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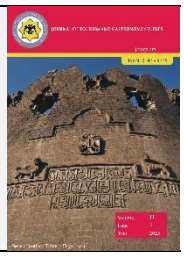

Biomass Potential of Organic Wastes in Hotels: A Case Study of Antalya

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Abstract

The innovations brought about by globalization have brought along the changes in consumption habits and resource waste with increasing population. Waste, which does not disappear in nature for years, harms our environment and threatens nature with various effects. Food waste, which is described as a global problem, is reaching greater proportions day by day. Today, food waste and losses in hotels have spread over a wide area, especially due to the open buffet option and the large menus that are created more than necessary. In this study, Antalya region, which is one of the most important tourism regions of Turkey, is discussed. The amount of biomass that can be obtained from the organic waste of a five-star hotel in this region has been calculated. Food waste, grass waste and waste oil were taken into consideration as organic waste. The electrical energy that can be produced by using hotel wastes was calculated at the end.

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INTRODUCTION

The rapid growth of the global population, improvements in the quality of life and rapid technological advancements have led to shifts in consumption patterns and significant alterations in both the volume and nature of waste generated. In addition to the various negative effects of wastes on the environment, the use of productive agricultural areas as landfills and poorly managed waste management may harm the environment and public health. In developing countries, waste is generally landfilled (open dump areas) or openly incinerated. These applications create serious health, safety and environmental consequences (Öner et al., 2019; Sinha & Pushplata, 2021; Worldbank, 2023).

The world population is expected to reach 10 billion in 2050 and with this increasing population, the amount of produced food is also increasing. However, not all of these foods are consumed, some of them are lost during production and supply, and some of them turn into waste during preparation and consumption. European Union member countries generate 173 kg of food waste per person annually. While the amount of solid waste produced in the world in 2012 was 1.3 billion tons, this amount is expected to increase to 2.2 billion tons in 2025 with rapid population growth and urbanization. These food wastes cause environmental damage as a result of the disruption of biogenic cycles in agriculture, as well as waste of land, water, energy resources and human power (Öner et al., 2019; Sinha and Pushplata, 2021; Worldbank, 2023; Leverenz et al., 2021, Bilgin & Özen, 2021). They also cause climate change, pollution of water resources and greenhouse gas formation through methane and CO_2 production, leading to various environmental problems. The Food and Agriculture Organization of the United Nations explained that, the carbon footprint of the food that is produced but not consumed is 3.3 billion tons of CO_2 and is the 3rd factor after the USA and China which causes the most greenhouse gas emissions. Aligned with its sustainable development objectives, the United Nations has set forth an ambitious target of halving per capita global food waste by 2030. This goal is driven by the escalating levels of food waste worldwide and the associated material, social, and environmental repercussions. In this context, FAO launched the “Global initiative on food loss and waste reduction” in order to reduce food waste by raising awareness (FAO, 2023; Papargyropoulou et al., 2019).

One of the areas where the most food waste is created is food and beverage businesses. High amounts of food waste are generated in the food and beverage departments of accommodation establishments. Along with these waste foods, there are great losses in monetary terms due to the cost of purchasing, storage and preparation. However, these businesses can prevent both food and financial losses with food waste management practices, and they can also support the protection of the environment (Baytok et al., 2015).

In today's conditions, it is known that there is an increase in the number and characteristics of tourism enterprises in direct proportion to the demand. Accordingly, the all-inclusive system has been developed, in which all services such as accommodation, food, beverage and entertainment are offered at a single price rather than paying separately for the needs of the people. In Turkey, most accommodation establishments in destinations such as Antalya, Bodrum and Marmaris have adopted and implemented the all-inclusive system. Along with this adoption, the positive aspects of the system such as extending the tourism season, providing ease of marketing to businesses, knowing the services to be offered with the number of customers coming to the business, providing ease of management to the business and facilitating the sales of tour operators and travel agencies appeared (Keskin et al., 2019).

The open buffet service system is stated as a food culture that spreads from France to the whole world and makes

