MANAGEMENT OF SOLID WASTE FROM PHUKET INTERNATIONAL MARATHON RUNNING EVENT

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ABSTRACT

Sporting events with a large number of people are an important source of waste. Marathon running is a popular sporting event that attracts competitive runners. Therefore, the race venues are major sources of waste and are difficult to manage. This research aimed to study the management of solid waste from an international marathon running event in Phuket. The data comprised the types and compositions of the waste, the characteristics of waste containers, waste storage and collection, waste transfer and transport, and waste disposal. Data of the waste materials were recorded on 7–9 June 2019 from two mains activities, 14 sub-activities and 6 distance running events. The total amount of waste within 3 days was 4,168.20 kg which included 3,737.20 and 431.00 kg that were related directly to the marathon running and not related directly to the marathon running, respectively. The rate of waste based on the amount per person was 0.31–0.37 kg/person/day. All waste was separately recorded into compostable waste, general waste, recyclable waste and hazardous waste for each main activity. General waste was the greatest amount and hazardous waste was the lowest amount in each group. Some containers and vehicles did not follow the laws. The waste workers wore unsuitable personal protective equipment. The waste materials were separated into two main groups for disposal: (1) compostable waste, general waste and hazardous waste that were mixed without separation before transfer for disposal and (2) recyclable waste that was separated at the sources before transfer. The first group of waste was removed for incineration and the recyclable waste was taken to recycling shops. However, all waste at a race venue needs to be reduced and classified at the source before transfer for disposal or recycling for the best solid waste management at a marathon.

Keywords: international marathon running event, Phuket, solid waste.

1 INTRODUCTION

Marathon running is a long-distance race that is usually run as a road race. It has many distance routes such as fun run (3.5–5 km), mini marathon (10.5 km), half marathon (21.0975 km) full marathon/marathon (42.195 km), ultra-marathon (>42.195 km), triathlons, cross-country and trail racing. Recently, marathon running is the most popular and brings runners from around the world to the competition. World famous running events are as the London Marathon, BMW-Berlin Marathon, Boston Marathon, Chicago Marathon, New York City Marathon and the Tokyo Marathon [1]. Although Thailand does not rank in the top ten competitions in the world, some races in Thailand are qualifiers for other marathons. The international running marathon event in Phuket, Thailand is the biggest marathon in South-East Asia and meets the highest international standard that is also the qualifier for the Boston Marathon. This event is professionally scheduled by Sportstats Asia and is certified by the Association of International Marathons and Distance Race [2]. All of competitions produce waste during the race, such as food waste, packages and goodie bags [3]. In the Boston Marathon of 2017, 1.4 million paper cups were scattered by the runners and 171,380 paper brochures and visitor's guides were

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printed [4]. In the London Marathon of 2018, the Westminster City Council collected 5,200 kg of rubbish and 3,500 kg of materials for recycling that included 47,000 plastic bottles from the street [3]. Even though many competitions try to control and manage the waste from the races, it is inefficient. Therefore, this research aimed to study the management of solid waste at an international marathon running event in Phuket. The data were studied in five steps: (1) the type and composition of waste, (2) the characteristic of waste container, (3) waste storage and collection, (4) waste transfer and transport and (5) waste disposal.

2 METHODOLOGY

2.1 Study area and time scope

It must be noted that we replaced the true name of the running event to protect the entity that was responsible for the management of the solid waste from the marathon running event. In this paper we refer to the event as the Phuket International Marathon Running Event (PIMRE). The event was set in Thalang district, Phuket province. Phuket is located in the southwest part of Thailand (Fig. 1). The PIMRE was held on 7–9 June 2019 and offered six distance running routes on 8–9 June 2019. On 7 June, the runners received a race pack collection and agenda with a bib number and waiver form. The competitions started with three distance running events in the afternoon (16.00–17.20) of 8 June: kids run (2 km); fun run (5 km) and minimarathon (10.5 km). Three distance events took place in the early morning (04.30–05.30) of 9 June: marathon (42.195 km), marathon relay (42.195 km) and half marathon (21.0975 km).

