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Illicit Layer: Social Network Analysis applied to Medical Waste handling in Developing Countries

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ABSTRACT

Medical waste management in a megacity was studied using a range of sampling strategies. Data were collected in Dhaka, the capital city of Bangladesh using a variety of techniques including observation (third person listening approach), pictorial data, formal structured interview and informal dialogue. Sampling strategies included formal representative sampling and purposive sampling.

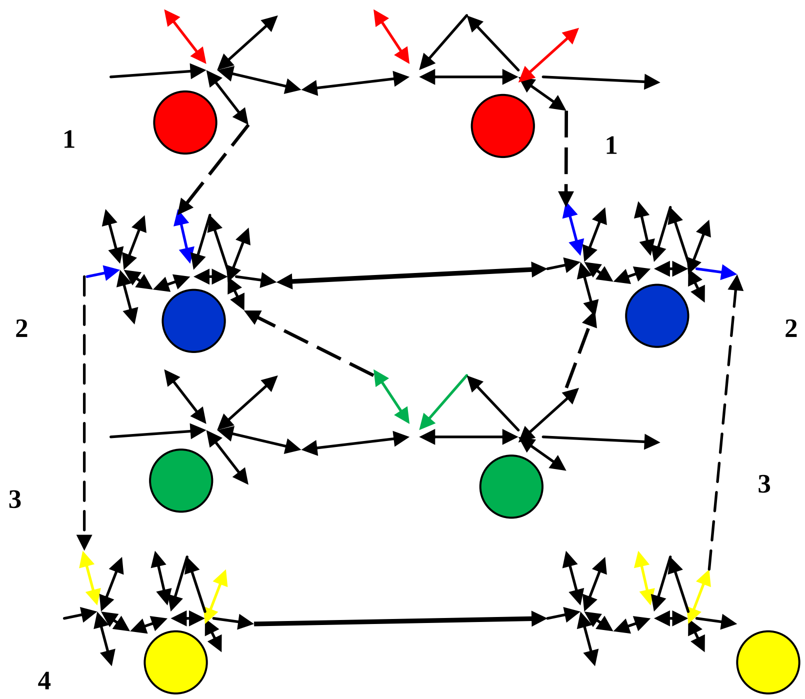
Observations revealed that most Health Care Establishments (HCEs) failed to implement proper segregation, secure storage and safe disposal. HCE and Dhaka City Corporation (DCC) employees were poorly trained and lacked of sufficient knowledge. In some cases there was segregation at the point of use, but subsequent remixing with general waste. Potential serious health issues were also identified. The attitudes and motivations that contributed to these practices were investigated using qualitative techniques. These revealed poor understanding of the risks, combined with a culture of clientelism and subservience.

INTRODUCTION

The rapid growth of the medical sector around the world and the rapid move towards the use of disposable medical products have contributed to increased potential disease transmission or accidental injury due to waste produced by Healthcare Establishments (HCEs) Many countries maintain stringent management systems for management and safe disposal of medical waste to minimise the risk but where this is badly managed it is not only a threat to the individuals directly exposed to medical waste, but also to the surrounding community and to the wider environment. There is a particular concern in rapidly growing megacities, where private health care provision is growing more rapidly than public infrastructure. Poor segregation and insecure storage of hazardous waste lead to a significant danger from unauthorized recycling processes. This contrasts with the situation in developed countries where medical waste is treated with extreme caution. No doubt this partly reflects the difference in healthcare budget, but some of my previous findings (in Dhaka, Bangladesh) also suggest that other factors are at work, with evidence for a lack of accountably and corrupted networks.

THE LAYERING OF NETWORKS IN DHAKA

Previous work in Dhaka revealed that there may be a stacked arrangement of networks impacting on the actors involved in waste disposal. At the top of the stack are the agents of national governance. At the bottom are scavengers and unofficial recycling operatives. (Figure 1) Different networks operate within each layer and interaction between the networks does not appear to be constructive. Previous attempts to address the problems with medical waste disposal in Dhaka, in particular attempts to require HCEs to improve their management of medical waste through national regulation, have more or less failed (World Bank, 2003; PRISM 2005; Hassan et al., 2008; Patwary et al., 2009a). On the other hand, the most effective attempts have been based on the efforts of NGOs working within specific localities and communities. It is possible that their initiatives have partially succeeded because they are integrated within a particular local network and within a particular layer, but consequently they are not in a position to disseminate their message to higher or lower layers, or much beyond the localities in which they operate.



1 Governmental agent
2 NGO, International donor agencies, Academics
3 HCE managers and owners
4 Waste operatives, scavengers, recycle operatives

In our previous study we observed a rigid superior-subordinate relationship (Patwary et al., 2010) stabilised by poverty, caste, fatalistic beliefs and a culture of patronage and clientalism (Patwary, 2010; Patwary and Uddin, 2010). Managers in HCEs displayed a lack of empathy with operatives, associated with a high power distance between superior and subordinate. Limited inter layer communication was observed, dominated by cycles of flattery-command. Much inter-layer communication was of negative or neutral valency, failing transmit reliable information or promote actions that would reduce the risks from medical waste but rather promoting ritualized work practices and shifting responsibility to others (World Bank, 2003; Transparency International. 2008).

Beyond these managed layers, we also observed many people who relied on unregulated and unmanaged systems for their livelihoods, including scavengers, plastics recyclers and waste dealers. These layers also exhibited a network structure, with ordered relationships and pathways of communication between actors. Communication between the managed and unmanaged layers seemed to be semi-formal, possibly mediated by HCE officials and union leaders. This may have been linked to interlayer communication at the other end of the stack, where there was some suggestion that corrupt practices among officials and union leaders went unnoticed because of their political connections.

AIMS AND OBJECTIVES

The study will attempt to elucidate local social network, socio-cultural, socio-economic and psycho-cultural influences on internationally accepted procedures for medical waste handling and on attitudes towards risks associated with medical waste.

ILLICIT ECONOMY AND NATIONAL CONCERN

As reported by Atkins *et al.,* (2007) most of the institution and organisation are politicized in Bangladesh (Transparency International, 2005) as in other developing countries (Rouse, 2006). Political pluralism in Bangladesh has led to jostling for political power in public institutions and local authorities (World Bank, 2003; Atkins *et al.,* 2007; Transparency International, 2008). This may explain why proper collection and safe disposal of medical waste is given such a low priority by the local authorities. Some officials and trade unions collect not only daily profit from the illegal waste selling, but also promote this illicit economy by their involvement; a portion is also allocated to party leaders. Important party leaders dominate the labour associations, and have a key role in illegal operation (Transparency International, 2008). Such operatives may not pay appropriate attention on their own duties to the senior management, but are beyond reproach because of their political connections. Control of labour unions gives operatives rent-seeking opportunities, including proceeds from illicit trade and of contraband goods such as infectious medical waste selling.

EXTERNAL SCENARIO

There are likely to be other reasons why scavengers have managed to continue living and working with this dangerous activity for the long period. One obscure reason relates to the drugs abuse. Most of the scavengers were observed to be drug addicted. They are involved with this illegal activity to earn their daily cash money and use date expire medicine as a drug. There are often complex reasons why it can be important to the scavenger to retain relationships associated with their work. HCE operatives and officials are engaged to sell high sensitive drug such as morphine and pathedrine injection, painkillers, including morphine and sleeping pills to the waste scavenger. HCE operatives and officials are in a unique position where they have easy access to gain drug as a medication. To make the matters worse, HCE operatives and officials are engaged to expand the drug dealing through medical waste scavenger. In Dhaka, scavengers relied on recyclable material dealers as their sole access to credit. Scavengers pay some cash to the truck drivers to delay the waste collection from bin and road site. So that, they can easily collect the medical waste and resell to the waste vendors. Some corrupted HCE employees sold their high sensitive drug such as morphine injection which is used only for particular medication purpose, sold to the scavengers to earn extra money. Scavengers resold this high sensitive drug very costly to the young generation. This is a most significant ground of illicit economy and drug use expansion to the community. Many people rely on the present unregulated and informally managed system for their livelihoods, including waste workers, scavengers, truck drivers, waste dealers, HCE officials and union leader. It has also been suggested that some local authority staff may also be receiving money to turn a ‘blind eye’ to activities, and that in addition to payment for waste scavenging, the truck drivers also delaying to transport the hazardous waste due to earn extra cash. This would not be possible if the system was closely monitored by the authority or the self accountability. This is likely to be threatening for the authorities to manage the governance. They may also be reluctant to use further force for fear of the political or legal ramifications. HCE officials are selling drugs almost in broad day light. Drug dealers have developed a strong network with the scavengers. At night, some scavengers use to carry drugs to residential areas. Residents are helpless because they are threatened to keep quiet by local so called cadre “*mastan*”. Some of them are directly involved with the selling process. This situation is deteriorating due to local administrative inaction and poor governance, and contributed to street capital by street competency.

The absence of proper treatment facilities and poor application of legislation has been widely discussed in the literature, with calls for coherent national plans for medical waste management in developing countries. Barriers to adoption often appear to include a lack of resource and a lack of commitment at the national level, but there is also evidence for cultural and organisational barriers. Thus, to minimize the potential risks associated with medical waste it is necessary not only to identify the structured network, but also identify how the network is structured to a plan for socio-cultural and organisational acceptance from top to bottom. Therefore, need to identify the behavioural socio-cultural aspects towards structured network that may influence psychological attitudes.

Behavioural phenomenon can be studied at multiple levels for example, can be approached from a psychological perspective social cognition (that may underlie fatalistic attitudes and casual behaviour), a contextual perspective (focusing on interpersonal processes that influence exposed individual and subservient behaviour), or a genetic perspective (focusing on the endocrinology, or genetics of sensation). All of these levels of analysis are potentially informative, and most scholars of behavioural psychopathology agree that the study of psychological behavioural causality has developed using these various approaches.

There is an increasing interest in achieving change through a better understanding of networks (refs). Network theory is one approach to including the social dimension in any attempt to understand acceptance or failure of policy. From this perspective, a successful strategy for minimisation of the potential risks associated with medical waste is most likely to arise from an analysis of the structures of the relevant actor-networks. While the decisions of individuals in a group may be affected directly by what others to whom they are connected do, rather than being purely autonomous, independent or even rational, it would be an example of downward conflation to treat the individual agents in the network simply as malleable actors. Thus, at the same time, behavioural phenomena and individual agency can be studied from multiple perspectives, including from psychological, social cognition, cultural and contextual perspectives. All of these analyses are potentially informative.

EVIDENCE FOR NETWORKS WITHIN LAYERS

It was observed that drug dealers have developed a strong network among the scavengers, involving the resale of date expired medicines. This trade seemed to be protected by the so called cadre "*mastan*".

PREVIOUS INTERVENTIONS

Previous attempts to address the problems have, to a greater or lesser extent, failed.
The most effective attempts have been based on the efforts of NGOs working within specific localities and communities. Their initiative has partially succeeded precisely because they are integrated within a particular layer, but they are not in a position to disseminate their message to higher or lower layers, or beyond the locality in which they operate.

DISCUSSION

The present study revealed that the existing situation in the organisational management is a culture of subservience with lack of knowledge, responsibility and accountability or ethics. The main assumption of this study is that subservient culture affects administrative culture in the management system. This assumption is derived from previously conducted research and findings (Ouchi, 1981; Tayeb, 1988; Trompenaars, 1993; Hofstede, 1997; Hofstede, 1984; Jamil, 1998). Within these theoretical backgrounds, organisational administrative culture is seen as the thinking pattern, attitude and belief system as an employers, administrators and boss towards employees. Given this background, this study addresses the following theoretical questions- (a) what is the situation of the administration in organizational management? (b) What is the nature of interpersonal relationships among the employees? (c) What is the relationship between administrative culture and subservient attitude? This paper tries to answer the above questions by relying on two theoretical foundations in organisational culture. First, "culture is what organization has", and second "culture is what organization is" (Allaire and Firsirotu; Jorgensen; Meek; Schein; Smircich; cited in Jamil 1994:277).

The present study exposed that senior officials do not follow standard policy while making administrative decisions and procedures. Most often administrative decisions are influenced by informal sources than formal rules such as personal connection. Senior officials, managers and head of the organisations are concerned with their positional status and building subservient attitudes. In this sense administrative decisions are not 'impartial' and 'objective' but highly personalized. Lack of knowledge to common administrative rule allows shifting responsibility to others. These characteristics support the subservient view.

Managers consider themselves as rulers rather than colleague to the subordinate. They interpret organisational rules, regulations, and working procedures according to their self interests and convenience. In consequence, it is 'nightmare' for employees to received occupational safety from their administrator as they thought the present situation is their fate. The research revealed that the subservience attitude in the sampled organisations is characterized by values that may be termed bureau-subservient. It is because in the sampled organisations of the study area, in overall, characterized more by particularistic rather than universalistic, and authoritarian rather than participatory values.

On the other hand, managers show 'clientelistic' attitudes towards their subordinates while allocate their duties. This may build power distance between superior and subordinates. Furthermore, it develops responsibility shifting attitudes among the junior employees and promotes authoritarian decision making culture in administrative level. In turn, it affects organisational performance. In the studied organisation, personal and informal relations are more important than formal official relations in the administrative level. Subordinates try to please superiors whom they think as 'job saver' in the organization. In such a circumstance, an employee feels at home inside the office. An official relation is converted into personal relation. One can get personal support from ones colleagues and superiors while one is in trouble by using official relations. For example, it is common scenario in the study area for an official to use discretionary powers to dispense favours to staff, based on feelings and personal relationships irrespective of prescribed rules and regulations. This attitude to grant favours under the excuse of official work to solve individual problems is a result of the current clientelistic work culture. Similarly, most of the unqualified, corrupted and dishonest employees follow each and every order of their bosses without questioning. In turn, the employees lack professionalism, they pay more allegiance to their bosses than duty. This allows developing a kind of superior-subordinate relationship and vice versa. Figure 1 shows the thematic observation of the overall current occupational safety situation and attitudes from different position of the employees in the study area.

This study revealed that the most important challenge in the study area is to change its administration from clientellism to universalism. Organisational administration and attitude is needed to develop its own administrative culture in the context of new public management and good governance.

Does subservience and clientelism really matter to ensure occupational safety as a part of organisational management? On the basis of the above discussion the conclusion seems to be an obvious. This is not the conclusive evidence that ignorance of occupational safety is similar in all of the public and private organisations or in NGOs in the study area. But it could be assumed that the situation is not very glowing in all other organisations. There is insufficient evidence in the literature for a possible cause of ignorance to ensure occupational safety in organisational structure in Bangladesh. This study is so far the first evidence that subservient attitude and senior-subordinate relationship may cause of barrier to ensure not only occupational safety execution but also other official rules and norms in the organisational structure. This practice of culture is not only threat in the study area but in all other city like Dhaka where this type of culture is being practiced. The study revealed that occupational safety culture must be regarded as something a policy ‘‘is” rather than ‘‘has”. Managers' and employees' behaviour should be changed as an organisational behaviour in a frame conditions for the development of organisational attitudes.

CONCLUSION

Thus, to minimize the potential risks and apply health and safety procedure it is necessary not only to identify the structured network, but also identify how the network is structured to a plan for socio-cultural and organisational acceptance from top to bottom. Therefore, need to identify the behavioural socio-cultural aspects towards structured network which may influence psycho-social networks. Behavioural phenomenon can be studied at multiple levels for example, can be approached from a psychological perspective social cognition (that may underlie fatalistic attitudes and casual behaviour), a contextual perspective (focusing on interpersonal processes that influence exposed individual and subservient behaviour).

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Existing Scenario of Hospital Waste Management in Rajshahi City: A Case Study

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ABSTRACT

To lead a happy and healthy life, it is essential to manage all types of waste properly. But in Rajshahi City it becomes a very difficult task to manage all types of waste due to lack of the proper knowledge about the waste management and the unmanaged implementation of rules and regulations during the process of management. The study has been carried out on the current situation of hospital waste management in Rajshahi City. Recently Rajshahi City Corporation (RCC) has been involved in medical waste collection. According to RCC register, there are 8 hospitals, 47 clinics and 22 diagnostic centers in RCC area. Among these, 3 hospitals, all clinics and diagnostic centers are covered by RCC collection system. The total waste generation in Rajshahi city is about 250 ton/day. The amount of medical waste generation is 3.5-4 ton/day which is 1.4-1.6% of the total wastes.

INTRODUCTION

Over the last two decades, management of solid waste has become one of most critical environmental problems facing the world's urban centers. The socio-economic development, urbanization and growth of population in most cities of developing countries have caused an increase in the amount and complexity of municipal solid waste and a greater demand for solid waste management. One of the important components of solid waste, waste generation from hospital, is a serious problem in the developed as well as developing countries. In many developing countries, hospital waste as a whole is being dumped with the municipal garbage (Pathak, 1998). But hospital waste management in developing countries is still poor and done without adequate guidance and supervision. In some other countries, hospital waste has not been legally defined (Dutta, 1998; Kwok-Kuen, 1998). Now, many countries are in the process of developing plans and regulations for safe management of hospital waste. Hospital wastes include sharps, human or animals tissues or excretions, medical products etc. other substances which can risk human health include pathological waste, chemical waste and radiological waste. Hospital waste can cause occupational health risks to those who generate, collect, store, transport, treats and disposal. They create environmental and public health risks due to inappropriate management techniques and spreading infectious diseases. Incident of public exposure to discarded blood vials, needles, empty bottles and syringes from municipal garbage bins and disposal sites are not uncommon in countries where hospital waste is not properly managed. Thus in most developing countries, there is an urgent need for environmentally safe management pf hospital waste. Rajshahi is one of the most populated city in Bangladesh and has been significantly increasing over past few years. With the city expanding in size and population, the problem of solid waste has come to the forefront. One of the important components of the solid waste in selected city is hospital waste. Hospital waste management includes collection, storage, segregation, handling, treatment and disposal of hospital waste. Most of the hospital are not treated properly and not separated with other household wastes in Rajshahi city. Therefore, it causes many environmental problems from solid wastes such as foul odor, flies, mosquitoes, rodents, stray dogs, littering of waste in the surrounding areas, ground water contamination and many adverse effects on human health. Sometimes hospital waste may cause serious virus infections such as HIV/AIDS and hepatitis B and C (Survey Report). hospital workers particularly nurses and doctors are the greatest risk of infection through injuries from contaminated sharps. Other hospital workers and waste management operators outside hospitals are also as significant risk, as are individual who scavenge on waste disposal sites. Therefore, the present study has taken onto consideration to study the existing scenario of hospital waste management in Rajshahi city with respect to generation, collection, storage, transportation, recycling and disposal.

HOSPITAL WASTE

Hospital waste is defined as the total waste stream from a healthcare facility that includes both potential infectious waste and non-infectious waste materials. Infectious waste includes infectious sharps and infectious non-sharps material. Infectious sharps consists of syringes or other needles, blades, infusion sets, broken glass or other items that can cause direct injury. Infectious non-sharps include materials that have been in contact with human blood or its derivatives, bandages, swabs or item soaked with blood, isolation wastes from highly infectious patients, used and obsolete vaccine vials, bedding and other contaminated materials infected with human pathogens. Human excreta from patients are also included in this category. Non-infectious wastes may include materials that have not been in contact with patients such as paper and plastic packaging, metal, glass or other wastes which are similar to household wastes (World Health Organization, 1997). Hazardous hospital wastes are unique forms of solid and liquid wastes generated in the diagnosis, treatment, prevention or research of human and animal disease (World Health Organization, 1997).

HOSPITAL WASTE IN ENVIRONMENT

Cheremisinoff and Shah (1990) identified the relation between the waste system and its waste in the environment as shown in figure 1. This can be relied that hospital wastes are released to the environment by many hospital activities in terms of as air emission, wastewater and solid wastes.

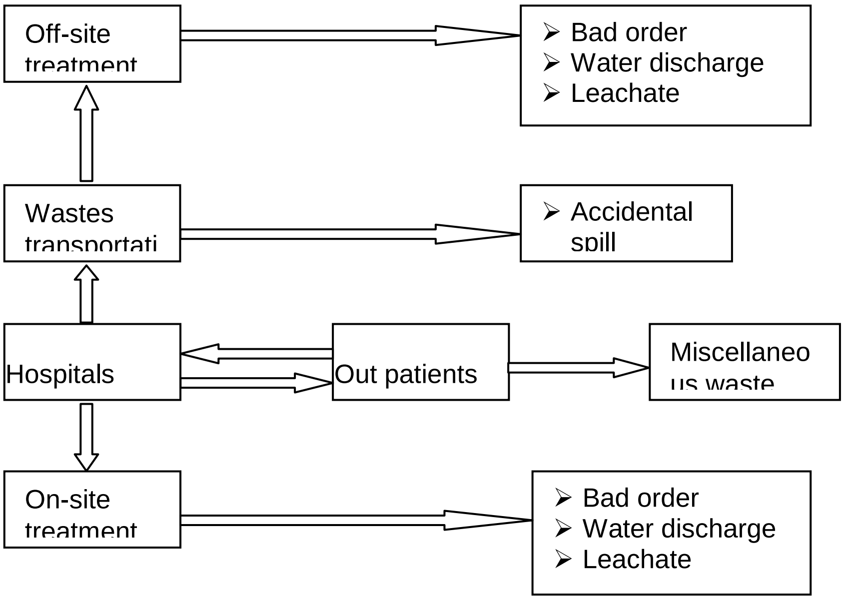

Figure 1. Hospital wastes in environments (Cheremisinoff and Shah, 1990)

DESCRIPTION OF STUDY AREA

Rajshahi City Corporation (RCC) is located in the northern region of Bangladesh. It occupies an area of 48.06 sq. km. It is located between 24°21´ and 24°23´ north latitude and between 88°28´ and 88°38´ east latitude. Closely, it can be said that it is bounded on the north by Noahata upazila, on the east by Parila and Horian union, on the south by Padma river and on the west by Haragram union and Harupur mouza. Thy city is situated at a road distance of about 270 km from the capital Dhaka. The climate of Rajshahi is generally marked with a typically tropical monsoon climate with high temperature, considerable humidity and moderate rainfall. The hot season commences early in March and continues till the middle of July. The maximum mean temperature observed is about 32°C to 36°C during the month of April, May, June and July on the other hand the minimum temperature recorded in January is about 7°C to 16°C. The highest rainfall is observed during the months of monsoon. The annual rainfall in the district is about 1,448 mm. The city is divided into 30 wards. In

2001, the population was estimated to be 350,000. Rajshahi city is now producing about 300M tones of solid every day. The city corporation is unable to manage this amount of solid waste. Expansion of city boundary as well as human settlement enhances the solid waste generation. The solid waste management will be a big problem for Rajshahi city in future. The present management system of solid waste is unhygienic. The RCC is now collecting and dumping both biodegradable and non-biodegradable waste together in landfill. The landfill at Nawdapara was started in 1963 but it is still traditional. There is no sanitary landfill in RCC area.

