Environmental Burden of Tanneries in Bangladesh

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ABSTRACT

Tannery industries have been vitally important to the economy of Bangladesh, yet they have proved to be detrimental to the environment mainly due to the discharge of huge quantities of untreated wastewater containing heavy metal chromium. Using the IMPACT 2002+ methodology under the SimaPro software environment, we study and compare the environmental burden of two leather products: full-chrome leather (FCL) and chrome retanned crust leather (CRL). For both FCL and CRL, it was found that significant environmental impacts were associated with tanning, rechroming, neutralization, deliming-bating and acid wash processes in the production cycle. FCL had 5 times, 4.53 times and 2.53 times higher impact on categories of aquatic ecotoxicity, non-carcinogens and ecosystem quality respectively compared to CRL.In addition, aquatic acidification potential of FCL was greater than that of CRL while CRL had marginally higher contribution to aquatic eutrophication.

INTRODUCTION

In the recent years, there has been a large shift of leather industries from industrialized to developing countries like Bangladesh and India prompted by stringent environmental regulations in the former[1].The leather tanning process is composed of several batch stages associated with the consumption of large amounts of freshwater as well as the generation of liquid and solid wastes. Although tanning can be performed according to different procedures, most of the leather is obtained with chromium salts as the tanning agent. The wastewaters are characterized by significant organic load and remarkably high concentrations of inorganic compounds such as chromium, chloride, ammonia, sulfide, and sulfate[2][3]. This poses a challenge to the future sustainability of the leather industry with a growing number and layers of non-tariff barriers, including environmental considerations and eco-criteria emanating from major export markets.There are 113 tanneries in Bangladesh that produce 180 million square feet of hides and skins per year but most of them do not have effluent treatment plants and they generate about 20,000 m^3 tannery effluent and 232 tones solid waste per day[4]. Considering these issues, quantifying the use of resources such as fossil fuel, other forms of energy, water and chemicals and the release of wastewater, air emissions and solid waste during different operations of producing leather in Bangladesh has become increasingly important. A useful tool to evaluate the environmental burden associated with a product, process or activity is life cycle analysis (LCA) which is a management tool involving identification and quantification of the input and output flows of the processes; energy and materials used and wastes released into the environment[5].Studies of environmental impacts related to leather have not been carried out so far in Bangladesh for the leather production supply chain.

METHODOLOGY

Goal definition and Scope

In order to identify hotspots in the leather manufacturing industry in Bangladesh, we have assessed the environmental burden of the two most representative crust leather articles in Bangladesh - full-chrome leather (FCL) and chrome retanned leather (CRL) over one calendar year (July, 2013 - June, 2014). The major life cycle processes having environmental burdens are listed in the legends of figure 1. All environmental impacts of slaughtering are allocated to be 14% on the raw hides[1]. Range of thickness of crustleather does not vary substantially from one article to the other. All the emissions are calculated in relation to the production of 1 square meter leather which is chosen to be the functional unit.The data on proxy processes (transportation for raw material, chemical and product delivery, electricity production, packaging material production, electricity generation using diesel generator and emission data of diesel fueled steam boiler) were taken from SimaPro database libraries (Ecoinvent v3). Slaughtering data was sourced from Joseph and Nithya, 2009[1]. System boundary of FCL system given in the following figure 1

