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Solid Waste Management in Large Events: A Pathway Towards Socio-Environmental Responsibility

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***Abstract*—** *Large events in ecologically dynamic environments can generate serious environmental footprints, if inadequately planned. Poor management practices can cause environmental and economic damage of large magnitudes, directly and indirectly, to the local community and the surrounding areas of seaside cities and towns. This can be especially problematic in North-eastern Brazil, where tourism is a highly relevant source of income. Therefore, this study focuses on the analysis of waste management in large-scale events in coastal areas. The objective of this work was to evaluate the management of the solid waste generated during the Dragão Fashion Brasil 2019 event, which took place in Fortaleza, Brazil. The methodology employed was of qualitative-quantitative, exploratory, and experimental nature. Firstly, on-site monitoring was carried out for the qualitative-quantitative characterization of solid waste,along with an accelerated composting experiment usingelectromechanical equipment. The processes of separate waste collection, sorting, and final disposal of waste during the event proved to be environmentally beneficial, as it avoided the disposal of over 1,900 kg of solid waste and 200 kg of organic waste into landfills. It also prevented the pollution of close-by marine ecosystems. Additionally, six institutions benefited from the donation program by receiving 731*

kg of recyclable waste. This has also contributed a discount on the energy bill of one NGO.It was concluded that the adoption of an environmental management program for solid waste ensured its environmentally friendly redirection and the avoidance of cross-contamination by mixing it with recyclable waste. The sustainable practices observed in this large-scale event, carried out in a coastal and touristic region, can be said to have left a legacy for other events with a similar potential for social and environmental impacts.

I. INTRODUCTION

The organization of large events can bring clear benefits to local communities, such as economic boosting, job generation, income diversification, cultural appreciation, investment attraction, among others. These benefits are consonant with a prior strategic planning and the careful execution of such events [1]. On the other hand,failures or inadequacies in their planning and/or execution can cause negative economic, social, environmental, and cultural impacts, such as unexpected changes in the way ofliving of the local community, energy inefficiencies, gas emissions, waste generation, etc.

Private enterprises require planning that is underlined by a socio-environmental responsibility [2], and the organization of events also demands such sustainable approaches, especially in regard to their ecological, social, and economic dimensions. While an event is a passing occurrence with a fixed duration, sustainability "[...] is dynamic, and it presupposes continuous improvement; it is a pathway, something on which we rely when faced with decisions, choices and future advances. Thus, it is understood that nothing is fully sustainable, but (...) there is an attempt to constantly contribute to sustainability" [3].

Clearly, the classification of an event as 'sustainable' requires a balanced act among its different responsibilities: the environmental, exemplified by low emissions of greenhouse gases or minimal generation of solid waste; the social, by a thorough consideration of human resources and inclusion of minorities; and the economic, when there is a drive for transparency and via job creation strategies [4].

For Portugal et al. [5], events with audiences ranging between 10,000 and 100,000 people are considered 'super events'. The Brazilian Association of Technical Standards (ABNT) [6], through its NBR 16004, also categorizes these as large-scale events, given their great economic, environmental, and social impacts, in addition to the high degree of complexity in their organization, visibility, and their national and international outreach. This is reflected by the participation of a large number of individuals involved, which include both the attending public and the organizing professionals. Sustainability is a key principle to be followed by organizations that create and promote events, with a view to improving quality of life and environmental awareness, given the fact it encompasses the economic and social realms. Therefore, the need to cater to the three aforementioned dimensions is highlighted, especially in the case of events located inpeculiar areas of dynamic, fragile and tourist-reliant characteristic, such as coastal zones [3].

In these areas, the most serious environmental problems are those related to the generation of solid waste. When incorrectly managed, they show a great potential to impart negative environmental impacts, such as the eutrophication of seas, contamination of beaches, and the compromising of the marine biota and of the local health [7].

These problems may generate environmental impacts and economic losses of crucial relevance to the wider society and, above all, to those who subsist on the local natural resources. In the case of the Brazilian Northeast, the coastal tourism industry is an essential source of income for the regional population.

The correct management of the resulting waste promotes several environmental, economic, and social benefits, since there can be many alternative end routes for the recycled materials [8]. For example, recycling 1 ton of aluminum saves 5 tons of bauxite and 95% of energy, as it takes 17,600 kWh to manufacture aluminum from virgin raw material, against 750 kWh for recycled aluminum. In addition, there is a reduction of 85% in air pollution and 76% in water consumption [9].

