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Research Article

Assessment of Infectious Solid Hospital Waste Incineration in Health Facilities of Douala, Cameroon

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Abstract

Incineration of infectious solid hospital wastes (ISHWs) is a high-temperature oxidation process that reduces organic and combustible wastes to inorganic and incombustible materials through two options: «decentralised» incineration, where wastes from one health facility (HF) are destroyed on its site, and «centralised» incineration, where wastes from several HFs are pooled for destruction. Particularly in Douala HFs, decentralised incineration is the common option practised using artisanal incinerators which are potential sources of health and environmental risks. This paper assesses the ISHW incineration in the specific case of public and private HFs of Douala, in order to identify shortcomings and propose a sustainable management strategy. The methodology used was divided into three parts: (i) documentary research, (ii) data collection and (iii) data processing. 623 HFs were identified with annual production of ISHWs of 31.317 tonnes per year. Of the 88 ISHW incinerators inventoried, 83 are artisanal and 5 modern. Uncontrolled decentralised incineration of ISHWs is practised by 13.3% of HFs against 0.8% of HFs practising controlled decentralised incineration of ISHWs. In the perspective of safe ISHW incineration, the pooling through the creation of incineration pools between HFs close to those with modern incinerators, appears as a sustainable management strategy in Douala.

Keywords: Infectious Solid Hospital Wastes; Health Facilities; Pooling; Incineration; Sustainable Management Strategy; Douala

Abbreviations

BWMP: Biomedical Waste Management Plan; BMCS: Borough Medical Center and Similars; CHS: Central Hospital and Similars; COVID-19: Corona Virus Disease 2019; DHS: District Hospital and Similars; Fig.: Figure; GHS: General Hospital and Similars; HFs: Health Facilities; HNPSD: Higher National Polytechnic National

School of Douala; IHCS: Integrated Health Center and Similars; ISHWs: Infectious Solid Hospital Wastes; Minhealth: Ministry of Health; PPE: Personal Protective Equipment; PPRCC+AF: Project for Preparation and Response to COVID-19 in Cameroon and Additional Financing; RHS: Regional Hospital and Similars; UD: University of Douala; UHC: University Hospital Center; WHO: World Health Organization

Introduction

Infectious solid hospital wastes (ISHWs) are defined as all waste of biological or non-biological origin resulting from medical or paramedical activities and consisting of (i) anatomical waste (tissues from organs of the human body, fetuses, placentas, biological samples, amputation elements, other physiological fluids), (ii) pointed or sharp waste (saw blades, needles, syringes, scalpels, various catheters, tubes, perfusion tubing, glasses containing blood or any other object that could cause a cut), (iii) dressing residues (soiled cotton pads and compresses, various linens, blood bags) and plasters [1]. Thus, the unhealthy management of ISHWs constitutes a major risk to human health and the environment, in the sense that mishandling and improper disposal by uncontrolled dumping, landfill or incineration have serious consequences for people, air, soil and water [2]. The risks associated to the ISHWs and the means of managing them are relatively well known and described in the literature [3]. The health risks of ISHWs can be infectious or biological, traumatic or psycho-emotional and mechanical, while the environmental risks can be the contamination of water sources during their treatment, air pollution due to the emission of highly toxic gases such as dioxins and furans when ISHWs are burnt in the open burning pits or in an incinerator whose emissions are not controlled [4]. However, increased awareness of inadequate ISHW management has led to a large number of independent investigations in african countries of which published data on the subject remains sparse in Africa compared with the rest of the world [5].

Since December 2020, an exponential increase in the quantity of ISHW production across health facilities (HFs) worldwide has been observed, due to emergence of the Coronavirus disease 2019 (COVID-19) pandemic and has been estimated between 30% and 40% [6]. In China, an illustration of this response to the COVID-19 pandemic is medical services produced more infectious wastes than usual, including masks, gloves, gowns and other protective equipment with a very high risk of infection by this virus [7]. In Wuhan, China, during this global COVID-19 pandemic, the average production of hospital wastes per 1000 persons, rose significantly from 3.64 kg/day to 27.32 kg/day [8]. With the emergence of the Coronavirus disease 2019 epidemic, hospitals have become places of high risk for the circulation of the virus and the management of infectious healthcare wastes has become a global concern [9], until reaching the energy sector where both negative and positive impacts were felt [9].