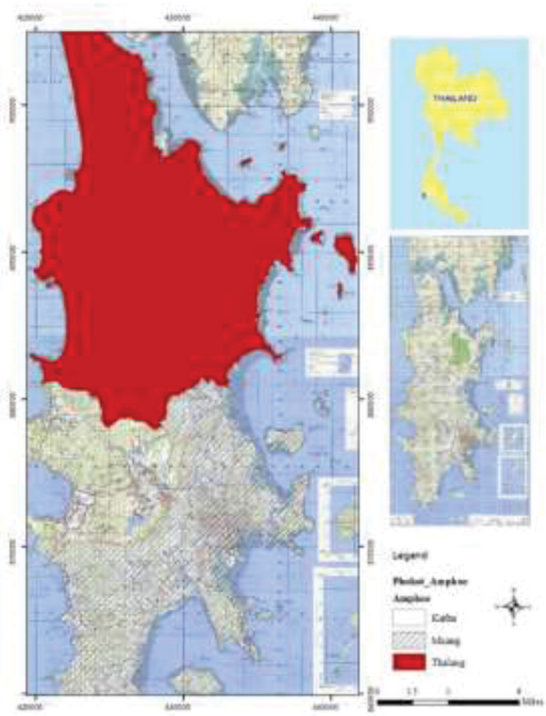


Figure 1: Location of the PIMRE site in Thalang district, Phuket province, Thailand.

2.2 Survey methods and sampling

2.2.1 Surveys and studies

Surveys and studies were performed in five steps: (1) to study the types and compositions of the waste materials, (2) to study the characteristics of the waste containers, (3) to study the waste storage and collection, (4) to study the waste transfer and transport and (5) to study the waste disposal. These steps were conducted with the organizer team, the owner of the race venue, and the waste workers related to the PIMRE.

2.2.2 The sampling scope

The types and compositions of the PIMRE waste materials from all activities at the race venue were studied by segregation and weighed during 7–9 June 2019 that covered the race pack collection and expo area (7 June) and the six distance running routes (8–9 June). The waste materials were collected for a period of 17 h from 04.00 to 21.00. The waste was categorized according to materials related directly to the marathon running (RDMR) and unrelated directly to the marathon running (URDMR) (Table 1).

Table 1: PIMRE schedule and sampling source.

Date	Time	Locations and source of waste	
		RDMR	URDMR
7/6/2019	13.00–21.00	1. Race pack collection 2. Baggage storage	1. Expo 2. Food zone
8/6/2019	09.00–19.30 (16.00–17.20) starts 2, 10.5, 5 km.	1. Race pack collection 2. Water station 3. Relaxing massage station 4. Food race service for runners 5. Start & finish line 6. Sponsor service station 7. Winner register station 8. Aid station 9. Baggage storage 10. Water station along the running route 11. Toilets	1. Expo (09.00–19.30) 2. Pasta party (12.00–15.00) 3. Food zone (15.30–19.30)
9/6/2019	04.00–12.00 (04.30–05.30) starts 42.195, 21.0975 km.	1. Race pack collection 2. Water station 3. Relaxing massage station 4. Food race service for runners 5. Start & finish line 6. Sponsor service station 7. Winner register station 8. Aid station 9. Baggage storage 10. Water station along the running route 11. Toilets	1. Expo (08.00–12.00) 2. Food zone (04.00–12.00)

3 RESULTS AND DISCUSSION

3.1 Types, compositions and quantities of waste

The waste of the PIMRE on 7–9 June 2019 were classified into four types from the two main categories of waste, i.e. RDMR and URDMR, of the 14 activities: (1) compostable waste, (2) general waste, (3) recycle waste and (4) hazardous waste. The amount of RDMR waste was much greater than the URDMR waste. The total amount of waste of the RDMR was 3,737.20 kg, whereas the total amount of waste of the URDMR was 431.00 kg. In each group, general waste was the greatest proportion. The amounts of general waste in the RDMR and URDMR groups were 1,832.60 kg (49.04%) and 208.70 kg (48.42%), respectively. Hazardous waste was the least in both the RDMR and URDMR groups at 32.90 kg (0.88%) and 2.80 kg (0.65%), respectively. The types and quantities of all waste in the 3 days are shown in Tables 2 and 3.

In addition, the types, compositions, activities, and sources of waste related to the quantities of waste are shown in Tables 4–9. The data are classified by date of competition.

On 7 June 2019, the total amount of waste in the RDMR group was 9.80 kg from two stations at the sources of waste. General waste represented the greatest amount at 5.80 kg (59.20%) which was found at the baggage storage area (3.10 kg) and at the race pack collection area (2.70 kg). The waste was comprised of plastic bags, foam boxes, plastic straws, wooden skewers for ice-cream and meatballs, and paper materials (bowls, plates, wax cups). The percentage of paper wax cups was similar to reports by Mahmud [5] and Mervosh [6]. Following general waste, the total amount of recyclable waste was 2.40 kg (24.50%) which

Table 2: Types and compositions of RDMR waste on 7–9 June 2019.

