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A Survey of Leather Waste Generation and Disposal Mode in Selected Counties in Kenya

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ABSTRACT

Disposal of leather waste from urban tanneries is a major challenge. Sustainable and environmentally friendly methods are required in urban settings. This paper therefore, deals with the identification and quantification of all types of tanned solid wastes generated by 6 pre-selected urban tanneries in Kenya vis a vis corresponding quantity of hides and skins processed. Questionnaire survey and key informant interviews were conducted. The data collected in this study was analysed using descriptive statistics, and the analysis showed that 1,443,000kg of chromium contaminated leather waste was generated by the 6 pre-selected tanneries in the month of study. The generated wastes constituted chrome shavings (32.1%), chrome splits and trimmings (36.2%), vegetable shavings (9.1%), vegetable splits and trimmings (14.9%), crust trimmings (3.5%), buffing dust (2.4%) and finished trimmings (1.8%), all of which amounted to 2,112,560kg for one month in the 6 pre-selected tanneries that were investigated. The current modes of disposal of the waste include landfilling, dumping in open grounds, and or incineration. Out of the total amount of hides processed in the 6 pre-selected tanneries during the month of study (6,642,525kg), 31.8% of this amount (i.e. 2,112,560kg) was actually converted into leather solid wastes. The proportion of leather solid wastes generated vis a vis the corresponding amount of hides processed was found to match closely with what is reported in literature (standard practice). It was also established in this study that chromium-containing leather waste formed the highest percentage (68.3%) of the various types of leather solid wastes generated in the 6 tanneries that were investigated.

1. Introduction

Solid wastes generated in leather industries pose great risks both to the environment and public health Kanagaraj et al., (2006). The leather industry wastes are generated in huge quantities as reported by Raamasami, (2001) and Fela K. et al., (2011). It has been estimated that tanneries generate solid wastes to the tune of 800kg for every ton of hides processed from raw to the finished stage. The wastes constitute 50-60% fleshings; 35-40% chrome shavings, chrome splits and buffing dust; 5-7% skin trimmings and 2-5% hair (Kanagaraj et al., 2006). Tannery beamhouse process steps contribute the bulk of the solid wastes (80%) while the rest of the wastes are produced during tanning (19%) and finishing (1%). Such kind of solid wastes can be processed to produce useful products, which include leather boards, carpets from recovered hair, gelatin (for food supplements), office glue, building bricks, fatliquors, cosmetics, photographic films, animal feeds and fertilizers among others, in order to reduce environmental contamination (Ramasami, 1999). Statistics given in literature indicate that around 60,000 metric tons of chromium-containing leather waste (i.e. chrome shavings) (Cabeza et al., 1998), are generated by the leather industry each year in the United States and also, ten times this amount is generated worldwide. Disposal of this waste has over the years been by landfilling, but there is an acute shortage of landfill sites due to the ever-increasing human population growth vis a vis limited land availability. Besides, this mode of disposal is rather expensive and environmentally unfriendly for a material that can be put into better use through recycling. For instance, chromium-containing tannery wastes could be processed further into better products, which can then be sold for revenue generation or be used as raw materials for other industries (Li et al., 2019). In the past, extensive research had been done around the world on methods for hydrolyzing leather waste to recover amino acids and peptides for use in animal feeds and fertilizers. In addition, research on the viability of chromium recovery from chromium-containing leather waste for re-use in tanning has shown great potential (Sundar et al., 2011; Jiang et al., 2016). In this study, a survey on the various types and quantities of leather solid wastes generated in selected tanneries in Kenya vis a vis the corresponding quantities of hides and skins processed, was carried out. The study also explored the current modes of disposal and utilization of tanned solid wastes generated in the Kenyan tanning industry.

