M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.3 (1-6)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Iron Recycling- an Income Generating Activity towards Sustainable Solid Waste Management in Khulna, Bangladesh

S. M. Moniruzzaman* and Q. H. Bari*

**Department of Civil Enginerring, Khuna University of Enginerring & Technology, Khulna-9203, Bangladesh*

ABSTRACT

The informal sector has been practicing recycling as a source of income since long ago in Khulna city. In the context of solid waste recycling, the informal sector refers to the waste collectors, dealers and recycling industries. Scrap iron, which includes its refined product steel, is the most widely used of all the metals in Khulna. This paper looks in brief at the present scrap iron recycling pattern in terms of collection, transportation and transformation in Khulna. It is also worthwhile to evaluate the income generation from this informal sector recycling existing in the city. The study reveals that the profit margin for iron recycling is 30%. The study finds that about 25.81 ton mild steel and 3 ton cast iron are recycled daily in Khulna. Due to this recycling, the informal sector is saving the expenditure of solid waste management of about 10,372,637 BDT/year (1 USD = 84 BDT).

INTRODUCTION

Solid waste recycling approach is a part of sustainable and effective waste management system for most cities of the world. In the course of achieving proper solid waste management, many efforts in developing countries especially in Bangladesh have been focused on waste collection and disposal only. The generation of solid waste is increasing day by day in Bangladesh as well as in Khulna city. The total municipal solid waste (MSW) generated in Khulna city is about 520 ton/day and its physical composition is food & vegetables 78.9%, paper 9.5%, plastic 3.1%, textile 1.3%, metal 1.1%(mostly iron), glass 0.5%, rubber 0.5%, dust 3.7% and others 1.3% (WasteSafe, 2005). Although the recycling option of waste management has been ignored by the government, the informal sector has been practicing recycling as a source of income since long ago in Bangladesh. The informal sector is characterized by small-scale, labor-intensive, largely unregulated and unregistered, low-technology, manufacturing or provisions of services (Wilson et al., 2001). Informal sector entrepreneurs or enterprises do not pay taxes, have no trading license and are not included in social welfare or government insurance schemes (Haan et al., 1998). In the context of solid waste recycling, the informal sector in Khulna refers to the waste collectors, dealers and recycling industries.

Iron, which includes its refined product steel, is the most widely used of all the metals in Bangladesh as well as in Khulna city. Iron and steel products are used in many construction and industrial applications, such as appliances, bridges, buildings, containers, highways, machinery, tools, and vehicles. The scrap iron recycling is an important and well established activity of recovering iron generated from manufacturing scrap as well as from products after their useful life. It has many important benefits, and plays a powerful role in supporting both environmental and economic outcomes. It is highly successful in diverting iron scrap from landfills, and provides raw material for new products, offering a much lower carbon footprint and more efficient utilization of resources than new material. According to Diamadopoulos et al. (1995), if solid wastes are not recycled, the space in landfills will be exhausted very quickly and necessitate the construction of new ones. Iron recycling saves energy and conserves natural resources. Recycling one ton of steel conserves 2,500 pounds of iron ore, 1,400 pounds of coal and 120 pounds of limestone. Aside from environmental benefits, metal recycling is an extremely powerful economic activity, generating over 64 billion USD to the U.S. in 2010, according to ISRI, 2012.

The study looks in brief at the present scrap iron recycling pattern in Khulna city and evaluates the income generation from it. It is expected from this research that the scenarios in Khulna city can serve as an example in explaining the traditional recycling pattern not only as a way of sustainable solid waste management but also as an income generating activity in the other cities and towns of Bangladesh.

ISBN: 978-984-33-7045-7, PI.3 (1-6)

SURVEY PROCEDURE

Khulna, the third largest city of Bangladesh, is located in the south-western part of the country. In order to a get a clear picture of the scrap iron recycling activities, reconnaissance surveys were done all over Khulna city in this study.

From this reconnaissance survey it was observed that the recycling industries (RI), many individual waste collectors and recyclable dealers are practicing scrap iron recycling activity in Khulna. It was found that recycling industries and dealers were available only in some areas, namely Shiromoni, Fulbarigate, Daulatpur, Khalishpur, Shekhpara, Sonadanga, Gollamari and Lobonchora. Therefore all those areas were selected for the detail survey of the study. A different set of questionnaires were designed for the employees of RI, dealers and waste collectors to obtain information about the ongoing iron recycling system.

All of the iron RI in Khulna were visited and their recycling processes were investigated. The study used surveys about the employees working in the RI in order to get information concerning problems, prospects, procedure and the quantity of recycling in real life situations. The number of RI that are producing different recycled materials from the processed scrap iron was obtained by the field survey. Each of these RI was surveyed in this study once every three months for two years. The quantities of scrap iron collection and the quantity of recycled products were obtained from the record book of industries. Information about the number of employees and their working conditions were also obtained from the field survey.

About sixty collectors of different ages were selected from all over the study area to take the interview. Information about their sources of scrap iron collection, selling place and working conditions was obtained from the questionnaire survey. About one hundred dealers were surveyed in this study and most of them participated in the interview. The scrap iron collection process, their buying and selling places were obtained from the questionnaire survey.

RESULTS AND DISCUSSIONS

Iron Recycling Pattern

From the field survey it was found that the various groups of the informal sector such as waste collectors, dealers and RI have been practicing iron recycling activity in an unorganized and unplanned way in Khulna city as a source of their income from long ago. The scrap iron recycling pattern in terms of collection, transportation and transformation is described below.

Sources: Households, institutes, market places, construction sites are the primary source of scrap iron in Khulna. People are using iron products for different purpose of their daily life. Scrap iron have economic value. Generally people separate scrap iron at primary source for the purpose of sale.

Waste collectors: The waste collectors are the first link in a long chain of recycling. They are visible in every community of the city and came from nearby slums. This group comprises of men, women and children. According to Moniruzzaman et al., 2011, the number of waste collectors in Khulna were 2000 and they were categorized into two groups: House to house waste collectors (usually men and women; locally known as feriwala) and waste bin collectors (usually children; age below 15 years; locally referred to as tokai). Generally tokais collect recyclable solid waste (RSW) such as scrap iron products, paper, plastic etc. from the mixed waste dumped in the waste bin, disposal site and road side as shown in Figure 1(a). They carry the separated waste in a plastic bag and sell it to the dealers at different prices depending on the type and quality of the waste. Feriwalas, on the other hand, buy the separated scrap iron items stored for selling in homes and institutions as shown in Figure 1(b). They purchase RSW which is not contaminated by mixing with biodegradable waste in exchange for money or gifts and sell those materials to the dealers at a small profit as shown in Figure 1(c).


(a) Collection by a tokai


(b) Collection by a feriwala


(c) Collection by a dealer

Figure 1: Scrap iron collection by informal sector in Khulna

Dealers: Recycle dealers are the second link in the chain of recycling. They were categorized into three broad groups on the basis of the quantity of waste collection according to Moniruzzaman et al., 2011 as follows. (1) Small Scale Recycling Dealers (SSRD): their collection of RSW is less than 250 kg/day on average, (2) Medium Scale Recycling Dealers (MSRD): RSW collection by each MSRD is within a range between 250 kg/day to 600 kg/day on average and (3) Large Scale Recycling Dealers (LSRD): On an average the amount of RSW collection by each LSRD is greater than 600 kg/day. The SSRD purchase scrap iron and other RSW from waste collectors'. They sort, clean and sell the processed wastes to the MSRD. The MSRD purchase scrap iron and other RSW from different SSRD, accumulate the processed waste and sell those to LSRD. The LSRD collect processed scrap iron from all MSRD, accumulate and sell it to recycling industries (RI).

Recycling Industries (RI): Finally, the scrap iron collected by different actors starting from feriwalas, tokais comes to RI through a chain of dealers like SSRD, MSRD and LSRD. The RI recycle the processed scrap iron and finally sell it to market.

It was found that the average scrap iron collected by each collector was 3.33 kg/day. Therefore, total scrap iron collected by 2000 collectors was 6.66 ton/day. The amount of scrap iron processed by different dealers such as SSRD, MSRD, and LSRD were 10.43 ton/day, 15.38 ton/day and 32.71 ton/day, respectively as shown in Table 1. The quantity of scrap iron recycled by RI was 28.81 ton/day as summarized in Table 1.

Table 1 Average quantity of scrap iron processed by informal sector in Khulna

Location	Amount of Scrap Iron Processed (Kg/day)			
	SSRD	MSRD	LSRD	RI
Fulbarigate	240	-	-	-
Shekhpara	6345	12882	29680	19000
Dakhbangla	216	85	310	-
Munshipara	300	-	-	-
Dawlotpur	630	356	-	-
Khalishpur	1140	846	720	-
Gollamari	300	227	-	-
Sonadanga	168	-	-	-
Labonchara	100	-	-	-
Shiromoni	66	-	-	3000
Other places	925	982	1997	6805
Total	10430	15378	32707	28805

The schematic mass balance of scrap iron recycling in Khulna is shown in Figure 2. From this study it was observed that 10.43 ton/day of scrap iron were recovered by SSRD for recycling of which 6.66 ton/day was collected through the waste collectors and 3.77 ton/day was collected directly from sources. SSRD processed it and sold it to MSRD. MSRD recovered 15.38 ton/day of scrap iron of which 10.43 ton/day was collected through SSRD and 4.95 ton/day was collected by the MSRD directly from sources as shown in Figure 2. In the recycling chain SSRD, MSRD and LSRD were found to process scrap iron by sorting, cleaning etc. LSRD recovered 32.71 ton/day of iron of which 15.38 ton/day was collected from MSRD of Khulna city and imported 17.33 ton/day from Chittagong. They exported 3.9 ton/day of processed iron to Jessore or Dhaka depending on the market price for their business purpose. They sold 28.81 ton/day of processed iron to RI of Khulna for final recycling. The RI recycled all of the 28.81 ton/day of iron and sold it to local markets as shown in Figure 2.

Iron Recycling Process in Industries in Khulna

There are eleven iron recycling industries (RI) in Khulna of which five RI recycle cast iron and six RI recycle mild steel. They were found to consume scrap iron to reprocess the iron product. The sources of iron are old and cut pieces of pipe, discarded building materials, industrial scrap and machine shop cuttings, construction debris etc. RI were found to purchase scrap iron from LSRD and recycle it by sorting, heating, melting, cooling, hammering (for mild steel) or casting (for cast iron). Machine Parts, Knives etc are the products from scrap mild steel. On the other hand, head of tube well, haman dista (one kind of grinding machine), frying pan, measuring weight, nut and bolts are the recycled products of scrap cast iron. The flow diagrams and the pictures of various steps of scarp iron recycling process in the RI of Khulna are shown in Figure 3 and Figure 4, respectively.

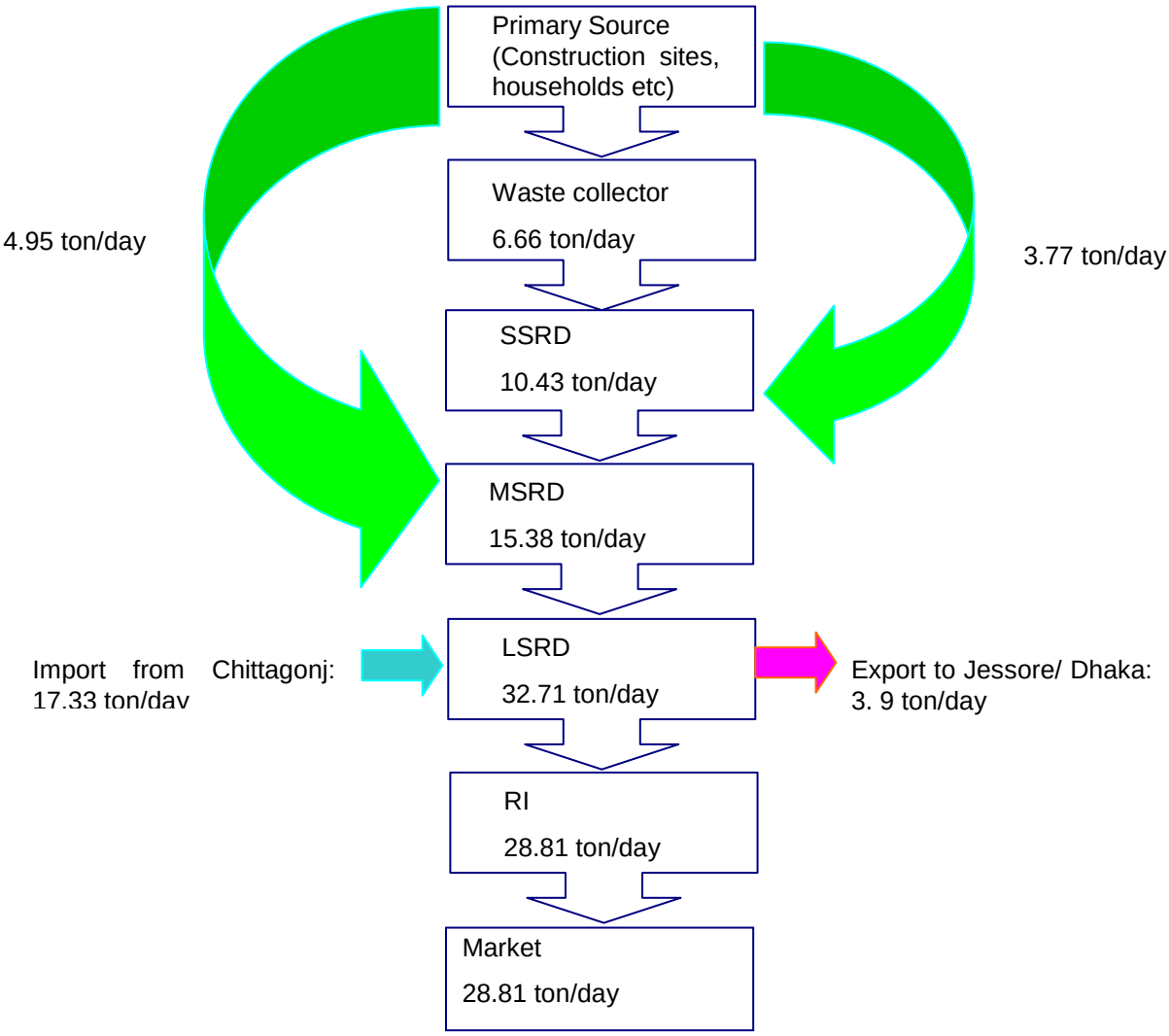
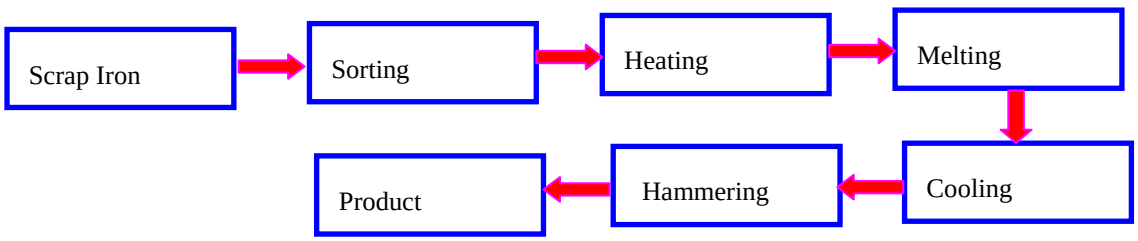
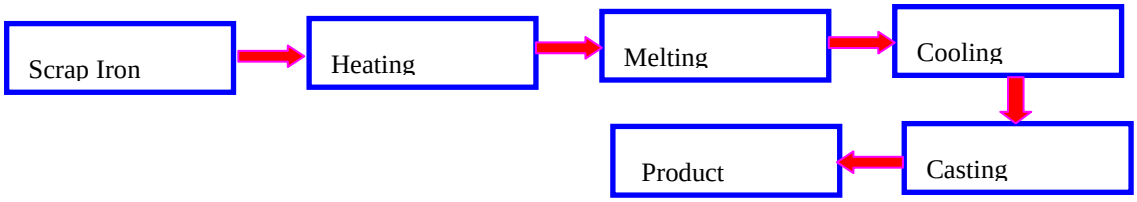


Figure 2: Schematic mass balance for scrap iron recycling activity in Khulna



(a) Mild steel



(b) Cast iron

Figure 3 Typical flow diagrams for (a) mild steel and (b) cast iron recycling process in Khulna

ISBN: 978-984-33-7045-7, PI.3 (1-6)

(a) Scrap Iron (b) Heating in a furnace (c) Die

(d) Die casting (e) Finishing (f) Product (Frying Pan)

Figure 4 Recycling process in an iron recycling industry in Khulna

Income Generation and Expenditure Savings

The recycling activity of scrap iron is going on in Khulna not considering those as wastes but as a source of income. The prices of separated and processed scrap iron at different dealers and industries were obtained from the field survey as shown in Table 2. The profit margin added to the prices of scrap iron in the waste recycling chain from the SSRD level to RI level was 30 %.

Table 2: Prices of processed iron at different recycling levels

Solid waste	Price at SSRD (Tk/kg)	Price at MSRD (Tk/kg)	Price at LSRD (Tk/kg)	Price at RI (Tk/kg)	Value added in the process
Scrap Iron	23.00	24.00	26.00	30.00	30 %

The Khulna City Corporation (KCC) is responsible for the waste management in Khulna. KCC spent 288,03,000 BDT during the 1998-99 financial year for solid waste management and collected only 80 tons/day. Thus the expenditure per ton per day for solid waste management in Khulna was 986.40 BDT (Enayetullah and Sinha, 2000). It was found that the informal sector was recycling 28.81 tons of scrap iron per day in Khulna. Therefore, it can be estimated that by removing these solid waste, the informal sector is saving revenue 10,372,637 BDT/year.

CONCLUSION

In Khulna, the recycling of iron is currently carried out by informal sector comprising waste collectors at the lowest end and a succession of dealers and industries. The existence of waste, mainly non-bio

degradable or slowly bio degradable such as iron, has opened quite an extensive possibility for various groups of the community to utilize it. Although recycling of solid waste is not included in the waste management policy of local authority, yet it has become a main source of income for several groups of the private sector. The process creates a market of iron, and value addition occurs for the recycled iron products. The study reveals that the profit margin for iron recycling in Khulna is 30 %. There are eleven iron recycling industries in Khulna and they recycle 28.81 ton/day. The iron recycling industries of Khulna use locally available technology for recycling such as manual sorting and cleaning and mechanical heating/cooling, die casting or molding. Due to this recycling the informal sector is saving the expenditure of solid waste management of 10,372,637 BDT/year.

In order to achieve proper solid waste management and improve recycling rates, one of the major challenges of Bangladesh is how to best effort with the informal sector to improve their working conditions, technologies and efficiency in recycling. Proper storage and source separation system can be adopted for recovering useable and recyclable waste such as iron. Moreover, solid waste management strategies in Bangladesh should be reorganized to include a separate collection and processing system for the recyclable solid waste to avoid mixing with biodegradable waste. That can work parallel with the traditional systems operated by the informal sector for waste separation, processing and final recycling. This approach results into not only the reduction of quantities of wastes to be disposed of but also increase employment and thus income for the disadvantaged urban poor.

REFERENCES

Diamadopoulos, E., Koutsantonakis, Y. and Zaglara, V. 1995. Optimal Design of Municipal Solid Waste Recycling Systems, *Journal of Resource Conservation and Recycling*, Vol.14, pp.21–34.

Enayetullah, I. and Sinha, A. M. 2000. Community Based Solid Waste Management, *the Asian Experience 4, 1st Ed*, Waste Concern, Dhaka, Bangladesh.

Haan, H. C., Coad, A. and Lardinois, I. 1998. *Municipal Waste Management: Involving micro-and-small Enterprises, Guidelines for Municipal Managers*, Turin, Italy. International Training Centre of the ILO, SKAT, WASTE. http://www.skat-foundation.org/publications/waste.htm.

Moniruzzaman, S. M., Bari , Q. H. and Fukuhara, T., 2011. Recycling Practices of Solid Waste in Khulna City, Bangladesh, *The Journal of Solid Waste Technology and Management*, Vol. 37, No.1, pp.1-14.

WasteSafe 2005. *Integrated Management and Safe Disposal of Municipal Solid Waste in Least Developed Asian Countries*, M. Alamgir, C. Mc Donald, K. E. Roehl and A. Ahsan edited final report of WasteSafe, a feasibility study project under Asia Pro Eco Program at KUET, Bangladesh.

Wilson, D., Whiteman, A. and Tormin, A. 2001. *Strategic Planning Guide for Municipal Solid Waste Management*, Washington DC, World Bank. http://www.worldbank.org/urban/solid_wm/erm/start_up.pdf.

ISRI 2012. Institute of Scrap Recycling Industries,1615 L Street, NW, Suite 600, Washington, DC 20036-5610. http://www.isri.org/

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7 PI. 37 (1-7)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

A Study on Roll of Ecosan Toilet in Rural Sanitation Practice of Bangladesh

Shuvo Ramo Saha[1], Khondoker Mahbub Hassan[2] and Md. Monzur Hossain[3]

[1]M.Sc Engineering Scholar, Dept. of Civil Engineering, KUET, Khulna-9203, Bangladesh
E-mail: srsahace@gmail.com
[2]Associate Professor, Dept. of Civil Engineering, KUET, Khulna-9203, Bangladesh
E-mail: khmhassan@yahoo.com
[3]M.Sc Engineering Scholar, Dept. of Civil Engineering, KUET, Khulna-9203, Bangladesh
E-mail: monzurce@gmail.com

ABSTRACT

The principles and practices involving to collection, treatment or disposal of human excreta, household wastewater and refuse as they impact on people and environment are called sanitation that has to be not only economically viable, socially acceptable and technically/institutionally appropriate, but also should protect the environment and natural resources to be sustainable. Ecological sanitation (EcoSan) system is an approach to avoid the disadvantages of conventional wastewater systems which are based on water as transport medium for collection and transport of human excreta via a sewer system. This study aims at investigating the roll of EcoSan toilets in rural Bangladesh with regards to improve the sanitation system. In the study area, in two years, rate of open defecation has been significantly reduced from 46.40% to 12% with ecological concept through providing EcoSan toilets. Recently, 61 families (49% of total families) are using EcoSan toilets when rate of using pit latrines and open defecation is 35% and 12% respectively. EcoSan is increasingly recognized as a realistic alternative to provide safe sanitation.

INTRODUCTION

Worldwide, about 2.6 billion people lack access to improved sanitation (WHO/UNICEF, 2010). Bangladesh, of which 70% of population is residing in rural areas, is a densely populated country in the world. Sanitation in rural areas of Bangladesh is getting worse gradually due to inadequate facilities of human excreta management through the traditional way, the great concern of environmental sanitation. At present, pit toilet with or without water seal, hanging toilet, direct pit pour-flash toilet, toilet with septic tank, urine diversion toilet etc. are common features in rural sanitation having no master plan of management for collection, transportation and disposal system of human excreta passing through a sewerage line. For this rationale, it is necessary to have not only improved toilet but also sanitary management of human excreta. However, we also know that proper sanitation positively affects the individual's nutritional status, diseases resistance, income opportunities, self-esteem, personal security, etc. Enhanced opportunities for improved livelihoods can be achieved through eco-system based sanitation with radical perspective on gender balance, social development, agricultural production and sustainability.

Ecology is an interdisciplinary branch of biology. The word "ecology" ("Ökologie") was coined in 1866 by the German scientist Ernst Haeckel (1834–1919). Presently, the term has been expanded as ecotope, ecological economics, ecological agriculture, ecological engineering etc. EcoSan applies the fundamentals of ecology, and takes the non-hazardousness, decrement as well as resources recovery of human excreta as the guiding principles for the construction of ecological facilities, and the rational utilization of non-hazardous treated human excreta as useful resources, so as to achieve the purpose on health protection of human beings and ecological balance (Shunchang et al., 2002). Nevertheless,

EcoSan is a cycle or a system or a closed-loop system which treats human excreta as a resource where excreta are processed on site until they are free from pathogen and sanitized excreta are recycled by using them for agriculture purposes. EcoSan is the appropriate method of human excreta management, where this might be used as both organic matter and fertilizer. The EcoSan toilet uses a special pedestal or squat plate in which urine enters the front part of pedestal and then diverted through the pipe and thus separated from the faeces which fall directly downwards into a vault or container. Some wood ash is added to cover the faeces after every visit. This covers the deposit and helps to dry out the surface of the faeces and makes them easier to handle and transfer. The distinct advantage of this method is that the urine can be collected separately, making it available as a liquid fertilizer. Also the solid component, being in semi dry state, is much easier to handle and safer from the beginning, even if it does initially contain pathogens. Being semi dry, it does not smell so much and its potential as a fly breeding medium is much reduced compared to the mixes of urine and faeces. Eventually, the faeces become completely composted.

The key objective of a sanitation system is to shield and endorse human health by providing and maintaining a clean environment without faecal contamination and by adopting measures that break the cycle of disease transmission. The system should be technically appropriate, economically feasible, socially acceptable and institutionally manageable which are factors that all affect the health outcomes to achieve the direct effects of containment and reduction of pathogenic organism. Human health and environmental impact are interlinked. When the products from a sanitary system should be considered as potential resources either for food production or for energy generation, the health issues and aspects of risk reduction need to be accounted for in addition to the benefits of nutrient recovery. In the technical improvement of existing sanitation systems or in the design and implementation of new ones, health risk considerations are crucial and should always be an integral part of the planning and decision making process (Stenstrom et al., 2011). So, EcoSan is the concept of dry sanitation, an innovative approach and viable solution to the problems cause by conventional sanitation because its benefits and advantages are successfully conveyed correctly shown through knowledge sharing and capacity building. The objective of this study is to evaluate the performance of newly established ecological sanitation concept through EcoSan toilets in rural areas of Bangladesh in view of improve sanitation system.

METHODOLOGY

Background

The acuteness towards the sustainability of EcoSan toilets with regards to improve sanitation system through providing concept of EcoSan in rural area of Keshabpur upazila under Jessore district was studied using household interview and observation. The survey was carried out in South Banshbaria village of Sagardari Union in Keshabpur upazila under Jessore district showing in figure 1. The village is low lying area and located in the bank of river “Kobadak”. The survey was based on 125 respondents of the village. Most of the residents in the villages are poor, illiterate, farmer and low income earners. The survey was conducted in two times; on March, 2009 and January, 2011 for a period of two weeks in each survey during the project periods. Data collection was commenced by conducting interviews.

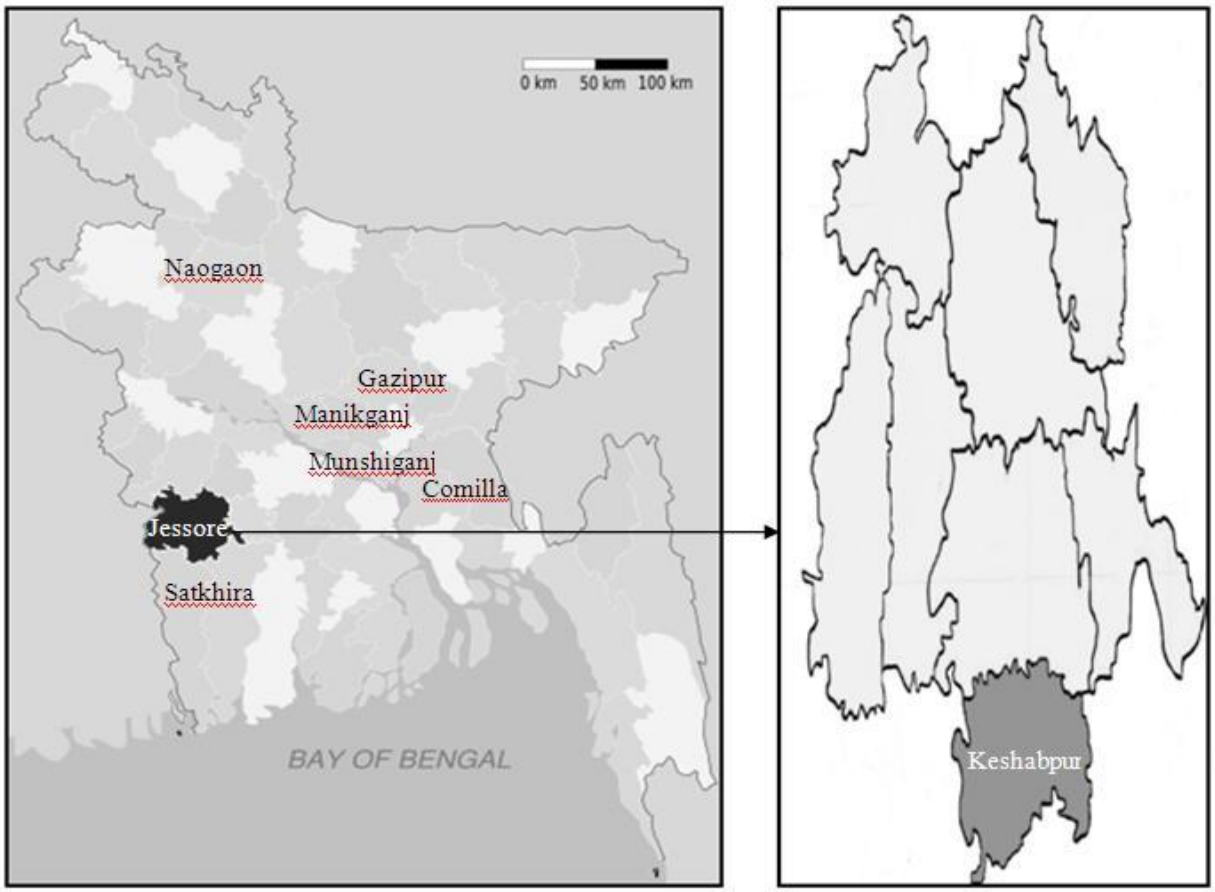
Site selection

The village was also selected because an EcoSan pilot project of three years duration was first implemented by JADE funding from Toto limited and Mitsui Limited, Japan and Australian High Commission, Bangladesh. The project was implemented in this area having an objective of humanizing the perception of ecological sanitation among the villagers. The toilets were given out on first come first serve basis to residents who requested for the toilet through the project coordinator. The beneficiaries paid a small fee because the toilets were subsidized by the project.

Household interviews and selection of respondents

Household interviews were conducted among 125 families in the village with support of a guide to locate household respondents’ homes. In cases where the household head or landlord was not present, any adult in the sampled household was interviewed. Data was collected using a structured questionnaire comprising both open-ended and close-ended questions. For open ended questions, the respondent was at liberty to give multiple answers and also to bring to discussion other issues he/she thought are relevant

to the questions. While close ended questions necessitated the respondents to rank, accept by indicating either yes or no answers. The questions were prepared in English language but translated into Bengali language in case the respondents felt more comfortable than speaking in English. However, some respondents were not willing to give information or be interviewed because they were busy at their work place while others were simply not interested because they have been interviewed several times by other researchers and that they have not seen any changes as a result. This necessitated a lot of convincing explanations by the interviewer to let those respondents accept to be interviewed.



(Source:en.wikipedia.org/wiki/Jessore_ District, ww.*studycirclebd.info /jessore-district.html)*

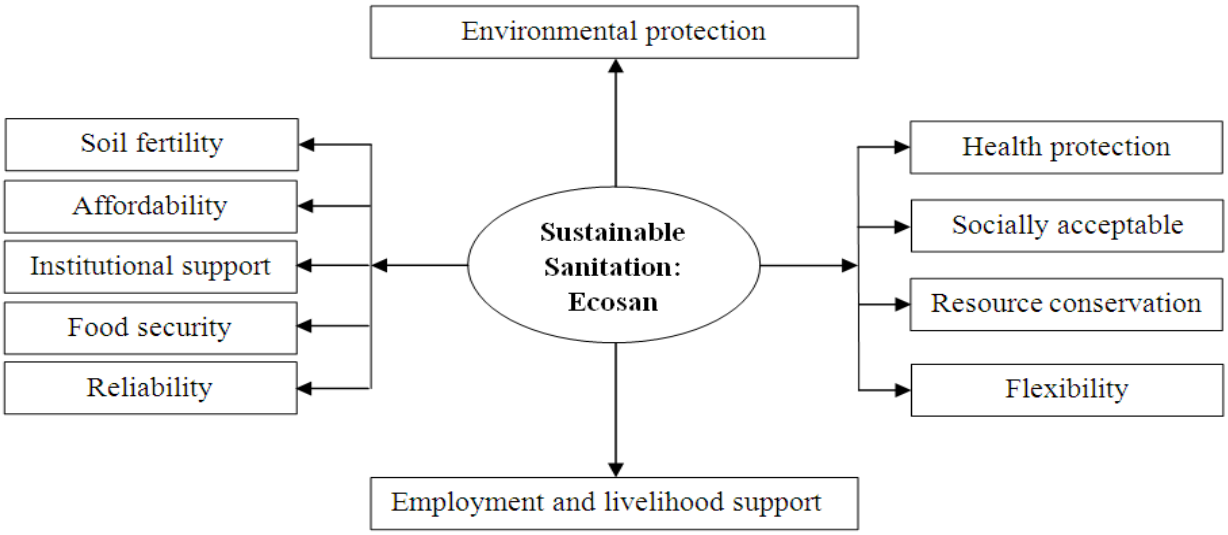
Figure 1: Location map of study area under Jessore district

Field observation

Field observations were carried out simultaneously with the household interview exercise. It was carried out to see the kind of sanitation facilities used within the community, the design of urine diverting toilets, their management and the general sanitation (solid waste management, drainage) within the areas. This method was made possible during each household's respondent interview as the researcher requested to have access to the sanitation facility in the household. Photographs of the toilet facility present were taken to show the type, design and general situation of the facility. This helped to relate to some information collected in interviews. This method was used because one can get accurate behavioral information which is not easily provided in an interview, as well as physical state of subject matter being studied. It was also time-saving and minimized costs since it was done during household interviews.

Sustainable sanitation technique

An overall simplified model of sustainable sanitation through EcoSan is shown in the figure 2 as follows:



(Source: Chowdhury and Mamun, 2007)

Figure 2: Components of sustainable sanitation

Structure of EcoSan toilet

EcoSan toilet is a structure which was built completely on the ground level. It has two portions, one is lower portion called feces chamber and another is upper portion called defecation place. Feces chamber is the most important part of the structure. During construction period, the chamber is made water proof carefully so that no water enters in it i.e. there is no scope that human feces get mixed with water. The feces chamber is made of bricks and well sealed with cement mortar at the bottom and surrounding corners. The front faced and backside wall of the chamber is typically 2.50 ft and 2.0 high from the ground level. An impermeable base is constructed underneath the feces chamber. In this process, a compacted sand layer is provided on the leveled ground followed by 3 inch brick flat soling and 3 inch cement concrete. Finally, both inside and outside of the chamber are plastered with neat cement finishing showing in figure 3.

In the figure, steps that are marked for construction are given below:

1: Sand filling with thickness of 3 inch on the plain ground
2: Flat brick soling with thickness of 3 inch
3: 3 inch thick cement concrete casting
4: Inside of the chamber plastered with cement grouting
5: outside of the chamber plastered with neat cement finishing

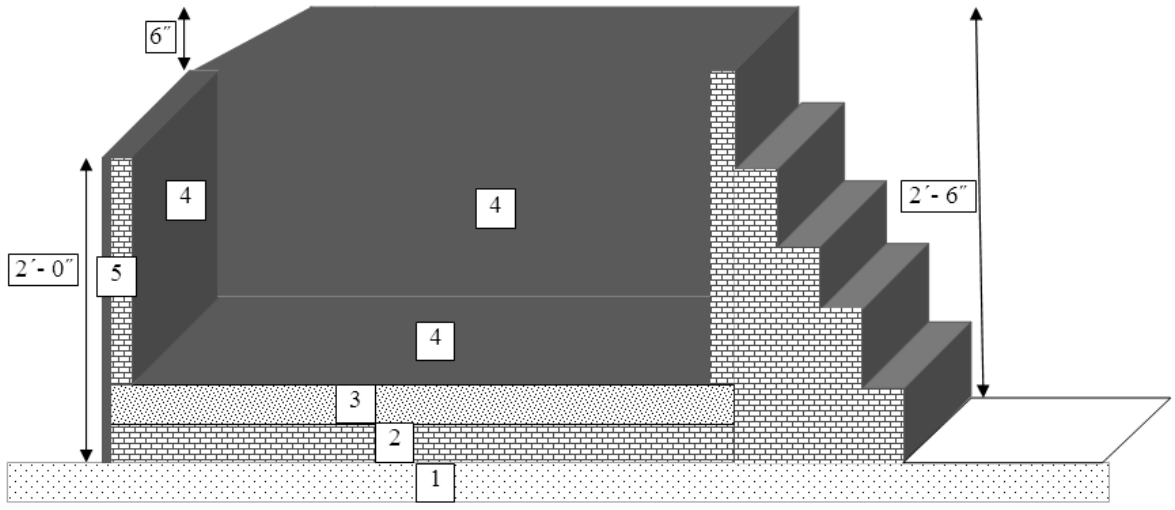
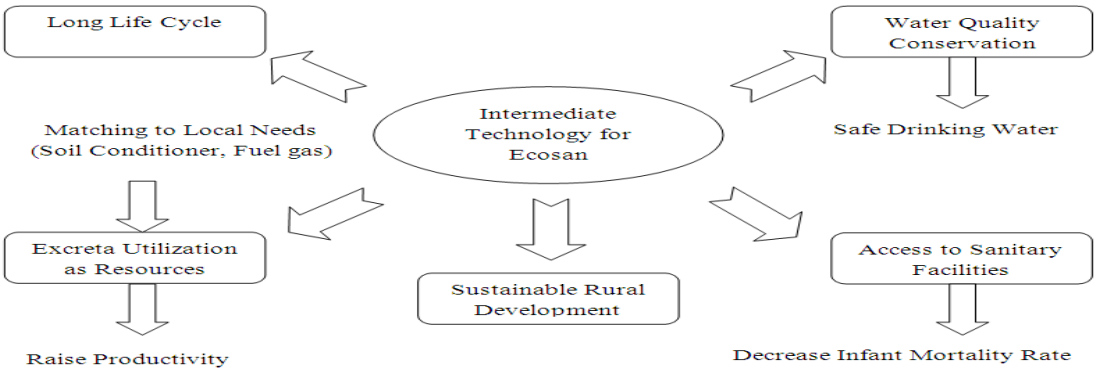


Figure 3: Construction stage of feces chamber

Purpose of ecological sanitation



(Source: Sakai, 2006)

Figure 4: Purposes of ecological sanitation

The figure 4 shows the purposes of ecological sanitation. In now a day, there is a movement called ecological sanitation (EcoSan), to apply technology which achieves human excreta recycling system together with satisfying sanitation function. However, installing new disposal site and establishing transportation system is not realistic. On the other hand, locally restoring resources derived from excreta corresponds to local requirement to improve deteriorated soil condition. EcoSan brings through sanitation improvement, locally restoring of human excreta so as to keep sanitary management of human excreta, reduction of environmental impacts in rural Bangladesh. After all, EcoSan also makes it possible to use toilet during flood period and extends life span of toilet.

RESULTS AND DISCUSSION

Improvement in household sanitation

Households remain steady in no. of 125 in the village of South Banshbaria from year 2009 to 2011. Census data on the prevalence of toilets in the area shows an improved percentage of household sanitation with the EcoSan toilets in figure 5. Result of pre-survey showed 58 out of 125 no. of households (46.40%) had no fixed toilet for defecation and 56 out of 125 no. of households (44.80%) used pit toilets with 2 (1.60%) no. of EcoSan toilet. So it is concluded that sanitation facilities was very poor in 2009. Lack of awareness about good sanitation, superior health protection and well hygienic environment is main reason for this problem. In one word, they were unknown to ecological sanitation. In 2011, rate of open defecation has been significantly reduced from 46.40% to 12% with ecological concept through providing EcoSan toilets. After passing two years (in 2011), sanitation facilities have been improved than previous situation in 2009. Recently, 61 families (49% of total families) are using EcoSan toilets when rate of using pit latrines and open defecation is 35% and 12% respectively. They are well known to use the toilet and its benefits. The toilet has achieved good response in the area and surrounding the village. Most of them have constructed the toilet very closed to their houses. They are well practiced to keep the toilet neat and clean. They are also capable to motivate others about the sanitation concept through benefit analysis of the toilets. However, the families who have not EcoSan toilet are not feasible due to economic and land scarcity.

