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Eco-friendly Management of Tannery Solid Wastes in Bangladesh

Islam, Raju Muhammad Shahidul

University of Rajshahi

Eco-friendly Management of Tannery Solid Wastes in Bangladesh

THE THESIS SUBMITTED TO THE INSTITUTE OF ENVIRONMENTAL SCIENCE, UNIVERSITY OF RAJSHAHI IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

of

DOCTOR OF PHILOSOPHY

in

ENVIRONMENTAL SCIENCE

By

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JUNE 2013

DECLARATION

I do hereby declare that the thesis entitled "Eco-Friendly Management of Tannery Solid Wastes in Bangladesh" submitted to the Institute of Environmental Science, University of Rajshahi for the award of Doctor of Philosophy in Environmental Science is the result of my own experimental research work through observations and experiments during the period of July 2009 to June 2012 carried out under the supervision of Professor Dr. Md. Sarwar Jahan, Institute of Environmental Science, University of Rajshahi, Bangladesh.

I further declare that this thesis or thereof the part of it has not been submitted to any other university for any degree or diploma. To the best of my knowledge and belief, the contents or part thereof the thesis was not published previously by anyone except due reference was made in the text whenever needed.

Date: 29 June 2013
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CERTIFICATE

This is to certify that the thesis entitled “Eco-Friendly Management of Tannery Solid Wastes in Bangladesh” submitted for the degree of Doctor of Philosophy is an unique experimental research work by Raju Muhammad Shahidul Islam, carried out at the Institute of Environmental Science, University of Rajshahi under my direct supervision. The thesis or part thereof has not been submitted previously for any diploma or degree to any other university.

I also certify that the researcher has made some distinct contribution through this experimental study to the arena of Leather Technology. I gladly recommend him to submit the thesis to the University of Rajshahi for the award of Ph.D degree in Environmental Science.

Date: 29 June 2013
Rajshahi

Supervisor

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Professor
Institute of Environmental Science
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Rajshahi-6205, Bangladesh.

Dedicated

To

My Family

Ph.D Thesis

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RAJU MUHAMMAD SHAHIDUL ISLAM

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LIST OF ABBREVIATIONS

Abbreviation		Connotation
BTA	:	Bangladesh Tanners' Association
BCLT	:	Bangladesh College of Leather Technology
BCSIR	:	Bangladesh Council of Scientific and Industrial Research
BDT	:	Bangladesh Taka
BFLLEA	:	Bangladesh Finished Leather, Leathergoods & Footwear Exporter's Association
BOD	:	Biological Oxygen Demand
BSCIC	:	Bangladesh Small and Cottage Industries Corporation
BSTI	:	Bangladesh Standard and Testing Institute
COD	:	Chemical Oxygen Demand
COEL	:	Center of Excellence for Leather Skill Bangladesh Limited
CTY	:	Controlled Tipping Yard
DCC	:	Dhaka City Corporation
DoE	:	Department of Environment
EPB	:	Export Promotion Bureau
FAO	:	Food and Agriculture Organization
GOB	:	Government of Bangladesh
IEE	:	Initial Environmental Examination
IES	:	Institute of Environmental Science
ILET	:	Institute of Leather Engineering & Technology
ISSN	:	International Standard Serial Number
IULTCS	:	International Union of Leather Technologists and Chemists Society
JSC	:	Junior School Certificate
JALCA	:	The Journal of the American Leather Chemists Association
JSLTC	:	The Journal of the Society of Leather Technologists and Chemists
MT	:	Metric Ton
NGOs	:	Non Government Organizations
PPE	:	Personal Protective Equipment
OSH	:	Occupational Safety and Health

Abbreviation		Connotation
SD	:	Standard Deviation
SHED	:	Society for Environment and Human Development
SSC	:	Secondary School Certificate
TDS	:	Total Dissolved Solid
TKN	:	Total Kjeldahl Nitrogen
TRIS	:	Technical Regulation Information System
TSS	:	Total Suspended Solid
UNIDO	:	United Nations Industrial Development Organization
WASA	:	Water and Sewerage Authority
WHO	:	World Health Organization
%	:	Percentage
US$	:	US Dollar

ABSTRACT

Bangladesh has the potential of developing leather industries due to having quality raw materials (hides and skins) and cheapest labourer market. But still no new entrepreneurs are attracted to set up new leather industries here because of generating huge amount of untreated pollutants from tannery and no one wants to bear the environmental risks of this country. Accordingly, generation, existing management system and impact assessment along with possible utilization of the tannery solid wastes as value added products were considered for investigations.

The existing management system of tannery solid wastes and its consequences were investigated through field survey with structured and unstructured questionnaire; the tannery workers, technologists, officials were interviewed during 2009-2011. The maximum amount of solid wastes generated was measured in the peak season (October-December) in the year 2011 through developed formula and found 443 metric ton solid wastes were generated in a day from tannery at Hazaribagh, Dhaka. It was also observed that 90% of the trimmers, (tannery workers) were directly affected by those solid wastes, the surrounding environment became polluted and soil of dumping ground was contaminated with organic carbon (7.97% ±0.170), organic matter (13.70% ±0.292), TKN (1.54% ±0.137), Chloride (0.247% ±0.0284) and Chromium (2.28 ±0.0291).

The manufacturing of Animal glue through appropriate utilization of more solid wastes, was targeted as a tool of tannery waste management. Its traditional glue manufacturing process was modified for producing animal glue from fleshings and pickle cuttings mixing with raw trimmings which imparted better physical and chemical properties in comparison to the sample glue collected from local market manufactured following traditional method.

The main target of this research had to enhance the efficacy of by-product industry through process modification and integrating with the main industry so that the solid wastes generated from tannery need not to be dumped and used at the point of origin triggered to the eco-friendly environment. The findings of this work along with the findings of the previous researchers created a hope for further progress in research in the field of leather technology and its eco-friendly environmental management.

CHAPTER-ONE

GENERAL INTRODUCTION

Chapter-1: General Introduction

1.1 Overview of the Leather Sector in Bangladesh

Bangladesh is densely populous country. The overall economic development of the country mainly depends on agriculture, industry, and trade and service sectors. The industrial blooms were come together in contributing to the national economy of the country from the mid seventy's when Jute and Leather industries in Bangladesh were developed on a large-scale basis. Previously, the leather industries especially tanneries were owned by Bangladeshi Traders from the Punjabi and Madraji traders after liberation war in 1971 while there were some tanneries owned by Bangladeshi people as well. The 350 numbers of industries were running with new management and tried to renovate across the country (Bangladesh Tanners' Association, 2011). BTA also mentioned that the 250 tanneries were located at the bank of river Buriganga in Hazaribag, Dhaka, the heart of the city. But the numbers of tanneries are decreasing day by day. According to the UNIDO survey report'2005/2006, only 35 numbers out of 192 tanneries are currently in operation regularly in Hazaribag.

These tanneries of Bangladesh has been almost entirely supported by local raw material resources while 1.0 million live cattle are imported every year from neighbouring countries to meet our protein demand adding extra number of raw hides and skins (Livestock Census, 2004 and Hides & Skins Merchants Association, 2005). According to the UNIDO and Hides & Skins Merchants Association Report (2005), about 85,000 Ton raw hides and skins are processed per year in Bangladesh. Among those 40% are done during the Qaurbani time (75 days) at 450 Ton/day rate and rests are processed in 225 days at 230 Ton/day production rate.

The capacity installed of these tanneries can provide employment for about 27,000 people by the leather industries directly (BSCIC Survey Report'2002). These people can produce 250 million sq.ft leather per year but the actual production is 180 million sq.ft/year (UNIDO Survey Report, 2006).

Most of those industries are export oriented and about 95% of leather and leather products, in the form of crust and finished leather, leather goods and footwear are marketed abroad. The value addition of leather and leather goods and footwear exports on average is 85% local and 15% foreign (Manzur, 1998). As per reports of Export Promotion Bureau, Dhaka export of the leather sector is approximately US$ 4203.53 million in last 13 years i.e. 1998-2011 out of which US$297.83 million has been earned through exporting leather in the year 2010-2011.

1.2 Environmental Challenges of Tanneries in Bangladesh

Tanning is the process by which animal hides and skins are converted into leather. The hides and skins after removal of flesh, fat and hair are treated with chemicals, which cross-link the microscopic collagen fibres to form a stable, durable material called leather (Datta, 1999). The chemicals used may be derived from traditional vegetable products or be specifically prepared by the chemical manufacturers.

Manufacturing of leather and leather goods produce high amount of wastewater, solid wastes and volatile emission containing different loads of pollutants. As a result the leather industry as a whole is under critical condition, needs to review by the environmentalists throughout the world. There is no exception for Bangladesh. Toxic gases such as ammonia, acid vapour, hydrogen sulphide, sulphur dioxide, carbon dioxide chlorine etc. are also produced in different steps of leather production. In fact, there is no chemical which is absolutely devoid of any harmful effect to the environment, plant, animal and human health; the variation is in the use of doses and the degree of toxicity and/or harmful effect of the reagents used in the process.

1.2.1 About Tannery Effluent

There is no single process for producing leather without generating huge amount of wastes. Some of the wastes will arise from surplus, spent or washed-out chemicals used in the process. Some chemical constituents may be toxic while others are powerful pollutants in water and on soil. The release of volatile sulphides contributes obnoxious and toxic odours. Certain solvent vapours can have adverse health effects after prolonged exposure (FAO, 1991).

Most of the leather industries haven't any arrangement for effluent treatment. They discharge a huge amount of untreated wastewater. According to a FAO report (1991), all these tanneries process 240 MT leather every day and generating 8.47 million litre liquid wastes. It is also estimated that tanneries discharge some 10 million litre of highly polluted effluent daily during the lean season and around 21.6 million litre daily during peak season (Bangladesh Gazette, 1997). In general, pollutants present in the tannery effluent are broadly categorized into:

a) Biodegradable Organic Compound measured in terms of Biochemical Oxygen Demand (BOD).
b) Non-biodegradable or persistent organic compounds measured in terms of Chemical Oxygen Demand (COD).
c) Heavy metals such as Chromium.
d) A wide range of dissolved substances, suspended solids and volatile emissions.

1.2.2 About Solid Wastes

The solid wastes generating from leather processing consists of raw trimmings, hair & wool, fleshings, wet blue trimmings, splitting, shaving dusts, buffing dusts, dyed trimmings, salts, lime sludge etc. According to a FAO report (1991), 98 MT solid wastes was generated every day from the tanneries of Bangladesh. Here, it may be mentioned that to process 1000kg raw hides and skins around 700kg of solid and suspended solid wastes are discharged (Puntener, 1995). The total leather production in Hazaribag was estimated to be around 74,000 – 85,000 Ton per year whereas the solid wastes generated from the tanning industries in Hazaribag during peak period was around 136.5 Ton/day and those during lean period was around 69.0 Ton/day and on an average 102.75 Ton per day (UNIDO report, 2006).

1.2.3 Effects of Pollutants Generating from Tannery

At present no control is practised by either the tannery owners or any agency like Water and Sewerage Authority (WASA), Dhaka City Corporation (DCC) or Department of Environment (DoE) due to some resource based limitations. So all the wastewater generated by the industries is discharged in untreated form in the roadside drains and low

lands, which sometimes overflow causing highly unhygienic environment. Add to this, the substantial quantity of solid wastes being dumped by the roadside, which are washed-out filling the drain reducing their carrying capacity. Thus the soil and groundwater are contaminated by the toxic pollutants severely, which determines the leather industry in 'RED" category (The Environment Conservation Rules, 1997).

As leather industries generate huge amount of toxic pollutants causing sever health problem of workers and other people living in the adjacent area. Society for Environment and Human Development (SEHD) collected the field level data and observed that 58% tannery workers suffers from Gastritis, 31.28% from Skin diseases, 11.0% from Hypertension and 10.61% from Rheumatic fevers while the average national morbidity rate of these three major diseases are only 0.509%, 0.703% and 0.406% respectively. It also said that some 34.63% of the workers occasionally suffer from various kinds of fever, 22.9% from cough and 19.0% from Jaundice. Someone may also suffer from Allergy, Dizziness, Nausea, Vomiting, Irritation of ear, nose and throat, Headache, Sinusitis, Bronchitis, Respiratory problems, Heart diseases etc. Among the sufferers some 87.5% claimed to have developed these diseases after joining the tannery. This report also quoted from Dr. Mohammad Hossain, Ex-Director of Health that Liquid and solid wastes containing various chemical residues are the main cause for the diseases (SHED Report, 2002).

According to the SHED Report (2002) and UNIDO Report (2006), about 89% of the tannery worker suffered from general illness. They need to take medical treatment sometimes and thus they are getting looser in their income. Therefore, the cost of human health impacts on the cost of living and their social status are evident due to income loss in absentia, loss of working hour, loss of efficiency, saving loss for the treatment and taking medical attention and occurring malnutrition resulting poor health of the earners and their family members.

Thus environmental impacts due to solid and liquid wastes from leather and allied industries are classified into following three major groups in UNIDO Report (2006):

1. **Loss of Human Health**: This is defined as death or increased probabilities of death and by illness including various diseases caused by relevant pollutants. For example, chromium, nitrate, sulphide, chloride, phenol etc. mostly causes morbidity and increased sufferings like cancer and other influential diseases.
2. **Loss of Human Welfare**: This is defined in terms of loss of land value and rent from the house and household materials and equipment used. For example, ammonia, hydrogen sulphide, carbon dioxide, chlorine, sulphur dioxide and acid vapour etc. causes serious damage on metallic materials even on gold ornaments.
3. **Loss of Resources**: This is defined in terms of its loss of vegetation and aquatic ecosystem including fishes, aquatic plants and biodiversity loss creating in the area. BOD, COD, pH, TKN, Colour, Odour, Solid wastes and Suspended solids etc. are causing this type of damages.

1.3 Problem Identification

Solid wastes generating from tanning industry would be valuable resources of producing by-products. But there were very few works found in this field eventually no research work was done regarding on this topic in our country at all, more researches were done with high technology by the foreign researchers which are not available in our country rather those research works showed the pathway of utilization of tannery solid wastes with its limitations.

Sykes (1973) indicated some areas in which the leather industry would need to direct technical resources, not necessarily to improve its product, but to comply with social demands which might frequently have the support of legislative action; he also said that essentially industries used resources wastefully and with little thought for the future as well as it contaminated the environment with the by-products of its operations and was therefore uncaring of people; he concluded that the qualities demanded of the products by the consumers and the qualities demanded for the environment were needed to be integrated. This was a hypothetical phenomenon given by Sykes and showed the light of doing something with the wastes generated from tannery at the end but not mentioning what required to do.

Islam (1993), Kaisar (1994), Rahaman (1995) reported that the untreated liquid and solid wastes of tannery were discharged directly through the roadside drain and deposited to the nearby low lying areas and finally fallen to the river Buriganga which were spreading the environmental pollution. ESDO (1995) also reported the same with mentioning some solid wastes such as rotten leather cuttings, fleshings, hair, blood and different types of chemical wastes which produced poisonous gas and polluted the environment. But presently these wastes cannot fallen into that river directly due to the obstruction of the Dhaka Flood Control Embankment which causes serious environmental hazards and public nuisances and a continuing source of environmental complaints for the local community and passer-by. Mondal (1997) also did the repeated work and showed the environmental impact of the City Protection Embankment at Hazaribag; as he found the sluice gate remain closed year after year and huge waste and garbage discharged from the tanneries remain stagnant at the upstream and the low lying lands from Lalbagh to Rayer Bazar Shikder Medical College which were filled with those poisonous wastes resulting the land fertility was destroyed and the grass and shrub got faded and stained. Yousuf (1998) did the work repeatedly. But nobody showed the data on the exact amount of solid wastes discharged from the leather manufacturing industries and the way of mitigating pollution.

Springer (1994) concerned about tannery solid wastes and classified it as Hazardous, Non Inert, and Inert with characteristics of Inflammability, Corrosiveness, Reactivity, and Toxicity; he also enlisted the possible utilization of it by following IULTCS compilation of by-products. His work was outstanding and showing the actual possibility of utilization of solid wastes but he did not mention the procedure of by-product production.

Brown *et al.* (1994) were first to develop the process to extract protein hydrolysate from contaminated leather waste. He extracted gelatin from chromium leather waste subsequently developed a two-step process that allowed a protein product to be isolated in the first step followed by a lower molecular weight, hydrolyzed protein product obtained enzymatic treatment of the remaining chrome sludge, a recyclable chromium product was also obtained. But he was considering only the chrome sludge containing chrome shaving dust and trimmings.

Rose *et al.* (1994) mentioned the uses of collagen contained in hides and skins as an adhesive as well as they highlighted on the use of collagen in food, cosmetics and brewing industries. This was a hypothetical attempt to use tannery solid wastes by converting it to animal glue and other products but did not mention the process of conversion clearly.

Puntener (1995) first published the tanner's responsibility for active environmental protection was being assigned more and more importance in the society. He mentioned that the reduction of pollution in tannery waste was being tackled on three fronts, such as, tanneries were optimizing and reducing their overall chemical consumption and improving waste-water purification; tanneries were more efficient in their use of chrome and were selectively employing non-chrome procedures;. and lastly, recycling of leather production waste was being more actively promoted. This paper also presented simple environmental balance scheme and showed a new tanning system which supplements existing tanning procedures. One of the major findings from this research was the quantification of solid wastes come out from the leather industry. i.e. 1000 Kg raw hides yields approximately 150 Kg Leather, 150 Kg Split, 700 Kg Solid Wastes and 30 m^3 or 400 Kg effluent. The segregations of these 700 Kg Solid Wastes are 430 Kg Raw Trimmings, 250 Kg Shavings and 20 Kg Crust and Finished Leather Trimmings. But the major limitation of this study was the limited cost-effective recycling options were available in this report; only disposal for landfill was performed in previous. Recently the situation has changed however, because environmental regulations have become more stringent. Puntener *et al.* (1995) were continuing their research work and presented the limited process of composting of metal free shaving dust.

Rutland (1995) introduced different phenomenon of waste disposal and leather manufacturing. He suggested making all process of tannery be eco-efficient or environmentally conscious, which was reached by the delivery of competitively, priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the Earth's estimated carrying capacity. He also adhered here the Chemical Manufacturers Association's commitment to the 'Community Awareness and

Emergency Response Code', Pollution Prevention Code, Process Safety Code, Distribution Code, Employee Health and Safety Code and Product Stewardship Code. This was an attempt to introduce the terminology eco-friendly in the leather manufacturing process rather to mitigate the existing pollution.

Lewis (1997), Kumaraguru *et al.* (1998) described about the utilization of the lime fleshings for making tallow or extracting amino acids and free fatty acids; continually, Cantera *et al.* (1997) also mentioned another possible way of using hair for felt manufacturing, organic fertilizer, biogas generation, regeneration of keratin, recover melanin for manufacturing sun-block lotions, manufacturing of nylon 6.6, etc.; Erickson (1997) stated about the alkaline hydrolysis process of chrome shaving dust for extraction of amino acid solution which could be used as a new raw material in powder form for animal feed manufacturing, fish feed manufacturing, foam enhancer, etc.; Taylor *et al.* (1998) also discussed about the protein recovery from chrome shaving dust with cost estimation; Sykes (1997) and Gish (2000) opined that chrome and vegetable tanned leather wastes could be used for making leather board; but no one clearly described the process of manufacturing the by-products. Finally, Bossche (1997) discussed about the uses of incineration for burning of chrome containing sludge and Reutlingen (1997) described about the legislation governing tannery solid wastes as feed for animals and toxic sludge for disposal as land fill.

Shelly *et al.* (2000) did research work on making Gelatin from wet blue shavings by protein hydrolysis method; Nogami *et al.* (2000) also recovered protein from chrome shavings containing up to 300 mg/kg of chromium was administered as a food supplement for the development of *Tilapia Oreochromis Niloticus*; Tahiri *et al.* (2001) classified the tannery solid wastes as tanned and un-tanned including raw trimmings, fleshings, splitting etc. which could be the raw materials of glue manufacturing factory; Berry *et al.* (2001) demonstrated about the extraction of chromium from leather shavings formulating pigments which would be utilized in ceramic industry; Chen *et al.* (2001) also mentioned about the hydrolysis process for protein extraction; Bowden (2003) described the conversion of tannery solid waste materials into useful energy like biogas; Pulavendran *et al.* (2005), Crispim *et al.* (2010) also stated the biogas production from

tannery solid wastes; Bitisli *et al.* (2006) experimented on using fleshing and vegetable shaving wastes in production porous brick; Puig *et al.* (2008) first suggested about the separate leather estate for all through controlling pollution; Galarza *et al.* (2010) also suggested to control pollution hypothetically.

1.4 Justification of the Study

In 1989, International Union of Leather Technologists and Chemists Societies (IULTCS) arranged a meeting in Philadelphia suggesting for future research guidelines on Leather Technology field. It mentioned that scientists must give attention on the following three major areas on development, such as, (A) Clean Technologies for Tanneries: (i) Solid Wastes Management, (ii) Effluent Management; (B) R & D for method development, and (C) Skill development and Cost reduction.

After deciding that, most of the researchers spread over the world are doing research for method development with cost reduction activities while introducing 'clean technology' faces severe challenges on this occasion in different countries. The outcomes of those research works are published in the following pioneer journals and reports –

i. The Journal of the American Leather Chemists Association (JALCA), ISSN = 0002-9276.
ii. The Journal of the Society of Leather Technologists and Chemists (JSLTC), ISSN = 0144-0322.
iii. World Leather, ISSN = 0894-3087.
iv. Indian leather, ISSN = 0019-5758.
v. Leather (International Journal), ISSN = 1473-6314.
vi. Government's and NGOs' Report.

So far available, a total of 630 research articles are published in the above mentioned journals during 1990 to 2010. Out of them minimum 33 were cost related, and 64 solid wastes related, 92 effluent related and rest 441 were found process development related articles. The last twenty (20) years literature survey revealed that a small number of research works were carried out in the field of clean technology while most of the researchers worked on tanning process development; only a few (11%) were done for solid waste management in tannery.

On behalf of IULTCS, every developed country has taken a project 'Technical Regulation Information System (TRIS)' which is very much involved in policy development to monitor standardization activities introduced by national standardization bodies. IULTCS formulated and imposed the necessary conditions on enterprises to develop their activities beyond their national border. It gives the leather manufactures information on draft technical regulations and special specifications. The general aim of this project is to improve capacities and skills to support member as well as non-member leather industries. Also on-line training would become fruitful for this purpose (http://ec.europa.eu/idabc/en/document/2072/5926.html). All industries ensure this policy to promote sustainable consumption of resources by following appropriate production pattern concerning environmental degradation. This resource sustainability involves four principles accordingly:

1. Continuing to reduce the usage of materials and energy through cleaner production processes to enhance production efficiency and reduce effluents of hazardous and toxic chemicals;
2. Moving towards circular flows of materials by promoting more strongly their continued reuse and recycling;
3. Shifting from nonrenewable to renewable sources of energy;
4. Changing the emphasis from selling products to supplying services.

On the basis of above principles of resource sustainability, German Solid Waste Disposal Act established technical guidelines for hazardous wastes, regulates intermediate storage, chemical, physical and biological treatments, combustion and final disposal according to state of the art technology (Hugo Springer, 1994). According to this guideline International Union of Leather Technologist and Chemists Society (IULTCS) compiled the following alternatives which can be produced from using tannery solid wastes:

- Raw trimmings could be utilized in Glue/Gelatin manufacturing;
- Fleshings could be utilized as Glue manufacturing, composting and landfill;
- Hair and wool could be used in brush industry;
- Other protein wastes such as chrome and vegetable shaving dusts could be used in fish or poultry feed manufacturing and brick manufacturing;
- Curing salts could be reused;
- Lime sludge could be converted in composting;

It has been found in the literature that the quantitative and qualitative potentials of raw hides and skins suitable for tannery vary widely, not only between continents, but from country to country, and even within districts. Thus the tannery produces wide range of solid wastes during its production process and it is very difficult to manage all kinds of solid wastes inside its own. So, they dumped most of the solid wastes by the low land and roadside in our country and spread pollution.

Consequently, in principle for sustainable eco-friendly management of solid wastes, prevention is the most preferred option to be followed while disposal is the least. But in between prevention and disposal there are another four steps required for managing solid wastes such as minimization, reuse, recycling and energy recovery respectively. Practically, prevention of generating solid wastes from tannery is not possible in traditional process of leather technology followed in Bangladesh, minimization is beyond the scope, some small amount of wastes i.e. salt is reused while recycle and energy recovery has no application at all. Therefore only disposal is currently practised in our country.

In addition, the final report published on June 2005 for Initial Environmental Examination (IEE) of Central Effluent Treatment Plant (CETP) and Other Industrial Installations in the Tannery Estate Dhaka Project described that a Controlled Tipping Yard (CTY) would be established to store the sludge and solid waste of tannery estate. Accordingly, 10 acres land was selected to construct the Controlled Tipping Yard. It is also expected that 61,000 Ton per year of solid waste from the tannery estate would be used in the Controlled Tipping Yard and after a fixed period, solid waste would be removed to another places as landfill. The yard has to be properly designed so that the environment, ground water and surface water are not affected particularly through leachate formation. This report also mentioned about the dumping of solid wastes rather utilizing it for producing by-product (UNIDO Report 2005).

Moreover, as solid wastes are the pieces of using raw materials in tannery, so resources are being lost while dumping. An effective by-product industry can manage the solid wastes and add value by converting the wastes to usable product.

So we need to find out the suitable way of using most of the solid wastes generating in the tannery for producing cost-effective by-products as per the IULTCS compilation as mentioned above which would minimize the resource loss and mitigate pollution.

UNIDO Report (2006) focused a few by-product cottage industries found in Hazaribag using on an average 29% of dumped solid wastes for various purposes. Some produces animal glue from raw trimmings, some produces poultry and fish feed from bones, some dried solid wastes are being used by the by-product industry and poor people living in the area for burning. As solid wastes contain microorganisms and chemicals, so that the people are affected very badly and the soil and air becomes polluted directly (UNIDO Report, 2006 and SHED Report, 2002). So, primarily the question comes in mind that 'does the by-product industry really support tannery to mitigate pollution in present situation?'

Again, Hugo Springer (1994) stated that tannery solid wastes could be utilized to produce different by-products. Animal glue is one of the by-product which is an adhesive that is created by prolonged boiling of animal connective tissue like skins, bones, tendons etc. at a certain temperature. Chemically it is the residue of collagen fiber, contains Carbon (51-52%), Hydrogen (6-7%), Oxygen (24-25%) and Nitrogen (18-19%). Most animal glues are soluble in water, useful for joints and can be applied hot with a brush or spatula.

$$\mathbf{C_{102}H_{149}N_{31}O_{38}} + \mathbf{H_2O} = \mathbf{C_{102}H_{151}N_{31}O_{39}}$$

Collagen Water Glue

Animal Glue joints are reversible, repairable and can be released easily with the application of heat and steam. It is also known as Technical Gelatin and used in the firebox, paper, jute, cotton, packaging, surface sizing of hand-made high quality paper industry, polymerization of plastics, cosmetics, light filters, Electrolytic refining of metallic Copper, White-wash or lime-wash of wall, etc (http://en.wikipedia.org/wiki/Animal_glue).

But the few existing glue manufacturing factory found in Hazaribag produce animal glue from small amount of dumped raw trimmings only. So, this study has chosen manufacturing animal glue from raw trimmings with addition of fleshings and pickle

cuttings while the fleshings and pickle cuttings are being dumped by the low land and roadside presently. Therefore, the maximum solid wastes could be utilized.

Consequently, as maximum solid wastes of tannery being used for producing animal glue it does not require dumping and helps to mitigate tannery pollution spreading over the city. Finally, it can be said that a new avenue for processing the solid wastes of tanning industry by enhancing economically and eco-friendly by-product manufacturing process creating new employment opportunity would be opened up on the basis of the outcome of this study. Thus the study has the following hypothesis, vision, aim and objectives to meet our goal:

Hypothesis: Manageable Tannery Solid Wastes Pollute Our Environment.

Vision: Wastes could be converted into Wealth.

Aim: The aim is the innovation of appropriate and eco-friendly techniques for utilizing the maximum solid wastes of tannery to facilitate the environment for sustainable tannery industry of the country.

Objectives:

1. To assess the status of tannery solid waste generation in tannery of Bangladesh.
2. To observe some environmental impacts due to existing management system of tannery solid wastes.
3. To support existing animal-glue manufacturing unit through modifying its traditional production process making it eco-friendly and cost effective.
4. To find out possible integration of tannery and by-product industry.