Types	Quantities (kg)						
	7/6/2019	8/6/2019	9/6/2019	Total	%	Mean	S.D.
Compostable waste	1.60	268.50	794.00	1,064.10	28.72	354.70	329.19
General waste	5.80	525.40	1,301.10	1,832.60	49.04	610.87	532.22
Recyclable waste	2.40	395.50	409.70	807.60	21.61	269.20	188.75
Hazardous waste	0.00	10.50	22.40	32.90	0.88	10.97	9.15
Total	9.80	1,200.20	2,527	3,737.20	100.00	1,245.73	1,028.23

Table 3: Types and compositions of URDMR waste on 7–9 June 2019.

Types	Quantities (kg)						
	7/6/2019	8/6/2019	9/6/2019	Total	%	Mean	S.D.
Compostable waste	16.30	87.20	47.50	151.00	35.03	50.33	29.01
General waste	38.10	91.30	79.30	208.70	48.42	69.57	22.78
Recyclable waste	4.90	15.20	48.40	68.50	15.89	22.83	18.56
Hazardous waste	1.10	1.40	0.30	2.80	0.65	0.93	0.46
Total	60.40	195.10	175.50	431.00	100.00	143.67	59.42

was found at the race pack collection area (0.50 kg) and baggage storage area (1.90 kg). Recyclable materials included glass bottles, aluminium cans and single-use plastic bottles which were similar to the reports by Mahmud [5], Smithers [7], United Nations Environment Programme [8], Mervosh [6], Lewis [9] and Cheung [3]. The percentage of single-use plastic cups was similar to the reports by United Nations Environment Programme [8] and Lewis [9]. Next, the amount of compostable waste was 1.60 kg (16.30%) which was food waste (0.80 kg) at the race pack collection and baggage storage areas. Hazardous waste materials were not found (Table 4).

Also on 7 June 2019, the total amount of waste in the URDMR group was 60.40 kg from the two stations. General waste was the greatest at 38.10 kg (63.10%) which was found at the food zone area (23.20 kg) and expo area (14.90 kg). The waste consisted of plastic bags and paper (bowls, plates, wax cups). The percentage of paper wax cups was similar to reports by Mahmud [5] and Mervosh [6]. Also found were wooden skewers for ice cream and meatballs, foam boxes, and plastic spoons and straws. Next, the amount of compostable waste was 16.30 kg (27.00%) of which 15.60 kg of food waste was found at the food zone. The amount of recyclable waste was 4.90 kg (8.10%) which was comprised of single-use plastic bottles, aluminium cans and cardboard materials at the expo area (3.90 kg) and at the food zone (1.00 kg). Similar percentages of plastic bottles were reported by Mahmud [5], Smithers [7], Mervosh [6], Lewis [9] and Cheung [3]. The number of aluminium cans was similar to the report by Mahmud [5]. The percentage of cardboard waste was similar to the report from the Monterey Bay Half Marathon [10]. Finally, a total of 1.10 kg (1.80%) of hazardous waste was found at the expo area that consisted of infectious waste, Accu-Chek FastClix, masks, medical plaster bandages and absorbent cotton/paper waste that was contaminated with blood. These waste materials were a result of the initial health check provided at a health insurance company booth within the expo area (Table 5).

On 8 June 2019, the total amount of waste was 1,200.20 kg in the RDMR group from 11 stations. General waste represented the highest amount at 525.70 kg (43.80%) of which 354.60 kg was found at the water station along the running route. The waste was comprised of sponges and paper materials (bowls, plates, wax cups). Similar percentages of paper wax cups were reported by Mahmud [5] and Mervosh [6]. Moreover, the total of all waste at the water station along the running route was the greatest at 382.70 kg. The amount of recyclable waste was 395.50 kg (32.95%) of which 256.50 kg was found at the race pack collection area and the largest proportion was cardboard materials. Next, the total amount of compostable

Table 4: Types and compositions of RDMR on 7 June 2019.

