. The study focused on water consumption footprinting and development of water efficiency plan an airport located in Turkey. Research period covered 12 months and consumption data obtained from 116 water meters were analysed for water footprinting. (WC, food service). Annual water consumption was about 436000 m^3/year in total. Results of the footprinting study showed that irrigation, fire control system, cooling towers and terminal WC uses accounted high use rated with 23%, 7%, 26% and 20 %. While water used for WC changed between about 6-8.5 L per pax, this value was between 1-1.5 L per pax for food consumption. Based on these results water efficiency plan was developed. In this plan several methods were suggested to minimize water consumption. Among them “training and education of airport staff” was proposed as the most economical solution. Furthermore “improved water consumption monitoring” system could be suggested as applicable method considering economical and physical aspects and should gain priority. Then alternative measures could be chosen based on their economical and physical applicability

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