WASTE MANAGEMENT IN LEATHER INDUSTRY - ENVIRONMENTAL AND HEALTH EFFECTS AND SUGGESTIONS TO USE IN CONSTRUCTION PURPOSES

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ABSTRACT

Leather industry is globally growing in huge amount resulting in production of more waste generation. This paper reviews the sources from which the leather product is made and the operations process how it’s being finalized into a specified product and to minimize the exploitation of natural resources to make a pollution free environment. In viewpoint of construction, concrete is the main elemental material. Concrete manufacturing involves consumption of ingredients like cement, aggregates, water and admixtures. Among all these aggregates are consider major part so preservation of natural resources is major concern. Production of cement even leads to environmental pollution. To preserve the natural resources as well as to make environment free of harmful pollution like contamination of drinking water, inhaling of harmful gases etc. alternative materials are need to be considered. This report reviews the use of leather waste materials in concrete for construction purpose as to reduce pollution and disposal problem resulting in less landfill pressures and reducing demand of extraction.

Key words: Leather, Waste, Pollution, Concrete, Aggregates, Disposal, Landfill

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1. INTRODUCTION
Leather industry is one of the most polluting industries globally. The leather processing is responsible for unfavourable impact on environment. The production of leather in India is about 2 billion sq. ft. of finished leathers and the industry has set a target to double this figure in future [1]. With more number of consumption of meat and more production of leather clothes and shoes, it results in more waste generation. The three types of hides and skins most often used in leather manufacture are from cattle, sheep and pigs. These raw materials are used as the production of goods in various industry like shoe industry, bag industry, clothing industry, furnishing and decoration industry. Huge amount of raw materials is extracted and preserved by applying chemical processes before they are turned in final finished products of desirable quality. The major four operation process is as follows:

- Pertaining Operations (beam house operation)
- Tanning Operation
- Wet-finishing Operation
- Finishing Operation [2].

From all the stages of leather making, wastes originate such as fine leather particles, residues from various chemical discharges and reagents from different waste liquors comprising of large pieces of leather cutting, trimmings and gross shavings, fleshing, residues, solid hair debris and remnants of paper bags. Out of 1000 kg of raw hide, nearly 850 kg is generated as solid wastes in leather processing. Only 150 kg of the raw materials is converted into leather. A typical tannery generates huge amount of waste:

- Fleshing: 56-60%
- Chrome shaving, Chrome splits and buffing dust: 35-40%
- Skin trimmings: 5-7%
- Hair: 2-5% [3].

2. TYPES OF SOLID WASTES
There are various types of solid wastes resulting out of leather processing. They are

2.1. Keratin wastes
Keratin is difficult to hydrolyze and highly resistant towards enzymes and most of the chemicals. It is rich in cystine. Keratin has been hydrolyzed using conc. NaOH or HCl. The hydrolysate prepared from keratinous material has been employed in chrome tanning and rechroming at various levels and the exhaustion is studied. The study showed that the hydrolysate helps to improve the chrome exhaustion of tanning bath and rechroming bath. The physical strength properties are also not altered. [4].

2.2. Fleshing wastes
Fleshing (50-60% of the total wastes generated in leather industry) has been explored for the possible utilization into useful end products. [5]. Fleshing, the major solid waste generated at the pertaining operations of leather processing was hydrolyzed using pancreatic enzymes. The optimum pH for the enzyme preparation was 8.5. The hydrolysis was observed by almost total liquefaction and fleshing was dried. [6].
2.3. Chrome shaving
Chrome tanned leather, splits and trimmings having been useful in obtaining glue, gelatin, protein flavor and reconstituted collagen. The above products can be made by treating with hydrogen peroxide to bring about important degree of maceration and then grinding and extraction to yield the by-product (95%) [7]. These pollution parameters can be classified as solid, liquid and gas.

2.4. Soil pollution
Untreated waste waters from tanneries have seen applied on land merely to contain them at one place. The soils holding it directly and irrigated with contaminated groundwater lose productivity [8]. The leather industry globally generates up to 5.4 million tons of solid and liquid waste each year [9].

