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Abstract	Air transportation is a fast-growing industry that provides fast and secure transportation, increases economic development and employment, and supports other sectors. The continued growth trend in aviation creates environmental and sustainability concerns because of the harmful effects like resource usage, energy consumption, and waste generation at the airport's peripherals. In addressing the ever-increasing amount of waste they generate, airports should use efficient waste management strategies in parallel to their day-to-day operations. Although environmental problems caused by waste constitute challenges to airport sites and surrounding society, related studies are limited and fall short of finding solutions to the problem. This study investigates the current waste management issues at

airports and trending waste management strategies used by airport management. It also considers the viewpoint of various stakeholders to attain and propose sustainable waste management strategies.

Keywords
(separated by '-')

Waste Management - Airport - Aviation - Sustainability - Stakeholder

Chapter 81 1

An Assessment of Sustainable Waste 2

Management Strategies in Airports 3

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Nomenclature

ATAG	Air Transport Action Group	6
LCC	Lockheed California Company	7
IATA	International Air Transport Association	8
ACI	Airport Council International	9

81.1 Introduction 10

Air transportation is a fast-growing industry that serves 4.5 billion passengers and 11
handles 62 million tonnes of cargo annually (ATAG 2021). Environmental effects 12
create undesirable problems for airports and surrounding areas, and 6.1 million 13
tonnes of waste are generated annually from air transport operations (IATA 2021). 14

Despite the common need, there exist few studies in the literature on finding 15
solutions to the problems. This study, by bridging the gap in the field, will 16

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investigate the most commonly used waste management strategies and alternatives to create and improve a sustainable green economy in airports.

The study assesses the sustainable solutions used by the world's leading airports to the various problems caused by airport wastes. For this purpose, an in-depth literature review on the subject was conducted. Additionally, Sustainability Reports, Annual Reports, and Company Web Pages of airports are studied using the Content Analysis Method.

Fast growth in aviation has raised concerns about its environmental footprint on the issues like energy consumption, materials use, and waste generation.

The airport waste management system usually encompasses the identification of the waste sources, equipment, facility, and infrastructure requirements to process various types and amount of waste and the effectiveness of waste collection, storage, recycling, and waste disposal (Janić 2011). It requires segregation of waste in waste collection areas, reduction in waste generation, increased reuse and recycling of wastes, and permanent improvement in airport waste management applications (Eriksson 2017; Arushanyan et al. 2017; Baxter et al. 2018).

Waste Management Strategy in the airports aims to eliminate or minimize the negative effects of the wastes and creates additional economic value through effective approaches like source segregation, reuse, recycle, etc.

The type and properties of the waste define both the proper waste management program and treatment and disposal technics (Shi et al. 2016).

Airports can use incentives and advertising programs as part of their waste management strategy. Participation and support from the businesses and airport stakeholders are crucial to achieving sustainable waste management goals for the airports.

81.2 Airport Waste Types and Handling

Airport Waste means unwanted or unused products/materials/substances that are generated or brought at the airport site and needs handling with special methods (Baxter et al. 2018).

Airports, especially large ones with heavy traffic, produce a large amount of waste like small cities. If the type and characteristics of the waste are known, proper waste management programs and treatment and disposal technics can be established (Shi et al. 2016).

Various types of waste are generated from airport operations, including Municipal Solid Waste (MSW); Construction and Demolition Debris (CDD); waste from aircraft flights (deplaned waste); compostable waste; hazardous and industrial waste; and lavatory waste. The management of waste in a proper and useful way leads to improved airport operations and decreases environmental impacts (ICAO 2022).

MSWs are wastes from daily operations in an airport terminal. They are produced by tenants, airlines, and cargo operators in the form of product packages, furniture, clothing, bottles, leftover foods, and newspapers (Mehta 2015; Parameshwar 2011).

Deplaned waste is a specific type of MSW that is unloaded from aircraft after flights. It constitutes almost 20% of an airport's total MSW and includes "galley waste"—materials collected as part of the de-catering process, including compactor boxes, waste bags, food carts, and bonded carts (ICAO 2022). The length of the flight affects the amount and type of waste generated on an aircraft (Chandrupa and Das 2012).

Cleaning wastes also arises from the left-over wastes of passengers, lavatory waste bins, and medical items. Compostable wastes are generated from unused or trash food in restaurants and food stores in an airport.

Research shows that around 25% of cabin waste worth US \$ 3.9 billion comprised leftover food and beverages in 2017. Since these wastes are landfilled or incinerated, minimization would lead to significant cost savings for airlines. This practice is included in the Sustainable Development Goals (SDGs), which require cutting global food waste per capita in half by 2030 (IATA 2019).

