REPORT
On
Preparation of Cleaner production Potentials
Sector-wise

Submitted to:
Ministry of Industry
Singha Durbar, Kathmandu

Submitted by:

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1. Background

Environment is a matter of concern to everybody now a day. The awareness on environmental aspects is rising at a faster pace also in Nepal. There are some proven tools to be applied in the organizations which will not only contribute to benefit the environment but also support in saving of valuable resources to enhance the profit margins. One of such tools and very popular environmental as well as business friendly tool to practice in any organization is Cleaner Production (CP). Ministry of Industry (MOI) is encouraging the Nepalese industries to adopt CP concepts in their industries since more than a decade. In this connection MOI intends to carry out a study on potential of CP in the Nepalese industries especially in the nine standard affected industrial sectors based on the finding of CP assessment carried out in the industries through MOI in the past.

A total of 332 industrial enterprises in various sectors located at different places in the country were supported with CP activities under the Danish Government assisted Environment Sector Programme Support (ESPS) and MOI as implementing agency during 2000 to 2005. Similarly, after the suspension of ESPS in 2005, MOI continued the support in the implementation of CP in some selected industries situated at different locations through its annual programme. MOI has also prepared manuals and directives on CP so that interested industries are able to implement CP in their units.

With a view to assist in this process further, MOI desires to prepare a report containing CP potentials for a number of sectors of Industries. MOI has the intention of making available such report to the interested industries through its website. This report has been prepared by PACE Nepal Pvt. Ltd. as per the agreement between MOI and PACE Nepal Pvt. Ltd. in connection with the carrying out the study on CP potential in the standard affected industrial sectors in Nepal by the later.

2. Objective of the study

The objective of hiring the services of the consultant is to prepare a report on the CP Potentials sector-wise, such that the information will be of use for the industries interested to implement CP in their units.

3. Output

The output from the services will be a report containing data and information on the CP Potentials by the sector based on the CP reports prepared during the ESPS and after ESPS.

4. Scope of the work

The scope of the work will be as follows:

1. Collection of CP Reports from ESPS and after ESPS under MOI
2. Collection of relevant literatures and Publications

3. Study of the CP Reports
4. Literature Study and Internet search
5. Preparation of the Draft Report for nine standard affected sectors of industries (for which MOEST has already gazette effluent standards) with the following contents
   a) Brief description of the sector in Nepalese Context
   b) Process flow chart and brief process description
   c) Inputs of Materials and Energy
   d) Waste Generation Scenario
   e) Potential no cost low cost CP Options
   f) Potential cost demanding options, rough estimate of investment required and payback period
   g) Productivity indicators and specific consumptions
   h) Overall potential monetary benefits and benefits in terms of reduction in solid, liquid and gaseous emissions

6. Submission of the draft report to the MOI for comments and feed back
7. Incorporation of relevant comments to finalize the report
8. Submit the final report – hard copy and also the digital version.

5. Methodology

The methodology adopted for the preparation of the report will be as follow:

- Nine sectors which are affected by the promulgated effluent standards by the Ministry of Environment will be considered for the studies.
- Books, publications, literature and internet sites will be used for the description of the sector and Nepalese context. Publications of Central Bureau of Statistics and Ministry of Finance will be included.
- The CP reports will be used along with some search in the internet for the remaining portion of the draft report
- The comments and suggestions from the Ministry will be studied and relevant comments and suggestions will be incorporated to finalize the report.

6. Findings and Recommendations

The findings and recommendations of the study are as follows:

- A number of no cost and low cost CP options can be generated in all the nine sectors of industries. These options are very important with regards to improvement in the production processes of the organizations. These options are mainly related to housekeeping, process control and the operating practices.
- Besides no and low cost CP options, a number of cost demanding CP options can also be generated in these sector industries. These options can be implemented as per the priority of the organization and with a focus on the financial evaluation. An action plan for the implementation is essential for effective outputs.
- Implementation of the CP options supports the standard affected industries in complying the standard set by government.

- The productivity indicators / specific consumptions are calculated for the sector industries. These indicators can be considered as bench mark for the productions. The improvement in the activities of the organization can be compared with these indicators and it is envisaged that the indicators will also be helpful to the organizations in decision making.
- The standard affected industries need to be encouraged to implement Cleaner Production in their respective organizations to achieve the benefits mainly productivity enhancement through optimization of resources consumption, reduction in the wastes generation to ease the compliance of standard and to improve the working environment within the premises of the organizations.

Following nine standard affected industrial sectors taken for the study of Cleaner Production potentials and the details of the sector wise study are given as follows:

A. Cotton Textile
B. Dairy
C. Fermentation
D. Leather Tanning
E. Pulp and Paper
F. Soap
G. Sugar
H. Vegetable Oil and Ghee
I. Wool Dyeing

A. Sector: Cotton Textile Dyeing

a. Brief Description

Textiles are one of the very important basic needs of the people. Textiles were manufactured in Nepal since a long time in conventional and manual operated looms at the household level. "Dhaka" a type of cloth made from cotton yarn is famous in Nepal. The traditional Nepalese costumes prepared from this cloth are still popular among the people. With the development of the technology, power driven semi-automatic and automatic looms were introduced later in industries for the commercial productions to cater the needs of modern textile fabrics to the people. As per the information available in the database of PACE Nepal, there are169 textile industrial enterprises are registered in Nepal out of which 89 such units carry out finishing of textiles. Most of these industries are located in central and eastern part of Terai (southern plain area) belt. These industries provide employment to about 7,000 persons. The capacity utilization of this sector industry is around 50 % only. At the moment, the growth of the sector is not satisfactory. Textile industries are in the downward trend. The major reason for this is the import of significant quantity of textiles from neighbouring countries India and China. The imported textiles are believed to be better in quality and comparatively cheaper as well. The local productions are unable to compete with these imported textiles in the cost in the market.

The locally produced and imported textiles are used in the country for the domestic use and also for the export of textile commodity in the form of converted products like readymade garments, which helps in earning valuable foreign currency as well as helps in generating employment opportunities in the country.

Besides the purchasing of yarn and cloth materials, this sector industry also imports dyes and chemicals like caustic soda and salts for the use in the processes of washing and dyeing. In view of the processes carrying out by the industry, the generation of wastes as effluent is a matter of concerned, henceforth, a standard for the generation of effluent from this sector industry is in place through publication of the same by the Government of Nepal in the gazette.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Textile Dyeing Industry

INPUTS	PROCESS	OUTPUTS
	Batch Preparation	
Wet Fabric Water Electricity	**Washing**	No discharge
Caustic Soda, Steam Electricity Manpower	**Souring**	Waste water and Vapor
Water Electricity, Steam Manpower	**Hot Washing**	Waste water and Vapor
Water Hydrochloric Acid Electricity, Steam Manpower	**Neutralization**	Waste water Vapor
Water Steam, Electricity	**Hot Washing**	Waste water Vapor
Water Sulphur Blue MRG Sulphur Black Sodium Sulphide Common Salt, Soda Ash Hexamate Phosphate Electricity, Steam Manpower	**Dyeing**	Waste water Vapor Color
Water Electricity Manpower	**Cold water washing**	Waste water
Water, Detergent Steam	**Soaping**	Waste water Vapor
Water Steam, Electricity	**Hot Washing**	Waste water Vapor
	Finishing	
	Wet Fabric	

Brief Process Description

The major processes of Textile dyeing are described in brief as follows:

Batch Preparation

The grey fabric is received in length and it is stitched, repaired, measured and weighed before loading to Jigger or jet machine. The weighed grey fabric in the form of length is loaded into the jigger uniformly for scouring. The jigger machine is filled with water up to the required level and run the machine to wet the fabric completely..

Washing

The wetted fabric is washed with continuous flow of cold water for an hour and drained out the washed water. The jigger is again filled with water as required and detergent or liquid soap is added accordingly. Then the machine is run and the steam is passed until the water is heated as required (85^0 C). And the water is drained out. The cleaned fabric is washed in running hot water for some minute and again wastewater is drained out.

Scouring

The jigger is filled again with fresh water. The required chemicals such as Birta scour, Soda ash, Hydrogen peroxide, Ztab etc are added in water. Then the machine is run and at the same time stream is passed into the water. The scouring process is continued until the grey fabric is completely free from the impurities present in the fabric. The scouring process is performed at about temperature 85^0 C. The more temperature is better. But due to open jigger the temperature can not be raised more than this. The scouring process is continued for 4 hours Lastly the hot spent water is drained out. There is no system of heat recovery and recycle of the wastewater. The drained water is discharged directly to nearby drain without any treatment.

Neutralization

After the completion of the scouring process in the jigger machine, machine is filled with fresh water and the fabric is washed in running hot water for an hour and lastly the wastewater is drained out. When all hot wastewater is drained out, the machine is again filled with cold water and run the machine for an hour with continuous running cold water and the wastewater is drained out. At last the jigger machine is again filled with fresh water and required quantity of acetic acid is added and the machine is run until the fabric is finished well as required. The wastewater is drained out. The scoured fabric is unloaded in a trolley

Dyeing

Well-scoured fabric is loaded into the Jet machine for dyeing of polyester part. And the water is added into the jet machine as required. There is no system to quantify the quantity of water.

After the completion of water adding, the machine is run for few minutes so that the fabric is well wetted. After the fabric is well wetted, the steam is passed so that the water inside the Jet machine is heated up to 60^0 C. Then at first already weighed required chemicals are added in to the running jet machine and the dyes are added 5 - 10 minutes after addition of chemicals. The steam is continued to pass till the temperature reached up to 130^0 C. And it holds for some time at this temperature. After dyeing process is completed, the hot spent wastewater is drained out. After dyeing, the cold water is circulated so that the fabric is cooled down to 65^0 C. The waste warm water is collected in to the general water storage tank.

Washing

The jet machine is filled with cold water and run for some time. The washed water is drained out. The Jet machine is filled again with cold water and run for some time so that the fabric is well washed. The washed water is drained out. The dyed fabric of polyester parts is unloaded in trolley. The dyed fabric in twisted form is unfolded or spread

Soaping

The neutralized fabric is treated with detergent at higher temperature to get shining and waste - water is drained out. During hot washing fabric is washed in running hot water for some time and the wastewater is drained out. After well washing, the fabric is unloaded in trolley and kept for finishing.

Finishing

The first step of finishing is done in stentor to get smooth surface and remove the shrinkage remained after dyeing. Using some body agent and other chemicals carries out the finishing. The decatise means ironing. The fabric is passed through decatise machine to get smooth and well packed fabric. Lastly the quality of fabric is checked for defects according to some adopted standard. And according to market demand the fabric is measured and cut and rolled manually and packed in plastic film and then in cartoon boxes.

c. Inputs of Materials

Major raw materials used in textile manufacturing are synthetic and cotton yarns, dyes and chemicals. All of the raw materials are imported from other countries, mainly India. The major chemicals and dyes used in the textile industries are as follows:

S. N.	Chemical and Dyes
1.	Sodium Hydroxide
2.	Sodium Chloride
3.	Sodium Carbonate
4.	Sodium Sulphide
5.	Sodium Hypochlorite
6.	Sodium thiosulphate
7.	Sodium Acetate
8.	Sodium Nitrate
9.	Sodium Hydrosulphide
10.	Hydrochloric Acid
11.	Acetic Acid
12.	Reactive Dyes
13.	Sulfur Dyes
14.	Vat Dyes
15.	Napthol Dyes

S. N.	Chemical and Dyes
16.	Caustic Soda
17.	Soda Ash
18.	Oxalic acid
19.	Ammonium Sulphate
20.	Common Salt
21.	Hydrogen Peroxide

d. Waste Generation Scenario

It has been observed that most of the textile industries lack in the proper management of the wastes. The discharges of the wastes are mentioned as follows:

Liquid emission

Wastewater is, by far, the largest waste stream for the textile industry. Large volume wastes include wash water from preparation and continuous dyeing, alkaline waste from preparation, and batch dye waste containing large amounts of salt, acid, or alkali. Because of the wide variety of process steps, textile wastewater typically contains a complex mixture of chemicals.

An observation has revealed that the average wastewater generated textile industries account to 270 tons per ton of fabric processed. Calculating from the above value, total wastewater generated by the Textile sector accounts to be around 1.13 Million cubic meter.

In terms of pollution load from the effluent, the laboratory analysis has shown that the generations of COD, TDS and TSS per ton of the product is 220 Kg, 247 Kg and 30 Kg respectively. Calculating from the above value, total pollution load created by this sector accounts to 925 Tons COD, 1040 Tons TDS and 130 Tons TSS per year.

Air Emissions

Although the textile industry is a relatively minor source of air pollutants compared with many other industries, the industry emits a wide variety of air pollutants, making sampling, analysis, treatment, and prevention more complex. Textile operations involve numerous sources of air emissions. Operations that represent the greatest concern are coating, finishing, and dyeing operations. Textile mills usually generate carbon dioxide, carbon monoxide and sulfur dioxides from boilers.

Other significant sources of air emissions in textile operations include resin finishing and drying operations, printing, dyeing, fabric preparation, and wastewater treatment plants.

Other Wastes

The primary residual wastes generated from the textile industry are non-hazardous. These include fabric and yarn scrap, off-spec yarn and fabric, and packaging waste. Cutting room waste generates a high volume of fabric scrap

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:
It has been observed that in the production of the textiles, the raw materials consumption to production ratio is 1.04.

Energy consumption:
The production of textile mainly consumes electrical energy in its processes. The specific electrical energy consumption is found to be 2.7 kWh / Kg.

Water consumption:
The specific consumption of water in textile industry is around 165 Litres / Kg.

Man-day utilization:
A total of around 0.2 man-day (1.6 man-hours) is utilized for the each Kg production of textile.

f. Potential of no cost and low cost CP options

In order to reduce the wastages, increase productivity and ensure the quality in textile industries, it is necessary to exercise control at each stage of various process starting with raw materials and ending with good quality of finished product.

Implementation of CP options leads towards greater environmental benefits. In general the implementation of the low and no costs CP options contributes to savings and unnecessary losses to impact ultimately to the environment, whereas the cost demanding options will obviously benefits to the generation of wastewater to increase the pollution load due to COD and TDS. The no and low cost CP options are basically the improvements in the good housekeeping measures and adaptation of better operating practices. Some of the no and low cost CP options are given as follows:

S. N.	CP options
1.	Control the presence of oil/grease, starch etc in yarn by minimizing use in weaving
2.	Practice the proper handling and transportation of fabric by using appropriate trolley and tools
3.	Keep the shop-floor free from dust, chemicals and dirty water
4.	Training and awareness programme to employees regarding keeping clean gray house and conservation of water and chemicals.
5.	Reduce the addition of soda ash, as there is already detergent water in hot washing operation
6.	Make accurate weighing/measurement of chemicals by repairing of digital balance
7.	Make provision of rubber squeezing/roller to squeeze the liquor more effectively
8.	Control the use of running water by improving operating practice (minimization of valve opening)
9.	Avoid the over running of machine
10.	Use good quality dyes and chemicals
11.	Optimize the temperature and m/c running time
12.	Feed the warm water at 45-50^{0}C
13.	Install the thermometer to maintain the temperature

14.	Place the plastic sheet on jigger to avoid the effect of splashing
15.	Stop the spillage and leakage of chemicals and dyes
16.	Keep the chemical/dyes containers always close
17.	Store the dyes and chemicals in dry place
18.	Introduce the preventive maintenance schedule
19.	Solid and liquid chemicals should be stored on plastics covered wooden palette.
20.	Sacks should be stored in cross tying type.
21.	Provide space between different types of chemicals and chemicals should not be in contact with wall.
22.	Storage areas should be clearly marked with yellow line demarcation and placed the nametag for each.
23.	Avoid using of hook during unloading.
24.	Managing aseparete storehouse for gray cloths.
25.	Strictly restrict the employees to remove the slipper and shoes and clean the foot with water and drying system for employees before enters to gray house
26.	Cloth should be stored according to date or size or color.
27.	Close the all container of pigment after use.
28.	All container should be marked for easy identification.
29.	Provide better spatula to handle the pigments.
30.	Compulsory to use of dust mask and gloves during handling of any pigments.
31.	Avoid storing the flammable chemicals in working areas
32.	Introduce emergency preparedness system including emergency exit, communication system, assembly point, fire-fighting equipment.
33.	Install fire extinguisher
34.	Installation of hydrant system providing the internal and external pipeline.
35.	Arresting of Steam leakage
36.	Insulation of heated surface areas
37.	Arresting of leakages in the compressed air line
38.	Installation of translucent sheets to make use of daylight

g. Estimated investment and pay back period

In course of carrying out CP assessment in textile industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

S.N.	Nature of option	Estimated Investment (NPR)	Expected savings/year (NPR)	Pay back period (Year)	Anticipated Benefit
1.	Reduction in bath ratio	Nil	374000	Immediate	Reduction in COD, TDS and overall pollution load
2.	Recycling of spent scour bath	724,472	1,575,700	0.5	Reduction in COD, TDS and overall pollution load
3.	Reuse of spent scour liquor for cleaning powder	Nil	21,000	Immediate	Reduction in COD, TDS and overall pollution load
4.	Recycle of hot water bath for	10,000	7062	1.4	Reduction in COD, TDS and overall pollution load

S.N.	Nature of option	Estimated Investment (NPR)	Expected savings/year (NPR)	Pay back period (Year)	Anticipated Benefit
	bleach bath				
5.	Recycle of spent dye stuff for compatible colour	67,000	425,000	0.15	Reduction in COD, TDS and overall pollution load
6.	Replace high bath ratio jet machine by U-Tube	935,000	678,000	1.38	Reduction in COD, TDS and overall pollution load
7.	Reuse of wash water for next process (Jet)	Nil	7600	Immediate	Reduction in COD, TDS and overall pollution load
8.	Reuse of spent bath (Jiggers)	40,000	262,000	0.15	Reduction in COD, TDS and overall pollution load
9.	Replace acetic acid by formic acid	Nil	82,500	Immediate	Reduction in COD, TDS and overall pollution load

h. Environmental Benefits

With an experience of undergone Cleaner Production intervention in some of the textile industries, it has been concluded that Cleaner Production options are very much helpful in reduction of pollution load and monetary savings after implementation of CP options. It has been found that in some textile industries can reduce its COD Load by as high as 80 %, TDS Load by 90 % and wastewater discharge by 50 %.