Therefore in Cameroon, the large quantities of wastes produced by health facilities and the growing interest in infection prevention in accordance with the riposte against the COVID-19 diseas, mean that the management of hospital wastes was becoming an increasingly important issue, especially materialized with Cameroon's commitment to sustainable development [10]. So that the promulgation of Decree N^{0}. 2012/2809/PM of 26 September 2012 on the conditions for sorting, collecting, storing, transporting, recovering, recycling, treating and finally disposing of waste, which stipulates in Article 12(1) that: medical and pharmaceutical wastes shall be subject to specific management aimed at avoiding any harm to the public health and the environment [11]. Similarly, Order N^{0}. 003/MINEPDED of 15th October 2012, setting the conditions for the management of medical and pharmaceutical wastes, classifying them into different categories, including category 1 which corresponds to ISHWs [12].

However, many recent studies affirm that incineration is the most common option of infectious solid hospital waste treatment method used worldwide. In Italy, a systematic review of the scientific literature on international governance of solid hospital waste management in Brescia, showed that incineration was the most common treatment method used worldwide [13]. In Benin, the study carried out on biomedical wastes management in various health facicities of Abomey-Calavi district revealed also that incineration is the most common treatment method [14]. In Algeria, a survey of the various health facilities in the municipality of Sidi-Bel-Abbès showed that biomedical wastes were treated by incineration [15]. Incineration appears to be the optimum solution for treating ISHWs, for the fact that this process is most often chosen to treat this particular type of solid hospital wastes, which cannot be recycled, reused or deposited in a landfill site [16]. In Pakistan, data from United State Environmental Protection

Agency reports and the operational experiences of industries show that incineration is one of the mature and reliable technologies for the treatment of critical healthcares wastes and it is possible that this option will remain relevant in the future, because while reducing the volume of wastes, it can easily treat hazardous organic materials, as well as pathogens contained in medical wastes [17]. In Senegal, the similar study highlighted that incineration was the most common method of disposing solid hospital wastes in four out of five hospitals [18].

Unfortunately in 2020, an obsevation emerges that uncontrolled incineration of ISHWs by old artisanal incinerators is the most common method of treating hazardous waste in most health facilities in Cameroon [10]. This is how in 2021, the Ministry of health (Minhealth) by following the revision of the Biomedical Waste Management Plan (BWMP) in relation to the Project for Preparation and Response to COVID-19 in Cameroon and Additional Financing (PPRCC+AF), the most recommended technological option for the management of ISHWs chosen in Cameroon is the controlled high-temperature dual-chamber incineration with flue gas treatment [12], when knowing that the exponential increase in hospital waste production during the COVID-19 pandemic response strategy caused a heavy burden on pre-existing treatment facilities, so that co-incineration of infectious solid hospital wastes in municipal solid waste incinerators had become an emergency treatment method [19].

This observation justifies the focus of this study, whose general objective is to assess the incineration practice of ISHWs in the specific case of public and private health facilities (HFs) of Douala, in order to identify shortcomings and propose a sustainable management strategy. Specifically, the study aims to quantify the production of ISHWs and then to analyse the types of ISHW incineration practised in HFs of Douala.

Material and Method

Documentary research

The literature review enabled us to take note of the scientific work already carried out in the field of solid hospital waste management throughout the world, which led us to give originality to this paper which assesses the incineration practice of infectious solid hospital wastes (ISHWs) in the specific case of public and private health facilities (HFs) of Douala.

Data collection

This study which is both transversal, descriptive, quantitative and qualitative took place from March 2023 to October 2023 and allowed to collect informations as follows:

- A formal letter requesting access to the data, drawn up by the Coordinator of our Research Laboratory in Engineering Sciences of the Higher National Polytechnic School of Douala (HNPSD), University of Douala (UD), was sent beforehand to the Littoral Regional Delegation of Public Health, led us to obtain both the health file of Douala city and the autorisation paper to access informations from the various health facilities (HFs) categories of Douala.
- Referring to the health file of Douala city, the census of the different categories of HFs was conducted by using a census sheet developed for this purpose.
- A survey form including the direct observation grid and a digital camera were used respectively to collect the quantitative and qualitative data for the study and to photograph the different ISHWs incineration equipment used in the different categories of HFs during the field investigations.
- The ISHW weighing campaigns, accompanied by the systematic wearing of personal protective equipment (PPE), were carried out by using 100 kg black plastic packaging bags in three-quarters filled which were then weighed on a Roberval scale, in order to quantify the daily ISHW production ratio by health facility category in Douala.
- The sampling for this study was carried out using a non-probability sampling technique and was non-exhaustive, as the study took into account the first six (06) of the seven (07) categories of health facilities that make up the Cameroon health system in Douala.
- The study population specifically included managers of medical services, surgical services, pharmaceutical services, laboratory services, hospital hygiene and sanitation services, quality services, surface technicians services, general supervisors, incinerator operators, as well as health facility security guards.