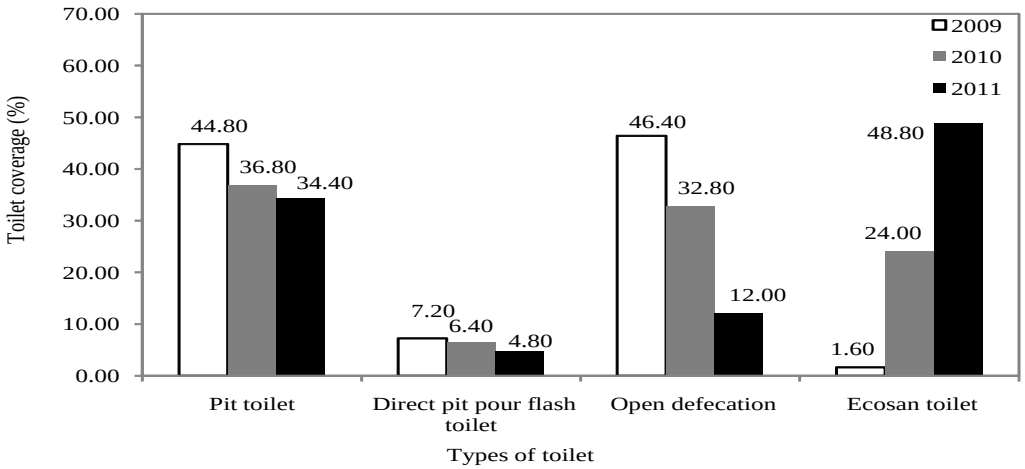


Figure 5: Improvement of household sanitation in South Banshbaria from 2009 to 2011

Practice of EcoSan toilet in Bangladesh

Government and non-government organizations as well as international agencies are involved in promoting EcoSan toilets in Bangladesh. 493 nos. of EcoSan toilets have already been constructed in 34 villages of 7 districts in Bangladesh where organic fertilizer, an alternative to chemical fertilizer are using with good management of human excreta. Location of 7 districts has been shown in figure 1. Table 1 shows that presence of EcoSan toilet in rural areas of Bangladesh. From the table, it is observed that Jessore district carries highest coverage of EcoSan toilet and lowest coverage in Munshiganj district. Maximum no. of EcoSan toilet is 61 in village of South Banshbaria in Keshabpur upazila under Jessore district. Minimum no. of EcoSan toilet is 2 in Balukapara and Southpara village in Niamotpur upazila of Naogaon district.

Table 1: List of EcoSan toilets constructed in rural areas of Bangladesh

District	Village	No. of EcoSan Toilet	Total No. of EcoSan toilet in each district
Comilla	Hatigara	29	120
	Joypur-North	14	
	Joypur- South	14	
	Bamail	4	
	Kalikapur	14	
	Raicho	45	
Gazipur	Chakpara	34	59
	Choyshotopara	4	
	Chokpara East	5	
	Pathar Para	6	
	Khondokar Para	10	
Manikganj	Dhulondi	18	60
	Boro Dhulondi	24	
	Amlapur Dhulondi	18	
Munshiganj	Bejgoan	13	24
	Masorgoan	7	
	Basail Bogh	4	
Naogaon	MridhaPara	7	40
	DangaPara	8	
	RobidashPara	5	
	BalukaPara	2	
	SahaPara	4	
	SouthPara	2	
	MadhuPara	12	
Jessore	North Banshbaria	33	140
	South Banshbaria	61	
	Raghurampur	15	
	Kasta	11	
	Samta	7	
	Tengra	13	
Satkhira	Ufapur	13	50
	Kamarali	12	
	Sotokupt	13	
	Kashimari	12	

Management of human excreta through land application

EcoSan toilet is a source of resource recovery through producing organic fertilizer that is applicable in agricultural land. In figure 6, it is shown that human feces have been changed in dried feces named organic manure, replacement of phosphate. However, EcoSan toilet has two feces chambers and each chamber is filled by feces with wood ash within about one year although it depends on no. of users. After filling first one, it is closed at airtight condition and second one is used. When second chamber was fulfilled, first one is emptied and feces are dried in sunlight. Then it can be stored for

using in future. During this period of one year, pathogens are decreased for which risk of contamination is reduced.

Figure 6: Organic fertilizer produced from dried human feces and its application in cabbage

CONCLUSIONS

People have recognized the concept of EcoSan and accepted EcoSan technology from planning to resource utilization in practice. It is proved that EcoSan as a new approach can be applied at rural areas in Bangladesh to improve the sanitation. In addition, EcoSan can provide comfortable toilets for people in the rural area of Bangladesh. EcoSan toilet is not only compulsory but also ecological concept with hygiene practice is most imperative for the rural people to lead themselves diplomatic life. It is an appropriate technology to improve the rural agriculture through sanitation practice. Acceptance of EcoSan technology in these areas is good. EcoSan technology is considered as most expectable alternative for sanitation facilities with resource recovery in agriculture in place of pit latrines and open defecation in context of rural Bangladesh.

REFERENCES

Chowdhury M.H. and Mamun A.A. 2007. *Ecological sanitation: An Intermediate Technology for Environmental Management*, BARD, ISBN: 984-559-169-2, vol. 2, Kotabari, Comilla

Sakai A. 2006. *Ecological sanitation: An Intermediate Technology for Environmental Management*, BARD, ISBN: 984-559-167-6, vol. 1, Kotabari, Comilla

Shunchang P. et. al. 2002. *Ecological sanitation and human health, Institute of Environmental Health and Engineering*, China Academy of Preventive Medicine Beijing 100050

Stenstrom T.A. et. al. 2011. *Microbial Exposure and Health Assessments in Sanitation Technologies and Systems*, Stockholm Environmental Institute, ISBN: 978-91-86125-36-3, Stockholm, Sweden,

WHO/UNICEF 2010. *Progress on Sanitation and Drinking Water*

Winblad, U. and Simpson-Hébert, M. 2004. *Ecological sanitation –revised and enlarged edition*, Stockholm Environmental Institute, ISBN: 91-88714-98-5, Stockholm, Sweden.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7 PI. 39 (1-5)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Wash Services Study in a Deprived Rural Part of Chittagong

Kabir Parvage, Golam Rabbani and Aysha Akter
Department of Civil Engineering, Chittagong University of Engineering & Technology (CUET)
Chittagong 4349, Bangladesh;
E-mail: aysha_akter@cuet.ac.bd , aysha_akter@yahoo.com

ABSTRACT

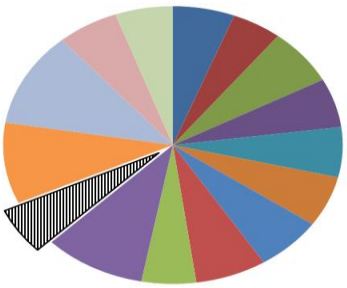
Water, Sanitation and Hygiene (WASH) services in Pahartali union has identified deprived among 15 unions of RaozanUpazila in Chittagong. In Pahartali, approximately 90% water (for drinking / other domestic use) is based on groundwater (shallow tubewell) and around half of the population facing sanitation difficulty due to lack of water-seal toilet. Thus, the water supply and sanitation in Pahartali needs to be improved. Findings from the closed questions in survey on WASH showed that 90% of the Households are using shallow tubewell, 100% pit latrine and without any health facility. Open question survey raised issues related to (i) lowering of water table; (ii) pond water as a secondary source; (iii) water availability and collection distance; (iv) latrine facilities, and (v) hygiene practices. It is expected that this study will provide useful information for WASH service providers in Unosottorpara community and ground for further research work in this regard.

BACKGROUND

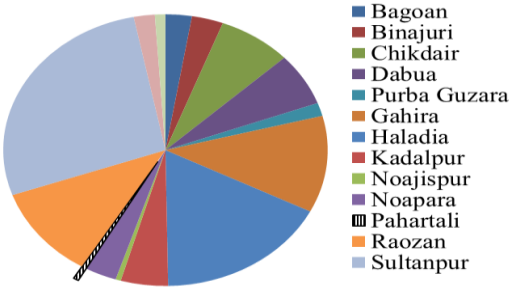
Water, Sanitation and Hygiene (WASH) services and practices still under development in rural parts of Bangladesh similar to the other developing countries(Whittington et al., 2012). Raozan, located in Chittagong containing 45775 units of household on its total area of 246.58 km² (Fig 1 a). Out of 15 unions in Raozan, Pahartali has identified deprived in Water, Sanitation and Hygiene (WASH) Services. In Pahartali, approximately 86% water for drinking / other purpose is based on groundwater (shallow tubewell) and around half of the population facing sanitation difficulty due to lack of water-seal toilet (Fig. 1 b, c, d and e). For this reported study an area of 45 acre in Unosottor Para (22°27'57"N & 91°57'59"E) under Pahartali union was selected. The aim of this study was to understand the water supply and sanitation facility and there consequence on human health in a deprived rural. To achieve this aim, the objectives were-

(i) to prepare a WASH identification map and
(ii) to develop a door-to-door basis inspection on WASH services.

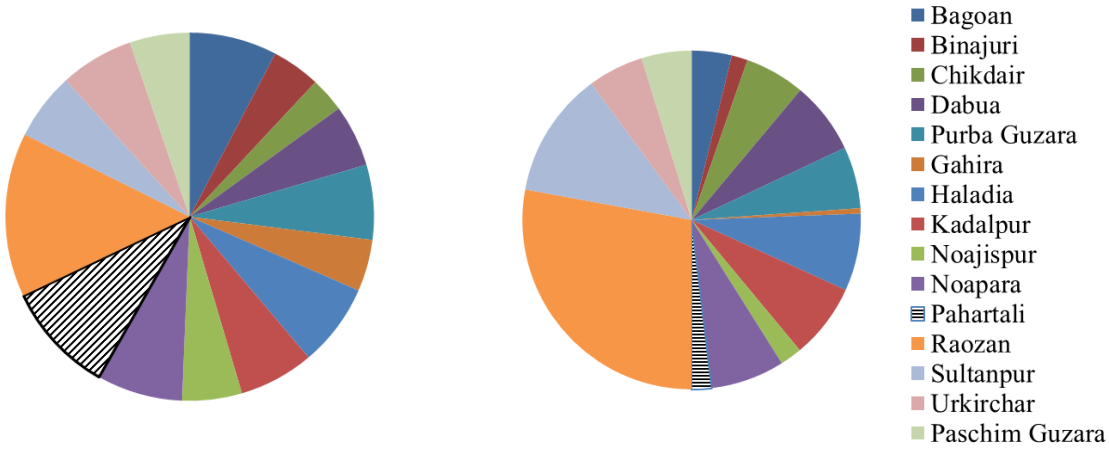
(a) Study area



(b) Numbers of shallow tubewell



(c) Deep tubewell coverage



(d) Numbers of water seal latrin (e) Existances of non-water seal latrins

Figure 1: WASH facilities in study location

MATERIALS AND METHODS

Intensive survey on (A) WASH identification map and (B) Door-to-door basis inspection on WASH services were considered. The production of WASH identification map, was carried out through a baseline survey, using Global Positioning System (GPS) during field visit and afterward representation on a Google map (Fig 2). Door-to-door survey included a questionnaire and was aided by photo and video of real situation. A total of 27 questions (56% closed questions and 44% open questions) highlighting (a) socio-economical condition; (b) sources of water for drinking/other purposes; (c) water collection problems due to distance/handling; (d) existing latrine facilities; and (e) hygiene practice along with identified water borne diseases were considered.

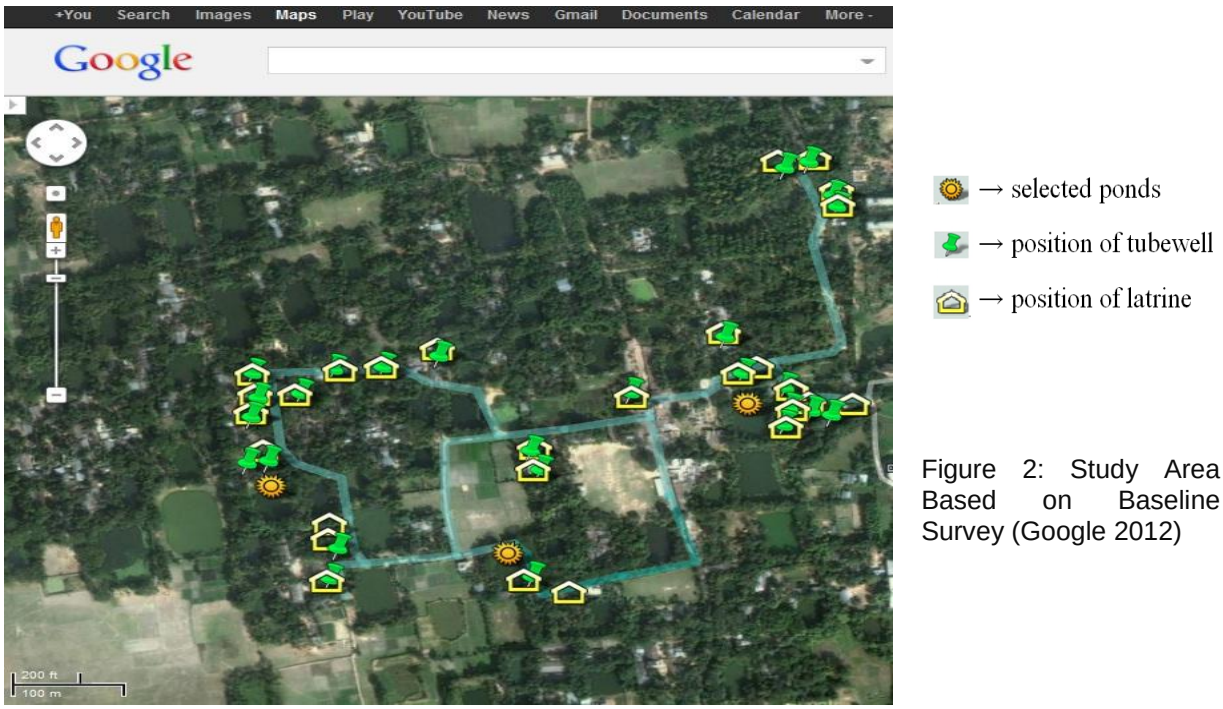


Figure 2: Study Area Based on Baseline Survey (Google 2012)

The interview was carried out with 28 randomly selected households and the selected households then divided into 6 groups. The interview was done with the respondent of household; Questionnaires were made for the Door-to-Door survey. The responses from the survey are tabulated in Table 1. The group wise findings are:

- Households in group ‘A’have been facing drinking water supply scarcity throughout the year (Fig. 3a). Survey showed the distance between tubewell and latrine are too less from the

standard value. For this condition sometimes water might be polluted and causes different diseases. Overall the water demand is also not fulfill by this tubewell, so both quality and quantity needs to be solved on priority basis (Fig. 3b).

- In group 'B', tubewell and latrine are closer (within 2-3 m). The ground water table lowering possibly placing troubles to operate thetubewellfor drinking purpose. The usual practices in this group are to use pond water for bathing, washing etc. Serious water born related disease was not reported in this group (Fig 3c and d).
- Residences in group 'C' and 'D' normally have access with the existing tubewell and adjacent ponds to meet their daily requirements (Fig.4 a and b).
- In group 'E', the only one pond supports for all the water demand for cooking, cloth washing and bathing and the water colour indicated highly polluted source (Fig. 5a). On the other hand existing latrine condition is also not acceptable level.
- The supply for drinking water in group 'F' remains
- shows that the tubewell is damaged, so it is a problem for drinking water. In figure-28 the demand of tubewell water is not sufficient for the households. In figure-29 it is shown that pond water is not so much good & not sufficient.

Table 1: Respondent based survey summary on WASH services

Group Name	No. of Household	No. of family member	Education Type	Age	Occupation	Tubewell (Shallow)	Latrine (Pit)
A	Total = 7 Male=43% Female=57%	1-5: 86%	Illiterate=28% Class I-V=29% SSC=28%	18-25:43%	Housewife:43%	7	7
B	Total = 5 Male=40% Female=60%	1-5: 80%	Illiterate = 20% Class I-V=40% SSC=40%	18-25:40% 41-60:40%	Housewife:40% Student:40%	5	5
C	Total = 6 Male= 50% Female=50 %	6-10: 83%	Class I-V=50%	41-60: 67%	Housewife:50%	5 1(Deep)	6
D	Total = 3 Male = 90 % Female = 10%	6-10: 67%	Class I-V=34% SSC=33% HSC = 33%	26-30:34% 41-60:33% 61-80: 33%	Teacher:33% Field Worker: 33% Business:34%	3	3
E	Total = 2 Male=100 % Female=0 %	6-10: 100%	Literate = 50% HSC=50%	31-40: 50% 61-80: 50%	Office Worker: 50% Mechanic:50%	2	2
F	Total = 5 Male=40% Female=60%	11- 15: 60%	Literate = 60%	41-60:40% 61-80:40%	Housewife:20% Business:30% Office Worker:20% Field Worker:20% Abroad:20%	5	5

(a)Existing tubewell fails to meet the demand in group 'A'

(b) Tubewell and latrine situated within 1-1.5 m , group 'A'

(c) Short distance between the latrine and tubewell in group 'B'

(d) The usual source of water for group 'B'

Figure 3 (a to d): Water supply and sanitation practices in group 'A' and 'B'

(a) Pond supported daily life, group 'C'

(b) existance of tubewell adjacent to the pond, group 'D'

Figure 4 (a andb): Water supply in group 'C' and 'D'

(a) Cleaning in poluted water, group 'E'

(b) Inoperative tubewell, group 'F'

Figure 5 (a and b): Water supply in group 'E' and 'F'

FINDINGS

The baseline survey both on observations and the closed questionnaires indicated that the tubewell is the main source of drinking water as well as washing purposes while the pond water stands as the secondary option. Appearance of pond water and some water born disease report pointed out the water quality should be tested. Specific survey on WASH showed that:

- 90% of the households use shallow tubewell,
- there is only one mode of defecation practice i.e. pit latrine; and
- there is no health service providers working for this study area.

From Open questions, it was found that possibilities of water table lowering restricts water supply and demand throughout the whole year, collection distance, crowding in water source at the collection time, latrine facilities, hygiene practices and inadequate hygiene knowledge. Due to lack of ground water, pond water used for utensil washings, cooking, bathing etcand thus spreads the water borne diseases.Field survey experiences short distances between tubewell and latrine is 2-5m, this is less than the acceptable limit. Researches suspecting the existing setup might be causing different water borne diseasesviz.Diarrhoea, Typhoid, Cholera, Dysentry etc. During questionnaire survey, Diarrhoea and Typhoid are recorded as common diseases in this locality. Since, there is no government or private health service provider in this community, no record on the frequency of water borne diseases are available for the study area.

CONCLUSION

WASH practices surveyed in the study area, visual observation, closed and open questionnaire concluded that the area still needs to be developed. Water supply often faces quality and quantity problem, sanitation remained unhygienic and absence of health services. In next phase of the research intensive laboratory works will cover the quality of tubewell water once this is very close to the latrine as well as the secondary sources i.e., pond water. Thus the research will provide recommendations for the responsible health service providers.

ACKNOWLEDGEMENTS

This study was supported by funds provided by the Department of Civil Engineering, Chittagong University of Engineering and Technology (CUET), Bangladesh. Sincere thanks are due to the staff of Chittagong University of Engineering and Technology and the Unosottorpara community, for providing necessary supports to carry out this study.

REFERENCES

WHITTINGTON, D., JEULAND, M., BARKER, K. & YUEN, Y. 2012. Setting Priorities, Targeting Subsidies among Water, Sanitation, and Preventive Health Interventions in Developing Countries. *World Development,* 40**,** 1546-1568.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7 PI. 42 (1-9)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Review on Urban Brownfields' Development Techniques and Planning Methodologies to Redevelop Hazaribagh Area

Sisir Karmaker
Urban Planner, Troyee Associates, Dhaka, email: mailboxsisir@gmail.com

Ranver Ahmed
Town Planner, Kushtia Municipality, Kushtia, email: ranverahmed@yahoo.com

ABSTRACT

A Brownfield is a site, or portion thereof, that has actual or perceived contamination and an active potential for redevelopment or reuse. Recovery of these Brownfield by redevelopment of the site or through transforming it into other land use can result green neighborhoods, promote economic expansion and inhibit sprawl. In Bangladesh, residential areas are in huge shortage of ancillary facilities. Hazaribagh Area near Dhanmondi, in the heart of the Dhaka City experiences similar crisis as low and middle income settlers are settling in this zone and suffering from the shortage of urban service facilities. High rate of contamination is leading this organically built up zone unlivable. This toxic industrial zone along with residential areas has extended its pressure on physical condition which results it into a brown field. In this study, it is tried to review the tools of Brownfield development techniques used worldwide for the redevelopment of Hazaribagh Area.

INTRODUCTION

Brown fields-those once-productive properties now left idle because of actual or perceived low-level hazardous material contamination-hang like albatrosses around the necks of thousands of urban and not so urban neighborhoods. Brown field properties vary in size, location, age, and past use. They can be anything from a five hundred acre closed steel mill to a small abandoned corner gas station. So, a brown field is a parcel of real property, or a portion of the parcel, that has actual or perceived contamination and an active potential for redevelopment. Public and private land-use decision-makers often find it simplest to bypass brown fields, focusing their attention instead on virgin properties and other lands that do not pose the same challenges. As a consequence, even as intensifying development pressures migrate elsewhere, communities with these land-use white elephants miss out on economic opportunities; moreover, the very existence of derelict properties shrouded in possibly toxic mystery squelches land use and community spirit neighborhood wide. The current effect extends far beyond, since housing, commercial, or community facilities construction frequently shifts instead to "path of development" lands at the leading edge of urban sprawl (Leung, 2001). All these effective guidelines or developing techniques for Brownfield site can be achieved by studying various Brownfield development options throughout the world.

OBJECTIVES

- To identify social, political, environmental and economic context of brown field development.
- To review brown field development options practiced through out the world.
- To see relevance of such developments in context of Hazaribagh Area in Dhaka City.

METHODOLOGY

This is a secondary information based study. Different related papers, journals, articles, books and dissertations are reviewed to execute the objectives. Information is also collected on the basis of the objectives. Finally after incorporating all related information, a paper following the standard journals is formed containing all the study findings with necessary corrections and rearrangements. This paper

contains of all the facts and findings of the study those are conducted. Here the step wise procedure of the study has been conducted by a methodology diagram:

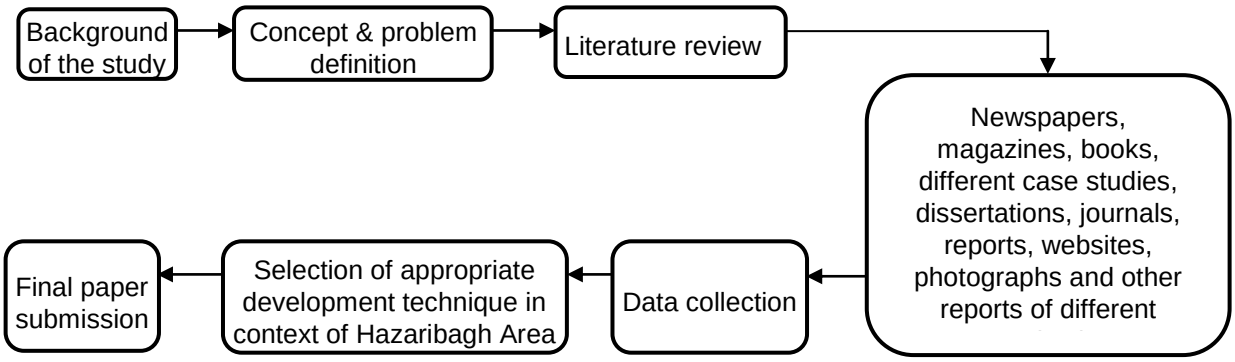


Figure 1: Methodology Diagram

EFFECTS OF BROWNFIELD PROBLEM FOR A COMMUNITY

Brownfields can pose a number of threats to a community's well being. Brownfield sites can:

- Potentially harmful to human health and the environment.
- Reduce local employment opportunities and tax revenue.
- Limit economic growth and development.
- Attract vandals, open dumping, or other illegal activity.
- Lower surrounding property values and contribute to neighborhood deterioration.
- Contribute to urban sprawl as businesses relocate to farmland and open space.

BENEFITS OF BROWNFIELD REDEVELOPMENT

It has been realized that effective Brownfield redevelopment can transform environmentally impaired property into productive uses and can bring the following community benefits:

- Improved public health and environment.
- Economic growth and increases in local employment opportunities.
- Revitalized neighborhoods.
- Increased local tax revenues.
- Reduced public service demands.

MAKING THE RIGHT DECISIONS

All relevant factors should be taken into account from the start, which can minimize the likelihood of unexpected delays partway through a scheme:

- Inform less experienced stakeholders of the decision making process and phasing of Brownfield projects;
- Inform decision-makers already familiar with the redevelopment of Brownfield land of recent changes to legislation, advances in partnership working and available remediation technologies;
- Inform regulators of case studies nationally where different approaches have been taken and the lessons learned, as well as providing a resource for regulators to pass on to land owners of currently underutilized land;
- Inform community groups and individuals of the general phased approach to Brownfield development, where community involvement can take place voluntarily and where it is a legal requirement, as well as providing examples of how communities have been involved in Brownfield projects across the country; and
- Inform other stakeholders, including financial institutions, of the points at which assessment of risk needs to be carried out and where more focused work at earlier stages can help minimize the risk further along the decision-making process.

PROJECT MANAGEMENT

Brownfield projects can draw together local authorities, regeneration agencies, the local community, local businesses and developers in a Local Brownfield Partnership. Working together with a land management organization can help the site operators minimize or prevent future dereliction and contamination. This will not only reduce the cost of aftercare but also ensures the site can be brought forward for redevelopment more easily.

- Brownfield developers who do not fully engage with stakeholders often fail to understand community needs, and hence fail to gain local support for their proposals;
- Often community engagement is not managed in a way that balances aspirations and expectations against affordability and long-term appropriateness;
- Poor management of stakeholder expectations can result in management by committee, resulting in reduced project benefits, or no benefits at all; and
- Failure to recognize and exploit commonalities and/or economies of scale for preparatory or remediation work could lead to higher overall costs for a portfolio of sites.

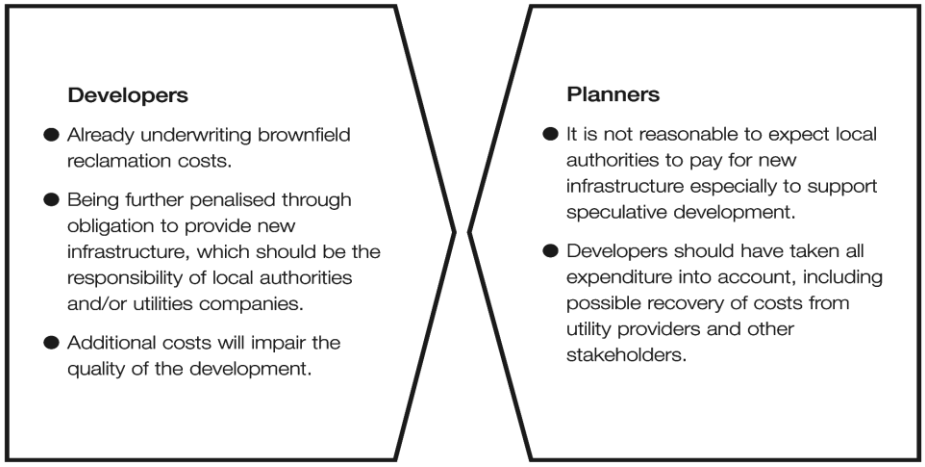


Figure 2: Typical opposing viewpoints of Brownfield developers and planner

PARTNERSHIP WORKING THROUGH A BROWNFIELD LAND ACTION PLAN (BLAP)

Brownfield Land Action Plans form a regional approach to tackling Brownfield land on a local and sub-regional basis. The objectives for each BLAP are to:

- Ensure that the Brownfield agenda is not overlooked when development and regeneration priorities are being pursued; and
- Accelerate the pace of reusing Brownfield land.
- The opportunity to improve both the future availability of developable Brownfield land, and the perceived competitiveness of local areas by appropriate interventions.

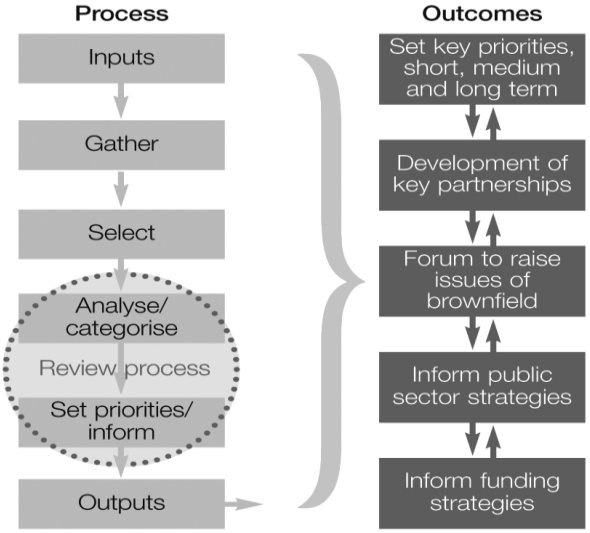


Figure 3: Process of Brownfield Land Action Plan

Outputs that can be achieved by the BLAP process include:

- A summary of the key spatial and other thematic strategic development priorities across the study area that impinge on Brownfield land reuse;
- Validated data sets and mapped information providing a consolidated view of the known stock of Brownfield land within the study area;
- A categorization of each parcel of Brownfield land in terms of effective market availability, made with reference to the strategic objectives being pursued within the area; and
- A shortlist of Brownfield sites related to the locality's strategic objectives that are worthy of further detailed investigation and, depending upon the local circumstances, an agreed programme of interventions by one or more partners on specific sites.

Reviewing assorted case studies on brownfield site development around the world, a comprehensive course of actions to be performed are proposed here with a view to execute the outputs of BLAP process successfully.

LAND CONDITION RECORD (LCR)

The key features of a Land Condition Record (LCR) are that it contains factual information and is completed on the basis of information that is available. Unlike a site investigation report, an LCR does not provide assessments or evaluations of environmental risk, nor does it provide an assessment of potential liabilities or estimates as to related costs. A typical LCR may contain the following:

- Document management, including a record of the chain of control and responsibility for completing the LCR;
- Land referencing information, containing sufficient information to identify the land, together with other information relevant to its location;
- Current land use and access, including information as to who has access to the property and it assists in the identification of possible 'receptors' in respect of environmental risk;
- Surrounding land, land use activities in the area, to assist in the identification of potential receptors;
- Proximity to controlled waters, including water quality objectives and standards but not detailed hydro-geological information;
- History, aimed at summarizing site usage from its earliest known use to present day, with additional information relevant to current condition of the land;
- Desk study and investigation information, summarizing the information in more detailed studies and investigations, with further information and the underlying bases for the information being included in annexes; and
- Most recent remediation, containing a summary of remediation work already carried out on the site and/or current risk management arrangements, with separate entries for different zones or sub-areas, as appropriate.

REDEVELOPMENT ACTION PLAN

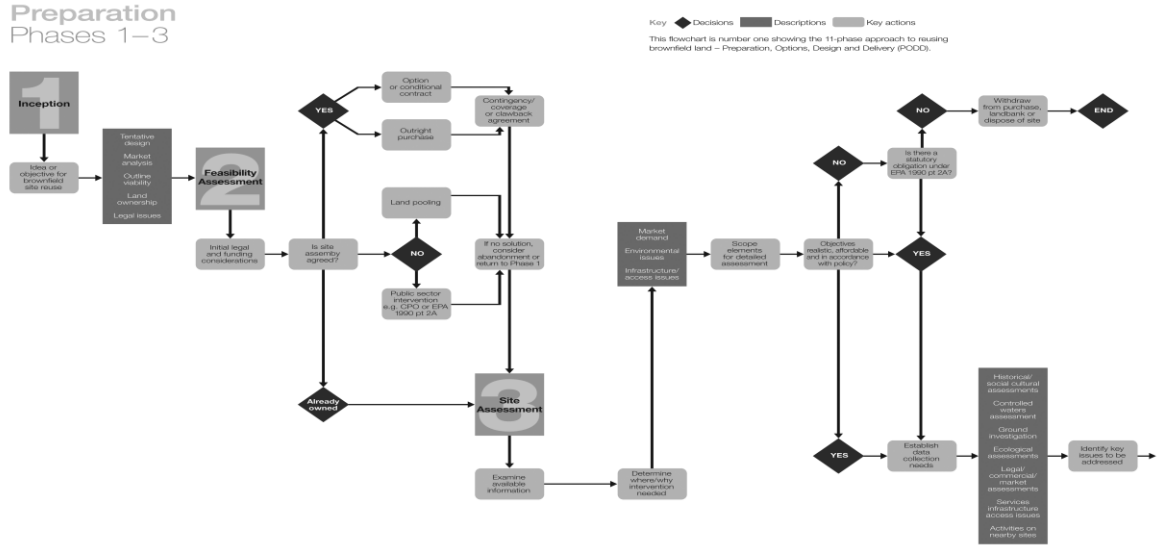


Figure 4: Redevelopment Action Plan (Phase 1-3)

Phase 1: Inception

The inception of a Brownfield project may arise through a number of reasons, from a hypothetical idea or perceived demand, which may involve the developer in seeking out a suitable site. It may also arise through a need to do something about a site or building that is already owned, for example where an existing tenant is vacating at the end of a lease, or in compliance with regulatory enforcement procedures. Regardless of how the project inception comes about, the idea or objective is usually to improve utilization of the site. Typical drivers are financial (need to sell site/make money), to improve the environment or to discharge a statutory obligation.

Phase 2: Feasibility assessment

The project inception phase should have given the developer some ideas as to the development type, mix and density, as well as addressing the initial legal and funding considerations, in order to arrive at an early assessment as to project viability.

Phase 3: Site assessment

Although regard will have been given in the previous two phases to the possibility of adverse site conditions, this phase commences the site characterization, beginning with an examination of available information, e.g. due diligence information, existing Health and Safety file, old reports/records/plans/photos etc of the site and historic activities thereat.

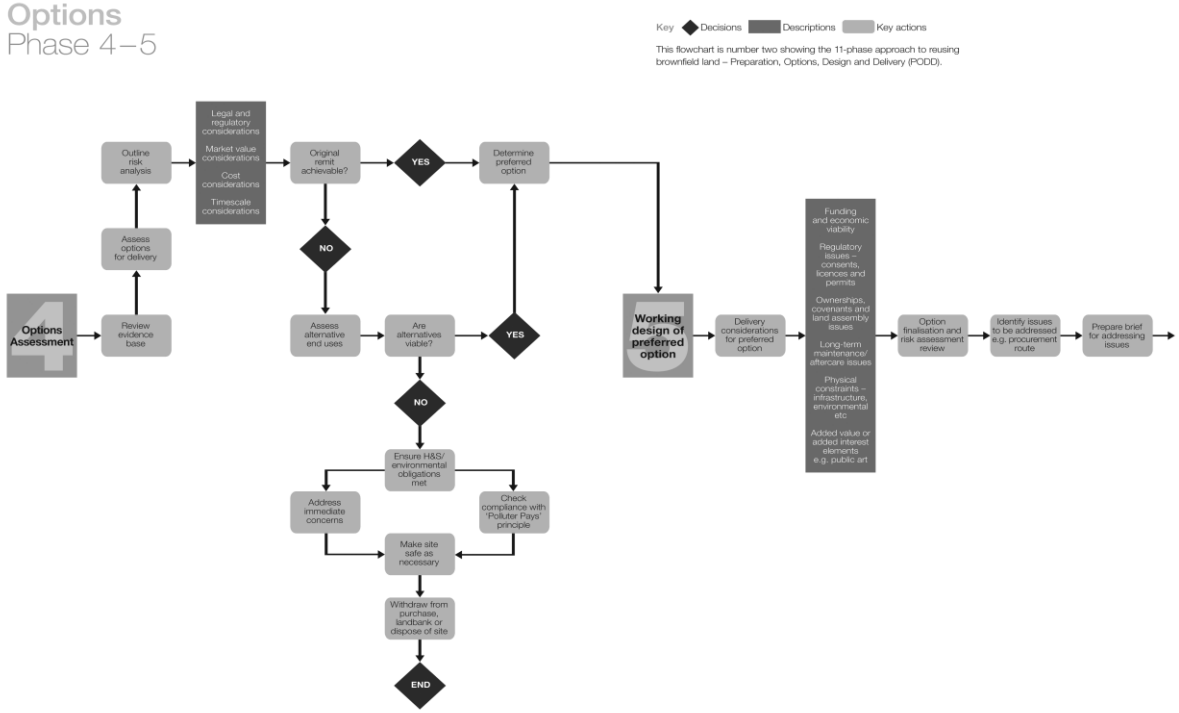


Figure 5: Redevelopment Action Plan (Phase 4-5)

Phase 4: Options assessment

The point at which it becomes appropriate to involve the local community in Brownfield projects will vary from site to site and according to the nature of the project itself. While it is desirable to involve the community as early as possible, this can sometimes produce adverse results through the raising of unrealistic expectations, either on the part of the community as to what it might expect to receive out of the project, or the landowner in terms of price.

Phase 5: Working design of preferred option

Although the project team will have had a working understanding of the project objectives and expected outcomes through the earlier phases, only now can the full nature and likely cost of the

project be determined. In this phase, the outline of the project is more fully worked up. This may not be much more than an outline or partial design, depending upon the procurement method to be adopted.

Phase 6: Detailed design

For the most part Phases 1 to 5 of the brownfield project will need to be undertaken consecutively, although a degree of overlapping for some elements may be achievable. Assuming that work in these earlier phases is complete and has yielded a comprehensively acceptable set of answers, it may be possible to parallel track much of the work in Phases 6, 7 and 8. Phase 7 represents the critical path at this stage of the project. Information flows to and from Phases 6 and 8 are essential to ensure that the project is designed in such a way as to satisfy the regulatory authorities and meet financial criteria. The flow arrows have been omitted from the diagram for the sake of clarity, suffice to say that information flows across the phases are essential at all stages in the process.

Phase 7: Regulatory and planning

Phase 7 starts with a review of the existing evidence base and checks against compliance with the requirements of planners and regulators. In the event that any aspects of the project are deemed to be non-compliant, further consideration of the preferred option may be called for. Assuming that the project is found to be compliant, work can commence on obtaining the necessary consents and permits.

Phase 8: Legal, property and funding

Once again, this phase starts with a review of the existing evidence base.

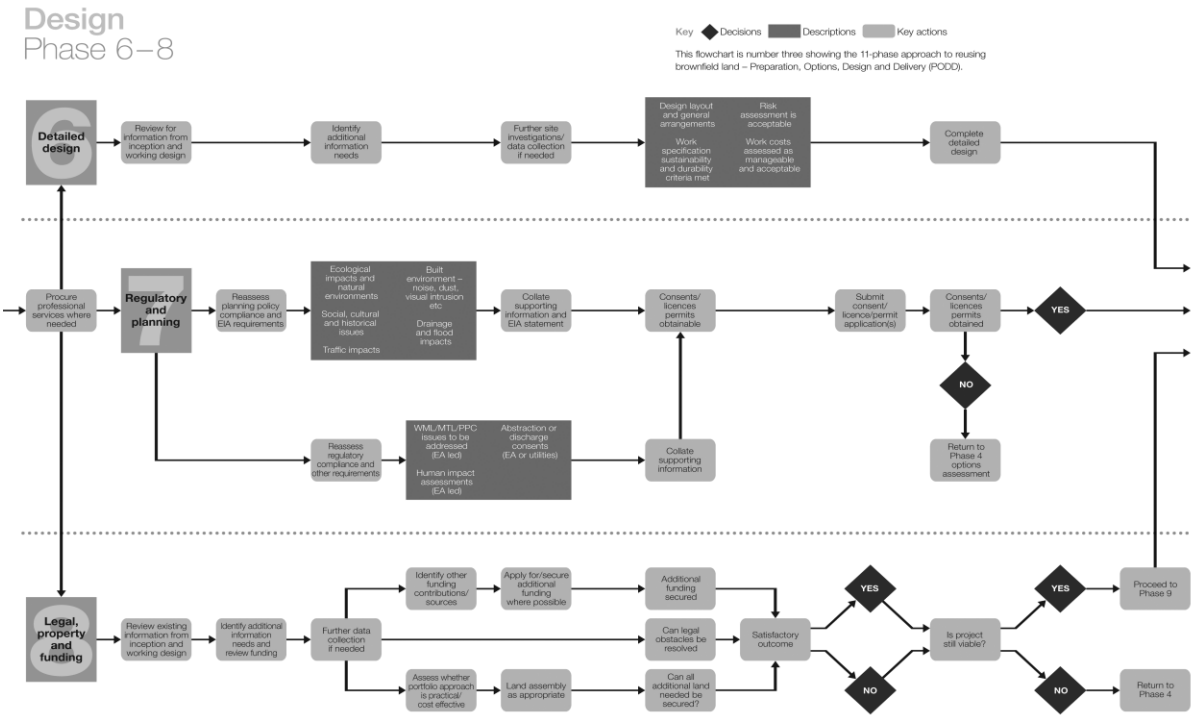


Figure 6: Redevelopment Action Plan (Phase 6-8)

Phase 9: Financial appraisal

In order to achieve a valid appraisal, completed Phases 6, 7 and 8 must precede Phase 9.