B. Sector: Dairy

a. Brief Description

Milk and milk products are popular food items all over also in Nepal. The commercial production of these items was not seen into the practice in Nepal earlier until the initiative of the government in supplying processed milk to the people. In earlier days, it used to be happened pet cattle (cow and buffalo) in the household premises, with an exception in many households in urban areas, to supply milk inputs to the family. The practice still exists in many places especially in the rural and hilly areas and some of the urban areas as well. In the present day world of the business, the purpose of cattle farming in these areas is not just only to cater milk inputs in the households but also to supply it to the dairy units through collection centers mostly run by the cooperatives at local level. At the moment, besides the government owned milk processing units, there are a big number of similar units run by the private sector.

As per the information available from the National Dairy Development Board (NDDB), an umbrella organization of the dairy related stakeholders, the number of total dairy related enterprises registered under different authorities in the country is about 131 including 5 units government owned plants situated at different locations within the country under DDC (Dairy Development Corporation).

The total Fluid Milk processing rate, as liters per day, by DDC plants, Private Medium, Large and small scale Dairy industries was about 421,000 liters/day, this amounted to about 72 % utilization of the approved running capacity (582,000 liters/day). Employment generated by these industries is about 9,000 persons and farmers' family involvement is about half a million.

Milk and milk products are directly supplied in the market to be used by the general public. Hence, a due attention on the hygienic condition of the product is a matter of concerned to all. Besides, these products being food item and easily biodegradable, dairies are considered as pollution prone industry also. Government of Nepal has already introduces a wastewater standard for the dairy industries.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Milk Processing Industry

Input	Process	Output
Raw milk → Water (Tanker/can wash) →	**Receiving** ↓	→ Spillages → Waste water
Ice water (cooling) →	**Chilling / Storage** ↓	→ Waste water
Steam (heating) →	**Pre-heating** ↓	→ Condensate
Cream →	**Standardization** ↓	→ Spillages
Normal water (cooling) →	**Homogenisation** ↓	→ Hot water
Steam (heating) → Ice water (cooling) →	**Pasteurization** ↓	→ Condensate → Hot water
	Storage ↓	
Polythene bag →	**Filling** ↓	→ Milk waste → Spillages → Waste polythene bag

Processed milk in pouch

Brief Process Description

Milk Reception:
Milk collected from farmers is received in the chilling centers and transported to the factory through tankers. At reception, sample is taken and tested for quality (fat contents, Solid not fat (SNF) contents and others) in the laboratory.

Chilling:
After laboratory testing, measured quantity of milk is passed through the plate chiller and chilled to 4^0C which is then stored into different milk storage tanks.

Standardization/ Homogenization/Pasteurization:
Milk from the storage tank is sent to pasteurization clarification, skimming (cream separation), regeneration or standardization. Cream separated, more than required for both the milk i.e standard milk having 3% fat and 8% SNF and whole milk having 5% Fat and 8% SNF, is stored in separate tank. The standardized and homogenized milk after pasteurizing i.e. holding the milk at 72^0C and immediately chilled to 4^0C, holding time is 3 to 4 minutes and is sent to the tank, from where it goes to the filling/sacheting machine.

Yoghurt Production Process:
For yoghurt making, standard milk is taken from storage tank, homogenized and pasteurized batch wise and collected in cans after cooling to 40^0C with the help of tap water. Milk poured in packs / containers are inoculated and incubated at 46^0C for about 3 hours. In general electrical heaters are used to maintain the temperature of incubation room. After incubation the packs are kept in cold room and supplied as required.

Ghee Production Process:
The skimmed cream after milk separation is taken for batch pasteurization. During the process of batch pasteurization cream is heated first at 72^0C and then cooled to 5^0C. For heating purpose steam is used and during cooling process chilled water is circulated. Batch pasteurized cream is kept in butter churner after churning of cream butter is produced. The butter is kept in ghee boiler and heated up to 100^0C to produce ghee, which is then filtered and filled in containers and pouches and sent for hardening.

Ice-Cream Production Process:
Desired amount of pasteurized milk and cream are mixed for ice cream production. The 'mix', containing 12% fat is homogenized, chilled to 0^0C in ice cream mixer and finally filled up in cups / containers and refrigerated.

c. Inputs of Materials and Energy

In order to process milk to produce different milk products such as processed milk, yoghurt, Paneer, Ice cream, Butter and Ghee, the essential materials and energy, other than the main raw material milk, required are given as follows:

S. No.	Resources
1.	Water
2.	Ammonia
3.	Nitric Acid
4.	Washing Soda
5.	Cleaning agent
6.	Caustic Soda (NaOH)
7.	Electricity
8.	Diesel (For Boiler)

Water Consumption
Dairy processing characteristically requires very large quantities of fresh water. Water is used primarily for cleaning process equipment and work areas to maintain hygiene standards

Energy Consumption
Electricity is used for the operation of machinery, refrigeration, ventilation, lighting and the production of compressed air. Like water consumption, the use of energy for cooling and refrigeration is important for ensuring good keeping and maintaining quality of dairy products and storage temperatures are often specified by regulation. Thermal energy, in the form of steam, is used for heating and cleaning.

d. Waste Generation Scenario

By nature of the industry, dairy-processing activities are liable to consumption of high quantity of water and hence these units do discharge a lot of effluent with high organic loads. Wastes being biodegradable nature, causes odour in the unit premises and in the surrounding areas.

As mentioned above, dairy industries are pollution prone industries. The waste arising in the dairy industries are due to spillages and passage of milk and milk products in drain, during reception, Pasteurization, CIP, Churning and ghee boiling, ice-cream production and yogurt production processes. The effluent generated from the Dairy industries gives rise to high BOD, COD, TDS, pH, etc., which adversely affect the environment and health. Despite these, most of the industries are still operating in a conventional way without any pollution prevention or control measures.

The dominant environmental problem caused by dairy processing is the discharge of large quantities of liquid effluent. Dairy processing effluents generally exhibit the following properties:

- High organic load due to the presence of milk components;
- Fluctuations in pH due to the presence of caustic and acidic cleaning agents and other chemicals;
- High levels of nitrogen and phosphorus;
- Fluctuations in temperature.

If whey from the cheese-making process is not used as a by-product and discharged along with other wastewater, the organic load of the resulting effluent is further increased.

Characteristic of effluent

Dairy effluents contain dissolved sugars and proteins, fats, and possibly residues of additives. The key parameters are biochemical oxygen demand (BOD), with an average ranging from 0.8 to 2.5 kilograms per metric ton (kg/t) of milk in the untreated effluent; chemical oxygen demand (COD), which is normally about 1.5 times the BOD level; total suspended solids, at 100-1,000 milligrams per liter (mg/1); total dissolved solids: phosphorus (10-100 mg/1), and nitrogen (about 6% of the BOD level). Cream, butter, cheese, and whey production are major sources of BOD in wastewater. The waste load equivalents of specific milk constituents are: 1 kg of milk fat = 3 kg COD; 1 kg of lactose = 1.13 kg COD:and 1 kg protein = 1.36 kg COD. The wastewater may contain pathogens from contaminated materials or production processes. A dairy often generates odors and, in some cases, dust, which need to be controlled. Most of the solid wastes can be processed into other products and by-products.

Solid wastes

Dairy products such as milk, cream and yogurt are typically packed in plastic-lined paperboard cartons, plastic bottles and cups, plastic bags or reusable glass bottles. Other products, such as butter and cheese, are wrapped in foil, plastic film or small plastic containers. Milk powders are commonly packaged in multi-layer Kraft paper sacs. Breakages and packaging mistakes cannot be totally avoided. Improperly packaged dairy product can often be returned for reprocessing; however the packaging material is generally discarded.

Emissions to air

Steam, which is used for heat treatment processes (pasteurization, sterilization, drying etc.) is generally produced in on-site boilers, and electricity used for cooling and equipment operation is purchased from the NEA.

Air pollutants, including oxides of nitrogen and sulphur and suspended particulate matter, are formed from the combustion of fossil fuels, which are used to produce both these energy sources.

In addition, discharges of milk powder from the exhausts of spray drying equipment can be deposited on surrounding surfaces. When wet, these deposits become acidic and can, in extreme cases, cause corrosion.

Refrigerants

For operations that use refrigeration systems based on chlorofluorocarbons (CFCs), the fugitive loss of these gases to the atmosphere is an important environmental consideration, since CFCs are recognised to be a cause of ozone depletion in the atmosphere. For such operations, the replacement of CFC-based systems with non- or reduced-CFC systems is thus an important issue.

Hazardous wastes

Hazardous wastes consist of oily sludge from gearboxes of moving machines, laboratory waste, cooling agents, oily paper filters, batteries, paint cans etc. At present, some waste is incinerated, much is simply dumped.

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:
It has been observed that in the production of the milk and milk products, the average ratio of raw materials consumption to production is around 1.04.

Energy consumption:
The production of milk and milk products mainly consumes electrical energy in its processes. The specific electrical energy consumption is found to be around 58 kWh / Ton. Similarly liquid fuel consumption for the use of thermal energy in the plant is around 22 Litres / Ton production.

Water consumption:
The specific consumption of water in dairy industry is around 3.5 cu. m. / Ton of production of milk and milk items.

Man-day utilization:
A total of around 5.25 man-days (42 man-hours) are utilized for the each Ton production of milk and milk products.

f. Potential of no cost and low cost CP options

The results have shown that the potentiality of CP in the dairy sector is very high in almost all the processing operations. The simple good housekeeping measures such as stopping leakage from the water pipes, adaptation of better operating practices, recycle and reuse of cooling water streams, optimization of CIP process and recycle reuse of cleaning chemicals are some of the important no and low cost options. Similarly, Recovery of heat from boiler blow down, switching over to continuous pasteurizer, automation or semi automation of filling operation for ghee and yogurt are some of the cost demanding CP options.

Cleaner Production opportunities in this area focus on reducing the amount of milk that is lost to the effluent stream and reducing the amount of water used for cleaning. Ways of achieving this include:

1 Avoiding milk spillage when disconnecting pipes and hoses;
2 Ensuring that vessels and hoses are drained before disconnection;
3 Providing appropriate facilities to collect spills;
4 Identifying and marking all pipeline to avoid wrong connections that would result in unwanted mixing of products;
5 installing pipes with a slight gradient to make them self-draining;
6 Equipping tanks with level controls to prevent overflow;
7 Making certain that solid discharges from the centrifugal separator are collected for proper disposal and not discharged to the sewer;
8 Using ‘clean-in-place’ (CIP) systems for internal cleaning of tankers and milk storage vessels, thus improving the effectiveness of cleaning and sterilization and reducing detergent consumption;
9 Improving cleaning regimes and training staff;
10 Installing trigger nozzles on hoses for cleaning;

11 collecting wastewaters from initial rinses and returning them to the dairy farm for watering cattle.

Some of the general CP options

To save water

1. Install fixtures that restrict or control the flow of water for manual cleaning processes;
2. Use high pressure rather than high volume for cleaning surfaces;
3. Reuse relatively clean wastewaters (such as those from final rinses) for other cleaning steps or in non-critical applications;
4. Recirculate water used in non-critical applications;
5. Install meters on high-use equipment to monitor consumption;

To reduce material loss and pollutant load in effluent

6. Collect spills of solid materials (cheese curd and powders) for reprocessing or use as stock feed;
7. Fit drains with screens and/or traps to prevent solid materials entering the effluent system;
8. Install in-line optical sensors and diverters to distinguish between product and water and minimise losses of both;
9. Install and maintain level controls and automatic shut-off systems on tanks to avoid overfilling;
10. Clearing milk residues from the pipes using compressed air before the first rinse;
11. Collecting the more highly concentrated milk wastewater at start-up and shut-down for use as animal feed;
12. Collecting all first rinses during butter churning, and separating the residual fat for use in other processes;
13. Recovery of cheese solids by installation of screens and settling tanks

To save energy

14. Implement switch-off programs and installing sensors to turn off or power down lights and equipment when not in use;
15. Improve insulation on heating or cooling systems and pipe work;
16. Favour more energy-efficient equipment;
17. Improve maintenance to optimise energy efficiency of equipment;
18. Maintain optimal combustion efficiencies on steam and hot water boilers;
19. Eliminate steam leaks;
20. Capture low-grade energy for use elsewhere in the operation.

g. Estimated investment and pay back period

In course of carrying out CP assessment in dairies, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

S.N.	***Options***	***Investment***	***Saving***	***Payback***	***Remarks***

		(NPR)	(NPR)	Period	
1.	Trigger nozzle and maintenance of leakages for water hoses	10,000 for nozzles	10,000	1 year	20%water saving=2,000 m^3/year
2.	Trigger nozzle for yoghurt filling with gravity flow.	50,000 for tank and nozzle	90,000	0.5 years	75% reduction in spillage=4,500 L of mix
3.	Ensure proper sealing of churn after charging it with cream	no	5,400	Immediate	Saving of 600 L butter milk x .06 x 150 Rs
4.	Place a tray below the churn to re-collect the cream and butter, can easily be re-churned to recover the fat	no	5,400	Immediate	Saving of 30 Kg of butter x 180 Rs
5.	Wipe out the butter with a piece of cloth to, re-use it in ghee making, prior to rinsing the transfer crates/utensils with water	no	2,700	Immediate	Saving of 15 Kg butter
6.	Feed water/Condensate Recovery	1,000,000	460,000	2.2 years	2000 m^3 water and 15,000 L of diesel

h. Environmental Benefits

It has been estimated on the basis of CP assessment in the dairies and its findings that the environmental impact of this sector could be minimized by about 60%, with the CP intervention and implementation of Cleaner Production Options.

Although the pollution load seems to be reduced by about only 60% after CP Intervention, it is recommended further to go for the primary, secondary and Tertiary treatments to comply with the proposed standards for effluent to be discharged to inland water or sewerage. CP measures will reduce the size of treatment plant required hence its installation as well as operating cost would reduce accordingly. The characteristics of the parameters of effluent discharged by dairies found in course of CP assessment in some of the units are given as follows:

Characteristics	*Present status*	*Expected * reduction*	*Status after CP*	*Tolerance Limit Proposed*
pH	5.0-6.7		Within 5.5-8.5	Within 5.5-8.5
TSS (mg/l)	20.5-436.6		175 max	150 mg/liter max
BOD (mg/l)	856-1,935		770 max	100 mg/liter max

COD (mg/l)	1,142–2,580		1032 max	250 mg/liter max
Oil and Grease (mg/l)	45.8		18 max	10 mg/liter max
Effluent (m^3/1,000 liters of milk processed)	1.2-5.7	20%	0.96-4.56	

C. Sector: Fermentation

a. Brief Description

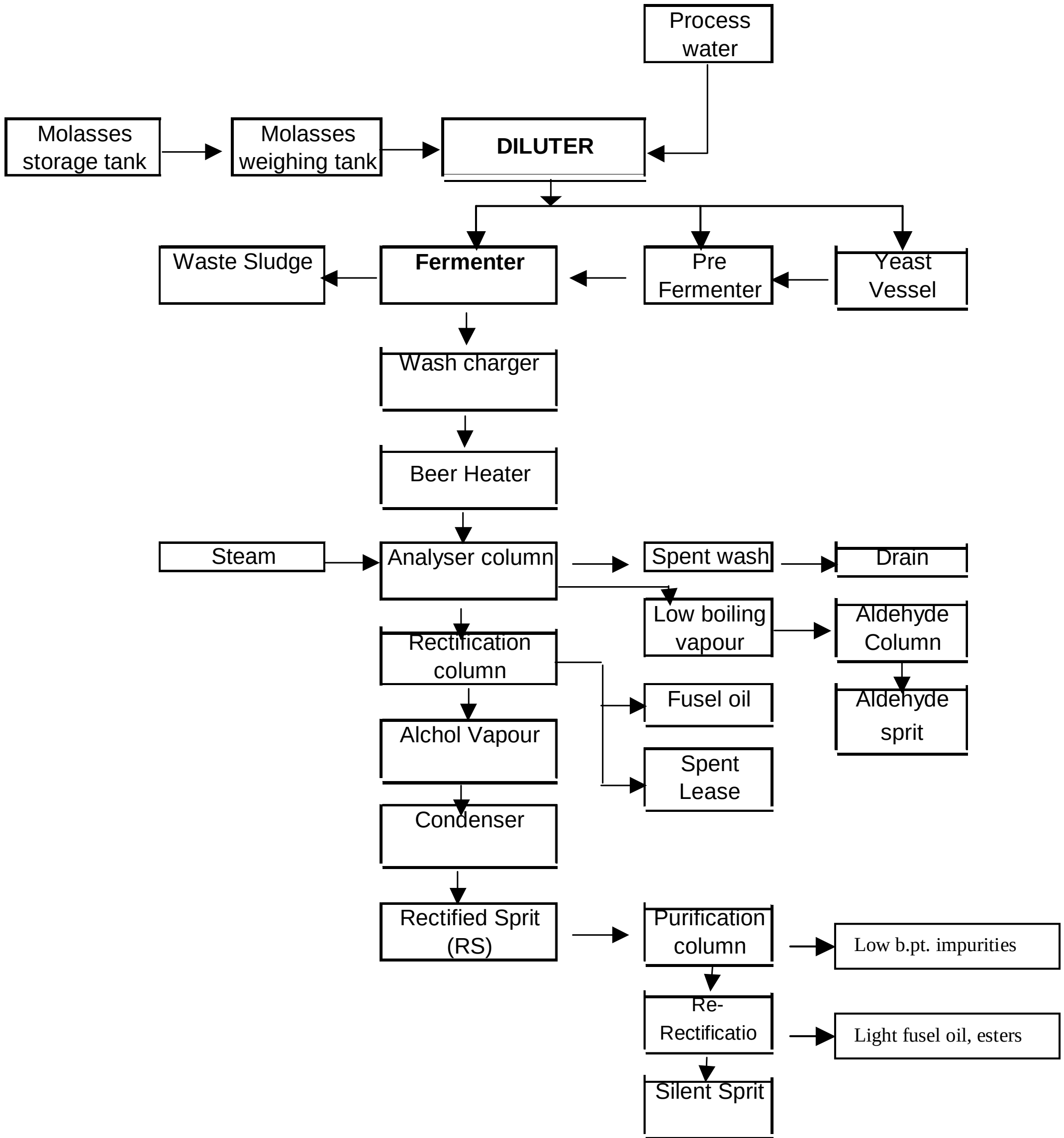
The number of breweries and distilleries in operation in Nepal are found to be 5 and 52 in numbers. As per the information available from the VAT department the number of units involved in distillation operations is 19 only and rest others are mostly of small-scale units and generally carry out blending and bottling operations. There are also, in all probability, a significant number of tiny and cottage scale units which, with simple and crude fermentation and distillation processes, produce “country liquor”. These units are not registered, and located even within the household and residential periphery. Production of liquor or beer from basic raw material like grain/ molasses occurs primarily in the medium or large-scale units.