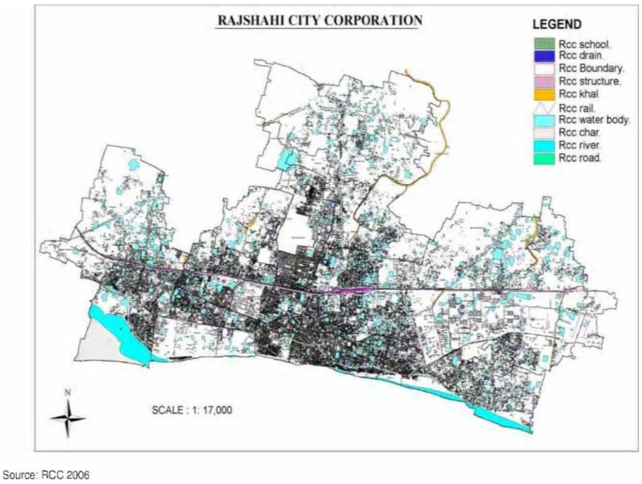

Figure 2. RCC area

TYPES OF HOSPITAL IN RCC AREA AND SELECTION OF HOSPITAL

According to RCC report there are 8 hospitals, 47 clinics, and 22 diagnostic centers at RCC (based on RCC report). Among these hospitals/clinics/diagnostic centers, 52% are general hospitals. 11% are specialized hospitals i.e. chest hospital, infectious disease hospital, leprosy hospital and another is a blood bank. Another 14% hospitals are treating specific diseases like heart, old-age problems/hospital for old-aged people, surgery, ENT, orthopedic, etc. Remaining 23% are diagnostic centers (Figure 3). Different types of services are provided by these hospitals/clinics such as primary healthcare, examining patients, surgery, pathological examinations, x-ray, ultra-sonography, treatment of chest-related diseases, etc. Few hospitals also provide nursing training. In this study four hospitals of various sizes are considered to investigate the generation, collection, storage, transportation, recycling and disposal of hospital waste in Rajshahi city. Table 1 shows that the selected hospital and their characteristics.

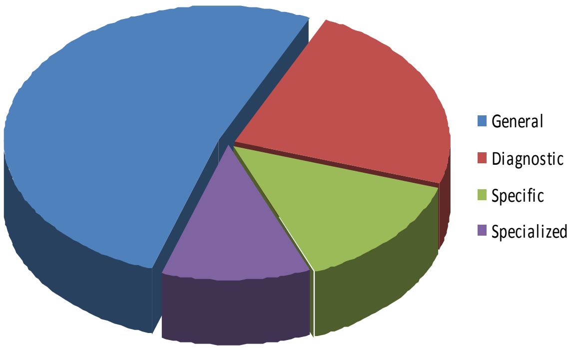

Figure 3. Type of hospitals in RCC area

Table 1. Selected hospitals and their characteristics

Symbolic name	Hospital name	Size of hospital	Type of hospital
Hospital A	Rajshahi Medical College Hospital	Large scale	General
Hospital B	Islami Bank Medical College Hospital	Medium scale	Private
Hospital C	Islami Bank Hospital	Small scale	Private
Hospital D	Christian Mission Hospital	Medium scale	Specialist

RESEARCH METHODS

The questionnaire survey and interview had done to identify the existing practices from the selected hospitals. Existing situation of hospital waste management covers primary data collection such as review and study of hospitals. This study also contains secondary data collection. The following are provided the procedure of undertaking the study are and the method of data collection for this study. The purpose is to improve the health condition of people and environmental quality of Rajshahi city, Bangladesh. The overall work to be done is described schematically by the flowchart showing in the Figure 4.

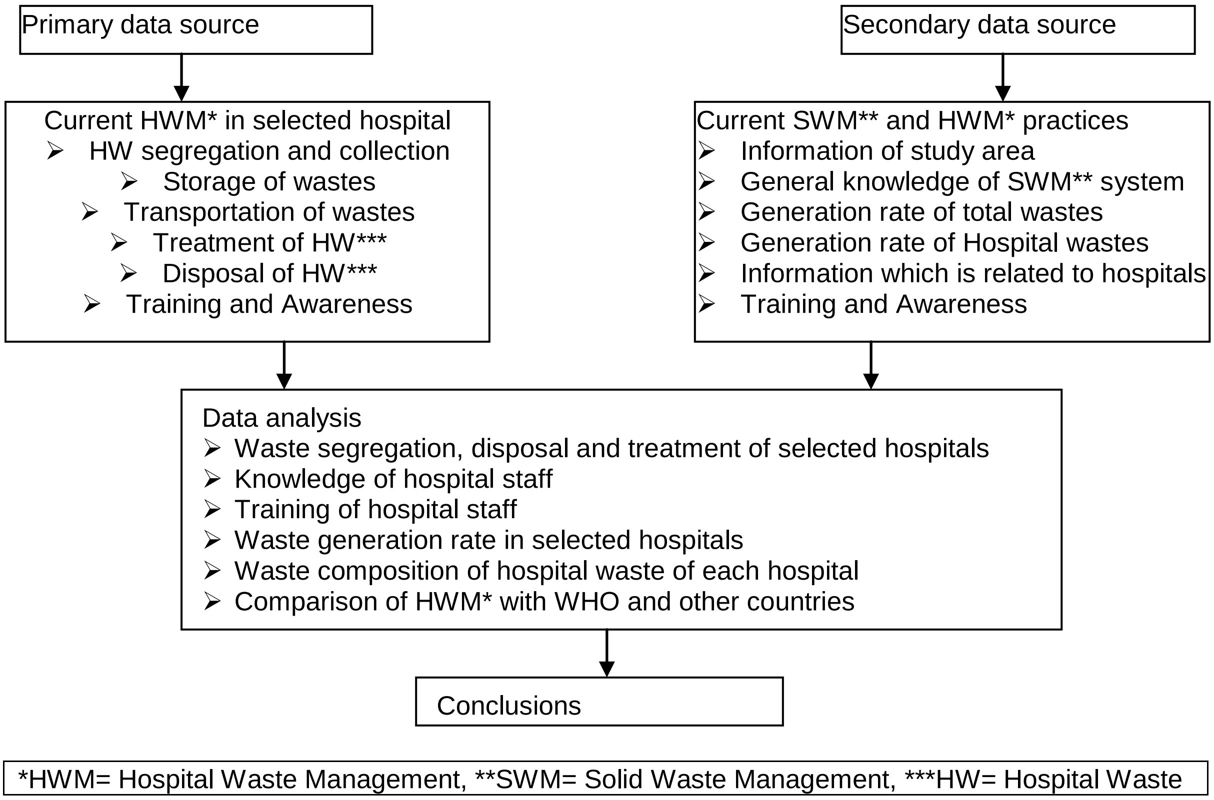

Figure 4. Flow chart of methodology

FIELD OBSERVATION AND QUESTIONNAIRE SURVEY

In order to obtain more adequate information about the hospital waste management practices, field observation to the hospitals in Rajshahi city, Bangladesh were scheduled. Field observation has done in the selected hospitals that focus on the current situation of waste management practices. Main emphasis was the current hospital waste generation rates and waste management practices of hospital before disposal. Field observation was done by inside and outside the hospitals. Observation also covered the behavior or attitude of doctors, nurse and waste handlers on the issue of waste generation and handling. Interviews were conducted with the involvement of the hospital waste management authority, word master of the hospital and office staff and RCC. Questionnaire were conducted with people involved in providing waste handling and pretreatment of hospital waste before final disposal. Doctors, nurses, cleaners and people around the area were included in the questionnaire survey. The main purpose was to assess the knowledge of the awareness about the improper disposal of waste, knowledge and skill necessary for handling waste properly.

WASTE GENERATION RATE IN SELECTED HOSPITALS

The waste generation rate is very important in deciding on the best disposal option. It is not obtained for the quantities of wastes from all hospitals; however some data have been provided. The waste generation rate of hospital differs from hospital to hospital. The waste from hospital was divided into

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two categories; general waste and hazardous waste. Among general waste and hazardous waste from hospital, general waste quantity is higher than hazardous waste in selected hospitals. The total amount of waste per day can be calculated by multiplying the number of beds by amount of waste per bed. From the detailed estimation and waste quantities of selected hopitals, it is found that hazardous waste per bed night in hospital A is 0.80 Kg, hospital B is 0.58 Kg, hospital C is 0.55 Kg and hospital D is 0.65 Kg. the quantity of hazardous waste, general waste and total waste is shown in Table 2 and Figure 5.

Table 2. Waste percentage of selected hospitals

Hospitals	No. of beds	HW per bed (Kg)	GW per bed (Kg)	Total HW per day (Kg)	Total GW per day (Kg)	Total waste per day (Kg)
A	530	0.80	1.10	424	583	1007
B	70	0.58	1.02	41	74	115
C	54	0.55	0.95	30	51	81
D	100	0.65	0.90	65	90	165

HW= Hospital Waste, GW= General Waste

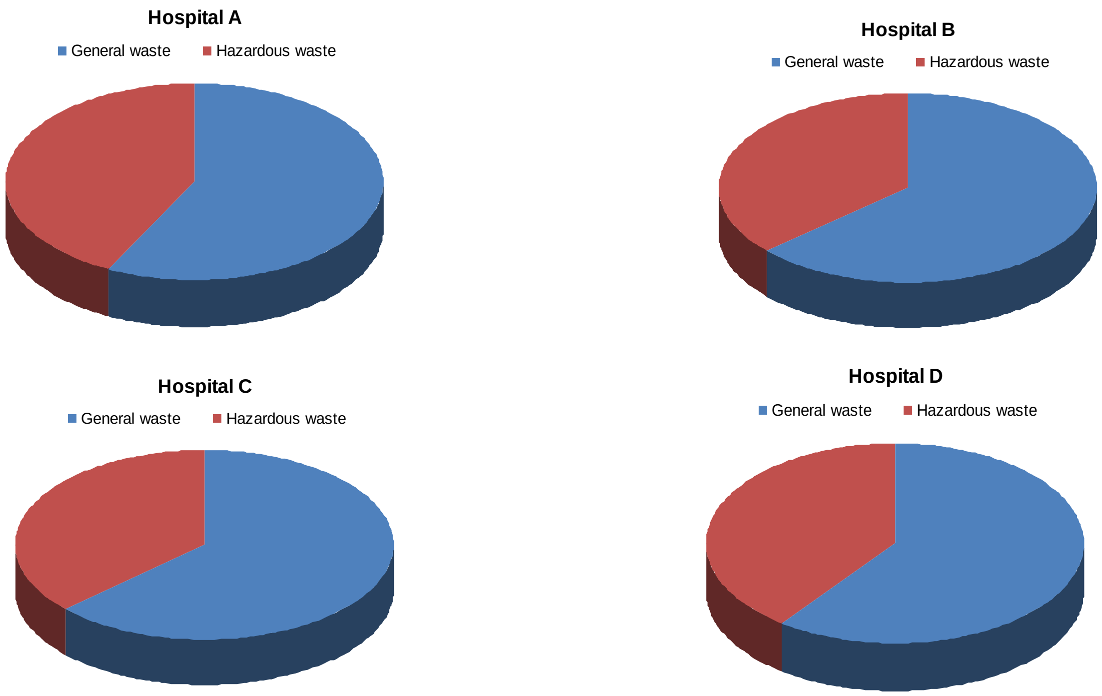

Figure 5. Waste percentages in selected hospitals

HOSPITAL WASTE MANAGEMENT IN RAJSHAHI CITY

A study conducted in Rajshahi city on the solid waste generation, collection and disposal by RCC has revealed that the generation of hospital waste is 1.6% of total waste. Therefore, total generation rate of solid waste in Rajshahi is 250 ton/day at maximum generation rate and amount of hospital waste generation is ton/day. The hospital waste management and RCC collection and treatment of hospital wastes is described by the flow charts showing in Figure 6.

DISCUSSION

From the field observation and questionnaire survey, it is observed that hospital D (Christian Mission Hospital) is more systematic for the color coding and segregation. Other three hospitals follow color coding system and segregation but comparatively less than WHO standard. Recycling is not done in any hospital of the Rajshahi city. The hospital staffs from selected hospital have awareness about hospital waste management practices but they need more training to do this in systematic way.

Hazardous hospital waste is the serious problem for the Rajshahi city. Therefore, the efficient hospital waste management practices is essentially needed for all hospital in Rajshahi city. The authorized person from the hospitals and solid waste management organization should try for possible waste reduction way from the hospitals and to improve their waste management practices.

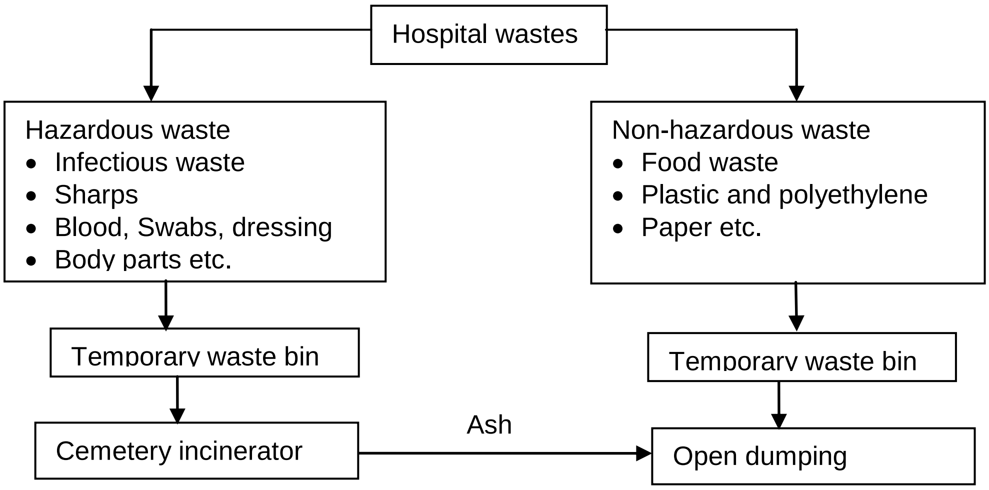

Figure 6. Flow chart of hospital waste management in Rajshahi city

CONCLUSION

This study aims to research the opinion of doctors, nurses and cleaners/workers in hospitals about hospital waste management and survey the weakness of hospital waste management in Rajshahi, Bangladesh. According to this study, are selected hospitals, Rajshahi medical college hospital is the biggest one and others are smaller in size. Total waste per day from hospital A, B, C and D is 1007 Kg, 115 Kg, 81 Kg and 165 Kg respectively. Hazardous waste in hospital A, B, C and D is 42.10%, 36.65%, 37.04% and 39. 40% of total waste respectively. RCC is responsible for treatment and disposal of hospital waste in Rajshahi city. They used incineration method for treatment. They do not follow WHO guideline properly. General waste from hospital is sent to the open dumping site. In comparison with the other countries (USA and Thailand), all the hospitals of Rajshahi city do not follow WHO guideline. Therefore, all the hospitals of Rajshahi city should try to improve their waste management practices.

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An Environmental Study on the River Buriganga

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ABSTRACT

River- the main attraction of beauty of a city has a great role to human settlement since the ancient era has established along their banks. Dhaka, the capital of Bangladesh has been expanding along the bank of Buriganga from last 400 years. Buriganga is now one of the most polluted rivers in Bangladesh.The study has been conducted to find out the existing condition of Buriganga, to assess the river water quality and to recommend some urgent improving measures. Water samples have been collected from some points of Buriganga river and tested for some important parameters. From the test results it is revealed that most of the samples exceed the standard limit of ECR'97.Thus Buriganga poses serious environmental threats to the Dhaka City's sustainable environment. It is high time to save the river to rebuild and rejuvenate the virtually extinct and lost flora and fauna of this mega city.

INTRODUCTION

Buriganga a tide-influenced river passing through the west and south of Dhaka city was once the lifeline of Bangladesh capital. It has a traditional story behind naming it. In ancient times, one course of the Ganges used to reach the Bay of Bengal through Dhaleshwari. This course gradually shifted and ultimately lost its link with the main channel of the Ganges and was renamed as the Buriganga. The scenic beauty of the river which astonished the Mughals is now one of the most polluted rivers in Bangladesh. Water pollution in the River Buriganga is at its highest. In the dry season, the dissolved oxygen level becomes very low or non-existent and the river becomes toxic (Iffat, 2008). According to environmental experts, much of the Buriganga is now gone, having fallen to insatiable land grabbers and industries dumping untreated effluents into the river. The water of the Buriganga is now so polluted that all of the fish have died and increasing filth and human waste have turned it into a black gel. Even rowing across the river is now difficult for it smells so badly. And because of encroachment, unplanned urbanization and establishment of polluting industries in the city, water pollution has taken such a devastating shape that the river, mother of the civilization, has been killed by the 'civilized' people (Ershad, 2009). So it is high time to save the river from the devastating effect of urbanization and to establish the flora and fauna of this mega city by giving a new life to Buriganga.

OBJECTIVES OF THE STUDY

Dhaka-the capital of Bangladesh, a city of 16 million people largely depends on the Buriganga's water. The river has an enormous significance to the residents of Dhaka including water supply, navigation, recreation, irrigation, fisheries, flood control & domestic and industrial utilization. The Buriganga [Figure1] is of great economic importance to Dhaka as it provides river connection to the rest of the country by launch and country boats. But the river has dramatically been disrupted due to extreme reduction of its water flow, encroachment of the banks and vigorous pollution due to domestic, industrial & solid waste dumping. The study has been conducted in the Department of Civil Engineering at Stamford University Bangladesh with the specific objectives to study the surrounding environment at some selected locations around Buriganga river, to assess the river water quality in terms of some very cardinal water quality parameters, to investigate the reasons behind this extreme water pollution and finally to provide some suggestions to improve the existing condition.

Figure1 The River Buriganga

METHODOLOGY

The methodology for this particular study consists of practical field observation and field based data collection through structured & non structured questionnaires, formal & informal interviews with the concern person(s) .The relevant secondary data for this survey is collected from the Department of Environment (Doe) and other published & unpublished sources. The collected water samples were tested in the Environmental Engineering Laboratory of Stamford University Bangladesh. Simple statistical methods such as averages and percentages are applied to compare different variables and then statistical graphs in term of bar chart are drawn to clearly point out the scenario.

SAMPLE COLLECTION AND TESTING

The Buriganga River is the main out let of waste water of Dhaka city. About eighty percent (80%) of Dhaka's sewage is said to be untreated and thrown to the river (DoE, 2005). A large number of industries including tanneries discharge their chemical wastes directly in to the river. That is why four different locations for collecting representative sample were carefully chosen to correctly measure the water quality parameters. The sampling points are Dholaikhal intake point, Sadarghat, Chandnighat, and Hazaribagh as shown in Figure 2. Water samples were collected from three chosen points of each selected locations one from the left bank ,one from the right

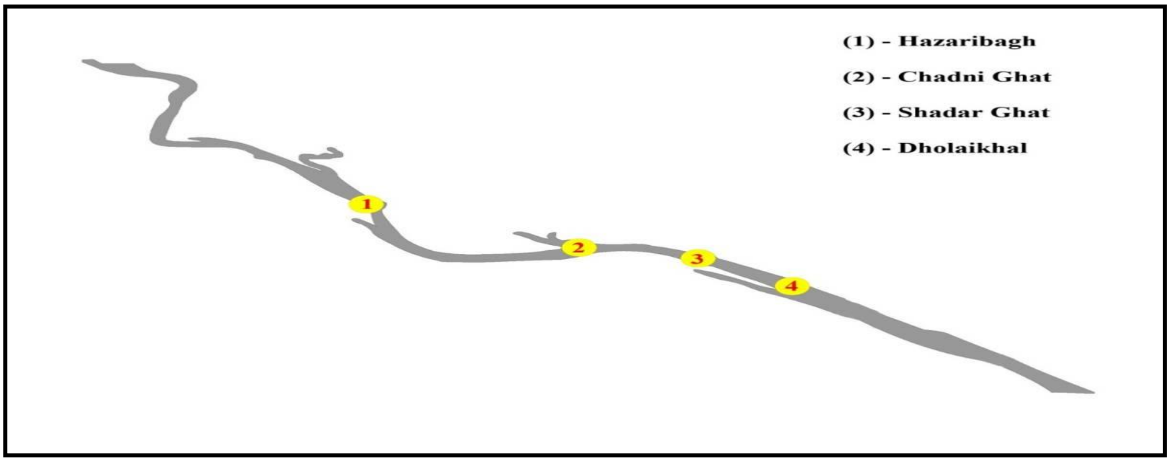


Figure 2 The sampling points on Buriganga

bank and the rest from the middle cross-section in November 2011.The samples were then tested for a wide range of water quality parameters included pH, color, turbidity, alkalinity, hardness, chloride, iron, and BOD5 .The samples were collected in plastic bottles. Before sampling, the bottles were thoroughly cleaned up by fresh water. The bottle mouth and caps were carefully cleaned. The collected samples were transported to laboratory as quick as possible. The test results are shown in table 1.