Phase 10: Works procurement and execution

The first step is to confirm that adequate and competent resources are in place to manage the procurement and supervision of the work, including administering the contract.

Phase 11: Sales and marketing

This phase is shown as the final phase on the flow chart, as it is usually the ultimate objective of commercial brownfield projects. There may also be some degree of marketing required for non-commercial projects, for example to make potential users aware that a new country park has been opened and to demonstrate that required outputs have been achieved.

The figure showing the phase 9-11 is in the next page.

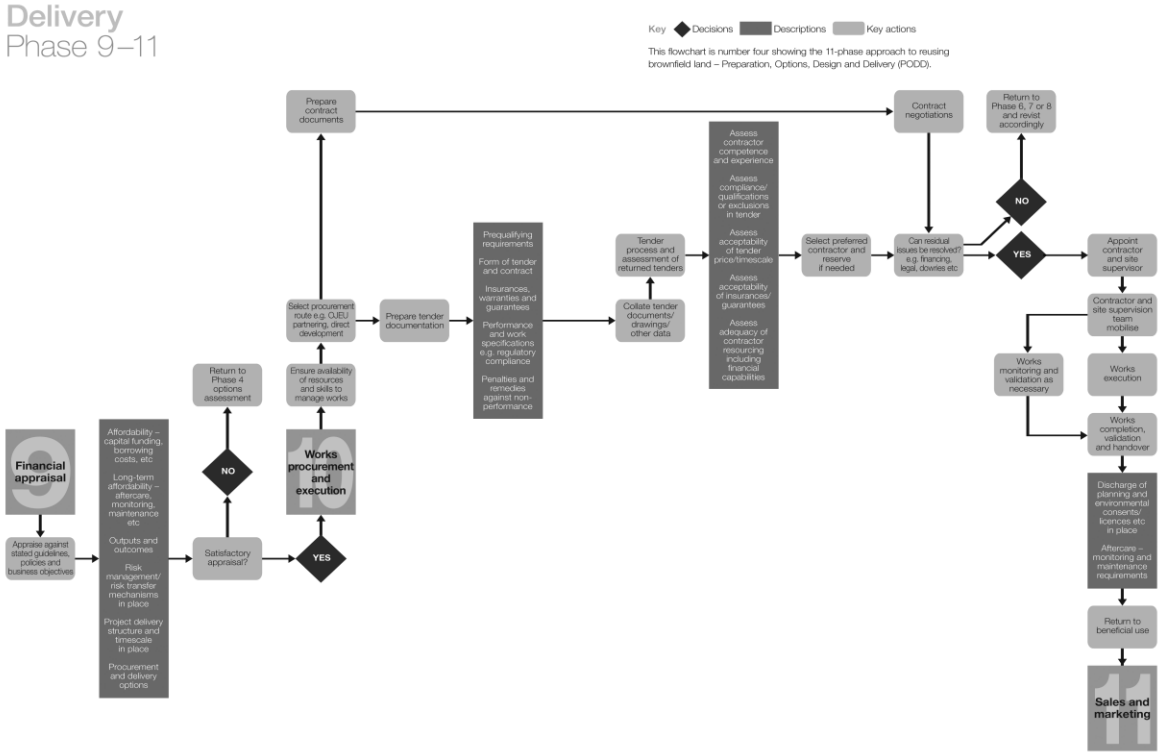


Figure 7: Redevelopment Action Plan (Phase 9-11)

LAND ACQUISITION

Brownfield properties can be acquired using many of the same mechanisms that governments use to acquire any properties, including tax foreclosure, eminent domain, lien foreclosure, and negotiated sale. While communities usually prefer that Brownfield redevelopment occur in the private sector with little government involvement. However, there are some brownfield sites that will never be redeveloped by the private sector. Brownfield redevelopment is a complicated process and there are a number of financial and legal hurdles that can sometimes best be overcome when the local government takes ownership of the property. If a piece of property is tax delinquent and have a number of liens on it, the only way to clear the title may be for a local government to acquire the title. Furthermore, cities may already own property that was used for municipal purposes or that was acquired earlier for some other reason. Another reason cities may want to acquire title to the brownfield property is so they can assemble a number of pieces of property together for a large redevelopment project like an industrial park (Girard, 2005).

BARRIERS IN LAND ACQUISITION

It is not always easy for local governments to acquire brownfield property. Generally, the mechanisms described above can be time consuming, expensive, complicated, and fraught with uncertainty. There are some problems related to the acquisition of the property:

- Before brownfield property can be redeveloped, site assessment and clean up is usually necessary. As a result, purchasers often feel that the price of the property should be reduced to reflect these assessments; courts did not consider environmental cleanup costs in determining the fair market value in eminent domain proceedings.

- Another problem is land assembly. It can be difficult to acquire a number of different pieces of property and put them together for a large redevelopment project. This is often time consuming, complicated, and can run into a number of legal road blocks.
- While land acquisition can be time consuming and expensive, a number of local governments have evaluated the costs and benefits and concluded that their community will be better off in the long run if they acquire brownfield sites for redevelopment.

ACTIONS TO CLEANUP AND REDEVELOP A BROWNFIELD SITE

Each brownfield redevelopment project is different and there is no easy "how to" formula that can be used for every site. Listed below are some general steps that communities can take for brownfield projects:

- To connect with a private business or group interested in using a particular piece of property. Large redevelopment projects like downtown renovation efforts can also include brownfield properties.
- To investigate the ownership and legal status of the property. This includes reviewing tax records and any liens on the property.
- Doing site assessments and cleanups require technical expertise; it has to hire an environmental consultant to perform these activities.
- Depending on the situation, partnerships with interested parties may involve working with the current and past owners of the property, the businesses interested in developing or using the redeveloped property, community members, civic organizations, and government agencies.
- To research what sources of funding are available for the site acquisition, cleanup, and redevelopment project. Local Community Development Corporations (CDCs) can coordinate private financial sources for brownfield projects.
- If necessary, municipal governments can take over title to the property. Local governments can use the following methods to acquire property:
    a. Eminent Domain / Condemnation
    b. Tax Delinquent property acquisition
    c. Demolition Lien or other liens foreclosure
    d. Negotiated Sale
- Enroll in the Site Remediation Program and clean up the property.
- Finalize a redevelopment agreement with a developer or end user for the property.

TECHNOLOGIES TO BE USED TO REMEDIATE AT BROWNFIELDS SITE

Various treatment technologies may be used to remediate contamination at Brownfields sites. Brief descriptions of some of the remedial technologies are given below:

- Air Sparging involves injection of air or oxygen into a contaminated aquifer. The injected air helps to flush the contaminants into the unsaturated zone.
- Bioremediation involves use of microorganisms to degrade organic contaminants in soil, sludge, solids, and groundwater either in situ or ex situ.
- Chemical treatment is also known as chemical reduction/oxidation (redox), typically involves redox reactions that chemically convert hazardous contaminants into compounds that are non-hazardous, less toxic, more stable, less mobile, or inert.
- For Flushing, a solution of water, surfactants, or cosolvents is applied to soil or injected into the subsurface to treat contaminated soil or groundwater. Injected water and treatment agents are recovered together with flushed contaminants.
- Mechanical soil aeration involves agitation of contaminated soil by using tilling or other means to volatilize contaminants.
- In OB operations, materials are destroyed by self-sustained combustion, which is ignited by an external source, such as a flame, heat, or a detonation wave. In OD operations, materials are destroyed by detonation, which generally is initiated by an energetic charge.
- Physical separation processes use physical properties to separate contaminated and uncontaminated media or to separate different types of media.
- Phytoremediation is a process in which plants are used to remove, transfer, stabilize, or destroy contaminants in soil, sediment, or groundwater.
- Soil vapor extraction (SVE) is used to remediate unsaturated (vadose) zone soil.

- For Soil washing, contaminants sorbed onto fine soil particles are separated from bulk soil in a water-based system based on particle size.

REDEVELOPMENT FINANCING

A variety of funding sources can be used by local governments for brownfield redevelopment. These can include grants, loans, bonds, taxes and fees, and private funds. Successful brownfield projects find creative ways to use money from different sources to pay for the project. Tax Increment Financing (TIF) is one of the most widely used tax incentive programs available to local governments all over the world. TIF money has been used for property acquisition, site planning, conducting environmental site assessments, cleaning up contaminated property, and infrastructure improvements such as upgrading streets. Bonds could be used in conjunction with a TIF project, with the intent to pay back the bonds using money generated from the tax increment over the life of the TIF. Some cities have special funds for economic development that can be used for Brownfields (Stewart, 2003).

BROWNFIELD DEVELOPMENT OPTION IN CONTEXT OF HAZARIBAGH AREA

Unfortunately a recent observation of Hazaribagh clearly shows an active decay and destruction primarily attributed to unplanned growth, random alteration and poor maintenance. This area now appears no more than an inner city unhygienic environment. After the above study on brownfield site cleanup and development, it can be said in case of Dhaka City especially for Hazaribagh Area that if the industrial zone as well as tannery area is located to other place then this area can be treated as brownfield. Government will be the initial investor and implementer of the project as they start the project in the very beginning. If it is needed govt. can involve different organizations to complete and manage the project as well for the sustainability of the project. These projects should be completed in different stages and different implementing authorities should be responsible for carrying out different activity. To ensure the effectiveness of the project, private developer and public authorities will work simultaneously. Public authorities will ensure the legal aspects of development activities and the private developer will provide services and amenities according to the regulations involved. In case of planning and development of the site, in every stage opinion and demand of the residents of that area and its surroundings should be acknowledged. Because proper public participation can ensure the proper success and sustainability of that kind of project.

CONCLUSION

Preparing Brownfield sites for productive reuse requires integration of many elements - financial issues, community involvement, liability considerations, environmental assessment and cleanup, regulatory requirements, and more - as well as coordination among many groups of stakeholders. The assessment and cleanup of a site must be carried out in a way that integrates all these factors into the overall redevelopment process. In addition, the cleanup strategy will vary from site to site. Such strategies may include cost-effectiveness, timeliness, avoidance of adverse effects to site structures and neighboring communities, and redevelopment of land in a way that benefits communities and local economies.

REFERENCES

Girard, O. H. 2005 “Brownfields assessment pilot fact sheet” New York, viewed on Feb 26, 2007 http://brownfieldstsc.org/roadmap/beforeyoubegin.cfm.html

Leung, H. L. 2001 “Brown field Cleanup and Redevelopment” New York, viewed on April 10, 2007 http://www.epa.state.il.us/land/brownfields/faq.html

Stewart, A. J., 2003. “Guide to Contaminants and Technologies” London, viewed on March 05, 2007 http://www.brownfieldstsc.org/roadmap/contguide.cfm.html

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7 PI. 56 (1-7)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

State of Sanitation in Suburban Dwellers: A Case Study in Jogipole Union

Esteaque Mahmud and Dr. Khondoker Mahbub Hassan
Department of civil engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh, E-mail: emrifat07@gmail.com, khmhassan@yahoo.com

ABSTRACT

Good sanitation and hygiene practices are essential to preventing contamination of environmental resources. At the same time, good hygiene practices and sanitation facilities provide health benefits. The population of Bangladesh is increasing very rapidly, of which a major portion live in the urban and suburban areas. With the increasing of population it is natural to expect an increase the production of waste due to urbanization and industrial development. If these wastes are not properly managed, it can have detrimental effects on the environment. Adequate sanitation and solid waste management is one of the biggest challenges in Bangladesh to achieve the Millennium Development Goals. This study was undertaken to evaluate the sanitation facilities and waste management system in Jogipole union of Khulna district in Bangladesh. This study revealed that on an average, 56.89% dwellers of this area had been using pit latrines while 43.11% had sanitary latrines with septic tank system. Approximately, 31.56% of total generated solid wastes were found to be dumped in the open space while disposal in ditch, drain, and bin were accounted for 36.44%, 22.11%, and 9.44%, respectively. Thus, motivation and promotion of sanitary waste management practices were deemed urgent in the studied suburban dwellers and hence guidelines were proposed for the sustainable development of sanitation system and solid waste management in Jogipole union.

INTRODUCTION

Sanitation means the safe management of human excreta, including environmental cleanliness, hand washing, garbage removal and wastewater disposal. Proper sanitation is the basis of a healthy environment. Every year, 1.5 million children under five die from diarrhea. Without proper sanitation, a sustainable environment is not possible. To remain healthy, human beings need adequate sanitation facilities (EGSSAA, 2009). Many debilitating or even fatal illnesses are spread by contamination of the environmental resources with human fecal matter containing disease-causing viruses, bacteria, and parasite. Good sanitation and hygiene practices are essential to preventing contamination of water resources. At the same time, good hygiene practices and sanitation facilities provide few health benefits if the water resource remains contaminated. Unfortunately, over one-third of the world's populations, nearly 2.5 billion people, have inadequate access to sanitation. A major challenge faced by the developing countries is that of human waste management and disposal (Ahmed M.F and Rahman M.M , 2000). The United Nations, in their MDG report 2008, stated that in Southern Asia, 33% people are using improved sanitation facilities while the MDG target is 61% for this region. Therefore, they labeled this region as very low coverage in sanitation Lack of hygiene, especially failure to wash hands after defecation, leads to disease transmission.

Bangladesh is in the zone of very low coverage stage in sanitation. Bangladesh is the 9th most densely populated country in the world. According to Joint Monitoring Programmed by WHO and UNICEF in 2006, 51% of urban areas had improved sanitation facilities and only 7% urban areas had sewerage connection. In addition, only 32% of the rural population was using improved sanitation in 2006. Rural people make up the majority of our country, 75% of the population lives in rural areas without any sewerage facilities. Only 16% of the rural people uses sanitary latrines and another 22% uses so-called home-made pit latrines. The rest practice open defecation. The provision of adequate sanitation facilities

ISBN: 978-984-33-7045-7 PI. 56 (1-7)

and waste management to the dwellers of the rural and suburban areas is one of the major challenges that Bangladesh be able to achieve the Millennium Development Goals.

Khulna is the third largest city in Bangladesh and there are about 528 small, medium and heavy industries in and around Khulna City (Karim M. R *et. al.* 2007). The Jogipole union is situated on the north side of Khulna city Corporation and merging the border line of KCC. Most of the low-income labors of these industries and other daily labors live in the sub urban area like Jogipole union. To ensure a good quality of life in a area, the environmental conditions within which a dweller is living is of utmost importance.(Murtaza G,2001**).** In order to obtain accurate data on the magnitude of the sanitation problem of an area, a house to house survey of the different points of the area concerned needs undertaking. This would facilitate in finding out ways and means to address the problems. This study was conducted in 2011-12 to evaluate the situations of sanitation facilities and waste management in Jogipole union nearby Khulna city.

METHODOLOGY

The jogipole union is a sub urban area and comprised by nine wards. The dwellers of this union have different occupations, but the economic and living standard are nearly the same. A details questionnaire on sanitation practices and solid waste management was developed and field investigation and door-to-door interview of 50 peoples from each ward were conducted according to the structural questionnaire during the field survey. The respondents were selected in different parts of the area to represent different groups of people like labor, rickshaw puller, caretaker, small business and housewife living in the area.

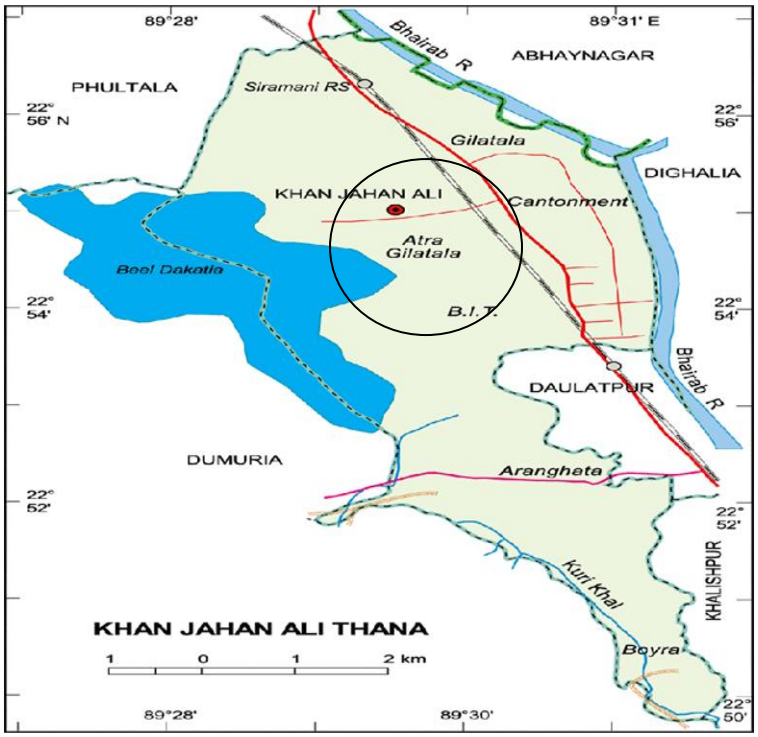


Figure 1: Location map 0f Jogipol Union.

Besides these information have been collected from different government organization like local government engineering department, department of public health engineering and some non government organization like BRAC, PROSHIKA and some reports, papers that are currently published

ISBN: 978-984-33-7045-7 PI. 56 (1-7)

RESULTS AND DISCUSSION

Sanitation situation in Jogipole union

Sanitation situation is satisfactory in the study area with respect to the other area of Bangladesh. Every family is the owner of the latrine and the commonly available sanitation facilities include pit latrines and latrine with septic tank system. But the people are not aware about the use and maintenance of their latrine. During the field survey, it was observed that the pit latrines are not properly lined and covered and due to the leakage of septic tank, waste water comes out the surrounding environment and creates the odor problem and pollutes the surface water. As all the sanitation systems are on-site system, so it can be easily filled. The cleaning system of these latrines is too much worse because cleaning wastes are stored in the open place or thrown in the drain. It is observed that most of the people especially male and children urinate in the open space or near the drain. During the field survey, it was also observed that the sanitation situation becomes worse during the rainy season due to higher water level and leachate problem. Lack of sufficient awareness and people's negligence for cleanness, hygienic condition of most of the latrines is very disappointing and fouling and odors problem are very common.

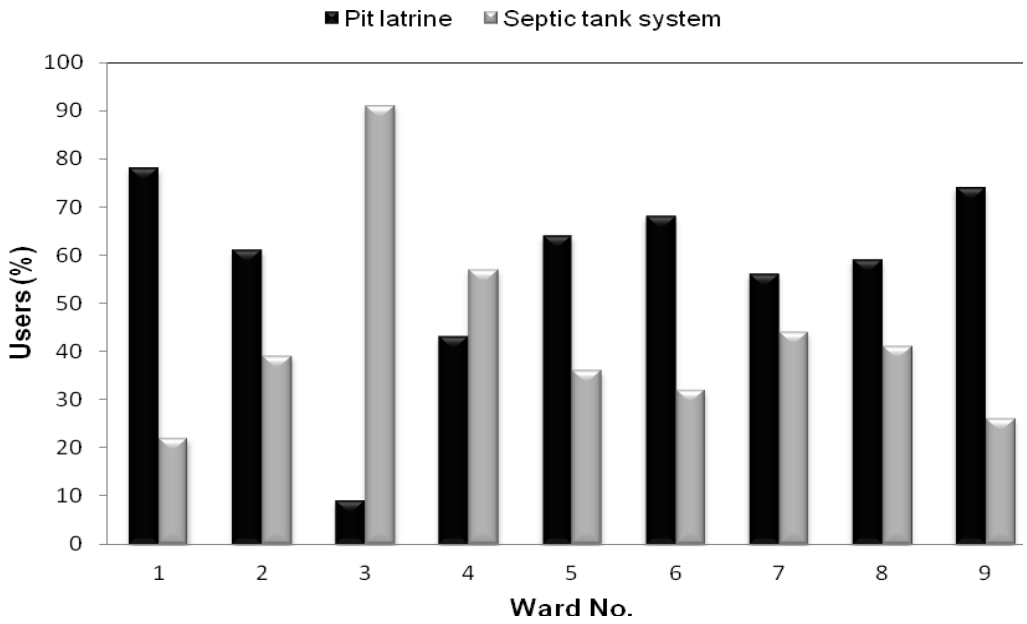


Figure 2: Variation of sanitation practice in different ward in Jogipole Union.

The overall sanitation situation of different ward in Jogipole union is expressed by figure 2. In ward no. 3 the septic tank system was mostly used. As most of the portion of ward number three was hold by KUET campus and septic tank was facilitated all the residential and all other buildings. Pit latrine was mostly used in ward no. 1 & 9. The living standard of peoples of these wards was low and they cannot arrange modern latrine facility because of lack of sufficient finance. Rest of wards both pit latrine and septic tank system was used nearly same proportion but pit latrine was more used than septic tank.

ISBN: 978-984-33-7045-7 PI. 56 (1-7)

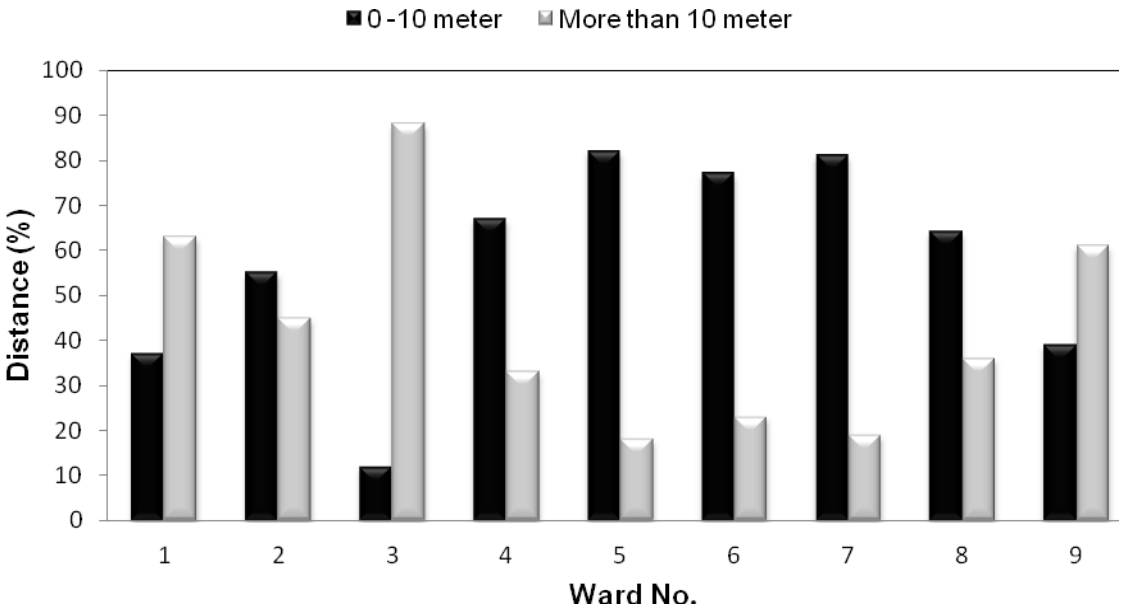


Figure 3: Distance between tubewell and latrine in Jogipole union.

The distance between tubewell and latrine is a vary important consideration for hyigin. The tubewell water may be contaminated if the tubewell is located near the latrine. The sceniro of distance between tubewell and latrine in the study area is presented by the figure 2 . In ward no. 2, 4, 5 , 6, 7 & 8 the most of the tubewells and latrines were located unsafe distance. The land value of this zones were high. Because the lack of sufficient land people couldnot establish the tubewell and latrine in safe distance.

Figure 4: Unsafe distance between tubewell and latrine in Jogipole union

ISBN: 978-984-33-7045-7 PI. 56 (1-7)

Figure 5: Problems in sanitation facilities in jogipole union.

In the recent years, several km lined and earthen drains has been constructed in the study area to drain storm and wastewater to the main drain; however, the drainage system is not working properly due to discontinuity of the drain, lack of proper outlets and maintenance and disposal of all types of solid wastes into drainage channel especially non degradable solid wastes. Some of the drain outlets are fall into the nearby ponds or ditches, causing the pollution of surface water. Most of the drains were found to remain block with garbage or solid waste and during rainy season, area remains water logged for several days. Nevertheless, there is no cover on the drain, so it creates odor pollution.

Solid waste disposal system in Jogiple union

The disposal system is worse than water supply and sanitation situation in the study area. There are no systematic arrangement for solid waste collection and disposal. Solid wastes are mainly organic kitchen waste and the average generation is 1.0-1.5 kg/household/day depending on season. The scenario of solid waste disposal practices of the dwellers of different ward of the union is presented in figure 6. It reveals that most of the dwellers are disposed of their solid waste to the open space, into ditches and drains which cause the deterioration of the overall environmental situation. In ward no.3 maximum dwellers were well educated and they had adequate dustbin facilities. People used dustbin for their disposal but their ultimate disposal had no systematic arrangement or landfill. In ward no. 1, 5 & 9, the disposal practice in the open space was high because they have available land surroundings the household. In ward no 2, 6, 7 & 8 ditches were mainly used for disposal of waste. The dwellers have limited land and population density was high in those areas. Nevertheless people were slightly conscious about waste disposal. In ward no 4 waste disposal practice in the drain was high because drains were constructed near the household and dwellers could easily through their waste in the drain.

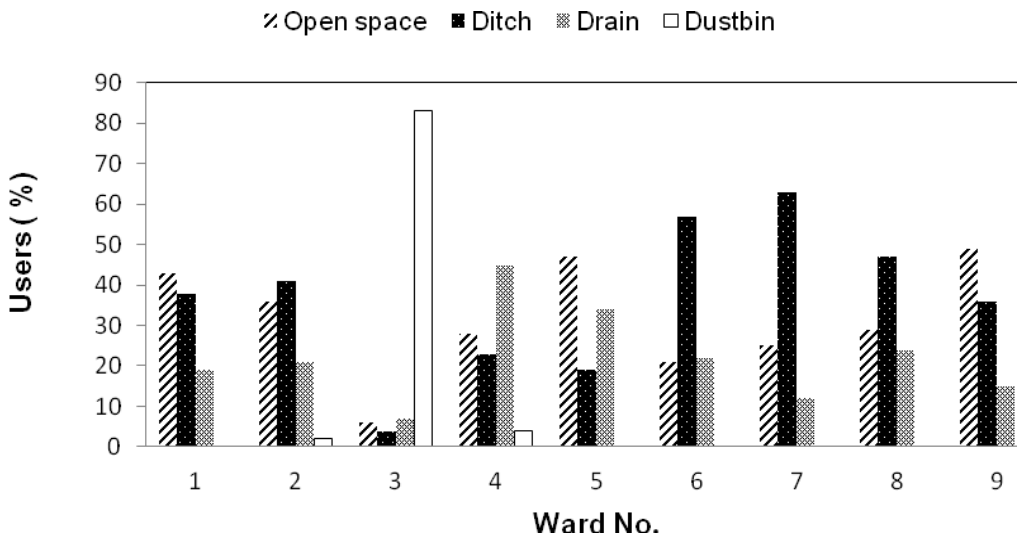


Figure 6: Disposal practice in different ward in Jogipole

Figure 7: Disposal practices in Jogipole union

CONCLUSIONS

This study reveals that the dwellers mainly use pit latrine and septic tank for defecation purpose. However, solid waste disposal services in the area were not established and dwellers dispose their waste in the open space, drain or ditch. The most important factor is the awareness of the dwellers that positive change is possible by proper motivation and guidance to practice hygienic behavior. The future success of various development activities by Government and NGOs depend on awareness and community participation of the dwellers in the development activities. To achieve the total sanitation for all, provision of safe water and sanitation in suburban area is a big challenge and both technical and social program like motivation and awareness of slums dwellers about sanitation should be undertaken. This study finding would be useful in formulating the guidelines for total sanitation in suburban area in developing countries like Bangladesh.

ACKNOWLEDGEMENT

The author wishes to express profound gratitude and heartfelt appreciation to the dwellers of Jogipole Union for their good assistance and response. The author of this paper would like to thank the different government and non government organization for their good cooperation.

REFERENCES

Ahmed M.F. and Rahman M.M. (2000), Water Supply and Sanitation, Rural and Low Income Urban Communication, ITN Bangladesh, center for water supply and waste management.

Bangladesh Bureau of Statistics (2002). *Statistical Bulletin of Bangladesh*, Government of Bangladesh.

Environmental Guidelines for Small-Scale Activities in Africa (EGSSAA), (March 2009).

Karim M.R, Rahman M.M., Hasan M.M. (2007), Water Supply and Sanitation Situation of Slums in Khulna City, Bangladesh.

Murtaza G. (2001**),** Environmental Problems in Khulna City, Bangladesh: a Spatio-Household Level Study.

Sanitation deserves highest priority; http://nation.ittefaq.com/issues/2010/01/09/news0715.htm (accessed on 5 September, 2012).

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI. 66 (1-8)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Study on Solid Waste Recycling and Reuse in Jessore Town

Md. Faisal Ahmed Shumon
Department of Civil Engineering, KUET
faisal.ce07@gmail.com

Prof. Dr. Quazi Hamidul Bari
Department of Civil Engineering, KUET
qhbari@yahoo.com

Md. Atikul Islam
Department of Civil Engineering, KUET
atikkuetce07@gmail.com

ABSTRACT

The study was done to have a complete view of solid waste recycling including the amount of recyclable and recycled solid waste and recycling pattern in Jessore area. A questionnaire survey was performed among those people who handle the wastes in different stages of the recycle process such as collection, transportation, processing of wastes, making new products etc. There are 133 recycling shops and seven numbers iron, seven numbers plastic and one tyre recycling industries were found in Jessore area. From collected data, it was found that collected recyclable solid waste is about 22639 kg/day and collected old Tyre is 280 number/day. The average component of solid waste is 29.08% Iron, 0.72% Aluminum, 33.65% Plastic, 3.61% Glass, 25.64% Paper, and 7.31% others. In Jessore area, only plastic, iron and tyre is recycled of total recyclable solid waste. Quantity of actual recycled solid waste (iron and plastic) is 3279.15 kg/day. The recycled solid waste is about 14.5 % of total generated recyclable solid waste, which is 1.8% of total generated municipal solid waste. It is observed that the recycling of iron and plastic are not up to the level because many industries are already closed and some are about to be closed. But the recycling of tyre is quite satisfactory (80%) in Jessore which is known from shopkeepers and families related to the recycling process. Finally it is observed that Jessore pourashava is not concerned about solid waste management.

INTRODUCTION

The useless, unwanted and discarded materials coming from production and consumption that are normally solid are called solid wastes (Ahmed and Rahman 2007). Wastes are unwanted but unavoidable and are generated everywhere from small houses to large industries even in the open space in the community. The quantity of solid waste increases day by day with the development of civilization. Along with the increase in the population and industrial and technical development use of resources is increasing and for this the generation of waste is also increasing (Haque 2011). Wastes arise from human and animal activities and reflect the full diversity of man's action (Talukder et al. 2011).

Solid waste management is very important part from environmental aspects as it minimizes the adverse environmental effects caused by the indiscriminate disposal of solid wastes. A variety of environmental and health problems arise due to mishandling or mismanagement of solid wastes. If solid waste is not properly managed then all the activity and productivity of human will suffer an injury by their own waste and it will be burden for them. So the proper management of solid waste is necessary.

Solid waste management is difficult without the help of people who produce it. Men use some technique to reduce the volume of solid waste such as incineration, composting, recycling and reuse etc. Among them recycling and reuse is economical (Karim and Haque 2009). Recycling and Reuse is an important part of solid waste management. Recycle means extraction of the raw material from the wastes by processing it and making new product or the same product from it. Reuse means using

used materials again and again for the same purpose without changing its end use form. The recyclable solid waste come to recycling shop and industry is mainly from household, commercial area and demolition works (Haque 2011).

In present days, recycling and reuse are strongly promoted for conservation of resources and it has been focused on job creation and generation of income. On the other purpose recycling decreases the cost of solid waste management (Karim and Haque 2009). In poor countries recycle or reuse has great importance as these countries have limited resources. In our country traditional methods are used and must be developed to make the recycling process more effective (Haque 2011).

Jessore is an important town in southern zone of Bangladesh. It is necessary to observe the present condition of solid waste recycling and reuse of Jessore town. So the study was mainly focused on the objectives:

- To know the present recycling pattern in Jessore town and to identify the locations where solid waste is being recycled by doing an extensive questionnaire survey.
- To identify the components of solid waste which can be recycled and calculate their percentage.
- To estimate the total quantity of recyclable solid waste collected in Jessore town and the fraction which is really recycled.

METHODOLOGY

To know the existing recycling pattern in the Jessore town, a detailed questionnaire survey was carried out among the Primary waste collectors (feriwala), Waste recycling shops and industries owners. The main reason of field survey is to calculate the amount of recyclable solid waste in Jessore pourashava and to calculate the percentage of solid waste is recycled. The study also has an aim to observe the recycling process and various products are made from recyclable material in industries. Jessore Sadar has 18 Unions/Wards, 326 Mauzas/Mahallas and 250 villages. It has class one Pouroshave (Municipality). It has 94348 units of house hold and total area 432.81 km^2.The population number in Jessore sadar is 530582 (WWW.Wikipedia.Com/JessoreSadar_Upazila). The locations of various recycling shops and industries are shown in Table 1.

Table 1 Location of recycling shop and industry in Jessore area

Location	Objects
Chopderpara, Shankarpur	Recycling shop, Industry(plastic)
Asrom Road, Shankarpur	Recycling shop
Mollapara , Dhaka Road	Recycling shop
Barandipara, Dhaka Road	Recycling shop
Shekhati Bablatola, Dhaka Road	Recycling shop
Beltala	Recycling shop
Newmarket	Recycling shop
Dharmatala	Recycling shop, Industry (iron)
Monihar, Jessore	Recycling shop(only tyre)
BISIC area, Jhumjhumpur	Industry (iron)
Baliadanga – Shashan Road	Industry(plastic)
Upazila – Narail Road	Industry(plastic)
Monirumpur area, Jessore	Industry (tire)

Primary waste collectors (feriwala)

They are buyers of separated recyclable items from households and sell to the recycling shops. They carry a basket of round shape or sometimes use van for collecting wastes. Generally purchase materials include iron, plastic materials, aluminum /silver utensils, bottles, broken glass, papers, etc. They buy these in exchange of money or sweets.

Waste recycling shops

To collect the information a questionnaire form was developed and then filled up by direct conversation with the shop owner or workers. The questionnaire form contains information about the quantity of waste material, type of wastes, the number of workers, their working hour, their salary, the collection process of wastes, where the wastes are sent etc. Some small recycling shops sell their

recyclable materials to the large recycling shops and large shops sell it to the recycling industry or send to Dhaka or other places.

After collecting information from shops, the total amounts of the different recyclable materials are estimated for each shop. And then categorize the shops in small, medium, and large depending upon the following condition:

- Large : > 1000 kg/day
- Medium : 450 ~ 1000 kg/day
- Small: < 450 kg/day (Moniruzzaman 2007).

Waste recycling industries

In the recycling industry, the recyclable materials come from the large recycling shops, some from medium and small recycling shops and sometimes directly from feriwala. Various products are made here from the collected recyclable material. Recycling of tyre, iron, and plastic are done in Jessore.

a) Feriwala

b) Recycling shop

Figure 1 Solid waste collection systems

Recycling industry

Figure 2 Production from recyclable material in industry

RESULTS AND DISCUSSIONS

Data of recycling shops

A detailed questionnaire survey was carried out among small, medium and large recycling shops is represented by Table 2.

Table 2 Total number of shops according to different location and amount of recyclable solid waste

Location	Total number of shop according to type in each location			Total number of shop	Total quantity of collected recyclable solid waste in shops according to type in each location (kg/day)		
	SRS	MRS	LRS		SRS	MRS	LRS
Chopderpara, Shankarpur	9	0	2	11	1440	0	3334
Asrom Road, Shankarpur	20	5	0	25	4070	2500	0
Mollapara , Dhaka Road	4	0	1	5	363	0	2323.5
Barandipara, Dhaka Road	2	0	0	2	422	0	0
Shekhati Bablatola, Dhaka Road	0	3	0	3	0	2067.5	0
Beltala	4	0	2	6	796.07	0	2763
Newmarket	9	0	0	9	1359	0	0
Dharmatala	5	0	0	5	1200.8	0	0
Total	53	8	5	66	9650.9	4567.5	8420.5

Location	Total number of shop	Average number of collected tyre in each shop (number/day)	Total quantity of collected recyclable old tyre (number/day)
Monihar, Jessore	67	4.17	280

SRS = Small recycling shop
MRS = Medium recycling shop
LRS = Large recycling shop

The quantity of various components of recyclable solid waste according to different locations is present below in Table 3. It is shown that plastic is collected more than other types of solid waste and iron is the next highest. Maximum plastic is collected in Chopderpara, Shankarpur area and maximum iron is collected in Asrom Road, Shankarpur area.

Table 3 The amount of various component of collected recyclable solid waste

Location	Quantity collection in (kg/day)						
	Iron	Aluminum	Plastic	Glass	Paper	Others	Total
Chopderpara, Shankarpur	285	18	4039	228	66	138	4774
Asrom Road, Shankarpur	2900	15	2950	210	275	220	6570
Mollapara , Dhaka Road	444	4.5	84	58	2044	52	2686.5
Barandipara, Dhaka Road	40	3	20	20	330	9	422
Shekhati Bablatola, Dhaka Road	450	23.5	90	85	1365	54	2067.5
Beltala	1106.7	46.07	132	77.7	1128	1068.7	3559.2
Newmarket	840	45	186	105	105	78	1359
Dharmatala	516.7	8.3	116.7	33.3	491.7	34.2	1200.9
Total	6582.4	163.4	7617.7	817	5804.7	1653.9	22639

Location	Quantity collection in (number/day)	
	Tyre	Total
Monihar area, Jessore	280	280

Only iron, plastic and tyre are recycled in Jessore. The percentage of collected recyclable solid waste can be calculated from Table 3 and that is presented in figure 3.

Percentage of iron = ((Quantity of iron 6582.4 kg/day)/ (Total quantity 22639 kg/day))*100 = 29.08 %.So, the percentage of iron in Jessore town is 29.08. Same procedure is applied for other recyclable materials.

ISBN: 978-984-33-7045-7, PI. 66 (1-8)

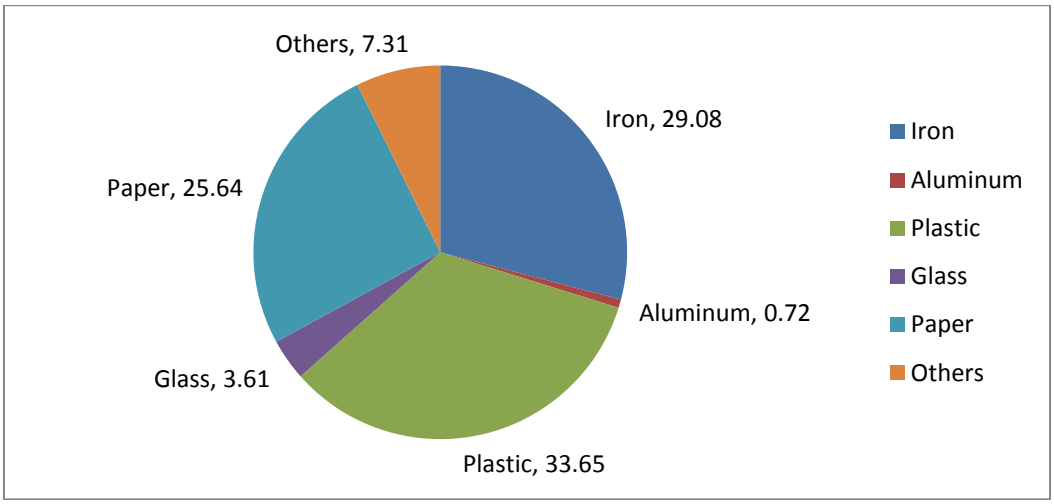


Figure 3 Percentage of recyclable solid waste (Without tyre)

The average quantity of recyclable solid waste collected by each type of shop per day, approximate number of person involves in each shop and income per worker of every types of shops per month are presented below (table 4) .

