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Medical Waste Management at Upazila Level in Bangladesh

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Abstract

The study was conducted at healthcare establishments of Abhaynagar Upazila of Jessore District in Bangladesh to quantify amount of medical waste (MW) generated from the medical services; determine physical composition of MW; find out the correlation of waste quantity with relevant factors; identify problems and develop future guideline regarding management. The average waste generation rate was 37.11 kg/hospital, 1.56 kg/bed/day, and 1.90 kg/patient/day. The hazardous waste was recorded 9.71%, whereas, non-hazardous waste 90.29%. MW consisted eight categories of waste materials with vegetable/food being the largest component (74%), and varied significantly ($p \leq 0.05$) among other hospitals surveyed. The quantity of MW was positively correlated with the number of occupied beds ($R^2=0.898$, $P \leq 0.05$) and with the number of patients ($R^2=0.785$, $P \leq 0.05$). Separate legislation must be formulated to address the issue of medical waste management as a separate environmental mandate and regular supervision of them are very much necessary.

Key words: Medical Waste, Health Care, Hazardous, Non-Hazardous, Composition

1 Introduction

Medical waste (MW) has been considered as one of the major health and environmental concern in Bangladesh over the last three decades (Biswas *et al*., 2011). Poor management, lack of handling knowledge and unscientific disposal of various health-care wastes pose serious direct and indirect public health threats to health-care personnel, nurses, technicians, waste workers, hospital visitors, patients, surrounding communities and hence, the environment (WHO, 1999; Tamplin *et. al*., 2005). MW, due to its content of hazardous substances such as heavy metals, PCBs, chemical solvents and preservatives, poses serious threats to environmental health such as, air pollution through release of toxic pollutants (e.g. dioxin), water pollution through surface run off and infiltration of leachate into water bodies and underground aquifer (Klangsin P *et al*., 1998; Levendis Y *et al*., 2001). The hazardous substances include pathological and infectious material, sharps, and chemical wastes (Askarian M *et al*., 2004, Mato RRAM *et al*., 1999, Henry G *et al*., 1996). In hospitals, different kinds of therapeutic procedures (i.e. cobalt therapy, chemotherapy, dialysis, surgery, delivery, resection of gangrenous organs, autopsy, biopsy, para clinical test, injections etc.) are carried out and result in the production of infectious wastes, sharp objects, radioactive wastes and chemical materials (Prüss A *et al*., 1999). MW may carry germs of diseases such as hepatitis B and AIDS. Improper medical waste management (MWM) is alarming in Bangladesh and it poses a serious threat to public health. A variety of methods are used by the medical facilities to dispose of waste. These included burning, burial, selling, dumping, reuse and removal by municipal bins. There is no clear guidance to segregate wastes and ensure their proper disposal. Most hospitals collect all wastes together and dump in a common place. Those places are roadsides, hospital surroundings, dustbins of city corporation, Corporation's drum. Waste is placed in dustbin, resold or poured down drain to the main sewer. Also, saline bags, x-ray water, syringes, vials, slides, empty packets and bottles are collected and sold. But MWM should follow scientific methods such as on-site incineration, autoclaving, and steam disinfection.

MW contains highly toxic metals, toxic chemicals, pathogenic viruses and bacteria (Coronel *B et al*., 2002, Muhlich M *et al*., 2003, Chintis V *et al.*, 2004), which can lead to pathological dysfunction of the human body (Sigsgaard T *et al.*, 1994, Ray MR *et al.*, 2005). MW presents a high risk to doctors, nurses, technicians, sweepers, hospital visitors and patients due to arbitrary management (Massrouje HTN, 2001, Becher S *et al.*, 2002). It is a common observation in Dhaka City that poor scavengers, women and children collect some of the MWs (e.g. syringe-needles, saline bags, blood bags etc.) for reselling despite the deadly health risks. It has long been known that the re-use of syringes can cause the spread of infection such as AIDS and hepatitis (Tamplin SA *et al.*, 2005). The collection of disposable medical items (particularly syringes), its re-sale and potential re-use without sterilization could cause a serious disease burden (WHO, 2002). The safe disposal and subsequent destruction of MW is a key step in the reduction of illness

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or injury through contact with this potentially hazardous material, and in the prevention of environmental contamination (Blenkharn JI, 2006). The transmission of blood-borne viruses and respiratory, enteric and soft tissue infections through improper MW disposal is not well described (Prüss A *et al*., 1999). The management of MW therefore, has been of major concern due to potentially high risks to human health and the environment (Da Silva CE *et al.*, 2004, Mukesh Y, 2001).