Green wastes are generated from landscaping activities like tree, bush, and grass cutting, leaves, weeds, tree branches, etc. They can be composted in airport sites or regional facilities (Sebastian and Louis 2021).

Activities like land clearing, maintenance of runways and taxiways, and new terminal construction generate C&D wastes. These generate wastes like pieces of concrete, asphalt, wood, metal, soil, bricks, rock, stone, gravel, sand, roofing materials, drywall, carpet, plastic, pipe, etc. (ICAO 2022). Airports need to handle C&D wastes with special waste streams and facilities.

Wastes from airplane lavatories contain cleaning agents, bacteria, virus, or other harmful microorganisms, which can be harmful to health. These wastes in the airplane are kept in special tanks and carried away to the cleaning sites with special trucks, undergo a disinfection treatment, and after that they can be released for drainage (Sebastian and Louis 2021).

Spill clean-up and remediation waste arises during the cleaning of spills and the remediation of contamination. They can be generated as a result of spills from storage tanks, vehicles, and maintenance activities and during oil and gas production (Mehta 2015; FAA 2013; Baxter et al. 2018).

Hazardous wastes are generated from aircraft refueling and maintenance, vehicle maintenance, emergency power generation, and other operations. Oil leakages, chemicals used for cleaning, and substances having combustible, toxic, corrosive, or reactive effects are the primary type of hazardous waste and should be handled in accordance with special regulations (ICAO 2022).

Hazardous waste disposal should be controlled and supported by the necessary funding at local, regional, and national levels. In the USA, it is regulated by the Environmental Protection Agency (EPA), the Organization for Health and Safety (OSHA), and the Department of Transportation (DOT) (Wieher 2002).

98 **81.3 Airport Waste Management**

99 Waste management is the process of handling the waste from aircraft, concessioners,
100 maintenance operations, ground vehicles, offices, construction, and other activities
101 at the airport as well as compliance with the different requirements of the various
102 types of waste (ICAO 2022).

103 The Waste Management Strategy in the airports aims to minimize the negative
104 effects of the waste streams and generate economic advantages by focusing on the
105 alternative usages of the wastes.

106 The airport waste management system includes the identification of the waste
107 sources, facility, equipment, and infrastructure requirements for different types and
108 volumes of waste streams and the efficiency and effectiveness of the waste collec-
109 tion, storage, recycling, and disposal practices (Janić 2011).

110 Waste management system incorporates source separation, recycling, and mini-
111 mization of waste streams, a charging regime for airport waste generators, reuse of
112 material and equipment as much as possible, and the promotion and usage of
113 renewable products that cause minimum harm to the environment (Dimitriou and
114 Voskaki 2010).

115 Three main waste treatment options at airports are as follows (Baxter et al. 2018):

- 116 • Recycling: the waste is broken down to get ingredients for the manufacturing of
117 new items or waste-to-energy conversion (Spilsbury 2010).
- 118 • Incineration: “an established combustion process to reduce the wastes into CO₂,
119 water vapor, gases and a relatively small, non-combustible residue” (Guyer
120 2011).
- 121 • Landfill: depositing the waste that cannot be recycled or incinerated in a special
122 area. Airports eliminate the cost of transportation if their landfilling sites are close
123 to the airport, but these sites can attract pests and birds (ICAO 2021).

124 **81.4 Results and Discussion**

125 Waste Management Strategy and Practices of World leading international airports
126 with high volumes of passengers are studied from the Company Reports. The result
127 of the study is presented in Table 81.1. Table 81.1 also includes the amount of waste
128 and recycling rates of the airports, which can provide benchmarking information
129 among the airports.

130 The practice of the world’s leading airports indicates several waste disposal
131 streams. Wastes from the terminals and airport services are processed at the central
132 container station, where they are separated for incineration, disposal, or landfilling
133 (Baxter et al. 2018).

134 Source segregation significantly contributes to the success of waste management
135 programs. Multiple-bin collection system is used at airports to collect paper, mixed
136 recyclables, organics, etc. (ADR 2019).