Table-1: Test results of samples collected from different locations of Buriganga river

Location	Sampling points	pH	Color(TCU)	Turbidity(NTU)	Hardness(mg/l asCaCO3)	Chloride(mg/l)	Alkalinity(mg/l as CaCO3)	Iron(mg/l)	BOD5(mg/l)
Hazaribagh	Left Bank	7.3	774	54.8	322	180	387	0.91	92
	Middle	6.9	698	47.3	288	175	366	0.93	
	Right Bank	7.1	712	41.5	302	178	382	0.91	
Dholaikhal	Left Bank	6.9	318	8.9	486	167	460	0.33	72
	Middle	6.8	354	7.6	467	160	469	0.26	
	Right Bank	6.8	341	7.2	473	163	463	0.31	
Sadarghat	Left Bank	7.3	732	14	466	61	462	0.61	92
	Middle	7.1	674	14	450	55	449	0.63	
	Right Bank	7.2	656	13.7	452	59	457	0.63	
Chandnighat	Left Bank	7.3	662	53.3	382	59	464	0.88	90
	Middle	7.1	648	55.5	410	40	461	0.80	
	Right Bank	6.9	666	51.5	391	54	461	0.83	

RESULTS AND DISCUSSIONS

Overall Water Quality

The pH of water of the river Buriganga has shown a variation from 6.8 to 7.3. The left bank of the river contains higher pH value from the right bank and middle. The weighted average values of pH of water in Hazaribagh, Chandnighat Sadarghat and in Dholaikhal intake point were 7.1,7.1 7.2 and 7.2 respectively. This indicates that pH is increased from Hazaribagh to Dholaikhal in the direction of water flow. No sample has crossed the range set by Environmental Conservation Rule (ECR,1997) which is 6.5 to 8.5. The color of the river water has shown a variation from 318 to 774 TCU. The weighted average values of color of water in Hazaribagh was 728, where as in Chandnighat it was 659 , in Sadarghat it was 687 and in Dholaikhal intake point it was 338. From the average value, it can be said that the color is very high in Hazaribagh, because many tanneries, lather industry and dying industry discharges their waste water directly into the river [Figure 3,4,5].


Figure 3 Industrial waste water falls into the river

'ECR 1997' recommends that the limit of color of fresh water should not be greater than 15 TCU. Now a day the river water looks like black gel due to huge discharge of industrial and household waste [Figure 6].

Figure 4 People as well as domestic animals bathing in the river.

Figure 5 Aquatic plants boom in the river

The turbidity of the river water shows a variation of 7.2 NTU to 55.5 NTU. The weighted average values of Turbidity of water in Hazaribagh was 47.87 NTU, where as values of Turbidity in

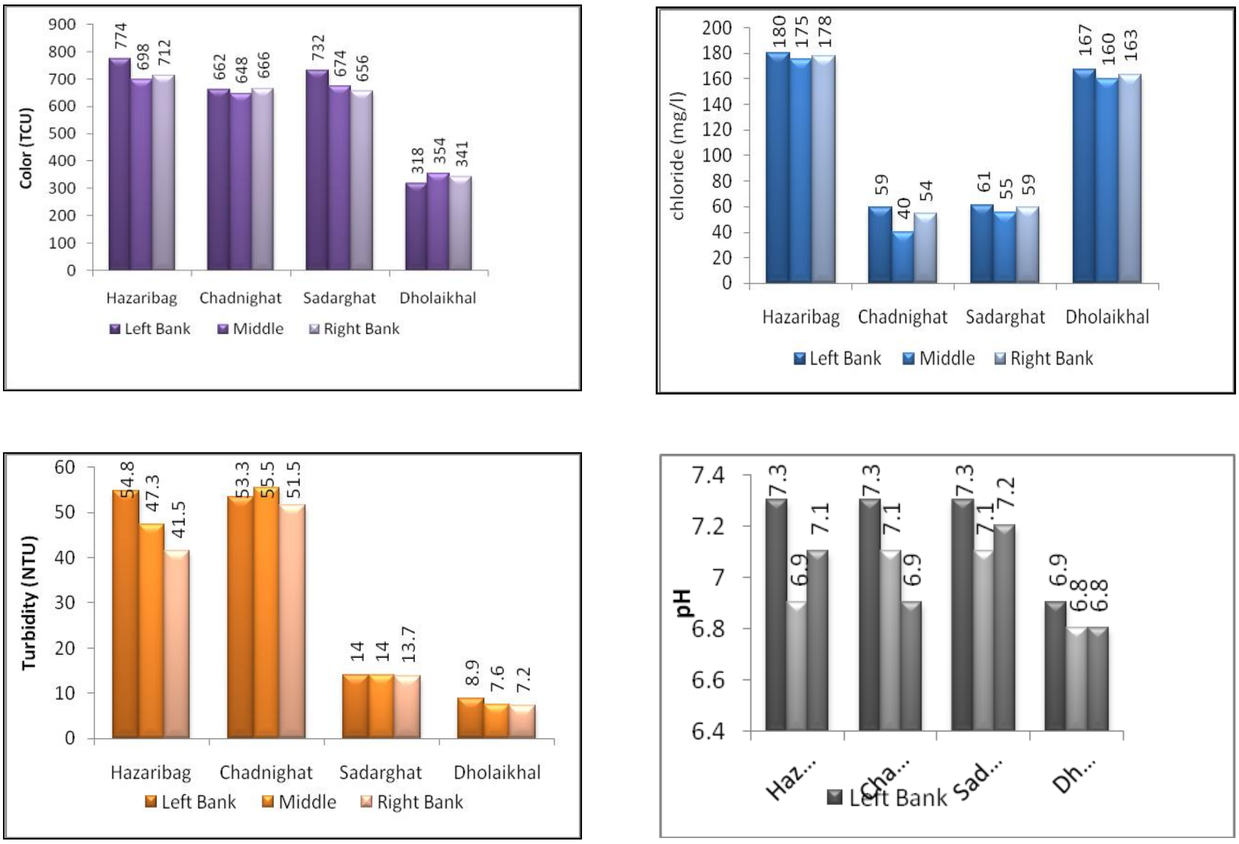
Chandnighat,Sadarghat and Dholaikhal intake point were 53.43,13.9 and 7.9 NTU. From the average value, it can be said that the Turbidity of water is high in Chandnighat. According to ECR 1997, the standard value of turbidity is 10 NTU. Turbidity has crossed the standard value in every sampling point except Dholaikhal .The hardness of water of the river Buriganga has shown a variation from 288 mg/l to 467 mg/l as CaCo3. The weighted average values of Hardness of water in Hazaribagh was 304 mg/l, where as in Chandnighat it was 394 mg/l and in Sadarghat it was 456 mg/l and in Dholaikhal intake point it was 475 mg/l. From the average value, it can be easily seen that the hardness of water is high in Sadarghat. The ECR 97 recommends a range of hardness for surface water will be the range in 200 to 500 mg/l as CaCo3. No sample was found to have crossed the upper limit.

Figure 6 River water turns into a black gel

Alkalinity of water of the river Buriganga was found to vary from 366 mg/l to 469 mg/l as CaCO3. 366 mg/l was found in Hazaribagh and 469 mg/l was shown in Chandnighat. The weighted average values of alkalinity of water in Dholaikhal was 464 mg/l, and in Hazaribagh Sadarghat and Chandnighat it was 378 , 456 and 462 mg/l respectively. A thorough analysis of the values shows that, the value of alkalinity is nearly same for all samples. The chloride of water of the river Buriganga was found in a range of 40 mg/l to 180 mg/l. The weighted average value of chloride of water in Dholaikhal was 163 mg/l, in Hazaribagh it was 178 mg/l and in Sadarghat and Chandnighat it was 58 mg/l and 51 mg/l respectively. From the average value, it can be revealed that the chloride of water is shown highly variation in Dholaikhal and Hazaribagh than in Sadarghat and Chandnighat. So much salt is used in tanneries for processing of lather in Hazaribagh. The ECR allows a range of 150 mg/l to 600 mg/l chloride in drinking water. None of the samples has crossed the upper limit. Iron of water of the river Buriganga was found in a range of 0.26 mg/l to 0.93 mg/l. The weighted average value of iron of water in Dholaikhal, Hazaribagh, Sadarghat and Chandnighat was 0.30, 0.92, 0.62 and 0.84 mg/l respectively. Weighted average value shows that iron of water has not exceeded the standard limit of 1 mg/l set by ECR 97. Biochemical Oxygen Demand (BOD) is not actually a water quality parameter but it is the most commonly used indicator of the general health of a surface water body. Now in present, BOD (Biochemical Oxygen Demand) is very high in river Buriganga. Test results have shown that the BOD5 in Hazaribagh was 92 mg/ l and in Dholaikhal , Sadarghat and Chandnighat it was 72, 92 and 90 mg/l respectively which exceeds the limit set by ECR,1997.

Figure 7 Hospital established on the river side.

The variation of pH, Color, Turbidity, Hardness, Alkalinity, Chloride, Iron and BOD5 of the samples collected from the study area are shown in the Figure 8.



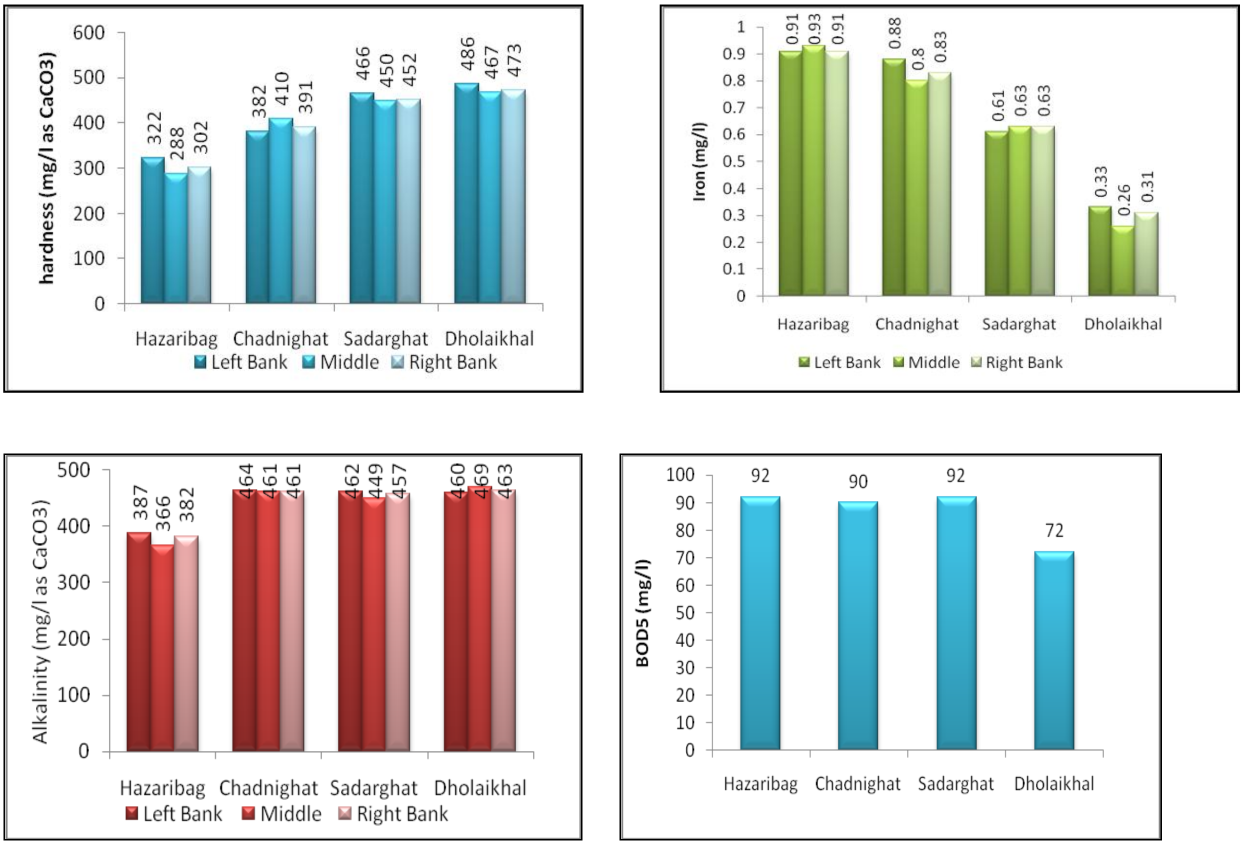


Figure 8 Variation of water quality parameters on the study area

Surrounding Environment of the Study Area

Dholaikhal is an important area of Dhaka city as the historic Lalbagh fort, Ahsan Manzil, Barakatra and Chhotakatra is located here. Dholaikhal is now a busy centre of trade and commerce. There are more than 5,000 shops in the area. Also there are innumerable small workshops for repair or manufacturing of many types of household items, machinery parts and some dockyard on the opposite bank. Major business activity in the area is the sale of automobile parts and spares, sanitary fittings and computer accessories. Most of the polluted water from these workshop directly enters into the Buriganga river through the canal .Dholaikhal once used for boat race and other sports, including swimming has now become a marsh [Figure 9].Annual fairs which were held at different places on the banks of the canal on festive occasions is now a nightmare.


Figure 9 Dholaikhal –a marshy land

Sadarghat is one of the most dynamic areas in Dhaka, but its fullest potential has not yet been realized. It is part of one of the historic centers of Dhaka where the city begins and a vital riverine node, the area has now become the symbol of sharp physical and environmental deterioration of the river and its banks. All along the roadside of Sadarghat has a wide range of merchandise. Sadarghat Launch Terminal is a large gnat or wharf in Dhaka. It is located on the banks of the Buriganga river, it is also referred as Sadarghat Port. It stands a little left in front of the Ahsan Manzil. It is the main port and dock of Dhaka. It was built for landing boats, launches and even ships coming to Dhaka. According to officials at the terminal, an average of 30,000 people uses the terminal for departure and arrival every day. About 200 large and small passenger launches depart and arrive at the terminal every day. Water pollution is at its extreme condition in Sadarghat due to throwing of wastes by the passengers, washing, painting & repairing of launches, boats etc [Figure 10]. About 7.7 million litres of liquid waste including burnt oil, leak oil, paint material is discharged into the river (Ershad, 2009).

Figure 10 Painting of a ship in Sadarghat

There is a water treatment plant in Chandnighat which is established 1890 by Nawab Khawaja Abdul Ghani to supply potable water in the city and from there a narrow canal falls in the rivers main stream. Hazaribagh is famous for tanneries and lather industries. A big tannery produces about 2500 gallons of liquid waste and Leather sector also produces 150 tons solid waste a day which is thrown into Buriganga (IEDS, 2003)[Figure10]. These harmful wastes, including chromium, lead, sulphur, ammonium, salt and other materials, are severely polluting the capital city and the river Buriganga. The photographs of the existing condition of Buriganga are shown in Figure11 and12.

Figure 11 Domestic and industrial waste discharged into the river in Hazaribagh

Figure 12 Oil and plastic waste polluting the river in Chadnighat

CONCLUSIONS AND RECOMMENDATIONS

As Dhaka city is expanding day by day with the increasing rate of population, now a day it has become a regular event that river area is used up by the land grabbers. As a result all the main rivers are becoming narrow day by day. Because of high growth rate of population the country is expected to have its population more than 280 million by the year 2050. About 40% of these total rural or urban migrations will take place to greater Dhaka. Dhaka has now become a mega city that causes enormous pressure on the surrounding rivers because maximum drainage outlets and sewerage of this mega city falls into the rivers like Buriganga. Literature review reveals that there are many industries developed on the river bank and those discharges about 1.5 million cubic meters of untreated waste water everyday into the river. This is one of the most vulnerable reasons behind the extreme pollution of the river water. The water quality parameters that are tested for the river water showed that most of the samples crossed the limit set by ECR, 97. Few samples were within the standard limit and still some kingfishers are flying over the river to collect their daily meal from it. It is high time to save the river from the devastating effect of urbanization and to establish the flora and fauna of this mega city by providing a new life to Buriganga.

The existing condition of the river can be improved by proper dredging of the river and removing non degradable matters from the river bed. Unauthorized establishment on the river bank should be demolished and maintain a regular monitoring system against the land grabbers. Polluted water should be treated according to the international guidelines to minimize environmental pollution. All tanneries as well as other industries should have in house plant for the treatment of effluent discharged and should monitor effluent routinely. Law enforcement should be strictly maintained to prevent abuse of water ways and by creating a special law enforcement force to save Buriganga. Public Awareness should be increased for proper usage of the river water. Decentralization of some important industries, e.g. tanneries, dying industries etc from the center of the city to the periphery will help to rebuild and rejuvenate the virtually extinct and lost flora and fauna of this mega city. The Buriganga will get its life back; the city will be again economically vibrant, environment friendly, aesthetically pleasant and physically healthy and prosperous.

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Hospital Waste Management and Disposal in Dhaka City

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ABSTRACT

The increased number of clinics and hospitals in Dhaka are resulting in the increased amount of waste generation. Hospital waste contains toxic chemicals and hazardous materials from several diagnostic and treatment processes. The improper disposal of hospital waste in the country poses a high health risk to humans as well as the environment. Being concerned about public health and environmental aspect in the light of human rights perspective, this study is concentrated to create a cynosure that the issue of disposal of hospital and clinical waste which is yet to become a matter of concern in Dhaka, Bangladesh. Unfortunately there is no organized and appropriate hospital and clinical waste mechanism existing in Bangladesh and as a consequence, our human right of enjoying and protecting the environment for present and future generation is being threatened and infringed. The improvement of waste management in clinics and hospitals is essential to minimize the spread of infectious diseases.

PROBLEM STATEMENT

The safe disposal of Medical waste has been ignored in Bangladesh. Medical waste is a source of contamination and pollution to both humans and the environment capable of causing diseases and illnesses to people, either through direct contact or indirectly by contaminating soil, groundwater, surface water and air if not carefully handled. The rapid increase of hospitals, clinics, diagnostic laboratories etc in Dhaka city exerts an even more tremendous impact on human health ecology. More than 600 clinics and hospitals existing in the DCC generate an estimated 200 tons of waste a day (Lawson, 2003). According to World Bank (2003), only 10-25 percent of the hospital wastes are infectious or hazardous. The amount of such hazardous waste is quite small in figure and until recently this is not handled properly (WHO, 2001).

Bangladesh lacks both effective waste management facilities and relevant government policy to guide health providers and punish offenders and there has been little research done on Medical waste disposal in Bangladesh. Clinical and toxic wastes, without being treated separately, are dumped on the same ground as domestic wastes following primitive disposal practices, because there is no contained, sanitary lands fill sites in the country (UNCHS, 1996:32). Often medical staffs was found to generate revenue through sale of medical waste due lack of knowledge and interest in safe waste disposal and absence of a budget to effectively implement safe waste disposal (Rashid, Kazi, Akter, Nasima, Zerin, Ahmed, Chowdhury). To make the matter worse, poor scavengers (tokai) rummage through the pile, earnestly searching for saleable items like syringes. These are collected, washed, repacked and resold to the public.

The improper management of hospital waste is not only endangering the environment but also very much violating our human right. So, the present study endeavors to focus on this issue by bringing the real pictures of hospital waste management and knowledge level of hospital staff associated to the risks involved to it also indicating the lacking of essential systems, rules and regulations in to light especially in Bangladesh perspective based on Dhaka city along with the indications of parameters of possible recommendations in this regard.

OBJECTIVES

The objectives of this study were to:

- To identify the current medical waste handling practice (e.g. storage, collection, transportation and disposal) within the hospital premises
- Know the level of awareness of the people related to medical services regarding Medical waste.
- Assess the health and environmental risk of Medical waste (such as: chemicals used in laboratory, pathogenic organism)
- Provide recommendations and guidelines on methods to handle Medical wastes with a minimum impact to human health and the environment.

METHODOLOGY

This is an exploratory research based on qualitative and quantitative approach. In order to fulfill the aims and objectives, the project tasks were structured as data collection and data analysis.

a) Data Collection: Only secondary data have been collected for the study. The relevant secondary data for this project were mainly collected from the published and unpublished sources like books, journals, research reports etc.