Data processing

The information collected during the field investigations was analysed and processed using Excel 2016.

The study variables included: the quantity of ISHWs produced in Douala (number of public and private health facilities by category, daily production ratio by category of health facilities, daily and annual production by category of health facilities) and analysis of the types of ISHWs incineration practised in Douala (inventory of incinerator types by category of health facilities and assessment of incineration types by category of health facilities).

Results

Quantifying the production of ISHWs in Douala

Number of public and private health facilities (HFs) by category in Douala

A total of 623 public and private HFs were identified in Douala all categories combined of the Cameroon's health system (Figure 1) as follows:

- Category 1: General Hospitals and Similar (GHS) (2);
- Category 2: Central Hospitals and Similar (CHS) (1);
- Category 3: Regional Hospitals and Similar (RHS) (0);
- Category 4: District Hospitals and Similar (DHS) (89);
- Category 5: Borough Medical Centers and Similar (BMS) (158);
- Category 6: Integrated Health Centers and Similar and similar (IHCS) (373)

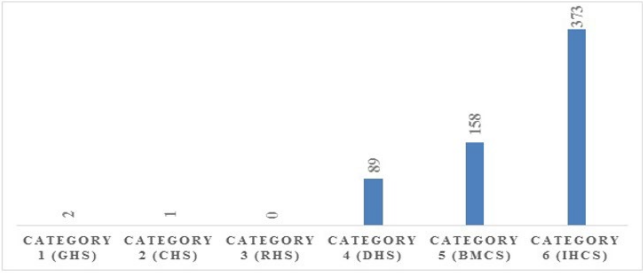

Figure 1: Number of health facilities by category in Douala.

Figure 1 shows that Douala had no Category 3 (RHS) health facilities. The respective categorization of HFs depends on the size of the technical platform, allowing the distinction between highest HFs (respectively categories 1, 2, 3, 4) and smallest HFs (respectively categories 5, 6) according the Cameroon health system.

Ratio of daily ISHWs production by category of HFs in Douala

With regard to the existing categories of health facilities in Douala as shown in Figure 2, the number per day of 100 kilograms (kg) of ISHW black plastic packaging bags in three-quarters filled, weighing 80 kg per bag on a Roberval scale, lead to obtain the following results illustrated in Table 1 respectively: (GHS) (13) with a ratio of 1014 kg/day; (CHS) (10) with a ratio of 800 kg/day; (DHS) (6) with a ratio of 480 kg/day; (BMCS) (2) with a ratio of 160 kg/day; finally (IHCS) (1/2) with a ratio of 40 kg/day.

Where:

Ratio (kg/day) = Number of 80 kg filled ISHW packaging black plastic bags x 80 kg x day^{-1}.

City	Categories of HFs	Number of 80 kg ISHW packaging bags filled per day	Ratio (Kg/day)
Douala	GHS	13	1040
	CHS	10	800
	DHS	6	480
	BMCS	2	160
	IHCS	1/2	40

Table 1: Ratio of daily ISHW production by category of HFs in Douala.

Daily and annual production of ISHWs by category of HFs in Douala

The evaluation of the daily production of ISHWs (kg/day) by category of HFs in Douala illustrated in Figure 2 was obtained (Table 2) as follows: GHS (2080); CHS (800); DHS (42 720); BMCS (25 280); IHCS (14 920), with a total production (kg/year) of ISHWs of 85 800 kg/day. Consequently, the annual production of ISHWs by existing categories of HFs in Douala gave the following results: GHS (759 200); CHS (292 000); DHS (15 592 800); BMCS (9 227 200); IHCS (5 445 14 800), with a total production (kg/year) of ISHWs of 31 317 000 kg/year (31 317 tonnes/year).

Where:

Total daily production of ISHWs (kg/day) = Ratio (kg/day) x Number recorded of the corresponding HF category.

Total annual production of ISHWs (kg/year) = Total daily production of ISHWs (kg/day) x 365 days x year^{-1}.