CHAPTER-TWO

MATERIALS AND METHODS

Chapter-2: Materials and Methods

As the study was related with utilization of tannery solid wastes converting to glue, it required extensive field work for collecting data, experimental work for modifying glue manufacturing process which should not make any harm to our environment on trial and error basis, and laboratory work for analyzing soil, effluent, and the quality of glue produced from the wastes. Thus this study was the combination of experimental research and applied research consisting field survey, analytical works and technological modification. The analytical part of the study was carried out at Institute of Environmental Science (IES), University of Rajshahi and Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratory, Dhaka. Moreover, the modified method of glue production was followed in the bulk production of animal glue which was carried out in a glue manufacturing factory adjacent to the tannery, M/S. Kalim Leathers located at Hazaribagh.

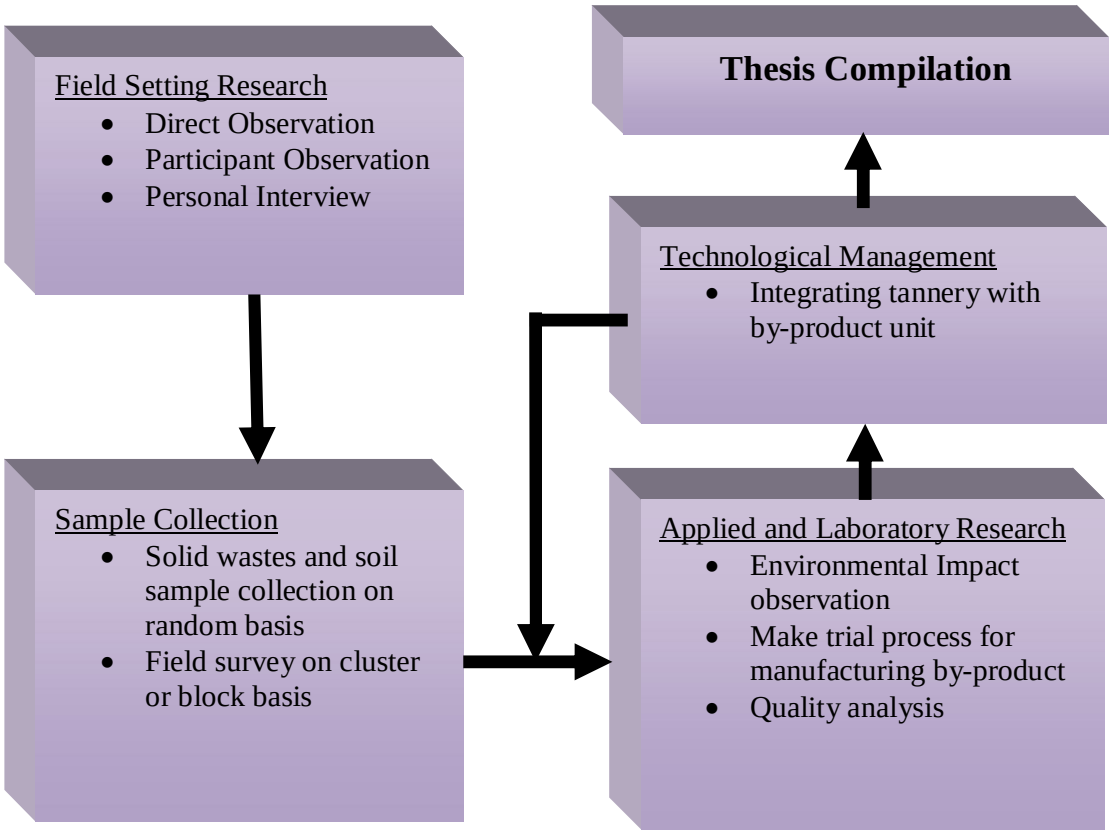


Figure-1: Research methods flow chart

2.1 Study Area

Tanneries are mainly located in Dhaka and Chittagong, two main economic regions of Bangladesh, out of which Hazaribagh of Dhaka city is the prominent place where the maximum number of tanneries are situated near the Buriganga River, becoming the largest leather processing zone of Bangladesh. This is a principal area of Dhaka Metro which was built during Mughal period and becomes a part of Old Dhaka. This area is located in the western part of Dhaka city which is surrounded by Nawabgonj (south), Pilkhana-Jighatola (north-east) and Rayerbazar (west). The Dhaka Flood Protection Dam is in the west. Once the river Buriganga was near to the dam but in course of time it has shifted to about two kilometers away from there by siltation.

The area is densely populated. According to the Bangladesh Bureau of Statistics report (2001), Hazaribagh area is 5.3 km² with a density of 35,026.2 per square kilometer and an approximate population of 185,639.

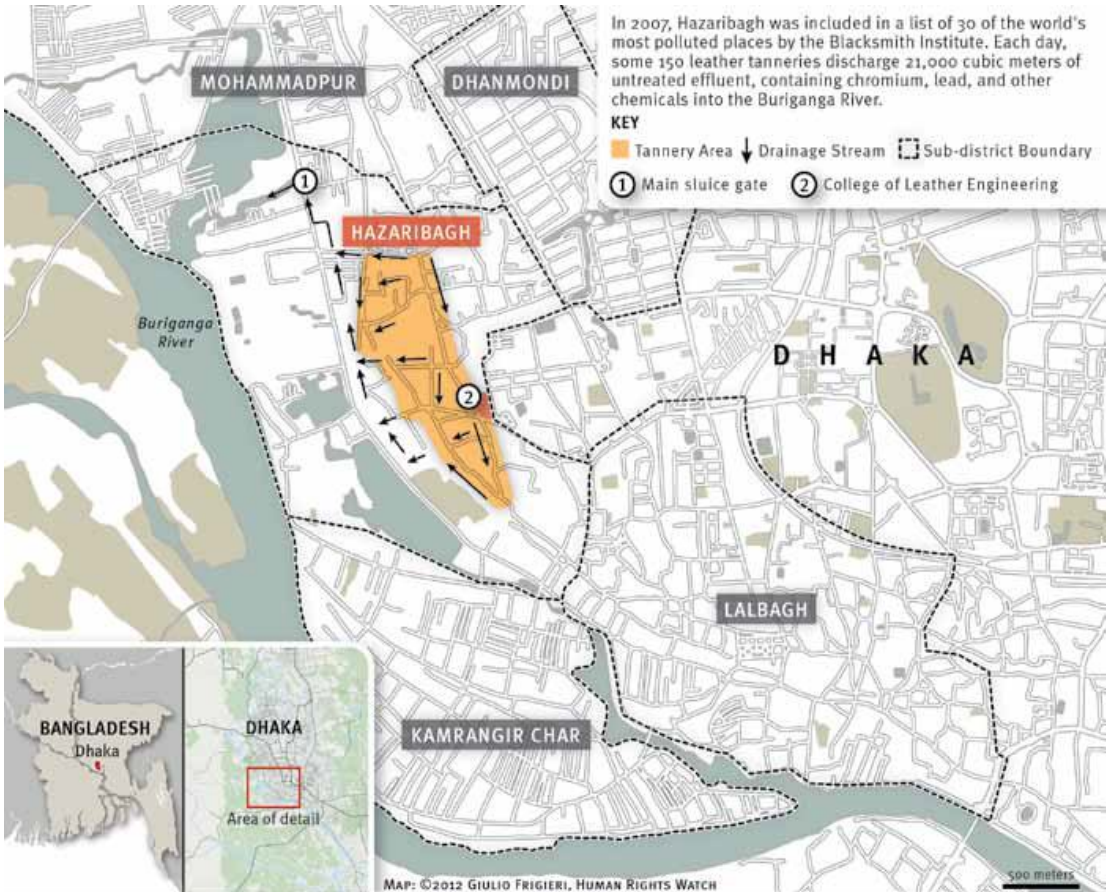


Figure-2: Map of Hazaribagh (*Source: Human Rights Watch, 2012).

In general, solid wastes generating from the tanning industries consist of raw trimmings, hair & wool, fleshings, wet blue trimmings, splitting, shaving dusts, buffing dusts, dyed trimmings, salts, lime sludge etc. which are same everywhere in the country. So, Hazaribagh tannery area of Dhaka city was selected for the study carried out. The study area lies between 23°43′48″ N, 90°22′12″ E and latitude 23.73, longitude 90.37.

2.2 Survey for Data Collection

A total of 60 acres of lands occupied by the tanneries at Hazaribagh of Dhaka city (BSCIC survey report, 2002) was clustered in 5 different blocks (B-1: Monessware Road Block, B-2: Sher-e Bangla Road Block, B-3: Mid Hazaribagh Block, B-4: Sonatangar/Gojmohal Block and B-5: Kalu Nagar Block) for collecting primary data by applying pre-tested unstructured and structured questionnaires.

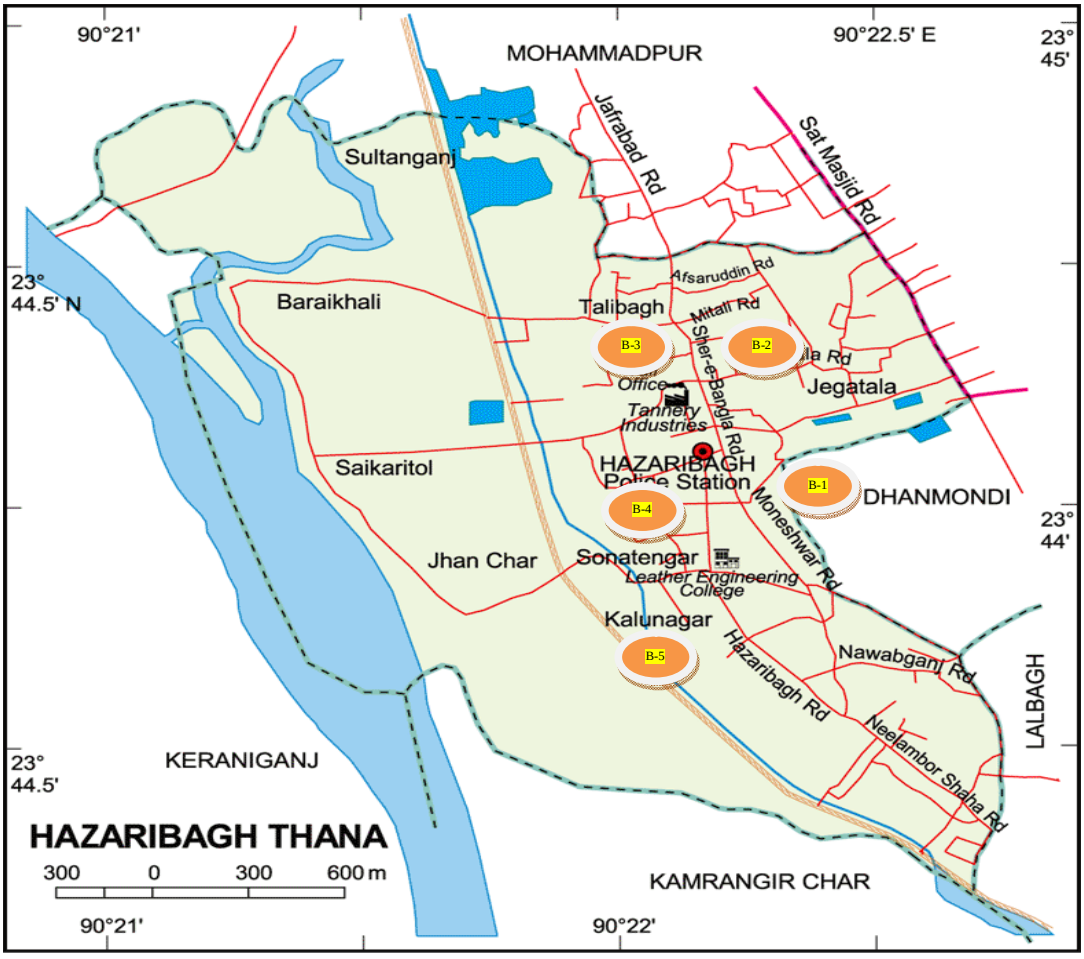


Figure-3: Map indicating the locations of sampling sites (B-1, B-2, B-3, B-4 and B-5) at Hazaribagh.

The survey questionnaire was prepared to find out the number of tannery situated in Hazaribagh area as well as the maximum pieces of cow hide, buffalo hide, goat skin, and sheep skins processed by those tanneries in a day which was converted into weight as metric ton by applying the formula developed:

$$W = \frac{w \times n}{1000} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Here,

W = Weight of Hides/Skins (in MT)

w = Weight of Hides/Skins (in Kg/Piece)*

n = Number of Hides/Skins (in Piece)

***N.B.** The average weight of one piece raw cow hide, buffalo hide, goat/sheep skin are 12 Kg, 22 Kg and 1.5 Kg per piece respectively (UNIDO report, 2006).

Similarly, the amount of solid wastes generated was also quantified by using formula developed based on calculated raw weight of the hides and skins processed.

$$M = \frac{W \times p}{1000} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Here,

M = Weight of Solid Wastes generated (in MT)

W = Weight of Hides/Skins processed (in MT)

p = Weight of Solid Wastes generated (in Kg)**

****N.B.** 1000 Kg raw hides yields approximately 430 Kg Raw Trimmings, 250 Kg Shavings/Fleshings and 20 Kg Crust and Finished Leather Trimming. (Puntener, 1995).

Besides, the number of workers worked in those tanneries was also counted. The researcher used door to door method for collecting required information and made for direct observation, participant observation, and personal interview of related people such as executives, technologists, officers, workers, and experts to find out the impact of tannery solid wastes on people, economy and their socio-economic status.

In addition, some soil samples were also collected from the dumping area at Hazaribagh to know the impact of tannery solid wastes on environment. Some secondary data were also used here to process the primary data.

2.3 Collection and Preparation of Soil Sample

Soil samples were collected on random basis from five (5) different stations approximately 2Km apart from each other of the low land under the clustered areas of Hazaribagh thana and adjacent areas. The stations were named by the known local name, which are as follows-

Station No.	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**
Name of the Station	Beribandh	Kalunagar	Company Ghat	Rayer Bazar	Gojmohol

Soil samples were taken by digging six inches deep position from the surface of randomly selected five (5) different spots of each of the above stations and mixing vigorously. About 1kg of the mixed sample of each stations were then collected in the pre-labeled plastic poly bags. These samples were prepared in the IES laboratory for the chemical parameter analysis. The soil samples were placed on thin and clean piece of paper and left until air dried (about one week in dry season and longer in rainy season). Visible roots, plant fragments were removed from the sample and discarded. The soil was dried in the laboratory at room temperature. During drying the windows were kept open in the working hours and fans were operated continuously. The different sizes of soil samples were grinded with mortar and pestle after drying and then those were passed through the 2mm sieve. The grinding and sieving were continued until the entire soil samples were separated from gravel particles and stones. The mortar and pestle were kept clean and dry properly in every time after grinding to avoid contamination. After grinding and sieving properly, 500gm of each soil sample was kept separated in pre-labeled plastic container covered with screw cap. These samples were analyzed in the BCSIR Laboratory, Dhaka for determining pH, Organic Carbon, Organic Matter, Total Kjeldahl Nitrogen (TKN), Chloride and Chromium.

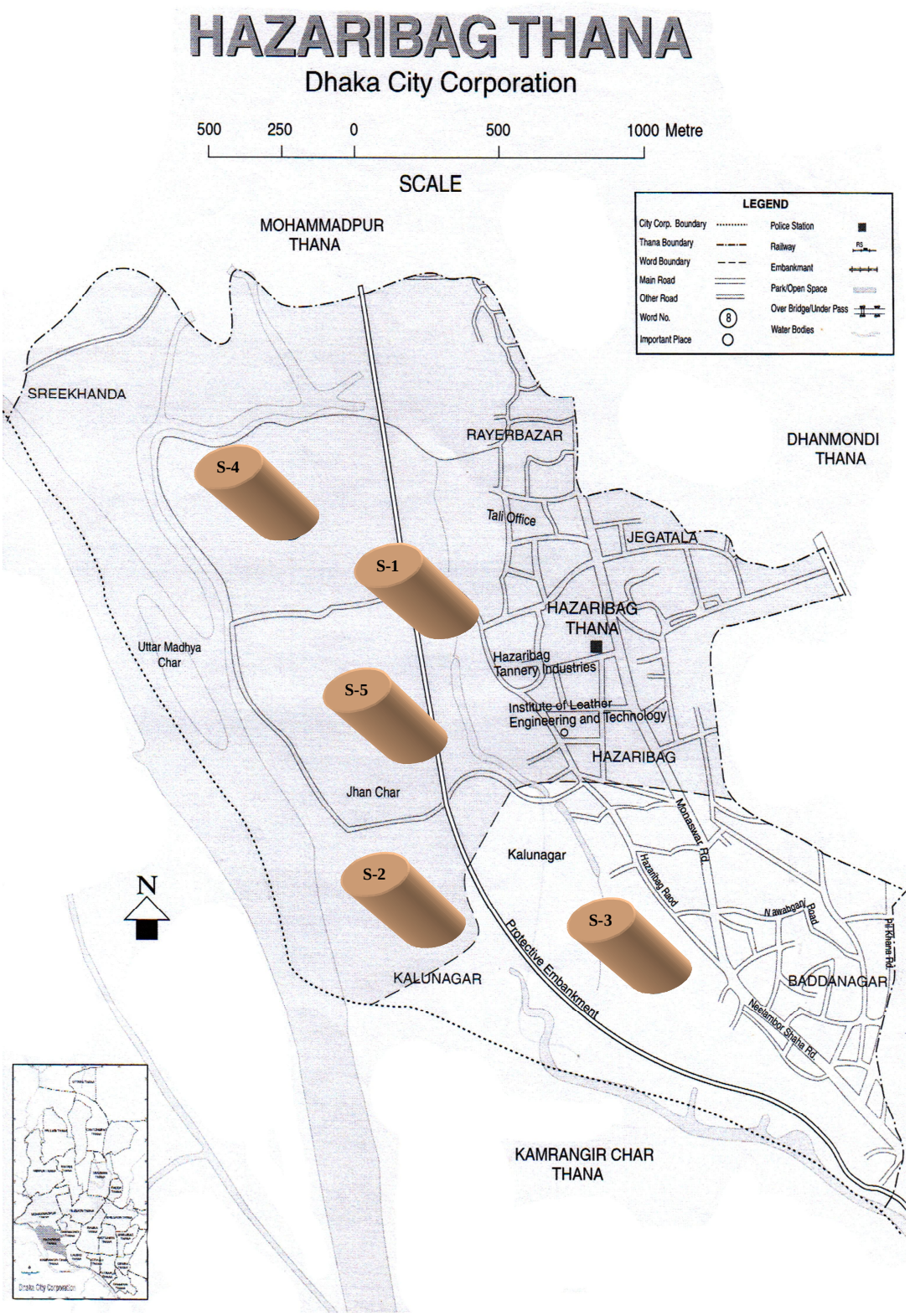


Figure-4: Map indicating the locations of sampling sites (S-1, S-2, S-3, S-4 and S-5) for collecting Soil Sample at Hazaribagh.

2.4 Collection and Preparation of Tannery Solid Wastes

Solid wastes of tanning industry viz. raw trimmings, fleshings and pickle cuttings of hides and skins with small amount of vegetable and chrome shaving dusts were collected from different tanneries located at Hazaribagh on random basis. Initially approximately 5 kg of each solid waste as mentioned were collected in plastic poly bags separately, dried and preserved in the pre-labeled plastic container with screw cap for using in glue manufacturing trial process. Moreover, a total of 250 kg raw trimmings, 104 kg fleshings and 30 kg pickle cuttings were collected in 5 different slots for using in bulk production of animal glue by modified method. In every slot of bulk production, 50 kg raw trimmings and 6 kg pickle cuttings were kept same but fleshings were varied as 6kg, 13kg, 20kg, 25 kg, and 40 kg.

2.5 Glue Manufacturing Method

2.5.1 Traditional Method

Traditionally, animal Glue is produced from raw hides and skin scraps by the alkaline hydrolysis method at a certain temperature. This process has several sequential steps to follow consisting cleaning raw trimmings to remove dirt, wetting the cleaned wastes in lime water, cleaning again to remove lime, and finally heating with boiling water for several hours, then filtering the liquid glue, evaporated and dried.

This process was followed for producing animal glue from raw trimmings of cow hides and goat skins separately with applying and avoiding wetting agents and sodium sulphide in the process respectively. Another ready-made glue sample was collected from the local market for its quality analysis.

1. Cow hide trimmings with using wetting agents and Sodium Sulphide (G-1)
2. Cow hide trimmings without using wetting agents and Sodium Sulphide (G-2)
3. Goat skin trimmings with using wetting agents and Sodium Sulphide (G-3)
4. Goat skin trimmings without using wetting agents and Sodium Sulphide (G-4)
5. Sample Collected from Local Market (G-5)

Another two trials were done to produce animal glue from vegetable shaving dust and chrome shaving dust following the same cooking process directly.

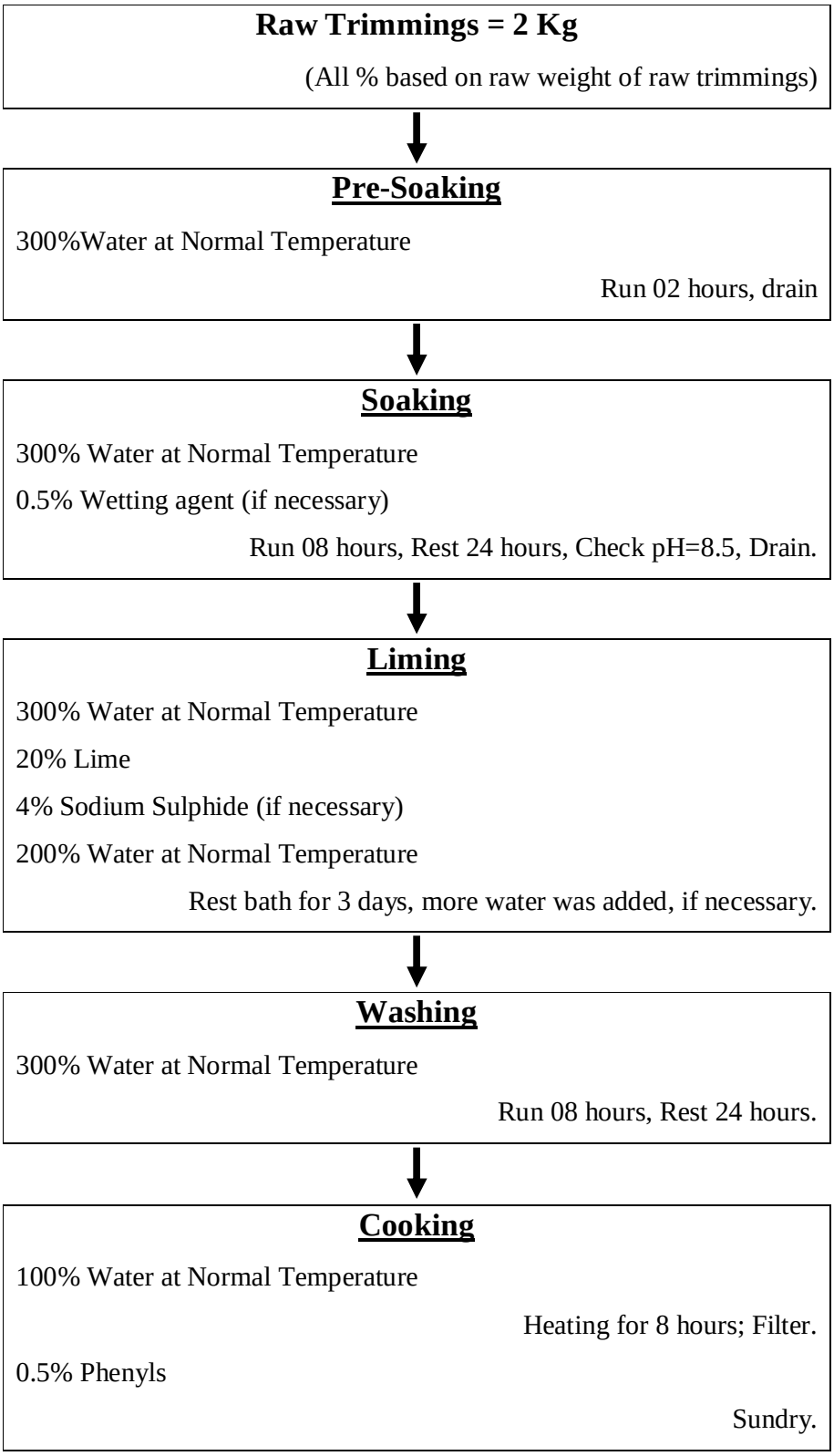
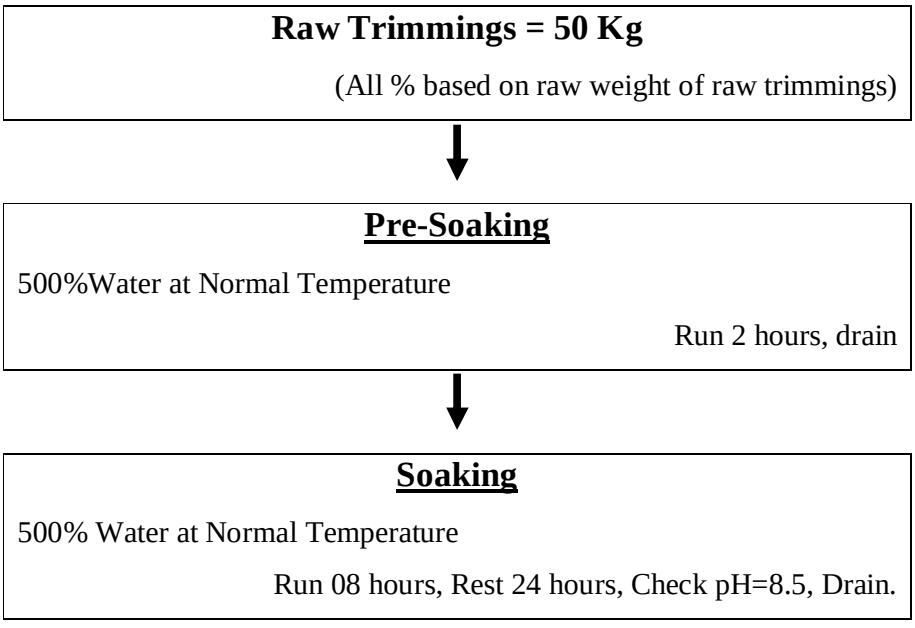


Figure-5: Flow chart of traditional glue manufacturing process.

2.5.2 Modified Method

Traditionally, animal Glue is produced from raw trimmings only with applying wetting agents and sodium sulphide in soaking and liming stages respectively. Wetting agents are hydrocarbons made of saponified chemicals, which creates foam in the effluents creating barrier to sunlight diffusion in the water body (http://chemwiki.ucdavis.edu/Physical_Chemistry/Physical_Properties_of_Matter/Intermolecular_Forces/Cohesive_And_Adhesive_Forces/Wetting_Agents). On the other hand, sodium sulphide is highly corrosive and producing hydrogen sulphide in oxidation, a toxic gas (http://en.wikipedia.org/wiki/Sodium_sulfide).