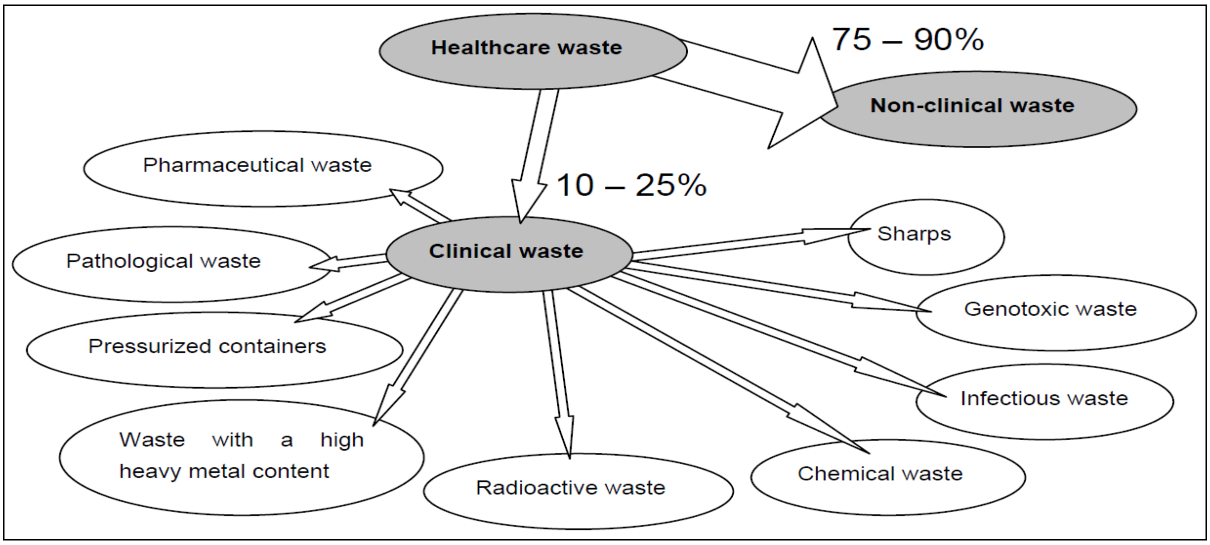
b) Data Analysis: The data were analyzed to address the central issues of hospital waste management with relation to the generation of wastes in different sources. The collected quantitative and qualitative data were analyzed by different techniques. The quantitative data analyses were based on statistical operations. While the qualitative analysis for this paper is based on the interpretation of text and observations.

c) Selection of the Study: Due to the availability of data Salimullah Medical College Hospital, Dhaka Medical College Hospital, Dhaka Medical College Hospital, Infectious disease hospital (T.B. hospital), Ibrahim Memorial Diabetic Hospital (BIRDEM), Sohrawardi Hospital and Shishu Hospital, Dhaka was selected for the study.

WASTE DISPOSAL AND MANAGEMENT PRACTICE IN HEALTH FACILITIES OF DHAKA

Generally, hospital waste is defined as the discarded or unwanted material or garbage or solid waste which is generated from the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals (Lee, 1989). These have the potential to cause disease and are a health risk. It is a by-product of health care that includes sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials (WHO, 2002).

The different categories of waste that HCEs produce are elaborated in the figure below.



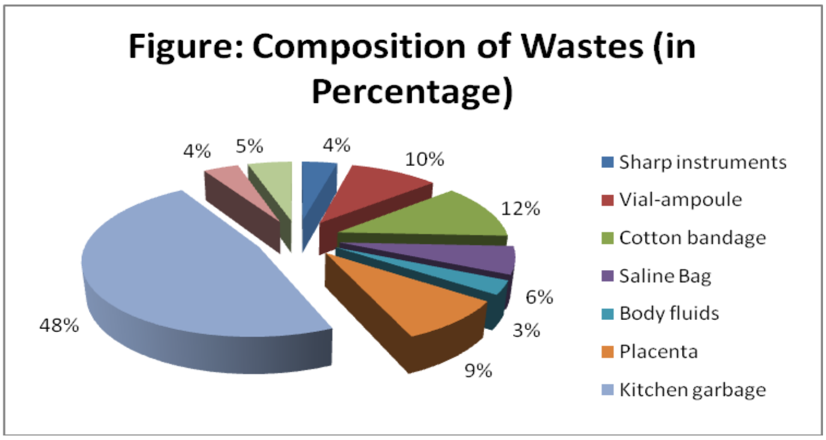
Source: Author's own assumptions based on the classification of health care wastes by Appleton J. and Ali M. in 2000 from "Risks from Healthcare Waste to the Poor, Healthcare or Health Risks?"

Figure 1: Categories of medical wastes

Figure 2: Different Types of Medical Wastes

The waste disposal practice in Health care establishments (HCE) of DCC can be divided into a number of steps. Below an overview is provided in a sequential manner.

a) In-house waste management: In some HCE, radioactive, infectious, and sharp wastes are separated from the non-infectious waste stream at the site of production and they are not stored in similar containers and are disposed together. In all hospitals, pharmaceutical waste and pressurized containers are disposed along with the general waste. Liquid pharmaceutical waste is poured into the drains along with liquid chemical waste.



Source: PRISM Bangladesh

Figure 3: composition of wastes

The table below shows that most of the HCEs (81.4%) don't even follow a systematic manner of waste collection regardless to disposal practices.

Table 1: Waste Collection Status of the HCEs

HCE Types	Systematic Collection	Non-Systematic Collection	Total
General Hospitals	11.86%	38.98%	50.8%
Private Clinics	3.39%	22.03%	25.9%
Diagnostic Centers	3.39%	20.34%	23.7%
Total	18.6%	81.4%	100%

Source: PRISM Bangladesh

b) Segregation: This study reveals that segregation of all wastes is not conducted according to definite rules and standards, some amount of infectious waste is stored in the same containers as the domestic wastes, and no control measures exist for the management of these wastes. Most of the HCE do not have plastic bags and strong plastic containers for infectious waste in accordance with the WHO guideline. In general, in most of the HCE, plastic and aluminum made containers are used. Intermingling of dangerous wastes with general waste in the hospitals is due to the lack of comprehensive staff training and to a lesser extent due to the lack of facilities.
There is no segregation system for infectious and non-infectious waste stream at the site of production almost in all the HCE. Only 81.4% of the HCE do not have any systematic waste collection procedure, while the rest one-fifth (18.6%) of the HCE collect their in-house waste systematically). Some HCE, say, Medinova, Ibn Sina, Popular Diagnostic centre, Central Hospital, and Dr Salahuddin Hospital segregate their sharp instruments and infectious wastes in separate bins and sent off to the ICDDR'B for incineration.

Only 8.47% HCE segregate their waste in separate bins. A total of 91.53% do not segregate the waste, but they have special storage before disposing them into the roadside DCC bin. The DMCH, BMCH, and Samorita dispose their wastes into the DCC bin without segregating them. Cleaners appointed in the HCE are responsible for cleaning and managing the waste generated in the HCE. They collected the waste from different Wards, OT, Pathology Department and other in-house sources and dispose it to the hospital bins before disposing them into the DCC bin. The integrity of packaging can be preserved during handling, storage, transportation and treatment. It is noted here that in all the surveyed HCE, sharp instruments are generally stored in separate refuse receptacles. In some HCE small empty bottles are separated and used for storage of blood and urine specimens. In some hospitals offering delivery services placentas and bottle stained cotton pads are put in separate containers. Pathological wastes from theatre are treated in a similar manner, but most HCE do not do the same.

c) **Temporary storage:** Some small HCE do not have any temporary storage and they simply disposed the waste into the DCC bin. Most of the HCE keep their waste in different designed bins located in the corner of the hospital yard until disposing into the DCC bin. In some HCE, the infectious and non-infectious wastes are kept in separate containers and are not mixed together in the hospital's own bin. It is noted here that all the wastes generated in the HCE finally intermingled when disposing them to the DCC bin.

d) **Disposal system:** The generated wastes are finally disposed into the DCC bin located close to any HCE. It can be done by each HCE, or NGO, or CBO. Almost 93% of the HCE collect and dispose their waste into the DCC bin. A very few HCE surveyed receive services from some private company engaged in refuse collection services. Western Organization, First Clean, RAKT, Nepcone etc, is involved in collecting and managing the generated wastes from different HCE. Western Organisation is engaged in cleaning and managing the waste from Medinova, a reputed diagnostic centre in Bangladesh located in Dhanmondi. Prism Bangladesh situated at Dhanmondi at present they have contracts with more than 150 private hospitals and clinics in Dhaka. They do not collect the general garbage but only they are concerned about hazardous garbage. They use two methods to manage the hospital waste by incinerator and by land filling.
At the end of each shift, hospital waste is collected and transported to a bin for temporary storage by hospital cleaners. In some HCE, closed containers are used for off-site transport of waste from the sites of production (different wards) to the DCC bin. The cleaners employed for handling waste in HCE do not use complete personal protective equipment (special dress-shirt and trousers along with gloves, mask, boots etc), but in very few cases, cleaners use only masks and gloves. Lacking of suitable and sufficient protective equipment and knowledge could expose them to serious health problems.

Table 2: Status of Waste Disposal Practice

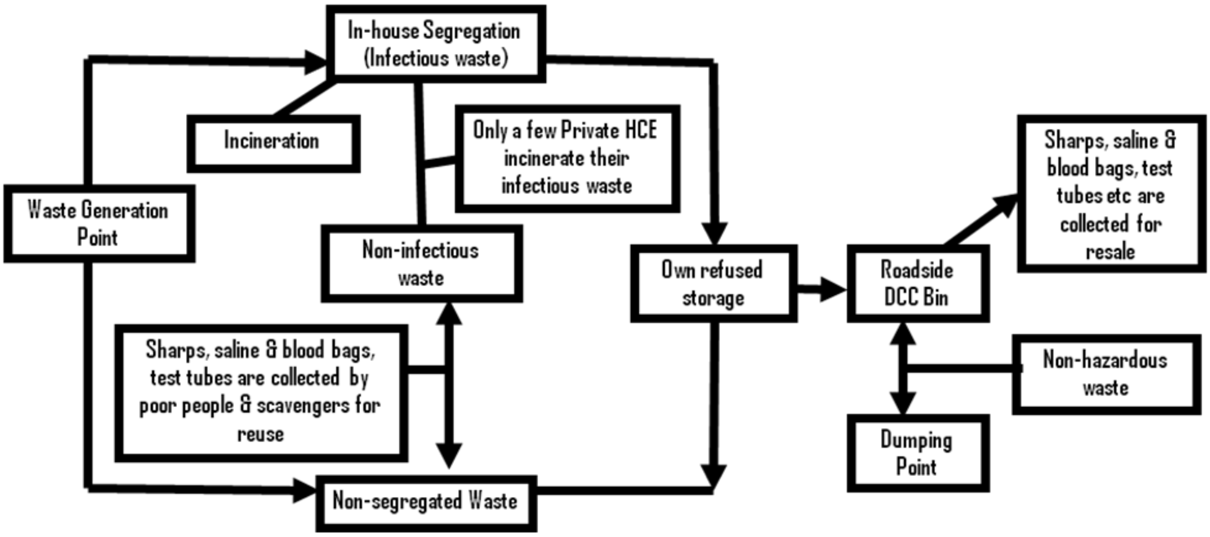
HCE Types	Own	NGO	CBO	Total
General Hospitals	47.4%	1.69%	1.69%	50.8%
Private Clinics	23.7%	-	1.69%	25.9%
Diagnostic Centers	22.03%	-	1.69%	23.7%
Total	93.22%	1.69%	5.08%	100%

Source: PRISM Bangladesh

e) **Off-site Transport and Final Disposal:** All the HCE surveyed dispose of their domestic waste at the same site as the civic waste. As the separation of hazardous waste from the domestic is not carried out properly, the domestic waste of the hospitals cannot be compared with the common city waste. Therefore, due to the intermingling of hazardous waste, these wastes should be considered infectious.

f) **Segregation of Wastes in the DCC Bin:** It has been found that some people are responsible in collecting, segregating and selling the used hazardous wastes. It is also noted here that the existing laws are generally outdated and characterized by low penalties and sometimes no penalties for offenders. Thus awareness towards this issue could be effective until formulating new laws to protect people and environment from deadly clinical waste.

Figure 4: Collection and segregation of medical wastes by scavengers found near DMCH



Source: Author's own observations based on secondary sources

Figure 5: Existing Hospital Waste Management Practice in DCC

Awareness and Training Regarding Medical Waste Management

It seems that most people were not aware what to be considered as medical waste. The respondents were also not aware of the harmful or hazardous elements of medical waste. Few knew that pathogens present in medical waste might be hazardous to human health. There is no provision for formal training to teach staff how to dispose of Medical waste. Although they received training on laboratory analysis, this was done in an *adhoc* method. Medical officers were aware that Medical waste could pose a problem. However, most of them thought that they were handling the situation sufficiently (Zerin and Ahmed, 2009). Nurses, laboratory technicians, and *ayas*, had no training on handling and disposal of medical waste.

Table 3: Status of Training

HCE Types	Got Training	Did not get Training	Total
General Hospitals	13.56%	37.29%	50.8%
Private Clinics	6.78%	18.6%	25.9%
Diagnostic Centers	10.17%	13.5%	23.7%
Total	30.5%	69.4%	100%

Source: PRISM Bangladesh

Risks and Dangers of Hospital Wastes

Medical wastes are a source of contamination and pollution to both humans and the natural environment.

A. **Health hazards related to Medical waste:** The main health risks of Medical wastes are summarized below (modified from WHO, 1999).
   - Contamination of drinking water. Possibility of leachate entering an aquifer, surface water or drinking water system.
   - Non-biodegradable antibiotics, antineoplastics and disinfectants disposed of into the sewage system may kill bacteria necessary for treatment of sewage. Antineoplastics flushed into watercourses may damage aquatic life or contaminate drinking water.
   - Burning of waste at low temperatures or in open container results in release of toxic pollutants (e.g. dioxin) in the air.(United States Environmental Protection Agency, 1998)
   - Carcinogenic waste such as heavy metals, chemical solvents and preservatives pose serious human health risks not only to workers but to the general public as well.
   - Inefficient and insecure sorting and disposal may allow drugs beyond their expiry date.
   - Unprotected and insecure landfill may pose health hazard to the scavengers and inhabitants at the vicinity.

B. **Environmental hazards related to Medical waste:** The following are environmental impacts associated with improper disposal of Medical wastes:
   - Pollutants from Medical 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).
   - Groundwater contamination, decrease in water quality.
   - Bio-accumulation in organism's fat tissues, and biomagnify through the food chain.
   - Repeated and indiscriminate application of chemicals over a long period of time has serious adverse effects on soil microbial population - reducing the rate of decomposition, and generally lowering the soil fertility.
   - Pathogens lead to long-term accumulation of toxic substances in the soil.
   - Specimens collected for analysis have the potential to cause disease and illness in man, either through direct contact or indirectly by contamination of soil, groundwater, surface water, and air
   - Windblown dusts from indiscriminately dumping also have the potential to carry hazardous particulate.
   - With domestic animals being allowed to graze in open dumps, there is added risk of reintroducing pathogenic micro-organisms into the food chain.
   - Public nuisance (e.g. odors, scenic view, block the walkway, aesthetics, etc.).
   - Improper sterilization of instruments used in labor room may cause infection to mother and child.
   - Combination of both degradable and non-degradable waste increase the rate of habitat destruction due to the increasing number of sites necessary for disposal of wastes (degradation of habitat).
   - Plastic bags, plastic containers, if not properly destroyed may contaminate the soil and also reduces the chance for water percolation into the soil during precipitation.
   - Open air burning does not guarantee proper incineration, and releases toxic fumes (dioxin) into the atmosphere from the burning of plastics i.e., PCB's.

There exist risks of possible injuries related to medical waste handling and carrying by waste hauler and/or cleaner. For example, cut-injury punctured wound, laceration, strain and sprain of the joint of Limbs and backache due to load hauling. Akter et. al., (1998) reported that, there were several incident (10 cases out of 17) of injury due to exposure to medical wastes inside or outside of hospital. As BAN & HCWH (1999), sharps, which include syringes and needles, have the highest disease transmission potential amongst all categories of medical waste. Almost 85% of sharp injuries are caused between their usage and subsequent disposal. More than 20% of those who handle them encounter 'stick' injuries. Infectious waste contains different kind of pathogens or organisms that is potential for infection or disease if it is not properly disposed. Bacterial Tetanus, gas gangrene and other wound infection, anthrax, cholera, other diarrheal diseases, enteric fever, shigellosis, plague, HIV-infections, HBV, TB, rabies etc (Akter, N., 2000). Moreover, the infections which can originate from patients while they are admitted in the hospitals are termed as endogenous infections and others derived from the hospital environment are termed as exogenous one. These kinds of infection may be transmitted through various sources, such as, air, dusts, droplets, food, utensils and apparatus and also by direct contact with carriers. Both endogenous and exogenous infections may lead to innumerable diseases like respiratory infection, urinary tract infection, wound infections and gastrointestinal infection. The more astonishing fact is that human blood, stool and urine are also directly thrown to the dustbins where it is handled by the tokais.

There were several incidents of injury due to the exposure of Medical waste inside or outside of hospital premises. These were as follows:

- Hands cut due to handling of broken glasses
- Fingers permanently damaged/became curved due to injury by needle,
- Right hands became paralyzed by injury from a needle,
- Two legs became paralyzed due to injury from a needle,
- Skin diseases on legs and hands,
- Puss due to injury, and
- Ulcer on legs. (N. Akter, 2005)

CONCLUSIONS

It is the human right of every human being to have a congenial, healthy and safe environment to ensure the quality of life that is consistent and commensurate with the status, dignity and prospects of human life. But the improper disposal or non-disposal of hospital waste is degrading our environment which is undoubtedly a clear violation of the right to life as guaranteed in our constitution (Article 32) including the protection of the human right to health. But unfortunately like other human rights' issues, this sector is not cared and protected by the respective authorities, rather it ignored by them as this violation of human right is indirect, slow, silent and for not being that much visible and audible. So, the collection, storage and disposal of medical wastes needs immediate attention before it go out of hand. The most important principles underlying effective programs for the management of medical waste include the awareness, assignment of legal responsibility, developing the rules and regulations concerning to the medical waste management as there is lack of systems, rules and regulations, and financial support. The HCE do not have any budgetary provision to manage their generated waste systematically either.

According to the US Army Centre for Health and Preventive Medicine (1995), Medical waste must be segregated from regular waste starting at the point of generation and continuing during storage, in transportation and through to point of treatment. Also, everyone concerned by medical waste should understand that medical waste management is an integral part of health care, and that creating harm through inadequate waste management reduces the overall benefits of health care (WHO, 2002).
In order to arrange a proper and systematic in-house waste management, the following alternatives could be considered:

a) More information must be collected on impacts, disposal and management of the hospital wastes by sufficient research activities to identify the real scenario and to draw a clear conclusion. Assistance of the developed countries, WHO and other organizations can be taken by the developing countries to establish a mechanism for hospital waste management.

b) To avoid the risk of health effect from the wastes, it needs to formulate proper policy and should promulgate and implement laws and regulations regarding medical waste management regarding this issue. Separate legislations must be formed to address the issue of hospital waste management as a separate environmental mandate and regular supervision of them are very much necessary. The government should take into consideration the WHO guidelines and other international instruments for formulating an effective mechanism. These legislations must be enforced by the appropriate judicial actions.

c) The health care waste management issue is becoming critical in view of the growing amounts of health care 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 infectious waste.

d) Medical wastes are needed to be segregated separately, according to its characteristics, at the point of generation (Prüss *et al*, 1999). All the HCE should use the WHO permitted color-coded, high-density polyethylene bags for easy identification and segregation of bio-medical solid waste. Non-infectious and domestic type of waste should be collected in black polyethylene bags, placed in bins while the infectious wastes should be collected in red, yellow and blue color-coded polyethylene bags placed within blue high-density polyethylene bags labeled with a bio-hazardous infectious materials symbol in specific bins (Patil and Pokhrel, 2004).

Figure: Medical Waste Containers according to WHO Guidelines for Infectious Wastes and Sharps

e) 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 commercial environment friendly incinerator can be suggested.

f) Safety protection must be taken in handling hazardous waste. Gloves, masks, aprons, etc. must be used during handling of medical waste,

g) To minimize the generation of medical waste, good housekeeping, replacement of chemicals, etc. may be adopted.

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Chemical Characterization of Khulna City Waste and Its Effects on Surrounding Soils through Lateral Movement

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ABSTRACT

The study was conducted for chemical characterization of Khulna city waste and to know its effects on surrounding soils.Waste samplewas collected from the dumping sites and soils were collected from the surroundings of the dumping sites,a reference soil was also collected far away from the dumping sites.The waste contained 3.82% OM, 0.11% N, 0.33% P, 0.64% K, 0.17% S, 0.15% Na, 686.72 mg/kg Zn, 429.20 mg/kg Pb, 23.96 mg/kg Mn, 2.83 mg/kg As, 2.20% Fe and 1.60 mg/kg Cd. The major nutrient elements and heavy metalscontents were higher in surroundings soils than that of reference soil. Though the higher contents of nutrient elements may improve the soil fertility, the heavy metals would be induced to the soil body. So, there might be a possibility to contaminate the surrounding soils by heavy metals through the lateral movement from the waste dumping sites to surrounding soils.

INTRODUCTION

The increasing quantity of solid waste is a growing environmental problem in developing countries. Compared to the cities and towns of developed countries, those of developing countries generate less solid waste per capita. In developing countries, people have less purchasing power and therefore consume less, there is less industrial activity and there is a very high rate of reuse of solid wastes by the poorer sections of community Cairncross and Feachem (1993). Despite this, large volumes of solid wastes are produced and constitute an enormous public health and environmental problems in most developing countries. Unplanned and inadequate collection of solid wastes, contribute greatly to an unhealthy environment. Bangladesh is a densely populated developing country in Asia and Khulna (22°49′0″N89°33′0″E), the third largest city in Bangladesh and a major industrial and commercial center, has the wider statistical metropolitan area at the same time an estimated population of about 1.39 million BBS (2009). On an average about 450 metric tons of solid waste are generated per day (http://www.khulnacity.org) and the civil administration Khulna City Corporation (KCC) is responsible for this city waste management. The KCC workers collect the waste as a whole and dispose into two dumping sites *viz.*Rajbath and Joykaly very near to the city as land filling. A part of them are used locally as organic fertilizer in crop fields. The city solid waste comprises garbage and rubbish materials like plastics, glasses, metallic cans, fibers, papers, rubbles, street sweepings, fuel residues, leaves, containers, paints and varnishes, dried sludge of sewage, abandoned vehicles, kitchen wastes and other discarded manufactured products which contribute to soil pollutionSharma (2001). The leachates from the land filling dumping sites are also extremely harmful and toxic as these wastes may contain numerous toxic heavy metals, which may pollute soil and enter into the plant/food chain Sattar and Blume (1999), Goldstein (1997). Since, the Khulna city waste is used as landfills as well as a part of them are locally used as organic fertilizer and the detrimental effect of these untreated wastes has not yet been investigated properly in soil and plants, so there is a possibility to contaminate the surrounding agricultural field through lateral movement from the site and there also might be a risk to contaminate the crop field through the waste that are using as organic fertilizer. So, there is necessity to its chemical characterization. To keep these in mind, this work was conducted for chemical characterization of Khulna city waste as well as to know the effects on surrounding soils through lateral movement in respect to heavy metal.