Proper management of MW is crucial to minimize health risks. The improvement of present waste management practices for Healthcare establishment (HCE) in Bangladesh will have a significant long-term impact on minimizing the spread of infectious diseases. MW requires specialized treatment and management from its source to final disposal. Simply disposing of it into dustbins, drains, and canals or finally dumping it to the water reservoir, fellow land, road side canal of outskirts of the City poses a serious public health hazards. Thus, there is a need to initiate a concentrated effort to improve the MWM to reduce the negative impact of waste on: (a) environment; (b) public health; and (c) safety at health care facilities. There are different types of MWM systems (incineration, steam autoclave disinfection, microwave disinfection, and mechanical/chemical disinfection) in different countries (Askarian M *et al*., 2004, Mato RRAM *et al*., 1999, Patil GV *et al*., 2004, Mato RRAM *et al*., 1997, Tudor TL *et al*., 2005, Miyazaki M *et al*., 2007, Borg MA, 2006). Although, MW disposal options are not completely risk-free, the risks can be minimized with care (Blenkharn J, 2006). Improper disposal of MW may include to damage of humans by sharp instruments, diseases transmitted to humans by infectious agents, and contamination of the environment by toxic and hazardous chemicals (Lee B *et al*., 2002, Jang YC *et al*., 2006, Abdulla F *et al*., 2008).In India, infectious hospital waste could range from 15 to 35% depending on the total amount of waste generated (BAN & HCWH, 1999). In Pakistan, about 20% of hospital waste is found to be potentially infectious or hazardous (Agarwal, 1998). Improper disposal may be hazardous if it leads to contamination of water supplies or local sources used by nearby communities or wildlife. MWs, therefore, poses risk of individuals, communities and the environment if not carefully handled (Akter *et al*., 1998). Moreover, MW is potential reservoirs of different pathogenic organisms and it is evident that microorganism loads in MWs is several times higher than that of the general wastes (Morshed *et al*., 2004). The management of MW therefore, has been of major concern due to potentially high risks to human health and the environment (Da Silva *et al*., 2004; Mukesh, 2001). In developing countries, Healthcare wastes have not received sufficient attention. In many countries, hazardous and Healthcare wastes are still handled and disposed of together with domestic wastes, thus creating a great health risk of municipal workers, the public and the environment. In Bangladesh, MWM systems to reduce the environmental and public health risk are grossly inadequate (World Bank, 2002, PRISM Bangladesh, 2005).

In Bangladesh, wastes generated in most urban and rural areas are disposed of by open dumping in either low depressions or high areas for natural degradation. MWM should be carried out in appropriate way like incineration, autoclave disinfection, microwave disinfection, and mechanical/ chemical disinfection. As a result the soil underlying the waste is contaminated by pathogenic microorganisms, heavy metals, salts and chlorinated hydrocarbons. Bangladesh is a densely populated country, which lacks health facility for the people (Morshed *et al*., 2004). Rapid growth of urbanization degrading the urban environment and placing a serious threat to the natural resources and consequently holding back equitable sustainable development (Sujauddin *et al*., 2008). In urban areas hospitals are dependent on unreliable waste collection services from the city corporation/municipality, whereas in rural areas, the HCEs have to find their own disposal solutions. A variety of methods including burning, burial, selling, dumping, reuse and removal in municipal bins are generally used by these medical facilities to dispose of their waste materials. Most hospitals collect all waste materials together and dump them in a common place such as the roadside, hospital surroundings or dustbins/drums for collection by the waste management service. Waste is, in some instances, resold or poured down the drain into the main sewer (Akter, 2000).

MWs account for a very small fraction, about one percent of the total solid wastes generated in Bangladesh (World Bank, 2002). However, when this tiny amount is not handled properly, it gets mixed with domestic solid waste, and the whole waste stream becomes potentially hazardous. Until recently, there was no system for proper MWM in Bangladesh to protect environmental health hazards. It was generally disposed of in the same way as ordinary domestic waste. But, very recently, government is trying to develop a system to handle MW properly. Healthcare waste (HCW) is defined as the total waste stream from a healthcare facility (HCF) that includes pathological wastes, textile stained with blood, cotton pads, used syringes, broken bottles and glass, paper, cans and other metals, vegetable/rubbish and sharp instruments. Almost 40kg/bed of HCW is generating each year in Bangladesh (Akter *et al*., 1998). Dhaka itself generates 0.8-0.67 kg/bed/day of HCW out of which 0.66-1.52 kg/bed/day and 0.1-0.3 kg/bed/day are non-hazardous and hazardous, respectively (Rahman *et al*., 1999).The HCEs in Dhaka and Khulna city are about 250 and 60, respectively including public, non-profit and for-profit HCEs. Of these, more than 98% simply dispose of their waste into the dustbins of city corporations. Major portions of private healthcare services do not have the required registration provided with the related authorities like Directorate of Health Services or Department of Environment (Rahman and Ali, 2000).

MW management is a branch of the waste management field which focuses on medical and clinical waste, waste generated in medical facilities like hospitals, clinics, and nursing homes. There are a number of issues unique to MW which must be addressed by the waste management agencies which handle it, and several governments have laws specifically pertaining to MW which are designed to ensure that it is properly regulated. The improvement in present waste management practices for HCEs in Bangladesh will have a significant long-term impact on minimizing the spread of infectious diseases. Thus, it is necessary to study the characteristics and management of MW in Bangladesh. Until, there was no system for proper

MWM in Bangladesh to protect environmental health hazards. This study attempts to make a movie in this direction.

Bangladesh is one of the most densely populated south Asian countries with more than 150 million populations overburdened with MWs, industrial wastes, municipal solid wastes, sanitation congestion, lack of water supply, air pollution, traffic jam, and with all, an obvious unsustainable environment. Research in the areas of MWM has been wide nationally and internationally. There is no policy or guideline for present MWM system by government, and no concrete regulation has been established yet. Bangladesh government has prepared an action plan 2011-2016 for management of MW at public and private hospitals. However, very few studies were conducted in this field in Bangladesh. In order to deal with the prevailing situation in a planned way, proper study is required to analyze the MWM scenario of Bangladesh. It is necessary to quantify the amount of waste generated as well as the current MWM practice so as to identify the problem and future prospects. This study attempts to make a move in this direction. The study was conducted to quantify the total amount of MW generated from the medical services; determine the physical composition of MW; find out the correlation of waste quantity with relevant factors; identify the problems and develop future guideline regarding management.

