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**SUGAR MANUFACTURING PLANT AND  
DISTILLERY EFFLUENT TREATMENT**

SI/NEP/94/801

NEPAL

**Technical report: Industrial pollution control and monitoring  
programme for the sugar and alcohol industries in Nepal\***

Prepared for the Government of Nepal  
by the United Nations Industrial Development Organization,  
acting as executing agency for the United Nations Development Programme

*Based on the work of P. J. Newell, expert in effluent treatment,  
D. Chaux, expert in sugar and alcohol manufacturing and  
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## ABSTRACT

This project is concerned with the provision of advice and technical assistance to the Nepal Government on the establishment of an industrial pollution control and monitoring programme for five sugar factories and adjacent distilleries and for the growing sugar industry in the country.

The report contains a characterisation and assessment of the various effluent streams from these sugar factories together with an appraisal of the in-house processing, recovery and operational techniques within the factories. It also discusses the agro-industry development strategies for the general sugar industry in Nepal. Recommendations are contained within the report for improvements in manufacturing, technology, reductions in effluent quantity and concentration, the best use of the most appropriate technology for the implementation of the proposed national industrial pollution control and monitoring schemes and methods for improvements in the productivity and quality of the raw materials.

The work involved in this report was carried out during the period 22.1.95-19.2.95 and consisted of site meetings, factory investigations, sample collections, laboratory analysis and assessment, field investigations and inspections concerning the growing of the raw material. The conversion of the raw material in Kandsaris and the production of guar was also investigated. The data which was collected was assessed and presented during meetings with representatives from the sugar factories which were visited and presentations were also made to government officials in Kathmandu. The findings and recommendations concerning this work are contained within this report.

An explanation of the monitoring procedures and assessment techniques was provided to the government appointed counterparts and to the relevant staff within the institutions which were visited. Training in relation to site investigations, sampling, analytical procedures, results, interpretation and reporting was also included in the duties carried out during this study.

Based on the findings of this study, it is recommended that a national pollution control and monitoring programme should be implemented at the very earliest opportunity. Using the "Industrial Pollution: Control Regulations for Air and Water Discharges (1994)" draft regulation which was made under the Industrial Enterprises Act 1992, it is recommended that some form of effluent discharge licensing system should be enacted. Using the proposed "industry - specific discharge standards for airborne and waterborne environmental contamination" as a basis, regulation and control of environmental pollution should be instigated over a period of time which is consistent with the rate of national development within Nepal. While it is accepted that standards similar to those which apply in Europe or the U.S. cannot be implemented immediately in Nepal, it is recommended that these standards should be set as the final goal for the pollution abatement legislation. Information on these international standards, e.g. WHO, EPA, and EU standards is included in the report. Information on a typical application form to discharge effluent into receiving waterbodies is also included in this report.

At present, Nepal is not self-sufficient in sugar production and it is the stated aim of the government under the Industrial Enterprises Act, 1992 that this industry should be encouraged to grow and meet the national demands with a view to possible export potential to third countries. The present waste treatment facilities in most of the sugar factories is non-existent and in-house management and efficiency within these factories is low in most cases. The waste discharging from these factories is mostly discharged into dry or almost dry stream beds where very little dilution takes place. The resulting untreated effluent stream is therefore a major source of pollution in these streams and waterbodies for a very substantial distance downstream of the outfall. In most cases, this discharge passes across the international border into India. There have been several complaints from the native population and international complaints from the Indian authorities. It is very important therefore that the situation is remedied at the very earliest opportunity. Conscious of the economic state of Nepal, it is recommended in this report that the best available and most appropriate technology should be used and that direct discharge from the distillery effluents should be prevented. Recommendations on processes and procedures is contained within this report. The sugar industry is very important to the national economy and based on the assessments made in this study, it is recommended that assistance and encouragement should be given by the national authorities towards the development of better strains of sugar cane and the instigation of better cropping routines should be encouraged and developed. Training, financial incentives and tax incentives can greatly assist in achieving this aim.

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## I. INTRODUCTION

### 1.1 Background

Following a request by His Majesty's Government in Nepal, to the United Nations Industrial Development Organisation (UNIDO), Vienna for assistance in providing advice on the establishment of an industrial pollution control and monitoring programme for sugar factories and distilleries, Messrs Patrick J. Newell, Didier Chauv, and Sergio Miranda da Cruz were appointed as consultants to the Ministry of Industry in Nepal for a period of one month from January-February, 1995. The job descriptions for this project are reproduced in Annex 1.

### 1.2 Objectives

The main objectives of this study concerned

- the characterisation of the industrial processes concerned in order to determine the volume of liquid and solid waste generated and to assess the chemical and physical position of the waste being generated
- assistance with the establishment of an industrial pollution control and monitoring programme for three sugar factories (expanded to five sugar factories) and adjacent distilleries.
- the provision of information and training to nominated government employees and factory operatives on sampling techniques, analytical procedures, treatment systems, in-house pollution auditing, process modification for greater efficiencies, and general appreciation for environmental protection
- assistance with the establishment of national standards which are achievable in Nepal and which are based on the industrial pollution control standards being employed internationally.
- assistance in the provision of recommendations concerning greater productivity and better quality product through the use of appropriate strains of sugar cane

### 1.3 Current Situation

Effluents from five major sugar factories and associated distilleries were characterised together with an effluent from a separate distillery which was utilising anaerobic digestion as a waste treatment system (See Annex VII Tables 1 - 6) Reports on the

each factory are contained in Annex VI. Two government nominated officials assisted with the sampling and analysis of these effluents. A portable laboratory facility, complete with chemicals was provided by Dr. Newell during the course of this study. In the absence of this facility, it would have been difficult to achieve a characterisation of the effluents being discharged. On completion of this consultancy, these testing facilities will not be available within Nepal and it will not be possible to achieve proper pollution control monitoring and pollution auditing until such time as a suitable laboratory is equipped and manpower provided to carry out these tests. It is therefore very important, that a suitable testing facility be established within a designated division of the Department of Industry which will be staffed with suitably qualified operators and suitable equipment. (See Annex IV and V). The provision of more basic training and equipment within the factory complexes should also be encouraged so that higher efficiencies and product recovery can be achieved and hence a corresponding reduction in pollution load can be achieved. Assistance by donor bodies is recommended towards the training and equipping of the national laboratory and the facilities within the factories. Assistance in the establishment of a demonstration effluent treatment system at one factory is also recommended.

#### **1.4 Sugar Industry in Nepal**

##### **1.4.1 General**

The importance of the sugar and molasses industry to Nepal is clearly evident from the data presented in Table II of Annex VII. By the year 2000, it is estimated that 19,954 people will be employed in the sugar industry. This is an increase of over 357% in a period of 10 years from 1990 - 2000. The total estimated increase in output value over the same period is 388%, increasing from 447 million RS to 1,736 million RS. The total value added increase in the same period is estimated at approximately 406%, increasing from 179 million RS - 799 million RS.

The estimated sugar cane production in 1994-95 is 1,582,000 metric tonnes with the productivity estimated at 35.0 metric tonnes per hectare. This figure has increased from 408,000 metric tonnes in 1984-85 with a productivity estimated at 23.4 metric tonnes per hectare. The projected figure for the 1999-2000 season is a production of 2,773,000 metric tonnes of sugar and a productivity of 40 metric tonnes per hectare. The corresponding quantity of sugar produced in the 1984-85 season was estimated at 11,039 metric tonnes which increased to a figure of 31,927 tonnes in the 1989-90 season. This is an estimated annual growth rate of 10.5%. The projected domestic demand for sugar in Nepal in the 1989-90 season was 65,000 tonnes. The demand therefore exceeded the production capacity by a figure of approximately 204%. There is a projected annual increase in demand of 10% in the period 1989-2000. It is obvious therefore, that substantial investment will have to be made in the sugar industry in order for Nepal to become self-sufficient in this natural product. There is a ready made national market for this agricultural cash crop and it is the stated intention of His Majesty's Government to develop the sugar industry to its maximum potential (Industrial Policy, 1992, His Majesty's Government, Ministry of Industry, Singha Durbar, Kathmandu).



At present, the sugar industry is estimated to be the second largest employer in the food sector, second only to the grain mill products. It is also the second largest total value added product in the food sector. The projected employment figure in the sugar industry by the year 1999, 2000 is 19,954 which is second only to the projected figure of 45,097 figure which is projected for grain mill products. In addition to this 19,954 employment level, an additional 10,766 people will be employed in the liquor industry. Most of this liquor industry is related to the fermentation of molasses, the combined total employment figure is 30,720. If the numbers of people associated with the direct production of the sugar cane i.e. the farmers, farm workers, helpers, drivers, etc. is included, then it is very obvious that the sugar industry in Nepal is a major source of livelihood and income to a large section of the population. This industry is even more significant when it is realised that it is based in an area of the country which is relatively remote and at the lower end of the social and economic scale of development in Nepal. Not only do the projected trends for production of sugar cane show an increase in production but they also show an increase in the productivity, i.e., the quantity of the sugar cane produced per hectare of ground. An estimated increase of approximately 14% is projected, i.e., an increase from 35 metric tonnes per hectare in the 1994-95 season to a value of 40 metric tonnes per hectare in the 1999-2000 season. Part of this report deals with methods and suggestions which might be employed in order to achieve this increase in productivity and also achieve an increase in the production of raw material.

The increase in the sugar industry will also result in an increase in the quantities of molasses which will be produced within Nepal. This in turn will lead to an increased production of alcohol and associated products. These are added value products and depending on the government policies, these can become a major source of income for both the suppliers and the national economy.

#### **1.4.2 Environmental Protection**

The processing of sugar cane for the recovery of sugar requires the use of considerable amounts of water and energy. With proper management procedures, it should be possible to recycle most of the water within the factory complex. It will be necessary to discharge some excess water but through proper in-house management and entrapment procedures, the concentration of polluting elements in this waste stream should be relatively low. Effluent treatment is a major source of energy consumption and is normally very expensive. It is therefore, imperative that maximum recovery of products be achieved within the factory, particularly in a country such as Nepal where energy and resources are very limited. Environmental protection through the use of sophisticated treatment systems is not an option which can be applied in Nepal in the near future. Encouragement and incentives should be given to the industry in order to reduce and prevent unnecessary discharges of polluting materials.

Energy consumption within the factory is a major cost factor. In a properly managed factory and processing system, it should be possible for factories to be self-sufficient

in energy through the use of the bagasse as a primary fuel source for the generation of the steam which is used in the processing of the sugar. Inefficient management will result in a demand for external sources of raw material. The most commonly utilised external sources of raw materials in Nepal are firewood and rice husks. Deforestation is already a problem in Nepal. The factories should be given encouragement and assistance in upgrading the boilers and burning systems in order to make these as efficient as possible and also as environmentally friendly as possible. Fly ash and polluting exhaust gasses should be reduced to minimum.

Molasses is a major by-product of the sugar production process and in most cases this molasses is used to produce alcohol in an associated distillery. The waste stream from the production of this alcohol is spent wash which is a very strong organic polluting stream. In all developed countries and in many developing countries, including neighbouring India, the national regulations require that this effluent be treated so that most or all of the organic material is removed from the waste stream. In order to achieve this the most appropriate and best available technology should be used as most of the treatment systems in operation in developed countries are very expensive both in terms of capital expenditure and operating costs. As part of the project brief, the consultants have examined this issue in detail and a recommendation is made which will allow for the use of the spent wash in combination with the waste ash and filter mud as a liquid organic fertiliser in the sugar cane fields. (See Annex IX). This appears to be the most practical and suitable solution for the industry in Nepal.

All economically operating effluent treatment plants which have been installed to treat spent wash have included anaerobic digestion as a primary treatment phase. This process recovers energy while removing a substantial portion of the organic polluting material. A second stage of treatment is carried out in an aerobic plant where National Standards require high treatment efficiency. Anaerobic digestion is being employed in the new Shree Ram sugar factory which is under construction with the intention of using the energy produced as the main source of steam production for the distillery. Anaerobic digestion is also being investigated by the Jawalakhel Distillery with a view to treating the effluent from a proposed new plant and utilising the energy produced in the form of biogas as a source for steam production in the distillery.

The use of anaerobic digestion as a primary treatment system for the spent wash from distilleries does not alter the recommendation concerning the combined use of spent wash, ash and filter mud as a liquid organic fertiliser in the sugar cane fields because the anaerobic digestion process only removes the carbon content in the effluent. The nitrogen, phosphorous and trace nutrient content remains almost the same during the digestion process.

## **1.5 White Plantation Cane Sugar Manufacturing**

### **1.5.1 General**

Approximately 1,582,000 metric tonnes of sugar cane will be produced in the crop

year 1994-95 in Nepal. This crop is harvested manually and transported by many different means to at least six factories for processing. Additional processing occurs in kandsaris and for guar in local village complexes. The studies carried out in this report were mostly concerned with five sugar factories.

The processing procedure is similar in all the plants, variation within the factories occurs due to the different types and ages of the equipment utilised. The factories which were examined range in age from 30 years to a new factory in its very first season. The equipment installed in these factories was acquired from many parts of the world, Czechoslovakia, China, India and some new equipment which has been purchased from Germany. The management and efficiency of the factories varies from plant to plant. A simplified flow diagram for raw sugar cane processing is given in Figure 1.

The procedure can be generally divided into five main steps:

- juice extraction
- juice filtration and clarification
- juice concentration
- crystallisation
- centrifugation

Products and waste streams are produced in association with each step.

During the juice extraction stage, a concentrated stream of soluble sugar is produced which is sent forward for filtration and clarification. In a properly managed factory, all of this liquid sugar stream should be recovered and no wastage should occur. However, in a number of the factories, the surveys revealed wastage from this stream. Because this stream contains soluble sugar, the organic content is very high and any excess waste water in this stream is therefore a very polluting source. Proper in-house management can prevent this wastage. This juice extraction stage requires very heavy equipment and the bearings are normally cooled with water. This bearing cooling water is normally discharged as an effluent from the factory. This stream should not normally contain a high quantity of organic material but it will invariably contain oil and grease. Treatment of waste streams from sugar factories should therefore always contain an oil and grease trap. This is an inexpensive mechanical separation process which can be easily maintained and operated.

At the filtration and clarification stages, filter cake solids are produced. A substantial quantity of this material is produced with a moisture content which can vary greatly depending on the method of filtration. At present, this material is transported away from the factory and spread as organic fertiliser in the sugar cane fields. The collection, loading, transportation and spreading is all carried out manually. This filter cake contains substantial quantities of plant nutrients with a relatively high fertiliser value.

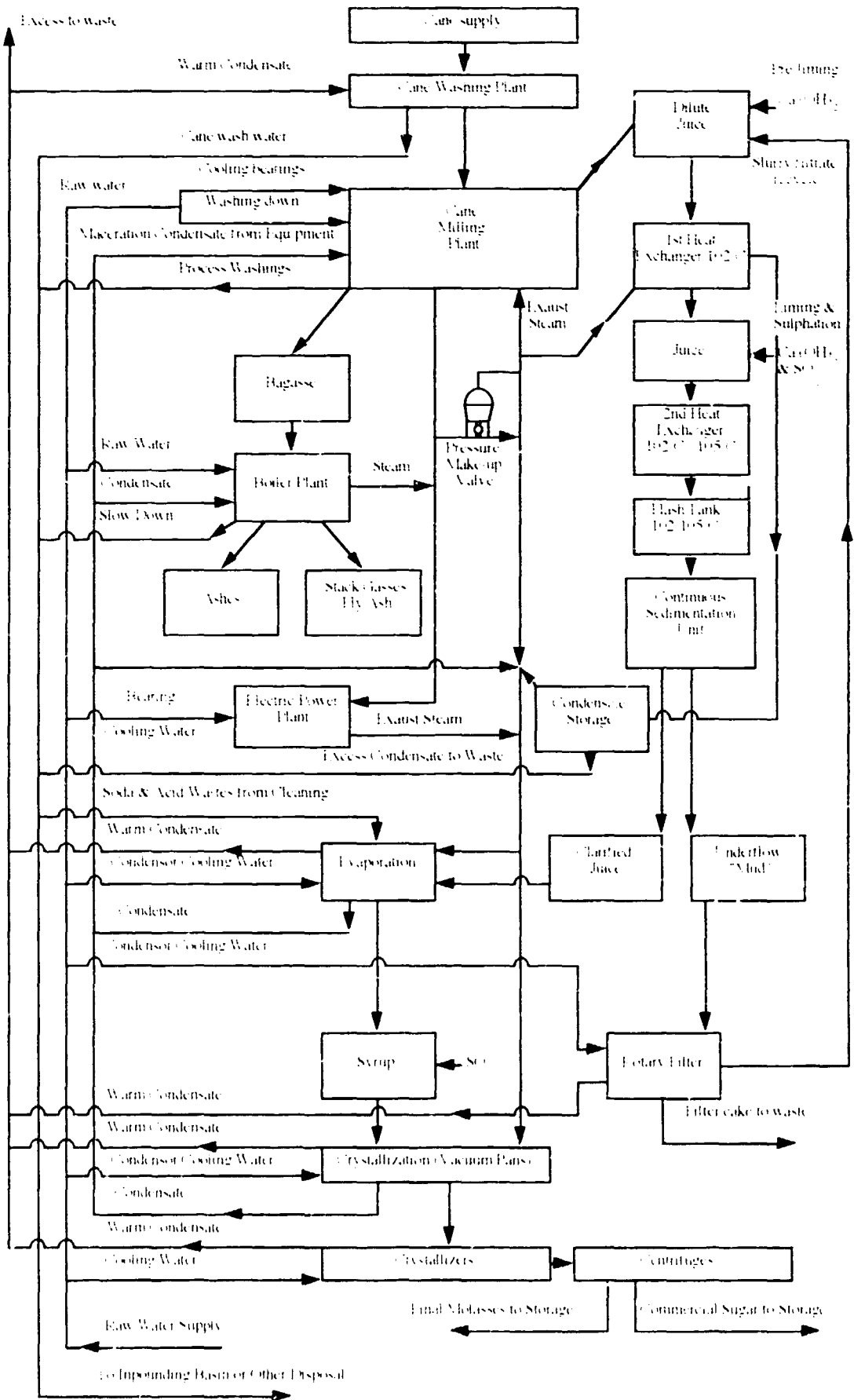


Figure 1: Simplified flow diagram for white plantation sugar cane manufacture  
(Visible sulphitation process)

The concentration procedure involves increasing the solids content from approximately 16% to 65%. This is achieved through boiling and vacuum evaporation. A very large quantity of condenser cooling water is used in this process. Through proper management within the factory, it is possible to recycle almost all of this condenser cooling water. Because the evaporated water is added to this stream, there will always be an excess quantity which will be discharged as waste. However, if the process is properly managed, the excess quantity for discharge will be relatively low and the organic content will also be low. In this scenario, the waste stream from this recycled condenser cooling water loop will not cause a major environmental impact. In situations where this recycled water is not conserved, the discharge can be so great that a very major environmental impact can occur. Badly maintained and operated evaporation equipment can result in the discharge of concentrate juice into this recycled loop, resulting in high levels of organic contamination.

With increasing concentration and purification of the liquid mass, crystallisation of the sucrose molecules occurs. These crystals are further separated in the final centrifugation stage. The remaining liquid phase is described as molasses. Molasses has a very high organic content and any spillage from this syrup like material will have a major impact on the effluent quality from the factory.

## **1.5.2 Sources of pollution**

### **1.5.2(a) Air Pollution**

It is estimated that approximately 245,210 tonnes of bagasse is produced from the processing of the 1, 582, 000 tonnes of sugar cane per year. This bagasse is used to fuel the boilers which produce the heat and steam required for heat and power in the total plant. In most cases, there should be adequate bagasse to operate the sugar factory and the associated distillery provided these are located in close proximity. However, the surveys carried out in Nepal indicate that in most cases, additional raw material is required. This raw material is supplied in the form of timber or rice husks. The boilers and incinerators produce flue gasses and air pollution. It is recommended that scrubbers, cyclones or precipitators should be installed in the stacks in order to reduce air pollution and air contamination.

### **1.5.2(b) Waste solids**

Bagasse, the solid residue remaining after the sugar cane juice has been extracted is used to produce the heat and power. This results in approximately 3% of the bagasse remaining as ash waste. This ash is removed from the burners in the form of a clinker or as neat ash. This material is normally transported away from the factory and used as agricultural fertiliser or may also be used as landfill.

Mud solids are generated in the filtration process. These solids contain both organic and inorganic solids. This material contains substantial quantities of plant nutrients and is a good source of organic fertiliser. At present, this material is

transported away from the factory and used as an organic fertiliser in the sugar cane fields. The handling of this material is labour intensive and is mostly carried out manually.

### 1.5.2(c) Water pollution

Water pollution from sugar cane processing is the most serious source of pollution in the whole process and is normally the central focus of attention for most Regulatory Bodies. Large volumes of waste water can be produced if in-house auditing of the process is not instigated. With proper management, this volume can be relatively small and the concentration of organic material can be greatly reduced. Because of the location of the sugar plants and the economic development of the economy, formal waste treatment of this stream at this time and for the foreseeable future is not an economically viable option. Reduction in quantity and organic strength is therefore imperative in order to protect the local environment.

Fortunately, through the proper design and operation of the condenser vacuum pans and the recycling of the condenser cooling waters, it is possible to achieve both a minimum waste flow and a low organic concentration.

An associated source of pollution in this waste stream is the absorbed heat which is entrapped during the process. Some effort should be made to reduce the temperature of the waste stream to ambient temperatures before discharging this waste into a surface water body.

Another very important source of contamination in the waste water from the sugar factory is associated with the periodic cleaning and washing down of the heat exchangers and other vessels. Sodium hydroxide and sometimes hydrochloric acid are used in this cleaning process. These wastes which are discharged in batch flows and in relatively large volumes contain substantial quantities of both chemical and organic pollutants. It is imperative that this waste flow should be recovered and recycled if possible or alternatively recovered and held in a separate holding tank so that the waste water can be discharged over a long period and under a proper blending and disposal regime.

Other sources of waste water include: floor washings, bearing cooling water, spillages, boiler blowdown, domestic waste, waste from the factory laboratory which may contain lead and other chemicals, etc. These sources constitute the main continuous flow of organically contaminated waste water within the sugar factory. It is recommended that an oil and grease trap be installed in this waste stream in order to remove the oils and grease before discharge into the receiving water body.

In a properly operated sugar factory/distillery, the most significant waste stream is associated with the spent wash from the distillery. This spent wash can

typically contain a chemical oxygen demand (COD) concentration of 100,000 mg/l. The liquid is normally discharged from the bottom of the distillation column and typically has a temperature of 100°C. This is a very concentrated source of pollution and is not suitable for discharge into any water body, surface or sub-soil. In order to protect the environment, it is necessary to provide some degree of treatment for this waste stream. At present, all the distilleries discharge the spent wash either into a surface water body or via irrigation channels into the fields. One Kandsari discharges this waste into shallow wells. Many complaints have been received from the local population and from the Indian Government into whose country most of the surface waters discharge within a relatively short distance. Not only are these waste streams interfering with the supply of water to the local inhabitants but they are also interfering with the social life of the population and many religious ceremonies which are associated with these surface streams. Formal treatment of these waste streams invariably requires pre-treatment in an anaerobic digester followed by secondary treatment in an aerobic plant. The costs associated with a formal treatment are far beyond the financial capabilities of any of the sugar factories or associated distilleries in Nepal. An alternative waste disposal method is suggested in this report via the combining of this relatively low volume stream with the filter mud and the ash and the subsequent disposal of the liquid slurry as an organic fertiliser in the sugar cane fields (See Annex IX). Anaerobic treatment of the spent wash is recommended where this is shown to be financially viable so that energy can be recovered and used as a primary source of fuel for the production of steam in the distillery. The plant nutrient balance of the spent wash is unaltered in the anaerobic process.

#### **1.5.2(d) Yeast solids**

Alcohol is produced from molasses by growing yeast cells which ferment the sugars in the molasses and produce alcohol as a by-product. At the end of fermentation, these yeast cells are recovered through settlement and appear as a waste solids material in the distillery. These yeast solids are a particularly obnoxious material and at present in most Nepalese distilleries are disposed of via mixing with the spent wash and subsequent discharge into surface water bodies. This is not an acceptable procedure and it is recommended that the yeast solids should be collected in a separate tank where they can be concentrated and sent for disposal by: drying, use as animal feed, blending with other solids to form an organic fertiliser, local use for other purposes, etc. The COD content of settled yeast cells is typically in the order of 250,000 mg/l. The pollution potential from even a very small quantity of this material is obvious. Natural organic breakdown of this material is relatively slow and formal waste treatment is not an option in Nepal.

#### **1.5.3 Waste Treatment Options.**

##### **1.5.3(a) General.**

There are many different types of effluent treatment plants which can be utilised

to remove the pollution loads which are generated in a Sugar Cane Factory and associated Distillery. While there are many technical processes which can be used, the economic viability and suitability of each process should be checked before any such system is recommended for installation. Effluent treatment systems can be divided into aerobic (requiring oxygen) and anaerobic (occurring in the absence of oxygen) groups.

### **1.5.3(b) Aerobic Treatment.**

Aerobic effluent treatment plants are very common and can generally achieve very good treatment efficiencies. In these systems, micro-organisms convert the organic pollution into carbon dioxide and new biological cells (biological sludge). These micro-organisms require large quantities of oxygen in order to carry out this conversion. They are very suitable for the more dilute effluents. However, the operating costs and energy consumption associated with these systems is relatively high and in locations where electrical energy is very expensive, the operating economics associated with these systems may be prohibitive. It is estimated that for each kg of COD removed at least 1 kWh of electrical energy will be consumed. Associated sludge production is estimated at 0.3 - 0.5 kg per kg of COD removed. Sludge disposal can be a major secondary problem, particularly in densely populated areas. In the past, these sludges were usually spread on land or sent for stabilisation in an anaerobic digester. Recent legislation in the EU and US has limited the land spreading of these sludges to very specific areas and to guaranteed non-toxic sludges. Anaerobic digestion of these sludges is only economically viable where large volumes are available. Operating costs and sludge disposal difficulties are the main problems associated with aerobic effluent treatment. Biological nutrient imbalance can also cause problems in certain effluents.

### **1.5.3(c) Anaerobic Treatment.**

Anaerobic digestion (AD) is an alternative form of effluent treatment. The micro-organisms involved in this process operate in the absence of oxygen and generate methane gas as a by-product in the reduction of the organic pollution load in the effluent. This methane gas can be used as a primary source of energy in various combustion chambers. Theoretically, it is possible to produce 3.3 kWh (heat energy) for every kg of COD removed. Biological sludge production is estimated to be 0.03 - 0.05 kg per kg of COD removed. It is obvious that anaerobic digestion has many advantages over aerobic effluent treatment. However, AD is a very complex biological process which is mediated by several groups of micro-organisms, most of which operate in a sequential fashion. The bacteria which mediate the final stages of this process require very special environmental conditions. By comparison with aerobic treatment, the numbers of bacterial species which are capable of growing under strict anaerobic conditions especially towards the end of the complex sequence are very limited. This lack of bacterial diversity and the requirement for very stringent environmental conditions can make the AD process very difficult to commission and operate. It is, therefore,



very important that a complete economic assessment and feasibility study is carried out at the initial design stage before a choice is made between aerobic and anaerobic treatment systems and between the different systems which are commercially available within each category. In general, anaerobic digestion will economically remove 70 - 90% of the BOD in a strong effluent, while aerobic treatment systems can be designed to remove greater than 99% of the BOD. As anaerobic digestion is the only economically viable means for treating spent wash, a more detailed description of the process is given in Annex XI

#### 1.5.3(d) Conclusions.

In general, aerobic treatment is favoured for the more dilute effluents, while anaerobic digestion is more cost effective for treating the stronger effluents, particularly where these effluents have a temperature above 30°C (Anaerobic digestion works best at a mesophilic temperature range 30°C - 40°C or a thermophilic range 45°C - 55°C. The process is not as stable in the thermophilic range). Anaerobic digestion is very cost effective for removing large quantities of organic pollution from concentrate effluents but it is not capable of reducing the organic content to a level which will make the effluent suitable for direct discharge into a receiving water body. Aerobic polishing will always be required when an effluent is being discharged directly into any water body. However, it may not always be necessary to discharge the treated effluent directly into a receiving water body, it may be possible to directly irrigate the effluent onto suitable arable lands where saturation and run-off are not a problem and where the additional nutrients contained in the effluent can be absorbed by the growing plants.

General effluent treatment practice within the sugar industry favours the use of aerobic treatment for the waste waters from the Sugar Factory, where the flows are relatively small, and anaerobic digestion for the spent wash from distilleries and sugar factories where the waste flows are very large. The Upflow Anaerobic Sludge Blanket (UASB) process has been used very successfully on large effluent flows from sugar factories in Europe and South America. Other types of anaerobic processes may be more appropriate for treating spent wash, particularly the hybrid type of reactor.

Capital and operating costs are major factors in the choice of a particular system and the specified final discharge limits also greatly influence the particular choice or combination of choices. It is for this reason that the Government of Nepal are anxious to avoid the introduction of excessively severe standards which will be uneconomically sustainable at the present time in Nepal.

From the surveys which were carried out during this mission, it would appear that organic pollution from the waste streams within the sugar factories can be greatly reduced by proper in-house management and recycling of the process waters. The volumes and organic content in the final waste water flow which must be discharged from these sugar factories should be of such quantity and quality that

it will not greatly affect the natural eco-system into which it is being discharged. At some future date, when the economic development of Nepal has increased to a more acceptable standard, aerobic treatment of these streams may be considered. The flow of spent wash from the Distilleries is the most polluting aspect of the general sugar industry and its by-products. Even in the present economic climate within Nepal, it is not acceptable to discharge this effluent to any receiving water body, either surface or ground water. A proposal is contained within this document for the safe and economic disposal of this material in a useful and environmentally friendly manner. It is also suggested that a demonstration anaerobic effluent treatment plant should be installed in a suitable sugar factory, so that an appropriate and cost effective effluent treatment system can be introduced into the sugar industry in Nepal. The use of this anaerobic digestion system will not affect the proposal for the safe and economical disposal of the spent wash - it will assist this proposal by reducing the organic load which will be applied to the soils.

In neighbouring India, the government has imposed effluent discharge limits on distilleries (See Table 12, Annex VII). It is estimated that there are in excess of 200 distilleries in India with an estimated spent wash production of 9,567.84 million litres from the production of 798.32 million litres of alcohol. The COD of the spent wash normally approximates 100,000 mg/l with a BOD value estimated at approximately 50,000 mg/l. In order to comply with the relevant standards, most of the distilleries are installing anaerobic digesters for the removal of an estimated 90% of the BOD with the treated effluent being irrigated onto the productive farm lands. In theory this should allow the distilleries to comply with IS 3307 (1977). The 500 mg/l BOD limit is only allowed for effluents disposal as a secondary stage of treatment and then only for irrigation onto lands which have been properly assessed for uptake and run-off. It is further stipulated that the BOD in the adjacent ground water can not increase above 3 mg/l and the nitrate level can not increase above a level of 10 mg/l as N.

Many of the Indian distilleries adjacent to the open border with Nepal have been forced to comply with this standard and these distilleries are very vociferous in complaining about the untreated effluent which is being discharged by the Nepalese distilleries, north of the border, into streams and rivers which very rapidly flow into India. Because of the cost of these effluent treatment plants, there are complaints also about the competitive production cost advantage which accrues to the Nepalese distilleries.

Even though many anaerobic digestion plants have now been installed in India, the track record of these plants is not very good. It is very important, therefore, that relevant training, advice and assistance should be given to the decision makers in the Sugar Industry, the appropriate Government Agencies and all concerned in the installation of such plants in Nepal, so that the appropriate anaerobic technology will be installed. Two anaerobic plants are under consideration already, one at the Shree Ram Sugar Factory and the other at the Jawalakhel Distillery. It appears that a contract has been signed for the supply of a full

scale anaerobic plant at the Shree Ram factory and pilot studies are being conducted at the Jawalakhel distillery where a fixed film reactor is being used. From an initial assessment of the data supplied for the Shree Ram unit, it would appear that an over optimistic 'return-on-investment' is being used and the contract format does not allow for adequate guarantees on plant performance. Assistance with the training of operating personnel is not adequate within the scope of the contract which has been signed and no assistance has been offered in connection with the supply and installation of adequate and relevant laboratory and/or monitoring equipment. The approach which is being applied by the Jawalakhel Distillery is more suited to the situation in Nepal and this project should receive as much technical and financial assistance as possible.

#### **1.5.4 Additional information**

The surveys and reports on the five sugar factories and distilleries which were studied during this mission are contained in Annex VI and a report on the separate distillery is also included in this Annex. Proposals for the treatment of the waste streams is contained in the recommendations section.

## II. INDUSTRIAL POLLUTION CONTROL MONITORING PROGRAMME

### 2.1 General

The Nepal Government has recently drafted the general regulation entitled "Industrial Pollution Control Regulations for Air and Water Discharges (1994)". This regulation is made under the Industrial Enterprises Act 1992. It describes requirements imposed on certain classes of industries defined in the act to restrict and manage environmental emissions. In order to implement this act, the Government of Nepal is anxious to establish guideline standards for the control of industrial effluents. These standards should be broadly based on WHO, EPA and EU standards with due recognition of the economic status of Nepal and its ability to achieve these standards. Adoption of less stringent discharge standards is being considered with the introduction of the more demanding standards being phased in over a period of at least twenty years.

Tables 7, 8 and 9 in Annex VII list the standards associated with water quality in the EU. Table 12 lists some relevant Indian Standards relating to Environmental Protection. Table 10 lists the proposed tolerance limits for industrial effluent discharges in Nepal. These limits are broadly based on Indian Standards. At present, there are no discharge limits applied to effluents in Nepal but the Ministry of Industry is obliged to adopt and publish discharge standards for the first industries within two years of approval of the above proposed tolerance limits. Appropriate discharge standards for other industries will follow at reasonable intervals. A great deal of work on standard setting has been accomplished in the past 30 years by national and international environmental agencies. The common goal has been the attainment of suitable air and water quality standards which are appropriate for the protection of public health and which are economically sustainable.

While ambient air and water quality management remains the final aim, means of its attainment is focused more and more on the use of best practical abatement technology. This accommodates the need to have due regard for the prevailing economic climate. In adopting national standards, the Nepal Government is proceeding along a route of industry-specific discharge standards. The standards and accounts of successful abatement published in "Environmental Guidelines" by the Environmental Department of the World Bank, September, 1988 are being used as a basis for these industry-specific discharge standards. The discharge standards which are being initially proposed are less onerous than those contained in the WHO, EPA and EU standards and are more closely aligned to the standards specified by the Indian Government. As an initial stage, this seems to be the most appropriate method of introducing environmental protection in Nepal.

In most countries, as well as adopting a national standard, discharge limits are set on an individual basis, i.e. a licence is issued to each discharger which limits the type, quality and quantity of pollution which the industry is allowed to discharge into the environment. These limits are based on information supplied by the industry in an inventory which lists the complete characterisation of the waste streams and specifies the location of the stream on a suitable site location map. A sample application form

is outlined in Annex X

These limits also take into account the assimilative capacity, if any, of the receiving waterbody.

## **2.2 Water quality objectives**

The determination of water quality parameters and of water quality objectives for all beneficial uses of the national water bodies is a very complex process. However, in arriving at water quality objectives, all beneficial uses should be taken into account and the quality objectives must be designed to meet the most stringent beneficial use requirement. This use will normally be one associated with human consumption, fisheries, agriculture, industry, tourism, etc.

There are basic physical, chemical and biological differences between marine, estuarine, river and lake waters and even in single water courses, ecological conditions may vary widely within short distances. It is very difficult for global national water quality standards to meet the needs of all the individual aquatic eco-systems and such standards should therefore be applied with considered judgement of local conditions and in consultation with local authorities and local agencies.

## **2.3 EU Water Quality Standards**

The mandatory minimal water quality objectives for surface waters intended as sources for drinking water within the EU are listed in Table 7. The mandatory quality requirements for bathing waters within the EU are listed in Table 8, while the water quality objectives for spawning and salmonid freshwaters, estuaries and other coastal waters are listed in Table 9. These values list the minimal quality objectives. Member states may set more stringent limits for certain of these parameters. The EU also identifies certain of the above parameters to which it ascribes more stringent 'desirable limits'.

## **2.4 Effluent Discharges**

### **2.4.1 General**

Tables 7, 8 and 9 indicate the maximum allowable concentrations for certain chemical parameters in different water bodies, depending on the use of these water bodies. If an effluent discharges into a water body, the resultant mixture should meet these minimum requirements. These tables do not list any recommendations for organic loads or alterations in, dissolved oxygen levels, nutrients enrichment (eutrophication), suspended solids or temperature.

In defining the discharge limits for these parameters reference must be made to the existing status of the water body and its assimilative capabilities, including such physical characteristics as, dilution factor, reaeration capabilities, flow patterns, seasonal variations and other hydrological influences.

In deciding what portion of the assimilative capacity of a receiving water may be allocated to an individual discharge, it is essential to consider other existing and possible future discharges. The more important parameters which are used to assess and regulate discharges are listed and discussed in the following paragraphs.

#### **2.4.1(a) Organic Loads**

Most of the recommendations for organic loads relate to the work of the 'Royal Commission' in England in 1912. The reports from this Commission are mostly concerned with domestic effluents but over the years these recommendations and findings have been extended to include other organic wastes.

In these Reports, it is recommended that the Biochemical Oxygen Demand (BOD) of an effluent should be such that on admixture with the receiving water, the BOD value of this receiving water will not be increased by more than 1 mg/l. In no circumstances should the BOD value of the effluent be such that the BOD of the receiving water will be increased to a value greater than 5 mg/l. In the case of discharges from large urban areas, the Commission recommended that an effluent with a BOD of 20 mg/l or less and a suspended solids (SS) content of 30 mg/l or less would be acceptable, provided that there is a minimum dilution factor in the receiving water body of 1 in 8, at all times of the year.

It is a cumbersome and expensive procedure to carry out BOD analysis on a routine regular basis for a large number of samples. Hence, Chemical Oxygen Demand (COD) data is used as an alternative, where ever possible. For each individual effluent, the relationship between BOD and COD should be established at the outset. COD data can then be substituted for BOD data. It is very important that accurate BOD data be obtained initially so that a true picture of the organic pollution in the water body can be obtained.

#### **2.4.1(b) Dissolved Oxygen**

The kinetics of BOD and dissolved oxygen are described in many publications and will not be repeated here. For protection of the aesthetic quality of waters, it is only necessary to have sufficient dissolved oxygen to prevent the occurrence of septical or anaerobic conditions. However, in order to protect fish and other aquatic life more stringent standards are required. In addition, salmonoid and certain other fish species bury their fertilised eggs in bottom gravels. In order to ensure an adequate supply of oxygen in the interstices of the gravel for the developing fish of these species, even more stringent standards are required. The following standards refer to water quality outside the mixing zone. (The mixing zone should not be so long and intense as to reduce the DO level across the full river section by more than 50%).

