CLEANER PRODUCTION FOR SOLID WASTE MANAGEMENT IN LEATHER INDUSTRY

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ABSTRACT

The leather industry is characterized as an industry that uses many chemicals and large quantity of water. From the processes, wastes are generated which include wastewater effluents, solid wastes, and hazardous wastes. In developing countries including Ethiopia, many leather industries discharge wastes into the environment without any proper treatment. The best approach to reduce the environment burden is to eliminate the problem at source, using cleaner production options. In this paper, the study is performed in one of the leather industry in Ethiopia, namely Addis Ababa Tannery by implementing cleaner production methodologies. The solid waste inventory of the factory has been carried out. The major problems have been identified. In order to accomplish this, the possible cleaner production steps have been suggested. Technical and economical aspects of the best steps have been evaluated. Result of the study indicates that the implementation of the suggested cleaner production steps would bring about significant benefits for the factory.

INTRODUCTION

Ethiopia is well endowed with livestock resources being among the ten top in the world. The leather industry is one of the country's most vibrant and important industries for Ethiopian economy as it generates the largest export revenue in industrial sector. Modern tanning in Ethiopia has started 70 years ago. Currently there are 21 tanneries in operation and most of them are located in the vicinity of Addis Ababa [1]. Most of the factories do not posses well- established treatment plants for their wastes and simply dump their waste into the rivers nearby. This dumping to the river causes a serious pollution problem to the habitants of Addis and the surrounding villages.

The production of leather from the raw hides and skins involves an intensive use of water as well as many mechanical and chemical processing steps. These processes generate considerable amounts of solid, liquid and gaseous wastes. Figure 1 shows schematic overview of the liquid and solid pollutants generated from 1000 kg of raw hide, which yields an average of 250kg of finished leather [2].

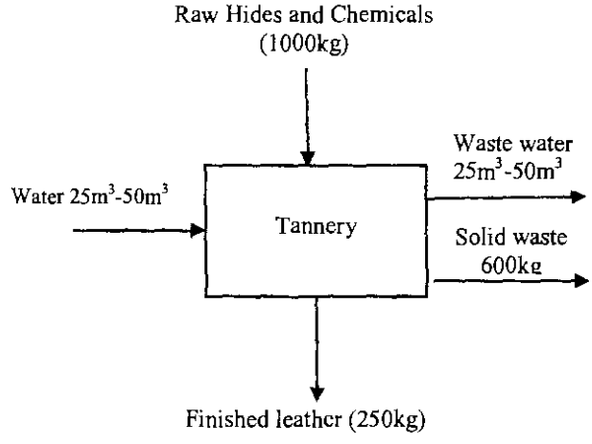

Figure 1 Schematic diagram for inputs and outputs of a typical leather industry

The 1999 uptake from 15 operational tanneries in Ethiopia was one million hides, twelve million sheepskin and fourteen million goatskins with a resultant generation of five million cubic meters of tannery effluent giving rise to gross pollution load of6000 tons of biochemical oxygen demand 5 (BOD5) [3]. Similar situation can also be identified in many developing countries where hides, skins and leather products represent a significant proportion of their national economies. Figure 2 gives the four main tannery operations namely: beam house, tanning, post tanning and finishing where each comprises of a number of sub-operations with its liquid and solid wastes.

