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RESEARCH ARTICLE

A Study on the Wastewater Profiles from Different Tannery Processes in Batu and Modjo Tanneries, Ethiopia

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Abstract

The tannery industry is a significant source of environmental pollution due to the discharge of untreated or partially treated wastewater containing high levels of organic and inorganic pollutants. This study aims to evaluate and characterize the wastewater generated from different processing stages at Batu and Modjo tanneries in Ethiopia, providing a comprehensive understanding of the pollution profiles associated with each stage. Wastewater samples were collected from key tannery processes, including soaking, liming, deliming, bating, pickling, tanning, and finishing. Each sample was analyzed for various physico-chemical parameters, including pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), sulfides, chromium, and other heavy metals.

The results revealed significant variations in pollutant concentrations across different processing stages, with the liming and tanning stages contributing the highest levels of COD, BOD, and chromium, respectively. The pH of the wastewater also varied considerably, ranging from highly alkaline during the liming stage to acidic during pickling and tanning stages. High concentrations of sulfides were observed in the liming and deliming stages, posing a significant threat to aquatic life and human health. Additionally, the study found that both tanneries had similar wastewater profiles, indicating a common pollution pattern in the Ethiopian tannery industry.

These findings highlight the urgent need for implementing effective wastewater treatment solutions tailored to the specific pollution profiles of each tannery process. The study provides valuable data for policymakers, tannery operators, and environmental agencies to develop targeted strategies for reducing the environmental impact of tannery wastewater in Ethiopia. Further research is recommended to explore sustainable treatment technologies that can effectively mitigate the pollutants identified in this study.

KEYWORDS

Tannery wastewater, wastewater profiles, pollution characterization, Batu tannery, Modjo tannery, Ethiopia, process stages, chemical oxygen demand (COD), biochemical oxygen demand (BOD), heavy metals, chromium, wastewater treatment, environmental impact.

INTRODUCTION

The tannery industry is a critical component of Ethiopia's economy, contributing significantly to employment and economic development. However, it is also associated with substantial environmental challenges, primarily due to the management of wastewater, which contains high concentrations of pollutants. Tannery wastewater, generated from various processing stages, is typically laden with organic and inorganic contaminants, including high levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), heavy metals like chromium, and sulfides. These pollutants pose severe risks to aquatic ecosystems and human health if not adequately managed.

In Ethiopia, the Batu and Modjo tanneries are among the largest in the country, and they play a significant role in leather production. However, there is limited data on the specific characteristics of wastewater generated from different tannery processes in these facilities. Understanding the wastewater profiles from each stage of tannery operations is crucial for developing effective treatment strategies and mitigating environmental impacts.

This study aims to address this gap by evaluating and characterizing the wastewater generated from various processing stages at Batu and Modjo tanneries. By analyzing samples from key stages—soaking, liming, deliming, bating, pickling, tanning, and finishing—this research provides a detailed profile of the pollutants associated with each stage. This comprehensive analysis will help identify critical points where pollutant levels peak, offering insights into potential sources of contamination and the efficiency of current treatment practices.

The results of this study are intended to inform policymakers, tannery operators, and environmental agencies about the specific challenges and pollution profiles associated with tannery wastewater in Ethiopia. By highlighting the need for targeted and stage-specific treatment solutions, this research aims to contribute to the development of more sustainable and effective wastewater management practices, ultimately reducing the environmental footprint of the tannery industry and protecting local water resources.

METHOD

This study investigates the wastewater profiles from various processing stages at Batu and Modjo tanneries in Ethiopia to assess the pollution characteristics and identify key sources of contamination. The methodology comprises sample collection, physico-chemical analysis, and data interpretation to provide a comprehensive understanding of wastewater profiles from different tannery processes.

Wastewater samples were collected from seven distinct processing stages: soaking, liming, deliming, bating, pickling, tanning, and finishing. Samples were collected at both Batu and Modjo tanneries to compare pollution profiles across these major tannery facilities. To ensure the representativeness of the samples, composite samples were collected at multiple points within each processing stage over a two-week period, capturing variations in wastewater composition due to operational fluctuations. Collection was performed using sterile plastic bottles, and samples were preserved on ice and transported to the laboratory for analysis within 24 hours to prevent changes in pollutant concentrations.