- 1) Non salmonid waters

- 1) General DO levels to be not less than 70% of the saturation value in 50% of the samples.
  - 2) DO level to be not less than 4 mg/l in 95% of the samples.
  - 3) No sample to have been less than 3 mg/l DO.
  - 4) BOD not to exceed 5 mg/l.
- (ii) Salmonoid and spawning waters
- 1) General DO levels to be not less than 90% of the saturation value in 50% of the samples.
  - 2) DO level to be not less than 6 mg/l in 95% of the samples.
  - 3) No sample to have less than 4 mg/l DO.
  - 4) BOD not to exceed 4 mg/l.
- (iii) Estuaries and other coastal waters
- 1) General DO levels to be not less than 70% of the saturation value in 50% of the samples.
  - 2) DO level to be not less than 5 mg/l in 95% of the samples.
  - 3) No sample to have less than 4 mg/l DO.
  - 4) BOD not to exceed 4 mg/l.

#### 2.4.1(c) Nitrates

Nitrates are important nutrients in eutrophication. They are abundant in nature and are easily leached from soil or fixed from the air as nitrogen. It is not practical, therefore, to recommend a nitrate concentration for eutrophication control in freshwater.

Problems similar to eutrophication, however, can occur in estuaries and even at sea. Phosphate is rarely the limiting nutrient in marine waters, usually it is nitrate, or, out of reach of land, silicate. Particular attention should be paid to the discharge of nitrogenous effluents near estuarine mud-flats which may cause problems of weed growth and decay. In order to prevent eutrophication in estuaries and coastal waters, a value of 1 mg/l nitrate is recommended as a suitable quality objective for these waters. Since concentrations of nitrate or nitrite, sufficient to cause toxic effects on fish life can rarely occur in natural waters, no recommendations for these parameters are being made for the

protection of aquatic life.

High nitrate concentrations pose a potential health risk to infants under 3 months of age. The mandatory limit for drinking water is 50 mg/l.

#### **2.4.1(d) Ammonia**

When ammonia dissolves in water a chemical equilibrium is established which contains un-ionised ammonia ( $\text{NH}_3$ ), ionised ammonia ( $\text{NH}_4$ ) and hydroxide ions ( $\text{OH}$ ). Total ammonia refers to the sum of the un-ionised and ionised forms ( $\text{NH}_3 + \text{NH}_4$ ). The harmful effects of ammonia in water are attributed to the un-ionised ( $\text{NH}_3$ ) fraction, which increases with rising pH and temperature. The toxicity of ammonia in freshwater is, therefore, dependent on the concentration of total ammonia, pH value and temperature.

To avoid adverse effects on aquatic life, a water quality objective of 0.02 mg/l of un-ionised ammonia ( $\text{NH}_3$ ) is recommended for freshwater.

The  $\text{NH}_3$  concentration is also dependent on ionic strength, decreasing with increasing salinity in dilute saline solutions. Since data on the effect of ammonia on marine species is limited, no water quality objective is recommended for coastal waters.

#### **2.4.1(e) Phosphorous**

Limitation of phosphorous in effluent discharges is generally associated with control of nutrient enrichment or eutrophication of fresh water bodies, particularly lakes.

The physical and ecological characteristics of lakes are so variable that it is not possible to suggest a single or even a range of values for phosphat concentration which would assure control of eutrophication in any particular case.

However, the Vollenweider method of controlling the annual phosphate loading of lakes provides a useful approach to eutrophication control. Vollenweider relates total phosphorus (P) loadings, in grams per square metre of surface area per year, to the ratio mean lake depth in metres divided by the hydraulic detention time in years. The loadings suggested by Vollenweider, and presented in the following Table, range from oligotrophic or permissible loadings to eutrophic or critical loadings. If phosphorus loadings are not allowed to reach the eutrophic level and are limited as nearly as possible to the oligotrophic levels, positive results can be expected.



**LOADING VALUES FOR PHOSPHATES AS TOTAL PHOSPHOROUS (P) IN  
LAKES VOLLENWEIDER, 1973**

Mean depth/ Hydraulic detention time <hr/> (metres/year)	Oligotrophic or Permissible Loading <hr/> (grams/metre <sup>2</sup> /year)	Eutrophic or Critical Loading <hr/> (grams/metre <sup>2</sup> /year)
0.5	0.07	0.14
1.0	0.10	0.20
2.5	0.16	0.32
5.0	0.22	0.45
7.5	0.27	0.55
10.0	0.32	0.63
25.0	0.50	1.00
50.0	0.71	1.41
75.0	0.87	1.73
100.0	1.00	2.00

**2.4.1(f) Oil and Grease**

Since oil and grease do not constitute definite chemical categories, but include thousands of organic compounds with varying properties, it is not possible to set numerical values as water quality objectives. They may be volatile or non-volatile, soluble or insoluble, biodegradable or persistent, and may be lethal or sub-lethal in their effects on aquatic life. Bioaccumulation of even minute concentrations of petroleum products may result in tainting of fish life or danger to human health. The following descriptive water quality objectives are recommended.

Oils and grease should not be present in qualities such as to:

- 1) form visible films on the surface of waters.
- 2) form coatings on the beds of watercourses, benthic biota or food sources.
- 3) cause deleterious effects on aquatic life.
- 4) impart a detectable taste or odour to edible aquatic species.

**2.4.1(g) Suspended Solids**

Suspended and settleable solids and turbidity measurements are important parameters in water quality management. They are particularly important in the context of public and industrial water supplies. High turbidity makes water unattractive for recreational purposes, especially water contact sports. The effects of suspended solids on fish can be summarised as follows:

- (i) Direct effect resulting in fish kills, reduced growth or reduced resistance to

disease.

- (ii) Prevention of the successful development of fish eggs and larvae by blanketing the bottom of water bodies.
- (iii) Interference with natural movement and migration of fish.
- (iv) Reduction of available food supplies by blanketing benthic populations and by a decrease in primary food production caused by reduced light penetration

The present state of knowledge does not allow firm water quality criteria to be set for all waters in this context. However, the following guidelines are recommended.

- (1) Artificial increase in turbidity should not be allowed to reduce the depth of light penetration by more than 10% outside the mixing zone.
- (2) In the absence of adequate seasonal records of light penetration, total suspended solids should not exceed 30 mg/l in its effluent.
- (3) Scum and other floating or suspended solids should not be present in the receiving water in unsightly or deleterious amounts.
- (4) Deposition of solids shall not be such as to affect bottom feeding flora and fauna, or spawning or shellfish beds, or to form putrescible or otherwise objectionable sludge deposits.

#### **2.4.1(h) Temperature**

Temperature is one of the most important factors regulating the composition, variety and activity of living species in an aquatic environment. It is also an important physical parameter which can effect many of the beneficial uses of water. Changes in ambient water temperature have effects which are notable for their complexity and diversity and which are not sufficiently well understood to enable comprehensive thermal standards to be set for all waters or effluents.

Increased temperatures in polluted waters can cause aesthetic deterioration and danger to aquatic life by increased oxygen absorption caused by accelerating the biodegradation of organic matter both in the water column and in benthic deposits. This effect is magnified by the fact that the solubility of oxygen in water decreases with rising temperature.

Natural diurnal and seasonal changes in the temperatures of water bodies caused by climatic conditions determine the community structure and diversity of species, and are necessary to regulate certain life functions. For instance, the reproductive cycle is recognised as being most sensitive to temperature variation and is often induced by low winter temperature. In addition, a slight increase above naturally occurring temperatures, in early Spring can lead to advanced spawning with the result that young fish are hatched before their normal food source is available.

Uniform elevation of temperature over the year is less serious than brief fluctuations in temperature, particularly if these coincide with reproductive functions in the life cycle. Nevertheless it is important that thermal increases be minimised during all seasons of the year. In Summer the maxima are particularly important since they can cause critical conditions for brief periods which may result in death, emigration or other sub lethal effects. These Summer thermal maxima should, if possible, be established for each water body and no increase on these maxima by artificial means should be allowed.

As a general guide, it is recommended that effluent discharged into a water body should not elevate its ambient temperature by more than 1 Deg. C at any time throughout the year.

#### **2.4.1(i) Toxic Pollutants**

In an ideal situation the basis for establishing the safe concentration of a toxic pollutant would be to select the species in the receiving water most sensitive to the particular pollutant and to subject this species to long-term bioassays with various concentrations of pollutants, in conditions as closely as possible resembling those in the receiving water. In view of the cost involved in such long-term testing the "safe" level is normally estimated firstly by determining the concentration of pollutant which is lethal to 50% of the test species in 96 hours. This concentration is known as the 96 hour LC50 value. An "application factor" or safety factor is then used to calculate a concentration of pollutant which will protect all life stages of the test organism and of all other organisms in the receiving water. The application factor is generally assigned on the basis of scientific knowledge of the relation between safe levels and lethal levels.

Where this approach is not possible reference should be made to an appropriate list of water quality objectives such as that given in Table 9. The particular objectives listed apply to two important categories of water, namely fresh waters which support salmonoid fish or spawning areas, and estuaries and other coastal waters. The objectives are based on laboratory experiments into the lethal and sub-lethal effects of the substances listed. Because of differences in water chemistry between the laboratory and the field, quality objectives for toxic substances may not be valid in all localities. For example, there may be situations where naturally occurring levels exceed those listed in Table 9. In such cases the natural level should be regarded as the water quality objective. It should be emphasised that water quality objectives are to be applied at the boundary of mixing zones and not to the water body as a whole.

#### **2.4.1(j) Other Quality Characteristics**

Recommended water quality objectives for other characteristics such as pH and sulphate are also given in Table 9.

### III. CONCLUSIONS

- The sugar cane industry is very important to the economic well-being of Nepal
- This is an expanding industry which is generally located in the less well developed regions of the country.
- The country is not self sufficient in sugar and the demand for sugar is increasing due to the increase in population and the increasing economic and social development within the country.
- The sugar industry is a very important cash crop for many thousands of farmers
- There is plenty of additional land available for increased production.
- The government is encouraging an increase in sugar cane production and the building of new sugar factories.
- The productivity of cane production per hectare is relatively low. Better husbandry and new varieties should be introduced into Nepal.
- The scheduling of cane harvesting needs to coincide with processing schedules in the factories
- The time delay between cane harvesting and processing in the factories needs to be reduced. This can be achieved through better access roads and better farmer - factory co-ordination.
- Access roads in the cane harvesting areas are very poor
- The sugar factories and in particular the associated distilleries are major contributors to water pollution in the sugar cane growing areas
- The water table is generally high in the sugar cane growing areas
- Water volume in the rivers and streams in the sugar cane growing areas is generally very low during the sugar processing season and hence effluent dilution is very low
- Most of the discharged effluent passes into India across the open border.
- Only one of the five factories which were visited during this mission appears to be concerned with the availability of an adequate supply of process water. Water conservation within the factories was not, therefore, a major concern to the factory managers
- There is considerable water wastage within most of the factories

- Because of the large volume of effluent which is being discharged and the dilute nature of the wastes from the sugar factory itself (separate from the distilleries) it is not economically possible to instal and operate effluent treatment plants for these wastes, within the present context of the current or foreseeable future economic status of Nepal. For this reason, internal pollution auditing and excess organic discharge control within the factories should be encouraged and checked by a relevant government agency.
- With the exception of the two newer factories, the equipment within the factories is very old. The remaining useful life of this equipment is very limited and an immediate refurbishment should be instigated. Because of the importance of this industry to the farmers in these very disadvantaged areas of Nepal, the government should give some form of incentive to these factories to encourage processing improvement, better management practices and the replacement of old equipment with newer and more efficient equipment.
- There is a considerable difference in management quality and enthusiasm between the various factories. There is room for substantial improvement in many of these factories.
- The disposal of effluents from the distilleries is a major problem
- There is no attempt to treat the effluent from these distilleries.
- The economic viability of the complete sugar industry will be threatened if the government enforce the new proposed discharge limits without providing some form of incentive, either by direct grant aid or through tax reliefs. It appears that such incentives have been given by the Indian Government to distilleries within their jurisdiction
- It appears that most of the major effluents from the sugar factories and associated distilleries can be safely disposed of through land irrigation without much cost to the factories or the farmers. There appears to be an added advantage from the proposed irrigation method because of the nutrients which will be returned to the soil.
- Anaerobic effluent treatment is being installed in two locations for the treatment of spent wash. The management of these factories should be assisted and encouraged by the government through technical and possible financial assistance, in return for use of these plants for educational and demonstration purposes.
- The Government of Nepal is anxious to protect the native environment and has enacted various regulations and laws to encourage this protection.
- The national pollution monitoring and control structures are inadequate and should be expanded. Financial and technical assistance should be sought from outside agencies.

#### IV. RECOMMENDATIONS

- Provide technical and educational assistance to the farmers in order to improve crop productivity and provide assistance with the introduction of new varieties of sugar cane.
- The Sugar Companies and Farmers should agree on a suitable phased crop harvesting programme so that queues at the factories can be reduced, the freshly harvested cane can be rapidly transported to the factories and the factories can operate at a set capacity for the duration of the Season.
- The Government should assist with improvements in the arterial roads structures in the harvesting areas so that the speed of transport can be increased.
- Payments to the Farmers should be based on both quantity and sugar content. This will encourage better husbandry, crop management and phased harvesting.
- The Government should encourage better water usage within the sugar factories through Statutory Regulations combined with Pollution Audits and Discharge Licences. This can be achieved at minimum cost through conservation and recycle of most of the processing waters. Initial discharge limits can be relatively generous with more stringent limits being imposed at each new phase of licence approval.
- Direct discharge of the waste stream from the vacuum filters within the Sugar Factories should be prohibited.
- The caustic washes and acid washes in the factories should be collected in an individual tank so that these wastes can be blended with the general process waters or the waste stream, whichever is the most appropriate.
- The yeast cells from the Distilleries should be collected in a separate tank and should be disposed of for animal feed, soil conditioning or as a dried solid waste.
- The heat from the spent wash should be used to pre-heat the boiler feed water or any other suitable process water.
- The spent wash should be collected in a lagoon or tank and stored for direct application on to the arable fields.
- The spent wash should be combined with the filter mud and the ash from the boilers so that this combined mixture can be spread by vacuum tanker on the arable lands and thereby return the plant nutrients to the soil.
- The Government should provide technical assistance in the area of soil assessment suitability for the direct irrigation of spent wash or anaerobically digested spent wash.

- A demonstration vacuum tanker and four wheel drive tractor should be provided to at least one suitable factory (e.g. Lumbini Sugar Mills) so that this slurry spreading technology can be demonstrated to the local farmers. The vacuum tanker should be fitted for both automatic spreading and for connection to a manually controlled spray pipe system which will accommodate slurry spreading in the smaller fields.
- International assistance should be provided in the area of Anaerobic Digestion technology so that a suitable demonstration Anaerobic Digester can be provided for the treatment of the spent wash. Assistance could be provided to the Shree Ram Sugar Factory which has contracted to install an Anaerobic Digester but which does not possess the technical know-how to successfully commission and operate this plant and assistance could also be provided to the Jawalakhel Distillery which is in the process of assessing the most appropriate anaerobic technology for the treatment of spent wash in Nepal.
- The Government should provide incentives for the installation of effluent treatment facilities by way of tax credits or direct grant aid.
- Assistance should be provided for training suitable personnel in the Sugar Factories, the Distilleries and Relevant Government Agencies in the areas of Pollution Auditing, Effluent Monitoring and Effluent Treatment Techniques, including modern Anaerobic Digestion processes.
- Assistance should be provided to the relevant Government Agencies so that both central and local laboratories can be suitably equipped to carry out relevant monitoring and assessment of factory effluents for compliance with specified Discharge Licences.
- The older Sugar Factories should be encouraged to modernise and update equipment.
- Install simple V-notch flow monitoring devices in the open channels.

## ANNEX I

### JOB DESCRIPTION

SI-NEP 94 801-11-01

- Post title:** Expert in Sugar Agro-industry Effluent Treatment 2.0 months (1.0 month field work and 1.0 month home-office work)
- Date required:** As soon as possible
- Duty Station:** Kathmandu with travel within the country
- Purpose of project:** Based on the present status and on the perspective for future development of the sugar industry in the country, to provide His Majesty's Government with advice on the establishment of an industrial pollution control and monitoring programme for three sugar factories and adjacent distilleries.
- Duties:** In close co-operation with the Consultant in Sugar and Alcohol Manufacturing Processes (Post 11-02), the consultant in Sugar Agro-industry Development Strategies (Post 11-03), and using internationally accepted industrial pollution standards, e.g. WHO, EPA, EU, the consultant is expected to determine the requirements for the establishment of an "Industrial Pollution Control and Monitoring Programme" for the sugar and alcohol industries in Nepal. The consultant will be responsible for carrying out the following activities:
- (i) to study in detail the industrial processes in order to determine the volume of liquid and solid wastes generated;
  - (ii) to analyse the chemical and the physical characteristics of the wastes, comparing them with the standards observed in the countries where the industry is already controlled;
  - (iii) based on the characteristics of the wastes generated and on the industrial pollution control standards being applied internationally, to define the requirements for establishing an industrial pollution control and monitoring system for the sugar and alcohol industry in the country. This activity will be carried out after taking into account: a) the possibilities of modifying the process (introduction of the concept of "clean technologies") and b) the perspective for future development of the sugar industry in the country;



(iv) to define the minimum physical infrastructure and human resources required to implement the proposed industrial pollution control and monitoring system.

(v) to provide the technical information and the required explanation on the establishment and operation of an industrial pollution control and monitoring system to at least three factory employees and one government (Ministry of Industry or Nepal Bureau of Standard and Metrology) official appointed as individual technical counterparts to the consultant.

(vi) the consultant is also expected to prepare a joint detailed report pointing out all the conclusions of his/her assignment and recommendations to His Majesty's Government of Nepal

**Qualifications:**

Technical background in chemical or food engineering or with a strong background in environmental engineering with experience in pollution control and monitoring within the sugar and alcohol industry.

**Language:**

English

## **JOB DESCRIPTION**

SI NEP 94 801 11-02

- Post title:** Expert in Sugar and Alcohol Manufacturing Processes
- Duration:** 20 months (10 month field work and 10 month home-office work)
- Date required:** As soon as possible
- Duty Station:** Kathmandu with travel within the country
- Purpose of project:** Based on the present status and on the perspective for future development of the sugar industry in the country, to provide His Majesty's Government with advice on the establishment of an industrial pollution control and monitoring programme for three sugar factories and adjacent distilleries
- Duties:** In close co-operation with the Consultant in Sugar Agro-industry Effluent Treatment (Post 11-01) and the Consultant in Sugar Agro-industry Development Strategies (Post 11-03), the consultant will be responsible for introducing the concept of "clean technology" within the sugar and alcohol industry in Nepal. He/she will be responsible to carry out specifically the following activities:
- (i) to cooperate in the determination of the volume of liquid and solid wastes generated by the three industrial plants to be studied;
  - (ii) to cooperate in the analysis of the chemical and physical characteristics of the wastes generated;
  - (iii) to study in detail the industrial processes in each plant in order to identify the unit operations within the plants that could be improved in terms of the reduction of the amount of wastes generated. Attention shall also be given to the energy generation units of each plant.
  - (iv) to provide the required technical information and specifications to be implemented by the staff of each individual plant in order to make the necessary changes in the process. The proposal shall be made at two basic levels (i.e.) a) the changes with reduced or no additional investment and b) changes with expressive fixed investments.

(v) to transfer to the consultant in Sugar Agro-industry Effluent Treatment (post 11-01) all necessary information regarding the introduction of "clean technology" operations within the studied plants and the corresponding implication on the reduction of the amount and quality of wastes generated;

(vi) the consultant is also expected to prepare a joint detailed report pointing out all the conclusions of his/her assignment and recommendations to His Majesty's Government of Nepal.

**Qualifications:**

Technical background in chemical or food engineering with a wide experience in the manufacturing of cane sugar and production of ethanol.

**Language:**

English

## **JOB DESCRIPTION**

SI NEP/94 801/11-03

- Post title:** Expert in Sugar Agro-industry Development Strategies
- Duration:** 0.5 month (7.0 working days of field work and 3.0 working days of home-office work)
- Date required:** As soon as possible
- Duty Station:** Kathmandu with travel within the country
- Purpose of project:** Based on the present status and on the perspective for future development of the sugar industry in the country, to provide His Majesty's Government with advice on the establishment of an industrial pollution control and monitoring programme for three sugar factories and adjacent distilleries.
- Duties:** In close cooperation with the Consultant in Sugar Agro-industry Effluent Treatment (Post 11-01) and the Consultant in Sugar and Alcohol Manufacturing Processes (Post 11-02), the consultant is expected to provide an advice to His Majesty's Government of Nepal and to the other two consultants, the perspective for future development of the sugar industry in the country. He/she will be responsible for carrying out the following activities:
- (i) to assess the present situation of the sugar industry in the country regarding the physical infrastructure available as:
    - a) agricultural inputs (including raw material);
    - b) technical and scientific research institutions able to carry out research and training of technical personnel;
    - c) the required human resources;
    - d) other physical infrastructure required as:
      - distribution facilities
      - storage sites
      - transportation facilities
      - telecommunication system
      - banking facilities
      - etc.
  - (ii) to assess the present situation of the sugar industry in the country, regarding the non- physical infrastructure available as:

- banking and financing policies
- information system
- import/export policies
- labour policies
- etc.

(iii) to assess the industrial facilities and to identify the potential for production of sugar as well as alcohol and other sugar by-products in the country taking into consideration the present and future domestic and export market, the magnitude of the needs and the requirements of physical and non-physical infrastructure;

(iv) to transfer to the consultant in Sugar Agro-industry Effluent Treatment (post 11-01) all necessary information regarding the perspective for development of the sugar industry in the country in order that the information be taken into consideration in the design of the pollution control and monitoring system;

(v) the consultant is also expected to prepare a joint detailed report pointing out all the conclusions of his/her assignment and recommendations to His Majesty's Government of Nepal.

**Qualifications:**

Technical background in chemical or food engineering with experience in agro-industrial strategic planning particularly in the field of sugar and sugar by-products manufacturing.

**Language:**

English

## BACKGROUND INFORMATION

1. Sugar cane production in Nepal is estimated at nearly 1 million metric tons (MT) per annum. Industrial sugar production varies between 27,000 and 32,000 MT per annum. The main production units are:

(i) Lumbini Sugar Factory Ltd. in the Terai region, established under a joint venture agreement between His Majesty's Government (HMG) and the Government of the People's Republic of China. The production target is 1,000 MT cane-crushing per day producing 10,000 MT of sugar per annum. In addition, the factory produces 12,000 litres of rectified spirit per day using 600 quintal of molasses as a by-product. The factory directly employs some 1,200 persons and indirectly some 11,000 farmers. The factory uses 10,000 cubic metres of water per day from nine deep tube wells and the nearby Turia river.

(ii) Birganj Sugar Factory Ltd. in the Terai, established under an agreement between HMG and the former USSR. The production capacity of cane-crushing is 1,500 MT per day, with a production of 13,500 MT of sugar per annum. Actual production is 20,000 MT per annum with a season of 4-5 months. The sugar mill generates approximately 20 m<sup>3</sup>/day of organically polluted effluent (COD = 2,000 - 3,000 mg/l). Throughout the year the ceaseless fermentation and distillation of alcohol from molasses produces approximately 100m<sup>3</sup>/day of heavily polluted effluent (COD: 70,000 - 75,000 mg/l).

(iii) Bhairawa Sugar Mill in the Terai, established as a private enterprise using technology from India.

2. The raw materials and accessories used in the production process include:

- Sulphur
- Slaked lime
- Filter cloth
- Caustic soda
- Aluminium sulphate
- Resin
- Jute sack
- Phosphoric acid
- Sulphuric acid
- Firewood
- Diesel and light diesel oil
- Lubricants with different grades, grease
- Chemicals and accessories used in the laboratory.

3. During the course of the crop year, while the cane is being ground, considerable

quantities of liquid waste are generated at the plants. This waste water comes mostly from cleaning at the plant. This liquid waste has a very high organic load and high content of waste oils that comes from the machines. Presently, this waste is not being treated before it is discharged into the receiving environment, i.e. the nearby rivers. The problem is further aggravated as the quantity of water in the rivers is very small in winter causing health hazards to nearby localities. Some religious rites which were previously conducted in the rivers cannot be done anymore. The water used for irrigation affects the crops as well as the soil thereby reducing productivity.

4. HMG has identified the three sugar factories as the most polluting industrial enterprises in the Terai region and has requested urgent action in plans to control and monitor the effluent flow produced by the factories. HMG places particular emphasis on environmental aspects in its development plans and a number of activities have been launched recently in support of environmentally sustainable industrial development, including the following projects supported by the donor community:

- HMG/UNDP/NEP/91/029 Industrial Pollution Control Management with UNIDO as implementing agency building institutional capacities within the Ministry of Industry for the implementation of industry-related environmental policies, pollution control plans and programmes, together with the enforcement of appropriate legislation;
- HMG/UNIDO/NEP/92/120 Establishment of Model and Demonstration Tannery Effluent Treatment Facilities in Nepal;
- UNIDO/SI/NEP/93/801 Effluent Treatment Expert for Associate Craft Producers in Kathmandu;
- DANIDA projects on sewer rehabilitation and waste water treatment at Balaju and Hetauda industrial districts and water pollution baseline studies in Kathmandu valley; and
- HMG/UNIDO/NEP/93/166 Area-wide Environmental Quality Management Plan for Biratnagar and Birganj industrial districts (being negotiated with potential donors)

5. HMG has requested UNIDO assistance to complement the above activities by a detailed study on the technical effluent treatment issues at the three sugar factories described above, thus addressing the most urgent and environmentally most damaging problem of those industrial areas for which no specific programmes or projects are envisaged in the foreseeable future apart from the policy and legislative instruments being formulated under project NEP/91/029 (see above). The HMG and UNIDO staff of project NEP/91/029 will coordinate the activities and use the results of this case study in formulating policies and legislation.

## ANNEX II

### COUNTERPARTS

1. Mr. C.P. Neupane (National Consultant UNIDO).  
United Nations Buildings.  
Pulchowk.  
P.O. Box 107.  
Kathmandu,  
Nepal.
  
2. Mr. Surendra Khadka (Senior Officer MOI).  
Ministry of Industry.  
Singha Durbar.  
Kathmandu,  
Nepal.



## ANNEX III

### LIST OF PEOPLE MET

#### Government Members

1. Mr. P.P. Dahal (Secretary, MOI)  
Ministry of Industry,  
Singha Durbar,  
Kathmandu,  
Nepal.
2. Mr. Bimal P. Koirala (Joint Secretary, MOI),  
Ministry of Industry,  
Singha Durbar,  
Kathmandu,  
Nepal.
3. Mr. Mukesh Dev Bhattarai (Senior Divisional Engineer MOI),  
Ministry of Industry,  
Singha Durbar,  
Kathmandu,  
Nepal.
4. Mr. P.P. Manandhar (Director - General),  
Nepal Bureau of Standards and Metrology,  
Balaju,  
Kathmandu,  
Nepal.

#### Local UNIDO personnel

1. Mr. Arjun K. Upadhya (UNIDO National Director),  
United Nations Buildings,  
Pulchowk,  
P.O. Box 107,  
Kathmandu,  
Nepal.
2. Mr. Naheed Atiq Haque (UNDP),  
United Nations Buildings,  
Pulchowk,  
P.O. Box 107,  
Kathmandu,  
Nepal.
3. Mr. S. Devkota (National Consultant UNIDO),

United Nations Buildings,  
Pulchowk,  
P.O. Box 107,  
Kathmandu,  
Nepal

**Lumbini Sugar Factory, (Pub. Ent.), Sunwal, Dis: Nawalparasi, Zone: Lumbini.**

- |    |                |                              |
|----|----------------|------------------------------|
| 1. | Mr. M. Koirala | General Manager              |
| 2. | Mr. A.S. Thapa | Chief Production Officer     |
| 3. | Mr. Dahal      | Sugar Technologist           |
| 4. | Mr. L. Misra   | Alcohol Technologist         |
| 5. | Mr. A.S. Saiju | Cane Manager                 |
| 6. | Mr. K. Neupane | Chief Administrative Officer |
| 7. | Mr. Malla      | Chief Engineer               |
| 8. | Mr. Shah       | Chief Engineer               |

**Mahendra Sugar Factory, (Pvt. Ent.), Bhairahawa, Dis: Rupandehi, Zone: Lumbini.**

- |    |               |                        |
|----|---------------|------------------------|
| 1. | Mr. Bhandari  | Acting General Manager |
| 2. | Mr. Thapaliya | Chief Account Officer  |
| 3. | Mr. Parsad    | Chief Chemist          |

**Indu Shankar Chini Mill, (Pvt. Ent.), Hariown, Dis: Sarlahi, Zone: Janakpur.**

- |    |                |                 |
|----|----------------|-----------------|
| 1. | Mr. B.L. Kedia | Owner of Mill   |
| 2. | Mr. R. Kedia   | Director        |
| 3. | Mr. S.C. Jain  | Chief Chemist   |
| 4. | Mr. V.K. Jha   | General Manager |

**Shree Ram Sugar Factory, (Pvt. Ent.), Garuda, Dis: Rautahat, Zone: Narayani.**

- |    |                 |                 |
|----|-----------------|-----------------|
| 1. | Mr. L.N. Thakur | General Manager |
| 2. | Mr. Khour       | Chief Chemist   |
| 3. | Mr. Kularni     | Chief Engineer  |

**Birjung Sugar Factory, (Pub. Ent.), Birjung, Dis: Bara, Zone: Narayani.**

- |    |                   |                                   |
|----|-------------------|-----------------------------------|
| 1. | Mr. S.P. Pathak   | General Manager                   |
| 2. | Mr. C. Rout       | Chief Production Officer          |
| 3. | Mr. N.L. Choudari | Chief Engineer                    |
| 4. | Mr. Joshi         | Previous Chief Production Officer |

**Bagmati Khadasari (Pvt. Ent.), Nawalparasi, Dis: Nawalparasi, Zone: Lumbini.**

1. Mr. Shrestha Owner

**Jawalakhel Distillery (Pvt. Ent.), Patan, Dis: Lalitpur, Zone: Bagmati.**

1. Mr. Vijaya Shah Owner & Alcohol Technologist

**Association for Craft Producers, P.O. Box 3701, Kathmandu, Nepal.**

1. Mr. Mike Krajniak Advisor
2. Mr. Prabhat Kiran Pradhan Assistant Programme Director

**ANNEX IV**  
**PROPOSED TRAINING PROGRAMME**

It is suggested that at least **two** of the counterpart staff should be sent for **further formal training in Water Quality Management and Pollution Auditing Techniques**. This training should be carried out at a **third level college** culminating in a degree or diploma qualification.

This training is necessary in order that at least two staff members should have a formal training in both the theoretical and practical aspects of Water Quality Monitoring and Pollution Control. This qualification will be useful when dealing with the legal status of effluent discharge licences and statutory pollution controls which will be implemented under the Industrial Enterprises Act, 1992.

**There are also short courses available in water quality testing procedures from Hach Company, P.O. Box 389, Loveland, Colorado 80539, USA. These courses give technical training in analytical procedures for water quality assessment.**

At present there are no government officials with direct responsibility to carry out the necessary monitoring and assessment programmes. If a national programme is to be implemented and continuous monitoring carried out, additional staff will be required, together with a suitably well equipped government staffed laboratory. Mr. C. P. Neupane is already acting in an advisory capacity to the Government of Nepal under a UNIDO contract. Smaller regional laboratories will be required because of the transport difficulties between Kathmandu and many of the remote districts.

In addition to the above training programme, which relates to government employees, it is recommended that financial assistance should be made available, by way of Grant Aid, to at least **two technical personnel** in each Sugar Factory - Distillery, so that **technical training** can be obtained in **effluent quality monitoring and control** with particular emphasis on the **operating and economic aspects of effluent treatment systems**, as applied to sugar and distillery effluents including both aerobic and anaerobic techniques.

A **national training programme for the farmers/producers** should be instigated which would encourage and demonstrate the growth of better varieties of Sugar Cane, the use of fertilisers for better productivity, the application of liquid fertiliser slurry from the factories (spent wash, filter mud and ash), the importance of phased harvesting and the elimination of long queues at the factory and the advantages of rapid delivery of the harvested sugar cane to the factory. This should be a joint programme between the Government, Sugar Factories and the Farmers.

## ANNEX V

### LIST OF RECOMMENDED EQUIPMENT

In addition to the training programme proposed in Annex IV it will be necessary for the Government of Nepal to procure the equipment required to rapidly and accurately monitor the quality of the effluent being discharged from the various industries. Towards this end, it is recommended that the following equipment should be acquired by a designated Government Department which will have responsibility for monitoring, controlling and licensing all effluent discharges. (From the inspection of the laboratories at the Bureau of Standards and Metrology, it would appear that these laboratories are more ideally equipped and staffed to carry out tests for monitoring industrial processing and product standards. Ideally, environmental monitoring should be carried out in a separate central laboratory with associated minimal facilities located in each region.)

1. Hach Dr 2000 Spectrophotometer, complete kit DREL 2000 Catalogue No 45250-05

- i) Spectrophotometer DR 2000
- ii) Digital titrator
- iii) Operation manual
- iv) Portable pH meter with pH probe and 20' extension lead
- v) Portable conductivity TDS meter with probe and 20' extension lead
- vi) Battery recharger
- vii) Carrying cases for the equipment
- viii) Chemicals and reagents for,
  - (a) Nitrate nitrogen
  - (b) Ammonia nitrogen
  - (c) Phosphorus
  - (d) Hardness - (Digital titration method)
  - (e) Calcium - (Digital titration method)
  - (f) Magnesium - (Digital titration method)
  - (g) Iron
  - (h) Sulphate
  - (i) Dissolved oxygen
  - (j) Alkalinity - (Digital titration method)

Estimated cost = US \$18,500

2. Hach dissolved oxygen meter

Model No 16046-00 with 20' extension cable and probe, complete with battery charger and manual

Estimated cost = US \$4,800

**3. Hach COD reactor**

Model 45600-00 complete with.

- (a) Safety shield model No 23810-00 and 25 vials
- (b) 0 - 15,000 mg l range Model No 24159-25
- (c) 0 - 1,500 mg l range Model No 21259-25

Estimated cost = **US \$1,100**

**4. Hach Manometric BOD apparatus**

- (a) Model No 2173-01
- (b) Regulator 2597-00 - 115V
- (c) Buffer 14861-98

Estimated cost = **US \$1,900**

**5. Portable membrane filtration Apparatus (Millipore, USA)**

- (a) including 50 litre incubator

Estimated cost = **US \$2,100**

(Alternative Hach microbiological detection kit)

**6. Electronic balance - 4,000g x 0.01**

Estimated cost = **US \$1,050**

**7. Drying oven - Gallenkamp OVB 300 - 230 W**

Estimated cost = **US \$450**

**8. Muffle furnace - type FML 11 25 carbolite, Bamford, Sheffield S30 2AV, England**

Estimated cost = **US \$1,800**

**9. Autoclave - 500 x 500 x 500**

Estimated cost = **US \$4,500**

**10. Glassware and measuring cylinders**

Estimated cost = **US \$1,500**

## 11. Chemicals and equipment

Estimated cost = US \$1,500

In order to implement the proposal concerning the disposal of spent wash, filter mud and ash in the form of a liquid slurry, suitable for land spreading, it is recommended that a four-wheel-drive, 80 hp. tractor together with an 8,000 - 10,000 litre capacity vacuum slurry tanker and associated attachments to allow for both manual and automatic spraying, should be provided to at least one demonstration factory.

The estimated cost of this equipment = US \$ 60,000.

**ANNEX VI**

**FACTORY VISITS AND REPORTS**



## FACTORY

<b>Name:</b>	Lumbini Sugar Mills Ltd
<b>Address:</b>	Sunwal, District Nawalparasi, Zone: Lumbini.
<b>Tonnes of cane crushed/day: (Capacity)</b>	1,000
<b>Operating days/year: (1989-94)</b>	73-152
<b>Tonnes of sugar/day:</b>	96
<b>Water usage, m<sup>3</sup>/day: Design capacity</b>	10,000
<b>Tonnes of steam/hour:</b>	30-32
<b>Molasses, m<sup>3</sup>/day: (4.15%)</b>	41.5
<b>Alcohol, m<sup>3</sup>/day: Capacity</b>	12
<b>No. of employees: Permanent:</b>	543
Seasonal	<u>432</u>
Total	975
<b>No. of farmers:</b>	10,000
<b>Area of sugar cane fields: (hectares)</b>	6,000

## **Lumbini Sugar Factory**

### **General**

The Lumbini Sugar Factory was visited from the 26<sup>th</sup>-30<sup>th</sup> January, 1995. During this period the in-house processing of the sugar cane and the resulting effluents were assessed. Through the assistance of the factory manager, visits were arranged to Bagmati, Khadasari and to a Guar facility near the Indian border. Visits were also arranged to assess the growing and harvesting techniques for the sugar cane in the fields. During these visits, all three UNIDO consultants were present.

### **Introduction**

The Lumbini Sugar Factory is located in the general Terai district. This is a highly productive low-lying area of arable land which lies between the Indian border and the foothills leading into the Kathmandu valley. It has a sub-tropical climate with the monsoon season commencing around the beginning of June. The annual rainfall is 1,200-1,300mm with the average yearly temperature being 24-25°C. Maximum temperature in June is 43°C. The farm holdings in this area are generally small with most cultivation and harvesting being carried out manually. The sugar cane is transported by the farmers directly to the factory or in the more distant parts, the sugar cane is transported to a collection depot where centralised transport has been arranged by the sugar factory. The general road system in this area is not very good, hence delivery of the sugar cane may take up to three days. The average quantity of sugar cane crushed in the period 1988-1994 was 82,584 tonnes per year. This corresponded to an average sugar production of 7,934 tonnes per year. The corresponding quantity of molasses produced was 3,430 tonnes per year. The corresponding rectified spirit production over the same period was 624,117 litres per year. It should be noted that not all the molasses produced was used to produce rectified spirits.

The Lumbini Sugar Factory was established under a mutual co-operation agreement between the Government of Nepal and the Government of the Peoples Republic of China. The contract to establish this factory was signed on the 7<sup>th</sup> January, 1972. The first trial production run was carried out in the 1988-89 season. This factory has a designed capacity of 1,000 metric tonnes of sugar cane crushing per day and a rectified spirit of 12,000 litres industrial alcohol per day. The projected use of raw materials is as follows.