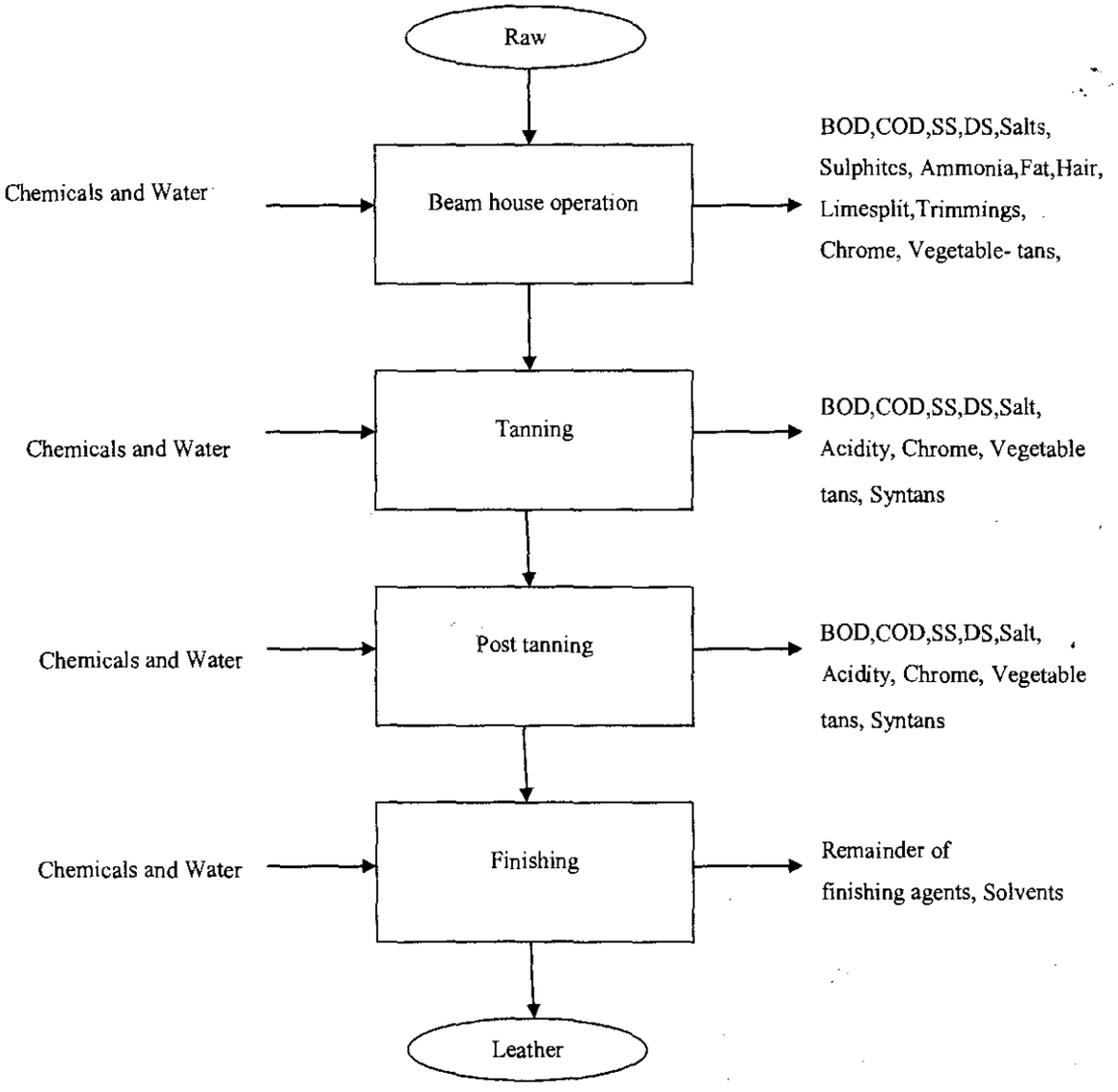

Figure 2 Process flow diagram for the main tannery operations

NB: BOD-biochemical oxygen demand; COD-chemical oxygen demand; SS-suspended solid; DS- dissolved solid

OBJECTIVE OF THE STUDY

The solid waste generated during leather production is significant. Only 25% of the raw material by weight ends up in the finished leather [2]. This creates huge environmental threat, especially to the Ethiopian tanneries where most of them posses obsolete machines and equipments, a lack of strong financial input and almost all the wastes are discharged to the nearby river. Thus, this study focuses on understanding the environmental burden in one of the tannery namely Addis Ababa Tannery (AAT) and to identification of cleaner production options that are environmentally and economically viable. To this end the following steps were conducted:-

- Pre-assessment of Addis Ababa Tannery and in-depth evaluation of the processes that generate solid wastes.
- Identification of problems existing in the process
- Generation of Cleaner Production options
- Identification of the best options that are economically and technically viable.

Pre- assessment of Addis Ababa Tannery

AAT was established in 1925 and is Ethiopia's oldest tannery. The tannery is located in the Gulele area, approximately 10 kilometers from Addis Ababa town center on the Ambo road. AAT has an attainable processing capacity of approximately 1,350,000 kg of cow hides per annum, and is currently producing at the level of approximately 950,000 kg of hides per annum, representing capacity utilization of approximately 70%. AAT currently employs 222 permanent staff. The tannery's principal products are shoe uppers, lining, unsplit wet blue hides, and natural and dyed crust [4]. The reassessment of the tannery takes place using audit principle.

The production processes in the tannery can be split into four main categories: hide and skin storage and beam house, tanning, post- tanning, and finishing operations. Operations carried out in the beam house, the tanyard, and the post- tanning area are often referred to as Wet processes, as they are performed in processing vessels filled with water. After post- tanning the leather is dried and operations are referred to as dry processing [5-7].