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2. Materials and Methods

2.1 Study Area

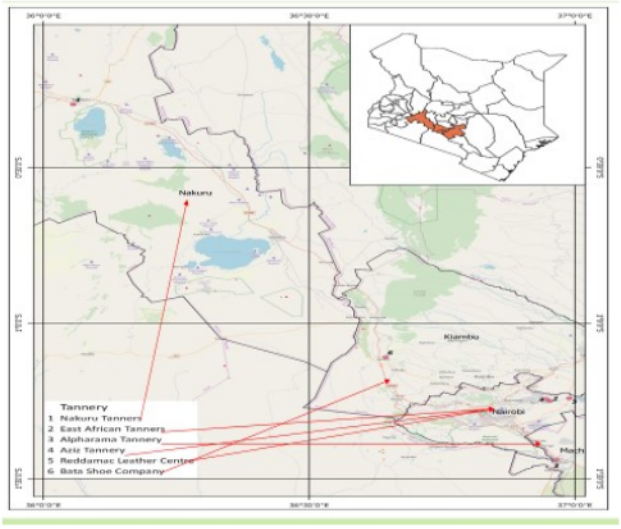

Figure 1: Map of Kenya showing the locations of the 6 pre-selected tanneries for this study
Source: www.spectregeospatial.co.ke

This study was conducted in six pre-selected tanneries (3 in Nairobi, 1 in Limuru, 1 in Nakuru and 1 in Athi River). They ranged from medium to large capacity tanneries processing leather to various stages, some up to the wet blue stage, and others up to the finished stage. The 3 tanneries in Nairobi (i.e. Reddamac, Aziz and East Africa tanneries) are of medium capacity manufacturing leather at wet blue, crust and finished stages of production. The other two tanneries namely; Bata (situated in Limuru, about 20km from the capital – along the Nairobi-Nakuru highway) and Alpharama (situated in Athi River town of Machakos County, around 15km from the capital city, off Mombasa road at the Namanga junction) are of large size each with an installed capacity of processing 40 tons of hides and 20,000 pieces of skins (goat and sheep) to finished leather daily. Bata tannery is currently not undertaking beam house operations, a move taken to alleviate the problem of environmental pollution emanating from the tannery beam house effluents and associated cost implications on their treatment and disposal. Nakuru tannery (situated in Nakuru town, 154 km from Nairobi) is a medium size tannery operating at full installed capacity of 20 tons of hides and 10,000pieces of skins (goat and sheep) processed daily. The tannery mainly produces wet blue leather for export.

2.2 Study Design

The study was descriptive and involved identification and quantification of different types of leather solid wastes generated daily over a period of one month in 6 pre-selected tanneries in Kenya. The research design in this study was both observational (involving personal observations and systematic recording of the various types and quantities of leather solid wastes generated in each of the 6 pre-selected tanneries daily for a period of 30 days) and a survey in which the respondents' views were described through structured questions put in a questionnaire. Besides, personal interviews were also conducted to ascertain the levels of leather solid wastes generated in selected Kenyan tanneries. Prevailing mode of disposal and utilization of this kind of tannery solid wastes as well as the challenges posed by their improper disposal were also studied.

2.3 Data collection and Sampling

A questionnaire was used to collect data on various types of leather solid wastes generation, mode of disposal and utilization as well as challenges faced by the various tanneries in leather waste management and constraints to growth of the Kenyan leather sector in general. 6 pre-selected tanneries (3 in Nairobi, 1 in Nakuru, 1 in Limuru and 1 in Athi River) which are medium to large capacity tanneries manufacturing leather at wet blue, crust and finished stages of production were investigated. This pre-selection was based on purposive sampling of the homogeneous type as the tanneries pre-selected had similar characteristics with the rest of the tanneries in Kenya (Kombo and Tromp, 2006). In each of these tanneries, data on leather waste generation and mode of disposal/recycling or re-use was collected both through own observations and interviews (as well as the use of a questionnaire). A total of 200 respondents drawn from all the technical departments (i.e. beam house, Tanyard, wet-end, machinery and finishing departments) in the 6 pre-selected tanneries (30 from each of the 5 bigger tanneries and 26 from Reddamac, which had comparatively less number of employees) were supplied with the structured questionnaires. Besides the use of the questionnaire, 4 members of the management staff in each of the 6 tanneries studied, were interviewed personally.

