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Developing a Novel, Sustainable and Beneficial System for the Systematic Management of Hospital Wastes

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ABSTRACT

Introduction: India is the 2nd most populated country in the world. Population of India is increasing at a tremendous rate. Proportionately, the numbers of people seeking health care are increasing. In that ratio the quantities of hospital wastes, in wider terms, healthcare wastes that are getting generated is also increasing. Current methods for the safe disposal of healthcare wastes are not able to cope up with the rate of generation of healthcare wastes and moreover are not eco-friendly at all. Due to this, the current rules and regulations regarding the safe disposal of healthcare wastes are getting violated, ultimately leading to improper management of healthcare wastes, posing a serious threat to the environment and to the community.

Aim: To develop a novel, sustainable and beneficial system for the systematic management of healthcare wastes utilizing the strategies of waste reduction, waste segregation and recycling of Non Hazardous Hospital Wastes (NHHWs).

Materials and Methods: Firstly a detailed study of the Healthcare Waste Management System (HCWMS) operational at the Jaslok Hospital and Research Centre was done. A pilot study was then performed. After that, data regarding the generation and management of healthcare wastes in the other healthcare settings was collected and analyzed. Considering all this, a novel, sustainable and beneficial template system for the systematic management of healthcare wastes was proposed. Lastly the possible positive impacts from the implementation of HCWMSs designed using proposed template HCWMS in significant numbers of healthcare establishments was gauged.

Results: The healthcare waste management system operational at the Jaslok Hospital and Research Centre was found to be very efficient and provided vital inputs about developing the novel HCWMS. The pilot study was successfully completed generating significant revenue from the hospital's own NHHWs while managing them in an eco-friendly way. The total healthcare waste generation in Maharashtra was approximately estimated at about 2,89,200kg/day of which about 43,380kg/day was Bio-Medical Wastes (BMWs) while about 2,45,820kg/day were the NHHWs. This stresses the need of implementing HCWMSs in Healthcare Establishments (HCEs) based on the proposed novel template of HCWMS.

Conclusion: The novel template system is proposed in a detailed manner under various heads in the form of a handbook which is scalable upwards or downwards as per the requirement of a HCE. The enormous economic and environmental positive impacts from the implementation of the HCWMSs based on the proposed HCWMS in significant numbers of HCEs were presented numerically, putting light on the necessity and tremendous potential of this field of research.

Keywords: Beneficial, Ecofriendly, Non hazardous healthcare wastes, Recycling, Sustainable

INTRODUCTION

Healthcare waste is any waste which is generated in the diagnosis, treatment or immunization of human beings or animals or in research in a healthcare setting [1]. In other words healthcare waste literally means discards generated at a healthcare setting that are not intended for any further use for healthcare purpose in that specific setting. These healthcare wastes can be classified broadly into two major categories:

1. **Non Hazardous Healthcare Wastes (NHHWs):** NHHWs are the discards generated at the healthcare settings that are not contaminated with any infectious material, that are not infectious in nature by themselves, and that couldn't transmit any infection even if handled normally, that, disposal of which of shouldn't require any specific norms or processes and hence can be disposed of by normal routine methods. It represents a major, 80-85% of the total healthcare waste stream [1].
2. **Hazardous Wastes:** These are the discards generated at the healthcare setting that had been in contact with some infectious material, are infectious in nature by themselves and as their disposal is regulated by stringent norms and specific processes, they can't be disposed of by routine methods. It represents only a minor, 15-20% of the total healthcare waste stream [1].

Hospital waste management in the world is a formal discipline and does occupy a critical place in the management of health care sector. The management of hospital waste requires its removal and disposal from the HCEs as hygienically and economically as possible by methods that all stages minimizes the risk to public health and to environment. The present situation analysis of medical waste management systems was performed in a study. The waste disposal practice was found to be quite unsafe, and both clinical and non-clinical wastes were found to be thrown together. Medical waste incineration was identified as the most preferred disposal method. It is important to point out that there is a great potential to emit air toxic pollutants from such incinerators if improperly operated and managed. There is not enough information on medical waste management technologies and its impact on public health and environment. Practice of proper medical waste disposal and management is also inadequate [2].