its presence felt in Turkey. This type of service, which is frequently used in restaurants, breakfast rooms and accommodation establishments, offers a wide variety of food to the guests at once, and it is a system that has been appreciated due to its ease of use. In this system, it is seen that the guests buy a variety of food in quantities that they cannot consume and that they get up to buy food again and fill their plates. For this reason, it is also known that guests cannot consume a significant part of the food and leave it on their tables somehow. This well-known fact supports the idea that the open buffet service type applied in accommodation establishments that adopt the all-inclusive system causes food waste. As a matter of fact, it is stated by Silvennoinen et al. that food waste in restaurants and restaurants is affected by the service type (Silvennoinen et al., 2015; Anasız, 2019; Dolnicar et al., 2020). They reported that, the volume of food waste in à la carte restaurants and dinners differs from the amount of food waste in buffet type food shops. The main reason for food waste in self-service buffets is characterized as excessive production of food. Çuhadar and Çuhadar indicated that, in four and five-star hotels and first-class holiday villages that implement the all-inclusive system operating in Bodrum and its borders, "all-inclusive system causes an increase in leftovers", "all-inclusive system increases food and beverage consumption in the facility" and the hotel ans sector managers approved this (Çuhadar & Çuhadar, 2017). It was also found that the all-inclusive system negatively affected the managerial work in the kitchen and produced large amounts of food. These results show that large amounts of food consumption and production were made in the 2000s in accommodation establishments that apply the all-inclusive system, and accordingly, there is the case of waste. In order to determine the role and importance of the all-inclusive system in Turkey's tourism, as well as the positive and negative aspects of the system, a study was carried out on the accommodation enterprises that implement the all-inclusive system in the Marmaris district of Muğla. In the study, it was determined that the majority of the managers agreed with the item "it increases the waste of food and beverage in the hotels". This shows that the idea that the all-inclusive system increases food waste is agreed by the business managers (Keskin et al., 2019). Salama and Abdelsalam stated in their study that "green hotel" can be described as an eco-friendly facility that operates with comprehensive environmental practices to create positive contributions. They used the flow diagram as in Figure 1. This figure shows the ways to include saving energy, water, employing eco-friendly policies and decreasing wastes emission/disposals with increasing approaches for recycling projects to keep the earth we live in and reduce operational costs (Salama & Abdelsalam, 2020).

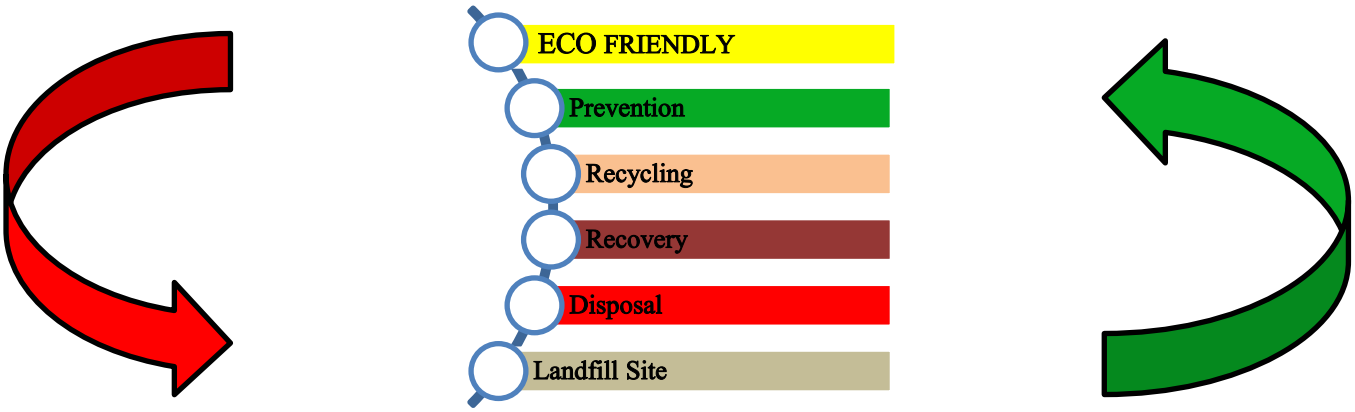

Figure 1. Eco-friendly management of food wastes (Salama and Abdelsalam, 2020).

This study discusses the organic wastes of a five-star hotel in Antalya region, which is one of the most important tourism regions of Turkey. Food waste, grass waste and waste oil were taken into consideration as organic wastes. As a result of the calculations, biomass amount that can be obtained from these wastes were calculated.

Materials and Method

The tourism industry is a globally growing industry in almost every country. In addition to the export of various industrial products, the tourism sector is one of the primary sources of income for most countries. According to the Ministry of Culture and Tourism of Turkey, 51,387,513 foreign tourists were hosted, and 46.5 billion dollars of tourism income was obtained in 2022. The hotel industry plays an important role in the development of the tourism industry with the employment service it provides, as well as making significant contributions to the country and local economy. However, it is obvious that the hotel industry causes serious damage to the environment due to the wastes generated during the operational activities. At the same time, there is high energy use in this process. These wastes cause global warming and environmental pollution as well as depletion of energy, water, natural resources and climate change. Today, hotel businesses are researching different methods to reduce the amount of waste generated during their activities. They also stated that with a sustainable production, waste, energy and water resources can be used effectively (KTB, 2023; Hazarhun et al., 2020).