To avoid producing foam and hydrogen sulphide and utilizing maximum solid wastes, the traditional glue manufacturing process was required to modify. The new process was developed on trial and error method in the IES laboratory. Fleshings in varied amount and pickle cuttings in fixed amount were added with fixed amount of raw trimmings in the cooking process for producing animal glue as well as wetting agents and sodium sulphide were avoided with increasing amount of water to be added and the duration of liming was increased. The modified method was followed in the bulk production of animal glue carried out in a glue manufacturing factory adjacent to the tannery, M/S. Kalim Leathers located at Hazaribagh. The modified process is mentioned here-



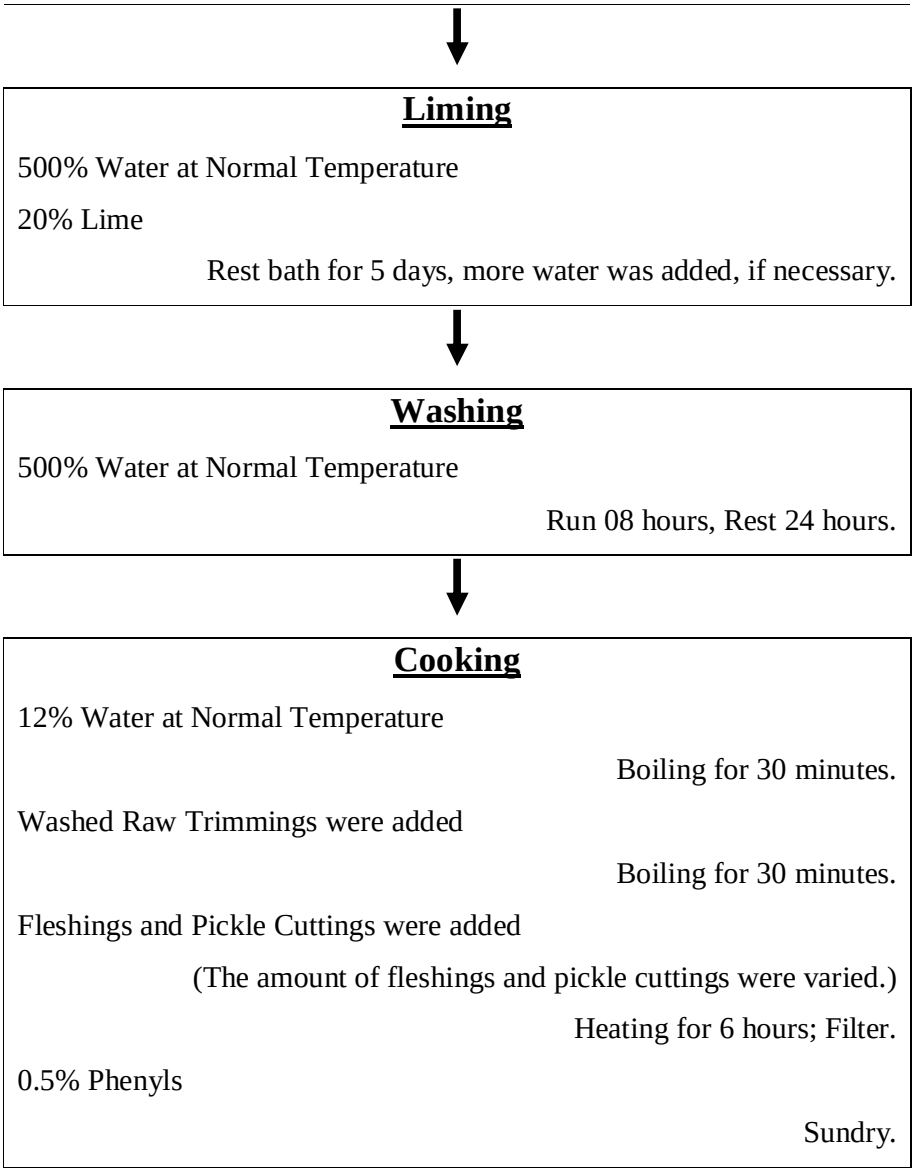


Figure-6: Flow chart of modified process of glue manufacturing.

After producing the animal glue by following the above mentioned processes, the quality was compared to the quality of the glue sample collected from local market. Five (5) different samples, regarding a varied amount of fleshings used (6kg, 13kg, 20kg, 25 kg, and 40 kg), were collected from the bulk production of animal glue separately for quality analysis.

1. Animal Glue produced by using 50 kg raw trimmings, 6kg pickle cuttings and **6kg** fleshings (AG-1).

2. Animal Glue produced by using 50 kg raw trimmings, 6kg pickle cuttings and **13kg** fleshings (AG-2).
3. Animal Glue produced by using 50 kg raw trimmings, 6kg pickle cuttings and **20kg** fleshings (AG-3).
4. Animal Glue produced by using 50 kg raw trimmings, 6kg pickle cuttings and **25kg** fleshings (AG-4).
5. Animal Glue produced by using 50 kg raw trimmings, 6kg pickle cuttings and **40kg** fleshings (AG-5).

The quality parameter includes pH, Colour, Odour, Adhesive strength, Chloride content, Total Kjeldahl Nitrogen (TKN), Protein content, Ash content, Moisture content, and Fat content. The glue samples were analyzed in the BCSIR Laboratory, Dhaka and the IES Laboratory respectively.

2.6 Collection and Preparation of Effluent

Animal glue manufacturing process has five (5) distinguished steps viz. Pre-soaking, Soaking, Liming, Washing, and Cooking. Effluents were generated in the former four different stages except cooking stage. Different chemicals were used or come out and mixed up from the solid wastes in different stages of both the traditional method and modified method of glue manufacturing process. Therefore, effluents of pre-soaking, soaking, liming and washing of both traditional and modified methods of glue manufacturing processes were collected to know its different environmental parameters.

The effluents were shook vigorously in the bath and collected in one liter of washed, dried and pre-labeled sample bottle with air tight cap. These were preserved for analyzing some physical parameters of effluent viz. colour, odour, pH, Total Suspended Solid (TSS), and Total Dissolved Solid (TDS). The effluents were prepared and analyzed in the BCSIR Laboratory, Dhaka and the IES Laboratory respectively.

2.7 Chemical Analysis

A total of twenty one (21) parameters of soil, animal glue and effluent were analyzed chemically in the BCSIR Laboratory, Dhaka and the IES Laboratory respectively. Among

those parameters six (6) were analyzed to know soil characteristics viz. pH, Organic Carbon, Organic Matter, Total Kjeldahl Nitrogen (TKN), Chloride and Chromium; ten (10) for glue characteristics including pH, Color, Odor, Adhesive strength, Chloride content, Total Kjeldahl Nitrogen (TKN), Protein content, Ash content, Moisture content, and Fat content; and five (5) for effluent characteristics such as, pH Color, Odor, , Total Suspended Solid (TSS), and Total Dissolved Solid (TDS).

Chemical analysis of different twenty one parameters as mentioned above were performed by following the methods described in Sarkar (1982), SLTC (1996), and Huq and Alam (2005) as belows:

2.7.1 Determination of pH of Soil, Animal Glue and Effluent

Apparatus:

1. Beaker, 100 ml.
2. Glass electrode pH meter
3. Spatula & stirring rods.

Reagents:

1. Standard buffer solutions of pH 4.0 and 7.0 or 9.0. Buffer solutions was prepared in the laboratory as follows:
    a) 10.21 gm potassium hydrogen phthalate per litre for a pH of 4.0.
    b) 3.81 gm borax ($Na_2B_4O_7.10\ H_2O$) per litre for a pH of 9.22.
    c) 9.78 gm KH_2PO_4 in a liter gives a 0.2N solution.
    d) 11.876 gm Na_2HPO_4 in a liter gives a 0.2 N solution.

6 ml of solution (c) and 4 ml of solution (d) mixed together will give a pH of 6.97 at 18°C.

Procedure:

pH meter method was followed to measure pH of the soil, animal glue and effluent sample. 20.0 gm each sample were taken into a 100 ml beaker and then 50 ml water (or 0.01M $CaCl_2$ solution) were added to each of it. The suspension was stirred several times

during the next 30 minutes. pH meter was switched on and was adjusted it with the buffers. Then the electrodes were placed into the suspension and the pH value was recorded. This process was followed three times for confirmation and the accuracy of the reading.

2.7.2 Determination of Organic Carbon of Soil

Apparatus:

1. Burette
2. 10 ml pipette
3. 500 ml conical flask
4. 10 ml and 100 ml measuring cylinder
5. Distilled water bottle
6. Analytical balance
7. Weight box
8. Retort stand
9. Clamp

Reagents:

1. Concentrated Sulphuric acid (not less than 96%)
2. Concentrated Phosphoric acid, 85%
3. Sodium fluoride (NaF)
4. Standard 1N potassium dichromate solution (dissolved exactly 49.03 gm of potassium dichromate in water and diluted the solution to 1 liter)
5. Ferrous sulphate solution (dissolve 278 gm of $FeSO_4.7H_2O$ crystals in water followed by an addition of 15 ml Conc. H_2SO_4 and diluting up to 1000 ml)

Procedure:

2 gm of soil sample were weighed and passed through a 2 mm sieve, and then transferred to a 500 ml clean dry conical flask. 10 ml of normal potassium dichromate solution was added to it with the help of a pipette. Then another 10 ml of concentrated sulphuric acid was also added with a measuring cylinder and the solution was mixed thoroughly. The

conical flask containing sample was placed for cooling on a sheet of asbestos with occasional shaking for half an hour. If the color was changed to green then an additional 10 ml of $K_2Cr_2O_7$ solution was poured. After half an hour, when the flask became cold, approximately 150 ml distilled water, 10 ml phosphoric acid and 0.2 gm of sodium fluoride and 60 drops or 3 ml of diphenylamine indicator solution were added to it. The color of the solution was turned into deep violet. Additional amount of indicator might be added, if necessary and the flask was chilled again. The excess of chromic acid left in the flask was titrated with the help of normal ferrous sulphate solution poured from a burette. At the end point, the color of the solution was changed to deep bottle green. The amount of ferrous sulphate solution (T) required in the titration was recorded. A blank experiment was run in the same way with all the reagents except soil sample and the amount of ferrous sulphate solution (B) required was recorded. The experiment was repeated for three times.

Calculation:

1000 ml of 1N $K_2Cr_2O_7$ solution = 1000 ml of 1N Carbon = 3 gm of C

1000 ml of 1N $K_2Cr_2O_7$ solution ≡ 0.003 gm C

Thus the amount of carbon in soil expressed as percent, oxidized by 1N $K_2Cr_2O_7$ solution was calculated as follows:

$$\text{Organic Carbon (\%)} = \frac{(B - T) \times f \times 0.003 \times 100}{W}$$

Here,

B = Amount in ml of 1N $FeSO_4$ solution required in blank experiment

T = Amount in ml of 1N $FeSO_4$ solution required in experiment with soil

f = Strength of 1N $FeSO_4$ solution from blank experiment

W = Weight of soil sample taken

It has been estimated that only about 77% carbon in soil is oxidized by normal $K_2Cr_2O_7$ solution. So, 0.003 should be multiplied by 1.3 to get the percentage of total carbon present in the soil. Then the expression becomes:

$$\text{Organic Carbon in Soil (\%)} = \frac{(B - T) \times f \times 0.003 \times 1.3 \times 100}{W}$$

Precaution:

1. The amount of soil to be taken should be less (1 g. to 0.5 gm) for soils containing high amounts of organic carbon.

2.7.3 Determination of Organic Matter of Soil

Apparatus:

1. Burette
2. 10 ml pipette
3. 500 ml conical flask
4. 10 ml and 100 ml measuring cylinder
5. Distilled water bottle
6. Analytical balance
7. Weight box
8. Retort stand
9. Clamp

Reagents:

1. Concentrated Sulphuric acid (not less than 96%)
2. Concentrated Phosphoric acid, 85%
3. Sodium fluoride (NaF)
4. Standard 1N potassium dichromate solution (dissolved exactly 49.03 gm of potassium dichromate in water and diluted the solution to 1 liter)
5. Ferrous sulphate solution (dissolve 278 gm of $FeSO_4.7H_2O$ crystals in water followed by an addition of 15 ml Conc. H_2SO_4 and diluting up to 1000 ml)

Procedure:

2 gm of soil sample were weighed and passed through a 2 mm sieve, and then transferred to a 500 ml clean dry conical flask. 10 ml of normal potassium dichromate solution was

added to it with the help of a pipette. Then another 10 ml of concentrated sulphuric acid was also added with a measuring cylinder and the solution was mixed thoroughly. The conical flask containing sample was placed for cooling on a sheet of asbestos with occasional shaking for half an hour. If the color was changed to green then an additional 10 ml of $K_2Cr_2O_7$ solution was poured. After half an hour, when the flask became cold, approximately 150 ml distilled water, 10 ml phosphoric acid and 0.2 gm of sodium fluoride and 60 drops or 3 ml of diphenylamine indicator solution were added to it. The color of the solution was turned into deep violet. Additional amount of indicator might be added, if necessary and the flask was chilled again. The excess of chromic acid left in the flask was titrated with the help of normal ferrous sulphate solution poured from a burette. At the end point, the color of the solution was changed to deep bottle green. The amount of ferrous sulphate solution (T) required in the titration was recorded. A blank experiment was run in the same way with all the reagents except soil sample and the amount of ferrous sulphate solution (B) required was recorded. The experiment was repeated for three times.

Calculation:

1000 ml of 1N $K_2Cr_2O_7$ solution = 1000 ml of 1N Carbon = 3 gm of C

1000 ml of 1N $K_2Cr_2O_7$ solution ≡ 0.003 gm C

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f = Strength of 1N $FeSO_4$ solution from blank experiment

W = Weight of soil sample taken

It has been estimated that only about 77% carbon in soil is oxidized by normal $K_2Cr_2O_7$ solution. So, 0.003 should be multiplied by 1.3 to get the percentage of total carbon present in the soil. Then the expression becomes:

$$\text{Organic Carbon in Soil (\%)} = \frac{(B - T) \times f \times 0.003 \times 1.3 \times 100}{W}$$

The organic matter of soil was determined by multiplying the content of organic carbon with a factor 1.724 on assuming that average soil contains 58% of organic matter.

Organic Matter in Soil (%) = Organic Carbon (%) × 1.72* (Van Bemmelen factor)

Precaution:

1. The amount of soil to be taken should be less (1 g. to 0.5 gm) for soils containing high amounts of organic matter.

2.7.4 Determination of Total Kjeldahl Nitrogen of Soil

Apparatus:

1. Kjeldahl digestion unit
2. 500 ml Kjeldahl flask
3. Distillation apparatus
4. 125 ml conical flask
5. 10 ml and 50 ml measuring cylinders
6. 10 ml pipette
7. Micro burette
8. Retort stand, etc.

Reagents:

1. Sulphuric acid, concentrated, 36 N
2. **Digestion mixtures**: Approximately 20 gm of $CuSO_4.5H_2O$ (previously grinded and dried in an oven at 110^oC), 3 gm selenium powder was mixed in a mortar. One part of this mixture was thoroughly mixed with 20 parts of anhydrous Na_2SO_4 and the mixture was called "Na_2SO_4 plus catalyst".
3. **40% NaOH**: 400 gm of pure NaOH was taken into a 2 litre heavy-walled Pyrex flask or bottle then 600 ml of water was added to it and the flask was swirled until the alkali was dissolved. The solution was cooled with rubber stopper in the neck

of the flask to prevent absorption of atmospheric CO_2. Filtration might be necessary. Then the bottle was swirled vigorously to mix the contents and fit the neck with some arrangements, which permits the alkali to be stored and dispensed with protection from atmospheric CO_2.

4. **Mixed indicator solution**: Bromocresol green and methyle red indicator mixed solution was prepared by dissolving 0.5 gm of bromocresol green and 0.1 gm methyl red in 100 ml of 95% ethanol. This indicator was pink at pH 4.2 or lower and bluish green as the pH rises to 4.9 and above.
5. **4% Boric acid mixed indicator solution**: 40 gm of pure boric acid was taken in a 1 litre flask, about 800 ml of water was added to it and heat and the flask was swirled until the H_3BO_3 was dissolved. The solution was cooled and 20 ml of mixed indicator was added. Thus boric acid mixed indicator stock solution was made. Then 0.1 N NaOH was added cautiously until the solution assumes a reddish purple tint or wine red colour (pH 5.0) and make the solution to a litre by addition of water. The solution was mixed thoroughly before use.
6. Sulphuric acid or hydrochloric acid, N/20 or N/56 or N/100 standard.

Procedure:

10 gm of finely powdered soil sample was taken in a 500 ml clean Kjeldahl flask. 20 ml of distilled water was poured into it and the flask was shake and left for 20 minutes. Then 25 ml of concentrated H_2SO_4 was added to it and the solution was mixed thoroughly. The flask was heated over a low flame in a digestion chamber for 15 minutes. If white fume of H_2SO_4 was appeared then the flask was removed from the heater and about 2-3 gm of catalyst was mixed to raise the boiling temperature of H_2SO_4 digestion and to accelerate the reaction. Then the flask was placed again over the heater and the temperature was raised slowly and the digestion was continued for two hours or more till the liquid was clear (the colour of the soil would turn light bluish in colour). The digest was chilled and diluted it with 100 ml of distilled water. The whole mass was transferred into a 250 ml volumetric flask and was made up to volume with distilled water. 10 ml of the extract was distilled at a time (twice) with 10 ml of 40% sodium hydroxide using micro Kjeldahl's distillation apparatus or the whole mass of 100 ml was distilled by putting it into the distillation flask of a distillation apparatus with equal volume of 40% NaOH and the

distillate was collected in 25 ml H_3BO_3 until the volume was about 50 ml. About 50 to 75 ml volume of distillate (NH_3 gas) was collected in a 125 ml conical flask containing 10 ml of 4% boric acid with mixed indicator (colour of distillate was blue). The conical flask (do not stop heating until the distillate was removed) was removed and washed the delivery outlet of the distillation apparatus with distilled water. The distillate was titrated against the standard H_2SO_4 or HCl and the end point was indicated by pink colour of the solution. The blank titration was run simultaneously using all the chemicals except soil. The experiment was repeated for three times.

Calculation:

1000 ml of 1N H_2SO_4 = 1000 ml of 1N Nitrogen = 14 gm of N

So, 1 ml of 1N H_2SO_4 = 0.014 gm of N

$$N_2 \text{ Content in Soil (\%)} = \frac{(T - B) \times f \times 0.014 \times 250 \times 100}{W \times \text{Volume of extract used}}$$

Here,

B = Amount in ml of N/20 or N/56 or N/100 H_2SO_4 required in titration of the blank experiment.

T = Amount in ml of N/20 or N/56 or N/100 H_2SO_4 required in titration of the experiment with soil.

f = Normality actor of N/20 or N/56 or N/100 H_2SO_4.

W = Weight of soil taken

Precaution

1. Standardize the N/20 or N/56 or N/100 H_2SO_4 used for titration with N/20 or N/56 or N/100 NaOH beforehand.
2. Standardize N/20 or N/56 or N/100 NaOH with N/20 or N/56 or N/100 Oxalic acid.
3. Neither the volume nor the strength of the boric acid need to be known exactly, because ammonium borate formed was titrated back to boric acid. In the titration 25 ml of boric acid will absorb 48 mg of nitrogen as ammonia which is approximately equivalent to 0.90% nitrogen in soil.

2.7.5 Determination of Total Chloride of Soil

Reagents:

1. **Standard silver nitrate solution, 0.005 N**: Exactly 8.494 gm of silver nitrate was dissolved in water and diluted to 1 litre to obtain 0.05 N solution. The silver nitrate solution concentration was usually checked by titration against a standard solution of NaCl (2.925 gm/litre for 0.05 N or N/20 NaCl).
2. **Potassium chromate indicator solution ($K_2Cr_2O_4$), 5%**: 5 gm of $K_2Cr_2O_4$ was dissolved in 50 ml of water and then $AgNO_3$ solution was added to it until a permanent red precipitate was produced, filter and dilute to 100 ml.
3. Sodium bicarbonate ($NaHCO_3$), 1%

Procedure:

10 gm soil sample was transferred in a 150 ml conical flask, 50 ml of distilled water was added to it and shook for an hour and the solution was filtered through filter paper Whatmann no. 42. 5 ml of clear aliquot was taken in a small size porcelain basin. The extract was made neutral or slightly alkaline with sodium bicarbonate usually a single drop of sodium bicarbonate solution was sufficient. 1 drop of Potassium chromate indicator solution was added. The solution was titrated with the standard silver nitrate until the appearance of red or reddish brown precipitate would be occurred. A blank correction was determined by titrating the same volume of chlorine free distilled water.

Calculation:

1000 ml of 1N $AgNO_3$ = 35.5 gm of Cl

So, 1 ml of 1N $AgNO_3$ = 0.0355 gm of Cl

$$\text{Cl Content in Soil (\%)} = \frac{(T - B) \times f \times 0.0355 \times 50 \times 100}{W \times \text{Volume of extract used}}$$

Here,

B = Amount in ml of $AgNO_3$ required in titration of the blank experiment.

T = Amount in ml of $AgNO_3$ required in titration of the experiment with soil.

f = Normality of $AgNO_3$.

W = Weight of soil taken.

2.7.6 Determination of Total Chromium of Soil

Reagents:

1. Pure concentrated nitric acid.
2. Acid mixture (230 ml 60% perchloric acid, 70 ml concentrated sulfuric acid).
3. 10% potassium iodide solution.
4. 0.1N sodium thiosulfate solution.
5. 2% starch indicator solution.
6. 0.1 N ferrous ammonium sulphate solution.
7. 0.1% solution of N-phenylanthranilic acid (sodium salt) in water.

Procedure:

10 gm of finely powdered soil sample was taken in a 500 ml clean conical flask. 20 ml of distilled water was added to it shook and left for 20 minutes. The flask was heated over a low flame in a digestion chamber for 15 minutes. A measured volume of the soil solution containing approximately 0.05 gm chromium was transferred to a 500 ml conical flask provided with a funnel in the mouth to act as a trap. 20 ml concentrated nitric acid was added followed by 20 ml of the perchloric/sulfuric acid mixture. The flask and contents were heated gently at the boil until the mixture became pure orange-red color. Boiling was continued for one minute after this point had been reached. The flask was removed from the source of heat and as soon as ebullition had ceased, cooled rapidly by swirling the flask in a bath of cold water. 100 ml distilled water was added carefully with a few glass beads or anti-bumping granules and boiled for 10 minutes to remove free chlorine. The solution was cooled and titrated by using either sodium thiosulfate solution or ferrous ammonium sulfate solution.

a. Using sodium thiosulfate solution- The solution was cooled to 20^0C and transferred to an iodine flask. 10 ml 10% potassium iodide solution was then added and moistened the stopper with the same reagent and replaced. The flask was allowed to stand for 10 minutes in the dark. The stopper and the neck of the flask were washed with distilled water into the solution and titrated with 0.1N sodium thiosulfate solution by adding the starch indicator solution when the titration was almost complete.

b. Using ferrous ammonium sulfate solution- 10 ml 30% v/v sulfuric acid was added and cooled the flask and contents to 20^0C. The solution was then titrated with freshly standardized 0.1N ferrous ammonium sulfate by using six drops of n-Phenylanthranilic acid solution as indicator. The end point was indicated by a colour change from violet to green.

Calculation:

Result should be calculated by using the following formula,

1 ml 0.1N titrant ≡ 0.00173gm Cr ≡ 0.00253gm Cr_2O_3.

Precaution:

1. Attention is drawn to an alternative procedure based on ammonium per sulfate and described in JSLTC, 49, 5, 179.
2. If the solution contains iron the ferrous ammonium sulfate titration procedure should be used.

2.7.7 Determination of Odour of Animal Glue and Effluent

Cold odour quality at room temperature was determined by taking 250 ml of the Animal Glue and effluent samples were taken separately in a 500 ml wide mouth Erlenmeyer flask and sniff the odour. To determine the hot odour quality same 250 ml samples were taken separately in a 500 ml stopper conical flask and heat to 58-60^0C. Sniff the odour.

2.7.8 Determination of Colour of Animal Glue and Effluent

Colour was observed physically and reported as earthy, yellowish, green, gray, brown, clear etc.

2.7.9 Determination of Adhesive Strength of Animal Glue

Adhesive strength was observed physically by applying the hot liquid animal glue on the surface of two pieces of papers, air dried and peeled them off. If the papers were sheared the strength of the glue was reported as sufficient.

2.7.10 Determination of Total Chloride of Animal Glue

Reagents:

1. 0.1N silver nitrate
2. Concentrated nitric acid
3. 0.1N potassium thiocyanate
4. Nitrobenzene
5. Ferric alum indicator solution (10 gm $FeNH_4(SO_4)_2.12H_2O$ dissolved in 92.5 ml hot distilled water and 7.5 ml concentrated nitric acid is added)

Procedure:

20 gm of Animal Glue was dissolved with 50 ml of hot distilled water and the liquor was filtered through coarse filter paper to remove suspended matter. A suitable aliquot, usually 10-25 ml, equivalent to 10-15 ml 0.1N silver nitrate was poured into a 250 ml Erlenmeyer flask and 25 ml 0.1N silver nitrate was added followed by 10 ml concentrated nitric acid; the mixture was heated on a water bath for 2-3 hours. The mixture was cooled. 50 ml distilled water and 2-3 ml nitrobenzene were added. The addition of nitrobenzene avoids the necessity of filtering before titration; presumably a film of nitrobenzene surrounds the silver chloride.

The excess silver nitrate was then titrated with 0.1N potassium thiocyanate. 1 ml 10% ferric alum solution was being used as an indicator. The end point was indicated by the formation of a persistent brown-red colour.

Calculation:

Results are expressed as gm NaCl per 100 ml liquor.

1 ml 0.1N silver nitrate ≡ 0.00585 gm sodium chloride.

2.7.11 Determination of Total Kjeldahl Nitrogen of Animal Glue

Apparatus:

1. 500ml Kjeldahl flask
2. Ammonia distillation apparatus
3. Usual laboratory apparatus.

Reagents:

1. Concentrated sulfuric acid (36N)
2. Catalyst mixture ($CuSO_4$:K_2SO_4=1:10)
3. 4% boric acid solution
4. 40% sodium hydroxide solution
5. 0.5N hydrochloric acid
6. Phenolphthalein indicator solution (10gm/liter in ethanol)
7. Bromocresol green indicator solution.

Procedure:

The glue liquor was passed through a plug of glass wool to remove hair debris. 10-20ml filtered liquor was taken into a Kjeldahl flask. 20 ml concentrated sulfuric acid and 6-8 gm catalyst mixture were added. Then the mixture was heated to boil and allowed digesting first with a low and latter with a high flame until 1 hour after all the carbon was oxidized. Heating was continued for two hours after clearing to ensure complete digestion. The flask was cooled and then 100ml distilled water was added followed by 1ml phenolphthalein solution. A few fragments of anti-bumping material was also added. The solution was made alkaline with an excess of 40% sodium hydroxide solution (a total of at least 150ml). The distillation apparatus was assembled and the solution was distilled. The ammonia and water vapour were distilled into a receiver containing 50ml of the 4% boric acid solution with the cooling tube dipping into the boric acid solution. The distillation was continued until the volume of the distillate collected was 150-200ml. Shortly before ending the distillation the receiver was lowed so that the cooling tube no longer dips into boric acid solution. The solution was distilled for approximately 3 minutes more and then rinsed the end of the condenser with water into the receiver. A few drops of bromocresol green indicator solution was added into the flask containing the

distillate. The combined distillate was titrated and rinsing with 0.5N hydrochloric acid. The end point was indicated that the colour of the solution is turned blue to bottle green. 50ml of 4% boric acid solution was taken with adding a few drops of bromocresol green and a blank test was carried out with 0.5N hydrochloric. For titration the end point wass turned blue to bottle green colour.

Calculation:

$$1 \text{ ml } 0.5N \text{ HCl} \equiv 0.0007003\text{gm } N_2 \equiv 0.0085\text{gm } NH_3.$$

$$N_2 \text{ content } (\%) = \frac{0.7003 \times (T_1 - T_2)}{\text{Mass of sample taken}}$$

Here,

T_1 = main titration reading (ml of 0.5N HCl)

T_2 = blank titration reading (ml of 0.5N HCl)

2.7.12 Determination of Protein or Hide Substance of Animal Glue

Apparatus:

1. 500ml Kjeldahl flask
2. Ammonia distillation apparatus
3. Usual laboratory apparatus.

Reagents:

1. Concentrated sulfuric acid (36N)
2. Catalyst mixture ($CuSO_4$:K_2SO_4=1:10)
3. 4% boric acid solution
4. 40% sodium hydroxide solution
5. 0.5N hydrochloric acid
6. Phenolphthalein indicator solution (10gm/liter in ethanol)
7. Bromocresol green indicator solution.

Procedure:

The glue liquor was passed through a plug of glass wool to remove hair debris. 10-20ml filtered liquor was taken into a Kjeldahl flask. 20 ml concentrated sulfuric acid and 6-8 gm catalyst mixture were added. Then the mixture was heated to boil and allowed digesting first with a low and latter with a high flame until 1 hour after all the carbon was oxidized. Heating was continued for two hours after clearing to ensure complete digestion. The flask was cooled and then 100ml distilled water was added followed by 1ml phenolphthalein solution. A few fragments of anti-bumping material was also added. The solution was made alkaline with an excess of 40% sodium hydroxide solution (a total of at least 150ml). The distillation apparatus was assembled and the solution was distilled. The ammonia and water vapour were distilled into a receiver containing 50ml of the 4% boric acid solution with the cooling tube dipping into the boric acid solution. The distillation was continued until the volume of the distillate collected was 150-200ml. Shortly before ending the distillation the receiver was lowed so that the cooling tube no longer dips into boric acid solution. The solution was distilled for approximately 3 minutes more and then rinsed the end of the condenser with water into the receiver. A few drops of bromocresol green indicator solution was added into the flask containing the distillate. The combined distillate was titrated and rinsing with 0.5N hydrochloric acid. The end point was indicated that the colour of the solution is turned blue to bottle green. 50ml of 4% boric acid solution was taken with adding a few drops of bromocresol green and a blank test was carried out with 0.5N hydrochloric. For titration the end point wass turned blue to bottle green colour.