According to a study, the current waste management practice observed at all studied hospitals in the Khartoum state was that most of wastes were all mixed together as they are generated, collected and finally disposed of. Only a small portion of waste in some hospitals (part of potentially infectious, body parts, and sharps) were collected separately and treated in a central incinerator. At the hospital level, no policies or rules were found [3]. Another study on 20 healthcare facilities in Akure, Nigeria, revealed that there was no uniform practice of hospital waste management among the hospitals studied. The study recommended that there should be

source segregation of waste within each hospital as all wastes were often mixed in the same waste basket [4].

Recently, worldwide awareness has grown regarding the need to impose stricter controls on the handling and disposal of wastes generated by healthcare facilities. In a study it was noted that the current system of healthcare waste management was underdeveloped and was in dire need of immediate attention and improvement, especially in Mongolia and Pakistan; the medical waste management practices were better in the hospitals studied in Thailand. The study underscored the importance for improvement of medical waste management of a national regulatory framework, a sound internal management system, and programs to train and ensure the safety of related personnel, as well as programs to estimate quantities of waste generated and to evaluate appropriate techniques of disposal. Once a healthcare waste management plan has been prepared, a regular program of inspection and review can be undertaken within the healthcare institutions [5].

The management of medical waste is of great significance due to its related potential environmental impacts and public health hazards. The results of a study conducted in 20 Khartoum state hospitals showed, that the hospitals generate a total of 6253.8 kg/day of wastes, of which about 5003 kg (80%) are non hazardous and 1250.8 kg (20%) are hazardous. The study revealed that partial segregation for medical waste was applied in 85% of the waste. Infectious - hazardous waste was mixed with general waste and disposed off in a municipal waste landfill. Only a few hospitals were found to be conducting training sessions and using the protective equipments. Most of the hospitals had no clear policy of waste management while hardly any hospital had a waste management plan. The study concluded that shortages in waste management in hospitals were generally due to lack of financial resources and training as well as administrative reasons [6].

In the UK, clinical waste and the way it is to be handled is closely regulated. Applicable legislations include the Environmental Protection Act 1990 (Part II), Waste Management Licensing Regulations 1994, and the Hazardous Waste Regulations (England & Wales) 2005, as well as the Special Waste Regulations in Scotland. In the United States, there are three main methods for medical waste generators to dispose of their waste: On-site, truck service, and mail-back disposal [7]. In Europe communities use a proprietary automated collection system known as 'Envac', which conveys refuse via underground conduits using a vacuum system. In Israel, the Arrow Ecology company has developed the ArrowBio system, which takes trash directly from collection trucks and separates organic and inorganic materials through gravitational settling, screening, and hydro-mechanical shredding. The system is capable of sorting huge volume of solid waste, salvaging recyclables. The system is also used in California, Australia, Greece, Mexico and United Kingdom. In Taipei, the city government charges its households and industries for the volume of rubbish they produce. This policy has successfully reduced the amount of waste the city produces and increased the recycling rate. In San Francisco, the local government established its mandatory recycling and composting ordinance in support of its goal of zero waste by 2020, requiring everyone in the city to keep recyclables and compostables out of the landfill. The City's "Pay-As-You-Throw" system charges customers by the volume of landfill-bound materials, which provides a financial incentive to separate recyclables and compostables from other discards. The City's Department of the Environment's Zero Waste Program has led the City to achieve 80% diversion, the highest diversion rate in North America [8].

Need for the Research

In India the management of BMWs is regulated by the 'Bio-Medical Waste Management Rules, 2016 [9]. It doesn't specifically spell any word about the management of NHHWs. That means in India the management of NHHWs is not regulated by any law, rule or regulation. When considering management of healthcare wastes generally most of the attention is focused only on the management of hazardous wastes i.e., BMWs which constitute only 15-20% of the overall healthcare wastes. Not much attention is paid towards the precise and systematic management of NHHWs. Due to lack of awareness about waste segregation, ignorance and for various other reasons, these NHHWs are habitually and unintentionally mixed and disposed off with the hazardous wastes, unnecessarily complicating the otherwise easy management of the major fraction of healthcare wastes i.e., of NHHWs [10]. The processes like landfilling and incineration that are majorly used for the disposal of healthcare wastes are causing severe pollution, are not sustainable and are already overburdened [1,9,11]. Ideally, bare minimum quantities of wastes should go for incineration and landfilling. Only the infectious hazardous wastes like needles, syringes, etc, must be incinerated and wastes like anatomical wastes, etc, must be landfilled [9]. Unnecessary load of managing NHHWs shouldn't be put on these methods. Hence, a novel healthcare waste management system must be developed whose implementation will also provide some incentive to the healthcare setting, so it will not be only the fear of legal action but it will be the willingness of healthcare settings as a driving force to implement such a beneficial healthcare waste management system.

