CHEMICAL ENGINEERING TRANSACTIONS

VOL. 57, 2017

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Sauro Pierucci, Jiří Jaromír Klemeš, Laura Piazza, Serafim Bakalis

ISBN 978-88-95608- 48-8; **ISSN** 2283-9216

DOI: 10.3303/CET1757087

Assessing the Water Footprint of Pets: the Case of Small Breed Dogs

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Although humans are not the only species that leave their footprint on the environment, they alone have the ability to reduce their environmental impact in contrast to animals. In this regard, pet owners should also “go green” on behalf of their beloved companions. At the same time, as pet food production constitutes the major hotspot of a pet’s ecological footprint, pet food manufacturers should be aware of the environmental profile of their products and thus act towards adopting sustainable practices. However, while a public discussion on the ecological footprint of pets in terms of biologically productive land or greenhouse gas emissions has been launched, a lack of research concerning the impact of food manufacturing and home caring of pets on freshwater resources is evident. In this study, we provide a first-effort conceptual framework for assessing the water footprint related to the basic everyday life activities of pets from a pet products’ manufacturer (indirect water use) and a pet owner (direct water use) perspective. More specifically, the paper focuses on the consumptive and degradative water use during the production of packaged pet food and other pet products, the preparation of homemade pet food, as well as the watering and washing of pets. As a next step, based on the proposed framework, we present a real-word case study on the assessment of the average annual pet water footprint, or else “water pawprint”, of a small breed dog, including the main typical activities of the dog’s life. The obtained results highlight that indirect water use associated with pet food production is responsible for almost the whole annual water footprint of the dog, while direct water use intended for home caring activities is minimal. Finally, this research is anticipated to provide value-added insights for both industry and society with respect to the sustainable management of freshwater resources appropriated for pets.

1. Introduction

Given that companion animals evidently offer physical, psychological and social benefits to humans (Wells, 2009), pet ownership is increasing worldwide. Indicatively, 68 % of households in North America own at least one dog, while 83 % of owners consider their pet as a part of the family (Mantle, 2014). Particularly in the United States, there are about 218 million companion animals (not counting fish), while households spend annually over 500 $ on them (BLS, 2013). In Italy, an astonishing number of 60 million domestic animals is documented, out of which dogs, cats and birds reach approximately 7, 7.5 and 13 million, respectively (Sarti, 2016). Notably, 43.3 % of Italian households own at least one pet, while 38.6 % of them spend up to 50 € per pet on a monthly basis (Eurispes, 2016).
Except for the socioeconomic perspective, pets leave their footprint on the environment just like every living organism. In particular, according to Vale and Vale (2009), the annual ecological footprint of a medium-sized dog, especially due to pet food production, is about twice as that of driving 10,000 km on a typical sport utility vehicle. Focusing on freshwater resources, pet food production often entails significant water requirements. As pet food industry competes with human food industry for several same ingredients (Swanson et al., 2013), the water footprint (WF) of the related crop-based (Mekonnen and Hoekstra, 2011a) and animal-based (Mekonnen and Hoekstra, 2012) raw materials can be considerably high. Further taking into account pet food manufacturing, Uttamangkabovorn et al. (2005) calculate that freshwater consumption for a canned fish-based

Please cite this article as: Aivazidou E., Tsolakis N., 2017, Assessing the water footprint of pets: the case of small breed dogs, Chemical Engineering Transactions, 57, 517-522 DOI: 10.3303/CET1757087

pet food equals to 13 m^3/t of raw material, mainly due to spray cooling and equipment washing, while they conclude that precooking contributes to high freshwater pollution.

Despite the indisputable role of pets in modern societies, it is obvious that research on sustainability issues of companion animals concerning both pet products' professionals and pet owners is rather myopic (Deng and Swanson, 2015). As such, the aim of this study is to motivate research towards evaluating the WF of pets, as well as stimulate discussion within the related industry in order to improve the overall sustainability of pet caring through identifying grounds for efficient WF management practices. The remainder of the paper is structured as follows. In Section 2, a concise conceptual framework for assessing the WF of pets is provided. In Section 3, a real-world case study on quantifying the average annual WF of a small breed (Maltese) dog is presented. Finally, conclusions and future research directions are discussed in Section 4.