Calculation:

$$1 \text{ ml } 0.5\text{N HCl} \equiv 0.0007003\text{gm } N_2 \equiv 0.0085\text{gm } NH_3.$$

$$N_2 \text{ content (\%)} = \frac{0.7003 \times (T_1 - T_2)}{\text{Mass of sample taken}}$$

Here,

T_1 = main titration reading (ml of 0.5N HCl)

T_2 = blank titration reading (ml of 0.5N HCl)

Crude Protein or Hide Substance (%) = N_2 content (%) × 5.62

2.7.13 Determination of Ash of Animal Glue

Apparatus:

1. Crucibles and dishes of glazed porcelain,
2. Muffle Furnace, capable of being maintained at high temperature,
3. Usual laboratory apparatus.

Procedure:

Dry Glue sample was taken and grinded as per requirement. 2.5 gm to 5.0 gm of the sample to the nearest 0.001 gm was taken into a weighed crucible which was previously heated to 750^{o}C and cooled. Then the sample was carbonized over a low flame in a crucible, so that the glue was burnt with a small flame. Heating was continued more vigorously and then the sample was ignited in the furnace at 750^{o}C until completely ashen. The sample was cooled in the desiccators and weighed.

$$\text{Ash Content (\%)} = \frac{(M_1 - M_2) \times 100}{\text{Mass of sample taken}}$$

Here,

M_1 = Mass of Ash obtained with crucible

M_2 = Mass of crucible

2.7.14 Determination of Moisture of Animal Glue

Apparatus:

1. Watch glass or dishes,
2. Oven, capable of being maintained at moderate temperature like (102 ± 2)^{o}C,
3. Usual laboratory apparatus.

Procedure:

Dry Glue sample was taken and grinded as per requirement. 2.5 gm to 5.0 gm of the sample to the nearest 0.001 gm sample was taken into a weighed watch glass or dishes which was previously heated to 98.5^{o}C to 105^{o}C and cooled. Then the sample was heated in an oven at 98.5^{o}C to 105^{o}C constantly for 8 hours, sometimes extended up to 24 hours.

The weight loss was recorded in every one hour interval until two adjacent weighing at an interval of one hour do not differ more than 2.0 mg.

Calculation:

$$\text{Moisture Content (\%)} = \frac{(M_1 - M_2) \times 100}{M_1}$$

Here,

M_1 = Mass of Sample before drying

M_2 = Mass of Sample after drying

Notes: If the weight of the dried material is found to increase with longer drying, then the lowest weight found must be taken.

2.7.15 Determination of Fat of Animal Glue

Apparatus:

1. Soxhlet apparatus.
2. Filter paper thimbles of suitable size and manufacture, or suitable glass filter bells, or Schleicher and Schüll thimbles No 603, or Whatman Extraction Thimbles 33mm × 80mm, are known to be satisfactory.
3. Oven, capable of being maintained at moderate temperature like (102 ± 2)^{o}C.
4. Usual laboratory apparatus.

Reagents:

1. Dichloromethane, boiling point 38^{o}C to 40^{o}C, freshly distilled and kept in a dark flask over calcium oxide.

Procedure:

Dry Glue sample was taken and grinded as per requirement. 10 gm to 20 gm of the prepared sample to the nearest 0.001 gm was taken and pressed evenly into the filter paper thimble, or into the glass bell. The sample was covered with a thin layer of cotton

wool. The extraction flask was dried with two glass beads in it by heating for half an hour at (102 ± 2)^{o}C. After cooling in desiccators, the weight was taken. Being the continuous extraction with dichloromethane, at least 30 changes of solvent were made and distilled the dichloromethane from the flask containing the extract. The extract was dried in the oven for four hours at (102 ± 2)^{o}C. After cooling for 30 minutes in the desiccators the weight was taken. The drying, cooling and weighing, were repeated for thrice more, but with drying periods of 1 hour, until either further loss in mass does not exceed 10mg, or the total drying time equals 8 hours.

Calculation:

$$\text{Fat Content (\%)} = \frac{M_1 \times 100}{M_2}$$

Here,

M_1 = Mass of Extract

M_2 = Mass of Sample taken

2.7.16 Determination of Total Suspended Solid of Effluent

Procedure:

250 ml to 500 ml sample was taken and filtered through a weighed filter paper. The filter paper was washed with distilled water and then finally dried, cooled in desiccators and weighed. The increase in the weight to the filter was equivalent to the suspended impurities present. The total solids contents of 500 ml sample could also be calculated by evaporating it to dryness on a steam bath and drying at 100-110^{0}C in an oven for about one hour. From this subtracted the dissolved solids to get the quantity of suspended solids.

Calculation:

$$\text{Suspended Solids (in ppm)} = \text{Weight of solids} \times \frac{10^6}{\text{Volume of sample taken}}$$

2.7.17 Determination of Total Dissolved Solid of Effluent

Procedure:

250 ml to 500 ml of sample was filtered and evaporated to dryness in a weighed porcelain basin. The evaporation was best carried out over a small flame until only a small quantity of water was left and then finally dried on the water bath. The residue was then dried in the steam oven at 100^0C to a constant weight. From the weight of total solids obtained the quantity present in 10^6 parts of water was calculated.

Calculation:

$$\text{Dissolved Solids (in ppm)} = \text{Weight of solids} \times \frac{10^6}{\text{Volume of sample taken}}$$

CHAPTER-THREE

OBSERVATIONS AND RESULTS

Chapter-3: Observations and Results

The data obtained from field survey, compiling from secondary sources and laboratory analysis in the course of three years (2009-2011) study period are presented in this chapter. Different parameters of soil, effluent and the quality of produced animal glue analyzed in different laboratories are also presented here.

The unstructured and structured questionnaire (Appendix-1) were prepared to collect primary data on the number of operable tannery at Hazaribagh, maximum hides & skins consumption per day, and to evaluate the environmental impact in the study area. The results of the study based on the direct observations of the tannery workers, interviewing technologists and officials through random survey are presented here in tabular and graphical method.

3.1 Export Earning

3.1.1 Export Earning from Tannery of Bangladesh

Tanning industries are the major export earning source of the leather sector of our country. As per the report of Export Promotion Bureau, Bangladesh (2010-2011), it earned US$297.83 million in 2010-2011 fiscal year by exporting crust leather, finished leather, lining leather, fur skin and other types of fancy leathers, etc. Most of the leathers were exported to China, Hong Kong, Spain, Italy, Japan, Korea, Poland, Turkey, Singapore, Taiwan, Vietnam, India, Indonesia, Iran, Kenya, Kuwait, Lebanon, Denmark, Ireland, Finland, Czech Republic, France, Germany, Greece, Hungary, Malaysia, Mexico, Morocco, Myanmar, Netherlands, New Zealand, Pakistan, Panama, Papua New Guinea, Philippines, Portugal, Romania, Saudi Arabia, Sri Lanka, and other countries. The country wise export earning data were mentioned in the appendix-5. The total export

earnings from tanneries in the last 13 years were US$2957.14 million (EPB Report, 1998-2011).

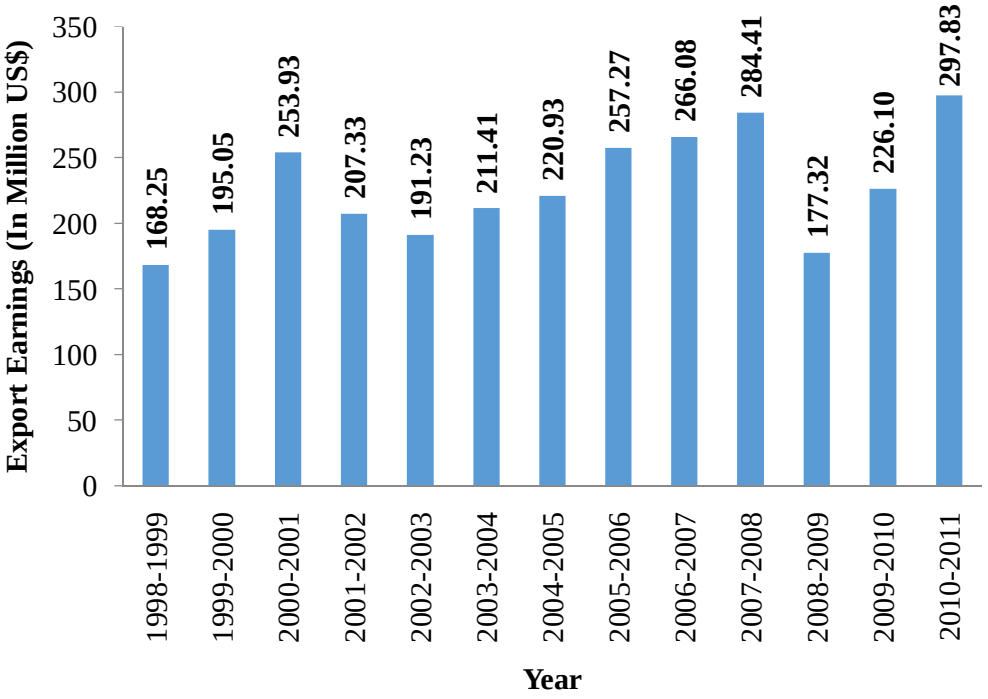


Figure-7: Export earning from tannery (EPB, Dhaka Office)

3.1.2 Export Earning from Footwear and Leather Products Industry

In the late forties a very few leather processing factories were established. Many of them were installed in the sixties. Some of them renovated their industries and set up footwear and leather goods manufacturing units in their existing premises while some of them were established separate footwear and leather products manufacturing industries in the mid nineties. It has been found that there are 47 Footwear and Leather Products industries (Bangladesh Finished Leather, Leathergoods & Footwear Exporters' Association, BFLLFEA, 2010) manufacturing goods from leather and exported to Argentina, Australia, Austria, Belgium, Bosnia & Herzegovina, Brazil, Bulgaria, Canada, China, Colombia, Czech Republic, Hong Kong, Spain, Italy, Japan, Korea, Turkey, Singapore, Taiwan, Kenya, Denmark, South Africa, Switzerland, United Arab Emirates, United Kingdom, United States, Malaysia, Netherlands, Norway, Portugal, Chili, India, Pakistan, and other countries. It has been found that a total of US$1246.39 million was earned by exporting footwear and leather products in the last 13 years (EPB Report, 1998-2011).

The trend of export earning from the footwear and leather products industry is increasing in the recent years.

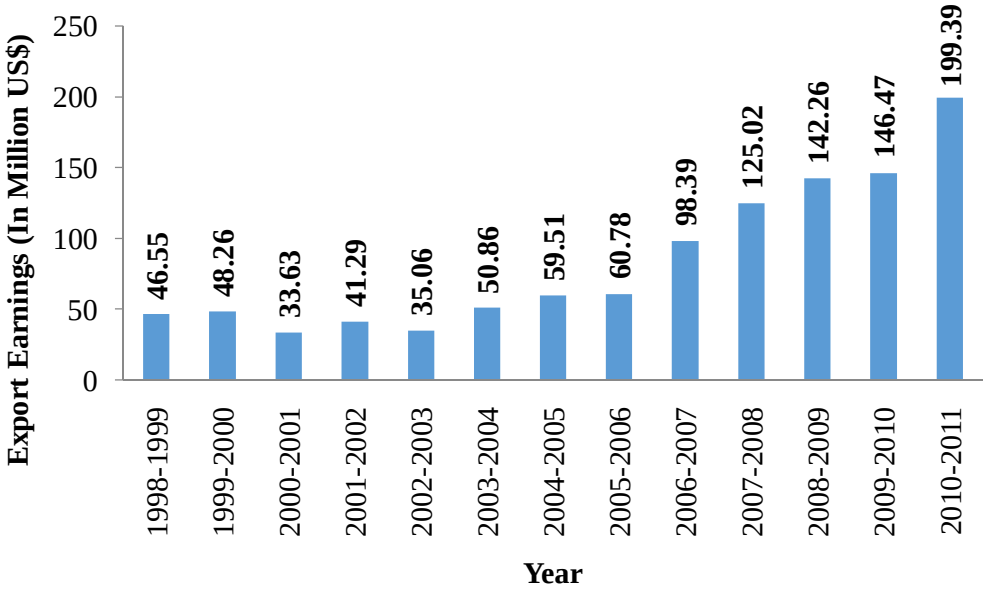


Figure-8: Export earning from Footwear industry (EPB, Dhaka Office)

The country wise data of export earning in 2010-2011FY from leather products and footwear industry in Bangladesh were mentioned in the annexure-5.

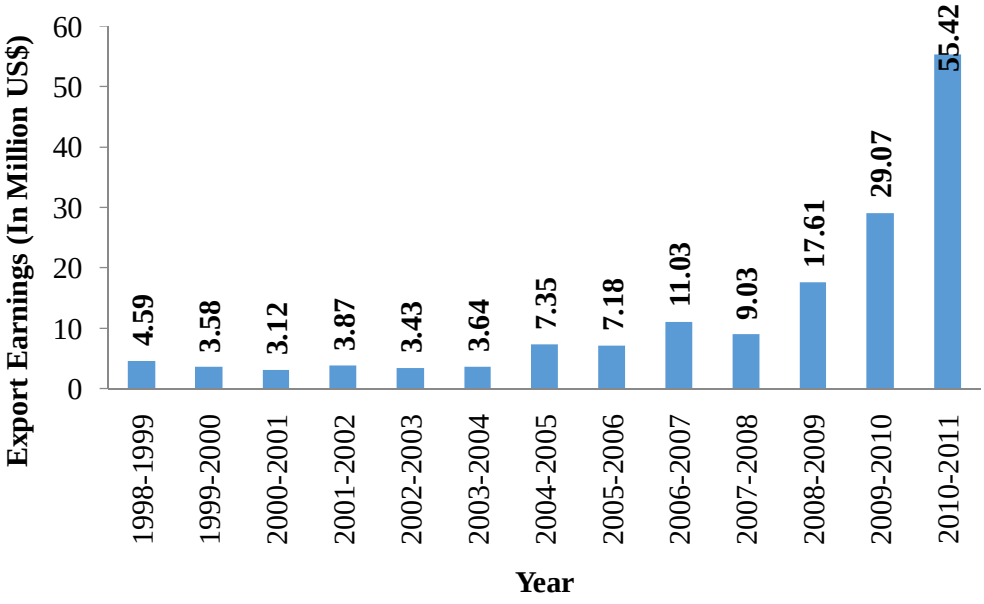


Figure-9: Export earning from Leather products industry (EPB, Dhaka Office)

3.1.3 Export Earning from Leather Sector

A total of US$4203.53 million was contributed by exporting crust leather, finished leather, footwear and leather products manufactured by three different industries viz. tannery, footwear industry and leather products industry of leather sector of Bangladesh in the last 13 years (EPB Reports, 1998-2011).

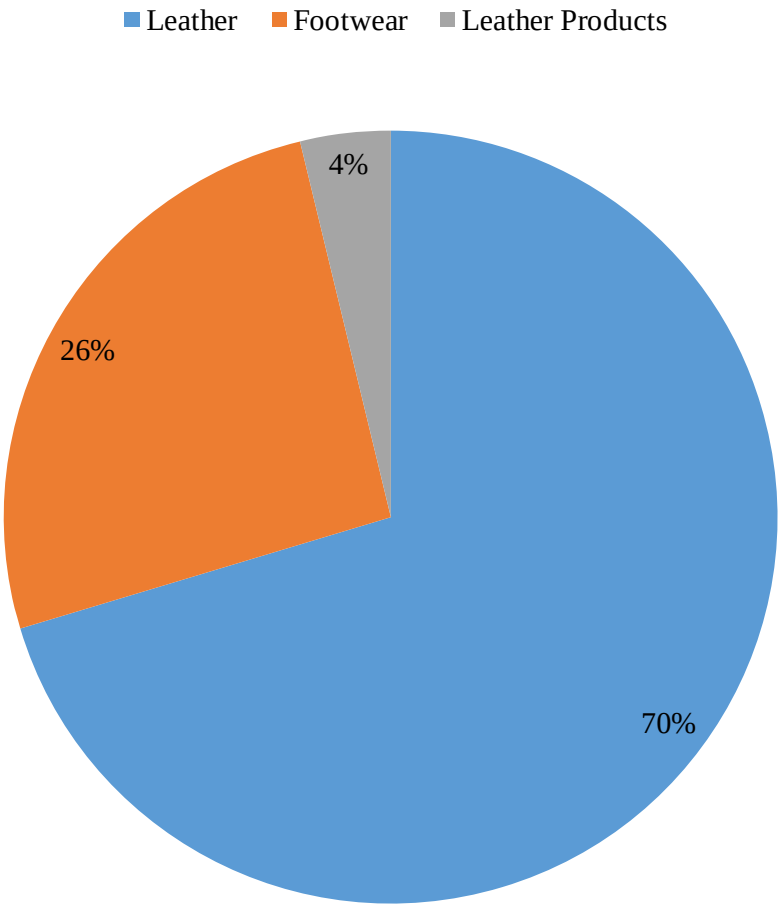


Figure-10: Percent of Export earning of Leather, footwear and leather products industry of the Leather sector in Bangladesh in 1998-2011 (EPB, Dhaka Office)

Most of our manufactured leather, footwear and leather products were exported to the Asian and European market with covering some US market as well (Appendix-5). The survey shows that the export earning from tannery has the highest contribution among the

leather, footwear and leather products industries and the trend of export earning from this sector is increasing day by day (Figure-11).

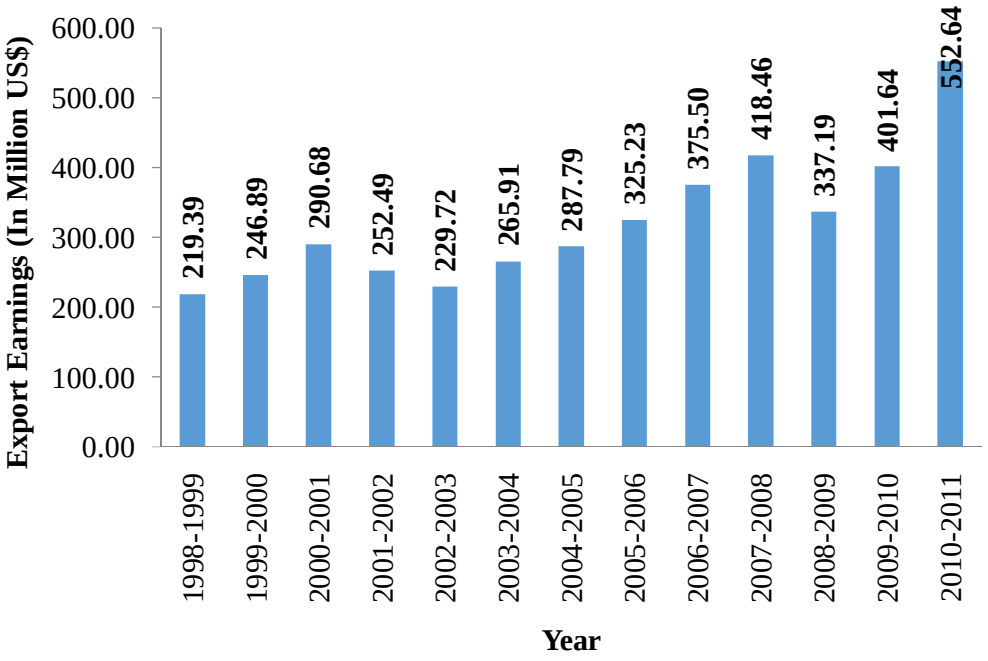


Figure-11: Export earning trend of Leather Sector of Bangladesh (EPB, Dhaka Office)

3.2 Number of Tannery at Hazaribagh, Dhaka

Table-1 indicates that a total of 122 tanneries found in the 60 acres of land at Hazaribagh, Dhaka out of which 112 and 10 were in working and laid off status respectively. Out of the working tanneries 43 self-exporters also hired 69 numbers of job-working tanneries. The list of the tanneries is mentioned block wise in appendix-2.

Table-1: Total number and status of tanneries in different blocks studied at Hazaribagh Area

Block		Production Type			Total
		Self-exporters	Job-worked	Lay-off	
B-1	**Monessware Road**	3	5	1	**9**
B-2	**Sher-e Bangla Road**	12	13	1	**26**
B-3	**Mid Hazaribag**	22	30	5	**57**
B-4	**Sonatangar/Gojmohal**	4	18	3	**25**
B-5	**Kalu Nagar**	2	3	0	**5**
Total		**43**	**69**	**10**	**122**

Some of those tanneries set up their own footwear and leather products unit inside and/or outside their premises (Appendix-13).

3.3 Hides & Skin Consumption at Hazaribagh, Dhaka

In course of survey it was revealed that the 112 working tanneries processed raw hides & skins in three shifts per day during the month of October - December, 2011on the occasion of Eid-ul-Azha (called as peak season) and in one or two shifts throughout the rest of the year (called as lean season). Maximum number of raw hides & skins processed by the tanneries in a day during the peak season were recorded to estimate maximum waste production in a day. Thus a total of 31645 pieces of cow hides, 107200 goat skins, 11200 sheep skins and 3420 buffalo hides (Table-2) were processed in a day found at Hazaribagh and the weight (in MT) of the raw hides & skins was calculated by using the previously developed formula-1.

Table-2: Maximum Hides & Skins Consumption (Piece) in a day during the peak season, 2011 by the tanneries of different blocks at Hazaribagh, Dhaka with calculated weight

Block	Cow hide		Goat skin		Sheep skin		Buffalo hide		Total	
	Piece	MT	Piece	MT	Piece	MT	Piece	MT	Piece	MT
Monessware Road	700	8.40	5000	7.50	0	0.00	0	0.00	-	**15.90**
Sher-e Bangla Road	775	9.30	5000	7.50	0	0.00	2700	59.40	-	**76.20**
Mid Hazaribag	18420	221.04	77200	115.80	11200	16.80	720	15.84	-	**369.48**
Sonatangar/Gojmohal	5750	69.00	10000	15.00	0	0.00	0	0.00	-	**84.00**
Kalu Nagar	6000	72.00	10000	15.00	0	0.00	0	0.00	-	**87.00**
Total	**31645**	**379.74**	**107200**	**160.80**	**11200**	**16.80**	**3420**	**75.24**	-	**632.58**

3.4 Total Working People in Tannery at Hazaribagh, Dhaka

A total of 7298 people were found working in the 112 tanneries at Hazaribagh, Dhaka during survey. The workforce included 157 technologists, 1212 permanent labourers, 4863 temporary labourers and 1066 office stuffs (Table-3). Among these workforce 882 directly handled raw hides & skins and solid wastes. They are called as trimmer. They were the main respondents of the surveyed questionnaire. It was also observed that all of the trimmers were male. Besides, a total of 6075 labourers (permanent & temporary labourers) were found working which was about 83% of total workforce working in

tannery at Hazaribagh, Dhaka. These people were not institutionally trained. They improvised their skill through working.

Table-3: Number of working people of different categories in Tannery at Hazaribagh, Dhaka

Block		Technologists	Permanent Labourer	Temporary Labourer	Office Staff	Total
B-1	**Monessware Road**	13	25	170	29	**237**
B-2	**Sher-e Bangla Road**	21	116	610	154	**901**
B-3	**Mid Hazaribag**	91	877	2817	653	**4438**
B-4	**Sonatangar/Gojmohal**	19	78	623	129	**849**
B-5	**Kalu Nagar**	13	116	643	101	**873**
Total		**157**	**1212**	**4863**	**1066**	**7298**

3.4.1 Age structure of the Trimmers

During the survey 882 trimmers were interviewed about their age. The ages of the trimmers were clustered in six groups, such as, (below 18 years), (19 – 30), (31 – 40), (41 – 50), (51 – 60) and (above 60 years). Maximum 291 respondents were found in the age group 19 – 30 years which was 33% of the total respondents. A total of 698 trimmers were found in the working age group viz. 19 – 60 year's age. The most alarming information was that, about 18% of the total trimmers were found child labourers lying below 18 year's age group (figure-12).

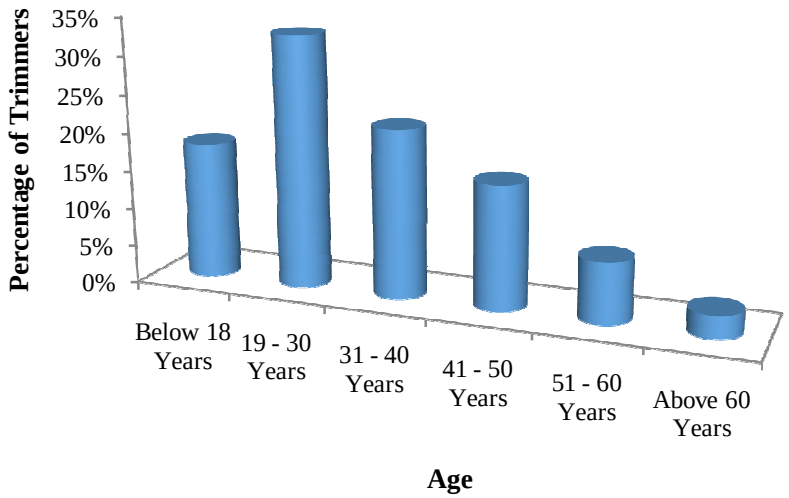


Figure-12: Percentage of trimmers belonged to different age groups in Hazaribagh Tannery area

3.4.2 Educational qualification of the Trimmers

The trimmers were also interviewed about their educational qualification. The education levels achieved by the trimmers were categorized as No Education, Informal Education, Primary Level, JSC Level, and SSC Level. It was found in the survey that most of the trimmers (45%) completed primary level education; 267 trimmers were found having informal education getting from different NGOs while some were having literacy but not getting any formal or informal education.

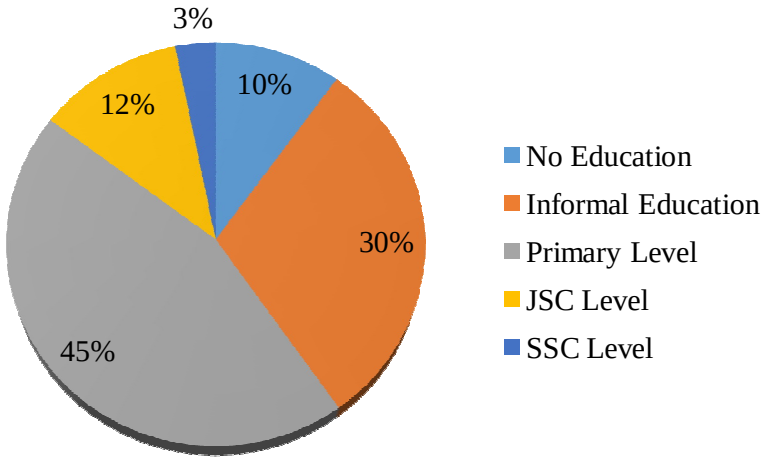


Figure-13: Percentage of trimmers with different level of education in Hazaribagh Tannery area

3.4.3 Income distribution of the Trimmers

It was observed that most of the trimmers worked contractually under a supervisor or their leader. The owners of the tanneries were verbally agreed with the trimmer's leader or supervisor to perform their activities by paying contracted amount of money following 'no work no pay rule'. Some owners paid the money weekly while some went for monthly payment. The owners paid the money to their leader and he disbursed it. During the contract the owners also mentioned that the trimmers were required to clean the

workplace by dumping all the solid wastes to the nearest dumping ground with their regular activities. The trimmers were treated like daily basis labourer.