The sample size of 200 respondents was determined using the formula described by Rao and Richard, (2016) on testing the difference between two proportions of respondents (i.e. the management and technical personnel in the respective tanneries). Considering the power of the test, it was decided that a 80% (1 – β) of the test was needed. Therefore, the sample size n was given by;

$$n = \frac{2(Z\alpha + Z\beta)^2 pq}{d^2}$$

where;

Zα is 1.96 which is the critical value at 5% level of the normal distribution rounded off as 2

p = rate at which false information may have been given by the respondents expressed as a percentage

q = rate at which true information may have been given by the respondents expressed as a percentage (p + q = 100%)

The standard error of p is given by the formula $\sqrt{pq/n}$

α = Type I error β = Type II error (often type I error is considered)

d = difference tolerated = 10 (i.e. p1 – p2)

Then, Zα = 1.96, Zβ = 0.842 (from statistical tables), p = 15 and q = 85

Sample size $n = \frac{2(1.96 + 0.842)2 \times 15 \times 85}{10^2} = 200$

The data obtained from the quantification of the various types of leather solid wastes generated in the 6 pre-selected tanneries was analysed by descriptive statistics where their means were calculated and then the results compared with set standards (Annadurai, 2007; Oruko et al., 2014). Data entry and analysis was performed using SPSS (statistical package for social sciences) (Rao and Richard, 2016).

3. Results

3.1 Types and quantities of leather solid wastes generated in selected tanneries

The proportions of the various types of leather solid wastes generated in selected tanneries in Kenya during the month of study are given in Table 1 and illustrated diagrammatically in figure 2. Chrome splits and trimmings constituted 36.2% of the total waste generated, followed closely by chrome shavings at 32.1%, vegetable splits and trimmings at 14.9%. Other types of leather solid wastes generated during the month of study included vegetable shavings, 9.1%, crust trimmings 3.5%, as well as buffing dust at 2.4% and finished trimmings at 1.8% respectively.

Table 2: Quantities of hides processed (kg) and leather solid wastes generated in selected Kenyan tanneries in the month of study

Tannery	Quantities of hides processed in the month of study (Kg)	Quantities of leather solid wastes generated in month of study (kg)
Nakuru Tanners	1,027,230	325,000
East African Tannery	811,414	259,500
Alpharama Tannery	2,128,420	675,060
Aziz Tannery	314,289	101,000
Reddamac	283,180	89,000
Bata	2,077,992	663,000
Total	6,642,525	2,112,560

Proportion (%) – the average percentage of leather solid wastes generated in the 6 pre-selected tanneries in Kenya = 31.8% of the total hides processed (kg) in the month of study

Table 1: Types and quantities of leather solid wastes generated in the month of study for the 6 pre-selected Kenyan tanneries

Type of waste (kg)	Nakuru	East Africa	Alpharama	Aziz	Reddamac	Bata	Total	Proportion (%)
Chrome shavings	150,000	100,000	148,000	60,000	40,000	180,000	678,000	32.1
Chrome splits& trimmings	175,000	120,000	205,000	15,000	20,000	230,000	765,000	36.2
Vegetable shavings	0	10,000	92,000	6,000	10,000	75,000	193,000	9.1
Vegetable splits & trimmings	0	12,000	165,000	3,000	5,000	130,000	315,000	14.9
Crust trimmings	0	4,500	38,000	2,000	5,000	25,000	74,500	3.5
Buffing dust	0	6,500	18,560	10,000	4,000	10,500	49,560	2.4
Finished trimmings	0	6,500	8,500	5,000	5,000	12,500	37,500	1.8
Total	325,000	259,5000	675,060	101,000	89,000	663,000	2,112,560	100

Total amount of leather waste generated in the month of study for the 6 pre-selected tanneries is 2,112,560kg

3.2 Tanned solid waste management practices in Kenya

As seen in table 3, the methods used in leather solid wastes disposal by most tanneries include, landfilling, open dumping, incineration, and use as a source of fuel. No recycling and reuse is done in any of the tanneries studied. There are no established methods of leather solid wastes utilization in Kenya at the moment. Therefore, the greatest challenge facing Kenyan tanneries is how to safely and economically dispose of or utilize chrome tanned tannery solid wastes (Table 3 and Plate 1).