It has been revealed from the compilation of data of eight distilleries (large / medium), the total production volume from these units is about 12,100 kiloliters per year. This amounts to 61 % utilization of the approved capacity. Similarly the five-medium / large scale beer-manufacturing units have an installed capacity of about 40,000 kiloliters per year. However, the annual capacity utilization is about 48 to 50%. Except for a unit in Kathmandu, other plants are located near larger towns in middle and southern Nepal.

Fermentation industries are pollution prone industries. The waste arising in the fermentation industries are due to surplus sugary or starchy materials, as the primary source of alcohol, a portion of which remained un-fermented and discarded, as spent wash, after fermentation and / or distillation during production of distilled or un-distilled liquor.. The effluent generated from the fermentation industries gives rise to high BOD, COD, TDS, pH, color etc., which adversely affect the environment and health. Despite these, most of the industries are still operating in a conventional way without any pollution prevention or control measures. Government of Nepal has already brought out standard for the discharge of the wastewater for the fermentation industries.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Fermentation Industry


Process water
Molasses storage tank
Molasses weighing tank
DILUTER
Waste Sludge
Fermenter
Pre Fermenter
Yeast Vessel
Wash charger
Beer Heater
Steam
Analyser column
Spent wash
Drain
Low boiling vapour
Aldehyde Column
Rectification column
Fusel oil
Aldehyde sprit
Alchol Vapour
Spent Lease
Condenser
Rectified Sprit (RS)
Purification column
Low b.pt. impurities
Re-Rectificatio
Light fusel oil, esters
Silent Sprit

Brief Process Description

Molasses

Molasses is the main raw material used by almost all the distilleries in Nepal. Some of the distilleries also use imported or local wheat / malt for producing grain sprit suitable for some selected high-grade liquor. Molasses is purchased and transported from sugar factories through tankers. All the distilleries have sufficient capacity (mild steel tanks or Shaded pit for its bulk storage).

Dilution

Molasses, at about 85^{o}Bx is diluted to setup brix required for yeast vessels, pre-fermenters and fermenters, generally the diluted molasses obtained at the brix ranging from 15 to 22^{o}Bx Dilution employ a cylindrical vessel with baffles inside, and counter-current connections for inter mixing of molasses and water. Feeding rate of water is regulated manually with the help of valve.

Culture preparation

Purpose is to grow and increase the number of yeast cells required for converting the fermentable sugar into alcohol, as more as possible. Yeast cell, after isolation and 3-4 incubation cycle on laboratory scale, transferred in 30-50 kg yeast vessel containing pre-sterilized diluted molasses at low brix (16-17^{o}Bx).After 12 hours of incubation the fermented mass is transferred to another vessel having capacity of 5 times of the first. Incubation results lowering of brix to 12-15 which is again maintained at original setup by adding sterilized molasses solution at calculated brix. Similarly, mass of second vessel is again transferred in 3rd vessel after an incubation of 12 hours. Sterilization of the diluted molasses in yeast vessels is done by injecting direct steam in the vessels. After completion of this step, the vessels are cleaned by filling and boiling the water with direct steam. Water and residual yeast cells are drained out.

Pre-Fermentation

After 36 hours of incubation and 3 incubation cycle, prepared culture is fed to a pre-fermenter having capacity of about 400 times of first yeast vessel. The un-sterilized and comparatively high brix medium facilitate the yeast cells to be acclimatized during another 12 hours incubation, for carrying out efficient conversion of fermentable sugar into alcohol in main fermentation process. Pre-fermentation lowers the brix to about 11-12^{o}Bx.

Fermentation

Yeast cells with the mass in pre-fermenter is transferred to the main fermenter, and to maintain the brix at about18-22^{o}Bx, molasses from diluter is charged and the volume is made-up 5-7 times equal to that of pre-fermenter. It takes about 2-4 hours to start up vigorous fermentation. Fermentation is completed in three phases. First is the "growth phase" in which multiplication of cells takes place. Second is the "conversion " phase in which fermentable sugars are converted into alcohol. Third is the "exhaustion", in which yeast cells started settling towards bottom of the fermenter because of the rise in alcohol percentage (5-6%) in the medium. It is an exothermic reaction so, to maintain the temperature between 30-37^{o}C water, through nozzles in circular coils mounted just above the fermenters, is sprinkled over the external wall of the fermenters, as and when required.

After the fermentation is completed (after about 20 hours) the "wash" or "beer" is now ready for distillation. To provide space for settled yeast cells wash unto the level of10-

20cm from the bottom of fermenters is taken out. Residual beer (About 2% of total volume of fermenter) is also drained out with wastewater after cleaning the vat. Very few distilleries have the facility to separate out the cells to recover the alcohol from this residue.

Distillation

Beer from fermenter is first received in a stabilization tank, from where wash, at constant feeding rate, is fed to the analyzer column. In some of the distillery wash, prior to feeding the analyzer column, is passed through one or two stage beer heater to pre heat the wash with recovered heat from spent wash and/or alcohol vapour from columns. From the analyzer column, low and high boiling point vapours are separated.

Low boiling vapours goes into heads column from where it is withdrawn as received as heads sprit (impure), about 12% of total distilled alcohol as bulk liter. This fraction of sprit, after mixing with Methilene blue or any poisonous component, converted into "denatured sprit".

The high boiling vapours enters the rectification column, where further fractional distillation of pure alcohol takes place. Steam at about 2-4 kg pressure (depending upon size, design and capacity of the columns) is fed to the distillation column. Fusel oil is another fraction drawn from higher boiling zone of rectification column in the amount ranging from 0.02- 0.05 %.

Rectified sprit obtained from this distillation does not contain cent percent "Ethyl Alcohol". Rectified Sprit contains only 96% v/v ethyl alcohol. For producing Extra Neutral Alcohol (ENA) or commonly called silent sprit, the "Rectified sprit" is mixed with soft de-mineralized water and re-distilled in specially designed distillation column. Rectified and/or Silent Sprit, after quality confirmation, received and stored in MS/SS tanks.

Blending and bottling

Blending operation is carried out according to the type of liquor to be prepared. Various ingredients are mixed in this process and activated for certain specified period. Distilleries also have the setup for producing Blended and bottled high and/or low-grade liquor under different brand names.

c. Inputs of Materials and Energy

The materials and energy used in the processes of fermentation and distillation are given as follows:

S. No.	***Resources***
1.	Molasses
2.	Water (consumed in process and sanitary purposes)
3.	Heat (as Kg of steam)
4.	Heat (as Kg of rice husk or liter oil)
5.	Electricity (kWh)
6.	NaOH (Kg)
7.	Salt
8.	Urea
9.	Bleaching powder

10.	Lime ($CaCO_3$)
11.	Hydrochloric acid (HCl)
12.	Sulfuric acid

d. Waste Generation Scenario

The major waste generation from the fermentation and distilleries are the effluent with high BOD, COD and TSS. The emissions and the environmental concerns of some of the selected processes are given below:

Selected processes	***Consumption/Waste/emission***	***Environmental concerns***
Mash preparation (only in the distilleries, using grain as a source of carbohydrate)	• High steam (energy) consumption for boiling	• Resource depletion and air pollution.
Fermentation	• Discharge of yeast and cleaning of vessels causes waste water with a high content of organic matter, phosphate and nitrate	• Eutrophication of rivers, lakes and sea and risk of habitat alterations and impact on bio-diversity • Especially contribution to the global warming caused by emission of carbon dioxide(CO_2) • Nuisance to neighbors
Separation of cells from fermenter.	• Wastewater containing alcohol remains and yeast	• Eutrophication of rivers, lakes and sea and risk of habitat alterations and impact on bio-diversity
Distillation	• High energy consumption (Steam uses) • Wastewater (spent wash) with low pH, high suspended solids, salinity, conductivity, BOD and COD.	• Resource depletion and air pollution. • Risk of toxic impacts on aquatic life. • Eutrophication of rivers, lakes and sea and risk of habitat alterations and impact on bio-diversity • Nuisance to neighbors
Bottle washing	• High consumption of hot and cold water, and consumption of detergent • High rate of solid waste generation (broken bottles)	• Risk of resource depletion and air pollution; contribution to the global warming • Risk of toxic impacts on aquatic life.

Selected processes	*Consumption/Waste/emission*	*Environmental concerns*
Ancillary operations: Steam generation, Combustion of oil or rice husk Steam generation, oil storage	• High energy consumption • Emission of CO_2., Nox and PAH (Poly aromatic hydrocarbons).Risk of oil spills and losses	• Resource depletion and air pollution • Especially contribution to the global warming caused by emission of CO_2., NOx causes smog and PAH is carcinogenic • Pollution of soil and water

Some observations with regards to the effluent characteristics on the basis of available data on the discharge of effluent from these industries are given below in the table as follows:

Characteristics	*Present status*	*Expected reduction*	*Status* after CP*	*Tolerance Limit (Gazetted)*
pH	4.0-5.1	-	4.0-5.1	5.5-9
TSS (mg/l)	1,000	10%	900	Max 100
BOD (mg/l)	14,000- 90,000	90%	5,000	Max 60
COD (mg/l)	81,000-1,53,600	70%	35,000	
Effluent (m^3/Kl)	15-20	30%	Max 15	

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:
It has been observed that in the production of the liquor from distillation plant, the ratio of consumption of raw materials in ton and production of liquor in cu.m. is about 4.7 and the same in the case of fermentation, the ratio of consumption of raw materials to production of beer in hectoliter is 0.02.

Energy consumption:
The specific electrical energy consumption is found to be 297.6 kWh / cu.m. and 14.4 kWh/ hectoliter in distillery and fermentation respectively. Similarly the fuel consumption in order to get the thermal energy in the processes are 1.63 Ton of fuel (Rice Husk) per cu. m. production liquor in distillery and 6.7 liters of fuel (oil) per hectoliter of beer production.

Water consumption:
The specific water consumptions in distillery and fermentation are 20.9 cu.m./cu.m. production of liquor and 1.3 cu.m./hectoliter production of beer.

Man-day utilization:
Mandays utilizations in the distillery and fermentation industries are 29.3 mandays / cu.m. of liquor and 0.16 manday / hectoliter of beer productions.

f. Potential of no cost and low cost CP options

Stopping leakage from the water pipes, adaptation of better biological control techniques like "Acclimatization", recycle and reuse of cooling water streams, separation of Yeast-spent wash stream and its recycle reuse are some of the important no and low cost options. Similarly, Recovery of heat from spent wash, use of better quality yeast strains, Biogas ferreters for methane production and conversion of spent wash in to bio fertilizer are the main cost demanding CP options.

With the implementation of these CP options the expected saving for a distillery having average production capacity, 750 KL/year of sprit seems to be more than NPR 3.5 million. Similarly, the expected saving for a Brewery having average production capacity, 138,000 hl/year of beer seems to be more than NPR 4 million. Some general and good housekeeping CP options in the industries is as follows:

- Proper calibration of the storage tanks or introduction of weighing balance for accurate molasses measurement.
- Regular maintenance of the delivery pump and installation of a tray to recollect the molasses from leaks, and deliver it with the same pump.
- Steam coils in yeast vessels to save the soft water, as condensate, going into drain.
- Introduction of CIP to save cleaning water, residue can be recent to fermenter.
- Use of high Brix and alcohol tolerance yeast for fermentation and acclimatization of yeast prior to fermentation.
- To minimize the consumption of cleaning water and chemicals by 80% CIP (cleaning in place, spray through nozzles) should be introduced..
- Introducing PHE (Plate heat exchanger) or concentric tubular heat exchanger for cooling/maintaining the temperature throughout the fermentation.
- Recovery of alcohol and yeast cells/Separation of yeast cells and beer from the residual wash drained after cleaning the fermenters with the help of Decanter/Vacuum filter/Centrifugal separator/Lamella.
- Composting of yeast cell mass, separated out from the fermenters.
- Fermenter cooling water can be re-circulated to save out 20 m^3 of water every day.
- Proper chemical control and aeration (initially) can increase the yield and decrease in BOD of spent wash.
- Covering the fermenters, CO_2 scrubber can separate out the alcohol escaping out along with evolved carbon dioxide.
- As the higher yield and the recovery of alcohol from same amount of molasses reduces the BOD and COD in the effluent of a distillery, work force involved should be trained to make them capable of controlling this biochemical conversion process. (Higher the conversion of sucrose into alcohol, lower will be the BOD and COD in spent wash).
- Pre-heating of wash with the spent wash.
- Pre-heating of wash just before feeding the column, installation of beer heater.
- Compressing the vapour from flashing the wash to recover the heat (104^{o}C) of wash.
- Installation of Rotameter for constant rate feeding of wash to check frequent venting out of alcohol mix from column end.

- Installation of pressure reducing valve in steam feeding line. To check frequent venting and alcohol loss in spent wash.
- Installation of dial thermometer (3 in numbers) in three different zones of column.
- Installation of fusel oil decanter to separate out extra Ethyl Alcohol from fusel oil recovery.
- Double stage heating of soft feed water for boiler, presently being heated only by passing it in condensers, second heating with "Lees" at (103^{o}C) through a Plate Heat Exchanger could reduce the amount burning fuel in boiler.
- Insulation of column could save 10-15% of steam consumed for distillation.

g. Estimated investment and pay back period

In course of carrying out CP assessment in fermentation industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

S.No.	*Options*	*Investment (NPR)*	*Saving (NPR)*	*Payback Period*
1	Installation of a tray to recollect the molasses from leaks, and deliver it with the same pump	10,000	25,000	5 months
2	Introduction of CIP (cleaning in place, spray through nozzles) to save cleaning water, residue can be re-sent to fermenter.	100,000	50,000	2 years
3	Use of high Brix and alcohol tolerance yeast (compressed yeast cream) or acclimatization of yeast prior to fermentation (expert), for fermentation.	150,000	375,000 (2% increase in recovery)	5 months
4	Introducing PHE (Plate heat exchanger) or concentric tubular heat exchanger for cooling/maintaining the temperature throughout the fermentation.	100,000	200,000 (53 lit alc/Day)	6 months
5	Recovery of alcohol and yeast cells/Separation of yeast cells and beer from the residual wash (sludge) drained after cleaning the fermenters with the help of Decanter/Vacuum filter/Centrifugal separator/Lamella.	100,000	300,000 (80 lit.alc/Day) (BOD reduction 3.5%)	4 months
6	Fermenter cooling water can be re-circulated to save 20 m^3 of water every day	50,000	50,000	1 year

S.No.	*Options*	*Investment (NPR)*	*Saving (NPR)*	*Payback Period*
7	Covering the fermenters, CO_2 scrubber can separate out the alcohol escaping out along with evolved carbon dioxide.	300,000	160,000	2 years
8	Compressing the vapour from flashing the wash to recover the heat (104^{o}C) of wash.	Yet to be explored		
9	Installation of Rotameter, and pressure reducing valve for constant rate feeding of wash and steam to check frequent venting out of alcohol mix from column end, minimize losses in spent wash and to maintain quality	50,000	100,000	6 months
10	Installation of dial thermometer (3 in numbers) in three different zones of column	5,000	Quality	
11	Installation of fusel oil decanter to separate out extra Ethyl Alcohol from fusel oil recovery and to maintain its quality.	50,000	75,000 (5 liters fusel oil @ 100 Rs/liter)	9 months
12	Double stage heating of soft feed water for boiler, presently being heated only by passing it in condensers, second heating with “Lees” at (103^{o}C) through a Plate Heat Exchanger could reduce the fuel need	100,000	40,000	2.5 years
13	Insulation of column to save heat	300,000	200,000	9 months
14	Insulation of distribution lines.	30,000	20,000	1.5 years
15	Installation of turbo generator (Low-pressure turbine) to generate required electrical power, exhaust steam can be used for rest of he operations.	800,000	700,000	1.1 years
16	Installation of bio-fermenter to produce bio-gas	5,000,000	1,250,000	4 years
17	Repair and maintenance of steam valves and flanges and installation or repairing of steam traps	Negligible	20,000	Immediate

h. Environmental Benefits

The study of CP implementation in the fermentation sector reveals that the environmental impact of this sector could be minimized by about 70%, with the intervention of Cleaner Production and implementation of the recommended CP options. The potentiality of CP options seen on the Fermentation sector is very high in both fermentation and distillation operations.

Although the pollution load seems to be reduced by about 70% after CP Intervention, primary and secondary treatments would be necessary to comply with the proposed standards for effluent to be discharged as inland water or in sewerage. CP measures will reduce the size of treatment plant required hence its installation as well as operating cost would reduce accordingly.

D. Sector: Leather Tanning

a. Brief Description

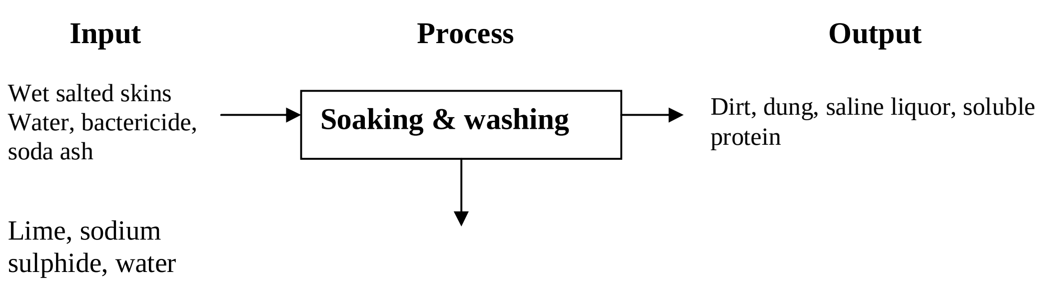
Although traditional productions of leather and shoes in Nepal were existing into practice since a long time with an involvement of a particular section of people in the society, the productions of leather and leather items in an organized manner started only in 1966 after the establishment of Bansbari Leather Factory in Kathmandu with an assistance of Government of China..