2. Materials and Methods

2.1 Background information

Abhaynagar is the second largest Upazila in Jessore district of Bangladesh. The rapid increase in hospitals, clinics, diagnostic labrotaries etc at Abhaynagar Upazila exerts a tremendous impact on human health ecology. Total areas of Abhaynagar Upazila are 246 square kilometers having a population of approximately 0.235 million (Source: Abhaynagar Upazila Parishad). To provide primary health care services to the dwellers, Abhaynagar Upazila has been operating 17 Health Care Establishments (HCEs). Beside, Abhaynagar Upazila Health Complex, a number of private hospitals (or clinics) is operating in the Upazila to ensure quality health services for the Upazila dwellers. Unlike the ordinary household waste, MW is highly infectious and hazardous. They may carry germs of dreadful diseases like hepatitis B, C and HIV/AIDS.

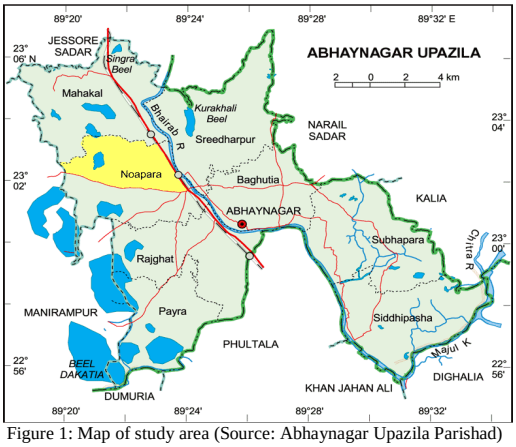

Figure 1: Map of study area (Source: Abhaynagar Upazila Parishad)

2.2 Selection of the study area

Out of 17, 12 HCEs were selected purposively based on interviewee's willingness to provide information. A detailed of the selected HCEs has been shown in Table 1.

Table 1: List of the studied HCEs at Abhaynagar Upazila

Name of HCES	Name and number of ward
Abhaynagar Upazila Health Complex	Nurbag (3)
Fatema Private Clinic	Hospital road (5)
Noapara Surgical Clinic	Hospital road (4)
Al - madina Hospital	Rajghat (3)
Noapara Sisoo Clinic	Noapara (1)
Shopner Setu Clinic	Noapara (3)
Surjer hasi Clinic	Pirbari Noapara (1)
Aarogo sadan (pvt.) Clinic	Upazila (3)
Ma o Sisoo (pvt.) Hospital	Mahakal (2)
Ar -Rahman Hospital	Professor para(3)
Niramoy Clinic	Taltola (4)
Arban Primary Health Care	Baghutia (5)
Total	37

2.3 Methods

The study was carried out from September 2009 to February 2010. The methodology of the study included empirical field observation and field level data collection through inventory, questionnaire survey and interviews with formal and informal ways, a review of related literature etc, to observe the physical composition of MW; and to collect information regarding quantity and quality of MW. Data were also collected through both direct observations and interviews with different officials of the studied HCEs. Waste materials from a hospital as a whole were analyzed (sorting, segregating, and weighting) three times for each HCE in three successive months. The waste materials of a particular HCE were collected and weighted. The types of MW were then segregated and the following items were weighted again.

Glass = glass/vial/blade; **Needle** = needle; **Textile** = textiles/cotton/bandage/gauze/net; **Rubber** = rubber/gloves; **Plastics** = plastic/syringe/saline bag/urine bag/ blood bag/polythene; **Pack** = packaging materials; **Paper** = paper; **Vegetable** = vegetable/food waste/others.

2.4 Questionnaire survey

An extensive questionnaire survey was provided, while in-depth interviews with nurses and different respondents in HCE allowed a greater understanding of the waste management system within each surveyed HCE. The collected data for this study were analyzed to address the central issues of hospital waste management in relation to the generation of wastes from different sources. In addition questionnaire included a number of attitudinal questions aimed at examining peoples' awareness and attitude toward the problems and management of MW (MW).

2.5 Data processing and analysis

The data obtained from the different hospitals were coded and compiled in the memory of the computer. All the data were analyzed statistically (frequency distribution, analysis of variance-ANOVA and Duncan Multiple Range Test) by using the computer software package Microsoft Excel and the Statistical Package for Social Science (SPSS) 14.

