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Eco-friendly Management of Medical and Pharmaceutical Waste: the case of Mdiq-Fnideq Hospital (Northern Morocco)

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Abstract

The management of harmful medical and pharmaceutical wastes were assessed in the provincial hospital of the city of Mdiq-Fnideq (Northern Morocco) based on an experiment conducted between 2013 and 2017.The hospital will subsequently become, an organization subjected to a managerial mode following a logic of cost / efficiency in promoting sorting at the source of its waste. The infectious waste will be separated, in special waste containers according to colour codes (Law 28-00), from waste considered as household waste. Thus, reducing treatment costs of harmful waste and increasing the quantity of recycled medical materials. Based on sorting at the source, Medical and Pharmaceutical Wastes (MPW) was implemented between 2013 and 2014 following four phases: mobilisation, observation, analysis, and synthesis, with interruption of the two last phases in 2015. The evaluation of MPW management protocols results during 2015 showed a significant increase (Tukey HSD test with $P < 0.05$), while the difference ratio showed that 2015 is more clearly significant compared to other years (2013 and 2014). Significant negative correlation ($r = -0.693$; $P < 0.01$) between the quantity of medical waste produced and the number of recycled-valued bottles, shows an increasing effort toward an eco-friendly institutions. In addition, the regression analysis confirm the negative correlation results, with $R^2 = 0.48$, $p < 0.05$.

1. Introduction

Environmental management is among the most pressing issues of our time. The irreversible nature of the environment is confirmed by the gradual decline of natural resources. Health facilities such as hospitals become today harmful waste producers. Since 1992 Morocco, ministerial directives were sent to public hospitals to resolve the situation of these wastes, however, the legal framework for medical and pharmaceutical waste has undergone major changes with the adoption of the following laws and regulations [1] - [2] - [3].

- Law No.28-00 on waste management and disposal
- Decree No. 2-07-253 carrying MPW classification and determining the list of hazardous waste
- Decree No. 2-09-139 on the management of medical waste and pharmaceutical
- Law No. 17-04 relating drug code and pharmacy
- Law No. 11-03 on the production and development of the environment
- Law No. 12-03 relating to environmental impact studies

However, the MPW management protocols are not respected or even transgressed [4] - [5]. These hospital wastes are among the most hazardous waste to health and the environment. They are classified at the higher level of risk into four categories depending on the classification of Moroccan Decree No. 2-09139 [1] - [3] - [6]:

- Category 1: includes waste with a high risk of infection or containing viable microorganisms or toxins that could cause disease to man or other living organisms. It includes as well human anatomical organs and tissues or unidentifiable animal (e.g. amputation organs), while spiky or sharp material intended for desertion, whether or not was in contact with a biological product. In addition to all blood products and by-products used in incompletely therapeutic use, damaged or expired.
- Category 2: Drugs, chemicals and biological unused, damaged or expired, and cytostatic and cytotoxic waste.
- Category 3: Human or animal anatomical organs and tissues easily identifiable by a non-specialist.
- Category 4: waste similar to domestic waste.

As a result, health facilities do not have shredders and sterilizers must subcontract their waste (category 1 and 2) treatment to specialised company, while those facilities with shredders & sterilizers must externalise part of their toxic waste (placenta, blood products, body parts, and cytostatic) for special treatment [1].

Wearing a close look at studied health institution, by monitoring of waste management process from sorting at the source to the treatment by autoclaving and disposal to landfill, and by analysing the situation of the PHC M'diq-Fnideq (questionnaire grid observation and interviews), it was found that:

- Although the process and the steps of MPW management are in place, the first step; which is the sorting; is not done properly, due to lack of information, staff training, monitoring, and control assessment process.
- The health facility is a producer of other non-harmful waste, which can be recycled and useful for people and for the environment [7].

Based on these findings, we advance the following hypothesis: A reliable and durable sorting in time will reduce MPW cost and quantity produced annually in hospital?