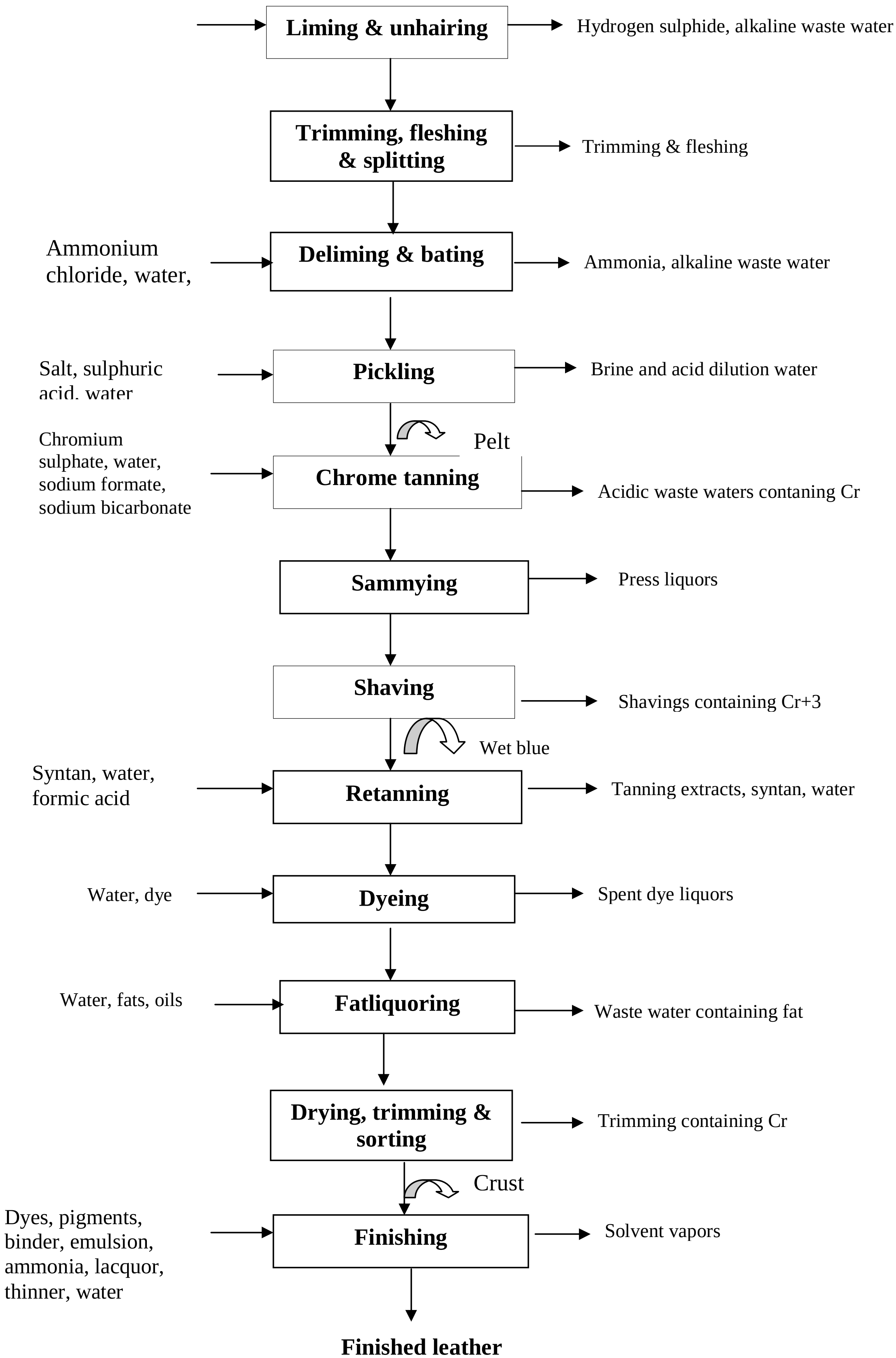
As per the available information and industrial data source at PACE Nepal, there are 12 leather tanning industrial units are in operation in the country. These units are mainly concentrated in Morang and Sunsari districts of eastern Nepal and Bara and Parsa districts of middle region of the country. In general these units are not in operation with an utilization of its full capacity. Tanning industry is an export-oriented industry and contributes significantly in the national economy. The export item of leather is mainly wet blue leather. This sector has given employment to about 600 persons in total in all 12 industries.

So far as leather production process is concerned, the units are not in use of a modern and or an improved technology and development in this regard is comparatively very slow. It has been observed that the leather processing knowledge and skills, both traditional and modern, are not properly disseminated. This is one of the main reasons for export of major quantity of semi processed wet blue form to yield less value-add on the product to the nation.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Leather Tanning Industry





Liming & unhairing
Hydrogen sulphide, alkaline waste water
Trimming, fleshing & splitting
Trimming & fleshing
Ammonium chloride, water,
Deliming & bating
Ammonia, alkaline waste water
Salt, sulphuric acid, water
Pickling
Brine and acid dilution water
Pelt
Chromium sulphate, water, sodium formate, sodium bicarbonate
Chrome tanning
Acidic waste waters contaning Cr
Sammying
Press liquors
Shaving
Shavings containing Cr+3
Wet blue
Syntan, water, formic acid
Retanning
Tanning extracts, syntan, water
Water, dye
Dyeing
Spent dye liquors
Water, fats, oils
Fatliquoring
Waste water containing fat
Drying, trimming & sorting
Trimming containing Cr
Crust
Dyes, pigments, binder, emulsion, ammonia, lacquor, thinner, water
Finishing
Solvent vapors
Finished leather

Brief Process Description

The principle operations in the tanneries to produce finished leather from raw hides and skins are described below.

Pre-tanning (or Beam house process)

The purpose of this process is to remove the undesirable constituents and to condition the skins for subsequent tanning process. Pre-tanning consists of following processes.

i) **Soaking:** The main raw material is hides and skins preserved using common salts. In this process the hides and skins are rehydrated to reverse the cure process with the help of water (25ºC), bactericide and soda ash as wetting agent. It removes blood, dung, curing salts, water-soluble and saline-soluble protein.

ii) **Unhairing and liming:** Lime blended with sodium sulphide is traditionally used to loosen wool and hair, or dissolve these into pulp. Additionally the process opens the fibre structure and plumps the hides and skins. The duration of the process may vary from 18 hours in drum to 7 days in pit.

iii) **Fleshing, trimming and splitting:** Limed hides and skins are fleshed mechanically in a fleshing machine to remove the adipose tissue from the flesh side of the hide. Then they are trimmed to remove the small-unwanted pieces from their edge.

iv) **Deliming and bating:** The lime from the limed pelt is removed by treatment with ammonium salts (ammonium sulphate) or weak acid (lactic acid) with water at a temperature of 37ºC.

v) **Washing and Pickling:** Water washing operation is carried out which is followed by pickling process in which the hides and skins are treated with delimed or bated pelts with a solution of salts and sulphuric acid with water at 25ºC to bring them to the desired pH for tanning.

Tanning

Tanning is the stabilization of the collagen structure of the hides and skins using natural or synthetic chemicals. The hides and skins after the tanning process are called wet blue. The most commonly used tanning agent is a basic chromium sulphate. The operation is carried out at 25ºC for one hour in already used pickled bath with 50% volume and is completed with a basification to bind the chromium in the leather. Sodium carbonate is used as a basifying agent. Boil test is used to check the proper tanning at this stage. In addition to this, sodium formate is used as masking agent and some fungicide is used as preservative to keep the wet blue for a longer period. After basification the wet blue leather is horsed up overnight.

Post tanning

The post-tanning processes are as follows:

Sammying: Sammying is the operation to bring wet blue leather to a uniform semi-dewatered state. The leather is passed into a sammying machine in order to squeeze surplus water out of the leather.

Splitting: Thick hides are splitted to required uniform thickness with the help of splitting machine. The top layer of the hides is called grain layer and the lower layer is called flesh layer.

Shaving: The shaving is a mechanical process to bring the leather to uniform thickness by shaving the material from

Chemical operation: It is during this process that the tanned hides and skins are converted into specific types of leather. It comprises five different wet processes. These are washing, neutralization, retanning, dyeing and fatliquoring. At the end of these processes hides and skins are dried and trimmed.

Finishing
Last operation carried out in the tanneries is the finishing operation. In this process the surface of the leather is coated with layers of finishing materials consisting of pigment, dye, binder, plasticiser, wax, emulsion and glazing material.

c. Inputs of Materials and Energy

Leather Tanning industries need a number of chemicals for its processes. The list of the major chemicals is given as follows:

1. Sodium Sulphide
2. Chromium Sulphate
3. Lime
4. Common salt
5. Sulphuric acid
6. Ammonium sulphate
7. Water

Besides, the industry also consumes electricity to run the machines and diesel is used for power back up through generating sets.

d. Waste Generation Scenario

Most of the tanneries do not have proper system for managing of wastes. Remnants of raw hides, fleshing, hair, trimmings and pieces of leather can be seen around. Decomposition of these solid waste and sludge is a major problem, which gives off foul and pungent smells. Similarly the proper treatment of effluent before discharging them to water bodies is lacking in almost all the tanneries. Simple sedimentation is done in the lagoons in some tanneries. Though an ETP, CETP and chrome recovery plants have been installed in the tanneries of Birgunj by the UNIDO project they have not been utilized properly. The following table projects the nature of waste, amount and their impact on the basis of assumption of processing of one-ton of hide.

Quantity of solid waste and its effect

Process	Type of waste	Quantity of waste (%)	Total quantity T, kg	Effect
Pre-tanning	Trimming Pulped hair Lime Fleshing	12 7-23	120 70-230	On land High BOD in the effluent On land
Tanning	Chrome containing organic matter Chrome split waste Trimming + shavings	 11.5 10	 115 100	On land
Post-tanning	Buffing dust	0.2	2	High dust particle affecting air quality the air
Finishing	Finished trimmings	3.2	32	
Total			439-599	

The liquid waste is generated mainly from pre-tanning and tanning operations and very little from post-tanning. The data given below is based on the technical literature.

Quantity of liquid waste and its effect

Process	Type of waste	Quantity of waste m^3 / T hides	Effect
Pre-tanning	Water effluent	18.0	High BOD, COD, TSS, TDS, salts, sulphides, organic N, ammonia N, pH,
Tanning	Water effluent	1.0	Chrome, acidity, BOD, COD, TDS, TSS,
Post-tanning	Water effluent	7.0	BOD, COD, TDS, chrome, syntans, dyes, fats
Other (mechanical operation, floor washing etc.)	Water effluent	25.0	TSS, TDS,BOD, COD, salts, sulphide, organic N, ammonia N, chrome, dyes, fats

Air emission

Air emission from this sector fall into three broad groups-odor mainly from beam houses, solvent vapor from finishing operations and gas emission from different pre-tanning operation. Odour arises from poor control of pre-tanning (beam house) operations, from poorly maintained primary treatment plants, and from decomposition of accumulated wastes. Solvent and other vapors from finishing operations on the other hand, depend critically on the types of chemicals used and it is said that even in an efficient process, up to 30% of the solvent used may be wasted and emitted. Gases like hydrogen sulphide (H_2S) and ammonia (NH_3) are produced due to chemical reaction in the processes like unhairing and deliming.

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:

It has been observed that in the production of leather, the average ratio of raw materials to leather production is around 1.3.

Energy consumption:
The production of leather mainly consumes electrical energy in its processes. The specific electrical energy consumption is found to be around 231 kWh / Ton of leather production.

Water consumption:
The specific consumption of water in tanneries is around 493 cu.m. / ton.

Man-day utilization:
A total of around 30.23 man-days are utilized for the each Ton production of leather.

f. Potential of no cost and low cost CP options

The experience of carrying out Cleaner Production activities in tanneries, it has been realized that the environment impact of this sector could be minimized with the intervention of Cleaner Production. The potentiality of CP options seen on the leather sector is very high in both pre-tanning and tanning operations.

Stopping leakage from the water pipes, adaptation of batch washing against continuous rinsing, installation of water meter at the water sources, shaking of wet salted hide and skin to remove salt, using green hide against wet salted hide and green fleshing are some of the important no and low cost options. A list of similar options and expected benefits from the implementation of the options are given below in the table.

S.N.	CP option	Expected benefit
1	Stop leakage from water pipes	Reduction of water volume in waste water
2	Installation of water meter at the water sources	Reduction of water use
3	Avoid spillage of water	Reduction of water volume in waste water
5	Awareness on water conservation	Avoid unnecessary water use
6	Adaptation of batch washing against continuous rinsing	Reduction of water volume
7	Proper storage of raw hide and skin	Prevention from damage
8	Proper storage of chemicals	Reduction in chemical wastage
9	Proper handling of chemicals	Reduction in chemical wastage and minimize health risk
10	Shaking of wet salted hide and skin	50 % reduction of salinity discharge in waste water
11	Proper weighing of hide and skin at different stage of processing	Reduction in chemicals and water consumption
12	Segregation of solid waste from different mechanical operation	Proper management of solid wastes and more cleaner sight

13	Proper screening of solid waste from waste water	Reduction in BOD and COD load
14	Use of trolley to carry hide and skin or leather	Improved OHS and increase in productivity
15	Good maintenance of machinery as well as drums.	Increase production efficiency
16	Training to workers on production process control	Controlled process, good quality product, reduction of unnecessary wastes and improve efficiency
17	Awareness to workers on health and safety aspects	Minimize accidental costs
18	Improvement in boiler efficiency	Reduces energy cost, improve air quality
19	Use of green hide from abattoirs against wet salted hide	Reduction in soaking time, water, wetting agents, & absence of salt in waste water
24	Green fleshing	Reduction in chemical & water consumption
25	Hides splits in limed condition	Reduce chemical consumption, and chrome tanned solid waste
28	Reuse of 1st wash after soaking for next batch soaking	Reduction of water use

g. Estimated investment and pay back period

In course of carrying out CP assessment in leather tanning industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

Process	CP option	Tentative investment, (NPR)	Saving (%)	Annual savings, (NPR)	Expected pay back period
Unhairing & liming	Reuse of spent lime-sulphide liquor for next batch liming	70,000	20% sodium sulphide 50% lime	1,37,200 1,13,400	4 months
Chrome tanning	Chrome bath recovery and reuse	1,000,000	95%	957600	18 months
Pre-tanning and tanning	Installation of water regulator in the water pipe	1,25,000	50%	98000	15 months
Total		11,95,000		13,06,200	12 months

h. Environmental Benefits

Tanning industry is a pollution prone industry. It uses various chemicals such as basic chromium sulphate, sodium sulphide, lime, acids etc., which are hazardous to health and the environment. The waste arising in the tanneries are due to surplus use or washed out chemicals, used during different processes of production. The solid wastes and effluent generated from the tanneries give rise to BOD, COD, TDS, pH etc., which and adversely affect the environment and health. Despite these, the industries are still operating in a conventional way without caring much on the pollution prevention or practicing control measures. Government of Nepal has published wastewater standard for the tanneries. The effluent characteristics, expected reduction and status are presented in the table below.

Characteristics	Expected Reduction (%)	Present status	Future status	Tolerance limit
BOD (mg/lit)	70	1600	480	100
COD (mg/lit)	50	4440	2220	250
Total chrome (mg/lit)	35	110	71.5	2
Sulphide (mg/lit)	20 - 50	170	110.5	2
SS (mg/lit)	95	2400	1200	100
pH		8-9	6-9	6-9

Although it is possible to reduce the pollution load discharged by practicing CP, it is clearly seen from above table that except for pH all other parameters will still be much higher compared to the tolerance limits set in the effluent standards.

E. Sector: Pulp and Paper

a. Brief Description

Nepal has a long history of paper production. Although produced in a limited quantity, the Nepali handmade paper is still very popular especially for the preparation of legal documents for procedures in the court and also to manufacture handicrafts and decorative items. The manufacturing of paper from modern milling units has a history of only nearly two and a half decades. There are five big paper mills in Nepal and all of them are located outside Kathmandu valley. These industries have given employment to more than 2000 people. Besides, there are a number of small-scale handmade Nepali paper manufacturing industries located at different place all over the country especially at the hilly regions where easily and abundantly its raw materials are available. Presently the bigger paper mills are producing mainly two types of products, the bleached Writing and Printing (W/P) and Newsprint paper and the unbleached Kraft paper. The Newsprint is consumed 100 % in the market and W/P is about 60%. Besides these papers, the demand of Kraft paper is also growing slowly in the country.

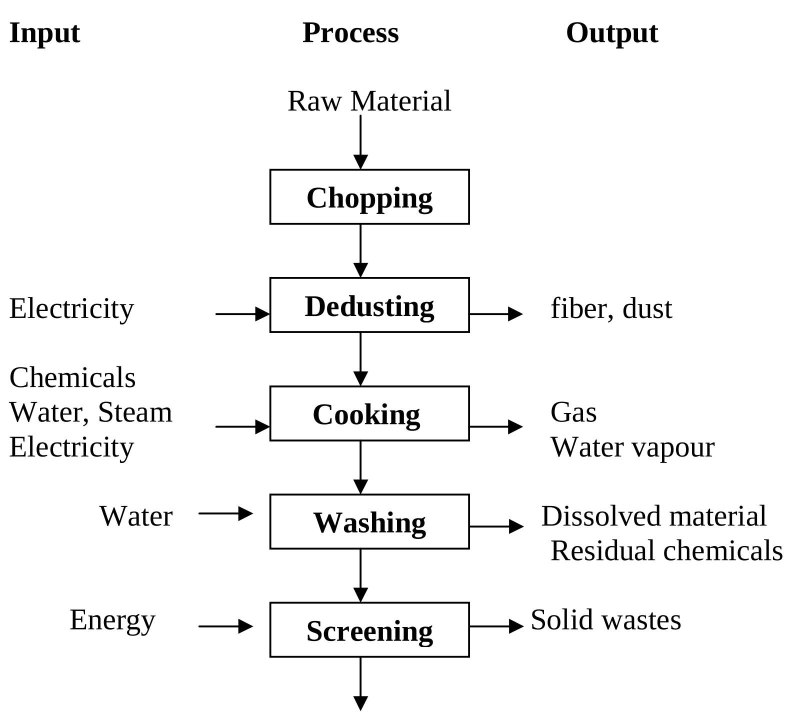
The papermaking fibers in Nepal are locally produced Non-wood pulp, which is consumed about 63 % and locally collected recycled papers, which is consumed about 37%. Newsprint and writing / printing consumption are growing very fast with the increasing of literacy and number of school goers, awareness and exposure among the people but on the other hand the consumption of the carton board and Kraft paper is not very significant in compare other papers. There is an estimation that the market of paper will grow in Nepal in future and it is estimated that the domestic requirement of the paper will go as high as 68,000 tons in the year 2010 that corresponds to the growth rate of 5.8 % per annum. The growth trend of paper consumption in Nepal is given in the table below.