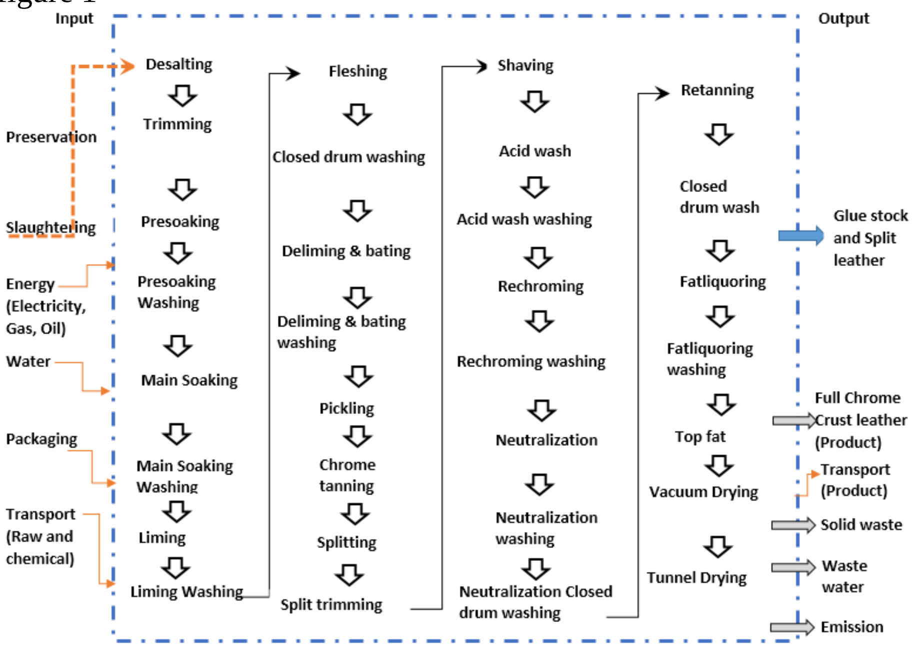

Figure 1: System boundary of FCL system

Life cycle inventory

An analysis of the physical and chemical characterization of wastewater emissions of the leather processes was performed. The major tests conducted on wastewater generated from the tanneries were chloride (Cl) , chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), NH_3-N, NO_2-N,NO_3-N, total Kjeldahl nitrogen (TKN), sulfide (as H_2S), PO_4-P, total chromium, chromium (as Cr^{6+}) and TDS. The samples being analyzed were the waste liquor of presoaking, main soaking, liming, deliming and bating, pickling, chrome tanning (for FCL), pretannage (for CRL), acid wash (for both), rechroming (for both), neutralization (for both), retanning (for both), fatliquoring (both) and top fat (both). Data regarding materials and processes included annual wet-salted raw hides/skins consumption, input chemicals consumption, water and steam consumption, tannery solid waste generation, electricity, fuel oil consumption for generator and steam boiler. The data collection and sample analysis period was representative of the high production time of the company.

Impact assessment method

Impact assessment is a technical quantitative, and/or qualitative process to characterize and assess the effects of the environmental burden. The impact assessment of FCL and CRL was conducted based on IMPACT 2002+ methodology [6]. This method links all types of results via several midpoint categories like carcinogens, non-carcinogens, aquatic ecotoxicity, terrestrial ecotoxicity, aquatic acidification, aquatic eutrophication, terrestrial acidification/nitrification, land occupation, global warming, non-renewable energy consumption and mineral extraction to four damage categories (human health, ecosystem quality, climate change and resources). Linking to midpoint is associated with certain conversion factors for each pollutant and conversion to damage categories is also associated with damage factors. SimaPro was used to analyze the impact of FCL and CRL systems[7].