Table 4 Data for collection of waste, engage people and their monthly income in shops

Type	Average amount of recyclable solid waste handling per shop (kg/day)	Approximate no. of worker involves in each shop	Average monthly income per worker (Tk/month)
Small recycling shop	182.09	2	1453
Medium recycling shop	570.94	4	3682
Large recycling shop	1684.1	7	2175

Data of recycling industries

A detailed questionnaire survey was carried out among iron, plastic and tyre industry in jessore area.

Iron

There are seven number iron recycling industries in Jessore. Among those six are located in BISIC area- Jhumjhumpur and one is located in Dharmatala. Number of people engaged in each industry is about seven.

In BISIC area and Dharmatala average collected waste is 500 kg/day per industry. All of these irons are collected from Jessore. Among those about 450 kg of recyclable waste are recycled per day. Various products are made in those industries such as machinery parts of shallow pumps, bus, trucks, machines of rice mills and biscuit bakery, pata of brick breaking machine etc. (fig 4).

Pata of brick breaking machine

Machinery parts

Figure 4 Products made from iron

ISBN: 978-984-33-7045-7, PI. 66 (1-8)

Plastic

There are seven number plastic recycling industries in Jessore. Among those one is located in Baliadanga – Shashan Road, three in Upazila – Narail Road and three in Shankarpur. About five numbers of people are engaged in each industry.

The amount of collected waste per industry is about 21.5 kg/day, where 20.5 kg/day are collected from Jessore and rest part from Dhaka. Among 21.5 kg about 18.45 kg of recyclable waste are recycled per day. Various products are made such as plastic bottle, caps of bottles, pots of jarda and gul, toy, small circular and granular piece of plastic etc. (fig 5).

Cap of bottle

Bottle

Figure 5 Products made from plastic

Tyre

There is one tyre recycling industry in Monirumpur area, Jessore. About 16 families are related to the industry. Average number of workers related to this work is 3 per family.

The average number of tyre and tube is collected in each family is 2 and 4 number/day respectively. There are various types of products such as Choppol (rare), Flat belt, Coupling, Cross belt, Check valve, Seat, V belt, Gratish, Gasket etc. (fig 6) are made from tyre and Ring tape, Gasket, Jhulfi rubber, Check valve, Washer, Uffer etc. (fig 7) are made from tube. After making products from old tyre and tube, the rest part (fig 8) are used in brick kiln as fuels. There are some wires inside the tyre (fig 9). These wires have many uses, such as for making Ring (used in sanitary latrine), Cage (Bird/Egg), Macha/Ban (for Vegetables) etc.

Gasket

Cross belt

Gratish

Flat belt

Seat

Figure 6 New product from old tyre


Check valve


Ring tape


Gasket


Uffer


Washer

Figure 7 New product from old tube


Rest part (from tube)


Rest part (from tyre)

Figure 8 Rest part after making products from tyre and tube

Figure 9 Wire from tyre

Calculation of Recycled solid wastes

Completed 100 % survey

From Table 4, for small recycling shop amount of solid waste in 53 numbers shops is (182.09)*53 = 9650.9 kg/day.
For medium recycling shop amount of solid waste in 8 numbers shops is (570.94)*8 = 4567.5 kg/day.
For large recycling shop amount of solid waste in 5 numbers shops is (1684.1)*5 = 8420.5 kg/day.
Total quantity of recyclable solid waste is (9650.9+4567.5+8420.5) = 22639 kg/day.
It is considered that the generation rate of municipal solid waste is 0.35 kg/capita per day. So the generated municipal solid waste is (0.35*530582) = 185703.7 kg/day.
The percentage of recyclable solid waste of generated municipal solid waste is (22639/185703.7)*100 = 12.19 %.
Amount of plastic material that are recycled in industries is (18.45*7) = 129.15 kg/day.
Amount of iron material that are recycled in industries is (450 *7) = 3150 kg/day.
Total amount is (129.15 + 3150) = 3279.15 kg/day.

So, the percentage of recycled solid waste (Iron and Plastic) of generated recyclable solid waste is (3279.15 /22639)*100 = 14.5 %.
And the percentage of recycled solid waste of generated municipal solid waste is
(3279.15 /185703.7)*100=1.8%

Now, for tyre recycling shop amount of recyclable tyre in 6 numbers of shops is 25number/day.
So, total amount of recyclable tyre in 67 numbers of (considering 100 %) shops is (25/6)*67 = 280 number/day.
Amount of tyres that are recycled in Rishipara, Monirumpur area is (16 families)* (2 number tyre required per family per day) = 32.
The recycling rate at Rishipara, Monirumpur area is [(32) /(280 number per day)]*100 =11.5 %.
But, it is known from owner of recycling shops that about 80% tyre are recycled in Jessore.
So, (80 – 11.5) = 68.5 % are sold to the driver (town service) or other shops or used in brick kiln as fuel (fully damage tyre), etc. Rest 20 % is sold to Dhaka for resoling.

CONCLUSIONS

Based on the evaluated results it can be concluded that:

- In Jessore town, collected recyclable solid waste is about 22639 kg/day and collected old tyre is 280 number/day.
- The average component of solid waste is 29.08% Iron, 0.72% Aluminum, 33.65%Plastic, 3.61%Glass, 25.64%Paper and 7.31%others.
- The recyclable components of solid waste are Plastic, Iron and Tyre.
- Quantity of municipal solid waste, recyclable solid waste and actual recycled solid waste in Jessore town is 185703.7, 22639 and 3279.15 kg/day respectively.
- The recycled solid waste is about 14.5 % of total generated recyclable solid waste, which is 1.8% of total generated municipal solid waste.
- There are about 80% tyres recycled and reused in Jessore.
- There are 133 shops are found in different places of Jessore town. Among those 66 shops are of iron, plastic, glass etc and 67 shops of tyre. Among 66 shops, 53 numbers of small, 8 numbers of medium and 5 numbers of large recycling shops.
- There are seven numbers iron, seven numbers plastic and one tyre recycling industries in Jessore.
- There are about 173 people are involved in waste recycling shops and about 156 people are involved in waste recycling industries.

RECOMMENDATIONS

The survey shows that the recycling of iron and plastic are not up to the level because many industries are already closed and some are about to be closed. These industries should be inspired by the government from the view of environmental safety and should be tax free. Rules and regulations should be provided to maintain worker's salary. Necessary instruments like gloves, glasses, sticks etc should be provided to the employee of shops and collectors and training for safety collection of risky waste such as broken glass, clinical wastes, battery etc.

REFERENCES

Ahmed, M. F. and Rahman, M. M. 2007. Water Supply and Sanitation, ITN Bangladesh, Center for Water Supply and Management BUET, 2007, 3rd Edition, Dhaka, Bangladesh.

Haque, M. E. 2011. Solid Waste Recycling in Rajshahi City. B.Sc. Thesis, Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh.

Karim, S. M. M. and Haque, S. M. M. 2009. Study on Solid Waste Recycling in Jessore. B.Sc. Thesis, Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh.

Moniruzzaman 2007. Solid Waste Recycling Pattern in Khulna City. M.Sc. Thesis, Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh.

Talukder, A., Mazumder, S., Muyeed, A. A., and Shadullah, A. M. 2011. Solid Waste Management Practice in Dhaka City. Proc. of the International Conference on Solid Waste Management-WasteSafe 2011, Khulna, Bangladesh, 13-15 February 2011, pp. 87 (1-10).

WWW.Wikipedia.Com/JessoreSadar_Upazila.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.81 (1-7)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Social Impact Assessment Methodology For Recycling Systems

Stefan Salhofer, Sandra R. Aparcana

BOKU University of Natural Resources and Life Sciences

Abstract

Several formalisation approaches of informal recycling have been implemented in developing countries aiming at its integration into formal recycling systems. The aim is to tackle not only the poor economic situation but also common social problems of the informal recycling sector e.g. social rejection, lack of education and inappropriate health and working conditions. Nevertheless the expected positive social impacts have not been precisely assessed. This paper aims at developing a methodological approach based on the Social Life Cycle Assessment for the assessment of recycling systems in developing countries. A field study in three Peruvian cities shows the feasibility of applying this methodology. The comparison of the case studies reveals strength and weaknesses of the two different models of formalisation.

1. Introduction

Waste management aims to improve health and sanitary conditions through appropriate waste treatment technologies and to safe resources by the recovery of materials from waste streams. Considering this second function, in most low income countries the informal sector plays an important, but underestimated role. The informal sector is defined as individuals or groups of mostly social and economic disadvantaged people that carry economic activities without formal assignment (eg. permits, work contracts etc.). In waste management, informal activities mainly focus on the collection of recyclable materials and therefore contribute significantly to the recycling rates of many cities in developing and emerging countries. For example, in Lima and Callao (Peru), about 19.7 % of the municipal waste is recycled by the informal sector and only about 0.3 % is recycled by the formal sector. Similar results were obtained from a case study in Pune India), where 22% of initially generated municipal were collected for recycling by the informal sector, with zero quantity of recycling in the formal waste management system (Scheinberg et al., 2010).Wilson et al. estimate recycling rate through informal waste recyclers of 20 to 50% (Wilson et al., 2009). Individuals in informal waste management are referred as scavengers, waste pickers etc., in this paper, individuals working with waste on an informal basis are called recyclers.

Because of the positive environmental and economic contributions of this sector some cities have identified the inclusion of the informal sector into the formal waste management systems as an effective strategy (cf. Wilson 2006). Through the last years different formalisation strategies were implemented to organise the recyclers and to eliminate or reduce social problems linked to their activities (child labour, inappropriate working conditions, lack of education, etc.). Some cities in India (cf. Rathi 2006), Colombiaand Mexico(cf. Medina 2000), Brazil (cf. Gutberlet 2011), Chile and Peru (cf. Diaz and Otoma 2012) have implemented such strategies.

With the implementation of formalisation strategies the reduction or elimination of social problems is expected. However, these positive impacts are mainly assumed and are often not precisely measured and assessed. It is hypothesised that recycling systems after the formalisation of the informal sector provide better conditions and are more efficient in economic and environmental terms. In order to analyse and evaluate the formalisation strategies in relation to their contribution to social sustainability of recycling systems in developing countries this research developed an approach based on the Social Life Cycle Assessment Methodology (sLCA). This approach then was tested in a field research with three case studies in Peru.

2. Methodology

Social LCAis defined asamethodologyto assess thesocialorsocio-economicaspectsof productsor services andtheir potential positive ornegative impacts along their life cycle. ItcomplementstheEnvironmental Life Cycle Assessmentand canbeusedon its ownorin combination with it(UNEP, 2009).The guidelines for the sLCA of products (UNEP, 2009) emphasises the need for a clear definition of the aims, the scope, the identification of stakeholders of the product value chain, their role and their social interactions. On the other hand it is pointed out that to date there is no standardised list of social aspects to be considered. They can be different depending on the product or production process and the stakeholders linked to them. According to Jørgensen et al. (2008) and Dreyer et al. (2006) social impacts have no causal link with the product or production process, unlike the environmental impacts directly caused by the production processes. The possible cause of the social impacts is the social conduct of the companies that perform the production processes.

2.1 Impact categories

The social impacts are mainly caused by the social relevant activities of the stakeholders within a system. Several studies (Klang et al., 2003, Brouwer and van Ek 2004, Kijak and Moy 2004) confirm this assertion and define the social impacts based on analysis of stakeholders involved in each process and their social relevant actions. The UNEP guideline indicates also that the social categories and their subcategories should be determined and classified in function of the social issues that affect the stakeholders and should reflect the internationally recognised social standards. Dreyer et al. (2006), Jørgensen et al. (2008), Flyskö et al. (2008) and Spillemaeckers et al. (2001) propose the social impact categories and subcategories according to the human rights and working conditions presented by the ILO (International Labour Organisation) conventions. They also recommend considering further international social standards (e.g. the Universal Declaration of Human Rights, the UN Declaration on Economic, Social and Cultural Rights, etc.). Despite these recommendations there is no international consensus about the stakeholder categories (e.g. workers, consumer, society, etc. cited by UNEP, 2009), their social impact categories and subcategories to be analysed within a sLCA.

2.2 Indicators

Based on the indicators suggested by previous studies 27 semi-quantitative indicators are proposed for this methodology (see table 1). The indicators were developed according to the impact categories that affect the formalised recyclers. They express the qualitative information of the social impacts in a quantitative form by assigning numerical values. Examples for indicators are: *child labour* (non-existence of working children), *fair wages* (the average wage is equal or higher than the average wage in this sector), the *absence of unjustified wage reductions*, *access to health care programs for employees*, etc. Both direct and indirect indicators are used. Direct indicators are the quantitative and one-dimensional representation of a social impact. A frequently used direct indicator is “number of employees under 15 years old”. Indirect indicators on the other hand represent preventive social measures. Examples for such indicators in relation to working conditions are the presence of management measures ensuring training of workers on safety issues, instructions for the safe use of machines etc.

Among the indicators used here three indirect indicators can be identified. They are related to prevention policies regarding *discrimination*, *occupational health and safety* and *training programs*. It is attempted to combine the use of direct and indirect indicators in order to detect the risk of threatening or negatively affect the social issues more accurately.

2.3 Characterisation and aggregation

In general in LCA studies the impact assessment is performed based on a "cause-effect” impact pathway (Dreyer et al., 2006). Currently there is no international consensus about the characterisation method for the social impacts and the modelling method for such "cause-effect" pathways. Dreyer et al. (2010a) and Dreyer et al. (2010b) developed a methodology for the characterisation of impact categories in the context of sLCA. It is oriented on a preventive approach that assesses social management measures and seeks to determine the potential social impacts caused by a company in the life cycle of a product. Further important aspect of this characterisation approach is the consideration of the social context where the company operates. The social context involves the

actual situation regarding frequency and severity of labour rights violations according the different geographic locations and industries (Dreyer et al., 2010).

Table 1: Social impact categories, subcategories and indicators for recycling systems

Impact categories	Impact subcategories	Indicators	Examples
Human rights	Child labour	1	no child labour
	Discrimination	2	Formal policy against discrimination
	Freedom of association and collective bargaining	1	Presence of collective bargaining
Working conditions	Fair wages, minimum wages	4	Absence of non-agreed wage deductions, regular payment for the workers
	Working hours	1	fulfilment of overtime agreed in working contracts
	Recognised employment relationships and fulfilment of legal social benefits	3	Existence of legal working contracts for all workers
	Physical working conditions	8	Vaccination, training programs for workers regarding occupational health and safety, appropriate working equipment
	Psychological working conditions	3	Work satisfaction
Society	Accessibility to education	3	No school absence of children from recyclers´ families
	Acceptance and social inclusion	1	Perception and acceptance of the recycling activities by citizens

Another methodological approach for the characterisation was developed by Spillemaeckers et al. (2001). The authors propose a methodology to assess actual social impacts and develop a characterisation approach using mainly direct semi-quantitative indicators. Scores regarding the compliance or non-compliance of social criteria are assigned (1 for compliance and 0 for non – compliance). This approach is also oriented to the assessment of human rights and working conditions and does not consider the social context of the company. In this work, a score system as proposed by Spillemaeckers was used. For each indicator, a score was determined from the answers of the interviews and then aggregated to a total score.

3 Case Studies

In order to apply and test the methodology described above, the social conditions of recyclers in three cities in Peru were analysed in detail. All three cities had undergone a development from informal recycling activities to a new recycling system. Background data were collected from the municipalities and NGOs as project developers. Direct data acquisition was undertaken through interviews with stakeholders in the three cities in the course of a field study in September 2011.

3.1 Description of the study areas

Three Peruvian cities were used as case studies: two of them (Canete, Colca)have implemented a recycling system based on formalisation of informal recyclers while the third (Surco) has a conventional recycling system operated by the municipality without participation of recyclers.

The recycling models based on formalisation of recyclers works through the cooperation of the municipality, the NGO and the recyclers´ association (former informal recyclers). While the NGO develops and finances the project implementation in the start-up phase, the municipality authorises the access of the recyclers to the households and permits the formal collection of the recyclable materials. The formalised recyclers collect the recyclable materials from the households for free and perform a more accurate manual separation in sorting centres in order to sell the recyclable materials on the local recycling market. Under this model the income of the recyclers depends entirely on the price and quantity of sold material as well as on the number of participating citizens. Some social measures are awareness raising campaigns and identification of the population with the recyclers, vaccination campaigns, access of the recyclers to health prevention as well as improvement of the work equipment.

In contrast to this the conventional recycling model is operated exclusively by the municipality without participation of recyclers. The waste collection is done door to door with waste collection vehicles and the exact separation is done at a recycling plant by using a sorting system with simple technology. The workers get a fixed income not depending on the amounts of sold materials. Some social measures in this model are mainly related to the improvement of working conditions and to the access to health and social insurance.Table 2 provides general information about the three case studies representing these models. It should be mentioned, that in all cases despite formalisation further informal recyclers may be present. However the field study did not give opportunity to quantify these activities.

Table 2: Case studies, main features

City	Cañete	Colca	Surco
Recycling model	Based on formalisation of recycler		Conventional
Stakeholders	NGO, recyclers association, municipality		Municipality
Households in system	15%	10%	38%
Collected materials	Glass, plastics, paper and cardboard, metals		
Hiring strategy	Agreement between association and municipality		Municipal collection
Income	variable		fixed
Presence of informal recyclers outside the assessed recycling system	yes (unknown quantity)		

3.2 Data collection

Regarding the data collection for assessing the social impacts this field study took into consideration the recommendations of previous studies and used interviews with involved stakeholders as main local information sources. For the two case studies with recycling systems based on formalisation interviews with the municipalities, recyclers and NGOs were conducted. In the case of the conventional recycling system (operated only by the municipality and without participation of recyclers) only the municipality and workers at the recycling plant as stakeholders were interviewed. Here no project developer exists.

A checklist of 56 closed-ended and open-ended questions was applied in order to collect the relevant information for the assessment of the social impact categories and their subcategories. The purpose was to get a precise and logical answers regarding the social impact of the formalisation measures to make possible the score assignation 1 or 0 (compliance or non-compliance of social criteria). The same check list was applied for the interviews with all stakeholders with exception of the data collection for the subcategories psychological working conditions and acceptance and social inclusion.

For psychological working conditions the interviews were carried out only with the formalised recyclers (system based on formalisation) and workers at the recycling plant (conventional system). They are considered as the most reliable source of information regarding work satisfaction and further indicators of this subcategory. In regards to acceptance and social inclusion only the recyclers from the two cities with recycling systems based on formalisation were interviewed and not the workers from the conventional recycling system. The data collection for the indicator “perception and acceptance of the recycling activities by citizens” was based on the impression of the recyclers about the acceptance or rejection degree of the citizens regarding their recycling activities in the city. The formalised recyclers carry out the collection door to door and receive feedback from the citizens about their acceptance. In contrast;the workers from the conventional system work only at the recycling plant no having direct contact with the citizens during the door to door collection. The question for the workers in the conventional recycling system related to acceptance and social inclusion was not made. Because of the lack of time and resources no direct interviews with the citizens were performed.

3.3 Results

The assessment (cf. table 3) displays similar negative performances of the two recycling models regarding the social subcategories *discrimination*, *recognised employment relationships and fulfilment of social benefits*,*physical working conditions*, and *access to education*. Although both models (represented by the three cities) showed an improvement of working conditions compared to the situation before formalisation (poor health and working condition, waste picking on the streets and

dumps, social rejection, etc.), not all criteria for appropriate working conditions were fulfilled.None of the assessed case studies offers full access to *legal social benefits* (e.g. retirement pension, preventive health for the workers´ families) and therefore are negatively evaluated. The same situation comes in relation to *discrimination*, where none of the case studies have implemented a preventive policy against discrimination. None of the evaluated case studies provide *educational programs* for the workers. Their social performance is also negative in relation to this aspect. A positive performance was observed in both models for *child labour*, which was not identified in the three case studies.

Regarding the positive social performance the conventional model was better evaluated for both *working time* as well as *fair wages* while the recycling model based on recyclers´ formalisation obtained better evaluations in relation to the *psychological working conditions* (high work satisfaction level), *freedom for association and collective bargaining* and *acceptance and social inclusion*.

In reference to *acceptance and social inclusion* the evaluation was performed through the perception of the recyclers about the acceptance level of the citizens regarding their recycling activities. The more positive is the feedback of citizens in relation to the recycling activities, the better the recyclers feel about their role within the society. They feel accepted as an important and meaningful part of their social milieu. Due to the work place of the workers of the conventional recycling systems (at the recycling plant), they do not carry out the waste collection and this kind of contact with the citizens (like the formalised recyclers) would be missing. Because of this the social acceptance was not evaluated for the conventional recycling system. The questions of the check list related to this subcategory were not made and no data about this issue was collected.

Table 3: Results

Impact categories	**Impact subcategories**	**Model based on formalisation**		**Conventional model**
		Cañete	**Colca**	**Surco**
Human Rights	Child labour	**1**	**1**	**1**
	Discrimination	0	0	0
	Freedom of association and collective bargaining	**1**	**1**	0
Working conditions	Fair wage, minimum wage	0	0	**1**
	Working hours	0	0	**1**
	Recognised employment relationships and fulfilment of legal social benefits	0	0	0
	Physical working conditions	0	0	0
	Psychological working conditions	**1**	**1**	0
Society	Access to education	0	0	0
	Acceptance and social inclusion	**1**	**1**	not determined

3.4 Limitations of the study

This study aimed at the development of a methodology to measure the social impacts of formalisation strategies. It compares results from three case studies after a change to a new system, either with a recyclers association or in the responsibility of a municipality. Therefore it does not compare the situation before and after the switch to the new system. Due to the high effort to gather detailed data and to conduct interviews, the number of case studies is limited. The authors intend to expand this in future research. The results should be perceived in the socio-economic context of the case studies. Best example is child labour, which was not observed in these case studies, but is well known from recycling activities in other regions.

4 Conclusions

Comparing the conventional model to a model based on formalisation of recyclers, the first shows advantages in terms of wages (not depending on quantity and quality of the collected material) and working time. Both areless regulated with formalised recyclers. Surprisingly, the interviews in the case studies showed a more positive perception of the psychological working conditions for the formalised recyclers than in the conventional system. Physical working conditions were evaluated as poor in both cases, while the perception seems to be rather different.

It is concluded that it is possible to use a methodology based on sLCA to assess social impacts of recycling systems. The developed methodology is oriented to measure the existing social impacts caused by recycling systems in operation. Its application for assessing potential social impacts of future scenarios is difficult. Several social factors like the socio-economic context, regulations, tendencies, perception about satisfaction, quality of life, etc. can change and cannot be precisely predicted. Further researches might investigate the potential social impacts by using an approach oriented to preventive management strategies (social responsibility policy, occupational health, etc.). It is concluded that the availability and reliability of the local data is of vital importance for the values assignment of the indicators and thus for the results of the evaluation. This study shows that direct indicators can be satisfactorily used to measure the social performance of a recycling system. Their use in combination with indirect indicators is also feasible for assessing current social performances of recycling systems.

In relation to the data collection for determining social inclusion, it is concluded that in order to compare different recycling systems the same data collection procedure should be applied meaning the same data sources, interviews procedures and questions.

Acknowledgement

The underlying study was supported by OEAD – Austrian Agency for Cooperation in Education and Research.

References

Brouwer R. and van Ek R. (2004) Integrated ecological, economic and social impact assessment of alternative flood control policies in the Netherlands. Ecological Economics **50**: 1 – 21.

Diaz R., Otoma S. (2012) Effect of informal recycling on waste collection and transportation: the case of Chiclayo city in Peru. J Mater Cycles Waste Manag (in press)

Dreyer C., Hauschild M and Schierbeck J (2006) A Framework for social life cycle impact assessment. International Journal of Life Cycle Assessment **11(2)**: 88 – 97.

Dreyer C., Hauschild M. and Schierbeck J. (2010a) Characterisation of social impacts in LCA. Part 1: Development of indicators for labour rights. International Journal of Life Cycle Assessment **15**: 247 – 259.

Dreyer C., Hauschild M., and Schierbeck J. (2010b) Characterisation of social impacts in LCA. Part 2: Implementation in six company case studies. International Journal of Life Cycle Assessment **15**: 385 – 402.

Flyskö A., Kruse S. and Kasperczyk N. (2009) Socioeconomic indicators as a complement to life cycle assessment – an application to salmon production systems. Journal of Life Cycle Assessment **14**: 8 – 18.

Gutberlet J. (2011) Waste to energy, wasting resources and livelihoods. In: Integrated Waste Management, Volume I. Chapter 12. InTech, pp. 219 – 236. See http://www.intechopen.com/books/integrated-waste-management-volume-i/waste-to-energy-wasting-resources-and-livelihoods for further details (accessed 10/01/2012).

Jørgensen A., Le Bocq A., Nazarkina L. and Hauschild M. (2008) Methodologies for social life cycle assessment. Journal of Life Cycle Assessment **13 (2)**: 96 – 103.

Kijak R and Moy D (2004) A decision support framework for sustainable waste management. Journal of Industrial Ecology **8**: 33 – 50.

Klang K., Vikman P. and Brattebø H. (2003) Sustainable management of demolition waste - an integrated model for the evaluation of environmental, economic and social aspects. Resources, Conservation and Recycling **38**: 317 – 334.

Medina M. (2000) Scavenger cooperatives in Asia and Latin America. Resources, Conservation and Recycling **31**:51 – 89.

Rathi S. (2006) Alternative approaches for better municipal solid waste management in Mumbai, India. Waste Management. **26**: 1192 – 1200.

Scheinberg A., Simpson M. and Gupt Y. (2010) Economic aspects of the informal sector in solid waste. GTZ. Eschborn. Germany. See http://star-www.inwent.org/dokumente/bib-2010/gtz2010-0896en-informal-sector-solid-waste-management.pdffor further details (accessed 29/09/2012).

Spillemaeckers S., Mazijn B. and Borgo E. (2001) An Integrated approach to chain analysis for the purpose of chain management by companies. Centre for Sustainable Development. Gent. See http://www.belspo.be/belspo/organisation/publ/pub_ostc/HL/rHL13s_en.pdf for further details (accessed 13/08/2010).

UN – HABITAT (2010) Solid waste management in the world´s cities. Water and sanitation in the world´s cities. United Nation Human Settlements Program, London. See http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2918 for further details (accessed 16/11/2011).

UNEP – SETAC Life Cycle Initiative (2009) Guidelines for social life cycle assessment of products. United Nations Environment Programme. Life Cycle Initiative. See for further details (http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines_sLCA.pdfaccessed 29/09/2012)

Wilson D., Velis C. and Cheeseman C. (2006) Role of informal sector recycling in waste management in developing countries, Habitat International **30**: 797–808.

Wilson D., Araba A., Chinwah K. and Cheeseman C. (2009) Building recycling rates through the informal sector. Waste Management **29**: 629 – 635.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI. 111 (1-8)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Preparation, Characterization and Removal of Iron by Microfiltration Nylon-6 Membrane

Prof. Dr Maksudur Rahman Khan[1,2]*, Tanmoy Kanti Deb[1], Srabani Majumdar[1], Shamima Yesmin Sony[1], Muhammad Zobayer Bin Mukhlish[1]

mrkhancep@yahoo.com, srabani0007@gmail.com, aodhoracep@yahoo.com, zobayer_ceps@yahoo.com, tanmoy_cep@yahoo.com

[1, 2] Faculty of Chemical and Natural Resources Engineering, University Malaysia Pahang, 26300 Gambang, Kuantan, Pahang, Malaysia
[1] Department of Chemical Engineering and Polymer Science, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh

ABSTRACT

Microfiltration membranes was fabricated by Nylon-6 polymer and intended removal of Iron from water by it was investigated. Preparation of membrane was done by phase inversion technique with various manufacturing condition as temperature, dope solution concentration, evaporation time, additives etc. to assess the effect of these parameters on final properties of membrane. After characterization of prepared membrane by Dead-End module arrangement, tubular modules of predetermined dimension was made and subjected to a pilot-plant scale lab membrane-reactor constructed from locally available material for removal of iron from synthetic waste water. The removal efficiency and regeneration efficiency was also analyzed in this respect. The present study shows that, the permeability, porosity are in positive correlation with bath temperature, solvent concentration and decreases with Nylon concentration etc. and also concludes the very effective removal of iron by such process.

Keywords: Microfiltration membrane, Dead- end module, Tubular module, pilot-plant scale & Flux.

1. INTRODUCTION

Now days, membrane technology is applied widely to separate individual components from mixtures of liquids and gases. Various polymeric hollow fiber membranes have been prepared and used due to their high surface per unit volume and high permselectivity (Qui et al. 2009), Arunima et al. 2009, Lu et al. 2009). Among the many membrane processes, the microfiltration is most widely used and can be fabricated by phase inversion technique.

Preparation of Nylon 6 micro-filtration membrane by phase inversion technique is a tricky assignment and several variables must have to be adjusted to be adjusted in order to get the membrane of required properties. In general, an appropriate preparation procedure of the dope encompasses forming a solution of Nylon 6 in a solvent (e.g., formic acid), inducing nucleation of polymer crystallization by a controlled addition of non-solvent (e.g., water) to obtain a visible precipitate, after blending it for inclusive dissolution. Such a dope is commonly referred to as been in a state of 'incipient precipitation' that contains a high population of pre-nucleation embryos. Here, amongst these parameters, the composition of the main polymer, concentration of additives used; temperature, composition, humidity and time of exposure to drying environment are of the topmost importance. But there are only few data available in literature in this respect.

On the other hand, the tremendous increase in the use of heavy metals over the past few decades has inevitably resulted in an increased flux of metallic substances into the aquatic environment and the metals are of special concern because of their persistence. Industrial wastes

constitute the major source of the various kinds of metals pollution in natural waters (Horsfall et al., 2003). Iron being the fourth most abundant element and second most abundant metal in the earth's crust (Silver 1993; WHO 1996), removal of which is one of the most common types of municipal water treatment in the globe. Iron occurs naturally in water, especially groundwater and also this element does not cause any adverse health effects; it is, in fact, essential to the human nutrition and drinking water gives a value of about 2 mg/1, which does not present a hazard to health (WHO 1996). Water to be used in the textile, dyeing, beverage and white paper industries should contain less than 0.05 mg/1 of iron (Cox 1964). However, water containing disproportionate amounts of iron is able to form ugly and insoluble rusty oxide-red, yellow or brown stains and streaks on laundry and plumbing fixtures (O'Connor 1971; Kothari 1988), interferes with the culinary use turning tea black and darkening the boiled vegetables (Hauer 1950), discolor plumbing fixtures, and sometimes add a “rusty” taste and look to the water. Also, the oxidation of iron-rich water applied to cultivated fields can lead to low-pH ferric hydroxide-rich soils that may severely damage agricultural productivity (Chapelle 1993). Iron passing into the distribution system may promote the growth of micro-organisms that obtains its energy for growth from the chemical reaction that occurs when iron mix with dissolved oxygen and leads the formation of thick slime growths on the walls of the piping system and on well screens. These accumulations, consisting of hydrous iron and manganese oxides and bacteria, increase the friction loss and power consumption, require higher chlorine dosage, deplete dissolved oxygen, reduce the carrying capacity and may eventually clog the distribution pipes. Sloughing or re-suspension of this material by high flow causes high turbidities (O'Connor 1971; Culp 1986; Salvato 1992; Vigneswaran and Visvanathan 1995).

Although the growth of iron bacteria can be controlled by chlorination, but, when water containing iron is chlorinated, the iron is converted from the ferrous state to the ferric state in other words, rust, liable to form coating on the inside of the water main and, when they break loose, cause the water solely unusable for domestic and industrial purpose. The adsorptive and ion exchange system may seems better in such case but handling the whole process is costly and time consuming with high maintenance requirements due to severe damages of active sites of the particles. So, here, the prepared Nylon-6 membrane was introduced in lab based pilot scale level(incorporated with the aeration technique) with the use of locally available materials and operated with some varying operating parameters to define the process and found very effective in order to solve these issues.

2. MATERIALS & METHOD

Materials: The nylon-6 (semi crystalline polymer) pellets were collected from Malaysia. Formic acid, H_2SO_4, Ferrous ammonium sulphate, 1, 10-phenanthroline monohydrate, hydroxyl ammonium chloride and sodium acetate was collected from Merck, Germany. A raw iron solution was prepared by dissolving 100mg of $FeSO_4$ with 2.5 ml of concentrated H_2SO_4 in 1 L distilled water followed by shaking vigorously to make the whole solute to be dissolved.

Preparation of membrane: A specific quantity of Nylon-6 polymer pellets (10%, 15% & 20% by volume) was blended with formic acid at room temperature for 24 hours to make the dope solution. The membranes are prepared by taking the dope solution in a fine glass plate, stretched uniformly to make a uniform layer followed by the immersion in a non- solvent bath (distilled water) for the completion of phase inversion. After the precipitation of membrane, it was rinsed with distilled water and stored for further study. The polymer-solvent ratio, evaporation time before immersion in solvent, addition of ingredients and effect of phase inversion bath temperature was varied in time of preparation of membrane in order to get the respective effect on iron removal efficiency and characteristics form water. The thickness of membranes was measured by micrometer and the membranes with thickness of 0.2mm±0.015mm were stored in distilled water for further use.

Experimental run of Nylon-6 membrane on dead-end module: The experimental run with membrane in dead-end module (model) was done to assess effect of parameters on the trend of change in performance of prepared membrane and to do so a membrane piece was attached on the bottom of dead-end module and the operation was carried out as per the Figure:1.

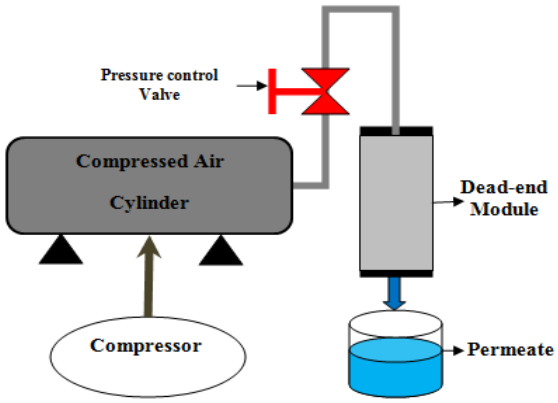


Figure 1: Membrane filtration in Dead-End module.

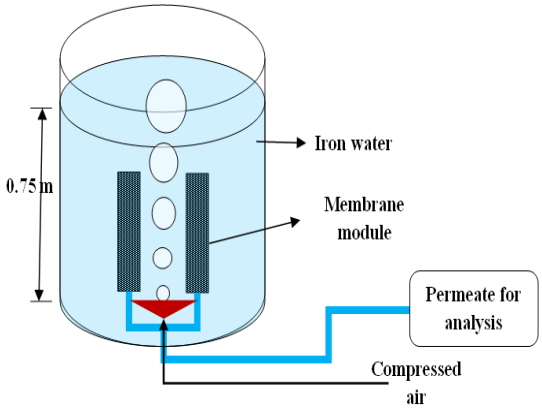


Figure 2: Lab based Pilot Plant scale membrane-reactor with continuous aeration.

Determination of Iron in permeates solution: Determination of Iron in permeates solution was done by photometric method in a spectrophotometer (SHIMANDJU-1650Pc, Japan) as per standard by APHA.

Fabrication of Lab Pilot-scale Membrane Separation unit: After the characterization of membrane, a lab scale iron removal unit was prepared by locally available material as shown in figure: 2. The construction of tubular module was done by isolating a perforated polymeric tube with membrane sheet (length: 7 cm, Outer Dia.: 1.25cm, effective surface area: 34.20 cm^2) and joining the open ends of it by silicon glue to make it solely leak proof. The reactor was continuously feed with a constant flow of iron water by a regulating valve with maintaining the level of water in the reactor at the desired position by the action of a level sensor. The whole operation was driven by the hydrostatic pressure and the effluent flux was continuously measured with the corresponding iron removal percentage with time. After blocking of membrane pores, it was removed from the unit and washed with distilled water to measure the effectiveness of regeneration.

Flux measurement by membrane: Permeate flux was measured in a dead end module at different applied pressure via compressed air as shown in figure. The flux is defined as amount of fluid passing through the per unit surface area of membrane per unit time and calculated as:

$$\text{Flux} = (V/A_m) \times t \qquad (1)$$

Where, V, Am and t are total permeate volume, effective area of membrane and operating time respectively.

Porosity, water uptake & permeability of membrane: The membrane samples (1.735×10^{-03} m^2) were immersed in the beaker containing 50ml distilled water at room temperature($27\pm2^{O}C$) for 24 hours and then the samples were taken out from the beaker and wiped with tissue papers followed by weighting in balance. Then the samples were dried in air oven at $100^{0}C$ until the weight of the samples reaches a steady value. Porosity was then determined using the following equation:

$$\textbf{Porosity (\%)} = \qquad \textbf{(2)}$$

And water uptake was calculated by following equation:

$$\textbf{Water uptake (\%)} = \qquad \textbf{(3)}$$

Where, W_w and W_d are the weight of the membrane sample at wet and dry state respectively, d = diameter of membrane sample, t=thickness of membrane and ρ_w = density of water.

Hydraulic permeability (L_p) was determined by Equation (4) in order to verify the integrity of the membranes. For this determination, standard Iron water of 100ppm was permeated varying the transmembrane pressure from 10psi to 40psi and the corresponding water permeate fluxes (J_v) were measured.

$$\mathbf{J_v = L_p \times \Delta P} \qquad \textbf{(4)}$$

3. RESULT & DISCUSSION

3.1 Effect of polymer concentration on permeates flux of Nylon-6 membrane: The Figure 3 to Figure 6, depicting the effect of polymer concentration on permeate flux of membrane prepared with different Nylon-6 concentration with zero evaporation time and from here, flux of 10 % nylon-6 membrane is higher than that of both 15% & 20% which implies the flux of the membrane decrease while the increment of polymer concentration. It is due to the thickening and getting denser of the outer layer of the membranes with increase of polymer concentration.

3.2 Effect of casting bath temperature on permeates flux: Figures 3 to 5 are showing the effect of casting bath temperature on permeates flux and from the experimental results, at higher bath temperature permeate flux become higher than that for lower temperatures. This effect can be explained from the viewpoint that at higher casting temperature, porosity of membrane increases as a result of rapid evaporation and hence diffusion of formic acid.

3.3 Effects of transmembrane pressure on permeate flux: With increasing pressure, in dead-end module, permeate flux gradually increases with applied pressure until reaching to steady state depending on the preparation condition of each membrane. Here, though the permeate flux at 20 & 30psi pressure is higher than 20 psi for whole experimental run, but for the ultimate steady state permeate flux at 40psi pressure is lower than the remaining two analyzing condition which is due to the rapid blocking of pores of microfiltration membrane at high operating pressure and these are represented by figures 8-10.

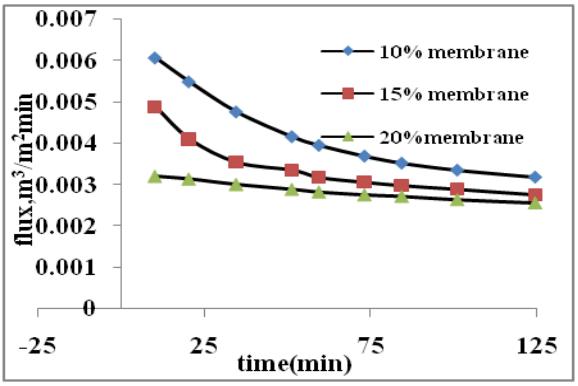


Figure 3: Flux vs. Time curve of different membrane at zero evaporation time at atmospheric pressure & 25^{0}C temperature.

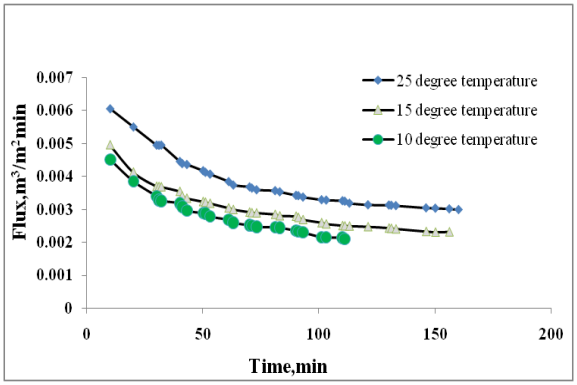


Figure 5: Flux vs. Time curve of different membrane at zero evaporation time at atmospheric pressure & 10^{0}C temperature.

