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Research Article

Assessment of Tannery Waste Management; The Case of Kombolcha Tannery in Kombolcha Town, South Wollo Administrative Zone of the Amhara National Regional State, North Central Part of Ethiopia: A Descriptive Cross-Sectional Study

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Abstract

Introduction: The tanning industry generates huge volume of wastes during leather manufacturing. However, almost all of these industries have no satisfactory waste treatment processes and hence, the environment is under extreme pressure from pollution by their subsequent wastes. The tanning industry is characterized as a pollutant-generating industry, which produce a wide variety of high-strength toxic chemicals. Therefore, to have evidence based analysis of these problems, the role of this study is vital.

Objectives: The study has aimed at assessing the exiting waste management practices of Kombolcha tannery in 2021.

Materials and Methods: A field test and laboratory-based cross-sectional studies were used to carry out assessment of the tannery's waste management system. The study was carried out from February 2021 to June 2021.

Result: The types of tannery wastes generated from Kombolcha tannery, as indicated by the study are wet-blue skin trimmings, shaving wastes, crust trimmings, finished leather trimmings and the waste effluents. Determination of solid waste generation rates using material balance analysis techniques showed that in processing 4,500 pieces of goat and sheep skins daily, the tannery generates 508.5kg of waste per day or 158,652kg of waste per annum, merely from the re-tanning and finishing stages of leather processing.

Conclusion: In order to decide the most appropriate strategies for successful waste management measures, it is highly important to acquire information concerning the process steps, from which these wastes are generated, the target product desired to be produced through these processes and the characteristics of these wastes.

Keywords: *Kombolcha Tannery; Waste Management Practices; Tannery Waste Management*

Abbreviations

BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; EPA: Environmental Protection Authority; ETP: Effluents Treatment Plant; FOG: Fats, Oils, or Grease; TDS: Total Dissolved Solid; TKN: Total Kjeldahl Nitrogen; TS: Total Solids

Introduction

Background information

Production of leather from raw hides and skins, byproducts of the meat industry, has been one of the most important industrial processes since ancient times. The Ethiopian leather industry is a relatively older industry with more than 80 years of involvement in processing leather [1]. Ethiopia is one of the leading countries that have the largest livestock populations in Africa and in the world, as well, providing a strong raw material base for the leather industry [1,2]. Its livestock population is estimated at 50 million cattle, 25 million sheep and 25 million goats [1]. This animal resource has encouraged the establishments of tannery industries in Ethiopia.

About 80% of all hides and skins entering the formal market come from rural areas where, they are collected by private traders. The remaining 20% are derived from slaughtering facilities found in major towns and cities. About 15.5 million pieces of sheep and goat skins and 1.2 million pieces of cattle hides are supplied to the tanneries per annum.

At present, there are 27 tanneries operating in the country, where most are privately owned, employing over 5,000 people and having a soaking capacity of 1.3 million pieces of hide and 32 million pieces of skins annually [1,2]. About one-third of these tanneries are found in Addis Ababa and its surrounding, the remaining two-thirds being distributed in the sub-country cities and towns. The existing daily soaking capacity of tanning industries is 145,524 pieces of skins and 7,800 pieces of hides [1]. The current production capacity based on the existing number of tanneries is estimated to exceed 8,000,000Kgs of hides and 25,000,000Kgs of skins [2].

Leather industries have been categorized as one of highly polluting industries; and they have adverse impact on the environment just because of the generation of liquid, solid and gaseous wastes. Since almost all of them have no satisfactory management systems, the environment is under extreme pressure from the mentioned wastes of leather manufacturing [3].

The effluents from these tanneries, containing hazardous chemicals of chrome, sulfides, minerals, and organic acids etc. are directly discharged to the nearby rivers without adequate treatment [4]. The wastes are hazardous and considerably higher compared to other main waste-generating industries in the country namely those of textiles, beverages, and sugar industries. The annual volume of liquid waste generated from these 27 tanneries, based on their annual production of processed leather is thought to exceed 2,500,000 cubic meters of waste [2].

Tanneries are also the major sources of highly toxic and hazardous solid wastes [5]. The solid wastes that are generated from leather processing plants are originated from the pre-tanning stages. These wastes are originated mainly from pre-fleshing, fleshing and trimming processes and they are characterized by high amount of fat contents [6]. Solid wastes of animal origin are powerful pollutants of water and produce odor when they decompose [5].

Kombolcha tannery, where our study has been carried out is one of the industries of the country engaged in the tanning process of raw hides and skins. It is a private share company which was established in 1967 G.C, having two separate processing plants in the towns of Kombolcha and Haik. The company processes hides and skins to semi-finished and finished leather and leather products for local and export purposes [5].

The tannery was established with the main objective of processing goat and sheep skins for export with an annual production capacity of 1.1 million. The tannery mainly specializes in the production of wet-blue goat skins. Daily attainable capacity of the tannery is 3,500 pieces of skin with normal and relaxed working conditions.