3 Results and Discussions

3.1 MW generation

A total of 277 sample beds of 12 studied hospitals indicates that an average 1.56 kg (total waste of hospital divided by number of patients) of wastes per bed per day was generated at Abhaynagar Upazila. MW generation per hospital, per bed and per patient per day at Abhaynagzar Upazila is shown in table 2. The statement of the result of 261 samples patient revealed that per patient total healthcare waste generation was 1.90 kg per day. The highest amount (2.04kg/bed/day) of waste generated by Noapara Surgical Clinic, whereas, lowest (1.33 kg/bed/day) in Al-Madina (Pvt.) hospital. It also revealed that the rate of MW generation varied significantly ($P \leq 0.05$) in different hospitals. The waste generation per hospital was 37.11 kg/day. Moreover, the waste generated by doctors, nurses, people involved in medical services and by the attendants of the patients were all contributing to the waste stream for a particular hospital. The number of patients was found to be less than the actual number of beds in almost all of the hospitals except Abhaynagar Upazila health complex and general hospital. But, in case of Abhaynagar Upazila health complex and general hospital, the authority had to arrange more beds even on the floor because the number of patients was greater than the actual number of beds, which sometimes created havoc and hampered the medical services and thereby deteriorate condition for the hospital management. The prime reason was numbers of patient load was more in above two hospitals and these are the public hospitals. Akter (2000) stated that the MW generation per bed per day in Bangladesh, India and Pakistan were 0.1, 0.2 and 0.1 kg, respectively. Per capita MW generation in Mumbai and Tanzania is 0.19-1.1 and 0.02-0.14 kg respectively (Coad and Christen, 1999) and in Karachi is 0.28-0.99 kg while studying the MWM in the capital city of Mongolia revealed that a total amount 2.65 tones of MWs are produced each day in Ulaanbaatar (0.78 tons of MWs and 1.87 tons of general wastes). Moreover, MW generation was recorded 0.67-0.8 kg per bed per day in Dhaka (Rahman *et al*., 1999) and 0.93 kg per bed per day in Sylhet. Pruss *et al*., (1999) reported per capita MW generation in high income, middle income and low income countries to be 1.1-12, 0.8-6 and 0.5-3 kg, respectively. The MW generation rate per kg per patient per day in the inpatient services of public healthcare facilities was 1.4-3 times higher than in the outpatient services ($P \leq 0.01$). The waste generation rate in India ranged between 0.5 and 2 kg per bed per day. It is estimated that annually about 0.33 million tons of wastes are generated in India (Patil and Shekdar, 2001). Dhaka medical college hospital and Bangabandhu medical college hospital generate about 6.4 tons per day (6392 kg per day) of healthcare wastes which has studied by PRISM Bangladesh (2005). Abhaynagar Upazila Health Complex generates 76.67 kg waste per day whereas 1.53 kg MW was generated per bed per day.

Table 2: Summary of Generated MWs at Abhaynagar Upazilla, Jessore, Bangladesh

Name of the hospital	No. of bed	WGR (Kg/Hospital/day)	WGR (Kg/Bed/day)	Average No. of Patients/Day	WGR (Kg/Patient/day)
Abhaynagar Upazilla health Complex	50	76.67^{a*}	1.53^{d}	72	1.06
Fatema (Pvt.) Clinic	25	37.33^{c}	1.49^{de}	22	1.71
Nowapara Surgical Clinic	30	61.33^{b}	2.04^{a}	24	2.57
Al Modina Pvt. Hospital	25	33.33^{d}	1.33^{e}	21	1.59
Nowapara Shishu Clinic	20	29.67^{f}	1.48^{de}	15	1.98
Shopner shetu Clinic	22	33.33^{d}	1.51^{d}	17	1.97
Shurjer Hasi Clinic	10	18.67^{h}	1.86^{b}	8	2.38
Arogya Sadan Pvt. Hospital	20	30.33^{ef}	1.51^{d}	17	1.79
Nowapara Ma o Shishu Pvt Hospital	20	36.33^{c}	1.81^{b}	18	2.02
Ar- Rahman Hospital	20	29.33^{f}	1.46^{de}	18	1.63
Niramay Clinic	15	26.33^{g}	1.75^{bc}	12	2.20
Urban primary Health care	20	32.67^{de}	1.63^{cd}	17	1.93
Total	277	37.11kg (Avg)	1.56 (Avg)	261	1.90 (Avg)

**Mean followed by the same letter(s) in the same column do not vary significantly ($p \leq 0.05$), according to DMRT (Duncan Multiple Range Test)*

3.2 Physical composition of MWs

Table 3 reveals the physical composition of MW generated by all hospitals at Abhaynagar Upazila. All the eight different types of wastes segregated varied significantly ($P<0.05$) among 12 different medical services. Glass/vial and ampoules/blade was found the highest (5.78kg) in Abhaynagar Upazila Health Complex and the lowest (0.67kg) in Surjer Hasi Clinic. The study sufficiently proved that a substantial portion of MW was vegetable/food waste.

Figure 2 indicates the percentage of segregated items of MW at Abhaynagar Upazila. Among all the eight segregated items of MW, vegetable/ non-hazardous waste was found the highest (74%) portion of MW and the lowest (1%) portion was packaging materials. Next to this, glass/vial and ampoules/blade and plastic/ syringe/ saline bag/ urine bag/ blood bag/ polythene and paper were found 8%, and 2% and; textile/ cotton/ gauge/ bandage/ net 3% respectively. Patil and Shekdar (2001) while studying the management of MW in India explained that the solid waste from the hospitals consists of bandages, linen and other infectious waste (30-35%), plastics (7-10%), disposable syringes (0.3-0.5%), glass (3-5%) and other general wastes including food (40-45%). MW in the developing countries can be classified into two broad categories, namely hazardous waste (infectious waste, sharps, pathological, pharmaceutical, geno-toxic, chemical, and radioactive wastes; pressurized containers; and, waste with a high concentration of heavy metals) and non-hazardous waste (waste from catering services, waste from administrative establishments, packing materials, etc) (Rahman and Ali 2000).The findings of the present study also coincide Mohee (2005), who reported that around 90% of hospital waste was general waste materials that had similar

properties to domestic waste. There is still a lack of specialized services for the collection and final disposal of MW at Abhaynagar Upazila.