Identifying Environmental Problems of AAT

Unfortunately till today, there is no mandatory regulation in Ethiopia concerning environmental issue. Almost all factories discharge their waste to nearby rivers. AAT does also the same. Generally to our observation, most of the wastes from AAT are manmade which can be controlled with a little effort to the environment. Some of the main problems observed in solid waste management of AAT are:

- The hides are not selected in size on arrival.
- The salted hides are not properly desalted.
- Beam balance in the beam house and tanning section are not well calibrated which results in improper weighing.
- The fleshing is directly discharged into the nearhy river.
- Lack of skilled manpower in trimming hides.
- Generations of solid wastes, such as unused splits, shavings, lime trimmings, crust and finished leather trimmings.

The amount of the solid waste generated in AAT is categorized in the processes of fleshing, trimming and finishing. The general material balance for the tannery and summary of solid waste generated is given in Fig. 3 and Table 1 respectively.

GENERATING CLEANER PRODUCTION OPTIONS

So far the reduction elimination of solid waste generated in the tannery is carried out using different treatment techniques. Nowadays cleaner production techniques are emerging. The techniques varys from house keeping to technology changes. This study is focused on simple affordable techniques rather than on addressing a technology change. The wastes are generated in AAT form different corners as liquid, solid and gases. The study is restricted to solid waste. These wastes are generated from different parts of the processes from various reasons. In other words there is a need for setting priority of implementing cleaner production options which are based on the

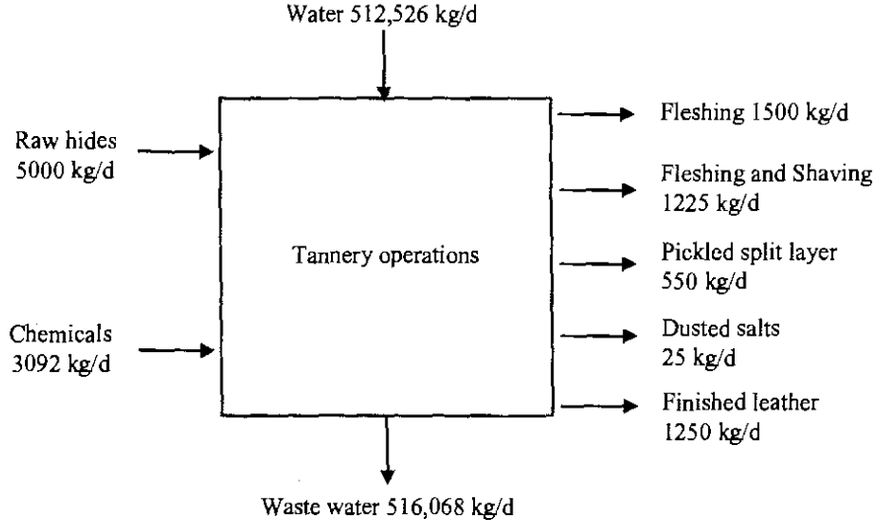

Figure 3 Inputs and outputs of tanning operation in Addis Ababa Tannery

establishment of priority setting criteria. The priorities are put on environmental and economical benefits (ECB) and easy implementation.

Table 1: Summary of solid waste generated per ton of salted hide in AAT

Solid waste type	Kg/ton
Dusted Salt	5
Lime fleshing	300
Lime trimmings	127
Unused chrome split	110
Shaving	90
Crust trimmings	13
Dust buffings	Not quantified
Finished Leather trimmings	15
Total	660

The Environmental Benefits (EB) have been given the largest weight point ranging from 1 to 50. Reduction in the total volume of solid waste and degree of contamination caused by process chemicals was taken as sub- criteria for environmental benefits. Accordingly, a reduction in the total volume of solid waste was been given the weight point range of 1-20. The radiation of environment impact caused by process chemicals was given the weight point range of 1-30 which is a large quantity that are discharged out with the solid waste. This is the main cause for the environmental pollution and contamination of the river.

The EB of waste reduction options should involve the comparison of investment cost where cost savings would be made and this was given a weight point range between 1 and 30 points. Low investment and cost saving are the sub- criteria that were considered in evaluating the economic benefits and were given the weight point range of 1-20 and 1-10 points, respectively.

The Easy of Implementation (EI) was given the weight range of 1-20 points. Under this as sub-criteria are considered the availability of equipment and hte ease of application, which have equal weight range of 1-10 for each sub criteria.

IDENTIFYING THE BEST OPTIONS

Introducing the following operations in AAT may be useful in reducing / eliminating / the solid wastes.