The supply of raw skins to Kombolcha tannery is from diverse sites such as South and North Wollo (60%) and other localities of Afar, Tigray, Addis Ababa, Gojjam and Gondar (40%). The tannery is known for its high quality goat skin production for export to the European markets, mainly to Italy [6].

Statement of the problem

Tanning industry is one of the oldest industries of the world and the problem of management and disposal of its wastes is probably as old as the industry itself [7]. It is typically characterized as pollutant-generating industry which produces a wide variety of high strength toxic chemicals. It is also recognized as a serious environmental threat due to high chemical levels including salinity, organic load (BOD and COD), inorganic matter, dissolved and suspended solids, ammonia, total Kjeldahl nitrogen (TKN), specific pollutants (sulfide, chromium, chloride, sodium and other salt residuals) and heavy metals etc.

The tanneries in many developing countries including Ethiopia are not well-mechanized and often use locally manufactured machineries that lack precision, resulting in the production of higher volume of waste. The less advanced the technology of the tanning process, the higher is the probable volume of the solid waste generated, leading to higher possibility of harming the environment [7]. Large quantity of water is used in tanning process, of which 90% of it is discharged as effluent. During the chrome tanning process, 40% unused chromium salts are usually discharged in the final effluents; causing a serious threat to the environment. Exposure to chromium, pentachlorophenol and other toxic pollutants increase the risk of dermatitis, ulcer nasal septum perforation and lung cancer. Without any exceptions, there is no effluent treatment plant (ETP) in leather tanning industries of the country and moreover, the owners of tanning industries are not much concerned about human health and environmental safety [8].

Those wastes, generated from leather manufacturing industries, being highly polluting industrial wastes, had to be managed in an environmentally-friendly manner. However, the solid wastes generated from Kombolcha tannery are collected and dumped in a specified dump site near the tannery and its liquid waste is discharged into a certain portion of land for land treatment without getting any further treatment prior to disposal, except some sort of physical treatment (sedimentation). These waste-receiving portions of the environment are not adequately farther from water courses and residential villages. As leather manufacturing industries mostly use heavy metals like chromium along with various toxic and hazardous chemicals [9], the residuals of these metals and chemicals can inevitably end up with the wastes of the tannery. As a result the soil, water, the ambient atmosphere and the general environment there around is at extreme pressure from pollution by these wastes and the residential villages near the tannery are victims of the noxious odor resulting from decomposition of its solid wastes [10].

Significance of the study

Despite the rapid expansion of industries including tanneries across the country, relevant and sustainable management systems for their consequent wastes are not yet been in place [11,12]. This may sometimes be attributed to lack of concern from research and academic institutions to carryout intense assessments in these industries for better understanding of the burden of the problem arising from their waste discharges.

While tanneries have been existed as one of the major areas of concern for research in environmental pollution studies, there are no evidences of earlier studies particularly for Kombolcha tannery. This is in fact, one that justifies why the study we have undertaken has been found important.

The tannery is also considered to be a major processing plant of most environmental significance over a range of other industries owing to the large quantity and high-strength hazardous wastes that it releases [9] and this had probably inspired us to carry out our research therein. The study was intended to investigate and analyze environmental suitability of the tannery's waste management systems associated with its overall leather production processes.

Had this study been undertaken, the findings are to serve as an initial scientific data capable of providing vital information on the existing real situations of the tannery for decision making and possible technical solutions frequently given for the tannery to help propose or facilitate future improvement measures.

Objectives of the Study

This study was done with the main objective of assessing the existing waste management practices of Kombolcha tannery in Kombolcha town, South Wollo Administrative Zone of the Amhara National Regional State, North central part of Ethiopia, 2021.

Specifically, the study was aimed at investigating the typical sources of wastes generated during leather manufacturing processes; determining the generation rate of solid wastes produced in the tannery; examining the characteristics of the wastes generated in the tannery; and describing the waste management systems practiced in the tannery.

Materials and Methods

Materials

Ice box; Sample bottles; Pocket balances/spring balances; Safety gloves; Crucibles; Conductivity meter; PH meter; Filter paper; Oven.

The Methods

Study type/study design: A field test and laboratory-based cross-sectional study design were employed.

Study area: The study area is Kombolcha tannery, a private share company having two processing plants for leather manufacturing in the towns of Kombolcha and Haik. However, this study is conducted with prior consideration of the processing stages and unit operations involved in Kombolcha. Kombolcha town is located in the North Central part of Ethiopia placed immediately South East of Dessie, the zonal seat of South Wollo Administrative Zone, in the Amhara National Regional State at 11°06' North latitude and 39°45' East longitude [13]. According to the 2007 population and housing census of Ethiopia, Kombolcha town is thought to have a total population of 58,673 of which 30,267 are females and 28,406 are males [14]. River Borkena crosses the town emerging from the east and running towards the West direction. Most of the factories including the leather tanning industry are found closely together in the middle of the town by nearby to the tributary rivers of Borkena River.