In this work, the management of harmful medical and pharmaceutical wastes were assessed in the provincial hospital of the city of Mdiq-Fnideq (Northern Morocco) based on an experiment conducted between 2013 and 2017 [8].

2. Materials and Methods

2.1 Place of study

This work was carried out in the provincial hospital (PHC) of the city of M'diq-Fnideq (Northern Morocco). Since its creation, the hospital offers diversified medical benefits, with a bed capacity of 40 beds up to 67 beds.

2.2 Initial situation:

The waste management monitoring protocol has been completed from the separation at source, treatment by autoclaving, until disposal to landfill. The following observations have been perceived:

- The MPW management protocol is implemented but the sorting is not done properly.

- The hospital is producer of other waste, not harmful, which can be recycled and used elsewhere.

2.3 Collection of data:

2.3.1 Quantitative Component:

- A questionnaire (11 questions) was distributed to all persons exposed to hazardous medical waste and risk to be injured or infected. Of 128 personnel surveyed, 97 responded to the questions, and 31 refused to answer.
- Direct observation: staff behaviour [9] - [10] in the daily management of infectious waste in their service.

2.3.2 Qualitative component:

- The consultation and analysis of archive documents related to the management of MPW provide clear overview about the amount of MPW generated by the hospital, the cost of treatment, CPS, investigation reports or supervision, monitoring documents, financial reports [10].
- Semi-structured interviews addressed to managers and PAA Chief on institutional waste policy, human resources, financial resources available, and the restraint and obligations related to waste management.

2.4 Definition of the study variables

- The dependent variable is the medical and pharmaceutical solid waste management system, which corresponds to a set of interacted elements (components). These components are organized to achieve a safe and effective management of MPW [5] - [10] - [11].
- The independent variables are represented by the resources, processes, and results [5] - [10] - [11].

2.5 Data analysis:

- Quantitative data were processed and analysed using Excel 2008 version 2010 (Results of the questionnaire, observation, and monthly and annual generation of waste)
- Statistical analysis were done (for the generation of medical and pharmaceutical waste management and waste recovery) by:
    - Test-one way ANOVA (Analysis of variance).
    - Post-Hoc test of Tukey HSD with P <0, 05 (difference Report).
    - Correlation Analysis
    - Regression analysis
- The qualitative data (interviews) were analysed based on content point of view.

3. Results and Discussion

3.1 Results of the questionnaire:

Despite the knowledge of infectious and biological risks, knowledge of waste categories and colour codes (Figure 1):

- The sorting practice at source is inadequate
- A vacuum in the legislative references and / or regulation is remarkable [12] - [13]
- The lack of training materials: guides and posters [14] - [15]
- Awareness by the administration is poor
- And the inexistence of a person responsible for the management of pharmaceutical medical waste.