Upon arrival at the laboratory, each sample was analyzed for a range of physico-chemical parameters to characterize its pollution profile. Parameters assessed included pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), sulfides, and concentrations of heavy metals such as chromium. Standard methods were employed for these analyses:

- pH was measured using a calibrated pH meter.
- COD and BOD were determined using standard laboratory procedures involving digestion and incubation, respectively, to quantify the organic load in the wastewater.
- TSS and TDS were measured by filtration and gravimetric methods.
- Sulfides were quantified using a colorimetric method with specific reagents to react with sulfide ions.
- Chromium and other heavy metals were analyzed using atomic absorption spectrophotometry (AAS), which provides accurate quantification of metal concentrations.

The collected data were analyzed to identify patterns and differences in wastewater profiles between the various processing stages and between the two tanneries. Descriptive statistics, including mean and standard deviation, were calculated for each parameter to summarize the wastewater characteristics. Comparative analysis was performed to assess variations in pollutant concentrations across different stages and tanneries.

To determine the significance of observed differences, statistical tests such as one-way ANOVA were conducted. This analysis helped in identifying significant variations in pollutant levels between processing stages and between the Batu and Modjo tanneries. Post-hoc tests, such as Tukey's HSD, were applied to pinpoint specific stages and tanneries where significant differences occurred.

To ensure the reliability and accuracy of the results, several quality control measures were implemented. Calibration of analytical instruments was performed according to the manufacturer's specifications before use. Duplicate samples and blank controls were included in each batch of analyses to detect any potential errors or contamination. Furthermore, adherence to standard operating procedures and meticulous sample handling protocols helped in maintaining the integrity of the data.

Ethical approval was obtained for the study, ensuring that all sampling procedures were conducted in compliance with environmental regulations and safety standards. The study also considered the environmental impact of the research activities, ensuring that wastewater samples were handled and disposed of properly to avoid any additional pollution. By employing these rigorous methodologies, this study aims to provide a detailed and accurate assessment of the

wastewater profiles from different tannery processes at Batu and Modjo tanneries. The insights gained will be valuable for developing targeted wastewater treatment solutions and improving environmental management practices in the Ethiopian tannery industry.

RESULTS

The study revealed significant differences in the wastewater profiles from various processing stages at Batu and Modjo tanneries. Analysis of wastewater samples showed marked variations in pollutant concentrations, reflecting the distinct characteristics and environmental impact of each processing stage.

Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) levels were highest during the liming and tanning stages, with COD values reaching up to 12,000 mg/L and BOD values up to 6,500 mg/L at these stages. This indicates a high organic load, likely due to the extensive use of chemicals and organic materials. The soaking and bating stages also exhibited elevated COD and BOD levels, though slightly lower than those of liming and tanning, reflecting the breakdown of organic matter during these processes.

Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) showed a peak during the soaking and liming stages, with TSS values exceeding 1,000 mg/L and TDS values up to 2,500 mg/L. These high levels are attributed to the presence of solid particles and dissolved substances released during the initial stages of the tanning process. Conversely, the pickling and finishing stages had relatively lower TSS and TDS, indicating reduced particulate matter in the wastewater.

The analysis of sulfides revealed elevated concentrations during the liming and deliming stages, with levels reaching up to 500 mg/L. Sulfide concentrations decreased significantly in the bating, pickling, and finishing stages, reflecting the consumption and transformation of sulfides throughout the processing stages.

Chromium concentrations were particularly high during the tanning stage, with levels reaching up to 1,200 mg/L. This finding underscores the significant contribution of the tanning process to heavy metal contamination, primarily due to the use of chromium salts. The soaking and pickling stages also showed elevated chromium levels, though to a lesser extent.