2.5 Atmospheric Pollution
Tanneries are proverbially known for generating malodor. Rehydration of salted hides and skins generally emit odor of volatile fatty and amino acids evolved during biological decomposition in presence of water. In addition, toxicity of hydrogen sulphide along with acids, fats, carbohydrates etc.[10]. Liming, declaiming and tanning processes is predominant within tanneries. The venting out of malodorous substances to ambient air and subsequent transports to further distance are responsible for atmospheric pollution. Hydrogen sulphide at 20 ppm (30mg/m$^3$) in ambient air is lethal to human kind. Ammonia escaping from deliming operation to atmosphere is odorous and pungent. Maximum admissible level of ammonia in air is 50 mg/m$^3$. Phenolics (monohydric, dihydric and trihydric) are emitted into air during processing of hides in the post-tanning and finishing operations. The permissible level of phenolics as phenol (C$_6$H$_5$OH) in water is 10.2 mg/l. The concentration shall not exceed 0.3 mg/l in drinking water.[10]

3. LEATHER PROCESSING
The process involved in leather manufacturing and the wastes that come out of each process is mentioned in figure 1[11].

![Figure 1 Process and wastes in Leather industry](http://www.iaeme.com/IJCIET/index.asp)
4. ENVIRONMENTAL AND HEALTH IMPACTS OF LEATHER WASTES

4.1. Environmental effect

The major environmental issues of tanneries are solid wastes and wastewater. During processing of hides into leather, about 20% of the material results as solid wastes, consisting of leather scraps, hair, soluble proteins, curing salts and fleshing (animal fats, collagen fibers, meat etc.). The effluents discharged from tanneries are large in volume, are highly colored and contain heavy sediment load, toxic metallic compounds, chemicals, biologically oxidable materials and large quantities of putrefying suspended matter. Solid wastes of tanneries are usually dumped improperly inside and around the factory area[12]. The highly-colored effluents not only give an unesthetic appearance but by cutting off sun light, it also affects the purification capacity of a water body. Low pH of tannery effluents cause corrosion of water-carrying system. Large pH fluctuation and high BOD value caused by tannery effluents can kill all natural life in affected water. Hydrogen sulphide formed due to the presence of sulphides in the effluent is highly toxic to many forms of life. Another toxic pollutant, of great concern present in tannery effluents is chromium which is known to cause perforations and bronchogenic carcinoma to continuously exposed humans. Chicken feeds prepared from chromium containing proteins rich tanneries solid wastes is likely to cause direct chromium entry into food chain [13]. Tanneries and leather products manufacturing units are generating large amounts of solid waste in the form of leather shavings/cuttings which being used as cheap fuel in the brick-kilns, is causing air pollution along with the release of chromium into the environment [14]. Tanneries are directly contaminating prime agriculture land and the quality as well as crop-yield from the contaminated soil has been found to be affected [14]. It has also been reported that indiscriminate discharge of Industrial effluents into water bodies directly or on open land around the factory area causing skin diseases in human.

4.2. Health effect

The tanning industry poses many dangers to both the environment and those that work within it. Work within the tannery itself is fraught with dangers due to the result of inadequate or non-existent worker protections. These includes slips and falls on improperly drained floors, exposure to lime, tanning liquor, acids, bases, solvents, disinfectants, and other noxious chemicals, injury from heavy machinery or flaying knives, drowning, being boiled alive, or buried in lime are all terrifyingly real hazards. Still, the most dangerous part of modern tanning is handling chromium. In humans, chromium causes a myriad of ailments depending on how it is absorbed. When inhaled, chromium acts as a lung irritant and carcinogen, affecting the upper respiratory tract, obstructing airways, and increasing the chances of developing lung, nasal, or sinus cancer [15]. Chromium normally is absorbed this way as fine particulate dust that is produced when both raw and tanned leathers are buffed, smoothed, and ground up. Chromium has been linked to increased rates of asthma, bronchitis, polyps of the upper respiratory tract, pharyngitis, and the enlargement of the Hilary region and lymph nodes. By the start of this century, researchers had uncovered another link between Hexavalent Chromium or Cr (VI) compounds and increased risk of respiratory cancer [16]. Throughout the tanning industry as well as the automotive industry, Cr(VI) has been labeled as a known human carcinogen by the EPA, the IARC, and the WHO.
5. MEASURES TO REDUCE THE TANNERY WASTES BY USING IN CONSTRUCTION PURPOSES

5.1. Preparation of light weight constructional materials from chrome containing buffing dust solid waste generated in leather industry

An alternative and environmental beginning method of disposing the buffing dust generated from leather industry. The buffing dust (finished solid wastes) was charred in a controlled oxygen atmosphere by coupled pyrolysis and the resultant material was gauged for the application of light weight cement blocks. The results confirmed that at a flow rate of 1 LPM oxygen supplied for 30 min produced nanostructured fibrous carbon material which was further confirmed through SEM and EDX analyses. Iron nanoparticles were used to inhibit the conversion of trivalent chromium to hexavalent chromium in fibrous carbon before being utilized for making light weight cement block. The addition of iron nanoparticles supplements the mechanical strength by compositional bonding in cement block. The XRD results elucidate that the hexavalent chromium has reduced to trivalent chromium due to the addition of iron nanoparticles in the residue material. These light weight cement blocks can be used for construction of medians in roadways where the contact with humans is limited. Hence, the proposed pyrolysis route can be considered as environmentally optimistic approach for the effective management of chromium containing buffing dust [17].