Such principles are related to the concept of circular economy, whose approaches are underlined by the elimination of waste and pollution, the continuous maintenance of products and materials in use, and the regeneration of natural systems.

As countries around the world seek to rebound their economies after theimpact of the Covid-19 pandemic, the transition to a circular economy becomes even more relevant and urgent [10]. Among major events held in Brazil, the *Dragão Fashion Brasil* (DFB) Festival is a fashion-related initiative held since 1999, in the city of Fortaleza, state of Ceará, which has become the largest author-fashion event in Latin America. It presents the latest trends in the sector and makes use of a multicultural

platform to welcome and promote national talents and artists in the following areas: fashion, gastronomy, culture, and related subareas. Furthermore, it promotes the exposure of regional artists and professional knowledge exchange through workshops, courses, and theme-specific presentations.

The attraction variety and the magnitude of the DFB festival highlights the need for commitment to social and environmental agendas, due to the products and services generated and, most importantly, to its location – the sandy shores of the city's coastal zone. This requires careful planning in order to prevent landscape and environmental impacts from happening. Within this scope, the generation of solid waste is particularly challenging and sensitive, considering its volume and type of disposal.

Thus being, the relevance of this study lies in the understanding of the generation of waste in large-scale events, through its quantification, the implementation of action plans aimed at its management, and the guarantee of a sustainable destination. Considering the preservation of the coastal and touristic environment, the proposition of sustainability regarding waste management is an urgent health-related matter to the quality of life of the local community. The objective of this work was to evaluate the management of the solid waste produced in the large-scale event *Dragão Fashion Brasil* 2019, held at Iracema beach, in Fortaleza, Ceará, Brazil.

II. METHODOLOGY

The methodological approach taken was of qualitative-quantitative, exploratory, and experimental nature. To this end, three main stages of study were outlined. The first encompassed the surveying of the theoretical and document-related foundations to this research. Subsequently, on-site techniques were carried out for the qualitative-quantitative characterization of the solid waste generated during the event. An accelerated composting experiment using electromechanical equipment was also carried out at this stage. The last step consisted of the analysis and interpretation of the data collected and the generation of the final results.

The bibliographic survey was carried out on virtual scientific and journalistic platforms, aiming at acquiring the scientific and documental support required to substantiate the topic to be explored. Keywords were pre-established to enable a thorough scientific search in national and international platforms, such as *Scielo* and *Capes Periodicals*, namely: 'recyclable waste', 'mega-events', 'event management' and 'sustainable actions'. Furthermore, the legal basis in legislation 12.305/10, which institutes the National Solid Waste Policy (PNRS) [11] and supports the regulation and deliberations regarding the correct disposal of solid waste in Brazil, was used as a benchmark in this study.

The exploratory and experimental research was carried out between May 3rd and 29th, 2019, during the *Dragão Fashion Brasil* (DFB) Festival, a large-scale event dedicated to fashion exhibitions. The event took place in the highly touristic region of Iracema Beach, in the city of Fortaleza, state of Ceará, Brazil. The study area covered three points of analysis: the area destined to food environments (restaurants and bars), which are the locations with the greatest generation of organic waste; the waste sorting and temporary storage areas; and lastly, the stationary container in the external area of the event, primarily set to collect waste classified as 'tailing residues', i.e., those not subjectable to recycling, reuse or composting, as indicated in (Fig.1).

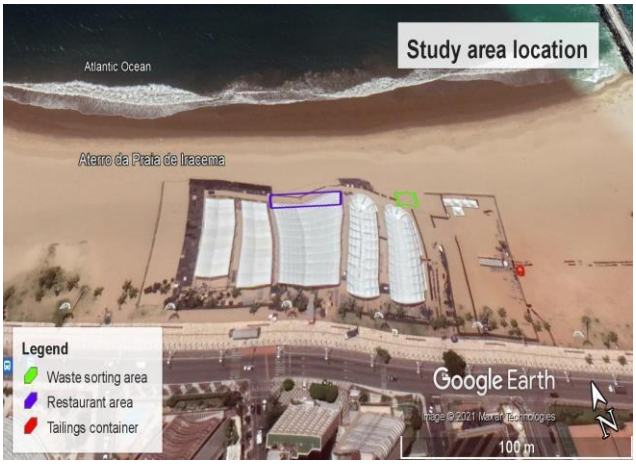

Fig. 1: Location of the study area

Source: *Google Earth Pro* (2020).