Variables of the study

- Independent variables are leather production capacity, water consumption rate, chemical consumption rate, the type of the raw material used; etc.
- Dependent variables are waste generation rates and physico-chemical characteristics of the wastes produced.

Data collection methods and tools: The data required for assessing the waste management practices of the tannery were collected with the aid of check lists, interviews and field observations. Laboratory examinations have also been made by taking the required samples from the tannery to examine the physico-chemical characteristics of the wastes.

Data processing, analysis and presentation: The data that have already been collected were properly handled, organized/sorted and processed manually just with the aid of sheets. Then, it has been attempted to present it using figures, tables, charts and the like as appropriate.

Sampling techniques

Liquid waste/waste water: Three sample stations along the waste stream were selected essentially due to the expected difference in their waste characteristics. The three sampling stations of the waste stream are the immediate exit site of the wastewater from the tannery, the equalization tank, and, the final sedimentation layer/tank from which the wastewater is ready for disposal.

Three samples of equal volume are taken from each one of the aforementioned sampling stations by using plastic sample bottles. Then, the samples were placed in an ice-box and are brought to the laboratory within 24 hours for laboratory analysis.

Solid wastes: Solid waste samples of the same amount are taken from the processing units of leather manufacturing, where there exists production of solid wastes. Then, these samples collected from separate units of leather processing are brought separately using plastic containers, to the laboratory for investigation.

Determination of the generation rate of tannery solid wastes

In order to determine the generation rates of each type of tannery solid wastes generated from the tanning industry, the following methods were used.

Based on random sampling technique, samples of ten pieces of wet-salted goat and sheep skins, being processed to produce finished leather for local and export purposes, were randomly taken at each unit operations of leather manufacturing processes, which are expected to generate solid wastes (i.e. skin trimming, shaving, crust trimming and finished leather trimming operational units) and then, material-balance-analysis techniques were applied to determine the generation rates of the solid wastes from the tannery.

Ethical statement: Before collecting the data, an ethical clearance was obtained from the research ethical review committee of CMHS, Wollo University. We have also received an approval letter of cooperation from executive bodies of Kombolcha Tannery to carry out the research therein. An oral consent has also been obtained from individuals working in each operational units of the Tannery, where the research has based.

Results and Discussion

The types and sources of tannery wastes

According to the study made at Kombolcha tannery Share Company, the waste types generated during leather manufacturing processes were found to be raw skin trimmings, shavings, crust trimmings, finished leather trimmings and waste effluents. Moreover, sludge and other suspended solid waste matter are also generated during primary effluent treatment process. The main source of solid waste production was found to be trimming, which is carried out in chrome shaving after the chrome tanning process, crust trimming after the re-tanning process, finished leather trimming after the finishing processes and the primary effluent treatment plant. On the other hand, the main sources of the waste water effluents were found to be re-chrome processes, neutralizing, re-tanning, dyeing, fat liquoring, fixing, washing and the like; all of which are carried out in the re-tanning processes of leather manufacturing.

Solid waste generation rate of the tannery

The waste generation rates found in different stages of tannery processes per a single piece of raw skins processed are given in the following successive tables (Table 1-5).

Wet-blue skin trimmings

Usually, raw wet-blue skins, passing across a series of beam house processes are trimmed to remove some unwanted parts of the skin just before they are going to be washed. Hence, to determine the solid waste generated as a raw wet-blue skin trimming per a single piece of skins processed, ten randomly selected pieces of wet-blue skins prepared for washing, were taken and weighed before and after the trimming operation. The results obtained are given in table 1.

S. No. of the sampled pieces of wet-blue skins	Weight of a single piece of wet-blue skin before trimming (Kg)	Weight of a single piece of wet-blue skin after trimming (Kg.)	Weight of raw skin trimmings generated (Kg/a single piece of wet-blue skin)
1	1.800	1.785	0.015
2	1.750	1.735	0.015
3	1.815	1.800	0.015
4	1.845	1.840	0.005
5	1.735	1.730	0.005
6	1.830	1.825	0.005
7	1.820	1.810	0.010
8	1.815	1.810	0.005
9	1.790	1.765	0.025
10	1.815	1.800	0.015
Average	1.802	1.790	0.012

Table 1: *Wet-blue skin trimmings generated per a single piece of wet-blue skins processed.*

As it can be seen from table 1 above, 0.012 Kg of solid wastes on average, in the form of raw skin trimmings, are generated per a single piece of raw wet-blue skins processed. It means that nearly 0.007 kg of raw skin trimming wastes are generated per kilogram of raw wet-blue skins processed during the raw skin trimming process. This implies that 54 Kg of raw skin trimmings are generated per day from the tannery having a daily soaking capacity of 4,500 pieces (8,109 Kg) of raw wet-blue skins. Other studies revealed a generation rate of 20.00 kg of raw skin trimmings per day per 1000.00 kg of wet salted sheep skin [1].