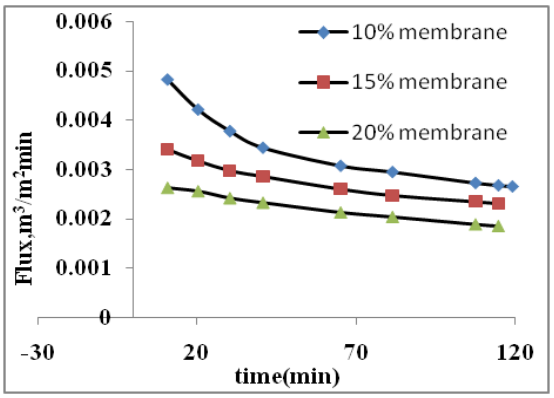


Figure 4: Flux vs. Time curve of different membrane at zero evaporation time at atmospheric pressure & 15^{0}C temperature

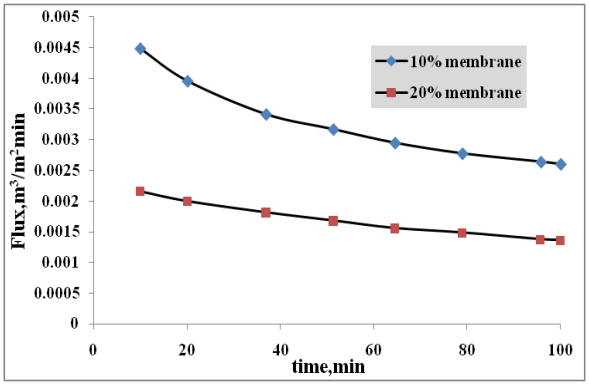


Figure 6: Flux vs. time curve of 10% nylon-6 membrane at different temperatures (10^0,15^0,25^0 C) & atmospheric pressure.

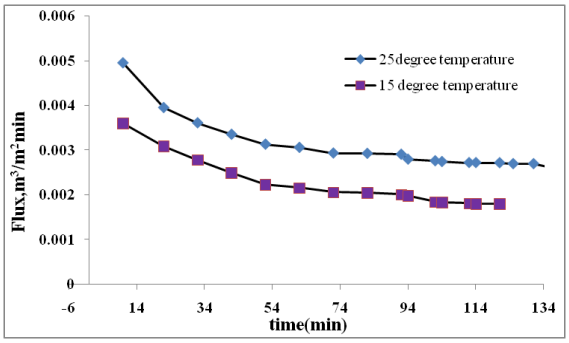


Figure 7: Flux vs time curve of 15% nylon-6 membrane at different temperatures (15^0,25^0 C) & atmospheric temperature.

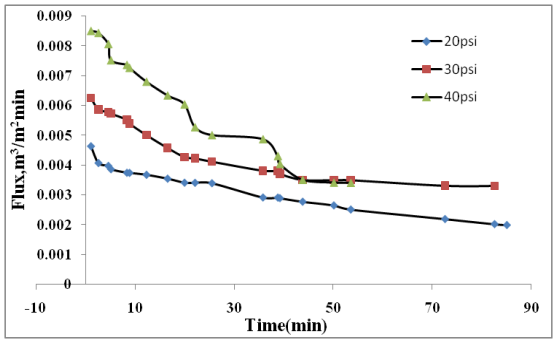


Figure 8: Flux vs. Time curve of 20% nylon-6 membrane at different Pressure (20, 30, 40 psi) & 25^0C temperature.

3.4 Effect of evaporation time: As shown in the figure: 12, the permeate flux increases with the increment of time of evaporation before immersion in phase inversion bath and the reason behind this is the increment of the interconnected pore formation with the increment of evaporation time. Here the effect is demonstrated for the 10% membrane prepared with different evaporation time at atmospheric pressure & 15^oC temperature.

3.5 Effect of additives: In order to asses this effect, poly vinyl acetate (PVAc) with different dose was blended with dope solution prior to membrane preparation and a dominant effect was seen. Here, with the increment of PVAc dose, the permeate flux decreases. The result is shown in figure:

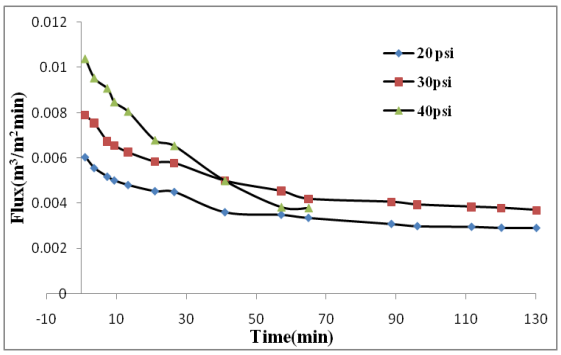


Figure 9: Flux vs. Time curve of 15% nylon-6 membrane at different Pressure (20, 30, 40 psi) & 25^0C temperature.

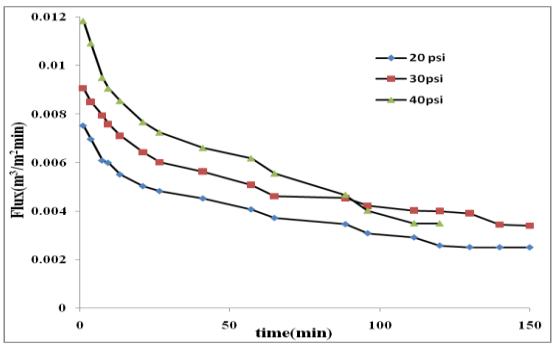


Figure 10: Flux vs. Time curve of 10% nylon-6 membrane at different Pressure (20, 30, 40 psi) & 250C temperature.

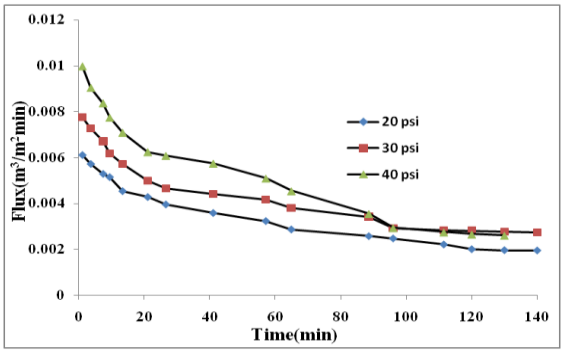


Figure 11: Flux vs. Time curve of 10% nylon-6 membrane at different Pressure (20, 30, 40 psi) & 15^0C temperature.

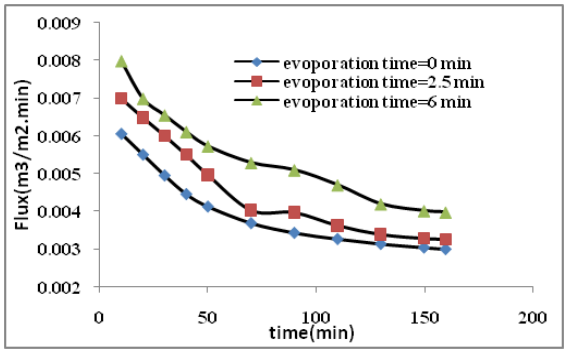


Figure 12: Performance of 10% membrane with different evaporation time at atmospheric pressure & 15^OC temperature.

3.6 Effect of various parameter on permeability of nylon-6 membrane:

3.6.1 Permeability constant dependence of membrane at various monomer concentrations at zero evaporation time: From figures given bellow we can see that permeate flux increases with increasing bath temperature. The cause of this effect is, with increasing temperature solvent, formic acid vapors hugely with formation of more porous membrane and as a result permeability constant increases. Also at higher monomer concentration, due to formation of thick surface layer, the permeability declines.

3.6.2 Permeability constant dependence of membrane at various preparation monomer concentrations at different evaporation time:

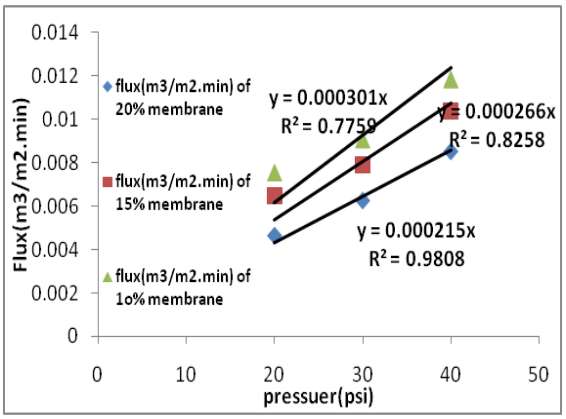


Figure 13: Variation of permeability of Nylon-6 membrane prepared at 15^{O}C, zero evaporation time.

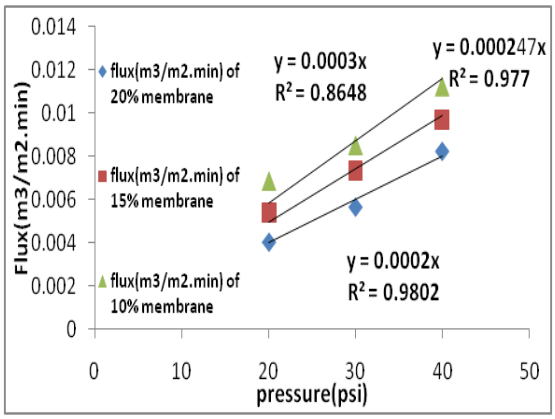


Figure 14: Variation of permeability of Nylon-6 membrane prepared at 10^{O}C, zero evaporation time.

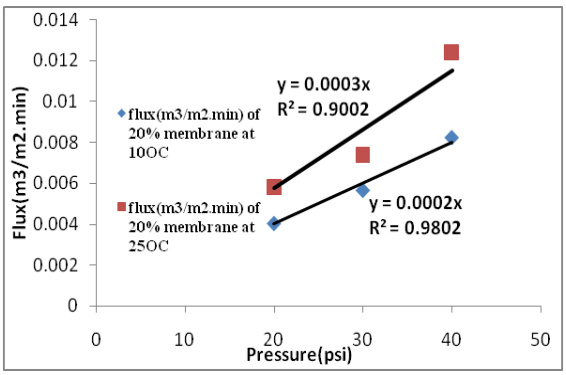


Figure 15: Variation of permeability of Nylon-6 membrane prepared at 10^{O}C and 20^{0}C with zero evaporation time.

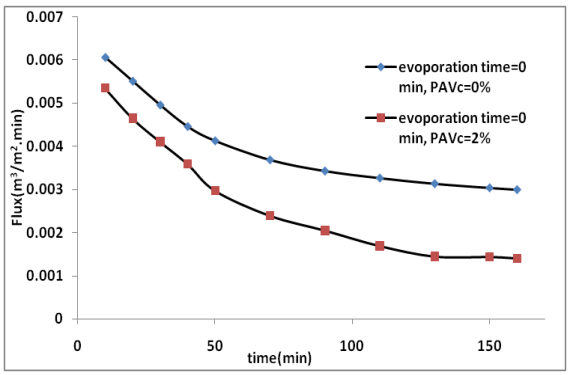


Figure 16: Variation of permeability of Nylon-6 membrane with PAVc dose prepared at 15^{O}C, 10% Nylon composition with zero evaporation time.

3.7 Physical properties of different membranes: From following table, it is evident that for prepared nylon-6 membrane, how the property of final membrane varies with condition of preparation.

Table 1: Properties of membrane at different preparation conditions

Types of membrane	Bath temperature (^{0}C)	Weight of wet membrane W_w gm	Weights of dry membrane W_d gm	Water uptake (%)= $\frac{(Ww - Wd)}{Ww} * 100$	Permeability constant (A)
10% nylon	10	0.0195	0.0071	71.15	0.000291
	15	0.017	0.0054	77.00	0.000301
	25	0.0173	0.0044	79.49	0.000319
15% nylon	10	0.0104	0.0030	63.59	0.000247
	15	0.0154	0.0035	68.24	0.000266
	25	0.0195	0.0040	74.57	0.000288
20% nylon	10	0.0306	0.0146	52.29	0.0002
	15	0.0354	0.0162	54.24	0.000215
	25	0.0388	0.00156	59.79	0.0003

3.8 Application of Nylon-6 membrane in Pilot Scale unit:

3.8.1 Iron removal vs. time curve of 15% membrane at 25^{0}C: The solution was taken in membrane-filtration pilot scale unit and effluent concentration and flux were measured with time and the result is plotted against time in following figure. From this, it is clear that the Percentage of iron removal is increased with time as the porosity of membrane is blocked with iron oxides (formed due to aeration) and consequently iron removal is increased. After 79 hours of operation the removal of iron was predicted as 60.417% of the initial. After regeneration of membrane by cleaning with HCl, the flux which was almost zero, rises rapidly with gradual increment of iron removal but the trend of removal was lower than the earlier. The possible reason is the permanent damage of pores of membrane by the Iron deposition.

3.8.2 Iron removal vs. time curve of 15% membrane at 10^{0}C: The iron removal result of this condition is here plotted in figure: 17 against time. From it is clear that the Percentage of iron removal is increased with time but the trend is lower than that for equivalent membrane of 25^{O}C. After 99 hours of operation the removal of iron was predicted as 79.55% of the initial and after regeneration, the trend is similar as per previous, but the trend of extent of removal is lower.

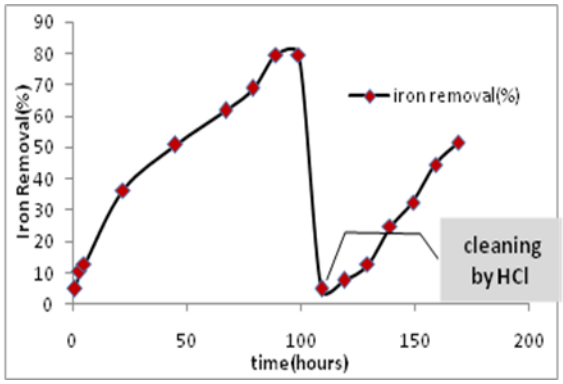


Figure 17: Performance of Pilot Scale base membrane reactor for iron removal (prepared by 15% Nylon-6 at 10^{O}C temperature).

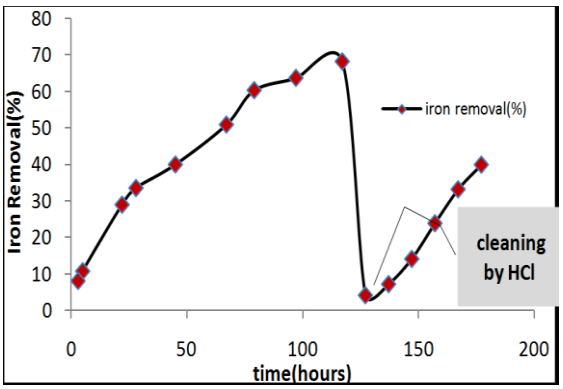


Figure 18: Performance of Pilot Scale base membrane reactor for iron removal (prepared by 15% Nylon-6 at 25^{O}C temperature).

CONCLUSION

The study successfully demonstrated the ease with which fabrication of submicron sized membranes could be achieved with the desired requirements on membrane property by controlling the parameters at time of preparation of membrane by phase inversion method. Iron molecules could be embedded on and within the polymer matrix and also the inclusion of Iron was possible with both the aeration

and non aeration but the effect was much higher for aeration due to formation of suspended ferric compounds. However, sorption capacity of the Iron was negotiated as flux of membrane decreased gradually following its inclusion in the polymer matrix and corresponding reduction of size of pores. Thus, it is concluded here that although there is a decline in sorption ability in case of Iron entrenched to the polymer fiber membrane due to the addition of the particles in a polymer matrix, it would nevertheless help to prevent release of such particles into the environment with the treated effluent, and keep away from or reduce the cost related with separation of it from treated water. Hence, such system should be very useful for commercial filtration application for developing country like Bangladesh.

REFERENCES

WHO (1996) *Guidelines for drinking water quality: 2nd edition, Vol 2 - Health Criteria and other supporting information,* WHO, Geneva.

Horsfall M (Jnr.), Abia AA, Spiff AI (2003). *Removal of Cu(II) and Zn(II) ions from wastewater by cassava (Manihot esculenta Ganz) Waste Biomass.* Afr. J. Biotechnol. 2 (10): 360–364.

Silver J.(1993) *Chemistry of Iron. First Edition, Blackie Academie and Professional*.

Kothari, N. (1988) *Groundwater, iron and manganese: An unwelcome trio. Water/Engineering and Management*, Febmary, 25-26.

O'Connor, J.T. (1971) *Iron and Manganese. In: Water Quality and Treatment - A Handbook of Public Water Supplies.* Chapter 11, p 378-396; McGraw Hill Book Company, New York.

Hauer, G.E. (1950) *Iron and carbon dioxide removal. Joumal AWWA*, 42, 555-561.

Cox, CR. (1964) *Operation and Control of Water Treatment Processes*. WHO,

Chapelle, F.H. (1993) *Groundwater Microbiology and Geochemistry. John Wiley & Sons Inc. USA*.

Bean, E.L. (1962) *Progress report on water quality criteria. Journal AWWA*, 54 (11), 1313-1331.

EC (1998) *Official Journal of the European Communities.* December 5 1998; Council Directive 98/83/EC on the quality of water intended for human consumption. L330/32 - L330/50.

A VEWIN Recommendations 1993. *In Dutch : VEWIN Aanbevelingen 1993 (a. de hoedanigheid van het water = waterkwalitiet),* VEWIN, The Netherlands.

A Vigneswaran, S. and Visvanathan, C. (1995) *Water Treatment Processes - Simple Options*. CRC Press,p 156-157.

Westner, Culp (1986) Handbook of Public Water Systems. Van Nostrand Reinhold Company, New York. Chapter 19, p 633-644.

Salvato, J.A. (1992) Environmental Engineering and Sanitation. Fourth Edition, John Wiley and Sons, Inc.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.113 (1-4)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Oxygen Uptake Behavior 0f Biosolid Materials Collected From Municipal Sewer Lines- A Respirometric Study

Engr. Mohammad Shahidur Rahman
Assistant Professor, Dept. of Civil and Environmental Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh

Dr. Md. Akhtarul Islam
Professor, Dept. of Chemical Engineering and Polymer Science, Shahjalal University of Science and Technology, Sylhet, Bangladesh

Md. Mominul Haque, **Tofayel Ahammad Ovee and Md. Shahadat Hossain**
Graduate students, Dept. of Chemical Engineering and Polymer Science, Shahjalal University of Science and Technology, Sylhet, Bangladesh

ABSTRACT

Biosolid materials play a vital role in the biodegradation process of wastewater stream as well as soil quality enhancer. This study justifies the applicability of respirometric technique for measuring the oxygen uptake behavior of biosolid materials present in sewer line. Samples of active settled sludge were collected from three different municipal sewer lines of Sylhet city area enriched with residential, commercial and industrial discharge respectively. Reaction vessel with biosolid samples and carbon dioxide scrubber were kept in water bath of the 'BIOSUST' low-cost differential respirometer. A thermobarometer was incorporated to neutralize the temperature-pressure effect on the manometric reading. Laboratory investigations were performed at the temperature of 32^0C. Results show that biosolids of residential source can be used effectively as soil conditioner due to its higher biodegradation rate while industrial sample exhibited toxic inhibitory effect on microbial degradation process.

INTRODUCTION

Biosolid (Sewage sludge) - the residue generated during treatment of domestic sewage or settled during flowing of wastewater through municipal sewer line is often used as an organic soil conditioner and partial fertilizer in many countries of the world (EPA, 2003). It is applied to agricultural land (pastures and cropland), disturbed areas (mined lands, construction sites, etc.), plant nurseries, and forests area. For making beneficial and effective use, it is very important to quantify the biomass activity with organic contents and assess the biodegradation criteria of the biosolid materials. Biosolids contain nutrients, organic matters and microorganisms that can also degrade flowing wastewater in the sewer line before discharge into the natural sinks. Passing time within the sewer line, flow velocity and turbulence, natural aeration, oxygen transfer rate etc. have a great influential effect on the degradation process of flowing wastewater.

Many procedures for measuring the biodegradation rate of biosolid materials are described in the literature (Grady, 1989; Roppola, 2009; Young, 1996); however, we have found that these procedures, involving the principles of carbon dioxide absorption, Barcroft-type differential respirometry, conventional Warburg-type respirometry and electrolytic respirometry, have not meet our experimental requirements of low cost, simplicity and accuracy. Microorganisms in sewage sludge use oxygen to consume organic matter. The level of microbial activity in sludge is indicated by the microorganisms' oxygen uptake rate. High oxygen uptake rates indicate high microbial activity and high organic matter content; low oxygen uptake rates indicate low microbial activity and low organic matter content (EPA, 2001). The objective of this study is to assess the biodegradation capacity of biosolid mass in terms of oxygen consumption obtained from respirometric investigation.

ISBN: 978-984-33-7045-7, PI.113 (1-4)

MATERIALS AND METHODS

Respirometry is a measurement and interpretation of the biological oxygen consumption rate (aerobic) or biogas generation rate (anaerobic) under well-defined experimental conditions. This oxygen consumption comes from the microorganisms contained in the wastewater or biosolid as their survival phase (endogenous) and biological oxidation of the biodegradable materials (exogenous). Under aerobic conditions the microorganisms consume oxygen in proportion to the organic matter and biomass in the sample. In case of headspace gas respirometer, microorganisms present in the wastewater sample take aerial oxygen to degrade (oxidize) the organic substances in it. As oxygen is consumed to oxidize the organic substances, carbon dioxide (CO_2) is evolved which is trapped by a special type of scrubber. As a result, headspace pressure is decreased which is indicated by the fluid movement in the manometer (Mahendraker, 1995; Ros, 1988; Xia, 2008).

Biosolids used in this study were sampled from three different sources of Sylhet municipal area. The three sampling points were enriched by residential, commercial and industrial discharge respectively. Before respirometric study, all samples were air-dried and ground to prepare well-mixed slurry with distilled water. Different parameters for the experimental setup are presented in table 1.

Table 1 Details of experimental setup

Reactor	Weight of biosolid sample, gm	Volume of sample, mL	Headspace volume of the respirometer, mL	Incubation period, hr
Experimental reactor	35	25 (biosolid slurry)	750	120
Thermobarometer rector	-	25 (inert material)	750	120

Oxygen uptake value of the biosolid materials were measured by a differential respirometer (Model BSMR-BS103) fabricated at Centre for Environmental Process Engineering (CEPE) of SUST which is shown in figure 1. The differential respirometer consists of two air-sealed glass vessels, two small pans filled with carbon dioxide scrubber, a U-tube manometer fitted with flexible rubber pipe. The whole system is kept in a water bath at constant temperature and agitation.

Figure 1 : 'BIOSUST' differential respirometer

ISBN: 978-984-33-7045-7, PI.113 (1-4)

RESULTS AND DISCUSSION

Results of the respiration of the biosolid samples in relation to time as expressed on a cumulative basis over a period of 5 days are illustrated in figure 2. It is revealed from the figure that the acclimation period for microbial mass is about 18 hrs and total oxygen utilization keeps going on beyond 120 hrs for the sample 1 and 2 while third sample shows remarkable inhibitory effect on the oxygen consumption.

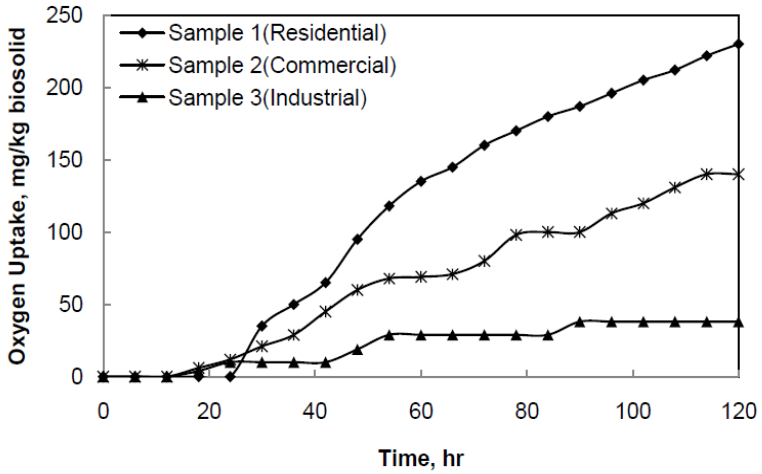


Figure 2 Respirogram representing cumulative oxygen uptake for 5 days incubation period

The fingerprint for biosolid sample 1 indicates the presence of three major groups of organic constituents. The first group of readily biodegradable organic constituents is oxidized at maximum kinetic rate through about 30 hrs of contact. Oxidation of second group of constituents causes the OUR to increase through about 48 hrs of incubation. Oxidation of third group of constituent extends beyond 120 hrs of contact.

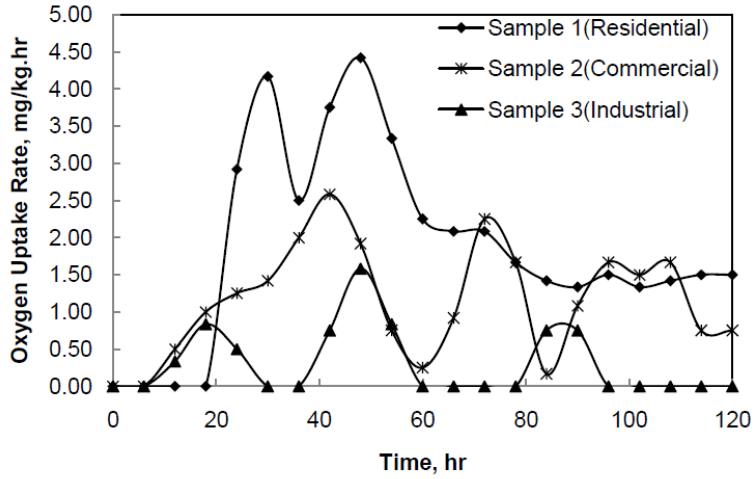


Figure 3 OUR profile for the biosolid sample

Respirogram for the sample 2 shows that three major groups of substances were degraded within the experimental duration; although endogenous respiration was not observed during 120 hrs.

The OUR fingerprint for biosolid sample 3 shows a critical phenomena. In this special case after bio-oxidation of certain organic group, microbial substrate consumption rate was suppressed. The cause behind the suppression may be due to the toxic inhibitory effect on microbial food consumption by some unknown end product generated during the oxidation of the first group. In total 5 days incubation, this type of dual degradation and inhibition effect was observed 3 times. Since the sample

was collected from a sewer line enriched with chemical industrial discharge, certain toxic compounds may interrupt the natural biodegradation process.

CONCLUSION

Respirometric method can be a suitable option for assessing biodegradation criteria of biosolid materials without employing complicated and costly microbial bioassay or biochemical laboratory investigation. Some important findings of the study are listed below.

- Biosolids enriched with residential wastewater can be used as soil conditioner and partial fertilizer.
- Due to toxic and inhibitory effect industrial biosolid should not be used for the soil conditioner.
- Industrial wastewater should be treated to minimize the toxicity effect before discharge to the natural sinks such as natural lake or river.

ACKNOWLEDGEMENTS

This study has been supported by the research funds of Shahjalal University of Science and Technology and Centre for Environmental Process Engineering (CEPE), Sylhet, Bangladesh. M.S. Rahman acknowledges NSICT fellowship awarded by Ministry of Science and Technology, Government of Bangladesh.

REFERENCES

Grady, C., Dang, J., Harvey, D., Jobbagy, A. and Wang, XL. 1989. Determination of biodegradation kinetics through use of electrolytic respirometer. *Water Science and Technology,* 21: 957–968.

Mahendraker, V. and Viraraghavan, T. 1995. Respirometry in environmental engineering, *Journal of Environmental Science and Health. Part A. Environmental Science and Engineering,* 30: 713–734.

Roppola, K. 2009. Environmental applications of manometric respirometric methods, *PhD thesis*, Dept. of Chemistry, University of Oulu, Finland.

Ros, M., Dular, M. and Farkas, P. 1988. Measurement of respiration of activated sludge. *Water Research,* 22: 1405–1411.

U.S. EPA. 2001, Specific Oxygen Uptake Rate in Biosolids *(*Method 1683*),* EPA-821-R-01-014*.* January 2001*.*

U.S. EPA. 2003, Control of Pathogens and Vector Attraction in Sewage Sludge, EPA/625/R-92/01, Revised July 2003.

Xia, W., Li, J. and Zheng, X. 2008. Biodegradability assessment of industrial wastewater by Warburg Respirometer*. The 2nd International Conference on Bioinformatics and Biomedical Engineering*, 16-18 May 2008, 3738 – 3740.

Young, J.C., 1996. Fundamentals of respirometry: Instrument types and basis of operation, 51st Perdue Industrial Waste Conference Proceedings, Ann Arbor Press Inc., pp. 441-451.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.115 (1-7)

Proceedings of the WasteSafe 2013 – 3rd International Conference on Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

EXPERIMENTAL STUDIES ON FLY ASH-SAND-LIME BRICKS WITH GYPSUM ADDITION

[1]Tahmina Banu, [2]Md. Muktadir Billah, [3]Fahmida Gulshan and [4]A. S. W. Kurny

[1]U.G. Student, Department of Materials and Metallurgical Engineering, Bangladesh University of Engineering and Technology

[2]Lecturer, Department of Materials and Metallurgical Engineering, Bangladesh University of Engineering and Technology

[3]Assistant Professor, Department of Materials and Metallurgical Engineering, Bangladesh University of Engineering and Technology

[4]Professor, Department of Materials and Metallurgical Engineering, Bangladesh University of Engineering and Technology

ABSTRACT

Coal fly ash, a burnt residue of pulverized coal, is hazardous and its disposal is a problem. In *Bangladesh*, the annual generation of this waste is approximately 0.6 million tons. On a global basis, less than 20 percent of coal fly ash (CFA) is used in the concrete related applications while the remainder is disposed of in landfills leading to various environmental problems such as polluting soils and groundwater.

In this study, production of light weight structural bricks using fly ash, generated at Barapu*k*uria Thermal Power Plant, as the major ingredient has been investigated. Optimum mix of fly ash, sand, hydrated lime and gypsum has been identified. The brick forming pressure and curing time were also optimized. 55% fly ash, 30% sand and 15% hydrated lime with 14% gypsum was found to be the optimum mix. The compressive strength, microstructure, shrinkage property, unit volume weight, Initial rate of absorption, absorption capacity, apparent porosity, open pore and impervious pore of the fly ash–sand–lime-gypsum bricks produced under the optimized conditions were investigated. The results of this study suggested that it was possible to produce good quality light weight non-fired structural bricks from coal fly ash generated at Barapu*k*uria Thermal Power Plant.

Keywords: *Coal fly ash, structural bricks, sand, gypsum, microstructure, properties.*

INTRODUCTION

Pulverized fuel ash commonly known as fly ash is a useful by-product from thermal power stations using pulverized coal as fuel. The high temperature of burning coal turns the clay minerals present in the coal powder into fused fine particles mainly comprising aluminium silicate. Fly ash produced thus possesses both ceramic and pozzolanic properties. Fly ash is a hazardous waste. The problem with fly ash lies in the fact that not only does its disposal require large quantities of land, water, and energy, its fine particles, if not managed well, by virtue of their weightlessness, can become airborne. When not properly disposed, fly ash is known to pollute air and water, and causes respiratory problems when inhaled.

Globally around 20% fly ash is used in concrete related applications. Mainly $CaO–SiO_2–H_2O$ and $CaO–Al_2O_3– SiO_2–H_2O$ phases contribute to hardening [Goni et al., 2003 and Klimesch and Ray, 1998]. Fly ash is also utilized in many different areas like paints, plastics and in agriculture [Baykal and Doven., 2000, Iyer and Scott, 2001, Pimraksa et al., 2001, Poon et al., 2002 and Toktay and Etin,

ISBN: 978-984-33-7045-7, PI.115 (1-7)

1991]. In Bangladesh about 0.6 million tons fly ash is produced annually and its production is likely to increase significantly because the future power plants in Bangladesh are likely to be coal fired. Use of fly-ash is, on the other hand, yet to be popular. A small quantity of imported fly-ash is reported to be used in the manufacture of cement in Bangladesh. A viable option for the bulk utilization of fly-ash could be in the production of structural bricks containing fly ash as a major ingredient. The manufacture of conventional clay bricks involves the consumption of large amounts of clay. This depletes topsoil and causes degradation of agricultural land. If fly ash bricks containing no clay could be manufactured then this would not only help preserve the topsoil but also reduce environmental problem caused by fly ash.

In this study an attempt has been made to produce light weight bricks for structural applications using fly-ash generated at the Barapukuria Thermal Power Plant.

MATERIALS AND METHODS

Fly ash, sand and hydrated lime mixtures with gypsum as a binder were used to make bricks. Process variables like the composition of the mix, pressure, curing conditions, etc were optimized. Finally the properties of the bricks produced under the optimum conditions were determined.

Fly ash used in this study was collected from Barapukuria Thermal Power Plant. The other ingredients hydrated lime, sand and gypsum were collected from the local market. The major ingredients in fly-ash used in this study are presented in Table 1.

Table 1: Chemical composition of Barapukuria Power plant fly-ash.

Compound	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
Mass fraction, %	48.20	41.24	3.37	3.31	0.20

Brick specimens were produced under the conditions given in Table 2. Five bricks were made for each specimen type. Before making a brick each ingredient of the raw materials was dried in a muffle furnace at 110^{O}C for 24 hour. Required amount of each ingredient was weighed, 14% moisture was added and the components were mixed thoroughly. To ensure uniform size of the bricks a known weight of mixture was used each time to fill the mould cavity. Dimension of the mould cavity opening was 6 X 3.5 cm. A hydraulic press was used to apply pressure for a period of 15 Sec (Fig. 1). The bricks (Fig. 2) were then ejected and finally cured for 7 days. Curing was done in air, using water spray, by putting the bricks under wet cloth and by keeping the bricks immersed in water.

Figure 1: Hydraulic press.

Figure 2: Fly ash-sand-lime-gypsum bricks.

TEST METHODS

Compressive strength

Compressive strength was determined by applying load on the specimen using a Universal Testing Machine. Load was applied on an area measuring 6mm X 3.5 mm [The size of one face of the entire brick].

Table 2: Test parameters.

Bricks code	Sand (wt %)	Fly ash (wt %)	Lime (wt %)	Gypsum (wt %)	Forming Pressure (psi)	Curing process	Other parameters
T1	10	80	10	2	1000	In air	14% moisture added Pressure applied for 15 sec Curing time 7 days No of bricks for each type is 5
T2	20	70	10	2	1000	In air	
T3	30	60	10	2	1000	In air	
T4	40	50	10	2	1000	In air	
T5	30	65	5	2	1000	In air	
T6	30	62.5	7.5	2	1000	In air	
T7	30	60	10	2	1000	In air	
T8	30	57.5	12.5	2	1000	In air	
T9	30	55	15	2	1000	In air	
T10	30	55	15	2	1000	In air	
T11	30	55	15	6	1000	In air	
T12	30	55	15	10	1000	In air	
T13	30	55	15	14	1000	In air	
T14	30	55	15	14	1000	In air	
T15	30	55	15	14	2000	In air	
T16	30	55	15	14	3000	In air	
T17	30	55	15	14	3000	In air	
T18	30	55	15	14	3000	Under water spray	
T19	30	55	15	14	3000	Under wet cloth	
T20	30	55	15	14	3000	Under water	

Microstructure

The samples were observed under an optical microscope (OM) and micrographs were recorded with a digital camera (OPTIKA Microscope B-600 MET) to investigate porosity. No preparation of the samples was done.

Shrinkage property

Dimensions of the bricks were measured immediately after making the bricks and also after curing to determine the shrinkage of the bricks.

Unit volume weight

After 7 days of curing period bricks were dried at 110^{O}C for 24 hr and then allowed to cool to room temperature. Dry weight D (gm) was then measured. Following that the bricks were immersed for 24 hr in water at room temperature and suspended weight S (gm) was measured. The bricks were then removed, the surface water was wiped off with a damp cloth and the saturated weight W (gm) was measured within 5 min after removing the bricks from the water bath. Unit volume weight B, gm/cm^3 = D/ V, where volume V, cm^3 = (W - S) was calculated.

Initial rate of absorption (IRA)

After measuring dry weight D (gm) as mentioned earlier, the bed surface of the brick (the face measuring 6mm X 3.5 mm) was caused to absorb water for 1 min. Water was wiped out completely from the surface of the brick within 10 s of removal from contact with the water and weight D' (gm) was determined within 2 minutes. Initial rate of absorption IRA, % = D' – D was then calculated [ASTM Designation C 67 – 00].

Absorption capacity

ASTM Designation C 67 – 00 was followed to measure the absorption capacity, A% = [(W – D)/D].

Apparent porosity, open pore and impervious pore

ASTM Designation C 67 – 00 was followed to determine apparent porosity, P% = [(W - D)/ V]. open pore volume, cm^3 = W – D and impervious pore volume, cm^3 = D – S.

ISBN: 978-984-33-7045-7, PI.115 (1-7)

RESULTS AND DISCUSSIONS

The effect of sand on compressive strength

The specimens T1 – T4 (Table 2) were prepared to determine the effect of amount of sand on compressive strength. The compressive strength could be increased from 93.2 kg/cm^2 to 132.74 kg/cm^2 by increasing the amount of sand from 10 to 40% (Fig.3). The maximum strength was found for 40% sand – 50% fly ash – 10% lime bricks with 2% gypsum. As bulk utilization of fly ash was the major goal of this investigation, the optimum amount of sand was taken to be 30% that gave a compressive strength of 124.98 kg/cm^2**.** The improvement in mechanical strength with increasing sand content has been attributed primarily to the increased amount of free SiO_2 which reacts more easily with lime than with fly ash [Cicek and Tanrıverdi, 2007].

The determination of the optimum lime and fly ash content

Compressive strength test results conducted on specimens T5 – T9 showed that maximum strength could be obtained with 15% lime and 55% fly ash (Fig. 4). Compressive strength found for this composition was 144.91 kg/cm^2.

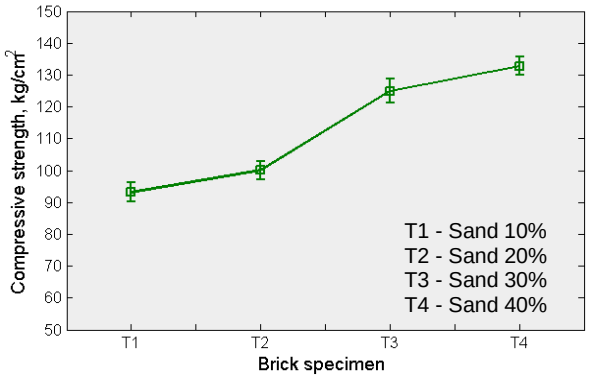


Figure 3: Effect of sand addition on compressive strength.

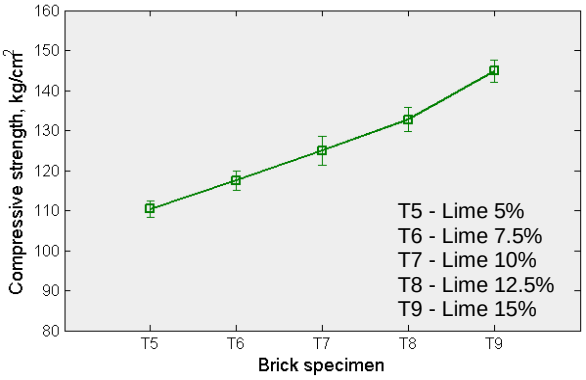


Figure 4: Effect of lime addition on compressive strength.

Optimum content of gypsum addition

The variation in compressive strengths of specimens T10 - T13 containing varying amounts of gypsum is shown in Fig. 5. It can be seen that the compressive strength increased from 144.91 kg/cm^2 for 2 percent gypsum to 225.24 kg/cm^2 for an optimum gypsum content of 14%.

Effect of brick forming pressure on the compressive strength:

Compressive strength tests on specimens T14 - T16 showed that compressive strength increased with increasing brick forming pressure (Fig. 6). Specimen T16 showed maximum compressive strength of 323.86 kg/ cm^2 for a brick forming pressure of 3000 psi.

