The Ecotoxicity of Leathers under Different Tanning Methods

Abigail Clare - Researcher, Karl Flowers - Technical Director, Eleanor Dring - Laboratory Technician at Authenticae

ABSTRACT

End-of-life is important when determining a materials sustainability credentials and, biodegradable leathers can play a key role in a sustainable future.

Leather samples tanned using different methods were analysed for detectable values of common toxins. Ecotoxicological screens were undertaken on 5-samples of each type of leather (chrome-tanned, chrome-free and vegetable-tanned). Chrome-tanned leather had significantly more detectable leathers of chromium, whereas vegetable-tanned leathers had significantly more detectable levels of extractable petroleum hydrocarbons (EPH).

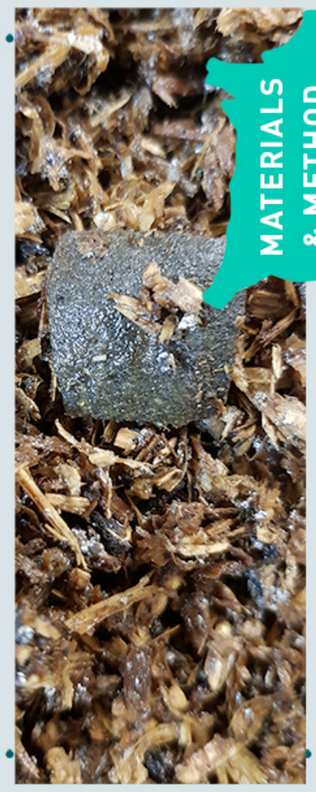
At end-of-life, toxins from biodegradable leathers may contaminate soils. Oxidants in soils may oxidise Cr (III) to more toxic Cr(VI). Chromium absorbed by plants can impact growth and development as it is structurally similar to other nutrients. EPH negatively impacts soil enzyme activities (which alters nutrient availability), stunts plant growth (and development) and can exert a carcinogenic effect. Toxins can bioaccumulate, posing a risk to animals and human health.

Tanning methods influence the ecotoxicological screen but, the highly diverse leather-making process means tanning type is not an accurate determinant of toxicity.

INTRODUCTION

Raw hide is naturally biodegradable; however, tanning alters the rate of disintegration. Application of leather compost to soil can provide a pathway for toxins to reach the soil and, therefore, tanning chemistry needs to be controlled to reduce the leather's overall environmental risk. With a greater focus on reducing toxic substances, coupled with the strive towards a circular economy, it is becoming more important to investigate the ecological effect of materials at end-of-life.

This study aimed to undertake an ecotoxicological screen to determine the types of toxins produced by different tanning methods: chrome-tanning, vegetable-tanning and chrome-free.



MATERIALS & METHOD

A modified version of EN ISO 20200 was used to simulate leather in an industrial composting environment. Five samples of each type of tanned leather were randomly selected. The reactors were placed in a 58 ºC oven for 90 days. The reactors were carefully mixed and weighed and watered according to the method.

An ecotoxicological screen was undertaken on the resulting leather compost to determine the detectable values of common toxins.

A Kruskal-Wallis test was undertaken to determine if there was a significant difference in the median detectable value of different toxins between leathers.

RESULTS & DISCUSSIONS

Obviously, there was statistically more detectable chrome in chrome-tanned leathers. Low levels were also detected in all other samples, likely due to a chrome retannage or machinery contamination. Depending on soil properties (i.e., oxide content, pH and organic matter), Cr (III) from chrome tanning agents may oxidise to Cr (VI). Cr (VI) is more mobile and bioavailable. Chromium toxicity to plants occurs through interaction with genetic processes, signal transduction pathways and cellular macromolecules – which likely stunts growth and development. Chromium can bioaccumulate and exert a carcinogenic effect on animals and humans.

Small concentrations of other toxic metals also appeared in all samples, but this was not correlated with tanning type. These likely result from inorganic pigments (finishes and dyes) that contain metal salts. There were also no specific toxins found in all chrome-free leather samples.

There were statistically more detectable EPH in vegetable-tanned leathers, likely resulting from sulphochlorinated aliphatic hydrocarbon fatliquors or mineral oils that are used to increase fullness, softness and water resistance. EPH can be degraded to more-toxic shorter forms, with greater water solubility and mobility. EPH in soils inhibits microbes; preventing microbial degradation and resulting in soil nutrient deficiency. Nutrient deficiency reduces plant productivity. EPH may physically obstruct plants – reducing access to light, water and nutrients. Exposure of EPH to animals occurs through ingestion, whereas humans are likely exposed through bioaccumulation or contamination of drinking water.

CONCLUSIONS

What happens to materials at end-of-life has become a growing concern in the sustainability of products. The widespread use of chromium tanning agents results in the presence of chromium in all leather samples. Ecological toxicity in soils may occur through the oxidation of Cr (III) to more toxic and bioavailable Cr (VI). The disadvantages of vegetable-crust result in the application of petroleum-based fatliquors that are likely responsible for high detectable levels of EPH. In soils, EPH can degrade into shorter, more toxic forms. Leather toxicity depends on the chemistry used throughout all tannery operations. Furthermore, Ecotoxicological screening methods should be continuously improved to cover all compounds of concern.

KEY REFERENCES

Kumar, V., Suryakant, P.K.S., Kumar, S. and Kumar, N., 2016. Effect of chromium toxicity on plants: A review. Agriways, 4(1), pp.107-120.

Maina, P., Ollengo, M.A. and Nthiga, E.W., 2019. Trends in leather processing: A Review.

Truskewycz, A., Gundry, T.D., Khudur, L.S., Kolobaric, A., Taha, M., Aburto-Medina, A., Ball, A.S. and Shahsavari, E., 2019. Petroleum hydrocarbon contamination in terrestrial ecosystems—fate and microbial responses. Molecules, 24(18), p.3400.

ACKNOWLEDGEMENTS

The authors declare there are no conflicts of interest.

The authors received no external funding for the research of this article