Shaving wastes

In order to determine the generation rate of the solid wastes from the shaving operation generated per a single piece of wet-salted skins processed, ten pieces of crust leather prepared for the shaving process, were randomly sampled and weighed before and after the shaving process. Table 2 shows the results obtained from the study.

As it can be shown in table 2 above, 0.039 Kg of dry shaving wastes are generated per a single piece of wet-salted skin processed. It means that nearly 0.022 kg of dry shaving wastes are generated per kilogram of wet–salted skins processed. Other studies revealed a generation rate of 0.032 kg of chrome shaving wastes per kilogram of wet-salted skins processed [15]. This result indicates that Kombolcha tannery with a daily soaking capacity of 4,500 pieces of wet-salted skins generates 175.5 Kg of dry shaving waste.

Crust trimmings

Crust trimmings are one form of tannery solid wastes generated during a trimming process in an attempt to remove some unwanted parts of the crust leather. To determine the generation rate of the crust trimmings waste generated per a single piece of wet-salted skins

S. No. of the sampled pieces of wet-salted skins	Weight of a single piece of wet-salted skin (Kg)	Weight of a single piece of crust skin before shaving (Kg)	Weight of a single piece of crust skin after shaving (Kg)	Weight of dry shaving wastes generated (Kg/a single piece of wet-salted skins)
1	1.800	0.148	0.100	0.048
2	1.750	0.152	0.115	0.037
3	1.815	0.163	0.095	0.068
4	1.845	0.157	0.120	0.037
5	1.735	0.149	0.100	0.049
6	1.830	0.168	0.095	0.073
7	1.820	0.153	0.132	0.021
8	1.815	0.164	0.135	0.029
9	1.790	0.153	0.140	0.013
10	1.815	0.162	0.150	0.012
Average	1.802	0.157	0.118	0.039

Table 2: *Dry shaving wastes generated per a single piece of wet-salted skins processed.*

processed, ten samples of pieces of crust leather were randomly selected followed by their weight measurement before and after the trimming process. Table 3 presents the results obtained from the measurements.

S. No. of the sampled pieces of wet-salted skins	Weight of a single piece of wet-salted skins (Kg)	Weight of a single piece of crust skin before trimming (Kg)	Weight of a single piece of crust skin after trimming (Kg)	Weight of crust trimmings waste generated (Kg/a single piece of wet-salted skin)
1	1.800	0.324	0.259	0.065
2	1.750	0.205	0.194	0.011
3	1.815	0.251	0.199	0.052
4	1.845	0.317	0.187	0.130
5	1.735	0.280	0.196	0.084
6	1.830	0.205	0.167	0.038
7	1.820	0.320	0.286	0.034
8	1.815	0.200	0.150	0.050
9	1.790	0.250	0.190	0.060
10	1.815	0.253	0.188	0.065
Average	1.802	0.261	0.202	0.059

Table 3: *Solid wastes of crust trimmings generated per a single piece of wet-salted skins processed.*

Table 3 shows that 0.059 Kg of crust trimmings waste is generated per a single piece of wet-salted skins processed. It means that nearly 0.033 kg of crust trimmings waste is generated per kilogram of wet-salted skins processed. A result from other study showed a genera-

tion rate of 0.012 kg of crust trimmings waste per kilogram of wet-salted skins processed [15]. Hence, it can be understood that 265.5 Kg of solid wastes are generated each day, exclusively from its crust trimming unit operation of leather manufacturing by a tannery having a daily soaking capacity of 4,500 pieces of raw skins.

Finished leather trimmings waste

To determine the amount of solid wastes contributed from finished leather trimmings per a single piece of wet-salted skins processed, ten samples of pieces of finished leathers which are readily prepared for trimming, were randomly taken with subsequent measurement of their weights before and after the trimming process. The results obtained are presented in table 4.

S. No. of the sampled pieces of wet-salted skins	Weight of a single piece of wet-salted skin (Kg)	Weight of a single piece of finished leather before trimming (Kg)	Weight of a single piece of finished leather after trimming (Kg)	Weight of finished leather trimmings waste generated (Kg/ a single piece of wet-salted skin)
1	1.800	0.176	0.170	0.006
2	1.750	0.160	0.159	0.001
3	1.815	0.155	0.153	0.002
4	1.845	0.180	0.175	0.005
5	1.735	0.156	0.150	0.006
6	1.830	0.161	0.160	0.001
7	1.820	0.158	0.154	0.004
8	1.815	0.165	0.163	0.002
9	1.790	0.159	0.155	0.004
10	1.815	0.164	0.161	0.003
Average	1.802	0.163	0.160	0.003

Table 4: *Finished leather trimmings waste generated per a single piece of wet-salted skins processed.*

From the data that can be seen in table 4, one can understand that 0.003 kg of finished leather trimmings are generated while processing a single piece of wet-salted skin. It really means that nearly 0.002 kg of finished leather trimmings waste is generated per a kilogram of wet–salted skins processed. Another study revealed a generation rate of 0.009 kg of finished leather trimmings waste per kilogram of wet-salted skins processed [15]. This clearly indicates that 13.5 Kg of solid wastes can be generated from a tannery having a daily soaking capacity of 4,500 pieces of skins, as finished leather trimmings.