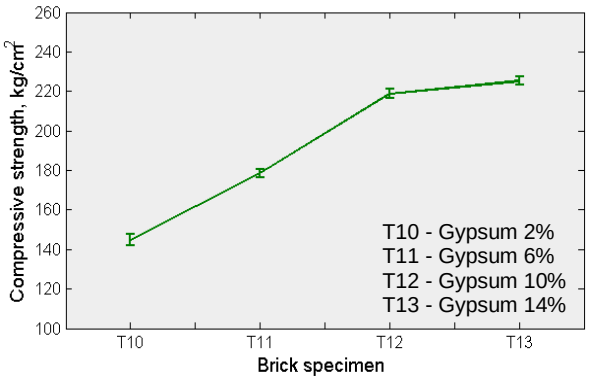


Figure 5: Effect of gypsum addition on compressive strength.

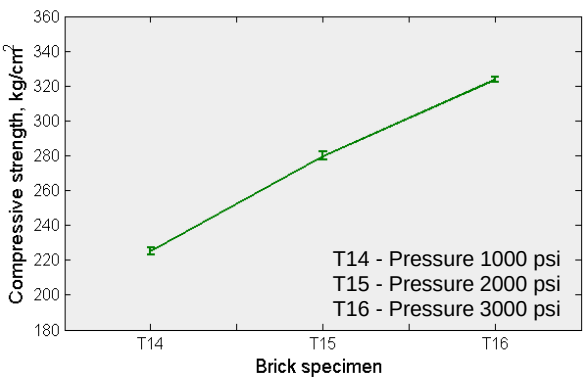


Figure 6: Effect of brick forming pressure on compressive strength.

ISBN: 978-984-33-7045-7, PI.115 (1-7)

Effect of curing process

Specimen T17 was cured in still air. Specimens T18, T19 and T20 were cured with water spray twice a day, keeping the specimen under wet cloth and keeping the specimen immersed under water respectively. Maximum compressive strength of 342.81 kg/cm^2 was found for specimen T18 (Fig. 7).

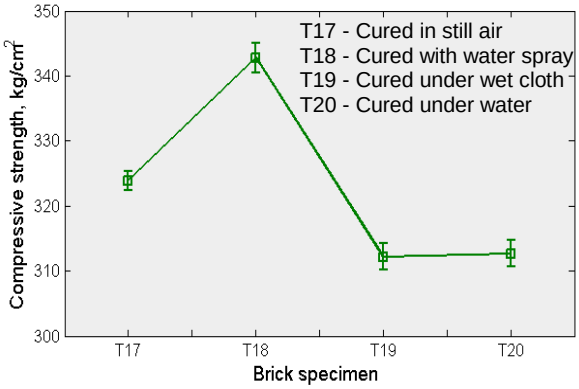


Figure 7: Effect of curing process on compressive strength.

Microstructure

Specimens T14, T15 and T16 are the specimens with optimum composition and different brick forming pressures. Microstructure and other properties besides compressive strength of these specimens were investigated to optimize brick forming pressure. Fig. 8 shows that both individual pore size and total porosity decreased with increasing brick forming pressure. This is to be expected.

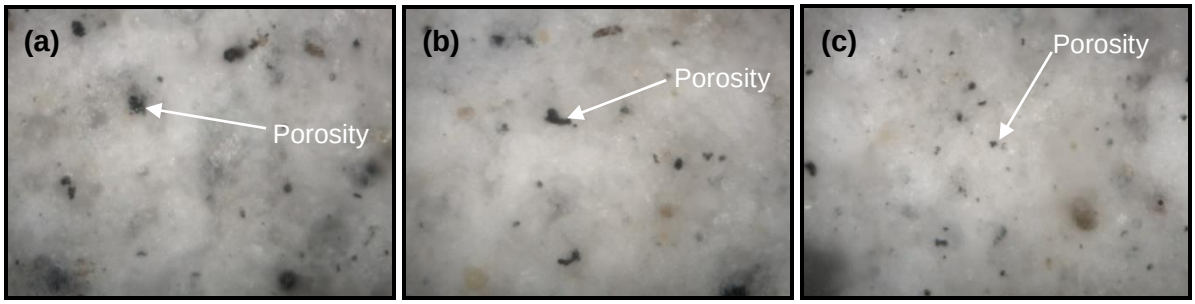


Figure 8: Microstructure of bricks formed with pressure (a) 1000 psi (b) 2000 psi (c) 3000 psi [All magnification 500X]

Shrinkage property

No noticeable shrinkage occurred as was measured for specimens T14, T15 and T16.

Unit volume weight

With increasing brick forming pressure unit volume weight of the bricks increased (Fig. 9). But above 2000 psi the change in density was insignificant. Maximum density of 1.81 gm /cc was found for bricks formed under 3000 psi pressure which is much lower than the density of fired clay based bricks.

Initial rate of absorption (IRA)

Initial rate of absorption of bricks made under 1000 psi pressure exceeded 30 gm and so according to ASTM C 67 – 00 these bricks should be wetted before laying (Fig. 10). With increasing brick forming pressure IRA decreased below 30 gm. Lowest IRA of 14.84 gm was found for a pressure of 3000 psi. The standard suggests that these bricks need not be wetted before laying..

Absorption capacity

As shown in Fig. 10 absorption capacity was 14.63% for brick forming pressure 1000 psi. With increasing pressure this value dropped down to 11.58% for a pressure of 3000 psi. Above 2000 psi pressure change in absorption capacity was not significant.

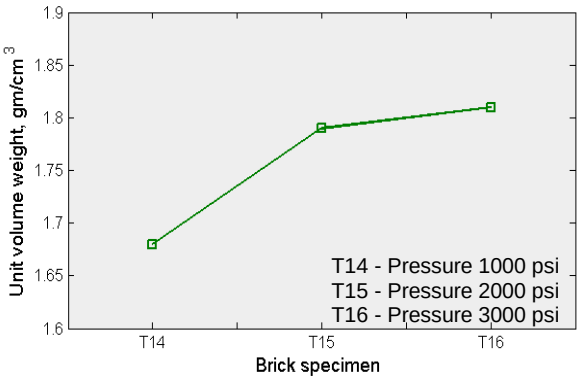


Figure 9: Effect of brick forming pressure on unit volume weight.

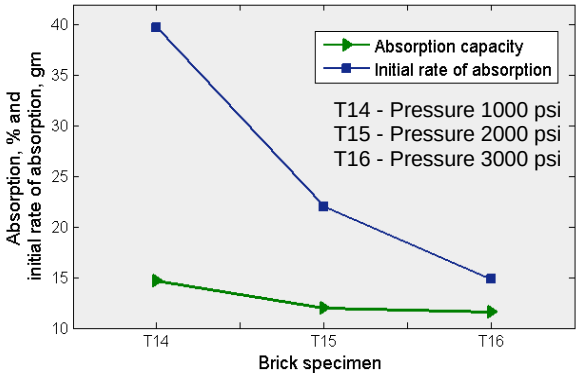


Figure 10: Effect of brick forming pressure on absorption capacity and IRA.

Apparent porosity, open pore and impervious pore

Effect of brick forming pressure on apparent porosity, open pore and close pore volume is shown in Fig. 11. Apparent porosity decreased with increasing pressure. Above 2000 psi the change was insignificant. Open pore volume also followed the same trend. Whatever, impervious pore volume was not affected by brick forming pressure.

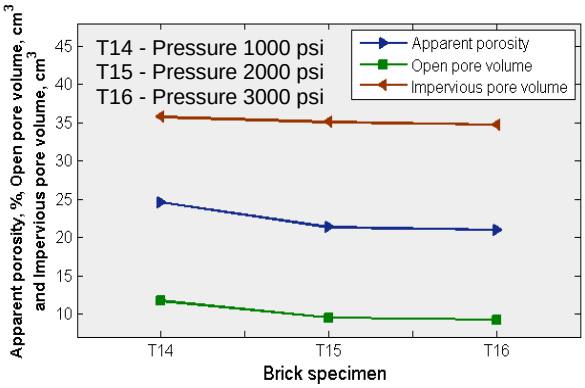


Figure 11: Effect of brick forming pressure on apparent porosity, open pore and impervious pore volume.

CONCLUSION

The following main conclusions can be drawn from this study:

- The optimum composition of fly ash-sand-lime-gypsum unfired bricks was fly-ash 55 percent, sand 30 percent, lime 15 percent and gypsum 14 percent and optimum brick forming pressure was 3000 psi.
- For optimum composition and pressure bricks cured under spray water twice a day exhibited maximum compressive strength of 342.81 gm/ cm^2.
- Increased brick forming pressure showed an increase in compressive strength and unit volume weight and a decrease in IRA, absorption capacity, apparent capacity and open pore volume. Impervious pore volume was found to be virtually independent of the brick forming pressure.
- For optimum composition and pressure bricks exhibited following properties:
    - No shrinkage.
    - Unit volume weight: 1.81 gm/ cm^3.
    - Initial rate of absorption (IRA): 14.84 gm. So these bricks need not be wetted before laying.
    - Absorption capacity: 11.58%.
    - Apparent porosity: 20.99%.
    - Open pore volume: 9.23 cm^3.
    - Impervious pore volume: 34.74 cm^3.

Even though further studies will be required before a final comment is made, the fly ash–sand–lime-gypsum bricks produced in this study seem to be suitable for use as construction material. The production of this type of bricks (if viable technically, commercially and health-wise) will certainly contribute to the recycling of the fly ash and hence minimize the negative impact on the environment.

REFERENCES

1. Baykal and Doven, A.G. 2000. Utilization of fly ash by pelletization process; theory, application areas and research results, *Resour Conserv Recy,* Vol. 30, pp. 59–77.
2. Cicek, T. and Tanrıverdi, M. 2007. Lime based steam autoclaved fly ash bricks, *Construction and Building Materials,* Vol. 21, pp. 1295–1300.
3. Goni, S. Guerrero, A. Luxan, M.P. and Macias, A. 2003. Activation of the fly ash pozzolonic reaction by hydrothermal conditions, *Cem Concr Res*, Vol. 33, pp.1399–405.
4. Klimesch, D.S. and Ray, A. 1998. Effect of quartz particle size on hydro garnet formation during autoclaving at 180 ^{O}C in the $CaO–Al_2O_3 –SiO_2 –H_2O$ system, *Cem Concr Res*, Vol. 28, pp. 1309–16.
5. Iyer, R.S. and Scott, J.A. 2001. Power station fly ash-a review of value-added utilization outside of the construction industry resources, *Conserv Recy*, Vol. 31, pp. 217–28.
6. Pimraksa, K. Wilhelm, M. Kochberger, M. and Wruss, W. 2001. A new approach to the production of bricks made of 100% fly ash, *International ash utilization symposium*, Available from: http://www.flyash.info/agenda.html.
7. Poon, C.S. Kou, S.C. and Lam, L. 2002. Use of recycled aggregates in molded concrete bricks and blocks, *Constr Build Mater*, Vol. pp. 281–9.
8. Toktay, M. C. and Etin, B. 1991. Mechanical strength and water absorption properties of autoclaved fly ash-lime bricks, TMMOB, *Chamber of Civil Engineers' Publication*, Vol. 1, pp. 385–394.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.118 (1-10)

Proceedings of the WasteSafe 2013 – 3rd International Conference on Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Extraction of Gelatin from Fish Processing by-Products and Its Utilization as Biodegradable Food Packaging Materials

Md. Sazedul Hoque[1*], Soottawat Benjakul[2] and Thummanoon Prodpran[3]

[1] Department of Fisheries Technology, Faculty of Fishereis, Patuakhali Science and Technology University, Dumki, Patuakhali, Bangladesh
[2] Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, 90112, Thailand
[3] Department of Material Product Technology, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, 90112, Thailand

ABSTRACT

Cuttlefish (Sepia pharanois) ventral skin was used for gelatin extraction to utilize the fish processing by-products. Extracted gelatin was used for preparation of film containing 3% protein and 20% glycerol. Stability of gelatin film (CG) and film incorporated with Fenton's reagent (H_2O_2 0.02 M + Fe_2SO_4 0.002 M) (FG) was evaluated after 21 days of storage. After storage time slight increase in tensile strength (TS) was found for FG film ($p<0.05$). Furthermore, water vapor permeability (WVP) increased for both films ($p<0.05$). When CG and FG film were used to cover chicken meat powder, the samples covered with both films had lower moisture content, peroxide values (PV) and thiobarbituric acid reactive substances (TBARS), compared with control samples (without cover) ($p<0.05$). Generally, FG film showed more preventive effect than CG film. However, both films were poorer in preventing moisture and retarding the color changes of chicken meat powder than low-density polyethylene (LDPE) films. Thus, gelatin-based film, especially modified with Fenton's reagent could be used as a biodegradable packaging material to prevent lipid oxidation in oil enriched foods.

Keywords: gelatin film; Fenton's reagent; cuttlefish skin; storage stability; shelf-life extension; food packaging; chicken meat powder; lipid oxidation

INTRODUCTION

Fisheries is an important sector of Bangladesh in terms of creating job opportunities, meeting the demand of animal protein, earning of foreign exchange and gross domestic growth. Fisheries sector are making a valuable contribution in economic development of Bangladesh. About 4603.83 core TK. was earned by exporting 96469 metric tons of fish and fisheries products in 2010-2011 contributing 2.73% of the country's total export earning (DoF, 2012). Different kinds of shellfish and finfish are the main exportable items from Bangladesh and other south-east Asian countries. The fish and fishery products are mainly exported as frozen products. Among the different fish, Cuttlefish has become an important fishery product in Thailand as well as other south-east Asian countries, and is mainly exported worldwide. During processing of cuttlefish, skin is generated as a by-product with the low market value. To increase its profitability, cuttlefish skin has recently been used for gelatin extraction (Hoque et al. 2010).

Biodegradable films made from renewable biopolymers have become important environmental friendly materials for packaging (Prodpran and Benjakul 2005; Hoque et al. 2010). Most synthetic films are non-biodegradable and are associated with environmental pollution and serious ecological problems. As a

consequence, biodegradable or edible films from biopolymers have paid increasing attention. Gelatin has been used as a material for preparing biodegradable films with high transparency and excellent barrier characteristics against gas, organic vapor and oil, compared to synthetic films (Jongiareonrak et al. 2006). However, gelatin film has poor water barrier property and this is the main drawback of gelatin films for their application as a packaging material (Hoque et al. 2011a;). Recently, Hoque et al. (2011b) reported that Fenton's reagent (H_2O_2 0.02 M + Fe_2SO_4 0.002 M) could increase the mechanical, barrier properties and thermal stability of cuttlefish skin gelatin-based film. This film could be used as an alternative packaging for prevention of lipid oxidation in foods. However, this protein films might undergo changes during extended storage and its function can be altered.

In general, edible film and coatings from proteins can extend the shelf-life of foods by functioning as solute, gas and vapor barriers (Krochta 1997). Artharn et al. (2009) found the lower thiobarbituric acid reactive substances and yellowness of dried fish powder than control (without cover), when round scad muscle protein-based films were used to cover fish powder stored at room temperature. Thus, the aims of this investigation were to study the extraction of gelatin from cuttlefish skin and preparation of gelatin-based films without and with Fenton's reagent, and to investigate the use of the films to extend the shelf-life of dried chicken meat powder.

MATERIALS AND METHODS

Chemicals

Bovine serum albumin and wide range molecular weight protein markers were purchased from Sigma Chemical Co. (St. Louis, MO, USA). All chemicals were used of analytical grade.

Collection and preparation of cuttlefish skin

Ventral skin of cuttlefish (*Sepia pharaonis*) was obtained from a dock in Songkhla, Thailand. Cuttlefish skin was stored in ice with a skin/ice ratio of 1:2 (w/w) and transported to the Department of Food Technology, Prince of Songkla University within 1 h. After cleaning cuttlefish skin was placed in polyethylene bags and stored at -20 ºC until use. Prior to gelatin extraction, the frozen skin was thawed using running water (25-26 ºC) until the core temperature reached 0 - 2 ºC.

Extraction of gelatin from cuttlefish skin

Gelatin was extracted from cuttlefish skin according to the method of Hoque et al. (2010). Skin was soaked in 0.05 M NaOH with a skin/solution ratio of 1:10 (w/v) with a gentle stirring at room temperature (26–28 ºC). The solution was changed every hour to remove non-collagenous proteins for totally 6 h. Alkali treated skin was then washed with distilled water until the neutral pH of wash water was obtained. The prepared skin was subjected to bleaching in 5% H_2O_2, using a sample/solution ratio of 1:10 (w/v) for 48 h at 4 ºC. The skin treated with H_2O_2 was washed three times with 10 volumes of distilled water. Gelatin was extracted from bleached skin using distilled water at 60 ºC for 12 h, with a sample/water ratio of 1:2 (w/v). The extract was centrifuged at 8,000xg for 30 min at room temperature using a refrigerated centrifuge (Beckman Coulter, Avanti J-E Centrifuge, Beckman Coulter, Inc., Palo Alto, CA, USA) to remove insoluble materials. The supernatant was collected and freeze-dried (Model Duratop™ IP/Dura Dry™ IP, FTS® System, Inc., Stone Ridge, NY, USA). The dry matter was referred to as 'gelatin powder'.

Preparation and storage of film from gelatin incorporated without and with Fenton's reagent

Gelatin powder was dissolved in distilled water and heated at 70° C for 30 min (Hoque et al. 2010). Gelatin solutions containing 3% protein were prepared. The solution was then added with glycerol at a level of 20% (based on protein content) and mixed thoroughly. The mixtures obtained were referred to as 'film-forming solution; FFS'. To prepare the film added with Fenton's reagent, gelatin solution was added with a mixture of H_2O_2 and $FeSO_4$ to yield the final concentration of 0.02 M H_2O_2 and 0.002 M $FeSO_4$, respectively (Hoque et al. 2011b).

FFS incorporated without and with Fenton's reagent were used for film casting. FFS (4 ± 0.01 g) was cast onto a rimmed silicone resin plate (5 x 5 cm^2), air-blown for 12 h at room temperature and dried in an environmental chamber (Binder, KBF 115 # 00-19735, D-78532, Tuttalingen, Germany) at 25 ± 0.5 ºC and 50 ± 5% relative humidity (RH) for 48 h. Dried films were manually peeled-off and subjected to analyses. Films obtained from gelatin (without addition of Fenton's reagent) and films added with Fenton's reagent were referred to as 'CG' and 'FG' films, respectively. Both CG and FG films were stored in an environmental chamber at 25 ± 0.5 ºC and 50 ± 5% relative humidity (RH). Films samples were taken at 0 and 21 days of storage for analyses.

ANALYSES

Film thickness

The thickness of film was measured using a digital micrometer (Mitutoyo, Model ID-C112PM, Serial No. 00320, Mituyoto Corp., Kawasaki-shi, Japan). Ten random locations around each film sample were used for thickness determination.

Mechanical properties

Tensile strength (TS) and elongation at break (EAB) were determined as described by Iwata et al. (2000) using the Universal Testing Machine (Lloyd Instrument, Hampshire, UK). Ten samples (2 x 5 cm^2) with the initial grip length of 3 cm were used for testing. The samples were clamped and deformed under tensile loading using a 100 N load cell with the cross-head speed of 30 mm/min until the samples were broken.

Water vapor permeability (WVP)

WVP was measured using a modified ASTM (American Society for Testing and Materials 1989) method as described by Shiku et al. (2004). The film was sealed on an aluminum permeation cup containing dried silica gel (0% RH) with silicone vacuum grease. The cup was placed at 30 ºC in a desiccator containing the distilled water. It was then weighed at 1 h intervals for up to 8 h. WVP of the film was calculated as follows:

$$WVP \text{ (g m}^{-1} \text{ s}^{-1} \text{ Pa}^{-1}) = wlA^{-1} t^{-1} (P_2 - P_1)^{-1} \quad (1)$$

where w is the weight gain of the cup (g); l is the film thickness (m); A is the exposed area of film (m^2); t is the time of gain (s); (P_2 - P_1) is the vapor pressure difference across the film (Pa).

Film solubility

Film solubility in water was determined according to the method of Gennadios et al. (1998) with a slight modification. The conditioned film sample (3x2 cm^2) was weighed and placed in 50 ml-centrifuge tube containing 10 ml of distilled water with 0.1% (w/v) sodium azide. The mixture was shaken continuously at room temperature for 24 h using a shaker (Heidolph UNIMAX 1010, Schwabach, Germany). Undissolved debris film matter was determined after centrifugation at 3000xg for 10 min at 25 ºC and drying them at 105 ºC for 24 h to obtain the dry unsolubilized film matter. The weight of solubilized dry matter was calculated by subtracting the weight of unsolubilized dry matter from the initial weight of dry matter and expressed as the percentage of total weight.

Microstructure

Microstructure of upper surface and freeze-fractured cross-section of the film samples were visualized using a scanning electron microscope (SEM) (Quanta400, FEI, Tokyo, Japan) at an accelerating voltage of 10 kV. Prior to visualization, the film samples were mounted on brass stub and sputtered with gold in order to make the sample conductive.

EFFECT OF CUTTLEFISH SKIN GELATIN FILM ON STORAGE STABILITY OF DRIED CHICKEN MEAT POWDER

Preparation of dried chicken meat powder

Fresh chicken meat was purchased from a local market in Hat Yai, Songkhla, Thailand. Meat was washed with cold water. The meat was then steamed for 20 min with an electric steamer (Jixing, CS-032, Guangdong, China). After cooling in air, the steamed chicken was shredded manually. Prepared sample was subjected to drying using a hot-air oven with an air velocity of 1.5 m/s at 60 °C until moisture content was less than 5%. The dried sample was powderized using a blender (Moulinex, Type AY46, Shenzhen, Guangdong, China).

Quality changes of dried chicken meat powder covered with cuttlefish skin gelatin films during storage

Chicken meat powder (15 g) was transferred to a cylindrical glass cup with a diameter of 25 mm. The cup containing chicken meat powder was covered with CG and FG films and sealed with an O-ring. LDPE (CO_2, N_2 and O_2: 1.7 $x10^{-10}$, 0.1 $x10^{-10}$ and 0.4 $x10^{-10}$ m^3 mm/cm^2 s cmHg at 25 °C, 1 atm pressure, respectively) films with a thickness of 0.038 ± 0.003 mm were also used to cover the samples. Sample without film covering was used as the control. The samples were stored at 28–30 °C and were taken every 3 days for 21 days for analyses of moisture content (AOAC 1999), peroxide value, TBARS and color.

Peroxide value

Peroxide value (PV) was determined as per the method of Richards and Hultin (2002) with a slight modification. Chicken meat powder (1 g) was homogenized at a speed of 13,500 rpm for 2 min in 11 ml of chloroform/methanol (2:1, v/v) using an IKA homogenizer (Selangor, Malaysia). Homogenate was then filtered using Whatman No. 1 filter paper (Whatman International Ltd., Maidstone, England). Two milliliters of 0.5% NaCl were then added to 7 ml of the filtrate. The mixture was vortexed at a moderate speed for 30 s and then centrifuged at 3000x*g* for 3 min to separate the sample into two phases. Two milliliters of cold chloroform/methanol (2:1) were added to 3 ml of the lower phase. Twenty-five microliters of ammonium thiocyanate and 25 µl of iron (II) chloride were added to the mixture. Reaction mixture was allowed to stand for 20 min at room temperature prior to reading the absorbance at 500 nm. A standard curve was prepared using cumene hydroperoxide at a concentration range of 0.5–2 ppm.

Thiobarbituric acid-reactive substances (TBARS)

Thiobarbituric acid-reactive substances (TBARS) were determined as described by Buege and Aust (1978). Chicken meat powder (0.2 g) was mixed with 2.5 ml of a TBA solution containing 0.375% thiobarbituric acid, 15% trichloroacetic acid and 0.25 N HCl. The mixture was heated in a boiling water bath (95–100 °C) for 10 min to develop a pink color, cooled with running tap water and then sonicated for 30 min, followed by centrifugation at 5000*g* at 25 °C for 10 min. The absorbance of the supernatant was measured at 532 nm. A standard curve was prepared using 1,1,3,3-tetramethoxypropane (MDA) at the concentration ranging from 0 to 10 ppm and TBARS were expressed as mg of MDA equivalents/kg of sample.

Color

Color of chicken meat powder was determined using a CIE colorimeter (Hunter associates laboratory, Inc., Reston, VA, USA). Color was calculated according to the following equation (Gennadios et al. 1996):

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad (2)$$

where ΔL^*, Δa^* and Δb^* are the differences between the corresponding color parameter of the sample and that of white standard (L^*= 93.63, a^*= -0.92 and b^*= 0.42).

STATISTICAL ANALYSIS

Experiments were run in triplicate. Data were subjected to analysis of variance (ANOVA) and mean comparisons were carried out by Duncan's multiple range test, T-test was used for pair comparison (Steel

and Torrie 1980). Analysis was performed using the SPSS package (SPSS 11.0 for windows, SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Stability of cuttlefish skin gelatin films

Thickness

Thickness of CG and FG films at day 0 and 21of storage is shown in Table 1. The higher thickness was observed for FG film, compared with CG film ($p<0.05$). The result suggested that Fenton's reagent could affect the film matrix via radical mediated protein modification, in which the pretruded film matrix was developed when Fenton's reagent was added. This result confirmed that reported by Hoque et al. (2011b).

Mechanical properties

Mechanical properties of CG and FG films before and after storage for 21 days are shown in Table 1. FG films showed the higher TS but lower EAB, compared with the CG film ($p<0.05$). TS of FG film was 35.65% higher than that of CG film. 'Fenton-type' reaction is a metal-catalyzed oxidation system, where the $HO^{\bullet}$ radicals are produced when certain transition metals react with H_2O_2 (Kocha et al. 1997). Two different carbon-centered amino acid radicals can react with one another to form –C–C– protein cross-linked products (Stadtman 2001). Hoque et al. (2011c) also found the similar results for both gelatin and partially hydrolyzed gelatin films, in which TS increased via radical-mediated protein modification induced by Fenton's reagent.

After 21 days of storage, similar mechanical properties were observed for CG film ($p>0.05$). However, FG film had increased TS and EAB after storage for 21 days ($p<0.05$). The increases in TS and EAB of films during the storage were possibly due to the increased radical-mediated aggregation, which still took place to some extent during storage. Increased TS but decreased EAB were observed for fish muscle protein-based film during storage (Tongnuanchan et al. 2011; Artharn et al. 2009). Thus, modification or alteration of film matrix still occurred when Fenton's reagent was incorporated, especially as the storage time increased. Radicals generated in film might be involved in inducing the covalent cross-linking of gelatin, thereby strengthening film matrix.

Table 1: Thickness, mechanical properties, water vapor permeability and solubility of films from cuttlefish skin gelatin without and with Fenton's reagent at day 0 and 21 of storage.

Storage time (days)	Film sample	Thickness (mm)	TS (MPa)	EAB (%)	WVP ($x10^{-10}$ g $s^{-1}.m^{-1}.Pa^{-1}$)	Film solubility (%)
0	CG	0.038±0.002 bA	32.45±2.49 bA	5.94±0.49 aA	1.02±0.06 aB	93.36±1.31 aA
	FG	0.042±0.002 aA	44.02±1.20 aB	5.04±0.20 bB	0.92±0.04 bB	71.59±1.76 bA
21	CG	0.038±0.002 bA	35.50±2.83 bA	6.18±0.55 aA	1.26±0.07 aA	90.58±1.55 aB
	FG	0.042±0.002 aA	45.84±1.44 aA	5.60±0.48 aA	1.11±0.04 bA	66.85±1.93 bB

Values are given as Mean ± SD (n=3).
Different small letters in the same column under the same storage time indicate significant differences ($p< 0.05$).
Different capital letters in the same column under the same sample indicate significant differences ($p< 0.05$).
CG: control films from gelatin (without addition of Fenton's reagent).
FG: films from gelatin added with Fenton's reagent containing 0.02 M H_2O_2 + 0.002 M $FeSO_4$.

Water vapor permeability (WVP)

WVP of films prepared from CG and FG at day 0 and 21 of storage is presented in Table 1. FG film showed the lower WVP, compared with GF film ($p<0.05$). The result suggested that radical-mediated cross-linking of protein molecules in film matrix might decrease the free volume and mobility of polymeric structure, thereby lowering the diffusion of water as indicated by the lower WVP. After storage of 21 days,

WVP of both films increased (p<0.05). The result suggested that the hydrophilic nature of gelatin favored interaction between gelatin molecules and water during storage. An increased hydrophilicity of film matrix contributed to the decreased water barrier property of film. Increased WVP was also observed for cod skin gelatin film with and without addition of sunflower oil after storage for 30 days (Pérez-Mateos et al. 2009). Different changes in WVP between films from varying proteins might be governed by the differences in amino acid compositions and molecular weight distribution of materials used for film preparation.

Film solubility

Films solubility of CG and FG films at day 0 and 21 of storage is shown in Table 1. CG film showed the higher solubility than FG film. Gelatin from cuttlefish skin had high hydrophilic amino acids, thus it was soluble with ease in water (Hoque et al. 2010). However, Fenton's type reaction induces the covalent cross-linking of gelatin via radical generated (Stadtman 2001), as evidenced by decreased film solubility. It was noted that the decreases in film solubility were observed for both films after storage for 21 days (p<0.05). The intermolecular rearrangement of gelatin to form rigid polymeric structure might cause a decreased solubility. The slight decrease in solubility was in accordance with the slight increases in TS and EAB of film. Thus, interaction of gelatin molecules still proceeded in film matrix to some extent during storage.

Microstructure

SEM micrographs of the surface and freeze-fractured cross-section of CG and FG films at 0 and 21 days of storage are illustrated in Figure 1. At day 0, smooth surface was observed for both films. After 21 days of storage, no obvious changes were found on the surface of both films. For cross-section, the rough cross-sectional structure was observed in CG film, whereas FG film samples showed the compact/coarser structure. After storage for 21 days, the crack was formed throughout the film. The fracture was more pronounced in FG films. Those cracks in the film matrix could allow water vapors to migrate through the fracture, as indicated by increased WVP of both films after 21 days of storage. This resulted in the formation of higher micro-crack in the film matrix. Those cracks exhibited the detrimental effect on the water barrier property of gelatin film during storage. The increase in crack with higher gap in cross-section was also found in red tilapia (*Oreochromis niloticus*) muscle protein isolate (FPI) and unwashed mince (UWM) films during storage of 40 days (Tongnuanchan et al. 2011).

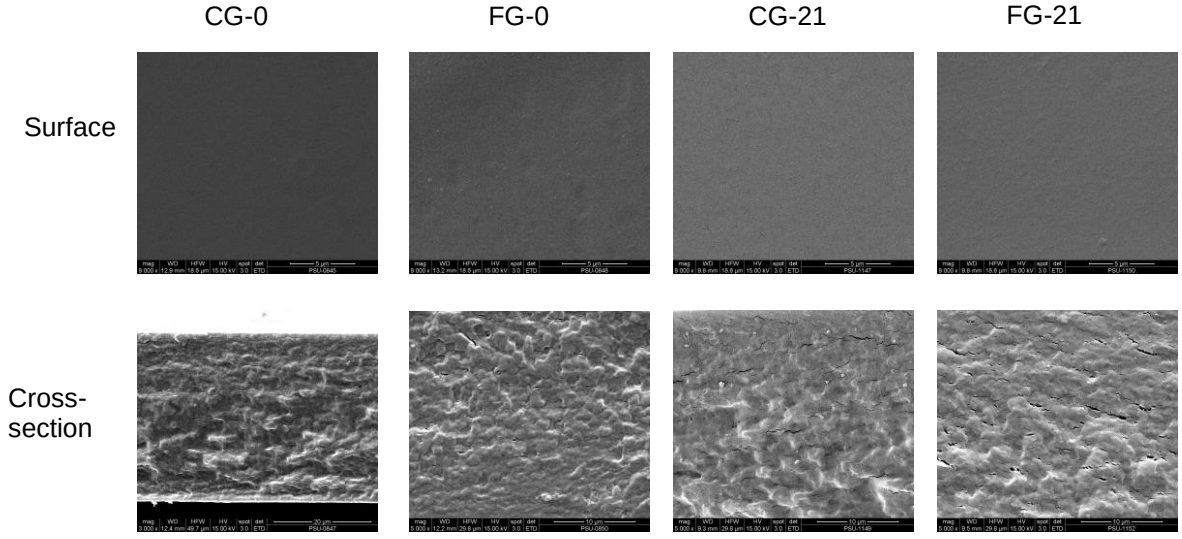


Figure 1: Morphology of films from cuttlefish skin gelatin (CG) and gelatin film added with Fenton's reagent (FG) at day 0 and 21 of storage. Magnification: x 8000 and x 5000 for surface and cross-section, respectively.

EFFECTS OF CUTTLEFISH SKIN GELATIN FILMS ON QUALITY CHANGES OF DRIED CHICKEN MEAT POWDER DURING STORAGE

Moisture content of dried chicken meat powder

Moisture contents of dried chicken meat powder without cover (control) and covered with CG and FG films in comparison with those of samples covered with low density polyethylene (LDPE) films during storage of 21 days at 28-30 ºC are shown in Figure 2. In general, moisture content of dried chicken meat powder uncovered and covered with CG and FG films increased continuously during 21 days of storage ($p< 0.05$). However, the highest increase in moisture content of dried chicken meat powder was observed from the uncovered samples, especially during the first 12 days of storage ($p<0.05$). The sample covered with LDPE films had much lower moisture content than other samples during the storage ($p< 0.05$). Dried chicken meat powder was able to bind water molecules via specific hydrophilic domains, such as carboxylic, amino and hydroxyl residues of proteins. The higher moisture diffusion from the environment through the packaging material increases the moisture content of packed sample. Additionally, the micro-cracks formed in CG and FG films (Figure 1) might favor the migration of water into chicken meat powder. The result suggested that gelatin film possessed poor water barrier property, mainly due to high amount of hydrophilic amino acids (Jongiareonrak et al. 2006). Artharn et al. (2009) also reported that moisture content of dried fish powder packed with round scad protein-based film and chitosan film containing 25 % palm oil was higher than that of those packed with HDPE film ($p<0.05$) during storage of 21 days. Thus, the gelatin and modified gelatin film able to prevent moisture absorption by the products to some extent but their preventive effect was lower than LDPE films.

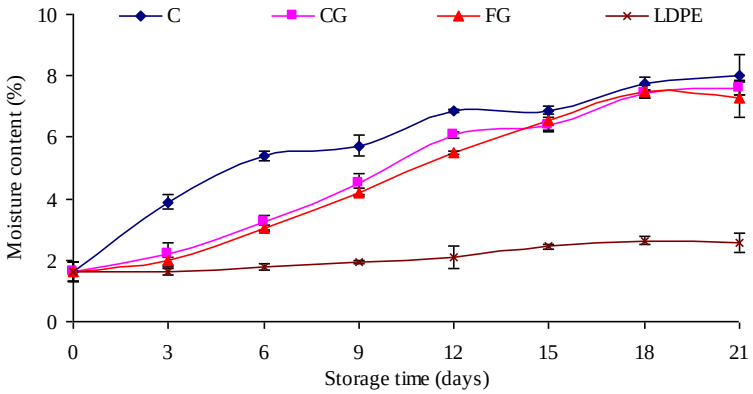


Figure 2: Changes in moisture content f dried chicken meat powder uncovered and covered with different films during storage of 21 days. C: Uncovered; CG: cuttlefish skin gelatin film; FG: gelatin film added with Fenton's reagent; LDPE: low density polyethylene. Bars represent the standard deviation (n=3).

Lipid oxidation of dried chicken meat powder

Lipid oxidation of dried chicken meat powder uncovered (control) and covered with CG and FG films in comparison with that of samples covered with LDPE films during storage of 21 days was monitored by measuring PV and TBARS (Figure 3Aand 3B respectively). PV value of chicken meat powder samples uncovered and covered with all films increased at day 3 of storage ($p<0.05$). Thereafter, the decrease was found in all samples at day 6 ($p<0.05$), except the uncovered sample. In general, the highest PV was found in uncovered samples during 6-21 days of storage ($p<0.05$). No marked changes in PV were observed for sample covered with all films during storage. Nevertheless, sample covered with FG film tended to have the lowest PV, followed by CG film, suggesting the prevention of oxidation by the FG film. Hydrophilic nature of gelatin can successfully prevent the hydrophobic oxygen gas permeation into the products, thus reducing the oxidation catalytic process. Jongiareonrak et al. (2006) reported that gelatin film has excellent barrier characteristics against gas, compared to synthetic films. Thus, gelatin film, especially gelatin film incorporated with Fenton's reagent, could retard the lipid oxidation of dried chicken meat powder during extended storage time.

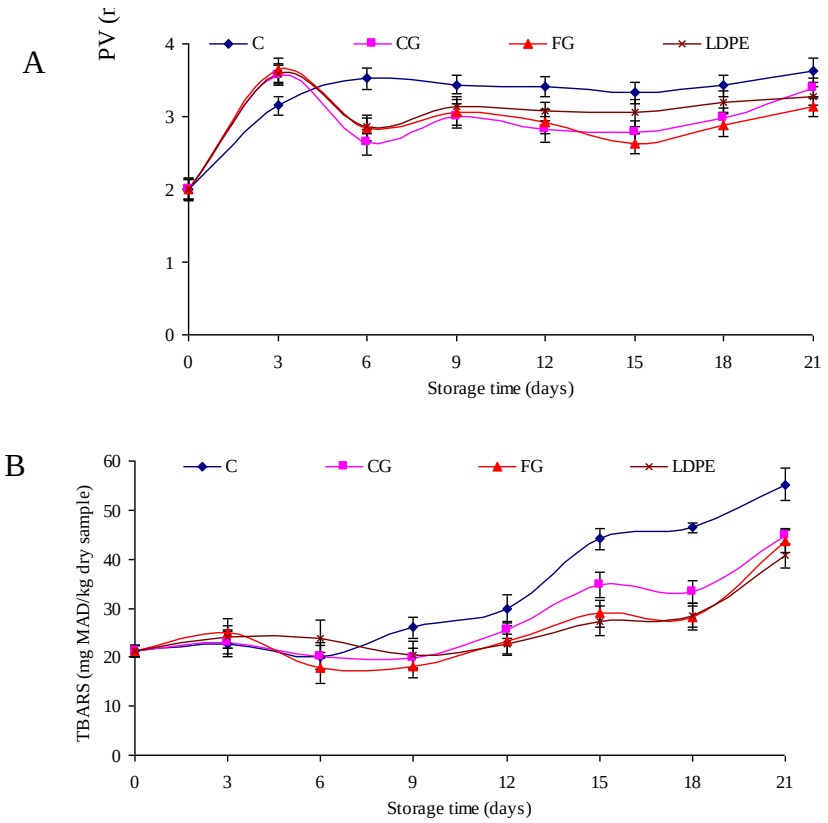


Figure 3: Changes in PV (A) and TBARS (B) of dried chicken meat powder uncovered and covered with different films during storage of 21 days. C: Uncovered; CG: cuttlefish skin gelatin film; FG: gelatin film added with Fenton's reagent; LDPE: low density polyethylene. Bars represent the standard deviation (n=3).

TBARS of dried chicken meat powder uncovered (control) and covered with different films during storage of 21 days at 28-30 ºC are presented in Figure 3B. Similar TBARS values of chicken meat powder samples uncovered and covered with all films were observed within the first 6 days of storage (p>0.05). Subsequently, the gradual increase in TBARS was observed for all samples up to 21 days of storage (p<0.05). The sample without cover showed the highest TBARS value than those covered with all films up to 21 days (p<0.05). It was noted that TBARS values of sample covered with FG and LDPE were similar throughout the storage of 21 days. However, sample covered with CG film had the higher TBARS value than others during 15-18 days of storage (p<0.05). The result suggested that FG film, a radical induced modified gelatin film, had higher oxygen barrier properties than CG films. Protein-based films have impressive oxygen and carbon dioxide barrier properties in low relative humidity condition compared to synthetic films (Limpan et al. 2010). Therefore, the protein-based film can be used as the packaging material to retard rancidity of foods.

Color of dried chicken meat powder

L*, a*, b* and ΔE*-values of dried chicken meat powder uncovered (control) and covered with different films during storage of 21 days are shown in Figure 4. Generally, continuous changes in color values were observed for all samples during storage. The uncovered dried chicken meat powder and powder covered with CG and FG films had the increase in L*-value but decrease in a*-, b*- and ΔE*-values during the extended storage of 21 days (p< 0.05). Highest moisture content in the uncovered sample might contribute to light scattering, leading to increased lightness. Generally, chicken meat powder covered with LDPE films had the constant values for L*-, a*-, b*- and ΔE*-values during 21 days of storage. The result suggested that the poorer water barrier property of CG and FG films was more likely associated with the induced changes in color of dried chicken meat powder. Higher moisture content might favor the movement of reactants for discoloration reaction, especially the decrease in a*- values (redness) and b*-

values (yellowness). Thus, lipid oxidation products, especially in the control, in the presence of high moisture content, might destruct heme pigments. This resulted in decreased a*- and b*-values during the storage. Seydim et al. (2006) reported that the decreased redness in ground ostrich meat was due to myoglobin oxidation.