Table 81.1 Waste data and management practices in busiest airports

t1.1

Airport/reference	Pax/year (millions)	Waste/ year (tons)	Recycle rate	Waste management practices	t1.2
Istanbul Airport (IGA 2020)	52.9	26.7	31%	All stakeholders signed the Zero Waste Declaration, which is a prerequisite for the purchasing processes. Zero Waste Program trainings are performed. The waste-related KPIs of all the firms are monitored regularly. Records of all sorts of waste, from its source to disposal, are kept by a database and software running 24/7. Wastes are mainly sorted at the source; mixed wastes are handled at the Solid Waste Collection and Sorting Center. A Waste to Art workshop was held to re-evaluate the construction wastes. The workshop aimed to create artwork and design products from waste, reduce waste, and raise waste awareness. A photo art competition in collaboration with a social organization was organized. The award-winning photos and videos were published in airport advertising areas and social media channels. Management of 240 tons of waste in a day is planned.	t1.3
Mumbai Airport (Mumbai Airport 2020)	45	5.4	43%	Source separation and recycling of nonhazardous waste streams and processing of organic waste at OWC (Organic Waste Compactor) facility. E-Waste bins are set up at terminals. SRA (Strategic Research Agenda) for disposal mechanism. Universal storage facility for hazardous waste. Single-use plastic-free airport status. Single-use plastic items are banned. All waste is handled by a third-party contractor at the airport using national standards.	t1.4
Heathrow Airport (Heathrow 2020)	80.9	23.9	48.9%	New passenger bins were installed to better segregate waste at the source. Waste contracts are awarded based on circular economy principles. Tried new technology to help turn unrecyclable plastic waste into useful products, including low-carbon fuels.	t1.5

(continued)

t1.6 **Table 81.1** (continued)

	Airport/reference	Pax/year (millions)	Waste/ year (tons)	Recycle rate	Waste management practices
t1.7	Hongkong Airport (Hong Kong Airport 2020)	60.9	33.9	12.4%	Built-in hand dryers to reduce the use of paper towels in washrooms were installed in the passenger terminals. 108 washrooms will be renovated by mid-2021. Trial of an Artificial Intelligence (AI) robotic sorter system to recover recyclables from different waste streams. Food waste was converted into fishmeal and biogas at a facility.
t1.8	Incheon Airport (Incheon Airport 2019)	78.39	53.8	71%	Use of the resources recovery facility, and resources classified treatment facility based on the integrated waste operation system. The ice removal solution wastes are treated through an outside treatment agency after piled up in storage tanks. Process improvement to reduce the amount of vinyl packaging and use of plastic boxes and rolltainers instead of pouches for duty-free item transportation.
t1.9	Kuala Lumpur Air- port (Malaysia Air- ports 2019)	62.3	14.5	14%	A Recycling Awareness Program is conducted at landside and airside areas, and offices. Collected recyclables are weighed, and monetary incentives are given based on the weight. The DHES Material Recovery Facility is used to collect, sort, and recycle the wastes.
t1.10	Frankfurt Airport (Fraport 2019)	70.6	28.21	68.8%	An advanced sorting systems is used for separating nonhazardous waste either for recycling or sending into regional waste-to-energy plants. Hazardous waste is disposed of in incinerators or in physical/chemical treatment plants where recycling facilities are not available. The hazardous waste is collected separately and channeled away for recycling, where recycling facilities are not available. Management of wastes is performed in the Integrated Facility Management service unit. Working together with stakeholders like disposal companies, contractors,

(continued)

Table 81.1 (continued)

Airport/reference	Pax/year (millions)	Waste/ year (tons)	Recycle rate	Waste management practices
				universities, and authorities. Up-to-date knowledge acquired from benchmark activities is added into established airport practices.
JFK Int Airport (JFKIAT 2019)	62.5	6757	57%	Implement K-Cup recycling program for airport terminal offices. A K-Cup recycling program in the JFKIAT office has been implemented. K-Cups are collected and converted into waste-to-energy. The electricity is used to power homes locally. Collaborate with food and cleaning partners to implement waste and recycling strategies. All staff are trained on source segregation, composting, waste, and recycling practices. Work with food and beverage partners for composting all food. Processed food waste is taken to local farms.
Leonardo da Vinci Airport (ADR 2019)	73	12,775	82.7%	Separate waste collection in the terminals and car parking areas. An organic waste composting plant is built, enabling 150 tons of reduction. Planned to build a composting plant capable of eliminating 1000 tons of organic waste per year. Special equipment is installed near the security checks for compacting PET bottles to optimize the collection of plastic and reduced waste by around 20 tons. All temporary waste storage areas are fenced to prevent unauthorized third parties from abandoning waste without control, enabling 200 tons of waste reduction. Regular meetings with the F&B operators served by door-to-door collection to raise their awareness. Increase separate waste collection process, elimination of nonseparated waste containers from the Food & beverage areas and kitchens, and launching a special promotional campaign for passengers. Prohibition of nonbiodegradable and/or noncompostable items in food

(continued)

t1.14 **Table 81.1** (continued)

t1.15	Airport/reference	Pax/year (millions)	Waste/ year (tons)	Recycle rate	Waste management practices
t1.13					and beverage items through the contracts; these biodegradable materials and food waste will be delivered to the airport's self-composting plant and the compost produced will be reused in the airport's green areas.