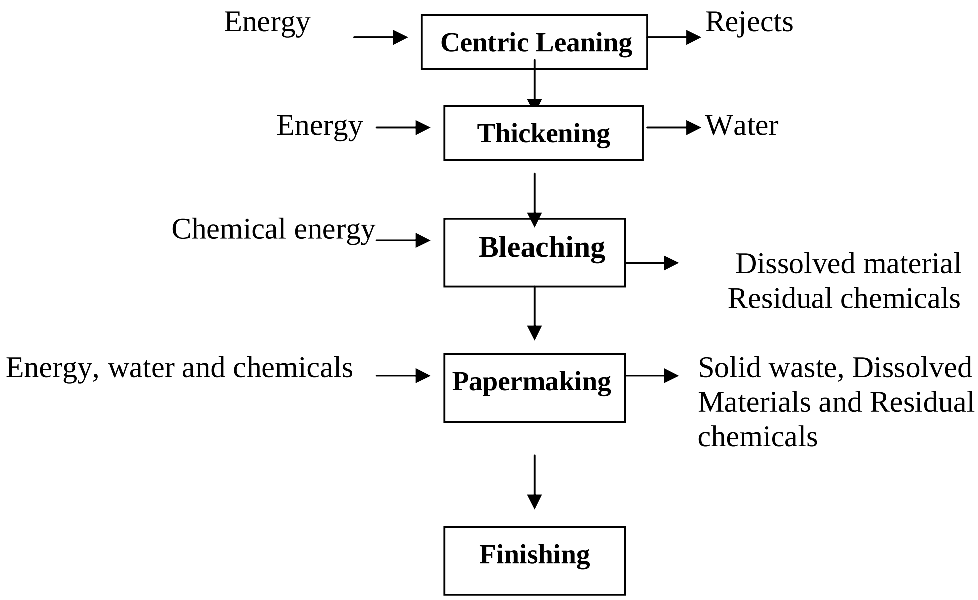
Paper Type	1980	1995	2010
Newsprint	1	3	10
Uncoated Paper	4	15	30
Coated Paper	0	0	2
Tissue Paper	0	0	2
Corrugating Material	4	5	11
Carton Boards	0	0	2
Other Paper and Boards	2	6	11
Total	**11**	**29**	**68**

Figures shown in the table are paper consumption in thousand tons

b. Process Flow Chart and Brief Process Description

Process Flow Chart Pulp and Paper industry





Brief Process Description

Raw Materials Storage and Preparation:
Rice straw, bagasse, wheat straw, kans, sabai grass, jute are procured in loose in trucks and stored in an open yard. How ever rice straw and sabai grass are stacked. Raw material preparation The raw materials (agriculture residue/ forest grass) are cut to desired chip size and de-dusted to remove the dust and fed to the continuous digester for cooking. Whereas in the case of bagasse it is de-pithed to remove the pith before feeding to the digester.

Cooking:
The raw material is cooked in the continuous or batch digester along with caustic / sodium sulphide at a given particular temperature and pressure by applying steam. During cooking the cellulose fibres gets disintegrated and the binding material lignin is separated out. Cooked material from the digester is transferred to the blow tank. Process parameter like Temperature, pressure and time are very important in cooking.

Washing and cleaning:
The cooked raw material (brown pulp) is required to be washed and cleaned. The washing is achieved with the help of vacuum or potcher washers. The washed pulp is passed through screen, centri-cleaning and thickener to remove the un-cooked materials, foreign materials and sand. The washed and cleaned pulp is transferred to the bleaching section.

Bleaching:
The washed and cleaned pulp is bleached with the help of chlorine and hypo solution. The sequence of bleaching is C-E-H-H. The bleaching sequence is followed according

to prescribed parameters to achieve pulp of desired brightness. The bleached pulp is washed through vacuum washer and passed through the centri-cleaner for the stock preparation.

Paper making:
The bleached pulp after washing is prepared for papermaking. The furnish (blending of different qualities of pulp) is decided depending upon the type/quality of the paper to be produced. Once the furnish is decided, the pulp is mixed with different chemicals (rosin, alum, talc etc), dyes and mixing is done mechanically to achieve the desired pulp quality. The furnish is transferred to the head box of the paper machine through a centri-cleaner.

Re-winding, cutting and finishing:
Paper rolls are cut and rewound to the required width and cut to the required sizes. After quality checking the finished products are wrapped, strapped and stored ready for dispatch

c. Inputs of Materials and Energy

The major raw materials for Pulp and Paper Industry sector are:
- Agro-Residues
- Baggasse
- Secondary Fibers
- Kans and Sabai Grass

Agro-Residues: These are the residues left after agricultural production. The Raw Material consists of rice and wheat straw. The availability of the raw materials in the country is good because rice and wheat are the main agricultural productions to provide people of Nepal as main food. However, some paper mills also do import wheat straw from India due to easy availability in terms of transportation and price.

Baggasse: Baggasse are also the residues left after sugarcane crushing in the sugar mills. These are also very good raw materials for Pulp and paper. The domestic baggasse cannot fulfill the demand of all the mills so are also imported from India

Secondary Fibers: Secondary fibers are the recycle paper. The recycle papers are collected from the different sources especially through the scrape collectors.

Grasses: Grasses like Sabai grass and Kans are very good raw materials for paper mill. A few paper mills use these grass locally available in the country as their raw materials.

Chemicals: Besides these basic raw materials, large quantities of chemicals are used in paper mills for pulping and bleaching process. Chemicals used for pulping are Sodium Hydroxide and Sodium Sulphite. The chemicals used in bleaching are Hypo chlorite prepared from Lime and liquid Chlorine. The chemicals are imported from local companies of India. The Chemicals used for neutralization and washing purposes are Hydrochloric acid, Sodium silicate, household detergent, softener etc.

The chemical consumption in pulping process varies according to bath ratio of the raw material. Bath ratio is the ratio of fiber and water in the digester. All the paper mills have the ratio 1:3.5. The chemical varies according to the property of the fiber that how smoothly the chemical penetrates inside the fiber. The % of chemical consumption varies with different types of raw material.

Consumption of water: Water requirement is very high in pulp and paper industries. The major consumption of water occurs in washing and papermaking units.

Consumption of energy: The major consumers of energy in the papermaking units are screening and drying. The screening units consumes electrical energy and drying units mainly the thermal and electrical energy. Other units consume electrical energy for lightening purpose.

d. Waste Generation Scenario

Liquid waste: The liquid waste generated from paper mills is generally consists of dissolved chlorinated organic compound and the residual chemicals. The majority of wastes from screening washing units discharged with their effluent directly or indirectly into surface water only after simple pre-treatment. The industries have different system regarding effluent treatment facilities. Some have small sedimentation ponds for settling effluent, some have lagooning system and some already have effluent treatment plant but none of them have heat recovery system of the discharged black liquor. The pre-treated waste from all the industries finally discharged to the river near by.

Solid waste: The solid waste generated from paper industry is mainly the fines and fiber. The other are dusts, uncooked material, and rejects from centricleaner and ash from the boiler house. The wastes accounts about 40 – 50 % for total production. The fines, fibers are sold to local people for about NPR 10-15 / Kg. The percentage of waste generation varies from 56 to 65 % in case of writing / printing paper and about 42 % in case of media and craft pappers.

Air emission: The air pollution from the paper mills is mainly from boiler units and a few from pulping unit. The air pollution comes from the burning of fuel for the generation of steam in boiler. Most of the industries use rice husk and the major pollutants are NO_2, CO_2, CO and SO_2.

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:

It has been observed that in the production of the paper from the paper mills, the average ratio of consumption of raw materials to the production is about 3.5.

Energy consumption:

The specific electrical energy consumption is found to be around 1,312 kWh / ton of paper production. Similarly the fuel consumption in order to get the thermal energy in the processes is around 0.77 Ton of fuel (Rice Husk) per ton of production of paper.

Water consumption:

The specific water consumption in paper mills is around 285 cu.m. / ton of paper production.

Man-day utilization:
A total of around 14.92 man-day is utilized for the each ton production of paper.

f. Potential of no cost and low cost CP options

With regards to the reduction of resources going waste in paper mills and to yield monetary benefit to the organization and at the same time to reduce the environmental consequences, Cleaner Production assessment is believed to be an important activity and must to adopt. Some of the low and no cost CP options with some expected befits are highlight below in the table.

Process	C.P. options	Expected benefits
1. Raw Material Preparation	1) Proper storage and covering shed for raw materials.	-Reduction in water consumption - Reduction in pollution load
2. Cooking	1) Proper handling of raw material	- Reduced chemical requirement - Reduction in rejects
	2) Wet cleaning of straw for removal of fines and dust	- Reduction in consumption of steam - Reduction in screenings
	3) Proper loading of raw material in the digester	- Improve packing density - Increased digester capacity
	4) Proper insulation of digester and steam pipes	-Reduce steam requirement
	5) Improving boiler efficiency	-Energy saving
	6) Degasification of digester	- Reduction in chemical consumption
	7) Reduction in fiber liquor ratio (Bath ratio)	-Reduction in cooking time - Reduction in steam consumption by 5-10 %
	8) Use of black liquor in the preparation of caustic lye	Water and chemical savings
	9) Constant feeding system to continuous digester to reduce blow back	Reduction in pulp loss
3. Pulp Washing	1) Proper Maintenance of the consistency of potcher washer	Reduction in water consumption and pollution load
	2) Proper maintenance of the mesh size of washing drums and Decker	Reduction in fiber loss and pollution load
	3) Direct feeding system to the screens after washing	Reduction in chemicals and pollution load
	4) Application of chemicals as per quality of carpet	Reduction in spillage of black liquor, pulp and pollution load
	5) Replacement of manual handling of jute pulp by mechanical handling	Reduction in pulp loss during transportation
	6) Avoiding spillage of chemicals and water	Reduction in chemicals and pollution load
	7) Making proper specification of chemicals for purchasing	Reduction in chemicals and pollution load
	8) Consistency test at regular intervals	Reduction in overuse of chemicals, water, pulp and pollution load
	9) Regular maintenance of temperature profile of MG dryer	Energy saving
	10) Regular maintenance of pressures in Dryers and digester	Energy saving
3.Centricleaning	11) Reuse of pulp from stone arrestor at reffeler	Pulp saving

	12) Proper maintenance of orifice, nozzle of centricleaners	Saving fiber losses

g. Estimated investment and pay back period

In course of carrying out CP assessment in pulp and paper industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

Process	C.P. options	Estimated investment (NPR)	Annual operating cost (NPR)	Expected annual savings (NPR)	Expected pay back period (Year)
Raw material preparation	Installation of depither	6,403,000	2,050,000	3,719,277	2.0
Washing	Wet washing of raw materials	5,428,340		339,660	1.9
	Squeezing Black liquor	1,310,080	300,000	342,000	2.8
Energy	Installation of energy efficient motors	195,000	10,000	196,314	1.0
	Installation of reffler	50,000	5,000	50,000	1.0
	Installation of capacitators	360,000	60,000	339,660	1.0
Centricleaners	Collection of T.C.C rejects	255,000	50,000	600,000	0. 5
Effluent treatment plant	Install effluent treatment plant	3,500,000	600,000	2,557,600	1. 3

The above figures are estimated for 1 ton /day production

h. Environmental Benefits

The environmental impact of this sector could be minimized with the intervention of Cleaner Production. The potentiality of Cleaner Production seen on this sector is very high. With the implementation of Cleaner Production options, in average, a Paper mill can reduce its COD Load by up to 87 %, BOD load up to 92 %, TSS Load by 55% and wastewater discharge by about 50% with an investment of approximately NPR 1.5 millions.

All the options (no/low cost and investment demanding options) either reduce the pollution load or energy consumption and consequently this leads to a positive impact in the environment. The expected result can be described as follows:

Parameters	Expected reduction	Present Status
Energy savings - Thermal - Electrical	 20% 20%	 1710 - 68656 6.5 - 150
Chemical saving	30%	2.9 - 20.6
BOD	92 %	7315 - 9975
COD	87 %	20520 - 37152
TSS	50 %	101 - 310
PH	8 (Expected value)	6 - 7.5
Water consumption Reduction	20%	550 - 27000

Similarly, the critical standard parameter of the effluent comparing with the existing Nepalese effluent standard before and after implementing CP is given in the table below:

Parameter	Before C.P. implementation (At present)	After C.P. implementation (Expected)
pH	6.7 - 8.0	5.5 - 9.0
TSS	200 – 2,044	100 - 350
COD	20,520 – 37,152	1,000 – 1,800
BOD	7,315 – 9,975	250 - 400

F. Sector: Soap

a. Brief Description

Soap was made by the conventional method in domestic and cottage level with the help of boiling pan where oils, caustic and other additives were added to produce soap. This method is still practiced in some parts in spite of commercial production of soap by modern plants. Industrial manufacturing of soap started only from 1976 with the establishment of Mahashakti Soap and Chemical Industries in Hetauda Industrial District. Presently, 26 number of soap industries are registered in Nepal out of which 23 industries are in operation. Most of these industries are located in central and eastern part of Terai (southern) belt. About 3,000 persons are involved in this sector. The major products are laundry soap and toilet soap. Annual production is estimated to be around 50,000 Tonnes of soap. The average capacity utilisation of this sector is found to be in between 67 to 77 %.

Other than domestic market, Soap is also exported to other countries mainly from India. On the other side, some laundry soaps are also export to India especially to the adjoining boarder areas. Its total contribution to the major industrial product exported to India is around 7 to 8 %. The contribution of Soap and Detergent Industries in the overall production of Manufacturing Industries at the national level is around 2 % only.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Soap Industry

Input	Unit process	Output
Fatty Acid Steam	**Oil Melting**	Spilled/Residual Oil Waste Steam
Sodium/Potassium Hydroxide Steam	**Saponification**	Spent Lye Nigre
Silicate Filler Colour	**Mixing**	Gaseous Emissions
Steam	**Filtering**	Condensate
	Intermediate Storing	Leftover soap
Electricity Steam	**Vacuum Spray Drying**	Leftover soap
Electricity Chilled Water	**Extrusion**	Heated Water
Electricity	**Cutting**	Trimmed Soap
Electricity	**Stamping**	Waste Soap
Packing Materials	**Packing**	
	Soap	

Brief Process Description

Oil melting

Oil contained in 185 Kg mild steel drums are melted using direct steam jets. The drums are placed either vertically or in an inclined position, so that as oil melts it is automatically drained out from the drums. Approximate time for melting varies from 45 – 85 minutes depending on the ambient temperature.

Saponification

Oil from the feed tank, ranging 40^0C – 45^0C in temperature, is fed into the Saponification pan where caustic solution of approximately 30 % - 45 % concentration is mixed with oil for Saponification reaction to take place. Mixing and boiling is done with the help of live steam for 2-3 hours depending on the batch size, quality and composition of oil used and desired output soap product

Mixing
Mixing of neat soap with builders, silicates, colours and other additives is done in Crutcher. To maintain the temperature of the soap mass, the crutcher is heated through jacketed steam system. The temperature of the soap mass is maintained at 90^0C.

Filtering
After the operation in Crutcher, the mixed soap is transferred to feeding tank through filter to remove unwanted material. The filter and the transfer line is steam jacketed to maintain the flow of the soap mass.

Intermediate Storing
The Soap mass is collected in the feed tank for spray drying in the Mazzoni.

Vacume Spray Drying
The soap is pumped into the spray chamber maintained under vacuum (710 mmHg to 720 mm Hg) by variable speed metering pump. The spray is directed against the wall of the chamber and during this operation; the soap solidifies and sticks to the surface of the chamber. It is continuously scraped by the scraper and discharged to the bottom of the spray chamber in the form of soap chips. A Refiner located at the bottom of the chamber extrudes the soap through a perforated plate assembly in the form of noodles, which is simultaneously cut into smaller bits and fed into a plodder located below and maintained under vacuum.

Extrusion
Extrusion or Plodding is an operation by which soap is extruded through a die plate in the form of continuous bar. There are two types of plodder, one with single screw, which operated in atmospheric pressure and other with twin screw rotating within the casing, which operates in vacuum (500 - 600mm Hg). The vacuum ensures that any entrapped air is removed from the soap and the twin screw develops a positive pressure for extrusion than single screw. Compression of the soap by the plodder worm leads to generation of heat, which is removed by jacket of chilled water.

Cutting, Stamping and Packing
The soap extruded from the plodder is cut into long billets continuously by reciprocating wire cutter or rotary cutter. Generally, in small scale industries it is done manually with the help of a wire cutter of fixed length. The cut billet is then fed to the reciprocating wire cutter where required sizes of bar is made and fed to stamping machine. Stamping is normally carried out by passing the cut bar between pair of rotating dies actuated by the bar itself. Then finally the stamped bar is wrapped and packed for dispatch. Common wrapping material for the laundry soap is wax coated poster paper.

c. Inputs of Materials and Energy

Soap industries are chemical based industry. The industry uses a number of chemicals including hazardous to manufacture the soap. Some of the major raw materials and their characteristics used in the industry are given as follows:

S.N.	Raw materials	SAP Value	Iodine Value %	Unsaponifiable Matter (% Max)	Free Fatty Acids(% Max)	Usage (Soap)
1.	Rice Bran Oil	175-195	85-105	7	75	Laundry
2.	Sal Oil	186-195	35-42	1	12	Laundry
3.	Castor Oil	177-185	65	1	6	Toilet
4.	Coconut Oil	250-264	7.5-10	0.8	3.5	Toilet
5.	Groundnut Oil	188-195	87-98	0.8	5.0	Laundry
6.	Acid Oils	185-195	80-90	2	>60	Laundry
7.	Palm Oil	195-205	45-56	1	5	Toilet/Laundry
8.	Palm Kernel Oil	237-255	10-23	1	3	Toilet
9.	Tallow	192-202	32-50	0.5	2-4	Toilet

Besides, the industry uses caustic soda, fatty acid, silicate, filler, salt and colours.

d. Waste Generation Scenario

The major waste stream of soap industry is the effluent dischrged. The industry also generates solid wastes. An estimated loss of resources through discharge of the waste is given in the table below:

S.N.	Process	Type of waste	Quantity of waste, %	Remarks
1.	Raw Material Preparation	Oil and Chemical spills	0.012	Washed out as effluent
2.	Saponification	Spent Lye with chemicals like Caustic Soda, Salts, soap, unsaponified fatty acid etc.	19.2	Most quantity can be reused after Settling and Bleaching
3.	Mixing	Fillers and Additives	0.032	Washed as effluent
4.	Filtering and intermediate storing	Soap	0.35	Reused in previous process
5.	Vacume Spray Drying	Soap	0.47	Reused in previous process
6.	Extrusion	Soap	0.16	Reused in previous process
7.	Cutting	Soap	4.45	Reused in previous process
8.	Stamping and Packing	Soap	2	Reused in previous process

Approximately 90 % of the waste soap after the saponification process is reused in the previous process. Even then, the industry is losing a lot of resources.

In most of the industries, there is no proper system for managing the wastes. The Spent Lye discharged from the industry passes through a tank where upper layer is skimmed off and reused. The final effluent is discharged directly to nearby stream / sewer or left in a wide area where part of the water gets evaporated and some chemicals with water seeps in the ground thereby causing groundwater pollution.