3.3 Challenges in the management of tannery solid wastes and constraints to the growth of the leather sector in Kenya

Generally, challenges facing solid waste management in Kenya are real (Gakungu, 2011), and leather solid wastes management is no exception.

This is mainly due to the fact that Kenya is urbanizing at a very fast rate as noted by Mwanzia et al., (2013) and Okalebo et al., (2014).

The most commonly used methods of leather solid wastes disposal in Kenyan tanneries are landfilling and open dumping, and to some extent, incineration as indicated in table 3. This is limiting considering the complex nature of solid waste and shortage of landfilling sites.

Other challenges include difficulty in accessing the dump sites due to poor road infrastructure (especially during the rain seasons), high transportation costs of the wastes to landfills, soil and ground water contamination due to leaching, and general environmental pollution due to lack of proper disposal and treatment mechanisms (Table 4). Escalating costs of handling hazardous solid wastes such as chromium containing leather solid wastes was also observed as another challenge in this study.

Some constraints to the growth of the leather manufacturing sector in Kenya have also been highlighted in table 4, and include the high costs of energy, machinery and spare parts, equipment and leather manufacturing chemicals as well as lack of skilled manpower, sufficient working capital and low competitiveness of Kenyan leather products in the global market.

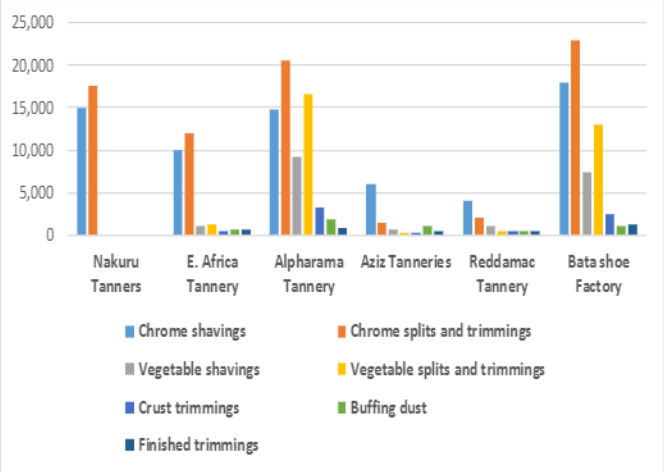

Figure 2: A graphical representation of the types and quantities (kg) of leather solid wastes generated by selected tanneries in the month of study

Table 3: Current modes of leather solid wastes disposal and utilization in selected Kenyan tanneries

Tannery	Current leather waste disposal/ utilization mode
Nakuru Tanners (Nakuru town)	Landfilling mode of disposal No documented method of recycling or re-using of leather waste Dried fleshings and trimmings are disposed of by: Open dumping Incineration Being used as a source of fuel No recycling of leather waste is done.
East Africa Tannery (Nairobi)	Landfilling is the only mode of disposal of leather waste in this tannery. Neither recycling nor re-using of leather waste is done. Leather waste disposal is done by the following methods: Open dumping Incineration.
Alpharama Ltd. (Athi River)	There is no documented mode of either recycling or re-using of leather waste in this tannery. Leather waste disposal is done by the following two modes: Open dumping Landfilling.
Aziz Tannery Ltd. (Nairobi)	Neither recycling nor re-using of leather waste is done. Landfilling is the only mode of disposal Neither recycling nor re-using of leather waste is done.
Reddamac Leather Centre (Zingo Investments, Nairobi)	
Bata Shoe Company (Limuru)	

Plate 1: Dumping of chrome tanned leather solid wastes in a landfill
Source: *Field Survey, 2016)*

Table 4: Challenges in the management of tannery solid wastes and constraints to the growth of the sector in Kenya