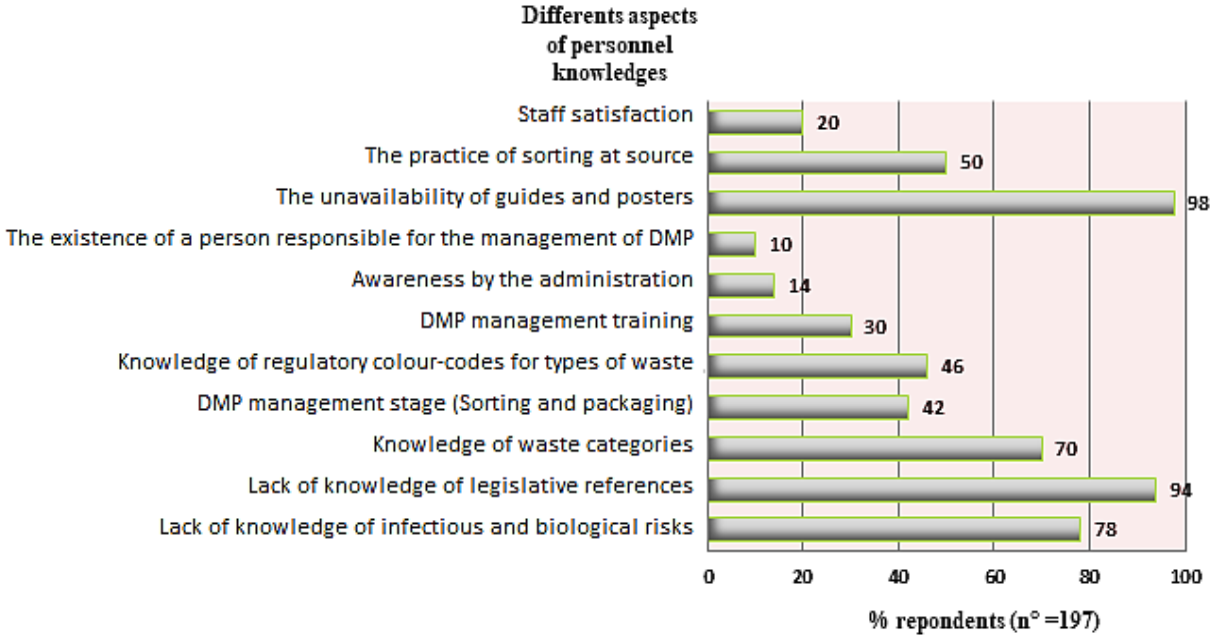

Figure. 1: Different aspect of personnel knowledge's

3.2 Results of observation

- **Professional practices of sorting and packaging:**
- 60% of health care staff do not practice and do not respect the sorting rules.
- 56% of them do not sort the MPW in suitable containers, despite the availability of materials (bags and containers specific for each waste).
- **Wearing protective equipment by staff**
- 90% nursing staff wear gloves (as protection) when performing each intervention, particularly when blood in involved. Meanwhile, not all staffs transporting and collecting MPW carry means of protection.
- **Professional practice of storage, collection, and transportation**
- The collection and transportation are provided a housekeeper and two professionals from ATHISA; a company responsible for transporting and processing MPW every Thursday at 13h.
- The hospital does not have a proper storage room meeting the national standards for MPW storage; they remain in each service (room care and sanitation) as until evacuation once a week.
- **Availability of equipment for collecting and transporting waste**
- A metal trolley with wheel is used internally to collect and transport MPW produced by the various services belonging to the hospital. However, wearing protection tools by the agent responsible for the waste treatment company is not fulfilled.
- **Availability of equipment for the evacuation of MPW outside hospital**

- A vehicle belonging to the company responsible for MPW processing provides the evacuation of the MPW.

- **Availability of documents between the hospital and the company responsible for MPW processing**

- The quantity delivered is not weighed at the hospital (weighed at the company), thus, there is a lack of traceability between the two parties (certificate or voucher).

3.3 Results of the interview:

- **The institutional policy for MPW Management**

According to the interview with the director and the head of administrative affairs, we noticed a willingness to improve their MPW management policy.
We noted that the provincial hospital of the city of Mdiq-Fnideq (hospital Mohammed VI) won the first price in the quality contest edition 2011 (category of less than 120 beds).The DMP management system was among the points to be improved by signing up in the 2013 edition of quality competition (lack of documentation, lack of commission, and resistance to change attitudes and behaviours were a challenge for the hospital) [7] - [8].

- **The organization of the MPW management system in hospital**

The MPW management system in Mohammed VI hospital (PHC Mdiq) was organized as part of the contract signed in 2012, and was reorganized as part of a call No. 09/2013 for externalisation and treatment of waste [16]-[17]-[18]. This call framework is for a period of three years (2013-2015). The objective is 'the collection, transport, and treatment of medical and pharmaceutical waste of various services of the hospital subject of this study.