Table 3: Physical composition of HCW generated by different hospitals at Abhaynagar Upazila

Name of hospitals	Kg/day							
	Glass[1]	Needle[2]	Textile[3]	Rubber[4]	Plastic[5]	Package[6]	Paper[7]	Vegetables[8]
Abhaynagar Upazila Health Complex	5.78^{a*}	0.20^{c}	2.38^{a}	3.22^{a}	6.13^{a}	0.94^{c}	1.71^{a}	57.31^{a}
Fatema Pvt. Clinic	1.83^{b}	0.04^{d}	1.49^{c}	0.37^{de}	1.38^{bcd}	0.28^{fg}	1.48^{e}	30.50^{b}
Nowapara Surgical Clinic	1.48^{cd}	0.05^{d}	2.17^{a}	0.54^{bcd}	1.39^{d}	0.22^{fgh}	1.41^{bc}	54.01^{a}
Al Madina Pvt. Hospital	0.87^{e}	0.01^{d}	0.42^{f}	0.18^{e}	0.53^{e}	0.20^{gh}	0.47^{bc}	31.05^{b}
Nowapara Shishu Clinic	0.85^{e}	0.06^{d}	0.84^{e}	0.56^{bcd}	1.40^{bcd}	0.30^{ef}	0.78^{d}	24.85^{bc}
Shopner shetu Clinic	1.26^{d}	0.04^{d}	0.93^{de}	0.67^{b}	1.83^{b}	0.23^{fgh}	1.53^{ab}	26.84^{bc}
Shurjer Hasi Clinic	0.70^{e}	0.41^{b}	1.22^{cd}	0.53^{bcd}	1.34^{bcd}	0.62^{d}	1.32^{bc}	12.56^{d}
Arogya Sadan Pvt. Hospital	1.31^{cd}	0.10^{d}	1.51^{c}	0.63^{bc}	1.13^{cd}	0.17^{h}	1.54^{ab}	23.93^{bc}
Nowapara Ma o Shishu Pvt Hospital	1.57^{bc}	1.23^{a}	1.87^{b}	0.59^{bcd}	1.36^{bcd}	2.13^{a}	0.91^{d}	26.67^{bc}
Ar- Rahman Hospital	0.67^{e}	0.49^{b}	1.41^{c}	0.52^{bcd}	0.89^{de}	0.27^{fg}	1.28^{c}	28.80^{b}
Niramay Clinic	1.76^{b}	0.08^{d}	0.97^{de}	0.43^{bcd}	1.43^{bc}	0.70^{e}	1.49^{abc}	19.80^{c}
Urban Primary Health Care	1.28^{d}	0.01^{d}	0.68^{ef}	0.41^{cde}	1.17^{cd}	1.13^{b}	1.31^{bc}	20.98^{c}

**Mean followed by the same letter(s) in the same column do not vary significantly ($p \leq 0.05$), according to DMRT (Duncan Multiple Range Test)*

Glass[1] =Glass, Vial, and Blade; Needle[2] = Needle; Textile[3] = Textile, Cotton, Bandage and Gauge; Rubber[4] = Rubber and Gloves; Plastic[5] = Plastic, Syringe, Saline bag, Urine bag, Blood bag and Polythene; Package[6] = Packaging materials; Paper[7] = Paper; Vegetables[8] = Vegetables, Food wastes and others.

3.3 Hazardous and non-hazardous wastes

The present study reveals that almost 90.29% of MW was non-hazardous in nature, whereas, the rest (9.71%) was hazardous which was shown in Figure 3. This finding is in agreement with Mohee (2005) who reported that around 90% of hospital wastes were general wastes similar in properties to domestic wastes and the remaining was infectious wastes. Pruss *et al*., (1999) found that 10-25% of MWs were termed as infectious, pharmaceutical, radioactive and chemical wastes which may produce a variety of health and environmental risks.

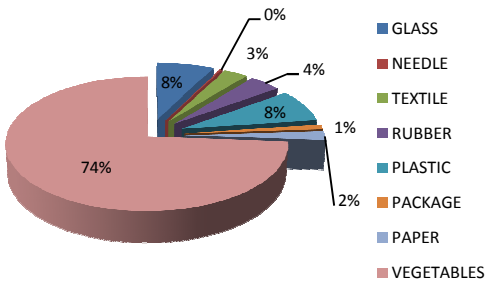

Figure 2: Physical composition of medical waste at Abhaynagar Upazila

The amounts of hazardous and non-hazardous wastes at Abhaynagar Upazila were shown in Table 4 and 5. The hazardous waste generated per hospital per bed and per patient at Abhaynagar Upazila area was found to be lower than the non-hazardous waste generated per day. The average quantity of hazardous waste generated from each hospital was 3.61 kg per day. Each hospital generates 0.16kg hazardous waste per bed per and 0.19 kg per patient per day (Table 4). In contrast, on an average, 33.50 kg non-hazardous waste was generated from each hospital per day. The average amount of non-hazardous waste per bed per day and per patient per day was 1.46 kg and 1.70 kg respectively (Table 5). These results support Rahman *et al.* (1999) who reported 0.1-0.3 kg of infectious waste per bed per day in Dhaka city whereas, the non-hazardous waste was 0.66-1.52 kg per bed per day. The present finding is also in agreement with Coad and Christen (1999) who recorded 0.1-0.74% kg/capita per day of hazardous waste and 0.07-0.6 kg/capita per day of non-hazardous waste in Mumbai city. In some countries, where adequate waste management systems are in place, the percentage of hazardous MWs ranges from 10-20% (Mohee, 2005).