In general, the generation rate of the main types of tannery solid wastes generated during the re-tanning and finishing stages of sheep and goat skin processing are summarized as follows in table 5.

From table 5, it can be seen that processing one piece of raw skin generates 0.113 Kg of solid waste. Equivalently, it does mean that processing a kilogram of raw skins of goats and sheep generates nearly 0.063 kg of solid waste which is 6.3% of the total weight of goat/sheep skin processed, just only from the four unit operations of the tannery considered. It is about 0.066 Kg of solid waste per a kilogram of raw skins of goats and sheep (accounting to 6.6% of the total weight of goat/sheep skin processed) revealed by other study from similar

S. No.	Types of tannery solid wastes	Solid wastes generated per a single piece of raw skins processed (Kg/piece)	Solid waste generation rate per day (Kg/day)
1	Wet-blue trimmings	0.012	54
2	Shaving wastes	0.039	175.5
3	Crust trimmings	0.059	265.5
4	Finished leather trimmings	0.003	13.5
Total		0.113	508.5

Table 5: *Solid waste generation rate, by Kombolcha tannery, during the re-tanning and finishing stages of leather processing.*

unit operations of ELICO tannery [1]. Given that the daily soaking capacity of Kombolcha tannery is 4,500 pieces of skins, 508.5 Kg of solid wastes are generated by the tannery each day. Taking in to account 312 working days in a year, it represents that the tannery generates 158,652 Kg of solid wastes per annum during the re-tanning and finishing stages of leather manufacturing. This volume of solid waste goes nowhere else; it is disposed to an open dumping site, just somewhere near the tannery.

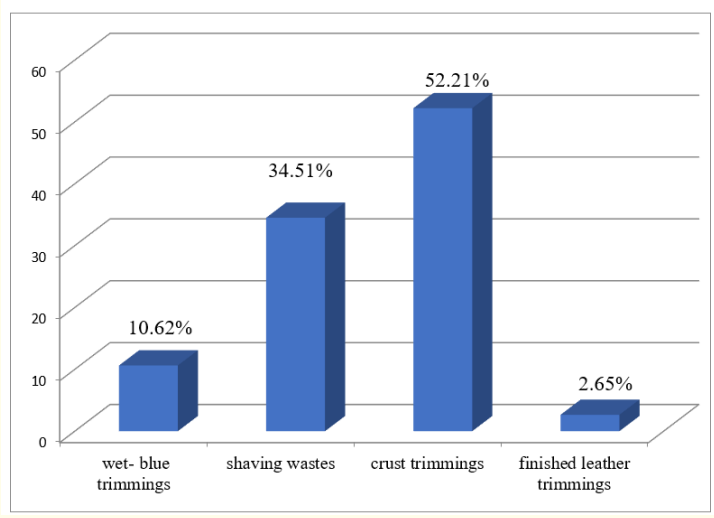

Figure 1: *The percentage share of each types of solid wastes generated in Kombolcha tannery.*

Since the leather processing plant in Kombolcha involves only the re-tanning and finishing stages of leather manufacturing, the percentage share of these processing stages in generating solid wastes are displayed in the figure below (Figure 2).

Physico-chemical tests of tannery solid wastes

PH

From the laboratory result, it has been observed that the pH values for most of solid waste types of the tannery fall in the range to which the skins are processed in their respective unit operations. The chart below (Figure 3) shows pH values for the identified types of tannery solid wastes generated from Kombolcha tannery.

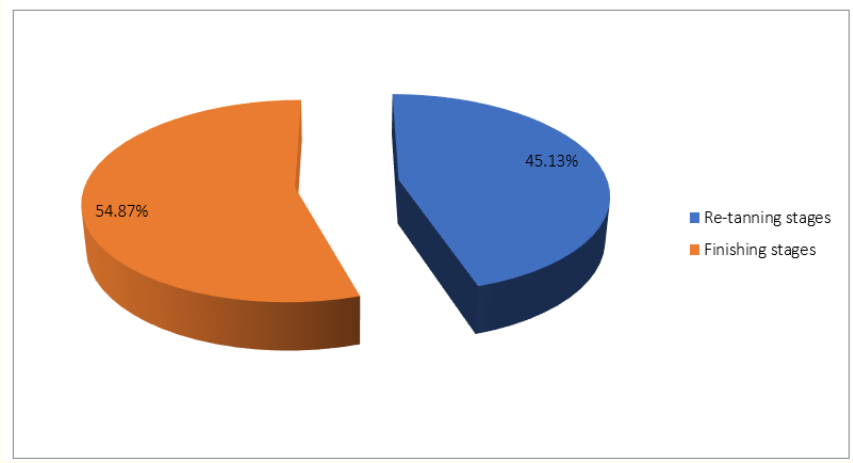

Figure 2: *Percentage share of the available leather processing stages in generating solid wastes.*

