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Comparative assessment of conventional and alternative leather tanning processes from a life cycle perspective

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ABSTRACT

The environmental impact of leather processing is an area of increasing interest for consumers and legislators. The popular chromium salt tanning, which holds the lion share of total world leather production, is under pressure for environmental concern. The new so-called cleaner tanning agents such as aluminium, titanium, zirconium, and aldehydes set out to avoid the use of chromium salts. Various alternative systems have been developed but not yet assessed in terms of quantitative environmental impact assessment. We selected tanning process using agents such as chrome (conventional), aluminium and aldehydes and attempted to understand corresponding environmental impacts from a life cycle perspective. One (1) m^2 of leather was chosen as the functional unit. The direct input profile consists of pickled pelt as raw material for all three processes, chemicals, water, and energy. The main outputs are tanned leather (chrome/alum or aldehyde), wastewater and solid wastes. Also, a comparative analysis was done to show whether there are significant variations in the mechanical properties such as tensile strength, tear strength, and softness; hydrothermal properties such as shrinkage temperature. Moreover, an analysis of the physical and chemical properties of wastewater emissions from the tanning processes was performed. The wastewater samples were analysed for chloride, chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia (NH_3-N), nitrite (NO_2-N),nitrate (NO_3-N), total Kjeldahl nitrogen (TKN), phosphate (PO_4), sulphate (SO_4), total chromium (total Cr), chromium (as Cr^{6+}), total solids (TS), and total dissolved solids (TDS). IMPACT 2002+ method has been used under the framework of the SimaPro software to measure the environmental burden of the studied systems. The comparative results show that aluminium tanning process has more than 13 times the higher impact on aquatic ecotoxicity, 4.43 times higher on aquatic acidification than chrome tanning process. Also, aluminium tanning has terrestrial ecotoxicity. In contrast, chrome tanning has a marginally higher value of non-carcinogens. Besides, aldehyde tanning had a significantly higher impact on aquatic ecotoxicity. The mechanical properties of aluminium and aldehyde tanned leathers were found to exhibit no significant differences from the leather tanned using traditional method (chrome tanned). However, the softness and hydrothermal stability of chrome tanned leather are much higher than that of aldehyde and aluminium tanned leather. These findings will pave the way for setting up priorities in abatement measures and will ultimately aid in achieving sustainability leather production in Bangladesh.