- Classification of the hides into small, medium, large sizes and dedusting the salt manually or mechanically.
- Proper weighing of chemicals
- Introducing green fleshing
- Installing a lime splitting machine
- Training the workers on how to operate
- Manufacturing a leather board from the shaved leather

From these operations the priority was setup using the aforementioned criteria. Table 2 indicates proper weighing of chemicals, green fleshing and lime splitting to the first, second and third priority, respectively.

Table 2: Summary of priority setup of the suggested cleaner production options

Operations	Focus	Criteria	Weight point	Total weight point	Priority
Hides classification and dedusting the salt	F1	EB	25	59	4
		ECB	18		
		EI	16		
Proper weighting of chemicals	F2	EB	43	88	1
		ECB	27		
		EI	18		
Introducing green fleshing	F3	EB	40	70	2
		ECB	15		
		EI	15		
Training workers in how to Trim	F4	EB	15	50	6
		ECB	20		
		EI	15		
Introducing lime splitting	F5	EB	35	66	3
		ECB	18		
		EI	13		
Manufacturing a leather board from the shaved leather	F6	EB	38	58	5
		ECB	10		
		EI	10		

NB. EB: Environmental Benefits, ECB: Economical Benefits, EI: Ease of Implementation

RESULTS AND DISCUSSION

Proper Weighing of Chemicals

For a proper chemical preparation AAT does not have a calibrated beam balance. Chemicals are used by assumption and due to this AAT uses higher amount of chemicals than the standard recipe. This was proved in the audit of the process. Table 3 shows the amount of chemicals and cost saved by proper weighing of the same.

Table 3 indicates that by proper weighing of chemicals, the company can save 873,690.00 Birr per year. To save this money, it has to purchase two well- calibrated beam balances for the beam house and tanning operations, amounting 100,000 Birr. Introducing the well calibrated beam balances into the factory also reduces the discharge of excess chemicals into the river. Table 4 depicts environmental benefits achieved by implementing the well calibrated beam balance.

Table 4: Environmental benefits of process chemical preparation

Description	Reduction (in ton) / yr
Sodium Silico Fluoride	1.52
Sodium Sulphydrates	9.20
Sodium Sulphate	11.98
Lime Powder	21.16
Ammonium Sulphated	34.63
Sodium Formate	7.90
Denatured salt	87.54
Tankrom AB	4.03
Formic acid	11.40
Sulphuric acid	1.34
Other Chemicals	40.58

Table 3: Cost saved by proper preparation of chemicals per ton of salted hide

Operation	Chemicals	Actual chemical consumption per ton of salted hide kg	Recipe based chemical consumption per 1 ton of salted hide kg	Difference between the actual & recipe based consumption per 1 ton of salted hide kg	Unit cost/ kg (Birr)	Cost saved per ton of salted hide (Birr)
Beam-house	Sondozin	5.14	5	0.14	13.58	1.80
	Soda ash	15.00	15	0.00	-	0
	Sodium	3.60	2	1.6	7.69	12.30
	Sodium Sulphate	14.67	5	9.67	8.33	80.55
	Sodium sulphydrate Flakes	40.00	25	15.00	6.39	95.80
	Lime powder	92.24	70	22.24	0.502	11.20
Tanning	Ammonium Sulphate	46.40	10	36.40	3.47	126.30
	Sodium Formate	19.30	5	14.30	7.53	107.67
	Recolosc EP – 1196	4.50	2	2.50	29.68	74.20
	Sodiuk Formate	23.30	15	8.30	4.32	35.85
	Denatured salt	142.00	50	92.00	1.12	103.04
	Formic acid	22.00	10	12.00	7.14	85.68
	Sulphuric acicd	11.45	10	1.45	2.64	3.83
	Tankrom Ab	39.20	35	4.20	9.78	41.07
	Pervental WB	5.00	3	2.00	50.59	101.18
	Sodium Bicarbonate	14.60	5	9.60	3.64	34.94
Total						915.41

Introducing Green Fleshing

The unhairing and liming was shown to be the major contributor to pollution. AAT fleshes the hides after they are unhaired/lime. The fleshing which contains chemicals, mainly lime and sulfide, is directly discharged to the river. This has serious impact on the aquatic organisms and the surrounding residents. In order to reduce the environmental impact caused by the lime fleshing the hides are fleshed directly after soaking, i .e. green fleshing.Economic benefits by implementing green fleshing may be 94,164 Birr/year. Using a green fleshing the factory reduces the negative environmental impact caused by a direct discharge of fleshing that contains sulphide and lime. Table 5 illustrates the amount of reduction of chemicals and cost saved by using green fleshing. To obtain the above results the factory has to purchase green fleshing machine, which may cost 1,565,650 Birr, which is a onetime fixed cost investment.