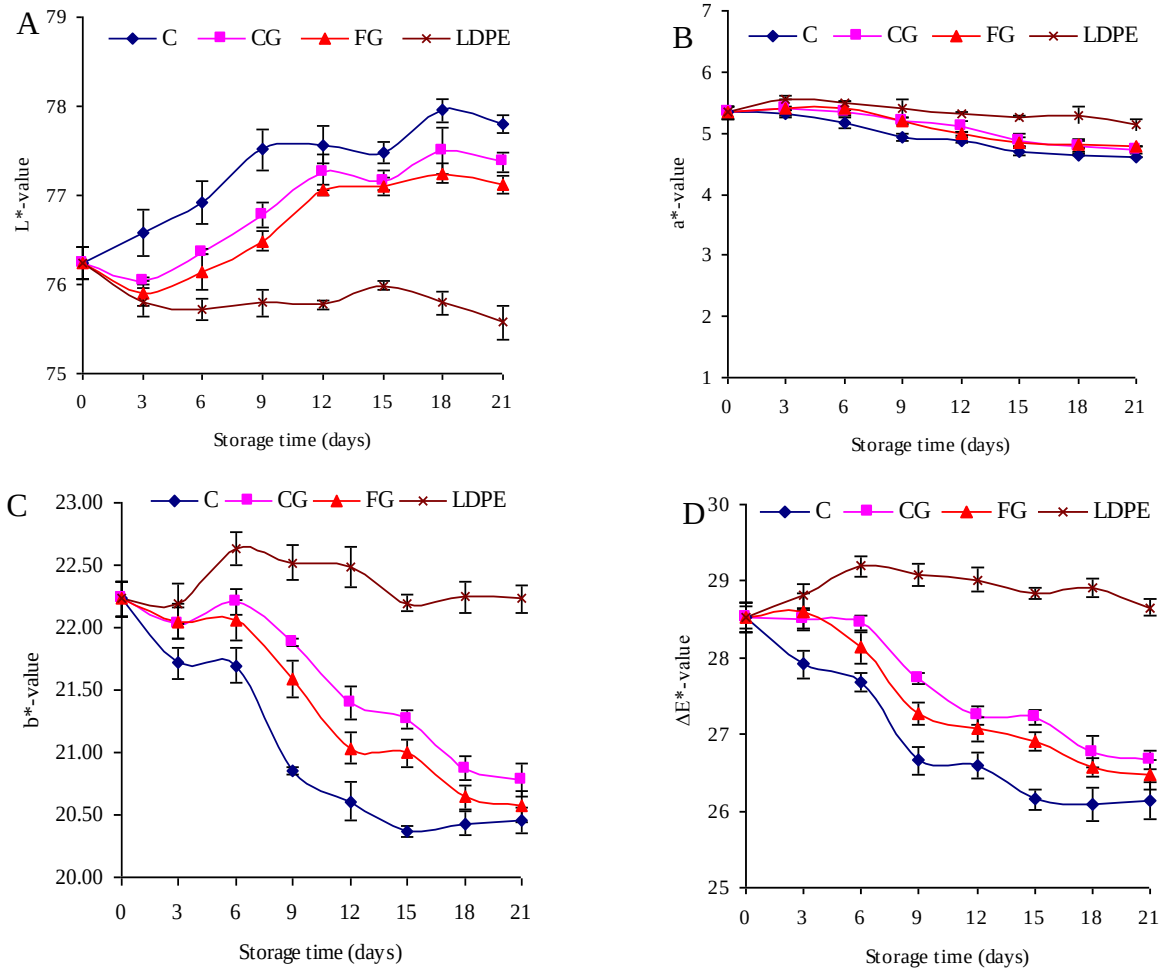


Figure 4: Changes in L*-value (A), a*-value (B), b*-value (C) and ΔE*-value (D) of dried chicken meat powder uncovered and covered with different films during storage of 21 days. C: Uncovered; CG: cuttlefish skin gelatin film; FG: gelatin film added with Fenton's reagent; LDPE: low density polyethylene. Bars represent the standard deviation (n=3).

CONCLUSION

Fish processing by products could be used for gelatin extraction. Gelatin has good film forming ability and stability during storage. Both CG and FG films underwent the molecular changes during storage of 21 days. This was associated with the increased mechanical properties but lowered water vapor barrier property. This change directly determined the protective role of films in dried chicken meat powder. FG film could prevent lipid oxidation of chicken meat powder comparably to LDPE film, but had the poorer water barrier property. Thus, the gelatin-based films could be used as environmental friendly biodegradable food packaging materials.

ACKNOWLEDGEMENT
The authors would like to thank the National Research University Project of Thailand's office of the Higher Education Commission and the Graduate School, Prince of Songkla University for financial support.

REFERENCE

Artharn, A., Prodpran, T. and Benjakul, S. 2009. Round scad protein-based film: Storage stability and its effectiveness for shelf-life extension of dried fish powder. *LWT - Food Science and Technology, 42*, 1238-1244.

ASTM. 1989. Standard test methods for water vapor transmission of materials. Standard designation E96-E80. In Annual book of ASTM standards (pp. 730–739), Philadelphia: ASTM.

AOAC. 1999. Official methods of analysis. 14th ed. Washington, DC: Association of Official Analytical Chemists.

Barreto, P. L. M., Pires, A. T. N. and Soldi, V. 2003. Thermal degradation of edible films based on milk proteins and gelatin in inert atmosphere. *Polymer Degradation and Stability, 79*, 147–152.

Buege, J. A. and Aust, S. D. 1978. Microsomal lipid peroxidation. *Methods Enzymol*, 52, 302-310.

DoF. 2012. National Fisheries Week. Statistics of exportable fish and fishery products. Department of Fisheries, Ministry of Fisheries and Livestock. pp 128.

Gennadios, A., Weller, C. L., Hanna, M. A. and Froning, G. W. 1996. Mechanical and barrier properties of egg albumen films. *Journal of Food Science, 61*, 585–589.

Gennadios, A., Handa, A., Froning, G. W., Weller, C. L. and Hanna, M. A. 1998. Physical properties of egg white-diadehyde starch films. *Journal of Agricultural and Food Chemistry, 46*, 1297-1302.

Hoque, M. S., Benjakul, S. and Prodpran, T. 2010. Effect of heat treatment of film-forming solution on the properties of film from cuttlefish (*Sepia pharaonis*) skin gelatin. *Journal of Food Engineering, 96*, 66-73.

Hoque, M. S., Benjakul, S. and Prodpran, T. 2011a. Effects of partial hydrolysis and plasticizer content on the properties of film from cuttlefish (*Sepia pharaonis*) skin gelatin. *Food Hydrocolloids, 25*, 82 -90.

Hoque, M. S., Benjakul, S. and Prodpran, T. 2011b. Effects of H_2O_2 and Fenton's reagent on the properties of film from cuttlefish (*Sepia pharaonis*) skin gelatin. *Food Chemistry*, Article In Press, Accepted Manuscript. Doi: 10/1016/j.foodchem. 2011.03.112.

Iwata, K., Ishizaki, S., Handa, A. and Tanaka, M. 2000. Preparation and characterization of edible films from fish water-soluble proteins. *Fisheries Science, 66*, 372-378.

Jongiareonrak, A., Benjakul, S., Vesessanguan, W., Prodpran, T. and Tanaka, M. 2006. Characterization of edible films from skin gelatin of brownstripe red snapper and bigeye snapper. *Food Hydrocolloids, 20*, 492-501.

Krochta, J. M. 1997. Edible Protein Films and Coatings. In Food Proteins and Their Applications. (Damodaran, S. and Paraf, A., eds.). pp. 529-549. Marcel Dekker. New York.

Kocha, T., Yamaguchi, M., Ohtaki, H., Fukuda, T. and Aoyagi, T. 1997. Hydrogen peroxide-mediated degradation of protein: different oxidation modes of copper- and iron-dependent hydroxyl radicals on the degradation of albumin. *Biochimica et Biophysica Acta (BBA) - Protein Structure and Molecular Enzymology, 1337*, 319-326.

Limpan, N., Prodpran, T., Benjakul, S., & Prasarpran, S. (2010). Properties of biodegradable blend films based on fish myofibrillar protein and polyvinyl alcohol as influenced by blend composition and pH level. *Journal of Food Engineering, 100*, 85-92.

Prodpran, T. and Benjakul, S. 2005. Effect of acid and alkaline solubilization on the properties of surimi based films*. Songklanakarin Journal of Science and Technology, 27*, 563 – 574.

Richards, M. P., & Hultin, H. O. (2002). Contributions of blood and blood components to lipid oxidation in fish muscle. *Journal of Agricultural and Food Chemistry, 50*, 555-564.

Seydim, A. C., Acton, JC, Hall M.A. and Dawson P.L. 2006. Effects of packaging atmospheres on shelf-life quality of ground ostrich meat. Meat Science, 73(3), 503-510.

Shiku, Y., Yuca Hamaguchi, P., Benjakul, S., Visessanguan, W. and Tanaka, M. 2004. Effect of surimi quality on properties of edible films based on Alaska pollack. *Food Chemistry, 86*, 493-499.

Stadtman, E. R. 2001. Protein oxidation in aging and age-related diseases. Annals of the New York Academy of Sciences, 928, 22-38.

Steel, R. G. D. and Torrie, J. H. 1980. Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill, New York.

Tongnuanchan, P., Benjakul, S., Prodpran, T. and Songtipya, P. 2011. Properties and stability of protein-based films from red tilapia (*Oreochromis niloticus*) protein isolate incorporated with antioxidant during storage. *Food and Bioprocess Technology*. DOI 10.1007/s11947-011-0584-9.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.124 (1-9)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

A Study on Impact of LPUPAP (Local Partnerships for Urban Poverty Alleviation Project) in Urban Poverty Alleviation: A Study on Greenland Slums in Khulna City

Alamgir Ahmed[1] and Didarul Alam Chowdhury[2]

[1]Urban & Rural Planning Discipline, Khulna University, Khulna
[2]Community Development Centre (CODEC), Bangladesh

ABSTRACT

Rapid population growth in urban areas of Bangladesh ,including Khulna the third largest city, caused by a heavy influx of migrants from rural areas, has led to mushrooming of slums and squatters in urban areas without any basic service facilities. Rapid growth of urban population has had serious social, economic and environmental consequences with slow urbanization in third world countries. The life of Bangladesh's urban poor is more difficult than that of the rural poor in some ways. In the last few years there has been growing awareness about the seriousness of the problems of urban poverty and the need for undertaking poverty alleviation programs. The city is growing without proper attention of the respective authorities. Consequently the slums and squatter settlements are growing desperately in the city. So, provide them all the urban facilities are going hard for the government. In Khulna there are 172 slum and squatter settlements. There are various program are organized for upgrading the condition of poor people who are living in slums and squatters. LPUPAP (Local Partnerships for Urban Poverty Alleviation project) is one of them. Main aim of this project was poverty reduction and provides the better living environment. Increasing the women participation was the other objectives of the project. The urban poor are the most unorganized section of any urban area- Empirical evidence suggests that there is a very little social development program in the poor urban communities where can participate and involves themselves to organize such programs as LPUPAP at the community level effectively. It's not possible to remove poverty at a small time period. But, if the Government and the NGOs are takes some initiatives like LPUPAP and takes some continuous program, then poverty could be alleviated.

Key Words: Population Growth, Urban Poor, Urban Poverty, LPUPAP (Local Partnerships for Urban Poverty Alleviation project)

INTRODUCTION

Bangladesh is the most populous country in the world with a population of over 153 million. It is also one of the world's poorest nations with a third of its population living in extreme poverty (UNDP 2008; WSUP 2007). While about only 26% of its population presently lives in urban areas, Bangladesh is rapidly urbanizing and is expected to have more than 40% urban population by 2030. The capital Dhaka is one of the fastest growing megacities in the world with a population of over 13.5 million, one-third of which lives in slums (CUS et al 2006). 300,000-400,000 mostly poor rural migrants arrive in cities annually in search of improved livelihoods (WSUP 2007), adding to the large slum population.

This rapid growth has been due primarily to migration by the rural poor, particularly to large metropolitan areas. On arrival, these poor migrants routinely turn to slums and squatter settlements for shelter. As quality urban housing is costly, the increasing numbers of urban poor living in slums and squatter search out inadequate water and sanitation facilities, and living conditions are crowded and often unhealthy (USAID 2003, Islam et. al. 2009). Given the country's poverty, weak governance and political instability, and assailed by frequent natural disasters, the urban poor have to fend for themselves against the regular fear of eviction and live in an environment of crime, violence and anarchy controlled by local gang lords. Slum dwellers have almost no voice in influencing policy decisions that affect their daily lives.

A large network of international and national NGOs operate in Bangladesh and many have community development programs in slums. The government has relatively less engagement in such programs, but a notable example is the Local Partnerships for Urban Poverty Alleviation Project (LPUPAP). The LPUPAP works with local government authorities and attempts to improve their services to the poor.

GENERAL OVERVIEW OF LPUPAP

Local Partnerships for Urban Poverty Alleviation Project (LPUPAP), executed by the Ministry of Local Government, Rural Development & Cooperatives and implemented by the Local Government Engineering Division (LGED) with funding from the United Nations Development Program (UNDP) and in partnership with UN-Habitat.

The project was implemented during 2000-07 and since then has moved into a second phase entitled Urban Partnerships for Poverty Reduction Project (UPPRP).

The objectives of the Local Partnerships for Urban Poverty Alleviation Projects are;

- Poverty alleviation through the empowerment of urban poor communities.
- To increase direct linkage between urban poor communities, national and local level government and non-government supportive efforts for poverty alleviation
- Increasing participation of urban poor in the basic services planning, implementation and monitoring.
- Utilizes their collective capacity, resources and power to improve their social and economic conditions.
- Coordination of concerned government and non-government organizations involved in providing services to the urban poor and ensuring increased participation of the community at ward level
- To provide guidance and inspiration to the Government and development affiliated organizations to reduce/remove urban poverty.

OBJECTIVE

- To explore the role of LPUPAP (Local Partnerships for Urban Poverty Alleviation Project) in urban Poverty Alleviation in Khulna city.

METHODOLOGY

The systematic and logical study is guiding a research towards achievement of the desired goals. The study will be based on a multifaceted research design comprising both qualitative and quantitative methods to achieve the objective.

Study Area and Sample Size Selection: The study area is selected for this study is Greenland slums 5 no. ghat in ward no.21 of Khulna City because of high concentration of urban poor people in this area. The study area is selected by considering some criteria's. Those are;

- The settlement cluster should be located on illegally occupied public land.
- Limited access to different service and facilities.
- Should be significant in terms of size of population, location, total area etc. within all other competitive clusters.
- Implemented LPUPAP project in this area.

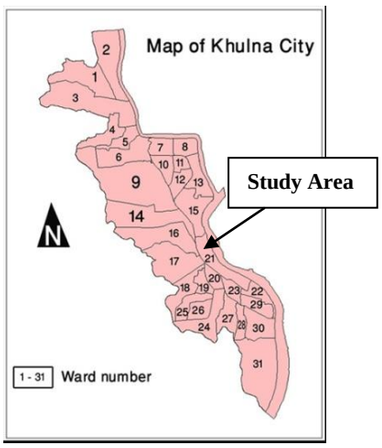


Table 1: Sample size selection

Cluster Name	Ward No.	Household Number	Population	Slum name	Sample Size (10 Percent)
Railway Colony	21	1021	895 905 1055 905 504 225	Green Land-A Green Land-B Green Land-C Green Land-D Green Land-E Green Land-F	102

The total number of sample size for this study is 102 and a systematic random sampling is conducted in the household level for this study.

Data Collection Protocols: For fulfilling the objectives of proposed study, required information will be collected from both primary and secondary data source.

Secondary Data: The secondary data is collected through reviewing different types of literature, official project documents, existing rules regulations, policy and strategies documents, development plans etc.

Primary Data: For this study the primary data is collected through using different tools and techniques. The tools and techniques are,

Direct Observation: It is constitute an effective tool from reconnaissance stage to actual survey. It will include transect walk through the case study area, taking photographs, documentation of special features etc. It provided the actual situation about the infrastructural, environmental, cultural aspects of the study area.

Household Survey: The study intends to conduct a household survey in order to get the information about the current situation and pattern of case study area. It will extract the information about socio-economic condition of the household, projects initiatives, success, lacking or gaps. The household survey is employed semi-structured questionnaires for conducting interview with household head.

Focus Group Discussion: It helps for extracting the combined information through meeting with a group of dwellers. In the study area there also conducted some FGD because of clarifying different past and

present situation in the case study area and cross check between other collected information. It also makes some joint suggestion for further improvement.

Data Compilation and Processing: After raw data collection, both primary and secondary data is compiled manually. The descriptive and unstructured materials from interviews, observation survey and other records were arranged in sequential order. The computer software packages as SPSS (Statistical Package for Social Sciences), office packages, Microsoft EXCEL is used for data processing.

Data Analysis and Conclusion Drawing: Processed data have been analyzed in the possible simple format by using tabular, graphical, charts, diagram and other interactive ways. The analysis is statistical and calculative as far as possible for the purpose of the study. Finally, based on the analysis a conclusion is drawn.

ANALYSIS OF THE STUDY FINDINGS

It has already been mentioned that a pre-structured questionnaire survey was conducted on the people who are in the selected study area. Various aspects of the findings are presented below:

Household Information

Household Size: On average, each household is composed of 4.4 for Greenland slum. Households of 4 to 6 members are the most common accounting for this slum. 55.9% are household members are 4 to 6. 13.7% are 1 to 3 household members, 23.5% are 7 to 9 household members, 6.8% are more than 9 household members.

Table 2: Household size of the study area

Household Size	Number of household	Percentage
1 to 3	14	13.7%
4 to 6	57	55.9%
7 to 9	24	23.5%
>9	7	6.8%
Total	102	100%

Source: Field Survey, 2011

Income and Occupation Pattern

Occupation Distribution of Adult Male: Main occupation of the Adult Male dwellers of the study area is labors and rickshaw/van pullers. According to the survey it reveals that 41.7% are Day labor, 15.7% are Rickshaw/Van puller. 10.8% is Retail Shopper and others are engaged in varied types of occupation.23% are day labor, 17% are engaged in small trading. 8% is engaged in domestic service.

Table 3: Occupation of the adult male

Occupation	Respondent			
	Before LPUPAP	%	After LPUPAP	%
Day labor	36	35.2	42	41.7
Rickshaw/Van puller	11	10.8	16	15.7
Retail Shopper	8	7.8	11	10.8
Tailor	6	5.9	7	6.9
Hocker	12	11.7	9	8.8
Driver	8	7.8	7	6.8
Helper	7	6.8	5	4.9
Caretaker	3	2.9	2	1.9
Others	10	9.8	3	2.9
Total	102	100	102	100

Source: Field Survey, 2011

Above the table show that before LPUPAP project the highest occupation (35.2%) was day labor and after LPUPAP project the highest occupation (41.7%) is day labor.

Occupation Distribution of Adult Women: Only the income of the male person is not sufficient for living. So women are related with various works. Most of the women are engaged with domestic service, statistically its 38.2%. Before this LPUPAP most of the women were workless or engaged in domestic service. But, now there are some variations of women's job. 15.7% are engaged with packet making, 12.7% are in small business, 9.8% are in Tailor, 3.9% are in beauty parlor, 7.8% are in preparing handicraft, 8.8% are in day labor/ construction worker and 2.9% are in others work.

Table 4: Occupation of adult women

Occupation	Number of respondent	Percentage (%)
Domestic work	39	38.2
Packet making	16	15.7
Small business	13	12.7
Tailor	10	9.8
Beauty parlor	4	3.9
Handicraft	8	7.8
Day labour	9	8.8
Others	3	2.9
Total	102	100

Source: Field Survey, 2011

Monthly Income of the Household: Income and savings of the households is most important indicator to assess their living condition. Level of Income of the family also indicates the nature of savings, social status, and quality of houses, expenditure pattern and other socio- economic aspects. Most of the respondents have an income less than 3000 BDT. According to the survey their total income range is minimum 2000 BDT to maximum 5500 BDT.

Table 5: Monthly Income of the Household.

Monthly Income (in tk)	Number of Household	Percentage
0-2000 tk	7	6.9
2000-3000 tk	43	42.2
3000-4000 tk	33	32.3
4000-5000 tk	14	13.7
>5000 tk	5	4.9
Total	102	100

Source: Field Survey, 2011

The above table shows that the 42.2% household income is a range of 2000-3000tk and 32.3% household income is in a range of 3000-4000tk.

Impact of LPUPAP to Basic Services

Accessibility of the urban poor to the basic services: People entree to various basic essential is very limited to urban poor. The poor populations of urban area increases but the services are not. Though the slums are located within city corporation limits, the peoples of these slums and squatter have limited access to the urban services such as water supply, sanitation, drainage, garbage disposal, child education, health facilities, electricity etc. The problems are becoming acute in the overcrowded slums in Khulna City. Though these services are basic right for every urbanite, but the slum dwellers are not able to get these services. Accesses to services are crucial to the survival of the poor in Khulna City.

Access to Water Supply: Municipality doesn't provide water supply facilities in this slum. But in Greenland slum LPUPAP project provides water supply facilities as a community service sinking deep tube - wells for the dwellers. There are 21 tube well are provided by UNDP and 5 Tube-well are provided KCC. Thus almost 100 percent households have water supply facilities in Greenland slum. Before this project people used different sources for drinking water, but now for this project 100% people are used tube well water for drinking water, and 46% people are used Tube-well water for their household chores. From the focus group discussion it finds that, after good water supply condition the water borne diseases arc decreases. From the observation survey it's come out that, the tube wells are near hand of the households.

Table 6: Number of Tube-well in the study area

Provider	No. of Tube-well
LPUPAP	21
KCC	5
Total	26

Source: Field Survey, 2011

Sources of Water Supply: Khulna City Corporation is the responsible authority for water supply in the city. KCC provide piped water supply and shallow or deep tube wells in the city. Piped water is generally provided from house to house and a few roadside taps for the common public use are available. Greenland slum dwellers have no any access to the piped water supply.
There are 21 shallow and deep tube wells in this slum. These tube wells which are provided by the under LPUPAP are mainly the source of water for the inhabitants living in this area.

Table 7: Sources of Water in the Study Area

Source	Drinking				Cooking				Bathing				Washing			
	User no				User no				User no				User no			
	Before LPUPAP	%	After LPUPAP	%	Before LPUPAP	%	After LPUPAP	%	Before LPUPAP	%	After LPUPAP	%	Before LPUPAP	%	After LPUPAP	%
River	0	0	0	0	27	26.47	0	0	48	47.05	3	2.94	23	22.54	5	4.9
Tube well	90	88.23	102	100	47	46.07	102	100	33	32.35	96	94.11	26	25.49	97	95.09
Pond	9	8.82	0	0	21	20.58	0	0	18	17.64	1	.98	38	37.25	0	0
Pond and Tube well	3	2.94	0	0	7	6.86	0	0	3	2.94	2	1.96	15	14.7	0	0
Total	102	100	102	100	102	100	102	100	102	100	102	100	102	100	102	100

Source: Field Survey, 2011

Before LPUPAP most of the families depend on the pond and river for every use of water. After LPUAP most of the families depend on the tube well for every use of water. Before LPUPAP, for drinking purpose 88.23% families in the study area use tube well water, whereas 8.82% families use ponds water and 2.94% families use pond Tube wells water. People do not use river water for drinking. After LPUPAP, for drinking purpose 100% families use Tube wells water. After LPUAP people do not use river and pond water for drinking. Before LPUPAP, for cooking purpose 26.47% use river, 46.07% tube wells, 20.58% use pond water and 6.86% use pond and tube well water. After LPUAP, for cooking purpose 100% use river water. After LPUAP people do not use river and pond water for cooking. Before LPUPAP, for bathing purpose 47.05% inhabitants use river water, 32.35% use tube wells, 17.64% use pond water and 2.94% use ponds and tube wells water. After LPUPAP, for Bathing purpose 2.94% inhabitants use river water, 94.11% use tube wells, .98% use pond water and 1.96% use ponds and tube wells water. Before LPUPAP, for washing purpose 22.54% inhabitants use river water, 25.49% use tube wells, 37.25% use pond water and 14.7% use ponds and tube wells water. After LPUPAP, for Washing purpose 4.9% inhabitants use river water, 95.09% use tube wells water.

Access to Sanitation Facilities: Sanitation facilities are the prime requirement for a healthy living environment. The sanitation systems found in Bangladesh are sewer system, septic tank, pit latrine, bucket latrine and others. Sewer system is found only in part of Dhaka. Sewer system is not introduced in Khulna City. Different types of latrines are found in this city.

Common Toilets and Bathing Facilities: LPUPAP try to providing 1 latrine for 3 household. The responsibility of maintenance is the beneficiary's families. 100% people are used sanitary toilet. Before this project only 5% are used sanitary toilet others are used hanging toilet. There are 250 sanitary toilets in the study area. For the bathing 94 %(96) people are used the tube well water and rest of them are used river and pond.

Types of Latrines: Before the LPUPAP in Greenland slum the inhabitants are mostly used hanging latrines. This represents that the unhygienic sanitary condition and also the causes of different types of diseases and environmental pollution. During the LPUPAP phase in the Greenland slum there built 250 community shared hygienic latrine. It is basically provided on the basis of 1 toilet for 3 households. Although there exists lacking of maintenance of latrines in some cases but in the present situation it shows the almost 100% coverage of hygienic latrines in the study area.

Table 8: Uses of Latrine in the Study Area

Type of latrine	User no			
	Before LPUPAP	%	After LPUPAP	%
Sanitary latrine	0	0	102	100
Pit latrine	0	0	0	0
Hanging	96	95.32	0	0
Water sealed	2	1.80	0	0
Open field	4	2.88	0	0
Total	102	100	102	100

Source: Field Survey, 2011

Table 9: Average No. of people use latrine

	Use Hanging latrine before LPUAP	Use Sanitary latrine after LPUAP
Average	25	16

Source: Field Survey, 2011

Before LPUPAP, average 25 persons used one hanging latrine which was very harmful for health and environment. After LPUPAP, average 16 persons use one sanitary latrine which represents that the good sanitary condition.

Condition of Latrines: Before LPUAP latrine condition in the slums of this area was not well. Because sanitary latrines were not available for the slum dwellers and they used pit and hanging latrines which was not suitable for a healthy living environment. Most of the pit and hanging latrines had no roofed sometime just a polythene sheet. Slum dwellers do not have enough knowledge of cleanliness and they do not clean their latrines when necessary. Human wastes are open to the flies and other insects commonly in all types of latrines in the area. As a result infectious diseases flourish in the slum area easily. Water sealed latrines were made over the ditch water. This type of latrines contaminates the whole ditch water. But at present latrine condition in the slums of this area is well. Almost all of the slum dwellers use sanitary latrine due to helping the LPUPAP.

Ownership Pattern of Latrines: In Greenland slum most of the latrines are now community shared and that is build under the project of LPUPAP. Besides this a few household posses some hanging latrine that is mostly un-useable in nature.

Table 10: Types of ownership of latrines

Types of latrines	Private latrine users		Shared latrine users		Total
	Before LPUAP	After LPUAP	Before LPUAP	After LPUAP	
Sanitary	0	0	0	102	102
Hanging	19	0	83	0	102

Source: Field Survey, 2011

Before LPUAP Only 19 families used private Hanging latrines and 83 families used shared latrine. Before LPUAP, no any family used sanitary and pit latrines. It means 18.62% of the households used private hanging latrines and 81.38% households used shared hanging latrines. Though they used shared hanging latrines the condition was not well at all. Moreover, slum dwellers were not aware of cleaning the sanitary latrines. Flies and other insects fly in the latrines and this was the caused for the spread out diseases in slums. After LPUAP, 102 households use shared sanitary latrines. It means that 100% households use sanitary latrines due to helping LPUAP in the study area.

Educational Institutions: The educational facilities are not so much remarkable in this slum. Most of the people are labor and their income is not so high. So, most of the children are not go to school. But now a day, the children are start to going school. Under this project, they provide some monetary help of the students. In 2001 only 3% people are goes to school; now 20% children are going school.

Table 11: Functions of Educational Support

Category	Support (in tk)
Class 1 to 5	2000 – 3000
Class 6 to 9	4000 - 5000

Source: UNDP, 2011

LPUAP is only provided this support for those children who are poor and meritorious.

Health Facilities: There is no any permanent health centre in this Greenland Slum. But, in a week day an MBBS doctor are comes to their health service. A delivery centre is here. LPUPAP takes initiatives the old people whose are eye patient and its takes initiatives disabled children. For the eye camp BNSB is the liable authority. There are three children gets the monetary helps who are disabled.

Footpath and Drainage System: Before the starts this infrastructure development program under LPUPAP, there are no any puuca footpath in this area. The road condition is so much poor. The roads are muddy and sleepy. Now, the footpath condition is good. There are 450m brick soiling footpath in this area. And the drainage condition is moderate. Because, in rainy season more frequently water logging is occurred here. The organization will takes some initiatives for this problem.

Garbage Disposal: The LPUPAP organizes some awareness programs sometimes to aware slum people about how a person can remain in a healthy environment. It makes aware about garbage disposal to make a whole near the house. Before the LPUPAP garbage disposal initiatives most of the households dispose garbage on river and nearby drainage. The surrounding situations of Greenland slums are very much polluted. But now, under this project 2 van are provided garbage collection. About 60 percent households of Greenland slums are facilitated by this project garbage disposal with a moderate service condition. From the visual survey its get that, the overall condition of this study area is good. Most of the roads and comer of houses are clean.

Electricity: About 18.75 percent households of Greenland Slum have access to electricity. But it's an illegal connection. The UNDP can provide the electric pole, but they can't do this. Because this area is not permanent for settlement and the slum dwellers can evict anytime.
Capacity Building: A range of training programs are provided through LPUPAP for capacity building of Primary Groups and CDCs on aspects such as leadership, economic skills and women's rights as well as management of project activities.

SUSTAINABLE ISSUES

Community Mobilization: The LPUPAP had an organization structure from the grassroots to the national level. The slum communities are organized in Primary Groups comprised of mainly women. These groups implemented the infrastructure projects with the Community Development Fund and applied for the Poverty Alleviation Fund, through which they could receive credit for economic development. Each Primary Group had a chairperson, and the chairpersons formed Committee Development Committees (CDC), which coordinated the different activities. This was the basic structure, which extended beyond to various levels through a number of services and functions.

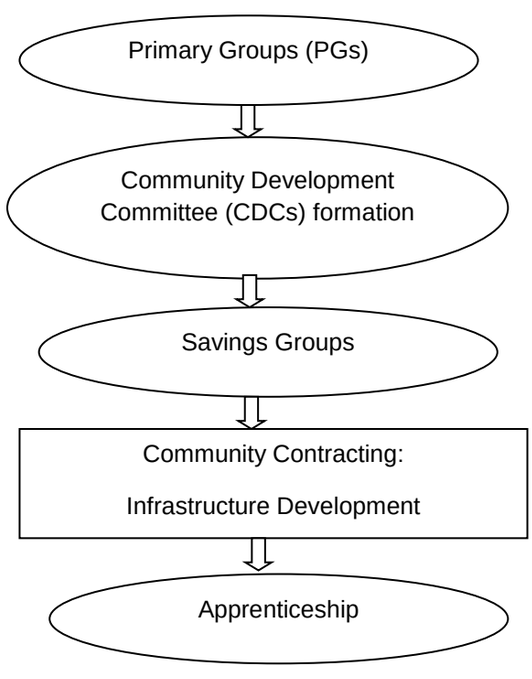


Figure 1: Community Mobilization Process

ISBN: 978-984-33-7045-7, PI.124 (1-9)

Community Development Committee (CDC): For the development of this Greenland Abasan, under this project Primary group are organized. Every 15-20 household's makes a PG. The Community Development Committee is the central focal point for implementing project activities. The CDC is composed of the Group Leader and Secretary from each Primary Group within the community. Thus they have a mixed, male-female composition. The majority of CDC members are female by a ratio of around 9:1.

Community Savings and Credit Activities: The CDC members, in turn, elect four office bearers to manage the CDC and their activities. The office bearers are the Chairperson, Vice Chairperson, Secretary and Cashier The CDC maintains four bank accounts, under joint signature of the Cashier and the Chairman. Under this CDCs Saving Groups are generated. The savings groups collect 20tk per week from their member. The member can takes loan from this savings groups at the 15% interest. This loan is distributed in the development works of the community. The CDCs are also selected the member for the apprenticeship Program.

Skill and Entrepreneurship Development: First one is Apprenticeship Program, where people are trained up. They take raining for 6 months in various institutes. They get 1500 BDT in the training period and in this study area 200 households are trained up under Apprenticeship Program. And now they are in good position from previous.

RESULTS

LPUPAP have some visual as well as effective results in the study area. These are;

- Success in providing water supply and Sanitation facilities.
- Successfully established CDCs & Community savings and credit activities.
- Success in providing Education help, Health support, Apprenticeship Program.
- Provide footpath & drainage which is moderate in condition.
- Lack of maintenance of providing services.
- In some cases lack of monitoring and evaluation of the project.
- Sometimes, Faulty selection process for providing grants and supports.

WAY FORWARD

Since 2007 second phase entitled Urban Partnerships for Poverty Reduction Project (UPPRP) is running, which plans for;

- More intensive targeting of the extreme poor
- Provision of other services (such as housing) in addition to infrastructure and,
- In general augmenting the activities conducted under the LPUPAP phase.

CONCLUSION

Bangladesh is among the world’s most populous and poorest nations with a large and growing urban poor population. Slums and squatter settlements is a common issue in its urban centers. For the last few decades the growth of urban population is extremely high. This is due to high migration rate of rural to urban area as well as the natural increase of population. The major cities of the country contain large number of slums and squatter settlements where the large portion of urban population is living. But these urban people are deprived of urban basic services.

There are various program are organized for upgrading the condition of poor people who are living in slums and squatters. Among them LPUPAP has led to an overall improvement in the lives of large numbers of the poor in project slums. In the study area improved health and well-being due to project installed infrastructure, reduced medical expenditures and increased income as direct and indirect benefits of the community development fund, the poverty alleviation fund and project initiated savings activities. Most of the roads and drainage system are pucca and semi-pucca. All of the slum dwellers use tube-well water for drinking, cooking, bathing, washing and other purposes. All of the Green Land slum dwellers use hygienic latrine. Their economic and social conditions have improved due to Local Partnership for Urban Poverty Alleviation Project. Though it's not possible to remove poverty at a small time period but, if the Government and the NGOs are takes some initiatives like LPUPAP and takes some continuous program, then poverty could be alleviated.

REFERENCES

Neuman W. L. (2000), *Social research methods*, Forth edition, Allyn and Bacon, Needham Heights.PP-157-221.

Sufian A. J. M. (2009), *Methods and techniques of social research*, second edition, University press limited, Dhaka, Bangladesh.

WSUP (2007), Water and Sanitation for the Urban Poor (scoping report). London, Water and Sanitation for the Urban Poor (WSUP).

UNDP (2007), Local Partnerships for Urban Poverty Alleviation Project. United Nations Development Programme.

CUS (2008), Slums of urban Bangladesh, Mapping and census, 2005,Center for urban studies,Dhanmondi R/A, Dhaka, Bangladesh

USAID, (April 2003), Urban poor child health in Asia and the Near East, Environmental Health Project (EHP) brief, activity report 109.

UN- Habitat (2003, A), *The challenges of urban slums*, Earthscan Publications Ltd. London and Sterling, VA.

UN- Habitat (2003, B),Slums of the World: The face of urban poverty in the new millennium?, working paper, Nairobi, Kenya.

Khulna Development Authority (KDA) 2000, *Structure Plan, Master Plan and Detailed Area Plan for Khulna city*, Draft Final Report, Volume III.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.128 (1-7)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Informal Solid Waste Recovery and Recycling in Dhaka City: Context of Environmental and Socio-Economic Aspects

MoushumiZahur
Graduate Student, Faculty of Environmental Engineering, University of Kitakyushu,
1-1 Hibikino, Wakamatsu, Kitakyushu City, Fukuoka, 808-0135 Japan.
E-mail address: moushumi_geo@yahoo.com

SuehiroOtoma
Professor, Faculty of Environmental Engineering, University of Kitakyushu,
1-1 Hibikino, Wakamatsu, Kitakyushu City, Fukuoka,808-0135 Japan
E-mail address:otoma@kitakyu-u.ac.jp

ABSTRACT

Waste is an unavoidable by product of human activities. Rapid growth of industries, lack of financial resources, inadequate trained manpower, inappropriate technology and lack of awareness of the community are the major constraints of solid waste management for the fast growing metropolis of Dhaka. As the demand of recyclable products is increasing day by day in order to save resource and energy, informal waste pickers/scavengers play an important role in the waste recycling process. Waste recovery and recycling are carried out by underprivileged people, that's why social and health issues are now considered as the integral part of the solid waste managementfor developing a sustainable society. The study help us to identify the current amount of municipal waste generation and their effects on the environment, collection of inorganic waste by the scavengers, their socio-economic status, how the recycling chain formed at the city andenvironmental and socio-economic problems related with recycling and recovery processes.

Keywords: Solid waste, Recycling, Dhaka city, Scavengers, Socio-economic aspects

INTRODUCTION

Waste is an unavoidable by product of human activities. Economic development, urbanization and improving living standards in cities, have led to an increase in the quantity and complexity of generated waste. Rapid growth of population and industrialization degrades the urban environment and places serious stress on natural resources, which undermines equitable and sustainable development. Municipal corporations of the developing countries are not able to handle increasing quantities of waste, which results in uncollected waste on roads and in other public places. There is a need to work towards a sustainable waste management system, whichrequires environmental, institutional, financial, economic and social sustainability.Solid wastes management and recycling is one of the major environmental problems faced by the city authorities in developing countries. In Bangladesh, the urban population has been increasing at a verysteep rate, about 6% and is concentrated mostly in six major cities, where nearly 13% of total population and 55 to 60% of total urban population are living.Management of these increasing vast quantities of solid wastes is a very complex process indeed. Due to severe financial constraints, absence of appropriate technology, lack of people's awareness, motivation and participation, ineffective legislation and law enforcement to protect the environment, the whole system is becoming a threat to city dwellers, planners and other stakeholders (Alamgir et al., 2007). Like other developing cities, Bangladeshi cities often collect only 40% to 50% of waste generated, with open dumping which isthe onlyavailable disposal method (Wilson et al., 2006).Insufficient collection, uncontrolled street collection points and improper disposal in open dumps allow refuse to be readily available for informal waste recycling through scavenging/waste picking. This type of waste picking is generally carried out by the poor and marginalized social groups (scavengers/waste picker, locally called '*tokai*') who involve into it for income generation and some even for daily livelihoods. In fact, formal waste recycling system is still not fully functional in low income cities and thus this disadvantaged group plays the primary role in the

informal or extensive recycling process. Waste recovery and recycling are carried out by underprivileged people, that's why social and health issues are now considered as the integral part of the solid waste management in the cities of developing countries and urges to develop a social planning dimension within the framework(Furedy,1990;Jabbar et al.,2008).

SOLID WASTE AND RECYCLING

Waste generally means `something unwanted`, but its precise definition differs from one country to another country (Tanaka, 1997).The definition of solid waste encompasses all those wastes which are neither waste water discharges nor atmospheric emissions (Cointreau, 1986). According to WHO (1971), solid waste is defined as useless, unwanted or discarded materials arising from domestic, trade, commercial, industrial, agricultural as well as from public services. The Chinese often say that a thing can be both a raw material and a waste at the same time. A material is considered as waste until it is considered as beneficial again. Thus a solid (semi-solid) material is generally considered as solid waste in the eyes of the producers when it loses its worth to them and is discarded. The nature and abundance of the solid waste in different countries depends on geographic location, climate, degree of industrialization, available resources, socio-economic conditions, religious custom, lifestyle, and behavior of consumers and also the season of the year.

Recycling means the use of waste itself as resources.Waste traditionally has been seen having no value.In a resourceefficient economyand society, the term 'waste' wouldrefer only to those residual materials that have absolutely no potential to be utilized and, therefore, economic value. Under this definition, traditionally 'valueless' streams of waste can be considered resources for a new tier of the economy. They can be recovered (or prevented from being lost) through greater efficiency and management at every stage of production and consumption.Even some hazardous or toxic materials may be recycled or re-refined for reuse.