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:
It has been observed that in course of production of the soap, the average ratio of consumption of raw materials to the production is around 0.76.

Energy consumption:
The specific electrical energy consumption is found to be around 90 kWh / ton of soap production. Similarly the fuel consumption in order to get the thermal energy in the processes is around 0.6 Ton of fuel (Rice Husk) per ton of production of soap.

Water consumption:
The specific water consumption in soap industry is found to be around 12.3 cu.m. / ton of soap production.

Man-day utilization:
A total of around 6.5 man-day is utilized for the each ton production of soap.

f. Potential of no cost and low cost CP options

Cleaner Production intervention in some of the soap industries reveals that there are potentials of implementation of a number of no and low cost CP options, which would obviously enhance the productivity reducing pollution load to the environment. A number of such CP options including options relating to the good housekeeping and better operating practices are list below as follows:

S.N.	Option	Remarks
1.	Use of better quality raw materials (Oil, Caustic)	-Waste minimize
2.	Better waste soap handling	-Loss minimize
3.	Awareness, Attitudinal change, Motivation	-Losses minimize
4.	Employment of skilled Boiling man / on the job training	-Loss minimize
5.	Installation of measuring device	-Waste minimize
6.	Collection of spent lye in Retention pond and extract materials before discharge	-Environmental benefit
7.	Preventive maintenance of machines and equipment	-Productivity enhanced

S.N.	Option	Remarks
8.	Installation of Translucent sheets	-Energy saving
9.	Increase frequency of cleaning	-Risk of accident reduce -Better work place
10.	Awareness on OHS	-OHS condition improve
11.	Provision of First Aid with trained person / Emergency preparedness plan	-Risk of damage reduce
12.	Introduction of drum trolley to handle the oil drum in oil melting and drum storing	-Risk of accident reduce -Manpower saving
13.	Caustic solution is prepared with care and responsible person	-Risk of hazard reduce
14.	Strictly use of provided PPE during handling of caustic soda and drum and Providing safety goggles for involved workers in caustic / silicate handling and soap pan boiling	-Risk of accident reduce
15.	Switching off tube light during day time	-Energy saving
16.	Cleaning / Replacement of translucent sheets and painting with white lime paint	-Energy saving

g. Estimated investment and pay back period

In course of carrying out CP assessment in soap industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

S.N.	Nature of option	Estimated Investment (NPR)	Expected savings/year (NPR)	Pay back period (Year)	Anticipated Benefit
1.	Use of Flue Gas for Oil Melting	333,000	217,500	1.5	Reduction in GHG Emissions
2.	Installation Economizer for Boiler Feed water Heating	400,000	268,466	1.5	Reduction in GHG Emissions
3.	Installation of cover on the Saponification pan with mech. agitator.	322,160	Nil	No Payback	Reduction in heat stress to the workers. Better working environment.
4.	Replacement of traditional belt conveyer with screw conveyer	282,920	220,000	1.3	Enhancement in productivity. Reduction in risk of accidents due to

S.N.	Nature of option	Estimated Investment (NPR)	Expected savings/year (NPR)	Pay back period (Year)	Anticipated Benefit
					slippery floor.
5.	Installation of Variable speed drive for the Feed Pump at the Podder	50,000	431,000	0.12 (2 months)	Enhancement in Productivity. Less jamming of machine.
6.	Reuse of Spent Lye	522,000	389,000	1.3	Saving Of Raw Material. Reduced Pollution Load

h. Environmental Benefits

With the implementation of the CP options in the soap industry, besides monetary benefit to the industry, there are significant benefits on the environment also. The environmental impact of this sector could be minimized with the intervention of Cleaner Production. The potentiality of Cleaner Production seen on this sector is very high. Reuse of Spent lye is one of the major options which can reduce the pollution load of this sector. It has been observed that by implementing CP options, an average soap industry can reduce its COD Load by up to 54 %, BOD Load by up to 50% and wastewater discharge by around 66%.

G. Sector: Sugar

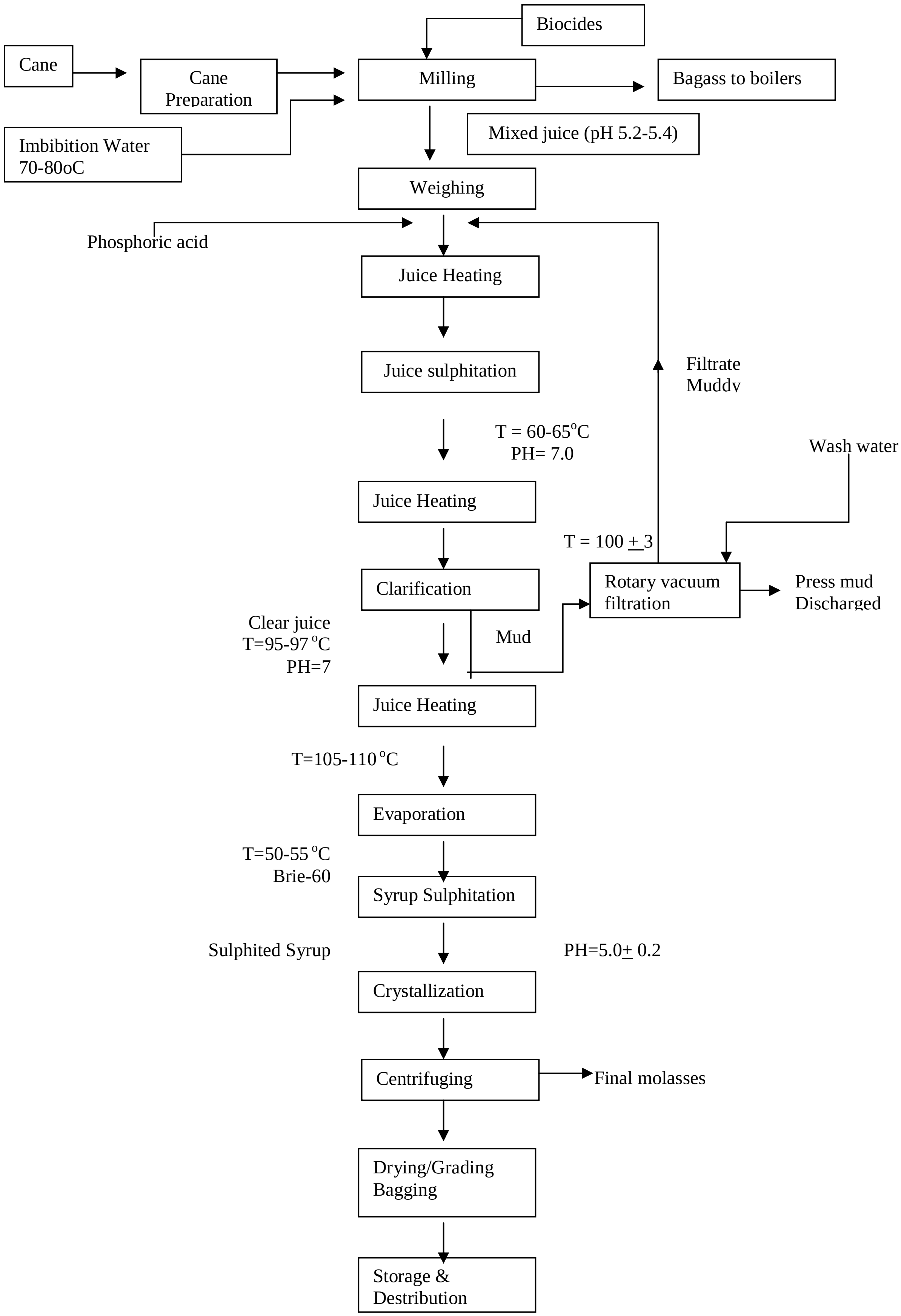
a. Brief Description

Sugar is an essential food commodity. There are altogether nine medium and large scale sugar industries operating in the country. The annual production volume of these sugar industries (large / medium) is about 1 lakh Tons, which amounts to around 44 % utilization of the approved capacity of these industries. Employment generated by these industries is about 6,000 persons. There are a number of small scale units which produce "Khandsari" and "Sakhar" from the crushing of sugarcane. Production of white plantation crystalline sugar occurs primarily in the medium or large-scale units. Khandsari and other Sakhar manufacturing units are involved in producing low grade sugar (brownish and very small sized crystals).

In general, each of the sugar mills has the installed capacity of cane crushing ranging from 1,000 to 3,000 sugarcane crushing capacity per day (TCD). The recovery of sugar varies from one unit to another. It has been observed that the lowest yield is around 8 % and the higher side of it is towards 9.4 %.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Sugar Mill


Biocides
Cane
Cane Preparation
Milling
Bagass to boilers
Imbibition Water 70-80oC
Mixed juice (pH 5.2-5.4)
Weighing
Phosphoric acid
Juice Heating
Juice sulphitation
Filtrate Muddy
T = 60-65°C PH= 7.0
Wash water
Juice Heating
T = 100 ± 3
Clarification
Rotary vacuum filtration
Press mud Discharged
Clear juice T=95-97 °C PH=7
Mud
Juice Heating
T=105-110 °C
Evaporation
T=50-55 °C Brie-60
Syrup Sulphitation
Sulphited Syrup
PH=5.0± 0.2
Crystallization
Centrifuging
Final molasses
Drying/Grading Bagging
Storage & Destribution

Brief Process Description

Cane preparation:

Sugar cane is transported to the factory using private trucks bullock carts and tractors, which are unloaded to the feeder or stored in the cane preparation unit consists of cane yield or directly feed to the can carrier. The can production unit consists of can kicker controls the feeding orientation. It smoothens the can prior to the cane cutter. The can cutter chops the can stalks into smaller pieces.

Juice extraction:

Shredded cane or cane fibers from the fibriser drop into the rake elevator and are conveyed into the Donnelley chute pressure feeder. Pressure feeder feeds the fiber into the first mill. By means of intermediate rake carrier bagasse is conveyed. The extracted juice from the first mill is called primary juice. Tit is collected in the mixed juice tank after filtering in the DSM or Rotating vacuum filter with the help of juice pump. The bagasse removed by the DSM filter is returned to the first mill. The mixed juice will have pH of 5.2-5.4 juice from second, third and the fourth mills is used as the imbibition for the first second and third mills respectively. Beside the extracted juice , imbibition water (fresh condensate) at 70-80^{o}C is sprayed on the bagasse in the third mill in order to increase the efficiency of extraction. Phosphoric acid is added to the mixed juice after weighing and the juice is then sent to the juice heaters. Bagasse from the fourth mill is sent to the boiler as fuel to generate the high-pressure super heated steam.

Clarification of juice:

Juice is composed of various organic and inorganic compounds in different concentration. Mixed juice, which leaves the mills is greenish-gray to dark green opaque liquid that carries suspended matter such as bagacillo, gums, wax, colouring matter, soil particles etc. A clarification operation is carried out and forwarded to evaporation station for concentration.

Evaporation:

The main purpose of the evaporation in multi stages is to concentrate the clear juice from 13-15 Brix to around 60-75 Brix. This requires evaporation of approximately 75-80% of water in the clear juice.

Syrup suphitation:

The syrup from the last effect of the evaporator set is pumped to a syrup sulphiter unit where Sulphur dioxide gas is bubbled through it. Sulphur dioxide is a powerful bleaching agent and decolourises the syrup. At the same time, it reduces the viscosity of syrup. The pH of sulphited syrup is maintained at 4.8-5.2.

Pan Boiling:

Pan boiling is the heart of the sugar manufacturing process. Generally pan boiling is carried out in three stages (A, B and C). The boiling operation is done under vacuum to reduce the boiling temperature of syrup. The vacuum maintained inside the pan is around 635-660 mm of Hg (25-26"Hg). A sugar is the final product and is bagged. B sugar is developed from the molasses obtained from purging A massecuite.

Crystallization:

After pan boiling A, B and C massecuites are sent to the respective crystallisers for initial cooling and further crystal growth. A massecuite is cooled in air-cooled crystallisers while B and C massecuites employ water-cooled crystalliser. As the massecuites cool in these crystallisers, further sucrose deposition in the crystals formed during pan boiling is achieved and the crystals grow in size. While it is advantageous to cool all grades of massecuite. But A and B massecuite generally cured hot. However cooling of C massecuite is significant to control the purity of final molasses and hence reduce the sugar loss. C massecuite is initially cooled to 42°C-43°C in the crystalliser and reheated to 51°C -52°C prior to curing in the centrifugal machine.

Centrifugation:
Centrifugal machines are of two types: Batch and continuous. Batch types are generally used for A massecuite curing and continuous types are used for B and C massecuite curing. These machines rotate at high speed and employ centrifugal force to separate crystals from mother liquor. These machines are equipped with combined electrical and mechanical control systems. The final product A sugar is directly discharged in to sugar hopper. After drying and grading, the sugar is bagged and stored.

c. Inputs of Materials and Energy

In order to produce 1 Ton of sugar, it is estimated that the following quantities of raw material are used.

S.N.	***Raw materials***	***Quantity***
1.	Sugar cane	11,000 Kg
2.	Quick lime	33 Kg
3.	Sulfur	11 Kg
4.	Filter cloth	0.044 m2
5.	Coagulant	0.05 Kg

Major raw materials and energy consumption per ton of cane crushed.

S. No.	***Resources***	***Specific consumption, Per Ton of cane crushed***
13.	Sulfur	0.001 T
14.	Quick lime	0.0016-0.003 T
15.	Water (except the colony within premises)	5-10 m^3
16.	Filter cloth	0.0083 m2
17.	Coagulant	0.0033 kg
18.	Caustic Soda	0.000041 T
19.	Alum	0.00033 T
20.	Resin	0.000025 KL
21.	Salt	0.000083 T
22.	Sacks (Jute-100 Kg)	0.9166 Nos.
23.	Ammonium Sulfate	0.000125 T
24.	Washing Soda	0.0000017 T
25.	Electricity	40-50 kWh
26.	Steam (1 bagasse=1.8 steam)	0.565-0.621 T
27.	Fire Wood	0.0083 T
28.	LDO	0.005 KL

S. No.	*Resources*	*Specific consumption, Per Ton of cane crushed*
29.	Diesel (For transporting cane)	0.0025 KL
30.	Lubricants	0.0002 KL

d. Waste Generation Scenario

Sugar industries are pollution prone industries. The waste arising in the Sugar industries are due to spillages and passage of cane juice, Molasses and sugar dust in drain, during Milling, Concentration and Centrifugation processes. The effluent generated from the sugar industries gives rise to high BOD, COD, TDS, pH, color etc., which adversely affect the environment and health. Despite these, most of the industries are still operating in a conventional way without any pollution prevention or control measures. Government of Nepal has published a wastewater standard for the Sugar industries. The wastes generation from the sugar mills as specific discharge per ton of cane crushing is estimated as follows and given below in the table.

S. No.	*Resources*	*Specific Discharge, T Per Ton of cane crushed*
1.	Mud from vacuum filter (having 70% moisture)	0.026 T
2.	Fly ash (In air)	0.0055 T (5.5 Kg)
3.	Ash	0.090 T
4.	Bagasse	0.300 T (50% moisture)
5.	TSS (Ton)	0.0060-0.0075 T (6-7.5 Kg)
6.	BOD (Ton)	0.0036-0.0045 T (3.6-4.5 Kg)
7.	COD (Ton)	0.0060-0.0075 T (6-7.5 Kg)
8.	Effluent (m^3/T)	1.2-1.5 m^3 (excluding distillery effluent)

Solid waste:
Two types of solid wastes are produced during the manufacturing of sugar. Bagasse is produced in the mill house in a quantity of about 30% of the crushed cane. The bagasse contains 50% moisture. Press mud or filter cake is produced in vacuum filters. The mud is produced in a range of 3-8% of the crushed cane, depending upon the nature of sugar manufacturing process. The mud contains nearly 75% of moisture. On dry basis mud contains about 70% organic matters and about 29% minerals.

Press mud is usually used by nearby farmers as manure although in some cases its application as manure is preceded by bio composting. In few cases Brick manufacturers are also using this mud either to mix with clay or directly as fire retainer in kilns. Bagasse is used as fuel for boilers. It is estimated that 70% of the power requirements of sugar mill is fulfilled in this way. Bagasse is also used for Paper manufacturing (by other manufacturers).

Liquid waste:

Besides the characteristics given below, effluent from sugar industry has high ammonium content. The wastewater may contain pathogens from contaminated materials or production processes. A sugar mill often generates odor and dust, which need to be controlled.

Air Emissions:

The major source of air pollution in sugar mills relates to boiler emissions. Boilers are operated under three different conditions: fuel oil only, bagasse only and mixed fuels (fuel oil and bagasse). The choice of fuel source significantly changes the emissions mix. Sulphitation process in sugar refining is also responsible for generating SOx Gases.

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:

It has been observed that in the production of the sugar from the sugar mills, the average ratio of consumption of raw materials to the production is about 10 - 11.

Energy consumption:

The specific electrical energy consumption is found to be around 40 kWh / ton of sugar production. Similarly the fuel consumption in order to get the thermal energy in the processes is around 3 - 4 Ton of solid fuel (Bagasse) per ton of production of sugar.

Water consumption:

The specific water consumption in sugar mills are about 14 cu.m. / ton of sugar production.

Man-day utilization:

A total of around 8.7 man-days is utilized for the each ton production of sugar.

f. Potential of no cost and low cost CP options

The potentiality of CP options seen in the Sugar Sector is very high in almost all the processing operations. The Stopping leakage from the water pipes, adaptation of better Operating Practices, recycle and reuse of cooling water streams, juice flow stabilization, Optimization in the evaporators and pans cleaning and recycle reuse of leaning chemicals are some of the important no and low cost options. Some example of general and no cost and low cost CP options generated in the sugar mills are given as follows:

1. Flow measurement (through flow meters) and monitoring at inlet and outlet of each consumer unit at the mill for better water management practices.
2. Use of optimum imbibition rate to save energy in terms of steam consumption and to reduce organic and hydraulic load from the process house.
3. Dry cleaning of mill floors with bagasse
4. Efficient operation of evaporators will reduce waste disposal problems and enhance sugar recovery. Overloading of evaporators and vacuum pans, boiling at excessive

rates, operating them at incorrect liquid levels, and variation of vacuum lead to a loss of sugar through condenser water. Improper design of these units—particularly the entrainment separator—may result in irregular boiling and splashing.