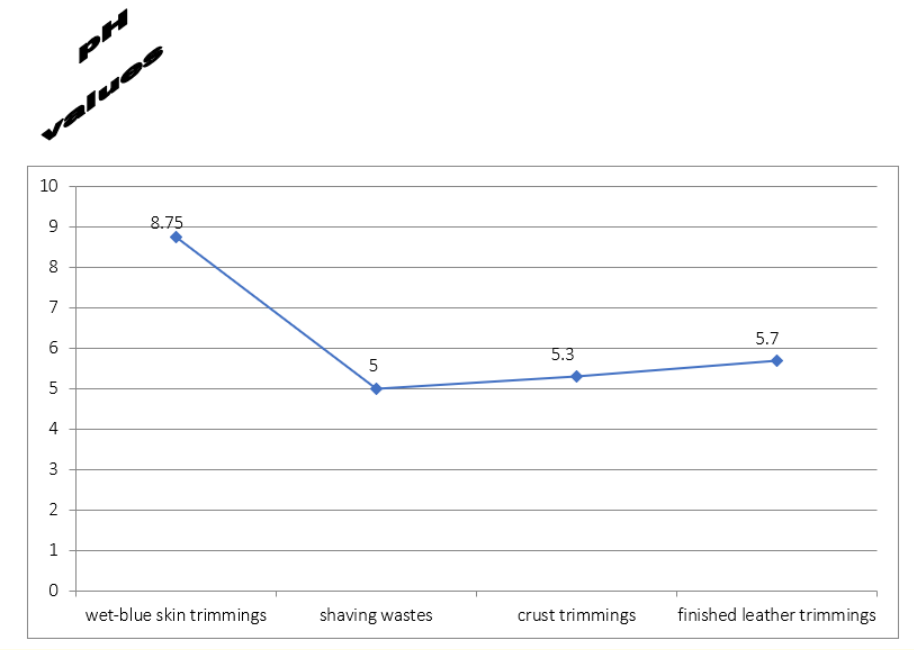

Figure 3: *The trend of PH values for tannery solid wastes of Kombolcha tannery.*

As it can be observed from the chart above (Figure 3), shaving wastes, crust trimmings and finished leather trimmings bear an acidic pH values. It is because; leather processing operations producing these wastes are carried out at acidic conditions [1]. On the contrary, wet-blue skin trimmings, generated from the trimming unit operation of the tannery, which operates at alkaline conditions, bear a waste of alkaline pH. Almost similar PH variations have been recorded along these waste types in other studies [12,16].

Conductivity

Conductivity test made at a unit sample of tannery solid wastes, composed from equal amounts of each solid waste type revealed a value of 756.5 µS/cm. This indicates that the availability of chemicals as anions and cations were higher in the solid wastes generated from the tannery [17,18]. This higher conductivity value alters the chelating properties of water bodies when getting access to water courses through run-off [1,19]. As a result, it will create an imbalance of free metal availability for flora and fauna [20].

Total solid and moisture content

A laboratory test made to determine the total solids of tannery solid wastes revealed 83% by weight of the solid waste sample being investigated. The remaining 17% by weight of the solid waste sample is lost as moisture through evaporation in the oven. The total solids of the wastes are higher that might probably be due to the production of the wastes from dry processing stages. The properties of the solids present in tannery solid wastes mainly depend upon the nature and quality of hides and skins processed in the tannery [21]. Even though the moisture content obtained from the laboratory test is not as such higher, high moisture content of tannery solid wastes cause infusion of the chemicals into soil, surface and ground water; causing the deterioration of the natural structures of the waste receiving environments [1].

Laboratory analysis of tannery waste effluents

In this study, three samples from each sampling station, across the waste stream were investigated for their physic-chemical characteristics such as pH, TS, TSS, TDS and electrical conductivity. The results obtained from the study are shown in table 6.

Parameters	Sampling stations of the waste effluent		
	The immediate exit site	Aeration tank	The final route to disposal
pH	7.51	7.643	7.647
Total solids	3678.05	3026.77	2981.77
TSS	721.87	691.37	673.7
TDS	2956.18	2335.4	2308.07
Conductivity	8076.27	7986.83	7925.87

Table 6: *Laboratory results for the physic-chemical characteristics of waste effluents from Kombolcha tannery [all in (mg/L) except for pH and conductivity, conductivity in (µS/cm)].*

As we can understand from table 6, the pH values for the waste effluents getting out of Kombolcha tannery falls in the range 7.51-7.65 on average. This could explain high counts of microorganisms, for most of them are more likely to thrive well in such pH values. As we can see from the results, the tannery effluents, as passing through certain treatment processes, approaches slightly to be alkaline. Discharge of these wastes with alkaline pH may be detrimental to aquatic life such as zooplankton and fishes. However, no matter how detrimental the effluents are to the aquatic biota, their pH values are really in the range of the discharge limits in Ethiopian context [13]. The alkaline nature of tannery effluents may be attributable to the presence of carbonates and bicarbonates in the effluent.

