Waste Management xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

What gets measured gets managed: A new method of measuring household food waste

Efrat Elimelech [a,b,*], Ofira Ayalon [a,b], Eyal Ert [c]

[a] Department of Natural Resources and Environmental Management, Faculty of Management, University of Haifa, Mt. Carmel, Haifa 3498838, Israel
[b] The Natural Resources and Environmental Research Center (NRERC), University of Haifa, Mt. Carmel, Haifa 3498838, Israel
[c] Department of Environmental Economics and Management, Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot 76100, Israel

ARTICLE INFO

Article history:
Received 21 October 2017
Revised 12 February 2018
Accepted 16 March 2018
Available online xxxx

Keywords:
Food waste quantification
Food waste composition
Avoidable food waste
Food waste generation rate
Household food waste

ABSTRACT

The quantification of household food waste is an essential part of setting policies and waste reduction goals, but it is very difficult to estimate. Current methods include either direct measurements (physical waste surveys) or measurements based on self-reports (diaries, interviews, and questionnaires). The main limitation of the first method is that it cannot always trace the waste source, i.e., an individual household, whereas the second method lacks objectivity. This article presents a new measurement method that offers a solution to these challenges by measuring daily produced food waste at the household level. This method is based on four main principles: (1) capturing waste as it enters the stream, (2) collecting waste samples at the doorstep, (3) using the individual household as the sampling unit, and (4) collecting and sorting waste daily. We tested the feasibility of the new method with an empirical study of 192 households, measuring the actual amounts of food waste from households as well as its composition. Household food waste accounted for 45% of total waste (573 g/day per capita), of which 54% was identified as avoidable. Approximately two thirds of avoidable waste consisted of vegetables and fruit. These results are similar to previous findings from waste surveys, yet the new method showed a higher level of accuracy. The feasibility test suggests that the proposed method provides a practical tool for policy makers for setting policy based on reliable empirical data and monitoring the effectiveness of different policies over time.

1. Introduction

1.1. Cutting food waste to meet the UN's Sustainable Development Goals

The Sustainable Development Goals (SDG) comprise a collection of 17 goals set by the United Nations (UN) as a universal call to action to protect the planet and ensure that all people enjoy peace and prosperity. SDG-12 addresses the challenge of ensuring sustainable consumption and production patterns (UN, 2015). One of its focal points is unsustainable patterns of waste generation. Target 12.3 calls for reducing food loss, which refers to the decrease in edible food mass throughout the entire supply chain (Gustavsson et al., 2011), and cutting in half per capita global food waste, which refers to final consumption (Gustavsson et al., 2011), by 2030 (UN, 2015).

There are three main aspects to the growing concern over food loss and waste. The first of these concerns food security – the need to feed the growing population, which is predicted to reach 9.8 billion by 2050 (UN, 2017). The threat is so severe that studies suggest the world will need 70% to 100% more food by 2050 (e.g., Gomiero et al., 2011). Cutting food loss and waste is a possible solution for ensuring food security (e.g., Foley et al., 2011; Godfray et al., 2010; Kummu et al., 2012; Smith and Gregory, 2013). The second aspect concerns monetary losses. Annual losses due to food loss and waste are estimated at $1.3 billion in the US alone (Buzby et al., 2014), while around the globe they amount

Abbreviations: CBS, Central Bureau of Statistics; FAO, Food and Agriculture Organization; $GtCO_2$ eq, gigatons of CO_2 equivalent; ID, identification code; IQR, interquartile range; MSW, municipal solid waste; NIS, New Israeli Shekel; QR code, quick response code; RFID, radio frequency identification; SDG, Sustainable Development Goals; SII, Standards Institution of Israel; SWA - Tool, Methodology for the Analysis of Solid Waste; UN, United Nations; US, United States; WRAP, Waste & Resources Action Program.

* Corresponding author at: Department of Natural Resources and Environmental Management, Faculty of Management, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.

E-mail addresses: eelimelec@staff.haifa.ac.il (E. Elimelech), ofira@sni.technion.ac.il (O. Ayalon), eyal.ert@mail.huji.ac.il (E. Ert).

https://doi.org/10.1016/j.wasman.2018.03.031
0956-053X/

to $750 billion (FAO, 2013). Financial losses per household reach $566–$593 a year in Italy and the United Kingdom, respectively (Secondi et al., 2015). The third aspect concerns negative externalities – the carbon footprint of global food loss and waste equals 3.6 $GtCO_2$ eq (FAO, 2016). Other negative externalities resulting from food loss and waste include air and water pollution, soil erosion, salinization, and nutrient depletion.

According to the Food and Agriculture Organization (FAO), one-third of global food production is lost every year. However, there is no consensus on that proportion, and estimates actually range between 10% and 50% of total global food production (Parfitt et al., 2010). As these discrepancies might suggest, although research on food loss and waste has significantly increased with time (Chen et al., 2017, Xue et al., 2017), major data and methodology gaps remain unresolved. Data regarding the amount of food waste is fragmented and inconsistent (Bellemare et al., 2017; Hoj, 2012; Roodhuyzen et al., 2017), and different studies have employed different definitions and methods (Chaboud and Daviron, 2017; Garcia-Garcia et al., 2017; Hebrok and Boks, 2017; Janssen et al., 2017; Parfitt et al., 2010; Ponis et al., 2017; Ramukhwatho et al., 2017; Richter and Bokelmann, 2017). Therefore, researchers have stressed the need for commonly agreed-upon and improved metrics for food waste (e.g., Stenmarck et al., 2016; Williams et al., 2015).