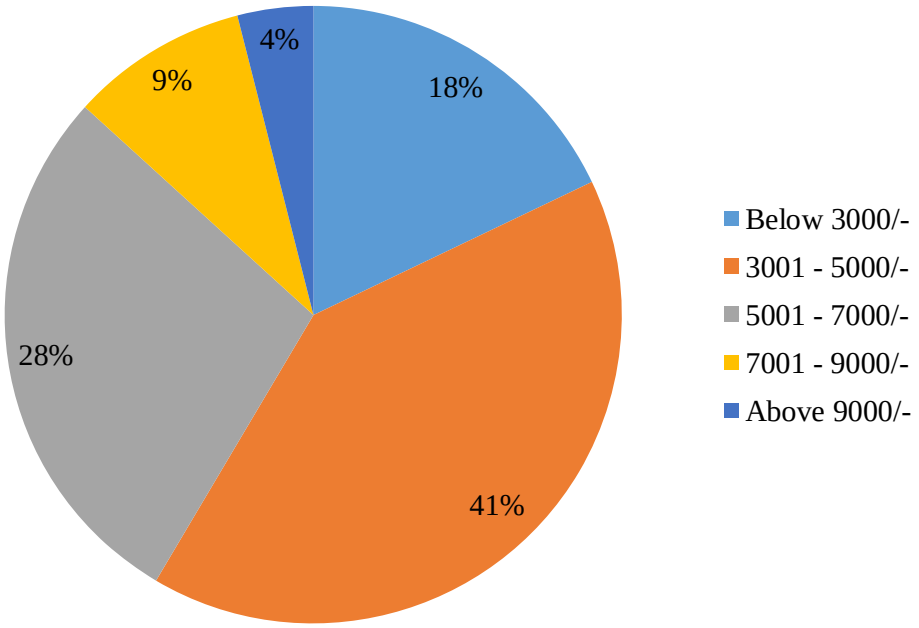


Figure-14: Percentage of trimmers with their range of monthly income in Taka during 2011 in Hazaribagh Tannery area

It was found in the survey that maximum 41% of trimmers were getting wages at the range of BDT 3001 to 5000/-. A total of 607 trimmer out of 882 were getting their wages at the range of BDT 3001 to 7000/-. Interestingly, it was observed that 18% of the trimmers were getting taka below 3000/- per month and most of them were child labourer, apprentices and aged people with having no previous work experience as trimmer.

3.4.4 Length of Job of the Trimmers

Total length of job performed in terms of year, as trimmer were surveyed among 882 trimmers which were clustered in five groups such as, (1 – 5), (6 – 10), (11 – 15), (16 –

20) and (above 20 years). Maximum 337 respondents were found who were working for 6 – 10 years which was 38% of the total respondents.

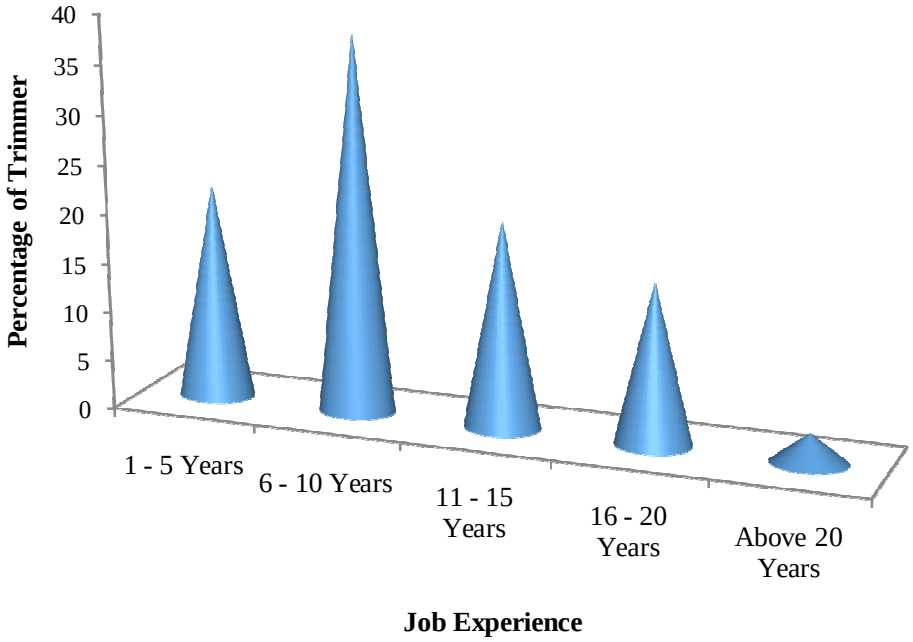


Figure-15: Percentage of trimmers with their range of job experience in years during 2011 in Hazaribagh Tannery area

3.4.5 Chronic Health Problem of the Trimmers occurred during job

During the survey, it was observed that most of the trimmers (90%) had been suffering from some selective diseases viz. gastric, skin diseases, fever, common cold, hypertension, asthma and dysentery etc. severely due to direct contact of raw hides & skins, chemicals and wastes. They also replied on asking about their sufferings that they were affected more than one disease after getting the job and not so much aware on using personal protective equipments in the workplace. Moreover, they expended a significant amount of money for their treatment which required to be earned by working more time

in the tannery and they did not afford sufficient nutritious food for themselves and for their family members.

Photograph-1: Skin disease affected foot of a trimmer

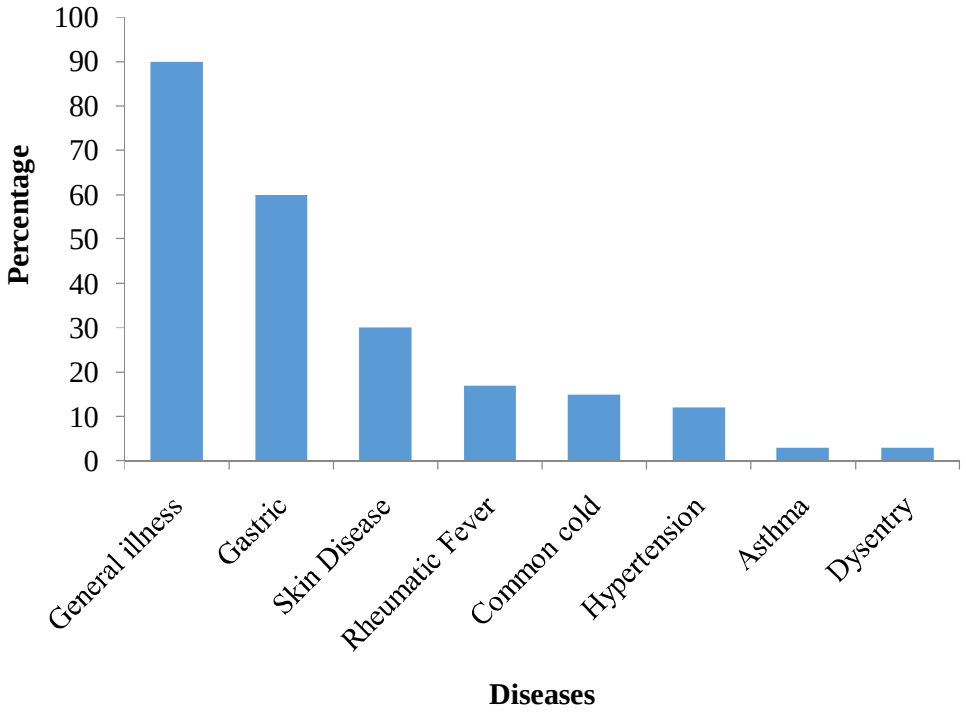


Figure-16: Percentage of affected trimmers by diseases in Hazaribagh Tannery area

3.5 Manpower Development at Hazaribagh, Dhaka

During survey it was found that the Institute of Leather Engineering & Technology (ILET) and Centre of Excellence for Leather Skill Bangladesh Limited (COEL) trained manpower to meet the workforce demand of leather sector in Bangladesh.

3.6 Source of Fund and its Utilization for Tannery Operation at Hazaribagh, Dhaka

The tanneries of Hazaribagh, Dhaka were operated by their owner's equity with getting bank loan including BMRI Principal. It was revealed from the Balanced Sheet and by peer interviewing with the management people of some tanneries that 64% of them got running capital from both owner's assets and bank loan, 9% self financed and another 9% got loan from Mahajans, the local loan providers.

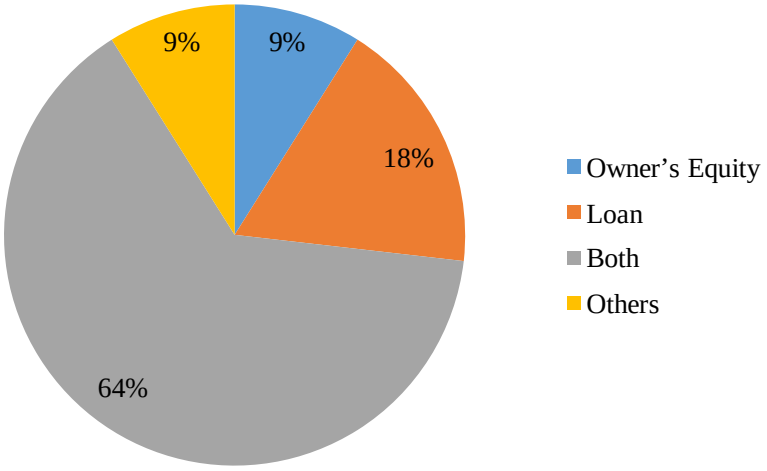


Figure-17: Percentage of tanneries with their source of fund during 2011 in Hazaribagh Tannery area

It was also observed that most of the funds were utilized for collecting raw materials, disbursing wages & salaries, payment for bank interest & Mahajan's interest, and payment for utility services; but there was no fund using to manage tannery pollution; no agreement found between tannery and corresponding government agencies for maintaining Polluter's Pay Principle (PPP). Therefore only dumping was followed here for solid wastes management.

3.7 Chemical Used in Tannery

During the observation and participant's observation it was found that almost 80% chemicals used in this sector were produced by European company such as, BASF, BYER, CIBA-GAIGY, STAHL, ICI etc. A few were imported from USA Company like BUCKMAN while some chemicals from China and India. These chemicals were categorised into three major groups. Such as, (1) Pre-tanning Chemicals, (2) Tanning Chemicals, and (3) Performance Chemicals (Table-4).

Table-4: List of chemicals used in leather production processes under different categories at Hazaribagh

Pre-tanning chemicals	Tanning Chemicals	Performance Chemicals
Ammonium sulphate, $(NH_4)_2SO_4$	Chromium salts, $Cr_2(SO_4)_3$ or $Cr(OH)SO_4$	Bactericides & Fungicides
Ammonium chloride, NH_4Cl	Vegetable tanning materials	Enzymes
Calcium hydroxide, $Ca(OH)_2$	Phenol based materials	Oil and Fat liquors
Calcium format, $Ca(COOH)_2$	Potash alum	Pigments & Dyeing materials
Dimethylamine sulphate	Zirconium salt	Syntans & Resins
Formic acid, HCOOH		Aldehydes
Hydrochloric acid, HCl		Nitro-cellulose lacquer
Oxalic acid, HCOOH-HCOOH		Methylethyl ketone
Sulphuric acid, H_2SO_4		Ethanol
Sodium sulphide, Na_2S		Ethyl glycol
Sodium bisulphate, $NaHSO_3$		Alizerdine
Sodium chloride, NaCl		
Sodium carbonate, Na_2CO_3		
Sodium sulphate, Na_2SO_3		
Sodium hypochlorite, NaOCl		
Sodium bicarbonate, $NaHCO_3$		
Sodium format, NaCOOH		

3.8 Solid Wastes Generation and it Types

Most of the solid wastes were generated in tannery from five different steps (annexure-2) of leather processing, identified as (1) Before Soaking, (2) After Liming, (3) After Wet-blue leather production, (4) After Crust leather production, and (5) After Finished leather production. The amount of solid wastes generated in this area was measured by using pre-developed formula -2 and it was found that a maximum amount of 443 metric ton solid wastes were generated in tannery of Hazaribagh per day during the peak season of 2011. It included 272 metric ton raw trimmings, 158 metric ton fleshings & shavings and 13 metric ton others (Salt, dust, Cuttings of Wet Blue, Crust & Finished Leather etc.). Mostly solid wastes were generated during trimming of raw hides & skins and removing flesh after liming operation.

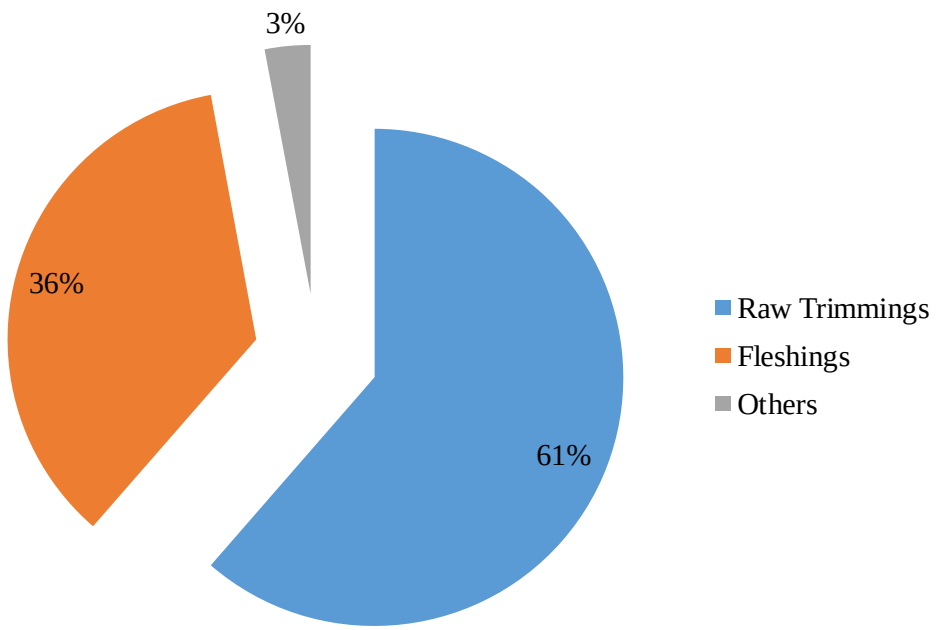


Figure-18: Percentage of different categories of solid wastes generated from the tannery in a day in peak season, 2011 at Hazaribagh, Dhaka and its status

3.9 Existing Management System of Tannery Solid Wastes and its Consequences Observed at Hazaribagh, Dhaka in 2011

It was clearly observed that the hides & skins were collected through different distribution channel and stored inside the tannery for processing leather. After receiving the hides & skins in tannery, the trimmers trimmed the raw materials as per requirement which produced the raw trimmings, a major solid waste. These raw trimmings were carried out by a cart or trolley and dumped by the roadside or low land close to the tannery area. There were 12 numbers of glue manufacturing factories found in Hazaribagh, Dhaka who used very small amount of the dumped raw trimmings as their raw materials to produce the animal glue. Mostly raw trimmings were remaining unutilized and spread over the area by scavengers.

On the other hand, fleshings were generated after completion of liming operation of leather processing at beam-house. Maximum 158 metric ton fleshings were produced in a day at Hazaribagh and being dumped by the roadside, drain or low land adjacent to it. Some fat recovery factories were found there to digest very little amount of dumped fleshing and sold it to the soap manufacturing industry. Mostly fleshings were remaining unutilized, blocking the drain and reducing the carrying capacity of the canal. It is rotten materials containing lime and sulphide which produces pungent smell.

There were a few fish and poultry feed producing factory utilized little amount of the dumped shaving dusts for producing their product. But they did not separate toxic chemicals like chromium etc. from those solid wastes.

Same system was followed for dumping cuttings of wet-blue, crust & finished leather occurred in different steps of leather processing as mentioned previously.

Additionally, some solid wastes carried out with the effluents discharged from the tannery at Hazaribagh through the drainage system of Dhaka City Corporation remained stagnate for a long time at the low land of Lalbagh to Rayer Bazar area near the Dhaka Flood Protection Embankment. The effluent became evaporated and the solid wastes became

sun-dry. Poor people residing adjacent to this area used the dried solid wastes for their daily fire-works inspiring air pollution, bad odour, and carcinogens.

Photograph -2: Raw Hides & Skins stored inside the M/S. Shahjada tannery at Hazaribagh

Photograph -3: Raw Trimmings were stored inside M/S. Shahjada tannery at Hazaribagh

Photograph -4: Workers are removing fleshing from the pelt in M/S. Javed tannery at Hazaribagh

Photograph -5: Fleshings were stored inside M/S. Shahjada tannery at Hazaribagh

Photograph -6: Fleshings were carried out from the tannery of Hazaribagh for Dumping

Photograph -7: Crust & Finished Leather Trimmings ready for Dumping at Hazaribagh

Photograph -8: Dumped Raw Trimmings near Kalunagar slum area at Hazaribagh

Photograph -9: Dumped shaving dust near Institute of Leather Engineering & Technology at Hazaribagh

Photograph -10: Dumped fleshings near M/S. R. M. M. Tannery at Hazaribagh

Photograph -11: Fleshings blocking the drain at Hazaribagh Bazar area

Photograph -12: Fleshings & other Solid Wastes reducing the carrying capacity of Hazaribagh_Canal near Kalunagar at Hazaribagh

3.10 Observed Effects of Tannery Solid Wastes on Soil

The Hazaribagh Tannery area of Dhaka city is surrounded by the river Buriganga. The total land area occupied by the sector in here is 60 acres. Now a day, the area is protected from flood by the embankment which created some low land inside and outside of the area. This low land is used for dumping solid wastes of tannery. There is a by-pass road of Dhaka city linking Gabtoli to Sadarghat on the embankment. As the dumping ground is located by the roadside, the soil of this area is duly affected by the solid wastes. Simultaneously, the effluent is discharged through a canal and several drains to this low land and finally falls into the Buriganga River.

The soil samples were collected from this low land as described in the chapter-2 of this thesis, analyzed in the laboureratory for five times and the average values (Mean ± SD) of each parameter are presented in annex-1 and table-5.

Table-5: The estimated average (Mean ± SD) values of Chemical parameters of Soil at Hazaribagh, Dhaka in the year 2011

Sl. No.	Name of the Station	pH	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Chloride (%)	Chromium (%)
S-1	Beribandh	7.86 ±0.225	7.97 ±0.170	13.70 ±0.292	1.54 ±0.137	0.247 ±0.0284	2.28 ±0.0291
S-2	Kalunagar	7.59 ±0.353	2.48 ±0.042	4.27 ±0.075	0.33 ±0.037	0.034 ±0.0022	0.17 ±0.0170
S-3	Company Ghat	4.08 ±0.192	3.59 ±0.008	6.18 ±0.013	0.21 ±0.029	0.003 ±0.0003	0.02 ±0.0003
S-4	Rayer Bazar	6.53 ±0.260	3.15 ±0.004	5.42 ±0.069	0.23 ±0.056	0.009 ±0.0004	0.35 ±0.0158
S-5	Gojmohol	6.56 ±0.164	3.15 ±0.164	5.42 ±0.284	0.35 ±0.041	0.012 ±0.0016	0.11 ±0.0151
	Standard for Soil	**7.00**	**1.85**	**3.1**	**1.35**	**0.05**	**0.08**

It has also been found that not only the soil and water of Hazaribagh area are being polluted by tannery solid wastes and effluents but the air is also being polluted in different ways especially due to the production of smog emitted by the animal glue manufacturing factories.

Photograph -13: Smog comes out from the traditional glue manufacturing factory at Beribandh at Hazaribagh

3.11 Analytical Results of Manufactured Animal Glue

It has been found that the existing management system of tannery solid wastes is very poor structured and tanneries do not follow proper way of dumping of tannery solid waste. So, solid wastes being generated from tannery spread pollution over the densely populated area at Hazaribagh, Dhaka. Moreover, a few (12) of by-product unit against 122 tanneries were found in this area which produced animal glue, poultry feed, etc. in limited condition. But they faced some challenges on performing their activities, such as-

- Their by-product manufacturing process was not scientific and they produced Animal glue from Raw Trimmings only.
- They were not much aware about environmental concerns and health hazards so that DoE did not recognize them and creating barrier on their activities.
- They did not separate toxic pollutant such as chromium from the wastes.
- They did not get bank-loan or any other financial support for further development.

3.11.1 Glue Manufactured by Traditional Method

3.11.1.1 Physical and chemical parameters of produced glue by traditional method

Animal glue was produced in the IES laboratory, Rajshahi following traditional methods and analyzed to compare physical and chemical properties of the glue samples with those of the sample glue collected from local market. The results are presented in the table-6.

Table-6: Physical and chemical parameters of glue produced in the laboratory following traditional methods

Sl. No.	Glue Sample	Physical parameters			Chemical parameters				
		Colour	Odour	Adhesive Strength	pH	Ash (%)	Fat (%)	Chloride (%)	Moisture (%)
1.	G-1	Brown	Bad	Sufficient	7.5	30.86	3.30	37.44	30
2.	G-2	Brown	Bad	Sufficient	7.5	25.63	7.60	83.35	46
3.	G-3	Brown	Bad	Sufficient	7.5	63.53	7.90	81.98	31
4.	G-4	Brown	Bad	Sufficient	7.5	23.14	4.36	70.02	18
5.	G-5	Brown	Bad	Sufficient	8.0	18.71	0.90	6.72	17.77
6.	**Standard**	**Yellowish**	**Nil**	**Sufficient**	**6.5**	**3.50**	**0.50**	**2.00**	**15**

All types of glue produced from the above process including showed the same physical properties but varied in chemical analysis which beyond the standard level of quality. Also the sample collected from the local market producing by traditional method of glue manufacturing process does not show the similar properties as described standard.

3.11.1.2 Environmental parameters of Effluent generated in glue manufacturing process

Effluent generated in producing animal glue in the IES laboratory, Rajshahi following traditional methods and analyzed to compare environmental parameters of the effluents generated from tannery and with those of Bangladesh standard. The results are shown in the table-7.

Table-7: Environmental parameters of Effluent generated in glue manufacturing process

Parameters	Steps	Effluents					
		G-1	G-2	G-3	G-4	Tannery Effluent*	Bangladesh Standard**
Colour	Pre-Soaking	Earthy	Earthy	Earthy	Earthy	Earthy	Nil
	Soaking	Yellowish	Yellowish	Yellowish	Yellowish	Yellowish	
	Liming	Green	Gray	Green	Gray	Gray	
	Washing	Clear	Clear	Clear	Clear	Clear	
Odour	Pre-Soaking	Septic	Septic	Septic	Septic	Septic	Nil
	Soaking	Septic	Septic	Septic	Septic	Septic	
	Liming	Foul	Foul	Foul	Foul	Foul	
	Washing	Nil	Nil	Nil	Nil	Nil	
pH	Pre-Soaking	6.5	6.5	6.5	6.5	6.7	6 - 9
	Soaking	8.5	8.5	8.5	8.5	8.7	
	Liming	13.0	11.0	13.0	11.0	13.2	
	Washing	11.0	11.0	11.0	11.0	11.0	
Total Suspended Solid (in ppm)	Pre-Soaking	2800	2320	2560	2237	2320	150
	Soaking	14315	10000	12860	9870	12860	
	Liming	3730	3145	2700	2500	2700	
	Washing	1236	1142	1798	1500	1798	
Total Dissolved Solid (in ppm)	Pre-Soaking	26090	20165	24920	18127	24920	2100
	Soaking	35753	28315	30560	20385	30560	
	Liming	30175	22000	27100	23200	27100	
	Washing	2142	1528	1760	1240	1760	

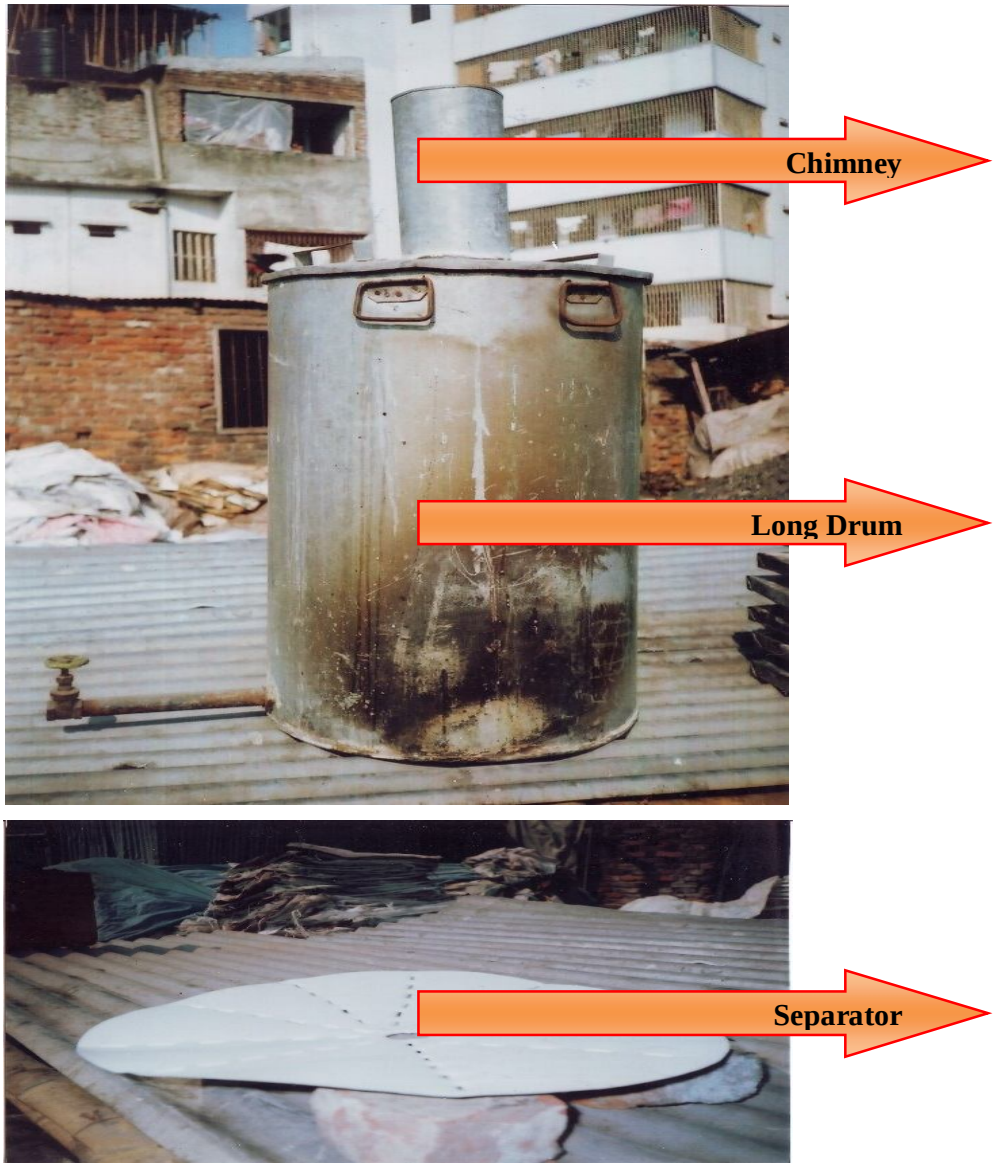
* Source: Islam, R.M.S., 1998, Studies on the Degree of Pollution Resulting during the Production of Wet Blue Leather from Goatskin, *B. Sc. In Leather Technology Dissertation*, University of Dhaka, 60pp.

**Bangladesh Gazette, 1997

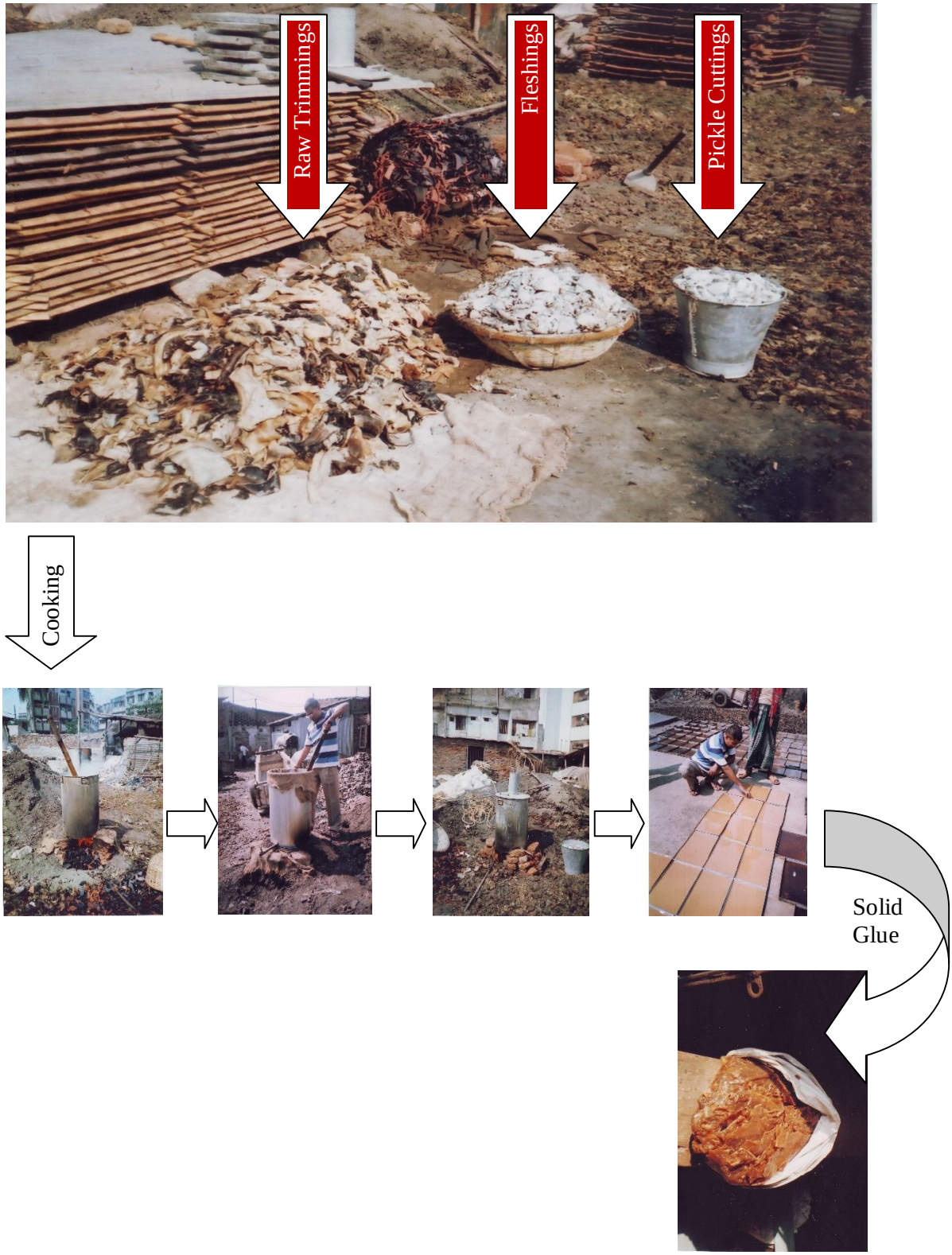
3.11.2 Glue Manufactured by Modified Method

3.11.2.1 For Machine Management

It has been observed that, most of the machines used in glue production factory are local made. The steel drum using for cooking the wastes does not have any chimney to control the odour and smog. Therefore a steel drum with capacity of cooking 100 Kg solid wastes has been made with chimney. There is a separator made of steel has been used inside the drum. It can filter liquid glue primarily from hair & wool and dirt. 20 different trays have also been made of steel for sun-drying of the liquid glue.