Tannery	Challenges in tannery solid wastes management	Constraints to the growth of the leather manufacturing sector in Kenya
Nakuru Tanners Ltd.	High transportation costs of the leather waste to landfills Bad smell	High cost of energy Marketing constraints (fluctuation of prices)
East Africa Tannery	High transportation costs of the tannery solid wastes to the dumping site High handling and treatment costs for chromium containing leather solid wastes	High costs of machinery and spare parts, equipment and leather manufacturing chemicals Lack of skilled manpower Lack of sufficient working capital Lack of sufficient land for tannery expansion
Alpharama Tannery	Difficulty in assessing the buffer zone area/ dumping site because of poor road infrastructure (especially during the rain seasons) Pollution due to solid waste decomposition/ degradation Soil and ground water contamination due to leaching	Unscrupulous merchants exporting raw hides and skins causing scarcity of raw materials for local values addition Stiff competition in the global market
Aziz Tannery	Environmental pollution due to lack of proper disposal and treatment mechanisms for both tannery solid wastes and effluent	Influx of cheap synthetic shoes from China Influx of second hand leather goods and footwear into the country from China Low government support for value addition in the leather sector

Plate 2: A mixture of chrome leather shavings and trimmings dumped outside the Leather Industries of Kenya (Thika) due to lack of a better disposal/recycling method
Source: Field Survey, 2016

4. Discussion

It has been established in this study that about 31.8% of the total quantities of hides processed (6,642,525kg) in the 6 pre-selected Kenyan tanneries during the month of study was actually converted into tanned leather waste (2,112,560kg) as indicated in Table 2. This was in agreement with the work done by Simeonova and Dalev, (1996), which indicated that approximately 30 tons of leather waste is generated in a middle capacity leather factory which processes about 100 tons of hides daily. This figure matches closely with what has been established by other researchers that out of every 1000kg of wet salted hides processed into finished leather, tanned waste amounting to 200kg (constituting of shavings, trimmings, splits and buffing dust) and also, 50-100kg of dyed and finished leather trimmings are produced (Veeger, 1993; Taylor *et al.,* 1998; Langmaier *et al.,* 1999).

Currently there are 14 tanneries in Kenya operating at an average installed capacity of 70% with a daily production of 40 million tons of wet blue leather (Oruko *et al.,* 2014). This explains why chrome splits and trimmings gave the highest numbers of leather waste generated in each of the 6 pre-selected tanneries in the month of study as compared to the other forms of leather waste (Table 1 and Figure 2). This pattern was also reflected in the generation of chrome shavings as a clear indication of the huge quantities of wet blue leather production in Kenyan tanneries.

The amount and composition of the leather waste generated depends on several factors which include the tanning technique used, that is the number, type and sequence of unit operations – as some of the operations may not be necessary, chemical offer of the various reagents used in the tanning process and control of the process variations. It can be seen in Table 1 that the proportions of both chrome splits and trimmings as well as chrome shavings were among the highest of various types of tanned solid wastes generated in the 6 selected tanneries for this study (i.e. 36.2% and 32.1% respectively). These types of waste are also the most difficult to dispose of due to the effects of chrome on the environment. It is therefore of paramount importance to provide an appropriate treatment and/or disposal facilities for tannery solid wastes, especially those that contain chromium (Abebaw, 2015).

The huge quantities of chromium-containing leather solid wastes generated can be associated with the fact that most of the tanneries in Kenya process hides and skins up to the wet blue stage for export due to lack of the necessary technology and infrastructure for processing up to the finished stage. The market for finished leather is also quite demanding in terms of fashion and customer specifications. Other factors that could influence the generation of relatively large quantities of leather solid wastes include regional and social economic factors prevailing in the leather industrial sector (Padilla-Rizo *et al.,* 2018).

One of the key findings of this study was that the most common mode of leather waste disposal in the Kenyan tanning industry is by landfilling followed by open dumping and incineration in that order (Table 3). Disposal of waste by dumping in landfills is the least favoured option of waste management according to DEFRA, (2011).