Sugarcane	-	120,000 MT
Sulphur	-	120 MT
Unslaked lime	-	360 MT
Fire wood	-	1,000 MT
LDO	-	600 KL
Diesel (for Sugarcane Transport)	-	300 KL
Lubricants (various 7 types)	-	20 KL
Filter cloth	-	1,000 m <sup>2</sup>
Sepran AP	-	400 KG
Turkish Red Oil	-	3 MT
Caustic soda	-	5 MT
Alum	-	40 MT
Resin	-	3 KL
Salt	-	10 MT
Sacks	-	110,000 No.
Sulphuric Acid	-	30 MT
Ammonium Sulphate	-	15 MT
Others	-	

In order to produce one tonne of sugar, it is estimated that the following quantities of raw materials are used

<b>1 tonne of sugar =</b>	Sugar cane	11,000 kg
	Quick lime	33 kg
	Sulphur	11 kg
	Filter cloth	0.044 m <sup>2</sup>
	Sepran A.P. - 30	0.05 kg

The Lumbini Sugar Factory produces only one quality plantation white sugar, A - Sugar, which has the following quality indices. B and C sugars are also produced, but these are reprocessed to yield A - Sugar.

Indices	A-Sugar	B-Sugar	C-Sugar
Polarisation	99.50 min.	95-96	80-85
Purity	99.6	96 min	80 min.
Invert sugar	0.1% Max.		
Ash	0.1% Max.		
Moisture	0.1% Max.		
Colour	150-200 ICUMSA		

Most of the molasses produced in the sugar factory is used to produce rectified spirit (industrial alcohol) in the associated distillery at Lumbini. In order to produce 1 kilo litre of rectified spirit, the following raw materials are used.

1 kilo litre of rectified spirit =	Final molasses (50% TRS)	4,166 kg
	Steam	5,000 kg
	Ammonium Sulphate (N2 20.8%)	12.5 kg
	Sulphuric acid (98% Sp. G. 1.84)	20.8 kg

The quality indices of the finished product, rectified spirit from this distillery are as follows:

#### Indices

Appearance	Transparent
Strength (V)%	>95 at 20° C
Sp. Gravity	0.81144 at 95° and 20° C
Fusel oil as (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> OH and (CH <sub>3</sub> ) <sub>2</sub> CH(CH <sub>2</sub> ) <sub>2</sub> OH	<0.04%
Methyl alcohol as CH <sub>3</sub> OH	<0.25%
Acidity as CH <sub>3</sub> COOH	<0.003%
Residue on Evaporation	<0.0025%

The installed electricity production is 3,000 kW while the demand is estimated at 45,600 kWh per day during the season, the off-season requirement for electricity is 630 KVA. The estimated design water usage was 10,000 m<sup>3</sup> per day. This water was to be sourced from underground wells and the nearby Turia River.

The distillery plant with a capacity of 12m<sup>3</sup> rectified spirit per day is a continuous Chinese multistage cascade type system. The total number of fermenters is nine, with five fermenters having a capacity of 37m<sup>3</sup> each and four fermenters having a capacity of 33m<sup>3</sup> each. The quantity of spent wash generated from this distillery is estimated as to be 200-240m<sup>3</sup> per day with an estimated average characteristic composition as shown below

## Average characteristics of spent wash

### Characteristics

Odour	Jaggery
Colour	Dark Brown
pH	4.3 - 4.5
COD	90,000 - 100,000 mg/lit
BOD	38,000 - 50,000 mg/lit
Total Solids	80,000 - 90,000 mg/lit
Chlorides	5,000 - 6,000 mg/lit
Nitrogen	1,000 - 1,200 mg/lit
Potassium	8,000 - 10,000 mg/lit
Sodium	200 - 300 mg/lit
Phosphate as PO <sub>4</sub>	800 - 1,200 mg/lit
Calcium (Ca)	500 - 600 mg/lit
Sulphate	2,000 - 5,000 mg/lit

The estimated approximate period of operation for the distillery was 120 days.

### Installed effluent waste water treatment system

No major effluent treatment facilities were installed at design stage in this factory. At present, the spent wash is discharged into the general sugar mills waste water stream where dilution and temperature reduction takes place. A manual lime dosing system has been installed on this line to correct the pH of the spent wash from 4.3 - 4.5 to pH 7-8. The combined streams discharge via a 1km pipeline to the Somanath stream. The estimated discharge volume at design stage was 6,000m<sup>3</sup> per day. During the dry season, this Somanath stream is almost completely dry which means that the highly polluting effluent stream from the sugar mills and distillery does not receive any dilution. This stream continues almost undiluted for a distance of 21km to the Indian border.

The other main sources of effluent in this factory are.

- a) filter cake with an estimated annual production of 2,916 tonnes containing potassium, phosphorous, nitrogen and organic matter and
- b) furnace ash with an estimated annual production of 78 tonnes containing potassium and phosphorous.

## Present situation

This is a new factory which is in its seventh year of operation. In general, the installed equipment is good and well maintained. Management in this factory is good and the buildings and grounds are well maintained, clean and tidy.

Initially, at design stage, there was no attempt to conserve water usage and hence only a small portion of the processed cooling water was recovered and recycled. The installed freshwater supply system was designed to provide 10,000m<sup>3</sup> per day. This was to be achieved by pumping from boreholes in the immediate vicinity of the factory by taking water from the Turia River. The water table in this particular area is relatively high but the quality achieved from the several borings (at least 10 in number) was found to be unacceptable due to contamination. The main contaminating agent was found to be iron which varied in concentration from 0.88 mg/l to 48.67 mg/l. The maximum recommended allowable iron concentration for potable water is 0.05 mg/l (EU) and 0.3 mg/l (WHO). The alternative source of water, from the Turia River was found to be unsatisfactory due to the low flow during the sugar cane processing season. The small quantity of water in this river during the dry season is required by many other users. The reduced availability of raw water has necessitated a re-assessment of the complete water balance within the factory. At present, a new pipeline is being installed which will facilitate a complete recycle of the cooling water. The major source of water usage within the factory complex relates to this particular cooling water cycle. While a certain amount of recycling already exists, the quantity which is being recycled is very small. Based on simple open channel flow measurements without allowance for coefficients of roughness etc., it is estimated that 163m<sup>3</sup> per hour (3,912m<sup>3</sup> per day) is wasted. This volume is discharged as effluent and is combined with the waste stream from the distillery before discharged into the receiving stream. The COD (Chemical Oxygen Demand) in this waste stream was measured at 2,630 mg/l. This represents a daily load of 10.3 tonnes COD per day. The temperature in this effluent stream was measured at 50° C. This stream also contains excess quantities of ammonia, phosphorous, iron and sulphate. In all the other factories examined, this cooling water was recycled through various types of cooling lagoons. The discharge from this loop in the other factories was therefore relatively small and contained relatively low levels of COD. The results obtained from the tests which were carried out during this mission are presented in Table I, Annex VII.

The other major source of liquid waste within this factory was found in the filter cloth wash water stream. In the two government owned sugar mills, i.e. Lumbini Sugar Mills and Birganj Sugar Factory, a vacuum filtration system utilising filter cloth was used to de-water the settled process solids. In all the other factories, porous stainless steel vacuum cylinders were used. In order to wash the filter cloth, a backwashing system is employed. The wash water from this process was discharged directly as waste effluent water. Because this waste water stream contained unrecovered sugar, the COD was extremely high, measured at 75,600 mg/l with a flow rate of 12m<sup>3</sup> per hour. This represents a daily COD load of 21.8 tonnes/day. The recycling of this waste stream for use in the cane crushing mills would remove a major source of organic pollution and would also help the factory efficiency by recovering extra sugar per tonne of cane processed. A recommendation to recycle this waste stream was made at a meeting with factory management on the 30<sup>th</sup> January, 1995. We have been advised that this loop was installed within one week and that an increase in sugar

recovery was noticed. Some problems with the spray nozzles in the crushing mills were experienced but this situation was being rectified.

Another source of liquid effluent within the factory relates to bearing cooling water and general floor washings. This source of effluent will always be present and it is recommended that an oil trap be installed to remove all such materials from the stream. Attempts should be made in-house, to reduce to a minimum all sources contributing towards this stream.

The other main source of effluent within the factory relates to the spent wash from the distillery. This is an extremely polluting stream with a COD concentration of 123,800 mg/l and an hourly flow of 8.33m<sup>3</sup>. This represents a COD load of 25.2 tonnes COD/day. The solids contents of this stream was measured at 11.5%. The discharge of waste yeast sludge at periodic intervals throughout the day contributes even more COD and solids to this stream. The COD of the yeast sludge was measured at 227,200 mg/l and the solids content was measured at 15.37%. The volume was estimated at 0.25m<sup>3</sup> per hour or 6m<sup>3</sup> per day. The total COD contribution from the yeast sludge was estimated at 1.4 tonnes COD per day. There is very little that can be done within the factory to reduce the volume or strength of this particular effluent stream. It is recommended however that the yeast sludge should be collected separately from the spent wash and treated in a separate system.

### **Recommendations**

- install the recycle loop for the cooling water as a matter of urgency.
- recycle the filter cloth wash water to the crushing mills
- install an oil and grease trap on the stream from the bearing cooling water and floor washing stream
- collect the yeast sludge in a separate settlement tank and allow the solids to settle for a maximum period of time
- decant the supernatant liquor and mix with the spent wash
- remove the settled solids to an air drying bed or for other use
- control the excess freshwater overflow from the header tanks associated with the distillery
- examine the possibility of utilising the spent wash for irrigation purposes and/or for mixing with the filter cake, ash and excess bagasse for use as a liquid fertiliser in the sugar cane fields
- examine the possibility of recovering waste heat from the spent wash stream for pre-heating the process water

- install simple flow measuring devices such as a V-notch in the waste stream channels so that an accurate measurement of flow can be obtained.
- instigate suitable training for qualified personnel in the area of water quality monitoring and pollution auditing.
- install a suitable recovery loop for the caustic soda used during the washing cycle and/or a collection tank for this caustic soda so that it can be blended with the general waste stream over a long period or so that it might be used for pH adjustment elsewhere in the factory.



## FACTORY

<b>Name:</b>	Mahendra Sugar Factory
<b>Address:</b>	Bhairahawa, District Rupandehi, Zone Lumbini
<b>Tonnes of cane crushed/day: (Capacity)</b>	600
<b>Operating days/year:</b>	
<b>Tonnes of sugar/day:</b>	
<b>Water usage, m<sup>3</sup>/day:</b>	833
<b>Tonnes of steam/hour:</b>	26
<b>Molasses, m<sup>3</sup>/day:</b>	
<b>Alcohol, m<sup>3</sup>/day:</b>	
<b>No. of employees:</b>	1,000
<b>No. of farmers:</b>	7,000
<b>Area of sugar cane fields: (Hectares)</b>	5,000

## Mahendra Sugar Factory

### **General**

The Mahendra Sugar Factory was visited from the 31<sup>st</sup> January - 2<sup>nd</sup> February 1995. During this period the in-house processing of the sugar cane and the resulting effluent was assessed. During this assessment, two of the UNIDO consultants were present.

This sugar factory is situated in the Bhairahawa district and in the general Lumbini area. It is a privately owned factory and is at least 25 years old. The sugar cane supplied to this factory comes from an area adjacent to the supply area for the Lumbini sugar mills. The typical soil and growing conditions are similar to those described in the report on Lumbini Sugar Mills. The estimated number of farmers/suppliers to this factory is 7,000 with a combined total area of approximately 5,000 hectares. The soil in this area is fertile and the water table is relatively high. Most of the cultivation and harvesting of the sugar cane is carried out manually and transport to the factory is by ox cart or mechanically in tractors and trailers. The ox cart is the most common method. The access roads in this area are not particularly good.

In general, the equipment in this factory is very old and will soon need to be replaced if this factory is to continue in operation. Maintenance of the equipment and facilities within the factory also require attention in order to achieve better productivity and efficiencies. Monitoring and laboratory facilities within this factory are very limited. This will make it very difficult for the staff to carry out effluent monitoring or pollution auditing.

### **Present situation**

Freshwater supply for this factory is obtained from two bored wells which have been drilled to a depth of 400 ft. The cooling waters in this factory are recycled through a spray aeration lagoon where the temperature is reduced from 40°C to 34°C. Because the cooling waters are recycled, the demand for freshwater is relatively low and hence, the supply from the two bored wells is adequate to meet the demands of the factory. The management of the factory advise that on occasions excess pumping of these wells occurs in order to provide irrigation water for the farmers in the immediate catchment area. This excess pumping also helps to reduce the concentration of the effluent from both the sugar factory and the distillery.

The two main sources of effluent from this factory complex are the general sugar factory waste water and the spent wash from the distillery. Most of the general sugar factory wash water comes from the bearing cooling water and general floor washings combined with various leaks and spillages within the factory. Because of the age of the equipment within the factory and the general standard of maintenance, it was not possible to isolate and identify each individual source of waste water within the sugar factory. Most of the general sugar factory effluent is discharged onto the floor and from there, into channels which join a main header channel outside the factory. This general sugar factory effluent is discharged into a small holding lagoon and from there it passes into an irrigation channel for use by the farmers. There is a certain amount of wastage of cane juice at the milling plant. This waste

juice is discharged into a channel and collected with the main effluent. The COD of this particular stream was measured at 2,690 mg/l. Another waste stream from floor washings and described as mixed sugar factory effluent in Table 2, Annex VII was found to contain a COD value of 1,270 mg/l. The organic strength of the combined discharges from the sugar factory was found to contain a COD of 5,410 mg/l with an estimated flow of 11.06 - 13.8 m<sup>3</sup>/hour. The measured temperature in this waste stream was 32°C and it had a pH of 4.7. The nitrate, ammonia, phosphorous, iron and sulphate levels were all relatively high. The COD of this particular stream, when measured at approximately 0.5km from the factory and adjacent to the public road, had reduced to 2,740 mg/l. This reduction may have been due to settlement of some of the suspended solids in the effluent. The measured suspended solids had reduced from 0.364% to 0.25% at this point. Vacuum filter wash water in this particular factory is not a major problem as a stainless steel drum is used and bagasse is added to the filter mud in order to give the filter cake consistency. The filter cake is scraped off the surface of the vacuum cylinder and therefore no wash water is discharged into the effluent stream. Excess cooling water from the cooling loop was discharged into the spent wash stream. The COD of the spent wash stream at point of discharge from the distillery was measured at 139,000 mg/l with an average flow of 2 m<sup>3</sup>/hour and a temperature of 100°C. The suspended solids content of this spent wash stream was measured at 7.2% solids. The general distillery effluent which included excess dilution water and floor washings combined with the spent wash was found to have a COD of 29,000 mg/l with a flow of 23.86m<sup>3</sup> and a temperature of 45°C. The suspended solids content of this stream was measured at 0.32% solids. While the COD concentration had reduced considerably, the total volume had increased, with a resulting increase in the COD load which increased from 6.7 tonnes/day to 16.6 tonnes/day. It is obvious from this analysis that there was considerable wastage of raw material, e.g. molasses, and that the general distillery effluent also contained waste yeast sludge. The combined waste stream from the distillery was discharged into a holding lagoon and from there the water was used for irrigation purposes. The COD value of the water in this lagoon was measured at 550 mg/l with a temperature of 33°C and a pH of 7.1. There was a considerable amount of nitrate, ammonia, iron and sulphate in this waste water sample which was taken from the lagoon. The dilution factor achieved for the COD readings in this particular waste stream from the distillery is difficult to explain. The explanation given by the management of this factory was that excess freshwater was pumped through the system in order to dilute the effluent and hence make it suitable for direct irrigation to the land.

The two main waste streams from this factory, i.e. the general sugar factory effluent and the general distillery effluent were both discharged to separate lagoons. The water from these lagoons was used by the farmers for irrigation purposes and hence the management of the factory claimed that no subsequent pollution or contamination of streams occurred. The management also claimed that sufficient groundwater is available from the two deep boreholes to continue diluting both streams to meet any specified discharge limits.

### **Recommendations**

- examine the cane milling plant and arrange to prevent spillage of the raw juice
- carry out suitable maintenance on the factory equipment so as to reduce water

and steam wastage

- install an oil and grease trap on the stream from the bearing cooling water and floor washing stream.
- instigate a regular cleaning schedule for the general factory area
- collect the yeast sludge in a separate settling tank and allow the solids to settle for a maximum period of time.
- decant the supernatant liquor and mix with the spent wash
- remove the settled solids to an air drying bed or for other use.
- examine the possibility of recovering waste heat from the spent wash stream for pre-heating the process water
- install a simple flow measuring device such as a V-notch in the waste stream channels so that an accurate measurement of flow can be achieved.
- purchase and install adequate equipment and testing facilities in a suitable laboratory space within the factory complex.
- instigate suitable training for qualified personnel in the area of water quality monitoring and pollution auditing
- install a suitable recovery loop for the caustic soda used during the washing cycle and/or a collection tank for this caustic soda so that it can be blended with the general waste stream over a long period or so that it might be used for pH adjustment elsewhere in the factory.

### FACTORY

<b>Name:</b>	Indu Shankar Chini Mill
<b>Address:</b>	Hariown, District Sarlahi, Zone Janakpur
<b>Tonnes of cane crushed/day:</b>	721
<b>Operating days/year:</b>	86
<b>Tonnes of sugar/day:</b>	66
<b>Water usage, m<sup>3</sup>/day:</b>	835
<b>Tonnes of steam/hour:</b>	25
<b>Molasses, m<sup>3</sup>/day:</b>	4
<b>Alcohol, m<sup>3</sup>/day:</b>	1
<b>No. of employees:</b>	900
<b>No. of farmers:</b>	15,000
<b>Area of sugar cane fields: (hectares)</b>	6,000

## The Indu Shankar Chini Mill

### **General**

The Indu Shankar Chini Mill was visited from 3<sup>rd</sup>-5<sup>th</sup> February 1995. During this period, the in-house processing of the sugar cane and the resulting effluents were assessed. During this visit, two of the UNIDO consultants were present. The results of the tests which were carried out during this mission are presented in Table 3, Annex VII.

### **Introduction**

The Indu Shankar Chini Mill is located in the Hariown district and in the general Janakpur area. This is the most easterly sugar factory in Nepal which was visited during this study tour. The factory is located in a highly productive, low-lying area of arable land which lies between the Indian border and the foothills leading into the Kathmandu Valley. It has a subtropical climate with the monsoon season commencing around the beginning of June. The farm holdings in this area are generally very small with most cultivation and harvesting being carried out manually. This is a remote area of the country with very little infrastructure. The sugar cane is transported by the farmer directly to the factory and because of the poor standard of the road system, the cane is normally four days old before it is processed. The distillery is capable of producing approximately 4m<sup>3</sup> of rectified spirits per day but this is not adequate to utilise all the molasses produced. Some of the molasses is sold to other distilleries for alcohol production. All the bagasse produced in the sugar factory is utilised for the production of steam but this is insufficient for the total factory demand. Additional energy is obtained from wood chips which are mostly burned in the boiler associated with the distillery. The distillery is approximately 300m distant from the sugar factory and operates on its own energy system.

The Indu Shankar Chini Mill was built in 1986. The factory was fitted with second-hand equipment which was purchased in India. This factory is privately owned. While the equipment in this factory is very old, it is well maintained and operates as efficiently as can be expected for such old equipment. The in-house management of this factory is extremely good with maximum efficiency of juice extraction being obtained with the equipment available.

### **Present situation**

The freshwater for use in this factory is obtained from two deep wells. Excess water is used in this factory because the vacuum filter wash water is discharged into the waste stream. The volume of this vacuum filter wash water was measured at 20.856 m<sup>3</sup>/hour and it had a COD concentration of 867 mg/l. This corresponds to a COD load of 0.434 tonnes/day. Because of the drainage layout in this factory, it was not possible to measure the volume of water emanating from the general sugar factory effluent stream. However, the COD concentration of this stream was measured at 820 mg/l. The combined discharge from the sugar factory and the distillery was measured at approximately 94 m<sup>3</sup>/hour. This is a very considerable flow. At the measured COD concentration of 11,600 mg/l, this represents a COD load of 1.09 tonnes/day.

The general process cooling water was recycled through a cooling lagoon. At the time of inspection, this cooling lagoon was only achieving a 5°C reduction which is not very efficient. The COD concentration in this stream was measured at 835 - 853 mg/l. Lime is added to this recycled stream in order to maintain the pH in an alkaline or neutral range. The pH measured in this cooling lagoon varied from 7.8 - 7.9. There was a considerable discharge of excess water from this cooling loop which had a pH of 8.5 and a COD concentration of 853 mg/l. In this particular factory, the vacuum filter wash water was discharged into the waste water stream. While the COD concentration at 867 mg/l was not excessively high, the substantial volume at 20 856 m<sup>3</sup>/hour helped to create a significant COD load in the waste stream from the sugar factory. It is recommended that the waste stream from the vacuum filter wash water should be returned and used at the milling station in the factory.

The estimated flow of spent wash from the distillery attached to this factory is 3.3 m<sup>3</sup>/hour. The COD concentration measured in this waste stream was 72,500 mg/l. The total COD load from the spent wash was estimated at 5.8 tonnes per day with a solids content of 0.334%. As with most of the distilleries examined in Nepal, the waste yeast sludge was mixed with the spent wash which added considerable additional COD load to the total waste stream. The COD concentration of the waste yeast sludge was measured at 191,000 mg/l. The temperature of the spent wash was 100°C and it had a pH of 5.1. The general distillery effluent which included waste wash water and other extraneous streams had a pH of 4.7 and a temperature of 65°C.

The general sugar factory effluent and general distillery effluent were combined into a single drain which discharged into a dry stream approximately 0.5km from the factory. This dry stream in turn discharged into a large river, the Lakhanda, approximately 3-4km from the factory. This river in turn crossed into India approximately 35km from the factory. There had been a number of complaints from the local population and the people downstream of the factory concerning the odour and pollution associated with the wastes which were discharged into the stream and the river.

## Recommendations

- return the vacuum filter wash water for use within the milling section of the plant.
- install an oil and grease trap on the stream from the bearing cooling water and the floor washing stream.
- collect the yeast sludge in a separate settlement tank and allow the solids to settle for a maximum period of time.
- Decant the supernatant liquor and mix with the spent wash.
- Remove the settled solids to an air drying bed or for other use.
- control any excess freshwater which was used to top up the recycled cooling water.
- examine the possibility of utilising the spent wash for irrigation purposes and/or for mixing with the filter cake, ash and excess bagasse for use as a liquid fertiliser in the sugar cane fields.
- examine the possibility of recovering waste heat from the spent wash stream for pre-heating the process water.
- install simple flow measuring devices such a V-notch in the waste stream channels so that an accurate measurement of flow can be achieved.
- purchase and install suitable testing equipment to carry out water quality monitoring and pollution auditing.
- provide adequate training for suitably qualified personnel to carry out the necessary water quality monitoring and the pollution auditing.
- install a suitable recovery loop for the caustic soda used during the washing cycle and/or a collection tank for this caustic soda so that it can be blended with the general waste stream over a long period or so that it might be used for pH adjustment elsewhere in the factory.



## FACTORY

<b>Name:</b>	Shree Ram Sugar Factory.
<b>Address:</b>	Garuda, District: Rautahat, Zone: Narayani.
<b>Tonnes of cane crushed/day: (Capacity)</b>	1,500
<b>Operating days/year:</b>	
<b>Tonnes of sugar/day:</b>	
<b>Water usage, m<sup>3</sup>/day:</b>	1,454
<b>Tonnes of steam/hour:</b>	40
<b>Molasses, m<sup>3</sup>/day:</b>	
<b>Alcohol, :</b>	1m <sup>3</sup> 4,000 kg of molasses
<b>No. of employees:</b>	700
<b>No. of farmers:</b>	15,000
<b>Area of sugar cane fields: (hectares)</b>	6,000

## Shree Ram Sugar Factory

### **General**

The Shree Ram Sugar Factory was visited on the 6<sup>th</sup> February, 1995 and samples were taken. The Factory was revisited by one of the consultants again on the 9<sup>th</sup> - 10<sup>th</sup> February, 1995. During these periods the in-house processing of the sugar cane and the resulting effluents were assessed. However, the factory was not in full operation as processing problems had been experienced during the previous week. This is a new factory operating in its first season. The operating personnel were still in training and experience with the processing equipment was still being gained. The complete effluent treatment system had not been fully constructed. The proposed distillery for converting the molasses from the sugar factory into rectified spirit had not been completed. During these visits, two of the UNIDO consultants were present.

### **Introduction**

The Shree Ram Sugar Factory is located in the Garuda district and lies between the Indu Shankar Chini Mills and the Government owned Birganj Sugar Factory. It is privately owned and privately funded. The construction works were not fully completed. It is expected that all works associated with the sugar mill and effluent treatment will be completed by the end of the 1995 season. While work had not started on the proposed distillery, a contract has been signed for the delivery of an anaerobic digester system for the treatment of the spent wash effluent. This is a unique proposal for the treatment of distillery effluents within Nepal but it is a technology which is widely used elsewhere particularly in India which adjoins Nepal and with which it has a long open border. The use of anaerobic digestion should result in energy production in the form of bio-gas which can be used to generate direct heat or combined power and heat. The success of this effluent treatment system and its economic viability should be encouraged and assisted so that it will become a model demonstration plant for the other sugar factories in Nepal. The documents relating to the proposed anaerobic installation were examined and assessment is given below.

Similar to the other sugar factories, this Shree Ram Sugar Factory is located in a highly productive low-lying area of arable land which lies between the Indian border and the foothills leading into the Kathmandu Valley. It has a sub-tropical climate with a monsoon season commencing around the beginning of June. The annual average rainfall is estimated at 1,200-1,300 mm with an average yearly temperature of 24-25°C. Maximum temperature in June is estimated at 43°C. The farm holdings in this area are generally small with most cultivation and harvesting being carried out manually. The general road system in this area is very poor and we have been advised by the factory management that an application has been made for the installation of an improved main road through the catchment area which should include a bridge over the adjacent river. This should result in a substantial increase in the available land area for sugar cane production. The estimated number of farmers supplying this factory is 15,000 with the holdings of these farmers covering an approximate area of 6,000 hectares. It is expected that the number of employees will be approximately 700. The management of the factory estimate that the combined and indirect employment

generated by this factory in this area will approximate to 30,000 people. The factory will be a major source of income in this underdeveloped area and will greatly assist the social development and financial well being of the local population.

### **Present situation**

The projected first operational season from this factory was the 1995-1996 season but because construction work proceeded at a very rapid pace the management were able to start crushing cane during the 1994-1995 season. However, this season is being used as a trial and training period, which is very necessary as most of the staff are unskilled. The equipment used in this factory is Indian designed and most of the hardware has been purchased in India. Work on the proposed associated distillery has not started yet. The installed effluent treatment facilities at present consist of holding lagoons for the excess contaminated water from the sugar factory. It is proposed to dispose of the settled and cooled contaminated waste water by direct irrigation into the adjacent sugar cane fields. It is also proposed to treat the spent wash from the distillery in an anaerobic digester system, the contract for which has been placed with an Indian company, using a recognised technology which has been imported from France. The foundations for this anaerobic system has already been installed. Freshwater supply for this factory is taken from two artesian wells which were installed adjacent to the factory grounds.

During the visits by the UNIDO consultants, the factory was not in full operation due to cross contamination of the feed water to the boiler system. However, samples were taken from the general cooling water loop, the waste vacuum filter water and from the freshwater source. The results of these tests are presented in Table 4, Annex VII. Additional samples were also taken from the cooling water loop to check the effect of the lime which was being added into this loop. It appears that this lime was being added to correct the pH. At the time of sampling the pH was corrected from 6.7 to 11.15. The cooling loop consisted of passing the water through a spray aeration tank but because the factory was not working at the time of sampling, it was not possible to assess the efficiency of this cooling system. In general, the quality of the water within this cooling loop was similar to the quality of water found in other factories. The freshwater from the two artesian wells was collected and stored in a storage reservoir. While the analysis for the freshwater does not indicate a very high level of nitrate and phosphorous, there was clear visual evidence of algal growth in these storage reservoirs. The combination of the nitrate, ammonia, phosphorous and iron may have been responsible for this algal growth. The presence of algae in the storage reservoirs will cause problems in the supply pipelines and equipment. This algae should be controlled and/or removed. Acceptable proprietary algaecides or rapid use of the freshwater should be employed. The overflow from this cooling loop is combined with the general waste water from the factory which includes the bearing cooling water and floor washings. The combined waste effluent is held in storage lagoons which allow the solids to settle and the temperature to stabilise. It is proposed to directly irrigate the settled and cooled effluent from the lagoons. The estimated temperature of supply is 23°C. The waste vacuum filter water is recycled within the sugar mill and hence the COD load in the general effluent stream should be considerably reduced. The measured COD concentration of 2,160 mg/l in this waste vacuum filter water stream is very high and requires investigation. It is possible that the operational problems that were being experienced at the time of testing within the factory,

may have been responsible for this high COD value. Close attention should be paid to this particular stream when the factory is operating properly in order to ascertain the true COD concentration in this stream.

In general, it should be possible to attain relatively high processing efficiency and sugar recovery in this new factory, if the work force can be trained in the proper use of the equipment supplied. Maximum assistance should be given to the owners of this factory in order to facilitate the proper training and management of this factory, as it can become a model for the other proposed new factories in Nepal.

### **Anaerobic digestion for the treatment of the spent wash**

Based on a preliminary economic assessment and encouraged by the developing awareness of environmental concerns within the country and the government of Nepal, the owners of this new factory have decided to install an anaerobic digestion system to reduce the pollution potential from the spent wash associated with the alcohol distillery. It is generally accepted that spent wash from such a distillery will have a COD concentration in the order of 100,000 mg/l. It will also have a temperature of approximately 100°C. The pollution potential from such an effluent is therefore very great.

From the preliminary economic assessment carried out by the owners of this factory, it appears that adequate energy, in the form of bio-gas, can be recovered from the spent wash stream to meet the complete steam demand for the distillery itself. The indicated payback period is estimated at 5 - 7 years.

The contract for the supply of the anaerobic digester has been placed with Degremont, India. This company is selling a system which is based on an anaerobic technology acquired from Degremont, France. This is a two stage anaerobic digestion process with the acid and methane stages separated into two different stages. The first stage consists of converting the soluble organic material into short-chained fatty acids while the second stage consists of the utilisation of these acids by the methane bacteria to produce bio-gas. Buffering of the first stage is initially carried out through the addition of lime but is subsequently adjusted through recycle of the treated effluent from the second stage. Because the effluent contains a very high COD concentration, dilution is required, particularly before addition of the waste to the second stage, i.e. the production of the bio-gas. This dilution is achieved by recycling the treated effluent from the second stage and through use of a relatively long retention time within the system. The design retention time is sixteen days within the system. The second stage of this general anaerobic treatment system utilises a technology which is commonly called, upflow anaerobic sludge blanket (UASB). This is a recognised anaerobic treatment method for sugar based effluents and if properly installed and operated, should work very well on the proposed effluent. However, the proper operation of a successful anaerobic digestion treatment system requires considerable supervision and monitoring and also requires a high level of technical training in the field of anaerobic digestion. There are many recorded failures of anaerobic treatment systems and many more anaerobic systems are operating well below their maximum efficiency. If this anaerobic plant in the Shree Ram Factory is to be used as a model and demonstration plant for other factories within Nepal, it is very important that suitably qualified staff should be employed to operate this facility and also that this staff should have proper training in anaerobic technology. Adequate laboratory and testing

facilities should also be provided

If the pollution load contained in the spent wash from distilleries is to be treated and removed from these waste streams, then the only economically viable treatment process will incorporate anaerobic digestion as the major treatment element. From an environmental protection point of view, it is very important that this first anaerobic digestion facility within the sugar industry in Nepal should be assisted in every manner so that the plant is operated to its maximum potential.

It should be noted that an anaerobic digestion system is not capable, on its own, of producing an effluent suitable for discharge into a stream or waterbody. A properly operated AD system should be capable of removing between 70 and 90% of organic pollution in the effluent stream. The residual 10-30% must be removed in an associated aerobic effluent treatment system. A proposal by Degremont, India has been put to the management of the Shree Ram Factory for the installation of such a system. However, because of the operating costs associated with such a system, it is unlikely that an economically viable process can be installed. Direct irrigation, at a suitable rate, into the sugar cane fields would appear to be the most suitable solution for the final disposal of the anaerobically digested waste stream. The porosity and suitability of the soils within each catchment area should be assessed prior to the application of this irrigation water. Effluent which has been processed through an anaerobic system is still very rich in nutrient quality, i.e. nitrogen and phosphorous, as the anaerobic bacteria which grow in these systems only require minute quantities of these nutrients. The waste stream therefore from an anaerobic digestion system should be an ideal source of plant nutrients. Most of the carbon and acids in the effluent will have been removed during anaerobic digestion.

Based on the data and information supplied by Shree Kam Sugar Factory, it would appear that the projected payback period of 5 - 7 years is very optimistic. The concentration of the effluent, the projected degradation efficiency, the estimated bio-gas production, the conversion efficiency and the economic evaluation of the replaced coal all appear to be extremely optimistic. These are factors which should be thoroughly investigated before this anaerobic digestion project is included in any demonstration scheme, as failure to achieve only over optimistic projections could be seen as a failure rather than a success.

#### **Recommendations**

- install an oil and grease trap on the stream from the bearing cooling water and floor washing stream
- install simple flow measuring devices such as a V-notch in the waste stream channel so that an accurate measurement of the flow can be achieved
- install effluent monitoring equipment and pollution auditing within the factory complex
- provide suitable training for qualified personnel in the area of water quality

monitoring and pollution auditing.

- minimise all extraneous spillages and waste streams within the factory.
- provide suitable training for qualified personnel in the area of anaerobic digestion technology.
- provide for the separate removal of yeast sludge when the distillery is being constructed.
- examine the possibility of heat recovery from the spent wash stream at the design stage for the proposed distillery.
- investigate the soil suitability for irrigation purposes both for the waste sugar effluents from the lagoons and for the anaerobically treated spent wash stream.
- examine the possibility of combining the treated spent wash stream with the filter cake and ash from the boiler in order to produce a slurry which will be suitable for direct land irrigation or spreading.
- carry out a thorough investigation on the possibility of using a combined heat and power unit which will operate on the bio-gas produced.
- install a suitable recovery loop for the caustic soda used during the washing cycle and/or a collection tank for this caustic soda so that it can be blended with the general waste stream over a long period or so that it might be used for pH adjustment elsewhere in the factory.

## FACTORY

<b>Name:</b>	Birganj Sugar Factory Ltd.
<b>Address:</b>	Birganj, District: Bara, Zone: Narayani
<b>Tonnes of cane crushed/day: (Initial Capacity)</b>	1,500
<b>Operating days/year:</b>	120
<b>Tonnes of sugar/day:</b>	13.5
<b>Water usage, m<sup>3</sup>/day:</b>	2,952
<b>Tonnes of steam/hour:</b>	48
<b>Molasses, m<sup>3</sup>/day:</b>	183
<b>Alcohol, m<sup>3</sup>/day:</b>	4.5
<b>No. of employees:</b>	1,200
<b>No. of farmers:</b>	10,000-12,000
<b>Area of sugar cane fields: (hectares)</b>	9,000

## **Birganj Sugar Factory**

### **General**

The Birganj Sugar Factory was visited from the 7<sup>th</sup>-11<sup>th</sup> February, 1995. During this period the in-house processing of the sugar cane and the resulting effluents were assessed. Two UNIDO consultants were present during this visit. As this is the largest and oldest sugar factory within Nepal, a considerable amount of data was collected on the plant. This data is present in Table 6, Annex VII.

### **Introduction**

The Birganj Sugar Factory is located in the central low-lying area of Nepal adjacent to the Indian border. This is a highly productive area with most of the soil being suitable for sugar cane growing. It has a sub-tropical climate with a monsoon season commencing around the beginning of June. The annual rainfall is estimated 1,200-1,300 mm with the average air temperature being 24-25°C. Maximum temperature in June is estimated at 43°C. The farm holdings in this area are generally small with most cultivation and harvesting being carried out manually. The sugar cane is transported by the farmers directly to the factory or in the more distant parts, the sugar cane is transported to a collection depot where centralised transport has been arranged by the sugar factory. The general road system in this area, while not being of a very high standard, is probably the best available within the sugar growing areas of Nepal.

The average sugar cane crushing per day is estimated at 1,500 tonnes with the associated sugar production being estimated at 13.5 tonnes/day. The average operational period per season is estimated at 120 days. Rectified alcohol production from the associated distilleries is estimated at 4.5 m<sup>3</sup> per day with the associated volume of spent wash being estimated at 84 m<sup>3</sup> per day.

The Birganj Sugar factory was established under an agreement between the government of Nepal and the former USSR circa 1975. The original equipment within the factory is of Czechoslovakian origin and while being slightly antiquated by present day standards, it is still in very good condition where proper maintenance has been carried out. Over the years, since the factory was built, additional equipment and replacement equipment has been installed. This equipment originated in various countries and hence, there is now a mixture of several different types of plant within the factory complex. This has made proper maintenance and repairs within the factory very difficult.

### **Present situation**

It appears from a general examination of the factory and from an examination of the pipe runs/channels, that no attempt has been made over the years to control waste discharges. At present, there are several different sources of point discharges within the factory complex. It appears that the initial design contained several collection/recycle loops which were designed to reduce to a minimum the amount of effluent being discharged from the factory. However, most of these loops have been disconnected or by-passed and there is a very



considerable wastage of product and water within the total factory. In order to reduce this wastage and hence reduce the quantity of organic material being discharged as effluent, it is important that an in-house effluent audit be carried out as a matter of urgency. A programme for the installation and re-connection of the recovery loops should be instigated at the very earliest opportunity.

There have been several reports of contamination in the receiving stream and for this reason, an analysis of the pollution load in the stream before discharge, after discharge and at a distance of 10km downstream was carried out. This 10km test point was located at the Indian border. Analysis of the freshwater, the general waste from the sugar factory, the spent wash, the general distillery effluent, distillery effluent at approximately 500 m from point of origin, the combined sugar factory and distillery effluent, the filter cloth wash water and the cooling water loop was carried out. Freshwater for this factory was obtained from boreholes within the factory complex and adjacent to the factory property. The general quality of this water was reasonable with a pH of 8.2 and a hardness of 183 mg/l. There was evidence of some ammonia, nitrate, phosphorous, iron and sulphate in the water supply. At the time of inspection, one of the main electrical generators was not working which resulted in an inadequate supply of electricity. For this reason, one of the pumps supplying the spray aeration system in the cooling tanks was switched off, resulting in the discharge of a large volume of cooling water into the general waste stream. This greatly increased the volume of waste from the sugar factory and helped to dilute the combined sugar factory and distillery waste. The COD concentration in the cooling loop was relatively low, ranging from 93 - 107 mg/l. The estimated discharge volume from the general sugar effluent was 123 m<sup>3</sup>/hour with a COD concentration of 2,250 mg/l. This is a very high effluent load which represents approximately 8.5 tonnes COD/day. On examination of the in-house streams, it was noted that the filter cloth wash water from all three installed vacuum filters was discharged directly into the general waste stream. Because of the vacuum filter system which this factory uses, i.e. the use of a filter cloth, the COD concentration in the stream was very high, similar to the Lumbini factory. In this case it was estimated at 2,880 mg/l with an average hourly flow of 9.6 m<sup>3</sup>/hour. This contributes approximately 0.7 tonnes COD/day to the general effluent. If this waste stream is recovered and used in the raw sugar cane crushing mill, then an increased efficiency of sugar production will occur and there will be a corresponding decrease in the effluent load. During the factory inspection, it was noted that there was a considerable spillage of raw juice at the intake mills. This represents a waste of raw product and results in a high effluent load. By proper control of the recycling pumps in the mills, it should be relatively easy to prevent spillage's from this section.