The total solids of tannery effluents are determined as to be in the range of 2981.77 to 3678.05 mg/L, which very much exceeds the permissible limit (110 mg/L) [9]. These solid impurities cause turbidity in the receiving streams, when getting access to water courses.

In a similar occasion, the average levels of suspended solids in waste effluents of Kombolcha tannery were found to be higher (673.7 - 721.87mg/L) when compared to the permissible limit (100 mg/L) for effluent discharge. High amounts of suspended particles have detrimental effects on aquatic flora and fauna and reduce biodiversity in the aquatic system. High levels of total suspended solids in tannery effluents could be ascribed to their accumulation during the processing of finished leather [9].

The total dissolved solids of the effluents released from Kombolcha tannery are found to exceed 2308.07 mg/L and may range up to 2956.18 mg/L. This result is significantly greater, than the tolerance limit which is 2100 mg/L [1,9]. High levels of TDS are aesthetically unsatisfactory and may also produce distress in human and livestock. Total dissolved solids are mainly due to carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates, etc. The presence of TSS and TDS in higher levels may also be attributed to the insoluble organic and inorganic matter present in the effluent.

Electrical conductivity test for the waste effluents of the tannery revealed a value within the range of 7925.87 µS/cm to 8076.27 µS/cm. This higher level of electrical conductivity may really be due to high concentrations of acids, bases and salts within the effluents.

In sum, if a tannery effluent is discharged without any treatment, it reduces the growth of phytoplankton, bacteria, and fish in the receiving water body. The nature and quality of hides and skin determine the composition of solids in the tanning effluent. The maximum concentrations of physicochemical parameters are more likely observed either in the liming/unhairing or in the chrome tanning processes owing to the fact that most of the chemicals were used in these tannery processes [22].

Tannery waste management practices in Kombolcha tannery share company

Industrial wastes in general and tannery wastes in particular, need special attention of management, due to the fact that they are hazardous and health threatening for human being and the environment. However, an assessment on the existing waste management practices of Kombolcha tannery Share Company has shown that all the wastes (both solid and liquid wastes) generated during leather manufacturing processes of the tannery are being managed in a way that wouldn't grant future continuity of the vicinity. No matter what the types and characteristics of tannery solid wastes are, they are simply collected and dumped in an open dumping area just near the processing plant. In the same way, the liquid waste discharged from the tannery is conveyed to a certain sedimentation process after which it is directly released to the plants to be up taken by them. Unfortunately, the areas where dumping of solid wastes and discharging of tannery effluents for land treatment take place, are found at a near distance from a stream called "EYOLIE", a tributary of "BORKENA" river, so that leakage of the waste water and entrance of the solid wastes through runoff are inevitable pollution threats.

Conclusion

The study results obtained from the assessment of tannery waste management in Kombolcha tannery lead to the following conclusions.

The major types of wastes generated during leather manufacturing processes of Kombolcha tannery are found to be wet-blue skin trimmings, shaving wastes, crust trimmings, finished leather trimmings and waste effluents. The trimming operational unit of leather processing is identified as the main source of solid waste production. On the other hand, the waste effluents are sourced mainly from the re-tanning stage of leather processing such as re-chroming, neutralizing, re-tanning, dyeing, fat-liquoring, fixing, washing and the like.

In processing 4,500 pieces of goat and sheep skins daily, the tannery generates about 508.5 kg of solid waste every day, only from the re-tanning and finishing stages of leather processing. This implies that the tannery is generating 158,652 kg of solid wastes annually

within 312 working days. From this finding, anyone can easily imagine how much the generation rate will be, if combined with the wastes of the beam house processes, where, they are believed to be leather processing stages of more waste production. Wet-blue skin trimmings, shaving wastes, crust trimmings and finished leather trimmings account 10.62%, 34.51%, 52.21% and 2.65% by weight of the total waste mass generated from the tannery respectively.

It has been observed from the physic-chemical tests of tannery wastes that the pH values for most of the wastes fall in the range at which inputs for the tanning process are processed in their respective unit operations. The availability of chemicals in the form of ions and cations have been found higher, giving rise for higher waste conductivity. It has also been found that 17% by weight of the total solid waste accounts for its moisture content.

Despite the ultimate need of managing tannery wastes, no proper waste management procedures are observed in the case of Kombolcha tannery. The liquid wastes are directly discharged to the nearby plants for uptake except perhaps subjected to a certain sedimentation process. At the same time, the solid wastes are collected in a certain dumping area near the tannery. This all poses pollution potential for the vicinity resulting from the natural processes of the waste that it undergoes.