Şahin and Bekar studied the food waste in hotels. They reported that the total amount of food waste generated in hotel establishments in a day is 5976.8 kg, and its ratio in other waste types reaches approximately 70%. Also, a hotel customer generates approximately 180 kg of food waste in a year. Food waste has the largest share among other waste types. Glass waste is in the second place with 11%, paper, cardboard waste is in the third place with 10%, plastic waste is in the fourth place with 5% and metal waste has the least share with 4%. Since the amount of waste is calculated on a kg basis and glass material is heavier than other types of waste by weight, it is possible that it took the second place. According to the information obtained after the research, when it is accepted that the total amount of waste generated by each customer on average is 700 g and the ratio of food wastes in all wastes is 70%, "each hotel customer generates approximately 500 g of food waste per day" is possible to conclude. Similarly, the amount of food waste generated by a customer in a year is calculated as 180 kg. (Şahin and Bekar, 2018). Sandaruwani and Gnanapala reported the production of solid wastes by hotel as follows: 46.2 % food and non-recyclables, 11.7% cardboard, 25.3% paper, 5.6% glass, 6.7% plastic and 4.5% metal. Accordingly, a large amount of food waste is produced by the hospitality sector compared to the other types of solid waste (Sandaruwani & Gnanapala, 2016). The average waste classification of hotels in literature can be shown as in Table 1.

Table 1. Waste classification of hotels

Type of waste	Average percentage (%)
Food	45-70
Glass	5-10
Paper-cardboard	10-11
Plastic	5-6
Metal	4-5

In this study, a five-star hotel with 450-500 rooms located in the Antalya which is in the Mediterranean Region of Turkey was taken as case. The hotel offers various types of accommodation. These are only bed, bed and breakfast, half board and full board system. Data from a time period when the occupancy rate was approximately 93% were used. The materials examined are food wastes, oil wastes and grass wastes. Food and grass waste is considered as a source of biogas, and oil waste is considered as a source of biodiesel. Since food waste data could not be obtained from the hotel on a kg basis, the values in previous studies and the literature were used. Grass and cooking oil values

were taken from the hotel. The weekly amount of waste used in the calculations were given in Table 2.

Table 2. Amount of waste in the hotel for the study

Type of waste	Weekly waste amount
Food	3350 kg
Grass	1200 kg
Cooking oil	50 liter

Waste to Biomass

Biogas

Various techniques are applied to convert wastes into added value products such as the production of biogas, organic fertilizers and chemicals. Since most of the wastes consist of organic matter, anaerobic digestion is the most proper way for the evaluation of the wastes as well as the available feedstock. Also because of the tropical nature of Antalya and its high temperature throughout the year, this energy treatment strategy is suitable for the region. Anaerobic digestion has many more advantages with respect to gasification, land filling and incineration. Methane (CH_4) and nitrogen (NH_3) are produced by anaerobic digestion and aerobic digestion of organic wastes. Anaerobic digestion produces digestates that are rich nutrient sources for soils and plants. So, it is major technology for energy production from organic wastes. Temperature, pH, solid waste content, C:N ratio etc. is the main factors affecting the biogas production by anaerobic digestion. The biogas slurry amount can significantly increase the biogas generation by anaerobic digestion which in consequence can be utilized to produce heat energy and/or electrical energy (Salama & Abdelsalam, 2020).

In this study, it is planned to obtain biogas from food waste and grass waste. When the food waste potential is examined, the electric energy obtained is as much as 18500 kWh/year. The calculation algorithm is shown in Figure 2, and it is as follows: First the yearly food waste amount was obtained. It is assumed that, a hotel guest can produce 1 kg/day of waste (Ghadban et al., 2016). If the hotel room was taken as 475 averagely, by considering 1 guest would stay in 1 room, the amounf of food waste was calculated as 3350 kg weekly. This amount will be doubled, tripled if the guest number per room is increased. The volatile solid amount for food waste was calculated acoording to the previous studies. Then, the biogas to be produced and its conversion to electricity was found by using literature values (Mirmohamadsadeghia et al., 2019; Yilmaz & Atalay, 2003).

Likewise, when the biogas potential from grass waste is examined, nearly 11725 kWh/year electric energy was calculated (Ulukardesler, 2023-1). The result for grass was given in Figure 3.

Figure 2. Yearly produced electricity from hotel food waste

Figure 3. Yearly produced electricity from hotel grass waste

Biodiesel

Biodiesel, which is obtained from oils obtained from oilseed plants, vegetable and animal oils and waste oils is formed as a result of the reaction with short-chain methanol in the presence of a catalyst and is formed as a product of the transesterification used. Potassium hydroxide (KOH) and sodium hydroxide (NaOH) are widely used as catalysts in biodiesel production due to their high activity and low cost. Exposure to heat and mixing of water in frying oils increases the hydrolysis rate of triglycerides, the amount of free fatty acids, density, viscosity, saponification value and decreases the iodine value. As a result of the reactions that take place at different temperatures and through different mechanisms depending on the frying conditions, decomposition products with very different structures, but all of them with polar character, occur in frying oils.