The initial design for the distillery which is attached to this sugar plant incorporated the use of sequential lagoons in order to achieve temperature reduction and maximum solids settlement before discharge of the spent wash into the stream. However, at the time of the visit, the channel leading to these lagoons had been disconnected and the lagoons were not being used. It was obvious from the state of the channel that these lagoons had not been used for a considerable period of time. At present, the raw spent wash discharges directly into the waste flow from the sugar factory and from there into the adjacent stream. The measured COD concentration of the spent wash was 97,900 mg/l COD with an estimated volume of 3.5 m<sup>3</sup>/hour. This represents an organic load of 8.22 tonnes COD/day. Discharge temperature of the spent wash was measured at 100°C. In this particular distillery, it is

possible to collect the waste yeast sludge in a separate tank. This tank is designed to allow the yeast solids to settle while the supernatant liquor can be discharged into the spent wash stream. However, in order for this facility to work properly, it is necessary to de-sludge the settlement tank at regular intervals. At the time of inspection, there was no evidence to suggest that this regular de-sludging of the settlement tank was being carried out. The typical COD concentration of waste yeast sludge is in the order of 250,000 mg/l. The measured concentration in this particular factory was 44,000 mg/l but it was noted during sampling that some of the solids had settled before the sample was taken. The pH of the spent wash and general distillery effluent was 5.4 and when this stream was combined with the general sugar effluent, the combined pH was 5.3. This combined effluent had a temperature of 35°C and had a very high sulphate level of 28 mg/l. It also contained high levels of nitrate, ammonia, phosphorous and iron. The COD concentration in this combined stream was measured at 5,700 mg/l. It was not possible to estimate the total combined flow as the discharge channel was irregular and contained a lot of settled solids and all kinds of debris. Before discharging into the stream, this combined effluent had a temperature of 33°C, a pH of 6.7 and a COD concentration of 2,080 mg/l. The stream, before receiving this effluent, had a temperature of 25°C, a pH of 8.7 and a COD concentration which ranged from 11-50 mg/l. Immediately downstream of the outfall at the 30m mark the temperature had increased to 27°C, the pH had increased to 7.2 and the COD concentration had increased to 300 mg/l. At the 10km point downstream the temperature had decreased to 23°C, the pH had increased to 7.6, the nitrate had increased to 9 mg/l, ammonia had increased to 2.9 mg/l, phosphorous had increased to 3.8 mg/l, the iron concentration was 2.26 mg/l, the sulphate concentration was 50 mg/l and the hardness measured 208 mg/l CaCO<sub>3</sub>. The COD had only decreased by 42 mg/l from the original 300 mg/l down to 258 mg/l. It is obvious from analysis at the 10km point that very little self-purification had occurred in the stream and that the stream was effectively dead for the full length of this 10km stretch. From the information supplied by the local people, it would appear that the stream remains highly contaminated for a distance of at least 100km from the factory. There have been many complaints from local inhabitants concerning the degree of pollution in this river. Because there are a number of tanneries upstream of the sugar factory outfall, a lot of the blame for this contamination was attributed to these tanneries. However, the analysis of the samples taken on the 8<sup>th</sup> February, 1995 would indicate that almost all the contamination in the stream originated from the Birganj Sugar Factory. It is therefore very important that a proper pollution auditing scheme should be instigated in this factory at the earliest opportunity.

In general, there is a lot of potential for reducing the pollution load by preventing several unnecessary waste discharges within the factory complex and by recycling contaminated water where possible particularly the waste from the filter cloth wash water. The unnecessary discharge of cooling water from the cooling circuit should also be prevented. The re-installation of the lagoon system and the proper operation of these lagoons will also greatly facilitate a reduction in the organic content of the waste stream going into the river. However, even the proper operation of these lagoons and of the settlement tank for the yeast sludge will not reduce the COD concentration in the spent wash to such a level that it will make this material suitable for discharge into a stream. It will therefore be necessary to install some treatment system which because of economic necessity must include an anaerobic digestion stage or an alternative disposal mechanism which might include the combining of the cooled spent wash with filter cake and ash to form a slurry which would be suitable for

direct irrigation onto the sugar cane fields. An assessment of the soil profile and type will be necessary before such a slurry spreading scheme can be instigated.

### **Recommendations**

- recycle the filter cloth wash water to the crushing mills
- install an oil and grease trap on the stream from the bearing cooling water and floor washing stream
- prevent the discharge of raw juice at the crushing mills
- instigate proper management control in order to prevent unnecessary discharges within the factory
- prevent the excess discharge of waste water from the cooling loop.
- re-instigate the lagoon system for the spent wash.
- allow the yeast sludge settling tanks to operate properly and remove the settled yeast sludge for air drying or animal feed on a very regular basis.
- examine the possibility of utilising the spent wash for irrigation purposes and/or for mixing with filter cake, ash and excess bagasse for use as a liquid fertiliser in the sugar cane fields
- examine the possibility of recovering waste heat from the spent wash stream for pre-heating the process water
- install simple flow measuring devices such as a V-notch in the waste stream channel so that an accurate measurement of the flow can be achieved
- install suitable effluent monitoring equipment and instigate proper pollution auditing within the factory
- instigate suitable training for qualified personnel in the area of water quality monitoring and pollution auditing
- install a suitable recovery loop for the caustic soda used during the washing cycle and/or a collection tank for this caustic soda so that it can be blended with the general waste stream over a long period or so that it might be used for pH adjustment elsewhere in the factory.
- install a proper sulphur generating facility which will protect the health of the operators and all other staff working in this general area.

## FACTORY

**Name:** Jawalakhei Distillery.

**Address:** Patan, District Lalitpur, Zone Bagmati

**Tonnes of cane crushed/day:** 0.0

**Operating days/year:** 365

**Tonnes of sugar/day:** 0.0

**Water usage, m<sup>3</sup>/day:** 72

**Tonnes of steam/hour:**

**Molasses, m<sup>3</sup>/day:**

**Alcohol, m<sup>3</sup>/day:** 4.5

**No. of employees:**

**No. of farmers:**

**Area of sugar cane fields:**

## Jawalakhej Distillery

### **General**

The Jawalakhej Distillery is located in the Patan district of Kathmandu. This distillery was visited on the 15<sup>th</sup> February by one of the UNIDO consultants and samples were taken from the spent wash stream and the effluent from a pilot anaerobic digester plant

### **Introduction**

This distillery is located in a suburb of Kathmandu and uses molasses or guar as a feed substrate for the production of alcohol. The distillery is not associated with any particular sugar factory and buys these raw materials on the open market. At the time of the visit, the distillery was operating on guar. The owner of this distillery intends to re-locate to a new location in the Terai district where he will be closer to the source of the raw materials. Because of the new awareness within Nepal concerning the importance of environmental protection and the proposed new legislation to control effluent discharges from industrial sources, the owner of this distillery is very anxious to obtain first hand knowledge on the most economically viable treatment system for spent wash effluent.

### **Present situation**

The present distillery is located in the Patan district of Kathmandu and discharges its spent wash effluent directly into the public sewer. Because this is a stand-alone distillery, the owner of the factory uses high grade raw material whenever possible, i.e. guar or high grade molasses. At the time of carrying out the tests on the spent wash and anaerobic effluents, the raw substrate being used was guar. As a consequence the COD concentration both in the spent wash and in the subsequent anaerobic digester effluent was considerably lower than what was measured in the other distilleries which were all operating on molasses. The COD concentration in the spent wash was only 4,500 mg/l which was approximately 20 times lower than the average values recorded with the other distilleries. The average daily floor rate was estimated at 72 m<sup>3</sup> per day. This presents a COD load of 0.324 tonnes/day.

A pilot scale anaerobic digester has been installed in the factory and has been under tests for the a period of months. The type of digester used in this particular case is a downflow fixed film reactor. The present pilot plant is operated in an uninsulated condition and is operated throughout the various seasons and varying temperatures. This was considered to be part of the test procedures for an anaerobic facility. Stopping of regular feeding and re-starting after a period of days or weeks was also part of the test regime. These are very important considerations in relation to anaerobic digesters as the fermentation process which occurs within the reactor is extremely complex and prone to upset by variations in temperature, feed concentration, etc. The ability of a fixed film digester to re-start in a relatively short period and to adjust to both liquid and/or organic overloads, is a very important attribute. An up-flow anaerobic sludge blanket (UASB) reactor is much more susceptible to variations in these parameters. The presence of substantial solids in effluents supplied to both types of digesters is a significant detrimental factor and is a factor which must be closely assessed at design stage. Alkalinity and buffering capacity are also very

important factors in assessing the suitability of a particular effluent for anaerobic digestion

The results from the present pilot plant study are very encouraging and show an extremely good degree of stability with both overload and shutdown occurrences being easily accommodated by the digester system. At the time of sampling the outlet temperature from the digester was 35°C, the pH was 7.5 and the COD concentration was measured at 2,600 mg/l. The alkalinity of the effluent was measured in the range 6,600-11,000 mg/l as CaCO<sub>3</sub>. While the efficiency of COD removal was less than 50%, this single sample assessment is not an accurate reflection of the true efficiency which can be obtained in a suitable anaerobic digester. The relatively dilute nature of the spent wash being fed into this digester is also a major contributory factor in the resulting efficiency of the digestion process. The use of a fixed film anaerobic digestion process which has been properly designed is a very commendable effluent treatment system. In a properly designed fixed film system with proper feed distribution very high treatment efficiencies can be achieved particularly with concentrate effluent such as spent wash which has a typical average COD concentration of 100,000 mg/l. The system is extremely stable and is capable of dealing with many variations in the raw feed.

### **Recommendations**

- install simple flow measuring devices such as a V-notch in the waste stream channel so that an accurate measurement of the flow can be achieved
- install proper monitoring equipment and test facilities within the factory laboratory
- ensure that suitable training is made available for qualified personnel to carry out the water quality monitoring and pollution auditing
- examine the possibility of recovering waste heat from the spent wash stream for pre-heating of the process water
- collect the yeast sludge in a separate settlement tank and allow the solids to settle for a maximum period
- decant the supernatant liquor and mix with the spent wash
- remove the settled solids to an air drying bed or for some other use
- ensure that proper distribution of the raw effluent is achieved within the anaerobic reactor
- if an upflow of fixed film reactor is used, examine the possibility of installing a pulse feed system with guaranteed localised feed distribution at the base
- locate the most suitable combined heat and power generating plant which is capable of dealing with the corrosive elements contained in bio-gas

- examine the possibility of creating a joint venture with the local steel manufacturer in the fabrication of this plant with a view to the commercial marketing of a proven system.
  
- examine the possibility of using the anaerobically treated effluent in a lagoon system for alternative protein generation. (An aerobically digested effluent will not be suitable for discharge directly into a stream and uses other than direct irrigation into the sugar cane fields may be more economically viable for a highly industrialised commercial operation such as the present distillery). The owner of this distillery is examining the possibility of growing fish in a suitable lagoon system.

**ANNEX VII**

**EXTENDED TABLES AND CHARTS**



**TABLE 1 - LUMBINI SUGAR MILLS LTD., SUNWAL, DISTRICT: NAWALPARASI, ZONE: LUMBINI.  
29<sup>TH</sup> JANUARY, 1995**

Location	Temp °C	pH	Nitrate (NO <sub>3</sub> ) mg/l	Ammonia (NH <sub>3</sub> ) mg/l	Phosphorus (PO <sub>4</sub> ) mg/l	Iron (Fe) mg/l	Sulphate (SO <sub>4</sub> ) mg/l	Alkalinity (CaCO <sub>3</sub> ) mg/l	Hardness (CaCO <sub>3</sub> ) mg/l	COD mg/l	Volume m <sup>3</sup> /h	COD Tonne/d	Solids %
Combined outfall	42	5.98	2.4	0.05	2.28	3.3	75	230	600	3210			0.306
Downstream 9km		6.76	0.0	>0.55	2.74	1.98	73	500	530	984			
Downstream 12km		7.18	0.0	>0.55	0.84	2.06	57	730	470	816			
Downstream 21km		7.20	0.0	0.0	0.59	2.55	16	470	350	284			
Vacuum pan cooling water	44	6.90	0.1	>0.55	0.02	0.27	74	180	290	20			
Filter cloth wash water	50	7.76							8600	75600	12	21.8	5.965
Vacuum filter wash water	43	7.25	0.0	>0.55	0.04	0.25	68	160	240	28			
Evaporator cooling water	55	7.0	0.1	>0.55	0.02	0.36	71	150	240	10			
General sugar effluent	50	7.18	0.0	>0.55	2.75	1.19	75	320	440	2630	163	10.3	
Spent wash	102	4.30								123800	8.33	25.2	11.525
Yeast sludge	28	4.18								227200	0.25	1.4	15.37

**TABLE 2 - MAHENDRA SUGAR FACTORY, BHAIRAHAWA, DISTRICT: RUPANDEHI, ZONE: LUMBINI.  
1<sup>ST</sup> FEBRUARY, 1995**

Location	Temp °C	pH	Nitrate (NO <sub>3</sub> ) mg/l	Ammonia (NH <sub>3</sub> ) mg/l	Phosphorus (PO <sub>4</sub> ) mg/l	Iron (Fe) mg/l	Sulphate (SO <sub>4</sub> ) mg/l	Alkalinity (CaCO <sub>3</sub> ) mg/l	Hardness (CaCO <sub>3</sub> ) mg/l	COD mg/l	Volume m <sup>3</sup> /h	COD Tonne/d	Solids %
General sugar effluent	32	4.7	2.01	4.6	11.9	5.70	180	110		5410	11.06 - 13.8	1.612	0.364
Sugar factory at road	30	4.8	3.0	1.0	0.08	6.28	96	125	560	2740			0.25
Effluent from cane mill	25	6.2	0.0		0.96	10.36	0.0	235	525	2690			
Mixed sugar factory effluent	33	9.1	0.0		0.0	1.22	128	125	275	1270	13.8	0.421	
Cooling water (out)	40	7.7	0.0	>2.2	0.02	1.9	272	110	332	200	1016.8		
Cooling water (in)	34	7.9	0.0	>5.5	0.0	1.94	272	90	340	300	1016.8		
Vacuum filter wash water	36	7.6	0.0	>2.2	0.02	1.86	176	100	400	220			
Spent wash	100									139000	2	6.672	7.198
General distillery effluent	45									29000	23.86	16.6	0.324
Distillery effluent at lagoon	33	7.1	2.3	>2.2	0.05	2.02	104	153	440	550			

**TABLE 3 - INDU SHANKAR CHINI MILL, HARLOWN, DISTRICT: SARLAHI, ZONE: JANAKPUR.  
4<sup>TH</sup> FEBRUARY, 1995**

Location	Temp °C	pH	Nitrate (NO <sub>3</sub> ) mg/l	Ammonia (NH <sub>3</sub> ) mg/l	Phosphorus (PO <sub>4</sub> ) mg/l	Iron (Fe) mg/l	Sulphate (SO <sub>4</sub> ) mg/l	Alkalinity (CaCO <sub>3</sub> ) mg/l	Hardness (CaCO <sub>3</sub> ) mg/l	COD mg/l	Volume m <sup>3</sup> /h	COD Tonne/d	Solids %
General sugar effluent	47	8.1	0.8	0.3	0.28	0.10	80	190	250	820			
Cooling water (out)	47	7.8	0.0	1.2	0.0	2.4	110	180	260	829			
Cooling water (in)	44	7.9	0.0	0.2	0.0	2.8	120	166	254	835			
Waste water from cooling circuit	45	8.5	0.0	0.6	0.0	3.5	130	218	306	853			
Vacuum filter wash water	45	7.7	0.0	0.0	0.0	2.3	90	172	246	867	20.856	0.434	
Combined outfall	33	5.5	5.7	17.5	2.2	7.7	240	380	178	11600	94	1.09	
Spent wash	100	5.1								72500	3.3	5.8	0.334
General distillery effluent	65	4.7			1.3					53900	3.3	4.31	6.24
Distillery effluent with yeast	24	5.2								191000	3.4		16.46

**TABLE 4 - SHREE RAM SUGAR FACTORY, GARUDA, DISTRICT: RAUTAHAT, ZONE: NARAYANI.  
6<sup>TH</sup> FEBRUARY, 1995**

Location	Temp °C	pH	Nitrate (NO <sub>3</sub> ) mg/l	Ammonia (NH <sub>3</sub> ) mg/l	Phosphorus (PO <sub>4</sub> ) mg/l	Iron (Fe) mg/l	Sulphate (SO <sub>4</sub> ) mg/l	Alkalinity (CaCO <sub>3</sub> ) mg/l	Hardness (CaCO <sub>3</sub> ) mg/l	COD mg/l	Volume m <sup>3</sup> /h	COD Tonne/ d
Freshwater		7.6	0.3	0.7	0.5	0.71	1.0	278	226	0.0		
Cooling water in spray aeration tank	40-45	7.2	0.9	3.8	0.02	2.85	190	68	212	116	804	
Waste vacuum filter water		7.5	1.6	0.5	8.3	3.1	130	220	642	2160		
General cooling water without lime		6.7	1.1		0.04	2.45	30.0	205	300	510	804	
General cooling water with lime		11.15		2.4	0.0	0.25	0.0	600	685	590	804	

**TABLE 5 - JAWALAKHEL DISTILLERY, PATAN, DISTRICT: LALITPUR, ZONE: BAGMATI.  
15<sup>TH</sup> FEBRUARY, 1995**

Location	Temp °C	pH	Nitrate (NO <sub>3</sub> ) mg/l	Ammonia (NH <sub>3</sub> ) mg/l	Phosphorus (PO <sub>4</sub> ) mg/l	Iron (Fe) mg/l	Sulphate (SO <sub>4</sub> ) mg/l	Alkalinity (CaCO <sub>3</sub> ) mg/l	Hardness (CaCO <sub>3</sub> ) mg/l	COD mg/l	Volume m <sup>3</sup> /h	COD Tonne/ d
Spent wash	100	3.9								4500	3	0.324
Anaerobic Digester effluent	35	7.5						6600-11000		2600		

**TABLE 6 - BIRGANJ SUGAR FACTORY LTD., BIRGANJ, DISTRICT: BARA, ZONE: NARAYANI.  
8<sup>TH</sup> FEBRUARY, 1995**

Location	Temp °C	pH	Nitrate (NO <sub>3</sub> ) mg/l	Ammonia (NH <sub>3</sub> ) mg/l	Phosphorus (PO <sub>4</sub> ) mg/l	Iron (Fe) mg/l	Sulphate (SO <sub>4</sub> ) mg/l	Alkalinity (CaCO <sub>3</sub> ) mg/l	Hardness (CaCO <sub>3</sub> ) mg/l	COD mg/l	Volume m <sup>3</sup> /h	COD Tonne/d	Solids %
Upstream	25	8.7	0.90	3.2	0.10	0.66	38.0	132	120	11-50			
Combined outfall	33	6.7	5.0	0.5	12.1	4.6	0.0	215	256	2080			
Downstream 30m	27	7.2	3.2	0.7	0.4	1.45	24.0	142	186	300			
Downstream 10 km	23	7.6	9.0	2.9	3.8	2.26	15.0	196	208	258			
Freshwater	25	8.2	0.8	1.2	0.08	0.34	1.0	205	183	0.0			
Filter cloth wash water	41	8.0	2.4	0.7	85.00	1.7	0.0	190	238	2880	9.6	0.664	
General sugar effluent	35	6.4	6.4	0.9	25.1	3.8	0.0	100	350	2250	123	8.5	
Cooling water (out)	41	8.0	3.6	0.7	0.04	1.19	0.0	188	164	93			
Cooling water (in)	37	8.0	2.4	0.3	0.03	1.06	0.0	188	168	107			
Combined effluents	35	5.3	8.0	1.3	41.0	8.6	28.0		286	5700			
Spent wash	100	5.4								97900	3.5	8.22	5.88
General distillery effluent	45	5.4								82500			5.65
*Distillery effluent @ 500m	36	5.4								65100			3.87
Yeast sludge	24	5.3								**44000	0.07	0.07	3.17

\* Distillery effluent before joining general sugar factory discharge.

\*\* Some of the solids had settled before the sample was taken.

**Table 7 - Minimum Quality Requirements for Surface Waters to be used as Sources for Drinking Water within the EU (Directive 75/440/EEC)**

Parameter	Units	A 1	A 2	A 3
Colour after filtration	mg/l Pt scale	20	100	200
Temperature	Deg. C	25	25	25
Nitrates	mg/l (NO <sub>3</sub> )	50	50	50
Fluorides	mg/l (F)	1.5		
Dissolved Iron	mg/l (Fe)	0.3	2.0	
Copper	mg/l (Cu)	0.05		
Zinc	mg/l (Zn)	3	5	5
Arsenic	mg/l (As)	0.05	0.05	0.1
Cadmium	mg/l (Cd)	0.005	0.005	0.005
Chromium (Total)	mg/l (Cr)	0.05	0.05	0.05
Lead	mg/l (Pb)	0.05	0.05	0.05
Selenium	mg/l (Se)	0.01	0.01	0.01
Mercury	mg/l (Hg)	0.001	0.001	0.001
Barium	mg/l (Ba)	0.1	1.0	1.0
Cyanide	mg/l (CN)	0.05	0.05	0.05
Sulphates	mg/l (SO <sub>4</sub> )	250	250	250
Phenols	mg/l (C <sub>6</sub> H <sub>5</sub> OH)	0.001	0.005	0.1
Dissolved or Emulsified Hydrocarbons	mg/l	0.05	0.2	1.0
Polycyclic Aromatic Hydrocarbons	mg/l	0.0002	0.0002	0.001
Total pesticides	mg/l	0.001	0.0025	0.005
Ammonia	mg/l (NH <sub>4</sub> )		1.5	4.0

\* A1, A2, A3: These correspond respectively to increasing degrees of water treatment required to make them potable.

**Table 8 - Quality Requirements for Bathing Waters**

<b>Parameters</b>	<b>G</b>	<b>I</b>	<b>Minimum Sampling Frequency</b>
Total coliforms/100 mls	500	10,000	2 weeks
Faecal coliforms/100 mls	100	2,000	2 weeks
Faecal Streptococci/100 mls	100		(2)
Salmonella/1000 mls		0	(2)
Enteroviruses PFU/10 litres		0	(2)
pH		6 - 9	(2)
Colour		No change	(1)
Mineral oils (mg/l)		No visible film or odour	2 weeks
Surface active substances reacting with methylene blue (mg/l lauryl sulphate)		No lasting foam	2 weeks
Phenols (mg/l C <sub>6</sub> H <sub>5</sub> OH)		No odour	2 weeks
Transparency (m)	2	1	2 weeks
Dissolved oxygen (% saturation O <sub>2</sub> )	80 - 120		(2)
Tarry residues & floating materials	0		2 weeks
Ammonia (mg/l NH <sub>4</sub> )			(3)
Nitrogen Kjeldhal (mg/l N)			(3)
Pesticides (mg/l)			(2)
Heavy Metals (mg/l)			(2)
Cyanides (mg/l Cn)			(2)
Nitrates & Phosphates (mg/l)			(2)

G = Guide

I = Mandatory

\* EEC Directive 76/160/EEC

(1) If sampling from the previous year indicates a water of better quality and if no obvious source of contamination has occurred, sampling frequency may be reduced by a factor of 2.

(2) Concentrations to be checked by competent authorities when an inspection shows that these substances may be present or that the water quality has deteriorated.

(3) These parameters should be checked where there is a tendency towards eutrophication.

**Table 9 - Water Quality Requirements for Salmonoid and Spawn  
Freshwaters, Estuaries and other Coastal waters**

Parameter	Units	Salmonid & Spawning Freshwaters	Estuaries & Coastal Waters
Cadium	$\mu\text{g/l (Cd)}$	5	10
Chloride	$\mu\text{g/l (Total residual Chlorine)}$	5	10
Chromium	$\mu\text{g/l (Cr)}$	50	100
*Copper	$\mu\text{g/l (Cu)}$	25	50
Cyanide	$\mu\text{g/l (CN)}$	10	10
Fluoride	$\mu\text{g/l (F)}$	1.5	
Lead	$\mu\text{g/l (Pb)}$	50	100
Manganese	$\mu\text{g/l (Mn)}$		100
Mercury	$\mu\text{g/l (Hg)}$	0.05	0.10
Nickel	$\mu\text{g/l (Ni)}$	500	500
Nitrate	$\text{mg/l (NO}_3\text{)}$	50	1.0
pH		6 - 9 (No change greater than 0.5 units from natural)	6.5 - 8.5 (No change greater than 0.2 units from natural)
Phenol	$\mu\text{g/l (C}_6\text{H}_6\text{O)}$	1.0	1.0
Silver	$\mu\text{g/l (Ag)}$	10	10
Sulphate	$\text{mg/l (SO}_4\text{)}$	250	
Sulphide	$\mu\text{g/l (Undissolved H}_2\text{S)}$	2.0	2.0
*Zinc	$\mu\text{g/l (Zn)}$	100	100

\* The recommended values for these parameters apply to waters with a hardness greater than 50 mg/l as CaCO<sub>3</sub>.

The above recommended values apply at the boundary of the mixing zone.

The values for chromium, copper and zinc may not provide sufficient public health protection in the case of edible shellfish. Special quality requirements apply to these activities.

(Table taken from Memorandum No. 1, Water Quality Guidelines, D.O.E., Dublin, Ireland, 1990).



**Table 10 - Proposed Tolerance Limit for Industrial Effluent Discharged into Inland Surface Waters in Nepal. Pursuant to Regulations 4 and 7 under Industrial Pollution Control Regulations for Air and Water Discharges (1994)**

Characteristics	Unit	Tolerance Unit
Total suspended solids	mg/l	30 - 200
pH		5.5 - 9.0
Temperature	C	< = 40 in any section of the stream within 15m downstream from effluent outlet.
BOD at 20 C	mg/l	30 - 100
Oils and grease, Max	mg/l	10
Phenolic compounds, Max	mg/l	1.0
Cyanides, Max	mg/l	0.2
Sulfides (as S), Max	mg/l	2.0
Total residual chlorine	mg/l	1
Fluorides (as F), max	mg/l	2.0
Arsenic (as As), Max	mg/l	0.2
Cadmium (as Cd), Max	mg/l	2.0
Hexavalent Chromium (as Cr), Max	mg/l	0.1
Lead (as Pb), Max	mg/l	0.1
Mercury (as Hg), Max	mg/l	0.01
Zinc (as Zn), Max	mg/l	5.0
Copper (as Cu), Max	mg/l	3.0
Silver (as Ag), Max	mg/l	0.1
Ammoniacal nitrogen, Max	mg/l	50
COD, max	mg/l	250
Nickel (as Ni), Max	mg/l	3.0
Selenium (as Se), Max	mg/l	0.05
Radioactive materials	mg/l	
Alpha emitters, Max	c/ml	$10^{-7}$
Beta emitters, Max	c/ml	$10^{-8}$

**Table 11 - Economic Profile of the Sugar-molasses Industry in Nepal (Source: Government Official Report)**

**Capacity Utilisation of the FBT Sub-sector Industries, 1989/90**

Industry/Product	Unit	Capacity	Production	Capacity Utilisation (%)
Sugar/Khandsari	MT	57270	31927	56

**Performance Indicators of the FBT Sub-sector, (1986/87)**

Industry/Product	Gross Output/Employee Rs '000	Hourly Output Rs	Worker Wages Rs '000	Worker Hours '000	Hourly Worker Cost	Output/ Worker Cost	Estimated Average Plant Shifts*
Sugar	60.92	25.43	18161	10869	1.67	15.22	0.91

**Composition of the FBT Sub-sector, 1986/87**

Industry/ Product	Number of Units	No. of Persons Employed	Operatives & Contract Workers	Fixed Assets (Rs'000)	Gross Output (Rs'000)	Value Added (Rs'000)	Value Added/Gross Output	Value/ Added Inv.	Value Added/ Employee (Rs '000)	Percent Share of sub-sector Value Added
Sugar	22	4537	3388	135376	276413	122904	0.440	0.908	27.09	5.48

**Production of FBT Sub-sector Industries, 1982/83 - 1989/90**

Product	Unit	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	Annual Growth Rate(0%)
Sugar	MT	22357	17496	11039	15190	24565	30040	24197	31927	10.55

**Table 11 continued**

**Projected Domestic Demand for the FBT Sub-sector Products, 1989/90 - 1999/2000**

Industry/Product	Unit	1989/90	1994/95	1999/2000	1989/90-1994/95 % annual increase	1994/95-1999/2000 % annual increase
Sugar	MT	65,000	106,294	171,184	10.00	10.00

**Trends of Production and Productivity of Major Cash Crops, 1974/75 - 1999/2000**

Crop	Actual Production and Productivity (Production '000 MT, Productivity Mt/Ha)								Targets			
	1974/75		1979/80		1984/85		1989/90		1994/95		1999/2000	
	Production	Productivity	Production	Productivity	Production	Productivity	Production	Productivity	Production	Productivity	Production	Productivity
Sugarcane	251.43	16.541	385.07	17.175	408.26	23.356	988.30	31.375	1,582	35.0	2,773	40.0

**Available Resources for Processing, 1989/90 - 1999/2000 (Production '000 MT)**

Crop/Livestock Product	Actual Production 1989/90	Production Targets		Post Harvest Loss & Seed (%)	Total Resources			Fresh Consumption and Household Processing			Resource available for processing		
	1989/90	1994/95	1999/2000		1989/90	1994/95	1999/2000	1989/90	1994/95	1999/2000	1989/90	1994/95	1999/2000
Sugarcane	988	1582	2773	35	642	1028	1802	25	20	15	395	712	1387
Molasses	16	28	55		16	28	55				15	28	55

**Table 11 continued**

**Indicative Production Targets for the FBT Sub-sector, 1984/85 - 1999/2000**

Industry/Product	Unit	1984/85 (Actuals)	1989/90 (Actuals)	1994/95 (Proposed)	1999/2000 (Proposed)
Sugar and Khandsari	MT	11039	31927	64000	124,000

**Industrial Production and Capacity Required in the FBT Sub-sector, 1989/90 - 1999/2000**

Product	Unit	1989/90		1994/95		1999/2000	
		Annual Approved Capacity Operation	Anticipated Production	Capacity Required	Anticipated Production	Capacity Required	
Sugar/Khandsari Sugar	MT	57270	64000	80000	124000	155000	

**Investment Requirements in the FBT Sub-sector, 1990 - 2000 (Rs Million)**

Industry/Product	Unit	Incremental Plant Capacity Required		Additional Investment Requirements (at 1989/90 prices)		Projected Cost of Maintenance of Capital Stock at 5% of Capital Value		Annual Working Capital	
		1990-95	1995-2000	1990-95	1995-2000	1994/95	1999/2000	1994/95	1999/2000
Sugar	MT	22730	75000	480	1441	33	105	143	278

**Table 11 continued**

**Estimated Output, Value Added and Employment During 1989/90 - 1999/2000**

Industry/product	Total Output (Rs Million)			Total Value Added (Rs Million)			Total Employment (No.'s)		
	1989/90	1994/95	1999/2000	1989/90	1994/95	1999/2000	1989/90	1994/95	1999/2000
Sugar	447	896	1,736	197	403	799	5,587	10,667	19954

<b>Table 12 - Relevant Indian Standards Relating to Environmental Protection</b>
--

IS 3307 (1977) Industrial effluent tolerance limits for discharge onto land for irrigation purposes.

BOD<sub>5</sub> = 500 mg/l  
TDS = 2,100 mg/l  
Oil and Grease = 1 mg/l

IS 7968 (1976) Marine control areas.

pH = 5.5 - 9.0  
BOD<sub>5</sub> = 100 mg/l  
TSS = 100 mg/l  
COD = 250 mg/l

IS 3306 (1974) Effluent for discharge into public sewers.

BOD<sub>5</sub> = 500 mg/l  
pH = 5.5 - 9.0  
TSS = 600 mg/l  
Oil and Grease = 100 mg/l  
TDS = 2,100 mg/l  
Phenolic compounds = 5 mg/l

IS 2490 (1974) Discharge limits for inland surface waters - ponds and lakes.

pH = 5.5 - 9.0  
BOD<sub>5</sub> = 30 mg/l  
TSS = 100 mg/l  
Oil and Grease = 10 mg/l  
Phenolic compounds = 1 mg/l

Additional constraints (1990)

BOD<sub>5</sub> = 30 mg/l with a minimum dilution of 1/12.

T = 40 °C.

## ANNEX VIII

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**Ministry of Industry, 1994.** Discussion paper proposed industry-specific discharge standards for airborne and waterborne environmental contamination. *Ministry of Industry, Singha Durbar, Kathmandu, Nepal.*

## ANNEX IX

### PROPOSED METHOD FOR THE COMBINED DISPOSAL OF SPENT WASH, FILTER MUD & BOILER ASH

#### **Utilisation of spent wash as a fertiliser**

The replenishment in the soil of the quantities of potassium, phosphorous and lime which are consumed by the sugar cane crop during the growing season and which is recovered in the sugar factory in the form of spent wash, filter mud and ash cinders is a very important economic factor for African and similar countries which import artificial fertilisers.

The quantity of spent wash produced in a sugar factory and an associated distillery which uses all the molasses is very important. 40 kg of molasses is produced per tonne of raw sugar cane and distillation of each kg of molasses produces approximately 3 litres of spent wash. Therefore, for each tonne of raw sugar cane approximately 120 litres of spent wash is produced. This spent wash is acidic and polluting but it contains almost all the potassium which was extracted by the raw sugar cane from the fields.

If one wishes to replace all the minerals removed from the soil, then in the case of a harvest containing 100 tonnes of sugar cane per hectare, it will be necessary to re-apply  $120 \times 100 =$  to 12,000 litres of spent wash.

The same reasoning can be applied to the filter mud. In a sugar factory which is equipped with rotating vacuum filters, approximately 26kg of fresh mud with a moisture content of 70% is produced for each tonne of raw sugar cane. This filter mud contains almost all the phosphorous which was taken up by the plants during their growing season and the greater part of the calcium which was also taken up during this season. Additional lime is also added during the clarification of the juice within the factory. In order to return the equivalent amount of fertiliser to the soil, it will be necessary, in the case of a crop producing 100 tonnes of cane per hectare, to spread  $26 \times 100 = 2,600$  kg of filter mud per hectare.

Instead of applying two spreading applications, one of spent wash containing 12,000 litres per hectare and the other of 2,600 kg of filter mud per hectare, it would make more sense to blend both of these materials and apply these in one spreading of 15,000 litres per hectare. This material will have the same consistency as a standard agricultural slurry.

It is also possible to combine the ash cinders which are produced within the factory with this above mixed stream.

The advantages which accrue from this solution are immediately evident. The filter mud (and the ash cinders) neutralises the acidity of the spent wash. It may be necessary to verify that the recommended blending of 2,000 kg of filter mud with 12,000 litres of molasses will alter the pH from 1.5 to 4/5.5.

There will be only one transport system instead of the original two.



The spreading of the combined material in the form of 15,000 litres of liquid per hectare will ensure the equal distribution of all the fertiliser compounds over the complete surface. It is practically impossible to obtain a similar situation when filter mud at the rate of 2,600 kg per hectare is being spread. This technique permits the homogenous spreading of filter mud over the total surface and not just an increased dosage on special parcels of land.

Finally the use of this liquid is far easier than storage and spreading of chemical fertilisers in the field.

The proposed solution consists of building a facility, in close proximity to the factory, where the spent wash, the filter mud and the ash cinders can be combined. This mixture can be maintained in a homogenous manner through the use of floating agitators. By a judicious blending of the spent wash and the filter mud, it is possible to obtain a liquid syrup which will be very suitable for land spreading. Filter mud obtained from vacuum filters which do not require the addition of bagasse is more suitable to the blending process. Filter mud containing bagasse which is mixed with ash cinders is more difficult to mix and it is necessary to ensure that a properly designed floating agitator is used. These agitators or pumps could also be used for the filling of the slurry tankers which will spread the material in the fields.

Spreading in the fields can be carried out by slurry tankers with an approximate size of 7.5 tonnes (8,000 litres). These tankers can be pulled by four wheel drive tractors with an engine capacity of approximately 80 horse power. Spreading of the 15,000 litres per hectare (2 full slurry tanker loads at 7.5 tonnes each) will not be as expensive as the individual spreading of 2.6 tonnes per hectare of filter mud and 4 tonnes per hectare of spent wash. Spreading of the material in the form of a liquid application will give better distribution of the minerals over the soil surface.

## Agricultural aspects

In order to verify the fertiliser value of the proposed blending, Technisucre has established trial plots in Siranala, Madagascar and in Sosuco, Burkina Faso which received the following applications:

1. One trial plot with chemical nitrogen without the addition of phosphorous or potassium.
2. One trial plot with chemical nitrogen, phosphorous and potassium.
3. One trial plot with chemical nitrogen + filter mud + molasses.
4. One trial plot with chemical nitrogen + filter mud + spent wash.

In order to recover 100 tonnes of cane per hectare, the dosage rates shown in the following table were recommended for this experiment.

Elements	Treatment	Artificial fertiliser	Molasses Filter mud	Spent wash Filter mud
N	120kg/ha (urea)	120kg/ha (urea)	110kg/ha* (urea)	110kg/ha* (urea)
P <sub>2</sub> O <sub>5</sub>	0	80kg/ha (phosphorous triple)	2,600kg/ha Filter mud	2,600kg/ha Filter mud
K <sub>2</sub> O	0	160kg/ha (CI k)	4,000kg/ha (molasses)	12,000l/ha (spent wash)

\* This nitrogen is added in order to compliment the nitrogen in the filter mud, molasses and spent wash.

In order to assess the effect of the proposed slurry spreading regime, it is recommended that trials be carried out on the proposed soil. It is recommended that four treatments of slurry, replicated in six different plots, i.e. 24 parcels of ground should be utilised to obtain a balanced statistical result from the treatments. The parcel sizes should range from 5-12 metres or alternatively 3-10 metres. A register of the results should be kept. The pH of the soil should be measured in the 24 parcels of ground before planting, after application of the materials and each following year. Each year the quantity of sugar cane in tonnes per hectare, the percentage of sugar in the cane and the quantity of sugar produced in tonnes per hectare should be recorded.