Unique Novel Component of the Research

This research is associated with a major branch of applied biology i.e., Applied Environmental Biology. Through this research we aimed to solve a major crisis of healthcare waste management by developing a novel, sustainable and a beneficial system for the systematic management of healthcare wastes through waste reduction, waste segregation and continual recycling of segregated NHHWs. The newly developed HCWMS is presented in the form of a handbook as a conclusion of this research, which could act like a template for any healthcare setting to build their own tailored, personalized and customized healthcare waste management system according to their own specific requirements just by scaling the proposed template system up or down.

MATERIALS AND METHODS

This research project, approved by the Research Recognition Committee of the University of Mumbai, was conducted at The Jaslok Hospital and Research Centre from September 2012 to November 2015.

This project was planned, executed and completed in the following stages:

STAGE 1: Getting acquainted with the Jaslok Hospital and Research Centre with a detailed study of HCWM system operational at the Jaslok Hospital and Research Centre.

Procedure:

- Getting acquainted with the Jaslok Hospital and Research Centre at large.
- Realizing facilities and services available at the Jaslok Hospital and Research Centre.
- Understanding the floor distribution of the Jaslok Hospital and Research Centre.
- Understanding the different types of wastes generated at the Jaslok Hospital and Research Centre.
- Figuring out the quantities of wastes generated at the Jaslok hospital and research centre through direct discussions and interviews with the key waste management personnel of the Jaslok Hospital and from the available temporal records of the Jaslok Hospital about waste generation.
- Identifying the areas of generation of these wastes at the Jaslok Hospital and Research Centre.

- Identifying the persons responsible for waste generation at those sites.
- Identifying the persons responsible for waste management at the Jaslok Hospital and Research Centre.
- Understanding the hierarchical distribution of the personnel related to WMS.
- Understanding duties of each of the post in the hierarchy according to the WMS.
- Understanding the waste segregation system followed at the Jaslok Hospital and Research Centre.
- Understanding the colour coding system followed at the Jaslok Hospital and Research Centre.
- Understanding the placement of different waste receptacles throughout the jaslok Hospital and Research Centre.
- Understanding the movement of wastes inside the Jaslok Hospital and Research Centre.
- Understanding the collection schedules of wastes from different areas of the Jaslok Hospital and Research Centre.
- Understanding the manner in which the wastes are stored in the Jaslok Hospital and Research Centre.
- Understanding the manner in which the wastes are sent out of the premises of the Jaslok Hospital and Research Centre.

Hazardous healthcare wastes	Non hazardous healthcare wastes
Catheters, Tubings, Cannulae, Syringes Used gloves, IV sets, Infected plastic wastes, Microbiological cultures, Discarded blood bags, Vaccines, Human tissues, Body parts, Contaminated Cotton. Chemotherapy wastes, Cytotoxic wastes, discarded medicines. Sharps, Blades, Needles, Scalpels, etc.	General wastes Non infected plastic material Cardboards Metal containers Office wastes Paper wastes Disposables like glasses, tissue papers, etc.

[Table/Fig-1]: Healthcare wastes divided into primary segregation categories in Jaslok hospital

As evident from [Table/Fig-1], though the items in the non hazardous list are fewer than those in the hazardous list, the quantity of non hazardous wastes is far more than that of the hazardous wastes.

In the Jaslok hospital, the generated healthcare wastes are properly segregated and then stored in containers and bags of specific specifications according to colour coding prescribed by the national governing authority and then they are safely handed over to different agencies according to the types of wastes for offsite transport, as detailed in [Table/Fig-2].

Permitted agency	Type of waste
SMS Envo-Clean	Non sharp hazardous wastes
	Sharp hazardous wastes
Municipal Corporation	Wet non hazardous wastes
Contractor	Dry non hazardous wastes

[Table/Fig-2]: Permitted agencies and types of wastes they can carry out of the premises of Jaslok hospital

With reference to [Table/Fig-2]: During the said research, the researcher was allowed to work only on the left over dry NHHWs of the Jaslok hospital which were not taken out by the contractor. So, the quantification data about the dry NHHWs in the said research about Jaslok hospital is excluding the part taken out by the contractor.