MATERIALS AND METHODS

The sampling site was situated at Rajbath union in Batiaghatathana under Khulna district. The samples were collected from two areas *viz.*Joykhali and Rajbath. The sampling areas were approximately 7 and 8 kilometer, respectively away from the Khulna city and on the right side of the Khulna-Satkhira highway.

Sample Collection

The waste materials were collected from both the two waste dumping sites. To collect the sample each sampling site was divided into 4×4=16 plots. Then one representative sample from each plot was collected in individual polythene bags and brought to the laboratory.Soil samples were collected at two distances one from very close to the dumping site (adjacent soil) and another from 5.0 meter far from the first sampling spot (far area soil). A total of forty soil samples were collected in individual small polythene bag and brought to the laboratory. A reference soil sample was also collected far away from the dumping site where there was no possibility of contamination. The organic fertilizer that was locally made beside the dumping site was also collected from the site.

Sample Preparation

The collected samples both soil and waste were processed in the laboratory. All the samples were opened in laboratory and air dried. After drying, the samples were separated from many unwanted small brick pieces, plastic materials, papers, polythene *etc*. All the dried waste samples were mixed thoroughly to make a composite sample. Then the samples were gently broken by wooden hammer and passed through a 0.5 mm sieve and stored into polythene bag for laboratory analysis. The collected soil samples were also dried in air individually by spreading them on sheet of plastic paper. After drying in air, the larger aggregates were gently broken with the help of wooden hammer. Then the soil was also passed through a 0.5 mm sieve and stored in separate polythene bag for laboratory analyses.

Laboratory Analysis

Some important properties as well as nutrient elements and some heavy metals were analyzed in all the samples in the laboratory by following the laboratory methods that are described in ImamulHuq and Alam (2005). For determining the total content of As, Fe, Mn, Zn, Cu, Pb and Cd the sample was extracted with aqua regia ($HCl:HNO_3$ = 3:1) and the extract was analyzed for by using atomic adsorption spectrometer Portman and Riley (1964). The QC and QA were strictly maintained during the analysis.The generated data were statistically analyzed by using the common statistical software MINITAB 13.0.

RESULTS AND DISCUSSION

The analytical results of the reference soil (the soil that was collected where there is no possibility of waste contamination), composite waste (collected from both the dumping sites) and the organic fertilizer (locally made beside the dumping site) are shown in the Table 1.

Table 1 Analytical result of the reference soil, composite waste sample and organic fertilizer

Parameters	Reference soil	Waste sample	Organic fertilizer
pH	7.10	7.59	6.80
EC (dS/m)	1.97	1.78	1.19
OM (%)	1.57	3.82	6.17
Na (%)	0.07	0.15	0.38
N (%)	0.05	0.11	0.18
P (%)	0.02	0.33	0.64
K (%)	0.27	0.64	1.25
S (%)	0.15	0.17	0.18
As (mg/kg)	3.81	2.83	2.34
Pb (mg/kg)	18.10	429.20	85.60
Cd (mg/kg)	0.40	1.60	3.00
Fe (%)	0.15	2.20	3.33
Zn (mg/kg)	2.12	686.72	256.80
Mn (mg/kg)	0.06	23.96	31.08

Table 1 shows that the waste contained higher amount of all the parameters except EC and As than the reference soil but of which Pb, Zn and Mn concentrations were very high. The organic fertilizer that was made from the waste also contained higher amount of both nutrient elements and heavy metals. Though the waste sample contained higher amount of nutrient elements, it also contained higher amount of heavy metals. So there might be the possibility to move the elements laterally from the dumping sites to the surrounding soils. Thus the soil samples collected from the surroundings of the dumping site were analyzed for all the parameters that were analyzed for waste, reference soil and organic fertilizer. The reference soil was considered as the standard because the reference soil was collected far from the dumping sites. The analytical results of the soils are presented and discussed in this section of the paper.

Soil Reaction or pH

The average pH value of adjacent soil samples was 7.30±0.59 ranging from 5.30-8.37 where most of the values were within the range 7.0-7.92. But the average pH value in far area soil was 7.48±0.65 ranging from 6.05-8.44 (table 2). Both the average pH value as well as the pH range in adjacent soils was lower than that of far area soilsbut in both the cases the average value is higher than that of reference soil. About 95 percent of the individual soil pH values from adjacent area was higher than the reference soil where as it was 80 percent for far area soils. The lower average pH, pH range, individual pH values in adjacent soil samples might be due to the release of different kinds of organic acids from the waste during the decomposition. Though the pH values between the two areas were different, the difference was not statistically significant.

Table 2 pH, EC, OM and Na contents in soils

	Adjacent area (n=20)				Far area (n=20)			
	Range	Average	SD	*%	Range	Average	SD	*%
pH	5.30- 8.37	7.30	0.59	95	6.05-8.44	7.48	0.65	80
EC (dS/m)	1.16-13.43	2.61	1.72	60	0.94-40.7	2.02	0.91	60
Na (%)	0.06-0.15	0.10	0.02	95	0.07-0.13	0.09	0.02	90
OM (%)	1.56-14.31	5.62	3.32	90	1.08-11.68	3.67	3.12	80

*content of the elements in percent of individual no. of soils higher than the reference soil
SD=Standard deviation, n=no. of samples

Soil Electrical Conductivity (EC)

The soil EC values varied among the collected soil samples as well as between soils from two different distances. The average EC values in adjacent and far area soil samples were 2.61±1.72 dS/m and 2.02±0.91 dS/m, respectively. There was one sample that contained extreme higher EC value (13.43 dS/m and 40.7 dS/m for soils adjacent to the dumping sites and far from the dumping sites, respectively (table 2). The average EC value was higher in soils from adjacent area than the far area from the dumping sites but it was not statistically significant. The EC values in both the cases were higher than that of reference soil (1.97 dS/m). About 60 percent of the individual soil sample's EC was higher than that of reference soil in both the areas. As the soil EC means the presence of soluble salts in it this could be due to the presence of soluble salts in city wastes which release from dumping site to surrounding soils. So, there might be a risk in future of the salinity effect in surrounding soil from waste dumping sites.

Sodium (Na)

Sodium percentages in most of the individual adjacent soil samples were higher than that of far area soil samples. The average value of Na in adjacent soil samples was 0.10±0.02% ranging from 0.06-0.15% which was higher than that of reference soil sample (0.07%) whereas in far soil samples the average value was 0.09±0.02% and ranging from 0.07-0.13% (table 2). About 95 percent of the individual soil samplesfrom the adjacent area and 90 percent of the individual soil samples from the far area were higher in Na content than the reference soil (0.07%). So, there might be a possibility to increase the salinity level in surrounding soil bodies.

Organic Matter (OM)

The average organic matter content in adjacent area was 5.62±3.32% ranging from 1.56-14.31%. But in far soil samples the average value was 3.67±3.12% ranging from 1.08-11.68%. Most of the individual values in adjacent area OM percentage were higher than far area soils. Individually 90 percent soil samples from adjacent area and 80 percent from far area the organic matter content was higher than the reference soil (0.91%). As the city waste contains different types of organic substances the high percentage of organic matter in adjacent area soils might be due to the lateral movement of liquid from the dumping sites to the surrounding soils during the decomposition.

The total content of the major nutrient elements (N,P,K and S) were analyzed and the data are presented in the table 3.

Nitrogen (N)
The average N percentage in collected soils from adjacent area was 0.17±0.13% ranging from 0.05-0.41% and from far area it was 0.11±0.09% and ranging from 0.01-0.34% (table 3). The reference soil N percentage was 0.12%. Not only the average N content in both the adjacent area soils and far area soils is higher than that of the reference soil, but also all the individual soils from adjacent area and 80 percent individual soils from far area contained higher amount of N than the reference soil. As the waste sample contained higher amount of N in it so there might be a possibility to increase the N content in surrounding soils by lateral movement.

Table 3 Total content of the nutrient elements (N,P,K and S) of the soils

	Adjacent area (n=20)				Far area (n=20)			
Total (%)	Range	Average	SD	*%	Range	Average	SD	*%
N	0.05-0.41	0.17	0.13	100	0.01-0.34	0.11	0.09	80
P	0.02-0.34	0.15	0.09	100	0.01-0.13	0.08	0.04	100
K	0.43-0.78	0.61	0.12	100	0.4-0.75	0.57	0.09	100
S	0.05-0.33	0.16	0.08	65	0.02-0.24	0.12	0.08	55

*content of the elements in percent of individual no. of soils higher than the reference soil
SD=Standard deviation, n=no. of samples

Phosphorus (P)
The waste contained very higher amount of P (0.33%) in it and the reference soil contained lower amount of P (0.02%) whereas the average P percentage in soils of adjacent area was 0.15±0.09% ranging from 0.02-0.34% and in far area soils it was 0.08±0.04% ranging from 0.01-0.13%. Most of the individual adjacent soils P percentage was higher than that of far area soils as well as all the individual soils contained higher amount of P than the reference soil. The reason would be the presence of higher amount of P in the waste.

Potassium (K)
The range of K content in adjacent area soils was 0.43-0.78% and the average value was 0.61±0.12% and it was 0.57±0.09% ranging from 0.4-0.75% for far area soils. The waste contained a higher amount of K (0.64%) and the reference soil contained 0.27%. All the individual soils contained higher amount of K than the reference soil. Through the decomposition of raw vegetables and others degradable waste nutrient element like K might be released to the surrounding soils.

Sulfur (S)
The average S percentage in collected soil samples from adjacent area was 0.16±0.08% ranging from 0.05-0.33% whereas the samples collected from far area the value was 0.12±0.08% ranging from 0.02-0.24% except one higher S percentage of 0.72%. The reference soil and waste contained S percentage as 0.15% and 0.17% respectively. Though the samples from adjacent area contained higher amount of S than that of far area soils, the percentage is very low. Only 65 percent of individual soil from adjacent area and 55 percent of far area soil contained higher amount of S than the reference soil.

The results showed that the soils of the surroundings of the dumping sites contained higher amount of nutrient elements like N,P,K and S than the reference soil. So, it is clear that the nutrient elements were laterally moved from the dumping sites to the surrounding soils through decomposition as the waste contained those nutrient elements in higher amounts. Besides, the organic fertilizer that was locally made by using that waste also rich in these nutrient elements which is good for plants. But the waste contained higher amount of heavy metals also. That’s why the metal contents of the soils were also analyzed and the data are presented in the table 4.

Arsenic (As)

The average soil As concentration in adjacent area was 3.35±2.24 mg/kg and ranging from 0.14-7.07 mg/kg. But the average soil As concentration in far area was 3.73±1.90 mg/kg and ranging from 0.55-6.15 mg/kg. Though the average soil As concentration in both the areas were lower than the reference soil about 65 percent of the individual adjacent soils and 60 percent of far area soilscontained higher content of As than the reference soil. Besides, the As content in reference soil was also higher than the As content in waste. The reference soil was collected from a field which is very far from the dumping site and that was an agricultural field in which groundwater irrigation is practiced. So, the higher content of As in the reference soil might be due the As load in soil from irrigation water.

Table 4 Metal contents in soils

	Adjacent area (n=20)				Far area (n=20)			
Total	Range	Average	SD	*%	Range	Average	SD	*%
As (mg/kg)	0.14-7.07	3.35	2.24	65	0.55-6.15	3.73	1.9	60
Pb (mg/kg)	bdl-89.6	26.98	24.65	65	bdl-46.2	11.13	13.77	40
Cd (mg/kg)	0.32-2.25	1.40	0.62	95	0.28-2.88	1.25	0.70	90
Fe (%)	1.10-3.07	2.27	0.59	100	0.67-3.77	2.21	0.81	100
Zn (mg/kg)	bdl-133.73	37.36	18.90	95	bdl-74.3	14.82	4.02	60
Mn (mg/kg)	1.88-54.28	39.89	6.68	100	24.08-53.0	38.03	8.55	100

*content of the elements in percent of individual no. of soils higher than the reference soil
SD=Standard deviation, n=no. of samples, bdl=below detection limit

Lead (Pb)

The average Pb concentration in adjacent area soils was 26.98±24.65 mg/kg ranging from 89.6 mg/kg to below detection limit and in two cases an extreme Pb concentration was found as 89.60 mg/kg and 72.80 mg/kg. This higher values were found the soils collected from very near to the highway that why this higher values might be due to the deposition from the automobile exhaust from the highway. The average Pb concentration in far area soils was 11.13 mg/kg ranging from 46.20 mg/kg to below detection limit. The average Pb concentration in adjacent area soils was higher than the reference (18.10 mg/kg) soil as well as far area soils. About 65 percent of the individual adjacent soil samples and 40 percent of the far area soil samples contained higher Pb content than the reference soil. So, there might be a possibility to contaminate the surrounding soil in future by lead.

Cadmium (Cd)

Individually 95 percent of the adjacent soils and 90 percent of the far area soils contained higher amount of Cd than the reference soil. The average Cd concentration of adjacent soils was 1.40±0.62 mg/kg ranging from 0.32-2.25 mg/kg whereas the value was 1.25±0.70 mg/kg and ranging from 0.28-2.88 mg/kg for far area soils. The high concentration of cadmium in adjacent soil samples than that of reference soil and far area soils samples might be due to the decomposition of waste from where cadmium could be released. Though the average value of Cd in in adjacent area soils was higher than that of far area soils, there were few samples in far from the dumping site that contained higher Cd than that of samples from the adjacent area. The far field is an agricultural field and fertilizers were used in the field to grow crops where phosphate fertilizer was a common one. As the phosphate fertilizer contain sustainable amount of Cd Grant (2011), so this might be the possible reason of higher Cd in far samples than the adjacent samples.

Iron (Fe)

The average iron concentration in adjacent soil samples was 2.27±0.59% and ranging from 1.10-3.07% except one higher extreme value. But the average iron concentration in far soil samples was 2.21±0.81% and ranging from 0.67-3.77% except two higher extreme values. In both the areas the Fe content was more or less uniform. Individually, all the collected soils contained higher amount of Fe than the reference soil. The higher Fe concentration in collected soils than the reference soil might be due to the leachate of iron from dumped area to adjacent soils because the city waste may contain higher amount of iron also.

Zinc (Zn)

The average Zn concentration in adjacent area soils was 37.36±18.90 mg/kg whereas it was 14.82±4.02 mg/kg in far area soils, though there were few soil samples which contained the Zn concentration at below detection limit. Moreover, Zn concentration in reference soil sample was 2.12 mg/kg which was much less than the average concentration of both the areasoils. Individually 95 percent of adjacent soils and 60 percent of far area soils contained higher amount of Zn than the reference soil. Since, the waste sample contained very high amount of Zn (686.72 mg/kg) itself, so this was the probable source of high concentration of Zn in soils collected around the dumping sites.

Manganese (Mn)
There is no uniform trend of Mn concentration of soil samples between the two areas. In some cases the individual soils from adjacent area contained higher Mn concentration than individual soils from far area and *vis-à-vis*. But average concentration of Mn in adjacent soils was (39.89±6.68 mg/kg) and for far soil samples it was (38.03±8.55 mg/kg) which are higher than that of reference soil (0.06 mg/kg). Individually, all the collected soils contained higher amount of Mn than the reference soil. This higher amount of Mn in surrounding soils of the dumping site might be due to the lateral movement of waste liquid.

The results showed that like the nutrient elements the heavy metal contents were higher in soils collected from the surroundings of the dumping sites than that of the reference soil irrespective to the distance. It was reported that the city waste of Bangladesh contains different types of trace metal like Cr, Ni, Cd, Pd, Hg, Mn, Zn, Cu, As, etc.Sattar and Blume (1999).These higher contents of the heavy metal ions in the surrounding soils clearly indicates the lateral movement of metals from the dumping sites to the surroundings soil body as the waste contained those metals.

CONCLUSION

The present study showed that the Khulna city waste and the organic fertilizer which is made locally from the city waste contains higher amount of nutrient elements as well as toxic heavy metals. The nutrient elements may improve the fertility status of the soil but the heavy metal may be induced to the plant-human system which is not desirable. The soils of the surroundings of the dumping sites contained higher amount of both the nutrient elements and heavy metals than the reference soil. So, there might be a possibility to contaminate the surrounding soils through the lateral movement of the metals from the disposal sites and there also might be a risk to contaminate the crop field through the waste that are using as organic fertilizer as the organic fertilizer contained a substantial amount of heavy metals.

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SCENARIO OF MEDICAL WASTE MANAGEMENT: A STUDY ON RAJSHAHI CITY CORPORATION, RAJSHAHI

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ABSTRACT

Medical waste (MW) poses a significant impact on health and environment especially for the third world country like Bangladesh. As one of biggest cities in Bangladesh, Rajshahi is facing various hygienic and environmental hazards due to lack of knowledge and awareness of individuals involved in medical waste generation, handling and disposal. The methodology of this project was descriptive and consisted of the use of field survey and interviews with the authorities of the different HCEs and personnel involved in the management of MW. The survey reveal that the surveyed HCEs generate a total of 1441 kg/day of MW, of which about 1287.1 kg/day (89.32%) are non-infectious and about 153.9 kg/day (10.68%) are infectious. The waste generation rate for surveyed HCEs is 1.55 kg/bed/day or 0.29 kg/patient/day. It was also found that there is no proper and systematic medical waste management in surveyed HCEs.

INTRODUCTION

Medical wastes are infectious and hazardous. Hassan *et al (*2008*)* reported that It poses serious threats to environmental health and requires specific treatment and management prior to its final disposal. According to BAN & HCWH (1999), Medical wastes are arising from diagnosis monitoring and preventive, curative or palliative activities in the field of the veterinary and human medicine The basic concept of waste management in a hospital do not differ basically from that In hotels, schools and catering establishment since certain areas of hospital render the same type of basic services. But some wastes generated in hospital are too hazardous to be negligently and any carelessness in the management of these wastes in a hospital tends to spread infectious diseases and contaminate the entire living environment prevailing in a hospital.

As Rajshahi is one of metropolitan city in Bangladesh, it is expanding very rapidly. The present population of Rajshahi City Corporation (RCC) is about 0.75 million. Due to fulfill the healthcare demand of huge population, healthcare establishments (HCEs) are growing rapidly. By this way, amount of medical wastes are increasing day by day. The duty of the conservancy division of RCC is to dispose of and manage waste including the medical wastes. The amount of medical waste collected by the RCC is 2-2.5ton/day (According to RCC conservancy division). Usually the hazardous medical waste is burnt in the Rajshahi medical college incinerator. Non-hazardous wastes generated in different HCEs are temporary stored either containers or heap up at the side of premises and finally dispose of "Nowdapara bhagar" for dumping travelled by RCC fixed vehicle.

METHODOLOGY

The methodology is very important of any project to bring about the detail work schedule in summary. The methodology for this project includes empirical field observation and field level data collection through inventory, questionnaire survey and interviews in formal and non-formal ways.

Data collection planning: A lot of formal and informal approaches were adopted in order to collect data. Before entering into hospitals or clinics we were trying to arrange formal meetings with the concerned authority of each hospital, clinics, and diagnostic centers. After getting a green signal from different HCEs, started our fieldwork, which first began from RMCH. A series of talks with the authorities of the RMCH helped us to understand them about our goals and this enabled us to collect information smoothly. During data collection phage in RMCH, we spent lot of time with Ward master, lab-technicians, nurses and cleaners for building a rapport. By this process, we have taken data from other Hospitals, clinics and diagnostics centers.

Data analysis: Analysis of data has to be done with great care. Survey data was taken on different days of six months and verify that whether it was true or not. Then it was represented in tabular form. Then we have calculated the amount of various components of Medical wastes per day and measured waste generation rate in different HCEs by Mathematical approach. In addition, a number of statistical graphs in terms of pie diagram, bar chart, etc, have been used to clearly focus the situation.

STUDY SITES

There are about 0.75 million people live in the RCC area of 97square km. A total of 53 health care establishments are in the city according to RCC deliberation, 2007. They have no present report about the number of HCEs existing here. Most of the hospitals, clinics and diagnostic centers are situated at laxmipur area in Rajshahi city. we surveyed about twelve HCEs which involves Public hospitals, private hospitals, clinics and diagnostic centres named Rajshahi Medical College and Hospital (RMCH), Islamic Bank Medical College and Hospital (IBMCH), Islamic Bank Hospital (IBH), Zamzam Islamic Hospital (ZZH), Mukti Clinic (MC), Dalphin Clinic (DC), Mahanagar Clinic (MHC), Popular Diagnostic Centre (PODC), Plasma Diagnostic Centre (PLDC), Albaraka Islamia Diagnostic Centre (ADC), Seba Diagnostic Centre (SDC), City Diagnostic Centre that are mostly biggest as well as popular and generate large amount of medical wastes,

CLASSIFICATION OF MEDICAL WASTES

Medical waste is defined as waste generated during the diagnosis, testing, treatment, research or production of biological products for humans or animals. Medical waste includes syringes, live vaccines, laboratory samples, body parts, bodily fluids and waste, sharp needles, cultures and lancets as Palanisamy Pasupathi (2011). It is a by-product of health care that include sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials according to WHO (1999).