3<sup>rd</sup> Congres A R T A S , La Reunion, October 1988 Paper by Yves Lemaire, Agro-Industrie Sucriere

**ANNEX X**

**MODEL LICENCE APPLICATION TO DISCHARGE EFFLUENT**

**MINISTRY OF INDUSTRY, NEPAL**

**Application for a license to discharge trade effluent to Waters.**

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1. Name of Applicant:  
Address:
2. If Discharger is a Registered Company state:
  - (a) Registered name of Company:
  - (b) Address of Registered Office:
  - (c) Name of Company Secretary:
3. Name and address of premises from which the discharge is/will be made:
4. General description of process or activities giving rise to the discharge:
5. Location and site plan showing the points of discharge to the waters:
6. Details of size and type of discharge outlets:
7. Is the discharge an existing discharge:
8. If the drainage is existing, state the date on which the discharge commenced:
9. Give details of any other discharges from the premises:
10. State reference number and date of planning permission (if applicable):
11. State source of water supply:
12. Give details of provisions made for sampling and measurement of effluent flows:
13. Give details of any special arrangements to prevent accidental discharge:
14. Trade Effluent:      Volume of effluent to be discharged:
  - (a) Normal per day:
  - (b) Maximum in any one day:
  - (c) Maximum rate per hour
  - (d) The period or periods of the day in which the discharge is to take place
  - (e) Any seasonal or other variations (including any arising from plant malfunction), total volume to be discharged:
15. Particulars of any effluent treatment:

16. Characteristics of the Trade Effluent:

Complete for all applicable characteristics, giving concentration ranges where applicable. The following list is meant to be indicative only - such other physical, chemical or other characteristics as are pertinent to the effluent in question should be specified.

Characteristics:	Prior to Treatment:	As Discharged
Temperature (Deg. C)		
pH		
B.O.D.		
C.O.D.		
Colour		
Suspended Solids		
Settleable Solids		
Dissolved Solids		
Ammonia (as N)		
Nitrates (as N)		
Phosphorous (as P)		
Sulphates (as SO <sub>4</sub> )		
Chlorides (as Cl)		
Fluorides		
Phenols (as C <sub>6</sub> H <sub>5</sub> OH)		
Detergents (as Lauryl Sulphate)		
Oils, Grease and Fats		
Metals: (Specify each)		
Organohalogen compounds (Specify)		
Organophosphorous compounds (Specify)		
Mineral Oils		
Hydrocarbons of Petroleum origin		
Other Toxic substances		

Any other relevant characteristics

I hereby make application for a license to discharge the above mentioned effluents to waters under the Industrial Pollution Control Regulations for Air and Water Discharge (1994) in accordance with the plans and particulars submitted.

Signed: \_\_\_\_\_

Date: \_\_\_\_\_

## ANNEX XI

### ANAEROBIC DIGESTION

#### **Anaerobic Digestion - General**

Anaerobic digestion is a process which has been well known for over a century. The process which involves the conversion of organic residue into a stable end-product concomitant with the production of valuable end-products, such as methane gas, has been applied to the stabilisation of sewage sludge for many decades. The presence of anaerobic digesters with their typical large-domed concrete tanks and associated gasometers is a common sight in most large sewage works. The use of anaerobic digestion, at present, is best known in connection with the treatment of organic effluents containing relatively high quantities of solids. Effluents with solids content in the range of 3-10% were generally considered to be suitable for anaerobic digestion. However, scale of operation dictated that only plants with large quantities of this type of effluent could economically be considered for this process. In this context, the solids concentration was important for two reasons. Firstly, they acted as the nutrient source for growth of the anaerobic bacteria, and secondly, the residual fraction of the solids which was non-biodegradable acted as a surface of attachment for the same bacteria. One of the critical design parameters for this type of anaerobic reactor was to maximise the solids concentration and hence increase the rate and intensity of the action. This design criteria created problems due to demands it placed on the mechanical equipment, such as pumps and mixers which were required to move this material into and out of the sealed reactor.

In the newer anaerobic designs, the necessity for having the solids within the sealed portion of the reactor has been removed through the use of surfaces and biological granules which remain within the reactor and onto which the anaerobic bacteria can fix. The degradable organic matter present in the solids fraction is solubilised prior to addition of the organic material to the reactor. Hence the same benefits of anaerobic digestion accrue without the associated mechanical problems due to the high solids content. These types of reactor are described in the following sections.

In many of the new anaerobic reactors, the principles of sedimentation and sludge stabilisation (conversion of the degradable organic fraction into soluble organics) is employed as a first-stage reaction. The soluble organics dissolved in the liquid fraction are subsequently removed in a strict anaerobic reactor and converted into useful biogas. Because the requirement for high levels of suspended solids within the reactor has been removed, the newer generation of anaerobic reactors are simpler, much more stable, easier to operate and less expensive than the totally mixed reactors previously used. It is also possible with these new digester designs to treat organic effluents which are low in suspended solids - effluents which were not previously amenable to anaerobic digestion.

In this context, the anaerobic digestion process must be compared with the contemporary aerobic waste treatment systems which are at present being used. The

present aerobic systems suffer from two major disadvantages: firstly, they are energy-consuming process requiring an estimated 0.5-1.0 kWh/kg COD removed and secondly, they produce large quantities of biological sludge estimated at 0.3-0.5 kg solids/kg COD removed. Disposal of this sludge from a large treatment works can be a very expensive process. Anaerobic digestion, on the other hand, produces biogas which can be converted directly into energy and the generation of biological sludge is only 1/10 the quantity produced in a similar aerobic works. Theoretically, it is possible to produce 3.3 kWh (heat energy) per kg COD removed in anaerobic digestion. It is these features which make the new generation of anaerobic reactors a very interesting alternative to existing waste treatment methods.

### Anaerobic Digestion - Biochemistry

In the conventional digesters, the primary organic sludge from the primary settling tanks is combined with the secondary biological sludge and placed in a sealed tank. The material is then heated to 35°C, continuously mixed and allowed to ferment and digest for 20-30 days. During this period, the digestible organic material is converted into biogas. The process must occur in the total absence of oxygen and where old digesters are used, under strict environmental control. The residual digested solids are thickened and dried ready for disposal. In the new generation of anaerobic reactors, it is preferred to treat the raw effluent and thus eliminate most of the sludge production problems.

Anaerobic digestion, while initially seeming to be a simple process, is when examined in detail a very complex biological phenomenon. Various general subdivisions can be made in the process, but to date, the full biochemical pathways are not known. These general subdivisions are shown in Fig. XI.1.

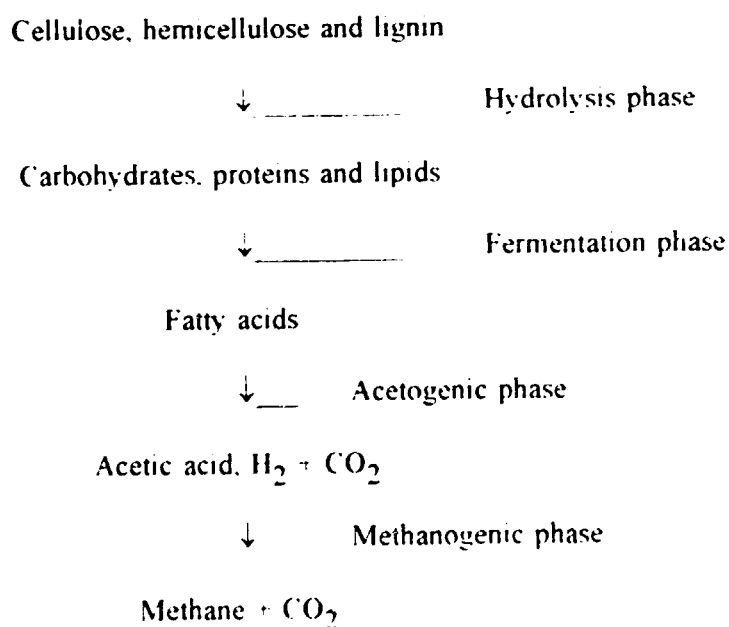


Fig. XI.1. CONVERSION OF ORGANIC WASTE TO METHANE.

In the first phase, high molecular weight compounds, such as cellulose and lignin, are hydrolysed to carbohydrates, proteins and lipids. This process is mediated through the action of extracellular enzymes. Research work indicates that the rate of action in this phase can be greatly increased through the use of thermophilic fungi and anaerobic/facultative species of bacteria. Chemical and heat conditioning can also be used to increase the rate of degradation of these compounds.

In many instances, the proportion of cellulose, hemicellulose and lignin in the waste is very low and as a result this stage is not of importance in the overall process. In effluents where large amounts of these compounds occur, modern anaerobic designs have tended to favour the use of a two-stage reactor. The first stage reactor is optimised for hydrolysis while the second stage is optimised for conversion of the end-products to methane and carbon dioxide. In these cases, the hydrolytic stage is often the rate-limiting step in the total complex process.

The second phase, the fermentation stage, is mediated by many varied groups of organisms. For this reason, it usually occurs naturally at a non-rate-limiting pace in nearly every environment and for most types of wastes. The acetogenic stage is an extension of the fermentation stage and recent studies indicate that this phase may be very important in limiting the overall rate of the complex anaerobic reaction. The availability of free hydrogen being the major factor. All free hydrogen produced is normally converted to  $\text{CH}_4$  very rapidly and only trace amounts should be present at any time in a balanced digester. In certain types of wastes various elements, such as sulphate, may compete with the methane producing bacteria for the hydrogen, thereby reducing the total  $\text{CH}_4$  yield. This may be a major loss of potential energy in wastes such as distillery wastes from molasses fermentation for alcohol production; wastes from margarine production; petroleum refineries, etc.

The final stage, that of conversion of the acetic acid  $\text{CO}_2$  and  $\text{H}_2$  to methane, is mediated by a limited number of strictly anaerobic bacterial groups. These groups can be subdivided into groups which oxidise hydrogen to methane and groups which metabolise acetate but not  $\text{H}_2/\text{CO}_2$ . The only methanogenic genera isolated to date are those which are limited to the catabolism of one carbon (e.g.  $\text{H}_2/\text{CO}_2$ ,  $\text{CH}_3\text{OH}$ ,  $\text{CO}$ ,  $\text{HCOOH}$ ,  $\text{CH}_3\text{NH}_2$ ) and two carbon compounds (e.g. acetate). Because of the limited number of substrates on which these methane producing bacteria grow, the slow growth rate of these bacteria and the exacting conditions required for their growth, it was assumed for many years that the overall rate of anaerobic digestion was governed by this stage. New methods of digester design have now altered this situation, so that the methanogenic phase is no longer the rate-limiting one.

### **Anaerobic Digestion - Stability**

A criticism which has been levelled at anaerobic digestion for many years is the difficulties in maintaining a stable population of organisms within the reactor. These difficulties arose due to the complexity of the anaerobic reaction combined with the use of totally mixed digesters. Because of the complexity of the reaction it was easy

to unbalance the chain of events which resulted in certain of the phases shown in Fig. XI.1 becoming dominant and producing their by-product in excess of what was required in the subsequent phases. Unfavourable environmental conditions rapidly built up with the resulting failure of the overall anaerobic process. The fact that the process was carried out in a completely mixed tank under continuous loading and unloading conditions meant that the required level of active flora within the reactor was rapidly depleted leading to the subsequent failure of the total process. The new generation of reactors have been designed in such a way as to prevent the washout of these active bacteria even when slugs of unfavourable elements are passed through the reactor. Elements which often influence the stability of these older reactors include pH and alkalinity, level of cations, temperature, nutrient concentration, solids concentration and mixing.

### **Anaerobic Digester Types**

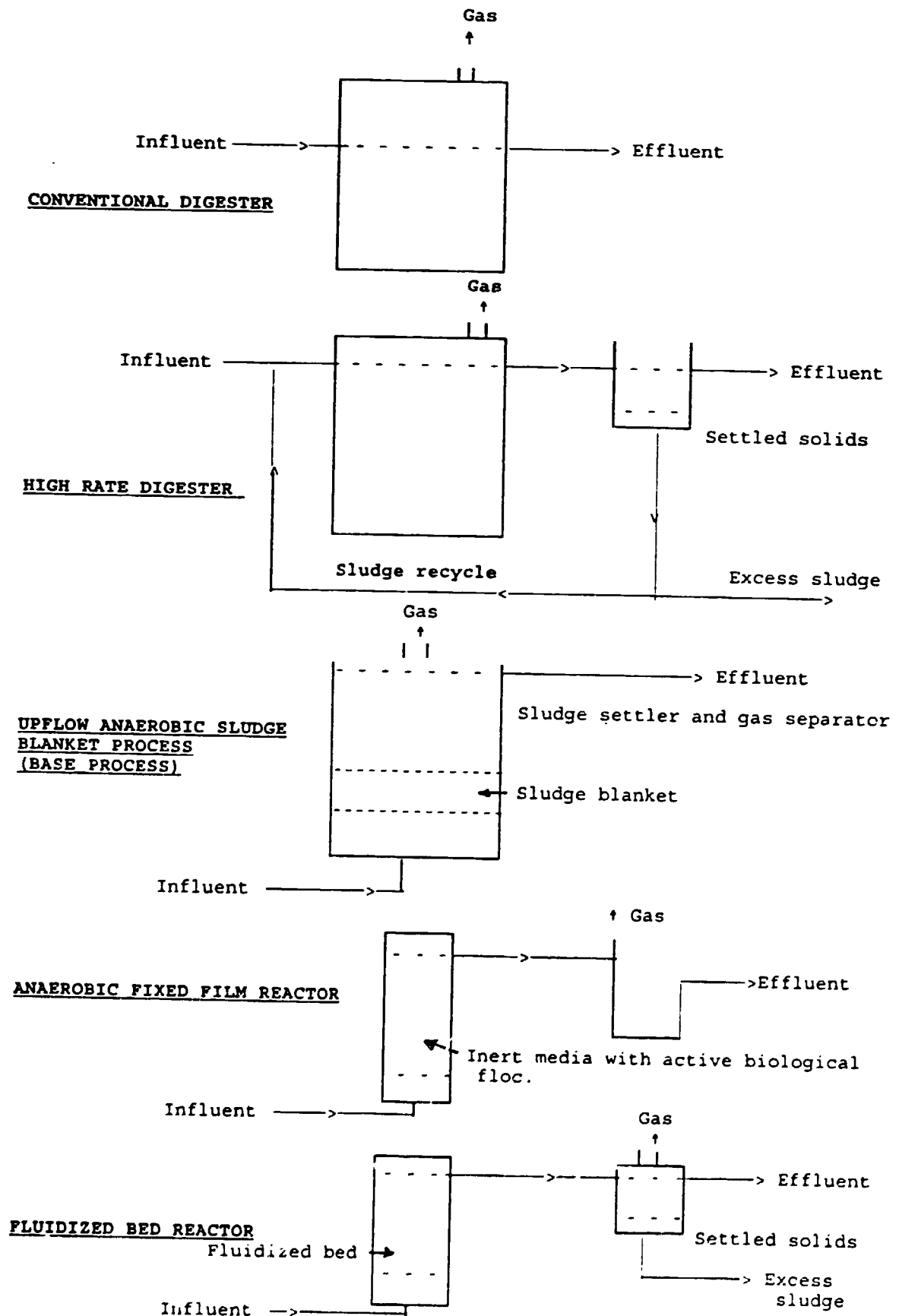
The anaerobic treatment process can be suitably divided into 5 different treatment procedures on the basis of digester design. These 5 general digester types are shown in Fig. XI.2. Most experience with anaerobic digestion has been obtained with the conventional digester. This type of unit mainly operates on wastes with a high solids content, notably domestic sewage sludge digesters. It is essentially a heated, stirred reactor with a relatively long liquid retention time. For this reason, these units tend to be very large involving high initial capital costs and lots of mechanical moving parts. Because these are the oldest designs, a lot of information has been gained on their operation. Most of the published data on anaerobic digestion relates to this type of unit. Due to its high capital and operating costs and as a result of some recent scientific findings, it is now being superseded by the second generation reactors.

The high rate anaerobic digester was developed to treat more dilute wastes and to reduce the liquid retention time. It has a mode of action similar to that of activated sludge. Active solids are returned to the digester while the treated liquid fraction is passed through the unit at a reduced liquid retention. A major difficulty associated with this type of digester is the poor settling properties of the digester solids. Commercial digesters based on this principle are presently on the market and are claimed to be suitable for the digestion of most organic effluents. Mechanical and thermal shock methods of solids separation are used and as a result capital costs and operating costs are relatively high.

The up-flow anaerobic sludge blanket (UASB) process consists of an active bed or solids, suspended by the upward flow of liquid and gas. This process has been applied to the treatment of sugar processing waste water in the Netherlands. It is a good process for treating effluents which are low in suspended solids content but because of the critical flow-characteristics and solids separation requirements, it has a relatively high capital cost and requires a lot of operational control. High suspended solids wastes have proven difficult to treat by this method.



Fig. XI.2



The fourth general type of digester is the anaerobic fixed film reactor. This consists of a container which is filled with inert material, usually gravel or plastic, to which the active bacteria attach. It is not always easy to achieve this attachment but once the bonds are formed, overall efficiency can be related to the available surface area. This system was first described in 1957 and received further attention in 1969 when it was studied in relation to dilute liquid effluents. Basic research has extended the use of this basic principle to the treatment of all organic effluents, both strong and weak and also to effluents which are high in solids content through the use of a two-phase reactor. This type of reactor gives very good COD removal efficiencies at short retention times. Mechanical moving parts are at a minimum, which results in ease of operation and prevents failure due to mechanical faults. Because the active organisms are held inside the digester, there is no need for solids recycle or for solids regeneration. Very long active bacterial retention times have led to high rates of digestion which results in greatly reduced capital costs through reduced reactor size. This type of reactor is now being applied to treat the effluent from such processes as molasses alcohol production, dairy wastes, food confectionery wastes and a variety of high strength wastes with both low and high quantities of solids.

A recent development has been the combination of the sludge bed and the fixed film technology in a hybrid reactor. This appears to be the favoured technology in modern high rate anaerobic fermentation processes and it combines the best design attributes of both types of plants.

The final anaerobic general treatment system is an extension of the anaerobic fixed film process. In this unit, an attempt is made to reduce the dead volume of the reactor to a minimum while still maintaining a high surface area for attachment. This is achieved through the use of an expanded fluidised bed of particles, usually 0.8 mm diameter. A thick film of active bacteria developed on the surface of the particles and very high treatment efficiencies have been reported. This is a very new anaerobic system and the economics involved, due to the high liquid recirculation ratio required to fluidise the bed, are not favourable at present. However, this system shows great potential for the future.

### **Parameters Influencing Anaerobic Digestion**

Anaerobic digestion is influenced by many environmental factors. The significance of these factors is dependent on the digester design. With most of the first generation digesters, pH, alkalinity, cation concentrations, temperature, nutrient concentrations, solids concentrations and mixing were of major importance. In some of the newer second generation anaerobic reactors, many of these influences are of minor significance in digester stability and operation.

#### **pH and alkalinity:**

The best operating pH for the first generation anaerobic digester has been found to be 6.8 - 7.5 but units have been known to operate from 6.0 - 8.0. It is evident from Fig

XI.1 that since volatile fatty acids are produced in the first stages of anaerobic digestion, any imbalance in the rate of acid utilisation by the methane bacteria will lead to a fall in the pH with subsequent souring of the digester. This has been a common problem with many first generation digesters in the past. A change in nutrient quality and quantity may result in failure of the unit due to pH variation. Alkalinity is a key factor in controlling pH. In effluents which have a low bicarbonate alkalinity, the buffering capacity is greatly reduced and even changes in the CO<sub>2</sub> concentration of the digester gas may result in significant changes in the pH. An alkalinity of 2,000 mg/l as CaCO<sub>3</sub> (or greater) is acceptable as suitable for anaerobic digestion.

#### Cation toxicity:

When mixed digesters of the first generation went sour, the cause was often found to be related to the concentration of some cations in the effluent. Ammonium, potassium, sodium, magnesium and calcium have all been found to affect the anaerobic process with failure occurring at specific concentrations of these elements. These elements may exhibit synergistic as well as antagonistic effects and because of this, it is not always possible to give definitive concentration for toxicity levels. Heavy metals such as copper, zinc, nickel, silver, mercury, chromium, etc. have also been shown to affect the digestion process at certain critical concentrations.

It is often very difficult to define a universal inhibitory concentration limit as several factors influence the toxicity of these elements, not least of these is the reaction of most of the heavy metals with sulphate-sulphide to form insoluble products which will not affect the digester bacteria. Table XI.1 below gives an indication of some of the published data on inhibitory levels of some of these compounds.

TABLE XI.1

<b>OPTIMUM AND INHIBITORY CONCENTRATIONS OF INORGANIC IONS IN DIGESTION TANKS</b>
---

Inorganic Ion	Optimum Concentrations	Moderate Inhibition	Strong Inhibition
Sodium mg/l	100-200	3500-5500	8000
Potassium mg/l	200-400	2500-4500	12000
Calcium mg/l	100-200	(2500-4500)	(8000)
Magnesium mg/l	75-100	(1000-1500)	(3000)
Ammonia mg/l	50-1000	15000	8000
Sulphide mg/l	0.1-10	100	200
Chromium % total solids	-	2	3
Cobalt mg/l	20	-	-

Trace amounts of some of these elements are required for the proper operation of anaerobic digestion, e.g., cobalt, zinc, nickel, etc. In the second generation anaerobic digesters, the effect of these toxic substances can be greatly reduced through digester design.

### **Temperature**

Anaerobic digestion is best performed at three different temperatures: psychrophilic 20°C - 40°C, mesophilic 30°C - 40°C and thermophilic 45°C - 55°C. Increasing temperature is characterised by increased biological activity which is combined with decreasing stability in the reactor. The choice of an operating temperature must be decided on economic grounds. Higher temperatures require smaller reactors but use a great amount of energy and are less stable than units operated at a low temperature. Most digesters operate at 30°C - 35°C

### **Substrate concentration**

The rate of digestion is affected by the nutrient type and its concentration. Effluents containing large quantities of soluble sugars, etc. are very rapidly and easily degraded while effluents containing large quantities of cellulose, hemicellulose, lignin, etc. require a much longer digestion time. In mixed digestion systems, the reactor size must be designed on the basis of nutrient load per unit volume. Design loads often fall within the range of 1-5 kg COD/m<sup>3</sup> day. In some of the second generation digesters, the slow stages of hydrolysis and fermentation are separated from the more exacting methanogenic stage and the two reactors are designed for maximum utilisation of the biological parameters operating in each unit. In these designs, loading rates from 1 - 10 kg COD/m<sup>3</sup> day may be used.

### **Nutrient concentration**

It is generally accepted that the nutrient concentrations required for anaerobic digesters are much lower than the equivalent concentrations for aerobic effluent treatment plants. This is due to the low conversion rate of organic carbon into biological solids. The recommended minimum carbon : nitrogen : phosphorous ratio (CNP) is accepted to be 400 : 7 : 1 (Malina J. F. & Pohland F. G., 1992). Higher figures have been noted in the literature but they have been the exception rather than the rule. Several other macro nutrients and trace micro nutrients are required for the proper operation of an anaerobic digester, e.g., iron, sodium, potassium, calcium, magnesium, etc. The presence of excess free sulphide in the digester can be a cause of great concern as this sulphide acts as a direct competitor to the bacteria for these nutrients. It is also directly toxic to the strict anaerobes. It is always recommended that excess free available iron should be available to act as a chemical sink for this free sulphide.

### **Solids concentration and mixing**

The rate of operation of anaerobic digesters is a function of the number of active organisms present in the reactor. In many of the first generation units, the active flora were maintained within the unit by attachment to the suspended solids. Increased

suspended solids leads to increased numbers of active organisms which results in increased rates of anaerobic degradation. However, since the incoming organic substrate has to be brought in contact with the active flora, mixing is required. Mixing is accomplished by either mechanical, hydraulic or gas recirculation systems and is limited by the concentration of solids within the reactor. A compromise has, therefore, got to be reached between the level of solids required for bacterial growth and the level which will allow efficient mixing. In some of the more recent second generation reactors, the need for solids addition to the anaerobic phase and the mixing requirement have been removed through the use of modern fermenter design practices.

**ATTACHMENT I**

**A SURVEY OF WATER USES AND EFFLUENTS IN  
NEPALESE SUGAR FACTORIES**

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2. Control and organization
3. The sugar factories
4. Institutional level

• • •

## FOREWORD

In absence of flow meters, the determinations of waters uses and effluents have to be done from observations, measurements (when it was possible) and calculations.

The calculations are based upon the mass balance and the steam balance of the factory and on the indications given by the equipment manufacturers when this information was available and was deemed to be reliable.

Under these conditions, the accuracy of the flow calculations can vary by a factor of +/- 15%.

All calculations are in the S.I. units and in the thermician system (1 kcal = 4 186 Joules = 3.97 BTV).

Pressure is always expressed in absolute bar (bar).

There are two appendices attached to each sugar factory report :

- Appendix 1 gives some recommandations for the introduction of "clean technology" within the sugar industry in Nepal. These recommendations require little or no investments.
- Appendix 2 gives a brief assessment on the sugar industry in Nepal. The indulgence of the reader is required for mistakes and emissions. In such a short mission, it was only possible to present general remarks and observations on the factors noted during our visits to the factories.

• • •



# LUMBINI SUGAR MILLS LTD

## 1. BASIC DATA

### 1.1 Location

Sunwall, Nawal Parasi district, Lumbini zone.

### 1.2 Main Production data

- 1st. operational season : 1988-89
- Crushing capacity : 1000 tcd (i.e 45.5 tch in 22h. or 41.7 tch in 24h)

• Production data	91/92	92/93	93/94	94/95 (target)
cane crushed (t)	148 948	106 520	78 608	110 000
sugar produced (t)	13 962	10 583	7 474	10 120
sugar recovery % cane	9.37	9.93	9.50	9.20
Final molasses produced (t)	6 759	3 798	2 982	4 400
Final molasses % cane	4.54	3.57	3.79	4.00
F.M. in distillery (t)	6 844	2 888	2 880	
Alcohol produced (Hl)	15 037	5 885.5	6 322	
Kg F.M./l alcohol	4.55	4.91	4.55	
Season days (d)	152	104	83	
Time efficiency (%)	88.8	89.4	n.a	
tch-crushing (incl. stoppages)	40.9	42.5	n.a	
tch-crushing (excl. stoppages)	44.6	47.6	n.a	

### 1.3 Type of process

Double sulphitation on juice and syrup. CBA system with single curing and remelt of C sugar.

### 1.4 Main characteristics of the equipment

- Cane milling plant  
2 cranes of 10 t cap. each. 2 feeding tables 5 x 8.5 m  
2 cane carriers L = 22 and 20.5 m. width = 1 370 mm  
2 cane cutters -46 knives. Diam = 1 250 mm. P = 110 and 130 Kw  
5 three rolls mills 710 x 1 370 mm driven by individual electric motors P = 200 Kw for crusher mill and 160 Kw for other mills.

- Clarification plant  
1 juice scale Maxwell Boulogne type 3 t/tip.

Juice heating : 7 vertical juice heaters unit surface : 60 m<sup>2</sup>

- on raw juice : 2+ 1 (stand by)
- on sulphited juice : 2 + 1 (stand by)
- on clear juice : 1

2 sets of juice sulphiters cap : 40m<sup>3</sup> each (multi jet type)

2 sulphur furnaces tray area : 0.7 m<sup>2</sup> each

1 clarifier 4 compartments Diam : 6 m cap 100 m<sup>3</sup>

1 rotary lime slaker L = 4 m, Di. : 800 mm

2 rotary vacuum filters Eimco belt type 3 000 x 3 900 mm

filtering area : 36 m<sup>2</sup>

• Evaporation and boiling plant

Evaporation : 1 quadruple effect with 5 bodies (1 always under cleaning)

n°1 and n°2 : 450 m<sup>2</sup> H.S. each n°3, 4 and 5 : 350 m<sup>2</sup> H.S. each

2 sets of syrup sulphiters (multi jet type)

syrup, melt and A light molasses storage : 7 tanks of 7 m<sup>3</sup> cap. each.

A heavy and B molasses storage : 4 tanks of 7 m<sup>3</sup> cap. each

vacuum pans : 4 pans : 20 m<sup>3</sup> cap. and 155 m<sup>2</sup> H.S. each

• Condensation plant :

- evaporation : 1 multi-jet condenser Diam 720 mm

- vacuum pans : 1 counter current condenser Diam 1 600 mm

2 injection water pumps for multi-jet condenser cap. 420 m<sup>3</sup>/h each

3 injection water pumps for barometric condenser cap. 485 m<sup>3</sup>/h each

3 reciprocating air pumps cap. 540 Nm<sup>3</sup>/h each

4 cooling towers cap. 300 m<sup>3</sup>/h each

Cooling, curing and drying plant

8 cristalizers : 4 no. air cooled type, 4 no. water cooled type

22 m<sup>3</sup> cap. and cooling area 14 m<sup>2</sup> each

3 vacuum crystallizers for seed and B and C grain storage. 14 m<sup>3</sup> each

• 7 centrifugal machines :

- mc A : 3 semi automatic Diam : 1 200 mm, height : 1 055 mm

- mc B : 2 semi automatic Diam : 1 200 mm, height : 1 055 mm

- mc C : 2 continuous Diam : 1 000 mm, cone 70°, 1 800 rpm

2 single stage air compressors 7 bar, cap. : 54 Nm<sup>3</sup>/h

3 sugar dryers, grass hopper type with hot and cold air blowers

• Steam generating plant

3 boilers, spreader stocker type cap. 15t/h each

p = 26 bar, temp. = 400°C, H.S. = 282 m<sup>2</sup> + 86 m<sup>2</sup>

with 1 economizer for each boiler of 202 m<sup>2</sup> H.S.

• Power generating plant

2 turbo alternators P = 1 500 Kw each inlet press. = 26 bar outlet pressure 3 bar

## 2. SIMPLIFIED MASS BALANCE

This balance (see fig. 1) only gives the main useful data for the calculation of the steam and water balances.

The balance has been established from the final report of the 1992/93 season.

## 3. SIMPLIFIED FUEL AND STEAM BALANCE

### 3.1 Fuel balance

Bagasse from mills : 309.8 kg/tc

NVC bagasse (Hugot's formula)

$NVC = 4\,250 - 48.5 w - 12 s = 1800.4 \text{ Kcal/kg}$  ( $w = 49.9, s = 2.45$ )

• Fire wood = 0.81 kg/tc      NVC = 2 900 kcal/kg ( $w = 30\%$ )

equivalent to 1.3 kg bagasse /tc

• HSD oil = 0.01 kg/tc      NVC = 9 800 kcal/kg

equivalent to 0.055 kg bagasse /tc

The total consumption would be equivalent to 311.2 kg bagasse/tc

Stream enthalpy = 773.1 ( $p = 26 \text{ bar, temp.} = 400^\circ\text{C}$ ).

Feeding water temperature =  $105^\circ\text{C}$

If  $q$  = quantity of steam generated by 1 kg of bagasse and assuming the boiler efficiency about 78%

$$BE = \frac{773.1 - 105 q}{1800.4} = 0.78 \quad \text{i.e } q = 2.1 \text{ kg steam/kg bagasse}$$

The total steam produced must be reduced by 5% in order to allow for stoppages, running tests, wastage and the deterioration of bagasse in storage. Thus we obtain the steam production in normal running conditions :  $Q = 0.95 \times 311.2 \times 2.1 = 621 \text{ kg steam/tc}$ .

### 3.2 Steam balance

Basis for calculations

#### • Juice heating

Raw juice : from  $32^\circ\text{C}$  to  $68^\circ\text{C}$  on 2nd bleeding

Sulphited juice : from  $63^\circ\text{C}$  to  $90^\circ\text{C}$  on 1st bleeding

from  $90^\circ\text{C}$  to  $103^\circ\text{C}$  on exhaust steam

Clear juice : from  $95^\circ\text{C}$  to  $107^\circ\text{C}$  on exhaust steam

from  $107^\circ\text{C}$  to  $110^\circ\text{C}$  in first body

#### • Steam and vapour conditions :

	Pressure (bar)	Temp. ( $^\circ\text{C}$ )	Enthalpy (kcal/kg)
Live steam	26	400	773
Medium pressure	8	400/175	773/670

	Pressure (bar)	Temp. (°C)	Enthalpy (kcal/kg)
Back pressure	2.02	150	662
Exhaust steam	2.02	120	646
1st bleeding	1.72	115	644.3
2nd bleeding	1.23	105	640.7
3rd body	0.89	96	637.4
To condenser	0.26	65	625.2

• Specific steam consumption for alternator turbine : 13.5 kg steam/Kw

• Distillery : it is assumed that :

- specific consumption : 5 kg steam/l alcohol (including losses)

- 4.55 kg of final molasses give 1 l. alcohol

The steam and vapour balance is given in figures 2 and 3.

It appears that the sugar factory is practically balanced with additional make-up steam averaging at about 4%

#### 4. WATER BALANCE (approximate)

##### 4.1 Distribution and uses (1000 tcd i.e 43.5 tch in 23h)

These are presented in table 1.

##### 4.2 Feed water

Available pure condensate	22.7 m <sup>3</sup> /h
Feed water for boilers	29.7 m <sup>3</sup> /h (including blow-down)
Additional make-up water	7 m <sup>3</sup> /h.

##### 4.3 Waters to drain

	Flow (m <sup>3</sup> /h)	Temp.(°C)
Excess hot water	-	-
Factory drain	28.6	52°
Excess from recirculation	9.4	32°
Domestic. etc...	15	25°
Total water drained out	53	41°

...

Table 1 - LUMBINI SUGAR MILLS : List of main water uses (m<sup>3</sup>/h) (\*)

Utilizations	Pure condensate	Hot water 70 to 75°C	Cold water 23 to 25°C	Total	Final destination	Remarks
Imbibition		6.1	6.1	12.2	process	temp. = 50°C
Cooling of mill bearings			(9.1)	(9.1)	recirculation	
Cooling of mill turbine		-	-	-	nil	
Cooling of alt. turbine			(43)	(43)	recirculation	temp. = 32°C outlet
Lime preparation		0.4	0.4	0.7 to 1	process	temp. = 50°C outlet
Cooling sulphur furnaces			1.8	1.8	to drain	temp. = 60°C outlet
Cooling gas scrubbers			1.4	1.4	to drain	temp. = 60°C outlet
Cooling air compressors			0.9	0.9	to drain	temp. = 32°C outlet
Washing of vacuum filters		1.3	-	1.3	process / cake	temp. = 65°C outlet
Washing of filter cloth (event)		12	-	12	to drain	temp. = 65°C outlet
Vacuum filter condenser			4.7	4.7	to drain	inlet temp. = 45°C, outlet = 50/53°C
Evaporation condenser			(390)	(390)	recirculation	inlet temp. = 45°C, outlet = 50/53°C
Pans condensers			(480)	(480)	recirculation	inlet temp. = 45°C, outlet = 50/53°C
∞ Cooling of air pumps (event)			(5)	(5)	recirculation	inlet temp. = 45°C, outlet = 50/53°C
Dilution of molasses		2.3		2.3	process	
Dilution of magma (event.)			-	-	process	
Cooling of mc B crystalizers			-	-	-	
Cooling of mc C crystalizers			(3.5)	(3.5)	recirculation	outlet t° of m.c C = 40°C
Reheating of mc C		2		2	to drain	temp of m.c C = 50°C
Sugar C melting (event.)		0.8		0.8	process	temp of m.c C = 50°C
Washing of sugar in centrif.			0.7	0.7	process	
Medium pressure steam desuperheater		-	-			
Low pressure steam desuperheater		-	-			
Back pr. and make up desuperheater		-	-			
Washing of pans, mill sanitation		0.5		0.5	process	
Feed water for boilers	22.7		7	29.7	boilers	
Blow down of boilers	0.2		0.1	0.3	to drain	temp. = 100°C after flashing
Glands, pumps...			4	4	to drain	t = 25°C
General washing			1.5	1.5	to drain	t = 25°C
Laboratory - Domestic - etc...			15	15	to drain	t = 25°C

(\*) Based on a 1 000 tcd capacity i.e 43.5 tch during 23 h.