Apart from the fact that there is a scarcity of suitable land for landfilling in urban areas, there is also an added cost incurred in the transportation of waste to a landfilling site. These challenges in the management of tannery solid wastes are highlighted in Table 4 among many other constraints to the growth of the leather manufacturing sector in Kenya. Besides, poorly designed landfills lead to contamination of ground water by leachates including chromium (Kirk *et al.,* 2002; Ahmed and Kashif, 2014). Work done by Sekaran *et al.,* (2007) confirmed that methane gas emanating from landfills also is a source of contribution to global warming. Leather waste disposal by incineration is a relatively more efficient way of reducing tannery solid wastes in the environment but the process produces air pollutants particularly, SO_2 and NOx, which need to be removed using air pollution control devices (Kanagaraj *et al.,* 2006). The ash produced due to thermal incineration is also a source for pollutants like chromium (Cr), halogenated organic compounds and polycyclic aromatic hydrocarbons (PAHs) (Sekaran *et al.,* 2007).

The other key finding established in this research is that out of all the various types of leather solid wastes generated in the selected tanneries, chromium-containing leather waste formed the highest percentage (68.3% as shown in Table 1) and was the most difficult to dispose of from the environment of the tannery (Plate 2). Chrome tanned leather waste hardly disintegrates when left in the environment (Ahmed and Kashif, 2014) and hence, if left unattended to, it leads to disposal problems both to the environment and human health. Thus, an accurate knowledge of the consequences of tannery solid wastes will help in making appropriate decisions that are aimed at reducing their environmental impacts.

Among all the heavy metals contained in leather waste, the presence of chromium in the tannery environment poses the greatest risk to tannery workers according to work done by Parvin *et al.,* (2017).

Several examples of workplace exposure to chromium have been reported (Parvin et al., 2017) where chromium was found in the serum and blood of tannery workers in Ontario, Canada. According to Randall and Gibson, (1987) the chromium levels in the body of the victims is not related to the length of employment in the tannery but on the amount of exposure to chromium during the day.

Tannery waste should be managed in an environmentally friendly manner as possible to reduce the effects of chrome on environment and human health. Several leather waste management strategies have been practised in line with the principle of sustainable development, with the following four being suggested as the best ways to deal with leather wastes; source reduction, recycling and composting, combustion (waste-to-energy) and, landfills (DEFRA, 2011). Currently, there is poor and uncoordinated implementation of solid waste recovery and disposal laws (legal instruments) in Kenya. According to NEMA, (2014), emphasis of solid waste management should be on re-use and recycling, enactment/ enforcement of regulatory and supervisory statutes as well as the formulation of policies, legislations and economic instruments to reduce waste quantities. Recycling of leather wastes to produce valuable products is an attractive option for dealing with leather waste as it will address both the environmental issues surrounding the tannery environment and employment issues in the leather sector (Onyuka, 2010).

5. Conclusion

The average amount of tanned solid waste that is generated during leather manufacture was found in this study to be 31.8% of the total amount of hides processed. The various types of wastes generated included chrome splits and trimmings 36.2%, chrome shavings 32.1%, vegetable splits and trimmings 14.9%, vegetable shavings 9.1%, crust trimmings 3.5%, buffing dust 2.4% and finished trimmings at 1.8%. Chromium-containing leather waste formed the highest percentage (68.3%) of waste produced and was the most difficult to dispose of from the environment of the tannery.

The methods used in leather waste disposal by most tanneries in Kenya include, open dumping, incineration, landfilling, and use as a source of fuel. These methods are not appropriate as they lead to environmental contamination with chrome. The most appropriate treatment method for chrome tanned leather solid wastes would be the one that will remove most of the chromium from the leather waste as efficiently as possible. There is need to explore best method of decontaminating these huge amounts of chrome leather waste so that the waste can be utilized to make fertilizer for soil conditioning to improve agriculture, or be used to produce useful products such as leather boards, carpets, gelatin (for food supplements), office glue, cosmetics, photographic films, animal feeds among others. This will reduce environmental contamination as well as create an extra source of income.

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