Locations	Types and Quantities (kg)				
	Compostable waste	General waste	Recyclable waste	Hazardous waste	Total
1. Race pack collection	0.80	2.70	0.50	0.00	4.00
2. Baggage storage	0.80	3.10	1.90	0.00	5.80
Total	1.60	5.80	2.40	0.00	9.80
%	16.30	59.20	24.50	0.00	100.00
Mean	0.80	2.90	1.20	0.00	4.90
S.D.	0.00	0.20	0.70	0.00	0.90

Table 5: Types and compositions of URDMR on 7 June 2019.

Locations	Types and Quantities (kg)				
	Compostable waste	General waste	Recyclable waste	Hazardous waste	Total
1. Expo	0.70	14.90	3.90	1.10	20.60
2. Food zone	15.60	23.20	1.00	0.00	39.80
Total	16.30	38.10	4.90	1.10	60.40
%	27.00	63.10	8.10	1.80	100.00
Mean	8.15	19.05	2.45	0.55	30.20
S.D.	7.45	4.15	1.45	0.55	9.60

waste was 286.50 kg (22.37%) of which 113.50 kg, that consisted of food waste and fruit peelings, was found at the food race service for runners. The percentage of fruit peelings was similar to a report by Mahmud [5] on the annual Singapore marathon and a report on the shrinking carbon footprint event at the Salzburg Marathon [11] where bananas peels were found. Hazardous waste represented the lowest amount at 10.50 kg (10.50%) that included infectious waste (toilet rolls at the toilets) and toxic waste materials such as spray bottles at the relaxing massage station, winner register station and baggage storage area (Table 6).

Also on 8 June 2019, the total amount of waste in the URDMR group was 195.10 kg from three stations. General waste represented the highest amount at 91.30 kg (46.80%) and the amounts of waste at the food zone and expo area were 57.90 kg and 33.40 kg, respectively. The waste materials consisted of plastic bags, paper (bowls, plates, wax cups), wooden skewers for ice-cream and meatballs, foam boxes, wet cardboard and sponges. The percentage of paper wax cups was similar to the results reported by Mahmud [5] and Mervosh [6]. The amount of compostable waste was 87.20 kg (44.70%) at the expo area and food zone that consisted of food waste and fruit peelings. The percentage of fruit peeling was similar to a report by Mahmud [5] on the annual Singapore marathon and a report on the shrinking carbon footprint event at the Salzburg Marathon [11] where bananas peels were found. The amount of recyclable waste was 15.20 kg (7.79%) that included single-use plastic bottles and cups and aluminium cans. The percentage of single-use plastic bottles was similar to the reports by Mahmud [5], Smithers [8], United Nations Environment Programme [8], Mervosh [6], Lewis [9] and Cheung [3]. Finally, the greatest amount of hazardous waste that consisted of infectious waste (toilet rolls) and toxic waste (batteries) was found at the expo area (1.40 kg). The rate of waste on 8 June based on the amount per person was 0.31 kg/person/day (Table 7).

On 9 June 2019, the total amount of waste in the RDMR group was 2,5270.20 kg from 11 stations. General waste represented the highest amount at 1,301.10 kg (51,48%) of which 1,035.20 kg was found at the water station along the running route. The waste was comprised of paper materials (bowls, plates, wax cups), sponges, wet paper, wet cardboard and plastic bags. The percentage of paper wax cups was similar to the reports by Mahmud [5] and Mervosh [6]. Moreover, the area with the greatest total amount of waste (1,770.00 kg) was at the water station along the running route. The total amount of compostable waste was 794.00 kg (31.42%) of which 505.60 kg, that was comprised of coconuts (the highest), food waste and fruit peelings, was found at the water station along the running route. The total amount of recyclable waste was 409.70 kg (16.21%) of which 229.00 kg, that consisted of plastic

Table 6: Types and compositions of RDMR on 8 June 2019.

Locations	Types and Quantities (kg)				
	Compostable waste	General waste	Recyclable waste	Hazardous waste	Total
1. Race pack collection	3.60	9.40	256.50	0.00	269.50
2. Water station	72.90	42.00	13.60	0.00	128.50
3. Food race service for runners	113.50	46.70	12.40	0.00	172.60
4. Relaxing massage station	11.90	7.60	2.90	0.40	22.80
5. Start & finish line	5.40	24.70	20.70	0.00	50.80
6. Sponsor service station	54.00	18.60	51.00	0.00	123.60
7. Winner register station	0.00	7.20	0.70	0.10	8.00
8. Aid station	6.00	9.30	0.20	0.00	15.50
9. Baggage storage	1.20	5.30	9.20	0.10	15.80
10. Water station along the running route	0.00	354.60	28.10	0.00	382.70
11. Toilet	0.00	0.30	0.20	9.90	10.40
Total	286.50	525.70	395.50	10.50	1,200.20
%	22.37	43.80	32.95	0.87	100.00
Mean	24.41	47.79	35.95	0.95	109.11
S.D.	36.66	98.09	71.24	2.83	118.12

Table 7: Types and compositions of URDMR on 8 June 2019.