2. A conceptual framework for water footprint assessment of pets

Building upon existing research on WF assessment for human consumers (Hoekstra et al., 2011), we define the WF of a pet, or else the "water pawprint", as the total volume of freshwater that is either used during the home caring services provided by pet owners or incorporated into the manufactured goods (e.g. pet food, shampoos, medicines) consumed by pets. In this sense, the pet WF refers to the total direct and indirect water consumption and pollution associated with all everyday life activities of the companion animals.

By analogy with the typical freshwater requirements of an average human during everyday life activities (GRACE, 2015), we propose a first-effort conceptual framework for pet WF assessment including all water consuming and polluting activities related to pets (Figure 1). The framework includes the assessment of:

(i) the direct water use, which refers to the total freshwater volume consumed to prepare homemade pet food and to water the animal, activities that are fundamental for ensuring the nourishment of the pet. In addition, direct WF accounts for the freshwater consumed in order to ensure pet's well-being concerning pet cleaning, as well as washing of accessories used for home caring and entertainment purposes.

(ii) the indirect water use, which mainly refers to the quantity of water consumed and polluted in order to manufacture packaged pet food. Furthermore, indirect WF is related to freshwater resources utilised for manufacturing industrial goods, such as pet clothes, hair care products or toys.

Although human food waste entails a significant impact on freshwater resources (Ridoutt et al., 2010), the proposed framework does not consider the WF of pet food losses, given that less than 1 % of pet food supplies are wasted uneaten (WRAP, 2009).

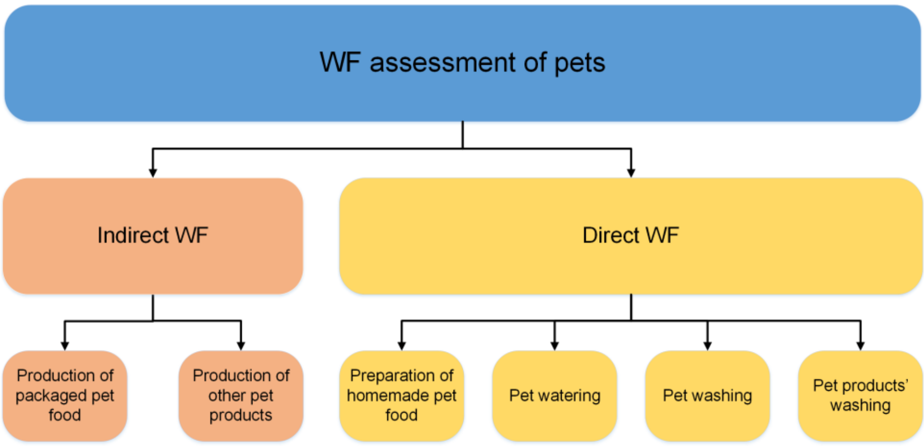

Figure 1: Conceptual framework for pet WF assessment.

3. The water footprint of small breed dogs: The Maltese dog case study

In this section, we present a real-world case of a small breed dog in order to quantify the direct and indirect WF associated with the pet's everyday life activities. In particular, we first provide a brief description of the case study and we then discuss the obtained results.

3.1 Description of the case study

<u>Research objectives</u>. The main scope of the study is to assess the average annual WF of a small breed dog that lives in a typical household (Figure 2). In fact, the research aims at investigating the basic freshwater requirements of household animals, such as dogs, in order to stimulate research on the WF of pets, as well as provide meaningful insights with respect to water management during pet food production and home caring.

System boundaries. The system under study includes the activities of packaged pet food production and home caring, which refers to homemade pet food preparation, pet watering and washing. Other activities, such as the manufacturing of non-edible pet products (e.g. shampoos, medicines, bowls, toys, clothes), as well as the washing of pet products, are excluded from the analysis due to lack of necessary data and/or negligible amounts of water consumed.

Functional unit and data acquisition. The total WF of the dog is calculated in litres per year (L/y). The data for calculating the indirect WF of food production are classified into two categories:

(i) the input quantities of the ingredients as provided by the pet food manufacturer (packaged food) and the dog owner (homemade food), and
(ii) the WF coefficients per input unit as provided by Mekonnen and Hoekstra (2011a) (crop-based ingredients) and Mekonnen and Hoekstra (2012) (animal-based ingredients).