5. Recycling of cooling and condenser water
6. The simple measure of controlling spillover of molasses can very significantly reduce the organic pollution content of the wastewater stream.
7. Segregation of oil from other effluent will allow for the recovery and reuse of lubricating oil and reduce soil contamination when wastewater is applied for irrigation.
8. Controlling the mixing of filter mud with wastewater can very significantly reduce the organic and inorganic pollution content of wastewater stream.
9. Routine inspection of units-particularly pumps, conveyers, pipes and other vessels.
10. Reducing water used for floor sweeping and washing by recovering water from various mill processes and reusing it for cleaning purposes.
11. Detaining filter cloth washing in a holding tank for a short time before being allowed to mix with other effluents from the mill will reduce the contamination in the wastewater stream.
12. Installation of circular mist eliminators or de-misters constructed of stainless steel or monel in the multiple-effect evaporators can eliminate sugar entry in the condenser water.
13. Bagasse management is of paramount importance in establishing overall energy efficiency in the mill. Steam and power generation and reduction in fuel oil consumption are largely dependent on an adequate supply and efficient utilization of bagasse. Benefits will also result from ensuring that maximum moisture has been removed before bagasse is used in the boiler.
14. As far as air emissions are concerned the first step should be to set up a system of regular monitoring of stack emissions with periodic boiler tune-ups. This can considerably increase boiler efficiency and minimize emissions.
15. Air Pollution Control for Particulate Matter including Fly Ash :Settling Chamber Cyclones Wet Collectors Electrostatic precipitator Gas Scrubber
16. Sound reduction at source, e. g, silencers, and design of fans etc. Interrupting the path of the sound. e.g., Sound barrier Protecting the recipient, e.g. Ear muffs, plug

g. Estimated investment and pay back period

In course of carrying out CP assessment in sugar mills, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. These options could be recovery of heat from boiler blow down, Biogas fermenters for methane production and conversion of spent wash, from associated distilleries, and Press mud from filtered juice, in to bio fertilizer etc. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

S.N.	*Options*	*Investment (NPR)*	*Saving (NPR)*	*Payback Period*
1.	Reversal of bagasse after first stage imbibition	200,000	7,365,000	
2.	Re-use of bearing cooling water after	Nil	117 m^3	

S.N.	*Options*	*Investment (NPR)*	*Saving (NPR)*	*Payback Period*
	removal of O/G, if necessary		water/day	
3.	Installation of level maintaining device to avoid air locking.	64,000	458,865	
4.	Arrangement for uniform juice flow by introducing hollow float-flexible hose	50,000	NQ	
5.	Re-cycle the sulfur furnace cooling water for Vacuum filter cleaning	Nil	154 m^3 water/day	
6.	Optimize-modify Cooling and heating arrangement of crystallizers	Nil	50 m3 water/day	
7.	Heat Recovery from boiler blow down	600,000	100,000	
8.	Proper adjustment of air/fuel ratio to optimize combustion.	25,000	2,473,200	
9.	Improvement of insulation	NQ	NQ	
10.	Proper storage and re-use of chemicals, used for washing of evaporators and pans	500,000	490,000	
11.	CP Awareness Training of the shop floor staff	NQ	Tremendous	
	Total	**1,439,000**	**10,887,065**	

h. Environmental Benefits

From the implementation of CP in sugar mills, it has been observed that the environment impact of the sector could be minimized by about 75 %, with the implementation all the recommended Cleaner Production Options. Although the pollution load seems to be reduced by about 75 % after CP Intervention, primary and secondary and Tertiary treatments would be necessary to comply with the proposed standards for effluent to be discharged as inland water or in sewerage. CP measures will reduce the size of treatment plant required hence its installation as well as operating cost would reduce accordingly.

H. Sector: Vegetable Oil and Ghee

a. Brief Description

Vegetable oil and ghee industry is a relatively new industrial sector in Nepal. The Vegetable oil and ghee (hydrogenated vegetable oil) sector exports, on an average, 80-90% of its products to neighboring countries. It is one of the major foreign exchange earning sectors for the country. As per the data source available at PACE Nepal, there are 16 medium and large-scale industries operating at present and most of these industries are located in and around Biratnagar and Birgunj areas. The medium and large-scale units produce vegetable ghee and refined oil as the main products. The production capacity of the medium and large scales units lies any where between 800-

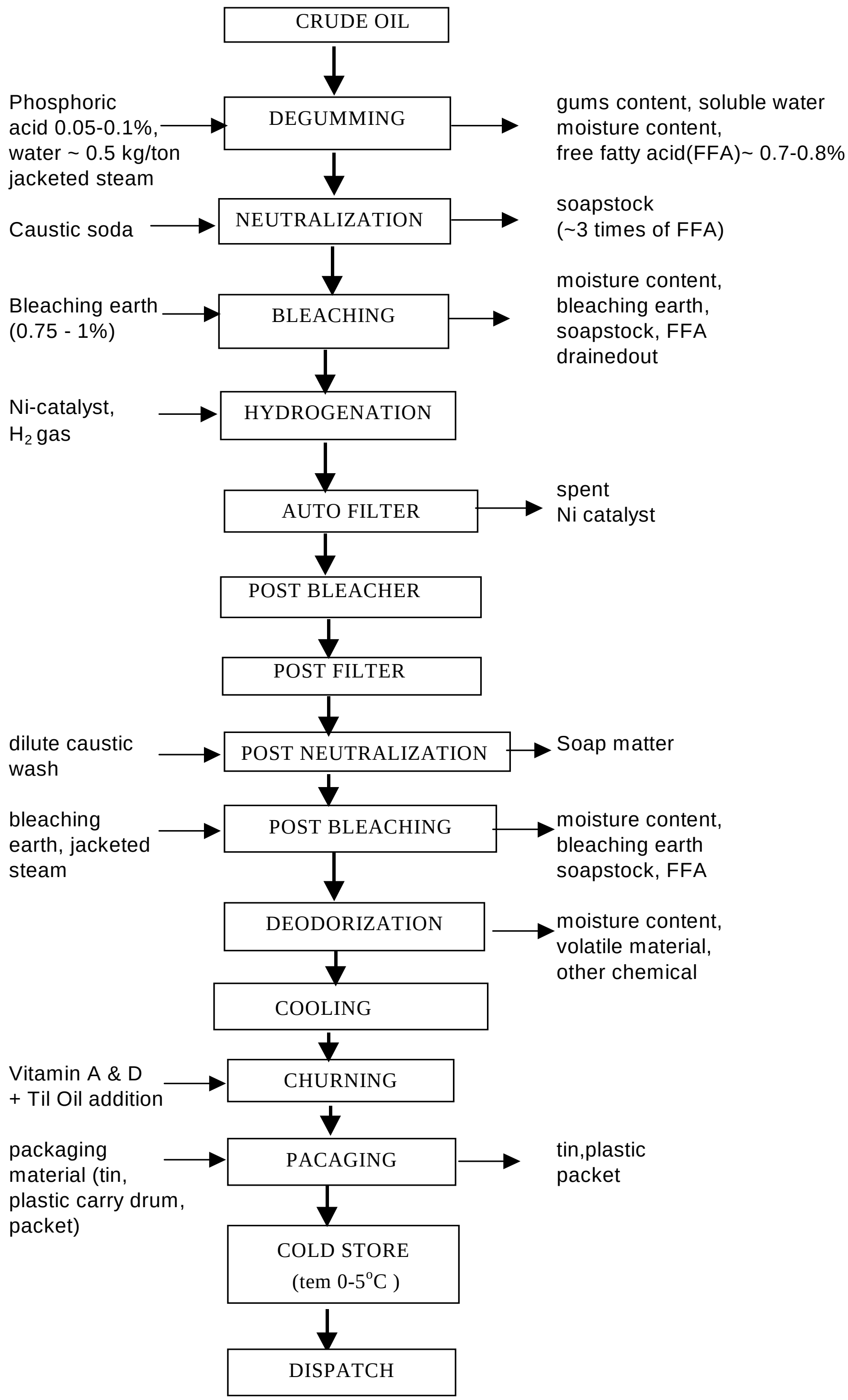
1200 T of veg. ghee and 300-600 T of refined oil / month. It has also been noticed that none of the vegetable oil and ghee industries is utilizing its full capacity due to various reasons. This sector employs about 5,000 persons.

Vegetable oil and ghee industry is a pollution prone industry. It uses various chemicals such as Caustic Soda, Bleaching Earth, acid activated Nickel Catalyst and acids, which are hazardous to health. The waste arising in the industries are due to passage of oil and chemicals during different processes of production. The solid wastes and effluent generated from the vegetable oil and ghee industries give rise to BOD, COD, TDS, pH etc., which adversely affect the environment and public health. Government of Nepal has already published the wastewater standard for this type of industry.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Vegetable Oil and Ghee Industry

Flow Chart of Vanaspati Ghee:



Brief Process Description

Degumming and Dewaxing:

Crude oils usually contain undesirable constituents, which need to be removed to make the oil product suitable for edible purposes. These constituents include free acids, colouring matters (pigments) odoriferous substances, gummy substances and waxes. The first three constituents are the basic impurities in all types of crude oils. The amount of gums and waxes present in the crude oil depends on the type of oilseed being processed. Degumming can be carried out by adding a phosphoric acid solution to help precipitate out the gums. The gum separated from crude soybean oil is also a useful by-product from which Lecithin, a natural emulsifier, can be obtained. With crude cottonseed oil, refining should be carried out using sodium hydroxide in order to remove the free acids and acidic pigments in the oil which impart dark colour to the oil. Chemical refining of crude cottonseed oil is quite sufficient to remove the small amount of gummy substances present.

Neutralization:
Extracted crude oil is acidic, due to the presence of high levels of fatty acids. These can be removed either by chemical methods, using caustic soda or by physical methods, where they are distilled out of the crude oil at a high temperature and low pressure. In Nepal, chemical separation is the most commonly used of these two methods. The addition of the alkali solution reacts with the free acids to produce a black semi-solid organic substance called mucilage. This settles out from the neutralized crude oil together with gummy and colouring substances. In almost all the factories separation is achieved by gravity settling, where the mixture is allowed to settle for several hours after which the neutralized oil is separated.

Washing and Drying:
The refined oil coming from the neutralization unit will normally contain traces of entrained soap from the heavier mucilage phase. The oil is washed with hot water in two or more stages, which is then separated from the oil by gravity. The washed oil is then dried under vacuum-this is essential as any traces of water can cause deactivation of the bleaching earth used in the next stage.

Bleaching and Filtration:
Bleaching of oils by adsorption involves the removal of pigments which are either dissolved in the oil or present in the form of colloidally dispersed particles. Adsorbents usually employed are bentonitic clays such as fuller's earth and activated carbon is less commonly used. Bleaching can be carried out in a batch or a continuous process. The bleaching earth or a mixture of earth and carbon is usually added to the bleaching kettle in the desired amount (about 1% of oil weight) at a temperature ranging from 100 to 120^0C.

After the adsorption step, the oil is passed to filter press to separate it from adhering bleaching clay and returned to the bleaching kettle for clarification. A cake or spent clay is left behind in the filter press, which is blown with air and steam to recover as much as possible of the entrained oil.

Deodorization:
The purpose of this process is to remove all substances which cause undesirable flavour odour from the bleached oil. The oil stock is subjected to the action of superheated steam at 250^0C under a very low pressure. The substances responsible for characteristic odour of the oil stock are volatilized with steam, which are then condensed in a barometric condenser.

Oil Hydrogenation and Shortening:
Hydrogenation is the main process applied in the production of margarine, fats, and oil shortenings. This involves the addition of hydrogen to the unsaturated bonds in the extracted oil to harden the oil and give it some specific edible properties, such as increasing its melting point giving it solid properties at ordinary temperatures. The hydrogenation of oil as carried out in Nepal is described in the following sections.

Hydrogen Injection and Autoclaving:
This is undertaken by heating the oil at a temperature of about 200^0C under vacuum in autoclaves. Hydrogen is then injected into the autoclave at a pressure of about 1-2 bar. The reaction between hydrogen and the oil is usually catalyzed by appropriate agent, usually nickel.

Cooling and Filtration:
After around two hours of autoclaving, the hydrogenated oil is being cooled and filtered to remove the spent nickel catalyst. It is often possible to recycle about whole of the recovered nickel catalyst from the filtration process unless and until it losses its catalyzing capacity.

Refining of Oil Shortening:
After hydrogenation, the oil would have inherited the desired plastic properties, and, hence, is called oil shortening. Oil shortenings pass through the same treatment and refining stages described for regular edible oils (neutralization, washing, bleaching, deodorization, etc). Oil shortenings are then packed in tin cans.

c. Inputs of Materials and Energy

The major input materials required for the vegetable oil and ghee production are imported out India and abroad. These are:
(a) Palm oil (Acquired from Malaysia)
(b) Soybean oil (from India, Brazil and other countries)
(c) Chemicals like Nickel catalyst, bleaching earth, caustic soda, sulfuric acid (very small quantities) and other chemicals and detergents primarily from India.

Some of the raw materials are locally available and these are as follows:
a) Sesame Oil (crude)
b) Empty containers, pouches, labels and cartoons.
c) Rice husk, from local paddy Sheller mills.
d) Furnace or Fuel oil.

Water needed for the units are generally drawn either from Artesian well or bore wells within the premises. Only a few depend on piped water supply. All units have water pumps. Very few plants meter their water consumption.

Electricity is available to the plant from two sources-from centralized supply by NEA (primary source), and one or more diesel generation set installed in the plant. The diesel generator set are switched on during both load shading or emergencies (all plants), and peak charge hours (only in some plants)

In general the estimated consumption of raw materials depicts the following trends per tone of oil or ghee produced.

a) Electricity-	145-150kWh
b) Raw oil-	1.02 tones (soya or palm)
c) Sesame oil-	30-70 kgs.
d) Rice husk-	0.65-0.8 tones
e) Caustic soda-	1.5501.7 kg
f) Phosphoric acid-	0.9-1.1 kg
g) Bleaching earth and/or activated carbon-	1.4-1.6 kg
h) Common salt-	
i) Furnace or fuel oil + Diesel oil-	0.7-0.85ltr.
j) Coal-	0.3-0.4 kg
k) Nickel catalyst-	6.25 kg

d. Waste Generation Scenario

A proper waste handling and management system lacks in most of the vegetable oil and ghee industries. The main waste stream in this sector industry is the wastewater. In general, the quantities of the parameters found in the discharged wastewater of vegetable oil and ghee industry is as follows:

PH-	6-7.5
TSS-	150-650 mg/l
TDS-	850-4500 mg/l
COD-	450-1550 mg 0_2/l
Oil and grease-	450-900 mg/l
Cr-	0.01-0.03 mg/l
Ni-	0.01-0.35 mg/l
Mn-	0.01-0.3 mg/l
Cu-	0.02-0.15 mg/l
Zn-	0.03-0.51 mg/l

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:
It has been observed that in the production of the oil / ghee from the vegetable oil and ghee industry, the average ratio of consumption of raw materials to the production is about 1.1.

Energy consumption:
The specific electrical energy consumption is found to be around 243 kWh / ton of oil / ghee production. Similarly the fuel consumption in order to get the thermal energy in the processes is around 0.4 Ton of solid fuel (Rice Husk) per ton of production of oil / ghee.

Water consumption:
The specific water consumption in vegetable oil / ghee industry is about 6 cu.m. / ton of oil / ghee production.

Man-day utilization:
A total of around 2.2 man-days are utilized for the each ton production of oil / ghee.

f. Potential of no cost and low cost CP options

The vegetable oil and ghee sector revealed that the environment impact could be minimized with the intervention of Cleaner Production. The potentiality of CP options seen on this sector is very high in almost all the processing operations. Stopping leakage from the water pipes, installation of water meter at the water sources, recycle and reuse of spent wash streams during neutralization are some of the important no and low cost options. Some the no and low cost CP options observed in the vegetable oil and ghee industries are given as follows:

- Crude oil reception in the factory should be carefully monitored and controlled, to ensure that unloading is complete and spillages kept to a minimum.
- Prevent spillage of oils and fats by improving procedural instructions. The recommendation made was to better control loading and unloading operations by improving operational instructions and by training the operators.
- Avoid wasting packaging materials
- Recycle or reuse empty containers (to prevent the generation of solid wastes)
- Install bunds around all storage tanks. If any leakage occurs, the material can be recovered and will be prevented from either entering the sewer, which will increase the organic load of the effluent; or fouling the surrounding area.
- Clean the floors regularly, especially in areas where slippery surfaces can develop.
- Regularly inspect all storage tank, pipes and connections to identify leaks as soon as possible.
- Install self-closing taps and water meters to control water consumption.
- Unnecessarily high levels of water consumption resulting from leaks, broken or missing valves, hoses left running.
- Provide water to the equipment only when required (i.e. do not allow water to flow continuously to equipment, whether or not it is being used).
- Cooling water should be recycled rather than disposed.
- In the oil refining process, wash water from the second stage can be recycled and reused in the first washing step. It can also be used to prepare the caustic soda solution required for neutralization.
- Steam condensate can be recycled to save both energy and minimize the consumption of water
- Construction of oil and grease traps at the outlet of each process unit to recover fats and minimize the strength of the final effluent. This should be collected on a regular basis and either processed on site or sold to soap producing factories.
- Recovery of fatty matter from the refinery effluent. Fat can be manually collected from the refinery effluent by scraper, acidulated and then split. The wastewater can then be treated or disposed and the fatty matter transferred to soap stock storage tanks. The benefits of this intervention are the recovery of product and reduced strength of wastewater.
- In the hydrogenation process- After the completion of hydrogenation reaction, H^2

supply is cutoff. But remaining H^2 gas is the autoclave is blown out in the atmosphere. This residual H^2, in substantial amount can be recovered by sending it in the H^2 gas accumulator (the holding tank).

g. Estimated investment and pay back period

In course of carrying out CP assessment in vegetable oil and ghee industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. In general adaptation of continuous or semi continuous Neutralization units, recycle and reuse of condensate, Recycle and reuse of Hydrogen are the main cost demanding CP options. During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

S. N.	Options	Investment (NPR)	Saving (NPR)	Payback Period
1	Installation of buns (tray) around the crude oil storage tanks	50,000	32,000	20 months
2	Installation of self closing taps and water meters to control water consumption by 30%.	20,000	30,000	18 months
3	Installation of tank, pipeline, valves to re-circulate the hot cooling water from different processes to recover the heat and use as heating media for other purposes	3,00,000	2,50,000	16 months
4	Recycling of second wash water from neutralizer to wash tank to re-use the heat, caustic and brine present in the wash.	50,000	2,00,000	3 months
5	Installation of the system to pre-treat the first wash water from neutralizer with sulfuric acid to convert oil into acid oil which will also reduce the BOD (9,000 mg/ltr) and (COD 10,000 mg/ltr.) by 90%	75,000	3,00,000	4 months
6	Recovery of O_2, its filling system and cost of cylinders.	45,00,000	23,00,000	2 years
7	Insulation of pipes vessels and required places.	75,000	75,000	1 year
8	Steam leakage-Proper maintenance	10,000	1,00,000	Immediate
9	Improvement of combustion efficiency	Negligible	2,00,000	Immediate
10	Use of natural day light-replacement of opaque roof sheets with transparent fiber sheets	30,000	60,000	6 months
11	Replacement of boiler with fluidized bed combustion boiler	40,00,000	15,00,000	2.7 years

S. N.	Options	Investment (NPR)	Saving (NPR)	Payback Period
12	Insulation of intermediate oil tanks	1,00,000	50,000	2 years
13	Recovery of heat from autoclave by installing a "water to oil" plate heat exchanger to pre heat the in coming oil	6,00,000	3,00,000	2 years
14	Heat recovery from deodorizer by installing oil to oil heat exchanger and final water cooler	10,00,000	4,00,000	2.5 years
15	Replacement of batch deodorizer with semi-continuous deodorizer	80,00,000	22,00,000	3.6 years
16	Installation of capacitor bank to improve the power factor	1,00,000	1,50,000	8 months
17	Improvement in electrolytic cell performance	Minimal	2,00,000	Immediate
18	Reduction in delivery pressure of hydrogen compressor (electrical saving)	8,00,000	5,00,000	1.6 years
19	Replacement of plate and frame filter with modern leaf filter	10,00,000	5,65,000	1.8 years
20	Re-cycling of residual H_2 gas of autoclave	1,00,000	1,50,000	7 months

In general, after implementation of the generated CP options in the industry, the expected annual saving of an unit with a production capacity 25 TPD is estimated to be as follows:

Item	Consumption	Expect reduction (%)	Estimated annual saving (NPR)
Water	52,500m^{3*}	30	15,750
Oil	225 T	40	24,20,000
Chemicals	*150 T*	*75**	*2,95,000*
Energy	*150 GJ*	*10*	**24,50,000*
Hydrogen	2700 m^3	75	1,10,000
Oxygen	*10,000 cylinder*	*50*	*15,00,000*
V.filter cloth	1500 meters*	50	1,20,000
		Total	**~69,00,000**

h. Environmental Benefits

Most of the industries are still operating in a conventional way without putting any reasonable effort towards pollution prevention or control measures. A few plants have oil and grease trap, sedimentation tanks and dust collectors. In overall the attention given to the control of pollution and treatment of the discharged effluent is negligence.