3.4 Correlation between quantities of MW with relevant factors

The rate of production of hospital waste depends on different factors such as number of beds, type of medical services provided by the hospital, patients' economic, social and cultural status, and regional condition of the hospital (Askarian *et al*., 2004). Correlation analysis was also employed to identify the degree of association between waste generation rate and different related factors (number of beds and patients, Figure 4 and 5).

The generation of MW at Abhaynagar Upazila was found to be positively correlated with number of beds (**r**xy = 0.898, P<0.05), which means the higher number of bed in a medical services the more the generation of MW. Number of patients was also found to be positively correlated (**r**xy = 0.785, P<0.05) with the generation of MW. This reveals that the higher the number of patients the larger the quantity of MW generated each year. The equations obtained from these relation were y = 0.865x + 18.29 and y = 1.541x + 1.519 where Y was the number of occupied beds and X was the total fresh weight (kg) in Figure 5 and number of patients in Figure 4. The present findings are

also in agreement with Mohee (2005) and Bdour *et al*. (2004) who studied MW characteristics in different medical institutions in Mauritius and northern part of Jordan, respectively while exploring different types of factors which influence the generation of MW.

Waste and its management has lately become a pressing topic in Bangladesh. The European Commission stated that waste management is the largest single problem in the environmental protection sector. Waste generation is also affected by a number of factors commonly: geographical location, season of the year, size of hospital, proportion of in and out-patients; type of institution and specialization; available waste segregation options; proportion of use of reusable items; social status of the patient (i.e. income, living standard, awareness about diseases); and, also the prosperity of the country (Mato and Kassenga, 1997). Communal landfills receive both communal and other waste including hazardous MW. That means a large quantity of various wastes ends up in the environment due to negligence, but also due to the lack of integrated waste disposal solutions.

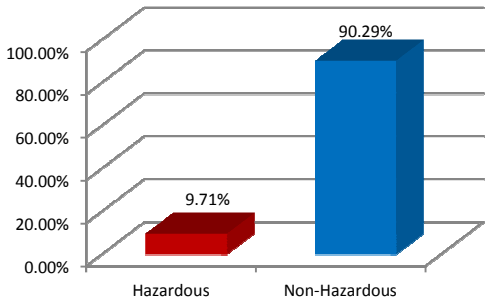

Figure 3: Percentage of Weight of Hazardous and Non-Hazardous MW

Table 4: Amount of Hazardous waste at Abhaynagar Upazila

Name of the Hospital	Hazardous waste (Kg)		
	Hospital/ day	Per patient /day	Per bed/ day
Abhaynagar Upazilla health Complex	6.56[a*]	0.09	0.13
Fatema (Pvt.) Clinic	4.10[a]	0.19	0.16
Nowapara Surgical clinic	5.80[a]	0.24	0.19
Al Modina Pvt. Hospital	3.40[bc]	0.16	0.14
Nowapara Shishu clinic	3.10[bc]	0.21	0.16
Shopner shetu clinic	3.40[bc]	0.20	0.15
Shurjer Hasi clinic	2.20[c]	0.28	0.22
Arogya Sadan Pvt. Hospital	2.90[c]	0.17	0.15
Nowapara Ma o Shishu Pvt Hospital	3.20[bc]	0.18	0.16
Ar- Rahman hospital	2.90[c]	0.16	0.15
Niramay clinic	2.60[bc]	0.22	0.17
Urban primary health care	3.10[bc]	0.18	0.16
Average	3.61	0.19	0.16

**Mean followed by the same letter(s) in the same column do not vary significantly (p≤0.05), according to DMRT (Duncan Multiple Range Test)*

Table 5: Amount of Non-Hazardous waste at Abhaynagar Upazila

Name of the Hospital	Non-hazardous waste (Kg)		
	Hospital/ day	Per patient /day	Per bed/ day
Abhaynagar Upazilla health Complex	70.11[a*]	0.97	1.40
Fatema (Pvt.) Clinic	33.23[c]	1.51	1.33
Nowapara Surgical clinic	55.53[b]	2.31	1.85
Al Modina Pvt. Hospital	29.93[cd]	1.43	1.20
Nowapara Shishu clinic	26.57 [cd]	1.77	1.33
Shopner shetu clinic	29.93 [cd]	1.76	1.36
Shurjer Hasi clinic	16.47[e]	2.06	1.65
Arogya Sadan Pvt. Hospital	27.43 [cd]	1.61	1.37
Nowapara Ma o Shishu Pvt Hospital	33.13[c]	1.84	1.66
Ar- Rahman hospital	26.43 [cd]	1.47	1.32
Niramay clinic	23.73[de]	1.98	1.58
Urban primary health care	29.57 [cd]	1.74	1.48
Average	33.50	1.70	1.46