RESULTS AND DISCUSSION

Figure 2 shows the impact assessment at midpoint and endpoint level corresponding to FCL and CRL with contribution from the different life cycle processes. In Figure 2, Kg equivalent of a reference substance expresses the amount of a reference substance that equals the impact of the considered pollutant (e.g. TEG-Triethylene glycol) in the midpoint categories. PDF•m^2•y (Potentially Disappeared Fraction of species disappeared on 1 m^2 of earth surface during one year) is the unit to measure the impacts on ecosystems. DALY (Disability-Adjusted Life Years) characterizes the disease severity, accounting for both mortality (years of life lost due to premature death) and morbidity (the time of life with lower quality due to an illness, e.g., at hospital)[8]. In this study, major emissions considered by IMPACT 2002+ method were heavy metal chromium discharge into water, high COD, gaseous emissions (H_2S, NH_3) and ammonia (as N) wastes produced in the tannery. These emissions are responsible for the contribution of the tannery to significant toxicological impacts such as aquatic ecotoxicity, non-carcinogens, aquatic acidification and aquatic eutrophication. Furthermore, energy consumption in the tannery and transportation (raw, chemical and products delivery) pose environmental burden through emissions to atmosphere. According to figure 2, at midpoint level, FCL has 5 times higher impact on aquatic ecotoxicity and 4.53 times higher impact on non-carcinogens than CRL. In addition, Aquatic acidification of FCL is greater than CRL but CRL has marginally higher value of aquatic eutrophication. Processing chemicals play a dominant role for increased eutrophication and acidification. At damage level, FCL has 2.53 times higher impact on ecosystem quality and Human health impact of FCL is also greater than CRL. Discharge of heavy metal chromium plays a dominant role for increased impact on ecosystem quality and human health. It is clearly indicated in the midpoint level that the company has serious impact on aquatic ecotoxicity and eutrophication which results in increased contribution to the damage category of ecosystem quality. Impacts due to non-carcinogen and acidification take the next position. Supply chain processes like transporting of raw chemicals and products, electricity and packaging were the main contributors in impact categories of global warming, carcinogens, ionizing radiation, ozone layer depletion, terrestrial ecotoxicity, terrestrial acidification, respiratory organics and inorganics, land occupation, mineral extraction and non-renewable energy which eventually contributed to damage categories of climate change and human health. Transportation of raw materials primarily contributed to impact categories of terrestrial ecotoxicity, terrestrial acidification, respiratory organics and inorganics whereas Electricity generation governed the impact categories of mineral extraction, land occupation, ozone layer depletion and ionizing radiation. The slaughtering activity plays a minor role in the creation of environmental impacts during the life cycle of studied leathers. The assessment shows that FCL production system has higher environmental impact than CRL.

Figure 3 and 4 are illustrated to identify hot spots associated with the production supply chain of leather articles. Irrespective of the systems, the main impact hotspots identified were chrome-tanning (for FCL), pretannage (for CRL), rechroming, neutralization, acid wash, deliming-bating, transport for raw material and chemical and electricity generation. Presoaking, main soaking, pickling, retanning, fat liquoring and top fat processes appeared to be the least polluting operation.