# LUMBINI SUGAR MILLS

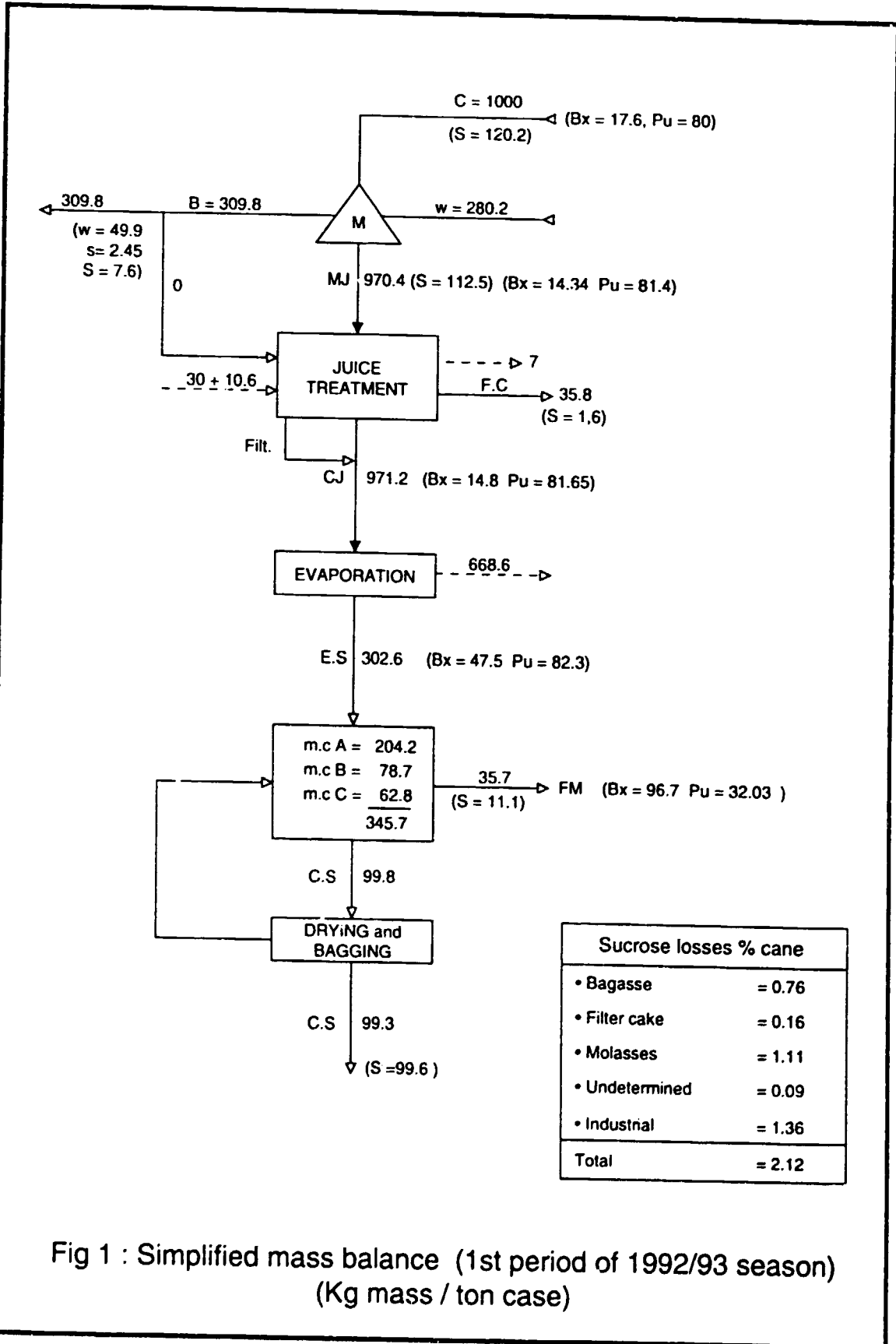


Fig 1 : Simplified mass balance (1st period of 1992/93 season)  
(Kg mass / ton case)

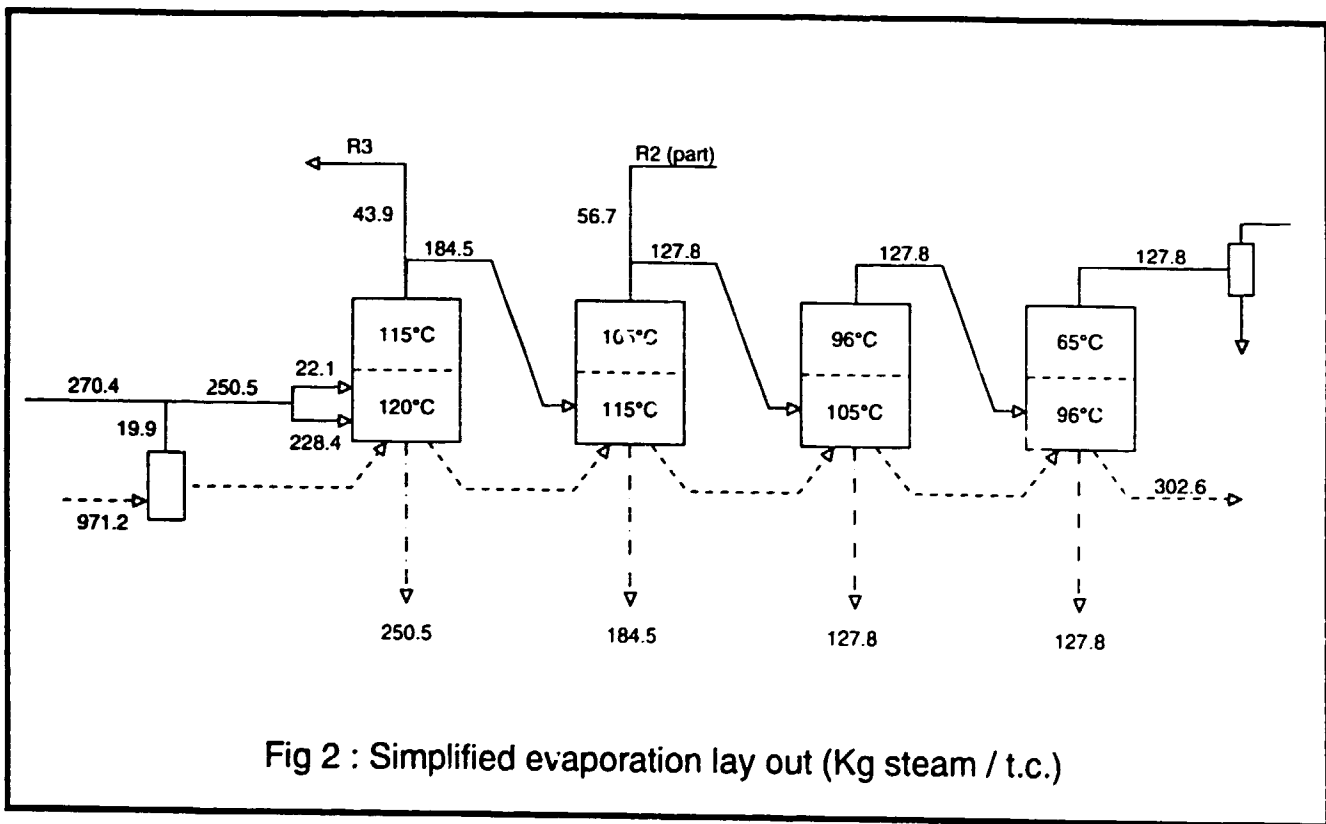


Fig 2 : Simplified evaporation lay out (Kg steam / t.c.)

# LUMBINI SUGAR MILLS

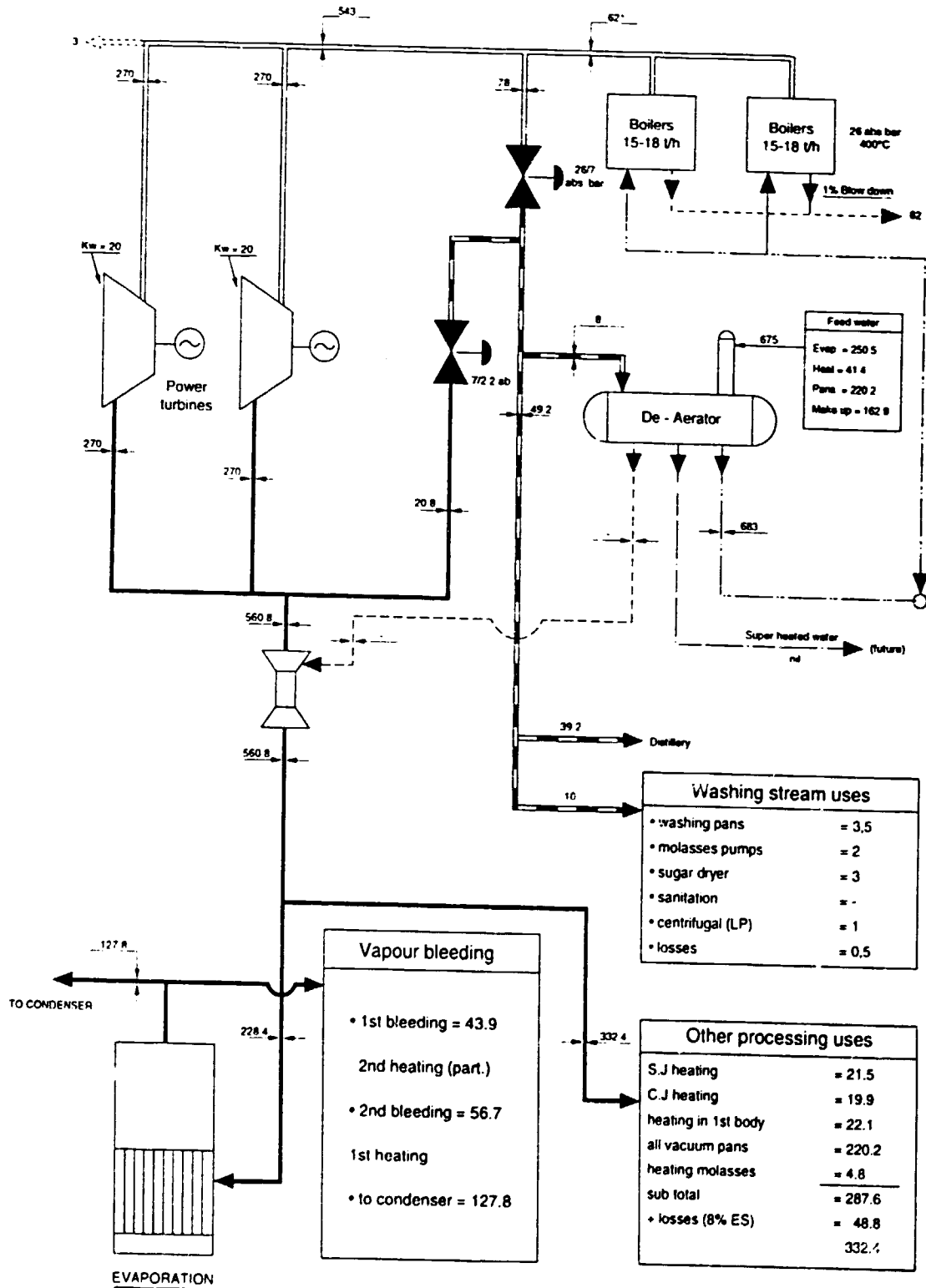


Fig 3 : Steam consumption in actual conditions  
(Kg stream / t. cane)

Live steam  
 Exhaust steam  
 Washing steam



# MAHENDRA SUGAR & GENERAL INDUSTRIES LTD

## 1. BASIC DATA

### 1.1 Location

Bhairahawa. Rupandehi.

### 1.2 Main Production data

- 1st operating season : 1965/66 (cap. = 500 tcd) Equipment : Mirless & Watson
- Theoretical capacity : 750 tcd (after increase in 1974), actual capacity : about 600 tcd (stoppages excluded), future target : 1 200 tcd (date : undetermined).
- Production and Performances
  - After the 62nd day of season 94/95 :
  - cane crushed : 28 566 t. per day : 492.5 t. out stoppage : 601 t
  - sugar produced : 2 488.6 t
  - commercial sugar % cane : 8.27
  - crushing per hour : 25 tch
  - overall time efficiency : 82%

No other available data.

### 1.3 Type of process

Double sulphitation on juice and syrup. CBA system with single curing, remelt of C sugar with clear juice.

### 1.4 Main characteristics of the equipment

- Cane milling plant
  - 1 cane gantry
  - 1 cane carrier L = 30.5 m width = 1 035 mm driven by vertical steam engine
  - 2 cane-knives n°1 : 20 knives mot. 75 HP 500rpm
  - n°2 : no data
  - 4 three roller mills Mirless & Watson 610 x 1 067 mm
  - 1 steam turbine P = 300 HP adm. pressure = 11 bara temp. = 240°C
  - back press = 1.7 bara
- Clarification plant
  - 1 juice weighing scale : out of order

5 juice heaters  $75 \text{ m}^2 + 3 \times 57 \text{ m}^2 + 75 \text{ m}^2$  (by pass)

2 sulphur furnaces + juice sulphiter

1 lime stacker

1 clarifier RAPIDORR 3 compartments Diam 18'

1 Oliver filter 8' x 12' + accessories

• Evaporation and boiling plant

1 quadruple effect :  $280 \text{ m}^2 + 187 \text{ m}^2 + 187 \text{ m}^2 + 187 \text{ m}^2 = 841 \text{ m}^2$

1 syrup sulfitation unit

4 vacuum pans 3 x 18 t and 1 of 30 t

3 multi-jets condensers Diam = 760 mm, 760 mm and 910 mm.

• Cooling, curing and grading plant

2 crystallizers U type 23 t unit for mcA

3 crystallizers U type 23 t unit for mcB

5 crystallizers U type 23 t for mcC

3 batch type centrifugal turbines semi automatic 34" x 48"

2 continuous type centrifugal turbine STOLZ Diam = 1 950 mm

• Steam generating plant

2 boilers unit cap. = 13 t/h Babcock & Wilcox type horse shoe

pressure = 11.6 bar temp. =  $275^\circ\text{C}$

feeding water temp. =  $90^\circ\text{C}$ , flue gas temp. =  $343^\circ\text{C}$

• Power generating plant

2 turbo alternators P = 550 Kw adm press. = 11 bara temp. =  $343^\circ\text{C}$

back pressure = 1.9 bara

## 2. SIMPLIFIED MASS BALANCE

There is practically no instrumentation in the factory and very little analysis carried out in the laboratory. Only the weight of the cane delivered and the weight of the sugar produced are known. Under these conditions it is impossible to calculate the mass balance of the factory. The following balance (see fig.1) is given only as an indication. Its composition is based on the following assumptions :

• Fiber content of cane = 16% (chemist)

• Total losses % cane = about 3% (chemist).

An ancient report of the National Sugar Institute (India - 1972) also gives theoretical values but they are not in conformity with the actual situation.

## 3. SIMPLIFIED FUEL AND STEAM BALANCE

These balances only give (see figures 2 and 3) the main useful data for the calculation of the water balance

### 3.1 Fuel balances

Bagasse from mills = 343 kg/te

Less bagacillo for filter = 4 kg/te

Available bagasse for boilers = 339 kg/te

There is no excess of bagasse and the factory has to use some extra fuel (spec. fire wood). It can be considered that the extra fuel consumption covers the incidence of stoppages, losses and running tests.

• Calorific value of bagasse (Hugot's formula)

$$NCV = 4250 - 48.5w - 12s \quad \text{with } w = 49.6\% \quad s = 2.6\%$$

$$NCV = 1813 \text{ kcal/kg}$$

• Feeding water temperature = 90°C

Steam enthalpy at 11 abs. bar, t = 275 H = 715.1 kcal/kg

If q = quantity of steam generated by 1 kg of bagasse and assuming that in actual running conditions the boiler efficiency would not exceed 65%

$$BE = \frac{715.1 - 90}{1813} \times q = 0.65 \quad \text{so } q = 1.89 \text{ kg steam/kg bag}$$

In this case, the average production of steam will be about 641 kg of steam/t. cane

### 3.2 Steam balance

Basis for calculation :

• Juice heating :

1st heating : on raw juice from 30°C to 75°C

2nd heating : on sulphited juice from 70°C to 105°C

no heating on clear juice

heating in 1st evaporation body from 95°C to 105°C

• Evaporation station : no bleeding (the heating surface is insufficient)

• Enthalpy of the exhaust steam = 640.7 kcal/kg (p = 1.23 abs. bar, t = 105°C)

• Specific steam consumption for steam turbines : would be 40 pounds/kW. This seems very high, thus we have taken :

- mill turbine : 17 kg/kW

- alternator turbine : 13 kg/kW

• Electrical power consumption : about 750 kW/h

• Distillery : we have assumed :

- specific consumption : 4.8 kg steam/l. alcohol (including losses)

- 3.8 kg of molasse gives 1 l. alcohol

• 80% of the molasse production is distilled during the season

## 4. WATER BALANCE (approximate)

### 4.1 Distribution and uses (650 tcd i.e 27 tch)

These are presented in Table 2.

#### 4.2 Feed waters

Available pure condensate	15.0 m <sup>3</sup> /h
Water for desuperheating	0.5 m <sup>3</sup> /h
Feed water for boilers	17.6 m <sup>3</sup> /h
Total needs in feed water	3.1 m <sup>3</sup> /h.

#### 4.3 Waters to drain

	Flow (m <sup>3</sup> /h)	Temp.(°C)
Excess hot water	6.8	65°
Factory drain	24.9	45°
Excess from spray pound	3	36°
Domestic. etc...	12	25°
Total water drained out	39.9	38°

...

Table 2 - MAHENDRA SUGAR MILLS : List of main water uses (m<sup>3</sup>/h) (\*)

Utilizations	Pure condensate	Hot water 70 to 75°C	Cold water 25 to 28°C	Total	Final destination	Remarks
Imbibition		4	3.9	7.9	process	
Cooling of mill bearings			5.6	5.6	to drain	
Cooling of mill turbine			3.9	3.9	recirculation	
Cooling of alt. turbine			(18)	(18)	recirculation	
Lime preparation			0.4	0.4	process	
Cooling sulphur furnaces			1	1	to drain	
Cooling gas scrubbers			0.8	0.8	to drain	
Cooling air compressors			0.7	0.7	to drain	
Washing of vacuum filters		0.5	-	0.5	process	
Washing of filter cloth (event)				-		
Vacuum filter condenser			4.2	4.2	to drain	
Evaporation condenser			(298)	(298)	recirculation	from 33°C to 40°C
Pans condensers			(380)	(380)	recirculation	from 33°C to 40°C
Cooling of air pumps (event)				-		
Dilution of molasses		1.4		1.4	process	
Dilution of magma (event.)				-	process	
Cooling of mc B crystalizers				-		
Cooling of mc C crystalizers				-		
Reheating of mc C				-		
Sugar C melting (event.)				-		
Washing of sugar in centrif.		0.8		0.8	process	
Medium pressure steam desuperheater				-		
Low pressure steam desuperheater				-		
Back pr. and make up desuperheater	0.5			0.5	process	
Washing of pans, mill sanitation		0.4		0.4	process	
Feed water for boilers	14.5		3.1	17.6	to boilers	
Blow down of boilers				0.3	to drain	temp. = 100°C after flashing
Glands, pumps...			4	4	to drain	
General washing			1.5	1.5	to drain	36 m <sup>3</sup> / day, but periodic
Laboratory - Domestic - etc...			12	12	main drain	

(\*) Based on a 650 tcd capacity i.e 27 tch.

MAHENDRA SUGAR & GENERAL INDUSTRIES

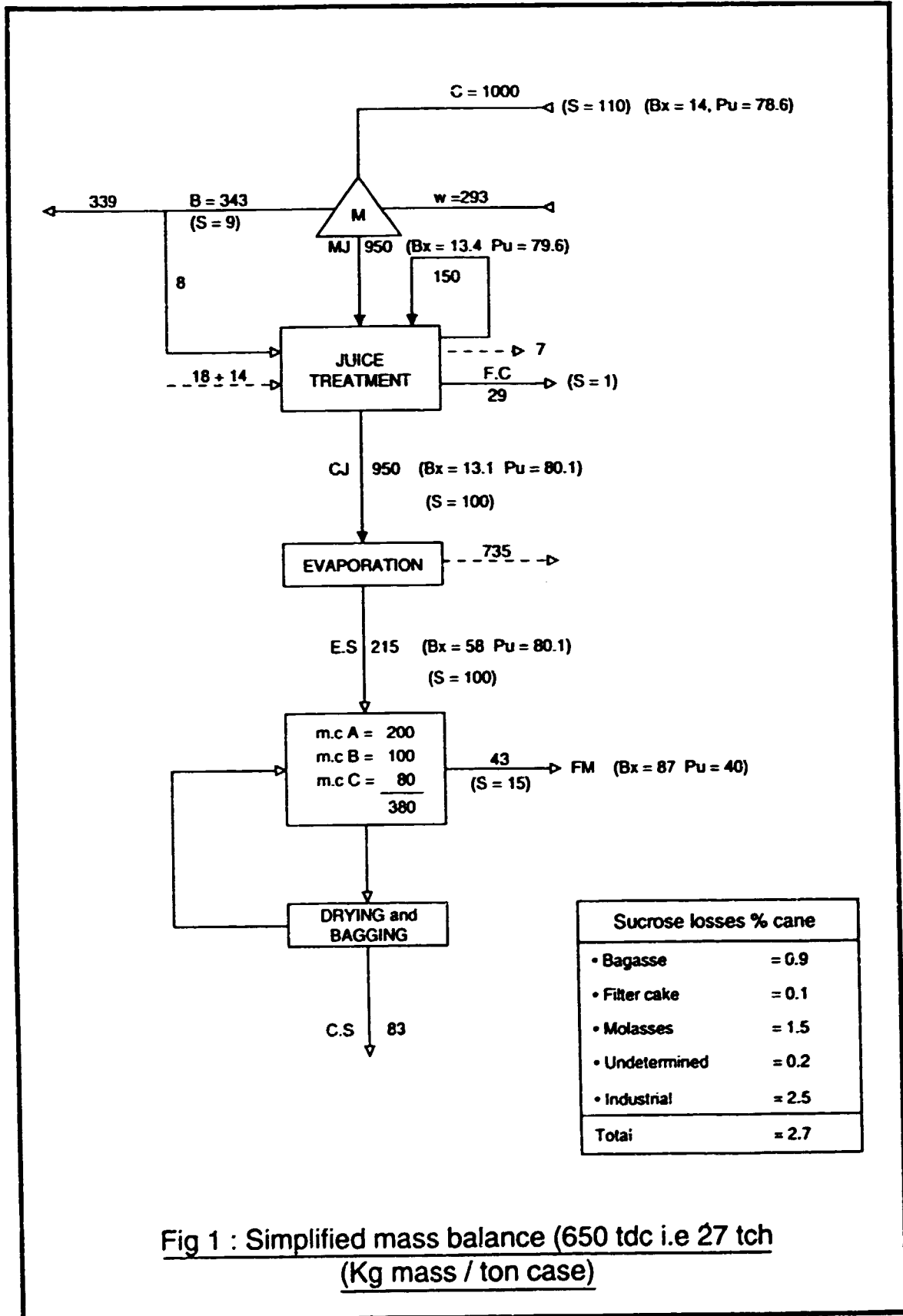


Fig 1 : Simplified mass balance (650 tdc i.e 27 tch)  
(Kg mass / ton case)

### MAHENDRA SUGAR & GENERAL INDUSTRIES

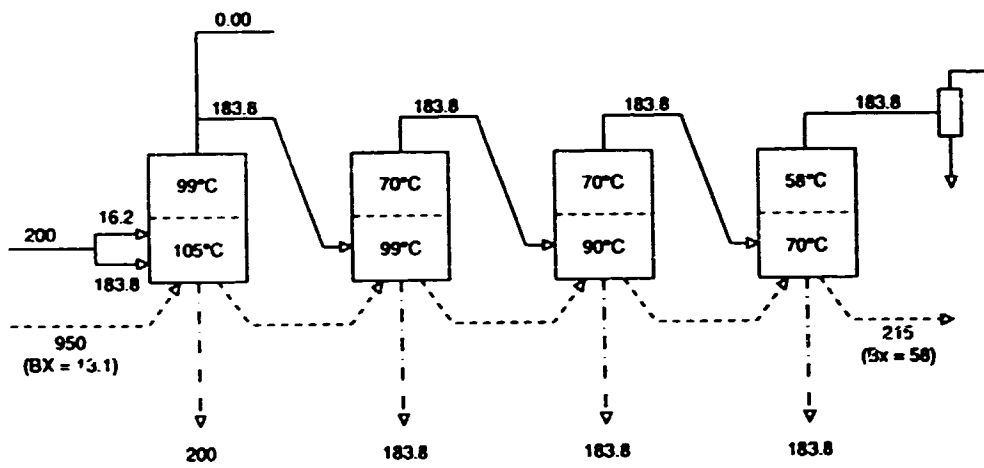


Fig 2 : Simplified evaporation lay out (Kg steam / t.c.)

# MAHENDRA SUGAR & GENERAL INDUSTRIES

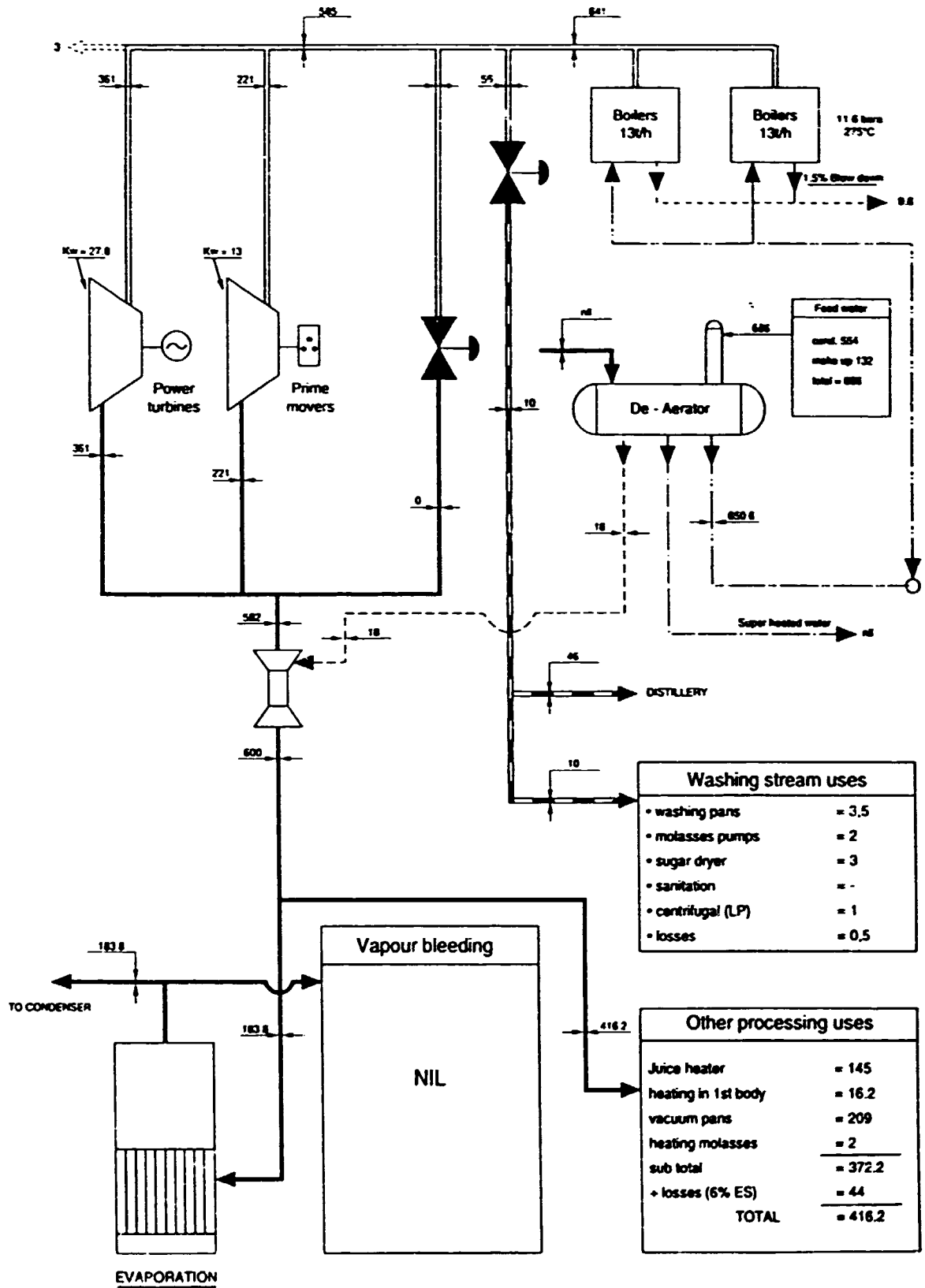





Fig 3 : Stream consumption in actual conditions  
(Kg steam / t. cane)

 Live steam  
 Exhaust steam  
 Washing steam



# INDU SHANKAR CHINI UDYOG LTD

## 1. BASIC DATA

### 1.1 Location

Harion, Sarlahi district Janakpur Zone.

### 1.2 Main Production data

- Installed in 1986 (800 tcd), extended in 1992
- Crushing capacity : 1 100 tcd (theoretical).
- Production data (season : 1992/93)
  - cane crushed : 61 544 t      sugar produced : 5 636.3 t
  - commercial sugar % cane : 9.09%
  - reduced extraction : 93.3%
  - crop duration : 86 days, available hours : 2 047.45
  - crushing hours % total : 76.84%
  - cane crushed per day : 721.3 t, on 24 h : 938.7 t

### 1.3 Type of process

Double sulphitation on juice and syrup, CBA system with double curing on C sugar.

### 1.4 Main characteristics of equipment

- Cane milling plant
  - 1 unloading-crane 5 t, 2 cane carrier : n°2 driven by a vertical steam engine 30 HP
  - 2 cane cutter    n°1 : 20 knives, setting : 44 mm, P = 90 HP  
                  n°2 : 28 knives, setting : 23 mm, P = 325 HP
  - 3 rolls mills : n°1 : crusher mill V grooves, 45 mm pitch  
                  n°2 : to n°5 V grooves, 30 mm pitch
  - 2 steam turbines    P = 495 HP, steam adm. : 18.6 bar, t° = 310°C    back pressure = 2 bar  
(n°1 drives the crusher mill and n°1 and 2 mills, n°2 drives the two last mills).
- Clarification plant
  - 1 juice weighing scale : cap 3.15 t/tip
  - 6 juice heaters, vertical type
    - on raw and sulphited juices : 4 heaters : 93 + 83.7 + 139.5 + 116.3 m<sup>2</sup>
    - on clear juice : 2 heaters : 2 x 65 m<sup>2</sup>
  - 2 sulphitation units for juice and syrup

2 air compressors for sulphitation units

1 rotary vacuum filter Oliver type 8' x 16' S = 37 m<sup>2</sup> + accessories

1 DORR clarifier 4 compartments Diam : 20' cap. : 142 t.

• Evaporation and boiling plant

- Evaporation 1 vapour cell (bleeding vacuums pans) + 1 quadruple effect (bleeding on 1st body for 2nd heating)

vapour cell : 422 m<sup>2</sup>, first body : 351 m<sup>2</sup>, 2nd body : 2 x 140.6 m<sup>2</sup>, 3rd body : 2 x 116 m<sup>2</sup>, 4th body : 2 x 116 m<sup>2</sup>.

- Vacuum pans :	6 pans	1	2	3	4	5	6
	capacity (t)	40	20	15	15	40	30
	surface ( m <sup>2</sup> )	114	63	46	49	144	123

- condensers 1 for evaporation, 6 for vacuum pans, multijet type

- 5 injection pumps cap. = 410 m<sup>3</sup>/h, read = 28 m, p = 75 HP

watercooling system + spray cond. : 3 pumps (545 m<sup>3</sup>/h, 200 and 227 m<sup>3</sup>/h)

• Cooling, curing and grading plant

6 crystallizers n°	8	10-11	12-13	14
Vol	115.8	124.6	124.6	104.5

1 crystallizer (n° 1) : Vol = 81 m<sup>3</sup> for storage of C single cured sugar

2 seed crystallizer under vacuum (cap. unit = 20 t)

Centrifugal machines :

A curing : 6 batch type, electric drive, 22" x 42" friction clutch

v = 960 rpm

B curing KCP continuous 30°, v = 1 900 rpm, p = 50 HP

C curing 1 : Buckau Wolf type 1 100 KT 6 to 8 t/h

1 : KCP 34°, v = 1 900 rpm

3 grass hoppers : 1 single tray + 2 multispray with hot and cold air blowing)

• Steam generating plant

2 boilers VRW Germany cap. 2 x 12.5 t/h 3 furnaces

pressure = 19.28 bar t° = 300°C S = 580 m<sup>2</sup> + superheater 75 m<sup>2</sup> with economizer 250 m<sup>2</sup>

+ air heater 250 m<sup>2</sup>.

• Power generating plant

1 multistage (8) turbine MBM, alternator GEC (1949)

adm. press = 18.6 bar, back press : 1.7 bar P = 1 250 kW

## 2. SIMPLIFIED MASS BALANCE

This balance (see fig. 1) only gives the main useful data for the calculations of the steam and water balances.

The balance has been established from the final report of the 1992/93 season.

### 3. SIMPLIFIED FUEL AND STEAM BALANCE

#### 3.1 Fuel balances

Bagasse from mills = 389.7 kg/tc (fiber % cane = 18)

Less bagacillo for vac. filter = 6 kg/tc

Available bagasse for boilers = 383.7 kg/tc

Deductions for various purposes = 46 kg/tc (stoppages, losses, tests...)

Total for normal running = 337.7 kg/tc.

According to the chemist, about 5% of the bagasse should be in permanent excess. Thus, the consumption of bagasse in normal running conditions would be about 320.8 kg/tc

• NCV bagasse (Hugot's formula)

NCV =  $4\,250 - 48.5w - 12s = 1\,757.8$  kcal/kg ( $w = 50.64$ ,  $s = 3.01$ )

• Steam enthalpy = 723 kcal/kg steam ( $p = 19.2$  bar,  $t = 300^\circ\text{C}$ )

• Feeding water temperature =  $45^\circ\text{C}$  (between  $90^\circ\text{C}$  and  $102^\circ\text{C}$ )

• If  $q$  = quantity of steam given by 1 kg of bagasse and assuming the boiler efficiency at about 65% (+/- 2.5%), we have  $0.65 = \frac{723 - 95}{1757.8} q$  and  $q = 1.82$  kg steam / kg bagasse

In this case, the average production of steam will be about 584 kg of steam / t.c.

#### 3.2 Steam balance

Basis for calculations :

• Juice heating

- Raw juice : from  $24^\circ\text{C}$  to  $50^\circ\text{C}$  on 3rd bleeding

from  $50^\circ\text{C}$  to  $70^\circ\text{C}$  on 2nd bleeding

- Sulphited juice : from  $65^\circ\text{C}$  to  $90^\circ\text{C}$  on 1st bleeding

from  $90^\circ\text{C}$  to  $103^\circ\text{C}$  on exhaust steam

- Clear juice : from  $95^\circ\text{C}$  to  $104^\circ\text{C}$  on exhaust steam

from  $104^\circ\text{C}$  to  $110^\circ\text{C}$  in vapour cell and 1st body on exhaust steam

• Steam and vapours conditions :

	Pressure (bar)	Temp ( $^\circ\text{C}$ )	Enthalpy (kcal/kg)
Live steam	19.2	300	723
Medium pressure	8	300/175	723/670
Back pressure	1.46	150	663
Exhaust steam	1.46	110	642.5
1st bleeding	1.13	103	640
2nd bleeding	0.82	94	636.7
3rd bleeding	0.53	82	632.1
To condensers	0.26	65	625.2

• Specific steam consumption

- mill turbines = 16 kg of steam/kW

- alternator turbine = 12 kg of steam / kW

• Distillery : we have assumed

- specific consumption : 4.5 kg steam / l. alcohol (including losses)

- 4 kg of molasse give 1 l. alcohol.

The steam and vapour balance is presented in diagrams 2 and 3. It appears that the sugar factory is practically balanced with an intermittent excess of back pressure steam (average 5%)

#### 4. WATER BALANCE (approximate)

##### 4.1 Distribution and uses (1 100 tcd i.e 45.8 tch)

These are presented in Table 3.

##### 4.2 Feed water :

Available pure condensate	22.1 m <sup>3</sup> /h
Feed water for boilers	21.2 m <sup>3</sup> /h
Total needs in feed water	27.2 m <sup>3</sup> /h
Additional make up water	6.3 m <sup>3</sup> /h.