City	Categories of HFs	GHS	CHS	DHS	BMCS	IHCS	TOTAL
DOUALA	Number recorded	2	1	89	158	373	623
	Ratio (Kg/day)	1040	800	480	160	40	2 520
	Total production of ISHWs (kg/day)	2 080	800	42 720	25 280	14 920	85 800 kg/day
	Total production of ISHWs (kg/year)	759 200	292 000	15 592 800	9 227 200	5 445 800	31 317 000 Kg/year

Table 2: Daily and annual production of ISHWs by category of HFs in Douala.

Analysis of the types of ISHWs incineration practised by category of HFs in Douala

Inventory of the types types of ISHWs incinerators used by category of HFs in Douala

This result shown in Table 3 revealed a total of 88 incinerators of ISHWs of which, 5 Grand total modern incinerators (Figure 2a and 2b) and 83 Grand total artisanal incinerators including small-scale ovens (Figure 3a and 3b) and open burning pits (Figure 4), which were inventoried by category of health facilities (Figure 1) as follows:

- In GHS: modern (2) and artisanal (0).
- In CHS: modern (1) and artisanal (0).
- In DHS: modern (2) and artisanal (21) including 16 small-scale ovens and 5 open burning pits.
- In BMCS: modern (0) and artisanal open burning pits (34).
- In IHCS: modern (0) and artisanal open burning pits (28).

Where:

Grand total modern incinerators = ∑Total modern incinerators.

Grand total artisanal incinerators = ∑Total artisanal incinerators.

City Douala	Incinerators number of GHS		Incinerators number of CHS		Incinerators number of DHS		Incinerators number of BMCS		Incinerators number of IHCS		TOTAL
	Modern	Artisanal	Modern	Artisanal	Modern	Artisanal	Modern	Artisanal	Modern	Artisanal	
TOTAL	2	0	1	0	2	21	0	34	0	28	88
GRAND TOTAL	MODERN										5
	ARTISANAL										83

Table 3: Inventory of the types of ISHW incinerators used by category of HFs in Douala .

(a)

(b)

Figure 2: View of modern ISHW incineration plant in Douala. (a): External view, (b): Internal view.

(a)

(b)

Figure 3: External view of ISHW small-scale oven incineration plant in Douala. (a): Inactive ISHW small-scale oven incineration plant near the residential houses, (b): Active ISHW small-scale oven incineration plant emitting high toxic untreated flue gases.

Figure 4: View of an open burning pit of ISHWs in Douala.

Evaluation of the types of ISHWs incineration practised by category of HFs in Douala

The various previous results of Figure 1 and Table 3 revealed that:

- 100% of HFs of categories 1 and 2 practised controlled decentralised incineration of ISHWs using modern two-chamber incinerators with flue gas treatment (Figure 2a and 2b). These incinerators were 100% functional and met environmental standards for atmospheric emissions from incineration (Nitrogen Oxides (NOx) less than 80 mg/N m^3; Dioxins and Furans limited to 0.1 ng/m^3) and safety standards (presence of fire extinguishers (100%) and generators (100%)) (Figure 2b). These modern incinerators offered satisfactory operating conditions: good fuel consumption capacity of 10 L/h and good maintenance capability with a breakdown profile that was 100% sporadic and 100% caused by burner failure. These modern incinerators were 100% identical INCINIX incinerators brand with a good incineration capacity of 280 kg/h and a very high acquisition cost of around 500 000 000 FCFA.
- 23.6% of HFs of category 4 practised uncontrolled decentralised incineration of ISHWs using artisanal incinerators, of which 18% were small-scale ovens (Figure 3a and 3b), compared with 5.6% using open burning pits (Figure 4), which are the real factors in worsening atmospheric pollution through the uncontrolled emission of highly toxic smokes (Figure 3b). Only 2.3% of HFs of category 4 practised controlled decentralised incineration of ISHWs by the use of modern incinerators of the same characteristics (Figure 2b).
- 21.5% of HFs of categories 5 and 7.5% of HFs of category 6, which were more numerous, practised uncontrolled decentralised incineration of ISHWs using 100% open burning pits (Figure 4).

In total, this result revealed that decentralised incineration of ISHWs is mainly practised by 14.1% of HFs in Douala including controlled decentralised incineration of ISHWs practised by only 0.8% of HFs and uncontrolled decentralised incineration of ISHWs practised by 13.3% of HFs which represent the potential factors of health and environmental risks in Douala.