Table 5: The quantity reduction and cost saved after using a green fleshing

Chemical lime	Chemicals used (kg/yr)			Cost saved/ yr (Birr)
	After unhaired lime	Green fleshing Based on the recipe	Reduction	
Sodium	11,415	7,134	4,281	63,133
Sodium Sulphid ratets	4.,186	1,27	2,759	17,326
Lime Powder	26,.324	19,977	6.347	13,705
Total	41,.925	27,238	13,387	94,164

Introducing Lime Splitting

The company splits hides after tanning (blue splitting). The tanning process converts the protein of the raw hide or skin into a stable material which is called leather. The leather does not putrefy, dries out soft and does not swell when wetted back and therefore is suitable for a wide variety of purposes. Tanning is done by introducing a tanning agent (e.g. chemicals) into the hides [5 -7]. Splitting after the tanning incurs quite substantial amounts of chemicals to be discharged together with the spitted hides. Table 6 illustrates the results obtained. It can be noticed that by introducing a lime splitting before tanning assures reduction of the solid waste (environmental) as well as cost savings (economical). By using this method the company can save about 195,905 Birr per year.

Summarizing, the main sources of wastes in AAT are the beam house and tanning operations. Thus, the company has to take appropriate cleaner production measures in order to overcome the problems. The top management of AAT and concerned governmental bodies should consider the seriousness of the problem and implement the cleaner production options suggested in this work. This can also be a model for other Ethiopian tanneries. Table 7 shows summary of solid wastes reduced and chemical saved per year in the main tannery operations.

Table 6: Chemical reduction and cost saved /yr by implementing lime splitting in AAT

Chemical Discharged	Cost- saved/yr of salted hide(Birr)	
	Actual Consumption	Cost- saved/yr of salted hide(Birr)
Ammonium Discharged	4,851.5	16,837.6
Sodium Bisulphate	1,997.7	15,030.0
Sando Clear MWQ	190.2	25,870.5
Bathing agent	475.6	14,031.3
Sodium Format	2,378.2	10,273.8
Denatured salt	14,840.0	16,618.8
Formic acid	2,283.0	16,894.6
Sulfuric acid	1,141.5	3,015.5
Tankrom AB	4,090.5	39,953.6
Preventol WB	475.6	24,067.3
Tankrom QB	3,139.2	31,078.2
Sodium Bicarbonate	1,522.0	5,517.4

Total	37,385.0	219,188.6

Table 7: Summary of solid waste reduced and chemical saved /yr in the AAT

No	Process	Solid waste reduces kg/yr	Chemical saved kg/yr
1	Beam house Operation	410,832	88,187
2	Tanning and Re- tanning	202,563	124,754
3	Finishing	14, 265	-
Total		627,660	212,941

CONCLUSIONS AND RECOMMENDATION

Commitment of the top management of AAT is the prerequisite for good environmental performance. Technology by itself is not sufficient, but needs to go together with good house keeping measure. A key to good performance is awareness of the inputs and outputs of the process with regard to the characteristics of the materials, the quantities, and their potential environmental impact. Criteria that ensure a better environmental performance can then be taken into account as well as technological criteria that focuses on the properties of the end product.

Reduction of solid wastes, spills, accidents water wastage and chemical usage can achieved by the choice of appropriate techniques, good maintenance and operation control, monitoring and adjusting process parameters and good staff training. Besides these, AAT has to substitute those chemicals, which are known to be harmful to the environment, by the less harmful ones. In order to do so, the company has to maintain a detailed inventory of inputs and outputs.

Implementing the selected cleaner production option, proper weighing of chemical can save a total of about 873.690 Birr/yr. Besides this economic benefit, it contributes to reduction of the environmental pollution load caused by the discharge of the waste into the nearby river.

In order to implement the cleaner production options, that is a green fleshing and a lime splitting the company has to seek for the best and ignorable machine. Although the new machines are a bit expensive, there are reconditioned machines which can lower the prices on the market. Besides the economic gain, it has big environmental achievement. The fleshing and splits can be used in producing some useful products. In order to utilize the fleshing and the trimmings splits, it is advisable to establish a small- hide glue plant near the factory.

AAT should work hard in order to create a good working environment for the workers and the people surrounding the factory. Therefore, the factory has to consider the following recommendations as it plays a great role in creating a good working environment for the workers and the society.

1. Training the workers on:
   - How to handle and prepare the chemicals
   - How to trim, flesh and shave the hides
   - In general, AAT has to practice good house keeping.
2. It is advisable to establish a hide glue manufacturing plant in AAT
3. AAT should work with its suppliers of the raw hides on the curing and other better handling methods.

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