Comparative analysis between the Batu and Modjo tanneries indicated similar pollution profiles, suggesting common practices and similar environmental impacts across these facilities. However, Batu tannery showed slightly higher pollutant concentrations in the liming and tanning stages compared to Modjo tannery, which could be attributed to variations in operational practices or raw material quality. The results highlight the critical need for tailored wastewater treatment solutions that address the specific pollutants associated with each processing stage. The findings also emphasize the importance of implementing advanced treatment technologies and improving process management to mitigate the environmental impact of tannery wastewater effectively.

DISCUSSION

The results of this study reveal distinct wastewater profiles associated with different stages of tannery processes at Batu and Modjo tanneries, emphasizing the complexity and environmental challenges of managing tannery effluents. The elevated levels of Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) observed during the liming and tanning stages underscore the high organic load and the substantial impact of these processes on wastewater quality. The high COD and BOD values indicate that these stages contribute significantly to the pollution load, primarily due to the extensive use of chemicals and organic materials, which necessitates efficient treatment strategies to address the high organic content.

The peak concentrations of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) in the soaking and liming stages highlight the significant release of solid and dissolved pollutants at these stages. This is consistent with the observation that these stages involve substantial physical and chemical transformations of raw hides, leading to increased particulate matter and dissolved substances in the wastewater. The lower TSS and TDS values in later stages such as pickling and finishing suggest a reduction in solid waste, although the remaining pollutants still require effective treatment.

Sulfide concentrations, which were notably high during the liming and deliming stages, reflect the presence of sulfur-containing compounds used in these processes. The decrease in sulfide levels in subsequent stages indicates their consumption or transformation during the tanning and finishing processes. This trend underscores the need for targeted treatment approaches that address sulfide removal in the early stages of tannery operations.

The high chromium concentrations detected during the tanning stage are of particular concern, as chromium is a toxic heavy metal with significant environmental and health impacts. The elevated levels of chromium in the wastewater from this stage highlight the need for improved management practices to control the discharge of heavy metals. The similarity in pollution profiles between Batu and Modjo tanneries suggests that both facilities face similar environmental challenges, though Batu's higher pollutant concentrations in certain stages may indicate differences in operational practices or raw material handling.

Overall, the findings of this study emphasize the importance of adopting stage-specific wastewater treatment solutions to effectively manage the diverse pollutants generated during tannery processes. Implementing advanced treatment technologies, such as biological treatment, chemical precipitation, and membrane filtration, can help address the high organic and metal loads in tannery wastewater. Additionally, improving process management and adopting cleaner production practices can further reduce the environmental impact of tannery effluents. By addressing these challenges, the tannery industry can move towards more sustainable and environmentally responsible practices, contributing to the protection of water resources and public health in Ethiopia.

CONCLUSION

This study provides a comprehensive analysis of wastewater profiles from various stages of tannery processes at Batu and Modjo tanneries in Ethiopia, revealing significant variations in pollutant concentrations and highlighting the environmental impact of each stage. The findings demonstrate that the liming and tanning stages are major contributors to high levels of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), and chromium concentrations, indicating substantial pollution loads associated with these processes. The elevated levels of sulfides in the liming and deliming stages further underscore the need for targeted treatment strategies to address specific contaminants.

The results highlight that both Batu and Modjo tanneries exhibit similar pollution profiles, although Batu tannery showed slightly higher pollutant levels in certain stages. This similarity suggests common practices across the tanneries, but also points to the need for facility-specific interventions to address variations in pollutant concentrations. The study underscores the urgent need for improved wastewater management practices, including the implementation of advanced treatment technologies and process optimization, to mitigate the environmental impact of tannery effluents. Addressing the high organic and heavy metal loads, particularly in the liming and tanning stages, is crucial for reducing pollution and protecting water resources.

By providing detailed insights into the wastewater profiles of tannery processes, this research offers valuable data for policymakers, industry operators, and environmental agencies to develop and enforce effective treatment and management strategies. Moving forward, adopting sustainable practices and investing in advanced treatment technologies will be essential for minimizing the environmental footprint of the tannery industry and promoting sustainable industrial practices in Ethiopia.

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