##### 4.3 Waters to drain

	Flow (m <sup>3</sup> /h)	Temp.(°C)
Factory drain	27.8	40°
Excess from spray pound	7	32°
Domestic, etc...	13	28°
Total water drained out	47.8	35.6°

• • •

Table 3 - INDU SHANKAR MILLS : List of main water uses (m<sup>3</sup>/h) (\*)

Utilizations	Pure condensate	Hot water 70 to 75°C	Cold water 25 to 28°C	Total	Final destination	Remarks
Imbibition		9	7.5	16.5	process	temp. = 52°C
Cooling of mill bearings			10.2	10.2	to drain	temp. = 32°C
Cooling of mill turbine		-	(8.1)	(8.1)	recirculation	
Cooling of alt. turbine			(25.3)	(25.3)	recirculation	
Lime preparation		0.7 to 1	-	0.7 to 1	process	
Cooling sulphur furnaces			1.9	1.9	to drain	temp. = 60°C
Cooling gas scrubbers			1.5	1.5	to drain	temp. = 60°C
Cooling air compressors				1	to drain	
Washing of vacuum filters		1.4		1.4	process / cake	
Washing of filter cloth (event)			-	-	-	
Vacuum filter condenser			5	5	to drain	temp. = 45°C
Evaporation condenser			(186)	(186)	recirculation	
Pans condensers			(650)	(650)	recirculation	
Cooling of air pumps (event)			-	-	-	
Dilution of molasses		2.8		2.8	process	
Dilution of magma (event.)			-	-		
Cooling of mc B crystalizers			-	-		
Cooling of mc C crystalizers			(4.8)	(4.8)	recirculation	from 65°C to 40°C
Reheating of mc C		2.3		2.3	main drain	from 40°C to 50°C
Sugar C melting (event.)			1.4	1.4	process	
Washing of sugar in centrif.		-		-	-	on syrup
Medium presure steam desuperheater)			-	nil		
Low presure steam desuperheater)			-	nil		
Back pr. and make up desuperheater			-	nil		
Washing of pans, mill sanitation		0.5		0.5		
Feed water for boilers	20.9		6.3	27.2	boilers	feed water temp. = 95°C
Blow down of boilers	0.3		0.1	0.4	to drain	temp. = 100°C after flashing
Glands, pumps...			4	4	to drain	temp. = 32°C
General washing			1.5	1.5	main drain	temp. = 27°C
Laboratory - Domestic - etc...			13	13	main drain	
Total	21.2	24.5				

(\*) Based on a 1 100 tcd capacity / a 45.8 tch

INDU SHANKHAR CHINI UDYOG LTD

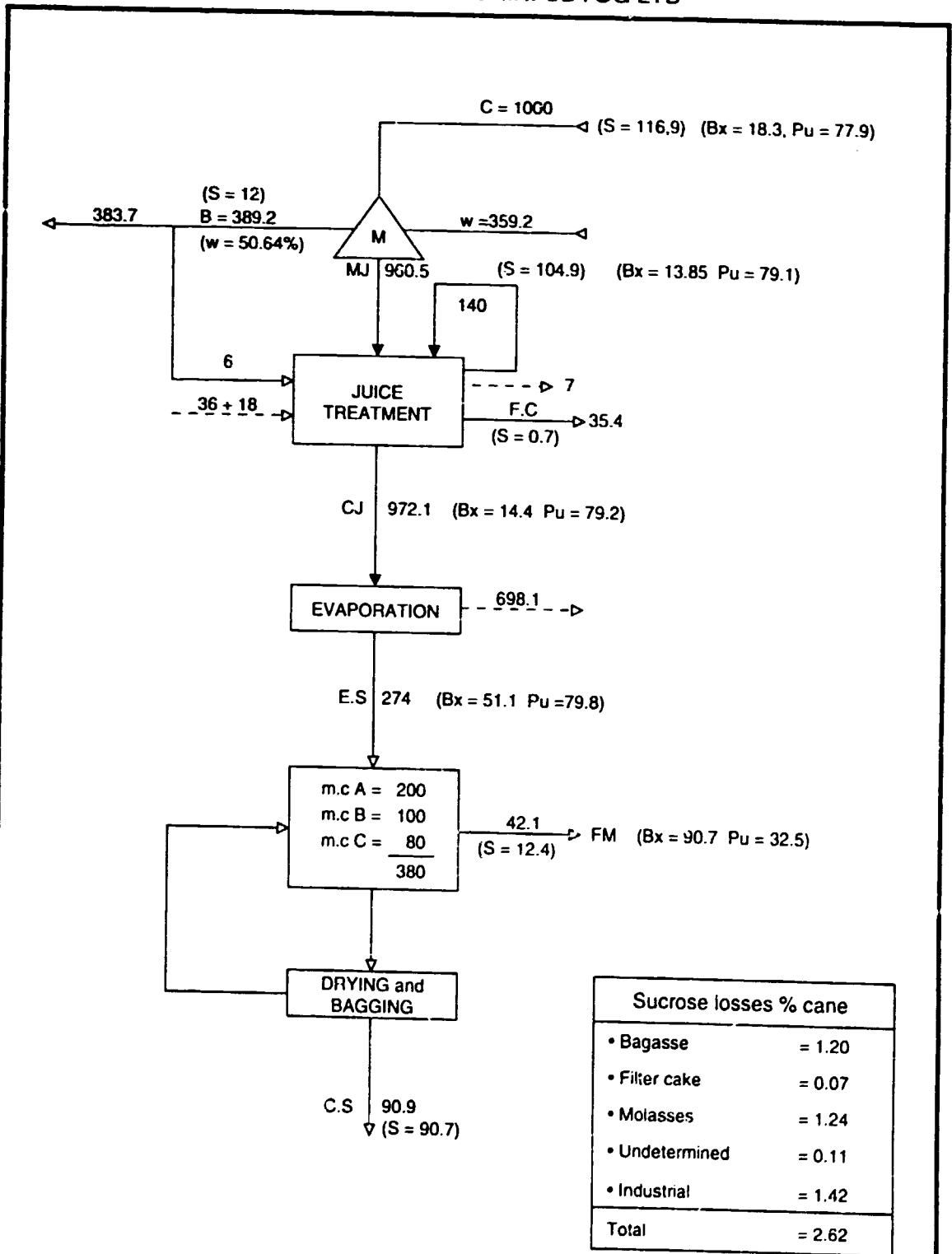


Fig 1 : Simplified mass balance (1992/93 season)  
(Kg mass / ton cane)

INDU SHANKAR CHINI UDYOG LTD

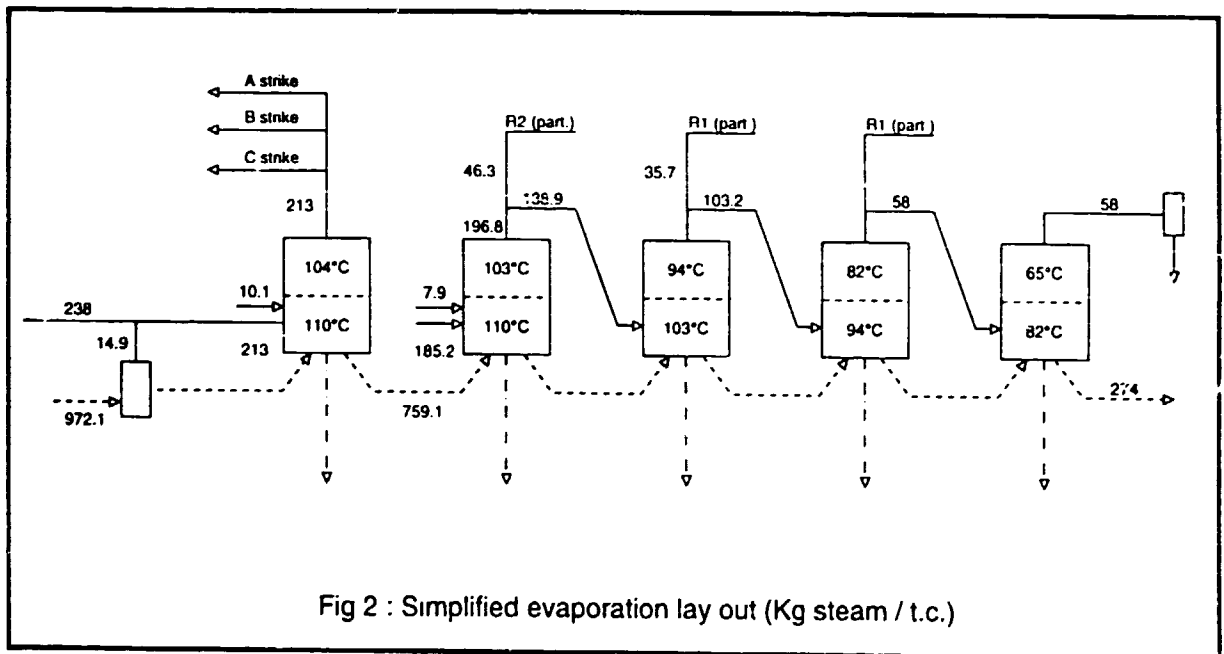


Fig 2 : Simplified evaporation lay out (Kg steam / t.c.)

INDU SHANKAR CHINI LTD

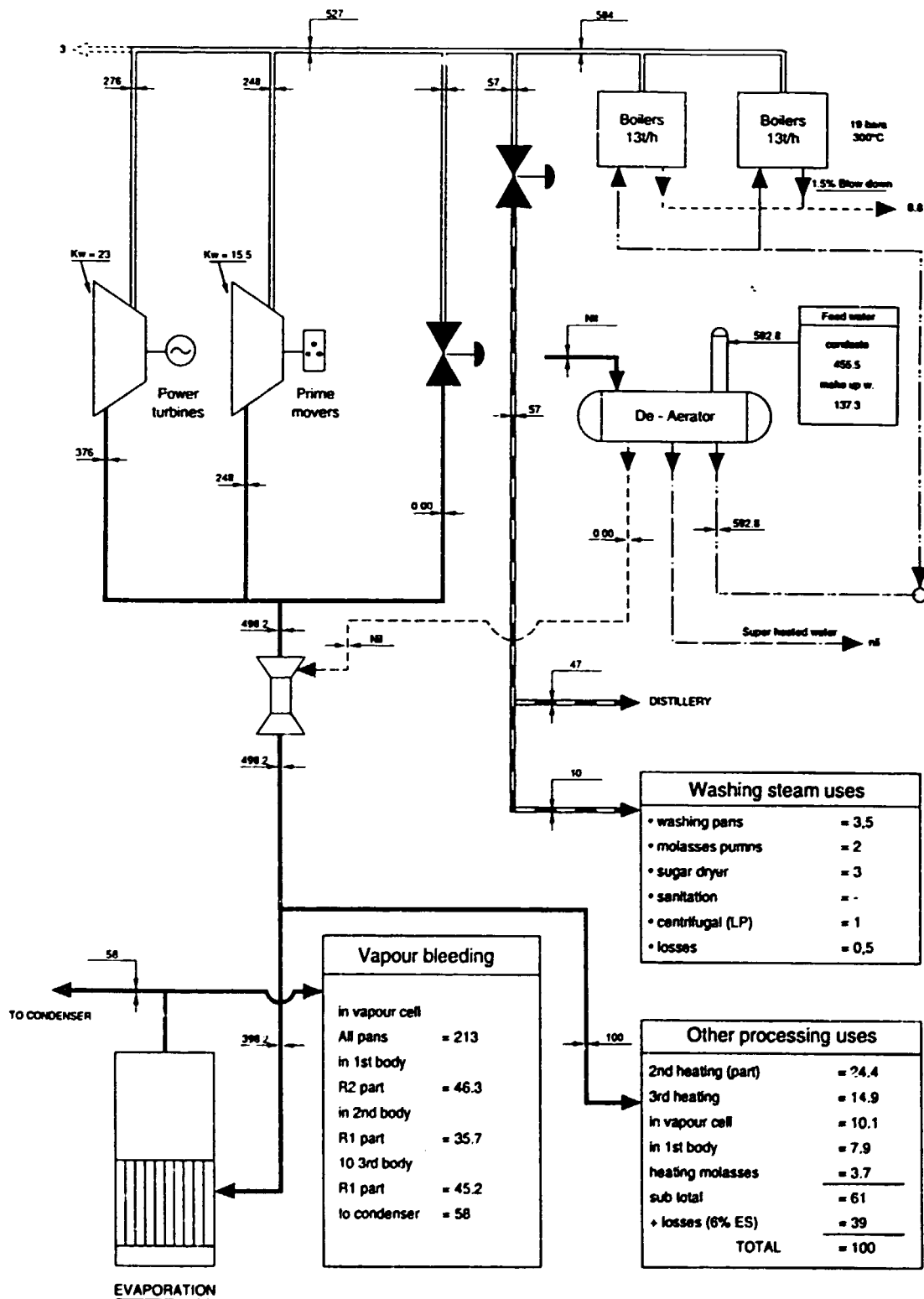


Fig 3 : Steam consumption in actual conditions  
(Kg steam / t. cane)



# SRI RAM SUGAR MILLS LTD

## 1. BASIC DATA

### 1.1 Location

Mahamadpur (Garuda), Rautahat District, Narayani Zone.

### 1.2 Main Production data

- Commissioning : 1994 (manufacturer W.I.L. India)
- First season : 1994/95
- Theoretical capacity : 1 500 tcd, practical : 1 250 tcd i.e 54.3 tch (1 day = 23 h)  
future target = 2 500 tcd (1995-96)
- Production and performances : no available data.

### 1.3 Type of process

Double sulphitation on juice and syrup, CBA system with double curing on C sugar.

### 1.4 Main characteristics of equipment

- Cane milling plant
  - 1 unloading-cane 5 t span : 22 m, length : 30 m
  - 1 feeding table 6 x 7 m motor : 15 HP
  - 2 cane carriers width : 1.525 m resp. motor 40 and 30 HP
  - 1 cane kicker (16 blades) - 25 HP
  - 1 cane cutter : 28 knives, motor : 200 HP 585 rpm
  - 1 shredder : 36 hammers, motor 350 HP 750 rpm
  - 4 three roller mills auto setting 762 x 1 525 mm
  - Donnelly type chute for 1st mill
  - 2 steam turbines (one each for driving two mills) : P = 600 HP at steam press. 18 bar, 300°C, back press. = 0.95 bar
- Clarification plant
  - 1 juice weighing scale : cap 5 t/tip
  - 1 vapour line juice heater : 140 m<sup>2</sup>
  - 5 vertical juice heaters : 120 m<sup>2</sup> (3 for continuous use, 1 stand by, 1 for clear juice)
  - 3 sulphur furnaces (S = 0.6 m<sup>2</sup> cap 70 kg sulphur/h)
  - 1 juice sulphiter, cap. : 120 Hl

2 air compressors, cap. : 400 m<sup>3</sup>/h and 300 m<sup>3</sup>/h  
 1 lime slaker, rotary type, cap. : 200 kg lime /h  
 1 clarifier type DORR, 4 compartments, Diam. 24', cap. : 200 m<sup>3</sup>  
 1 rotary vacuum filter : 8' x 16' filtration area = 36 m<sup>2</sup> + accessories (feed mixer, air blower, cyclone separator, vacuum barometric condenser)

• **Evaporation and boiling plant**

Evaporator : quadruple effect, HS total = 1 930 m<sup>2</sup>  
 (1st body = 750 m<sup>2</sup>, 2nd body = 500 m<sup>2</sup>, 3rd body = 340 m<sup>2</sup>, 4th body = 340 m<sup>2</sup>)  
 1 syrup sulphitation unit, cap. : 30 hl syrup/h  
 4 vacuum pans, cap.: 40 t (280 hl) s = 185 m<sup>2</sup>  
 1 seed crystallizer, cap. : 20 t + 1 vacuum crystallizer, cap. : 30 t  
 5 multijet condensers (1 for evaporation, Diam. : 1 000 mm + 4 for vacuum pans, Diam. : 900 mm)  
 5 injection water pumps (capacity 700 m<sup>3</sup>/h) + 2 spray pumps (cap. unit 1 600 m<sup>3</sup>/h)

• **Cooling, curing and grading plant**

2 crystallizers U type air cooled for A masse-cuite unit, cap. = 40 t  
 2 crystallizers U type water cooled for B masse-cuite unit, cap. = 40 t  
 5 crystallizers U type water cooled for C masse-cuite unit, cap. = 45 t  
 3 batch type centrifugal machines-automatic (charge : 750 kg 14 cycles/h)  
 5 continuous type centrifugal machines WALKONTI - 1150 (cap. : for C foreworker 6 to 8 t/h, for CA/B : 12 to 16 t/h)  
 1 single tray grass hopper + 2 multispray grass hopper (1 with hot air blowing, 1 with cold air blowing)

• **Steam generating plant**

2 boilers unit, cap = 20 t/h - 21 bar 300°C  
 feed water temp. = 85°C. Efficiency at MCR 65% +/- 2.5% on G.C.V. (bagasse at 50% moisture)  
 heating surface = 743 m<sup>2</sup> + superheater 55 m<sup>2</sup> with on air heater 55 m<sup>2</sup>

• **Power generating plant**

1 turbo alternator 1 500 kW i.p = 18 bar 300°C, b.p = 0.95 bar  
 2 diesel generator, each of 125 kW

## 2. SIMPLIFIED MASS BALANCE

This balance (see fig. 1) only gives the main useful data for the calculations of the steam and water balances.

In absence of available data due to start up difficulties in the factory, the balance is based on theoretical assumptions :

- saccharose in cane : 12% fiber content : 16%
- purity of mixed juice : about 82
- reduced extraction : 95% with imbibition % fiber : 200%

- purity of residual juice : about 72
- pol % filter cake : about 1.5
- purity of final molasses : about 32

### 3. SIMPLIFIED FUEL AND STEAM BALANCE

#### 3.1 Fuel balances

Bagasse from mills	= 342 kg/tc
Less bagacillo for mud filtration	= 8 kg/tc
Available bagasse for boilers	= 334 kg/tc
Less reductions due to various purposes (stoppages, losses, running tests...)	= 34 kg/tc (10%)
Total for normal running conditions	= 300 kg/tc.

- Guaranteed performance of the boilers 65% (+/- 2.5%)  
on GCV of bagasse at moisture content = 50%
- GCV bagasse = 19 050 - 41.9s - 190 w = 9 455.7 kJ/kg (2 259 kcal/kg)  
with w = 50 s = 2.25 (Yon Pritzelwitz - Van der Horst formula)

- Steam enthalpy at 22 abs bar 300°C H = 3 108 kJ/kg (721 kcal/kg)

- Feed water temperature = 85°C

If q = quantity of steam given by a kg of bagasse, we have :

$$BE = \frac{721 - 85}{2259} \times q = 0.65 \pm 2.5\% \text{ i.e } q = 2.2 \text{ to } 2.4 \text{ kg steam/kg}$$

This means that on NCV of bagasse BE = 80% +/- 3.5%

(NCV bagasse = 7 655.7 kJ/kg i.e 1 829 kcal/kJ)

For this type of boiler it can be assumed that, in fact, for the usual running conditions, the boiler will work at 85% of its guaranteed performance, therefore 1 kg of bagasse will give 1.9 kg of steam.

In this case, the average production of steam will be about 570 kg of steam /t. cane.

#### 3.2 Steam balance

Basis for calculations :

- Juice heating

1st heating : from 25°C to 70°C (raw juice)

2nd heating : from 63°C to 103°C (sulphited juice)

3rd heating : from 95°C to 105°C (clear juice)

• Steam and vapour conditions :

	Pressure (bar)	Temp (°C)	Enthalpy (kcal/kg)
Live steam	22/19	300	721/723
Medium pressure steam	22/19	300/175	723/670
Back pressure steam	1.95	148	665
Exhaust steam	1.95	111	643
1st vapour	1.5	103	640
2nd vapour	1.035	100	639.2
3rd vapour	0.6	86	633.6
Vapour to condensers	0.2	60	621.2

• Specific steam consumption

- mill turbines = 15 kg/kWh

- alternator turbine = 12 kg/kWh

The steam and vapour balance is presented in diagrams 2 and 3.

#### 4. WATER BALANCE (approximate)

##### 4.1 Distribution and uses (1 250 tcd i.e 52 tch)

These are presented in table 4 and diagrams 4 and 5.

##### 4.2 Condensates (m<sup>3</sup>/h)

	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>
Evaporation	22.8	10.2	4.8	4.8
Vacuum pans	4.7	8.3		
1st heating			5.4	
2nd heating	0.8	2.9		
3rd heating	0.9			
<b>Total :</b>	<b>29.2</b>	<b>21.4</b>	<b>10.2</b>	<b>4.8</b>

##### 4.3 Uses

- for boilers : 28.1 m<sup>3</sup>/h on P<sub>1</sub> + make up water : 3.5 m<sup>3</sup>/h = 31.6 m<sup>3</sup>/h

- general hot water = 36.4 m<sup>3</sup>/h available, 18.9 m<sup>3</sup>/h is used and 17.5 m<sup>3</sup>/h are in excess

- cold water (factory) : theoretical = 30.6 + complement for cooling waters.

#### 4.4 Going to drains :

	Flow (m <sup>3</sup> /h)	Temp.(°C)
Factory drain		
- hot water	20	65°
- cold water	28.6	28° - 32°
Total	48.6	44°
Excess from spray pound	12	32°
Domestic. etc...	15	25°
Total water drained out	75.6	38°

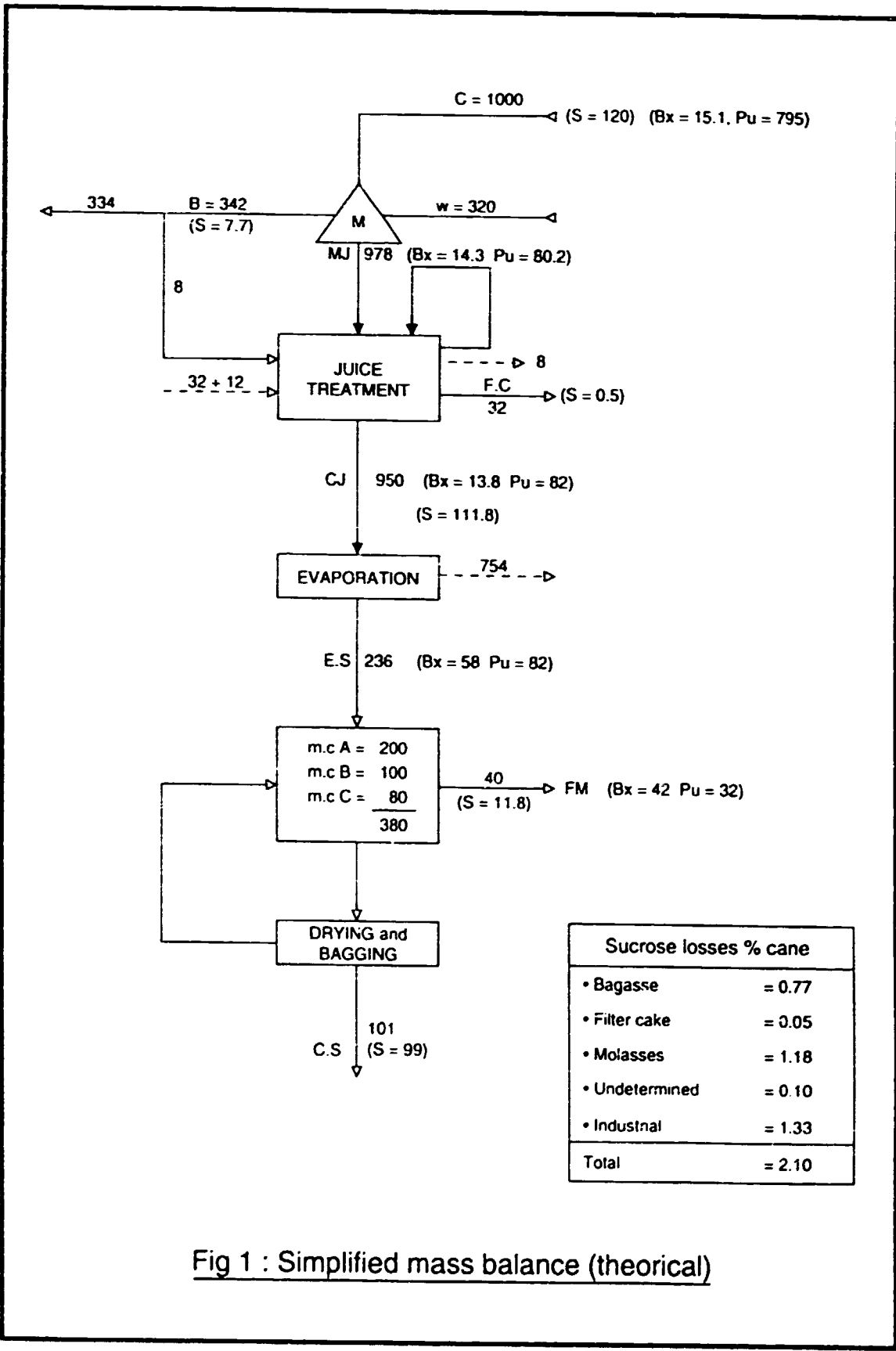
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Table 4 - SRI RAM SUGAR MILLS : List of main water uses (m<sup>3</sup>/h) (\*)

Utilizations	Pure condensate	Hot water 70 to 75°C	Cold water 25 to 28°C	Total	Final destination	Remarks
Imbibition		8.7	8.7	17.4	process	temp. = 50°C
Cooling of mill bearings			11.4	11.4	main drain	to be checked up
Cooling of mill turbines		-	(11.4)	(11.4)	recirculation	
Cooling of alt. turbines			(32.6)	(32.6)	recirculation	
Lime preparation			0.7	0.7	process	
Cooling sulphur furnaces			2	2	main drain	
Cooling gas scrubbers			1.7	1.7	main drain	
Cooling air compressors			1.2	1.2	main drain	
Washing of vacuum filters		1.7		1.7	process	
Washing of filter cloth (event)		-		-	-	
Vacuum filter condenser			5.7	5.7	main drain	to be checked up
Evaporation condenser			(170)	(170)	recirculation	
Pans condensers			(502)	(502)	recirculation	
Cooling of air pumps (event)			-	-	-	
Dilution of molasses		2.8		2.8	process	
Dilution of magma (event.)			-	-	process	
Cooling of mc B crystalizers			(3.1)	3.1	recirculation	from 65°C to 52°C
Cooling of mc C crystalizers			(5.4)	5.4	recirculation	from 65°C to 40°C
Reheating of mc C		2.5		2.5	main drain	from 40°C to 50°C
Sugar C melting (event.)		1.1		1.1	process	
Washing of sugar in centrif.		1.6		1.6	process	
Medium pressure steam desuperheater/ Low pressure steam desuperheater)	0.1		-	0.1	process	
Back pr. and make up desuperheater	1.0		-	1.0	process	
Washing of pans, mill sanitation		0.5		0.5	process	
Feed water for boilers	28.1		3.5	31.6	boilers	
Blow down of boilers				0.6	main drain	temp. = 100°C after flashing
Glands, pumps...			5	5	main drain	
General washing			1.6	1.6	main drain	40 m <sup>3</sup> / day but periodic
Laboratory - Domestic - etc...			15	15	main drain	
<b>Total</b>	<b>29.2</b>	<b>18.9</b>				

(\*) Based on a 1 250 tcd capacity 1 e 52 tch

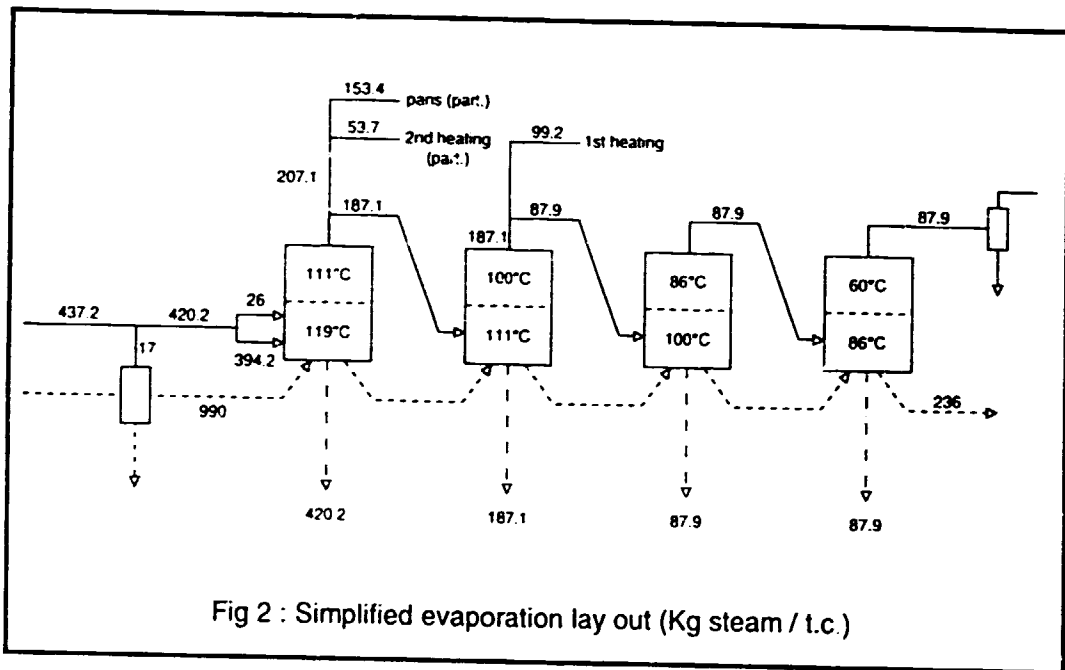
# SRI RAM SUGAR



Sucrose losses % cane	
• Bagasse	= 0.77
• Filter cake	= 0.05
• Molasses	= 1.18
• Undetermined	= 0.10
• Industrial	= 1.33
<b>Total</b>	<b>= 2.10</b>

Fig 1 : Simplified mass balance (theoretical)

### SRI RAM SUGAR MILLS





# SRI RAM SUGAR

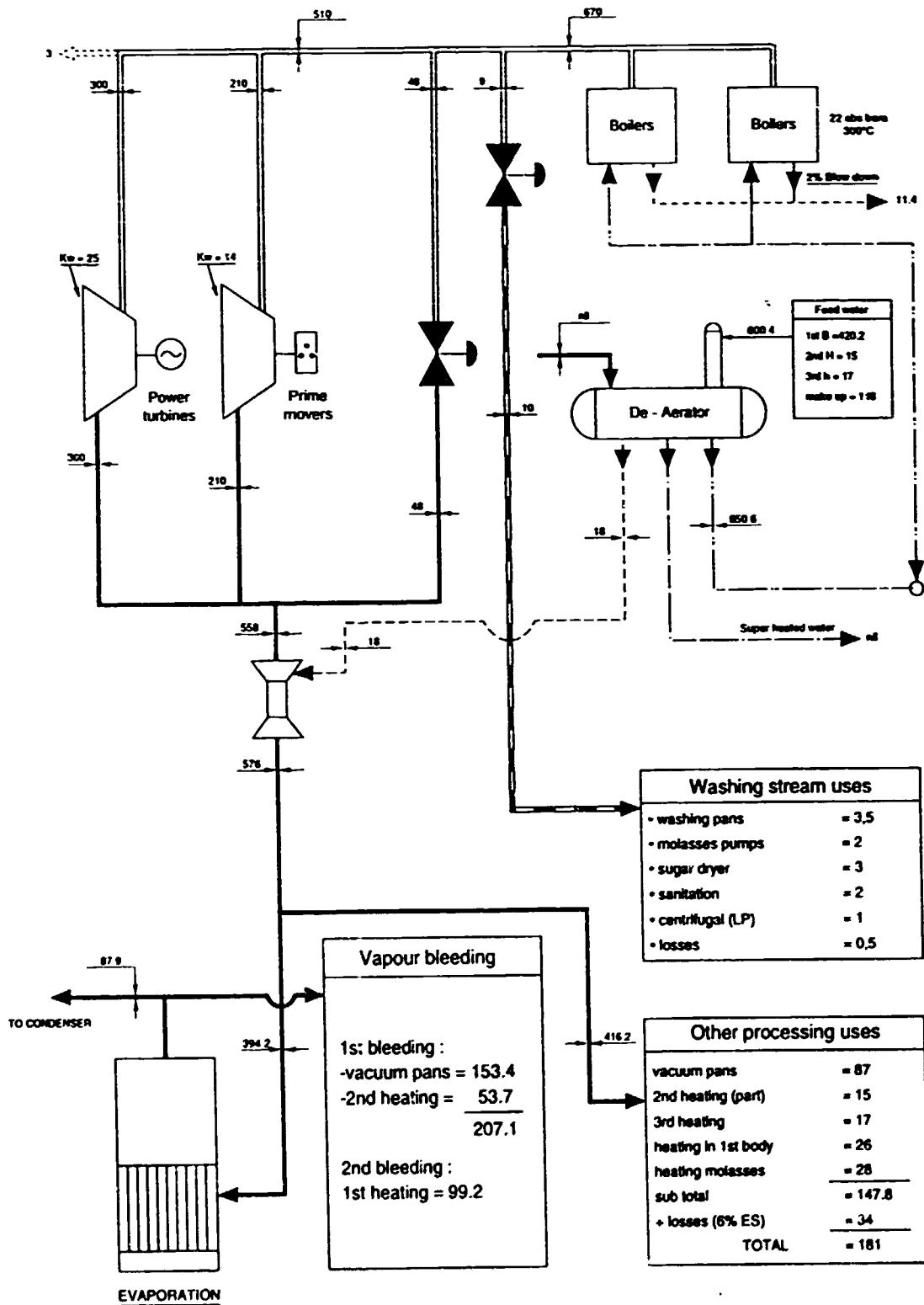


Fig 3 : Steam consumption in actual conditions  
(Kg stream / t. cane)

Live steam  
 Exhaust steam  
 Washing steam

# BIRGANJ SUGAR FACTORY LTD

## 1. BASIC DATA

### 1.1 Location

Birganj. Bara District. Narayani Zone.

### 1.2 Main Production data

- Initial year of production : no data (cap. 1 500 tcd)
- Actual crushing capacity : 2 250 tcd (i.e 97.8 tch in 23 h)
- Production data (1994/95 season)
  - target cane crushing = 120 000 t
  - target sugar production = 10 8000 t
  - sugar recovery % cane = 9%

The following balances are based on the first periodical manufacturing report (the final report for the past season was not available)

### 1.3 Type of process

Double sulphitation on juice and syrup. CBA system with double sulphitation on juice and syrup.

### 1.4 Main characteristics of equipment

#### • Milling plant

2 cane unloaders 5 t each

2 cane carriers

- n°1 horizontal L = 39.4 m width = 1 450 mm

- n°2 inclined L = 22.75 m width = 1 450 mm

1 cane cutter 44 knives Diam. 1 220 mm motor = 150 kW

1 fibrizer driven by a steam turbine of 550 kW

6 three rolls mills 750 x 1 450 mm driven by three steam turbines (1 for two mills) of 500 kW each (inlet pressure = 24 bar actual back pressure = 2.5 bar).

#### • Clarification plant

1 juice scale Maxwell Boulogne type 4.5 t/tip

Juice heating : 7 vertical juice heaters : 1 x 70 m<sup>2</sup> + 3 x 80 m<sup>2</sup> + 1 x 100 m<sup>2</sup> + 2 x 105 m<sup>2</sup>

2 sets of sulphur burners (1.1 m<sup>2</sup> each) + 1 juice sulphiter

1 rotary lime slaker L = 5 m Diam. = 1.2 m

1 clarifier DORR type (chinese). 4 compartments Diam. = 7.5 m

2 rotary vacuum filter Eimco Belt type (chinese). Filtering area : 36 m<sup>2</sup> each

• Evaporation and boiling plant

1 vapour cell + 2 sets of quadruple effect evaporators :

900 m<sup>2</sup> + 2 sets 480 m<sup>2</sup> + 350 m<sup>2</sup> + 350 m<sup>2</sup> + 300 m<sup>2</sup>

1 juice sulphiter

17 tanks of 100 Hl cap. each for syrup and molasses storage.

Vacuum pans = 7 pans : 2 of 50 t cap. (HS = 250 m<sup>2</sup>), 3 of 40 t cap. (HS = 170 m<sup>2</sup>) + 2 (no available data)

• Condensation plant

- evaporation : 1 barometric condenser Diam. 4 500 mm

1 multijet condenser

- pans : 3 multijets condenser Diam. 4 500 mm

5 injection pumps unit cap. = 900 m<sup>3</sup>/h

2 air pumps unit cap. = 3 720 Nm<sup>3</sup>/h

• Cooling, purging and drying plant

4 air cooled crystallizers. unit cap. 45 t for mcA and B

4 water cooled crystallizers. unit cap. 45 and 50 t for mc C

1 continuous crystallizer (chinese) for mcC

1 vacuum crystallizer for C grain cap. 30 t

17 centrifugal machines :

- 8 semi-automatic 1 200 x 610 1 000 rpm

- 3 semi-automatic 1 200 x 610 1 400 rpm

- 2 fully automatic 1 200 x 762 1 500 rpm

- 4 continuous (chinese) 8 to 10 t.m.c/h (in fact 4 to 5 t.m.c/h)

1 sugar drier cap. = 40 t/h (in fact 10 t/h)

• Steam generating plant

4 boilers SKODA cap. 16 t/h each working pressure = 26 bara  
temp. = 310°C HS = 580 m<sup>2</sup> + 130 m<sup>2</sup>

each boiler is provided with an economizer HS = 650 m<sup>2</sup>

• Power generating plant

2 turbo alternators 1 500 kW + 800 kW

inlet pressure = 23 bar. temp. : 300°C. back pressure : 2 to 2.5 bar.

## 2. SIMPLIFIED MASS BALANCE

This balance (see fig. 1) only gives the main useful data for the calculation of the steam and water balances.

The balance has been established from the 1st report of the 1994/95 season.

### 3. SIMPLIFIED FUEL AND STEAM BALANCE

#### 3.1 Fuel balance

- Bagasse from mills = 349.2 kg/tc
- Overall time efficiency = 54.3%
- Mechanical time efficiency = 89.2%
- First wood consumption : about 10 kg/tc
- NCV bagasse  
 $4250 - 48.5w - 12s = 1721.2$  ( $w = 51.5, s = 2.59$ )
- NCV fire wood : about 2900 kcal/kg ( $w = 30\%$ ) i.e 1 kg of firewood is equivalent to 1.68 kg of bagasse

Total fuel consumption : 366 kg/tc in equivalent bagasse.

If it is considered that 17% of the fuel consumption is due to the incidence of stoppages, then

Bagasse consumption in normal running conditions = 304 kg/tc

Steam enthalpy = 718.4 kcal/kg ( $p = 26$  bara,  $t = 300^\circ\text{C}$ )

Feeding water temperature =  $100^\circ\text{C}$

If  $q$  = quantity of steam generated by 1 kg of bagasse and assuming the boiler efficiency at approx. 67% (+/- 2.5%)

$$BE = \frac{718.4 - 100}{1721.2} q = 0.67 \text{ i.e } q = 1.86 \text{ kg steam/kg bagasse}$$

Thus, the steam production under normal running conditions is about  $1.86 \times 304 = 565$  kg steam/tc.

#### 3.2 Steam balance

Basis for calculation :

- Juice heating
  - Raw juice : from  $25^\circ\text{C}$  to  $70^\circ\text{C}$  on 2nd bleeding
  - Sulphited juice : from  $65^\circ\text{C}$  to  $103^\circ\text{C}$  on 1st bleeding
  - clear juice : from  $95^\circ\text{C}$  to  $105^\circ\text{C}$  on exhaust steam

- Steam and vapour conditions :

	Pressure (bar)	Temp ( $^\circ\text{C}$ )	Enthalpy (kcal/kg)
Live steam	26	300	721.2
Medium pressure	8	300/175	721/670
Back pressure	2.02	150	662
Exhaust steam	2.02	120	646
1st bleeding and VC	1.53	111	642.9
2nd bleeding	1.065	100.5	639
3rd body	0.63	86.5	633.4
To condenser	0.225	62.5	624.2

- Specific steam consumption

- fibrizer turbine = 16 kg steam/kW
- mill turbines = 16 kg steam/kW
- alternator turbines = 13 kg steam/kW

• Distillery : we have assumed :

- specific consumption = 5 kg steam/l. alcohol (including losses)
- 4 kg of final molasse produce 1 l. alcohol

The steam and vapour balance is presented in diagrams 2 and 3. It appears that the sugar factory is practically balanced with only a small addition for make up steam (about 3.2% average) : this means that, from time to time, an excess of exhaust steam is blown up into the atmosphere.

#### 4. WATER BALANCE (approximate)

##### 4.1 Distribution and uses (2 250 tcd i.e 97.8 tch in 23 h)

The data is presented in table 5.