STAGE 2: The pilot study

Procedure:

- Coordinating with the select persons in the WMS of the Jaslok Hospital and Research Centre to start the pilot study.
- Selecting the types and categories of wastes needed for conducting the pilot study.
- Finding a place to temporarily store the segregated NHHWs till they are vended to the contractors.
- Taking all the necessary permissions from the management of the Jaslok Hospital and Research Centre to carry the NHHWs of the hospital outside its premises for the pilot study.
- Selecting some persons from the WMS of the Jaslok hospital and,
  - Educating them for differentiating NHHWs from the hazardous ones.
  - Training them to segregate NHHWs wastes from the hazardous ones at the site of generation itself. Also, notifying them about the occupational hazards and associated protective solutions.
- Collecting a representative significant quantity of segregated NHHWs from the Jaslok Hospital and Research Centre segregated by these selected persons from the WMS of the Jaslok Hospital and Research Centre.
- Further segregating the collected NHHWs according to their selected component materials, Viz.,
  - Paper
  - Plastic
  - Metal
- Vending the segregated components of the NHHWs from the Jaslok Hospital and Research Centre to the contractors/ recyclers.
- Submitting the revenue generated by vending these component materials to the contractors/recyclers, back to the Jaslok Hospital and Research Centre.

STAGE 3: Data collection and analysis

Procedure:

- Preparing a questionnaire under the guidance of the guide, covering important aspects of the healthcare waste management systems. [APPENDIX].
- Taking a formal letter from the management of the Jaslok Hospital and Research Centre requesting the healthcare settings to provide the required information according to the approved questionnaire.
- Personally visiting the select healthcare settings and retrieving data from them according to the questionnaire.
- In case of failure of the healthcare settings in providing the required information, collecting the required data from authenticate reports of concerned responsible agencies working in the field of healthcare waste management, which will be more wide reaching.
- Numerically computing magnitude of the quantities of NHHWs from available data on BMWs taking help of the proportions stated by the World Health Organization (WHO).
- Logically analysing the collected data.

STAGE 4: Concluding the research by proposing the Novel Template HCWMS.

Procedure:

- Considering the HCWMS operational at the Jaslok Hospital, results of the pilot study and the extensive data analysis performed, the proposed novel template HCWM system was presented and detailed under the headings as mentioned in the discussion section of this article in the form of a handbook.

STAGE 5: Gauging the positive impacts

Procedure:

- Considering the collected data on healthcare waste management and the computed values thereof.
- Relating the data to the current market situation and healthcare waste management trends.

- Presenting the positive economic and environmental impacts in terms of expected:
  - o Economic benefits to the healthcare settings.
  - o Reduction in the quantities of wastes unnecessarily sent for incineration or landfilling.
  - o Reduction in the resource requirements by the CBMWTDFs.
  - o Reduction in the requirements of fresh raw materials by the paper, plastic and cardboard manufacturing industries due to the recycling of NHHWs.
  - o Numbers of trees that can be saved by recycling the NHHWs.

RESULTS

STAGE 1: Studying HCWMS at the Jaslok Hospital and Research Centre

We thoroughly studied the working of the Jaslok Hospital with a major focus on the HCWMS operational over there. The HCWMS operational at the Jaslok Hospital and Research Centre was found to be very efficient. Following key findings were recorded in [Table/Fig-3].

Waste	Approx. per day (kg)	Approx. per month (kg)	Approx. per year (kg)
Total Hospital Wastes	700	21000	252000
Hazardous Wastes	300	9000	108000
Non Hazardous Wastes	400	12000	144000
Wet NHHWs (kitchen/pantry wastes)	200	6000	72000
Dry NHHWs (excluding the part taken out by the contractor)	200	6000	72000

[Table/Fig-3]: The average approximate generation of waste in the Jaslok Hospital per day, per month and per year.

STAGE 2: The Pilot study:

The researcher collected some quantity of segregated dry NHHWs from the Jaslok hospital for vending it to the recyclers and submitted the generated revenue back to the Jaslok hospital, the intent of the research was hence proved on a smaller scale as detailed in [Table/Fig-4].