In order to clearly define the location of the wastesorting area and to better organize the collected data, four previous meetings were held among the event organizers, the company responsible for managing the waste, and the cleaning service providers. Also, it was decided that the recyclable waste generated by the event would be redirected to the *EcoEnel* program, run by the company ENEL, which is the Italian electricity distribution company largely responsible for the energy supply in the state of Ceára.

The program compensates donors with a discounton their energy bill. It is important to highlight that the company was chosen by the organizers of the DFB 2019 due to it being one of its sponsors.

It was also defined that the School of Development and Social Integration for Children and Adolescents (EDISCA), a non-governmental entity located in Fortaleza,would be the recipients of the financial bonus on their electricity bill.

Finally, concerning other wastes that could be reused, such as scraps of fabric and wood, a survey was carried out by the waste management company as to potential Non-Governmental Organizations interested in receiving them.

During the event, technical observations were carried out *in situ* to firstly identify and characterize the local dynamics. At this stage, we sought to evaluate and plan the logistics to be executed by the cleaning team responsible for collecting and moving the waste to the sorting area, as shown in the Fig. 1 above.

To this end, the displacement and packaging of waste materials relied on a team of ten people – three in supervisory roles and seven in operational roles. A timetable was then drawn up with the division of the event stages, dates of operation and numberof employees involved in the waste collection, sorting and conditioning groups, as shown in (Table 1).

Table 1: Event stages

Stages	Dates	Number of collaborators
Pre-event	May 3 to 10, 2019	01
Pre-event	May 10 to 14, 2019	02
Event	May 15 to 18, 2019	10
Post-event	May 19 to 29, 2019	03

Source: Authors.

Collection and packaging of waste started on May 3, 2019, in the pre-event phase, with one member in the operational team. On this date, the assembly of the collection structures and the marking of the space to be occupied by them took place.

The operator remained onsite until May 10, 2019, and was responsible for the sorting, separation and packaging of the waste collected bythe outsourced cleaning team. From that date and for the four subsequent days, one more operator joined the team to cater for the increase in the generation and disposal of waste by the growing number of companies working in theassembly of structures.

With the cultural and musical activities starting on May 15, as well as the opening of the space to the public, an extra eight people were hired during the four days of the DFB, totaling 10 workers. Naturally, the peak of waste generation took place during these days.

Finally, in the post-event phase, two operators remained in the field for the following eleven days. It is important to highlight that the members of supervisory team constantly carried out activities to monitor the operators' work and coordinate with the recipients of the recyclable and reusable wastes.For the sorting and packaging of waste, the following instruments and materials were used: a) plastic bags with a capacity of 200 liters (L) for waste storage; b) self- adhesive labels for identification; c) latex gloves; d) plastic tarpaulins; e) pendulum-type scales; f) calculators; g) camera phones; h) two wooden benches; i) five bulk bags of 1,000 kg each; and j) 20L raffia bags.

Also, aiming at a more accurate weighing of the different categories of waste collected, the waste destined for reuse was weighed in kilograms (kg), with recyclable materials being weighedwith digital scales.

Tailings were accounted for in volume units (m^3). Organic waste was collected from the 15 food shops in operation. After separation from the other waste types, these underwent an *in-situ* accelerated composting process.

According to the Brazilian Association of Technical Standards (NBR 13591) [12], this is a composting method performed by electromechanical equipment that can greatly expedite the start of the inherent biological process by maintaining a highly controlled environment. The electromechanical composter used was of the model 'Express 20', with a loading capacity of 20 kg, as shown in (Fig. 2).

Fig. 2: Electromechanical composter, model Express

Source: Authors' files.

The organic residues identified were, in their majority, food residues of similar composition to household waste, such as citrus peels (e.g., orange and lemon), vegetable peels (e.g., tomatoes and cabbage), meal leftovers, rice, coffee grounds, bread, and others.

No criteria were adoptedto restrict the use of organic waste for composting, such as critical fruits, bones, or fat-rich foods (these are usually neglected and restricted by other composting methods).