- **Constraints linked to MPW management in CHP Mdiq**

Interviews with the director, the heads of nursing centres and administrative officer confirms that the medical and pharmaceutical waste management system is facing a number of constraints [16] - [17]. The main ones include the non-involvement and the immoral behaviour of most head nurses and staff of the various departments of the hospital [14], the lack of training and lack of traceability and monitoring and supervision tools.

3.4 MPW Management Protocol (medical and pharmaceuticals waste)

Following the findings revealed by the survey, observation, and interviews conducted, the implementation of an operational plan resolving of the identified problems will improve the performance of the MPW management in the hospital Mohammed VI. Thus, the idea to take action and implement sorting protocol at source [18] that will:

- Ensure the safety of staff
- Respect public health and the environment [5]
- Ensure that each waste follows an appropriate way
- Control costs [19]

In order to reduce processing costs and increase the amount of recycled materials to be reused [20], infectious waste will be separated from waste similar to household waste [21] - [22].
This protocol management of MPW (sorting) was introduced in 2013 and 2014 with these 4 phases:

- mobilization phase is a preparatory phase
- observation phase which is an implementation phase
- Analysis Phase: is a monitoring and evaluation phase
- Control phase.

And the year 2015, with interruption of two phases (phase of analysis and synthesis phase) (Figure 2) The medical waste management protocol is based on legislation, and good organization, throughout the waste channel (from the point of production to final disposal) (Figure 3).