Locations	Types and Quantities (kg)				
	Compostable waste	General waste	Recyclable waste	Hazardous waste	Total
1. Expo	6.00	33.40	5.30	1.40	46.10
2. Food zone	34.60	57.90	9.90	0.00	102.40
3. Pasta party	46.60	0.00	0.00	0.00	46.60
Total	87.20	91.30	15.20	1.40	195.10
%	44.70	46.80	7.79	0.72	100.00
Mean	29.07	30.43	5.07	0.47	65.03
S.D.	17.03	23.73	4.05	0.66	26.42

bottles, wax cups and cardboard, was found at the water station along the running route. The amount of hazardous waste was the lowest at 21.10 kg (0.89%) that included infectious waste at the toilets (toilet rolls) and toxic waste that included pain relievers in the forms of spray, creams and gels, bottles for 70% alcohol, and containers for pain relief medicine for relief of muscular aches. They were found at the race pack collection area, relaxing massage station, sponsor service stations, aid stations, baggage storage area, and the water stations along the running route (Table 8).

Also on 9 June 2019, the total amount of waste in the URDMR group was 175.50 kg from two stations. General waste represented the greatest amount at 79.30 kg (45.20%) of which 54.10 kg and 25.20 kg were found at the expo area and food zone, respectively. The general waste consisted of plastic bags, paper (bowls, plates, wax cups), wooden skewers for ice-cream and meatballs, foam boxes, wet paper, wet cardboard, sponges, plastic spoons and boxes, packages of energy gel and shoes. The percentage of paper wax cups was similar to the reports by Mahmud [5] and Mervosh [6]. Next, the amount of compostable waste, that consisted of food waste, was 47.50 kg (27.07%) which was found at the expo area and food zone. Finally, the amount of hazardous waste, that consisted of toxic waste (spray bottles), was 0.30 kg (0.20%) which was found at the expo area and food service for runners. The rate of waste on 9 June based on the amount per person was 0.37 kg/person/day (Table 9).

Table 8: Types and compositions of RDMR on 9 June 2019.

Locations	Types and Quantities (kg)				
	Compostable waste	General waste	Recyclable waste	Hazardous waste	Total
1. Race pack collection	3.50	22.70	11.90	0.20	38.30
2. Water station	75.30	66.50	11.50	0.00	153.30
3. Food race service for runners	110.80	72.20	15.60	0.00	198.60
4. Relaxing massage station	9.70	11.80	3.60	0.10	25.20
5. Start & finish line	4.90	24.20	17.50	0.00	46.60
6. Sponsor service station	64.40	26.40	22.40	0.20	113.30
7. Winner register station	3.10	10.40	19.80	0.00	33.30
8. Aid station	8.00	22.10	5.00	0.50	35.60
9. Baggage storage	7.70	8.40	72.40	0.10	88.60
10. Water station along the running route	505.60	1,035.20	229.00	0.20	1,770.00
11. Toilet	1.00	1.20	1.00	21.10	24.30
Total	794.00	1,301.10	409.70	22.40	2,527.20
%	31.42	51.48	16.21	0.89	100.00
Mean	72.18	118.28	37.25	2.04	229.74
S.D.	141.64	290.76	63.37	6.03	490.20

Table 9: Kinds and compositions of URDMR on 9 June 2019.