Photograph -14: Locally developed Animal Glue Production Drum through modification of the traditional one with imparting chimney



Photograph -15: The researcher is working in bulk production of animal glue at Hazaribagh following modified methods

3.11.2.2 Wastes Utilized and Glue Produced

A total of 384Kg of solid wastes were used in bulk production of animal glue following modified methods producing 89.5Kg of glue in five slots. The data has been shown in the following table-8.

Table-8: The amount of solid wastes utilized in the animal glue manufacturing process following modified methods at Hazaribagh, Dhaka

Sample	Solid Wastes Used (Kg)				Glue Produced (Kg)	Solid Remaining/Gaad (Kg)
	Raw Trimmings	Fleshings	Pickle Cuttings	Total		
AG-1	50	6	6	62	13.5	19.5
AG-2	50	13	6	69	14.0	18.5
AG-3	50	20	6	76	19.0	21.0
AG-4	50	25	6	81	21.0	23.0
AG-5	50	40	6	96	22.0	30.0
Total	250	104	30	384	89.5	112

3.11.2.3 Physical and chemical parameters of produced glue by modified method

Animal glue was produced in bulk quantity following modified methods and analyzed to compare physical and chemical properties of the glue samples with those of the sample glue collected from local market. The results are presented in the table-9.

Table-9: Physical and chemical parameters of glue produced following modified methods at Hazaribagh, Dhaka

Sl. No.	Parameter	Standard	Market Sample	Sample AG-1	Sample AG-2	Sample AG-3	Sample AG-4	Sample AG-5
1	Colour	Yellowish	Brown	Yellowish	Yellowish	Yellowish	Yellowish	Yellowish
2	Odour	Nil	Bad	Nil	Nil	Nil	Nil	Nil
3	Adhesive Strength	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient
4	pH	6.5	8.0	8.5	8.0	8.0	8.0	8.5
5	Moisture (%)	Max. 15	17.77	12.57	11.34	14.88	8.13	13.08
6	Ash (%)	< 3.5	18.71	2.37	2.94	2.21	2.39	2.41
7	Fat (%)	< 0.5	0.90	2.17	2.95	3.51	3.57	3.73
8	Chloride (%)	< 2.0	6.72	1.41	1.67	1.17	1.35	1.28
9	Nitrogen (%)	< 18	12.76	15.03	13.82	13.09	14.91	13.20
10	Protein (%)	-	80	93	86	82	93	83

3.11.2.4 Cost Involved

A total of 50 Kg lime at the rate of Taka 10/- per kg lime and 1.75 Kg phenyl Taka 300/- per kg rate were purchased from the local market to process solid wastes for manufacturing animal glue from raw trimmings, fleshings and pickle cuttings following modified process. There were some excess costs involvment for collecting solid wastes which referred to as dumping cost in the cost sheet.

There were 4 workers directly involved in producing the animal glue from using the tannery solid wastes. A lump sum amount of Taka was expended for using water and miscellaneous performance during animal glue production period following modified method. A significant amount of money was expended for making the modified steel drum with chimney for controlling smog generation, which was not mentioned in the cost sheet as it was a fixed cost. This cost sheet includes the running production cost only which was calculated as Taka 3193/-. The produced animal glue was sold to the local buyer at the rate of Taka 37/- per Kg. Thus a total of Taka 3311.50 was the selling price of the produced glue and Taka 118.50 was the profit margin on the basis of production cost.

Table-10: Production costs of glue manufacturing following modified methods at Hazaribagh, Dhaka

Materials Required			Total Cost (BDT)
Name	Quantity (Kg)	Rate (BDT/Kg)	
Lime	50	10	500
Phenyle	1.75	300	525
Solid Wastes (Dumping Cost)	384	2	768
Labourer	4	300	1200
Water & Others	-	-	200
		Production Cost	3193
Glue Sold	89.5	37	3311.50
		Profit margin	118.50

3.11.2.5 Environmental parameters of Effluent generated in modified glue manufacturing process

Effluent generated in producing animal glue at Hazaribagh, Dhaka following modified methods and analyzed to compare environmental parameters of the effluents generated from tannery and with those of Bangladesh standard. The results are shown in the table-11.

Table-11: Environmental parameters of Effluent generated in glue manufacturing process following modified methods at Hazaribagh, Dhaka

Parameters	Steps	Effluents					Tannery Effluent*	Bangladesh Standard**
		AG-1	AG-2	AG-3	AG-4	AG-5		
Colour	Pre-Soaking	Earthy	Earthy	Earthy	Earthy	Earthy	Earthy	Nil
	Soaking	Gray	Gray	Gray	Gray	Gray	Yellowish	
	Liming	White	White	White	White	White	Gray	
	Washing	Clear	Clear	Clear	Clear	Clear	Clear	
Odour	Pre-Soaking	Septic	Septic	Septic	Septic	Septic	Septic	Nil
	Soaking	Septic	Septic	Septic	Septic	Septic	Septic	
	Liming	Foul	Foul	Foul	Foul	Foul	Foul	
	Washing	Nil	Nil	Nil	Nil	Nil	Nil	
pH	Pre-Soaking	6.5	6.5	6.5	6.5	6.7	6.7	6 - 9
	Soaking	8.3	8.3	8.3	8.3	8.3	8.7	
	Liming	11.0	11.0	11.5	11.5	11.2	13.2	
	Washing	11.0	11.0	11.0	11.0	11.0	11.0	
Total Suspended Solid (in ppm)	Pre-Soaking	2650	2300	2260	2237	2400	2320	150
	Soaking	10315	10700	11860	12070	12160	12860	
	Liming	3080	3120	3200	3276	3310	2700	
	Washing	1200	1247	1298	1365	1400	1798	
Total Dissolved Solid (in ppm)	Pre-Soaking	25100	25345	24920	25756	26132	24920	2100
	Soaking	30335	29150	30560	30385	30896	30560	
	Liming	28313	27000	28297	29200	28100	27100	
	Washing	2056	1978	1760	1840	1960	1760	

* Source: Islam, R.M.S., 1998, Studies on the Degree of Pollution Resulting during the Production of Wet Blue Leather from Goatskin, *B. Sc. In Leather Technology Dissertation*, University of Dhaka, 60pp.

**Bangladesh Gazette, 1997

CHAPTER-FOUR

GENERAL DISCUSSIONS

Chapter-4: General Discussions

Tannery pollution in our country is well known to all stakeholders. Everyone is shouting to protect river and environment of Dhaka city from tannery pollution by relocating the industry (Kaisar, 1994) without taking any proper corrective measure. The study entitled "Eco-friendly management of Tannery Solid Wastes in Bangladesh" covers the three consecutive years (2009-2011) through observation, experiment and implementation. The study focuses specially on solid wastes pollution generating from tannery and its mitigation because a lot of previous works found inside and outside the country during 1990 -2010 in development of effluent treatment mechanism but very few works found on tannery solid wastes management. All the works related with tannery solid wastes found in developed country focused on by-product manufacturing with high technology which are not available in Bangladesh. So analyzing the soil parameters to know the consequences of tannery solid wastes were performed in this research and choosing one traditional production method of by product (Animal Glue) practicing in the country was studied and modified with local resources and technology which would be appropriate and available. Also primary data were collected through survey questionnaire to know the impact of tannery solid wastes on workers.

It was observed that 112 working tanneries found in the Hazaribagh tannery area of Dhaka city processed maximum 632.58 metric ton raw hides & skins in a day during the tenure of survey 2011 with involving 882 trimmers (tannery workers) who worked in the solid waste generating process producing 443 metric ton solid wastes. It was also observed that 33% of these workers belongs to 19-30 years age group, 45% has primary level education, 41% earned with the range of Taka 3001-5000/- per month, and 38% has 6-10 years work experience. Most alarming information found in the survey that 90% of the trimmers have been suffering from general illness and they affected various diseases after joining their job in the tannery.

These trimmers were found to clean the workplace through collecting and dumping of the solid wastes to the nearest dumping ground. Some soil parameters of that dumping ground were also collected on cluster basis, analyzed and observed impacts are discussed below:

pH: It was found that solid wastes do not impact pH of soil as much it affects in Company Ghat area. The pH of this area is found 4.08 which indicate that the solid wastes is decomposed in this low land and the acidic leachate come out by the decomposition contaminating and reducing the soil pH.

On the other hand, due to the heavy suspended solids present in the effluents sludge banks are formed in the receiving boady and present an unsightly appearance. The suspended matter gets deposited on the bed and decomposed and reducing the soil pH. Anaerobic conditions may develop in such sludge beds resulting in the emanation of foul odours and buoying up of dark coloured sludge particles to the surface.

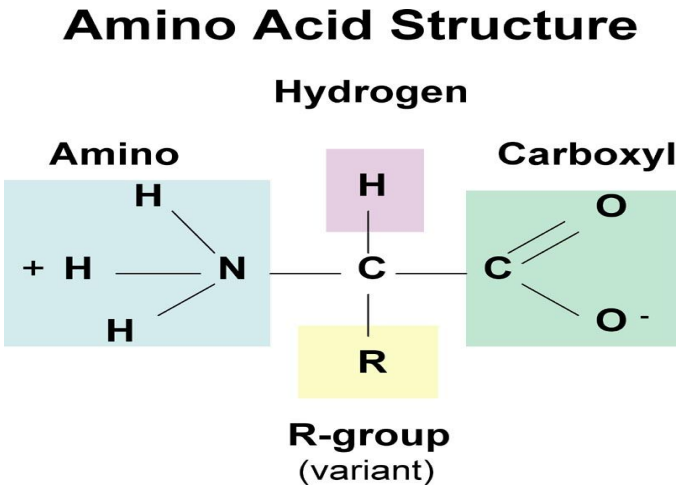
Local people mentioned that some vegetables and crops were cultivated in this low land during winter season many years before; but at present this land is becoming uncultivable. They also mentioned that this place is overflowed during the rainy season and the wastes are carried to the river Buriganga.

Soil Organic Matter: Solid wastes generated from tannery mainly contain hair & wool, hide scraps, fats and fleshings. All these wastes are biodegradable in nature. Chemically, hair & wool contains keratin, hide scraps contain collagen, fats and fleshings contain fatty acids and collageneous tissues (Dutta, 1999). Moreover, these wastes contain polyamide based organic matter. So when these wastes become decomposed by bacterial digestion system, the residues are mixing with the soil and increase the soil organic matter.

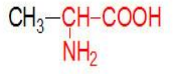
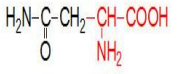
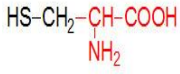
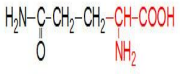
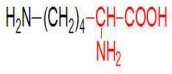
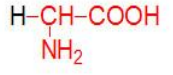
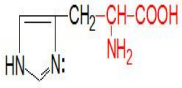
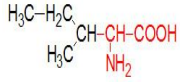
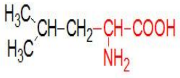
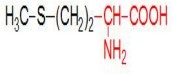
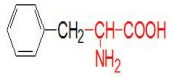
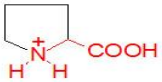
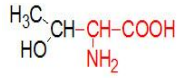
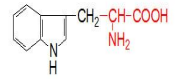
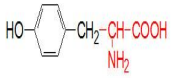
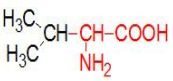
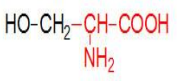
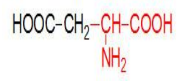
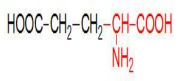
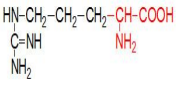
It was found that solid wastes impact soil organic matter directly. The percentage of soil organic matter is beyond the soil standard in every places of the sample location. It was much higher (13.7%) near the flood protection embankment (Beribandh) than any other location. Because most of the wastes being dumped here. Kalunagar (S-2) is far away from the previous place and thus the soil of this place is less contaminated. It seems that if the soil contains more organic matter then the soil becomes more fertile. But this is not true in all cases. Because, these protein wastes containing high amount of carbon, nitrogen and toxic materials which reduce the soil fertility (Sharma, 2003).

Total Nitrogen: From the previous discussion it is found that, Solid wastes generated from tannery containing protein based wastes referring to collagen, keratin, fatty acids, etc. It is

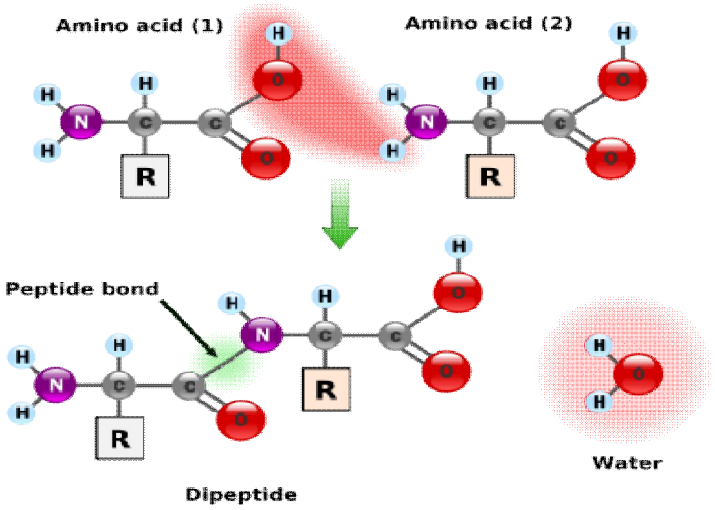
known to all that all proteins are made up of large number of units known as amino acid residues, each of which is composed of a small number of atoms. An amino acid, like other materials that go to make up a polymer, is bi-functional, that is, it has two places at which it can join on to something else. In the case of amino acid, these two places are amino group and the carboxyl group. The amino group contains nitrogen (en.wikipedia.org/wiki/**Amino-acid**).



There are twenty different amino acids found in the hides and skins (en.wikipedia.org/wiki/**Amino-acid**).

 Alanine	 Asparagine	 Cysteine	 Glutamine	 Lysine
 Glycine	 Histidine	 Isoleucine	 Leucine	 Methionine
 Phenylalanine	 Proline	 Threonine	 Tryptophan	 Tyrosine
 Valine	 Serine	 Aspartic Acid	 Glutamic Acid	 Arginine

Consequently, the amino group of one amino acid can join with the acid group of another amino acid, and this process can continue, so that a long chain of amino acids attached to one another can be built up and form the polyamide bondage.



When the protein wastes are decomposed then the polyamide bondage is broken down. Amino residue is coming up and mixing with soil and the soil bacteria further breaks the amino groups and nitrogen is come out (www.britannica.com/EBchecked/topic/20691/**amino-acid)**. It has been found in the analysis that the total nitrogen content of the soil collected from S-1 near to the embankment much higher than any other places due to the close dumping of solid wastes. Gradually the values of nitrogen content have been reduced.

It has also been observed that raw trimmings are being dumped by the roadside on the embankment, but in other places the fleshings and other solid wastes bonding with chemicals being dumped which contain less nitrogen and are not easily decomposed.

Moreover, local poor people are using dried solid wastes for fireworks for cooking purpose resulting the emanation of nitrogen to air. This is another cause of reducing the soil nitrogen in the sampling places.

Total Chloride: When the tannery waste gains access to cultivable lands or when the land is irrigated with such waste, it loose fertility. The wastes may change the characteristics of the soil and also may interfere with the water uptake of the plants. It influences the metabolic activities of the plants, resulting into reduced yield.

Chloride is one of the important indicators of soil pollution. Common salt adds to salinity of water. The salts concentration level in soil more than 1.35% is harmful to the plant life. Salts

reduce the fertility of agricultural land. If the salt builds up in soil exceed the trees or crops salinity tolerance reduction in growth or even death of the plant could occur. The high content of salt in sludge might prevent its use for composting and soil conditioning. Also the accumulation of sodium in the soil can cause deterioration in soil physical properties specially in porosity and permeability to water. High concentration of sodium affects the fertility of the soil. This is called 'Sodium hazard' to the soil. It corrodes the metal also. The local people have mentioned that their metallic home appliances are being poured in this area within a few years (Sharma, 1999).

Bangladesh has an abundant supply of raw hides and skins. It is not always possible to send the hides and skins to tanneries immediately after flaying because the sources of collection and the tanneries are not generally located in the same area. The time gap between the flaying operation and the start of tannery operations vary from one to two months. If hides and skins are not cured just after flaying, they get completely putrefied within 2 to 3 days. Curing is, therefore, the process by which we can protect putrefaction of raw hides and skins. Normally it is done by applying common salt on flesh side of the flayed hides and skins in our country. This is called wet-salting method of curing. This is the cheapest way of curing.

Therefore when the raw trimmings are dumped in the low land of the area salt also be dumped along with the wastes. Thus the salt level of soil is found high in the S-1 (Beribandh) of the sampling location. It is washed out by the overflowed water to other places of it.

Total Organic Carbon: Soil carbon is the generic name for carbon held within the soil, primarily in association with its organic content. Soil carbon is the largest terrestrial pool of carbon. Humans have, and will likely continue to have, significantly impacted on the size of this pool. Soil carbon plays a key role in the carbon cycle and thus is important in global climate models.

Soil carbon is primarily composed of biomass and non-biomass carbon sources. Biomass carbon primarily includes various bacteria and fungi. Non-biomass carbon sources or substrates reflect the chemical composition of plant biomass and primarily include cellulose, starch, lignin and other diverse organic carbon compounds. Some of the substrate carbon will bind to the mineral soil becoming encapsulated in soil aggregates.

Soil carbon improves the physical properties of soil. It increases the Cation Exchange Capacity (CEC) and water-holding capacity of sandy soil and it contributes to the structural stability of clay soils by helping to bind particles into aggregates. Soil organic matter, of which carbon is a major part, holds a great proportion of nutrients, cations and trace elements that are of importance to plant growth. It prevents nutrient leaching and is integral to the organic acids that make minerals available to plants. It also buffers soil from strong changes in pH. It is widely accepted that the carbon content of soil is a major factor in its overall health. Although exact quantities cannot be documented but it is calculated that on an average 1.85% of total organic carbon is good for soil structure (http://en.wikipedia.org/wiki/Soil_carbon).

Tannery solid wastes are mainly protein based wastes which are the polymers of amino acids, fatty acids etc. Amino acids have two functional groups; one is amino group which contains nitrogen and other group is carboxyl group containing carbon. Therefore all these organic materials contain high amount of nitrogen, Hydrogen and Carbon.

The sample location, S-1 refers to the Beribandh near Flood Protection Embankment is the main dumping ground of tannery solid wastes. This is why the decomposition of protein produces high amount of organic carbon here.

Total Chromium: Chromium is a lustrous, brittle, hard metal. Its colour is silver-gray and it can be highly polished. It does not tarnish in air, when heated it borns and forms the green chromic oxide. Chromium is unstable in oxygen, it immediately produces a thin oxide layer that is impermeable to oxygen and protects the metal below.

A suite of industrial activities has led to widespread Cr contamination within soils and natural waters. Although Cr is an essential element for humans, the hexavalent form is toxic, mutagenic, and carcinogenic (National Research Council, 1974). As such, the widespread presence of Cr in the environment poses a serious threat to human and animal welfare. The toxicity of Cr, however, is a function of oxidation state. Hexavalent Cr, which typically exists as the oxyanion chromate (CrO_4^{2-}), has a high solubility in soils and groundwater and, as a consequence, tends to be mobile in the environment.

In contrast, the reduced form of chromium, Cr(III), has a limited hydroxide solubility and forms strong complexes with soil minerals (Sass and Rai, 1987). While trivalent Cr is relatively innocuous and immobile, hexavalent Cr is actively transported into cells by the sulfate transport system where it is capable of causing damage to DNA as well as indirectly generating oxygen radicals. Accordingly, reduction of Cr(VI) to Cr(III) is an important means by which the deleterious effects of this toxin are mitigated (http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/2200/FPL_1851ocr.pdf).

The high amount of chromium has been found in the soil near embankment (S-1: Beribandh) which is the main dumping ground of the tannery solid wastes. It has been observed that there is no plant or trees and even grass cannot grow on this soil. It has also been observed that poor people living on this area are using dried solid wastes for their daily fireworks. Therefore trivalent chromium can easily be converted to the hexavalent chromium by heating. So the poor people living in this area are not aware as much as they can protect themselves from chromium toxicity. Thus there is a huge possibility to spread the chromium pollution among the local people and their lives become endangered.

The above data focuses on how the solid wastes containing toxic chemicals used in tanning process could be injurious to human health as the proper safety precautions are not taken; some are known human carcinogens causing cancer. Despite this, many workers complained that their tannery did not supply protective equipment such as gloves, masks, boots, and aprons, or supplied it in insufficient quantities. Additionally, they are not well informed and aware about the occupational safety and hazards. They are not practicing Occupational Safety and Health rule in their workplaces. Therefore they are suffering from various diseases and losing socio-economic status.

Finally, the observed effect of tannery solid wastes are mentioned below-

- Land occupied by solid wastes.
- Substantial quantity of solid wastes being dumped by the roadside, which are washed-out filling the drain and canal reducing their carrying capacity.
- Pungent odour come out.
- Scavengers spread out the solid wastes.

- Workers and people suffer from different diseases such as, Allergy, Skin diseases, Nausea, Vomiting, Headache, Sinusitis, Bronchitis, Respiratory problems, Heart diseases, etc.

On the other hand, it was found that a few by-product industries produced animal glue, poultry feed, fish feed etc. from using limited amount of solid wastes generating from tannery by following traditional method of production which was not scientific and exaggerate the air pollution to the city. It was also revealed that animal glue was produced from using raw trimmings only; to utilize more solid wastes, the manufacturing of Animal glue has been selected as a tool of waste management producing by-product. Its traditional glue manufacturing process was modified and producing animal glue from fleshings and pickle cuttings (solid wastes) mixing with raw trimmings which imparted better physical and chemical properties compare to the sample glue collected from local market manufactured following traditional method. The effluent generating from glue manufacturing process were collected, analyzed and found similarity with those effluents generating from the tannery. So it can be easily manageable through effluent treatment plant.

The main target of this research had to enhance the by-product industry through process modification and integrating with the main industry so that the solid wastes generated from tannery need not to dump and used at the point of origin to trigger the eco-friendly environment. The findings of this work along with the findings of the previous researchers will inspire future researchers for further progress in research in the field of leather technology and by-product.

We know that, there are four determinants of organizational structure viz. Strategy, Size, Technology, and Environment. The by-product industry itself small in size, using traditional technology and cannot mitigate the environmental pollution. So, the concern authority would have the strategy that the glue manufacturing industry (by-product industry) must be set up adjacent to the tannery. This study has chosen the location for glue manufacturing which is close to the tannery named M/S. Kalim leather. It helps to collect solid wastes with low labour-costs. Moreover, the solid wastes need not to dump in different locations which avoid the carrying costs involved and reducing the pollution.

Strategically, the layout plan has been drawn including tannery and the by-product industry. So, we can conclude this discussion, as for explosive growth and consistent innovation boundary less organic structure of organization has the suitability depending on its small size and local technology being used. Finally, the effluent might be managed through central effluent treatment plant (CETP). Therefore this is an aggregate comprehensive batch processing model of production though it faced some limitations as mentioned below:

i. Raw trimmings, fleshings and pickle cuttings were utilized in glue manufacturing process but it required high technology to converting other solid wastes into product which is unavailable in the country.

ii. Huge costs were invoked in trial process.

Till than the primary cost effective study revealed that the establishment of animal glue production industry incorporating developed modified methods will be profitable venture for new entrepreneurs creating new employment opportunities and scientific waste management approach in the field of tannery industry as well as to ensure the eco-friendly environment, the most urgent need of the day for sustaining foreign currency earning leather industry of Bangladesh.

CHAPTER-FIVE

RECOMMENDATIONS

Chapter-5: Recommendations

Naturally Bangladesh has abandoned supply of raw hides and skins, cheap labourers so that Leather industries of Bangladesh should be operated well with utilizing those available resources. But it was found in the tenure of this study that numbers of tanneries were being reduced gradually year after year due to unplanned industrialization, lack of knowledge of tannery people on environmental concerns and uncontrolled generation and dumping of wastes. It was also notified that huge amount of solid wastes were generated during processing of leather in tannery and spread the pollution over a large area of Dhaka due to uncontrolled dumping of it. It was also observed that in the present system of leather processing, solid wastes generation cannot be minimised for ensuring leather quality as well as there was no scope of set up new mechanism of scientific wastes management plant in Hazaribagh congested area to protect environment from tannery solid wastes pollution. So GoB has taken initiative to relocate tannery from Hazaribagh to Savar, Dhaka with set up effluent treatment plan for effluent management and dumping ground for scientific dumping of solid wastes.

But it should be considered that solid wastes are the part of valuable resources and required to utilize through process development and modification of by-product industry. And the by product industry should be set up adjacent to the tanneries which minimising the transportation cost of wastes as well as the wastes would be utilized at the point of origin so that environment would be clean and eco-friendly. Production of animal glue is one of the by product producing mechanisms from tannery solid wastes has taken as a tool of solid wastes management through utilizing more wastes in it by modifying its traditional production process during the tenure of the investigation. On the basis of the findings of present investigation and above discussions the following recommendations may be formulated for the concerned stakeholders of Bangladesh to ensure sustainable environment of tannery and by-products industry:

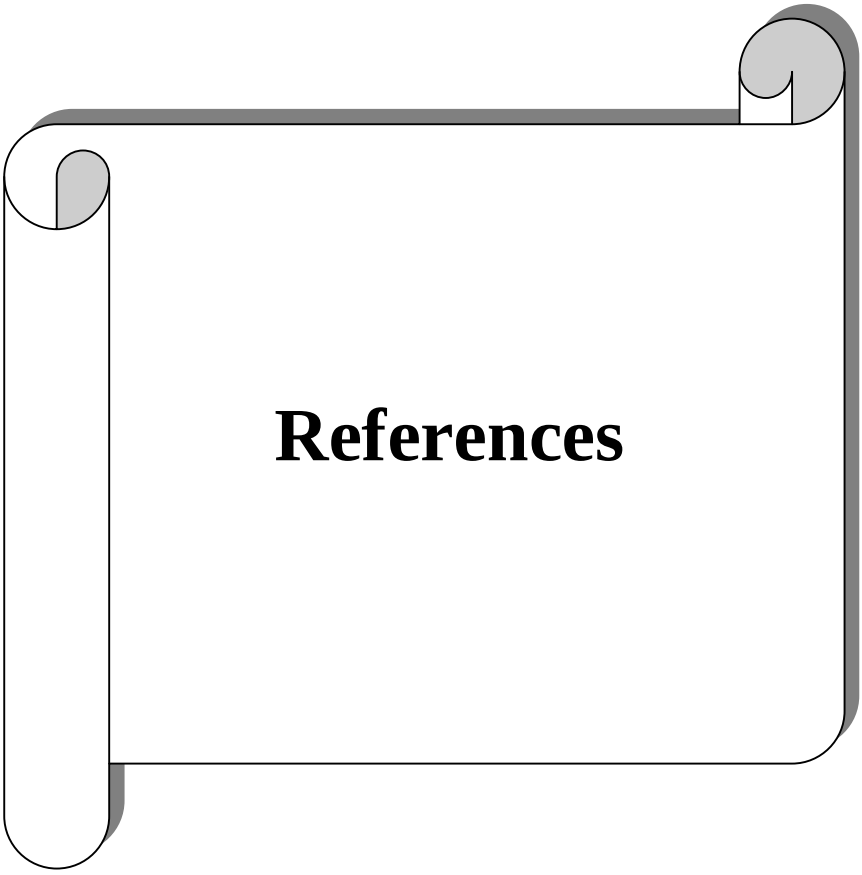
1. Use of sodium sulphide should be stopped in glue production process.
2. Animal Glue should be produced by using fleshings and pickle cuttings with raw trimmings.