OBJECTIVES AND METHODS

The aim of the study is to identify the current amount of municipal waste generation and their effects on the environment, collection of inorganic waste by the scavengers, their socio-economic status and how the recycling chain formed at the city. This study identifies environmental and socio-economic problems related with recycling and recovery processes. It also suggest recommendations which can be applied for the future development of waste recycling process and also set some guidelines to improve the socio-economic condition of the people who are related with recovery and recycling processes.

Relevant secondary information for literature reviewwere collected from books, thesis papers, magazines, Dhaka City Corporation (North and South)andthe organizations related to waste management activities.Secondary information also collected through internet. Field survey was conducted on scavenges in different locations of Dhaka city to know their socio-economic conditions, and recycling shops in various categories were also interviewed to identify the recycling chain of the waste by using pre-designed questionnaire.

STUDY AREA

Dhaka, the capital of Bangladesh, is one of the oldest urban agglomerations in the region, which came into promises from 1608 when it was made a provincial capital. Scavengers/waste pickers work in various cities and municipalities in Bangladesh. Generation of solid waste is increasing as the number of population increasing rapidly in the capital city and it`s creating a problem to inhabitants of the city. A large number of scavengers/waste pickers work in Dhaka city. As the demand of recyclable products is increasing day by day in order to save resource and energy, informal waste pickers/scavengers play an important role in the waste recycling process. On the other hand, informal waste recovery and recycling is particularly important for the cities in developing countries, where public authorities are financially and technically incapable of handling the major portion solid wastes. Dhaka City Corporation (North and South) areas considered as the study area for this research.

BACKGROUND AND PRESENT STATE OF THE PROBLEM IN DHAKA

Dhaka, the Capital City of Bangladesh, is expanding rapidly, turning it into a mega city with an enormous growth of population at a rate of around 6% a year. According to an Asian Development Bank study, the population of Dhaka city estimated in 1995 was 7.8 million, ranked as 14th populous city in Asia. But now the mega city is stretching over an area of 1,528 sq. km., with a population of 10.7 million.The population is expected to rise to 25 million in 2025 which will rank 4th in Asia(Zahur, 2008). Solid wastes are being generated at a faster pace, posing a serious management threat. Rapid growth of industries, lack of financial resources, inadequate trained manpower, inappropriate technology and lack of awareness of the community are the major constraints of solid waste management for the fast growing metropolis of Dhaka. A healthy life, cleaner city and better environment are the logical demands for the city dwellers as the municipality is traditionally funded for solid waste services from municipal tax system for waste collection and disposal. Due to limited finances and organizational capacity, it has been really difficult for the municipality to ensure efficient and appropriate delivery of solid waste collection and disposal services to the entire population.Dhaka City Corporation is the only formal organization responsible for waste management. The waste generation for this area is more than 3,000 to 4,000 tones every day. Of this quantity 55-60% is collected efficiently and the rest is left. These uncollected wastes are creating serious environmental problems to the overpopulated Dhaka city. In Dhaka,per capita solid waste generation is quite low; however, due to huge and densely populated city, solidwaste problem in Dhaka city is very acute in comparison to many cities of the developing countries.Of those200 metric tons of hospital and clinical waste is a mixture of toxic chemicals,radioactive elements and pathological substances.15-20% of medical wastes are highly dangerous for human lives. These waste when dumped with other municipal wastes in the open land poses threat to serious health hazard to the city people.

The nature of solid waste is changing over time and with development. Of this solid wastes plastic and polyethylene goods also cause problems towards human health, environment and drainage system. These goods are cheaply and easily available in the markets. The users do not care to reuse them. They rather throw these things out of the door and window. An Inception Report on Control& Management of polyethylene bags in Bangladesh shows that people of Dhaka City alone used 600 million bags a day. During floods, floodwater did not drain quickly, as one of the major reasons was polyethylene in the draining system. Polyethylene and plastic materials are not biodegradable. Natural process cannot decompose it. Polyethylene remains intact in the soil, disturbs the flow of nutrients to the soil and hinders even entering sunlight.It inhibits the growth of the beneficial bacteria of soil compaction. In the long run it affected the foundation of physical infrastructures, if there is any on the plastic dumpsite. However, due to effective regulation for banning the polyethylene bags in March, 2002, this problem has been overcome.

IMPACT OF WASTE ON ENVIRONMENT

Human beings are always surrounded by animals, plants, air, water, land, soil, solar energy, and other physical objects. All these are part of environment. Environment is thus sum of all social, biological, physical and chemical factors which compose the surrounding of human beings (Ahmed, 1994).The World Commission on Environment and Development (WCED) known as Bruntland Commission defined environment as- "where we all live" and sustainable development as- "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs".Environment as productive system provides basic supports that are required for flourishing all forms of lives, materials that are harvested, energy that are harnessed, services for transportation and recreation and aesthetic for spiritual renewal (Enayetullah,1995).

Today, Urban Solid Waste Management (SWM) is considered to be one of the most immediate and serious environmental problems in developing countries as only open air dumping is available disposal method in most developing cities, which imposes various impacts on the environment. This is mainly due to rapid urbanization taking place on an enormous scale in developing countries. Rapid urban growth accompanied by increasing population growth and uncontrolled industrial development, however, severly degrades urban environment. It places serious strain on natural resources and

consequently undermines equitable and sustainable development. Inadequate management of solid waste is an obvious cause for degradation of the environment in most developing cities. Solid waste is problem because it is the material that is not wanted by the producer who, of course, seeks to dispose of it at the lowest possible cost. It is, therefore, a task of society to ensure that the disposal is carried out without not seriously damaging the environment. The environmental impact of waste on environment are:

- Creatingenormous unhygienic threat to the people.
- Causing aesthetic problem and nuisance due to nauseating pungent odor.
- Promoting spreading of diseases.
- Further aggravating the situation by theindiscriminate disposal of hospital and clinical waste.
- Polluting water bodies. The infiltration of rainfall or surface water in solid waste dumps or landfill can produce leachate. If this leachate enters surface or ground water, it will cause severe water pollution.
- Generating global warming gases such as carbon dioxide and methane from solid waste.
- Causing flood in the rainy season by clogging water with wastes.

WASTE PICKING AND WASTE MANAGEMENT

In the past, waste recovery and sanitation works were performed by a particular social groups or traditional outcast groups in Indian sub-continent. But today, it is not restricted to only those groups rather many people are engaged in this profession for extra earnings. Scavenging is not a favorable job but so many children are also engaged in this job.Solid waste management, poverty and recycling are closely linked with each other. Waste management and waste picking provides jobs, support income and livelihood although waste pickers/ scavengers have no social recognition. They work in unhealthy and risky environment. Waste picking is an easy choice of profession, needs no skill or capital.Waste pickers enjoy freedom of starting and ending works.In Dhaka city about 15% (600-650 tons/day)of generated waste is recycled.About 120,000 urban poor are involved in informal recycling chain(Waste Concern, 2005).Majority of the waste pickers' income is US $14-40 per month. They migrated to Dhaka city from disaster prone areas or seasonal working opportunities in rural areas.

SOCIO-ECONOMIC STATUS AND INVOLVEMENT OFSCAVENGERS IN WASTES RECOVERY AND RECYCLING

Scavengers act as the primary processor in recycling process of Dhaka city who are found mostly in slums and squatter settlements.Significant numbers of female (36%) involved in waste picking (JICA, 2005). They are exploited by getting less money.In most cases, parents of the scavengers were unable to run their family, which restrains the children from attending school and pushes them towards waste picking. Poor living conditions, limited access to facilities and infrastructure, no provision of urban services such as water supply and sewerage and absence of social safety networks are typical in scavenging communities(Wilson et al.,2006; Field Survey, 2012).Poverty is the main reason of selecting scavenging as a means to lead their livelihood. The guardians of the scavengers/waste pickers are compelled to allow the children to pick waste due to their poverty and finding no other alternatives. Usually scavengers/waste pickers collect materials by roaming around the whole day, sometimes without taking food, crossing a very busy road. They face these risks only to collect some recyclable waste, which might be sold at recycling shops. They usually collect materials from dustbins, demountable containers, road side, low lying areas, secondary transfer points etc. Majority of them were found working seven days in a week due to their poverty. A very few of them engaged in other jobs to give more support to their families. Scavengers of the city work hard for their survival. They have no future plan and almost 50% do not want to stay long in this job. As there are no other alternatives for them, they are engaged on this work for their livelihood. Many of the scavengers/ waste pickers have to access to sanitation facilities, but the quality of them and the other facilities are very poor. Many of them do not have access in sanitation facilities in their living places, which causes diseases and various other problems. Problems are more severe in their working places as there are no provisions of toilets. This is one of the reason which creating pollution at the environment. Almost all scavengers collect water from tube well or WASA tap for their daily use such as drinking, bathing, washing and preparing food.Scavengers suffer from serious occupational health risks. Because of

manual handling and lack of protective clothing and equipment, they are undoubtedly exposed to various health risks (Wilson et al., 2006; Field Survey, 2012).Getting direct contact with toxic and infectious components, offensive odor, polluted air and water are most common factors responsible for health risks. Respiratory problems and skin diseases are common among the scavengers. Poor living condition also contributes to health problems, and in many cases, it is difficult to distinguish between health implications of work and living conditions (Eerd, 1996;Field Survey, 2012).Although a large number of money is saved by recycling of waste by scavengers/waste pickers, who in fact are helping DCC(Dhaka City Corporation)by saving disposal cost, no initiative has so far been taken by the authority for their working and living condition as they work in unhygienic way, nor for providing them intensives for salvaging recyclable materials in hygienic manner with proper safe guards against health hazards.

The DCCdoes not perform any kind of resource recovery activities. Wastes of some market value are being reclaimed or salvaged informally in three stages [8]. In first stage, the housewives separate the refuse of higher market value such as papers, bottles, fresh containers, old cloths, and shoes and sell them to street hawkers (locally called '*feriwallas'*). The second stage of salvaging is carried out by wastes pickers/scavengers. Scavengers act as the primary processor in recycling process of Dhaka city. They collect the refuse and domestic waste of low market value from bins, containers and sweeping accumulation centers. The third stage of salvaging is done by the refuse pickers when fresh refuse is unloaded by municipal collection vehicles at the local disposal sites.Scavengers also collect different materials from the final dumping sites Matuali and Amin bazar.The items include broken glass, can, card board, waste paper, rag, plastics, metals and miscellaneous wastes discarded by households (Field Survey, 2012).The reclaimed material goes to the waste and old material shops through the street hawkers who purchase the old material directly from the homesteads and through refuse collectors who reclaim materials from bins and final disposal sites. The refuse dealers separate the materials in proper form and sell them to consumers as well as supply them to appropriate processing or remolding mills and factories. The processed material recycled through market finally goes to users again.Like the scavengers, the people who are working at the recycling shop all face some occupational health risks because of manual handling and lack of protection equipment.

The study identified the current amount of municipal waste generation and their effects on the environment, collection of inorganic waste by the scavengers, their socio-economic status, how the recycling chain formed at the city and environmental and socio-economic problems related with recycling and recovery processes. The cycle goes on as long as the waste has economic or market value. Although recycling of solid waste is not included in the national environmental policy of Bangladesh, yet it has become a main source of income for several groups of the informal sector.

CONCLUSION

Scavenging and recycling activities bring good economic value and generate employment. It also supports municipalities to manage and reduce solid waste. So, these activities should be encouraged, considering current social and economic situation, but involvement of the children should not be encouraged. These activities are also treated as an informal sector although it contributes positively to the economy through waste collection, supplying raw materials to the recycling shops and finally to the recycling industry, and producing different goods in the factories by utilizing the recyclable waste.Over the last couple of decades, there has been a growing recognition of involvement of informal sector to ensure economic, social and environmental benefits from MSWM (Municipal Solid Waste Management). In a micro-economic perspective, informal waste recovery has substantial economic benefit as it provides options for small business without capital expenditures. The social aspects of the poor groups attached with the process are crucial for achieving sustainable outcome of MSWM. Though scavenging is an easy accessible employment for the urban poor, the occupation is associated with health risks as all sorting isdone manually inBangladesh.Unfortunately, the government policies in most of the developing countries are not supportive for the involvement of informal sector in solid waste management.Waste management authorities can intervene in the marketing of recyclable products to maximize profits through transportation support, occupation safety, promoting the use of recycled products. To enhance the efficiency and dignity in resource recovery works as well as other social aspects of solid waste management will require modes of co-operation in

which governmental agencies, community-based organizations, voluntary groups and the general public can work together (Furedy, 1990).The scavenging community also suffers from limited access to urban facilities (e.g., water supply and sanitation) and social safety networks (Field Survey, 2012). As the demand of recyclable products is increasing day by day in order to save resource and energy, scavengers play an important role in the wastes recycling process. Also informal waste recovery and recycling is particularly important for the cities in developing countries, where public authorities are financially and technically incapable of handling the major portion of solid wastes. Realizing the significance of this sector, it is imperative to integrate informal work with the formal MSWM, to help them organize themselves and to add value to their recycled materials before selling them. This can be done by moving up the hierarchy of waste pickers in the waste recovery and recycling chain to extract higher value from recovered materials. In addition, measures for protecting livelihoods while working need to be taken to improve both the efficiency and the living and working conditions of those involved (Wilson et al., 2006). To improve the social aspects of solid waste recovery and recycling, an in-depth understanding over the informal process is essential for the intermediary actors and institutions in bridging the institutional gap between state bureaucracies and informal social fields. Potential interventions include providing of specialized clothing and tools to the wastes pickers, organizing and capacity building to develop it as a small business, and increase public awareness to use recycled products (Ojeda-Benitez et al., 2002).Finally, cooperative action is also required among governmental agencies, community based organization, NGOs, voluntary groups and general public which can contribute in shaping of sustainable urban environment.

REFERENCES

Ahmed, M. F. (1994) “Environment and Sustainable Development”, paper presented at national Seminar on Sustainable Development in Bangladesh: Issues and Options, held during the 38th Annual Convention of the Institution Engineers Bangladesh(IEB), Dhaka, January, 18-21.

Alamgir, M., Bidlingmaier, W., Glawe, U., Martens, J., Sharif, L. A., Visvanathan, C., &Stepniewski, W. (2007) “Safe and Sustainable Management of Municipal Solid Waste in Khulna City of Bangladesh”, paper presented at the EleventhInternational Waste Management and Landfill Symposium, Cagliari, Italy.

Cointreau, S.J. (1986) “Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide”, The World Bank, Washington DC, USA.

Eerd, V. (1996) ‘The Occupational Health Aspects of Waste Collection and Recycling, A Survey of the Literature’, WASTE Working Document 4, part 1, Urban Waste Expertise Program (UWEP).

Enayetullah, I. (1995) “A Study on Solid Waste Management for Environmental Improvement for Dhaka City”, Unpublished MURP Thesis, URP, BUET, Dhaka.

Furedy,C. (1990) “Social Aspects of SolidWaste Recovery in Asian Cities, Environmental Sanitation Reviews”, 30.

Field survey, 2012.

Jabbar, M. A. U., Rahman, M. M. &Swapan, M. S. H. (2008) *Solid Waste Recycling for Sustainable Urban Environment in Khulna City-Issues Concerned with Recycling Process and Market Potentials of End Products*. In Alamgir, M.,Hossain, Q. S., Rafizul, I. M., Mohiuddin, K. M. & Bari, Q. H. (Eds.) National Seminar on Solid Waste Management, WasteSafe 2008. Khulna, Bangladesh, EU-Asia Pro Eco II Programme of the European Commission and KUET, Bangladesh.

Ojeda-Benitez, S., Armijo-de-Vega, C., & Rami-´rez-Barreto, M. E. (2002) “Formal and informal recovery of recyclables in Mexicali, Mexico: handling alternatives”, *Resources, Conservation and Recycling,* 34: 273–288.

Rahman, M. M., Salequzzaman, M., Bahar, M. M., Uddin, M. N., Islam, M. A., &Harun, M. A. Y. A. (2005) "People's Perception of the Existing Solid WasteManagement of Khulna City Corporation (KCC) Area:A Case Study of Participatory Management", paper presented at the National Workshop for REGA and CDM Awareness Building &Motivation under the ADB PREGA Project, Khulna, Bangladesh.

Saad, M. A. K. (2004) "Sustainable Solid Waste Management for Dhaka City",An Unpublished M.Sc. Thesis, Royal Institute of Technology (KTH), Sweden.

Tanaka, M. (1997) "Risk Management for Landfill Disposal of Solid Waste", Int. Direct.ofSolid Waste management 1997/98, The ISWA Yearbook, James & James Ltd, pp. 24-40.

JICA (2005) "Clean Dhaka Master Plan", Pacific Consultants International and Yachigo Engineering Co. Ltd., Dhaka.

Waste Concern (2005) "Urban Solid Waste Management Scenario of Bangladesh: Problems and Prospects, A TechnicalDocumentation", Dhaka.

Wilson, D. C., Velis, C., &Cheeseman, C. (2006) "Role of Informal Sector Recycling in Waste Management in Developing Countries", Habitat International, 30:797–808.

WHO (1971) "Technical Report", series no. 484.

Zahur, M. (2008) "Private Apartment Housing for Middle Income People:A Study on Affordability", Unpublished MURP Thesis, URP, BUET, Dhaka.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI. 133 (1-8)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Sustainability of Waste Management System in Developing Countries: A Case Study

Syeda Nishat Ashraf[1], Muhammed Alamgir[1] and Jhumana Akhter[2]

[1]Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh
[2]Department of Civil Engineering, International University of Business Agriculture & Technology (IUBAT), Dhaka 1230, Bangladesh

ABSTRACT:

The paper highlights the existing trends in solid waste management practices, related obstacles and key solutions to the constraints to attain sustainable waste management system in a city corporation area of a developing country. Here the ward no. 24 of Khulna City Corporation (KCC) is considered as the case study area to illustrate the practical application of WasteSafe approach and hence its sustainability. The paper points to the practical difficulties which were faced while conducting the field investigations at this ward and also some important findings about the ongoing system of Municipal Solid Waste (MSW) management at ward no. 24. To bring a development in the overall management system some practical initiatives were taken. The paper also explores the difference between the waste management situations before & after applying initiatives and therefore, suggests some approaches that might contribute to achieve sustainability to the adopted solid waste management system.

INTRODUCTION

Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of, which can pose serious risk to the environment and to public health. Where intense human activities concentrate, such as in urban centers, appropriate and safe solid waste management (SWM) are of utmost importance to allow healthy living conditions for the inhabitants. This fact has been acknowledged by most of the governments, however many municipalities are struggling to provide most basic services due to its inherent constraints as well as improper planning and commitment.

Bangladesh, the world's eighth highest populated country with population of 161.08 million (Wikipedia 2012) and one of the fastest urbanizing countries, is a land of physical, chemical, geographic, ecological, social, cultural and linguistic diversity. With the growth of urban population in a relatively high rate, solid waste generation has also increased proportionately. This has been creating higher per capita waste generation rendering the existing management system ineffective and has put on the risk of massive failure. According to a twelve months feasibility in Least Developed Asian Countries (LDACs) on MSW management done by WasteSafe(2005), the "waste management hierarchy" (reduce, reuse, recovery and disposal) should be socially adopted as well as environmentally and economically sustainable.

Developing cities like Khulna have now begun to confess the environmental and public health risks associated with uncontrolled dumping of solid wastes. That has occurred mainly due to the active participation of private sectors in Municipal Solid Waste Management (MSWM). In Khulna city, a significant portion of population does not have access to waste collection services from generation point and only 10% of generated wastes are actually collected by door-to-door collection system which is provided by Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) (Alamgir *et al.,* 2004). Major portion of their collected wastes are disposed to the secondary disposed site (SDS) of Khulna City Corporation (KCC) & other private low-lying lands while the rest are take to the compost plant. Composting of organic wastes and clinical wastes management are only dealings by NGOs in Khulna city (Alamgir *et al.,* 2004).

In the context of proper management of solid waste Khulna City Corporation holds relatively worse condition in respect of other cities of Bangladesh. Since its establishments in the year 1084 (Official website of KCC) it's facing the impacts of rapid urbanization consequently the excess burden of solid waste. Nearly 1.17 million (ADB 2009) population reside in corporation area of 45.65 square kilometer, but the reality speaks out the fact involved in management is, corporation has limited human resource and organizational setting for providing municipal services to this amount of population.

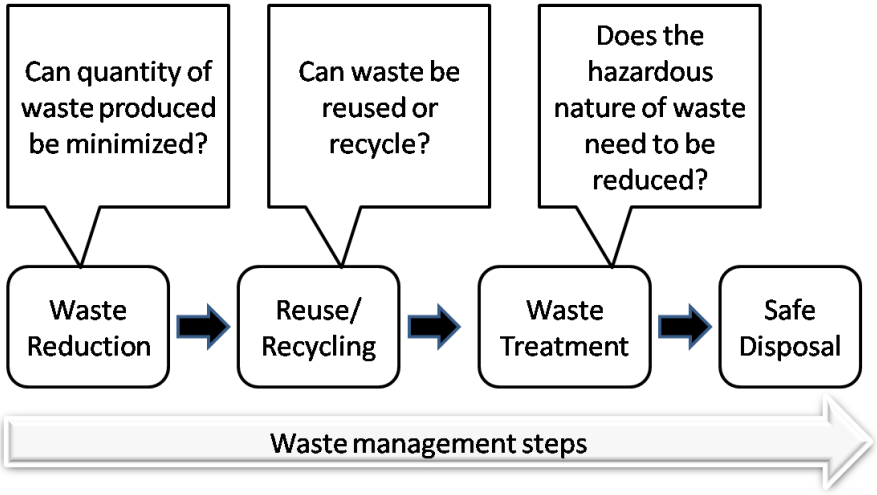


Figure 1 Hierarchy of waste management (suggested by WasteSafe 2005)

To implement the outcomes of and suggestions comes from WasteSafe (2005), the further project of European Commission (EC), WasteSafe II under Asia Pro Eco II Program took some practical initiatives. The study utilized the existing activities on MSWM in the cities of Bangladesh. To this attempt, Khulna – third largest city of Bangladesh is considered as the main case study area. To have a clean, hygiene and environmental-friendly Khulna city, ward no. 24, an important hub concerning the socio economic potentialities, was considered for some practical activities conducted on 2007 to 2009 on MSWM as a part of WasteSafe II activities. This study goes on the observation of sustainability of the system employed in Ward No. 24 and describing the outlines and concepts for sustainable management of municipal waste, highlights some important constraints and suggests possible solution.

OVERVIEW OF STUDY AREA

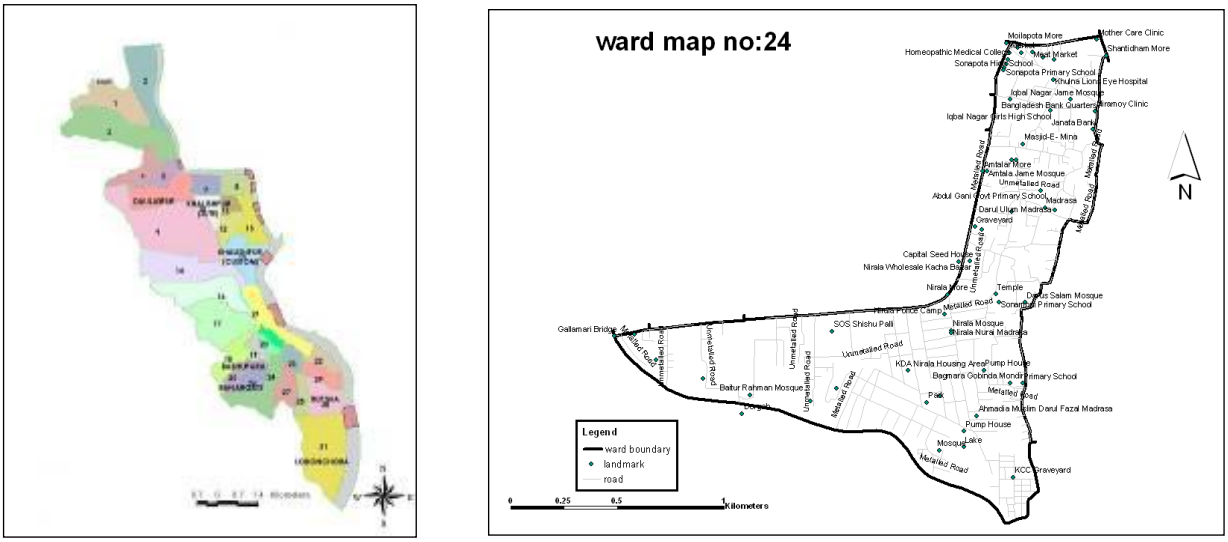


Figure 2 Map of Khulna city and the layout of ward no. 24.

Khulna, the south-western divisional city in Bangladesh, is situated between 21.38° and 23.1° North latitude and 88.58° East longitudes and is 2.15 m above mean sea level (official website of KCC). The city extends from the south-east to north-west along the bank of Rupsha- Bhairab river. Total area of Khulna city is 45.65 square kilometer and total population is 1.17 million as roughly estimated by ADB (2009). Gross population density of Khulna city is 25,630 persons per square kilometer. The KCC consists in total 31wards of which ward no. 24 is one of largest and densely populated ward. It is situated at south-western side of city lengthened up to the Gollamari Bridge. It occupies an area of 0.53 square kilometer. Wards no. 24 is surrounded by the ward no. 19, 20, 23, 26 and 27, as shown in Figure 2.

The total population of ward no 24 is 52,624 of which the percentage of male, female and children are 34.8%, 30.6% and 34.6%, respectively and the total no. of family in this ward is 9,225. The average family size of this ward is 5 to 6. The population density in the ward is 99290 persons/ sq.km. Some general information of this Ward is given in Table 1. The land use pattern is shown in Figure 3, in which the land of the ward is divided into eight major categories. From this figure, it can be seen that the residential area occupies the major parts.

Due to presence of higher number of educational institutes, cultural institutes, shopping centers, restaurants, mosques, governmental and non-governmental office, NGOs, CBOs and other important features, the ward has turned to most well known ward of Khulna city.

Table 1 Population data at major zones of ward no. 24 (Akter et al. 2008)

Name of the zone	No. of Family	Male	Female	Children	Total Population
South Farazi para (SFP) (SFP)	415	926	1096	589	2,611
South Gollamari (SG)	1398	2481	2588	2888	8,257
Ikbal Nagar (IN)	1400	3318	2653	2158	8,129
Muslim Para (MP)	1672	3247	2905	2778	8,930
Ray Para (RP)	1159	3051	2492	2349	7,892
West Bagmara (WB)	2956	5343	4693	5375	15,511
Total	9,225	18,624	16,427	18,573	52,624

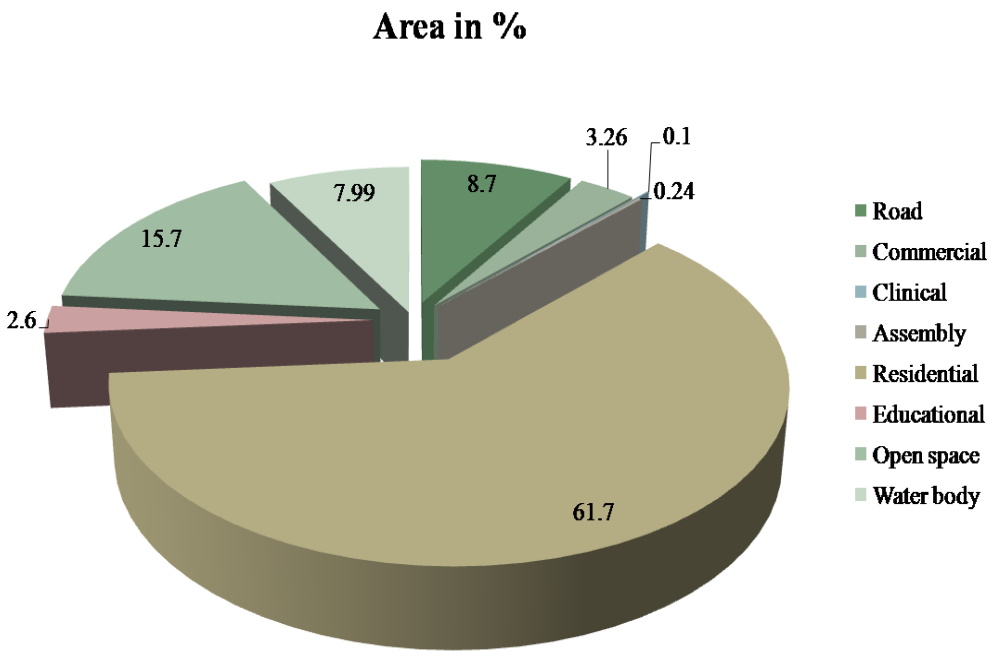


Figure 3 Area of different land use pattern (Jhumana *et al*., 2009)

ISBN: 978-984-33-7045-7, PI. 133 (1-8)

APPROACHES TAKEN BY WASTESAFE II

Awareness through Leaflet Distribution, Rally, Door To Door Campaign & Displaying Festoon

The leaflets were designed at middle of the year of 2007 and then printed and has been distributing among the city dweller since November 22, 2007. Mass awareness campaigning were held in two times on January 5, 2008 and November 25, 2008 conducting rally and door-to-door campaigning. To attract public attention, a number of festoons have been designed and thus installed for display at the important public places in Khulna city.

Awareness through Art and Culture: Children Art Competition, Cultural Show and Street Drama

To increase peoples' awareness, an Art and Cultural program was arranged at Khulna Art School. Theme of the program was waste management scenario of Khulna City. A good number of students of Khulna Art School, specially children, participated in that program. Their thoughts, ideas, views and opinions about waste management got reflection through their awesome colourful drawing. Cultural show & street drama were also arranged to draw peoples' attention about waste management.

Introducing Newly Designed Rickshaw Van

To enhance the primary collection efficiency and door-to-door coverage in ward no. 24, covered Rickshaw Vans were designed and fabricated using materials available in local market such as Galvanized Iron (GI) angle and stainless steel sheet to overcome the adverse impacts of saline weather as suffered by the Rickshaw Van in Khulna city.

IMPROVEMENT OF SWM IN WARD NO. 24 DUE TO WASTESAFE PROJECT

After implementation of all the above mentioned approaches to increase the effectiveness in primary collection and disposal of MSW in ward no. 24, again a survey was conducted to investigate whether the taken initiatives has put any positive impact on the solid waste management system or not. The survey was conducted to obtain people perception not only in ward no. 24 but also in some other surrounding wards of 24, just to compare the impact of the taken initiatives. Other surveyed wards were ward no. 20, 21, 22 and 29. Survey Results revealed that the MSW management scenario in ward no.24 was encouraging compared to other wards.

Figure 4: (a): Existing waste collection rickshaw Van (b) Newly designed waste collection

Due to continuous awareness build-up program together with other approaches to change the overall MSWM scenario in ward no. 24, it is clear that peoples' perception and response about waste management practices was encouraging in ward no. 24 comparing year to year response. However, after conducting physical survey recently, it is observed that the condition is worse than it was before. After conducting a long follow up people became aware and cooperative but after a break of follow up all the beneficial outcomes has reached to the brink of its application.

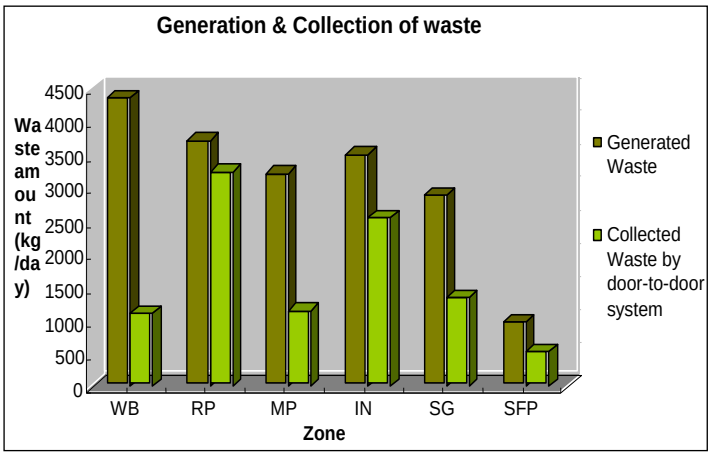
Source Storage and Primary Collection


Figure 5 Typical pictures of source storage & primary collection

Households those are cooperating existing management system, store wastes in a plastic or metal container of different size and shape and keep it inside the house or premises. People living in the slum area throw their wastes into drain or canals pass through the ward. As a result, a considerable portion of wastes is not managed properly. Study reveals that, storage and separation of organic, inorganic and hazardous wastes are highly neglected by the city dwellers.

Table 2 Door to door coverage in ward no. 24 (Akhteret al. 2009)

	Based on direct survey			Based on secondary data		
Zone	Generated waste (kg/day)	Collection by door-to-door system (kg/day)	Coverage by door-to-door system (%)	Projected Generated Waste (kg/day)	Collection by door-to door system (kg/day)	Coverage by door-to-door system (%)
SFP	298	230	77.2	966	518	53.62
SG	578	300	52.0	2890	1334	46.17
IN	307	255	83.0	3495	2538	72.62
MP	587	215	36.63	3215	1144	35.58
RP	269	229	85.1	3709	3238	87.3
WB	526	158	30.0	4343	1103	25.40
Total	2565	1387	**54.0**	18618	9875	**53.04**



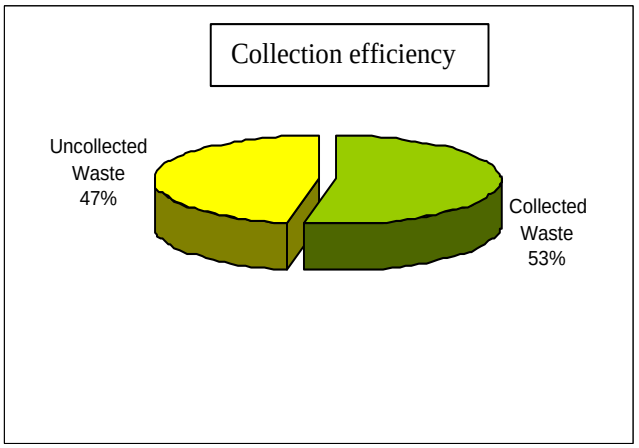


Figure 6 Generation versus collection amount and efficiency in six zones of ward no. 24

ISBN: 978-984-33-7045-7, PI. 133 (1-8)

There is no transfer station and handover point in ward no. 24. The number of SDS available in this ward is around 43. KCC authority places some Haul Containers (HCs) and permanent concrete/masonry bins in secondary sites. Only brick masonry bins are places in some sites near the road sites. The SDS situated in the commercial places like Nirala Kacha Bazar is insufficient in its capacity.

Figure 7 Typical secondary disposal sites in ward no. 24

PRESENT SITUATION

Several practical steps have been undertaken in this ward to improve level of people's awareness and collection systems. Solid waste management system in ward no. 24 displays an array of problems. Each of these constraints is discussed below in relation to the sustainability of waste management system.

Technical Constraints

There is a lack of human resources at both the national and local levels with technical expertise necessary for solid waste management planning and operation. Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or management. Another technical constraint is the lack of overall plans for solid waste management at the local and national levels.

Financial Constraints

Figure 8 Present condition of waste collection rickshaw given by WasteSafe

The door-to-door collection is done by non-motorized vehicles named "rickshaw van". As the collection is run by some non-profitable organizations, it becomes a problem to spend money for instant repair when needed, which hampers the collection efficiency. Again, workers are not satisfied with the little payment. As a result, they do not work properly and day by day it is growing tough to find

worker for this job. The scarcity of workers is high during wet season because in this time waste collection becomes more unhealthy and unsafe.

Political Interference

Along with other common problems in our country an additional big problem is noticed in waste collection system of ward no. 24. It is the political collusion. It has been found that, where an organization is collecting wastes, suddenly another organization is established and starts to collect wastes there. In this situation the working space of previous organization becomes constricted i.e., the income is reduced. As a result, the total arrangement of the organization has been collapsed.

Managerial Constraints

With rapid urbanization the amount of waste produce is increasing but the capacity and number of SDS remain same. As a result solid wastes are generally thrown haphazardly in and around the bin. Animal Scavenging those sites and odor nuisance is a major problem and peoples passing through this area with conceal neck.

Figure 9 Roadside unmanaged wastes in ward no. 24

The trucks of KCC collect wastes from SDS. This service is not found in Friday where it is the public holiday. It is obvious that people will create more domestic wastes during holidays. So, it creates more environmental problem when the excessive amount of waste is kept dumped openly for a whole day.

It would not be wrong to say that, the waste management system is mainly scavenger based. The collected wastes are dumped to the ultimate disposal site without minimum sorting. The scavengers mainly collected those things which are not decomposable like plastics, glasses etc. for their own benefit. If they did not collect those materials the condition could be worse.

Economic Constraints

It is true that people are more aware about waste management compared to before but still now some people consider this as an extra cost. They are not agreeing to give the solid wastes to door-to-door collectors if they are asked for monthly fees. For these few people the whole locality remains unsafe. Ward no. 24 has weak economic bases and, hence, insufficient funds for sustainable development of solid waste management systems.

Social Constraints

The social status of solid waste management workers is generally low. This owes much to a negative perception of people regarding the work which involves the handling of waste or unwanted material. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and poor quality of their work.

HOW TO MEET THE REQUIREMENTS:

- The first and foremost problem that obstacles the waste management system is financial scarcity. Enough funds should be raised by the government and local rich people and profitable business groups to continue the process without any interruption.

- All the organizations (CBOs, NGOs etc) those are collecting wastes from houses should be under direct control of KCC. The collection area of each organization should be fixed by a meeting among KCC, organizations and some local leaders of dwellers. This will prohibit the collusion among collecting organizations.
- KCC should change the holiday of truck service. It should be a day of a week except Friday and Saturday.
- Some committees consist of a few families should be grown in every "Para". The main objective of these committees will be to observe that, the member families are managing their daily wastes or not.
- It is urgent to rearrange the positions of SDS and at the same time some SDSs need extended capacity to manage the total waste produced that place.
- The most important thing that needed here is "transfer station". Proper waste management is impossible without sorting different types of wastes. Sorting not only reduces the amount of waste but also provides financial benefit and also gives an aid to the rate of decomposition.
- The ultimate disposal site needs an appropriate boundary to prevent scavenging of dogs, cows etc. It is needed to cover the wastes until the surrounding is threatened by it. It would be efficient if some technologies are used to accelerate the decomposition rate.

CONCLUSION

MSW management is technical issue as well as socio-economic. A sustainable system can not be obtained until people realized that they are waste generator, so it is their responsibility to manage it properly for giving a clean, hygiene and environment-friendly city to their next generation. No change in waste management system is sighted until the people's attitude for changing their habit is changed, which is much complex and difficult to achieve. This study noticed that, after conducting continuous awareness developing activities for about three years and implementing some other initiatives in the light of WasteSafe approach, people's satisfaction rate about waste management system got a surprising rise. But recent investigation shows a hopeless scenario when the awareness developing activities has been stopped for three years. Condition becomes worse than before. An affordable should be developed to ensure all kinds of logistic support from the concerned authority. The component of the system should be informed to the stakeholders through continuous awareness development program. The results of the study also depict that continuous monitoring, refinement of system, city authority's logistic support and the social movement rather than pure technical issue are required for the sustainability of the waste management system.

REFERENCES

1. Akter, J., Alamgir, M and Rafizul, I. M. (2008): Practical Application of WasteSafe Proposal in a Selected Location of Khulna City. Proc. of the National Seminar on Solid Waste Management – WasteSafe 2008, 9-10 February 2008, Khulna, pp 13-24.
2. Alamgir m. *et al*. 2004, Feasibility Study on Municipal Solid Waste Management in Khulna City Corporation, EU-Asia Pro Eco Programme of EC, KUET, Khulna, Bangladesh.
3. http://en.wikipedia.org/wiki/World_population#Most_densely_populated_countries (Accessed on 07/09/2012)
4. http://www.khulnacity.org/Content/index.php?pid=42&id=33&page=Administrative_office. (Official website of KCC).(Accessed on 03/11/2012)
5. Jhumana A., I. Jahan, M. Alamgir and K. M. M. Hasan, Field Investigation on the Increase of Effectiveness in Primary Collection and Disposal of MSW in a Selected Area of Bangladesh, International Conference on Solid Waste Management: Technical, Environmental and Socio-economical Contexts - WasteSafe 2009, 9 to 10 November 2009, Khulna, Bangladesh, pp. 663-672
6. http://www.cdia.asia/wp-content/uploads/gravity_forms/26/2011/07/Khulna-PFS-all-sectors.pdf (ADB 2009) (Accessed on 03/11/2012)