The current article presents a new measurement method to quantify household food waste designed to address the shortcomings of current measurement methods. This new method focuses on individual households and on collecting and measuring each household's waste on a daily basis. The identification of individual households' waste connects food waste with its source, even when multi-family buildings are studied. The feasibility of establishing this connection suggests some new, exciting research opportunities, such as investigating the relationship between self-reports and physical waste measures. Questions of interest may include how actual food waste relates to household routines, beliefs, and/or attitudes, and how accurate self-report estimates are in predicting actual waste. The second feature, which is the collection of waste on a daily basis, implies that waste is still fresh when measured. Waste freshness is important, as it increases the accuracy of the measurement and makes the differentiation and categorization of food items less difficult.

This article begins with a brief discussion of current measurement methods, as well as their main advantages and disadvantages (Sections 1.2–1.4). It continues with the presentation of the new method and explains how its design may address current challenges in sampling food waste (Section 2). This presentation is followed by a "proof of concept" study designed to test the feasibility of the proposed new method (Section 3). The article concludes with a discussion of the main characteristics of the new methodology and its potential usefulness for scholars and practitioners in the field (Sections 4 and 5).

Our focus on households is motivated by recent evidence that suggests that most of the food loss and waste in the developed world result from household consumption habits (Gustavsson et al., 2011; Jorissen et al., 2015; Lipinski et al., 2013; Monier et al., 2010; Parfitt et al., 2010; Parry et al., 2015; Rutten et al., 2013; Stenmarck et al., 2016). Demographic factors, psychographic factors, and socioeconomic characteristics have all been proved to be related to household food waste discarding behavior (Aschemann-Witzel et al., 2015; Secondi et al., 2015). Apparently, per capita food waste in the household tends to increase with an increase in per capita GDP (Xue et al., 2017).

The serious consequences of food loss and food waste, along with the difficulties in measuring it, imply a significant challenge for scholars and practitioners alike. The proposed "Daily Family Waste Collection" method aims to address at least some of the difficulties involved in the current mainstream methods of measuring food waste. In the next section, we briefly describe the current measurement methods to clarify the existing challenges. This short report is by no means an extensive review of the literature, but rather a brief description of notable benchmarks aimed at clarifying the properties of existing methods.

1.2. Food waste measurement methods

Assessments of food waste generation along the supply chain are fraught with considerable uncertainties (Bräutigam et al., 2014). Differences in definition systems and classification methods make it difficult, if not impossible, to compare food waste studies. Thus, establishing a valid estimation of the extent of food waste remains major challenge (Bräutigam et al., 2014; Girotto et al., 2015; Parfitt et al., 2010; Stenmarck et al., 2016; Williams et al., 2015).

Current food waste measurement can be classified into three major types. The first takes a top-down approach, in which data is based on mass balance or extrapolation of existing waste databases (e.g., Beretta et al., 2013; Bradley et al., 2009; Bräutigam et al., 2014; Herzog et al., 2016; Herzog et al., 2017; Kotzer et al., 2015; Priefer et al., 2013). The main strength of this method is the access to large amounts of data, which could facilitate comparability, although when combining different databases, this advantage might be diminished (Moller et al., 2014).

The second type of food waste measurement focuses on self-reporting methods, including questionnaires (e.g., Jorissen et al., 2015; Lorenz et al., 2017; Pekcan et al., 2006; Ponis et al., 2017; Quested and Luzecka, 2014; Stefan et al., 2013), food waste diaries (e.g., Koivupuro et al., 2012; Langley et al., 2010; Quested et al., 2013b; Richter and Bokelmann, 2017; Williams et al., 2012), and interviews (e.g., Aschemann-Witzel et al., 2015; Glanz, 2008; Parfitt et al., 2010; Ramukhwatho et al., 2017). Using questionnaires requires a good sample design and large sample sizes (Moller et al., 2014; Zorpas and Lasaridi, 2013). The strength of this method is that it is less invasive, time consuming, and expensive than direct measurements (Hoj, 2012; Visschers et al., 2016). However, it is implicitly based on the assumption that respondents can accurately recall specific waste events and accurately assess the amount of food wasted (Hoj, 2012). The fact that, in reality, respondents might not really know the exact amounts of waste they produce may undermine the reliability of this method (Visschers et al., 2016; Xue et al., 2017).

Interviews are considered a good tool for providing close observations of food waste practices and amounts (Moller et al., 2014), yet they are prone to biases similar to those of self-reporting. Interviews also dictate small sample sizes that might compromise representativeness (Moller et al., 2014; Zorpas and Lasaridi, 2013).

It is widely agreed that in order to accurately measure food waste weight and composition, one must record them as closely as possible to the point at which the food enters the waste stream (European Commission, 2004; Langley et al., 2010). Food waste diaries, in which waste is recorded each time it is produced, put this notion into practice. However, food diaries are also subject to self-reporting biases (e.g. Moller et al., 2014; Xue et al., 2017). The "observer effect" (Langley et al., 2010), for example, is a form of social desirability bias whereby people change their waste-discarding habits or underreport their waste in order to present themselves in a positive light in accordance with the well-known social desirability and experimenter demand effects (Hebrok and Boks, 2017; Hoj, 2012; Langen et al., 2015; Langley et al., 2010; Moller et al., 2014; Neff et al., 2015; Porpino, 2016). Another challenge of working with food waste diaries is that they are time-consuming and costly, and thus are mainly suitable for short sampling periods and small sample sizes (Moller et al., 2014; Xue et al., 2017; Zorpas and Lasaridi, 2013).

Please cite this article in press as: Elimelech, E., et al. What gets measured gets managed: A new method of measuring household food waste. Waste Management (2018), https://doi.org/10.1016/j.wasman.2018.03.031