##### 4.2 Feed water

available pure condensate = 45.4 m<sup>3</sup>/h

feed water for boilers = 56.4 m<sup>3</sup>/h (including blow down)

additional make up water = 11 m<sup>3</sup>/h

##### 4.4 Waters to drain

	Flow (m <sup>3</sup> /h)	Temp.(°C)
Excess hot waters	1.7	70°
Excess from spray pound	15	32°
Factory drains	65	52°
Domestic, etc...	10	25°
Total water drained out	95	43°
Total water supply	122	23°

• • •

TABLE 5 - BIRGANJ SUGAR FACTORY : List of main water uses (m<sup>3</sup>/h) (\*)

Utilizations	Pure condensate	Hot water 70 to 75°C	Cold water 25 to 28°C	Total	Final destination	Remarks
Imbibition			26.4	26.4	process	
Cooling of mill bearings			23.4	23.4	to drain	inlet = 23°C, outlet = 30°C
Cooling of mill turbine		-	(20.2)	(20.2)	recirculation	- id -
Cooling of alt. turbine			(32.9)	(32.9)	recirculation	- id -
Lime preparation			1.6	1.6	process	
Cooling sulphur fumaces			3.9	3.9	to drain	outlet temp. = 60°C
Cooling gas scrubbers			3	3	to drain	outlet temp. = 60°C
Cooling air compressors			2.4	2.4	to drain	outlet temp. = 32°C
Washing of vacuum filters		3.1	-	3.1	process / cake	
Washing of filter cloth (event)		18		18	to drain	outlet temp. = 60°C
Vacuum filter condenser			(10.9)	(10.9)	recirculation	to be checked up
Evaporation condenser			(548/750)	(548/750)	recirculation	
Pans condensers			(1020)	(1020)	recirculation	
Cooling of air pumps (event)			24.4	24.4	to drain	outlet temp. = 32°C
Dilution of molasses		2.4		2.4	process	
Dilution of magma (event.)			-	-		
Cooling of mc B crystalizers			-	-		
Cooling of mc C crystalizers			(15.4)	(15.4)	recirculation	out of order
Reheating of mc C			-	-	to drain	out of order
Sugar C melting (event.)		1.5		1.5	process	
Washing of sugar in centrif.			3.2	3.2	process	
Medium presure steam desuperheater)	-		-	-		
Low presure steam desuperheater)	-		-	-		
Back pr. and make up desuperheater	-		-	-		
Washing of pans, mill sanitation			6.5	6.5	process	
Feed water for boilers	45.4		11	56.4	boilers	
Blow down of boilers	1.1			1.1	to drain	
Glands, pumps...			3	3	to drain	outlet temp. = 32°C
General washing			2	2	to drain	outlet temp. = 25°C
Laboratory - Domestic - etc...			15	15	to drain	outlet temp. = 25°C
Total	46.5	25				

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(\*) Based on a 2 250 tcd capacity i e 97 8 tch in 23 h

# BIRGANJ SUGAR FACTORY LKT

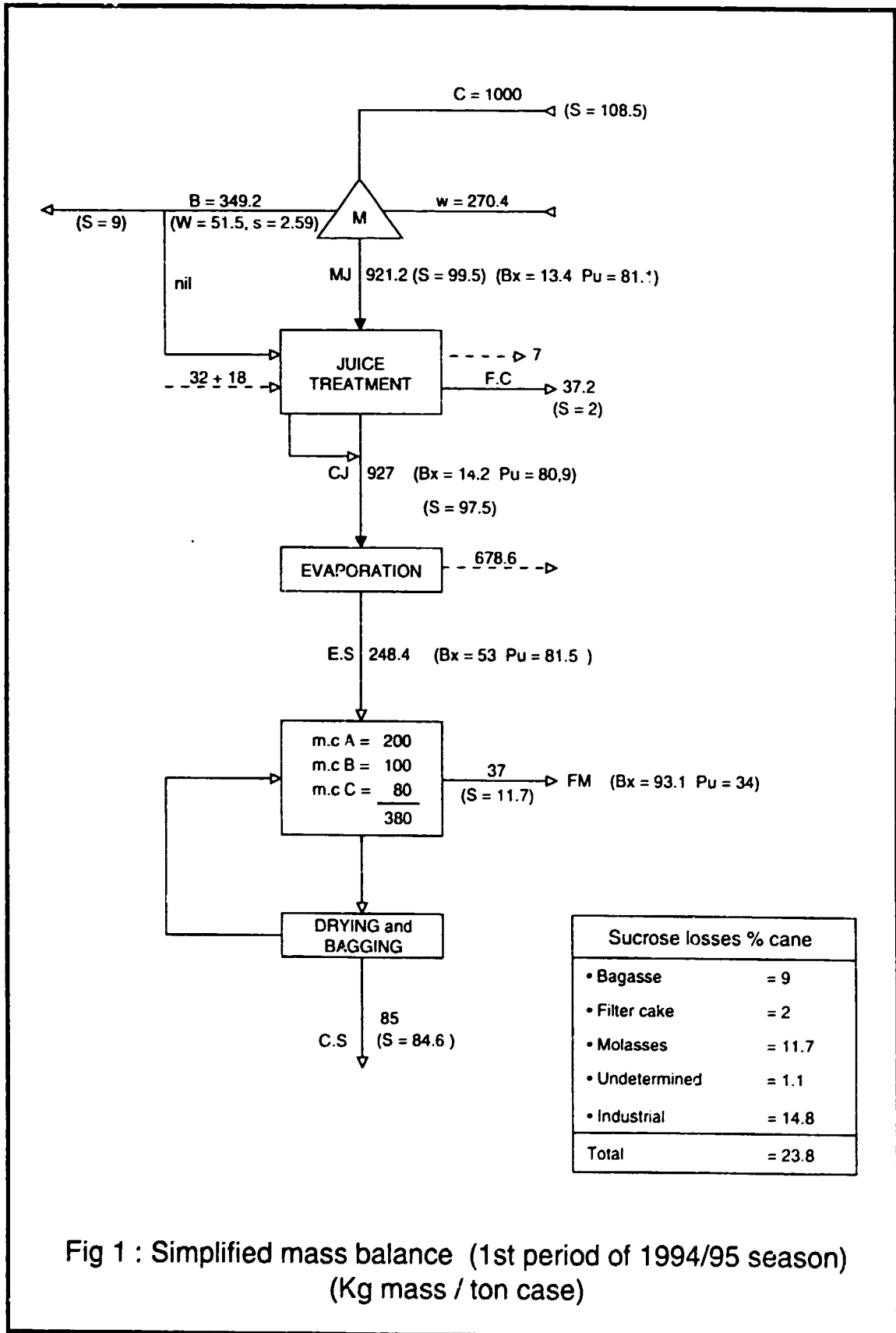


Fig 1 : Simplified mass balance (1st period of 1994/95 season)  
(Kg mass / ton case)

BIRGANJ SUGAR FACTORY LTD

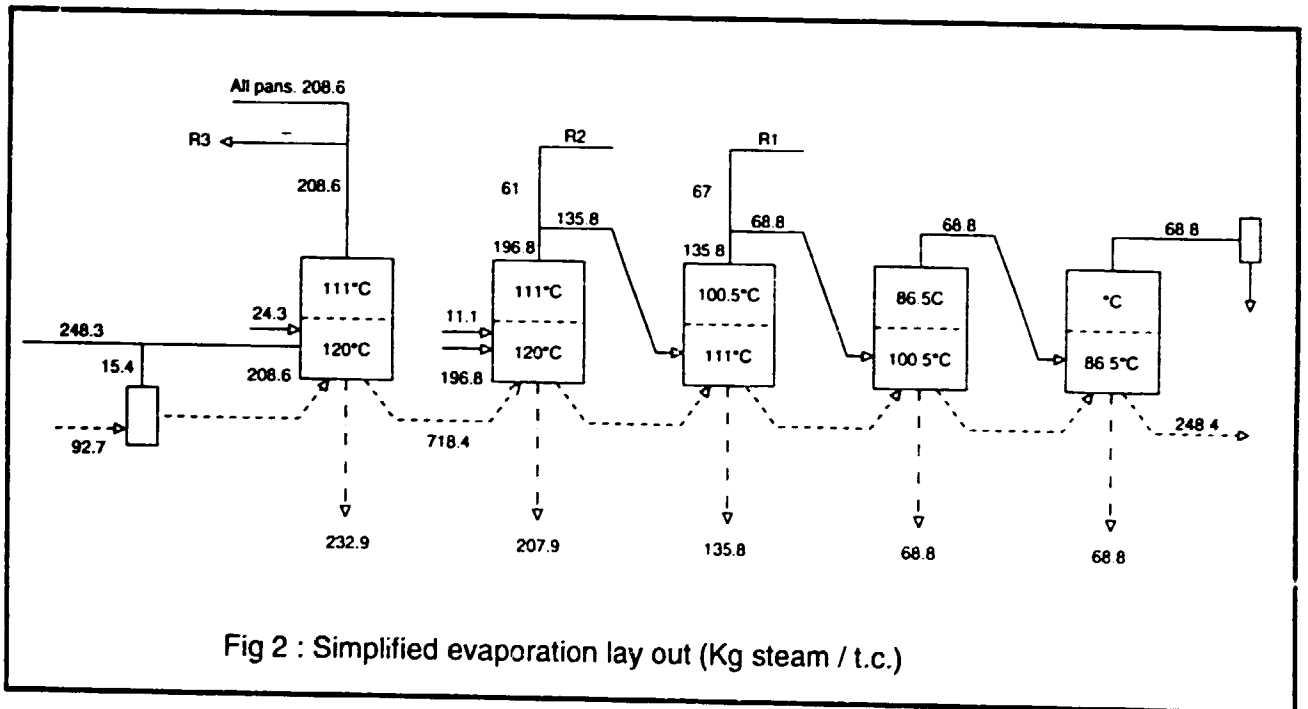


Fig 2 : Simplified evaporation lay out (Kg steam / t.c.)



# BIRGANJ SUGAR FACTORY

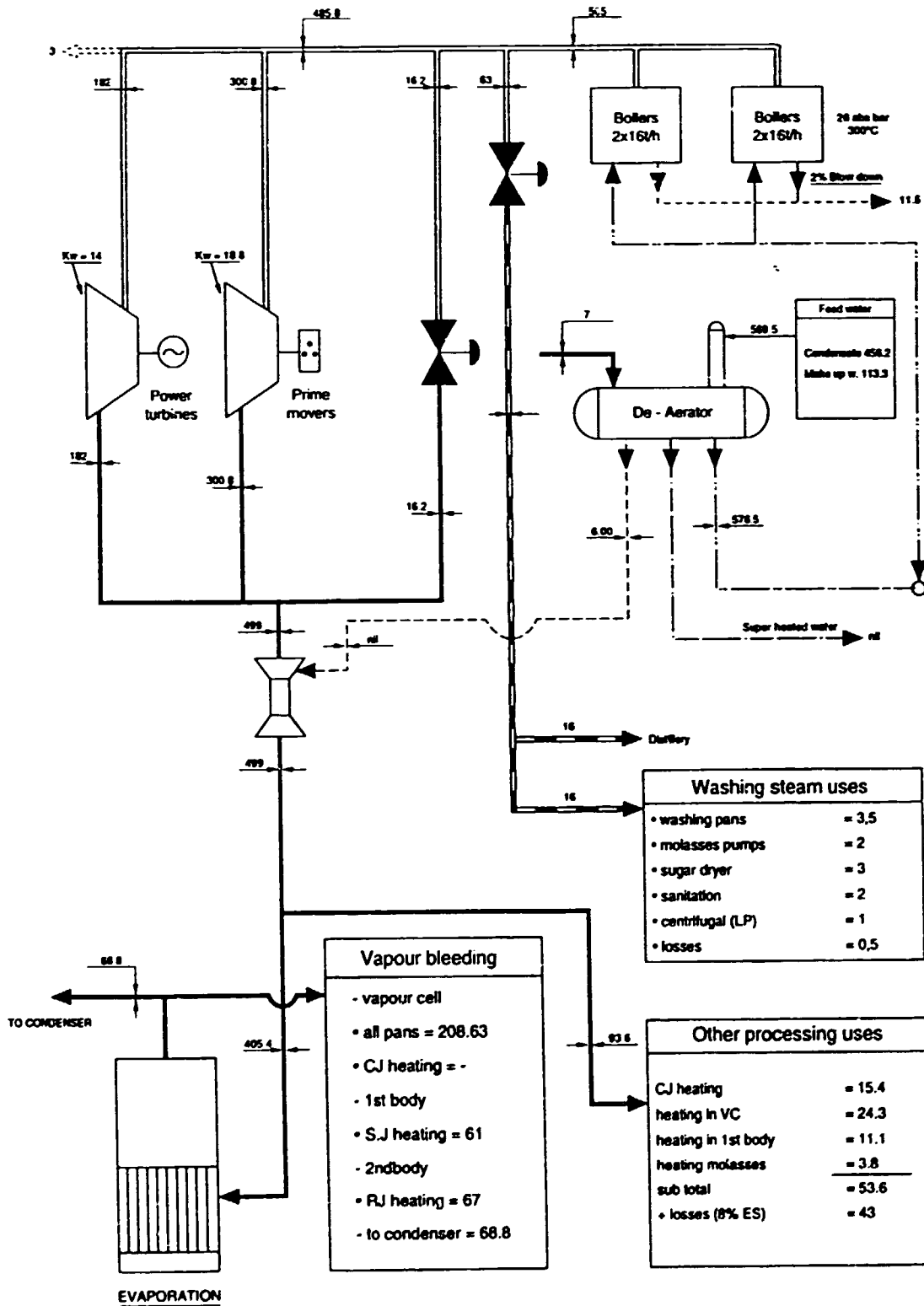


Fig 3 : Steam consumption in actual conditions  
(Kg stream / t. cane)

Live steam  
 Exhaust steam  
 Washing steam

## **APPENDIX 1 : SOME PRACTICAL GUIDE LINES FOR "CLEAN TECHNOLOGY" OPERATIONS IN NEPALESE SUGAR CANE FACTORIES (see note 1)**

### **1. GENERAL**

1.1 Check the systems for cooling waters and condenser waters in order to investigate which waters are not recirculated and study the ways to recycle them.

1.2 Check all glands, flanges, valves, pipes, pumps for leaks and implement immediate repairs.

1.3 Clean, once every day, all the drains inside and outside the factory and remove all inside deposits, do not permit any stagnation of waters inside (see note 2)

1.4 Replace the washing of the floors and at the different stations in the factory by dry cleaning. There should be no more floor washing but a sprinkling of water (if necessary) followed by application of bagasse on floor. The bagasse used for cleaning should be burnt in boilers.

1.5 Do not allow any overflow to mix with the effluents (see items 1.4 and 1.6)

1.6 Isolate the molasses and magma pumps and the final molasses tanks by parapet walls to prevent leakages and overflow and use bagasse to clean it.

1.7 Provide grease and oil traps on :

- the outlet of the cooling water from the mill bearings
- the main factory drain

1.8 ... and maintain a CLEAN factory (see note 3)

### **2. SPECIFIC POINTS**

#### **2.1 Milling plant**

- Cane conveyors : use a dry cleaning system to remove the trashes (for example a metallic brushmade from a tube provided with wires and coupled with the driving gear and a plate collector)
- Mill sanitation : install a superheated water distribution system instead of steam or hot (or cold) water. Do not allow the use of hoses.
- Juice trough : do not allow the use of hoses for the removal of the bagasse (see note 4). Use paddles instead.
- Do not let grease and heavy oil overflow from grease boxes
- Cooling water for mill bearings : (see 1.7).

## **2.2 Clarification plant**

- Liming and sulphitation station : see 3.4 and 3.5.
- Filter condenser water : this water is reputed to be one of the most polluted in a factory. We have found this water to be more polluted than the other condenser water. However in this case, it is not difficult to recirculate it.
- Filter coat wash water (in case of rotary filter Eimco Belt type)  
This water contains sugar and has a high COD content, we suggest not to drain it out but to recirculate it and use it as imbibition water with an eventual augmentation of cold or hot water (see note 5)
- filter cake wastes: do not allow the effluent drains to be polluted by the presence of filter wastes going down into a drain (ex : Sri Ram factory)

## **2.3 Heaters, evaporator bodies and pans :**

Cleaning of tubes : after use, the caustic solution should be collected in a separate tank and regenerated by adding soda. The sediment at the bottom of this tank should be removed before regeneration. After filtration it can be used as a neutralizing agent in the water recirculation system.

## **2.4 Water recirculation system (spray pond or cooling towers)**

- A drop by drop application of copper sulfate will avoid any proliferation of algae (seaweed) and improve the efficiency of the cooling system
- Maintain the system perfectly clean and, at least once a day, remove all solids from the filter.
- See also 1.1

## **2.5 Cooling, curing and drying plant**

- The drain from centrifugal pans should be collected and pumped back, this greatly reduces the COD load.

# **3. CONTROL AND MEASUREMENTS**

## **3.1 Flow measurement**

In absence of flowmeters, you can :

- Install an home-made V notch on the main drain and, if possible, an other drain to measure the effluent flow. The V notch can be removable to avoid any accumulation of solid matter (see note 6)
- On open spray pond water ducts, the flow measurement can be calculated by measuring the velocity (you need only a watch and a meter)

- In closed pipes, an approximation of the flow can be obtained by measuring with an A meter the intensity of the power absorbed by the pump. For each pump a characteristic curve  $F = f(I)$  can be established (see note 7)

### **3.2 Pollution measurements**

The most recommendable method is to provide a laboratory with COD measuring equipment. In the absence of such equipment a periodic measurement of the sugar content (saccharose and inverted sugar) should be carried out periodically. It will give valuable indications on the pollution of recirculated waters and effluents and on undetermined losses (see note 8).

### **3.3 Water balance of the factory**

A periodic and detailed water balance of the factory should to be calculated. The results of these calculations should be compared with practical measurements. The accuracy of this balance may vary by  $\pm 15\%$ , but major difference outside this range should be investigated.

### **3.4 Other measurements and control**

- The balance of non-sugars and the analysis of undetermined losses (by calculation) will give an indication of what is happening in the sugar factory (see note 9).
- For each water and effluent stream in the factory we need to know the pH and the temperature (especially for the cooling waters of the sulphitation station) in order to check eventual losses.

### **3.5 Neutralisation of the final effluents**

Indiscriminate application of lime from the liming station is not a scientific (nor recommendable) method :

- measure the pH before and after the application point and adjust the flow of lime to obtain a pH = 7
- do not allow lime grit to mix with the effluent

## **4. WATER MANAGEMENT AND HOUSE KEEPING**

- Generally, a specific employee should be appointed with responsibility for pollution control and water management. The duties of this employee should include :
  - the implementation, in collaboration with the production manager, of a monitoring programme
  - follow up and control of this monitoring programme
  - preparation of periodic reports
- The monitoring programme should include :
  - inspection guidelines

- instructions to the operators
  - test procedures, measurements and laboratory controls
  - standard periodic reports and water and waste audits
- In a well managed sugar factory, the effluent waters should be limited to excess from the condensate stream, cooling waters from the sulphitation station and some other cooling waters. The total amount of pollution in effluents should be less than 300 mg/l. of COD.

## ADDITIONAL NOTES

1. In Nepalese sugar factories :

- Cane is clean (manual cutting and handling). There is no need to wash the cane
- All sugar factories are provided with a recirculation system (spray-pond or cooling tower) with different degrees of efficiency.

2. The use of open drains is preferred. The author also prefers to use a DRY CLEANING system in the latter stages of the process.

3. A clean factory means :

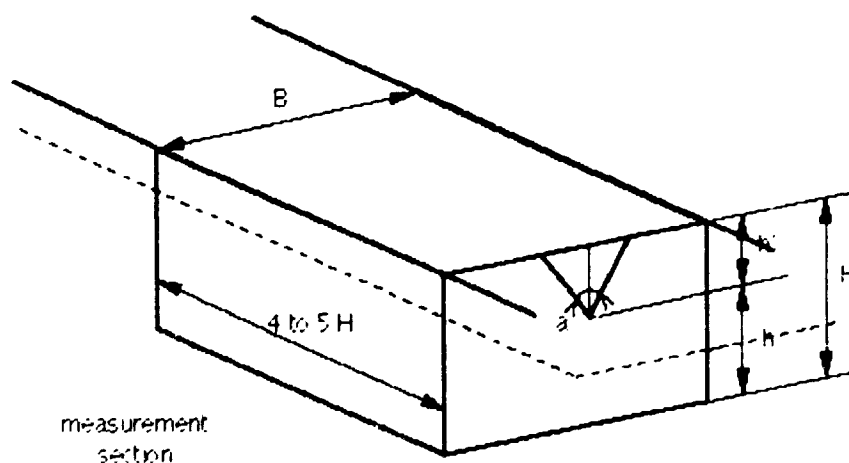
- Less fermentation points and less undetermined losses
- Better working conditions and inspections
- Demonstration of a good management and good house keeping.

This is inexpensive and finally means more sugar in bags.

4. An excess of bagasse in the juice trough, is often due to a poor or defective separation system.

5. Suspended particles in the water can be filtrated by successive passage through the bagasse. As the pH of the water is more than 8, there is no risk of future inversion (this method has been successfully applied in Lumbini Sugar Mills).

6. Installation of a triangular V-notch (thin plate weir) for simple flow measurement.



The

width of the notch surface should be 1 to 2 mm, the downstream edges of the notch should be chamfered if the weir plate is thicker than 2 mm.

• V-notch simplified formula :

$$Q = 1.42 (H - h)^{5/2} \tan \frac{a}{2}$$

with a 90°V notch  $Q = 1.42 (H - h)^{5/2}$

Q = waste-water flow in cubic meters per second

a = the notch angle in degree

H - h = the measured head over the weir in meter

• ranges of application for a 90°V notch :

$$0.1 < h/p < 2 \quad 0.1 < p/B < 1 \quad h \geq 0.06 \text{ m} \quad h > 0.09 \text{ m}$$

7/ Other simple flow measurement techniques :

1) Calculation from the power formula or the pump characteristic curves

2) Comparison between the data given by the manufacturer (allowing for the fact that the power of the motor is 20% higher than the requested nominal power) and the measurement

3) Volumetric tests (this is the best way but it is not always applicable).

8/ In recirculation waters the sugar content is low due to the large volume of water in circulation, but it will show a constant rise during the season. The measurement at the end of the season, multiply by the estimated volume of water from the condensers will give a more accurate value of the total losses of sugar attributable to these waters during the season.

9/ A simple but effective method involves the use of the pol balance of the NS content and the purity of the undetermined losses which gives an indication of the nature of indetermined losses. These losses can be defined as :

• Mechanical losses if :

Brix losses > Pol losses

N.S. losses > 0

1-  $80 \leq Pu \leq 90$  (these losses are due to light products e.g. clear juice, syrup)

2-  $Pu < 80$  (these losses are due to heavy products e.g. mc A and B, molasses)

• Chemical losses (inversion) if :

- NS losses < 0

- Brix losses < Pol losses i.e  $Pu \geq 100$ .

• • •

# APPENDIX 2 : A BRIEF ASSESSMENT ON SUGAR INDUSTRY IN NEPAL

## 1. GENERAL OVERVIEW

### 1.1 Cane quality and productivity

These are three points of major interest :

- 1°) A decline of yield in the field : t cane /ha and t sugar /ha in the last past years, as indicated by the Nepal Agricultural Research Council
- 2°) A low sucrose content in cane (between 10 and 12%) and a correlated high fibre content
- 3°) Low purity of the mixed juice sent for processing (below 80%)

This situation may be explained by :

- A lack of nutrient replenishment in the fields : the nutrients removed by cane from the soil are not renewed (low purchasing power of growers, cost of fertilisers, necessity to import them, absence of control and technical assistance). Only filter cake is returned to the fields. Spreading is difficult (it is too dry) and it is unbalanced in their NPK composition.
- The use of old varieties with an insufficient range of maturity : early and late varieties have to be introduced to widen the peak period of the sucrose content (interesting results have been obtained by experimental tests in the Birganj experimental station of the N.A.R.C.)
- Improvements are required in the organisation of harvesting and transportation. Some factories (not all) complain about a 4 to 5 days delivery time (this delivery time should be less than 36 h, especially with cane of low sucrose content)

### 1.2 Cane transformation and processing

The situation differs from factory to factory but some observations are common for all of them :

- Cane preparation and milling

Even in the two factories provided with a fiberizer the cane preparation is poor (settings appear to be too high and the driving power too low ).

The analysis of prepared cane for pol in open cells is not carried out, but it appears to be less than 75% for the two factories provided with fiberizer and below 70% for the others.

Even if the percentage of pol in open cells is an empirical value, it is nevertheless the only available method to measure the cane preparation, and it is therefore essential for the proper operational control of a milling plant.

Main observations on the milling plant :

- the feeding of the crusher mill, with insufficient load (75% of the juice has to be extracted from the 1st mill)
- working with thin coat (speed too high ) with some stoppages.
- imbibition rate and application can be improved (a rise of 20% in the rate of imbibition will raise the quantity of mixed juice by only 3%, therefore will give only a little relief to the evaporator and even less to the steam boilers contrary to common belief)
- the arking method on the top rolls (and trash-plate) should be generalized and improved for

those factories which use it.

The results are self explanatory, the reduced extraction in Nepalese sugar mills is generally less than 94%.

### **1.3 Clarification and filtration**

This section, which is the heart of the process, is generally poorly managed :

- manual controls by colorimetric measures are doubtful
- to high retention time in clarifier (> 2 h) with consequent risk of inversion
- water content of the filter muds from the clarifier is too high and consequently :
- there is not enough washing water applied to the filter (the rate should be between 100% and 150% on cake)

As a result the sucrose content in the filter cake is too high .

### **1.4 Evaporation**

All Nepalese sugar factories work with an extremely low value of syrup brix (Lumbini = 47.5, Birganj = 53, Sri Ram = 51.1), various reasons are involved and should be investigated (available evaporation surface, water temperature in condenser, wish to perform an easier sulphitation of the syrup). The draw-back are :

- a direct negative influence on steam economy
- a higher risk of inversion (same retention time but higher temperature and lower concentration)
- immobilization of a pan to concentrate the syrup

### **1.5 Boiling house**

All Nepalese sugar factories use a CBA system with remelt of C sugar (after single or double curing). The boiler system in use is satisfactory and does not need modification. Almost all of them use semi automatic centrifugal machines for A and B curing. Manual washing with hoses increases the remelt of sugar and the recirculation.

For further improvement it is recommended :

- The adoption of a CBA system with double magma on C and B sugars (and eventual double curing on C sugar). It is felt that with a good quality clear juice (improvement of the clarification process), this system will avoid the syrup sulphitation and its inconveniences.
- To use a superheated water distributor for the sugar washing instead of the water.

Quality of sugar

- Large size crystals more often accompanied with other shorter and blunt crystals (incidence of the washing on false grains), no conglomerates
- Good brightness and transparency
- The dryness is questionable (in many sugar factories the air vents in grass hoppers are obstructed), but the sugar is not stocked for a long duration.



## **1.6 Steam production and distribution**

• Almost all sugar factories have a small deficit in bagasse and need some additional fuel (firewood and oil). This deficit is mainly due to two factors.

1/ low boiler efficiency

2/ high consumption rate (kg steam /kW)

On the other hand, steam economy can be achieved in the steam distribution for the process.

Various ways can be studied to restore the balance

- Improvement in boiler efficiency
  - decreasing the water content in bagasse
  - increasing the feed water temperature
- Replacement of medium pressure uses by exhaust steam
- Using back pressure steam for the distillery instead of medium pressure steam (if the distance is suitable)
- Economy of steam in the process : 4 ways, in order of importance :
  - increase of the syrup brix
  - optimization in bleeding uses
  - recovery of low calories in condensates and auto-evaporation
  - locating the various sources of heat losses.

In this case the target is to have no necessity for make-up steam and the factory will blow off some excess back pressure steam. The excess can be used to heat the feed water of the boilers.

## **2. CONTROL AND ORGANIZATION**

Some important requirements for the sugar factories in Nepal :

- Instrumentation and equipment for analyses and control
- Some regulation devices in the process (control of pH, brix and level regulation in evaporation station)
- Installation of micro-computers in the laboratory and for the technical staff
- Modern methods of management for the maintenance of cost control and ware housing.

## **3. THE SUGAR FACTORIES**

### **3.1 Lumbini sugar factory**

*3.1.1* A large sugar factory with a very good and simple arrangement of equipment. The factory is clean and well managed by a dedicated team of technicians.

The results are good and constantly improving (total losses between 2.1 to 2.3, final molasses purity  $30 < Pu < 32$ ).

The analysis of sucrose losses indicates two weak points : the mill extraction and the mud filtration (losses in the filter mud are triple the maximum norms).

### *3.1.2 Cane preparation and milling*

Cane preparation is rough, in spite of a good setting of the cane knives. The system of cane reversing is rather inefficient due to the small height difference between the first and the second conveyor. We recommend the transformation of the second cane cutter in a reverse cane cutter and for the future extension of the factory, the installation of a shredder.

The water imbibition is sufficient but the first mill is underfed (angle of the feeding plate) and the coat of bagasse is not thick enough.

The arking practise on top rolls should be improved.

### *3.1.3 Clarification and filtration*

What has been described in 1.3 above also applies here :

The clarifier is a chinese copy of the Dorr-Oliver, with the usual defects of this clarifier :

- long retention time
- the slipping of muds from tray to the bottom
- the capacity of the mud bottom tank is too small and consequently the level of the mud occupies the whole diameter of the clarifier with a maximum surface of contact between muds and juice. As the clarifier is not provided with an independant flash tank, the injection of flocculant cannot be done under the best conditions and the turbulence affects the deposition of the muds.

The filtration station is composed of 2 rotary filters, Eimco-Belt type, there is no equipment for mixing bagacillo with mud and the filtrate is mixed with the clear juice.

The vacuum in the condenser is about 300 mm, which is insufficient (the temperature of the injection water is about 45°, the condenser being fed by the water from pan condensers)

As the washing water of the filter cloth has a high sucrose content (about 1%), we have recommended the recirculation of this water for mill imbibition.

We recommend also a complete revision and modification of the whole station

### *3.1.4 Evaporation*

The condenser is fed by the water from the pan condenser at 45°C. Thus the temperature at the outlet of the last body is about 70°C (vacuum is insufficient)

The system of water injection has to be revised in order to put the evaporation condenser and the filtration condenser in parallel with the pan condensers and not in series as they are at present.

### *3.1.5 Boiler house*

A good lay-out. The performance of the boilers will be improved when the bagasse is better processed (improvement on cane preparation and milling) : this is an essential condition for a spreader stocker boiler. Some points should be studied : the feeding system (this does not permit an efficient spreading and the bagasse burns on the grid and not suspended in the air flow. Three feeders of Thomson type should improve the feeding system.

## **3.2 Mahendra sugar factory**

This small scale factory (650 ted) works more as a distillery than as a sugar factory.

Instrumentation does not exist or is broken, very few analyses are carried out (the laboratory is not equipped) and the only data available is the weight of cane delivered to the factory and the sugar produced. The losses are reputed to be very high (about 3% sucrose).

It is difficult to give an assessment on such a factory and only some recommendations in order of

priority and cost are given:

- 1) Clean the factory
- 2) Restore weighing scale for juice and molasses, and also weigh the filter cakes
- 3) Restore all instrumentation in the factory and buy a minimum of equipment for the laboratory
- 4) In terms of equipment, priority has to be given to the curing station : this station needs 2 vacuum crystallisers for storage of C and B grains and more centrifuges (curing of A and B with same 3 batch centrifuges).

Note 1 : In fact, each station needs some revision and eventual revamping.

Note 2 : The factory does not use any bleeding. All heating and boiling is done on back pressure and make up steam

### **3.3 Indu Shankar sugar factory**

In spite of old equipment (second and third hand equipment), an intricate lay out of this equipment and pipes and a dubious cleanliness, the factory is working properly. The weakest point is the mill extraction ( pol bagasse = 3, % loss of sucrose in bagasse = 1.2) and losses in filter cake (% loss of sucrose = 0.07). All observations presented in chapt. 1 – General overview – are applicable to this factory, with the following additions.

- 1) The factory needs desuperheaters on medium and back pressure lines
- 2) A clear juice heater is recommended before the evaporation (if possible a plate exchanger type). A special mention has to be given to the boiling and double curing system practised in Indushankar, which is very good and could be considered as a model for other Nepalese sugar factories.

### **3.4 Sri Ram sugar factory**

Sri Ram sugar factory is a new plant and it is its first running season. Most of the time, the factory was not running during our visit, due to numerous start-up problems which is understandable for a first season. But the design is good and the factory is well sized in terms of lay-out and equipment : thus there is no special reasons, when the personnel will be more familiar with the equipment and operations, why goods results can not be obtained.

We have only few observations to make, as we have never seen the factory running in normal conditions and these observations are not precise:

- 1) With a fiberizer, the cane preparation should be better (my opinion is that the setting is insufficient, in a fiberizer the hammers have to be on the anvil, "iron on iron").
- 2) The mills were underloaded and the juice imbibition was unevenly applied, the juice was drained on only a part of the roller and a large proportion of bagasse went down the mills trough.
- 3) on filtration it was noted that : the muds were too wet, there was a lack of bagacillo, not enough washing water and insufficient vacuum. The quality of the clear juice was also doubtful.
- 4) The installed power (1 500 kW) is rather low for a 1 250 ted sugar factory with an electrically driven fiberizer .

### **3.5 Birganj sugar factory**

#### *3.5.1 Cane preparation and milling*

Same observations as for Sri Ram factory. In Birganj some mills are overloaded (on n<sup>o</sup>2, part of the bagasse goes over the top roll), while others are unloaded. The juice imbibition is poor and

with badly distributed (part of straining-plates are obstructed with bagasse). Part of the imbibition juice is short circuited by permanent hoses to wash the excessive amount of bagasse in the under mill trays. It is a perfect vicious circle as excess of bagasse under the mills is often due to a lack of imbibition.

The whole milling station needs to be entirely revised.

### *3.5.2 Clarification and filtration*

Same observations as for Lumbini sugar factory.

The losses in filter cake are specially high (0.2% cane).

The clear juice from the clarifier is a good quality one ( $P_2O_5$  in mixed juice > 500 mg/l) but unfortunately it is mixed with the filtrates which are very turbid. We recommend that this filtrate should be recirculated as soon as possible to the weighing juice tank.

### *3.5.3 Evaporation*

The system VC - quadruple or quintuple effect is well designed with a good recovery of bleedings. But as the spray pond is partly short circuited (see 3.5.7), the vacuum is insufficient.

### *3.5.4 Boiling and curing*

- The syrup sulphiter has leaks and cooling water (i.e sulphuric acid) is mixed with syrup.

- There is no cooling on masse cuite C. The chinese continuous crystalliser does not work properly.

- The factory has a very efficient BMA centrifugal turbine for B sugar, but this centrifuge is used on C sugar. On the other hand the chinese continuous C centrifuges give only 50% of their theoretical capacity (as indicated by manufacturer). All the station needs to be revised.

Note : 1) there is a hole in the screen of the BMA centrifuge and there is no spare. Sugar is passing through with final molasses and the purity of final molasses was about 40 during our visit.

Note : 2) the air catcher for drying the sugar is under the centrifuges. This is not the best location.

This is not very important as the air vents under the hopper are already obstructed by sugar.

### *3.5.5 Power house*

When we visited the factory, one turbo alternator was out of order and was being repaired (a broken gear due to a water pulse following upon a steam pressure drop).

### *3.5.6 Spray pond and recirculation water system*

To relieve the load of the other turbo alterlator, part of the spray pond had been short circuited but the remaining part is not working well : number of nozzles are not working at all, the height of water jet is different from one nozzle to nozzle. The overall system gave a very bad impression.

Note : I have never observed in an other factory people washing tractors, clothes or bathing in the open drains of a spray pond. It is not surprising that some nozzles were be obstructed.

## **4. INSTITUTIONAL LEVEL**

With the future installation of new sugar factories, the sugar industry sector will take a more and more prominent place in the economy of Nepal. We suggest the creation of an organism which will

promote better co-operation between sugar factories themselves , sugar factories and governmental institutions and sugar factories and farmers. to instigate studies and projects of mutual interest. common policies for the development of the sugar sector. to exchange information and statistics and which will defend the interests of the sugar industry.

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## BACKSTOPPING OFFICERS' COMMENTS

1. The production of sugar in Nepal, although it represents less than 50% of the present domestic consumption, it provides an important and increasing contribution to the national economy through the generation of employment, and the reduction of foreign exchange expenses.

2. In order to reduce future imports and to satisfy the growing internal demand it is expected (already planned by the Government) and recommended, based on technical grounds, that special attention be given by the national authorities to the **promotion** of the proper manufacturing of sugar and sugar by-products (particularly alcohol) in the country.

3. Since sugar and sugar by-products are being manufactured in several countries already very efficiently and competitively, it has been proposed in the report that the Government consolidates the **development and the implementation of a programme** which would consist essentially in (i) **increasing agricultural productivity**<sup>2</sup>, (ii) **improving the efficiency of sugar and sugar by-products** (presently only alcohol) **manufacturing plants**<sup>3</sup>, and (iii) **establishing mechanisms of stimulating the "self-sustainability" of the industry through the introduction of environmentally conscious (clean technologies and waste utilization treatment) and energy conservation production policies**.

4. The report presents in the **Attachment I** entitled "*A Survey of Water Uses and Effluent in Nepalese Sugar Factories*", a very detailed technical assessment of the five sugar manufacturing plants in the country. At the end of the **Attachment I**, two **Appendix** have been included, providing respectively "*Some Practical Guidelines for Clean Technology Operations in Nepalese Sugar Cane Factories*", and "*A Brief Assessment of the Sugar Industry in Nepal*". The **Appendix** consist, in fact, in the summary of the observations and recommendations made on all operational issues of the visited industrial plants together with a brief assessment of the sugar cane agricultural production. The technical information and recommendations on sugar manufacturing issues expressed in the report have been withdrawn from the **Attachment I**. In addition to the Government officials interested specifically in the improvement of the technical characteristics of the sugar production in Nepal, it is recommended that all sugar plant managers examine carefully the suggestions made to each of the plants, as well as the remaining contents of the **Attachment I**, in particular, both **Appendix**. Very concrete and practical recommendations, which can be applied, in several cases, even without additional technical support, can be found in that part of the document.

" At present, the sugar industry is estimated to be the second largest employer in the food sector, second only to the grain milling". pg.03.

The improvement of the **infrastructure** available (as for instance roads and transportation facilities), as well as the better **management** of agricultural production, harvesting and cane distribution shall be also seen as part of a programme for improvement of agricultural productivity.

With the improvement of the operational efficiency it is also understood that parallel to the reduction in production costs, additional amounts of molasses and bagasse will be available which would propitiate the future development of a solid and profitable "diversification" industry.

5. Regarding the **establishment of an industrial pollution control and monitoring programme for the sugar factories and adjacent distilleries**, clear conclusions and recommendations are made in **Chapters III and IV**. In addition to the very practical suggestions which can be carried out without complementary technical assistance, the following report recommendations would need to be emphasized:

(i) A suitable central **laboratory** testing facility, in line with the recommendations made and explained in details under **Annex IV** and **Annex V**, be established within a designated division of the Department of Industry. In support to the central national laboratory small facilities should be established in each region selected by the Government to be monitored.

(ii) An extensive **training programme** (*at the third level*) in water quality management and pollution auditing techniques for at least **two** Government officials should be organized. As a complement to the long term training proposal, a shorter training programme at the plant level for at least **two** staff from each of the sugar plants (*totalling, therefore, around 10-15 people*) should also be organized as part of the **Government industrial pollution control and monitoring programme**.

(iii) For most of the major **effluent** from the sugar factories and associated distilleries (particularly the filter mud ("cake"), the ash from the boilers and the spent wash from the distilleries) it is recommended that land irrigation be used as a safe and cost effective alternative for disposing them of. The cost of the required tank, which would have to be used with a tractor, is estimated in **US\$60,000**. It has been also recommended that one of the visited sugar mills (**Lumbini Sugar Mills Ltd.**) be used as a **demonstration** facility for testing the proposed technique. (Please, refer also to **Attachment I**).

(iv) Complementary technical assistance should be provided in the area of **anaerobic digestion technology** in order to have a suitable **demonstration Anaerobic Digester** for the treatment of the spent wash properly installed in one of the sugar factories. It has been recommended that the **Shree Ram Sugar Factory** (*which has contracted to instal an Anaerobic Digester but does not possess the technical know-how to successfully commissioning and operating it*) be selected as the mill to be assisted. In addition, it has been suggested that the **Jawalakhel Distillery** (*which is in the process of assessing the most appropriate anaerobic technology for the treatment of spent wash in Nepal*), be also assisted.

The recommendations are presented also in order of priority.

The cost of equipment for establishing the central laboratory unit has been estimated in **US\$40,000**.

The programme would be carried out in "effluent quality monitoring and control with particular emphasis in the operating and economic aspects of effluent treatment systems, as applied to sugar and distillery effluent including both aerobic and anaerobic techniques". **Annex IV**.