**Mean followed by the same letter(s) in the same column do not vary significantly (p≤0.05), according to DMRT (Duncan Multiple Range Test)*

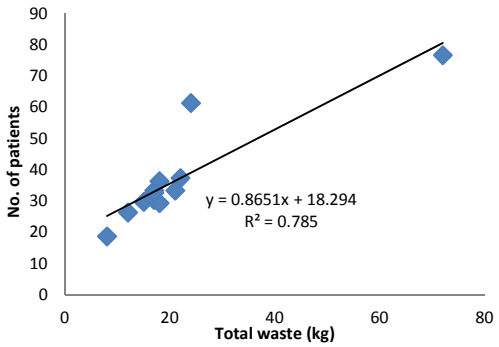

Figure 4: Relation between no. of patients and total medical waste at Abhaynagar Upazila

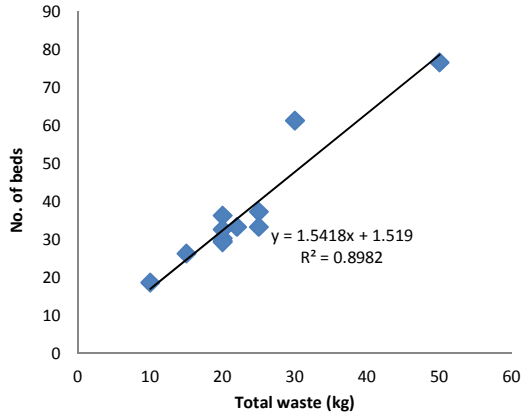

Figure 5: Relation between no. of beds and total medical waste at Abhaynagar Upazila

3.5 Scenarios of MWM

3.5.1 MWM: A recent past scenario

Until recently (April 2007), there has been an improper procedure of MWM at Abhaynagar Upazila. No hospital segregated their generated wastes, except a very few. MWs need to be segregated separately according to their characteristics at the point of generation (Pruss et al., 1999). In some hospital, all the hazardous wastes were found to be separated from the non-hazardous waste stream at the site of production, but during disposal at the Abhaynagar Upazila dustbins the wastes were then mixed together. In all of the hospitals, pharmaceutical wastes and pressurized containers (e.g. inhalers, spray cans etc.) were disposed along with the general waste. The intermingling of hazardous wastes with general waste in the hospital is a heart to environment. Field survey identified that a very few private hospital used to collect their in-house waste systematically.

3.5.2 New approach of MWM

There are a number of guidelines for the management of hazardous waste materials from medical institutions. Medical facilities in different hospitals in Bangladesh are characterized by inadequate and inappropriate refuse storage facilities, lack of refuse collection services, improper disposal methods and inadequate and inappropriate protective gear for refuse handlers. In Bangladesh, proper MWM is a new phenomenon and Government of Bangladesh is trying to develop a new and modern approach to deal with the MW properly.

PRISM Bangladesh with the financial support from Canadian International Development Agency (CIDA) has recently developed a disposal facility for low cost MW treatment and management in different city. The DCC has allocated one acre (0.405 hectare) of land in Matuail, a dumpsite near the city limit for the final disposal of MW (PRISM, Bangladesh, 2005)

3.5.3 Current trend of MWM and its deficiencies at Abhaynagar Upazila

The growing number of hospitals, clinics and diagnostic laboratories at Abhaynagar Upazila exerts a tremendous impact on public health and environment. All of the hospitals, clinics and diagnostic laboratories are considered here as the HEC. Like ordinary household waste, MWs are generally dumped into dustbins. The dustbins are either within hospital premises or outside the hospital. Waste from operation theaters, laboratories and hospital kitchens are also dumped into the same dustbins. This waste is then collected from Upazila authority by trucks and carried to the landfill area for final disposal. It is reported that even body parts are dumped on the streets by the HCE. The liquid and solid wastes containing hazardous materials are simply dumped into the nearest drain or garbage heap respectively.

Due to urbanization in Bangladesh has resulted in health care facilities in urban centers improving faster than those in the rural areas. Waste management systems in the urban areas are already overburdened. Hence, an additional load due to mixing of hazardous waste from HCEs aggravates the problem. Separate systems for disposal of HCE waste are available in only a few establishments.

The drawbacks in the existing management system are:

- Haphazard collection of wastes increases the quantity of hazardous waste
- Non-availability of treatment and processing devices compatible with waste generation
- Lack of common treatment and processing facilities
- Unplanned waste management systems
- Insufficient provision of budget allocation
- Lack of awareness of better waste management
- Lack of waste management training for hospital staff
- Absence of color-coded storage containers for different categories of waste.

Generally the hospital waste management in Bangladesh in the form of an environmental point of view is taking place with an improper procedure. Only a very few hospital are exceptional in this regard. Major portion of the solid wastes generated at all hospitals are collected by Municipal authority. The following are environmental impacts associated with the improper disposal of healthcare wastes: pollutants from healthcare waste (e.g. heavy metals and PCBs) are persistent in the environment.

- Accumulation of toxic chemicals within soil(proximity to agricultural fields, humans, soil organisms, wildlife, cattle)
- Ground water contamination, decrease in water quality

- Repeated and indiscriminate application of chemicals over a long period of time has serious adverse effects on soil microbial population
- Windblown dusts from indiscriminately dumping also have the potential to carry hazardous particulates.
- With domestic animals being allowed to graze in open dumps, there is the added risk of reintroducing pathogenic micro-organisms into the food chain.
- Public nuisance (e.g. odors, scenic view, block the walkway, aesthetics, etc.)