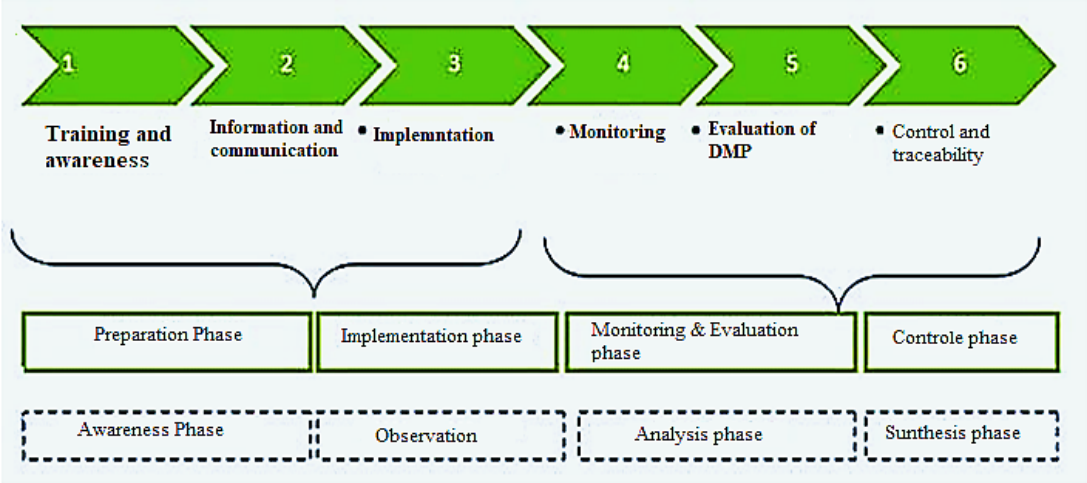

Figure. 2: Management Protocol (sorting) of MPW

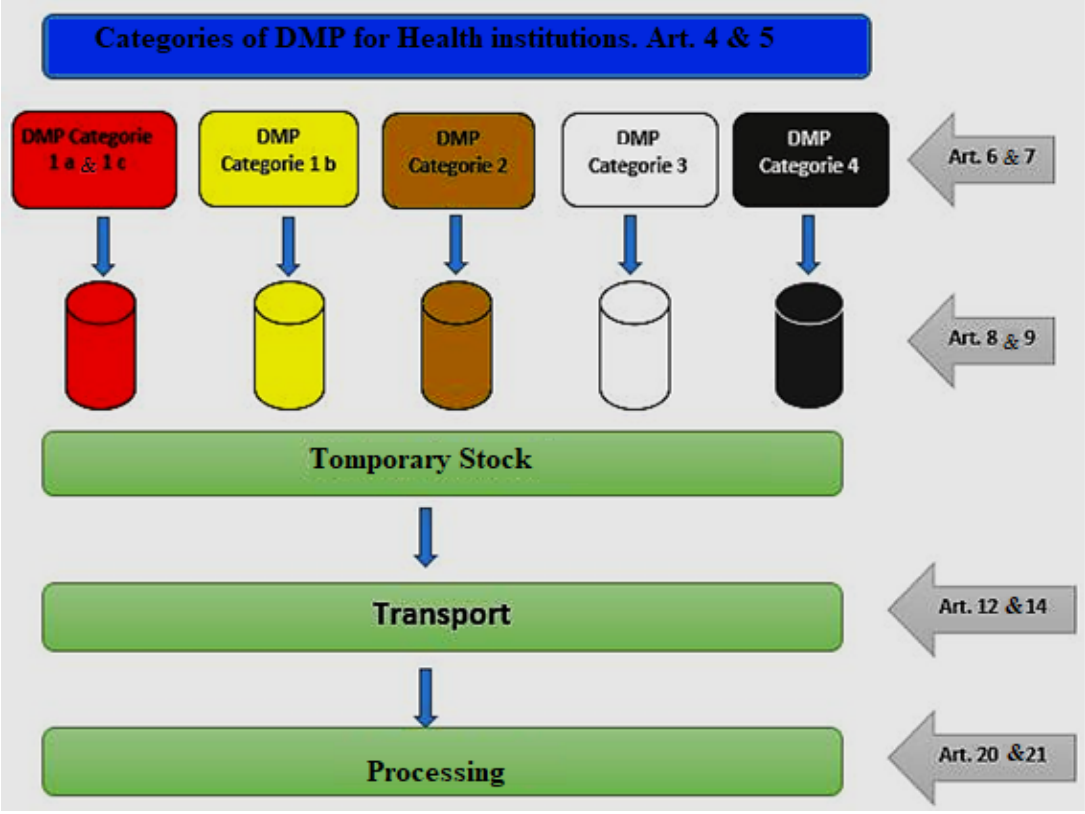

Figure. 3: Schematic of overall MPW management including regulatory conditions that apply (Derraji, 2011)

The evolution of the production of MPW during this period, 2013-2015 shows an increase (Table 1).

Statistical analysis was done to show that there is a significant difference between the years since 2012 to 2015 (Figure 4).

Table. 1: Evolution of the production of MPW by month and year (2013-2015)

	Quantity MPW2013 (kg)	Quantity MPW in 2014 (Kg)	Quantity MPW in 2015 (Kg)
January	**209**	**186**	**189.5**
February	**182.5**	**187.5**	**162**
March	**158.7**	**143.6**	**181.5**
April	**132.5**	**168.1**	**207**
May	**178.5**	**102.9**	**292.5**
June	**131**	**141**	**229.5**
July	**160.5**	**170**	**318**
August	**187.5**	**147.5**	**324**
September	**152.5**	**171**	**323**
October	**176.5**	**227**	**341**
November	**150**	**184.5**	**292.5**
December	**181.5**	**197**	**393**
Total	**2000.7**	**2026.1**	**3253.5**