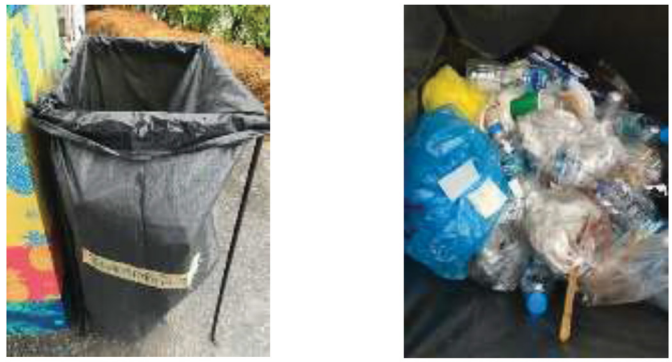
Locations	Types and Quantities (kg)				
	Compostable waste	General waste	Recyclable waste	Hazardous waste	Total
1. Expo	7.00	54.10	29.40	0.20	90.70
2. Food zone	40.50	25.20	19.00	0.10	84.80
Total	47.50	79.30	48.40	0.30	175.50
%	27.07	45.20	27.58	0.20	100.00
Mean	23.75	39.65	24.20	0.15	87.75
S.D.	16.75	14.45	5.20	0.05	2.95

3.2 Characteristics of waste containers

Three types of waste containers were used at the PIMRE for both the RDMR and URDMR. The first type was steel frames for hanging black plastic bags (size 36 × 45 inch). A total of 130 steel frames with plastic bags were used for the RDMR waste from the water stations along the running route. The second type was plastic buckets (size 26.9 and 240 l) that all held plastic bags (size 36 × 45 inch). One 26.9-l plastic bucket was located at the sponsor's service station. Four 240-l plastic buckets were used for waste at the expo area (URDMR) and two 240-liter plastic buckets were used at the race pack collection area (RDMR). The third type was small baskets with black plastic bags (size 18 × 20 inch). Eighteen baskets were used for waste at the race pack collection area (RDMR) and 16 baskets were used at the expo area (URDMR). However, the containers did not have symbols or labels to indicate the type of waste. The result was no separation of the waste materials. In addition, the small plastic buckets (26.9 l) and small baskets were incorrect according to the requirements of the Ministerial Regulation on General Waste Management B.E. 2560 (2017) [12].

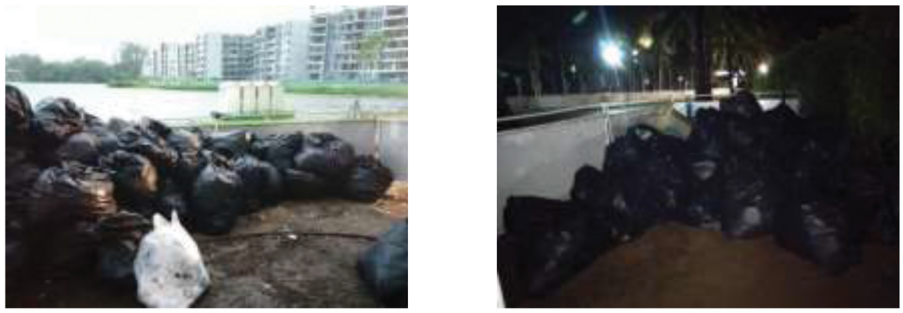
3.3 Waste storage and collection

All waste materials at the PIMRE were kept and collected from all containers and waste storage stations 1 and 2 by 12 waste workers from an outsourced company. In addition, the owner of the race venue hired five workers from the garden department and three temporary workers. Seventeen workers collected the waste from all activities at the race venue except for the running route. The three temporary workers collected the waste from the running route and carried it to waste storage station 1 by local vehicle. Next, the waste workers moved all waste to two waste storage stations where the waste awaited transfer for disposal around 2 days later. However, the waste was separated by the workers at the source. The waste materials were primary classified into general waste and recyclable waste for easier disposal at a later time. However, waste storage stations 1 and 2 were unsuitable according to the guideline because they were not in buildings and did not have roofs for protection from the rain in the event of rainfall. They were simple stalls in an area near the activities zone (Fig. 2). Moreover, the workers wore unsuitable personal protective equipment (PPE). They did not wear health masks, gloves, rubber boots, plastic aprons, medical caps, or eye goggles. These practices were in conflict with the Ministerial Regulation on General Waste Management B.E. (2017) [12].



(a) (b)

Figure 2: (a) The containers did not have symbols or labels to indicate the type of waste materials. (b) Mixed waste.



(a) (b)

Figure 3: Waste storage station: (a) waste storage station 1 and (b) waste storage station 2.

3.4 Waste transfer and transportation

Waste transfer and transportation were operated by six waste workers from a private company that was sanctioned by the government. They moved all waste by pickup truck from waste storage stations 1 and 2 only after the end of the competition. Transportation of the waste materials for disposal required nine round trips within 2 days. The waste from the running route was separated by the workers into recyclable waste and general waste before transfer to waste storage station 1 by local vehicles. At the end of the process, the recyclable waste was transported for disposal to a recycling centre and the general waste was transported to an incinerator for disposal.