In addition, the water content of the packaged food is further considered as indirect WF. The direct freshwater requirements during homemade food preparation, dog watering and washing are estimated empirically by the dog owner. All necessary data for quantifying the dog's WF are presented in Tables 1 and 2.

Evaluation method. Regarding indirect water use, we first implement the Hoekstra et al. (2011) methodology for assessing the consumptive (green and blue water) and degradative (grey water) WF of the basic ingredients of both packaged and homemade pet food and we then annualize the results according to the yearly dietary requirements of the dog. Concerning direct water use, we calculate the annual freshwater volumes (blue water) required for homemade pet food preparation, dog watering and washing based on the average estimates of the dog owner. In the context of the study, we assume that the dog's food and water requirements are the same during the course of a year and thus we do not take into account any seasonality effects.

Breed: Maltese dog

Type: Companion animal

Gender: Male

Age: 8 years

Weight: 4 kg

Home: Typical apartment, Thessaloniki, Greece

Figure 2: The small breed dog's characteristics.

Table 1: Input quantities.

Activity	Input	Average quantity		Frequency	
Packaged pet food production	Veal	33.2	g/can	0.5	can/day
	Cereals	5	g/can		
	Water content	332	mL/can		
Homemade pet food production	Rice	171.5	g/portion	1	portion/day
	Pure water	343	mL/portion		
Dog watering	Pure water	125	mL/bowl	1	bowl/day
Dog washing	Pure water	5,333	mL/bath	6	baths/month

Table 2: WF coefficients for crop-based (Mekonnen and Hoekstra, 2011a) and animal-based (Mekonnen and Hoekstra, 2012) inputs.

Input	Database name	WF type	WF coefficient (m^3/t)
Veal	Beef	Green	14,414
		Blue	550
		Grey	451
Cereals	Cereals	Green	1,232
		Blue	228
		Grey	184
Rice	Rice, paddy	Green	1,146
		Blue	341
		Grey	187

3.2 Results and discussion

The total green, blue and grey WF of the male eight-year-old Maltese dog is estimated at 260,832.6 L/y. Indicatively, the pet WF of a dog is approximately ten times smaller compared to the average consumer WF in the United States (2,842,000 L/y) or in Italy (2,330,000 L/y) (Mekonnen and Hoekstra, 2011b). The average annual WF assessment results, categorized according to each identified pet caring activity and type of WF, are summarized in Table 3.

The indirect WF attributed to the industrial production of the necessary pet food supplies (155,489.6 L/y) and to the homemade pet food production (104,788.2 L/y) constitutes a dominant contributor, indicating that the findings of Hoekstra et al. (2011), who argue that there is substantial demand for water (more than 80 % of the global supplies) for the production of humanity's food, further apply to the case of companion animals. To this end, pet food manufacturers could substitute pet food ingredients that exhibit a high WF by similar water-friendly raw materials (Jeswani et al., 2015). At the same time, assuming that relevant information is available, pet owners could select packaged dietary products that are either less water consumptive or sourced from low water scarcity regions.

The direct WF results indicate the role of pet owners in the dog's water appropriation. In particular, pet washing activities constitute the major direct WF component (384 L/y), due to the uncontrolled use of water by the owner. In addition, the direct WF of the homemade pet food production (125.2 L/y) highlights that the food prepared by the owner further affects the resulting water use. Dog watering accounts for a more controlled direct WF (45.6 L/y), as it reflects the actual needs of the pet. Notably, the direct WF of a small breed dog is several orders of magnitude lower than the indirect WF.

Figure 3 illustrates the percentile distribution of the WF by pet caring activity. On the whole, food consumption habits constitute the key factor (99.78 %) that determines the WF of a dog. However, as both direct and indirect freshwater requirements are interrelated with the size and the physical needs of the dog, the results may vary among different breeds and ages.

Table 3: Summary of the dog's WF assessment results.