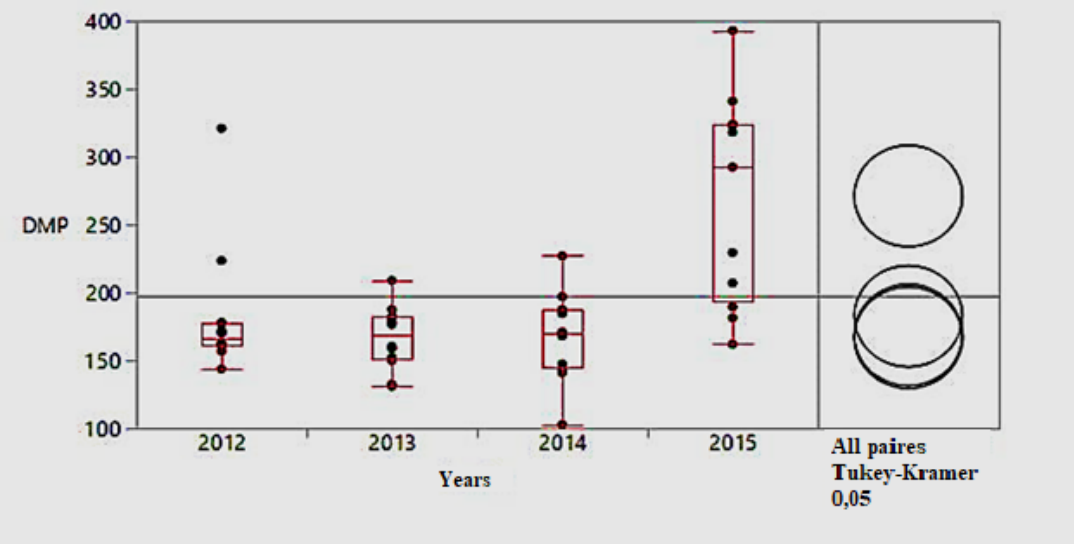

Figure. 4: MPW change between sampling years

The Analysis of variance (one-way ANOVA) shows that there is a significant difference (<0001 *) (Table 2). The evaluation of the production of DMP in 2015 shows significant increase proven by the multiple comparison test of tukey (Tukey HSD test with P <0.05), and the difference ratio, which showed that 2015 (A) is much more significant compared to other years 2014 (<0001 *) 2013 (<0001 *), and 2012 (0.0003 *). (B) (Table 3).

Table. 2: ANOVA test

Source	Degrees of freedom	Sum of square	Mean Square F	Report	Prob. > F
Year	3	88951.46	29650.5	12.6619	<.0001 *
residues	44	103,035.45	2341.7		
total corrected	47	191,986.90			

Table. 3: Test with Tukey HSD P <0.05

	Level	Average	letters
2015	A	271.12500	A
2012	B	182.54250	B
2014	B	168.84167	B
2013	B	166.72500	B

The cost-consequence analysis shows that the respect of sorting protocol has a positive impact on the MPW management, while nonfulfillment of the protocol cause an increase in the amount of waste in 2015 (combination of recyclable waste similar to household waste with non-recyclable infectious waste) (Table 4).

Table. 4: Report differences

Year (i)	Year (j)	Level Difference standard	Error of the difference	lower control limit	upper control limit	P-value
2015	2013	104.4000	19.75565	51.6523	157.1477	<.0001 *
	2014	102.2833	19.75565	49.5356	155.0310	<.0001 *
	2012	88.5825	19.75565	35.8348	141.3302	0.0003 *
2012	2013	15.8175	19.75565	-36.9302	68.5652	0.8537
	2014	13.7008	19.75565	-39.0469	66.4485	0.8990
2014	2013	2.1167	19.75565	-50.6310	54.8644	0.9996

Therefore, a tremendous work with various departments of the hospital was carried out, based on the mapping of MPW waste (e.g. waste type, production sources) [16] - [17].The work look at the possibilities of selling the recycled MPW materials such as bottles of glass [23] - [24]. This action required behaviour management, personal motivation and involvement of decision makers [25]. In Addition, it should have no negative effects on the provision of healthcare or slow down everyday tasks [25] - [26] - [27]. The aim is to provide a healthy ambiance, reduction and sorting of waste at source, and recovering and recycling of some residual materials [20] - [28] - [29].

To this end, an agreement between the hospital Mohammed VI Mdiq Tetuan and Faculty of Science of Abdelmalek Essaâdi University was signed. This partnership concerns the reuse and recovery of glass bottles produced as waste by the hospital. The Faculty laboratories received a steady delivery over the years 2015, 2016, and 2017. The first delivery was on 2015 to celebrate the World Earth Day or World Environment Day.