STAGE 3: Data collection and analyses

A questionnaire was prepared by the researcher about the health-care waste management to be filled by the select healthcare settings (Refer appendix for questionnaire). Researcher visited two reasonably old, renowned healthcare settings, whose names can't be disclosed as not to harm their reputation. None of the two settings were ready to fill the questionnaire. This puts light on the psychological state of unnecessary tabooed thinking or unnecessary fear of the law, rules and regulations related to healthcare waste management established in the mindsets of the healthcare industry. Hence, rather than wasting time in collecting data by this method, we thoroughly reviewed and analysed the data provided in the reports of The Maharashtra Pollution Control Board (MPCB) regarding the healthcare waste management [10] which was the most updated version of the document at the time this phase of research was going on and derived the required data from it. While reviewing and analysing the data in such reports, it was kept in mind that as implicated by the WHO, the quantities of NHHWs should be considered to be at least 75-80% of the quoted quantities of BMWs as pollution control boards record data only about BMWs.

Component material of NHHWs	Weight (Kg)
Paper	22
Cardboard	27
Plastic	10

Rate at which the component materials were vended to the contractors (Rs./kg):

Component material	Rate (Rs. / Kg)
Paper	9
Cardboard	5
Plastic	10

The revenue generated by vending these component materials to the contractors:

Quantity of component material	Multiplying by rate / Kg	Amount (Rs.)
22 kg Papers	22 x 9	198/-
27 kg Cardboards	27 x 5	135/-
10 kg Plastic	10 x 10	100/-
Total amount generated		433/-

[Table/Fig-4]: Results of the pilot study.
The revenue of Rs. 433/- that was generated from this pilot study was submitted to the Jaslok Hospital, vide receipt No. MR-01-12001360 dated 28/03/2013.

DISCUSSION

The Bio-Medical Waste Management Rules, 2016 as well as the respective state pollution control boards do not spell out any specific category, segregation system, colour coding, treatment and disposal method specifically for the management of NHHWs which constitutes about 75-80% quantum of healthcare wastes.

There is a major misconception established in the mindsets of most of the personnel involved in the management of healthcare wastes. If someone mixes hazardous waste with NHHW and disposes of this mixed waste by routine methods then it becomes an offence according to the law. But if someone mixes NHHW with hazardous waste and disposes off this mixed waste by regulated methods then it doesn't become an offence according to the law! This is an entirely wrong concept. Considering the enormous quantity of healthcare wastes getting generated nowadays, we must think to arrest damage to the environment due to ignorant mixed disposals of NHHWs and hazardous wastes. Hazardous and non hazardous wastes should strictly be segregated and managed by specific methods intended to manage these different types of wastes.

There are total 45,784HCEs in Maharashtra, excluding Chandrapur region, out of which 13,236 i.e. about 28% HCEs are not even a member of Common Bio-Medical Waste Treatment and Disposal Facility (CBMWTDF) nor they have their own facility for BMW disposal. What happens with the huge quantities of healthcare wastes generated in these non-compliant settings is totally unaudited and unknown.

The total quantity of BMWs generated per day in the state of Maharashtra is 43,380kg. Total quantity of BMWs treated per day in the state of Maharashtra is 38,202kg. It is totally unknown that what happens with the remaining 5,178kg/day of BMWs.

Considering the proportion of BMWs (15%) to the NHHWs (85%) as laid down by the WHO, the quantity of NHHWs in the state of Maharashtra estimates to be a stunning 2,45,820kg/day. As reviewed from the MPCB report and computed values as per the proportions laid down by the WHO about BMWs and NHHWs, the region wise generation of healthcare wastes in Maharashtra is detailed in [Table/Fig-5].

There are only 31 CBMWTDF operators and transporters for BMWs in Maharashtra. Considering the vast area of the state, ever increasing numbers of HCEs and according increase in the quantity of healthcare wastes in the state, the number of CBMWTDF operators seems insufficient, resulting in overloading of their work.

Ideally incineration use must be kept to a minimal extent. According to the data provided in the report of MPCB, on an average 79% of the total healthcare waste generated is getting incinerated. In some CBMWTDFs the incinerators operates like all day long. This is against the guidelines laid down by WHO and other agencies.