137 Some airports have set up counters for the disposal of liquids before the security
138 checks as a way of reducing energy usage in waste management processes. With the
139 “Refill” program, around 140 million tons of beverage bottles were collected at
140 security checkpoints of Manchester Airport Group airports, which serve 42 million
141 passengers annually (Winter 2019).

142 Food wastes can be donated, sent out for bioenergy production, and often
143 composted. Processed compost can be used for soil enrichment in the airport. Wastes
144 from landscaping, coffee grounds, paper towels, etc., are recycled at the composting
145 units (ADR 2019; USEPA 2009).

146 Waste compaction reduces the volume of wastes and is helpful during the
147 transportation of the wastes to treatment or disposal sites. Furthermore, 80% of the
148 waste from cabins can be recycled, which is a common practice in large airports
149 (ICAO 2021).

150 Since wastes from international flights can contain contaminants, diseases, or pest
151 infestations, some countries have special regulations and handle them separately
152 from the domestic ones. These wastes are either burned in the site or landfilled.
153 Biohazardous cabin wastes and hospital or healthcare wastes are usually incinerated
154 (Sebastian and Louis 2021).

155 Some airports use incinerators for diverting food wastes, paper cups, meal plates,
156 glasses, etc., and produce energy to heat terminal buildings (Fraport 2019).

157 Experiences showed that regional policies contribute to the success of airport
158 waste management programs. In this context, EU’s banning of single-use plastic
159 improved Europe airports’ waste reduction stream significantly (Chua 2019).

160 According to Sebastian and Louis (2021), airport’s approach to waste manage-
161 ment varies in a wide range; while some airports with larger passenger numbers
162 reach zero waste targets, others continue to landfill 75% of their wastes.

163 Airport tenants and businesses can be incentivized to use biodegradable packages
164 and sustainable alternatives. Using recycled food packages and serve ware, choosing
165 sustainable materials instead of single-use plastics, eliminating the Styrofoam usage,
166 and using biodegradable trash bags are among the sustainable measures of waste
167 management programs (ADR 2019).

168 Airports also use financial incentives, advertising programs, and nonfinancial
169 incentives like recognition awards for employees and businesses to reduce waste and
170 landfilling as part of their sustainable waste management. Banning single-use

plastics by authorities can create further supporting effects on the issue (ADR 2019; Mumbai International Airport 2020).

Stakeholder engagement, training programs, and campaigns constitute an important part of a sustainable waste management program in achieving collaboration and active involvement of the businesses, and other stakeholders in an airport (FAA 2013).

Continuous interest of research for the greening of airports is growing in aviation circles. There is a gap between studies and practices carried out by airports (Greer et al. 2020). Research on water management, climate change, and waste management specific to airport operations is limited, as evidenced that environmental accounting of airports needs further analysis.

81.5 Conclusion

The study assessed the sustainable solutions used by the world's leading airports to the actual problems caused by airport wastes.

Airport Waste Management Strategy aims to eliminate the negative effects of the wastes and creates additional economic values with the implementation of source segregation, reuse, and recycle practices.

The airport waste management system is based on the identification of the waste sources, equipment, facility and infrastructure requirements and effectiveness of the waste collection, storage, recycling, and waste disposal (Janić 2011).

The system requires segregation of waste in waste collection areas, reduction in waste generation, increased reuse and recycling of wastes, and permanent improvement in airport waste management applications (Eriksson 2017; Arushanyan et al. 2017; Baxter et al. 2018).

The type and properties of the waste define both the proper waste management program and the treatment and disposal technics as well (Shi et al. 2016).

Airports can use incentives and advertising programs as part of their waste management strategy. Participation and support from the businesses and airport stakeholders are crucial to achieve sustainable waste management goals for the airports.

Airports should benchmark the well-performing airports and have their own waste management strategies uniquely customized for their conditions.

The amount of resources used, waste generated, sources of waste generation, and recycle rates should be tracked continuously, and process and technology improvements should be made to improve waste management performance.

Route maps for waste generation, including the recycling processes, should be drawn starting from the material and equipment acquisition to the end of the life cycle.

Landfilling of wastes should be avoided as much as possible. If not, it should be performed in accordance with environmental standards.

211 Depending on the airport size and capabilities, setting up of waste processing
 212 facilities for recycling and energy generation can be made a priority; if not feasible,
 213 facilities outside of the airport can be used.

214 Airports can use incentives and advertising programs as part of their waste
 215 management strategy.

216 Participation and support from the businesses and airport stakeholders are crucial
 217 to achieve sustainable waste management goals for the airports.

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