In sum, the results of this study have revealed that the tanning industry generates wastes of different characteristics inherited from the conditions of the operational units, from which they are generated. Therefore, in order to determine the most appropriate waste management strategies, it is highly important to acquire the information concerning the processes undertaken in these unit operations, the target product desired to be produced through these processes, and the waste characteristics.

Recommendations

Environmental safety rules have to be strictly enforced by Environmental Protection Authority (EPA). The tannery shall better be fitted with proper waste treatment plant. The tannery shall adapt regular effluent quality assurance tests, in a well-organized laboratory, before releasing its waste directly to any part of the environment. Practically oriented training has to be given for the concerned bodies of the tannery on how to implement proper waste management strategies. Enabling conditions has to be arranged for entrepreneurs to promote utilization of tannery wastes for the generation of energy and recycling into other valuable products. It is better for the tannery if it could include waste management division in its organizational structure to realize proper waste management system and environmental safety.

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Conflict of Interest

We, the authors have declared that no financial or competing interests exist.

Bibliography

1. Abajihad Z. "Assessment of tannery solid waste management and characterization Case of Ethio-Leather Industry Private Limited Company (ELICO)" (2012).

2. Faris K., *et al*. Human and Other Liquid Waste Management. Jimma University In collaboration with the Ethiopian Public Health Training Initiative, The Carter Center, the Ethiopian Ministry of Health, and the Ethiopian Ministry of Education (2002).

3. Tare V., *et al*. Case Studies on Biological Treatment of Tannery Effluents in India Case Studies on Biological Treatment of Tannery Effluents in India (2012): 2247.

4. Mwinyihija M. Pollution Control and Remediation of the Tanning Effluent Pollution Control and Remediation of the Tanning Effluent (2015).

5. Hasnat A., *et al*. "Assessment of Environmental Impact for Tannery Industries in Bangladesh". *International Journal of Environmental Science and Technology* (2013): 217-220.

6. Getahun E. "Experimental Investigation and Characterization of Biodiesel Production from Leather Industry Fleshing Wastes". *International Journal of Sustainable Energy* 2.3 (2013): 120.

7. Buljan J. "Costs of tannery waste treatment". *Leather Wall Panels Manufacturers and Suppliers in India* (2005): 1-25.

8. Solomon M. "Short communication: Impact of ectoparasite control campaign on quality of processed skins in tanneries of the Amhara Regional Government: a rapid assessment". *Ethiopian Veterinary Journal* 15.1 (2011).

9. Azom MR., *et al*. "Environmental Impact Assessment of Tanneries: A Case Study of Hazaribag in Bangladesh". *International Journal of Environmental Science and Development* 3.2 (2012): 152-156.

10. Sarker BC., *et al*. Chromium effects of tannery waste water and appraisal of toxicity strength reduction and alternative treatment 3.11 (2013): 23-35.

11. Oruko RO., *et al*. Investigating the chromium status, heavy metal contamination, and ecological risk assessment via tannery waste disposal in sub-Saharan Africa (Kenya and South Africa (2021): 42135-42149.

12. Framis CP. Assessment of tannery solid waste management, A case of Sheba Leather Industry in Wukro (Ethiopia) (2018): 1-92.

13. Zinabu E., *et al*. Assessment of the Impact of Industrial effluents on the Quality of Irrigation Water and Changes on Soil Characteristics: A case of Kombolcha town (2008).

14. Statistical C and Authority. Population and Housing Census of Ethiopia Administrative Report (2012).

15. Tesema BH. Tannery Solid Waste Generation Rate and Preparation of Leather Board from Chrome Shaving Waste and Plant Fibersa Wealth From Waste Approach (2018).

16. Oruko RO., *et al*. Assessment of Tannery Based Solid Wastes Management In Asili, Nairobi Kenya 8.2 (2014): 227-238.

17. Nutrient and enzymatic changes of hydrolysed tannery solid waste treated with epigeic earthworm *Eudrilus eugeniae* and phytotoxicity assessment on selected commercial crops (2014): 641-651.

18. Hashem MA., *et al*. "Composting of limed fleshings generated in a tannery: sustainable waste management". *Environmental Science and Pollution Research* (2023): 0123456789.

19. Nigam M., *et al*. "Comprehensive technological assessment for different treatment methods of leather tannery wastewater". *Environmental Science and Pollution Research* (2022).

20. Vijayaraj AS., *et al*. "Effective bioremediation and toxicity assessment of tannery wastewaters treated with indigenous bacteria". *3 Biotech* 8.10 (2018): 1-11.

21. Arceivala Soli J and Shyam R Asolekar. "Wastewater Treatment for Pollution Control and Reuse". McGraw Hill Education (India) Private Limited (2007).

22. Shakil S., *et al*. "Assessment of physicochemical parameters and trace elements in tannery wastewater treatment facility and associated health risks". *International Journal of Environmental Science and Technology* (2023).

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