3. The Tannery should have by-product unit adjacent to it so that transportation and dumping cost of wastes would be minimized and wastes would be utilized at point of origin.
4. Long chimney is required to control the smog at the glue production process.
5. Safety gloves and shoes are required at working.
6. Integrity of by-product unit with tannery increases the profit margin and achieving the sustainability and making this sector eco-friendly.

Accordingly, the following outcomes are required for further research:

1. As the produced animal glue through modifying process, contains high amount of proteins (Table-9) so this can be used as food supplements which meet our protein demand for low earning people.
2. Hair and Wool can be separated from the Sludge and Solid remaining/Gaad for using in Brush manufacturing.

Therefore, the present research would become supplementary work of the tannery relocation project of GoB contributing on reducing pollution load.



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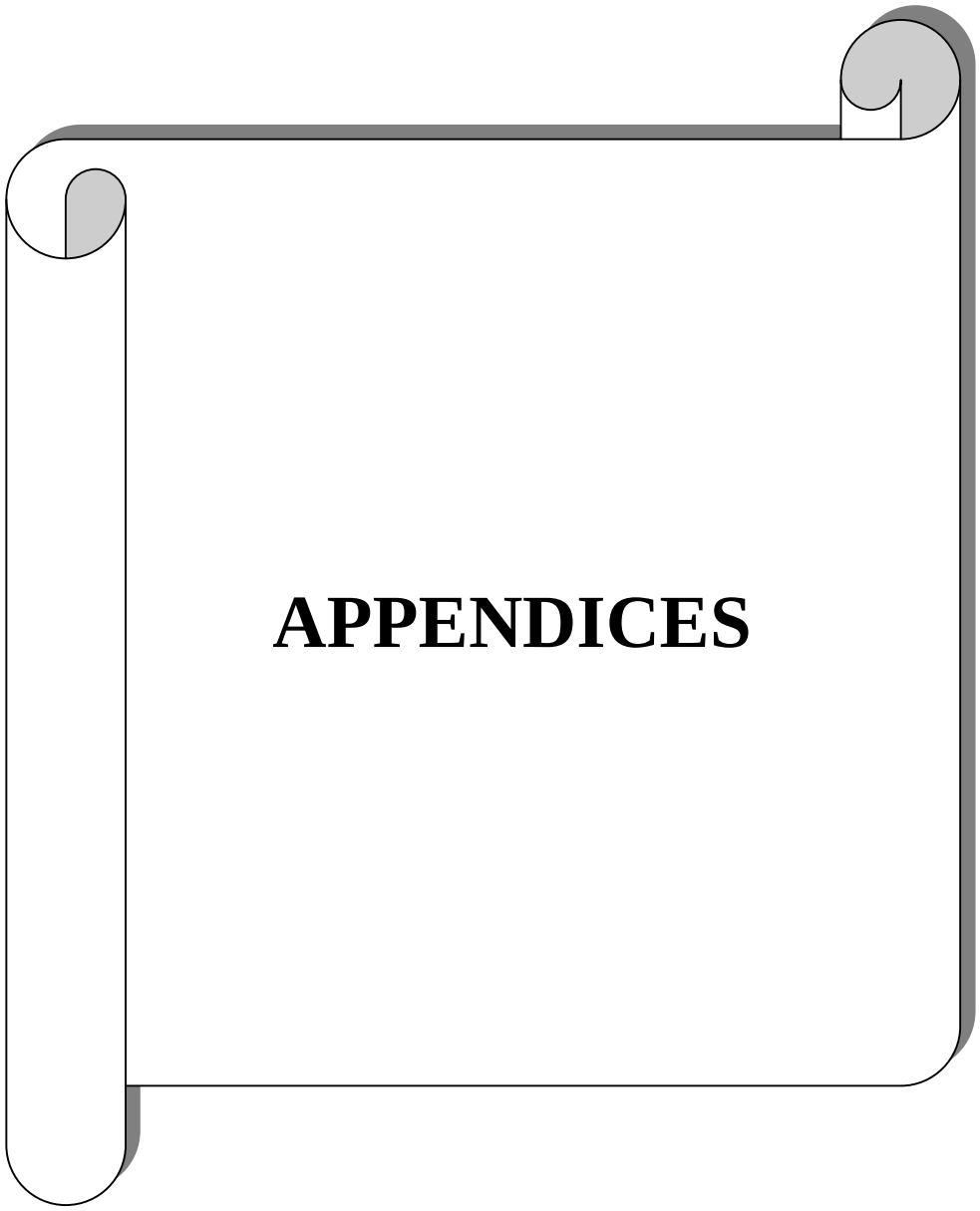


APPENDICES

Appendix-1: Survey Questionnaire

(Please √ as required)

A. For Tannery Owners

1. Name of the Organization	:	
2. Address of the Organization	:	Monessware Road Sher-e Bangla Road Mid Hazaribag Sonatangar/Gojmohal Kalu Nagar
3. Name of the Owner	:	
4. Educational Qualification (Latest)	:	No Education SSC Level HSC Level Graduation Post Graduation Others
5. Sex	:	Male Female
6. Age	:	Below 30 31 - 40 41 - 50 51 - 60 Above 60
7. Length of Business (years)	:	Below 10 11 – 20 21 – 30 Above 30
8. Work Nature	:	Self Job-work Lay-off
9. Total number of Raw Hides & Skins processed (Piece/Day)	:	**Raw Materials** / **No. of Piece** Cow Hide Buffalo Hide Goat Skin Sheep Skin
10. Total number of employees	:	**Employees** / **No.** Office Stuff Technologists Permanent Labour Temporary Labour Trimmer
11. Employee supportive initiative	:	Training Health service Others
12. Source of Fund	:	Owner's Equity Loan Both Others

13. Utilization of Fund	:	Fixed Asset Raw Materials Wages & Salaries Training Pollution Control Others
14. Solid Waste Management Practiced	:	Reuse Recycle Dumping By-product manufacturing

B. For Technologists

1. Name of the Leather Technologist	:	
2. Sex	:	Male Female
3. Age (Years)	:	Below 18 19 - 30 31 - 40 41 - 50 51 - 60 Above 60
4. Educational Qualification (Latest)	:	Certificate in Leather Technology Diploma in Leather Technology B. Sc. in Leather Technology Other
5. Length of Service (Years)	:	Below 2 2 – 5 6 – 10 11 – 15 16 – 20 Above 20
6. Origin of Equipment used (%)	:	Indian European American Mixed
7. Origin of Chemicals used (%)	:	Indian European American Mixed
8. Chronic Health problem occurred during job	:	Gastric Skin Disease Hypertension Asthma Common cold General illness

Continued

9. Utilization of Solid Wastes	:	Reuse	
		Recycle	
		Dumping	
		By-product manufacturing	

C. For Trimmer

1. Name of the Trimmer	:		
2. Sex	:	Male	
		Female	
3. Age (Years)	:	Below 18	
		19 - 30	
		31 - 40	
		41 - 50	
		51 - 60	
		Above 60	
4. Educational Qualification (Latest)	:	No Education	
		Informal Education	
		Primary Level	
		JSC Level	
		SSC Level	
5. Length of Service (Years)	:	Below 2	
		2 – 5	
		6 – 10	
		11 – 15	
		16 – 20	
		Above 20	
6. Monthly Income (BDT)	:	Below 3000	
		3001 - 5000	
		5001 - 7000	
		7001 - 9000	
		Above 9000	
7. Personal Protective Equipment used during job	:	Mask	
		Hand Gloves	
		Fingure guard	
		Apron	
		Gum Boot	
		Not used	
8. Chronic Health problem occurred during job	:	General illness	
		Gastric	
		Skin Disease	
		Rheumatic Fever	
		Common cold	
		Hypertension	
		Asthma	
		Dysentry	
9. Health problem occurred after doing job	:	Yes	
		No	

Appendix – 2: Block Wise List of the Tannery with functional status found during survey in 2011 at Hazaribag, Dhaka

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
Monessware Road Block														
1	M/S Asif Leather	42/7, Monessware Road, Hazaribag, Dhaka-1209	Self	0	0	0	0	0	2	10	1	13	8	Sole Leather from Cutting
2	M/S B. S. Leather Complex	48/48/1, Monesware Road, Hazaribag, Dhaka-1209	Self	110	1500	0	0	1	1	30	4	36	8	
3	M/S City Leather Tannery	30, Monessware Road, Hazaribag, Dhaka-1209	Job-Work	70	1500	0	0	0	3	8	3	14	5	
4	M/S Jasim Tannery	42, Monessware Road, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	4	2	8	4	Sole Leather from Cutting
5	M/S Muslim Tannery	30, Monessware Road, Hazaribag, Dhaka-1209	Job-Work	70	0	0	0	0	0	8	2	10	5	
6	M/S New Kajol Tannery	30/A, Monesware Road, Hazaribag, Dhaka-1209	Job-Work	40	0	0	0	1	0	6	3	10	6	
7	M/S Reliance Tannery Ltd.	48/2-Ka, Monessware Road, Hazaribagh, Dhaka-1209	Self	160	2000	0	0	8	16	69	13	106	9	
8	M/S Rupali Tannery	31, Monessware Road, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	0	0	0	0	0	
9	M/S Shahjada Tannery	29, Monessware Road, Hazaribag, Dhaka-1209	Job-Work	250	0	0	0	3	1	35	1	40	4	
Monessware Road Block Sub-Total (Self=3, Job-Work=5, Lay-off=1, Total=9)				**700**	**5000**	**0**	**0**	**13**	**25**	**170**	**29**	**237**	**49**	
Sher-e Bangla Road Block														
1	M/S Abul Khayer Tannery	121/5, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	60	0	0	0	1	12	20	3	36	8	

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
2	M/S Arafat Leather Complex Ltd.	6/1, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	60	0	0	0	0	0	8	3	11	5	
3	M/S Beraid Leather Complex	45/1, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	0	0	0	0	0	7	4	11	5	
4	M/S Chinese Tannery	Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	700	0	0	2	6	12	4	24	8	
5	M/S Chowdhury & Co.	Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	300	0	2	17	3	22	5	Sole Leather
6	M/S East Asia Tannery Ltd.	12/2, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	1000	0	200	1	30	100	4	135	30	
7	M/S Great Eastern Tannery Private Ltd.	48, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	300	1	2	20	12	35	8	Sole Leather
8	M/S Ibrahim Leathers	123/1, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	0	0	80	1	4	40	2	47	8	
9	M/S Iqbal Brothers	Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	300	0	1	10	2	13	5	Sole Leather
10	M/S Ismail Leather	121/4, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	300	0	0	10	2	12	5	Sole Leather
11	M/S Jakir Hossain Tannery	Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	300	0	0	10	2	12	5	Sole Leather
12	M/S Javed Tannery	119, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	0	0	0	2	3	17	3	25	6	
13	M/S Kalam & Leather	Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	100	0	0	10	2	12	5	Sole Leather
14	M/S M. B. Tannery	44, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	50	1000	0	0	3	4	38	16	61	8	

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
15	M/S M. I. Tannery	Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	0	0	0	220	0	0	10	2	12	5	Sole Leather
16	M/S M. S. Tannery	121/3, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	200	0	0	10	2	12	5	Sole Leather
17	M/S Paramount Tannery	50, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	2	0	0	2	0	
18	M/S Pubali Tannery	45, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	700	0	0	2	7	38	26	73	7	
19	M/S Saiful Leather	121/1, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	200	0	0	10	2	12	5	Sole Leather
20	M/S Sarwar Leather Corporation Ltd.	124, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	50	0	0	0	2	4	13	4	23	5	
21	M/S Shafiq Leather Corporation Ltd.	43/1, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	0	0	0	2	8	24	6	40	5	
22	M/S Shahjalal Tannery Ltd.	21, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	75	600	0	0	0	10	26	5	41	8	
23	M/S Supirior Leather/Kid Leather	19, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	1000	0	0	3	17	65	16	101	8	
24	M/S Tippara Tannery	49, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	4	50	3	57	10	Sole Leather from Cutting
25	M/S Yousuf Leather Corporation	124/2, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Job-Work	60	0	0	0	1	0	35	24	60	5	
26	M/S Zahir Tanning Industry	121/2, Sher-e Bangla Road, Hazaribag, Dhaka-1209	Self	0	0	0	200	0	0	10	2	12	5	Sole Leather
Sher-e Bangla Road Block Sub-Total (Self=12, Job-Work=13, Lay-off=1, Total=26)				**775**	**5000**	**0**	**2700**	**21**	**116**	**610**	**154**	**901**	**179**	

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
Mid Hazaribag Block														
1	M/S Al Madina Tannery Ltd.	109/3, Hazaribag, Dhaka-1209	Self	400	0	0	0	1	12	40	10	63	5	
2	M/S Anwar Tannery Ltd.	Hazaribag, Dhaka-1209	Self	400	0	0	0	2	10	40	12	64	8	
3	M/S Apex Tannery Ltd.	127, Hazaribag, Dhaka-1209	Self	5000	30000	0	0	18	300	700	100	1118	40	
4	M/S Asian Leather Complex	143/1, Hazaribag, Dhaka-1209	Self	400	0	0	0	1	3	55	12	71	8	
5	M/S Atik Leather Complex	54/2, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	0	0	0	0	0	
6	M/S B. L. I. Leather	Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	2	0	0	2	0	
7	M/S B. T. I. Tannery	94/1, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	20	2	24	5	Split Leather
8	M/S Bangla Tan Leather Products Ltd.	148/3, Hazaribag, Dhaka-1209	Job-Work	400	1500	0	0	0	22	44	13	79	10	
9	M/S Bay Tanneries Ltd.	21, Hazaribag, Dhaka-1209	Self	3000	10000	0	0	14	50	250	120	434	35	
10	M/S Bengal Leather Complex Ltd.	147, Hazaribag, Dhaka-1209	Self	600	0	0	0	4	20	200	20	244	10	Crust/Finished
11	M/S Bengal Tannery	Hazaribag, Dhaka-1209	Self	0	0	0	400	0	4	15	2	21	8	Sole Leather
12	M/S Capital Tannery	94, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	1	20	2	23	5	Split Leather
13	M/S Chandpur Tannery	Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	18	2	22	8	Split Leather
14	M/S Comilla Tannery	Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	1	24	5	30	10	Split Leather
15	M/S Crescent Tannery	Hazaribag, Dhaka-1209	Job-Work									0		
16	M/S Dhaka Nagar Tannery	Hazaribag, Dhaka-1209	Job-Work	400	0	0	0	0	2	30	2	34	8	
17	M/S Dhaka Tannery	Hazaribag, Dhaka-1209	Job-Work	400	1500	0	0	1	20	50	5	76	8	
18	M/S G. S. Leather Industries Ltd.	96/1-A, Hazaribag, Dhaka-1209	Self	0	1500	0	0	2	2	42	2	48	8	
19	M/S Green Arrow Tannery	Hazaribag, Dhaka-1209	Self	300	1500	0	0	2	5	25	4	36	8	
20	M/S Gulshan Tannery	Hazaribag, Dhaka-1209	Job-Work	300	0	0	0	2	2	48	18	70	10	
21	M/S H & H Tannery	Hazaribag,	Self	0	10000	10000	0	2	15	35	12	64	10	

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
		Dhaka-1209												
22	M/S Hitech Leather Complex	111, Hazaribag, Dhaka-1209	Job-Work	300	0	0	0	1	4	25	2	32	8	
23	M/S Ibrahim Tannery	Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	26	4	32	5	Split Leather
24	M/S J. A. Leather Complex	61, Hazaribag, Dhaka-1209	Job-Work	300	1500	0	0	1	2	30	8	41	8	
25	M/S Jamila Tannery Ltd.	112, Hazaribag, Dhaka-1209	Job-Work	300	1500	0	0	2	0	30	15	47	8	
26	M/S Kalam Brothers Tannery	109/2, Hazaribag, Dhaka-1209	Self	300	0	0	0	1	20	50	10	81	8	
27	M/S Kapil & Brothers	65/2-1, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	0	0	0	0	0	
28	M/S Karim Brothers Ltd.	180, Hazaribag, Dhaka-1209	Self	700	0	0	100	4	50	200	25	279	20	
29	M/S Kashem Tannery	Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	3	10	2	15	5	
30	M/S Khokon Tannery	136/4, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	20	2	24	3	Split Leather
31	M/S Lexco Tannery	146, Hazaribag, Dhaka-1209	Job-Work	300	1500	0	0	3	80	70	40	193	10	
32	M/S Lien Tannery	104/A, Hazaribag, Dhaka-1209	Self	200	1500	1200	20	3	0	45	7	55	10	
33	M/S Maizdi Tannery Ltd.	136/3, Hazaribag, Dhaka-1209	Job-Work	200	0	0	0	0	0	20	4	24	5	
34	M/S Mamun Tannery	Hazaribag, Dhaka-1209	Self	0	0	0	0	0	1	12	2	15	5	Split Leather
35	M/S Milon Tannery Ltd.	58, Hazaribag, Dhaka-1209	Job-Work	200	1500	0	0	0	10	20	5	35	8	
36	M/S Mukti Tannery	141, Hazaribag, Dhaka-1209	Self	300	0	0	0	2	0	40	12	54	10	
37	M/S Nabarun Tannery	56, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	15	2	19	7	Split Leather
38	M/S Nabipur Tannery	141/1, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	10	3	15	0	Split Leather
39	M/S Nazrul Leather & Co.	Hazaribag, Dhaka-1209	Self	0	0	0	200	0	2	12	2	16	5	Sole Leather
40	M/S Noakhali Tannery	107, Hazaribag, Dhaka-1209	Self	200	0	0	0	0	2	12	2	16	5	
41	M/S Olimpia Leather Complex	104, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	3	19	2	24	0	Head/Leg

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
42	M/S Overseas Tannery	Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	16	2	20	8	Split Leather
43	M/S Phoenix Leather Complex Ltd.	180/C, Hazaribag, Dhaka-1209	Job-Work	800	5000	0	0	2	100	150	20	272	25	
44	M/S Pragati Tannery Ltd.	109/1, Hazaribag, Dhaka-1209	Self	100	0	0	0	3	17	15	16	51	8	
45	M/S R. K. Leather Complex	135/A, Hazaribag, Dhaka-1209	Job-Work	100	0	0	0	0	2	15	2	19	5	
46	M/S R.M.M International	Hazaribag, Dhaka-1209	Self	600	0	0	0	7	25	47	22	101	12	
47	M/S Rana Leather Complex	132, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	2	0	3	5	0	
48	M/S Royel Tannery	Hazaribag, Dhaka-1209	Job-Work	200	0	0	0	2	5	20	5	32	8	
49	M/S Ruma Leather Industries Ltd.	131, Hazaribag, Dhaka-1209	Self	300	7200	0	0	4	25	60	40	129	10	
50	M/S Samata Leather Complex, Unit-1	120, Hazaribag, Dhaka-1209	Self	600	0	0	0	2	0	22	13	37	8	
51	M/S Sonali Tannery	Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	0	15	2	17	5	Split Leather
52	M/S Swadesh Tannery	Hazaribag, Dhaka-1209	Job-Work	200	0	0	0	0	2	10	2	14	5	
53	M/S Swadheen Tannery	101, Hazaribag, Dhaka-1209	Job-Work	0	1500	0	0	1	5	20	4	30	8	
54	M/S T. M. H. Leather Exports	136/2, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	2	0	1	3	0	
55	M/S United Leather International	136/A, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	1	15	1	17	3	Split Leather
56	M/S Vulua Tannery Ltd.	109, Hazaribag, Dhaka-1209	Self	400	0	0	0	3	25	75	25	128	10	
57	M/S Yousuf Tannery Ltd.	135/2, Hazaribag, Dhaka-1209	Job-Work	220	0	0	0	1	4	15	3	23	5	
Mid Hazaribag Block Sub-Total (Self=22, Job-Work=30, Lay-off=5, Total=57)				**18420**	**77200**	**11200**	**720**	**91**	**877**	**2817**	**653**	**4438**	**454**	
Sonatan Gar/Gojmohal Block														
1	M/S Amin Tannery Ltd.	Hazaribag, Dhaka-1209	Self	1200	0	0	0	2	4	60	20	86	8	
2	M/S Anjuman Tannery	72/A, Gojmohal, Hazaribag, Dhaka-1209	Job-Work	0	1500	0	0	0	2	13	4	19	8	

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
3	M/S Arab Tannery Private Ltd.	75/A, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	0	0	0	0	0	
4	M/S Asia Tannery	Hazaribag, Dhaka-1209	Job-Work	150	1500	0	0	2	2	35	18	57	8	
5	M/S Bhuyian Tannery	68/1, Hazaribag, Dhaka-1209	Job-Work	150	0	0	0	0	3	12	3	18	3	
6	M/S Chowdhury & Co. Ltd.	95/7, Gojmohal, Hazaribag, Dhaka-1209	Self	1200	6000	0	0	4	10	250	20	284	25	
7	M/S F. K. Leather Complex Ltd.	25/6/A, Gojmohal, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	2	10	20	5	37	5	Crust/Finished
8	M/S Golden Tannery Complex	Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	0	0	0	0	0	
9	M/S Helal Tannery	74, Hazaribag, Dhaka-1209	Job-Work	150	0	0	0	1	0	8	2	11	5	
10	M/S Hossen Brothers Tannery	68/2, Hazaribag, Dhaka-1209	Job-Work	150	0	0	0	0	0	8	3	11	5	
11	M/S International Tannery	Hazaribag, Dhaka-1209	Job-Work	150	0	0	0	0	0	13	4	17	5	
12	M/S Laki Tannery	Hazaribag, Dhaka-1209	Job-Work	150	0	0	0	1	0	9	4	14	5	
13	M/S Luna Tannery	66, Hazaribag, Dhaka-1209	Lay-off	0	0	0	0	0	0	0	0	0	0	
14	M/S Mamataz Tannery	Hazaribag, Dhaka-1209	Job-Work	150	0	0	0	0	1	5	1	7	3	
15	M/S Metro Tannery	67/2, Hazaribag, Dhaka-1209	Job-Work	0	0	0		0	0	15	3	18	3	Sole Leather from Cutting
16	M/S Mijan-Sumon Tannery	89/1, Hazaribag, Dhaka-1209	Job-Work	500	0	0	0	2	7	46	13	68	13	
17	M/S Mitali Tannery Ltd.	71/4-A, Gojmohal, Hazaribag, Dhaka-1209	Self	500	0	0	0	1	20	40	10	71	17	
18	M/S Murshid Brothers	Hazaribag, Dhaka-1209	Job-Work	200	0	0	0	0	0	8	2	10	5	
19	M/S Nishat Tannery	Gojmahal, Hazaribag, Dhaka-1209	Job-Work	0	1000	0	0	0	4	10	2	16	3	
20	M/S Rajib Leather Complex Ltd.	95/4, Gojmahal, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	1	10	16	3	30	3	Split Leather
21	M/S S. & S. Tannery	86/1, Hazaribag,	Job-Work	200	0	0	0	0	0	15	4	19	5	

Continued

Sl. No.	Name of the Tannery	Address	Production Type	Raw Consumption (Piece/Day)				Employee Status						Remarks
				Cow	Goat	Sheep	Buffalo	Tech.	Prm. Labour	Tem. Labour	Off. Stuff	Total	Trimmer	
		Dhaka-1209												
22	M/S Salma Tannery	83/1, Hazaribag, Dhaka-1209	Self	500	0	0	0	3	0	15	4	22	5	
23	M/S Shaheen Tannery	Hazaribag, Dhaka-1209	Job-Work	200	0	0		0	2	8	1	11	5	Sole Leather from Cutting
24	M/S T. Ahmad Tannery	89/2, Hazaribag, Dhaka-1209	Job-Work	0	0	0		0	2	10	2	14	3	Sole Leather from Cutting
25	M/S Zindabad Tannery	89/4, Hazaribag, Dhaka-1209	Job-Work	200	0	0	0	0	1	7	1	9	3	
Sonatan Gar/Gojmohal Block Sub-Total (Self=4, Job-Work=18, Lay-off=3, Total=25)				**5750**	**10000**	**0**	**0**	**19**	**78**	**623**	**129**	**849**	**145**	
Kalu Nagar Block														
1	M/S Dhaka Hides and Skins Ltd.	36, Kalunagar, Hazaribag, Dhaka-1209	Self	3500	10000	0	0	9	72	500	60	641	30	
2	M/S Fancy Leather Enterprise	34, Kalunagar, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	13	2	17	0	Head/Leg
3	M/S Pakunda Tannery	Kalunagar, Hazaribag, Dhaka-1209	Job-Work	0	0	0	0	0	2	35	5	42	0	Head/Leg
4	M/S Samata Leather Complex, Unit-2	Kalunagar, Hazaribag, Dhaka-1209	Job-Work	500	0	0	0	0	10	25	8	43	8	
5	M/S Samina Tannery	36/1, Kalunagar, Hazaribag, Dhaka-1209	Self	2000	0	0	0	4	30	70	26	130	17	
Kalu Nagar Block Sub-Total (Self=2, Job-Work=3, Lay-ff=0, Total=5)				**6000**	**10000**	**0**	**0**	**13**	**116**	**643**	**101**	**873**	**55**	
Grand Total (Self=43, Job-Work=69, Lay-off=10, Total=122)				**31645**	**107200**	**11200**	**3420**	**157**	**1212**	**4863**	**1066**	**7298**	**882**	

Appendix – 3: Export earning of leather sector in Bangladesh (value in Million US$) in 1998-2011 (**Source:* EPB, Dhaka Office.)