We have noticed an increase in bottles valued over the years 2015.2016 and 2017 (Figure 5), depending on their type (Figure 6).

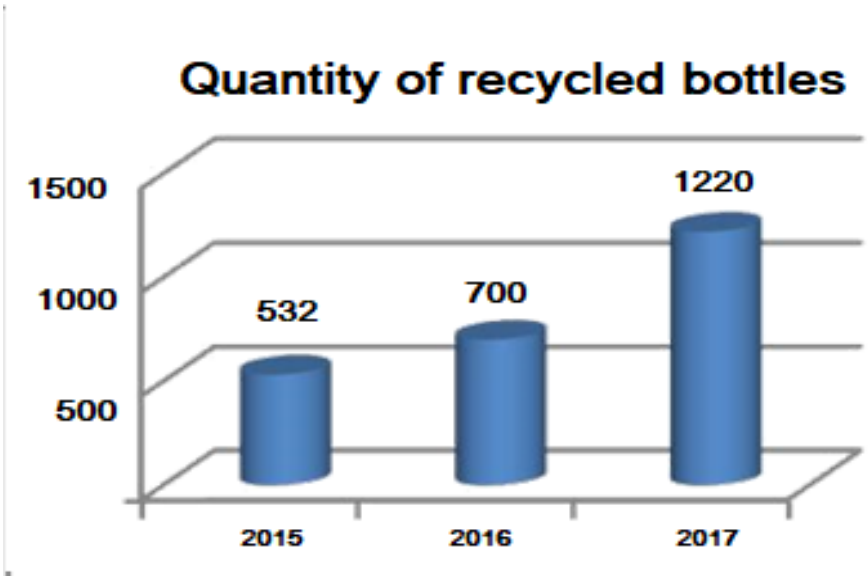

Figure . 5: Quantity of recycled bottles

Figure. 6: Types of glass bottles recycled and valued

An observation of the MPW management protocol over the years 2015, 2016, and 2017 showed a significant decrease during the year 2016 to 2017. It was marked by a major recycling glass bottles (the adoption of the recycling as a practice by employees of the CHP Mdiq-Fnideq) (Figure 7).

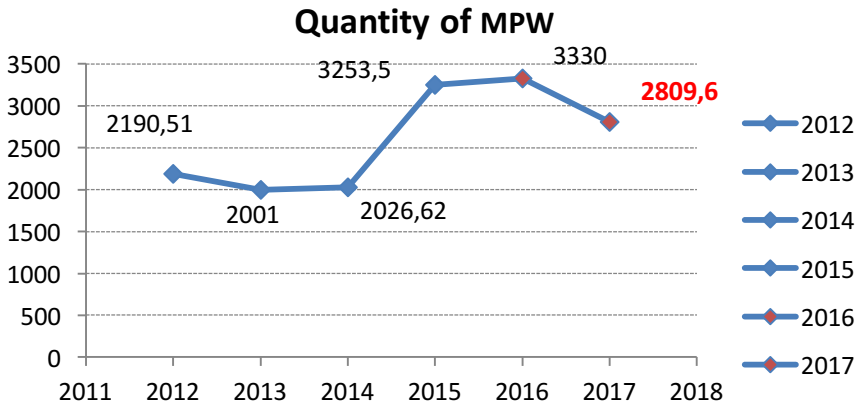

Figure. 7: Quantity of MPW

To demonstrate this impact, an analysis was done to identify the impact of recycling glass bottles on the management of medical and pharmaceuticals waste, and that by a correlation analysis and regression analysis.

*** Correlation analysis:**

Correlation analysis between the amount of the recovered bottles and quantity of waste for the 2016-2017 year. This analysis shows highly significant negative correlation between the waste and the amount of bottles valued in the range of - 0.693 ($P < 0.01$) which shows an increase in the valuation is for a decrease of pharmaceutical medical waste indirectly (Table 5).

