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Quantification Of Solid Leather Waste And Waste Mitigation Methods Used In The Zimbabwean Leather Industry: A Case Study

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ABSTRACT

The production processes involved in the manufacture of leather have an adverse negative effect on the environment which can be attributed to the high levels of solid, liquid and gaseous emissions generated during these processes. Literature says that, about 75% out of a tonne of raw hides is not utilised but remains as waste. Of the generated waste approximately 50% is considered hazardous as the waste is mainly from tanning and post tanning operations and thus may contain chromium. It is in this regard that a study was carried out to quantify the levels of solid waste being generated as well as the waste mitigation efforts being used, if any, in the Zimbabwean leather industry. This study analysed the actual processes performed in some of the still functioning tanneries in Zimbabwe in order to propose tannery solid waste management practices. The main aim of this study therefore, was to gather accurate and useful data of the nature and amount of solid waste generated during leather making operation from raw hides and skins input to finished leather. To achieve these goals, 3 tanneries were visited across Zimbabwe. This enabled to have a first-hand experience and also facilitated an in-depth study of the chosen facilities. A diagnostic industrial survey was conducted using both quantitative and qualitative methods. From these findings, it was clear that there exists a gap in waste mitigation in Zimbabwean tanneries and therefore there is a need to educate tanners on the advantages of introduction of such schemes for the benefit of the environment. Also huge costs are incurred in the disposal of the solid waste therefore introduction of recovery and recycling projects may be of greater advantage to the tanners.

Keywords: Leather industry, solid leather waste, waste mitigation

1.0 INTRODUCTION

Due to marked increase in production processes in response to increase in general demand of goods, societies generate as well as reject waste regularly from various sectors such as the agricultural, commercial, domestic, industrial and institutional sectors. It is in this regard that the leather industry is viewed as one of the highest polluting industries worldwide (Famielec and Wieczorek-Ciurowa, 2011, Mushahary, 2017, Kanagaraj et al., 2006, Ferreira et al., 2010, Ferreira et al., 2011, Dixit et al., 2015). This is attributed to the fact that during the tanning process large quantities of waste are produced in both liquid and solid form as well as putrid gaseous emissions. The major concerns associated with waste obtained from this industry is that some of this waste may contain chromium. This is because chromium tanning is the most prevalent form of tanning. Literature states that approximately 90% of all tanning processes carried out in the world including Zimbabwe use Basic Chromium Sulphate (BCS) as the tanning agent (Ozgunay et al., 2007, Azom et al., 2012, Jiang et al., 2016, Kesarwani et al., 2015, Ludvik and Buljan, 2000).

Although this form of tanning has several negativities, its benefits are far much more outstanding especially to the tanner. This may be attributed to the fact that hides tanned using BCS exhibit superior physicochemical properties as compared to those tanned using the vegetable tanning route. Also the process of BCS tanning is faster, which takes less than a day, as compared to the vegetable tanning which takes up to a month to complete (Azom et al., 2012). Thus, this ensures a faster turnover rate for the tanner in terms of revenue.

A considerable amount of waste rejected from the leather industry is in solid form. Data obtained from literature reveals that 80% of solid wastes are generated during the pre-tanning processes, while 20% of the waste is produced post tanning (Kanagaraj et al., 2006) . It is this 20% that raises major concerns. Tannery solid wastes containing chromium are difficult to dispose of because of the possibility of chromium (III), present in the solid waste, being converted to the more toxic hexavalent chromium in the presence of strong oxidising agents such as hydrogen peroxide and also under high temperatures (Jiang et al., 2016, Shaikh et al., 2017, Madera-Santana et al., 2002, Islam et al., 2014).