Year	Leather	Footwear	Leather Products	Total
1998-1999	168.25	46.55	4.59	**219.39**
1999-2000	195.05	48.26	3.58	**246.89**
2000-2001	253.93	33.63	3.12	**290.68**
2001-2002	207.33	41.29	3.87	**252.49**
2002-2003	191.23	35.06	3.43	**229.72**
2003-2004	211.41	50.86	3.64	**265.91**
2004-2005	220.93	59.51	7.35	**287.79**
2005-2006	257.27	60.78	7.18	**325.23**
2006-2007	266.08	98.39	11.03	**375.50**
2007-2008	284.41	125.02	9.03	**418.46**
2008-2009	177.32	142.26	17.61	**337.19**
2009-2010	226.10	146.47	29.07	**401.64**
2010-2011	297.83	199.39	55.42	**552.64**
Total	**2957.14**	**1087.47**	**158.92**	**4203.53**

Appendix – 4: Total contribution of the tannery, footwear and leather products industry (leather sector) of Bangladesh in 1998-2011

Types of Industry	Amount (in million US$)	%
Tannery	2957.14	70%
Footwear Industry	1087.47	26%
Leather Products Industry	158.92	4%
Total	4203.53	100%

Appendix – 5: Country wise Export earning from Leather sector of Bangladesh in 2010-2011 (*Source:* EPB, Dhaka Office)

Sl. No.	Name of the Country	Export Earning (US $)			
		Tannery	Footwear	Leather Products	Total
Grand Total		**297,826,056.87**	**199,388,739.00**	**55,397,660.93**	**552,612,456.80**
1	Argentina	-	48,968.00	-	-
2	Australia	227,490.46	64,421.00	62,339.42	354,250.88
3	Austria	-	4,490,044.00	21,265.43	4,511,309.43
4	Bahrain	-	881.00	-	-
5	Belgium	-	6,198,268.00	18,994.65	-
6	Bosnia & Herzegovina	-	209,086.00	-	-
7	Brazil	-	4,711.00	-	-
8	Bulgaria	-	14,615.00	-	-
9	Cambodia	1,069,163.58	-	-	1,069,163.58
10	Canada	4,673.04	3,676,447.00	34,302.71	3,715,422.75
11	Chili	-	15,063.00	-	-
12	China	13,647,579.85	1,719,442.00	3,175,027.34	18,542,049.19
13	Colombia	-	21,124.00	-	-
14	Croatia	-	23,596.00	-	-
15	Czech Republic	38,191.60	2,246,946.00	2,457.74	2,287,595.34
16	Denmark	-	95,712.00	-	-
17	Estonia	-	343,524.00	-	-
18	Fiji	-	70,121.00	-	-
19	Finland	-	749,508.00	-	-
20	France	466,327.62	14,584,615.00	76,321.21	15,127,263.83
21	Germany	3,189,047.64	28,365,778.00	8,253,425.41	39,808,251.05
22	Greece	41,094.37	707,936.00	-	749,030.37
23	Hong Kong	116,997,409.29	1,380,047.00	27,008,653.06	145,386,109.35
24	Hungary	-	954.00	-	-
25	India	9,631,491.87	5,038.00	29,059.23	9,665,589.10
26	Indonesia	332,876.91	-	-	332,876.91
27	Iran Islamic Republic of	41,639.50	-	-	41,639.50
28	Ireland	-	157,750.00	-	-
29	Italy	38,672,913.73	19,449,768.00	8,388,400.37	66,511,082.10
30	Japan	18,111,625.72	72,425,975.00	5,375,752.09	95,913,352.81
31	Kenya	-	54,805.00	-	-
32	Korea Republic of	54,632,247.65	4,130,615.00	68,061.40	58,830,924.05
33	Kuwait	3,181.95	-	-	3,181.95
34	Lebanon	19,750.54	-	-	19,750.54

Continued

Sl. No.	Name of the Country	Export Earning (US $)			
		Tannery	Footwear	Leather Products	Total
35	Malaysia	12,451.96	21,192.00	19,843.57	53,487.53
36	Mexico	516,761.64	147,599.00	-	664,360.64
37	Morocco	-	5,840.00	-	-
38	Myanmar	85,368.56	-	-	85,368.56
39	Netherlands	699.26	8,153,422.00	9,381.70	8,163,502.96
40	Newzealand	-	-	9,072.57	-
41	Norway	42,510.96	406,638.00	3,258.54	452,407.50
42	Pakistan	40,242.82	1,010.00	-	41,252.82
43	Panama	-	178,503.00	-	-
44	Papua New Guinea	-	2,280.00	-	-
45	Philippines	764,585.16	-	-	764,585.16
46	Poland	1,286,068.28	-	-	1,286,068.28
47	Portugal	58,403.38	23,196.00	1,031.90	82,631.28
48	Romania	7,802.00	112,435.00	-	120,237.00
49	Russian Federation	-	173,787.00	511.64	-
50	Saint Barthelemy	3,459,510.60	-	1,164,762.95	4,624,273.55
51	Saudi Arabia	-	687,316.00	249,458.37	
52	Singapore	287,858.56	4,567.00	786,001.24	1,078,426.80
53	Slovakia	-	391,290.00	-	-
54	Slovenia	-	844,472.00	-	-
55	South Africa	144,162.42	100,518.00	1,790.68	246,471.10
56	Spain	14,044,978.19	4,137,134.00	-	18,182,112.19
57	Sri Lanka	40,263.88	23,674.00	-	63,937.88
58	Swaziland	-	16,564.00	-	-
59	Sweden	-	1,260,741.00	98,459.65	-
60	Switzerland	-	4,418,797.00	20,649.30	-
61	Taiwan	7,981,634.74	233,624.00	52,416.70	8,267,675.44
62	Thailand	435,847.36	-	-	435,847.36
63	Togo	15,857.44	-	-	15,857.44
64	Turkey	2,007,152.85	719,295.00	-	2,726,447.85
65	Uganda	-	29,573.00	-	-
66	Ukraine	-	309,715.00	-	-
67	United Arab Emirates	6,857.68	227,983.00	11,408.29	246,248.97
68	United Kingdom	1,595,893.82	5,926,783.00	209,650.39	7,732,327.21
69	United States	231,000.47	8,848,036.00	245,903.38	9,324,939.85
70	Vietnam	7,332,153.24	-	-	7,332,153.24
71	Zambia	-	222,405.00	-	-
72	Others	301286.28	504,592.00	-	805,878.28

Appendix – 6: Age distribution of Trimmers working in Tannery at Hazaribagh, Dhaka

Age Group (Year)	Trimmer (No.)	%
Below 18	158	18%
19 - 30	291	33%
31 - 40	194	22%
41 - 50	143	16%
51 - 60	70	8%
Above 60	26	3%
Total	**882**	**100%**

Appendix – 7: Educational Qualification of Trimmers working in Tannery at Hazaribagh, Dhaka

Education Level	Trimmer	%
No Education	88	10%
Informal Education	267	30%
Primary Level	397	45%
JSC Level	102	12%
SSC Level	28	3%
Total	**882**	**100%**

Appendix – 8: Status of Monthly Income of Trimmers working in Tannery at Hazaribagh, Dhaka

Monthly Income (BDT)	Trimmer	%
Below 3000	158	18%
3001 - 5000	358	41%
5001 - 7000	249	28%
7001 - 9000	82	9%
Above 9000	35	4%
Total	**882**	**100%**

Appendix – 9: Status of Job Experience as Trimmers working in Tannery at Hazaribagh, Dhaka

Length of Job (Years)	Trimmer	%
1 – 5	192	22%
6 – 10	337	38%
11 – 15	184	21%
16 – 20	143	16%
Above 20	26	3%
Total	**882**	**100%**

Appendix – 10: Health Status of Trimmers working in Tannery at Hazaribagh, Dhaka

Sl. No.	Diseases	Number of Trimmer Affected	%
1.	General Illness	794	90%
2.	Gastric	529	60%
3.	Skin Diseases	265	30%
4.	Fever/Rheumatic Fever	150	17%
5.	Common Cold	132	15%
6.	Hypertension	106	12%
7.	Asthma	26	3%
8.	Dysentery	26	3%

Appendix – 11: Fund Status of Tanneries at Hazaribagh, Dhaka

Fund	No. of tanneries	%
Owner's Equity	10	9%
Loan	20	18%
Both	72	64%
Others	10	9%
Total	112	100%

Appendix – 12: Different categories of solid wastes generated from the tannery in a day in peak season, 2011 at Hazaribagh, Dhaka and its status

Types of Solid Wastes	Amount (MT/Day)
Raw Trimmings	272
Fleshings	158
Others	13
Total	443

Appendix-13: List of Footwear and Leather Products Industries in Bangladesh, 2011

Sl. No.	Name	Address
1.	M/s. Apex Adelchi Footwear Ltd.	House No. 6, Road No. 137, Block No. SE (D), Gulshan – 1, Dhaka, Bangladesh.
2.	M/s. Jennys Shoes Ltd.	Jennys House, House No. 6, Road No. 68/A, Gulshan – 2, Dhaka - 1212, Bangladesh.
3.	M/s. Lalmai Footwear Ltd.	Khan Mansion (5th Floor), 107, Motijheel C/A,Dhaka – 1000, Bangladesh.
4.	M/s. Legacy Footwear Ltd.	Robin Tower (5th Floor), 42/43, Purana Paltan,Dhaka - 1000, Bangladesh.
5.	M/s. Landmark Footwear Ltd.	"Twin Rose", House No. 407/8, (3rd Floor), Road No. 7, DOHS, Baridhara, Dhaka, Bangladesh.
6.	M/s. Suman Leather and Footwear Ltd.	Chattagram Bhaban (7th Floor), 32, Topkhana Road, Dhaka-1000, Bangladesh.
7.	M/s. Bay Footwear Ltd.	House No. 105 (2nd Floor), Road No. 4, Block No. B, Banani – 1213, Dhaka, Bangladesh.
8.	M/s. Tropical Shoes Industries Ltd.	A.R. Tower (3rd Floor), 24, Kamal Ataturk Avenue, Banani, Dhaka, Bangladesh.
9.	M/s. H.N. Shoes Ltd.	House No. 69, Road No. 8/A, Dhanmondi R/A, Dhaka, Bangladesh.
10.	M/s. Leatherex Footwear Industries Ltd.	House No. 34/A, Road No. 10/A, Dhanmondi R/A, Dhaka, Bangladesh.
11.	M/s. Cosmic Jute & Leather Industries Ltd.	Easel Dream, Flat No. M-3, House No. 17, Road No. 3-A, Sector No. 5, Uttara, Dhaka, Bangladesh.
12.	M/s. Advance Industrial Management Co. Ltd.	112/169, North Gazirchat, Dhansona Union, Baipal, Savar, Dhaka-1344, Bangladesh.
13.	M/s. Savar Industries (Pvt) Ltd.	Akij Chamber (7th Floor), Head Office: 73, Dilkusha C/A, Dhaka-1000, Bangladesh.
14.	M/s. Malim (BD) Co. Ltd.	34, Choidana, P.O. National University, Gazipur, Bangladesh.
15.	M/s. Shampan Shoes Ltd.	Plot No. B-54-55, BSCIC I/A, Kanchpur, Sonargaon, Narayangong, Bangladesh.
16.	M/s. Vannara Corporation Ltd.	Robin Tower (5th Floor), 42/43, Purana Palton,Dhaka-1000, Bangladesh.
17.	M/s. Five-R-Footwear Ltd.	Jennys House, House No. 6, Road No. 68/A, Gulshan – 2, Dhaka-1212, Bangladesh.
18.	M/s. Adelchi Footwear Bangladesh Ltd.	House No. 6, Road No. 137, Block No. SE (D), Gulshan – 1, Dhaka, Bangladesh.
19.	M/s. F.B. Footwear Ltd.	House No. 6, Road No. 109, Level NO. 2, Suite No. B-3, Gulshan – 2, Dhaka, Bangladesh.
20.	M/s. Rimex Footwear Ltd.	House No. 28 (1st Floor), Road No. 11, Block No. Kha, P.C. Culture Housing Society Ltd., Sekhertak, Mohammadpur, Dhaka-1217, Bangladesh.
21.	M/s. Bata Shoes Co. (BD) Ltd.	Tongi, Gazipur, Bangladesh.
22.	M/s. Megumi Footwear Ltd.	House No. 6, Road No. 3, Sector No. 10, UttaraModelTown, Dhaka-1230, Bangladesh.
23.	M/s. A B C Footwear Industries Ltd.	House No. 50/1 (1st Floor), Road No. 11/A, Dhanmondi, Dhaka-1209, Bangladesh.
24.	M/s. M.A.M.C.	11, Bangshal Lane (4th Floor), Dhaka-1100, Bangladesh.
25.	M/s. Bani Footex	255, North Badda, Satarkul Road, Dhaka-1216, Bangladesh.
26.	M/s. Rexus Leather Club.	3/20, Karnafully City Garden, Kakrail, Dhaka, Bangladesh.

Continued

27.	M/s. Hara Leather Products.	House No. 105, Road No. 5, Block No. A, Mirpur – 12, Bangladesh.
28.	M/s. Creative Products Enterprise	49, Motijheel C/A, 4th Floor, Room No. 507, Dhaka-1000, Bangladesh.
29.	M/s. Pathik Footwear.	House No. 190, Road No. 02, DOHS Baridhara (4th Floor), Dhaka-1206, Bangladesh.
30.	M/s. Taurus Footwear & Craft Industries Ltd.	Shilpi Bhaban, 27/Ka, Zigatala, Tannery Block, Hazaribagh, Dhaka-1209, Bangladesh.
31.	M/s. Akij Footwear Ltd.	Akij Chamber (7th Floor), 73, Dilkusha C/A, Dhaka-1000, Bangladesh.
32.	M/s. Nur-Al Footwear Industries Ltd.	655, Sadar Hospital Road, Feni, Bangladesh.
33.	M/s. MAF Shoes Ltd.	83, Khatungonj, Chittagong, Bangladesh.
34.	M/s. Firoz Sons and Co.	Gung Chor, Tana Road, P.S. Kotwali, P.O. Comilla, Bangladesh.
35.	M/s. Iqra Trade International	21/1, Haque Mansion, Zigatola, Dhaka-1209, Bangladesh.
36.	M/s. Modina Shoe Industries Ltd.	27, Dilkusha C/A, 11th Floor, Dhaka-1000, Bangladesh.
37.	M/s. Bay Footwear Ltd (Unit-2).	House No. 105 (2nd Floor), Road No. 4, Block No. B, Banani – 1213, Dhaka, Bangladesh.
38.	M/s. Earth Footwear Ltd.	House No. 38 B, Flat No. 2 B, Road No. 42, Gulshan – 2, Dhaka, Bangladesh.
39.	M/s. Bengal Shoe Industries Ltd.	147/1, Hazaribagh, Dhaka-1209, Bangladesh.
40.	M/s. Ha-Mim Footwear Ltd.	23, Nasa Bhaban, Faidabad, Faidabad Madrasha, Dakkhinkhan, Uttara, Dhaka-1230, Bangladesh.
41.	M/s. Footbed Footwear Ltd.	Flat No. B 3, Level No. 2, House No. 06, Road No. 109, Block No. CEN (H), Gulshan–2, Dhaka, Bangladesh.
42.	M/s. B.W. International Footwear Ltd.	House No. 06, Road No. 109, Flat No. B-3, Level No. 02, Gulshan – 2, Dhaka-1212, Bangladesh.
43.	M/s. B.B. Export Ltd.	70-77 Tongi I/A, Tongi, Gazipur, Bangladesh.
44.	M/s. Blue Ocean Footwear Ltd.	House No. 06, Road No. 137, Block No. SE (D), Gulshan – 1, Dhaka-1212, Bangladesh.
45.	M/s. Step Shoe-Last & Accessories Co. Ltd.	House No. 01, Road No. 15, Sector No. 01, Uttara, Dhaka, Bangladesh.
46.	M/s. Raj-Kamal Corporation Ltd.	Head Office: 1077, Malibagh Chowdhury Para, Dhaka, Bangladesh.
47.	M/s. Scarpe E Moda Ltd.	Plot No. 77 (2nd Floor), Dewan Iddris Road, Durgapur, Kathgora Bazar, Ashulia, Savar, Dhaka, Bangladesh.

*Source: Hossain, A., 2011, Market Opportunities and Development of Finished Leather in Bangladesh: A Case Study of Bay Footwear Limited, *CEMBA Dissertation*, Bangladesh Open University, Bangladesh, 132p.

Appendix-14: Comparative statement of Status of tanneries in Bangladesh (UNIDO Survey Report'2006)

Location	2003		2006	
	Total	Operational	Total	Operational
Hazaribag	194	105	192	35
Savar/Dhamri	3	1	3	2
Kaliakour	1	1	1	-
Noapara, Jessore	1	1	1	1
Jamalpur	1	-	1	-
Rangpur	1	-	1	-
Khulna	1	-	1	-
Chittagong	18	5	6	2
Total	**220**	**113**	**206**	**40**

Appendix-15: Installed Production Capacity of tanneries in Bangladesh (UNIDO Survey Report'2006)

No. of tanneries (Year'2006)	Total installed capacity	Total actual production	Average Installed Capacity
	Million sq.ft./year		Sq.ft./Year/Unit
142	80	48	5,60,000
42	70	50	16,70,000
15	60	52	40,00,000
7	40	30	60,00,000
Total = 206	**250**	**180**	-

Appendix-16: Animal population and production of hides & skins in Bangladesh (Livestock Census, 2004 & Hides & Skins Merchants Association, 2005)

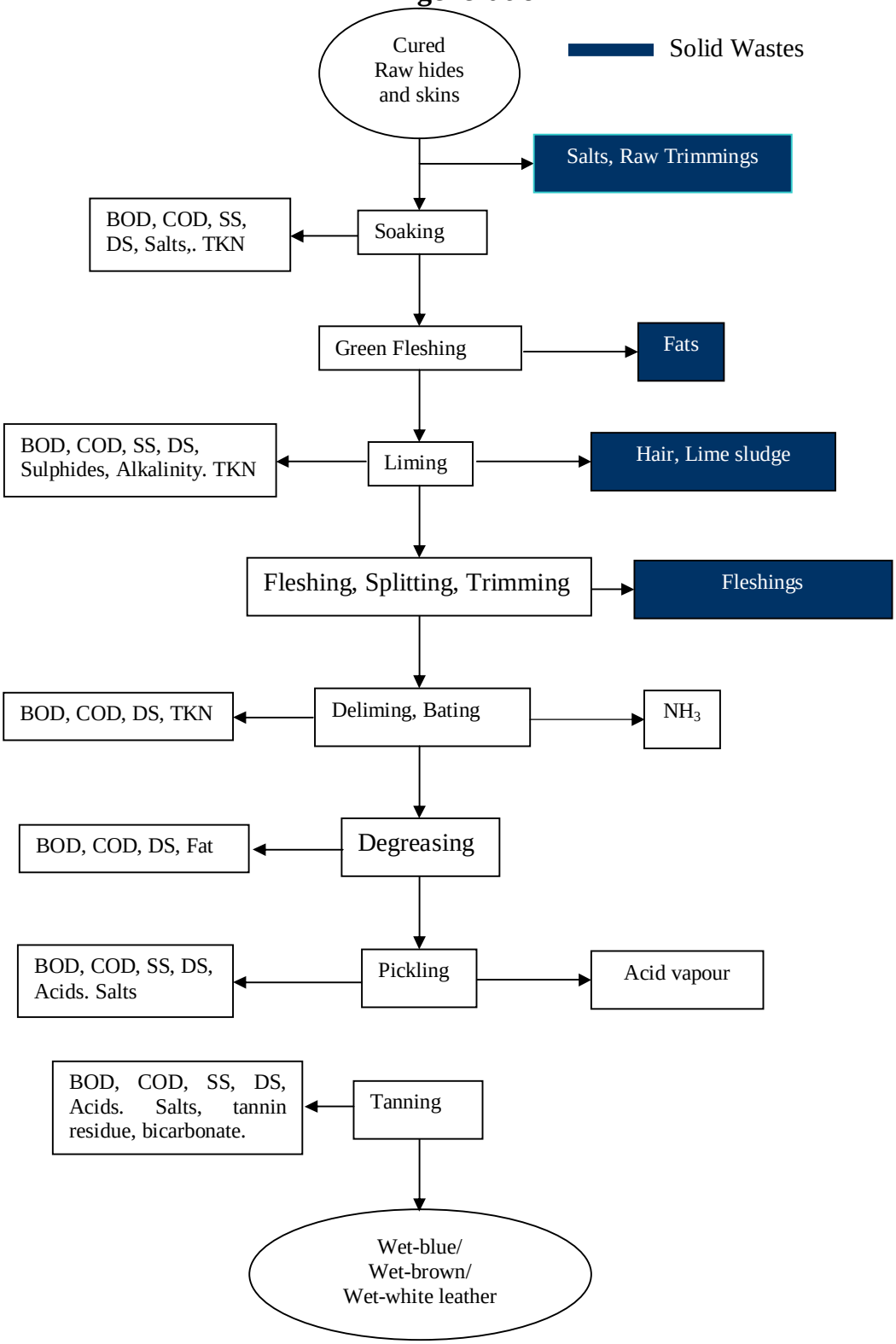
Category	No. of animals	Hides & Skins productions	Average weight	Total annual production	Average area
	Million heads	Million pieces	Kg/piece	Tonnes	Sq.ft./piece
Cow	24.31	4.00	12-15	48,000	20-22
Buffalo	0.85	0.50	20-25	11,000	32-35
Goat and Sheep	32.70	15.00	1.5-2.0	26,000	1.00-3.75

Appendix-17: Manpower involvement of tanneries in Bangladesh

(*Source*: BSCIC Survey Report, 2002)

Category	No. of People
Management	1540
Skilled Technologists	360
Skilled Labour	2740
General Labour	19,900
Traders	2460
Total	**27,000**

Appendix-18: Schematic view of leather processing and solid wastes generation



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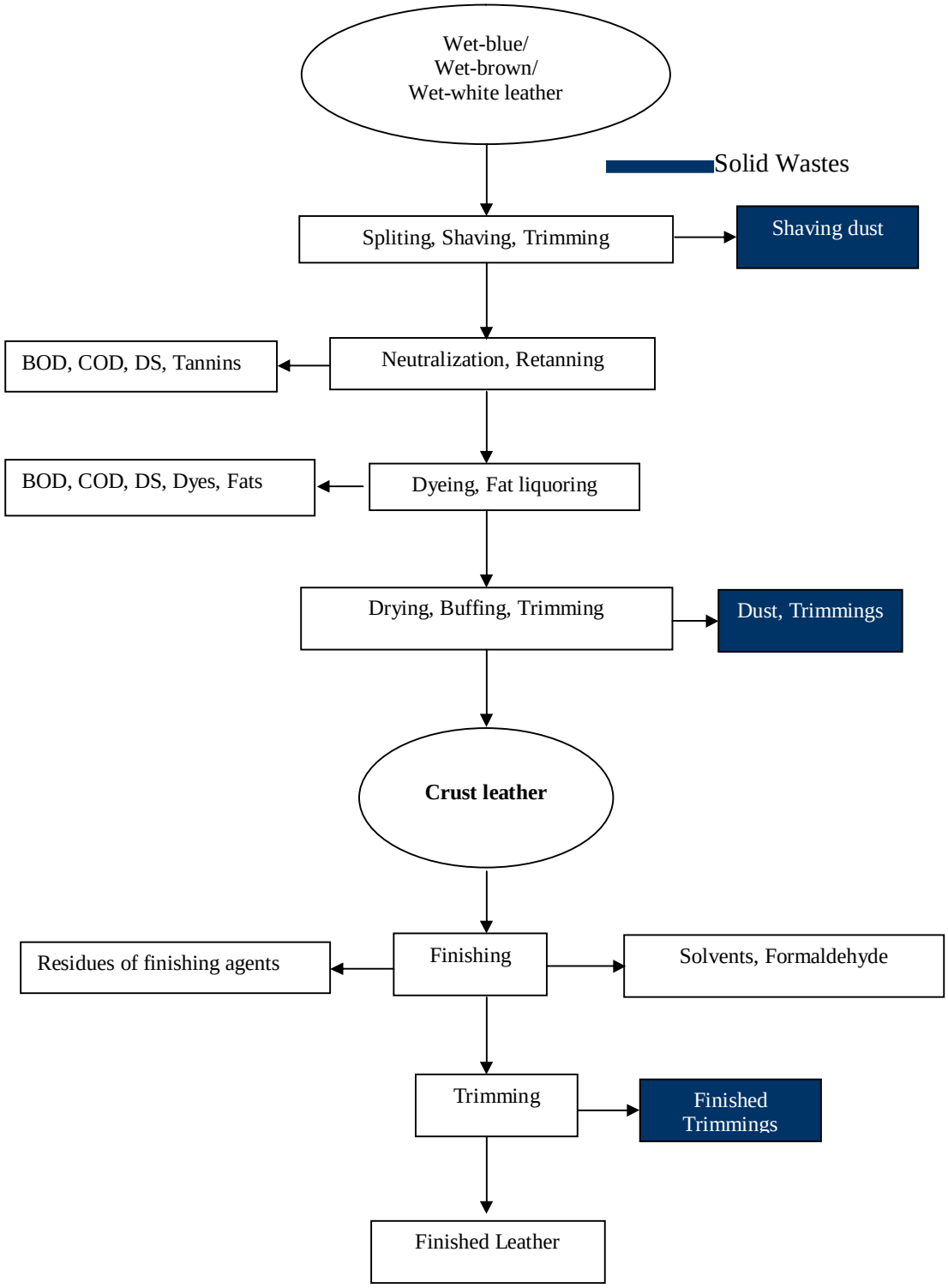
Wet-blue/
Wet-brown/
Wet-white leather
Solid Wastes
Spliting, Shaving, Trimming
Shaving dust
BOD, COD, DS, Tannins
Neutralization, Retanning
BOD, COD, DS, Dyes, Fats
Dyeing, Fat liquoring
Drying, Buffing, Trimming
Dust, Trimmings
Crust leather
Residues of finishing agents
Finishing
Solvents, Formaldehyde
Trimming
Finished Trimmings
Finished Leather

Appendix-19: The estimated values of Chemical parameters of Soil at Hazaribagh, Dhaka in the year 2011

Parameters	Name of the Station / Sample	Beribandh (S-1)	Kalunagar (S-2)	Company Ghat (S-3)	Rayer Bazar (S-4)	Gojmohol (S-5)
pH	Sample-1	8.14	7.91	4.17	6.90	6.79
	Sample-2	7.98	7.71	3.97	6.23	6.67
	Sample-3	7.91	7.89	4.00	6.42	6.38
	Sample-4	7.59	7.10	3.90	6.68	6.51
	Sample-5	7.67	7.36	4.38	6.43	6.47
Organic Matter (%)	Sample-1	13.25	4.20	6.16	5.47	5.83
	Sample-2	13.80	4.19	6.17	5.47	5.52
	Sample-3	13.87	4.30	6.19	5.42	5.43
	Sample-4	13.60	4.37	6.17	5.30	5.21
	Sample-5	14.00	4.29	6.19	5.42	5.10
Nitrogen (%)	Sample-1	1.30	0.38	0.19	0.20	0.33
	Sample-2	1.60	0.31	0.21	0.31	0.35
	Sample-3	1.54	0.37	0.19	0.17	0.39
	Sample-4	1.59	0.31	0.20	0.20	0.40
	Sample-5	1.65	0.30	0.26	0.26	0.30
Chloride (%)	Sample-1	0.291	0.035	0.0029	0.0091	0.013
	Sample-2	0.213	0.033	0.0037	0.0089	0.013
	Sample-3	0.251	0.037	0.0031	0,0093	0.010
	Sample-4	0.240	0.034	0.0030	0.0097	0.014
	Sample-5	0.238	0.031	0.0029	0.0087	0.011
Organic Carbon (%)	Sample-1	7.70	2.44	3.58	3.18	3.39
	Sample-2	8.02	2.44	3.59	3.18	3.21
	Sample-3	8.06	2.50	3.60	3.15	3.16
	Sample-4	7.91	2.54	3.59	3.08	3.03
	Sample-5	8.14	2.49	3.60	3.15	2.97
Chromium (%)	Sample-1	2.31	0.162	0.0029	0.337	0.114
	Sample-2	2.30	0.190	0.0027	0.340	0.098
	Sample-3	2.26	0.165	0.0021	0.369	0.117
	Sample-4	2.29	0.192	0.0021	0.355	0.096
	Sample-5	2.24	0.155	0.0023	0.371	0.133

Appendix-20: The estimated average (Mean ± SD) values of Chemical parameters of Soil at Hazaribagh, Dhaka in the year 2011

Parameter	St. No.	Sample Frequency	Minimum	Maximum	Mean	Std. Deviation
pH	S-1	5	7.5900	8.1400	7.8580	0.225986725
	S-2	5	7.1000	7.9100	7.5940	0.353454382
	S-3	5	3.9000	4.3800	4.0840	0.192950771
	S-4	5	6.2300	6.9000	6.5320	0.260518713
	S-5	5	6.3800	6.7900	6.5640	0.164255898
Organic Carbon (%)	S-1	5	7.7000	8.1400	7.9660	0.170235132
	S-2	5	2.4400	2.5400	2.4820	0.042661458
	S-3	5	3.5800	3.6000	3.5920	0.008366600
	S-4	5	3.0800	3.1800	3.1480	0.040865633
	S-5	5	2.9700	3.3900	3.1520	0.164377614
Organic Matter (%)	S-1	5	13.2500	14.0000	13.7040	0.292112992
	S-2	5	4.1900	4.3700	4.2700	0.075166482
	S-3	5	6.1600	6.1900	6.1760	0.013416408
	S-4	5	5.3000	5.4700	5.4160	0.069498201
	S-5	5	5.1000	5.8300	5.4180	0.284903492
Nitrogen (%)	S-1	5	1.3000	1.6500	1.5360	0.137586337
	S-2	5	0.3000	0.3800	0.3340	0.037815341
	S-3	5	0.1900	0.2600	0.2100	0.029154759
	S-4	5	0.1700	0.3100	0.2280	0.056302753
	S-5	5	0.3000	0.4000	0.3540	0.041593269
Chloride (%)	S-1	5	0.2130	0.2910	0.2466	0.028448199
	S-2	5	0.0310	0.0370	0.0340	0.002236068
	S-3	5	0.0029	0.0037	0.0031	0.000334664
	S-4	5	0.0087	0.0097	0.0091	0.000432049
	S-5	5	0.0100	0.0140	0.0122	0.001643168
Chromium (%)	S-1	5	2.2400	2.3100	2.2800	0.029154759
	S-2	5	0.1550	0.1920	0.1728	0.017020576
	S-3	5	0.0021	0.0029	0.0024	0.000363318
	S-4	5	0.3370	0.3710	0.3544	0.015805062
	S-5	5	0.0960	0.1330	0.1116	0.015175638