Various authors introduce different ways for classifying medical wastes. These are based on medical waste state (solid and liquid), character, source and effects. Medical wastes are classified into four different categories based on their sources and potential hazards according to Akter N. (1998). These are

a) **Clinical waste:** this includes body fluid, drainage bags, blood collection tubes, vials, culture dishes, other types of broken/unbroken glassware that were in contact with infection agents, gauges, bandages or any other materials that were in contact with infectious agents or blood, pathological waste including organs, body parts, tissues..
b) **Laboratory waste:** This includes chemical used in the pathological laboratory, microbial cultures and clinical specimens, slide, culture dish, needle, syringes, as well as radioactive waste such as Iodine-125, iodine-131 etc.
c) **Non-clinical waste:** this includes wrapping paper, office paper, and plastic that has not been in contact with patient body fluid.
d) **Kitchen waste:** this includes food waste, wash and waste water. It is a potential source of pests and vermin, such as cockroach, mice and rats and is thus an indirect potential hazard to the staff and patients in a hospital.

SOURCES, TYPES AND GENERATION

Generally, In HCEs, two types of wastes are generated: non-hazardous or non-infectious and hazardous or infectious. The first group contains the domestic wastes in terms of paper, kitchen wastes, food wastes and other form of hospital services, the second group includes wastes, which are produced in laboratories, operation room, consulting and various hospital units.

Medical wastes are produced by various activities. Different units within a hospitals and clinics such as Medical ward, Operation theatres and surgical ward, Health-care units, Laboratories and Pharmaceutical and Chemical stores would generate different wastes.
As there is no tabled data about medical waste management in RCC authorities or different HCEs, we had to analyze our project by Questionnaire survey. To get desirable situation of HCEs, there were number of respondents attends in the survey. The respondents were doctors, staff, ward-masters, nurses and cleaners (Sweepers, Ayas).

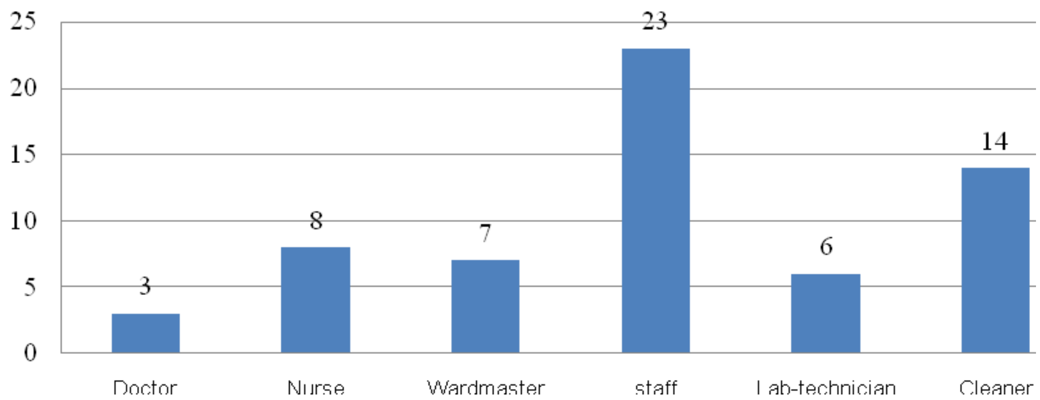

Figure 1 Respondent category of surveyed HCEs in RCC area

It was surveyed that different HCEs generate various types of medical wastes. Table-1 reveals the amount of different types of wastes generated in surveyed HCEs.

Table 1 Amount of wastes with type generated in surveyed HCEs

Type of wastes	Amount of wastes (% of total)								
	RMCH	IBMCH	IBH	MC	MHC	ZZH	DPC	DC	Total
Sharp instruments	14 (0.97)	10 (0.69)	4 (0.28)	2.5 (0.17)	2.5 (0.17)	1.5 (0.10)	1 (0.07)	8.3 (0.58)	43.8 (3.04)
Vial-ampoules	15 (1.04)	9 (0.62)	2 (0.14)	2 (0.14)	2.5 (0.17)	5 (0.35)	1.5 (0.10)	-	37 (2.56)
Cottons, bandages	30 (2.08)	13 (0.90)	2 (0.14)	2 (0.14)	1 (0.07)	5 (0.35)	1.5 (0.10)	0.9 (0.06)	55.4 (3.84)
Saline bags	30 (2.08)	18 (1.25)	10 (0.69)	6 (0.42)	3 (0.21)	5 (0.35)	1.5 (0.10)	-	73.5 (5.1)
Body parts (liquid, solid)	10 (0.69)	6 (0.42)	2 (0.14)	1 (0.07)	1 (0.07)	2.5 (0.17)	1 (0.07)	2.2 (0.15)	25.7 (1.78)
General wastes (Food waste, Medicine box, papers)	680 (47.19)	290 (20.12)	45 (3.12)	40 (2.78)	17 (1.18)	30 (2.08)	17 (1.18)	0.5 (0.03)	1119.5 (77.68)
Blood &Urine bags	10 (0.69)	7 (0.49)	2 (0.13)	2.5 (0.17)	1 (0.07)	5 (0.35)	1.5 (0.10)	-	29 (2.01)
Other (Chemical waste, plastic bottles and tissue papers)	25 (1.73)	11 (0.76)	4 (0.28)	5 (0.35)	3 (0.21)	5 (0.35)	1 (0.07)	3.1 (0.22)	57.1 (3.90)
Total	814 (56.49)	364 (25.26)	71 (4.93)	61 (4.23)	31 (2.15)	59 (4.09)	26 (1.8)	15 (1.04)	1441 (100)

It was found from the field survey that all the surveyed HCEs generates about 1.441 ton/day (1441 kg/day) of waste, of which only about 153.9 kg/day (10.68%) are infectious (hazardous) wastes and 1287.1 Kg/day (89.32%) are non-infectious (non-hazardous) wastes (Table 1). In this table, sharp instruments, cotton-bandage, body parts, blood or urine bags comprises Infectious wastes where Vial-ampoules, saline bags, general wastes (Food waste, paper, medicine box), others (liquid drags, tissue paper, solid drugs) comprises Non- infectious wastes.

Table 2: Waste generation rate in surveyed HCEs

HCE types	Patients		Total Patients	Waste generation rate		
	Beds	Out patients		Kg/day	Kg/Bed/day	Kg/patient/day
RMCH	530	2070	2600	814	1.54	0.31
IBMCH	250	500	750	364	1.46	0.49
IBH	50	300	350	71	1.42	0.20
MC	25	150	175	61	2.44	0.35
MHC	20	40	60	31	1.55	0.52
ZZH	30	250	280	59	1.97	0.21
DPC	25	30	55	26	1.04	0.47
DC	-	685	685	15	-	0.02
Total	930	4025	4955	1441	1.55	0.29

The survey reveals that the medical waste generation rate of different HCEs ranges between 0.02 to 0.52 Kg/patients/day (Table 2). The survey also shows the total waste generation rate for the surveyed HCEs is 1.55 Kg/bed/day or 0.29 Kg/patient/day. Figure-2 represents comparison of wastes generation rate in surveyed HCEs.

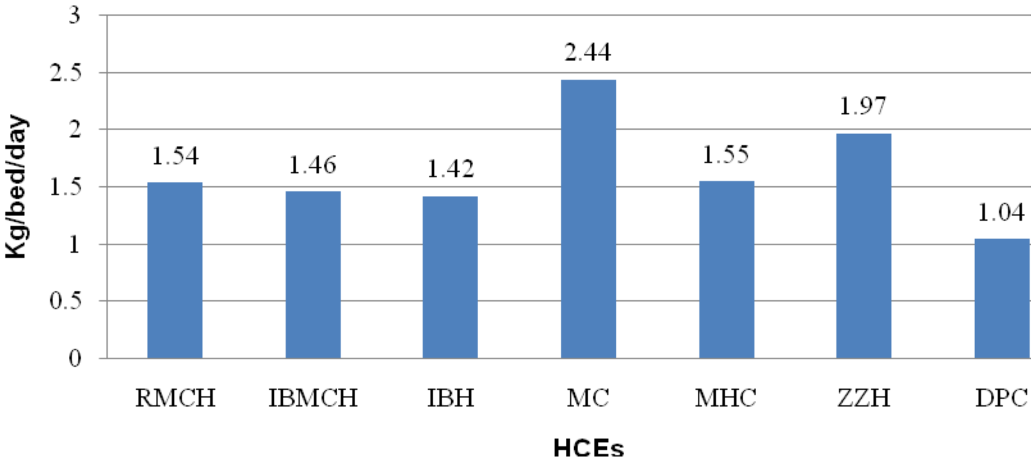

Figure 2 Comparison of waste generation rate of Surveyed HCEs

EXISTING WASTE MANAGEMENT

The existing situation of hospital waste management in Bangladesh is very poor. An environmental point of view it takes place with an improper procedure. The HCEs in Rajshahi City Corporation are not apart from this. Almost all the HCEs do not segregate the generated wastes at proper way. The materials presented in this chapter are aimed at providing the existing practice of waste management in terms of segregation, temporary storage, disposal system, off-site transport and final disposal.

Segregation: WHO, (1999) reported that the key to minimization and effective management of health-care waste is segregation and identification of waste. Appropriate handling, treatment and disposal of waste by type reduce costs and do much to protect public health. In our field survey, it was observed that there were no segregation systems for infectious and non-infectious wastes at the site of production almost in all the HCEs. There was little systematic collection in the surveyed HCEs. RMCH, the biggest hospital in RCC is kept hazardous wastes such as syringes, gauges, cotton, blades, knives and infectious substances in red and yellow colored containers and non-hazardous wastes such as saline bags, plastic bottles, paper, kitchen garbage etc in the green and black colored containers. Liquid substances such as Liquid drags, X-ray water and kitchen garbage are kept in Polythene bags. But it has been seen in most of the times that cleaners are not conscious about the separation of the wastes according to the containers and they have the tendency to cast away the wastes into the containers as their willing. Moreover at the time of dumping, they are found to mix hazardous waste with non-hazardous waste. The waste management system in others surveyed HCEs are very poor except IBMCH and IBH. Though the waste management system of IBMCH and IBH are not superior, they are better than other surveyed HCEs. IBMCH, the second biggest hospital in RCC and IBH, most popular clinic in Rajshahi city produce huge amount of medical wastes but segregation according to WHO guideline are little followed. They provide different size buckets at almost every corner of the wards, cabins, OTs, administrative units and appointed cleaners are taken those full-filled baskets to the containers which have been labeled with different colors for segregating waste according to hazardous and non-hazardous wastes. But they are always found to mishandle these wastes. Moreover when they dump the waste at specific storage site, frequently they mix hazardous waste with non-hazardous waste due to lack of consciousness.

Temporary storage: The place/storage area where medical wastes are kept before transporting to the incinerator or final disposing site is termed as temporary waste storage. Most of the HCEs in surveyed keep their wastes in different type's containers or buckets located in the corner of the hospital yard. Then all the waste generated finally intermingled in the large storage container/bin. In some HCEs, the infectious and non-infectious wastes are kept in separate containers and not mix together in the Hospital's own bin. It is also found that there are few HCEs which heap up their wastes at the corner of their premises. Mukti clinic heaps up their wastes at the corner of their building which is very unhygienic and spread bad odor to environment.

Off-site transportation: Medical waste should normally be collected everyday due to its hazardous nature. The RCC has the responsibility for off-site transport of the waste for final disposal or dumping. RCC authorities provide a van for collecting wastes from different HCEs. Every early morning, they collect wastes from HCEs and these collected wastes are transported to either the incinerator which is located at RMCH premises or Nowdapara Bhagar (final disposal site) for dumping. A fix amount of charge is paid to RCC authorities by HCEs of RCC for off-site transportation. In our survey, it is found that the charges of different HCEs varies according to waste generation of the HCEs.

Table 3 Charge to be paid by surveyed HCEs

HCEs	RMCH	IBMCH	IBH	MC	MHC	ZZH	DPC	DC
Amount to be paid in month (TK)	Free	1500	1500	1500	800	800	800	500

Incineration: The wastes which are considered as hazardous wastes or infectious wastes are managed by incineration process. There is only one incinerator in RCC which is situated at the RMCH premises. The hazardous waste generated in RMCH as well as other HCEs in RCC is treated in this incinerator. The incinerator was established in 1998 with a cost of TK. 10 hundred thousand. The incinerator which has a capacity of 18 cubic meter/ hour was formally inaugurated on June 5, 2001. Every morning the waste is combusted into it. It has two opening; one is in front of it and other is behind of it which is upper than that of first one. A stair is provided beside the incinerator for entering the waste into it through behind opening. The ashes produced by the combustion of wastes are taken out by the first opening.

Final disposal: All the medical waste which is generated in the surveyed HCE is ready for final disposing. The final disposing site in RCC is situated at Nawdapara which is locally called

“Nawdapara Bhagar”. Medical wastes are collected everyday by RCC van due to its hazardous nature. Every early morning, the collected waste is finally dumped by RCC registered cleaners to this “bhagar”. It has been found from our survey that there is no consideration of distinguishing infectious waste with non-infectious waste when dumping. So it may cause pollution of the environment as well as health hazard to people.

Segregation of waste for recycles: It has been found a different situation during our field survey. We have investigated that refused medical wastes have been segregated in terms of sharp instruments, saline and blood bags, plastic material, tubes and so on from the wastes. Some people are responsible in collecting, segregating and selling these wastes either resale or reuse. They collect these either from HCEs bins or final disposal site. But it is found for our field survey that there is no authorities from RCC who investigate what have been done with the recyclable wastes as it is environmental or not. Thus awareness towards this issue could be effective until formulating new laws to protect people and environment.

EFFECT OF MEDICAL WASTE

Due to lack of awareness of collecting, handling, processing and disposing of medical waste, several health and environmental risks causes a great extent. Also there is a risk of injuries related to medical waste handling and carrying by waste haulers and cleaners. For example cut injuries, punctured wound, Laceration, strain and sprain of the joint of limbs and backache due to load hauling. It was found from the survey that Infectious wastes represent only a small part of total medical wastes; yet, because of infection risks, it is a focal point of public interest. Infectious waste contains different kind of pathogens or organisms that is potential for infection or diseases if it is not properly disposed. as Akter *el al* (1998) showed few examples of different pathogen and disease caused by them

Table 4 pathogens present in infectious wastes and Diseases caused by them

Bacterial	Tetanus, gangrene and other wound infection, anthrax, cholera, other diarrhea diseases, enteric fever, shigellosis, plague etc.
Viral	Various hepatitis, poliomyelitis, HIV-infectious, HBV, TB, STD rabies etc.
Parasitic	Ameobiasis, girdiasis, ascariasis, ankylomastomiasis, echinococcosis, malaria, leishmaniasis, filariasis etc.
Fungal infection	Various fungal infections like candidiasis, cryptococcoses, coccidiodomycosis etc.

Apart from health issue, environmental impact associated with the improper disposal of medical waste has taken also. These are-1) Pollutants from medical waste (heavy metals) are persistent in environment. 2) Ground water contamination, decrease in water quantity. 3) Bio-accumulation in organism’s fat tissues and biomagnified through the food chain. 4) Repeated and indiscriminate application of chemicals over a long period of time has serious adverse effect on soil microbial population reducing the rate of decomposition and generally lowering the soil fertility. 5) Windblown dusts from indiscriminately dumping also have the potential to carry hazardous particulates. 6) Public nuisance (e.g. odor, scenic views, block the Walkway, aspheric etc). 7) Plastics bags, plastic containers, if not properly destroyed may contaminate the soil and also reduce the chance for water percolation into the soil during precipitation. 8) Open air burning does not guarantee proper incineration and releases toxic fumes (dioxin) into the atmosphere from the burning of plastics.

AWARENESS AND TRAINING NEED

Awareness is very important to improve the present status of medical waste management in RCC area. For doing so, personnel associated with HCEs such as Doctors, nurses, cleaners etc. even general people should come forward regarding this issue. Proper and systematic waste management rely on appropriate training on it which increases level of awareness. But it has been found that Most of the HCEs provide a few training on concerning authorities about medical waste management. Some hospitals and clinics provide training for the cleansing staff and in some nurse. But surveyed diagnostics centers do not provide any type of training to their appointees. It is investigated from our field survey that almost all the respondents from all the surveyed HCEs focused their opinion in favors of training concerning to the waste management. Some respondents urged on practical training rather than the traditional theoretical training for proper waste management. As cleaners (Sweepers, Ayas) are direct contacts with collecting, handling, processing and disposing of medical wastes, RCC or HCEs authorities should pay priority to provide practical training on them. Table-5 show the number of cleaners of different HCEs associated with medical waste management who has either got training or not.

Table 5 Number of cleaners of surveyed HCEs according to training

HCE Types	Number of cleaners	Got Training	Did not get training
RMCH	140	140	-
IBMCH	30	20	10
IBH	15	15	-
MC	12	12	-
MHC	8	5	3
ZZH	15	15	-
DPC	10	5	5
PODC	8	-	8
PLDC	5	-	5
SDC	3	-	3
ADC	4	-	4
CDC	5	-	5
Total	255 (100%)	212 (83%)	43 (17%)

From above table 5, it is shown that all our surveyed HCEs except Diagnostics centers provided training to their almost cleaners. RMCH, the biggest HCEs in RCC has 100% trained cleaner who are directly involved in medical waste management. Other HCEs have also trained clearers. But the current scenario of medical waste management in RCC is poor because of proper practical training. Moreover lack of willingness of cleaners and personnel associated with medical waste management is also responsible for disappointing conditions.

LIMITATIONS IN PROPER MWM

It was found from field survey that most of the HCEs did not have any budgetary provision to manage their generated waste systematically. A small amount of budgetary provisions were allocated to several hospitals and clinics. The management authority of HCEs and doctors pointed out that they are willing to manage the generated waste properly, but lacking of financial support and proper system, they are unable to do it. Nurses got their training on medical waste as part of their professional training, but due to lack of proper management, they are unable to apply their theoretical knowledge. In addition, Most of the technicians, cleaners and ward-boys are not aware properly about the medical wastes and its risk issues. Moreover, lack of van for waste collection, lack of dustbin and lack of manpower is major obstacle for proper waste management.

CONCLUSION

This study was carried out to assess medical waste management practices in different HCEs of Rajshahi City Corporation, Rajshahi. It identified waste generation rate, segregation procedure and waste disposal options of different surveyed HCEs. It was investigated from our field survey that The HCEs authorities also have lack of willing to collect generation data of medical wastes and proper management of those. So it is very difficult to manage appropriate information about waste generation and management. In our field survey, we tried best to collect information about different types of waste generated in Hospitals, clinics and diagnostics centers premises. we conducted survey on 12 HCEs in RCC and numbers of Respondents especially ward masters of different HCEs who helped us to get relevant information and data about medical wastes and its management techniques.

The collected field data showed that all the surveyed HCEs generated about 1.441 ton/day (1441 kg/day) of wastes of which only about 151.9 kg/day are infectious wastes and 1289.1 kg/day are non-infectious wastes. The average waste generation rate for the surveyed HCEs is 1.55 kg/bed/day. The RMCH along generate more than half (56.49%) of the total wastes generated in surveyed HCEs. The RMCH itself generate about 814 kg/day of total waste of which 64 kg/day (4.44%) are infectious wastes and 750 kg/day (52.05%) are non-infectious wastes.

It was found from field survey that some cleaners were engaged to mishandle the generated wastes. They did not segregate infectious wastes from non-infectious wastes. Most of the wastes were taken by RCC van for dumping at Nowdapara dumping site and rest of it were burnt by incinerator.

The level of awareness on medical waste is high, but they are not able to manage the wastes systematically since there are lacking of systems, willingness, rules and regulation and financial support.

Therefore, it becomes imperative for the RCC authorities and HCEs personnel to adopt sound medical waste management policy according to the guidelines of World Health Organization (WHO) to avoid the enormous future cost of abating medical waste related problems.
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Photocatalytic Degradation of Methylene Blue By H_2O_2 And Oxalic Acid in Presence 0f Mill Scale

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ABSTRACT

Wastewater effluent from textile dying plants is one of the major pollutants to the environment. Traditional chemical, physical and biological processes for treating textile dye wastewaters involve high cost, require high energy and generate secondary pollution during the treatment process. Recent studies have shown that the photocatalytic process using mill scale (waste iron oxide) semiconductor particles under UV light illumination is potentially advantageous and applicable in the treatment of wastewater pollutants. In this study, Methylene Blue (MB) was selected as a model pollutant and mill scale was selected as a semiconductor photocatalyst. The crystal structure and morphology of the mill scale was determined by X-ray diffraction analysis, the effects of variables on the kinetics of dye decomposition by mill scale suspension was investigated. Rates of dye decomposition by separately using oxalic acid and H_2O_2, under UV in presence of mill scale under UV were investigated. Dye decomposition rate was found to increase with an increase in the amount of mill scale in suspension up to 0.8g/100mL when 2mL H_2O_2/100ml solution was used, then decrease with increasing mill scale concentration; the decomposition rate decreases with increasing dye concentration. Faster dye degradation was observed with H_2O_2 than with oxalic acid under UV in presence of mill scale.

INTRODUCTION

The textile dyeing industries of Bangladesh generate large amount of effluents, sewage sludge and solid waste materials everyday which are being directly discharged into the surrounding channel, agricultural fields, irrigation channels, surface water and these finally enter in to river. The presence of dyes in surface and subsurface water is making them not only aesthetically objectionable but also causes many water borne diseases, viz. mucous membrane, dermatitis, perforation of nasal septum and severe irritation of respiratory tract. Various options have been employed to treat such wastes. These include chemical treatment such as chlorination and ozonation [1, 2], electrochemical treatment [3], physical treatment such as adsorption by activated carbon and membranes [4, 5], photocatalysis [6], biological treatment and advanced oxidation processes.