The vehicles that were used to carry the waste materials were unsuitable for hauling waste. The vehicles did not comply with the law that requires the vehicles not to leak, spill or allow the waste to fly away during transport which would otherwise contaminate the environment [13].

In addition, while working, the workers wore unsuitable PPE. They did not wear health masks, gloves, rubber boots, plastic aprons, medical caps, or eye goggles. The lack of proper

PPE was contrary to the policy set forth by the Ministry Regulation on General Waste Management B.E. 2560 (2017) [12].

3.5 Waste disposal

The waste materials from the PIMRE were separated into recyclable and general waste materials before transportation for disposal. The recyclable waste (3,292.10 kg) consisted of transparent plastic bottles, coloured plastic bottles, paper and cardboard. They were transported to recycling shops for disposal. The general waste (876.10 kg) included plastic materials (bags, boxes, bowls, plates and cups), paper materials (boxes, bowls, plates and cups), foam materials (boxes, bowls, plates) and other materials (compostable waste and hazardous waste). The general waste was transported to an incinerator plant in Phuket province. These methods met the requirements of the Ministerial Regulation on General Waste Management B.E. 2560 (2017) [12]. However, the hazardous waste should have been separated from the general waste before transport to the incinerator because some hazardous waste materials do not burn at the same temperature as general waste. Hazardous waste materials must be taken to a specific incinerator. The recycling methods were similar to a report from the AACR Philadelphia Marathon 2017 [14], Swiss City Marathon 2018 [15], Monterey Bay Half Marathon 2017 [10], BMW Berlin Marathon 2019 [16], Sanlam Cape Town marathon 2019 [15] and the London marathon 2019 [17].

3.6 Suggestions for solid waste management at marathon running events

3.6.1 Before the competition

(1) Plan to reduce waste in all activities using the 3Rs (Reduce, Reuse and Recycle) and estimate the amount of waste to prepare the containers depending on the type of waste materials, i.e. general waste, compostable waste, recyclable waste and hazardous waste. Also, consideration needs to be made of waste storage and collection, PPE for the waste workers, vehicular transfer/transport of the waste and disposal methods.
(2) Form a team of volunteers and train them on solid waste management for proper control and management of the waste within the race venue.
(3) Public announcement of the competition and registration should be done by an online system.
(4) Announce the information about solid waste management within the race venue for the runners and participants before the competition or along with public announcements of the competition and registration by the online system.
(5) Reduce and refrain from the use of plastic bags at all activities and replace plastic bags with paper bags. Runners should receive a single drawstring bag, a race bib with the timing chip within the race venue or by delivery to the runners prior to arriving at the venue which is part of the logistics.
(6) Refrain or avoid using single-use plastic items, such as cups, spoons, straws, boxes, bowls, bags and bottles, for food and beverage preparation for the runners and participants and replace with eco-friendly products.

3.6.2 During the competition

(1) Announce the information about solid waste management within the race venue.
(2) Have a team of volunteers to control and manage the waste at the stations.

3.6.3 At the end of the competition

(1) Strictly follow the solid waste management plan.
(2) Prepare a team of volunteers to remove the residue waste from the race venue.

4 CONCLUSIONS

The waste materials at the PIMREW were classified into four types from 14 waste stations at two main activity locations, i.e. RDMR and URDMR. The waste materials included (1) compostable waste, (2) general waste, (3) recyclable waste and (4) hazardous waste. The proportion of RDMR waste was much greater than URDMR and the greatest amount of PIMRE waste was general waste materials. The main source of general waste was from the water stations along the running route. The waste containers, waste storage station, waste collection, PPE and waste transfer vehicles were unsuitable and in conflict with the guidelines. Even though the waste disposal methods using incineration and recycling for the general waste were correct according to the laws of Thailand, the hazardous and compostable waste materials were blended with the general waste without separation at the source. The hazardous and compostable materials are unsuitable for incineration. Thus, the goals of solid waste management of a marathon should be to reduce the amount of waste, separate the waste materials at the source, and select suitable waste disposal methods. Moreover, all participants, including the organizer, sponsors, owner of race venue, and runners, need to be aware of the impact a marathon has on the environment.

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