Among the various solid waste mitigation measures available for chrome tanned leather solid waste (CTLSW), landfilling has emerged as the predominantly used measure during the last century (Jiang et al., 2016, Pati et al., 2014, Paul et al., 2013). However, it has since been learnt that this method is not the optimal route and has some limitations in its real-world use. In Zimbabwe, although the Environmental Management Act (as amended in 2006) prohibits the discharge of waste in a manner that causes pollution to the environment, it is normally disposed of at landfills without any prior treatment hence posing a serious environmental threat. This is mainly due to the high cost associated with treatment of chrome tanned solid waste. In any case an imperative consideration is that even with a primary treatment step the chromium may not be completely detached from the CTLSWs. Also, the inappropriate physical handling and transfer of CTLSW waste in open vehicles to these landfills often promotes unhygienic conditions as well as pollution.

Landfilling results in secondary pollution, that is, the chromium present in the solid wastes is effectively shifted into soil and groundwater which may result in the pollution of both the soil and groundwater. The pollution arises from the fact that the disposal of waste in low-lying areas without proper liners permits the leachate to mix with groundwater which leads to decline of water quality in the nearby areas. This method is also largely not viable as it requires huge landfill sites and has high operation costs. In unselective landfills of Chrome Tanned Leather Wastes (CTLSWs), approximately 40–50 % methane gas may be liberated which contributes significantly to global warming. Chromium also has the potential of leaching into the soil and thus rendering it unsuitable for agriculture and other uses. These cited drawbacks therefore make landfilling a highly undesirable waste mitigation measure (Jiang et al., 2016, karabay, 2008).

In this regard a study was carried out to quantify the levels of solid waste being landfilled in the leather industry. This study analysed the actual processes performed in some of the still functioning tanneries in Zimbabwe in order to propose tannery solid waste management practices. The main objective of this study therefore, was to gather accurate and useful data of the nature and amount of solid waste generated during leather processing from raw hides and skins to finished leather. To achieve the objective, 3 tanneries were visited across Zimbabwe. This enabled the researcher to have a first-hand experience and also facilitated an in-depth study of the chosen facilities.

2.0 Materials and Methods

A diagnostic industrial survey was conducted using both quantitative and qualitative methods. The study looked at three industries, that is, a tannery in Harare, one in Kadoma and the last in Bulawayo, which for the purposes of this study shall be named Tannery A, Tannery B and Tannery C respectively, all dealing with bovine and exotic leather. Collected data was more aligned at understanding solid waste landfilled in the leather tannery as well as to benchmark the performance of tanneries in terms of costs saved/incurred in leather solid waste management.

2.1 Sample Design

Non-probability judgmental and cluster sampling methods were used. Judgmental analysis was used with a specific motion in mind that is, with a belief that the chosen tannery industries were fit for research as compared to other industries based on their production efficiency, consistency and willingness/eagerness to disseminate necessary information. Tanneries in Zimbabwe were clustered according to region that is, Northern, Midlands and Southern and only one tannery was selected from each region for this focal study. Thus, due to the said sampling methods, the study were constricted to a sample size of 3, which is 27% of the population of tannery industries in Zimbabwe. Those are the three that had allowed us to conduct the study at their companies.

2.2 Data Collection

Collection of primary data was based on observations and direct communication with respondents. Respondents included management, shop floor workers and machine operators. The management were also given a structured questionnaire to fill out. The questionnaire explored on the key questions i.e. method of tanning used, nature of solid leather waste generated, average solid waste produced per ton of processed raw hides, availability of facilities for the disposal of solid leather waste, variable costs incurred during solid leather waste disposal and also on waste mitigation strategies being undertaken by the firms. To eliminate subjective bias and to ensure that the respondents gave adequate and realistic information, field checks were also performed to observe information on the ground and also to interact with operators in different departments (e.g. tanning and finishing departments). A number of general questions were asked to the operators and these questions varied from one industry to the other depending on whether the respondents were at ease and had expertise in leather processes. The survey also provided a deep insight into the operations, plant layout and the prevailing process conditions of the factory. It also helped in highlighting the sections with more solid waste in the factory floors.