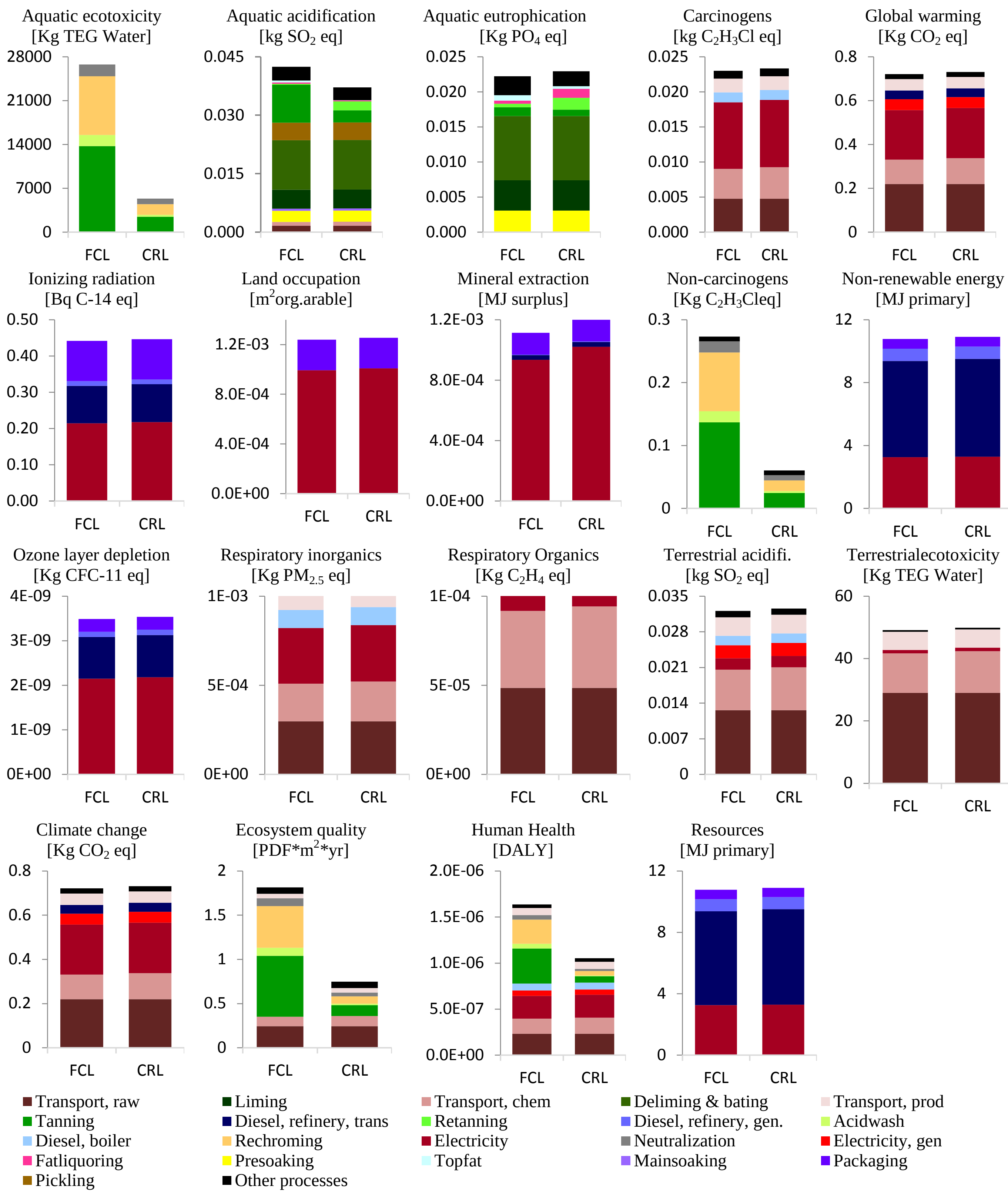

Figure 2: Impact assessment at midpoint and endpoint level of FCL and CRL with contribution from the different life cycle processes

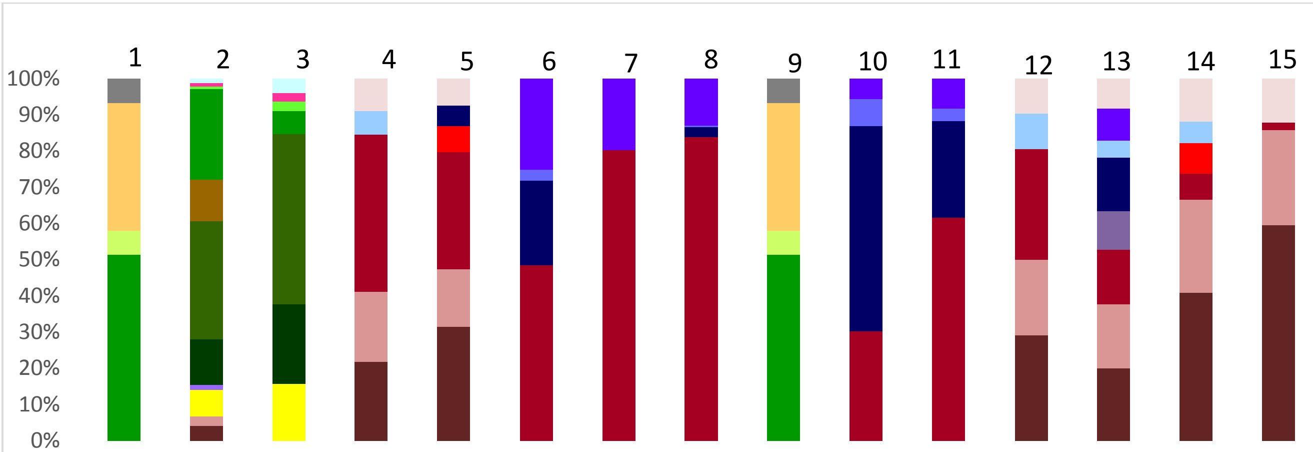

Figure 3: Relative contribution of each life cycle stages to all midpoint impact categories of FCL(color legends are same as in Figure 1). Midpoint impact categories are denoted by 1 to 15 as where 1= aquatic ecotoxicity, 2 = aquatic acidification, 3 = aquatic eutrophication, 4 = carcinogens, 5 = Ionizing radiation, 6 = land occupation, 7 = Mineral extraction, 8 = mineral extraction, 9 = non-carcinogens, 10 = non-renewable energy, 11= ozone-layer depletion, 12 = respiratory inorganics, 13 = respiratory organics, 14 = Terrestrial acidification, 15= terrestrial ecotoxicity