In the transesterification method, vegetable waste oil reacts with a small molecular weight alcohol to form glycerine and fatty acid ester as a result of its catalysis. Table 1 shows the comparison of technical properties of diesel and biodiesel fuels. As a result of this comparison, it is seen that there is no big difference between diesel and biodiesel fuels. In addition, the flash point of biodiesel is higher than that of diesel fuels. This feature of biodiesel supplies more reliable transportation and storage. When waste vegetable oils are converted into biodiesel, although their properties approach those of diesel fuel, their densities and viscosities are generally higher than those of diesel fuel, while their calorific values, volatility properties and oxidation stability are lower. In order to reduce the effects of these negative effects, it is preferred to use biodiesel mixed with diesel fuel. Biodiesel can be mixed with diesel fuel at any rate. At these mixing ratios; It has been determined that B2 (2% biodiesel) only improves the lubrication properties of the fuel, while B20 (20% biodiesel) both improves the lubrication properties of the fuel and reduces engine emissions. Pure biodiesel and diesel and biodiesel mixtures can be used in any diesel engine without the need for any modification (Zhao et al., 2021; Yaakob et al., 2013; Koçer & Durmuş, 2019).

Table 3. Technical properties of diesel and biodiesel (Zhao et al., 2021; Yaakob et al., 2013; Koçer & Durmuş, 2019).

Fuel Specifications	Unit	Limits	Diesel	Biodiesel
Molecular weight	g/mol	--	120-320	296
Density	kg/L	0.875-0.9	0.82-0.86	0.87-0.88
Kinematic viscosity (40°C)	mm/s	2-4.5	2.5-3.5	4.3
Flash point	°C	>55	>55	>100
Water content	mg/kg	<200	<200	<300

In this study, it is planned to obtain biodiesel from waste cooking oil of hotel in Antalya. For this reason waste cooking oil per year was calculated. Then, the optimum biodiesel yield for waste cooking oil, which is 95% was found from literature (Suzihaque et al., 2022; Jayakumar et al., 2021; Ulukardesler, 2023-2). Figure 4 shows the biodiesel production amount by using hotel waste cooking oil yearly.

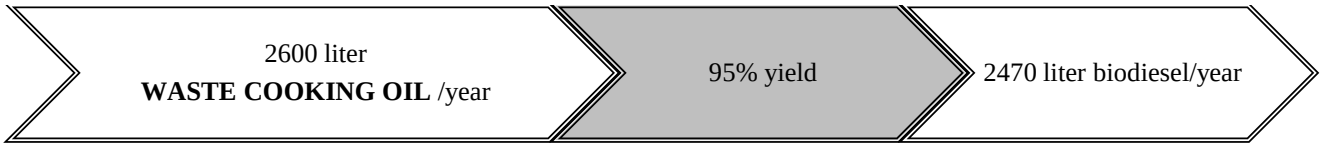

Figure 4. Yearly produced biodiesel from hotel waste cooking oil.

Conclusion

Waste, a prominent driver of climate change and global warming, stands as one of the most critical environmental issues jeopardizing our future. Today the food resources which are necessary for people, have gained a more strategic importance than energy resources. In this direction, the global problems that arise with food waste, hunger and malnutrition constitute the most important issues of today and the future. Solid waste is an issue that affects the whole world and all sectors. Hotel businesses are also one of the largest industries that generate solid waste, as they work hard and constantly host guests. In this respect, it is necessary to prevent and reduce the solid wastes that are formed or may occur in the front office and the solid wastes generated should be examined in the best way due to the protection of the natural environment.

In Turkey, it is aimed to minimize the wastes within the scope of the zero waste project. Although many hotels, especially in the Antalya region, are included in the Zero Waste Management System implemented by the Ministry of Environment and Urbanization, there is still a serious amount of food waste definitely. The use of these wastes as renewable energy is a sustainable solution.

In this study, results were obtained for only one hotel in the region. According to the statement made by the governorship of Antalya, the region has a total bed capacity of 643,051 and 392,097 of which are five-star hotel. The amount of organic waste in the region is huge. In addition, if it is considered that this figure spreads to the whole of Turkey's tourism, very serious results can be reached. In essence, this study underscores the tourism sector's potential to contribute significantly to its own energy needs.

Hotel-renewable energy conflict has not been encountered in Turkey in literature. So, it is obvious that it would be beneficial to expand the framework of this study and take steps in line with the data to be obtained. Also, at present time where it is aimed to reduce foreign dependency in energy, necessary steps must be taken for renewable energy to take the importance it deserves.

Conflict of Interest

Author declare that she has no conflicts of interest.

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