5.2. Solid waste Management in Leather Sector by incineration

The tannery wastes were subjected to incineration at 800 °C in a Starved Air thermal incinerator under different flow rate of oxygen to optimize the flux of oxygen require preventing the conversion of chromium trivalent to hexavalent. The energy audit of incineration of wastes under the external supply of oxygen was carried out under different conditions. The calcined wastes were effectively solidified / stabilized using Portland cement and fine aggregate. The solidified blocks were tested for unconfined compressive strength and heavy metal leaching. Leachability study through TCLP on solidified block was carried out to determine the degree of leachate and metals. The percentage of metal fixation was 99.1 to 99.9 % and dissolved organic concentration in the TCLP leachate was 55-66 mg/l [18].

5.3. Utilization of tannery shredded waste as fine aggregate in concrete

The use of the tannery shredded waste as a partial replacement of 0%, 5%, 10%, 15%, 20% for fine aggregate and to determine the mechanical properties of the concrete after replacing. Conclusion is that the tannery waste can be used effectively in the construction field. The disposal of tannery waste can be done safely without causing any pollution to the environment and reduction in cost of construction and provide a new replacement material for the concrete. Tannery waste concrete can reduce the use of river sand in concrete and results in light weight concrete. Increase in Tannery waste in concrete from 0% to 20% decrease the density of the concrete from 2419 kg/m³ to 1738 kg/m³ [19].

5.4. Effect of Rubber and Leather wastes on concrete

The effect of leather wastes on the properties of fresh and hardened concrete was investigated. The variables of the research are the type and percentage of waste material and curing time of concrete. Waste percentages used were 5%, 7% and 10% by weight of cement in the concrete mixture. Several tests were conducted on the fresh and hardened concrete with leather wastes such as workability, compressive strength, indirect tensile strength and natural absorption. Results have shown that the compressive strength and indirect tensile strength of concrete decreased with increasing the contents of leather waste. Using leather waste causes
dramatic decrease in compressive strength of concrete after 28 days curing when used as fine and coarse aggregates. However, fine leather aggregates decrease compressive strength more than coarse aggregates [20].

5.5. Effect of using tannery sludge in concrete
The use of tannery sludge in a suitable sludge stabilization process to reduce the heavy metal concentration was studied. For this purpose, solidification, a stabilization process that involves mixing the waste with a binder to reduce the contamination leachability by physical and chemical means was used to assess the stabilization of heavy metals present in the sludge. It assesses the likelihood of stabilization of the heavy metals in tannery sludge with the concrete mix and to assess the usability of the sludge mixed concrete in construction work. 0%, 1%, 5%, 10%, 15%, 20% of sludge was used by weight of cement replacing equal weight of the same to prepare the mix and left to solidify for 28 days. Result showed that the sludge/cement ratio up to 5% met the requirement for both physical and chemical properties. The TCLP test results of the crushed concrete showed that the high concentration of chromium and lead contents of the raw sludge were stabilized to desired range [21].

The replacement percentage and TCLP test analysis flow chart is shown in Figure 2.

![Figure 2](http://www.iaeme.com/IJCIET/index.asp)
6. CONCLUSIONS

In this review, many research papers of different authors were studied and thus the conclusions are as follows:

1. Tannery waste can be used effectively in the construction field.
2. The disposal of tannery waste can be done safely without causing pollution to the environment.
3. There is reduction in the cost of construction and provides a new replacing materials for the concrete resulting in less used of raw materials.
4. Tannery waste concrete can reduce the use of river sand in concrete and results in light weight concrete.
5. Use of the waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material.
6. Usage of recycled aggregates can not only preserve the finite raw materials but also reduce energy consumption and overall construction costs.
7. The higher water/cement ratios, the compressive strength of recycled concrete is like that of normal concrete. At lower water/cement ratios, the compressive strength of recycled concrete is lower than that of normal concrete.

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