2.3 Data Analysis Procedure

In this study, descriptive method of data analysis was used. This was guided by themes generated from the six main research questions in the questionnaire i.e. method of tanning used, type and nature of solid leather waste generated, average solid waste produced per ton of processed raw hides, availability of facilities for the disposal of solid leather waste, variable costs incurred in the disposal of solid waste and waste mitigation strategies in place.

3.0 Results

The visited tanneries process both bovine and exotic skins with the exception of Tannery B which only deals with bovine hides. All the tanneries visited preferred chrome tanning because of the inherent advantages of this method over other available methods save for Tannery C which also carries out vegetable tanning though for special orders.

The tanneries have suffered a major blow with the constant rise in prices of chemicals in the local market, shortages in foreign currency needed in sourcing the chemicals from the external market as well as turbulent leather good markets which see most of them downsizing and preferring to receive the hides in wet blue state. Tannery A and Tannery B both start the processing of leather from the beam-house. On the other hand Tannery C sources its raw material, that is, wet blue leather from Tannery B for the above stated reasons. Production at Tannery A and Tannery C has mainly order based production. However, because of loyal and consistent clientele, Tannery B is able to produce on regular basis.

3.1 Quantity and characteristics of solid leather waste produced

An effort was made to quantify the types of solid leather waste generated by each visited tannery on a monthly basis. The major concern was if this waste was classified and weighed according to type before disposal. The quantities of solid waste produced varied based on the level of production per given tannery. The type of solid leather waste generated also varied from tannery to tannery and was determined by the processes undertaken at each tannery. Of interest in this study was the waste produced during the post-tanning stage and respondents did agree that a considerable amount of solid leather was produced in this step with the most waste coming from the shaving as well as trimming processes.

Respondents from Tannery A were not clear on the quantities of solid leather waste produced and this showed that they were not greatly concerned about the waste but were more concerned on the leather production output. They did however state that the firm has a footwear factory which uses scrap leather trimmings to produce shoe insoles. Also, their splitting waste is sold to customers who use these to produce products like gloves, aprons and other small leather articles. However, there was difficulty in getting the actual amount of leather trimmings and splits that is converted into value added products due to ignorance of the firm in determining waste levels.

At Tannery C a value of approximately 28 tons of solid waste per month is produced. This value is directly proportional to the amount of raw hides being processed. The industry faces inconsistent market demands and due to this there was a drop in production leading to a drop in the levels of solid waste produced as well. Among the three study industries, only Tannery C gave a realistic waste quantity of 500 tons per month due to their constant production and proper record keeping of all waste types generated. However, it was noted that their waste levels are very high as compared to the production output and this may be as a result of use of poor, old processes and technology and low quality raw materials. Respondents from this tannery also said that they also classify waste according to type before disposal. However, reasons for this classification remained unclear as no values were given pertaining to the percentages of waste produced per given waste type.

This above findings from the tannery were in agreement with a statement by Dandira et al. (Dandira et al., 2012) which states that Zimbabwe tanneries are more concerned with increasing productivity than controlling the pollution as this is associated with huge costs.

3.2 On-site Storage and Collection

A quick survey of all the tannery premises visited showed that the waste material was often stored of on the ground, in open air causing highly unsanitary conditions (Figure 1 and 2). This showed a clear lack of understanding of the possible environmental impacts associated with such storage measures.

Figure 3.1: Waste storage on site at Tannery A, Harare Zimbabwe

The waste is usually stored on site for a number of days owing to the high cost associated with transportation, so that it can accumulate to quantities that are a more economic for the tannery to transport. After storage the waste is transferred to municipal dumping points/ landfills in open trucks. In often times this leads to further pollution as the waste may fall out of these cars.

Figure 2: Waste storage on site at Tannery B, Kadoma Zimbabwe

The sanitary storage and transfer of leather waste is of great importance because poorly handled and stored waste can be sources of nuisance, flies, smells and other hazards. As reported in literature (Ozgunay et al., 2007), because of the bad smell they produce and their harmful chemical content, leather solid wastes may have an undesirable impact on the soil and/or water bodies of the environment where they are discharged. Therefore, any uncontrolled discharge of such wastes should be prevented by taking adequate precautions.