Advanced oxidation processes (AOPs) have attracted wide interests in wastewater treatment since the 1990s. In principle, AOPs are based on the generation of hydroxyl radicals in water, which are highly reactive and nonselective oxidants being able to oxidize organic compounds particularly unsaturated organic compounds such as azo dyes. The use of semiconducting materials such as mill scale as a photocatalyst for various chemical reactions are well received due to their unique optoelectronic and photocatalytic properties. For the decomposition of dyes, mill scale with H_2O_2 under UV and sun light are considered due to its stability as a support in solution. Among AOPs, two of the most important processes to generate hydroxyl radicals are Fenton and photo-Fenton (Fe^{2+}/H_2O_2 and Fe^{2+}/H_2O_2/UV) systems [7].

Photocatalytic reactions promoted by aqueous suspensions of metal oxides have been subjected of abundant number of recent research. Iron oxide as n-type semiconductor with a band gap of 2.2 eV has been studied extensively for use in photoelectrolysis cell [8-10]. Leland and Bard [11] found that α- Fe_2O_3 is going as good catalyst for photooxidation of sulfite. Frank and Bard [12] studied the photo catalytic oxidation of some hazards at TiO_2 and $\alpha–Fe_2O_3$ surfaces. The photo chemistry of iron oxide colloids has also been studied by Stramel and Thomas [13]. Their experiments were unsuccessful in promoting chemical reactions by irradiation onto the Fe_2O_3 absorption band. Recently some studies demonstrated the evidence for photocatalytic formation of $^{\bullet}OH$ radicals [14, 15]. The generation of $^{\bullet}OH$ radicals is achieved through the utilization of oxidants such as oxalic acid and H_2O_2, often in combination, with or without UV radiation.

The rate of organic pollutant degradation could be increased by irradiation of Fenton with UV light (photo-Fenton process). UV light leads not only to the formation of additional $^{\bullet}OH$ radicals but also to recycling of ferrous catalyst by reduction of Fe^{3+}. In this way, the concentration of Fe^{2+} is increased and the overall reaction is accelerated. Among the AOPs, the oxidation using Fenton's reagent and photo-Fenton's reagent has been found to be a promising and attractive treatment method for the effective decolorization and degradation of dyes. Malik and Saha [16] reported that the removal rate is strongly dependent on the initial concentration of the dye, Fe^{2+} and H_2O_2.

The ultraviolet/H_2O_2 (UV/ H_2O_2) process involves the photolysis of hydrogen peroxide. The most accepted mechanism for this H_2O_2 photolysis is the rupture of the O-O bond by the action of ultraviolet light forming two hydroxyl radical (Beltrán et al., 1997):

$$H_2O_2 \xrightarrow{h\nu} 2\,OH^{\bullet}$$

Photochemical processes in the co-presence of mill scale and oxalate have previously being described in detail (Zuo and Deng. 1997, Balmer and Sulzberger, 1999). During the photochemical reaction of Fe (III)-oxalate complexes under illumination by UV and/or visible light, superoxides hydroperoxiyl radicals ($^{\bullet}O_2^-/^{\bullet}O_2H$) (Eqs. (2)- (6)) are formed as the key intermediates.H_2O_2 thought to be formed from $^{\bullet}O_2^-/^{\bullet}O_2H$ (Eqs. (7) and (8)) participates in a classical Fenton reaction with Fe (II), formed by photo-reduction of Fe (III), producing $^{\bullet}OH$ (Eq (9)):

$$\text{Mill scale} + nH_2C_2O_4 \rightarrow [Fe(III)(C_2O_4)_n]^{(2n-3)-} \quad (1)$$

$$[Fe(III)(C_2O_4)_n]^{(2n-3)-} + h\nu \rightarrow [Fe(III)(C_2O_4)_2]^{2} + {}^{\bullet}(C_2O_4)^- \quad (2)$$

$$[Fe(III)(C_2O_4)_n]^{(3-2n)-} + h\nu \rightarrow [Fe(II)(C_2O_4)_{(n-1)}]^{(4-2n)} + {}^{\bullet}(C_2O_4)^- \quad (3)$$

$${}^{\bullet}(C_2O_4)^- \rightarrow CO_2 + {}^{\bullet}(CO_2)^- \quad (4)$$

$${}^{\bullet}(CO_2)^- + O_2 \rightarrow CO_2 + {}^{\bullet}O_2^- \quad (5)$$

$${}^{\bullet}O_2^- + H^+ \rightarrow {}^{\bullet}O_2H \quad (6)$$

$${}^{\bullet}O_2^- + Fe_3^+ \rightarrow Fe_2^+ + O_2 \quad (7)$$

$${}^{\bullet}O_2^- / {}^{\bullet}O_2H + nH^+ + Fe^{2+} \rightarrow Fe^{3+} + H_2O_2 \quad (8)$$

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + {}^{\bullet}OH \quad (9)$$

In the present study, MB, was selected as a model organic pollutant which is extensively used in textile, foodstuff and pharmaceutical industries. Mill scale was selected as a photocatalyst. Degradation of MB was studied in the presence of various amount of mill scales in oxalate and H_2O_2 solution under UV. Several key factors such as H_2O_2 concentrations, mill scale content, MB concentration were investigated to provide a better knowledge of the AOP reactions. Moreover, the optimal conditions of experimental parameters for the degradation of MB were determined.

EXPERIMENTAL

Samples

MB and other chemicals with analytical grade were purchased. All the chemicals were used without further purification. Mill scale was collected from local steel industries. As received sample was used to decompose the dye.

MB photodecomposition experiments

The sample suspension was formed by adding varying amount of mill scale to 100ml of aqueous solution containing MB and H_2O_2/oxalic acid. Before photo reaction, the suspension was magnetically stirred in the dark for half an hour to establish absorption-desorption equilibrium. The various aqueous suspensions were then illuminated by UV using two 8W black light lamps with the main emission at 365 nm. At the given time intervals, the analytical samples were withdrawn from the suspension and then stored in the dark for needed analysis. The photodecomposition experiments were performed under the following experiment conditions, where variation were performed: MB concentration (C_o) = 0.01-0.1 mM, mill scale content = 0.1-1.3 gm/L, oxalic acid concentration 1mM and H_2O_2 concentration 1-4 mL/100mL aqueous suspension.

Characterization

The absorbance spectrum in each experiment was determined from 200 to 1100 nm with a UV-Vis spectrophotometer (optizen 3220UV, Korea) and degradation of MB was monitored by recording the absorbance at λ = 664 nm as a function of illumination time. The crystalline phase of mill scale was determined by X-ray powder diffraction with monochromated Cu Kα radiation and is shown in Fig.1.

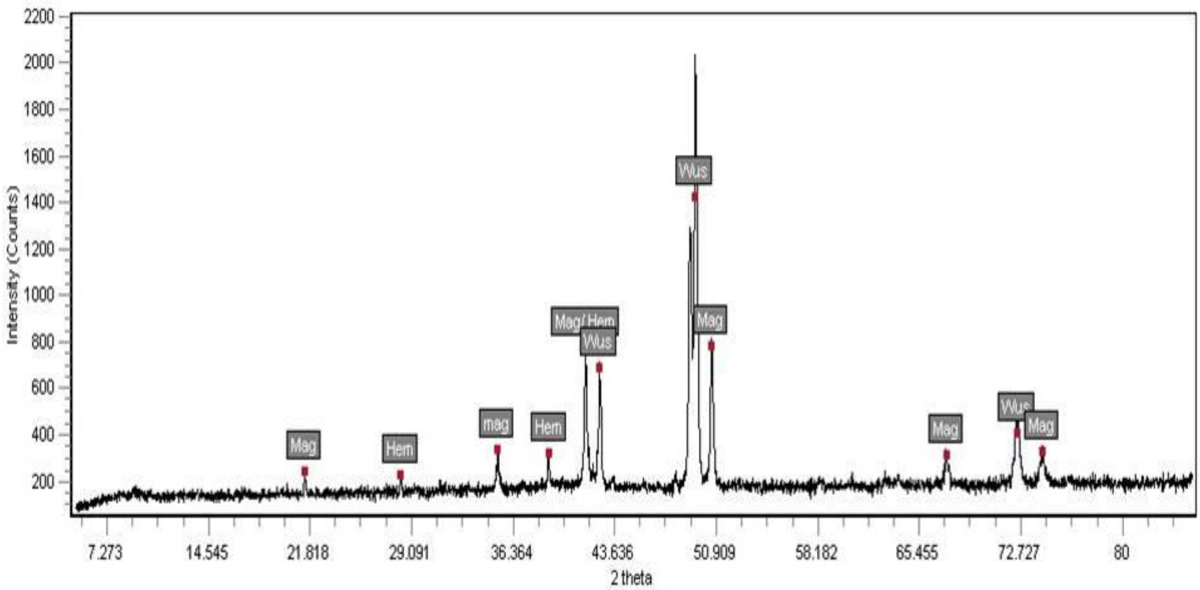

Figure 1 XRD pattern of mill scale

RESULT AND DISCUSSION

Effect of variables on the decolorization of MB

Figure 2 shows the MB degradation under different experimental conditions. MB degradation was carried out with1.0mM oxalic acid in absence of mill scale and UV light (curve a).Degradation was only 11% at this condition. Then degradation experiment was carried out only under UV irradiation and it was 12.5% (curve b) and it was 20% in the presence of only 2 ml H_2O_2 (curve c). Without OA and H_2O_2 MB degradation slightly increased to 38% under UV and addition of 0.8 g mill scale/100mL solution (curve d).The degradation of MB was 61.9% level under UV light irradiation and 1mM oxalic acid, but without mill scale (curve e). Another experiment showed degradation of 67% under UV irradiation and in the presence of 2 ml H_2O_2 (curve f). Degradation was found to be 88% level under UV light and 0.8gm mill scale/100mL solution with 1mM oxalic acid (curve g). Finally when 2.0mL H_2O_2 and 0.8g mill scale/100mL solution were added into the 0.05 mM MB under UV irradiation (curve h), the removal percentage of MB was significantly increased upto 96%. From the results under different experimental conditions it was clear that either the combination of UV light, mill scale and oxalic acid or the combination of UV light, mill scale and H_2O_2, are required for complete degradation.

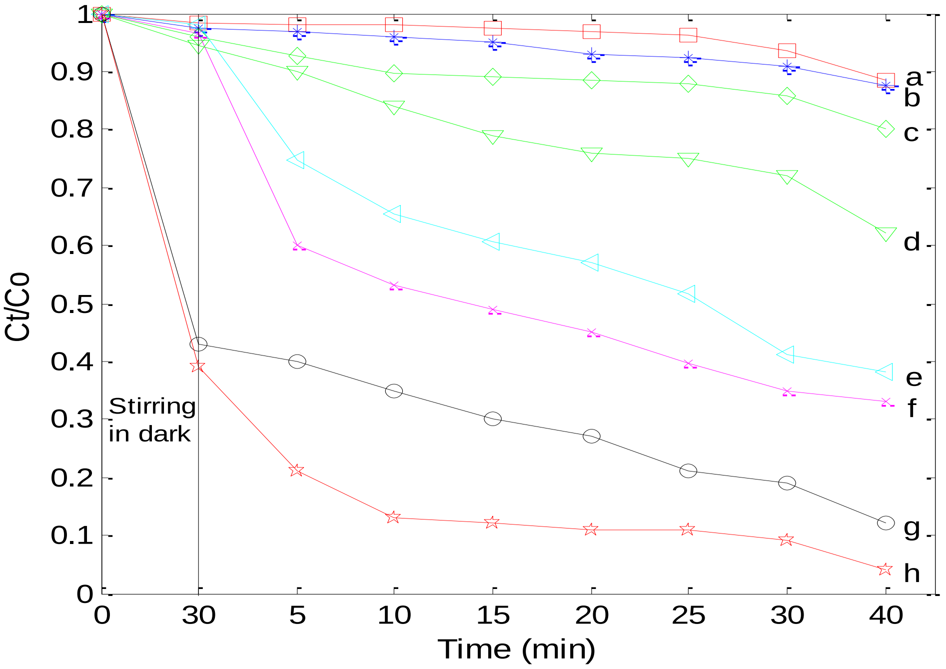

Figure 2 Decolorization of MB (0.05mM) under different condition (a) 1.0 mM OA (b) UV (c) 2mL H_2O_2 (d) UV+0.8gm mill scale (e) UV+1mM oxalic Acid (f) UV+2mLH_2O_2 (g) UV+1mM oxalic Acid+0.8 gm mill scale (h) UV+2mLH_2O_2+0.8 g mill scale

Effect of mill scale content on the decolorization of MB in presence of H_2O_2

Iron in its ferrous and ferric forms acts as a photo-catalyst [17]. Amount of ferrous/ferric ion is one of the main parameters to influence the Fenton and photo-Fenton processes. Figure 3 showed the dependence of MB photodegradation with the mill scale variation under UV light irradiation and in presence of H_2O_2. Mill scale content was taken as 0.1g, 0.3 g, 0.5 g, 0.8 g, 1g, 1.3 g/100 mL of solution. Almost 90% decolorization of MB was occurred in all cases within 30 minutes. The corresponding rate constant (after 5 minutes UV irradiation) values of these experiments show that MB decomposition rate increases with increasing mill scale content, reaches a maximum and then decreases again (Figure 4).

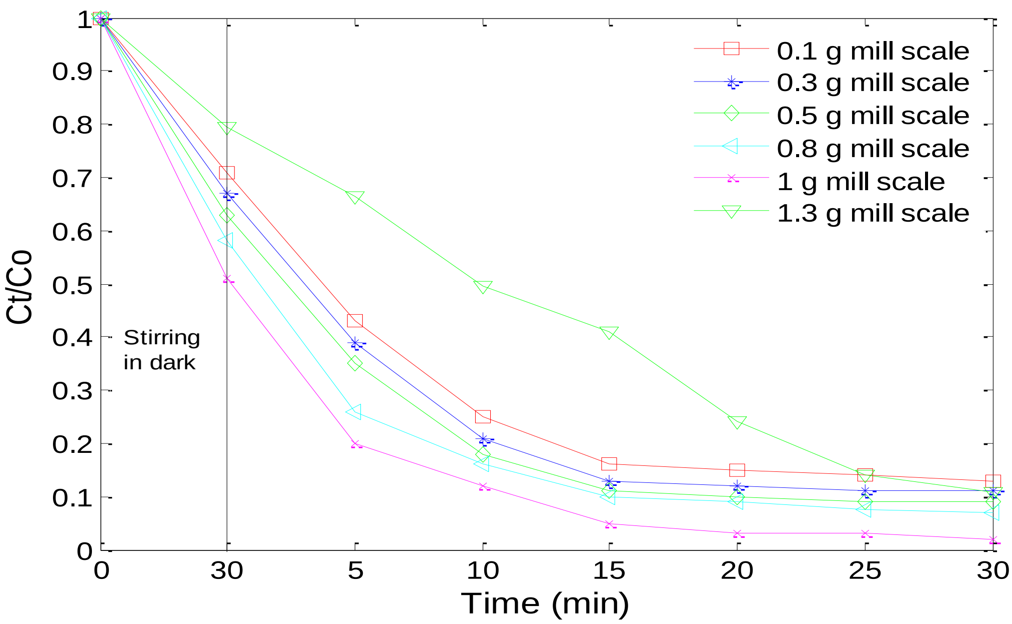

Figure 3 The effect of mill scale content on MB decomposition in presence of UV and H_2O_2

When the iron concentration (in the form of Fe^{2+} / Fe^{3+}) is too low, e.g., 0.1 g/L, the decolorization rate is slow because there are not sufficient ferrous ions (Fe^{2+}) available for Fenton's reaction. With increasing mill scale content upto 0.8 gm the decolorization rate also increased. Because when Fe^{2+} concentration is increased, the catalytic effect also accordingly increases and when its concentration was higher, a great amount of Fe^{2+} was produced. Fe^{2+} undergoes a reaction with hydroxyl ions to form Fe $(OH)^{2+}$ which in turn produces more $^{\bullet}OH$ radicals(Eqs. (10) - (12)) [18, 19]. This $^{\bullet}OH$ radical increases the rate of decomposition.

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + {}^{-}OH + {}^{\bullet}OH \quad (10)$$
$$Fe^{3+} + {}^{-}OH \rightarrow Fe\,(OH)^{2+} \leftrightarrow Fe^{2+} + {}^{\bullet}OH \quad (11)$$
$$Fe\,(OH)^{2+} + h\nu \rightarrow {}^{\bullet}OH + Fe^{2+} \quad (12)$$

On the other hand, when the iron powder concentration is too high, e.g., 1.3 g/100mL, the reaction suspension became more turbid with excessive oxide loading, and this suppressed the penetration of UV light and decreased the formation of $^{\bullet}OH$ radicals, lowering the photodecomposition ability.

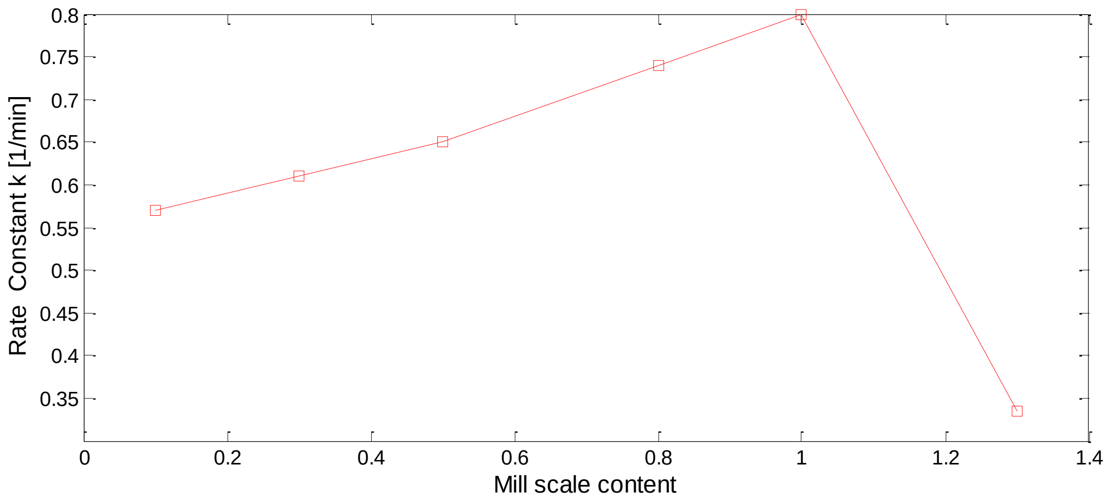

Figure 4 Change of photodecomposition rate constant values of 0.05 mM methylene blue by various content of mill scale

Decolorization of different concentration of MB in presence of H_2O_2, mill scale and UV

In this study, various concentrations of MB (0.01 mM, 0.05 mM and 0.1 mM) were decomposed under UV and in presence of 2 mL H_2O_2 and different content of mill scale (0.3 g, 0.8 g and 1.3 g/100 mL solution). The results are shown in Table 1. From the results it can be seen that for all cases decomposition rate decreased with increasing concentration of MB. When 0.3 g mill scale was used the rate constant values were 0.611, 0.4 and 0.33 for 0.01, 0.05 and 0.1 mM MB respectively. When 0.8 g mill scale was used the rate constant values were 0.83, 0.74 and 0.38 for 0.01, 0.05 and 0.1 mM MB respectively. And when 1.3 g mill scale was used the rate constant values were 0.75, 0.47 and 0.33 for 0.01, 0.05 and 0.1 mM MB respectively. It is clear from these results that with increasing dye concentration new process parameters have to be established for complete decolorization.

Table 1 Photodecomposition rate constants *k* on various concentration of MB in different mill scale concentrations on the presence of hydrogen peroxide (H_2O_2)

MB Concentration [mM]	Mill scale Concentration [gm]	Rate constant [5 min]
0.01		0.611
0.05	0.3	0.4
0.1		0.33
0.01		0.828
0.05	0.8	0.743
0.1		0.385
0.01		0.754
0.05	1.3	0.468
0.1		0.335
H_2O_2 2mL, Light source: UV		

Effect of mill scale content on the decolorization of MB in presence of oxalic acid

The oxide content was found to be an important experimental parameter when decomposition was carried out with H_2O_2. In this case decomposition was carried out with various mill scale content in presence of oxalic acid. Figure 5 showed the effect of mill scale content (0.1-1 gm/100 ml) on MB degradation (0.05 mM) in the presence of oxalic acid (1 mM) under UV irradiation.