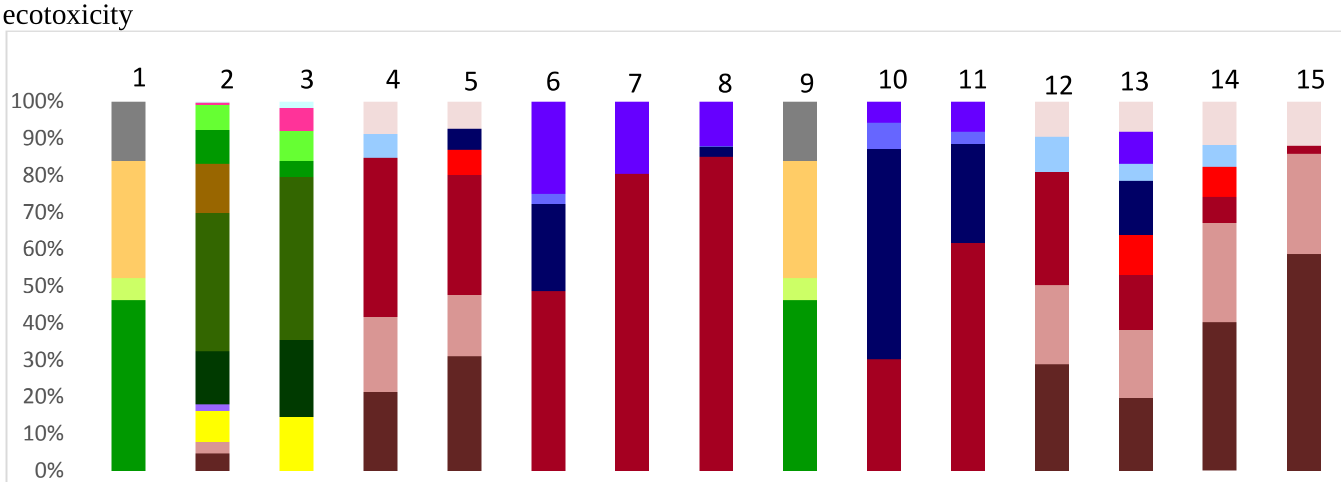

Figure 4: Relative contribution of each life cycle stages to all midpoint impact categories of CRLFCL (color legends are same as in Figure 1). Midpoint impact categories are denoted by 1 to 15 (same as in Figure 3)

CONCLUSION

The industries that are involved in converting crust leather to finished leather articles are insignificant in Bangladesh and the most tanneries are involved in producing crust leather from rawhide operating through the processes mentioned above. Therefore the impact assessment presented in this paper is representative of a typical tannery in Bangladesh. As different supply chain processes like emission due to electricity generation and transportation are out of the company's control, it is very difficult to take corrective action. However, by providing awareness program to the major suppliers and freight service providers, improvements (i.e. utilization of vehicle with low environmental impacts and avoiding using of old vehicles) can be expected. The condition of the existing boiler can be improved to minimize the quantity of steam consumed. Water consumption at production level can be reduced by reducing the washing time and practicing closed drum washing where applicable. Possible reuse of treated wastewater could be an option for washing processes in production phases. Installing an effluent treatment plant will significantly reduce environmental burden in the different damage categories. It was assessed using IMPACT 2002+ that installation of an ETP would minimize impact to negligible levels (~99% reduction) in midpoint categories such as aquatic ecotoxicity, aquatic eutrophication, aquatic acidification and non-carcinogens and thereby reducing the impact in the endpoint categories of human health and ecosystem quality. As a general measure, the company can prepare environmental management plans (EMP) and set environmental performance indicators that can easily be tracked. This study shows that LCA can be a very useful method in identifying environmental hotspots and prioritizing activities to minimize the environmental burden from tanneries in Bangladesh.

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