Discussion

Number of public and private health facilities by category in Douala

This study revealed in Figure 1 a total of 623 public and private health facilities (HFs) in Douala. This is significantly higher than the result of 47 public and private health facilities obtained in the study of Tidjani., *et al*. (2016) on biomedical wastes management in Abomey-Calavi district in Benin. This result allowed to observe a high density of health facilities in the city of Douala when comparing with many other African cities. This high density of health facilities observed in Douala represents the real potential high production of ISHW risk factor, as health facilities are the main producers of this hazardous wastes type. That is why the safe management of infectious solid hospital wastes by incineration in Douala appears nowaday as the major concern to control the health and environmental risks of ISHWs as identified in the similar studies carried out in Congo by Bertin., *et al*. (2015), in Cameroon by Messi (2016) and in Algeria by Khelifati., *et al*. (2017).

Ratio of daily ISHW production by category of health facilities in Douala

This result of Table 1 was obtained by the direct weighing of ISHW packaging black bags on a Roberval scale by category of health facilities in Douala. This method of quantifying the ISHW daily production ratio by direct weighing of ISHW packaging bags on a Roberval scale is the most accurate and should be used if there is an adequate weighing instrument in the health facility, when comparing with the various existing others as the method of adding numbers and estimating the volume of ISHW containers according to Sedrati., *et al*. (2017), or the method of the country income level according to Khelifati., *et al*. (2017), or the method of estimating by referencing number of persons (for example per 1000 persons) used by Yang., *et al*. (2021). It is very important to use the most accurate method of quantifying ISHW daily production ratio, because according to Sedrati., *et al*. (2017), the best quantification of ISHWs determines the choice of the best ISHW treatment system in order to evaluate the effectiveness of this managing system.

Daily and annual production of ISHWs by category of health facilities in Douala

This study revealed a high quantity of daily production (kg/day) of ISHW by category of health facilities in Douala as shown in Table 2 respectively of: GHS (1040); CHS (800); DHS (480); BMCS (160); IHCS (40). This result is respectively higher than that of CHS (175); DHS (30); BMCS (20); IHCS (15) obtained in the study in the city of Yaounde, Cameroon carried out by Messi (2016). This result is also higher than that of University Hospital Center (UHC) (500) a hospital of category 2 (CHS), obtained in the study of Khelifati., *et al*. (2017) carried out in Tizi-Ouzou in Algeria. In fact, this high quantity of ISHW daily production by category of HFs obtained in this study would be due not only to the high density of HFs by category observed in Douala as shown in Figure 1, but would be more related to the exponential increase of ISHW production observed since December 2020 across health facilities worldwide, due to the emergence of the Coronavirus 2019 pandemic (COVID-19) as explained the study carried out by Achili (2020). This is also revealed in the study carried out by Zhao., *et al*. (2021) who explained that in the reason of the response to the COVID-19 pandemic in China, medical services produced more infectious wastes than usual, including masks, gloves, gowns and other protective equipment with a very high risk of infection by this virus, thus compromising the capacity of pre-existing disposal systems. Yang., *et al*. (2021) in the same order of ideas explained it clearly that, during the global COVID-19 pandemic, the average production of hospital waste per 1,000 people in Wuhan, China, rose explosively, from 3.64 kg/day to 27.32 kg/day. Lan., *et al*. (2022) complained about it by explaining that this exponential increase in hospital waste production caused a heavy burden on pre-existing treatment facilities during the COVID-19 pandemic response strategy, so that co-incineration of infectious solid hospital wastes in municipal solid waste incinerators had become an emergency treatment method.

Inventory of the types of ISHWs incinerators used by category of health facilities in Douala

This study also revealed in Table 3 that of the 88 ISHWs incinerators inventoried in Douala, only 5 were moderns as illustrated by Figure 2a and 2b and 83 were artisanals including16 small-scale ovens as presented by Figure 3a and 3b and 67 open burning pits as viewed by Figure 4. This result is similar to the results of the similar studies carried out in Cameroon by Mbog., *et al*. (2020) and Algeria by Khelifati., *et al*. (2017) and Sonia (2021), which revealed that the incinerators found in the majority of health facilities were the old models emitting highly toxic combustion gases which are not in accordance with the current standards for new techniques as recommended by the WHO (2019).