In the process, a total of 200 kg of organic waste was processed per day of the event. For the weighing process, a pendulum-type portable digital scale was used. Subsequently, the organic waste was disposed of in plastic

boxes, for visual analysis and manual separation from inorganic waste such as plastic films, bottle caps and others. These data were recorded and compiled in an Excel spreadsheet.

Subsequently, sawdust from the wood discarded in the same event was used, in an average ratio of 3 kg for every 20 kg of organic waste, to reduce odors and leachate, which are very characteristic derivatives of this type of organic decomposition. After sorting and manual mixing, the residues were placed in the equipment's loading box prior to the decomposition process. The operating time of each decomposition cycle was 45 minutes. Each 20 kg load of waste processed required the input of 1.4 kg of mineral-based limestone material.

Also, 2.6 kg of vegetable-based raw materials were added five minutes before the completion of the composting process.

During four days of event, 10composting cycles of 45 minutes each were performed, totaling an operation time of 7 hours and 30 minutes. Finally, it should be noted that during the entire period of the event, the waste classified as tailings was packed in a 5m³ container, located outside of the event area, and sent to the Municipal Sanitary Landfill of Western Caucaia (ASMOC).

III. RESULTS AND DISCUSSION

Due to the hazards they may pose and their commercial and service origin, the waste collected during the DFB 2019 were categorized as Class II waste, as defined by the Brazilian Association of Technical Standards NBR 10.004 [13].

As a result of the organization's estimate of 40,000 people in the event, the accumulated residual amount totaled 1,906.53 Kg of Class II recyclable wastes.

In Graph 1, the types and weights of the collected materials are shown. The largest amount of waste materials recorded were PVC (polyvinyl chloride) plastic films (533.73 kg), cardboard (426 kg), and glass (316 kg). In addition to these, PET (poly terephthalate) plastic (302.8 kg), aluminum cans (200 kg), metal wires (83 kg), paper (35 kg) and cooking oil (10 kg) were also identified.

Graph 1: Illustration of the amount (in kg) of the waste materials collected

Source: Authors (2020).

All the recyclable waste was separately collected, weighed, and sent for recycling. Among the main benefits of this approach are the prevention of air, water and soil pollution; the minimization of landfill and dump overloading; clandestine disposal; and the promotion of separated collection and environmental education, according to legislation 12.305/2010 of the National Solid Waste Policy [11]. The selective or separated collection of waste from the event (Fig. 3) allowed for the environmentally appropriate disposal of paper, cardboard, glass, plastics, metals, and oils to their respective recycling industries, in accordance with municipal guidelines. The redirection of this waste for recycling also generated acredit of R$725.05 in the EDISCA's energy bill, through the EcoEnel program.

Fig. 3: Separated collection and waste redirection to the EcoEnel program

Source: Authors' files.

From the perspective of appropriate redirection, waste that could be reused or repurposed was packaged during the sorting process, for subsequent donation. The plan was for them to be used internally or by other institutions, NGOs and/or by teaching and research entities, as shownin (Table 2):

Table 2: Types and destination of wastes

Type of waste	Destination	Amount (kg)
Textile scraps (fabrics and carpets)	Institution *Irmão Sol Irmã Lua*; *Clara de Assis* Charitable Home; the Sustainable Women Entrepreneurs Network	626
Coffee pods	*Amigos de Jesus* home	17
PET lids	*Amigos de Jesus* home	8
Sawdust	Undergrad research project at Pitágoras de Fortaleza University (internal reuse)	47
Wood pieces	*Parque Escola* honey bee farm	33
Raffia bags	Internal reuse (residue storage)	12
	Total (kg)	**743**

Source: Authors.

In the relationship with the above institutions, the commitment to correct disposal was clearly noticeable, as well as the social and environmental valuation of their charitable and entrepreneurial roles. A highlight among these was the delivery of 140 kg of fabric and carpet scraps to the Sustainable Women Entrepreneur Network organization (REMES) for the development of educational items and articles (Fig. 4-1).

The institution *Amigos de Jesus* home, in turn, sells the materials received to recycling companies to raise funds. At the event itself, wood sawdust was reused in the accelerated composting process (Fig. 4-2). Also, raffia bags originating from the ice delivery logistics, were repurposed in the storage and packaging of waste (Fig. 4-3).