Most of the plant discharge effluents (end of pipe) into canals or rivulets. Some discharge into near by fields. The discharge rate of waste water is reported to range roughly between 30-550 liters per tones of products.

Although there is a possibility of reduction of pollution load in these industries is substantial but even then these measures would not be able to meet the discharge standard published by the government. Hence some primary and secondary treatments would be necessary to comply with the proposed standards for effluent to be discharged as inland water or in sewerage. CP measures will reduce the size of treatment plant required hence its installation as well as operating cost would reduce accordingly. From the analysis of the observation made in the sector industry, it is expected that the reduction in quantities of some of the parameters would be as follows:

Characteristic	**Expected reduction**	**Present status**	**Future status**	**Tolerance limit**
BOD (mg/l)	80%	124-500	100	Max100
COD (mg/l)	75%	475-1500	400	Max 250
Oil &Grease(mg/l)	90%	481-895	90	Max 10

I. Sector: Wool Dyeing

a. Brief Description

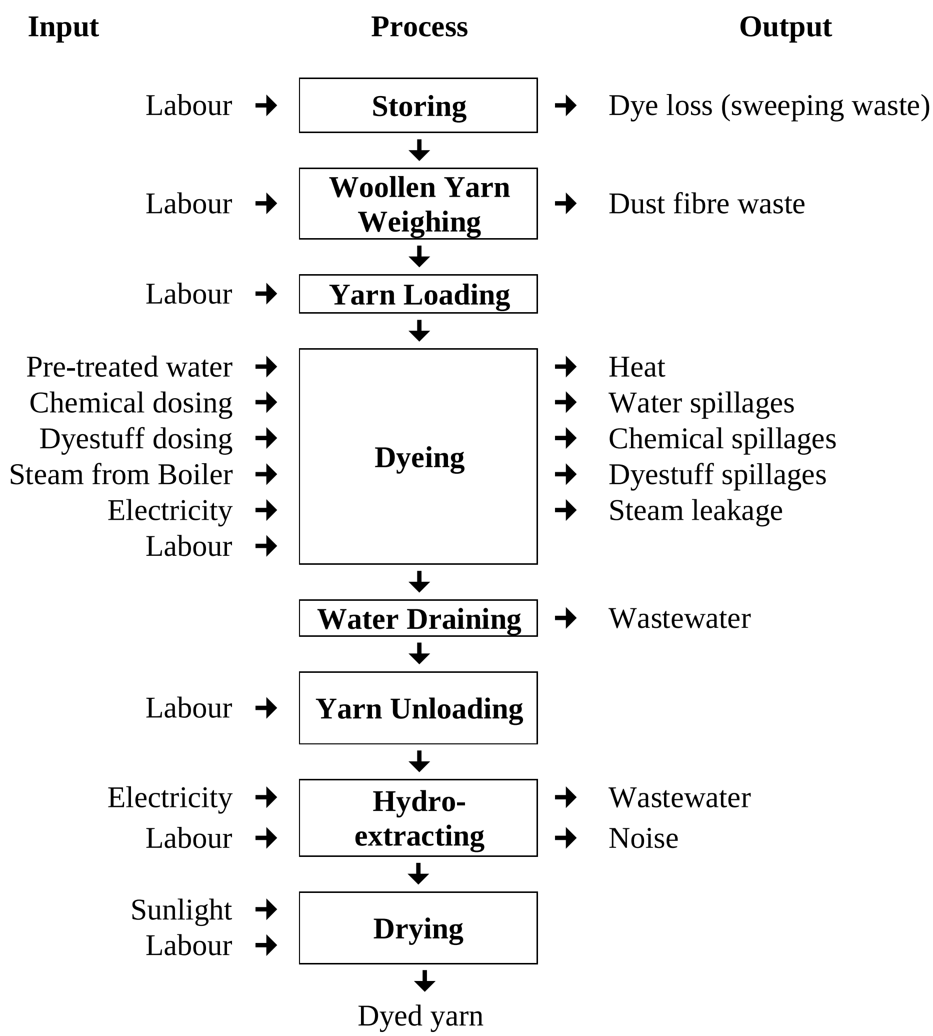
The history of woollen carpet making in Nepal is believed to be very long. Especially people dwelling in the high Himalayas regions bordering to Tibet of China were involve in making woollen carpets. The simple reason for flushing of this activity in the regions is due to sheep farming and availability of wool from the sheep. The commercial production of woollen carpets came into existence in Nepal only after its introduction in the foreign market resulting in one of the major foreign currency earning sources. The wool processing industries in Nepal are dominated by Hand knotted woollen carpet industries. The carpet industries in Nepal are mainly located in Kathmandu valley employing around 17,000 people. The number of carpet manufacturing and its supporting units is supposed to be around 400. Most of the processes in Carpet manufacturing are manual and belong to small or cottage scale industries. Besides carpet industries there are some other wool processing industries like woollen garments, pashmina products etc.

Although the export of hand knotted woollen carpets is not in an increasing trend, it is still one of the major sector of industries for Nepalese economy. It is estimated that around Nepalese Rupees 3,400 million worth woollen carpets are annually produced in Nepal.

The major processing of carpet making includes carding, spinning, dyeing, weaving and washing. Out of these carding, spinning and weaving are dry processing which mainly generate solid waste (wool fibers). The dyeing and washing are wet processing which generate large amount of liquid waste. These processes are often blamed for increasing the environmental pollution within the Kathmandu valley. The wool dyeing sector is one of the pollution prone sectors and its wastewater discharge standard has already been gazetted by the Government of Nepal.

b. Process Flow Chart and Brief Process Description

Process Flow Chart of Wool Dyeing Industry



Brief Process Description

The major manufacturing process of Dyeing industry is described in brief as follows:

Weighing of yarn:

The woollen yarn is received in hanks which is weighed and loosened before loading in the dyeing cabinets

Loading into the machine
The weighted woollen yarns in the form of hank are loaded into the dyeing cabinet uniformly

Water filling and circulation
The dyeing cabinet machine is filled with water upto the required level and run the machine for circulating the water inside. Under ground water from own well is used for this purpose.

Chemical dosing
Acetic acid, levelling agent etc are added to the cabinets. The quantity of chemical dosing depends upon the volume of the water inside the cabinet and the type of the shade of yarn to be dyed. The pH of the solution is maintained at 5.5 - 6.5 depending upon the shade to be dyed.

Dyestuff dosing
After 5-10 minute of the dosing of the chemicals, dyestuff solution blended with 2-4 different dyestuffs is added inside the dyeing cabinet. 1:2 metal complex dyestuffs are used for this purpose. The quantity of dyestuff depends upon the shade of yarn required.
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Heating the dye liquor
2-3 minute after the addition of the dye liquor, steam is supplied and the dye bath is heated through steam coil. Rice husk boiler is used to generate the steam. The heating rate is slow at the beginning and it is increased slowly up to 1 degree per 2 minute and it is controlled by gate valve. Some condensate is collected and reused. However, some improvement is needed to run condensate return system successfully.

Shade Inspection
When the temperature of the dye bath is reached to 70- 75^0 C, the sample is taken and inspected whether the shade is exactly to the reference or not. If yes, steaming is stopped. But if not, then depending upon the condition the shade, heating is continued without any addition or with the addition of acetic acid. For the darker shades the inspection is done at higher temperature of around 80- 85 ^{0}C.

Wastewater draining
After the completion of the dyeing process in the dyeing machine, machine is stopped and hot wastewater is drained out. There is no system of heat recovery and recycle of the wastewater. The drained water is discharged directly to nearby drain without any treatment.

Unloading
When all wastewater is drained out, the door is opened and it is kept for some time to cool down. In some cases, cool water is also added to wash and cool the dyed yarn. Then the dyed yarn is unloaded.

Hydro extraction (Spinning)

Unloaded dyed yarns are loaded into the hydro extraction machine to extract the water contained in the yarn. Some wastewater is generated in this process too.

Delivery
The dyed yarns are delivered directly after hydro extraction. There is no provision of drying the yarns. The quality of the dyed yarns is not checked in the industry. Quality testing facility is not available in the industry.

c. Inputs of Materials and Energy

The major raw materials for the wool dyeing industry are

1. Woollen yarn
2. Dyes and chemicals - Dyes and chemicals are used in dyeing of woollen yarn. The most commonly used dyestuff is 1:2 metal complex dye which is imported from the multinational companies of Europe like Clariant, Ciba Geigy, BASF etc. The commonly used chemicals in yarn dyeing are acetic /formic acid, ammonium sulphate, sodium sulphate, common salt/ Glauber salt etc. The consumption of dyes varies according to the shade of the colour ranging from 0.1 –1.0 % on the basis of weight of the yarn. Taking this figure as the average consumption figure, it can be estimated around 100 to 200 metric ton of dyes are consumed every year in the carpet sector. The consumption of chemicals in dyeing and washing vary in a wide range from industry to industry. However the consumption figure of chemicals in a well established dye house and another washing unit is given below for reference.

Consumption of chemicals in a dyeing unit (example)

Process	Dyes / Chemicals	Consumption of chemical with respect to yarn weight (%)	Remarks
Wool Yarn Dyeing	1:2 metal complex dyes	0.1 - 0.25	
	Acetic acid	0.5 - 1.0	
	Sodium sulphate/ Glauber Salt	5.0 - 10.0	
	Lyogen SMK (levelling agent)	0.1 - 0.3	
	Scouring agent	0.5	Applied only for Tibetan Wool

3. The dyeing industries use thermal and electrical energy. An observation has found that the monthly energy consumption in the dyeing units is estimated to be as follows:

Type of energy	Consumption in Dyeing (monthly)
Electricity	32,618 kWh
Diesel	45,300 liter
Kerosene	31,635 liter
Rice husk	430 Tons
Fire wood	7.8 Tons

Water is another important input material for the dyeing industry. In general, the dyeing units are using underground water by pumping within the premises of the units. It is estimated that the total water consumption by the wool dyeing industries is estimated to be around 400,000 cu.m. per annum.

d. Waste Generation Scenario

The wastes generation in the dyeing industries is briefed as follows:

Solid Waste: The major solid waste generated from the wool dyeing industry is the wool fiber.

Type of waste	Quantity of waste (%)	Total annual quantity (Ton)	Effect	Remarks
wool fiber	1.0	10	High BOD in the effluent	Wool fibers drained with waste water

Besides, there are some spillages waste coming out as sweeping waste from the store and laboratory.

Liquid waste: The liquid waste is mainly generated from dyeing and washing. Other units only generate sanitary waste.

Type of waste	Quantity of waste (on the basis of unit production)	Total annual waste	Effect
Wastewater (effluent)	30 liter / Kg	318,000 cu. m.	High COD, TSS

The major characteristics of the effluent from the dyeing and washing industries are given as follows:

Parameter	Unit	Dyeing effluent		Washing effluent	
		Range	Mid value	Range	Mid value
COD	Mg /L	500-2800	1650	200-1400	800
BOD	Mg /L	130-790	460	10-800	405
PH		4.0-5.5	4.75	1.4-6.0	3.7
TSS	Mg /L	20-150	8.5	100-1000	550
Oil and grease	Mg /L	10-80	45	10-100	55
Temperature	^{0} C	60-85	72	10-20	15
Total chromium	Mg /L	0.02-0.24		0.01-0.02	

Air emission:

The air pollution from dyeing units is mainly due to the operation of Boiler to get the direct steam for the heating during dyeing process. The air pollution comes from the burning of fuel for the generation of steam. Most of the industries use rice husk, diesel and kerosene. The major pollutants from the boiler are NO_2, CO_2, CO and SO_2.

e. Productivity Indicators and Specific Consumptions

Raw Materials consumption pattern:

It has been observed that in the wool dyeing industries, the average ratio of consumption of raw materials (dyes and chemicals) to the production dyed woolen yarn is about 0.03.

Energy consumption:
The specific electrical energy consumption is found to be 154 kWh / ton of woolen yarn dyeing. Similarly the fuel consumption in order to get the thermal energy in the process is around 2.9 Ton of fuel (Rice Husk) and 394 liter of oil (diesel) per ton of woolen yarn dyeing.

Water consumption:
The specific water consumptions in wool dyeing is around 25 cu.m. / ton of dyed woolen yarn.

Man-day utilization:
A total of around 23 man-days is utilized for the dyeing of each ton of woollen yarn.

f. Potential of no cost and low cost CP options

The potentiality of Cleaner Production is more in wool dyeing process because these process use water and chemicals and contributing more for especially water pollution. The common low and no cost options for wool dyeing process are given as follows:

Low and no cost CP options	Expected benefits
Proper storage and stock preparation of dyes and chemicals	Reduction in dyes and chemical consumption
Accurate measurements of chemicals	Reduction in chemical consumption
Proper inspection of woollen yarn before processing	Reduction in dyes and chemical consumption
Avoiding spillages of dyes and chemicals	Reduction in dyes and chemical consumption
Standardize the shade inspection method	Reduction in dyes and chemical consumption
Proper quality control of dyed yarn	Improvement in quality
Use of formic acid instead of acetic acid	Reduction in pollution load
Proper insulation of steam pipes	Energy saving
Improving boiler efficiency	Energy saving
Proper screening of wool fiber from the effluent before discharge.	Reduction in pollution load
Process control in dyeing by maintaining proper pH, time and temperature of the dye bath.	Reduction in dyes and chemical consumption
Improving leakages of water and steam	Water and energy savings
Installing water meter to monitor the consumption of water	Water savings
Providing trainings to the dye master and operators about C.P. and dyeing	Reduction in dyes, chemicals and pollution load

Low and no cost CP options	Expected benefits
Proper storage and stock preparation of chemicals	Reduction in chemicals and pollution load
Improving chemical pouring practices	Reduction in chemicals and pollution load
Avoiding unnecessary process steps	Reduction in chemicals and pollution load
Application of chemicals as per quality of carpet	Reduction in chemicals and pollution load
Improving processing methodology	Reduction in chemicals and pollution load
Avoiding spillage of chemicals and water	Reduction in chemicals and pollution load
Making proper specification of chemicals for purchasing	Reduction in chemicals and pollution load
Proper screening of wool fiber from the effluent	Reduction in chemicals and pollution load
Providing trainings to the washing master and operators about CP	Reduction in chemicals and pollution load

g. Estimated investment and pay back period

In course of carrying out CP assessment in wool dyeing industries, along with above mentioned no cost and low cost CP options, a number of cost demanding CP options are also generated, which are highly beneficial to the industry. Some of such options are mentioned below in the table.

C.P. options	Expected benefits
Heat recovery from hot water effluent	Fuel savings
Proper use of condensate	Fuel and water savings
Re use of process water from lighter shade to darker shades.	Chemical and water saving and reduction in pollution load
Pre-treatment of Supply water	Chemical and water saving and reduction in pollution load
Installation of proper steam traps and	Fuel and water savings
Heat exchange from exhaust air	Fuel savings

During the financial evaluation of some of such options, the estimated investment, expected annual savings and the pay back period in year are calculated and given in the table as follows.

C.P. options	Tentative investment (NPR)	Annual Operating cost (NPR)	Annual Savings (NPR)	Expected pay back period
Heat recovery from hot dye effluent	100,000	40,000	60,000 for Rice husk Boiler	2 year

			200,000 for Oil fired Boiler	7 months
Re use of process water from lighter shade to darker shades.	80,000	40,000	80,000 for Rice husk Boiler	15 months
			140,000 for Oil fired Boiler	9 months
Installation of proper steam traps (for 5 machines)	50,000		40,000 for Rice husk Boiler	
			80,000 for Oil fired Boiler	
Proper use of condensate	100,000		50,000 for Rice husk Boiler	2 year
			150,000 for Oil fired Boiler	8 months
Heat exchange from exhaust air	300,000		100,000 for Rice husk boiler	3 years
			200,000 for oil fired boiler	18 months

h. Environmental Benefits

All the options (no/low cost and investment demanding options) either reduce the pollution load or energy consumption but it has positive impact on environment. On the basis of CP implementation in the wool dyeing units, the estimate environmental benefits are given as follows:

Item	Improvement
Energy savings(Fuel)	20 -50%
Energy saving (Electricity)	10-20 %
Chemical saving	30- 70 %
COD Load reduction	20 -40 %
pH	5-6
Water consumption Reduction	30 - 40%