Region	Total healthcare waste generated (Kg/Day)	BMWs generated (Kg/Day) (15%)	NHHWs generated (Kg/Day) (85%)
Amravati	10560	1584	8976
Aurangabad	23200	3480	19720
Kalyan	6066	910	5156
Kolhapur	27933	4190	23743
Mumbai	67260	10089	57171
Nagpur	50113	7517	42596
Nasik	24053	3608	20445
Navi Mumbai	3606	541	3065
Pune	56633	8495	48138
Raigad	14106	2116	11990
Thane	5666	850	4816
Maharashtra	289200	43380	245820

[Table/Fig-5]: Region wise generation of healthcare wastes in the state of Maharashtra

A field survey was carried out by the MPCB at HCEs all over Maharashtra which was published in its report of June 2011. As mentioned in that specific report, quantities of BMWs generated, in most HCEs did not match with the numbers presented in the respective BMW authorizations. In most of the HCEs, per bed BMW generation figures were way higher (0.7-0.5kg/bed/day) than the average (0.3-0.1kg/bed/day). On enquiry by the MPCB it was revealed that most of the times non-contaminated wastes (NHHWs) were disposed off along with BMWs (hazardous wastes) [10]. According to this data about 0.4 kg/bed/day of NHHWs are mixed with hazardous wastes and disposed off. So, it is apparent that there is mixed disposal of hazardous and non hazardous wastes, unnecessarily increasing the total quantity of hazardous wastes. That means, around 57% NHHWs are getting mixed with 43% actual hazardous waste and are disposed off in a mixed fashion. The segregation practices still need immense improvements to bring down the percentage of hazardous wastes from 43% to 15% and to increase the percentage of NHHWs from 57% to 85% as laid down by WHO.

Sensing all these challenges, taking help of the study of the HCWM system operational at the Jaslok Hospital and Research Centre, the pilot study was done, extensive data analyses was conducted and recommendations made therein, considering requirements of the healthcare industry and time, we have developed our novel, sustainable, ecofriendly and beneficial template system for healthcare waste management.

Proposal for a Novel Template HCWMS

The proposed novel template HCWM system is presented and detailed in the form of a handbook under the following headings, encompassing even minute details about setting up of a novel HCWMS at any healthcare setting.

- Location of the healthcare setting.
- Specialty of the healthcare setting.
- Category of the healthcare setting.
- Financial status of the healthcare setting.
- Willingness of the top management of a HCE to implement a HCWMS designed using the proposed template HCWMS.
- Development of a waste management plan.
- Hierarchical Management structure of the WMS detailing responsibilities of each of the posts in the hierarchy.
- Implementation of the waste management plan.
- Assessing current situation of WMS (if any) at the healthcare setting.
- Understanding categorization of wastes generated at the healthcare setting.
- Assessment of waste generation.
- Strategies of waste minimization.
- Improved waste segregation.
- Waste receptacles.
- Color coding of waste receptacles.
- Closing and tagging of bags.
- Schedules for waste pickup.
- Internal waste transport.
- Storage areas for wastes.
- Offsite transport of wastes.
- Management of liquid wastes.
- Economics of healthcare waste management.
- Hospital hygiene, infection control, safe practices for WM staff.
- Training, education and public awareness.
- Healthcare waste management in emergencies.
- Inventory management.
- Personnel management including recruitments.
- Evaluation, feedback and improvement.
- Novel, beneficial component of the system.

Gauging the Positive Impacts

As mentioned in [Table/Fig-6], the state of Maharashtra generates a stunning quantity of 2,45,820 kg of NHHWs each day. Also from a survey conducted by MPCB, it was derived that about 57% of NHHWs is disposed of in a mixed fashion with 43% actual hazardous wastes [10], while the rest 43% of NHHWs may be given to the municipal waste management systems by the healthcare settings.

Region	Total NHHWs generated (Kg/Day)	NHHWs getting mixed with BMWs (57%) (Kg/Day)	NHHWs given to municipal settings (43%) (Kg/Day)
Maharashtra	2,45,820	1,40,117	1,05,703

[Table/Fig-6]: fate of NHHWs in the state of Maharashtra.

According to this, if healthcare settings in Maharashtra utilize the proposed template HCWMS to build their own and implement it sincerely, about 1,40,117kg of NHHWs per day can be prevented from getting mixed with BMWs and getting disposed off in a mixed fashion [Table/Fig-6]. The HCEs will save a considerable amount from their fees for BMW management as significantly less quantity of wastes will be sent to the CBMWTDFs. That means about 1,40,117 kg of NHHWs per day can be prevented from being incinerated. Accordingly the fuel and resources required for incineration will be saved with proportionate significant decrease in pollution. From the perspective of municipal waste management systems the unnecessary extra load of managing about 1,05,703 kg of NHHWs will be totally reduced. If had to managed by the municipalities these wastes would have landed up in the already overflowing dumping grounds with the normal wastes of the city.