Table. 5: Correlation between the amount of the recovered bottles and the amount of MPW in 2016-2017

	Quantity of recycled bottles
Waste in Kg	**-0,693** (P<0,01)

*** Regression analysis:**

The regression analysis between the amount of the bottles recovered and the quantity of waste shows that the decrease in the amount of waste is closely linked to the increase in the amount of the recovered bottles, with $R^2 = 0.48$, $p < 0.05$ (highly significant relationship between the amount of recycled bottles and the quantity of MPW) (Table 6)

Table. 6: Analyse of regression

Term	**Estimation**	**standard**	**t ratio**	**Prob. > |t|**

		Error		
Constant	357,3327	23,07476	15,49	<,0001*
quantity of recycled bottles	-0,96934	0,251875	-3,85	0,0014*

The management and recycling of waste (glass bottles) had a positive impact over time on MPW management at the hospital, well noticed on the ground, and statistically proven (Figure 8).

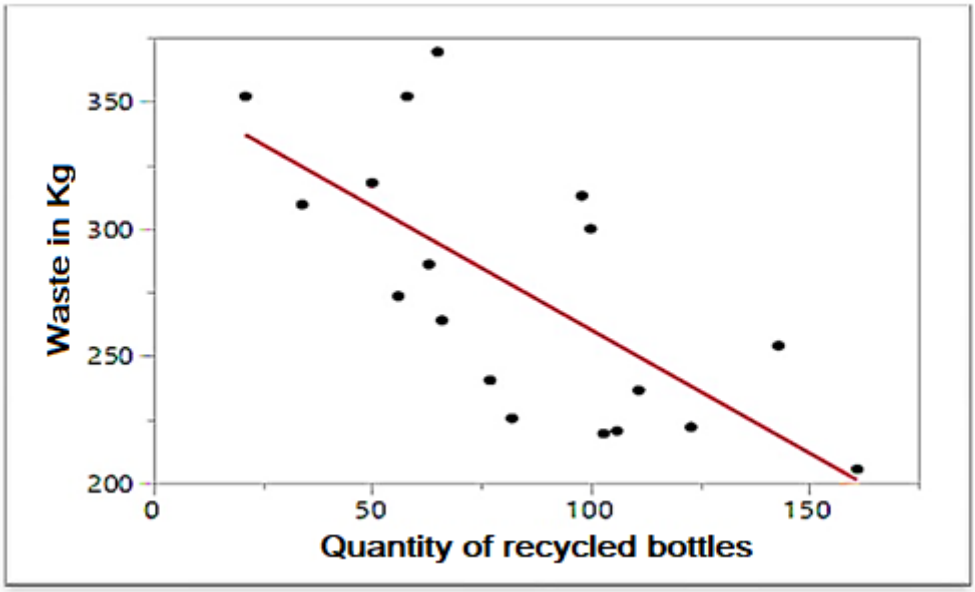

Figure. 8: Regression Analysis

Conclusion

This sorting of MPW adopted since 2013 has enabled the hospital to develop an internal strategy for sustainable development (2014 to 2017) by reducing the quantities of some waste dumped in landfills or processed in the processing units. A reliable sorting and sustainable over time, contributed to the prevention, protection of the internal and external environment of the HPC Mdiq-Fnideq. In addition, it contribute to the reduction treatment-cost and the annual amount of produced MPW.
In this study, we showed that the hospital Mohammed VI has contributed to the prevention and protection of its internal and external environment, by increasing the quantity of recycled waste and reducing the quantity of harmful MPW externalised for proper treatment. Thus, becomes a model of "rational and sustainable management."

Disclosure statement: *Conflict of Interest:* The authors declare that there are no conflicts of interest. *Compliance with Ethical Standards:* This article does not contain any studies involving human or animal subjects.

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