Fig. 4-1: Repurposed carpet scraps; 4-2: Sawdust; 4-3: Raffia bags

Source: Authors' files.

Another highlight was the donation of 33 kg of wood sawdust, generated in the process of assembling and decoration of stands and stalls, to undergraduate research projects of students in the courses of Gastronomy and Environmental Management at the University Pitágoras de Fortaleza. These projects were on the topic of composting in the gastronomy laboratory. The material was used to stabilize liquids and odors during the composting process (Fig. 5) and generated 10,305 kg of organic compost for direct application in the local vegetable garden. It contributed to the complementary study of the purchase, use, disposal, and recycling cycles of food waste.

Fig. 5: Sawdust being reused for vermicomposting

Source: Authors' files.

The organic waste collected (200 kg) was subjected to an accelerated composting process. Accordingto the literature, this volume can yield 70 to 80 kg of compost, i.e., less than half of the initial volume. The rest is turned mainly into carbon dioxide and water vapor [14]. Compared to the amount of waste processed, the 10 cycles in the electromechanical composter generated a total of 80 kg of composting material (Fig. 6), which was donated to the event organizer.

Fig. 6: Organic composting material donated

Source: Authors' files.

Non-reusable wastes, such as Styrofoam plastic, wood, contaminated fabrics, disposable plastics, and sanitary paper, were classified as 'tailings' and collected by a specialized outsourced company. 25 m³, or five full standard containers, of tailings were collected (Fig. 7) by a compactor-type truck and destined to a sanitary landfill.

Fig.7: 5m³ container

Source: Authors' files.

It has been shown that approaches with a sustainable agenda, as noted in this analysis, can foster the advancement of environmentally responsible events. These can also contribute to the direct achievement of Sustainable Development Goals (SDGs), as established by the United Nations (UN) [15] organization, as shown in (Table 3):

Table 3: SDGs achieved, directly or indirectly

SDGs achieved			
SDG No.	**Direct achievement**	**SDG No.**	**Indirect achievement**
12	Sustainable production and consumption patterns	13	Urgent actions to combat climate change and its impacts
14	Conservation and sustainable use of oceans,seas, and marine resources for sustainable development	15	Protect, restore, andpromote the sustainable use of land ecosystems

Source: UN Brazil, 2021.

Therefore, the ecological, economic, social, cultural, and political dimensions can be said to have been considered in this process, given the good socio-environmental practices followed. It was possible to confirm that the actions taken in the event contributed to the circular economy and sustainability in large-scale events.

IV. FINAL CONSIDERATIONS

With the results of this work, it can be concluded that an environmentally correct disposal of the waste collected in the event analyzed was achieved by adopting a solid waste management program, which included the separation of organic waste and an *in-situ* accelerated composting.

Contamination by mixing organic with recyclable waste was avoided, and the viability of employing sustainable practices in large-scale events located in coastal and touristic environments was confirmed.

The processes of separate collection, sorting and final disposal of waste during the event were also environmentally beneficial, as they avoided the discard of 1,906.53 kg of solid waste and of around 200 kg of organic waste into sites unfit for such materials.

This merited notoriety for safeguarding the local ecosystem and for preserving the dynamics and the laws applied to the beach environment in which the event was inserted. Concerning the social and environmental aspects, six institutions benefited from the event's donation program, which received 731 kg of recyclable or reusable waste. In addition, the donation contributed a discount on the energybill of one NGO, through the *EcoEnel* program.

Such measures portray an important aspect of the social responsibility of these events.

The event also contributed to the environmental education of all those directly or indirectly involved in the waste management processes, and to raising awareness and creativity towards the use of materials subject to disposal. Four SDGs were achieved, directly and indirectly, leaving a legacy for event organizers and employees that value socio-environmental sustainability.

The articulation with sponsors and the systematization of the collaboration team was also fundamental. Due to the careful definition of the planning, execution, and completion phases, it was possible to carry out this large-scale event in a coastal environment while simultaneously mitigating negative environmental impacts linked to the solid waste generated. Sustainable practices of this nature also promote credibility and good visibility of these events on the eyes of public bodies and the wider society.

Finally, the study of this subject allows for continuing and in-depth future investigations, given the intense dynamics of the environments involved and the streamlining of intelligent approaches for the management of waste, which counteracts the conventional economic reductionism.

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