According to the representative pilot study conducted by us at the Jaslok Hospital and Research Centre from the total NHHWs collected, the paper wastes were about 37%, cardboard wastes were about 46% and plastic wastes were about 17%. Considering the figures for the state of Maharashtra from the total NHHWs of 2,45,820kg/day about 90,953 kg will be paper wastes, about 1,13,077kg will be cardboard wastes and about 41,789kg will be plastic wastes generated per day, which all can be beneficially recycled.

Economically, again according to the pilot study conducted the recyclers were tendering paper at Rs. 9/kg, cardboard at Rs. 5/kg and plastic at Rs. 10/kg. So, in total the healthcare settings in Maharashtra can generate a revenue of Rs. 8,18,577/- per day by

recycling just their paper wastes, Rs. 5,65,385/- per day by recycling just their cardboard wastes and Rs. 4,17,890/- per day by recycling just their plastic wastes. The total revenue that can be generated by the total healthcare settings in the state of Maharashtra comes to around a stunning Rs.18,01,852/- per day.

One ton of recycled paper can save 17 trees, 380 gallons of oil = 1520L. oil, 2.3 cubic meter of landfill space, 4000 kilowatts of energy and 7000 gallons of water = 28000L of water [12]. Recycling 1 ton of cardboard saves, 17 trees, 390 kw of energy, 46 gal of oil = 184L of oil and 7 cubic meter of landfill space [13]. Recycling 1 ton of plastic saves 5,774 kWh of energy, 2,604 litres of oil and 22 cubic metres of landfill space [14]. In the state of Maharashtra, as per the calculations described herein above for the generation of NHHWs about 91 ton of non hazardous healthcare paper wastes, about 113 ton of non hazardous healthcare cardboard wastes and about 41 ton of non hazardous healthcare plastic wastes are generated per day.

Just by recycling the properly segregated NHHWs that too only in the state of Maharashtra, that too excluding Chandrapur region:

- About 3,468 trees can be saved per day.
- About 2,65,876 liter of oil can be saved per day.
- About 1,902 cubic meter of landfill space can be saved per day.
- About 6,44,804 Kw of electrical energy can be saved per day.
- And about 25,48,000 lit of water will be saved per day in this drought prone state.

CONCLUSION

In healthcare field, much of the focus of research is on the development of new technologies, techniques, drugs, drug delivery systems, etc. It is also important to think about how to manage the huge loads of healthcare wastes that are and will be getting generated and their eco-friendly management. A breakthrough in the form of a new healthcare waste management system is a need of hour. Hence, we concluded our research by providing a template novel, sustainable and perhaps beneficial system for the eco-friendly management of healthcare wastes. Implementation of the HCWMSs designed using the proposed template HCWMS in significant numbers of healthcare settings will help them to obey the government rules, regulations and laws in relation with the management of healthcare wastes, will automatically bring uniformity in the HCWMSs being followed at all those healthcare settings and will eventually create a win-win situation for the healthcare providers, patients, common people, government authorities, industries, job seekers, farmers and most importantly the environment at large to make it a better and a healthier place to live.

APPENDIX

Questionnaire to be filled by the healthcare settings about healthcare waste management.

Questionnaire

- Name of the healthcare establishment / hospital.
- Address.
- Type of the hospital : Government / semi-governmental / private.
- Number of beds (if applicable).
- Total quantity of waste generated / day.
- Whether NHHWs are segregated from hazardous wastes?
- Total quantity of hazardous wastes generated / day.
- Total quantity of NHHWs generated / day.
- How the NHHWs are stored?
- How the NHHWs are disposed?
- Whether the hospital is registered with any BMW management agency?
- How much waste is being given to the BMW management agency / day?
- Whether NHHWs are also given to BMW management agency?
- Whether the hospital is currently performing any recycling of NHHWs?
- Problems they are facing with Current system.
- Whether they would like to start recycling their NHHWs?
- What problems they feel in the implementation of our system?
- Any suggestions.
- Name of the personnel.
- Designation.
- Contact.

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