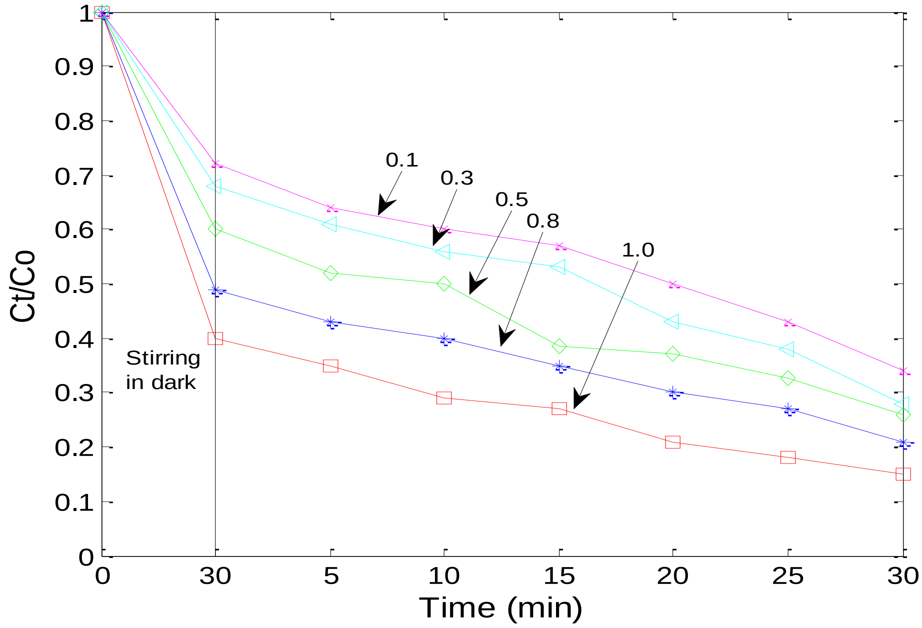

Figure 5 The effect of mill scale variation (0.1-1.0)gm/100ml solution on the photodegradation of MB (0.05 mM) in presence of UV with 1 mM oxalic acid

Since this type of photoreaction proceeds by generation of Fe (III)-oxalate complexes in solution (as shown in equation 1-9) so partial dissolution of the sample is essential. From the results it can be seen that MB degradation is increasing with increasing mill scale content. Maximum decomposition was found to be at 85% level under UV light irradiation with 1gm mill scale per 100ml solution after 30min. But it was 72% when 0.3 gm mill scale per 100 ml solution was used. In this case decomposition rate increased with increasing mill scale content but optimum mill scale content was not determined. More experiments are needed to find the optimum mill scale content.

CONCLUSION

The photodecomposition behavior of MB was investigated using various amount of mill scale in oxalate solution and hydrogen per oxide solution under UV. The following results were obtained:

1. Under standard experimental conditions (MB concentration = 0.05 mM and hydrogen per oxide = 2mL, under UV illumination), the optimum mill scale concentration was found to be 0.8gm/100ml solution.

2. The mill scale content was found to be an important experimental parameter, correlating strongly with the Fe ion concentration in the reaction suspension. This is suggested to be related to the formation of Fe (III)-oxalate complexes and •OH radical.

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A comparative study on the differences between public and private healthcare entities in healthcare waste management in Chittagong, Bangladesh

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Abstract: Rapid urbanization all over the world makes solid waste management (SWM) a daunting task for urban authorities in developed and developing countries alike. Management of all wastes excluding liquid and gases from households, institutions, and industries comprise the solid waste management. In SWM, healthcare waste management (HCWM) is of particular importance as it includes management of sharp, infectious, chemical and radioactive wastes with high potent to cause diseases. The number of healthcare entities (HCEs) is inadequate in Chittagong City Corporation (CCC) area while their distribution is highly uneven with most of the HCEs clustered around the Chittagong Medical College Hospital. In CCC, most of the HCEs belong to small to medium size and are private while only a few public healthcare facilities are large. Evidently, majority of financially ill-off patients are served at public HCEs where healthcare workers are ill-paid and less educated. We exclude physicians and include support staffs of HCEs in our definition healthcare workers. In comparison, a smaller number of financially well-off patients get better services, but may not be better treatment, at private healthcare entities having relatively highly paid healthcare workers. Therefore, we hypothesized that there should be noticeable variation in healthcare waste management between public and HCEs in Chittagong. Consequently, we aimed at comparing the differences between public and private HCEs in their management of HCWs. We conducted this study based on actual field observations, photographic image analysis and semi-structured questionnaire survey of healthcare workforce of public and private HCEs at CCC area between Decembers to May, 2012. We observed that the public HCEs do have more workers but due to lacks in proper regulation and worker management their HCW handling is improper. In contrary, private HCEs have smaller but more effectively managed workforce under better regulation and higher payment. Our study reveals that in case of public HCEs, HCW generation rate at Chittagong Medical College Hospital is 0.94 kg/bed/day; at Chittagong General Hospital it is 0.48 kg/bed/day; at Memon Maternity Hospital it is 1.13 kg/bed/day; at Mamata Naga Shasta Kendra it is 0.08 kg/patient/day and at Fateyabad City corporation dispensary it is 0.05 kg/patient day. On the contrary, HCW generation rate at private HCEs is completely different such as at Bangabandhu Memorial Hospital 1.52 kg/bed/day; at National Hospital 1.79 kg/bed/day; at Chittagong Diabetics Hospital 1.56 kg/bed/day; at Chittagong Eye Infirmary Hospital 0.9 kg/bed/day; at Surjer Hasi Clinic 2.4 kg/bed/day and at Metro Diagnostic center 0.08 kg/test/day. These differences are probably owing to socio-economic and cultural conditions along with living standard of taking service from them. It was found that in public hospitals color coding drums are used for temporary storage of waste but not properly. In contrary, private hospitals and clinics don’t follow any color coding rather they separate HCW into two categories such as general and clinical waste. Nevertheless, diagnostics and NGO running clinics use covered box. Workers of both categories of HCEs collect and segregate HCW manually without wearing any protective gears again they mix up during final disposal. All public hospitals, clinics and a few private hospitals burn major parts of HCW behind their premises and others discharge their generated HCW directly nearby CCC dustbins or roadside area. Inspite of having incinerator facilities, they never use them to save cost. Some small clinics and diagnostic centers are contacted with Innovation Sheva Sangstha (ISS) for managing their generated waste but a few of them still discharge HCW to near roadside area. It was also found that some staffs and workers are involved in selling HCW at BDT 20-50/kg to recycling shop without any treatment. Considering all our gathered experiences from filed survey it is stark clear that the over all process of HCWM scenario of private is better than public and the best management was seen in NGO-run HCEs in CCC.

Key Words*:* Solid waste, healthcare waste, Chittagong, segregation, management, treatment, disposal.

1.0 INTRODUCTION

Solid waste (SW) is a great concerning issue in the urban areas of developed and developing countries. Least Developed Asian Countries (LDAC) SW generation rate is little but due to high population total quantity is large (Glawe, U. & *et al*, 2005) and developing countries like Bangladesh it has been regarded as an immediate and serious issue owing to rapid urbanization (Alamgir, M. & *et al*, 2007). Solid waste includes healthcare waste (HCW), industrial waste (IW) and municipal solid waste (MSW) and all categories of waste those are reservoir of non-hazardous and hazardous waste. I study shows that 5000 tons of are disposed in Dhaka City per day which include domestic, construction and dangerous medical waste but the portion of hazardous or infectious waste is very little in quantity (Nasreen, M. 2005) among them HCW contains more hazardous than others which is in percentage 10-25% according to WHO (Pruess & *et al*, 1999), 15-35% in India and 15& HCW is regarded as infectious in USA (BAN & HCWH, 1999), 20% in Pakistan (Agarwal, 1998) and roughly 205 in Bangladesh (Kazi, 1998) and HCW is a small fraction comparing to total MSW (BAN & HCWH, 1999 and Akter, N. 2000). HCW is defined as the waste discarded or unwanted material or garbage or solid waste which is generated from the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological (Lee, C. 1989). Due to medical waste containing high amount of sharp, infectious, chemicals, pharmaceuticals and radioactive waste it needs immediate attention to handle carefully and safely disposal (Mato & Kaseva, 1999 and Askarian, M. & et al, 2004) and otherwise it is a potential risk of health hazard for handlers and associated people (Akter, N. 2000 and Hassan, M. M. & et al, 2008).

There are different estimation results of HCW generation rate in Dhaka city such as 200 tons/day (Lawson, 2003) which is close to 255 tons/day (Visvanathan, C. 2006), 13.6 tons/day (JICA, 2004), 37.6 tons/day (World Bank, 2003) that is close to 50 tons/day, reported in daily newspaper (DCC, 2003) and the highest estimation is 400 tons/day (Haque, 2000). While HCW generation rate in CCC is 15-18 tons/day (Hossain, M. M. & Alam, O. 2012) and 2.5 tons/day only in CMCH concluding 37% infectious waste (Alam, M. M. & et al. 2008).

A study conducted by PRISM Bangladesh (2005) reveals that HCW are collected by cleaners or sweepers which are temporarily stored in the same containers. The containers are made of plastic or aluminum. It was found that the HCE authority never manage segregation process rather poor scavengers, women and children who segregate recyclable HCW for earning their livelihood through selling or reuse inspite of deadly health risks (Hassan, M. M. & et al, 2008). In Rajshahi City Corporation of-side transport of HCW is performed by RCC trucks along with mixing MSW (Ali, M. M. 2006) and in Dhaka and Khulna city is done by city corporation or NGO (PRISM, 2005). HCW disposal options in Dhaka city are land filling, open burning and burial only limited quantity of sharp waste is incinerated through regulated process (Hassan, M. M. & et al, 2008 and PRISM, 2005). In Rajshahi (Akter, N. & et al, 2005), in Khulna (Alamgir, M. & et al, 2007) and in Sylhet (Sarkar, MSKA & et al, 2006) the most popular and common HCW disposal options are land filling and open burning of HCEs and management organizations.

From literature review we came to know that none has conducted such research in Bangladesh including Chittagong yet. But it is very necessary for finding out faults of existing HCW management system and to suggest improving present trend. With a view to conducting this study we began our program from

Decembers to May, 2012 within Chittagong metropolitan area along with a semi-structured preprepared questionnaire and taking legal permission from responsible authority.

In investigation it was found that there are many differences exist between public and private HCEs regarding to HCW handling and management in CCC. HCW generation rate high at Chittagong Medical College Hospital is 0.94 kg/bed/day; at Bangabandhu Memorial Hospital 1.52 kg/bed/day; at Surjer Hasi Clinic 2.4 kg/bed/day and Lowest at Mamata Naga Shasta Kendra is 0.08 kg/patient/day; at Fateyabad City corporation dispensary is 0.05 kg/patient day and at Metro Diagnostic center 0.08 kg/test/day. These differences are probably owing to socio-economic and cultural conditions along with living standard of taking service from them. In our investigation, it was found that HCW collection, storage, segregation, transport, disposal, treatment, reuse and recycling regarding process are performed by both public and private HCEs through unhygienic and environmentally hazardous way. Comparatively better HCW management system was found in NGO running HCE and Diagnostic Centers.

2.0 Study Methodology

2.1 Project Location

We selected the entire city for piloting this study which is situated within 22˚-14’ and 22˚-24’-30” N Latitude and between 91˚-46’ and 91˚-53’ E Longitude and on the bank of the river Karnafully. Again we gave priority mainly on road availability and density.

2.2 Reconnaissance Survey

Very beginning of this study we steered a reconnaissance survey within the area for the conveniences of preparation of questionnaire. During survey we deeply observed the existing HCW management process of public and private HCEs in Chittagong city and tried to find out comparisons between them.

2.3 Questionnaire Survey and Data Collection

With a view to questionnaire survey and data collection we selected different categories of HCEs both of public and private according to their size and running program. Before starting real program we took legal permission from responsible authorities. Then we surveyed questionnaire and measureable data through visualize estimation, if possible direct weighing and past experience of regarding persons.

2.4 Photo Collection

At the time of questionnaire survey and data collection we collected a lot of images by using digital camera of different HCEs regarding to HCW collection, storage, segregation, transport and final disposal process.

2.5 Data Analysis

The whole obtained data from study was compiled into MS-excel sheet of our PC. Both qualitative and quantitative data were analyzed by using simple statistical program Microsoft excels. Nevertheless, we solved some mathematical problems using scientific calculator.

3.0 RESULTS AND FINDINGS

3.1 Large Scale Public Hospital Vs Private Hospital

Chittagong Medical College Hospital (CMCH)

There are only a few private hospitals in Chittagong but large in sizes which serve the majority of people due to little fees. Among them Chittagong Medical College Hospital (CMCH) is prime which contains 1500 beds along with 34 wards recently (recently upgraded). It serves 1800-2200 residents and 3000-5000 outdoor patients per day. The total HCW generation rate of CMCH is 1.4-1.5 tons/day and 0.94 kg/bed/day. Details information is available in (table 3.1). Within the ward CMCH appointed workers and ayas collect and discharge through the corner to ground floor and their numbers is 60-70. CMCH uses 4-5 categories of color coding drums for source separation and temporary storage of HCW which are provided by Department of Health. But discharging time they mix up. To collect HCW from discharging point and handle to dustbin a private company named NEPCONS along with 60 workers is assigned by CMCH. It performs floor cleaning, collection, segregation and discharging HCW to dustbin regarding activities. But during survey it was found that some workers and staffs were involved in selling recyclable HCW at BDT 20-50/kg to shop and making open fire to reduce waste volume through illegal way. The workers both of them segregate and collect HCW manually without wearing any protective gears hardly seen using simple instrument. None of them provide any training to workers regarding to HCW handling and management along with associated risk. All of the operational instrument ands a few instruments are seen to reuse through disinfecting by boiling water, autoclave and sterilization.

Table 3.1: *Waste Generation Rate at Chittagong Medical College Hospital*

Ward Name	Number of beds	WGR (kg/bed/day)	WGR (kg/ward/day)	Average number of (patient/ward/day)
Emergency	12	1.50	19	400
Casualty	22	3.09	68	45
Medicine -14	54	1.02	55	100
Child Medicine	65	1	65	30
Gynae -33	48	1.67	80	50
Dental	-	-	15	95
Orthopedics Surg.-25	88	0.41	37	36
Surgery -26	60	0.97	58	40
Eye-20	49	0.16	8	12
Skin and Sex	20	0.45	9	15
ENT-19	58	0.55	32	25

Bangabandhu Memorial Hospital (BMH)

The number of private HCEs in Chittagong is comparatively high than public but small in size and a few facilities are available. Among them BMH is the largest which contains 220 beds along with 15 wards. It serves 200-250 residents and 500-750 outdoor patients per day. The total HCW generation rate is 250-300 kg/day and 1.52 kg/bed/day along with 45 workers and ayas who collect and handle their generated waste. To make clear appearance information is available in (table 3.2). They separate HCW into two categories such as general and clinical waste without using any color coding drums. They separately store sharp waste in box and sometimes burn or directly discharge to nearby CCC dustbin mixing with non-hazardous waste without any pretreatment.

Table 3.2: *Waste Generation Rate at Bangabandhu Memorial Hospital*

Ward Name	Number of beds	WGR (kg/bed/day)	WGR (kg/ward/day)	Average number of (patient/ward/day)
Emergency	3	1.67	5	120
Gynae	40	1.75	70	23
Male Medicine	45	1.45	65.25	25
Paediatric	30	1.30	39	15
Surgery	35	1.55	54.25	20
Orthopedics	20	1.40	28	10
Eye	5	0.45*	2.25	3
ENT	5	0.35*	1.75	2

3.2 Medium Scale Public Hospital Vs Private Clinic

Chittagong General Hospital (CGH)

CGH is the only public hospital after CMCH in Chittagong without police line hospital and CMH. It contains 150 beds along with 12 wards which are upgraded to 250 beds. It serves 150-200 residents and 500-700 patients in outdoor per day. Total HCW generation rate of CGH is 120-150 kg/day and 0.48 kg/bed/day along with 35 workers including workers, ayas and cleaners. They follow twice or thrice color coding for HCW separation and storage but not properly and regularly such drums are provided by Department of Health. They also make open burning of HCW and both ashes and un-burnt HCW are discharged to installed dustbins within the premises without any pretreatment from where after two or three days CCC truck collect HCW. The workers collect and segregate HCW manually without using any protective gears.

National Hospital

National Hospital is a representative of available number of clinic in Chittagong according to size and running programs. It contains 70 beds including VIP, cabin and general beds together. It serves 45-55 patients in indoor and 200-250 in outdoor per day. The total HCW generation rate ranging from 200-220 kg/day and 1.79 kg/bed/day along with 45 workers. They don't follow any color coding system to separate different categories of HCW rather they store general and clinical waste separately without any marking drum. The workers never wear any protective gears only simple dress and joining time get simple instructions regarding to HCW handling and associated risks. They are contracted with ISS for handling their generated waste on the basis of BDT 4000 per month.

3.3 Public Maternity Vs Private maternity

Memon Maternity Hospital (Unit-1)

There are four CCC running maternity hospitals in Chittagong among them Memon Maternity Hospital (MMH) is large and old. It contains 100 beds including VIP, Luxurious, cabin and general beds together and run childcare facilities too. It serves 50-60 residents and 100-150 outdoor patients per day. Total HCW generation rate of MMH is 120-150 kg/day and 1.13 kg/bed/day. It has 30 workers who perform HCW regarding works along with other assigned activities. They don't follow any color coding for temporary storage of HCW. The workers sometimes segregate recyclable HCW manually to sell illegally. They have own incinerator facilities which they sometimes use to incinerate their generated sharp HCW.

Both incinerated ashes and rest waste are discharged to CCC dustbin directly without any pretreatment. The workers never use any protective gears rather only wear simple dress.

Surjer Hasi Clinic

In Chittagong a few NGO running maternity exist. Among them we selected Surjer Hasi Clinic as representative of others which is located at Rahattarpool. It contains 15 beds along with 2 wards. It serves 4-5 residents and 40-50 outdoor patients per day. Total HCW generation varies from 15-20 kg/day and 2.4 kg/bed/day along with 4 workers who have simple knowledge about HCW management and associated health hazard. They store HCW in strong covered box but no color coding. They have own incinerator facilities which is used sometimes for incinerating sharp HCW. Finally incinerated ashes and other waste are dumped to nearby CCC dustbin or open roadside area.

3.4 Specialists Hospital and Clinics

Chittagong Diabetics General Hospital (CDGH)

Chittagong Diabetics General Hospital is the main such kind of healthcare facility providing in Chittagong and it has 2 other small branches. It contains 61 beds along 4 wards. It serves 74 residents and 300-350 outdoor patients per day. Total HCW generation rate varies from 60-70 kg/day and 1.56 kg/bed/day which are handled by 15 workers. They never follow any color coding which standardized by Department of Health rather they separate waste into two categories like general and clinical waste. It was also found they store HCW in empty room, stairs and open ground without using any drum. They are contacted with ISS to manage their generated waste on basis of BDT 3000 per month charge.

Chittagong Eye Infirmary Hospital

Chittagong Eye Infirmary Hospital is the largest healthcare facilities which provide such kind of service. It contains 120 beds along with 6 wards. It serves 96 residents and 1000-1200 outdoor patients per day. Total waste generation ranging from 70-80 kg/day and 0.9 kg/bed/day. The have 45 workers for HCW handling. They store sharp waste into plastic bottle and burn behind their premises along with other infectious waste. The burnt ashes and other wastes are finally discharged to nearby CCC dustbin. The workers never wear any protective gears except simple dress. They also never follow any color coding system for temporary storage and source separation of HCW.

3.5 Public Clinic Vs Private Diagnostic

Mamata Nagar Shasta Kendra

Small category of public clinics is run by CCC in Chittagong and Mamata Nagar Shasta Kendra is one of them which is located at Enayet Bazar. It serves 60-70 patients/day and run 20-30 test/day. Total waste generation rate is 15-20 kg/day and 0.08kg/patients/day. It has 3 workers. It has incineration facilities but which is not used. All of the generated waste is discharged to CCC dustbin directly without any pretreatment.

Metro Diagnostic Centre

The available numbers of HCEs in Chittagong is diagnostic centers among them we selected Metro Diagnostic Center. It runs 350-500 test/day and waste generation rate is 0.08 kg/test/day.
It has 8 workers for handling HCW who got simple instructions regarding to HCW during join9ng time from providing company. It separates generated HCW into two category such as general and diagnostic/lab waste. It is contracted with ISS for managing their generated waste on the basis of BDT2500 per month charge.

3.6 Public Dispensary Vs Doctor's Chamber

Fateyabad City Corporation Dispensary

It serves poor people by prescribing or providing free medicines. It serves 50-100 patients per day and generates total 5-6 kg/day and 0.05kg/patients/day. They have no waste separation system and mix up. Finally they discharge to CCC dustbins or roadside area.

Doctor's Chamber

Such kinds of healthcare facilities are available for poor people and normal treatment. Every DC generates HCW 1-1.5 kg/day along with syringes and saline bags. They have no workers and no HCW management system. So they directly discharge their generated waste into CCC dustbin without any pretreatment.

3.7 Discussions

Considering above mentioned information and gathered field experiences it is crystal clear to us that large scale hospital is few in CCC but they serve a great number of people and generate one-fifth of the total HCW. Small clinics and diagnostics centers are found mushrooming growth in CCC. Though they generate little quantity of HCW but totally is huge. In large hospitals mismanagement of HCW is noticeable while private clinics, diagnostic centers and NGO running maternity handle and manage HCW through better way due to proper regulations and monitoring. Only public hospitals follow color coding for temporary storage of HCW according to category but not properly and regularly. Nevertheless, DC and maternity use strong and covered box while others use drum or basket sometimes which are found open. None of the HCEs arrange treatment of HCW rather some workers, cleaners and staffs are found involved in selling recyclable HCW to nearby shop without any pretreatment which is a threat of disease spread and health hazard.

4.0 CONCLUSION

Chittagong being commercial capital of Bangladesh city dwellers is increasing rapidly comparing it healthcare facilities are in mushrooming growth. Despite of total number of HCEs and HCW generation quantity rate is less in Chittagong than Dhaka city due to improper management which has become a concerning issue and human health hazard in CCC. Lack of regulations and management facilities HCW handling and disposal process varies from HCEs to HCEs. HCW regarding options such as collection, segregation, storage, transport, treatment, recycling, reuse and disposal process are quite unsatisfactory and environmentally hazardous. It was a great wonder that HCW handling and management workers have no knowledge about HCW risks though doctors and nurses have little knowledge but never apply.

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