Activity	Type of pet WF	Average pet WF (L/y)
Packaged pet food production	Indirect-green	88,458.6
	Indirect-blue	64,130.5
	Indirect-grey	2,900.5
Homemade pet food production	Indirect-green	71,736.7
	Indirect-blue	21,345.8
	Indirect-grey	11,705.7
	Direct blue	125.2
Dog watering	Direct-blue	45.6
Dog washing	Direct-blue	384.0
Total		260,832.6

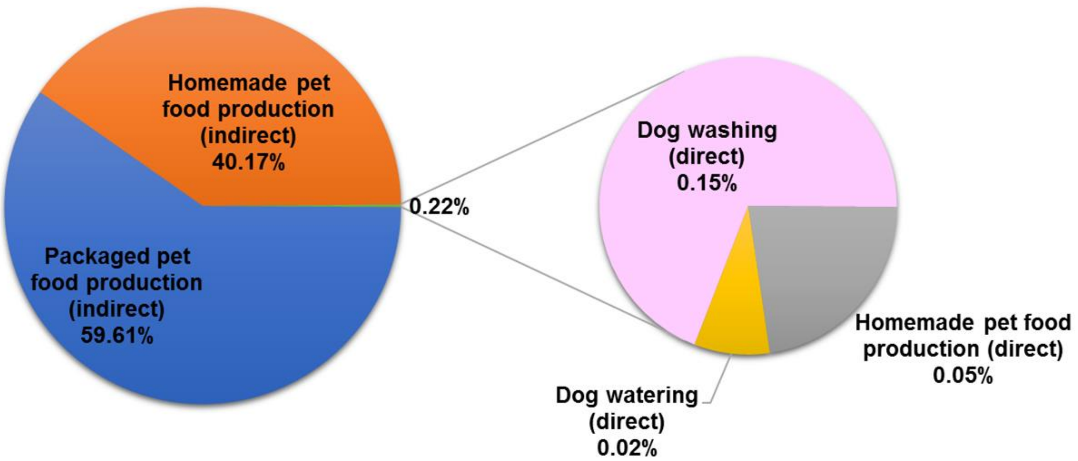

Figure 3: Direct and indirect WF allocation by activity.

4. Conclusions and recommendations

Although modern society is sensitive to the impact of humans on the environment, there is an apparent lack of awareness about the ecological footprint of household animals. Except for their contribution to climate change (Vale and Vale, 2009), pets require significant volumes of freshwater resources during their everyday life activities. Focusing on small breed dogs, the obtained insights highlight that indirect water use associated with pet food production accounts for approximately the total annual WF of the dog, particularly due to the high WF of the related raw materials, while direct water use for the necessary home caring activities of the dog, such as homemade food preparation, pet watering and washing, is minimal.
Given that pets are considered as an indispensable part of several families (Mantle, 2014), this study does not intend to imply that companion animals trigger the depletion of natural resources. On the contrary, this study serves as an eye-opening exploration of the origin of pet WF and the manner in which every aspect of a pet's life could affect the environment. To this end, this work aims at motivating pet food manufacturers to select water-friendly ingredients for the production of packaged food (Jeswani et al., 2015), always respecting the pets' nutritional needs, in order to reduce the related high indirect WF. At same time, considering that environmentally aware families try to reduce the WF of their own shopping basket, this research indicates that they should follow the same attitude with regard to pet food products. In this context, the incorporation of environmental labelling on pet products could assist owners to make more sustainable decisions on behalf of their animal friends (Leach et al., 2016). Moreover, despite the negligible direct WF of pet home caring, owners should be further educated on effective water management practices, such as prudent water use during homemade food preparation and pet washing.
Concerning future research directives, as freshwater resources are diminishing at an alarming rate (Aivazidou et al., 2015), a comparative WF assessment among diverse pets or dog breeds, as well as what-if scenario analyses in case WF mitigation policies are implemented either by pet products' manufacturers or pet owners, is recommended for a comprehensive evaluation and management of the "water pawprint" of pets.

Acknowledgments

E. Aivazidou is grateful to the Public Benefit Foundation Alexander S. Onassis for the financial support of this research work. Furthermore, the authors would like to thank Azor, the lovable Maltese dog, for being their inspiration for this paper.

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