3.3 Disposal

The ultimate disposal method of leather waste is of great importance because of the hazards associated with the waste. As mentioned before, in Zimbabwe the most prevalent form of leather waste mitigation is land-filling. This was also affirmed to be the preferred method of disposal in the tanneries visited. Furthermore, the respondents also said that the solid waste produced was disposed of without any further treatment into these municipal dumping site. In dumping sites, the waste undergoes the following process: dumping, covering with soil and leveling with bulldozers. Further, there is no provision of lining systems to prevent percolation of leachate to the ground water sources. According to Rishi Rana et al (2015) this method of disposal is not a properly engineered solution to handle the hazardous leather tannery waste. This leads to uncontrolled leaching and thereby contamination of groundwater. Also, this method is not sustainable and requires huge landfill sites and high operation costs (Jiang et al., 2016).

3.4 Costs associated with solid leather waste disposal

Landfilling is often associated with high operational costs (Jiang et al., 2016). These costs, for Zimbabwean tanneries is inclusive of the cost of transportation, the disposal license as well as the cost of excavating the hole where the waste is deposited into. All respondents stated that the dumping sites were far away from their factories and there was often a need for them to pay extra money for the transportation of the load which costs an average of US$50/load (approximately 8 tons). Transportation of waste depends upon such factors such as the type of waste, the number and type of vehicles, their capacity and the number of trips they can make in a day. Also, in accordance to the municipal regulations, each firm has to have a waste disposal license prior to disposal and this license cost US$550 and is valid for only 6 months. Also there is need to excavate a dumping site and this costs the company US$500. Due to huge amounts of solid waste generated dumping sites have to be dug once every 3 months and this further escalates the disposal costs.

3.5 Solid leather waste mitigation strategies

The tanneries were requested to highlight the measures, if any that their firms have taken to ensure that the amount of solid waste lost through landfills was kept at minimum. Although Tannery A and Tannery B showed a keen interest in seeing their waste levels decreasing gradually, they did however state that at the moment they had no major waste mitigation projects in place. Fortunately, Tannery A has a footwear factory which uses scrap leather trimmings to produce shoe insoles therefore minimising the amount of solid waste being channelled to the landfill sites. Also, leather splits are sold to customers who use these to produce products like gloves, aprons and other small leather articles. The respondents from the three tannery industries also expressed great concern over costs that may be incurred in taking on recycling projects and also pointed out the lack of equipment needed in this sort of projects as a major limitation. Therefore, disposal into landfills is often seen as a more viable option for managing solid waste. At Tannery C it was stated that the use of their clean production methods (use of combined aluminum, silicate and vegetable tanning and the cradle to the grave concept) had a way of reducing the levels of toxic tanned leather solid waste produced in their tannery.

Conclusion

The study was aimed at quantifying the amount of waste that is channeled regularly from the leather industries to municipal landfills for disposal. Findings showed that under consistent production schedules municipal landfills may become too small to cope with these huge amounts of solid leather waste discharge. Thus, instead of polluting the environment through landfilling the leather industry can adopt alternative technologies for the reuse of the said waste types. This will not only protect the environment but will ensure that valuable materials in leather solid waste are not lost, i.e. leather, protein, chromium and inorganic salts contained therein.

From these findings, it is clear that there exists a gap in waste mitigation in Zimbabwean tanneries and therefore there is a need to educate tanners on the advantages of introduction of such schemes for the benefit of the environment. Also huge costs are incurred in the disposal of the solid waste therefore introduction of recovery and recycling projects may be of greater advantage to the tanners. The foremost mode of cost recovery is through the adoption of “waste to wealth scheme” (Buljan and Kral, 2015). Using this scheme, solid leather can be reused in projects that include the generation of electricity, leather composite boards, gelatin, fertilisers etc (Senthil et al., 2015a, Senthil et al., 2015b, Senthil et al., 2015c, Ayalew, 2005, Ahmed et al., 2017).

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