4 Conclusions and Recommendations

4.1 Conclusions

Disposal and management of MWs is a concern issue in Bangladesh. Until recently, the management of MWs has received little attention despite their potential environmental hazards and public health risks. MW is infectious and hazardous. It poses serious threats to environmental and human health and requires specific treatment and management prior to its final disposal. The problem is growing with an ever-increasing number of hospitals, clinics, and diagnostic laboratories in Abhaynagar Upazila, Jessore, Bangladesh. However, research on this critical issue has been very limited, and there is a serious dearth of information for planning. This study seeks to document the handling practice of waste (e.g. collection, storage, transportation and disposal) along with the types and amount of wastes generated by HCEs. A total of 12 out of the existing 17 HCEs in the study area provided us the relevant information. The study has attempted to quantify different MWs generated from different HCEs. The surveyed HCEs generated 90.29% of non-hazardous and 9.71% of hazardous wastes. The average waste generation rate for the surveyed HCEs was 1.56 kg/bed/day. It was also found that almost all the HCEs do not segregate their generated wastes and they dispose of their domestic waste at the same site as normal civic waste. The generation of MW in Jessore has been increasing in quantity and variety, due to the wide acceptance of single-use disposable items. In the recent past, MW was often mixed with household waste and disposed of in municipal solid waste landfills. In recent times, increased concerns over improper disposal of MW have led to a movement to regulate the waste more systematically. Efforts have to be made for minimization and recycling of some MWs prior to final disposal, if not infected or contaminated. Incineration could be used in MW treatment until another common treatment method and steam sterilization is available in near future. Therefore, toxic substances such as dioxin emissions at MW incinerators should be closely monitored to reduce potential risks to humans and the surrounding environment. MWs shall be contained in exclusive containers. Of hazardous MWs, isolation MW, tissue distribution waste and injurious waste, as well as all liquid waste shall be kept in box-type exclusive containers that are made of synthetic resins, and the container in which liquid waste is kept shall have a lock so that the cover cannot be opened. Other wastes can be kept in containers that are made of corrugated cardboard.

Lack of awareness, appropriate policy and laws, and apathy are responsible for improper management of MW at Abhaynagar Upazila. The process of collection, segregation and disposal of MW is not performed according to recommended standards, and concerned people are exposed to the danger of such wastes. Safe disposal of MW is essential and handled in a very professional way in many countries. The existing MWM system currently serves a limited number of HCE. New facilities should be established in different parts of the city or the existing facility should be expanded.

4.2 Recommendations

Before any clear improvement can be made in MWM, consistent and scientifically based definitions must be established as to what is meant by MW and its components, and what the goals are for how it is managed. If the primary goal of "managing" waste from medical facilities is to prevent the accidental spread of disease, then it must first be acknowledged that there is only a small percentage of the waste stream that is contaminated in a manner that renders it capable of transmitting disease, and that the only documented transmission of disease from MW has been from contaminated shapes (syringes, etc). Hospitals generate large volumes of waste that can be highly toxic and infectious, and burning and dumping this waste threatens human and environmental health. In many countries the safe disposal of MW is considered very important and handled in a very professional manner. Minimizing waste not only protects people and the environment, but it can save facilities substantial amounts of money. Unfortunately, there is little effort in properly disposing hospital waste in Bangladesh. In order to arrange a proper and systematic MWM, the following recommendations should be considered:

i. Separating different types of waste at the point of generation and keeping them isolated from each other. By doing this, appropriate resource recovery and recycling techniques can be applied to each separate waste stream. The amounts of infectious waste, hazardous waste and low-level radioactive waste that must be treated according to special (and usually costly) requirements are minimized. If not separated, all hospital waste must be treated as potentially infectious.
ii. Recovery and reuse of materials from the waste stream. The majority of waste from health care facilities is surprisingly similar to that of an office building or hotel - paper, cardboard and food waste. Hospitals can implement fairly simple programs that divert these materials from the solid waste stream, lowering disposal costs.
iii. Disposal should not create harm to environment including water, air, soil, plants, animals and human beings in the neighborhood. For instance, it can be deeply buried but must be in line with the construction planning of local authorities.
iv. To avoid the risk of health effect from the wastes, it needed to formulate proper policy regarding this issue.
v. The healthcare waste management issue is becoming critical in view of the growing amounts of healthcare risk waste and fast increasing HIV/AIDS incidence among certain groups. Arrangement of training regarding this issue could minimize the health risk. Moreover, the training could increase attention to

blood safety, disposal of needles and syringes and other hazardous waste.

vi. Imposing segregation practices within hospitals to separate biological and chemical hazardous wastes (less than 10% of the waste stream) will result in a clean solid waste stream (90%) which can be easily, safely and cost-effectively managed through recycling, composting and land filling the residues.

vii. The field data shows that the medical facilities are characterized by inadequate and inappropriate refuse storage facilities, lack of refuse collection services, improper disposal methods and inadequate and inappropriate protective gear for refuse handlers. A remedial measure with the installation of a commercial environment friendly incinerator in the Upazila is suggested.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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