Evaluation of the types of ISHWs incineration practised by category of health facilities in Douala

This study at last also revealed that the disposal method of ISHWs by decentralised incineration is practised by 14.1% of HFs in Douala. This low percentage obtained relating to the ISHW incineration practice in Douala reveals that incineration is not the most commonly practiced method of ISHW treatment in the city of Douala. This result is not in accordance with the results obtained in various studies worldwide as the study in Italy carried out by Caniato., *et al*. (2015), which revealed in a systematic review of the scientific literature on international governance of hospital waste management that incineration was generally the most common treatment method used worldwide. Or the study in Algeria carried out by Benhaddou., *et al*. (2019), which a survey of the various health facilities in the municipality of Sidi-Bel-Abbès revealed that biomedical waste was treated by incineration. Or the study in Pakistan carried out by Ahmad., *et al*. (2019), which revealed that data from United State Environmental Protection Agency reports and the operational experiences of industries show that incineration is one of the mature and reliable technologies for the treatment of critical care waste so that it is possible that this option will remain relevant in the future, because while reducing the volume of waste, it can easily treat hazardous organic materials, as well as pathogens contained in medical waste. Also Or the study in Senegal carried out by Ndiaye., *et al*. (2019), which revealed that incineration was the most common method of disposal solid hospital wastes in four out of five hospitals. Yet the Minhealth (2021), by following the revision of the Biomedical Waste Management Plan (BWMP) in relation to the Project for Preparation and Response to COVID-19 in Cameroon and Additional Financing (PPRCC+AF), recommended the high-temperature incineration with flue gas treatment as the most technological option for the management of ISHWs throughout the various HFs of Cameroon to be in accordance with the current standards for new techniques as recommended by the WHO (2019) for the safe management of this infectious wastes.

However, it should be noted that of 14.1% of HFs practising decentralised incineration as disposal method of ISHWs in Douala, only 0.8% of HFs of categories 1, 2 and 4 (Figure 1) in a bite numbers practice a controlled decentralised incineration of ISHWs by using modern dual-chamber incinerators with flue gases treatment (Figure 2a and 2b) in Douala, against 13.3% of HFs of categories 4, 5 and 6 practised uncontrolled decentralised incineration of ISHWs by using small-scale ovens (Figure 3a and 3b) and open burning pits (Figure 4), which are the potential factors of health and environmental risks by emitting highly toxic combustion gases. This result is in accordance with the results obtained in various studies in Africa, as the study in Cameroon carried out by Mbog., *et al*. (2020), which revealed that incineration by old model incinerators is the most common method of treating hazardous wastes in most health facilities. Or the studies in Algeria carried out by Khelifati., *et al*. (2017) and Sonia (2021), which revealed all that the incinerators found in the majority of health facilities were the old models emitting highly toxic combustion gases which are not in accordance with the current standards for new techniques yet recommended by the WHO (2019). In order to safely incinerate the large volume of coronavirus-infected waste in Algeria, Sonia. (2021) proposed the purchase of modern dual-chamber incinerators (combustion temperature of between 1000°C and 1100°C) with flue gas treatment (Figure 1) for controlled incineration of ISHWs in the purpose to be in accordance with the Stockholm Convention as recommended by the WHO (2019).

Conclusion

In definitive, the management by incineration of infectious solid hospital wastes (ISHWs) in Douala health facilities (HFs) remains a real problem in view of the potential health and environmental risks of uncontrolled incineration, a major concern both for politicians and for the HFs that daily practise it. The general aim of this study was to assess the incineration practice of ISHWs in public and private HFs of Douala in order to identify shortcomings and propose a sustainable management strategy. Specifically, the study set out to quantify the production of ISHWs in Douala, and then to analyse the types of ISHWs incineration practised by category of HFs in Douala. In the light of the above, the methodology used revealed that uncontrolled decentralised incineration of ISHWs is the most incineration commonly practised option, due to a shortage of modern incinerators for each category of HFs in Douala. A sustainable management strategy for the safe incineration of ISHWs would necessarily involve the pooling of existing modern resources through the creation of incineration pools between the different categories of public and private HFs in Douala.

Credit Authorship Contribution Statement

Georges MVOGO EKANI: Conceptualization, Investigation, Methodology, Formal analysis, Data curation, Validation, Funding

acquisition, Project administration, Writing – original draft. Séverin MBOG MBOG: Methodology, Data curation, Validation. Julbin Paul NJOCK: Formal analysis, Data curation, Validation. Patrice NGOKO POLMBAYE: Data curation. Patrice BOULLEYS: Investigation, Data curation. Borel NETAM BELLE: Investigation. Dieudonné BITONDO: Supervision, Methodology, Data curation, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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